

**TURKISH**  
**GREENHOUSE GAS**  
**INVENTORY**  
**1990 - 2017**

National Inventory Report for submission under  
the United Nations Framework Convention on Climate Change

April 2019



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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 1990-2017.

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 (CRF) 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, have 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 Greenhouse Gas (GHG) Inventories (2006 IPCC Guidelines).

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 and Infrastructure (MoTI),
- Ministry of Environment and Urbanization (MoEU),
- Ministry of Agriculture and Forestry (MAF).

The National GHG emissions/removals are calculated by using 2006 IPCC Guidelines. The Emission Inventory includes direct GHGs as carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), fluorinated gases (F-gases); Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur hexafluoride (SF<sub>6</sub>), NF<sub>3</sub> and indirect GHGs as nitrogen oxides (NO<sub>x</sub>), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO), and Sulphur dioxide (SO<sub>2</sub>) emissions originated from energy, industrial processes and product use (IPPU), agriculture 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 National Emission and Removal Related Trends

Turkey's total GHG emissions, excluding the LULUCF sector, were estimated to be 526.3 Mt of CO<sub>2</sub> equivalent (CO<sub>2</sub> eq.) in 2017. This represents an increase of 27.8 Mt, or 5.6%, in emissions compared to 2016, and an increase of 140.1% above 1990 levels (Table ES 1).

**Table ES 1 Greenhouse gas emissions (excluding LULUCF), 1990-2017**

	1990	1995	2000	2005	2010	2015	2016	2017
Total (Mt CO <sub>2</sub> eq.)	219.2	247.6	298.9	337.2	398.7	472.2	498.5	526.3
Change compared to 1990 (%)	-	12.9	36.4	53.8	81.9	115.4	127.4	140.1

Turkey's total GHG emissions, including the LULUCF sector, were 426.3 Mt CO<sub>2</sub> eq. in 2017. Thus, LULUCF included total emissions increased 5.9% as compared to 2016 emissions. There is a 160.9% increase from 1990 to 2017 (Table ES 2).

**Table ES 2 Overview of GHG emissions and removals, 1990-2017**

	(Mt CO <sub>2</sub> eq.)							
GHG emissions	1990	1995	2000	2005	2010	2015	2016	2017
CO <sub>2</sub> (excluding LULUCF)	151.5	180.9	229.8	264.2	314.4	381.3	401.2	425.3
CO <sub>2</sub> (including LULUCF)	95.6	123.4	168.0	189.5	240.8	284.1	305.2	325.3
CH <sub>4</sub> (excluding LULUCF)	42.4	42.5	43.6	45.2	51.3	51.3	53.9	54.2
CH <sub>4</sub> (including LULUCF)	42.5	42.5	43.7	45.2	51.3	51.4	53.9	54.3
N <sub>2</sub> O (excluding LULUCF)	24.7	23.6	24.8	26.1	29.4	34.7	37.1	38.5
N <sub>2</sub> O (including LULUCF)	24.7	23.6	24.9	26.2	29.5	34.7	37.1	38.6
HFCs	NO	NO	0.1	1.1	3.1	4.6	6.1	8.0
PFCs	0.6	0.6	0.6	0.6	0.5	0.2	0.1	0.1
SF <sub>6</sub>	NO	NO	0.0	0.0	0.0	0.0	0.0	0.1
Total (excluding LULUCF)	219.2	247.6	298.9	337.2	398.7	472.2	498.5	526.3
Total (including LULUCF)	163.4	190.2	237.3	262.5	325.2	375.0	402.5	426.3

Total GHG emissions as CO<sub>2</sub> eq. for the year 2017 were 526.3 Mt (excluding LULUCF). In overall 2017 emissions, the energy sector had the largest portion with 72.2%. The energy sector was followed by the sectors of IPPU with 12.6%, the agriculture with 11.9% and the waste with 3.3%. GHG emissions by sectors are given in Table ES 3.

**Table ES 3 Greenhouse gas emissions by sectors, 1990-2017**

(Mt CO<sub>2</sub> eq.)

Year	Energy	IPPU	Agriculture	LULUCF	Waste	Total (Excluding LULUCF)	Total (Including LULUCF)
1990	139.6	22.8	45.7	-55.8	11.1	219.2	163.4
1991	144.0	24.7	46.5	-56.7	11.3	226.6	169.9
1992	150.3	24.3	46.6	-56.9	11.5	232.8	175.9
1993	156.8	24.5	47.0	-56.1	11.8	240.1	184.1
1994	153.3	24.2	44.6	-57.5	12.0	234.1	176.7
1995	166.3	25.2	43.7	-57.4	12.4	247.6	190.2
1996	184.0	26.2	44.4	-57.7	12.7	267.2	209.5
1997	196.2	27.0	42.2	-61.7	13.2	278.6	216.9
1998	195.9	27.4	43.6	-62.6	13.5	280.3	217.7
1999	193.8	25.8	44.2	-64.0	13.9	277.8	213.7
2000	216.1	26.2	42.3	-61.6	14.3	298.9	237.3
2001	199.2	25.9	39.8	-64.7	15.5	280.4	215.7
2002	205.8	26.9	37.4	-72.5	15.9	286.1	213.6
2003	220.3	28.2	40.9	-74.5	16.2	305.6	231.0
2004	226.1	30.8	41.4	-73.7	16.6	315.0	241.3
2005	244.0	33.6	42.3	-74.7	17.3	337.2	262.5
2006	260.0	36.7	43.5	-74.7	18.0	358.2	283.4
2007	290.8	39.2	43.2	-74.4	18.3	391.4	317.0
2008	287.3	40.9	41.0	-69.2	18.3	387.6	318.4
2009	292.5	42.5	41.7	-72.8	18.8	395.5	322.7
2010	287.0	48.1	44.0	-73.5	19.5	398.7	325.2
2011	308.7	52.7	46.4	-77.1	19.8	427.6	350.5
2012	320.5	55.0	52.1	-74.4	19.4	446.9	372.5
2013	307.5	58.1	55.2	-76.5	18.2	439.0	362.5
2014	325.8	58.5	55.5	-77.5	18.2	458.0	380.5
2015	340.9	57.0	55.4	-97.2	18.8	472.2	375.0
2016	359.7	62.2	58.2	-95.9	18.4	498.5	402.5
2017	379.9	66.5	62.5	-99.9	17.4	526.3	426.3

As shown in Table ES 3, emissions from energy increased by 5.6% to 379.9 Mt CO<sub>2</sub> eq. in 2017 as compared to 2016. However, there is 172% increase as compared to 1990. Emissions in the IPPU sector increased to 66.5 Mt CO<sub>2</sub> eq. in 2017 which is 6.9% higher than the emissions in 2016. Emissions in the agriculture and waste sectors were 62.5 and 17.4 Mt CO<sub>2</sub> eq. respectively in 2017.

### ES.3 Overview of Emission Estimates and Trends

The highest portion of total CO<sub>2</sub> emissions originated from energy sector with 86.3%. The remaining 13.4% originated from IPPU and 0.3% from agriculture in 2017. CO<sub>2</sub> emissions from energy increased 6.3% compared to 2016 while increased 182% as compared to 1990. CO<sub>2</sub> emissions from industrial processes increased 4.3% compared to 2016 and increased 170% as compared to 1990.

The largest portion of CH<sub>4</sub> emissions originated from agriculture with 62.3% while 21.3% from waste, and 16.4% from energy and industrial processes. CH<sub>4</sub> emissions from agriculture increased 11% compared to 2016. It increased 34.8% as compared to 1990. CH<sub>4</sub> emissions from waste decreased 10.9% compared to 2016. However, it increased 20.2% as compared to 1990.

While 71.0% of N<sub>2</sub>O emission was from agriculture, 15.1% was from waste, 10.7% was from energy and 3.3% was from IPPU. There is a 4.0% increase and 56.3% increase in total N<sub>2</sub>O emissions as compared to 2016 and 1990 respectively. GHG emissions by sectors are given in Table ES 4.

**Table ES 4 GHG emissions, 1990-2017**

Emission sources	(kt)							
	1990	1995	2000	2005	2010	2015	2016	2017
<b>CO<sub>2</sub></b>								
<b>Total</b>	151 508	180 903	229 791	264 201	314 380	381332	401 240	425 330
Energy	129 882	156 827	204 511	232 409	270 820	329782	345 298	366 898
IPPU	21 140	23 624	24 641	31 167	42 904	50738	54 645	56 980
Agriculture	460	426	617	613	645	811	1295	1450
Waste	27	26	21	12	11	1.1	1.8	1.9
<b>CH<sub>4</sub></b>								
<b>Total</b>	1 696	1 700	1 742	1 806	2 053	2053	2 155	2 168
Energy	311	286	361	338	491	296	420	356
IPPU	0.3	0.3	0.4	0.4	0.4	0.6	0.7	1
Agriculture	1 001	984	874	881	950	1212	1 216	1 350
Waste	384	430	508	587	611	545	518	462
<b>N<sub>2</sub>O</b>								
<b>Total</b>	83	79	83	88	99	116	124	129
Energy	6.5	7.8	8.5	10	13	12	13	14
IPPU	3.6	3.4	2.8	2.4	5.5	4.9	4.1	4.2
Agriculture	68	63	66	66	66	82	89	92
Waste	4.9	5.3	5.5	8.8	14	17	18	20

## ES.4 Indirect GHG Emissions

Emissions of CO, NO<sub>x</sub>, NMVOC and SO<sub>2</sub> are also included in the report because they influence climate change indirectly. Table ES 5 shows the indirect GHG emissions. CO emissions are 2.00 Mt in 2017 with more than 99% of them from energy sector. NO<sub>x</sub> emissions are 0.77 Mt in 2017 and more than 99% of which is from energy. NMVOC emissions are 1.09 Mt in 2017. The largest portion of NMVOC emissions is from agriculture with 41% and this figure is followed by IPPU with 33%. SO<sub>2</sub> emissions are 2.3 Mt and more than 99% is sourced from energy sector in 2017.

**Table ES 5 Indirect GHG emissions, 1990-2017**

								(kt)
<b>Emission sources</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2010</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>
<b>CO</b>								
<b>Total</b>	<b>2 025</b>	<b>2 400</b>	<b>2 605</b>	<b>2 317</b>	<b>2 899</b>	<b>2 182</b>	<b>2 047</b>	<b>2 004</b>
Energy	2 000	2 368	2 576	2 299	2 884	2 175	2 036	1 992
IPPU	8.60	8.75	8.54	8.12	7.70	7.01	11.1	11.3
Waste	16.4	22.6	20.0	9.74	7.48	0.39	0.56	0.56
<b>NO<sub>x</sub></b>								
<b>Total</b>	<b>254</b>	<b>374</b>	<b>494</b>	<b>670</b>	<b>704</b>	<b>709</b>	<b>718</b>	<b>765</b>
Energy	252	363	485	665	699	705	714	761
IPPU	0.95	9.53	7.62	3.60	3.70	4.03	3.86	4.22
Waste	0.93	1.29	1.14	0.55	0.43	0.02	0.03	0.03
<b>NMVOC</b>								
<b>Total</b>	<b>893</b>	<b>972</b>	<b>1 015</b>	<b>997</b>	<b>1 049</b>	<b>1 076</b>	<b>1 061</b>	<b>1 094</b>
Energy	283	313	311	313	351	271	245	245
IPPU	252	277	317	313	329	349	354	360
Agriculture	353	351	348	332	329	412	417	445
Waste	4.92	31.7	38.4	38.6	39.1	44.0	44.5	44.5
<b>SO<sub>2</sub></b>								
<b>Total</b>	<b>1 688</b>	<b>1 807</b>	<b>2 238</b>	<b>2 001</b>	<b>2 554</b>	<b>1 943</b>	<b>2 247</b>	<b>2 279</b>
Energy	1 687	1 806	2 237	2 000	2 553	1 943	2 246	2 277
IPPU	0.82	0.85	0.79	0.72	0.75	0.81	1.06	1.11
Waste	0.03	0.04	0.04	0.02	0.01	0.00	0.00	0.00

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### SYMBOL AND ABBREVIATIONS

2006 IPCC Guidelines	2006 IPCC Guidelines for National Greenhouse Gas Inventories
ABPRS	Address Based Population Registration System
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 <sub>2</sub> F <sub>6</sub>	Hexafluoroethane
CaCO <sub>3</sub>	Calcium carbonate
CAGR	Compound annual growth rate
CaMg(CO <sub>3</sub> ) <sub>2</sub>	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 <sub>4</sub>	Carbon tetrafluoride
CFCs	Chlorofluorocarbons
CH <sub>4</sub>	Methane
CKD	Cement kiln dust
CL-SL	Cropland converted to settlements

cm	Centimeter
CO	Carbon monoxide
CO <sub>2</sub>	Carbon dioxide
CO <sub>2</sub> 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
EF <sub>c</sub>	Baseline emission factor for continuously flooded fields without organic amendments
EHICIP	Environmental Heavy Cost Investment Planning
EMEP	European Monitoring and Evaluation Programme
EMRA	Energy Market Regulatory Authority
ENVANIS	Inventory Statistical System for Forests
ERT	Expert Review Team
EU	European Union
F	Fraction of methane
FAO	Food and Agriculture Organization of the United Nations
FCF	Fossil carbon content
F-gases	Fluorinated gases
FOD	First Order Decay
Frac <sub>GASF</sub>	Fraction of synthetic fertiliser N that volatilises as NH <sub>3</sub> and NO <sub>x</sub>

Frac <sub>GASM</sub>	Fraction of applied organic N fertiliser materials and of urine and dung N deposited by grazing animals that volatilises as NH <sub>3</sub> and NO <sub>x</sub>
Frac <sub>LEACH-(H)</sub>	Fraction of all N added to/mineralised in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff
g	gram
GDF	General Directorate 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 hectare
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
MC	Monte Carlo
MCF	Methane correction factor
ME	Main engine
MENR	Ministry of Energy and Natural Resources
MAF	Ministry of Agriculture and Forestry
MgCO <sub>3</sub>	Magnesium carbonate
MgO	Magnesium oxide
MJ	Megajoule
MoEF	Ministry of Environment and Forestry
MoEU	Ministry of Environment and Urbanization
MoT	Ministry of Trade
MoTI	Ministry of Transport and Infrastructure
MRV	Monitoring, Reporting, Verification
MS	Manure Management System Usage
MSm <sup>3</sup>	Million standard cubic meter
MSW	Municipal solid waste
Mt	Million tonnes
MW	Megawatt
N	Nitrogen
N <sub>2</sub> O	Nitrous oxide
NA	Not applicable
Na <sub>2</sub> CO <sub>3</sub>	Sodium carbonate
NaCl	Sodium chloride
NCV	Net calorific value
NE	Not estimated
NES	EU Integrated Environmental Adaptation Strategy
Nex	Annual nitrogen excretion
NH <sub>3</sub>	Ammonia
NIR	National Inventory Report
NMVOC	Non-methane volatile organic compounds
NO	Not occurred

NO <sub>x</sub>	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
PS	Plant specific
QA/QC	Quality assurance and quality control
R	Root-to-shoot ratio
S	Soil
SEM	Ship Emission Model
SF <sub>6</sub>	Sulphur hexafluoride
SFOC	Specific Fuel Oil Consumption
SF <sub>p</sub>	Scaling factor regarding water regime before the cultivation period
SF <sub>w</sub>	Scaling factor regarding water regime during the cultivation period
SO <sub>2</sub>	Sulphur dioxide
SO <sub>x</sub>	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 for National Greenhouse Gas Inventories (2006 IPCC Guidelines). Emissions and removals have been estimated and reported in line with the 2006 IPCC Guidelines. 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<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFCs, SF<sub>6</sub>, PFCs, NF<sub>3</sub> and indirect gases as NO<sub>x</sub>, NMVOC and CO, and SO<sub>2</sub> emissions originated from energy, IPPU, agriculture, and waste. The emissions and removals from LULUCF are also included in the inventory. Indirect CO<sub>2</sub> 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 2017, 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 centralized 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 Ministries related to foreign relations, finance, economy, energy, transport, industry, agriculture, forestry, health, education, TurkStat, and Non-Governmental Organisations (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 Emission 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 Decision 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 and Infrastructure (MoTI),
- Ministry of Environment and Urbanization (MoEU),
- Ministry of Agriculture and Forestry (MAF).

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 responsibilities for national GHG inventory**

Sector	CRF category	Collection of AD	Selection of methods and EFs	GHG emission calculations	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
	1.A.1.a – Public electricity and heat production	MENR	MENR	MENR	MENR	MENR
	1.A.3 – Transport	MoTI TurkStat	MoTI	MoTI	MoTI	MoTI
Industrial processes and product use	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 – LULUCF	MAF	MAF	MAF	MAF	MAF
Waste	5 – Waste	TurkStat	TurkStat	TurkStat	TurkStat	TurkStat
<b>Cross cutting issues</b>						
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. The publishing schedule for the press release of Greenhouse Gas Emissions Statistics can be found on National Data Release Calendar (<http://www.turkstat.gov.tr/ingtakvim/tkvim.zul#tb1>). 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 quality assurance and quality control (QA/QC) 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 product use, agriculture 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 processes (excluding F-gases), agriculture, 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 and Infrastructure. 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 Agriculture and Forestry.

Also country specific (CS) CO<sub>2</sub> 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 archiving the GHG inventory. Central archiving is carried out by TurkStat. EFs, AD, calculation sheets, CRF and NIR outputs, etc. regarding the emission inventory are



archived on TurkStat main server. All inventory related documents are also archived 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 guidelines (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 obtained 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**

<b>Data quality objective</b>	<b>Criteria for assessing achievement of quality objective</b>
Accuracy	<ul style="list-style-type: none"> <li>Emissions are neither overestimated or underestimated as far as can be judged,</li> <li>Uncertainty estimates are provided for AD, EF, and emissions in each category for the base year, the most recent year, and the trend.</li> </ul>
Comparability	<ul style="list-style-type: none"> <li>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.</li> </ul>
Completeness	<ul style="list-style-type: none"> <li>All categories for which methods are provided in the 2006 IPCC Guidelines are included in the national GHG inventory,</li> <li>Emissions estimates cover the entire geographic area of Turkey,</li> <li>Emissions values or notation keys are provided for each cell in the CRF tables,</li> <li>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.</li> </ul>
Consistency	<ul style="list-style-type: none"> <li>Turkey has applied the same method across the time series for a given category and can explain the trends observed in the time series,</li> <li>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.</li> </ul>
Improvement	<ul style="list-style-type: none"> <li>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,</li> <li>Turkey implements findings from review processes where feasible.</li> </ul>
Sustainability	<ul style="list-style-type: none"> <li>All inventory related documents (NIR, data sheets, EFs, CRF tables) are archived annually,</li> <li>All information on choice of methodology, EFs and parameters, assumptions used, are documented and updated as needed,</li> <li>All methodological manuals are prepared and updated as needed.</li> </ul>

**Table 1.2 Criteria for assessing achievement of quality objectives (cont'd)**

<b>Data quality objective</b>	<b>Criteria for assessing achievement of quality objective</b>
Timeliness	<ul style="list-style-type: none"> <li>• Inventory is submitted to the UNFCCC by 15 April annually,</li> <li>• Turkey is able to timely respond to questions from the UNFCCC ERT.</li> </ul>
Transparency	<ul style="list-style-type: none"> <li>• Information necessary to reproduce the emissions estimates is either provided in the annual submission or referenced therein,</li> <li>• 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: <ul style="list-style-type: none"> <li>• All methods selected and models used</li> <li>• Values and sources of AD, EFs and other parameters</li> <li>• Relevant information on key categories and uncertainties</li> <li>• Recalculations are clearly explained</li> <li>• Completeness of the inventory</li> <li>• Changes in response to the review process</li> <li>• Description of the national inventory arrangements.</li> </ul> </li> </ul>

### 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<sup>3</sup> CH<sub>4</sub>) 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.

For the period 2017-2019, TurkStat is responsible for implementing an investment project with the objective of improving the GHG Inventory. Under this project, a QA work was conducted for the agriculture sector in December 2017. Likewise, another QA work was conducted for the energy sector in 2018. Undertaking QA works related to the remaining sectors of the GHG Inventory are under consideration until the end of 2019 within the scope of this investment project.



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 Expert Review Team (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. In this report, the comments/actions for ERT recommendations have not been provided in the above-mentioned tables since the UNFCCC Secretariat has not organized the individual review of Turkey's inventory in 2017.

### 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 CO<sub>2</sub> 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](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 Inventory 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<sub>2</sub> emissions from energy are calculated by using Tier 2 (T2) approach except for biomass and other fossil fuels. CH<sub>4</sub> and N<sub>2</sub>O emissions from all subcategories of energy excepting 1A1a category are calculated by using Tier 1 (T1). Technology specific EFs are used for CH<sub>4</sub> and N<sub>2</sub>O 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 product use, T2 methodology was used for the CO<sub>2</sub> emissions from cement production, ammonia (NH<sub>3</sub>) production. T3 methodology is used for CO<sub>2</sub> emissions from iron and steel production and GHG emissions from aluminum 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<sub>2</sub> emissions from open burning of waste, which is only CO<sub>2</sub> emission source for waste sector is calculated by using T2 method. For CH<sub>4</sub> emissions from solid waste disposal, T2 methodology was used while T1 was used for the rest of CH<sub>4</sub> emission source category. For N<sub>2</sub>O 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, 2017

Greenhouse Gas Source and Sink Categories	CO <sub>2</sub>		CH <sub>4</sub>		N <sub>2</sub> O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
<b>1. Energy</b>	T1,T2,T3	CS,D	T1,T2,T3	D,PS	T1,T2,T3	D,PS
A. Fuel combustion	T1,T2,T3	CS,D	T1,T2,T3	D,PS	T1,T2,T3	D,PS
1. Energy industries	T3	CS,D	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 <sub>2</sub> transport and storage	T1	D				
<b>2. Industrial processes</b>	T1,T2,T3	CS,D	T1	D	T1	D
A. Mineral industry	T1,T2	CS,D				
B. Chemical industry	T1,T2	CS,D	NE	NE	T1	D
C. Metal industry	T1,T2,T3	CS,D	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
<b>3. Agriculture</b>	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					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
<b>4. Land use, land-use change and forestry</b>	T1,T2	CS,D	T1	D	T1	D
A. Forest land	T2	CS,D	T1	D	T1	D
B. Cropland	T1,T2	CS,D	NE	NE	T1	D
C. Grassland	T1,T2	CS,D	NE	NE	T1	D
D. Wetlands	T1,T2	CS,D	NE	NE	T1	D
E. Settlements	T1	D	NE	NE	NE	NE
F. Other land	T1	D	NO	NO	NO	NO
G. Harvested wood products	T2	CS,D				
H. Other	NO	NO	NO	NO	NO	NO
<b>5. Waste</b>	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 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)  General Directorate of Renewable Energy and PETKIM - 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	Ministry of Trade (MoT) - trade statistics
	2.G.1. Electrical equipment	MoT - trade statistics - Turkish Electricity Transmission Corporation (TEİAŞ)

**Table 1.5 Activity data sources for GHG inventory (cont'd.)**

<b>Sector</b>	<b>Category</b>	<b>Activity data source</b>
Agriculture	Agriculture – 3	TurkStat - Livestock population Crop production data Waste disposal and treatment statistics
		General Directorate of Meteorology - Temperature data
		MAF- Inorganic N Fertilizers application data, urea application data
Land Use, Land Use Change and Forestry	LULUCF - 4	MAF (General Directorate of Forestry) - Copernicus Land Use Map (Landsat) The ENVANIS (Inventory Statistical System for Forests) The annual commercial cutting and fuel wood data The annual forest fire information (area) The annual illegal cutting and wood gathering information
		MAF (General Directorate of Agricultural Reform) - Copernicus Land Use Map (Landsat) CORINE land use maps LPIS
		General Directorate of State Hydraulic Works - the data of dam constructions
Waste	Waste – 5	TurkStat - Waste disposal and treatment statistics Wastewater discharge and treatment statistics GDP Population and population projections
		MoEU, TurkStat - 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 (2006 IPCC Guidelines) 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” (2006 IPCC Guidelines); this term is used in reference to both source and sink categories.

For the 1990-2017 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 2017.

**Table 1.6 Key categories for GHG inventory, 2017**

Key Categories of Emissions and Removals	Gas	Criteria used for key source identification		Key category exc. LULUCF	Key category inc. LULUCF
		L	T		
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO <sub>2</sub>	X	X	X	X
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO <sub>2</sub>	X	X	X	X
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO <sub>2</sub>	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO <sub>2</sub>	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO <sub>2</sub>	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO <sub>2</sub>	X	X	X	X
1.A.3.a Domestic Aviation	CO <sub>2</sub>	X	X	X	X
1.A.3.b Road Transportation	CO <sub>2</sub>	X	X	X	X
1.A.4 Other Sectors - Liquid Fuels	CO <sub>2</sub>	X	X	X	X
1.A.4 Other Sectors - Solid Fuels	CO <sub>2</sub>	X	X	X	X
1.A.4 Other Sectors - Gaseous Fuels	CO <sub>2</sub>	X	X	X	X
1.A.4 Other Sectors - Biomass	CH <sub>4</sub>		X	X	X
1.B.1 Fugitive emissions from Solid Fuels	CH <sub>4</sub>	X	X	X	X
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH <sub>4</sub>		X	X	
2.A.1 Cement Production	CO <sub>2</sub>	X	X	X	X
2.A.2 Lime Production	CO <sub>2</sub>	X	X	X	X
2.A.4 Other Process Uses of Carbonates	CO <sub>2</sub>	X	X	X	X
2.C.1 Iron and Steel Production	CO <sub>2</sub>	X	X	X	X
2.F.6 Other Applications	F-gases	X	X	X	X
3.A Enteric Fermentation	CH <sub>4</sub>	X	X	X	X
3.B Manure Management	CH <sub>4</sub>	X	X	X	X
3.B Manure Management	N <sub>2</sub> O	X	X	X	X
3.D.1 Direct N <sub>2</sub> O Emissions From Managed Soils	N <sub>2</sub> O	X	X	X	X
3.D.2 Indirect N <sub>2</sub> O Emissions From Managed Soils	N <sub>2</sub> O		X	X	X
4.A.1 Forest Land Remaining Forest Land	CO <sub>2</sub>	X	X		X
4.G Harvested Wood Products	CO <sub>2</sub>	X	X		X
4(V) Biomass Burning	CO <sub>2</sub>		X		X
5.A Solid Waste Disposal	CH <sub>4</sub>	X	X	X	X
5.D Wastewater Treatment and Discharge	CH <sub>4</sub>		X	X	X
5.D Wastewater Treatment and Discharge	N <sub>2</sub> O	X	X	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<sub>4</sub> emissions from other sectors, solid fuels and oil and gas systems in energy sectors, CH<sub>4</sub> emissions from manure management, N<sub>2</sub>O 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

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 (2006 IPCC Guidelines) is used. Also for some key categories and non-key categories Monte Carlo Simulation (Approach 2) is implemented. Please refer to Annex 2 for more detailed explanations and distributions of applied techniques. However, general combined uncertainty is estimated with Approach 1 due to the lack of calculated categories.

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<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFCs, PFCs and SF<sub>6</sub>) 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 data are estimated by MoTI,
- The uncertainties of forestry and other land use data are estimated by MAF.

Quantitative estimates of the uncertainties in the emissions are calculated using direct sectoral expert judgement based on the data collection matters considering completeness, accuracy and other parameters. The overall combined uncertainty with LULUCF is 13.8%, and 5.3% without LULUCF by means of Approach 1.

### 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

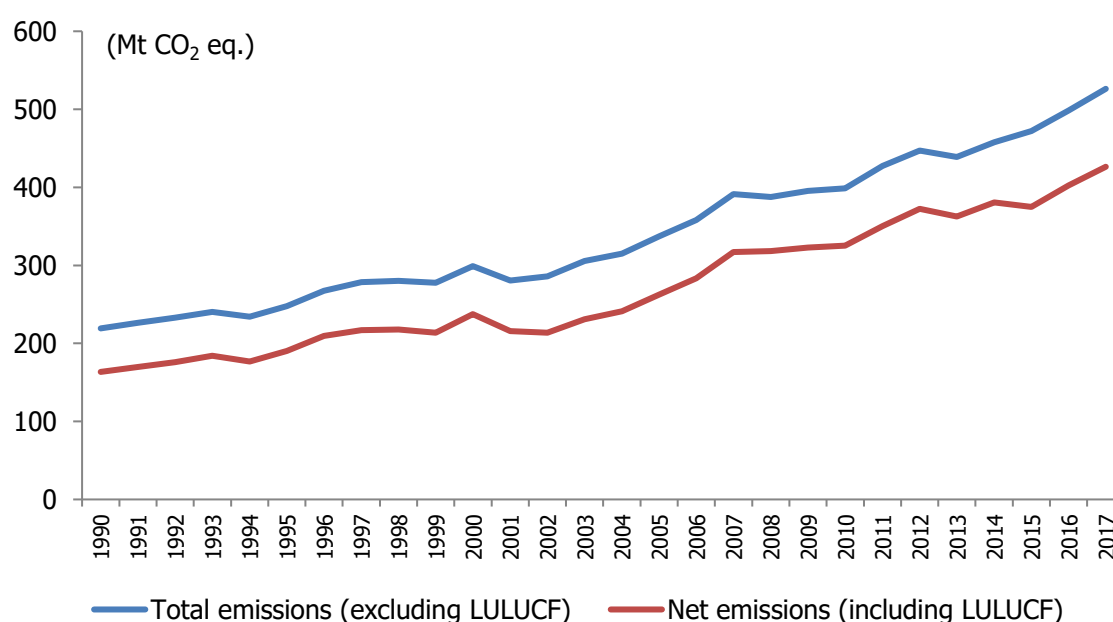
### 2.1. Emission Trends for Aggregated Greenhouse Gas Emissions

Total GHG emissions, excluding the LULUCF sector, were 526.3 Mt CO<sub>2</sub> eq. in 2017. This represents an increase of 307.1 Mt CO<sub>2</sub> eq. (140.1%) on total emissions in 1990 and an increase of 27.8 Mt CO<sub>2</sub> eq. (5.6%) in 2016.

Net GHG emissions, including the LULUCF sector, were 426.3 Mt CO<sub>2</sub> eq. in 2017. This represents an increase of 262.9 Mt CO<sub>2</sub> eq. (160.9%) on net emissions in 1990 and an increase of 23.8 Mt CO<sub>2</sub> eq. (5.9%) in 2016.

Figure 2.1 presents total and net GHG emissions from 1990 to 2017. The fluctuations in the emission trends 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.

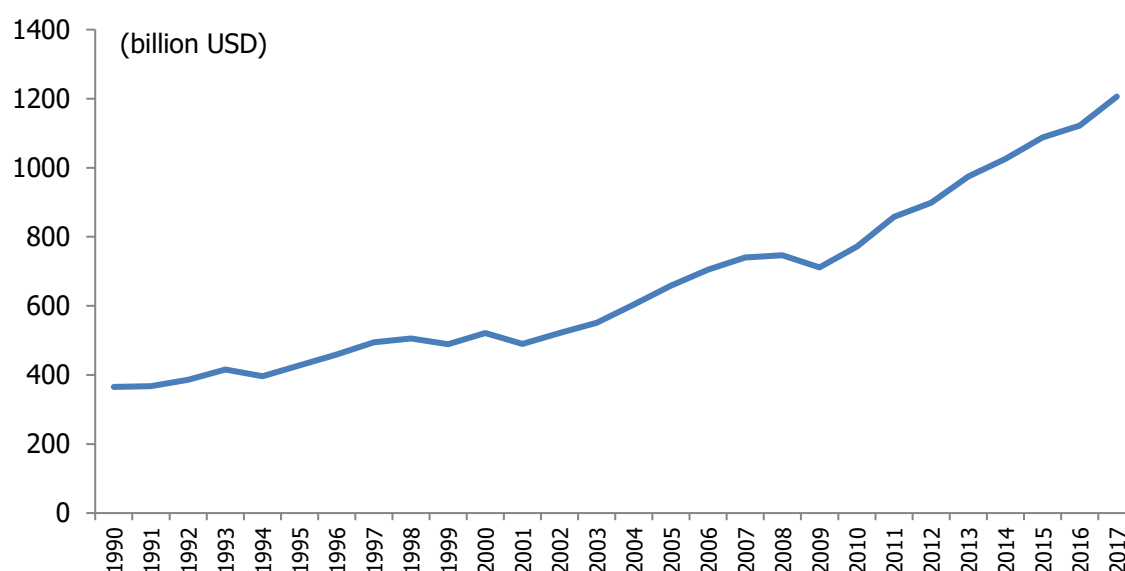
**Figure 2.1 Emission trend for aggregated GHG emissions, 1990-2017**



There is positive trend in the total emissions over the period 1990-2017. 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 2.5%, 0.9%, 6.2% and 1.0% as compared to the previous year's emissions respectively. Although there is no economic recession, total emissions are slightly decreased by 1.8% 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 trends 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, 1990-2017**



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 1990-2017. While it was about 365 billion USD in 1990, it reached 1206 billion USD with 2010 constant prices in 2017. Although economic crisis in 1994, 1999, 2001, 2009 caused 4.7%, 3.4%, 6.0%, 4.7% decrease in GDP, Turkish economy grew about 230% for the period 1990-2017.

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, 1990-2017**

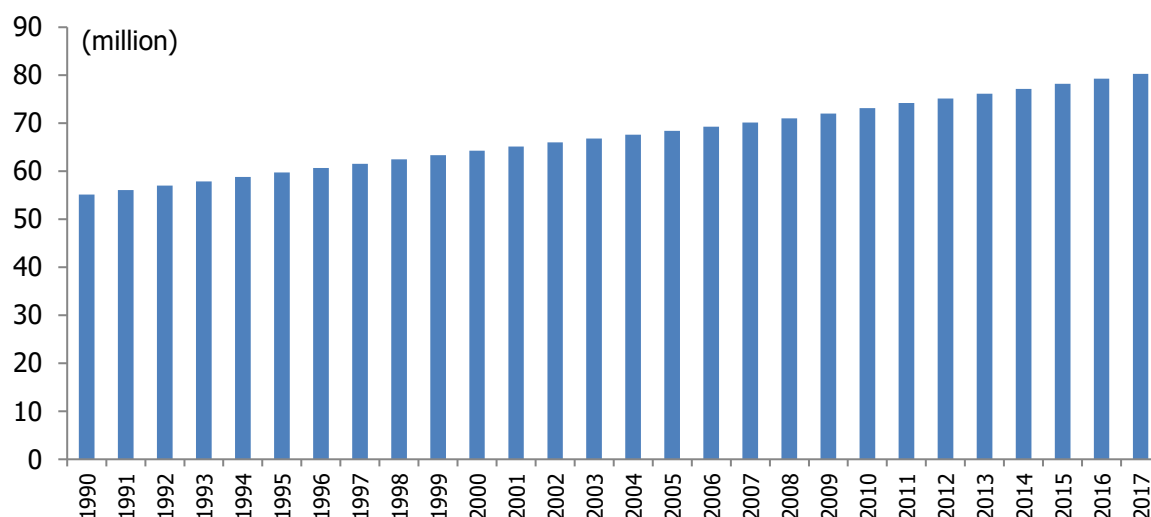


Figure 2.3 shows the mid-year population of Turkey with increase about 45.7% for the period 1990-2017. While it was 55.1 million in 1990, it reached 80.3 million in 2017. Moreover, Figure 2.4 shows GHG emission per capita.

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, 1990-2017**

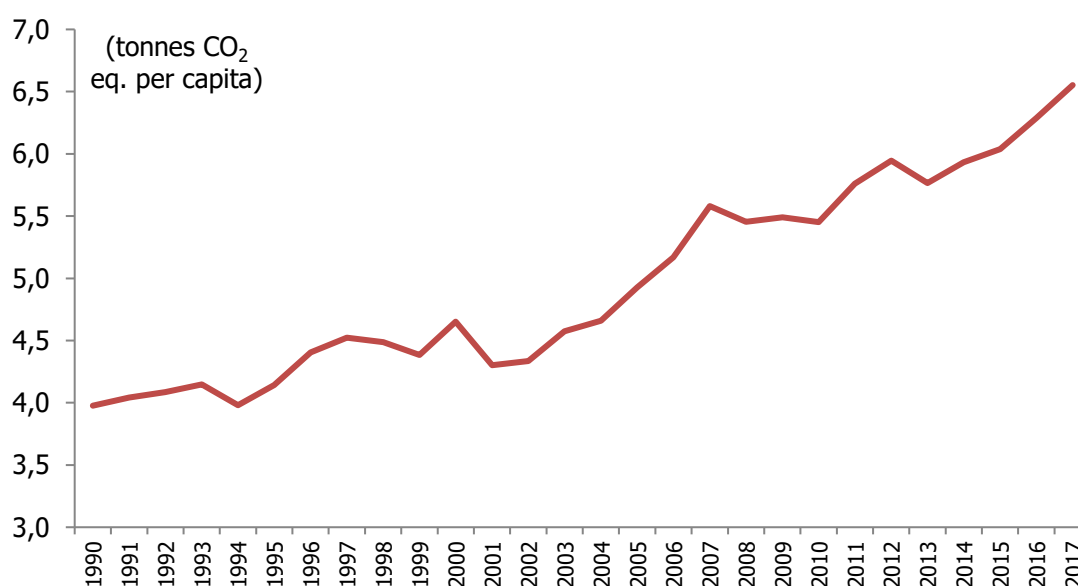


Table 2.1 gives summary data for GHG emissions for some selected years between 1990 and 2017.

**Table 2.1 Aggregated GHG emissions by sectors**

	(Mt CO <sub>2</sub> eq.)							
<b>Sector</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2010</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>
<b>Total (excluding LULUCF)</b>	<b>219.20</b>	<b>247.58</b>	<b>298.89</b>	<b>337.21</b>	<b>398.66</b>	<b>472.19</b>	<b>498.47</b>	<b>526.25</b>
Energy	139.60	166.32	216.05	243.96	287.05	340.91	359.67	379.90
IPPU	22.84	25.25	26.23	33.63	48.11	57.04	62.18	66.45
Agriculture	45.68	43.67	42.26	42.31	43.98	55.43	58.18	62.54
Waste	11.08	12.35	14.35	17.31	19.53	18.82	18.44	17.36
LULUCF	-55.76	-57.40	-61.56	-74.69	-73.49	-97.21	-95.93	-99.91
Compared to 1990 (%)	-	12.95	36.35	53.84	81.87	115.41	127.40	140.08

In overall 2017 emissions excluding LULUCF, the energy sector had the largest portion with 72.2%. The energy sector was followed by the IPPU with 12.6%. the agricultural activities with 11.9% and the waste with 3.3%.

## 2.2. Emission Trends by Gas

Total CO<sub>2</sub> emissions (excluding LULUCF) increased by 180.7% from 1990 to 2017. CH<sub>4</sub> emissions (excluding LULUCF) increased by 27.8% and N<sub>2</sub>O emissions (excluding LULUCF) increased by 56.3%.

Total CO<sub>2</sub> emissions (including LULUCF) increased by 240.2% from 1990 to 2017. There are no significant changes in other GHGs by taking into account the LULUCF sector. CH<sub>4</sub> emissions (including LULUCF) increased by 27.7% and N<sub>2</sub>O emissions (including LULUCF) increased by 56.2%.

As shown in Figure 2.5, the CO<sub>2</sub> emissions show a general increasing trend, while N<sub>2</sub>O and CH<sub>4</sub> emissions are not changing considerably.

**Figure 2.5 Emission trend of main GHGs, 1990-2017**

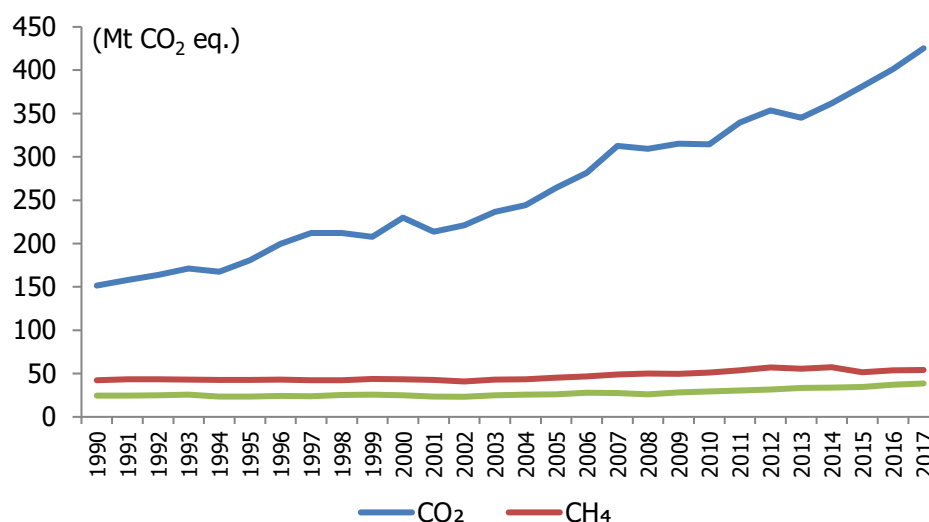


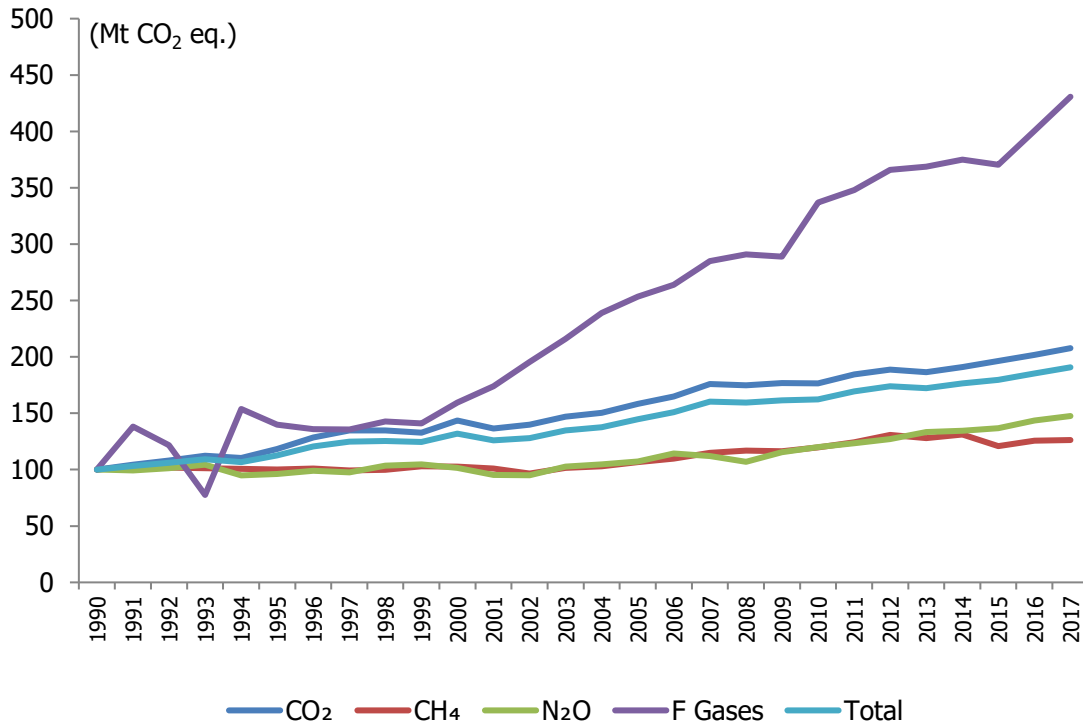
Table 2.2 gives summary data for GHG emissions by gas for some selected years between 1990 and 2017.

**Table 2.2 Aggregated GHG emissions excluding LULUCF**

(Mt CO <sub>2</sub> eq.)								
Gas	1990	1995	2000	2005	2010	2015	2016	2017
<b>Total</b>	<b>219.20</b>	<b>247.58</b>	<b>298.89</b>	<b>337.21</b>	<b>398.66</b>	<b>472.19</b>	<b>498.47</b>	<b>526.25</b>
CO <sub>2</sub>	151.51	180.90	229.79	264.20	314.38	381.33	401.24	425.33
CH <sub>4</sub>	42.41	42.50	43.56	45.16	51.32	51.33	53.87	54.19
N <sub>2</sub> O	24.66	23.57	24.81	26.13	29.43	34.69	37.07	38.54
HFCs	NO	NO	0.12	1.15	3.05	4.64	6.12	8.05
PFCs	0.63	0.61	0.60	0.56	0.46	0.16	0.14	0.07
SF <sub>6</sub>	NO	NO	0.01	0.02	0.02	0.04	0.04	0.07

Figure 2.6 shows that those all GHGs together for 1990-2017 period. It can easily be seen from this graph that all gases are showing increasing trend since 1990 generally. The largest contributor is CO<sub>2</sub> at 80.8% of the total emission in 2017. Second one is CH<sub>4</sub> with 10.3%. N<sub>2</sub>O contributes 7.3% and F gases are following with 1.5%.

**Figure 2.6 Emission trend of all GHGs, 1990-2017**

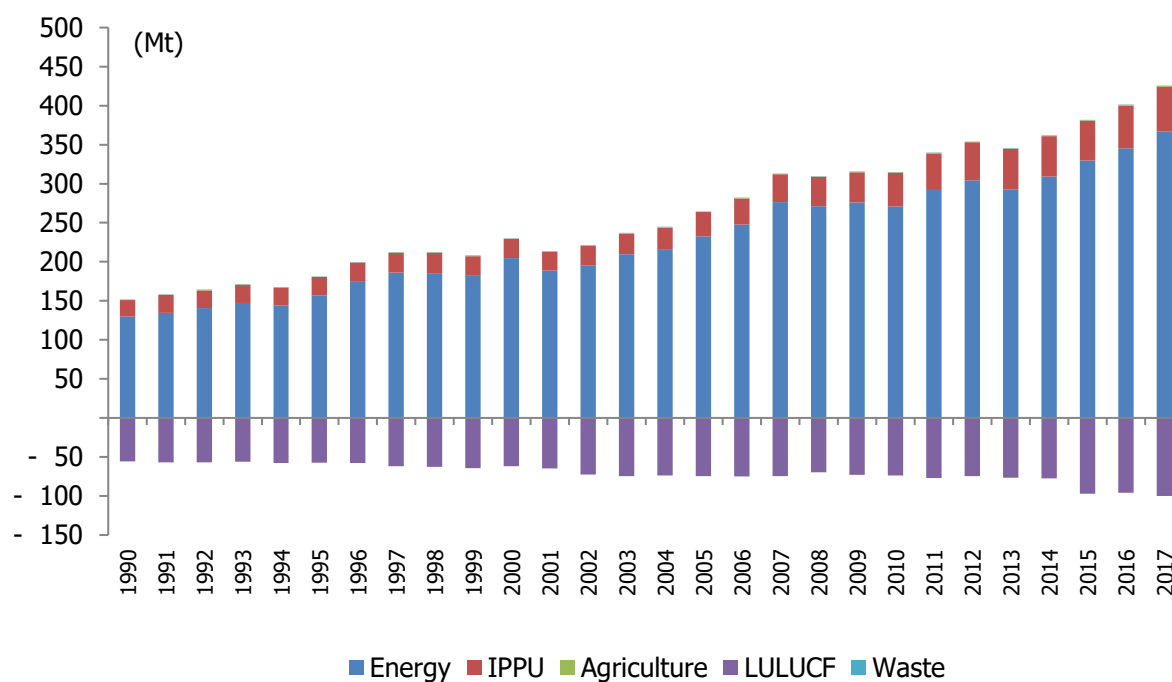


### Carbon Dioxide (CO<sub>2</sub>)

In 2017, CO<sub>2</sub> emissions are 425.3 Mt (excluding LULUCF), 6% above the 2016 level and 180.7% above the 1990 level. Figure 2.7 illustrates the trend in CO<sub>2</sub> emissions. It is seen that CO<sub>2</sub> 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 2017 excluding the LULUCF, energy sector is responsible for 86.3% of the total CO<sub>2</sub> emissions while IPPU is responsible for 13.4%. Agriculture and waste sectors do not cause significant amount of CO<sub>2</sub> emission.



**Figure 2.7 CO<sub>2</sub> emissions by sector, 1990-2017**

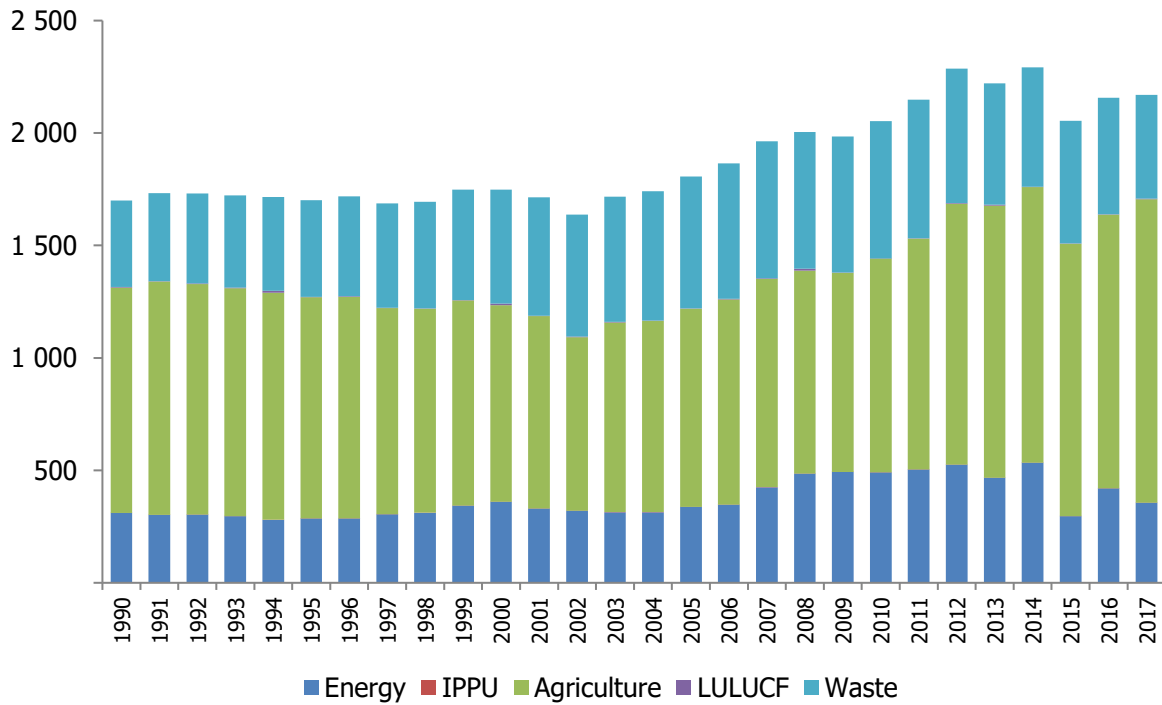


### Methane (CH<sub>4</sub>)

The trend in emissions of CH<sub>4</sub> is broken down by source in Figure 2.8, CH<sub>4</sub> is the second most significant GHG after CO<sub>2</sub> in Turkey since 1990. Emissions of CH<sub>4</sub> have increased 27.8% since the base year 1990 and have increased by 0.6% compared to 2016. In 2017, CH<sub>4</sub> emissions were 2 167.7 kt.

The major sectors of CH<sub>4</sub> 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<sub>4</sub> in comparison with other sector. Generally, all sectors have risen since 1990.

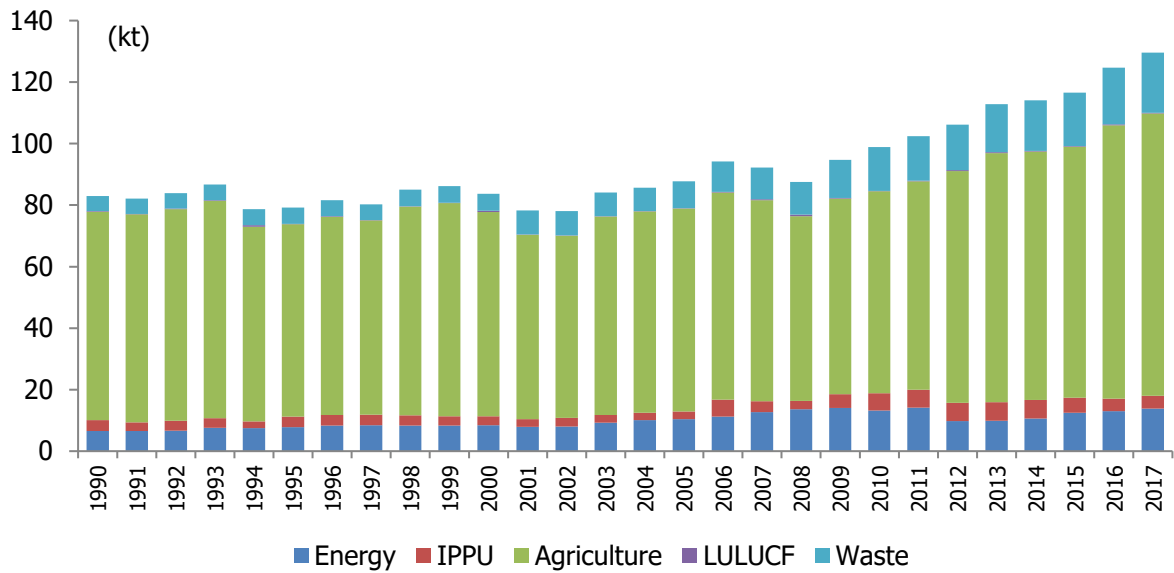
**Figure 2.8 CH<sub>4</sub> emissions by sector, 1990-2017**



### Nitrous Oxide (N<sub>2</sub>O)

In 2017, N<sub>2</sub>O emissions are 129.3 kt and it slightly increased from the level of 2016 (4.9 kt) but 56.3% above the 1990 level. As it is seen from the Figure 2.9, agriculture sector is the main contributor of N<sub>2</sub>O emissions in all the years and the share is 71% in 2017. Energy sector is responsible for 10.7% and waste sector is responsible for 15.1% of all N<sub>2</sub>O emissions. IPPU has a minor share for the N<sub>2</sub>O emissions by 3.3%.

**Figure 2.9 N<sub>2</sub>O emissions by sector, 1990-2017**



### Fluorinated Gases (HFCs, PFCs, SF<sub>6</sub>)

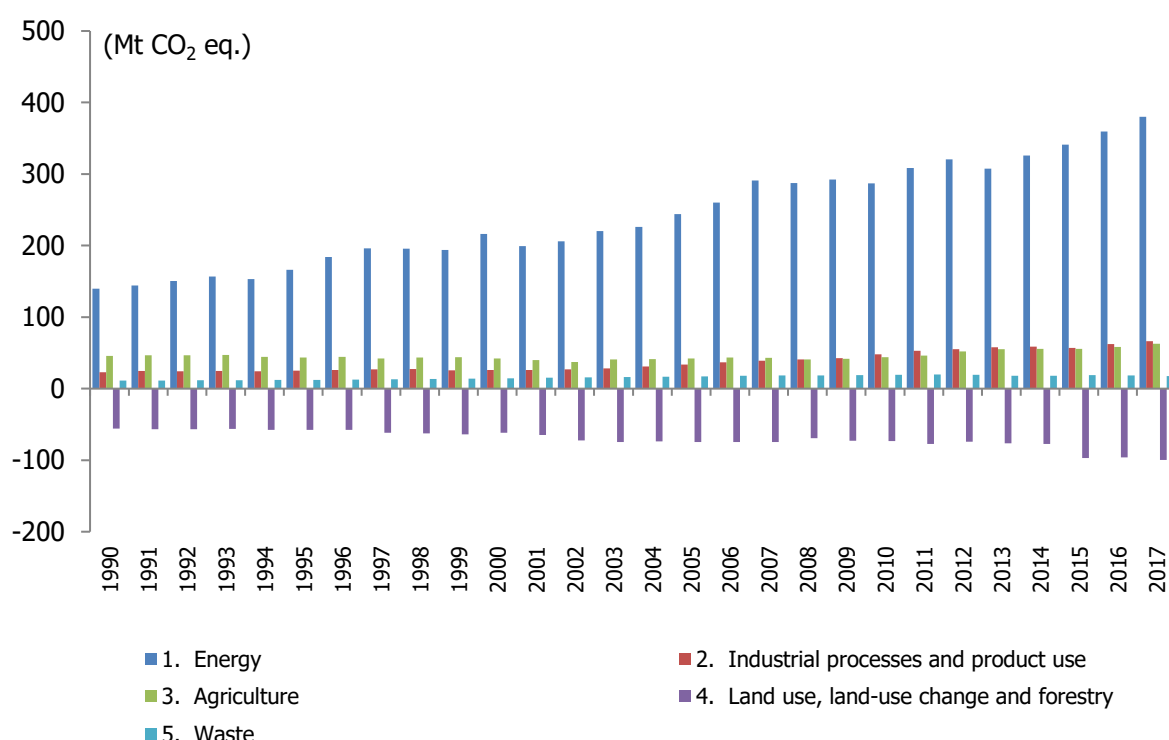
The F gases are only caused by the IPPU sector. In 2017, 8 122 kt CO<sub>2</sub> eq. of F gases released to the atmosphere. It is seen from Table 2.3 that total F gases emissions increased by 1199% since 1990. The main contributor of total F gas emissions is HFCs emissions and it is mainly due to increasing demand of Turkey's refrigerant and air conditioning sector.

**Table 2.3 Fluorinated gases emissions by sector, 1990-2017**

Year	(kt CO <sub>2</sub> eq.)		
	HFCs	PFCs	SF <sub>6</sub>
1990	NO	625.30	NO
1991	NO	863.34	NO
1992	NO	722.59	NO
1993	NO	403.08	NO
1994	NO	710.00	NO
1995	NO	611.44	NO
1996	NO	577.15	10.05
1997	NO	574.01	11.10
1998	NO	615.00	11.90
1999	NO	604.82	12.36
2000	115.66	601.00	13.34
2001	232.00	592.20	13.16
2002	417.19	586.39	13.95
2003	628.80	581.79	15.16
2004	909.37	580.13	16.44
2005	1 146.88	559.96	17.67
2006	1 424.19	460.96	19.40
2007	1 713.19	574.44	21.04
2008	1 896.14	527.72	21.98
2009	2 111.28	259.26	21.30
2010	3 054.28	461.74	23.39
2011	3 432.64	480.36	25.28
2012	4 256.83	359.06	26.49
2013	4 470.24	270.60	26.92
2014	4 778.45	255.42	32.78
2015	4 636.96	158.99	39.74
2016	6 116.92	140.67	36.52
2017	8 048.73	73.11	73.12

## 2.3. Emission Trends by Sector

**Figure 2.10 GHG emission trend by sectors, 1990-2017**



**1990-2017:** All sectors have an increasing trend from 1990 to 2017 included IPPU (191.0%), energy (172.1%), LULUCF (79.2%), waste (56.6%) and agriculture (36.9%).

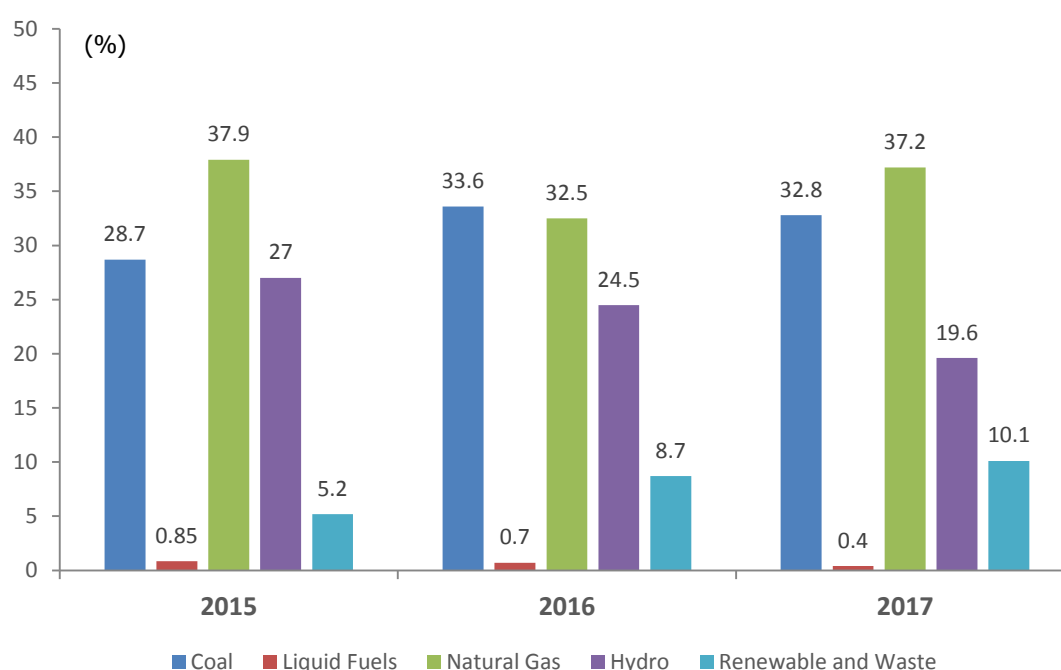
The main reasons of the increase for all sectors are population growth, a growing economy and an increase in energy demand.

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

**2016-2017:** There are both increasing and decreasing trends in the annual change for each sector from 2016 to 2017. The sectors having increasing trends are LULUCF (4.1%), energy (5.6%), IPPU (6.9%) and agriculture (7.5%). The only sector having decreasing trend is waste (5.9%).

The increase in energy sector is mainly originating from combustion emissions in public electricity, heat production sector and transport in 2017. Figure 2.11 shows electricity production from different energy sources for the period, 2015-2017.

**Figure 2.11 Electricity generation and shares by energy resources, 2015-2017**



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 2017, Table 2.5 shows the same shares for the GHG emissions without LULUCF.

**Table 2.4 Contribution of sectors to the net GHG emissions**

	<b>(%)</b>							
<b>Sectors</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2010</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>
<b>Energy</b>	85.42	87.45	91.03	92.93	88.28	90.91	89.35	89.11
<b>IPPU</b>	13.97	13.28	11.05	12.81	14.79	15.21	15.45	15.59
<b>Agriculture</b>	27.95	22.96	17.81	16.12	13.52	14.78	14.45	14.67
<b>Waste</b>	6.78	6.49	6.05	6.59	6.01	5.02	4.58	4.07
<b>LULUCF</b>	-34.12	-30.18	-25.94	-28.45	-22.60	-25.92	-23.83	-23.43

**Table 2.5 Contribution of sectors to the GHG emissions without LULUCF**

	<b>(%)</b>							
<b>Sectors</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2010</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>
<b>Energy</b>	63.69	67.18	72.29	72.35	72.00	72.20	72.16	72.19
<b>IPPU</b>	10.42	10.20	8.77	9.97	12.07	12.08	12.47	12.63
<b>Agriculture</b>	20.84	17.64	14.14	12.55	11.03	11.74	11.67	11.88
<b>Waste</b>	5.06	4.99	4.80	5.13	4.90	3.98	3.70	3.30

## Energy

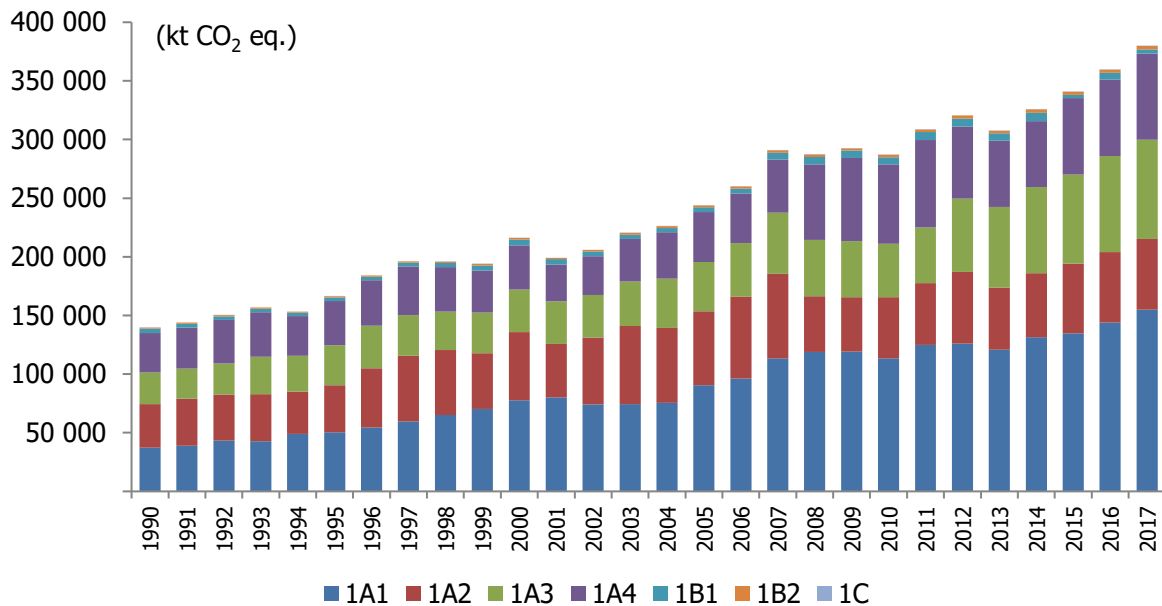
As in most countries, the energy system in Turkey is largely driven by the fuel combustion, followed by fugitive emissions from fuels and then CO<sub>2</sub> transport and storage. In 2017, emissions from the energy sector are 72.2% of total emissions, excluding LULUCF. Emissions in CO<sub>2</sub> eq. from the energy sector are reported in Table 2.6 and showed in Figure 2.12.

CO<sub>2</sub> emissions, 96.6% of the total energy sector emissions, showed an increase by 182.5% from 1990 to 2017. CH<sub>4</sub> emissions are just 2.3% of the total, increased by 14.4% in comparison with the 1990. N<sub>2</sub>O emissions, with 1.1% contribution to total emissions of energy sector, show 111.0% increase in proportion to year 1990.

**Table 2.6 Total emissions from the energy sector by source**

	(kt CO <sub>2</sub> eq.)							
	1990	1995	2000	2005	2010	2015	2016	2017
<b>Total</b>	<b>139 601</b>	<b>166 318</b>	<b>216 054</b>	<b>243 965</b>	<b>287 047</b>	<b>340 907</b>	<b>359 671</b>	<b>379 901</b>
1.A Fuel combustion	135 091	162 296	209 908	238 213	278 821	335 411	351 075	373 202
1.A.1 Energy industries	37 253	50 465	77 743	90 458	113 324	134 702	143 963	154 971
1.A.2 Manufacturing industries and construction	37 162	39 995	57 936	63 004	52 332	59 585	60 071	60 180
1.A.3 Transport	26 969	34 113	36 465	42 041	45 392	75 798	81 841	84 659
1.A.4 Other sectors	33 707	37 722	37 764	42 709	67 773	65 327	65 201	73 391
1.B Fugitive emissions from fuels	4 510	4 023	6 145	5 752	8 226	5 496	8 596	6 699
1.B.1 Solid fuels	3 598	2 985	4 836	3 941	6 151	2 733	5 896	3 681
1.B.2 Oil and natural gas	912	1 038	1 309	1 811	2 075	2 763	2 700	3 017
1.C CO <sub>2</sub> transport and storage	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13

**Figure 2.12 Trend of total emissions from energy sector, 1990-2017**



GHG emissions of energy sector, in CO<sub>2</sub> eq., show an increase by 172.1% from 1990 to 2017. Generally, an upward trend is noted from 1990-2017.



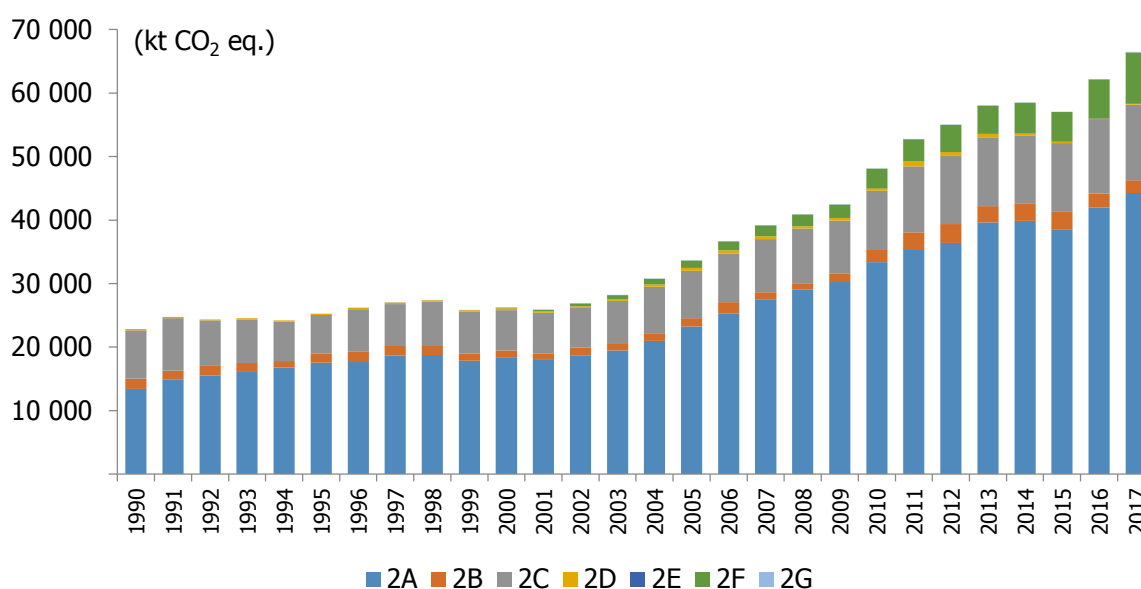
## IPPU

Emissions from industrial process and product use sector have a share of 12.6% of Turkey's total emissions excluding LULUCF in 2017. CO<sub>2</sub> emissions in year 2017, are 85.7% of total IPPU emissions. N<sub>2</sub>O has 1.9% share in IPPU emissions and increased by 18.7% compared to 1990. Whereas, CH<sub>4</sub> has a minor impact. Emissions by each subsector of IPPU are tabulated in Table 2.7 for the 1990-2017 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 <sub>2</sub> eq.)							
	1990	1995	2000	2005	2010	2015	2016	2017
<b>Total</b>	<b>22 836</b>	<b>25 247</b>	<b>26 227</b>	<b>33 631</b>	<b>48 107</b>	<b>57 040</b>	<b>62 175</b>	<b>66 455</b>
2.A Mineral industry	13 424	17 549	18 418	23 246	33 394	38 479	42 004	44 274
2.B Chemical industry	1 629	1 476	1 061	1 321	1 903	2 788	2 159	2 004
2.C Metal industry	7 601	6 019	6 342	7 453	9 301	10 829	11 712	11 903
2.D Non-energy products from fuels and solvent use	183	203	277	446	432	266	146	152
2.E Electronic industry	NO	NO	NO	NO	0.14	0.14	0.14	0.14
2.F Product uses as ODS substitutes	NO	NO	116	1 147	3 054	4 637	6 117	8 049
2.G Other product manufacture and use	NE, NO, NA	NE, NO, NA	13	18	23	40	36	73

**Figure 2.13 Trend of total emissions from IPPU sector, 1990-2017**



IPPU related emissions increased by 191% from 1990 to 2017. 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 2017, the agriculture sector accounted for 11.9% of total emissions in Turkey.

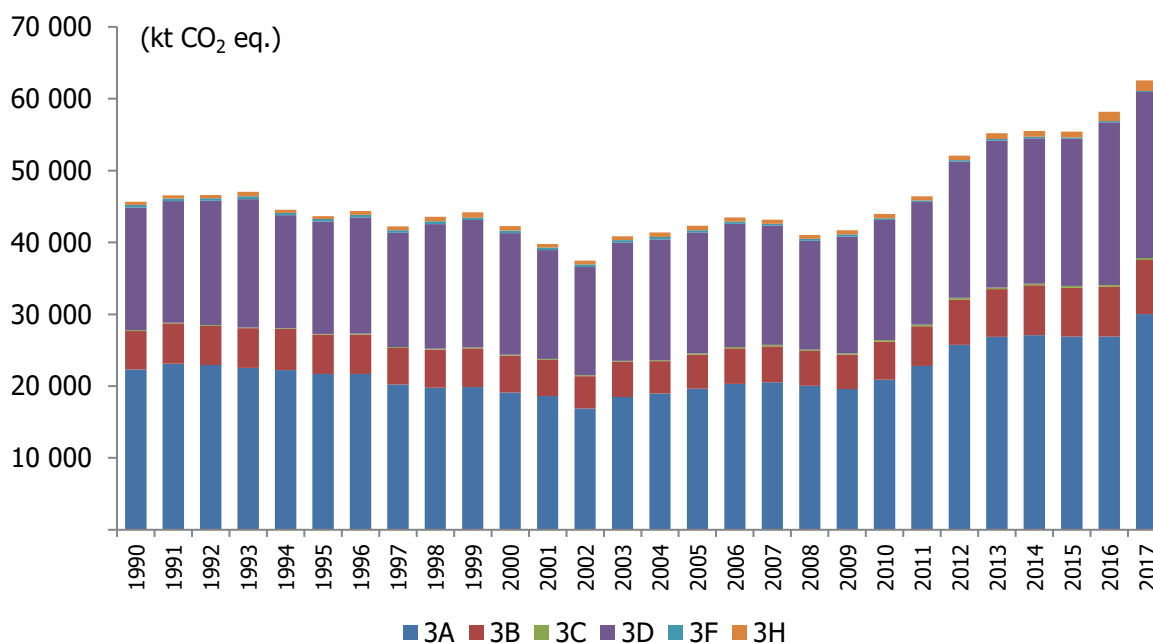
Enteric fermentation and agricultural soils dominate the trends in this sector between 1990 and 2017 as seen in Table 2.8 and they have an increase by 34.6% and 35.2% compared to 1990 respectively.

Most important portion in each gas is CH<sub>4</sub> with 54.0%, then comes N<sub>2</sub>O with 43.7% share in agriculture sector emissions. CO<sub>2</sub> has the lowest contribution with 2.3%.

**Table 2.8 Total emissions from agriculture sector by source**

	(kt CO <sub>2</sub> eq.)							
	1990	1995	2000	2005	2010	2015	2016	2017
<b>Total</b>	<b>45 680</b>	<b>43 668</b>	<b>42 261</b>	<b>42 307</b>	<b>43 976</b>	<b>55 428</b>	<b>58 182</b>	<b>62 543</b>
3.A Enteric fermentation	22 314	21 705	19 124	19 663	20 912	26 888	26 923	30 039
3.B Manure management	5 365	5 460	5 098	4 691	5 289	6 812	6 913	7 538
3.C Rice cultivation	100	113	128	183	202	240	243	234
3.D Agricultural soils	17 093	15 633	16 953	16 854	16 709	20 504	22 643	23 117
3.F Field burning of agricultural residues	347	332	340	302	219	174	164	165
3.H Urea application	460	426	617	613	645	811	1 295	1 450

**Figure 2.14 Trend of total emissions from agriculture sector, 1990-2017**



## LULUCF

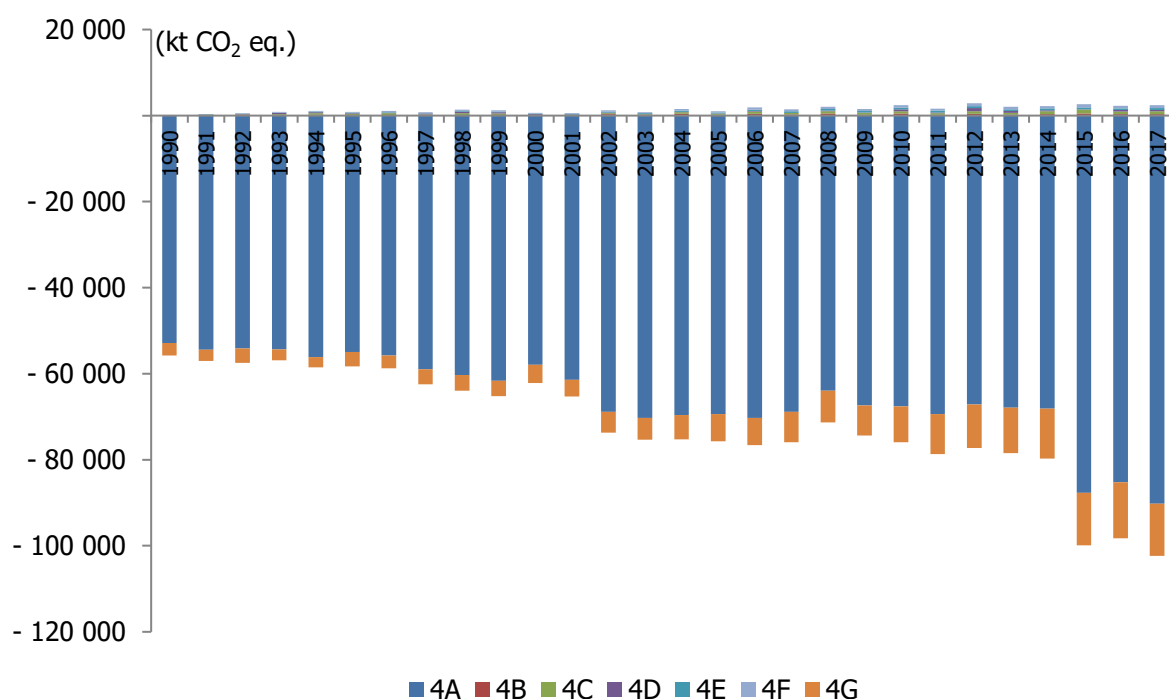
GHG emissions of LULUCF sector from sources and removals by sinks are estimated and reported for categories of managed lands: forest land, cropland, grassland, wetlands, settlements, harvested wood products, other land and others.

In 2017, total CO<sub>2</sub> eq. emissions and removals of the LULUCF sector has increased 4.1% compared to 2016. 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 <sub>2</sub> eq.)							
	1990	1995	2000	2005	2010	2015	2016	2017
<b>Total</b>	<b>-55 765</b>	<b>-57 400</b>	<b>-61 556</b>	<b>-74 693</b>	<b>-73 492</b>	<b>-97 206</b>	<b>-95 930</b>	<b>-99 907</b>
4.A Forest land	-52 830	-54 963	-57 890	-69 356	-67 614	-87 669	-85 233	-90 195
4.B Cropland	0.69	153	38	207	453	457	344	368
4.C Grassland	0.03	262	81	211	551	929	592	640
4.D Wetlands	12	169	188	40	426	93	344	328
4.E Settlements	NO, IE	132	145	273	426	419	406	413
4.F Other land	NO	181	187	310	601	764	617	653
4.G Harvested wood products	-2 948	-3 333	-4 305	-6 379	-8 334	-12 200	-13 000	-12 115

**Figure 2.15 Trend of total emissions from the LULUCF sector, 1990-2017**



LULUCF emissions or removals, in CO<sub>2</sub> equivalent, are variable over the reporting period 1990-2017 as seen in Figure 2.15. Generally, decreases in removals were influenced by fires and drought in the relevant areas. Moreover, rises are originated mainly from forest management, afforestation, rehabilitation of degraded forests, reforestations on forest land and etc.

## Waste

The waste sector includes GHG emissions from the treatment and disposal of wastes, open burning, 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 2017 are 3.3% of total GHG emissions (without LULUCF). Considering emissions by gas, the most important GHG is CH<sub>4</sub> which accounts for 66.5% of the total and shows an increase of 20.2% from 1990 to 2017. N<sub>2</sub>O levels have increased by 298.2% whereas CO<sub>2</sub> decreased by 92.8%; these gases account for 33.5% and 0.0001%, respectively.

**Table 2.10 Total emissions from the waste sector by source**

	(kt CO <sub>2</sub> eq.)							
	1990	1995	2000	2005	2010	2015	2016	2017
<b>Total</b>	<b>11 084</b>	<b>12 351</b>	<b>14 348</b>	<b>17 310</b>	<b>19 530</b>	<b>18 815</b>	<b>18 441</b>	<b>17 355</b>
5.A Solid waste disposal	6 730	7 628	9 582	11 562	12 272	11 231	10 513	9 079
5.B Biological treatment of solid waste	19	16	24	28	23	16	15	14
5.C Incineration and open burning of waste	105	103	87	47	37	2	4	4
5.D Wastewater treatment and discharge	4 230	4 604	4 656	5 673	7 198	7 565	7 909	8 258

**Figure 2.16 Trend of total emissions from the waste sector, 1990-2017**

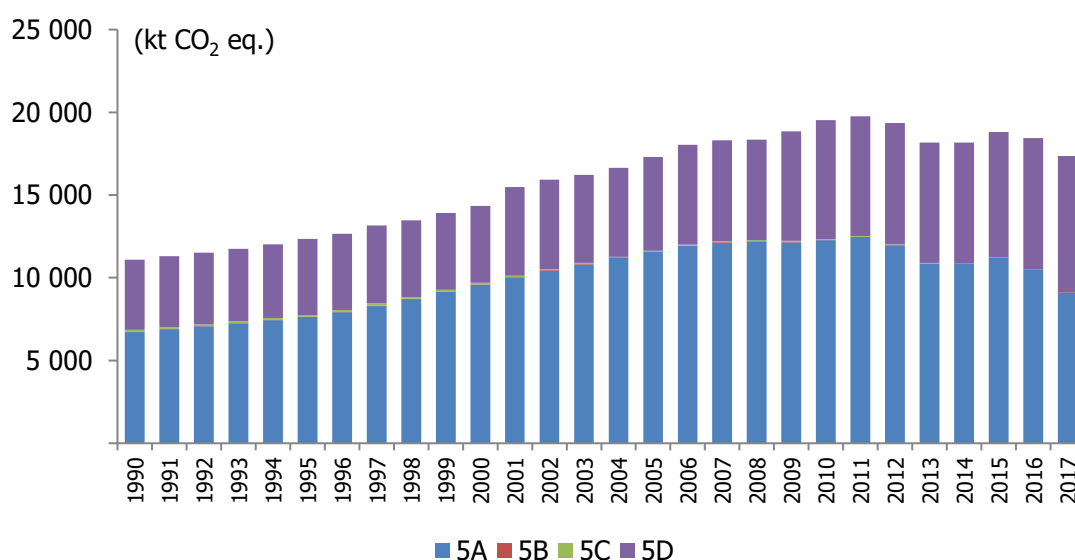


Figure 2.16 shows trends in waste sector between 1990-2017. The trend is mainly driven by solid waste disposal with 52.3% of the emissions were from, followed by 47.6% from wastewater treatment and discharge, 0.08% from biological treatment of solid waste and 0.02% from open burning of waste. Total emissions, in CO<sub>2</sub> equivalent, decreased by 5.9% from 2016 to 2017.

### 2.4. Emission Trends for Indirect Greenhouse Gases

Emission trends of NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub> from 1990 to 2017 are given in Table 2.11.

**Table 2.11 Total emissions for indirect greenhouse gases, 1990-2017**

								(kt)
Gas	1990	1995	2000	2005	2010	2015	2016	2017
NO <sub>x</sub>	254	374	494	670	704	709	718	765
CO	2 025	2 400	2 605	2 317	2 899	2 182	2 047	2 004
NMVOC	893	972	1 015	997	1 049	1 076	1 061	1 094
SO <sub>2</sub>	1 688	1 807	2 238	2 001	2 554	1 943	2 247	2 279

**1990-2017:** Almost all indirect gases have an increasing trend from 1990 to 2017 included NO<sub>x</sub> (201.2%), SO<sub>2</sub> (35.0) and NMVOC (22.5%) except CO with a decreasing trend 1.0%.

**2016-2017:** There are both increasing and decreasing trends in the annual change for each gas from 2016 to 2017. The gases having increasing trends are NO<sub>x</sub> (6.5%), NMVOC (3.1%) and SO<sub>2</sub> (1.4%). The gas has decreasing trends is CO (2.1%).

### 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) and CO<sub>2</sub> transportation and storage (1.C).

Energy sector is the major source of Turkish anthropogenic GHG emissions. In overall 2017 GHG emissions (excluding LULUCF), the energy sector had the largest portion with 72.2%.

Energy sector CO<sub>2</sub> emissions constituted 86.3% of total CO<sub>2</sub> emissions in 2017. The non-CO<sub>2</sub> emissions from energy-related activities represented rather small portion of the total national emissions. CH<sub>4</sub> emissions are 16.4% of total national CH<sub>4</sub> emissions and N<sub>2</sub>O emissions are 10.7% of total N<sub>2</sub>O emissions in 2017.

Total emissions from the energy sector for 2017 were estimated to be 380 Mt CO<sub>2</sub> eq. (Table 3.1) Energy industries were the main contributor, accounting for 40.8% of emissions from the energy sector. It is followed by transport sector with 22.3%, other sector with 19.3% and manufacturing industries with 15.8% (Table 3.2).

Energy sector GHG emissions increased by 172% between 1990 and 2017 whereas annual emissions from 2016 to 2017 increased by 5.6% (20.2 Mt CO<sub>2</sub> eq.).

**Table 3.1 Energy sector emissions by gas, 1990-2017**

Year	(kt)			
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub> eq.
1990	129 882	310.8	6.5	139 601
1991	134 500	301.6	6.5	143 985
1992	140 776	303.1	6.7	150 337
1993	147 170	296.0	7.6	156 827
1994	144 118	280.0	7.5	153 349
1995	156 827	286.2	7.8	166 318
1996	174 383	286.3	8.3	184 018
1997	186 039	305.1	8.4	196 178
1998	185 609	311.2	8.3	195 864
1999	182 763	343.3	8.3	193 817
2000	204 511	360.8	8.5	216 054
2001	188 624	330.2	7.9	199 233
2002	195 422	320.8	8.0	205 832
2003	209 683	314.2	9.3	220 300
2004	215 288	314.2	10.1	226 139
2005	232 409	337.5	10.5	243 965
2006	247 926	347.3	11.2	259 959
2007	276 375	425.0	12.7	290 771
2008	271 096	485.2	13.6	287 279
2009	276 022	492.2	14.0	292 501
2010	270 820	491.2	13.2	287 047
2011	291 845	504.4	14.1	308 666
2012	304 432	525.3	9.8	320 489
2013	292 914	466.6	9.9	307 523
2014	309 259	533.7	10.6	325 767
2015	329 782	296.1	12.5	340 907
2016	345 298	419.8	13.0	359 671
2017	366 898	355.7	13.8	379 901

Table 3.2 Energy sector GHG emissions, 1990-2017

Year	Fuel combustion					Fugitive emissions from fuels				CO <sub>2</sub> transport and storage
	Energy	Fuel combustion total	Energy industries	Manufacturing industries and construction	Transport	Other sectors	Total fugitive emissions	Solid fuels	Oil and natural gas	
1990	139 601	135 091	37 253	37 162	26 969	33 707	4 510	3 598	912	0.13
1991	143 985	139 685	38 791	40 335	25 673	34 887	4 300	3 219	1 080	0.13
1992	150 337	146 092	43 324	39 324	26 366	37 079	4 245	3 177	1 067	0.13
1993	156 827	152 694	42 752	39 986	32 143	37 812	4 133	3 114	1 020	0.13
1994	153 349	149 350	49 059	35 876	30 640	33 775	3 999	2 998	1 001	0.13
1995	166 318	162 296	50 465	39 995	34 113	37 722	4 023	2 985	1 038	0.13
1996	184 018	179 958	54 437	50 586	36 271	38 664	4 060	2 967	1 092	0.13
1997	196 178	191 814	59 581	56 029	34 690	41 515	4 364	3 187	1 177	0.13
1998	195 864	191 119	65 164	55 470	32 782	37 704	4 745	3 565	1 180	0.13
1999	193 817	188 096	70 360	47 365	34 617	35 753	5 720	4 481	1 239	0.13
2000	216 054	209 908	77 743	57 936	36 465	37 764	6 145	4 836	1 309	0.13
2001	199 233	193 530	80 022	45 656	36 455	31 397	5 702	4 387	1 315	0.13
2002	205 832	200 415	74 138	57 112	36 234	32 930	5 418	4 059	1 358	0.13
2003	220 300	215 110	74 371	66 682	37 825	36 232	5 190	3 664	1 526	0.13
2004	226 139	221 005	75 539	63 857	42 048	39 561	5 134	3 568	1 566	0.13
2005	243 965	238 213	90 458	63 004	42 041	42 709	5 752	3 941	1 811	0.13
2006	259 959	253 874	96 129	70 084	45 424	42 236	6 086	4 119	1 966	0.13
2007	290 771	282 821	113 570	71 874	52 099	45 279	7 949	5 725	2 224	0.13
2008	287 279	278 869	118 939	47 354	48 166	64 410	8 410	6 118	2 291	0.13
2009	292 501	284 372	119 280	46 226	47 907	70 959	8 128	6 061	2 067	0.13
2010	287 047	278 821	113 324	52 332	45 392	67 773	8 226	6 151	2 075	0.13
2011	308 666	299 601	124 975	52 585	47 386	74 656	9 065	6 662	2 403	0.13
2012	320 489	311 108	125 944	61 052	62 525	61 586	9 381	6 851	2 530	0.13
2013	307 523	299 000	120 773	52 978	68 865	56 384	8 524	6 324	2 199	0.13
2014	325 767	315 551	131 474	54 438	73 559	56 079	10 216	7 318	2 898	0.13
2015	340 907	335 411	134 702	59 585	75 798	65 327	5 496	2 733	2 763	0.13
2016	359 671	351 075	143 963	60 071	81 841	65 201	8 596	5 896	2 700	0.13
2017	379 901	373 202	154 971	60 180	84 659	73 391	6 699	3 681	3 017	0.13

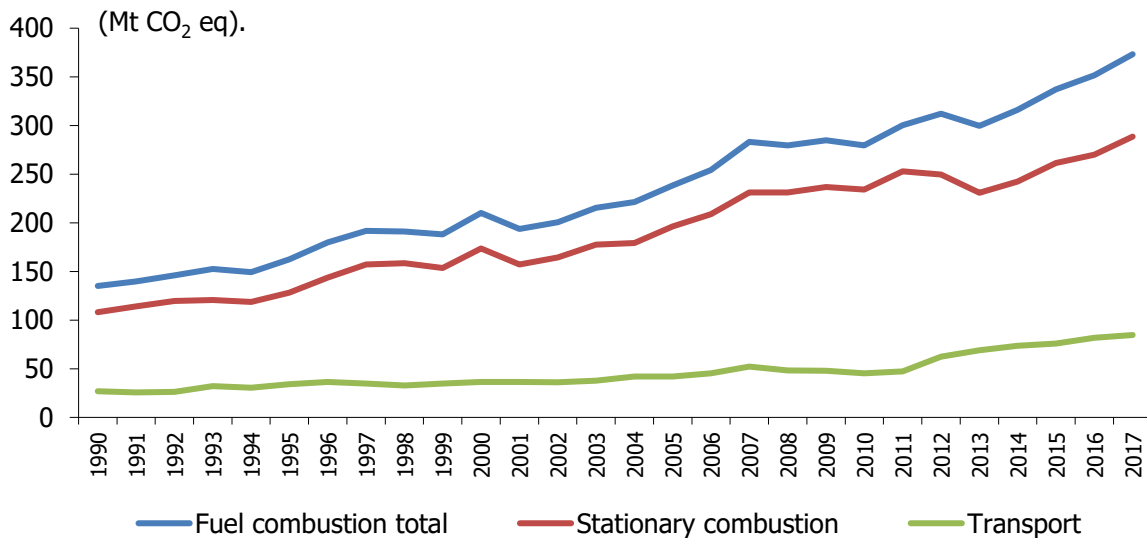


Energy sector GHG emissions mainly are coming from stationary combustion. Total emissions from stationary combustion are 288.5 Mt CO<sub>2</sub> eq. in 2017, equal to 54.8% of total national GHG emissions (excluding LULUCF).

The energy industries subsector (1.A.1) contributed 155.0 Mt CO<sub>2</sub> eq. in 2017 while the GHG emissions from manufacturing industries and construction subsector (1.A.2) emissions were 60.2 Mt CO<sub>2</sub> eq. and GHG emissions from other sectors (1.A.4) were 73.4 Mt. The transport sector GHG emissions were 84.7 Mt in the same year.

GHG emissions from stationary combustion increased by 167% (180.4 Mt CO<sub>2</sub> eq.) between 1990 and 2017, and increased by 6.9% (18.7 Mt CO<sub>2</sub> eq.) between 2016 and 2017.

**Figure 3.1 GHG emissions from fuel combustion, 1990-2017**



In 2017, transport contributed 84.7 Mt CO<sub>2</sub> eq., which is 16.1% of total GHG emissions (excluding LULUCF). The major source of transport emissions in Turkey is road transportation. It accounts for 93.0% of transport emissions. It is followed by domestic aviation while other sources are far smaller: domestic aviation with 4.5% and domestic navigation with 1.1%. Pipeline transport contribution was 0.9% and railway contribution was 0.5%.

Fuel used in international aviation and marine bunkers is reported separately from the national total. In 2017, international bunker GHG emissions were 14.0 Mt CO<sub>2</sub> eq.

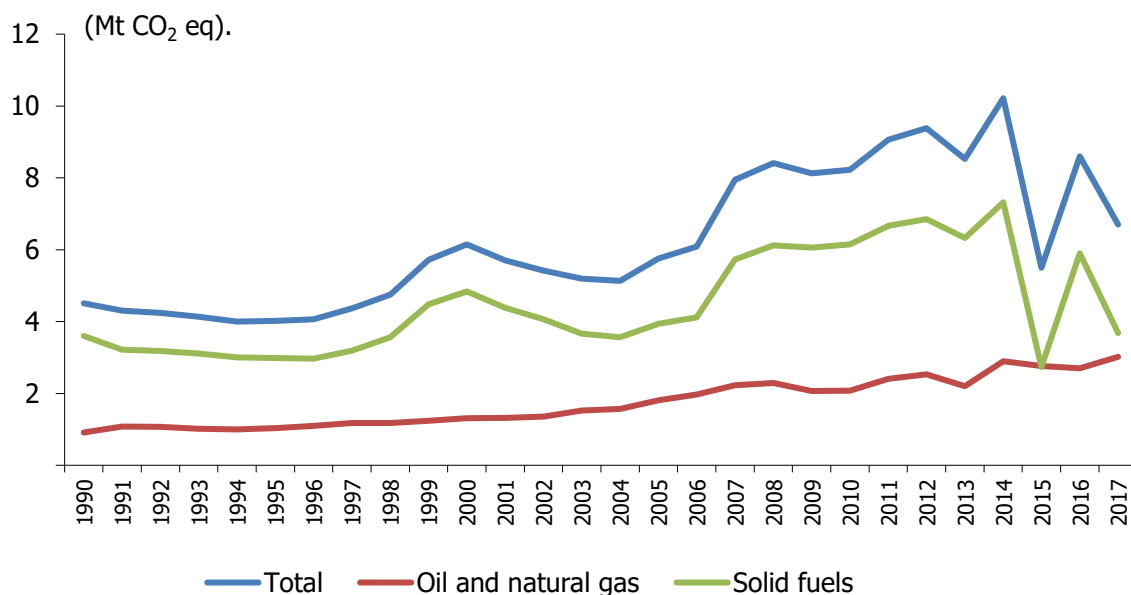
Emissions from transport sector increased 214% (57.7 Mt CO<sub>2</sub> eq.) in 2017 compared to 1990. In the same period increase in road transportation emissions was 218%, in domestic aviation it was 316% and

in domestic navigation it was 86%. Emissions from railway transport decreased by 43% between 1990 and 2017.

Total fugitive emissions for 2017 were 6.7 Mt CO<sub>2</sub> eq., representing 1.3% of total GHG emissions (excluding LULUCF). Oil and natural gas systems contributed 45%, solid fuels account for the remaining 55% of fugitive emissions.

Overall fugitive emissions increased 49% between 1990 and 2017. In 2014 a serious mine accident happened and many underground mines were closed in the following year as a precaution, therefore in 2015 fugitive emissions were decreased remarkably. In 2017, the underground coal production activity decreased and therefore in 2017 fugitive emissions from solid fuels were decreased. In overall, from 1990 to 2017, fugitive emissions from oil and natural gas systems increased by 231%. Emissions from solid fuels increased by 2% in the same period.

**Figure 3.2 Fugitive emissions, 1990-2017**



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 <sub>2</sub>		CH <sub>4</sub>		N <sub>2</sub> O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
<b>1. Energy</b>	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 <sub>2</sub> transport and storage	T1	D	-	-	-	-

Country specific and plant specific carbon contents of liquid, solid and gaseous fuels are used for CO<sub>2</sub> emissions estimation. For CH<sub>4</sub> and N<sub>2</sub>O emissions, 2006 IPCC default emissions factors are used.

### Sector QA/QC and Verification

Quality control for energy category was performed on the basis of QA/QC plan of Turkey. All emission factors and implied emission factors are compared with 2006 IPCC Guideline defaults and any outlines were examined. In this inventory, 1A2 and 1A4 sectorial approach emissions and 1AB reference approach fuel combustion emissions were calculated on SAS and it was double checked by the calculations on the Excel sheets by two different experts and any findings were corrected.

In 2017 August, energy sector expert, from Finland, have come to TurkStat to review the energy sector in scope of a project coordinated by TurkStat. Moreover, Turkish inventory have been reviewed by ERT in 2017 September. Based on those findings improvements were done in the energy sector. These improvements are explained and the effect of the recalculations are shown with in the relevant sectorial subtitle.

The main critic during the reviews is the consistency of the energy sector. This is because the national energy balance tables, which are the main data source of energy sector, are not in time series. Inconstancies come to exist when the national energy balance tables are used in the time series inventory calculations. In order to overcome this problem national energy balance tables should be reallocated and made consistent in the time series. This problem will be handled in the following years.

### 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 Ministry of Energy and National Resources (MENR) and the Ministry of Transport and Infrastructure (MoTI). The emissions from public electricity and heat production were calculated by MENR and the emissions from transport were calculated by MoTI, 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 public electricity and heat production (1.A.1.a) are calculated on the basis of plant specific fuel consumption and net calorific values (NCVs) with country specific carbon contents of fuels. Technology specific CH<sub>4</sub> and N<sub>2</sub>O emission factors from 2006 IPCC Guidelines are used for 1.A.1.a category for since 2003 and 2006 IPCC Guidelines default CH<sub>4</sub> and N<sub>2</sub>O EFs are used for 1990-2002 period since combustion technology data is available from 2003 onward for this category.

For petroleum refining sector (1.A.1.b), fuel consumption data, NCVs and carbon content of fuels are compiled directly from the refineries. In the same way for manufacture of solid fuels (1.A.1.c) categories, plant specific AD and plant specific carbon content are used in the emission estimation. 2006 IPCC Guidelines default EFs are used for CH<sub>4</sub> and N<sub>2</sub>O emission estimation.

Emissions from manufacturing industry and construction and other sectors (1.A.2), (1.A.4) were estimated by using energy balance tables. For CO<sub>2</sub> emission estimation both country specific and default carbon contents and oxidation factors are used depending on the data availability. 2006 IPCC Guidelines default EFs are used for CH<sub>4</sub> and N<sub>2</sub>O emission estimation.

Transportation sector (1.A.3) 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<sub>2</sub> emission estimations but for gasoline and liquefied petroleum gas (LPG) 2006 IPCC default emission factors are used. T2 methodology was used for the calculation of emissions from domestic aviation. Also T2 methodology was used for the calculation of CO<sub>2</sub> emissions from pipeline transportation. 2006 IPCC Guidelines default EFs are used for CH<sub>4</sub> and N<sub>2</sub>O emission estimation. The following table summarizes the data source for the 1A sectors.

**Table 3.4 Summary table for the data source in fuel combustion (1A) sector**

Category	Data Source
1A1a Electricity and Heat Production	Plant specific
1A1b Petroleum Refining	Plant specific
1A1c Manufacturing of Solid Fuels and Other Energy Industries	Plant specific
1A2 Manufacturing Industries and Construction	National energy balance table
1A3 Transport	See chapter 3.2.6
1A4 Other Sectors	National energy balance table
1AB Fuel Combustion Reference Approach	National energy balance table
1AD Feedstocks Reductants and Other non-Energy use of fuels	See chapter 3.2.3

National energy balance tables, which are published by the MENR every year, are the most important input for the energy sector emission calculations. The source of data for the electricity production sector of national energy balance is Turkish Electricity Transmission Corporation (TEİAŞ). The data that TEİAŞ sends includes electricity generation, fuel consumption in both original units and TJ, with respect to energy resources and license type of electricity generators. After the data is compared with previous years, it is directly used in the relevant sections of the energy balance table. For the supply part of national energy balance table (indigenous production, import, export, bunkers, stock change), the administrative sources of relevant stakeholders such as EPDK, BOTAŞ, TEİAŞ, TTK, TKİ, MİGEM, MTA, PİGM are utilized. For the demand part of national energy balance table, the industry sector data is collected through questionnaires applied by MENR/EİGM to the relevant companies/firms. For the other sectors, administrative sources of relevant stakeholders are used. In the process of compiling data, the sectoral reports of stakeholders are examined, as well as time series analysis and quality control with respect to both energy resources and sectors are applied. The following table shows the country specific carbon content (as ton carbon / TJ fuel) of fuels used in calculating the CO<sub>2</sub> emissions.

**Table 3.5 Country specific carbon contents of fuels**

Fuel types	Unit	1990	2000	2010	2015	2016	2017
Hard coal	t /TJ	25.79	26.38	27.28	26.16	24.16	26.43
Lignite	t/TJ	32.79	31.61	31.57	30.57	30.51	30.05
Coke	t/TJ	30.14	30.14	29.95	30.10	29.55	30.61
Petrocoke	t/TJ	26.55	26.55	26.55	26.55	26.55	26.55
Fuel oil	t/TJ	21.33	21.33	21.33	21.33	21.33	21.33
Diesel	t/TJ	20.03	20.03	20.03	20.03	20.03	20.03
Naphta	t/TJ	20.13	20.13	20.13	20.13	20.13	20.13
Natural gas	t/TJ	15.13	15.13	15.17	15.19	15.19	15.18

The following table shows the country specific oxidation factors of fuels used in calculating the CO<sub>2</sub> emissions factors

**Table 3.6 Country specific oxidation factor of fuels**

<b>Fuel types</b>	<b>1990</b>	<b>2000</b>	<b>2010</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>
Hard coal	0.988	0.988	0.985	0.963	0.963	0.975
Lignite	0.950	0.950	0.953	0.960	0.960	0.973
Fuel oil	0.984	0.984	0.984	0.984	0.984	0.984
Diesel	0.984	0.984	0.984	0.984	0.984	0.984

The following table shows the CO<sub>2</sub> emissions factors of all the fuels.

Either country specific carbon contents or IPCC default carbon contents are used in the calculations depending on the data availability. CO<sub>2</sub> EFs are calculated by the formula below.

$$\text{CO}_2 \text{ EF} = \text{C content of fuel} \times \text{Oxidation factor of fuel} \times (44/12)$$

Country specific carbon content and oxidation rates were calculated through fuel analysis and ash-slag or stack gas analysis reports.

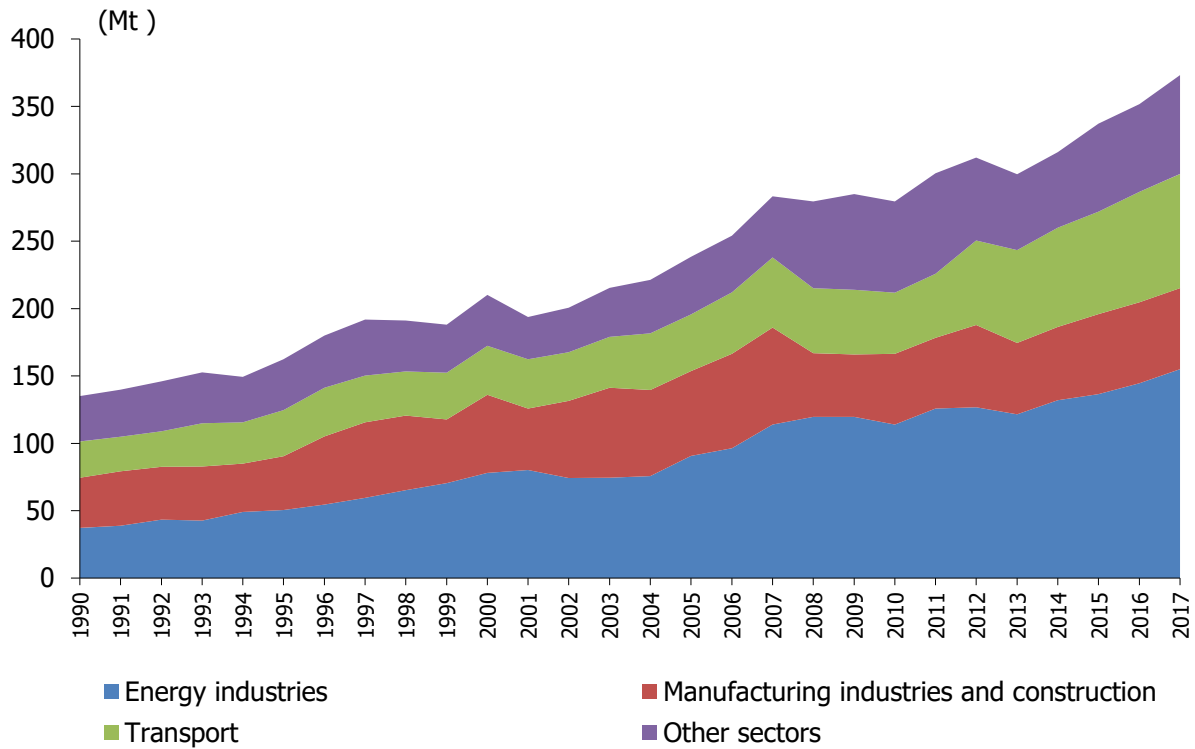
**Table 3.7 CO<sub>2</sub> emission factors of fuels**

<b>Fuel types</b>	<b>Unit</b>	<b>1990</b>	<b>2000</b>	<b>2010</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>
Hardcoal	t/TJ	93.4	95.5	98.6	92.4	85.3	94.5
Lignite	t/TJ	114.2	110.1	110.3	107.6	107.4	107.2
Asphaltite	t/TJ	96.1	96.1	96.1	96.1	96.1	96.1
Coke	t/TJ	110.5	110.5	109.8	110.4	108.3	112.2
Coal tar	t/TJ	80.7	80.7	80.7	80.7	80.7	80.7
Crude oil	t/TJ	73.3	73.3	73.3	73.3	73.3	73.3
Petrocoke	t/TJ	97.4	97.4	97.4	97.4	97.4	97.4
Fuel oil	t/TJ	77.0	77.0	77.0	77.0	77.0	77.0
Diesel	t/TJ	72.3	72.3	72.3	72.3	72.3	72.3
Gasoline	t/TJ	69.3	69.3	69.3	69.3	69.3	69.3
LPG	t/TJ	63.1	63.1	63.1	63.1	63.1	63.1
Rafinery gas	t/TJ	57.6	57.6	57.6	57.6	57.6	57.6
Aviation fuel	t/TJ	71.5	71.5	71.5	71.5	71.5	71.5
Kerosene	t/TJ	71.9	71.9	71.9	71.9	71.9	71.9
Naphta	t/TJ	72.7	72.7	72.7	72.7	72.7	72.7
Intermediate products	t/TJ	73.3	73.3	73.3	73.3	73.3	73.3
Base oils	t/TJ	73.3	73.3	73.3	73.3	73.3	73.3
White spirit	t/TJ	73.3	73.3	73.3	73.3	73.3	73.3
Bitumen	t/TJ	80.7	80.7	80.7	80.7	80.7	80.7
Other petroleum products	t/TJ	73.3	73.3	73.3	73.3	73.3	73.3
Natural gas	t/TJ	55.5	55.5	55.6	55.7	55.7	55.6
Fuel wood	t/TJ	111.8	111.8	111.8	111.8	111.8	111.8
Animal&Vegetable waste	t/TJ	100.1	100.1	100.1	100.1	100.1	100.1
Biofuels	t/TJ	70.8	70.8	70.8	70.8	70.8	70.8

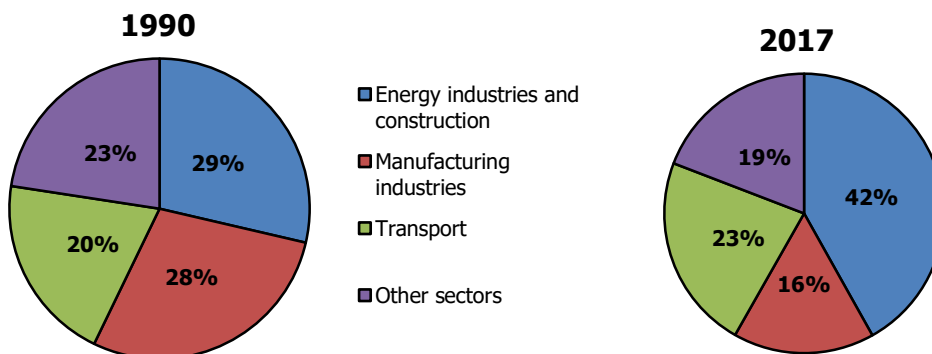
CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O Emissions from fuel combustion were calculated for the period 1990-2017

**Table 3.8 Emissions from fuel combustion (1A), 1990-2017**

Year	(kt)			
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub> eq.
1990	129 662	139.3	6.5	135 091
1991	134 236	140.2	6.5	139 685
1992	140 522	143.5	6.7	146 092
1993	146 939	140.0	7.6	152 694
1994	143 899	128.9	7.5	149 350
1995	156 618	133.7	7.8	162 296
1996	174 175	132.3	8.3	179 958
1997	185 832	138.8	8.4	191 814
1998	185 415	129.2	8.3	191 119
1999	182 585	121.6	8.3	188 096
2000	204 343	121.7	8.5	209 908
2001	188 469	108.3	7.9	193 530
2002	195 274	110.0	8.0	200 415
2003	209 538	112.5	9.3	215 110
2004	215 148	114.5	10.1	221 005
2005	232 267	113.1	10.5	238 213
2006	247 791	109.3	11.2	253 874
2007	276 242	112.4	12.6	282 821
2008	270 961	154.2	13.6	278 869
2009	275 883	172.7	14.0	284 372
2010	270 663	168.4	13.2	278 821
2011	291 695	147.8	14.1	299 601
2012	304 288	155.9	9.8	311 108
2013	292 768	131.5	9.9	299 000
2014	309 113	130.8	10.6	315 551
2015	329 627	82.5	12.5	335 411
2016	345 140	82.3	13.0	351 075
2017	366 740	94.0	13.8	373 202

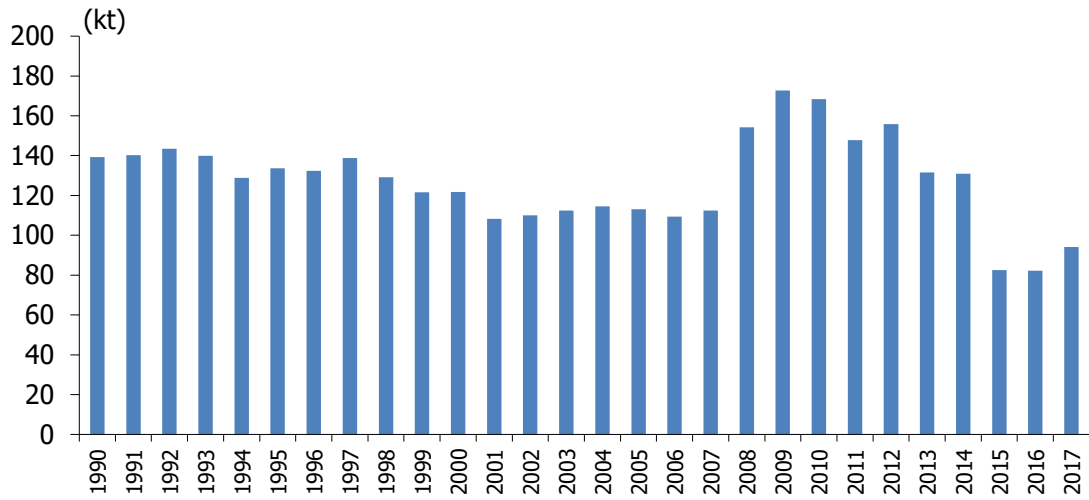
**Figure 3.3 CO<sub>2</sub> emissions from fuel combustion, 1990-2017**

Energy industry has the highest share in total CO<sub>2</sub> emission from fuel combustion in 2017. It is followed by transport, other sectors, and manufacturing industries and construction.

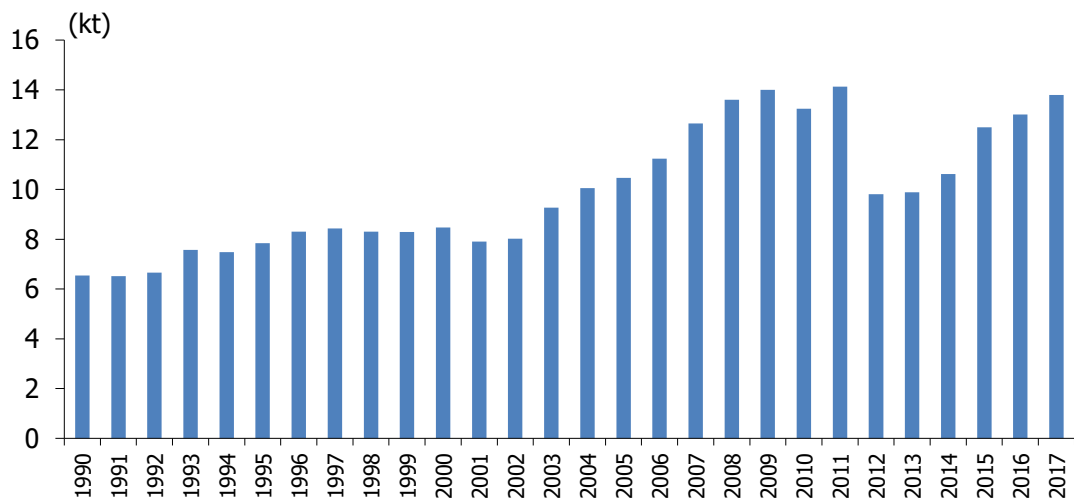
**Figure 3.4 CO<sub>2</sub> emissions from fuel combustion by sectors, 1990-2017**



**Figure 3.5 CH<sub>4</sub> emissions from fuel combustion, 1990-2017**



**Figure 3.6 N<sub>2</sub>O emissions from fuel combustion, 1990-2017**



### 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.

2006 IPCC methodology is used for reference approach CO<sub>2</sub> estimation. The estimation based on the apparent consumption of fuels in the country. The apparent consumption of primary fuels has been calculated by using the following formula:

$$\text{Apparent consumption} = \text{Domestic production} + \text{imports} - \text{exports} - \text{change (increase/decrease) in stocks} - \text{international bunkers}$$

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

$$\text{Apparent consumption} = \text{imports} - \text{exports} - \text{change (increase/decrease) in stocks} - \text{international bunkers}$$

The apparent consumption is need to be adjusted for feedstocks, reductants and other non-energy use of fuels. The fossil fuels used for non-energy purposes should be deducted from the apparent consumption in order to avoid double counting in reference approach. (See section 3.2.3 *Feedstocks, Reductants and Other Non-Energy Use of Fuels*)

Domestic production, import, export, stock change and international bunkers have been taken from national energy balance tables for all primary fuels and petroleum products in ktOE unit.

Note that the the reference approach emission calculation is dependent on the national energy balance tables and the fuel classification in the national energy balance table is different than CRF fuel classification. Therefore, the fuels in the national energy balance table is allocated into CRF fuel classification according to the table below.

The allocation of fuels into the CRF 1AB category is shown in the table below.

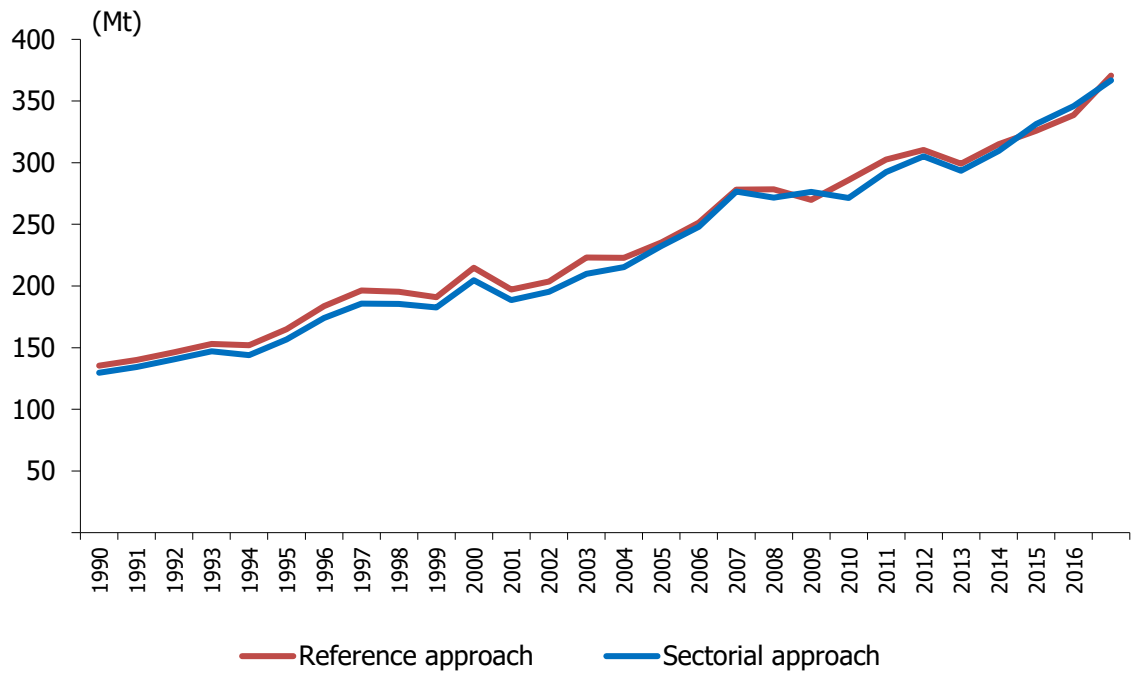
**Table 3.9 Fuel allocation in reference approach**

<b>Fuel allocated under national energy balance table</b>	<b>Fuel allocated under CRF 1AB sector</b>
Hardcoal	Coking coal
Lignite	Lignite
Asphaltite	Sub bituminous coal
Coke	Coke oven coke
Coal tar	Coal tar
Crude oil	Crude oil
Petrocoke	Petroleum coke
Fuel oil	Residual fuel oil
Diesel	Diesel oil
Gasoline	Gasoline
LPG	LPG
Raflnery gas	Other oil
Aviation fuel	Jet kerosene
Kerosene	Other kerosene
Naphta	Naphta
Intermediate products	Other oil
Base oils	Other oil
White spirit	Other oil
Bitumen	Other oil
Other petroleum products	Other oil
Natural gas	Natural gas
Fuel wood	Solid biomass
Animal&Vegetable waste	Solid biomass
Biofuels	Liquid biomass

Table 3.10 CO<sub>2</sub> emissions from fuel combustion, 1990-2017

Year	Reference Approach					Sectoral Approach					(kt)
	Liquid fuels (excluding international bunkers)	Solid fuels (excluding international bunkers)	Gaseous fuels	Other fossil fuels	Total	Liquid fuels (excluding international bunkers)	Solid fuels (excluding international bunkers)	Gaseous fuels	Other fossil fuels		
1990	66 028	63 851	5 538	NO	135 417	59 775	63 172	6 716	NO	129 662	
1991	63 928	68 970	7 090	NO	139 989	58 433	67 539	8 265	NO	134 236	
1992	68 820	69 670	7 888	NO	146 377	62 934	68 552	9 036	NO	140 522	
1993	79 456	64 674	8 849	NO	152 978	72 870	63 995	10 074	NO	146 939	
1994	76 788	65 631	9 582	NO	152 001	70 321	62 993	10 585	NO	143 899	
1995	83 270	69 406	12 363	NO	165 039	77 720	65 272	13 626	1	156 618	
1996	89 069	79 907	14 681	NO	183 657	81 746	76 505	15 918	5	174 175	
1997	88 669	89 285	18 378	NO	196 331	81 515	84 429	19 879	9	185 832	
1998	83 850	91 796	19 596	NO	195 241	77 139	87 610	20 655	12	185 415	
1999	85 127	81 524	24 329	NO	190 980	78 484	78 236	25 848	17	182 585	
2000	91 665	94 543	28 572	NO	214 779	82 159	93 045	29 371	42	204 617	
2001	86 964	79 147	30 951	NO	197 062	77 821	78 830	31 937	4	188 592	
2002	89 278	81 489	32 934	NO	203 702	79 708	81 799	33 875	39	195 421	
2003	90 895	92 306	40 026	NO	223 226	81 317	86 154	42 260	11	209 742	
2004	93 976	86 966	41 909	NO	222 851	85 186	86 843	43 265	37	215 331	
2005	94 669	89 723	50 823	NO	235 215	83 332	95 386	53 664	75	232 457	
2006	88 099	104 049	59 200	NO	251 348	81 906	104 646	61 441	48	248 041	
2007	90 542	117 673	69 921	NO	278 136	86 422	118 662	71 405	136	276 624	
2008	89 110	119 216	70 129	NO	278 455	85 180	115 342	70 824	175	271 520	
2009	77 819	123 733	68 337	NO	269 890	83 673	121 605	70 744	299	276 321	
2010	86 236	126 949	72 623	NO	285 808	79 645	120 412	70 832	441	271 331	
2011	85 800	131 104	85 643	NO	302 546	82 238	125 125	84 554	545	292 461	
2012	88 700	136 719	84 926	NO	310 345	87 931	131 068	85 351	803	305 153	
2013	93 760	119 302	86 085	NO	299 146	92 404	114 678	85 182	1 166	293 430	
2014	93 634	129 240	92 030	NO	314 904	97 162	119 336	91 869	1 237	309 603	
2015	103 507	131 803	90 528	NO	325 839	106 431	128 676	94 370	1 812	331 289	
2016	110 634	139 947	87 954	NO	338 534	114 082	140 462	89 708	1 507	345 759	
2017	115 696	153 054	101 863	NO	370 613	116 301	145 912	102 693	1 834	366 740	

**Figure 3.7 CO<sub>2</sub> emissions from fuel combustion, 1990-2017**



**Table 3.11 Comparison of CO<sub>2</sub> from fuel combustion between reference and sectoral approach, 1990-2017**

Year	Reference approach		Sectoral approach		Difference in emissions (%)
	Apparent consumption (PJ)	Emissions (kton CO <sub>2</sub> )	Apparent consumption (PJ)	Emissions (kton CO <sub>2</sub> )	
1990	1 795	135 417	1 794	129 662	4.4
1991	1 826	139 989	1 839	134 236	4.3
1992	1 914	146 377	1 922	140 522	4.2
1993	2 047	152 978	2 035	146 939	4.1
1994	2 007	152 001	1 997	143 899	5.6
1995	2 188	165 039	2 174	156 618	5.4
1996	2 410	183 657	2 365	174 175	5.4
1997	2 562	196 331	2 506	185 832	5.6
1998	2 580	195 241	2 497	185 415	5.3
1999	2 581	190 980	2 524	182 585	4.6
2000	2 891	214 779	2 778	204 617	5.0
2001	2 686	197 062	2 602	188 592	4.5
2002	2 796	203 702	2 679	195 421	4.2
2003	3 043	223 226	2 882	209 742	6.4
2004	3 138	222 851	2 988	215 331	3.5
2005	3 293	235 215	3 200	232 457	1.2
2006	3 601	251 348	3 416	248 041	1.3
2007	3 966	278 136	3 778	276 624	0.5
2008	3 918	278 455	3 700	271 520	2.6
2009	3 804	269 890	3 713	276 321	-2.3
2010	4 005	285 808	3 642	271 331	5.3
2011	4 300	302 546	3 938	292 461	3.4
2012	4 404	310 345	4 095	305 153	1.7
2013	4 320	299 146	3 987	293 430	1.9
2014	4 532	314 904	4 252	309 603	1.7
2015	4 750	325 839	4 511	331 289	-1.6
2016	4 978	338 534	4 689	345 759	-2.1
2017	5 361	370 613	4 987	366 740	1.1

**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 since the plant level NCVs is differ from average NCVs used in energy balance tables. Especially for solid fuels and more specifically for the Turkish lignite, such differences in NCVs are causing 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 regarding the NCV of lignite

changes in a wide range (from 1000 to 6000 kg/kcal). However, in national balance tables, an average NCV value is about 2200 kcal/kg is used. 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.

### **Recalculation:**

The recalculations done in the reference approach are described below;

Major revision was done on the national energy balance tables by the MENR in 04.05.2017. In this revision sectoral allocation of the fuels were elaborated, new fuels were added to the table and historical fuel consumption data were revised. Therefore, the total apparent consumption of fuels has been changed.

In the previous submissions, the activity data for the non-energy use of petroleum products (lubricant, bitumen, white spirit, paraffin and other oil) were taken from the Oil questionnaire that is sent to IEA. In this submission, these data are taken from the national energy balance tables in a more aggregated manner.

Besides that, the amount of coking coal used as reductant in the iron and steel production is recalculated (see chapter 3.2.3 for details)

The total amount of wastes which are combusted in the sectorial approach (1A1a, 1A2c, 1A2f) were accounted as apparent consumption and calculated in the reference approach previously. However, the apparent consumption of wastes should be zero since there is negligible amount of import or export of wastes. In this submission the apparent consumption of wastes is assumed to be zero.

The reference approach is recalculated and the effect of the recalculation in the time series can be seen in the table below.

**Table 3.12 Comparison on reference approach emissions recalculation in 2018 and 2019 inventory submissions**

Year	CO <sub>2</sub> emissions in reference approach in 2018 submission (kton)	CO <sub>2</sub> emissions in reference approach in 2019 submission (kton)	Difference in emissions (%)
1990	130 567	135 417	3.7
1991	134 513	139 989	4.1
1992	143 558	146 377	2.0
1993	148 469	152 978	3.0
1994	148 970	152 001	2.0
1995	159 851	165 039	3.2
1996	177 988	183 657	3.2
1997	191 482	196 331	2.5
1998	190 646	195 241	2.4
1999	187 154	190 980	2.0
2000	209 841	214 779	2.4
2001	191 347	197 062	3.0
2002	198 101	203 702	2.8
2003	212 025	223 226	5.3
2004	214 982	222 851	3.7
2005	222 501	235 215	5.7
2006	243 921	251 348	3.0
2007	268 724	278 136	3.5
2008	271 375	278 455	2.6
2009	257 800	269 890	4.7
2010	272 616	285 808	4.8
2011	297 366	302 546	1.7
2012	314 542	310 345	-1.3
2013	299 523	299 146	-0.1
2014	326 875	314 904	-3.7
2015	326 954	325 839	-0.3
2016	345 518	338 534	-2.0

### 3.2.2. International bunker fuels

In consistent with the UNFCCC reporting guidelines, CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O 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<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O from international aviation between 1990 and 2017.

GHG emissions from international aviation have an increasing trend in consistent with the growth in international aviation sector. CO<sub>2</sub>eq. emissions were 11.11Mt in 2017 while it was 0.56 Mt in 1990.



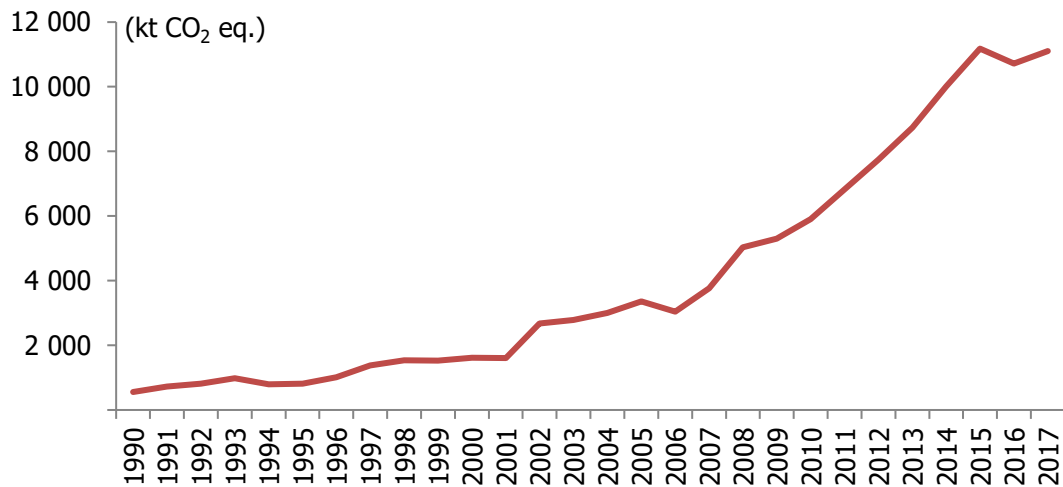
Emissions from international aviation are calculated using the T1 methodology given in the 2006 IPCC Guidelines. The following equation is used.

$$Emissions = fuel\ consumption * EF$$

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<sub>2</sub> (71500 kg/TJ), CH<sub>4</sub> (0.5 kg/TJ) and N<sub>2</sub>O (2 kg/TJ).

**Figure 3.8 GHG emissions from international aviation, 1990-2017**



**Table 3.13 Emissions and fuel for international aviation, 1990-2017**

<b>Year</b>	<b>CO<sub>2</sub> (kt)</b>	<b>CH<sub>4</sub> (kt)</b>	<b>N<sub>2</sub>O (kt)</b>	<b>CO<sub>2</sub> eq (kt)</b>	<b>Aviation bunkers (TJ)</b>
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
2016	10 630	0.074	0.30	10 720	148 668
2017	11 015	0.077	0.31	11 109	154 053

### 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<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O from international navigation between 1990 and 2017.

GHG emissions from international navigation have an increasing trend corresponding to the growth in the international navigation sector. CO<sub>2</sub> emissions were 2.9Mt in 2017 while it was 0.4 Mt in 1990.

Emissions from international navigation were calculated using the T1 and T2 methodology given in 2006 IPCC Guidelines. Country specific carbon content is used for CO<sub>2</sub> emission estimation. 2006 IPCC default EFs are used for CH<sub>4</sub> and N<sub>2</sub>O emissions. The following equation is used. Activity data is taken from national energy balance tables.

$$Emissions = \sum Fuel\ consumed_{ab} * EF_{ab}$$

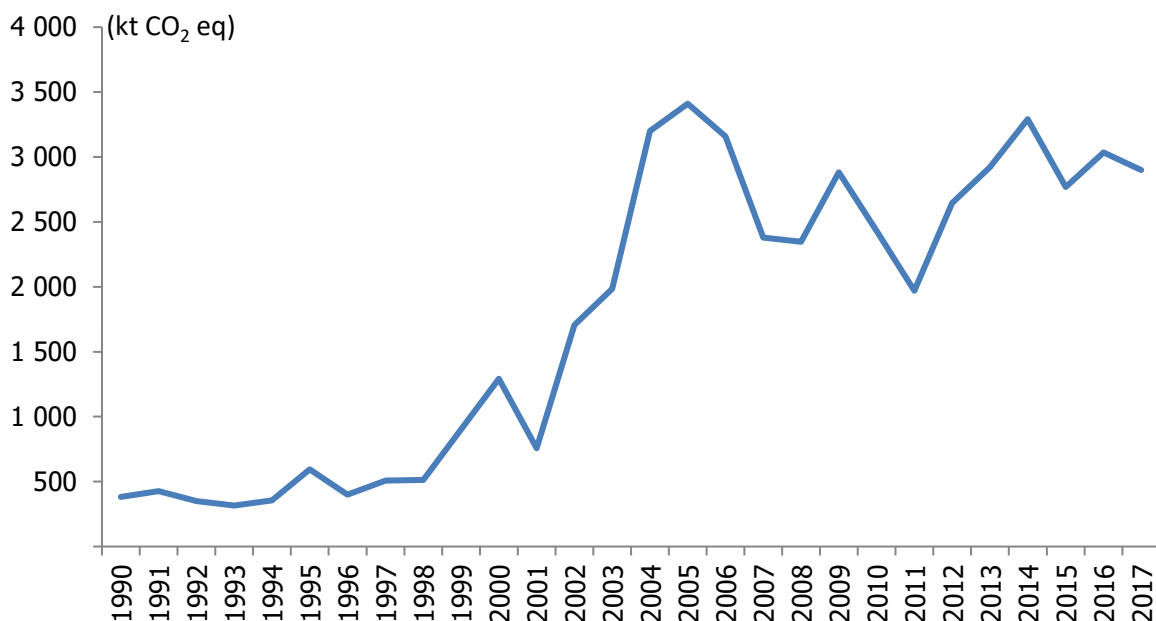
Where:

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<sub>2</sub> emission estimation. To estimate CH<sub>4</sub> and N<sub>2</sub>O emissions, Turkey applies the default emission factors from the 2006 IPCC Guidelines as follows: CH<sub>4</sub> (7 kg/TJ) and N<sub>2</sub>O (2 kg/TJ).

**Figure 3.9 GHG emissions from international navigation, 1990-2017**



**Table 3.14 Emissions and fuel for international navigation, 1990-2017**

<b>Year</b>	<b>CO<sub>2</sub> (kt)</b>	<b>CH<sub>4</sub> (kt)</b>	<b>N<sub>2</sub>O (kt)</b>	<b>CO<sub>2</sub> eq. (kt)</b>	<b>Navigation bunkers (TJ)</b>
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
2016	3 006	0.271	0.08	3 036	38 654
2017	2 871	0.262	0.08	2 900	37 487

**Recalculations:**

There is no recalculation for this category.

### 3.2.3. Feedstocks, Reductants and other non-energy use of fuels

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

The table below summarize reporting of carbon stored and emissions related to use of feedstock, reductants and other non-energy use of fuels.

**Table 3.15 Summary table for use of feedstock, reductants and other non energy use of fuels**

Use of fuel	Reported in inventory	Data Source
Reductant for ferroalloy production	Emissions in 2.C.2; in RA subtracted from coke	Plant specific
Reductant for carbide production	Emissions is 2.B.5; in RA subtracted from coke	Plant specific
Reductants for steel production in Electric Arc Furnaces	Emissions in 2.C.1; in RA subtracted from coke oven coke and natural gas	Estimated from EAF primary steel production data
Reductants for steel production in integrated iron and steel plants	Emissions is 2.C.1; in RA subtracted from coking coal	Plant specific
Feedstock for ammonia production	Emissions in 2.B.2; in RA subtracted from natural gas	Plant specific
Feedstock for petrochemical industry	Carbon stored, in RA subtracted from naphta	National energy balance table
Use of lubricants	Emissions in 2.D.1; in RA subtracted from other oil	National energy balance table (Aggregated under other oil)
Use of parrafin and wax	Emissions in 2.D.1; in RA subtracted from other oil	National energy balance table (Aggregated under other oil)
Use of bitumen for road paving, asphalt roofing etc.	Carbon stored, in RA subtracted from other oil	National energy balance table (Aggregated under other oil)
Refinery feedstocks	Carbon stored, in RA subtracted from other oil	National energy balance table (Aggregated under other oil)

Fossil fuels are used in integrated iron and steel plants for reducing iron ore into iron metal. The reduction process causes CO<sub>2</sub> emissions. These emissions are reported under IPPU category. The amount of carbon (fossil fuel originated, not limestone etc.) reported in the IPPU is converted into the amount of coking coal and it is subtracted from the reference approach.

In the national energy balance tables, feedstock and non-energy use of fuels are given separately and those consumptions 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 and refinery feedstocks. But they were not given separately in the national energy balance tables till 2015. They were given as aggregated form under "other petroleum products".

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 is stored in the products it is 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 as feedstock for petrochemical industry.

#### **Recalculation:**

In the previous submissions, the activity data for the non-energy use of petroleum products (lubricant, bitumen, white spirit, paraffin and other oil) were taken from the Oil questionnaire that is sent to IEA. In this submission, these data are taken from the national energy balance tables in a more aggregated manner.

Besides that, in the previous inventory report, all of the coke and coke gas used in the integrated iron and steel plants were reported as reductant in the reference approach. However, some portion of the coke is converted into Blast Furnace Gas and some portion of the BFG is used for energy purposes and its emissions are reported in the energy sector. This is a double counting of fuel as reductant and as energy use. This double counting is avoided in this inventory report. You can see the calculation steps below. This is the method in order to calculate the amount of carbon (in the form of coking coal) to be reported as reductant in the reference approach 1A(d).

(Total IPPU C emissions from integrated iron and steel plants) - (Total inorganic sourced C emissions from integrated iron and steel plants) = Amount of C to be excluded in 1A(d)

Amount of C to be excluded in 1A(d)/Coking coal carbon content = Amount of coking coal to be subtracted from the reference approach.

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

#### Source Category Description:

This source category includes the emission from the public electricity and heat production, petroleum refining and manufacture of solid fuels in Turkey. This category is one of the main emission sources in Turkey. The share of GHG emissions as CO<sub>2</sub> eq. from energy industries in total fuel combustion was 42% in 2017 while it was 28% in 1990. The source category 1.A.1 is a key category in terms of emission level and emission trend of CO<sub>2</sub> from liquid, solid and gaseous fuels in 2017.

**Table 3.16 GHG emissions from energy industries, 1990-2017**

Year	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	CO <sub>2</sub> eq. (kt)	Fuel consumption (TJ)
1990	37 130	0.4	0.4	37 253	395 856
1991	38 663	0.5	0.4	38 791	411 244
1992	43 178	0.5	0.5	43 324	456 727
1993	42 609	0.5	0.4	42 752	455 875
1994	48 892	0.6	0.5	49 059	519 646
1995	50 298	0.6	0.5	50 465	545 725
1996	54 254	0.6	0.6	54 437	584 018
1997	59 383	0.7	0.6	59 581	647 072
1998	64 948	0.8	0.7	65 164	712 882
1999	70 137	0.9	0.7	70 360	802 036
2000	77 503	1.0	0.7	77 743	906 993
2001	79 779	1.0	0.7	80 022	942 482
2002	73 926	1.0	0.6	74 138	891 876
2003	73 831	1.0	1.7	74 371	923 807
2004	74 883	1.0	2.1	75 539	932 120
2005	89 666	1.2	2.6	90 458	1105 479
2006	95 240	1.3	2.9	96 129	1173 383
2007	112 397	1.5	3.8	113 570	1392 862
2008	117 705	1.6	4.0	118 939	1465 366
2009	117 894	1.7	4.5	119 280	1467 055
2010	112 091	1.7	4.0	113 324	1399 222
2011	123 669	1.9	4.2	124 975	1539 469
2012	124 753	1.9	3.8	125 944	1575 464
2013	119 519	1.8	4.1	120 773	1509 951
2014	130 128	1.9	4.4	131 474	1681 459
2015	133 503	1.9	3.9	134 702	1676 362
2016	142 679	2.0	4.1	143 963	1753 313
2017	153 557	2.1	4.6	154 971	1914 595

### 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 (1.A.1.a) 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 (1.A.1.c) category, plant specific AD and carbon content were used in the emission estimation.

Emissions from CRF category 1.A.1.a, 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 using fuel analysis reports and oxidation rates are calculated using ash and slag analysis reports for solid fuels, and stack gas analysis reports for liquid and gaseous fuels. CO<sub>2</sub> emissions from liquid, solid and gaseous fuels used in public electricity and heat production (1.A.1.a) are calculated 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<sub>4</sub> and N<sub>2</sub>O emissions from CRF category 1A1a, have been estimated by using plant specific fuel consumption and NCVs. For the years 2000-2016 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<sub>4</sub> and N<sub>2</sub>O to be estimated with Tier 3.

Emissions from petroleum refining (CRF 1.A.1.b) were calculated according to 2006 IPCC T2 approach by TurkStat. Fuel consumption, NCVs and carbon content of fuels were compiled directly from refineries. CO<sub>2</sub> emissions from 1.A.1.b were calculated by using average carbon contents of fuels used in the refineries with IPCC default oxidation rates. CH<sub>4</sub> and N<sub>2</sub>O emissions from CRF category 1.A.1.b, 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 1.A.1.c) 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<sub>2</sub> emissions from 1.A.1.c were calculated by using plant specific AD, carbon contents of fuels and IPCC default oxidation rates. CH<sub>4</sub> and N<sub>2</sub>O emissions from CRF category 1.A.1.c, have been estimated by using plant specific fuel consumption and NCVs and IPCC default EFs.



**Recalculation:**

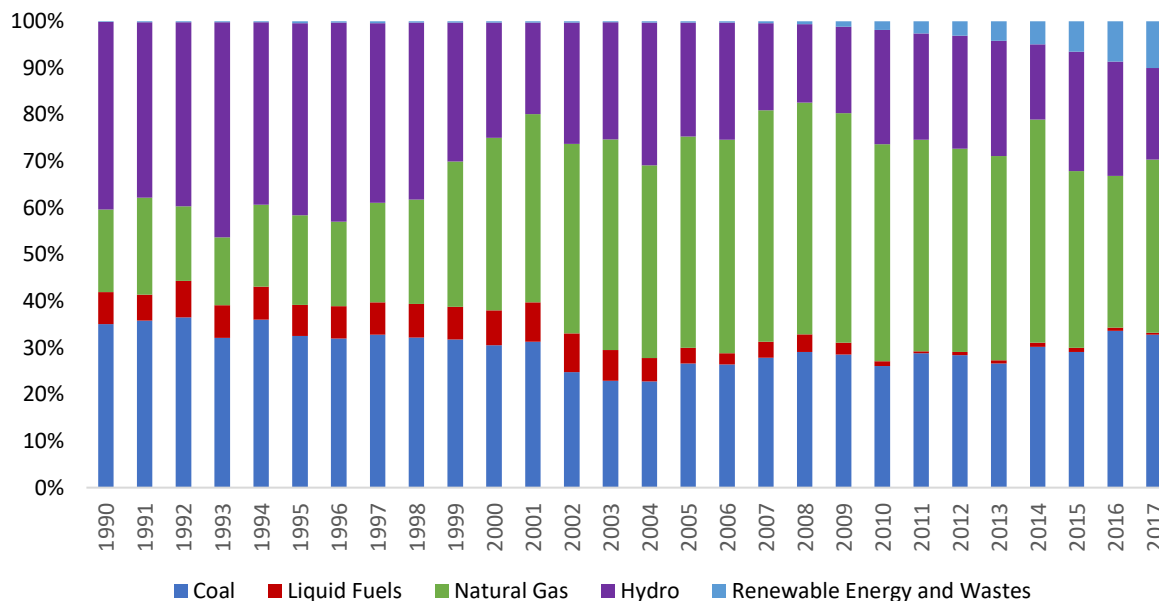
There are recalculations in this sector due to revision in the activity data. The CO<sub>2</sub> eq. emission estimation change is 0.5% for 2015.

**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 auto producers. Auto producers are the facilities that produce electricity that they use for their own purposes. Their AD (Activity Data) 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 Turkish Electricity Transmission Company (TEİAŞ).

Total installed capacity reached to 85.200 MW with 8.5% increase from the previous year and more than 5.2 times higher than 1990 values. The total gross electricity consumption has increased by 6.2% in 2017 compared to the previous year. In the year 2017, gross consumption was 296.702 GWh meanwhile in 2016 this figure realized as 279.286 GWh. Above mentioned installed capacities and consumption amounts belong to electricity production companies and auto producers as well. In 2017, natural gas had high share of 37.17% in all electricity production, which was followed by hydro and geothermal (21.65%), other bituminous coal (19.1%), Turkish lignite (13,69%), other renewable (8%) and oil (0.4%). From 2016 to 2017, Electricity production from hydropower plants decreased by 14%. Amount of electricity production from Turkish lignite has increased from 38,57 TWh to 40,69 TWh, from 53,70 TWh to 56,78 TWh for other bituminous coal respectively. On the other hand, electricity production from natural gas increased from 89,23 TWh to 110,49 TWh.

In 2017 electricity production from fossil fueled thermal power plants has accounted for 212,14 TWh of a total of 297,278 TWh production whilst in 2016 electricity production from fossil fueled thermal power plants had accounted for 185,79 TWh of a total of 274,408 TWh production. Fossil fueled thermal share in electricity production increased from 67.7% in 2016 to 71.3% in 2017.

**Figure 3.10 Energy mix of category 1.A.1.a, 1990-2017<sup>1</sup>**

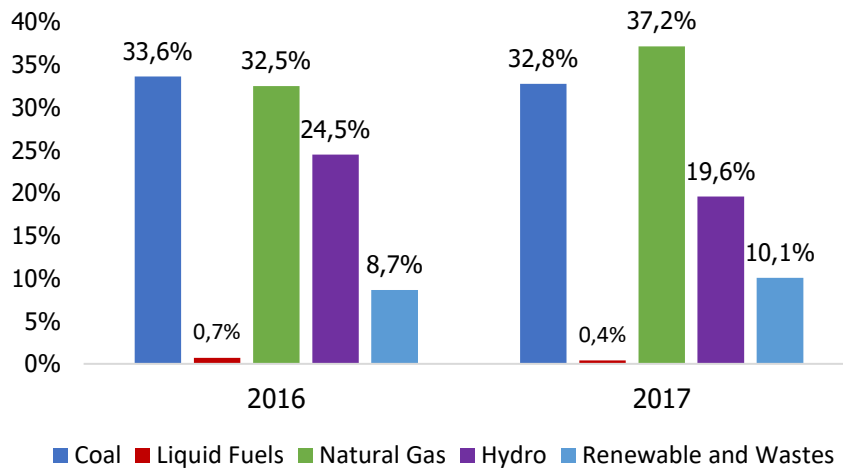
There was an accelerated increase in wind installed capacity from 5.751 MW in 2016 to 6.516 MW in the year 2017. Renewable Law which came into force in 2005 later revised in 2011 provided some supporting mechanism for purchasing electricity from solar, biomass, geothermal, wind and hydraulic energy. In the year 2017 solar power plants installed capacity raised to 3.421 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 25.3% compared to the previous year, reaching to 642 MW of installed power, generating 2.972 GWh of power in 2017.

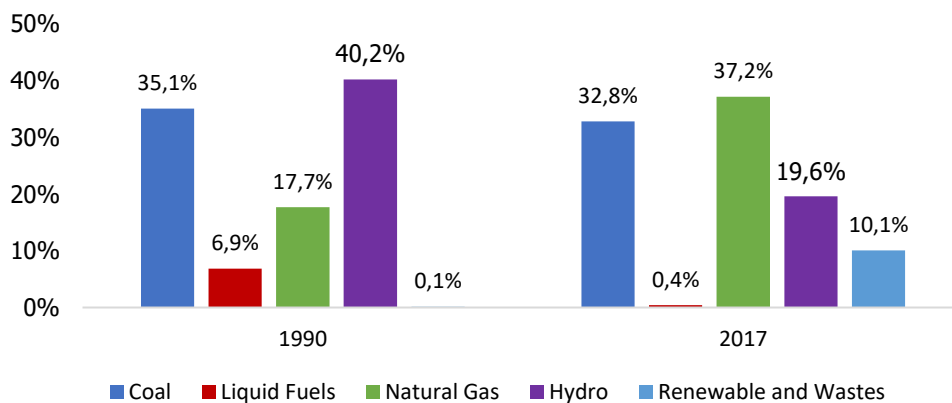
In 2017, Turkey's Total Primary Energy Supply (TPES) was 6 083 612.83 TJ, a 6.7% increase compared to 2016. Oil had a share of 1 855 861.49 TJ while hard coal and gas accounted for 1 034 414.53 TJ and 1 855 561,49 TJ respectively.

<sup>1</sup>Electricity Statistics, TEİAŞ (<https://www.teias.gov.tr/en/electricity-statisticsin-turkish>)

**Figure 3.11 Electricity generation and shares by energy resources, 2016 - 2017<sup>2</sup>**



**Figure 3.12 Electricity generation and shares by energy resources, 1990 - 2017<sup>3</sup>**



Primary energy (domestic) production was 1 480 325.87 TJ in 2017 and provided 24% of overall energy supply. The share of import in TPES increased from 83% in 2016 to 86% in 2017.

The production of solid fossil fuels, excluding animal & yard waste, has fell from 647 270.8 TJ in 2016 to 631 638.2 TJ in 2017. The main domestic energy source remains as Turkish lignite with a production increased from 70.24 Mt in 2016 to 71.46 Mt in 2017 which represented a rise by about %1.74.

<sup>2</sup>Electricity Statistics, TEİAŞ (<https://www.teias.gov.tr/en/electricity-statisticsin-turkish>)

<sup>3</sup>Electricity Statistics, TEİAŞ (<https://www.teias.gov.tr/en/electricity-statisticsin-turkish>)

The share of GHG emissions from public electricity and heat production in total fuel combustion was 39.2% in 2017 while it was 24.4% in 1990. According to Table 3.11, fuel consumption increased from 1 644 763 TJ in 2016 to 1 804 038 TJ in 2017 when the CO<sub>2</sub> emissions increased from 134280 kt in 2016 to 144814 kt in 2017. In other words, the increase in fuel consumption and CO<sub>2</sub> emissions was 9.7% and 7.8%, respectively. The main reason is that natural gas had highest share (79.6%) in the total increase in the electricity production from fuel combustion.

**Table 3.17 Emissions from category 1A1a, 1990-2017**

Year	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	CO <sub>2</sub> eq. (kt)	Fuel consumption (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	73 139	0.9	0.7	73 371	854 300
2001	75 351	0.9	0.7	75 586	888 392
2002	69 374	0.8	0.6	69 578	834 375
2003	68 970	0.9	1.7	69 501	862 965
2004	69 840	0.9	2.1	70 485	866 064
2005	84 623	1.1	2.5	85 407	1 036 864
2006	90 115	1.2	2.9	90 994	1 103 265
2007	107 431	1.4	3.8	108 595	1 323 995
2008	112 408	1.5	4.0	113 633	1 389 232
2009	113 842	1.6	4.5	115 222	1 413 335
2010	107 664	1.6	4.0	108 892	1 344 379
2011	118 730	1.8	4.2	120 031	1 478 115
2012	119 702	1.8	3.8	120 889	1 512 807
2013	114 861	1.7	4.0	116 110	1 451 358
2014	125 665	1.8	4.3	127 006	1 624 731
2015	126 767	1.8	3.8	127 958	1 581 303
2016	134 280	1.9	4.1	135 554	1 644 763
2017	144 814	1.9	4.6	146 220	1 804 038

### Methodological Issues:

#### Activity Data

The 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 checked whether there were data errors or omissions, and then data compared with fuel specific default values from IPCC guidelines and also literature. Cross checks including fuel capacity factor controls, and examining outliers give some opinion about data consistency. Suspicious data are corrected by getting contact with Turkish Electricity Transmission Company (TEİAŞ).

As soon as the 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). In order to obtain plant specific activity data, the amount of feedstock fuel used is multiplied by plant specific NCVs to get heat values in terms of TJ. Average NCVs are given in the Table 3.12.

**Table 3.18 Average NCVs of fuels used in category 1.A.1.a**  
(TJ/kt)

<b>Fuel Type</b>	<b>Weighted average</b>	<b>Default</b>
Sub-Bituminous Coal	16.66	18.90
Natural gas	53.03	48.00
Residual Fuel Oil	43.91	40.40
Other bituminous coal	24.44	25.80
Turkish lignite	6.88	11.90
Gas\Diesel Oil	44.63	43.00

The multipliers of EF, namely carbon content and oxidation rates were calculated. For Turkish lignite, sub-bituminous and other bituminous coal, ultimate analysis results, which were obtained from coal-fired power plants, were used to calculate carbon content of the related coal types. For liquid fuels the same procedure was applied through residual fuel oil characteristics and mass percentage of carbon. For natural gas, volumetric fractions of gas concentrations were obtained through gas chromatography analysis from Petroleum Pipeline Company (BOTAŞ). Using density of the gases and some stoichiometry carbon mass amount of each gas compounds were calculated and summed up to reach an overall carbon amount. Oxidation rate of solid fuels was calculated by using the mass percentage of carbon in ash-slag analysis reports obtained from coal firing plants. For gaseous fuels, measured CO concentrations in the stack gas were used in order to calculate mass percentage of the unoxidized carbon and then oxidation rate of the related fuel. In order to calculate the oxidation rate of gaseous fuels (natural gas), CO concentrations measured in the stack gas of the related plants were obtained from the Ministry of

Environment and Urbanization. Some of the analysis reports and calculation steps were shared in Annex 3. CO<sub>2</sub> EFs used for source category 1.A.1.a were listed in Table 3.13 for whole time series on fuel basis.

For CH<sub>4</sub> and N<sub>2</sub>O 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<sub>4</sub> and N<sub>2</sub>O were chosen.

EFs for CH<sub>4</sub> and N<sub>2</sub>O were listed in Table 3.14 for whole time series on fuel basis.

Table 3.19 CO<sub>2</sub> emission factors used for source category 1.A.1.a, 1990-2017

Year	Turkish Lignite	Sub-Bituminous Coal	Other Bituminous Coal	Natural Gas	Residual Fuel Oil	Diesel Oil	LPG	Biogas	Industrial Waste	Wood-wood waste	Coke				Blast Furnace		Petroleum		Oxygen Steel		Coal Refinery	
											Gas	Liquor	Gas	Gas	Gas	Gas	Coke	Furnace Gas	Furnace Gas	Steel Gas	Tar	Gas
1990	114.16	93.37	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
1991	114.01	101.38	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
1992	113.85	101.35	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
1993	113.70	100.54	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
1994	113.54	99.12	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
1995	113.39	102.17	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
1996	113.23	102.50	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
1997	113.08	103.34	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
1998	112.92	102.81	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
1999	112.77	93.39	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
2000	110.05	95.52	88.62	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
2001	110.58	99.28	88.62	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
2002	111.30	96.27	88.62	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
2003	112.00	100.90	79.88	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
2004	112.72	90.34	84.02	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
2005	113.50	94.23	85.24	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
2006	114.18	88.71	90.07	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
2007	113.62	88.52	91.17	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
2008	112.51	93.35	83.29	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
2009	111.39	96.03	90.35	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
2010	110.26	98.56	90.01	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
2011	109.48	95.10	89.11	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
2012	109.29	96.65	88.89	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
2013	109.09	96.18	93.57	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
2014	107.63	93.15	87.70	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
2015	107.63	92.38	92.64	58.66	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
2016	107.41	85.32	91.37	56.04	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57
2017	107.24	95.50	91.55	56.02	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	97.53	181.87	80.67	57.57	57.57	57.57

Table 3.20 CH<sub>4</sub> and N<sub>2</sub>O emission factors used for source category 1.A.1.a

	(kg/TJ)	
<b>Fuel Types</b>	<b>CH<sub>4</sub></b>	<b>N<sub>2</sub>O</b>
<b>Liquid Fuels</b>		
<b>Fuel Oil</b>		
Steam	0.8	0.3
Internal Combustion	0.8	0.3
Combined Heat	0.8	0.3
<b>Liquid Fuels</b>		
<b>Diesel Oil, Naphtha</b>		
Steam	0.9	0.4
Internal Combustion	0.9	0.4
Combined Heat	0.9	0.4
<b>Solid Fuels</b>		
<b>Turkish Lignite and Sub-Bituminous and Other Bituminous Coal</b>		
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
<b>Natural Gas</b>		
Boiler	4	1
Gas Engine	4	1
Gas Turbine	4	1
Internal Combustion	4	1
Combined Heat	1	3
<b>Other Fuels</b>		
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
<b>Biomass</b>		
Biogas	1	1
Wood waste	11	7

### Comparability and Accuracy through Nomenclature Change:

NCV of Turkish lignite differs significantly with that of Energy Statistics Handbook and general fuel literature. It is even lower the lowest value of lignite in all reports of the parties Parties. Analysis reports



support this NCV data of Turkish lignite. Its average carbon content in 2017 is 30.05 kg/GJ, approaches the upper limit of 2006 IPCC Guidelines (31.3 kg/GJ). In order to recategorise our local lignite, we renamed it as “Turkish Lignite” to separate it from literature lignite and therefore avoid misleading comparisons.

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

CO<sub>2</sub> capture from flue gases and CO<sub>2</sub> storage is not occurring in Turkey, except pilot scaled research fields.

### **Implied Emission Factor (IEF) Trends and Comments**

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

**Table 3.21 IEFs of fuels used for category 1.A.1.a, 1990-2017**

Years	CO <sub>2</sub>				CH <sub>4</sub>				N <sub>2</sub> O	
	Solid Fuels		Liquid Fuels		Gaseous Fuels		Biomass		Biomass	
	CHP	Electricity Generation	CHP	Electricity Generation	CHP	Electricity Generation	CHP	Electricity Generation	CHP	Electricity Generation
1990	-	113.41	-	76.88	58.23	58.23	-	-	-	-
1991	-	113.42	-	76.89	58.23	58.23	-	-	-	-
1992	-	113.01	-	76.93	58.23	58.23	-	-	-	-
1993	-	112.79	-	76.93	58.23	58.23	-	-	-	-
1994	-	112.62	-	76.93	58.23	58.23	-	-	-	-
1995	-	112.78	-	76.74	58.23	58.23	-	-	-	-
1996	-	112.60	-	76.70	58.23	58.23	-	-	-	-
1997	-	112.43	-	76.52	58.23	58.23	-	-	-	-
1998	-	112.28	-	76.13	58.23	58.23	-	-	-	-
1999	-	111.56	-	75.66	58.23	58.23	-	-	-	-
2000	120.03	110.62	74.03	75.42	58.23	58.23	4.80	2.92	2.13	1.65
2001	117.56	111.16	65.95	73.99	58.23	58.23	4.84	3.78	2.14	1.48
2002	123.56	112.49	75.38	76.36	58.23	58.23	4.80	4.73	2.13	1.59
2003	128.20	109.42	75.75	76.46	58.23	58.23	3.13	2.57	2.08	1.85
2004	130.18	109.07	75.99	76.42	58.23	58.23	3.00	1.89	2.00	1.44
2005	125.53	109.94	76.05	76.08	58.23	58.23	2.37	1.11	1.68	1.06
2006	140.06	111.03	76.95	76.12	58.23	58.23	2.61	1.44	1.81	1.22
2007	137.25	110.47	76.96	76.19	58.23	58.23	2.28	1.37	1.64	1.18
2008	136.91	108.29	76.94	76.11	58.23	58.23	2.83	1.41	2.02	1.22
2009	146.99	110.47	73.76	75.82	58.23	58.23	3.52	1.33	2.44	1.18
2010	130.35	108.16	70.62	75.15	58.23	58.23	4.57	1.44	3.06	1.25
2011	134.30	105.46	69.63	73.82	58.23	58.23	2.41	1.08	1.82	1.05
2012	132.06	103.22	60.18	70.95	58.23	58.23	1.11	1.10	1.03	1.05
2013	132.06	105.62	61.41	71.46	58.23	58.23	1.54	1.10	1.31	1.05
2014	111.14	100.88	64.07	72.82	58.23	58.23	2.29	1.09	1.74	1.05
2015	105.74	102.79	69.34	71.99	58.66	58.66	1.40	1.07	1.23	1.04
2016	120.84	102.19	76.97	74.61	56.04	56.04	1.38	1.04	1.22	1.02
2017	107.77	102.34	76.97	74.47	56.02	56.02	1.25	1.02	1.14	1.01

IEFs of CO<sub>2</sub> ranges from 102 to 146 t/TJ. It is mainly because of local Turkish 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.

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 and 2012 in 1.A.1.a.i subsector. Declines in the trend are mainly owing to the share of refinery gas in the related year.

IEFs of gaseous fuels do not change considerably over time. IEFs of CO<sub>2</sub> ranges from 56 to 58 t CO<sub>2</sub>/TJ. The reason for this change is the use of more gas chromatography results for analysis. After 2000 the values of CHP Generation are the same as Electricity Generation.

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 the T1 emission estimation results is given in Table 3.15.

**Table 3.22 Comparison of GHG emissions from 1.A.1.a category ,1990-2017**

Year	GHG emissions with plant specific data		GHG emissions with national energy balance data		Difference	
	GHG Emission (kt CO <sub>2</sub> eq.)	Fuel consumption (TJ)	GHG Emission (kt CO <sub>2</sub> eq.)	Fuel consumption (TJ)	GHG emission (kt CO <sub>2</sub> eq.)	Fuel consumption (TJ)
1990	32938	346707	35 018	360 733	-2 080	-14 026
1991	34550	362934	36 549	374 744	-1 999	-11 810
1992	39186	408249	41 241	423 770	-2 055	-15 521
1993	38390	403148	40 732	418 681	-2 342	-15 533
1994	44721	466134	47 185	484 105	-2 464	-17 971
1995	46020	490230	48 578	509 424	-2 558	-19 194
1996	49919	529408	52 909	551 496	-2 990	-22 088
1997	55000	590895	57 889	612 189	-2 889	-21 294
1998	60544	656466	63 307	680 233	-2 763	-23 767
1999	65993	749301	68 257	763 845	-2 264	-14 544
2000	73371	854300	80 730	956 721	-7 359	-102 421
2001	75586	888392	82 887	990 341	-7301	-101 949
2002	69578	834375	76 942	943 244	-7 364	-108 869
2003	69501	862965	81 077	990 602	-11 576	-127 637
2004	70485	866064	77 250	969 140	-6 765	-103 076
2005	85407	1036864	84 725	1 067 718	682	-30 854
2006	90994	1103265	92 608	1 148 644	-1 614	-45 379
2007	108595	1323995	108 250	1 352 507	345	-28 512
2008	113633	1389232	118 278	1 471 363	-4 645	-82 131
2009	115222	1413335	111 781	1 396 319	3 441	17 016
2010	108892	1344379	113 467	1 424 965	-4 575	-80 586
2011	120031	1478115	125 175	1 552 324	-5 144	-74 209
2012	120 889	1 512 807	125 969	1 581 762	-5 080	-68 955
2013	116 110	1 451 358	119 577	1 519 612	-3 467	-68 254
2014	127 006	1 624 731	136 042	1 726 147	-9 036	-101 416
2015	127 958	1 591 475	127 154	1 561 850	804	29 625
2016	135 554	1 644 763	135 118	1 647 281	436	-2 518
2017	146220	1804038	149 748	1 812 282	-3 528	-8 244

The differences between T1 (national energy balance data) and T2, T3 (plant specific data) results are mainly related to the solid fuels, especially NCVs of Turkish lignite. Because of the own character of the Turkish lignite, its NCV is lower than the lignite in literature. In plant specific data especially NCV of lignite changes in a wide range as 1000-5400 kg/kcal. However, in national balance tables an average NCV value is around 2000 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 16,2% 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 12,1% decrease in lignite consumption in TJ (Table 3.16). With the improvements in the energy balance table in recent years, the difference between the plant specific NCV and national balance average NCV has decreased gradually.

Table 3.23 Comparison of solid fuel consumption, 1990-2017

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	7 764	29 884	202 692
1991	782	10 611	32 293	217 563	782	10 615	32 293	219 301
1992	1 339	17 428	35 318	240 051	1 339	17710	35 318	241 619
1993	1 298	17 027	31 917	230 652	1 298	17320	31 917	232 249
1994	1 441	18 977	39 701	277 193	1 441	19 222	39 701	278 917
1995	1 246	15 866	39 815	275 859	1 245	16 232	39 815	277 051
1996	1 476	18 792	42 441	302 290	1 476	19200	42 441	304 029
1997	1 828	22 942	45 694	324 707	1 828	23 343	45 694	326 189
1998	1 884	23 778	52 115	353 093	1 885	24 332	52 115	354 785
1999	1 729	23 943	53 780	359 678	1 729	24 714	53780	361 615
2000	1 942	30 130	52 539	371 196	1 942	30100	52540	373 143
2001	2 167	35 209	52 883	372 593	2 179	35580	52 872	374 017
2002	1 945	32 979	41 883	307 731	1 945	33 005	41 901	307 004
2003	3 614	75 116	34 167	246 969	3 614	75 171	34 784	288 937
2004	4 471	99 803	32 994	242 008	4 471	99 848	32 933	242 124
2005	5 174	108 533	47 414	324 826	5 171	108 531	47 413	272 791
2006	5 476	119 784	49 709	337 847	5 476	119 862	49 709	338 073
2007	5 913	131 324	60 536	408 777	5 912	131410	60 536	409 045
2008	6 197	137 584	65 685	441 791	6 197	137 667	65 685	442080
2009	6 361	140 943	62 894	424 612	6 361	141 044	62 894	397 279
2010	6 935	154 215	55 437	389 958	6 934	154 272	55 436	391 552
2011	10 116	230 759	60 271	423 208	10 117	247 412	60 271	423 429
2012	11 760	287 433	54 584	378 208	11 761	287 616	54 586	378 692
2013	11 707	279 108	45 919	327 977	11 707	279 238	45 919	328 369
2014	13 826	332 019	51 967	363 512	14 039	337 447	57 411	407 424
2015	16 126	389 644	48 820	350 379	16 071	388 577	48 755	349 232
2016	17 966	436 847	58 974	420 041	17 966	436 657	58 974	424 445
2017	19 485	466 990	62 837	432 048	19 485	466 466	62 837	438 039

### 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. For hard coal and Turkish lignite there is no any bias for AD but 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 1%. The main reason of the bias explained above is the difference in the form of data supplied from TEİAŞ. In the surveys of GHG emissions Net Calorific Values of bioenergy and waste fuels were supplied

by TEIAS and they were used in the calculation of GHG emissions. On the other hand, a cumulative terajoule (TJ) value related to bioenergy and waste was supplied by TEIAS for Energy Balance calculations.

### CO<sub>2</sub> emission factors uncertainties

**Solid fuels:** Turkish lignite other bituminous coal sub-bituminous 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 3.5% with Approach 1 method. In this year's submission combined uncertainty estimates of solid fuels are quantified using the Monte Carlo simulation also. Uncertainty in Solid fuels CO<sub>2</sub> emissions in 2017 are estimated at -2.97% to +2.91% with Approach 2 method. For more details, please refer to the Uncertainty chapter at the end of the Inventory report in Annex 2.

**Liquid fuels:** Residual fuel oil diesel oil naphtha 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 4.24% with Approach 1 method. In this year's submission combined uncertainty estimates of Liquid fuels are quantified using the Monte Carlo simulation also. Uncertainty in Liquid fuels CO<sub>2</sub> emissions in 2017 are estimated at  $\pm 2.65\%$  with Approach 2 method. For more details, please refer to the Uncertainty chapter at the end of the Inventory report in Annex 2.

**Gaseous Fuels:** Natural gas has been used as gaseous fuels in 1.A.1.a category and uncertainty for gaseous fuels was calculated as 1.5% with Approach 1 method. In this year's submission combined uncertainty estimates of Gaseous fuels are quantified using the Monte Carlo simulation also. Uncertainty in Gaseous fuels CO<sub>2</sub> emissions in 2017 are estimated at -1.46% to +1.47% with Approach 2 method. For more details, please refer to the Uncertainty chapter at the end of the Inventory report in Annex 2.

**Biomass:** Default EF in 2006 IPCC Guidelines 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 Guidelines 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 Guidelines. On the other hand, there was no default uncertainty value for industrial waste EF throughout the guideline.

EFs uncertainty for CH<sub>4</sub> was considered as 25% and that for N<sub>2</sub>O was considered as 75% by making use of the table in 2006 IPCC Guidelines on page 2.40 (choosing The Netherlands as an example with PS and D EFs).

### Recalculation

1. The CO<sub>2</sub> emissions from coke oven gas are recalculated due to a changing CO<sub>2</sub> emission factor as 37.47 which are average of three integrated iron and steel plants in Turkey instead of 107.067 that was used in 2000-2017 submissions.
2. Since the changing the assumption of asphaltite as sub-bituminous coal instead of petrocake the CO<sub>2</sub> emissions from asphaltite is recalculated due to a changing emission factor as 96.46 instead of 97.53 that was used in 2000-2017 submissions. For this period the emission factors of CH<sub>4</sub> and N<sub>2</sub>O are changing due to revision fuel assumption.
3. For the fuel of Pyrolytic oil emission factor is corrected. It was mistyped in the previous three years calculation sheet. The emissions are recalculated accordingly.

### 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 fossil fuels consumed for petroleum refineries process operations were covered in CRF category 1.A.1.b. However autoproducers within the refineries were included in the 1.A.1.a category. The share of GHG emissions as CO<sub>2</sub> eq. from petroleum refining in energy industries sector (1A1) was 4.1% in 2017 and it was also 6.1% in 1990.

**Table 3.24 Emissions from petroleum refining, 1990-2017**

Year	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	CO <sub>2</sub> eq. (kt)	Fuel consumption (TJ)	Share in 1A1 category (%)
1990	2 280	0.07	0.014	2 286	32 091	6.1
1991	2 200	0.07	0.013	2 205	31 079	5.7
1992	2 316	0.07	0.013	2 321	33 474	5.4
1993	2 675	0.08	0.014	2 681	38 946	6.3
1994	2 908	0.09	0.016	2 915	42 342	5.9
1995	3 009	0.09	0.016	3 017	43 872	6.0
1996	2 944	0.09	0.016	2 951	42 422	5.4
1997	3 037	0.09	0.016	3 044	44 520	5.1
1998	3 108	0.10	0.017	3 115	44 866	4.8
1999	2 894	0.09	0.016	2 901	41 464	4.1
2000	2 931	0.09	0.017	2 939	41 749	3.8
2001	3 030	0.09	0.017	3 037	43 607	3.8
2002	3 223	0.10	0.017	3 231	47 386	4.3
2003	3 381	0.10	0.018	3 388	49 712	4.5
2004	3 567	0.11	0.019	3 575	52 654	4.7
2005	3 767	0.11	0.018	3 775	56 854	4.2
2006	3 754	0.11	0.018	3 762	57 307	3.9
2007	3 719	0.11	0.018	3 727	57 130	3.3
2008	3 956	0.11	0.017	3 964	62 444	3.3
2009	2 754	0.08	0.014	2 760	41 732	2.3
2010	2 706	0.07	0.010	2 710	43 348	2.4
2011	3 036	0.07	0.010	3 041	49 920	2.4
2012	3 097	0.07	0.010	3 102	50 405	2.4
2013	2 702	0.06	0.009	2 706	44 678	2.2
2014	2 409	0.06	0.008	2 413	42 134	1.8
2015	4 470	0.10	0.014	4 476	79 275	3.3
2016	6 372	0.13	0.018	6 381	95 149	4.4
2017	6 360	0.12	0.015	6 367	96 561	4.1

Total emissions from petroleum refining were decreased by 13 kt CO<sub>2</sub> eq. from 2016 to 2017 (0.2% of decrease).

#### Methodological Issues:

Emissions from petroleum refining (CRF 1.A.1.b) were calculated according to 2006 IPCC T2 approach by TurkStat. Fuel consumption, NCVs and carbon content of fuels were compiled directly from refineries by a questionnaire by TurkStat. CO<sub>2</sub> emissions from 1.A.1.b were calculated by using average carbon contents of fuels used in the refineries. 2006 IPCC default oxidation rate was used. CH<sub>4</sub> and N<sub>2</sub>O emissions from CRF category 1.A.1.b, have been estimated by using refineries total fuel consumption and average NCVs for refineries and 2006 IPCC default EFs.



**Uncertainties and Time-Series Consistency:**

All refineries are covered in the inventory. AD uncertainty both liquid and gaseous fuels for refineries is considered 2% as indicated in table 2.15 of 2006 IPCC Guidelines 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 Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO<sub>2</sub> and 100% (mid value in the range) for CH<sub>4</sub> and N<sub>2</sub>O.

**Source-Specific QA/QC and Verification:**

Quality control for 1.A.1.b category was performed on the basis of QA/QC plan. It was first confirmed with refinery authorities that AD do not include the autoproducers consumption in the refinery. Calorific values provided by the refinery are 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.

**Recalculation:**

There is no recalculation for this category.

**Planned Improvement:**

Emissions from petroleum refining are calculated both plant specific and from national energy balance tables. However, there are some differences in the results. Plant specific results are reported. However, there is a continuous work in order to understand the reasons of the differences.

**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 1.A.1.c. The share of GHG emissions as CO<sub>2</sub> eq. from manufacture of solid fuels category in 1A1 category was 1.5% in 2017 while it was 5.4% in 1990.

**Table 3.25 Emissions from category 1.A.1.c, 1990-2017**

Year	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	CO <sub>2</sub> eq. (kt)	Fuel consumption (TJ)	Share in 1A1 Category (%)
1990	2 027	0.02	0.005	2 029	17 058	5.4
1991	2 034	0.02	0.005	2 036	17 232	5.2
1992	1 815	0.02	0.005	1 817	15 004	4.2
1993	1 680	0.01	0.003	1 681	13 782	3.9
1994	1 422	0.01	0.001	1 423	11 170	2.9
1995	1 429	0.01	0.001	1 429	11 623	2.8
1996	1 567	0.01	0.001	1 567	12 188	2.9
1997	1 536	0.01	0.001	1 537	11 657	2.6
1998	1 504	0.01	0.001	1 505	11 550	2.3
1999	1 465	0.01	0.001	1 466	11 271	2.1
2000	1 432	0.01	0.001	1 433	10 944	1.8
2001	1 399	0.01	0.001	1 399	10 483	1.7
2002	1 329	0.01	0.001	1 329	10 115	1.8
2003	1 480	0.01	0.002	1 481	11 129	2.0
2004	1 477	0.02	0.004	1 478	13 403	2.0
2005	1 276	0.01	0.003	1 277	11 761	1.4
2006	1 371	0.01	0.004	1 372	12 812	1.4
2007	1 247	0.01	0.002	1 248	11 737	1.1
2008	1 341	0.01	0.002	1 342	13 690	1.1
2009	1 298	0.01	0.001	1 299	11 988	1.1
2010	1 721	0.01	0.001	1 722	11 494	1.5
2011	1 903	0.01	0.001	1 903	11 433	1.5
2012	1 953	0.01	0.001	1 954	12 251	1.5
2013	1 956	0.01	0.001	1 956	13 916	1.6
2014	2 054	0.01	0.001	2 055	14 593	1.6
2015	2 267	0.02	0.002	2 267	15 784	1.7
2016	2 028	0.01	0.001	2 028	13 402	1.4
2017	2 383	0.01	0.001	2 384	13 996	1.5

Total emissions from manufacture of solid fuels and other energy industries were increased by 356 kt CO<sub>2</sub> eq. from 2016 to 2017 (17.5% of increase) due to increase of fuel consumption.

### Methodological Issues:

Emissions from manufacture of solid fuels (CRF 1.A.1.c) 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, blast furnace gas, and rarely natural 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<sub>2</sub> emissions from 1.A.1.c were calculated by using plant specific AD, carbon contents of fuels and 2006 IPCC default oxidation rates. CH<sub>4</sub> and N<sub>2</sub>O emissions from CRF category 1.A.1.c, 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 Guidelines 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 Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO<sub>2</sub> and 100% (mid value in the range) for CH<sub>4</sub> and N<sub>2</sub>O.

**Source-Specific QA/QC and Verification:**

Quality control for 1.A.1.c 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. Carbon mass balances on integrated iron and steel plants is done in the IPPU sector as a part of QC/QA of activity data. This control also assures the fuel consumption in the coke ovens.

**Recalculation:**

The fuel consumption data of coke production units within the integrated iron and steel plants are revised. Another issue is that town gas and brown coal briquettes have been produced in Turkey until 1994 and 2008 respectively. In this submission, emissions from the production of these two fuels are covered in the inventory for the first time. The effect of the recalculations in the time series can be seen in the table below.

**Table 3.26 Comparison on manufacture of solid fuels and other energy industries (1A1c) emissions recalculation in 2018 and 2019 inventory submissions**

<b>Year</b>	<b>Emissions from 1A1c in 2018 submission (kt CO<sub>2</sub>)</b>	<b>Emissions from 1A1c in 2019 submission (kt CO<sub>2</sub>)</b>	<b>Difference in emissions (kt CO<sub>2</sub>)</b>
1990	1 781	2 029	249
1991	1 969	2 036	66
1992	1 822	1 817	- 5
1993	1 761	1 681	- 80
1994	1 593	1 423	- 170
1995	1 533	1 429	- 103
1996	1 659	1 567	- 91
1997	1 557	1 537	- 20
1998	1 501	1 505	4
1999	1 412	1 466	54
2000	1 432	1 433	0
2001	1 426	1 399	- 26
2002	1 464	1 329	- 134
2003	1 447	1 481	34
2004	1 289	1 478	190
2005	1 242	1 277	35
2006	1 217	1 372	156
2007	1 263	1 248	- 15
2008	1 248	1 342	94
2009	1 268	1 299	31
2010	1 750	1 722	- 29
2011	1 874	1 903	29
2012	1 913	1 954	40
2013	1 953	1 956	3
2014	2 085	2 055	- 30
2015	2 235	2 267	33
2016	2 056	2 028	- 28

**Planned Improvement:**

Recently carbon mass balance on integrated iron and steel plants in cooperation with sector experts have been done and good results are taken. There is no planned improvement at the moment.

**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. Until, 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.

**Table 3.27 Fuel combustion emissions from manufacturing industry and construction, 1990-2017**

Year	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	CO <sub>2</sub> eq. (kt)	Fuel consumption (TJ)	Share in fuel combustion (1A) category (%)
1990	37 004	2.17	0.347	37 162	386 908	27.5
1991	40 162	2.38	0.380	40 335	421 807	28.9
1992	39 168	2.14	0.344	39 324	422 604	26.9
1993	39 832	2.10	0.340	39 986	441 625	26.2
1994	35 741	1.84	0.300	35 876	394 963	24.0
1995	39 843	2.06	0.336	39 995	452 068	24.6
1996	50 376	2.88	0.462	50 586	553 552	28.1
1997	55 794	3.24	0.515	56 029	613 749	29.2
1998	55 221	3.46	0.545	55 470	597 667	29.0
1999	47 158	2.87	0.456	47 365	530 985	25.2
2000	57 657	3.91	0.609	57 936	629 742	27.6
2001	45 470	2.59	0.408	45 656	504 554	23.6
2002	56 856	3.58	0.560	57 112	633 369	28.5
2003	66 388	4.13	0.641	66 682	748 880	31.0
2004	63 558	4.20	0.651	63 857	750 894	28.9
2005	62 731	3.85	0.595	63 004	743 394	26.4
2006	69 749	4.76	0.726	70 084	846 725	27.6
2007	71 521	5.05	0.762	71 874	867 730	25.4
2008	47 169	2.63	0.401	47 354	578 884	16.9
2009	46 034	2.72	0.415	46 226	550 987	16.2
2010	52 120	3.00	0.461	52 332	639 363	18.7
2011	52 380	2.91	0.443	52 585	662 028	17.5
2012	60 821	3.28	0.499	61 052	760 755	19.6
2013	52 772	2.92	0.446	52 978	648 612	17.7
2014	54 233	2.93	0.444	54 438	680 149	17.2
2015	59 359	3.25	0.487	59 585	765 682	17.7
2016	59 840	3.30	0.498	60 071	785 911	17.1
2017	59 958	3.18	0.478	60 180	780 500	16.1

As can be seen from the table above, there is a sharp decrease in the emissions in 2008. This is due to the global economic downturn in 2008. GHG emissions from 1.A.2 category is 60.2 Mt CO<sub>2</sub> eq. in 2017 which is 16.1% of total fuel combustion and 12.0% of total national emissions (excluding LULUCF), whereas GHG emissions from 1.A.2 category was 37.2 Mt CO<sub>2</sub> eq. which is 27.5% of total fuel

combustion and 15.4% of total national emissions (excluding LULUCF) in 1990. GHG emissions from 1.A.2 category have been increased by 0.11 MtCO<sub>2</sub> eq. (0.2%) from 2016 to 2017.

**Table 3.28 GHG emissions from manufacturing industry and construction, 1990-2017**  
(kt CO<sub>2</sub> 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	37 162	6 686	1 088	4 893	NO,IE	2 909	8 262	13 324
1991	40 335	6 549	1 016	4 458	NO,IE	2 910	9 399	16 001
1992	39 324	7 066	1 069	4 926	NO,IE	2 340	8 198	15 726
1993	39 986	6 406	980	4 811	NO,IE	2 139	8 164	17 486
1994	35 876	6 236	1 307	4 244	NO,IE	1 573	9 512	13 005
1995	39 995	5 591	1 756	4 962	NO,IE	1 685	8 794	17 207
1996	50 586	6 333	1 359	4 881	NO,IE	2 235	10 352	25 426
1997	56 029	6 348	1 248	4 945	NO,IE	2 188	9 502	31 797
1998	55 470	6 152	1 167	4 086	NO,IE	2 641	8 395	33 030
1999	47 365	5 576	1 700	3 592	NO,IE	2 025	10 763	23 710
2000	57 936	6 566	1 952	3 762	NO,IE	2 143	9 249	34 263
2001	45 656	6 732	1 989	5 074	NO,IE	3 979	8 846	19 035
2002	57 112	6 461	2 142	4 561	NO,IE	3 910	8 912	31 127
2003	66 682	6 185	1 938	4 393	NO,IE	2 698	10 155	41 312
2004	63 857	5 057	2 188	6 857	NO,IE	2 341	13 219	34 194
2005	63 004	5 482	2 225	5 346	NO,IE	2 119	14 882	32 949
2006	70 084	4 524	2 489	4 491	NO,IE	2 011	14 901	41 670
2007	71 874	4 640	2 400	2 058	NO,IE	1 384	13 495	47 896
2008	47 354	4 223	239	945	NO,IE	1 371	18 594	21 983
2009	46 226	2 042	988	2 452	NO,IE	459	16 514	23 770
2010	52 332	3 657	1 153	2 900	NO,IE	880	21 359	22 383
2011	52 585	3 990	755	3 139	776	3 378	25 345	15 200
2012	61 052	4 380	1 173	4 646	743	3 529	27 939	18 643
2013	52 978	4 638	760	3 942	766	3 603	26 374	12 894
2014	54 438	4 992	989	3 705	888	3 322	28 257	12 285
2015	59 585	5 288	1 199	6 689	963	4 359	29 955	11 133
2016	60 071	4 190	1 407	6 071	1 076	4 962	31 633	10 733
2017	60 180	4 327	1 136	5 317	942	4 921	32 578	10 959

Non-metallic minerals and chemicals and other industries are the main contributors for GHG emissions in 1.A.2 category. The share of non-metallic minerals is 54.1%.

**Table 3.29 Contribution of subsectors of manufacturing industries and construction, 2016-2017**

	Emissions (kt CO <sub>2</sub> eq.)		Changes from 2016 to 2017		Share in manufacturing industry (%)	
	2016	2017	(kt CO <sub>2</sub> eq.)	(%)	2016	2017
<b>1.A.2 Total</b>	60 071	60180	110	0.2	100.0	100.0
Iron and steel	4 190	4 327	137	3.3	7.0	7.2
Non-ferrous metals	1 407	1 136	- 271	-19.2	2.3	1.9
Chemicals	6 071	5 317	- 753	-12.4	10.1	8.8
Pulp, paper and print	1 076	942	- 133	-12.4	1.8	1.6
Food processing, beverages and tobacco	4 962	4 921	- 41	-0.8	8.3	8.2
Non-metallic minerals	31 633	32 578	945	3.0	52.7	54.1
Other industries	10 733	10959	226	2.1	17.9	18.2

GHG emissions from 1.A.2 category have been increased by 0.2% between 2016 and 2017.

Manufacturing industry and construction category is a key category in terms of emission level and emission trend of CO<sub>2</sub> emissions from liquid, solid and gaseous fuels in 2017. It is also a key category in terms of emission level of CO<sub>2</sub> from other fossil fuels.

#### Methodological Issues:

GHG emissions from 1.A.2 sector are calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data are taken from the national energy balance tables in both kt and ktOE units.

Country specific CO<sub>2</sub> EFs are used when available, otherwise default CO<sub>2</sub> EFs are used. All CO<sub>2</sub> EFs are given in table 3.X under 3.2 Fuel Combustion Sector. All CH<sub>4</sub> and N<sub>2</sub>O EFs are default. The default CH<sub>4</sub> and N<sub>2</sub>O EFs for 1A2 sector are tabulated below.

**Table 3.30 Default CH<sub>4</sub> and N<sub>2</sub>O EFs for 1A2 sector**

Sub Sectors	Emission Factors		Source
	CH <sub>4</sub> (kg/TJ)	N <sub>2</sub> O(kg/TJ)	
1A2 sector			
Coal products	10	1.5	Table 2.3
LPG	1	0.1	Table 2.3
Other Petroleum products	3	0.6	Table 2.3
Derived gases	1	0.1	Table 2.3
Wood	30	4	Table 2.3
Natural gas	1	0.1	Table 2.3

Data on waste incineration for energy recovery have been compiled by TurkStat via survey until 2015 inventory year, after 2015 the waste incineration data were supplied by General Directorate of Energy Affairs. 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<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emission estimation.

#### **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 Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO<sub>2</sub> and 100% (mid value in the range) for CH<sub>4</sub> and N<sub>2</sub>O. 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. Country specific carbon content of fuels is checked with IPCC default values to ensure that they are in range. Reasonability of IEFs are compared with the previous annual submission and with the 2006 IPCC Guidelines.

The table shows the change in the CO<sub>2</sub> IEFs in the time series for liquid and solid fuels.



**Table 3.31 CO<sub>2</sub> implied emission factors for 1A2 category**

<b>Year</b>	<b>Liquid</b>	<b>Solid</b>	<b>Gaseous</b>
1990	77.8	117.7	55.5
1991	77.7	117.9	55.5
1992	78.5	119.7	55.5
1993	79.4	118.8	55.5
1994	80.1	119.0	55.5
1995	79.4	117.9	55.5
1996	81.1	114.0	55.5
1997	81.7	113.6	55.5
1998	80.3	112.0	55.5
1999	81.3	107.1	55.5
2000	79.9	105.5	55.5
2001	79.7	112.7	55.5
2002	80.7	107.4	55.5
2003	80.4	109.0	55.5
2004	80.8	100.3	55.5
2005	81.8	103.5	55.5
2006	82.1	97.8	55.5
2007	84.6	97.7	55.5
2008	86.4	107.0	55.5
2009	87.5	106.6	55.5
2010	85.0	106.4	55.6
2011	84.7	104.2	56.6
2012	87.0	106.0	55.5
2013	88.9	105.6	55.5
2014	91.2	103.9	55.5
2015	92.0	99.0	55.7
2016	93.1	92.5	55.7
2017	93.2	97.7	55.6

It can be seen on the table that CO<sub>2</sub> IEF for liquid fuels is increasing in the time series. This is because the share of petroleum coke usage has been increased since 1990 while the share of other petroleum products has been decreased since 1990.

On the other hand, it can be seen that CO<sub>2</sub> IEF for solid fuels is decreasing in the time series. This is because the share of lignite has been decreased since 1990 while the share of coking coal and coke has been increased since 1990.

#### **Recalculation:**

Major revision was done on the national energy balance tables in 04.05.2017 and this revision is reflected in this inventory. In this revision sectoral allocation of the fuels were elaborated, new fuels were added to the table and historical fuel consumption data were revised.

In the previous submissions, the process gas combustion emissions of integrated iron and steel plants under 1A2a category were not covered, in this submission it is calculated and added into the 1A2a category. (See section 3.2.5.1 for details)

Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated. As a result, there are recalculations in all the sub sectors of 1A2 category. The minor revisions of sub categories in the time series are due to the revision of the natural gas CO<sub>2</sub> emission factor. The table below shows the effect of recalculation of 1A2 Manufacturing Industries and Construction sector in the 2019 submission with respect to 2018 submission.

**Table 3.32 Comparison on manufacturing industries and construction (1A2) emissions recalculation in 2018 and 2019 inventory submissions**

<b>Year</b>	<b>Emissions from 1A2 in 2018 submission (kt CO<sub>2</sub>)</b>	<b>Emissions from 1A2 in 2019 submission (kt CO<sub>2</sub>)</b>	<b>Difference in emissions (kt CO<sub>2</sub>)</b>
1990	32 381	37 162	4 781
1991	35 854	40 335	4 480
1992	34 562	39 324	4 762
1993	35 875	39 986	4 111
1994	31 766	35 876	4 110
1995	36 431	39 995	3 564
1996	46 483	50 586	4 103
1997	51 772	56 029	4 256
1998	51 340	55 470	4 130
1999	43 522	47 365	3 844
2000	53 669	57 936	4 267
2001	41 110	45 656	4 546
2002	52 716	57 112	4 396
2003	62 509	66 682	4 173
2004	60 576	63 857	3 281
2005	59 019	63 004	3 985
2006	67 756	70 084	2 329
2007	69 565	71 874	2 309
2008	45 977	47 354	1 377
2009	45 718	46 226	507
2010	54 435	52 332	- 2 103
2011	56 596	52 585	- 4 011
2012	57 702	61 052	3 350
2013	51 777	52 978	1 201
2014	52 295	54 438	2 143
2015	57 309	59 585	2 276
2016	59 691	60 071	380

#### Planned Improvement:

Prior to 2011 several manufacturing sectors that have their own categories (Pulp, Paper & Print; Non-metallic minerals; Food processing, beverages & tobacco) were not fully separated out in the national

energy balance and therefore some or all of the emissions from these categories were reported under section 1A2g. This is because in the calculation of 1A2 subcategories the national energy balance tables are used and national energy balance tables are not created as time series. All relevant institutions are working together in order to overcome this inconsistency problem.

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

#### Source Category Description:

The source categories cover emissions from the iron and steel industries including primary and secondary steel producers and rolling mill plants.

Currently there are, 3 integrated facilities producing primary steel and 27 EAF mills producing secondary steel in Turkey. The share of GHG emissions as CO<sub>2</sub> eq. from 1A2a in total 1A2 was 7.2% in 2017 while it was 18.0% in 1990.

**Table 3.33 Fuel combustion emissions from iron and steel industry, 1990-2017**

Year	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	CO <sub>2</sub> eq. (kt)	Fuel consumption (TJ)	Share in 1.A.2 (%)
1990	6 678	0.10	0.017	6 686	51 756	18.0
1991	6 541	0.10	0.018	6 549	52 848	16.2
1992	7 057	0.11	0.019	7 066	57 620	18.0
1993	6 397	0.11	0.020	6 406	53 175	16.0
1994	6 228	0.10	0.018	6 236	50 715	17.4
1995	5 584	0.10	0.017	5 591	46 104	14.0
1996	6 325	0.10	0.018	6 333	51 497	12.5
1997	6 341	0.10	0.018	6 348	50 825	11.3
1998	6 145	0.10	0.017	6 152	48 952	11.1
1999	5 569	0.09	0.015	5 576	43 873	11.8
2000	6 559	0.09	0.016	6 566	49 855	11.3
2001	6 726	0.09	0.015	6 732	50 208	14.7
2002	6 455	0.09	0.014	6 461	47 941	11.3
2003	6 179	0.08	0.014	6 185	46 012	9.3
2004	5 052	0.07	0.011	5 057	37 403	7.9
2005	5 478	0.06	0.009	5 482	37 766	8.7
2006	4 521	0.04	0.006	4 524	30 178	6.5
2007	4 637	0.04	0.006	4 640	30 080	6.5
2008	4 220	0.05	0.006	4 223	45 251	8.9
2009	2 040	0.02	0.002	2 042	19 606	4.4
2010	3 652	0.08	0.012	3 657	47 148	7.0
2011	3 987	0.06	0.006	3 990	56 485	7.6
2012	4 377	0.05	0.005	4 380	50 211	7.2
2013	4 635	0.06	0.006	4 638	59 556	8.8
2014	4 989	0.06	0.006	4 992	61 286	9.2
2015	5 282	0.10	0.011	5 288	71 979	8.9
2016	4 186	0.07	0.008	4 190	63 997	7.0
2017	4 322	0.08	0.009	4 327	71 184	7.2

Total emissions from iron and steel subcategory was increased by 137 kt CO<sub>2</sub> eq. from 2016 to 2017(3.3% of increase) due to increase of fuel consumption.

### 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<sub>2</sub> EF are used when available, otherwise default CO<sub>2</sub> EF are used. All CH<sub>4</sub> and N<sub>2</sub>O EFs are default.

Integrated iron and steel plants are energy intensive and complex plants. 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;

- Emissions from 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),
- Emissions from the heating of coke ovens (for coke production) is considered under Energy-1.A.1.c (manufacture of solid fuels) category,
- Emissions from the heating of rolling mills and other miscellaneous combustion emissions are 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 determined by sector experts from TurkStat. Uncertainty values were determined as 25% for CO<sub>2</sub>. EFs uncertainty for CH<sub>4</sub> and N<sub>2</sub>O was taken from 2006 IPCC Guidelines Vol.2 page 2.38 Table 2.12 and considered as 100% (mid value in the range).

**Source-Specific QA/QC and Verification:**

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

**Recalculations:**

Due to the revision on the national energy balance tables, the 1A2a sector is recalculated. Moreover, the process gases of integrated iron and steel plants (BFG, Coke oven gas and BOF gas) are used for heating the rolling mills and for other miscellaneous combustion and their emissions should be reported under 1A2a category. However, in the previous submissions these fuels were excluded and not estimated. Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated. In this submission they are estimated and reported. The table below shows the effect of the recalculations with respect to 2018 submission.

**Table 3.34 Comparison on iron and steel industry (1A2a) emissions recalculation in 2018 and 2019 inventory submissions**

<b>Year</b>	<b>Emissions from 1A2a in 2018 submission (kt CO<sub>2</sub>)</b>	<b>Emissions from 1A2a in 2019 submission (kt CO<sub>2</sub>)</b>	<b>Difference in emissions (kt CO<sub>2</sub>)</b>
1990	1 942	6 686	4 744
1991	2 118	6 549	4 431
1992	2 327	7 066	4 739
1993	2 332	6 406	4 074
1994	2 133	6 236	4 102
1995	2 032	5 591	3 559
1996	2 181	6 333	4 152
1997	2 084	6 348	4 265
1998	1 973	6 152	4 179
1999	1 739	5 576	3 837
2000	1 833	6 566	4 733
2001	1 730	6 732	5 003
2002	1 604	6 461	4 857
2003	1 705	6 185	4 481
2004	1 428	5 057	3 629
2005	1 134	5 482	4 348
2006	834	4 524	3 690
2007	696	4 640	3 944
2008	2 086	4 223	2 137
2009	1 870	2 042	172
2010	2 921	3 657	736
2011	3 238	3 990	752
2012	2 522	4 380	1 858
2013	3 161	4 638	1 477
2014	3 187	4 992	1 805
2015	3 195	5 288	2 093
2016	2 858	4 190	1 332

**Planned Improvement:**

There is no planned improvement specific to this category.

**3.2.5.2. Non-ferrous metal (Category 1.A.2.b)****Source Category Description:**

The share of GHG emissions as CO<sub>2</sub> eq. from 1.A.2.b in total manufacturing industry fuel combustion was 1.9% in 2017 while it was 2.9% in 1990.

**Table 3.35 Fuel combustion emissions from non-ferrous metals, 1990-2017**

Year	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	CO <sub>2</sub> eq. (kt)	Fuel consumption (TJ)	Share in 1.A.2 category (%)
1990	1 084	0.05	0.009	1 088	13 187	2.9
1991	1 013	0.05	0.009	1 016	12 422	2.5
1992	1 065	0.05	0.010	1 069	12 967	2.7
1993	976	0.05	0.009	980	11 829	2.5
1994	1 302	0.06	0.012	1 307	15 676	3.6
1995	1 750	0.08	0.014	1 756	22 300	4.4
1996	1 355	0.06	0.010	1 359	18 282	2.7
1997	1 244	0.06	0.011	1 248	15 854	2.2
1998	1 162	0.06	0.011	1 167	14 014	2.1
1999	1 695	0.07	0.012	1 700	23 842	3.6
2000	1 945	0.10	0.016	1 952	25 668	3.4
2001	1 982	0.10	0.016	1 989	26 110	4.4
2002	2 134	0.11	0.017	2 142	28 721	3.7
2003	1 932	0.08	0.013	1 938	27 655	2.9
2004	2 182	0.09	0.014	2 188	32 282	3.4
2005	2 219	0.08	0.013	2 225	33 266	3.5
2006	2 482	0.09	0.014	2 489	38 255	3.6
2007	2 393	0.10	0.014	2 400	37 010	3.3
2008	239	0.00	0.000	239	4 256	0.5
2009	987	0.02	0.002	988	17 086	2.1
2010	1 151	0.02	0.003	1 153	20 089	2.2
2011	754	0.02	0.002	755	13 016	1.4
2012	1 171	0.03	0.003	1 173	20 393	1.9
2013	759	0.02	0.002	760	13 379	1.4
2014	987	0.02	0.002	989	17 371	1.8
2015	1 197	0.03	0.004	1 199	20 103	2.0
2016	1 404	0.05	0.006	1 407	22 925	2.3
2017	1 134	0.04	0.005	1 136	18 034	1.9

The decrease in total emissions of 1.A.2.b category from 2016 to 2017 is 271 kt CO<sub>2</sub> eq. (19.2% of decrease).

**Methodological Issues:**

GHG emissions from 1.A.2.b sector were calculated by using 2006 IPCC Tier 1 and Tier 2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

Country specific CO<sub>2</sub> EFs are used for emission estimation. CH<sub>4</sub> and N<sub>2</sub>O 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 Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO<sub>2</sub> and 100% (mid value in the range) for CH<sub>4</sub> and N<sub>2</sub>O.

**Source-Specific QA/QC and Verification:**

Quality control for 1.A.2.b 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<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O IEFs for all fuels are in the range of 2006 IPCC Guidelines but are changing based on fuel mix used in the sector

**Recalculation:**

Due to the revision on the national energy balance tables, the 1A2b sector is recalculated. Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated. The table below shows the effect of the recalculation with respect to 2018 submission.

**Table 3.36 Comparison on non-ferrous metals industry (1A2b) emissions recalculation in 2018 and 2019 inventory submissions**

<b>Year</b>	<b>Emissions from 1A2b in 2018 submission (kt CO<sub>2</sub>)</b>	<b>Emissions from 1A2b in 2019 submission (kt CO<sub>2</sub>)</b>	<b>Difference in emissions (kt CO<sub>2</sub>)</b>
1990	1 087	1 088	1
1991	1 019	1 016	- 2
1992	1 070	1 069	- 1
1993	981	980	- 2
1994	1 309	1 307	- 2
1995	1 758	1 756	- 2
1996	1 360	1 359	0
1997	1 249	1 248	0
1998	1 165	1 167	1
1999	1 700	1 700	0
2000	2 018	1 952	- 66
2001	2 033	1 989	- 45
2002	2 197	2 142	- 55
2003	1 964	1 938	- 25
2004	2 234	2 188	- 46
2005	2 261	2 225	- 35
2006	2 591	2 489	- 102
2007	9 111	2 400	- 6 711
2008	241	239	- 2
2009	1 063	988	- 75
2010	1 327	1 153	- 174
2011	366	755	389
2012	1 431	1 173	- 258
2013	889	760	- 129
2014	998	989	- 9
2015	1 189	1 199	10
2016	1 423	1 407	- 16

**Planned Improvement:**

There is no planned improvement specific to this category.



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

#### Source Category Description:

The source category includes manufacture of chemicals, fertilizer, basic pharmaceutical products and rubber and plastic manufacturing. The share of GHG emissions as CO<sub>2</sub> eq. from 1.A.2.c in total manufacturing industry was 8.8% in 2017 while it was 13.2% in 1990.

**Table 3.37 Fuel combustion emissions from chemicals, 1990-2017**

Year	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	CO <sub>2</sub> eq. (kt)	Fuel consumption (TJ)	Share in 1.A.2 category (%)
1990	4 875	0.24	0.040	4 893	62 789	13.2
1991	4 444	0.18	0.031	4 458	61 951	11.1
1992	4 912	0.18	0.031	4 926	70 629	12.5
1993	4 799	0.17	0.028	4 811	70 578	12.0
1994	4 233	0.15	0.026	4 244	61 162	11.8
1995	4 948	0.17	0.030	4 962	71 612	12.4
1996	4 868	0.17	0.029	4 881	70 777	9.6
1997	4 933	0.17	0.028	4 945	73 001	8.8
1998	4 073	0.16	0.028	4 086	56 268	7.4
1999	3 581	0.14	0.025	3 592	49 495	7.6
2000	3 751	0.15	0.027	3 762	51 629	6.5
2001	5 059	0.19	0.036	5 074	69 258	11.1
2002	4 549	0.16	0.028	4 561	65 875	8.0
2003	4 382	0.14	0.025	4 393	64 521	6.6
2004	6 838	0.24	0.044	6 857	97 606	10.7
2005	5 334	0.16	0.026	5 346	82 163	8.5
2006	4 481	0.13	0.023	4 491	68 710	6.4
2007	2 056	0.04	0.005	2 058	36 059	2.9
2008	944	0.02	0.003	945	16 381	2.0
2009	2 445	0.10	0.014	2 452	37 259	5.3
2010	2 889	0.14	0.023	2 900	40 314	5.5
2011	3 132	0.12	0.016	3 139	49 224	6.0
2012	4 635	0.16	0.023	4 646	74 005	7.6
2013	3 929	0.19	0.027	3 942	57 487	7.4
2014	3 692	0.19	0.026	3 705	54 713	6.8
2015	6 672	0.26	0.034	6 689	106 985	11.2
2016	6 054	0.26	0.035	6 071	97 036	10.1
2017	5 306	0.18	0.023	5 317	87 051	8.8

The decrease in total emissions of 1.A.2.c category from 2016 to 2017 is 753 kt CO<sub>2</sub> eq. (12.4% of decrease). The increase in GHG emission of this category is related to the increase in production of main contributing sectors.

### Methodological Issues:

GHG emissions from 1.A.2.c category were calculated 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<sub>2</sub> EFs are used for emission estimation. GHG emissions from waste incineration were estimated by using 2006 IPCC default EFs. CH<sub>4</sub> and N<sub>2</sub>O 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 Guidelines 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 Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO<sub>2</sub> and 100% was taken (mid value in the range) for CH<sub>4</sub> and N<sub>2</sub>O.

### 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.

### Recalculation:

Due to the revision on the national energy balance tables, the 1A2c sector is recalculated.

Moreover, the manufacture of rubber and plastic products sector was separated in the national energy balance tables in 2015 and since then this sector emission were reported under others (1A2g) category.

However, in this submission this sector is covered under 1A2c and because of that 2015 and 2016 emissions were recalculated. Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated.

The table below shows the effect of the recalculation with respect to 2018 submission.

**Table 3.38 Comparison on chemical industry (1A2c) emissions recalculation in 2018 and 2019 inventory submissions**

Year	Emissions from 1A2c in 2018 submission (kt CO <sub>2</sub> )	Emissions from 1A2c in 2019 submission (kt CO <sub>2</sub> )	Difference in emissions (kt CO <sub>2</sub> )
1990	4 893	4 893	0
1991	4 457	4 458	1
1992	4 925	4 926	1
1993	4 814	4 811	- 3
1994	4 246	4 244	- 1
1995	4 961	4 962	1
1996	4 880	4 881	1
1997	4 944	4 945	1
1998	4 086	4 086	0
1999	3 592	3 592	0
2000	3 857	3 762	- 94
2001	5 146	5 074	- 72
2002	4 689	4 561	- 128
2003	4 447	4 393	- 54
2004	6 939	6 857	- 81
2005	5 620	5 346	- 274
2006	4 842	4 491	- 352
2007	2 226	2 058	- 168
2008	933	945	12
2009	1 451	2 452	1 001
2010	3 307	2 900	- 408
2011	3 084	3 139	55
2012	4 364	4 646	282
2013	3 820	3 942	122
2014	3 254	3 705	450
2015	6 076	6 689	613
2016	5 710	6 071	360

#### Planned Improvement:

There is no planned improvement specific to 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<sub>2</sub> eq. from 1.A.2.d in total manufacturing industry fuel combustion was 1.6% in 2017 while it was 1.5% in 2011.

**Table 3.39 Fuel combustion emissions from pulp, paper and print, 1990-2017**

Year	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	CO <sub>2</sub> eq. (kt)	Fuel consumption (TJ)	Share in 1.A.2 category (%)
1990-2010	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
2011	774	0.04	0.005	776	11 127	1.5
2012	740	0.04	0.006	743	9 972	1.2
2013	764	0.04	0.005	766	11 118	1.4
2014	885	0.05	0.007	888	12 315	1.6
2015	960	0.06	0.008	963	12 946	1.6
2016	1 072	0.06	0.008	1 076	15 156	1.8
2017	939	0.05	0.007	942	13 014	1.6

The decrease in total emissions of 1.A.2.d category from 2016 to 2017 is 133 kt CO<sub>2</sub> eq. (12.4% of decrease).

#### Methodological Issues:

GHG emissions from 1.A.2.d sector were calculated 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<sub>2</sub> EFs are used for emission estimation. CH<sub>4</sub> and N<sub>2</sub>O emissions from liquid, solid and gaseous fuels have been estimated using 2006 IPCC default EFs. GHG emissions from biomass were estimated 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 Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO<sub>2</sub> and 100% (mid value in the range) for CH<sub>4</sub> and N<sub>2</sub>O.

#### Source-Specific QA/QC and Verification:

Quality control for 1.A.2.d category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series, then AD and emission calculation are re-examined.

#### Recalculation:

Due to the revision on the national energy balance tables, the 1A2d sector is recalculated. Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated. The table below shows the effect of the recalculation with respect to 2018 submission.

**Table 3.40 Comparison on pulp, paper and print industry (1A2d) emissions recalculation in 2018 and 2019 inventory submissions**

Year	Emissions from 1A2d in 2018 submission (kt CO <sub>2</sub> )	Emissions from 1A2d in 2019 submission (kt CO <sub>2</sub> )	Difference in emissions (kt CO <sub>2</sub> )
1990-2010	NO,IE	NO,IE	-
2011	763	776	13
2012	706	743	37
2013	730	766	36
2014	887	888	1
2015	959	963	5
2016	1 087	1 076	- 11

#### Planned Improvement:

There is no planned improvement specific to this category.

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

#### Source Category Description:

The source category includes food processing, manufacturing of beverages, tobacco industry and sugar industry. 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<sub>2</sub> eq. from 1.A.2.e in total 1.A.2 GHG emissions was 8.2% in 2017 while it was 7.8% in 1990.

**Table 3.41 Fuel combustion emissions from 1A2e category, 1990-2017**

Year	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	CO <sub>2</sub> eq. (kt)	Fuel consumption (TJ)	Share in 1.A.2 category (%)
1990	2 892	0.24	0.037	2 909	27 656	7.8
1991	2 894	0.24	0.036	2 910	27 243	7.2
1992	2 327	0.19	0.029	2 340	22 194	5.9
1993	2 127	0.17	0.026	2 139	20 484	5.3
1994	1 564	0.12	0.019	1 573	15 217	4.4
1995	1 676	0.13	0.020	1 685	16 894	4.2
1996	2 223	0.17	0.025	2 235	23 019	4.4
1997	2 176	0.16	0.025	2 188	22 416	3.9
1998	2 626	0.21	0.032	2 641	25 636	4.8
1999	2 014	0.16	0.025	2 025	20 370	4.3
2000	2 130	0.19	0.028	2 143	20 673	3.7
2001	3 960	0.26	0.042	3 979	44 605	8.7
2002	3 892	0.24	0.040	3 910	44 296	6.8
2003	2 685	0.19	0.030	2 698	29 055	4.0
2004	2 330	0.16	0.025	2 341	26 249	3.7
2005	2 108	0.16	0.024	2 119	22 373	3.4
2006	2 001	0.14	0.022	2 011	22 391	2.9
2007	1 377	0.10	0.015	1 384	14 436	1.9
2008	1 365	0.07	0.012	1 371	17 717	2.9
2009	456	0.04	0.006	459	4 622	1.0
2010	877	0.05	0.007	880	12 244	1.7
2011	3 364	0.21	0.030	3 378	43 421	6.4
2012	3 515	0.21	0.030	3 529	46 695	5.8
2013	3 591	0.19	0.027	3 603	50 942	6.8
2014	3 310	0.19	0.027	3 322	46 330	6.1
2015	4 342	0.26	0.037	4 359	58 490	7.3
2016	4 943	0.28	0.040	4 962	69 245	8.3
2017	4 902	0.28	0.040	4 921	67 426	8.2

Total GHG emission in 1.A.2.e category decreased 41kt CO<sub>2</sub> eq. (0.8% of decrease) from 2016 to 2017.

### 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<sub>2</sub> EFs are used for emission estimation. CH<sub>4</sub> and N<sub>2</sub>O 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 Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO<sub>2</sub> and 100% was taken (mid value in the range) for CH<sub>4</sub> and N<sub>2</sub>O.

### Source-Specific QA/QC and Verification:

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

### Recalculation:

Due to the revision on the national energy balance tables, the 1A2d sector is recalculated. Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated. The table below shows the effect of the recalculation with respect to 2018 submission.

**Table 3.42 Comparison on food processing, beverages and tobacco industry (1A2e) emissions recalculation in 2018 and 2019 inventory submissions**

Year	Emissions from 1A2e in 2018 submission (kt CO <sub>2</sub> )	Emissions from 1A2e in 2019 submission (kt CO <sub>2</sub> )	Difference in emissions (kt CO <sub>2</sub> )
1990	2 911	2 909	- 1
1991	2 873	2 910	38
1992	2 341	2 340	- 1
1993	2 154	2 139	- 15
1994	1 573	1 573	- 1
1995	1 686	1 685	- 1
1996	2 213	2 235	21
1997	2 189	2 188	- 1
1998	2 648	2 641	- 7
1999	2 561	2 025	- 536
2000	2 143	2 143	0
2001	3 982	3 979	- 3
2002	3 909	3 910	1
2003	2 705	2 698	- 7
2004	2 352	2 341	- 11
2005	2 128	2 119	- 8
2006	2 038	2 011	- 27
2007	1 416	1 384	- 32
2008	1 357	1 371	14
2009	435	459	24
2010	402	880	479
2011	1 146	3 378	2 232
2012	2 214	3 529	1 315
2013	2 211	3 603	1 392
2014	2 911	3 322	412
2015	4 341	4 359	19
2016	5 021	4 962	- 60

#### Planned Improvement:

There is no planned improvement specific to this category.

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

##### Source Category Description:

Glass, cement and ceramic production is covered under this category. For 1990-2010 period only cement industry was 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 license 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 are covered under this category.

1.A.2.f category is energy intensive sector. The share of GHG emissions as CO<sub>2</sub> eq. from 1.A.2.f in total manufacturing industry GHG emission was 54.1% in 2017 while it was 22.2% in 1990.

**Table 3.43 Fuel combustion emissions from non-metallic minerals, 1990-2017**

Year	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	CO <sub>2</sub> eq. (kt)	Fuel consumption (TJ)	Share in 1.A.2 category (%)
1990	8 216	0.64	0.100	8 262	85 781	22.2
1991	9 348	0.72	0.112	9 399	97 120	23.3
1992	8 155	0.60	0.093	8 198	84 425	20.8
1993	8 127	0.52	0.082	8 164	84 789	20.4
1994	9 463	0.67	0.106	9 512	95 240	26.5
1995	8 750	0.61	0.097	8 794	86 732	22.0
1996	10 301	0.69	0.110	10 352	102 402	20.5
1997	9 452	0.70	0.109	9 502	93 114	17.0
1998	8 354	0.57	0.091	8 395	82 232	15.1
1999	10 708	0.76	0.121	10 763	110 905	22.7
2000	9 204	0.63	0.100	9 249	94 531	16.0
2001	8 804	0.58	0.093	8 846	88 560	19.4
2002	8 870	0.57	0.093	8 912	90 270	15.6
2003	10 105	0.69	0.110	10 155	100 807	15.2
2004	13 152	0.92	0.147	13 219	136 689	20.7
2005	14 810	0.99	0.158	14 882	152 922	23.6
2006	14 824	1.06	0.169	14 901	156 317	21.3
2007	13 419	1.07	0.167	13 495	141 561	18.8
2008	18 497	1.34	0.213	18 594	192 996	39.3
2009	16 430	1.17	0.185	16 514	165 653	35.7
2010	21 240	1.66	0.258	21 359	209 775	40.8
2011	25 214	1.84	0.283	25 345	273 446	48.2
2012	27 797	2.00	0.309	27 939	298 718	45.8
2013	26 240	1.88	0.292	26 374	277 274	49.8
2014	28 122	1.89	0.295	28 257	309 282	51.9
2015	29 810	2.03	0.315	29 955	332 379	50.3
2016	31 482	2.09	0.330	31 633	360 842	52.7
2017	32 430	2.05	0.323	32 578	362 747	54.1

The increase in total GHG emission of 1.A.2.f category is 945kt CO<sub>2</sub> eq. (3.0% of increase) from 2016 to 2017.

### Methodological Issues:

GHG emissions from 1.A.2.f 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 survey until 2015 inventory year, after 2015 the waste incineration data were supplied by General Directorate of Renewable Energy. 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<sub>2</sub> EFs are used for emission estimation. GHG emissions from waste incineration and biomass were estimated by using 2006 IPCC default EFs. CH<sub>4</sub> and N<sub>2</sub>O 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 Guidelines 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 Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO<sub>2</sub> and 100% (mid value in the range) for CH<sub>4</sub> and N<sub>2</sub>O.

### Source-Specific QA/QC and Verification:

Quality control for 1.A.2.f 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<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O IEFs for all fuels are in the range of 2006 IPCC guidelines but are changing based on fuel mix used in the sector.

The emissions from this sector is compared with the production data of cement, glass and ceramics industry. The emissions and production data is found to be consisting with each in concerning the time series.

**Recalculation:**

Due to the revision on the national energy balance tables, the 1A2f sector is recalculated. Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated. The table below shows the effect of the recalculation with respect to 2018 submission.

**Table 3.44 Comparison on non metallic minerals industry (1A2f) emissions recalculation in 2018 and 2019 inventory submissions**

<b>Year</b>	<b>Emissions from 1A2f in 2018 submission (kt CO<sub>2</sub>)</b>	<b>Emissions from 1A2f in 2019 submission (kt CO<sub>2</sub>)</b>	<b>Difference in emissions (kt CO<sub>2</sub>)</b>
1990	8 222	8 262	39
1991	9 379	9 399	20
1992	8 173	8 198	25
1993	8 138	8 164	26
1994	9 516	9 512	- 4
1995	8 797	8 794	- 4
1996	10 400	10 352	- 48
1997	9 503	9 502	- 1
1998	8 440	8 395	- 44
1999	10 227	10 763	536
2000	9 262	9 249	- 13
2001	8 853	8 846	- 7
2002	8 917	8 912	- 5
2003	10 157	10 155	- 3
2004	13 226	13 219	- 6
2005	14 888	14 882	- 6
2006	14 913	14 901	- 12
2007	13 737	13 495	- 242
2008	19 431	18 594	- 838
2009	16 682	16 514	- 168
2010	17 951	21 359	3 408
2011	23 850	25 345	1 494
2012	25 729	27 939	2 209
2013	23 473	26 374	2 901
2014	26 218	28 257	2 039
2015	29 916	29 955	38
2016	32 332	31 633	- 699

**Planned Improvement:**

There is no planned improvement specific to 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 2016 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<sub>2</sub> eq. from 1.A.2.g in total manufacturing industry fuel combustion was 18.2% in 2017 while it was 35.9% in 1990.

**Table 3.45 Fuel combustion emissions from other industries, 1990-2017**

Year	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	CO <sub>2</sub> eq. (kt)	Fuel consumption (TJ)	Share in 1.A.2 category (%)
1990	13 258	0.91	0.145	13 324	145 738	35.9
1991	15 922	1.10	0.175	16 001	170 223	39.7
1992	15 652	1.01	0.163	15 726	174 768	40.0
1993	17 407	1.08	0.176	17 486	200 769	43.7
1994	12 951	0.72	0.119	13 005	156 954	36.2
1995	17 135	0.97	0.158	17 207	208 427	43.0
1996	25 304	1.70	0.268	25 426	287 576	50.3
1997	31 649	2.05	0.324	31 797	358 538	56.8
1998	32 862	2.36	0.365	33 030	370 563	59.5
1999	23 591	1.65	0.259	23 710	282 500	50.1
2000	34 068	2.75	0.422	34 263	387 385	59.1
2001	18 940	1.37	0.206	19 035	225 814	41.7
2002	30 957	2.41	0.367	31 127	356 265	54.5
2003	41 104	2.95	0.450	41 312	480 830	62.0
2004	34 004	2.73	0.410	34 194	420 665	53.5
2005	32 781	2.40	0.364	32 949	414 903	52.3
2006	41 441	3.29	0.493	41 670	530 874	59.5
2007	47 639	3.69	0.555	47 896	608 583	66.6
2008	21 905	1.14	0.166	21 983	302 283	46.4
2009	23 674	1.38	0.207	23 770	306 760	51.4
2010	22 310	1.05	0.158	22 383	309 794	42.8
2011	15 154	0.64	0.101	15 200	215 309	28.9
2012	18 587	0.79	0.123	18 643	260 761	30.5
2013	12 854	0.54	0.087	12 894	178 856	24.3
2014	12 248	0.53	0.080	12 285	178 853	22.6
2015	11 097	0.52	0.076	11 133	162 800	18.7
2016	10 699	0.50	0.072	10 733	156 710	17.9
2017	10 925	0.50	0.070	10 959	161 044	18.2

Total GHG emission in 1.A.2.g category decreased 226 kt CO<sub>2</sub> eq. (2.1% of increase) from 2016 to 2017.

### Methodological Issues:

GHG emissions from 1.A.2.g 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<sub>2</sub> EFs are used for emission estimation. CH<sub>4</sub> and N<sub>2</sub>O 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 Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO<sub>2</sub> and 100% (mid value in the range) for CH<sub>4</sub> and N<sub>2</sub>O.

### Source-Specific QA/QC and Verification:

Quality control for 1.A.2.g category was performed on the basis of QA/QC plan. CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O IEFs for all fuels are in the range of 2006 IPCC Guidelines.

### Recalculation:

Due to the revision on the national energy balance tables, the 1A2g sector is recalculated. Moreover, the manufacture of rubber and plastic products sector was separated in the national energy balance tables in 2015 and since then this sector emission were reported under others (1A2g) category. However, in this submission this sector is covered under 1A2c and because of that 2015 and 2016 emissions were recalculated. Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated. The table below shows the effect of the recalculation with respect to 2018 submission.

**Table 3.46 Comparison on other industry (1A2g) emissions recalculation in 2018 and 2019 inventory submissions**

<b>Year</b>	<b>Emissions from 1A2g in 2018 submission (kt CO<sub>2</sub>)</b>	<b>Emissions from 1A2g in 2019 submission (kt CO<sub>2</sub>)</b>	<b>Difference in emissions (kt CO<sub>2</sub>)</b>
1990	13 326	13 324	- 2
1991	16 008	16 001	- 7
1992	15 725	15 726	0
1993	17 455	17 486	31
1994	12 989	13 005	16
1995	17 196	17 207	10
1996	25 449	25 426	- 23
1997	31 804	31 797	- 7
1998	33 028	33 030	2
1999	23 704	23 710	6
2000	34 556	34 263	- 293
2001	19 367	19 035	- 331
2002	31 400	31 127	- 273
2003	41 532	41 312	- 220
2004	34 398	34 194	- 204
2005	32 989	32 949	- 39
2006	42 538	41 670	- 869
2007	42 378	47 896	5 519
2008	21 929	21 983	53
2009	24 218	23 770	- 448
2010	28 527	22 383	- 6 144
2011	24 148	15 200	- 8 948
2012	20 736	18 643	- 2 093
2013	17 492	12 894	- 4 598
2014	14 841	12 285	- 2 556
2015	11 633	11 133	- 501
2016	11 260	10 733	- 528

**Planned Improvement:**

There is no planned improvement specific to 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:

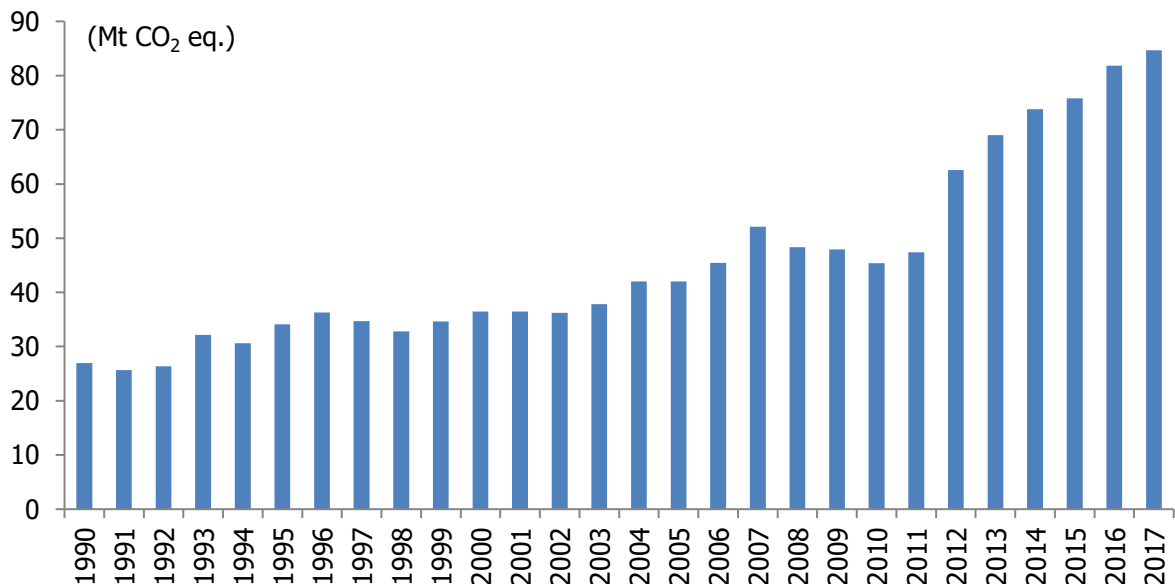
- Domestic Aviation (1.A.3.a)
- Road Transportation (1.A.3.b)
- Railways (1.A.3.c)
- Domestic water-borne Navigation (1.A.3.d)
- Pipeline (other transportation) (1.A.3.e.i)

Emissions from this category were 213.9% higher in 2017 than in 1990, and on average emissions increased by more than 7.6% annually.

In 2017, transport sector contributed to 84.7Mt CO<sub>2</sub> eq. emissions. GHG emissions (in CO<sub>2</sub> eq.) from transport sector as a share of total fuel combustion was 22.7% in 2017 while it was 20% 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<sub>2</sub> source contributing to 93% of transport emissions in 2017. Contribution of domestic aviation is 4.5%, domestic water-borne navigation is 1.1%, and railways are 0.5% in 2017. The share of pipeline transportation is 0.9%.

**Figure 3.17 GHG emissions for transportation sector, 1990-2017**



**Table 3.47 GHG emissions from transport sector, 1990-2017**

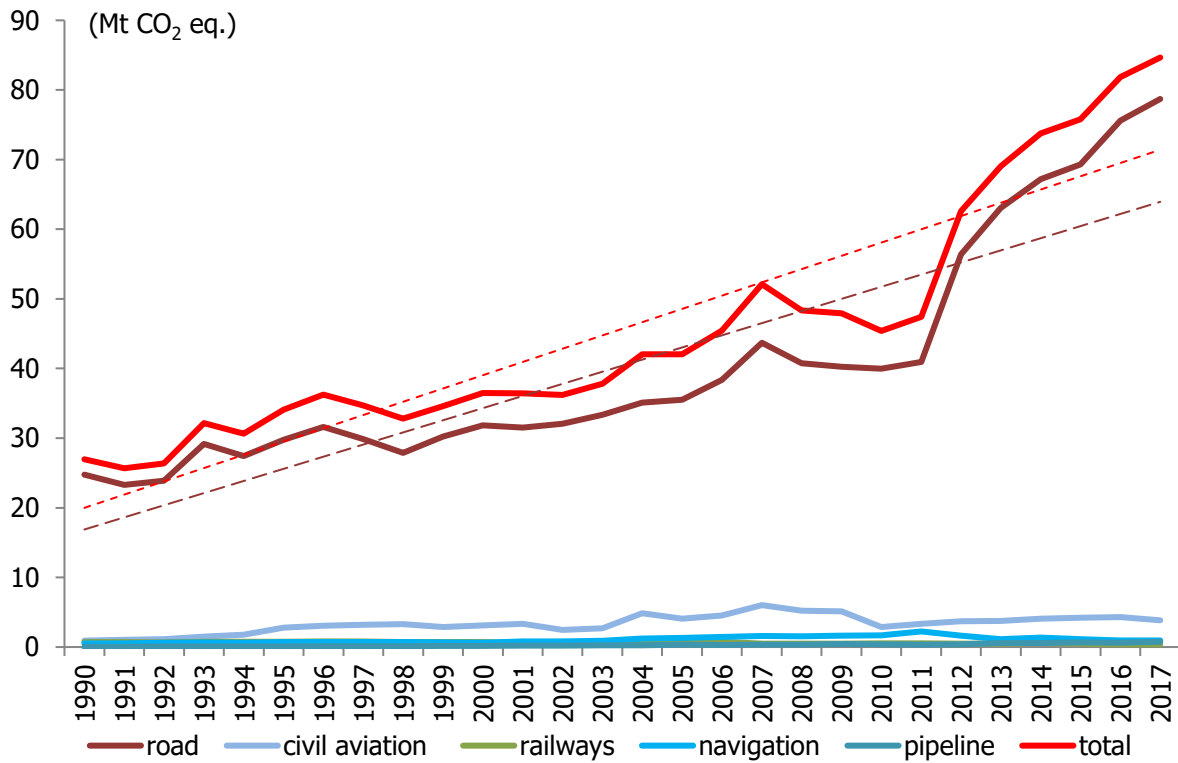
Year	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	CO <sub>2</sub> eq. (kt)	TJ
1990	26 251	4.0	2.1	26 969	364 617
1991	24 982	3.8	2.0	25 673	347 164
1992	25 640	4.2	2.1	26 366	356 995
1993	31 269	5.0	2.5	32 143	435 401
1994	29 789	4.9	2.4	30 640	415 493
1995	33 180	5.5	2.7	34 113	463 044
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
2016	80 208	15.4	4.2	81 841	1 129 546
2017	82 954	15.4	4.4	84 659	1 180 256



Table 3.48 GHG emissions by transport mode, 1990-2017

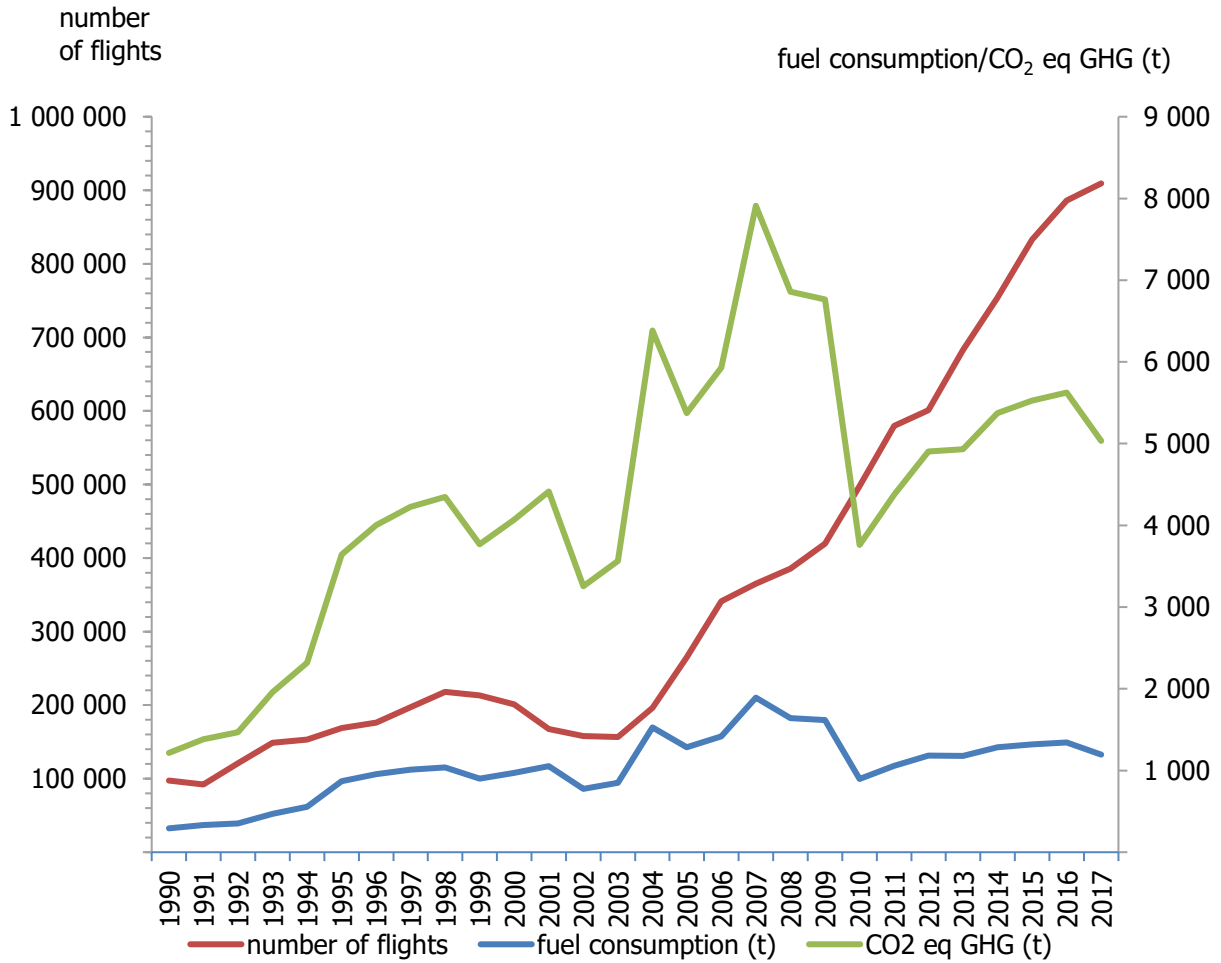
(kt CO<sub>2</sub> eq.)

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
2016	81 841	4 281	75 595	374	970	621
2017	84 659	3 838	78 706	413	944	758

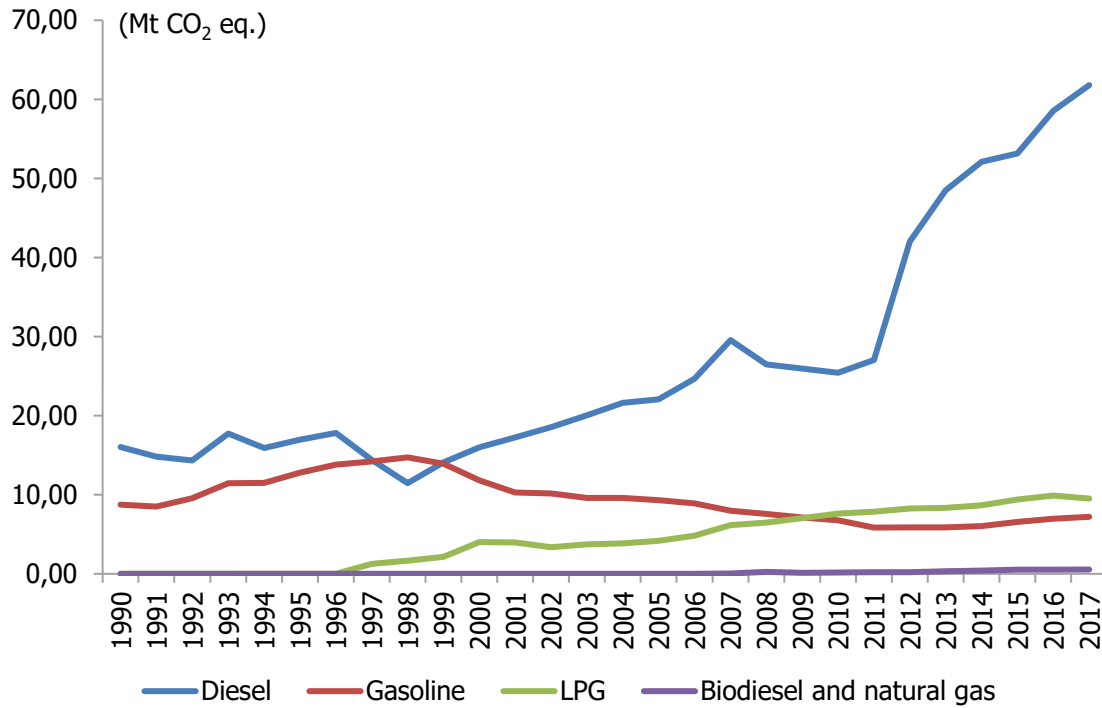
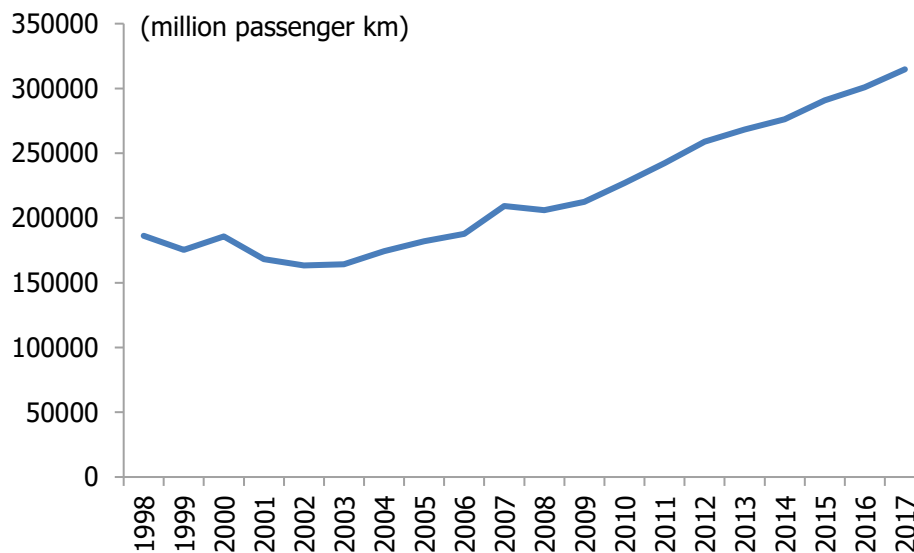
**Figure 3.13 GHG emission trend by transport mode, 1990-2017**

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 MoTI resulted in a sudden improvement in civil aviation sector. Then again, the number of flights and fuel consumption started to increase. However, 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 the main reason of decoupling could be determined with improving data quality in domestic aviation sector.

**Figure 3.14 Comparison of number of flights, fuel consumption and GHG emissions of civil aviation, 1990-2017**



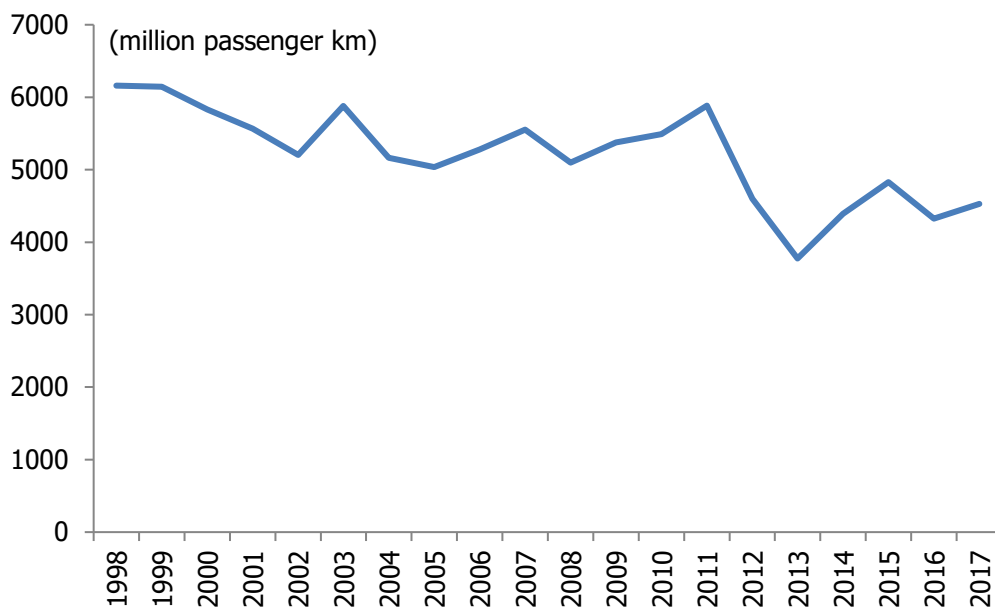
The other transportation mode needed to be analyzed is road transportation (Figure 3.20). In road transportation until the year 1997, only diesel oil and gasoline were used. Utilization of LPG started in 1997 and consumption increased steadily. Then, diesel oil consumption and LPG consumption increased 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. CO<sub>2</sub> eq.) and 2017 (61.799 kt. CO<sub>2</sub> eq.), an increase of 129%.

**Figure 3.15 Emission distributions by fuel types in road transportation, 1990-2017****Figure 3.16 Passenger-km by road, 1998-2017 <sup>(1)</sup>**

(1) <https://data.oecd.org/transport/passenger-transport.htm>

As seen from the figure, 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 3.17 Passenger-km by railway, 1998-2017 <sup>(2)</sup>**



(2) <https://data.oecd.org/transport/passenger-transport.htm>

Above figure 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. That is why there happened a fluctuation in emissions from 2011 to 2017.

### 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<sub>2</sub> emissions from jet fuel (level and trend),
- Road transportation in terms of CO<sub>2</sub> emissions from diesel fuel, LPG, gasoline and other ones (biofuel and natural gas) (level and trend),
- Domestic navigation in terms of CO<sub>2</sub> 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 1990-2017, 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 CO<sub>2</sub> (kg)

Fuel<sub>a</sub> = fuel sold (TJ)

EF<sub>a</sub> = 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 3.30.

**Table 3.49 Method used in the calculation of GHG emissions by transport modes**

Modes of transport	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	Tier I	Tier II
Domestic aviation	✓	✓	✓	X	X
Road transportation	✓	✓	✓	X	X
Railways	✓	✓	✓	X	X
Domestic navigation	✓	✓	✓	X	X
Pipeline transportation	✓	✓	✓	X	X

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

- Fuel consumption values for source categories (1.A.3.a.i), (1.A.3.a.ii), (1.A.3.b), (1.A.3.c), (1.A.3.d.i), (1.A.3.d.ii) and (1.A.3.e.i) were provided by MENR in the form of the national energy balance tables, EMRA, DGMPA and Petroleum Pipeline Corporation.
- 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 55 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:

There is no recalculation for this category.

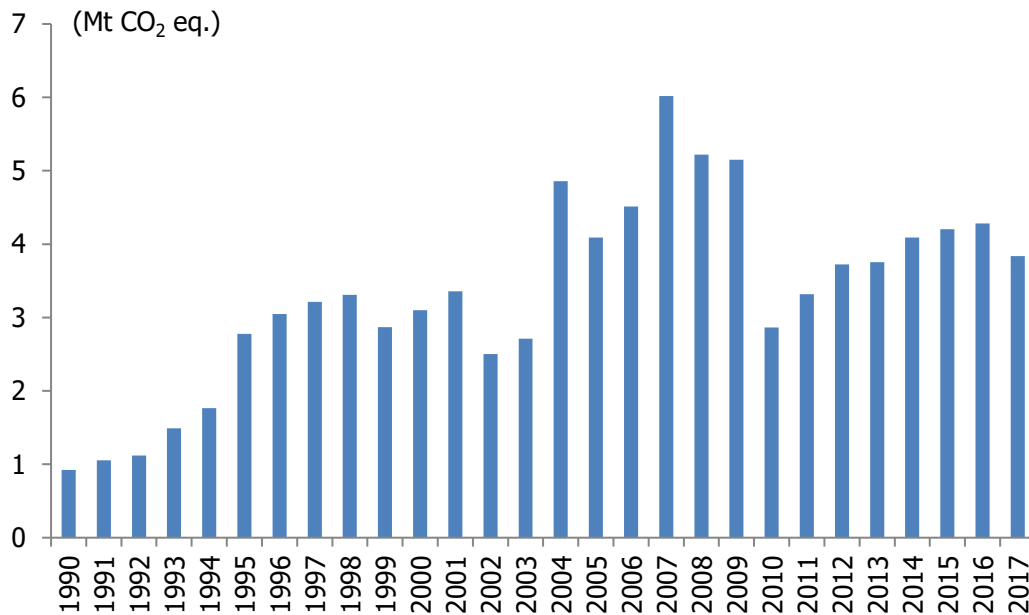
#### 3.2.6.1. Civil aviation (Category 1.A.3.a)

The domestic aviation source category was a key category in 2017, in terms of both the level and trend analysis of CO<sub>2</sub> emissions from the jet fuel. In domestic aviation only jet fuel is consumed.

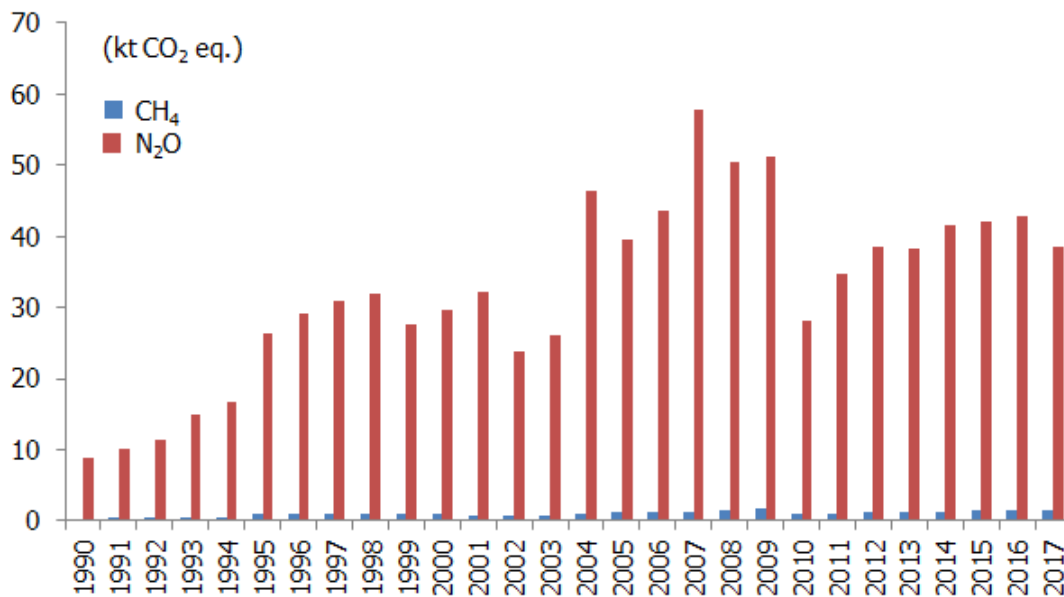
Figure 3.23 and Figure 3.24 illustrate the total emissions and the emissions of N<sub>2</sub>O and CH<sub>4</sub> increasing trends as CO<sub>2</sub> eq. CO<sub>2</sub> eq. emissions have increased approximately 368% since 1990 and reached to 3.84Mt CO<sub>2</sub> in 2017. The calculated amounts of N<sub>2</sub>O and CH<sub>4</sub> emissions were 38.51 kt. CO<sub>2</sub>eq. and 1.49kt. CO<sub>2</sub> eq. respectively in 2017. There was a relatively large decrease in CO<sub>2</sub> 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 3.18 GHG emissions for domestic aviation, 1990-2017**



**Figure 3.19 CH<sub>4</sub> and N<sub>2</sub>O emissions for domestic aviation, 1990-2017**





**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.

$$\text{Total emissions} = \text{LTOemissions} + \text{cruiseemissions}$$

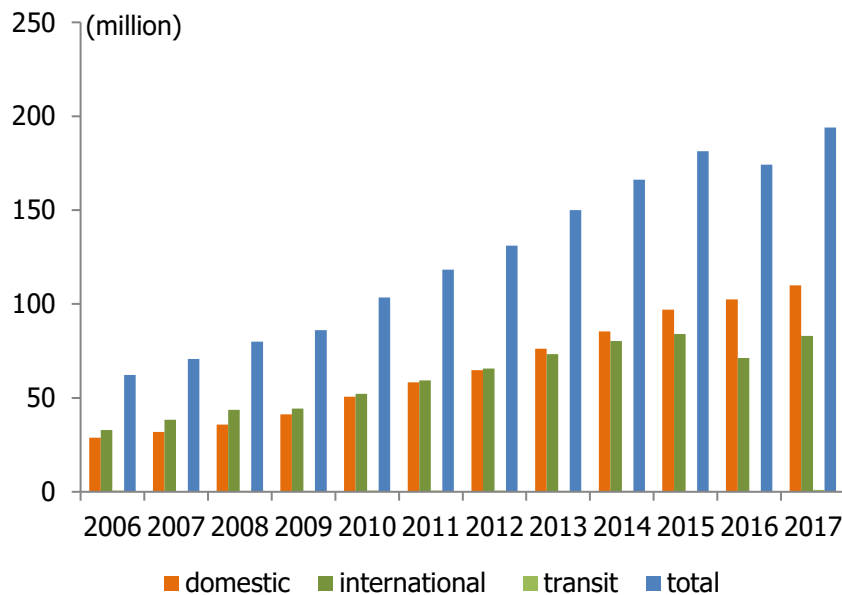
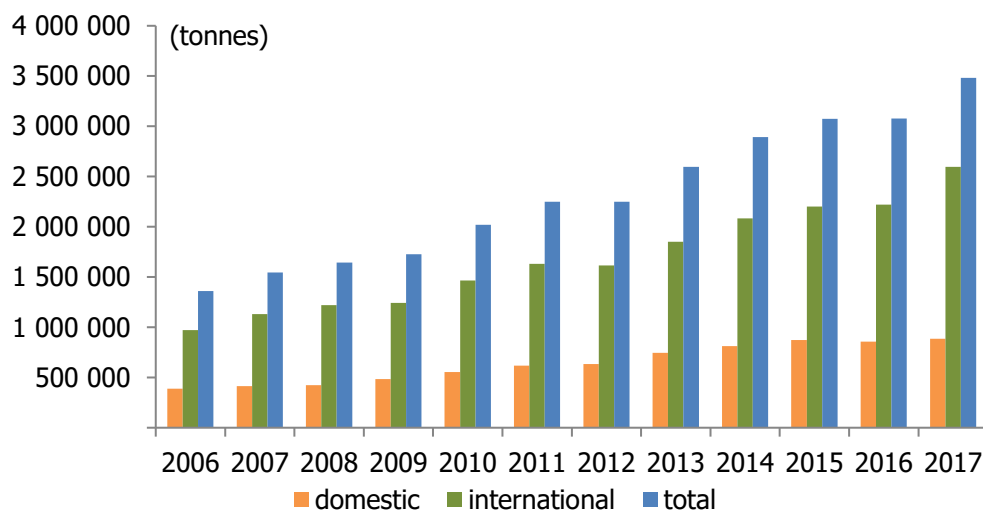
$$\text{LTOemissions} = \text{NumberofLTOs} * EF_{LTO}$$

$$\text{LTOfuelconsumption} = \text{NumberofLTOs} * \text{FuelconsumptionperLTO}$$

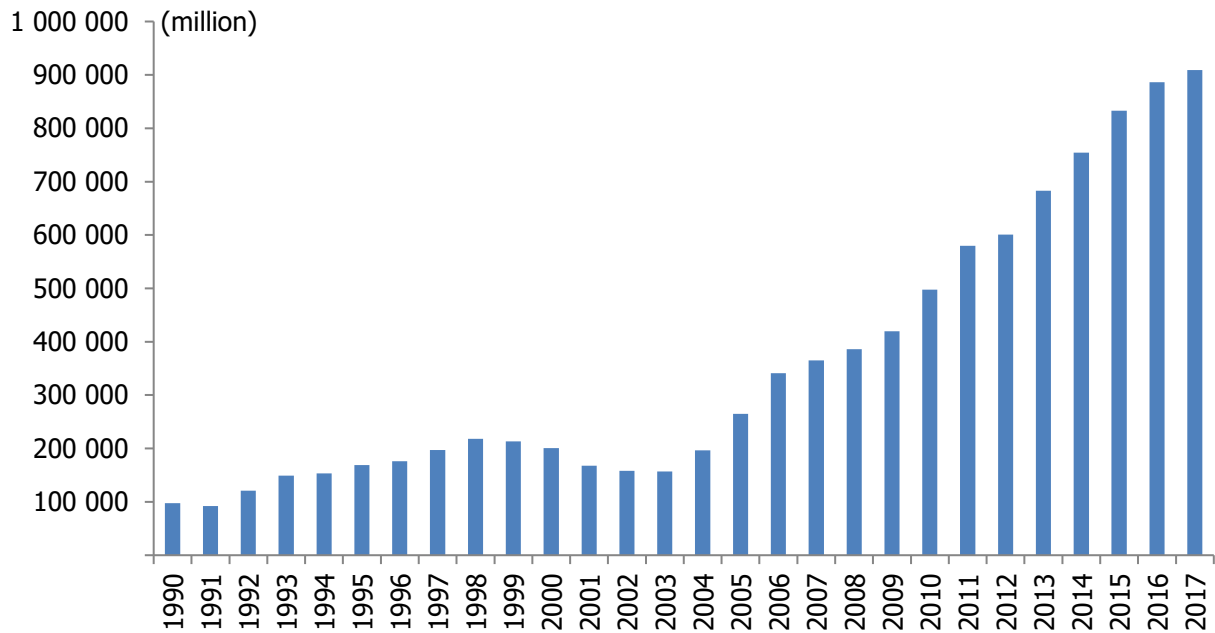
$$\text{Cruiseemissions} = (\text{TotalFuelConsumption} - \text{LTOFuelConsumption}) * EF_{Cruise}$$

**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 2017 total number of LTO's in domestic travel for all aircraft types is 909 332. Passenger and freight traffic from 2006 to 2017 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 2017.

**Figure 3.20 Passenger traffic, 2006-2017****Figure 3.21 Freight traffic, 2006-2017**

EFs for all aircraft types were obtained from 2006 IPCC Guidelines for National GHG Inventories (2006 IPCC Guidelines). 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 1.194Mt. 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 0.688Mt. To estimate cruise fuel consumption, Turkey subtracts LTO fuel consumption from total fuel consumption for each year of the time series. In 2017, cruise fuel consumption is 0.507 Mt.

**Figure 3.22 Number of domestic LTO, 1990-2017****Choice of Emission Factor:**

LTO fuel consumption factors, as well as default CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O 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<sub>2</sub> emission values of 2.203Mt and 1.596Mt were reported for LTO and cruise respectively. CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emission values are given in Table 3.31.

**Table 3.50 GHG emissions from domestic aviation, 1990-2017**

<b>Year</b>	<b>CO<sub>2</sub> (kt)</b>	<b>CH<sub>4</sub> (kt)</b>	<b>N<sub>2</sub>O (kt)</b>	<b>CO<sub>2</sub> eq. (kt)</b>	<b>TJ</b>
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	4 162	0.06	0.14	4 205	58 824
2016	4 237	0.06	0.14	4 281	59 884
2017	3 798	0.06	0.13	3 838	53 259
<b>Changes from 1990 (%)</b>	315.5	500	333.3	315.8	308.7

**Table 3.51 GHG emissions for LTO and cruise in domestic aviation, 2017  
(kt)**

	<b>CO<sub>2</sub></b>	<b>CH<sub>4</sub></b>	<b>N<sub>2</sub>O</b>	<b>Jet kerosene</b>
Total	3 798	0.06	0.129	1 194
LTO	2 203	0.06	0.079	687.7
Cruise	1 596	-	0.051	506.5

**Table 3.52 IEFs of domestic aviation 1990-2017**

	Activity	IEFs		
		CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
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	0.98	2.39
2016	59 884	70.75	0.99	2.39
2017	53 259	71.32	1.12	2.43

### 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<sub>2</sub> was considered as 5% as indicated in 2006 IPCC Guidelines Vol. 2 page 3.69. For CH<sub>4</sub> and N<sub>2</sub>O mid value of default uncertainty given in 2006 IPCC Guidelines as 80% and 85% were considered respectively.

**Recalculation:**

There is no recalculation for this category.

**Planned Improvement:**

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

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

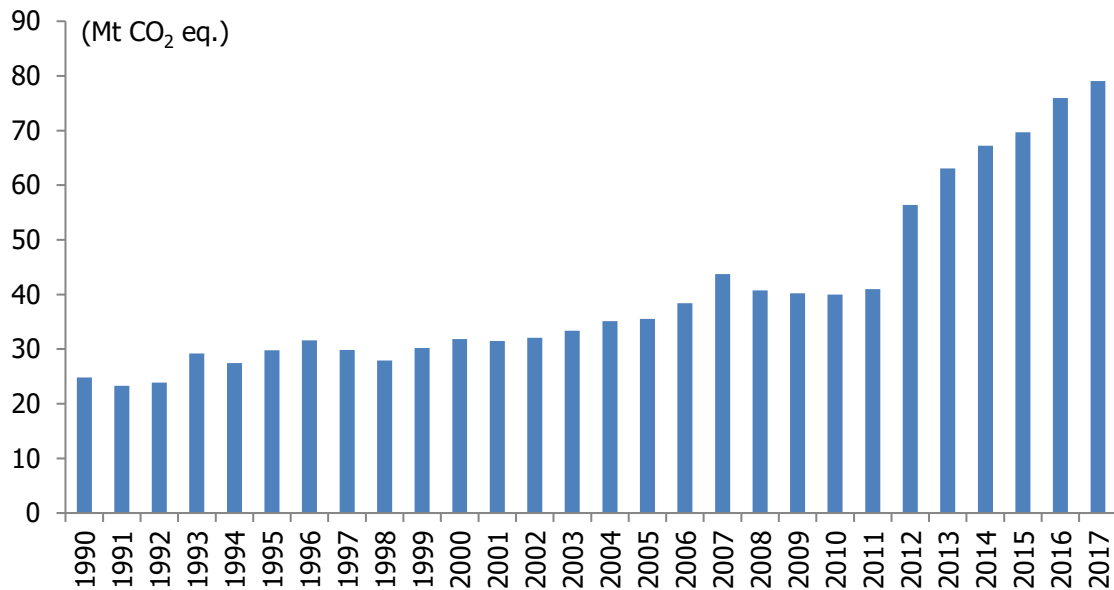
Road Transportation source category was a key category, in terms of emission level of CO<sub>2</sub> from diesel oil, LPG and gasoline in 2017. This category was also a key category in terms of emission trend of CO<sub>2</sub> from gasoline and diesel oil. The results according to IPCC Tier 1&2 were in Table 3.34.

**Table 3.53 GHG emissions from road transportation, 1990-2017**

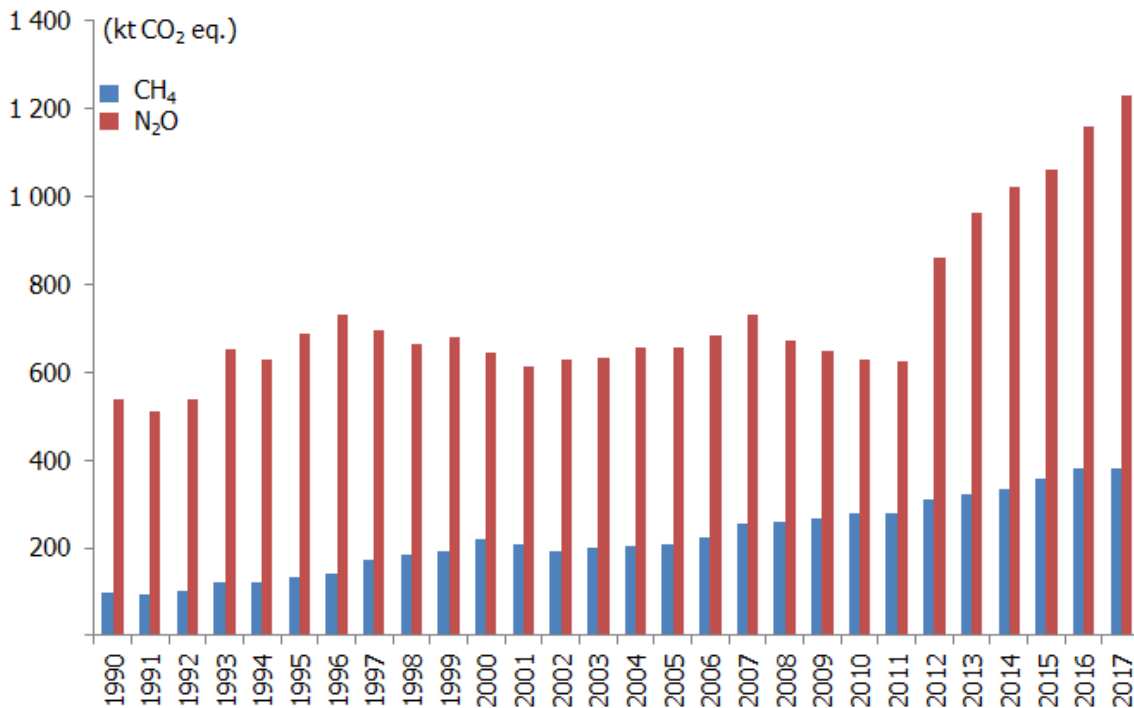
Year	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	CO <sub>2</sub> eq. (kt)	TJ
1990	24 143	3.9	1.804	24 777	335 589
1991	22 686	3.7	1.712	23 288	315 543
1992	23 232	4.0	1.804	23 871	323 808
1993	28 403	4.9	2.192	29 178	395 708
1994	26 672	4.8	2.105	27 419	372 206
1995	28 942	5.3	2.301	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
2016	74 055	15.2	3.887	75 595	1 041 071
2017	77 094	15.2	4.132	78 706	1 095 446
<b>Changes from 1990 (%)</b>	219.3	289.7	129.1	217.7	226.4

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 78.7Mt of CO<sub>2</sub>eq. The emissions of N<sub>2</sub>O reached 1.23Mt CO<sub>2</sub> eq. and CH<sub>4</sub> reached 0.38Mt CO<sub>2</sub> eq. in 2017 (Figure 3.29). Emissions from the consumption of biofuels were taken into consideration for CH<sub>4</sub> and N<sub>2</sub>O emissions.

**Figure 3.23 GHG emissions for road transportation, 1990-2017**

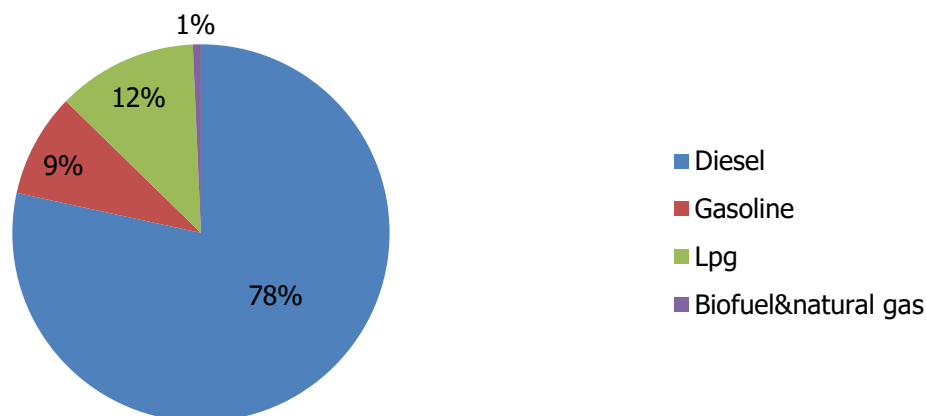


**Figure 3.24 CH<sub>4</sub> and N<sub>2</sub>O emissions for road transportation, 1990-2017**



CO<sub>2</sub> emissions according to fuel types are illustrated in Figure 3.30. Most important portion of CO<sub>2</sub> emission is occurred from diesel fuel consumption, which is about 78% of total emissions of road transportation.

**Figure 3.25 CO<sub>2</sub> emission distributions by fuel types (%), 2017**



#### Methodological issues:

CO<sub>2</sub> 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<sub>2</sub> emissions resulting from those fuel types were estimated with Tier 2. CO<sub>2</sub> resulting from gasoline, LPG and CH<sub>4</sub> and N<sub>2</sub>O 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 CO<sub>2</sub> 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 Mining and 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.

In addition, GHG emissions from road transportation were also calculated by using COPERT V program for the years 2016 and 2017. COPERT V results were compared with the results regarding current methodology (Tier 1, Tier 2) and in terms of CH<sub>4</sub>, COPERT result was found by far less than results obtained by using current methodology due to usage of default emission factors. Moreover, results obtained from COPERT V were also compared with CRF values of several countries (e.g. Denmark, United Kingdom, Greece, Italy) using COPERT methodology. Considered comparison of implied emission factors, values were found almost in line with each other.

**Table 3.54 Comparison of COPERT and current methodology for GHG emissions from road transportation, 2016, 2017**

Year	CO <sub>2</sub> (kt)		CH <sub>4</sub> (kt)		N <sub>2</sub> O (kt)		CO <sub>2</sub> eq. (kt)	
	Tier 2	COPERT	Tier 1	COPERT	Tier 1	COPERT	Tier 1&2	COPERT
2016	74 055	74 657	15.2	4.9	3.9	2.6	75 595	75 581
2017	77 094	78 694	15.2	5.6	4.1	2.8	78 706	79 690

With the first calculation results obtained from COPERT for the years 2016 and 2017, it is aimed to make calculations regarding previous years. For this purpose, ongoing studies will be taken into account for the next submissions.

### 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<sub>2</sub> was considered as 5% (max. value of given range) as indicated in 2006 IPCC Guidelines Vol. 2 page 3.29. For CH<sub>4</sub> and N<sub>2</sub>O mid value of default uncertainty given in 2006 IPCC Guidelines as 250% were considered.

### Recalculations:

There is no recalculation for this category.

**Planned Improvement:**

Copert V model was used to compare the results for the years 2016 and 2017. it is aimed to make calculations regarding previous years. For this purpose, ongoing studies will be taken into account for the next submissions.

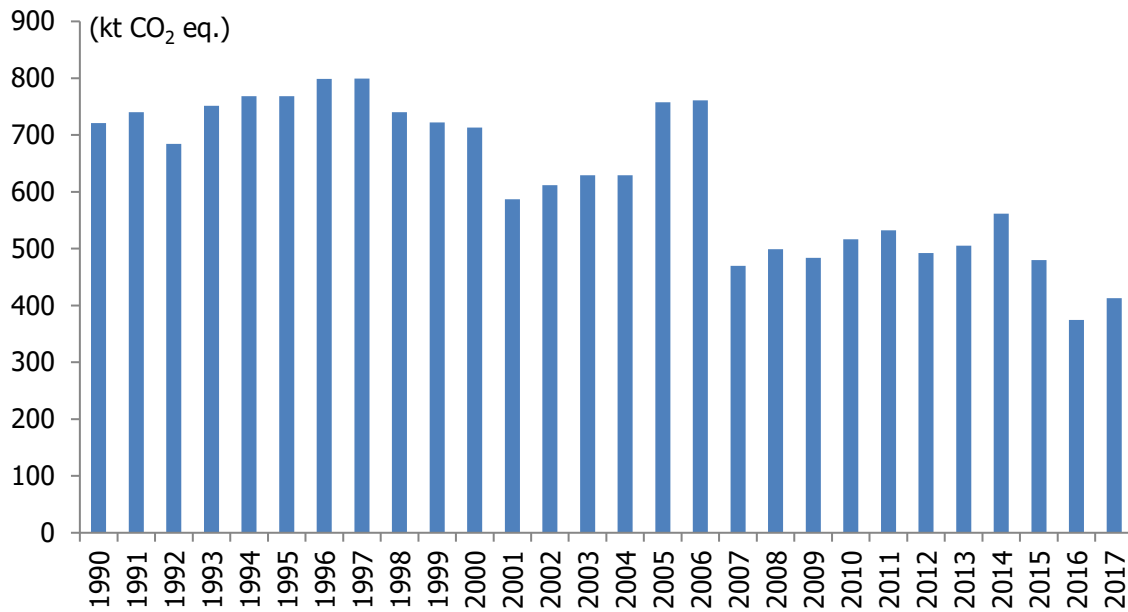
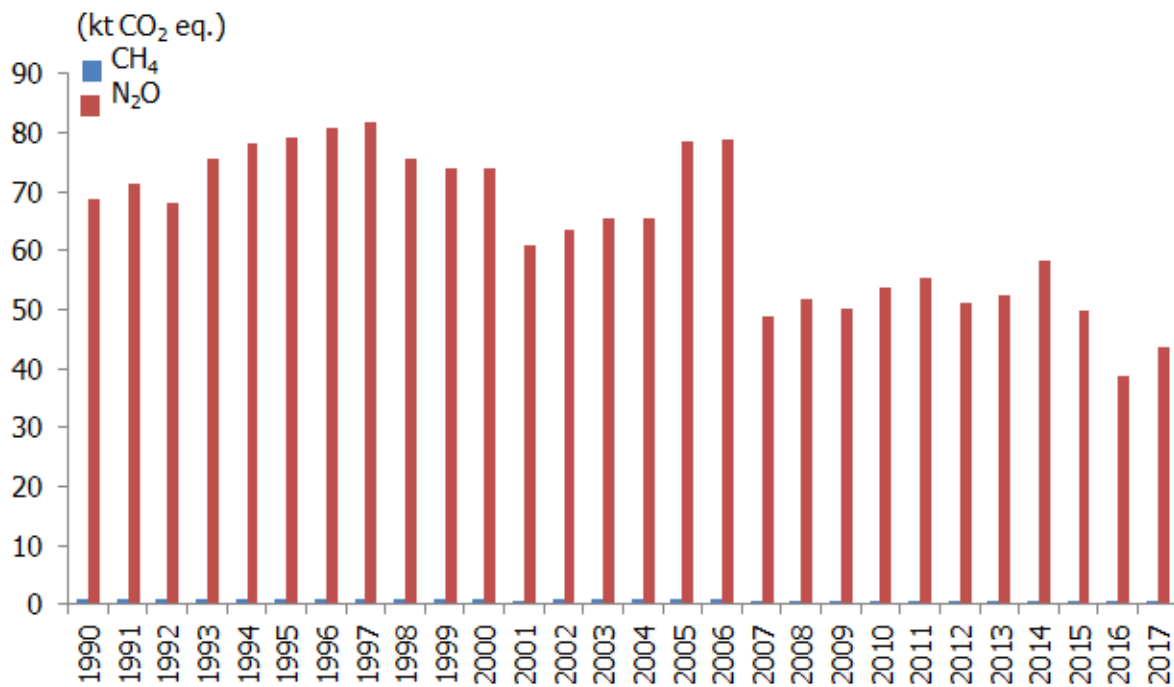
**3.2.6.3. Railways (Category 1.A.3.c)**

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 2017.

Figure 3.31 and Figure 3.32 show the total emissions and the emissions of N<sub>2</sub>O and CH<sub>4</sub> decreasing trends as CO<sub>2</sub> equivalents. CO<sub>2</sub> equivalent emissions have declined 48.1% since 1990. The amount of emissions calculated for railways is 0.41Mt CO<sub>2</sub> in 2017.

Table 3.55 GHG emissions from railway, 1990-2017

Year	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	CO <sub>2</sub> 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	5 848
2016	335	0.02	0.13	374	4 561
2017	369	0.02	0.15	413	5 105
<b>Changes from 1990 (%)</b>	-43.3	-33.3	-34.8	-42.7	-41.1

**Figure 3.26 GHG emissions for railways, 1990-2017****Figure 3.27 CH<sub>4</sub> and N<sub>2</sub>O emissions from railways, 1990-2017**

## Methodological issues:

The IPCC Tier 1&2 approach has been used to estimate CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions for this subcategory. The Tier 1 approach has been used to estimate CH<sub>4</sub> and N<sub>2</sub>O 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 CO<sub>2</sub> emissions, Turkey applies the country specific carbon content. Turkey does not modify the emission factors for CH<sub>4</sub> and N<sub>2</sub>O 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 2% for liquid fuels.

EF uncertainty for CO<sub>2</sub> was derived from 2006 IPCC Guidelines Vol. 2 table 3.4.1 as 1.5% for liquid fuels. For CH<sub>4</sub>, EF uncertainties were derived as 105% for liquid fuels. For N<sub>2</sub>O EFs uncertainties were derived as 142% for liquid fuels.

## Recalculations:

There is no recalculation for this category.

## Planned Improvement:

There is no planned improvement for this category.

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

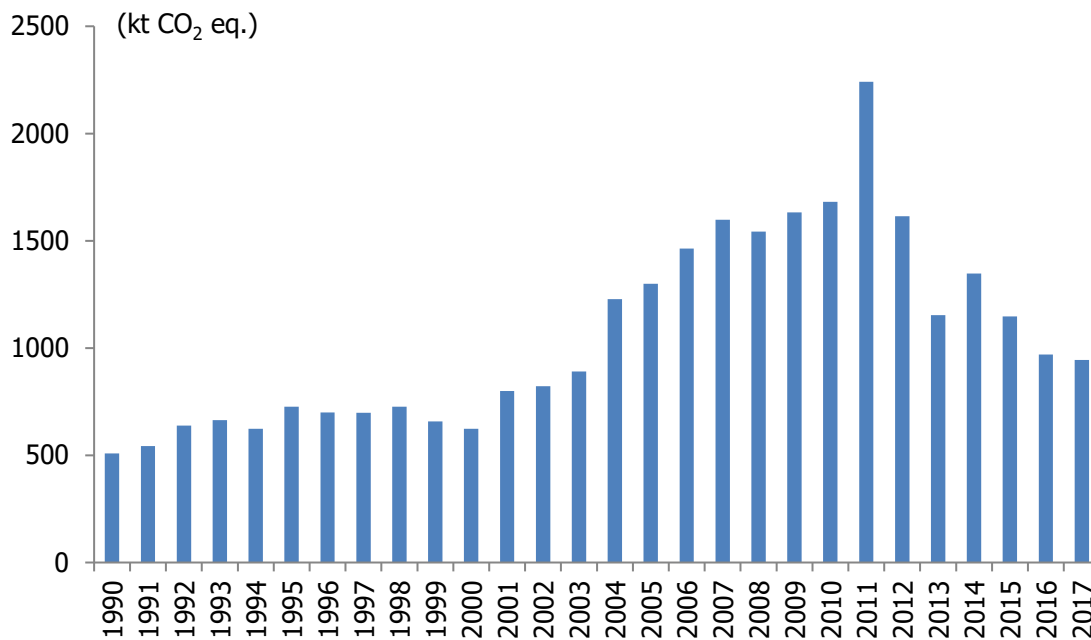
The domestic water borne navigation source category was not a key category in 2017. The data availability is limited in this sub-sector. In domestic water-borne navigation only, diesel and residual fuel oil were consumed as a fuel.

Domestic water-borne navigation contributed 0.94 Mt of CO<sub>2</sub> in 2017 while N<sub>2</sub>O emissions were 7.65 kt. CO<sub>2</sub>eq. and CH<sub>4</sub> 2.25 kt. CO<sub>2</sub>eq. (Figure 3.33 and 3.34). Overall, between 1990 and 2017 emissions from water-borne navigation increased by 85.5%.

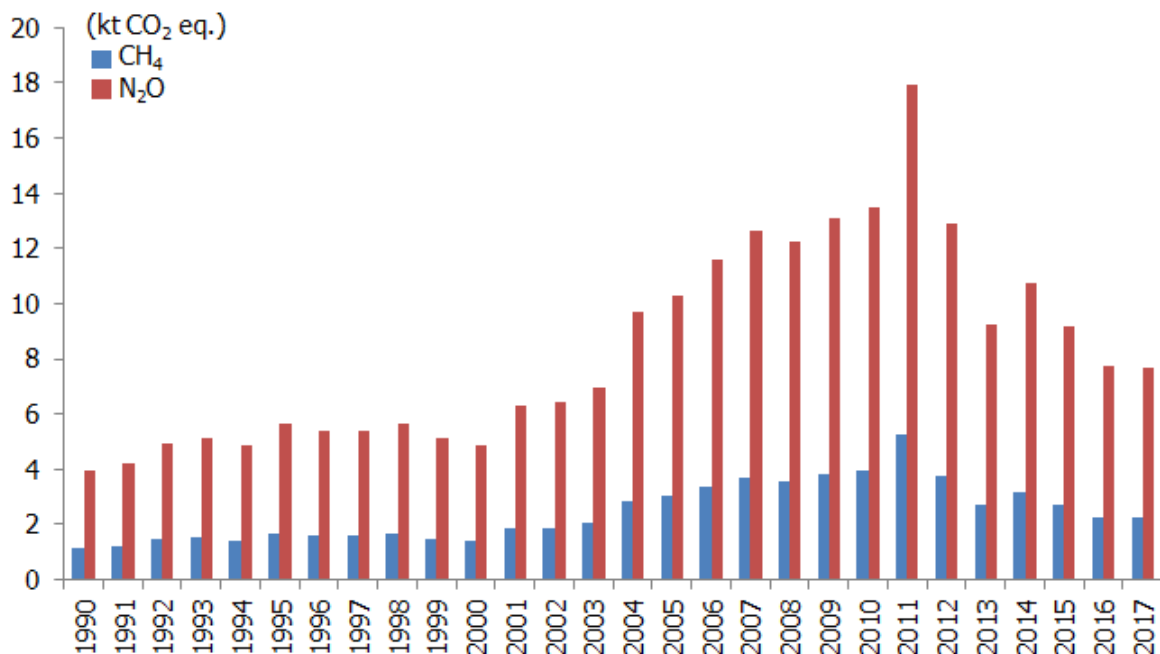
**Table 3.56 GHG emissions from domestic navigation, 1990-2017**

Year	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	CO <sub>2</sub> 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
2016	960	0.09	0.03	970	12 958
2017	934	0.09	0.03	944	12 836
<b>Changes from 1990 (%)</b>	85.3	80	133	85.5	93.8

**Figure 3.28 GHG emissions from domestic water-borne navigation, 1990-2017**



**Figure 3.29 CH<sub>4</sub> and N<sub>2</sub>O emissions from domestic water-borne navigation, 1990-2017**



**Methodological issues:**

The IPCC Tier 1&2 approach has been used to estimate CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions for this subcategory. The Tier 1 approach has been used to estimate CH<sub>4</sub> and N<sub>2</sub>O emissions.

**Collection of Activity Data:**

Energy consumption values for domestic navigation were provided by DG of Mining and Petroleum Affairs.

**Choice of emission factor:**

For CO<sub>2</sub> estimation, country-specific carbon contents were used. The EFs for CH<sub>4</sub> and N<sub>2</sub>O 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 MoTI's DG of Merchant Marine, 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 Mining and Petroleum Affairs regularly reports to the IEA.

**Uncertainties and Time-Series Consistency:**

The AD were taken from DG of Mining and Petroleum Affairs. AD uncertainties were determined as 15% for liquid fuels.

EF uncertainty for CO<sub>2</sub> 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<sub>4</sub> and 140% for N<sub>2</sub>O.

**Recalculations:**

There is no recalculation for this category.

**Planned Improvement:**

There is no planned improvement for this category.

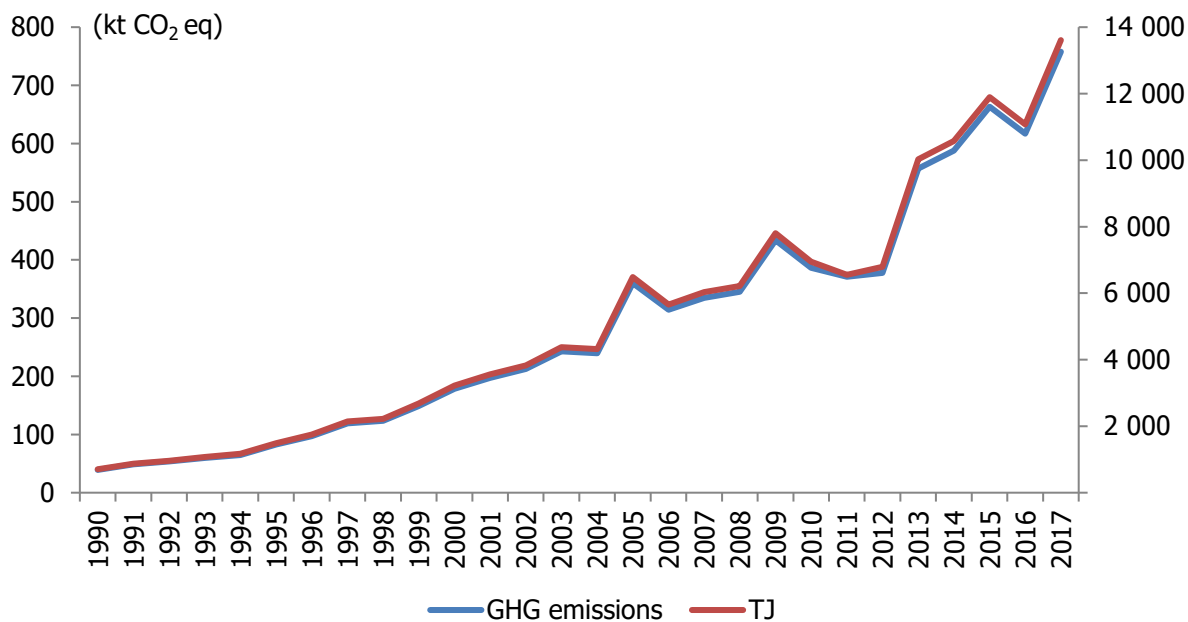


### 3.2.6.5. Pipeline transport (Category 1.A.3.e.i)

This category covers combustion related emissions from the operation of pump stations and maintenance 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 0.76 Mt of CO<sub>2</sub> in 2017. Table 3.38 shows the trend in GHG emissions from pipeline transport.

**Table 3.57 The trend in GHG emissions from pipeline transport, 1990-2017**

Year	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	CO <sub>2</sub> 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	53	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	119	2143
1998	123	0.0022	0.00022	123	2221
1999	149	0.0027	0.00027	149	2682
2000	178	0.0032	0.00032	179	3217
2001	197	0.0036	0.00036	197	3553
2002	212	0.0038	0.00038	212	3826
2003	243	0.0044	0.00044	243	4372
2004	240	0.0043	0.00043	240	4317
2005	360	0.0065	0.00065	360	6487
2006	314	0.0057	0.00057	314	5658
2007	335	0.0060	0.00060	335	6030
2008	345	0.0062	0.00062	345	6216
2009	433	0.0078	0.00078	434	7803
2010	386	0.0069	0.00069	387	6945
2011	371	0.0066	0.00066	371	6552
2012	377	0.0068	0.00068	378	6796
2013	557	0.0100	0.00100	557	10025
2014	587	0.0106	0.00106	588	10575
2015	662	0.0117	0.00117	663	11897
2016	617	0.0111	0.00111	617	11073
2017	757	0.0136	0.00136	758	13 610

**Figure 3.30 GHG emissions from pipeline transport, 1990-2017****Methodological issues:**

In emissions calculation, the 2006 IPCC Guidelines Tier 1&2 approaches are used. CO<sub>2</sub> emissions were calculated by multiplying estimated fuel consumption by a country-specific emission factor. CH<sub>4</sub> and N<sub>2</sub>O 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<sub>2</sub> estimation, country-specific carbon content was used. In Addition, default CH<sub>4</sub> (1 kg/TJ) and N<sub>2</sub>O (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 was a recalculation for pipeline transportation owing to revised data of natural gas carbon content from 1990 to 2016. The difference between CO<sub>2</sub> eq. emissions from pipeline transportation was around 0.5-1%. Thus the effect of recalculation is negligible.

	subm.	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
kt CO <sub>2</sub> eq.	2017	39,13	48,59	53,4	59,68	64,79	82,67	96,92	119	123,3	149	178,6	197,3	212,4	242,9
	2016	39,33	48,84	53,67	59,98	65,11	83,09	97,4	119,6	124	149,7	179,5	198,3	213,5	245,2
% Change		-0,502	-0,502	-0,502	-0,502	-0,502	-0,502	-0,502	-0,502	-0,502	-0,502	-0,502	-0,502	-0,502	-0,926

	subm.	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
kt CO <sub>2</sub> eq.	2017	239,7	360,2	314,2	334,9	345,2	433,8	386,5	371,3	377,7	557,2	588	663,1	617,3
	2016	242	363,6	317,5	338,1	347,8	437,3	390,2	369,7	381,3	562,7	593,5	656,1	621,4
% Change		-0,948	-0,955	-1,051	-0,964	-0,748	-0,810	-0,950	0,443	-0,947	-0,991	-0,937	1,062	-0,671

**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 trend of CO<sub>2</sub> from solid, liquid and gaseous fuels in 2017. The source category is also a key category in terms of emission trend of CH<sub>4</sub> from solid fuels and biomass.

The share of GHG emissions as CO<sub>2</sub> eq. from other sectors in total fuel combustion was 19.7% in 2017 while it was 25.0% in 1990. It was 13.4% of total GHG emissions in 2017.

**Table 3.58 Fuel combustion emissions from other sectors (1A4), 1990-2017**

Year	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	CO <sub>2</sub> eq. (kt)	Fuel consumption (TJ)	Share in fuel combustion (1A) category (%)
1990	29 277	132.70	3.735	33 707	646 591	25.0
1991	30 430	133.58	3.750	34 887	658 600	25.0
1992	32 537	136.70	3.774	37 079	685 301	25.4
1993	33 228	132.35	4.278	37 812	701 819	24.8
1994	29 477	121.52	4.230	33 775	667 014	22.6
1995	33 297	125.61	4.312	37 722	713 541	23.2
1996	34 267	122.91	4.442	38 664	734 303	21.5
1997	36 953	127.84	4.584	41 515	771 063	21.6
1998	33 429	117.52	4.485	37 704	735 920	19.7
1999	31 655	110.15	4.511	35 753	715 575	19.0
2000	33 693	107.92	4.610	37 764	737 948	18.0
2001	27 686	96.27	4.377	31 397	651 581	16.2
2002	29 176	97.62	4.408	32 930	654 967	16.4
2003	32 427	99.27	4.444	36 232	688 840	16.8
2004	35 645	100.92	4.674	39 561	726 309	17.9
2005	38 826	99.51	4.681	42 709	771 973	17.9
2006	38 425	94.04	4.899	42 236	770 378	16.6
2007	41 335	95.38	5.233	45 279	798 938	16.0
2008	58 971	139.45	6.553	64 410	986 839	23.1
2009	65 084	157.26	6.522	70 959	1 030 352	24.9
2010	62 070	152.26	6.364	67 773	973 007	24.2
2011	69 279	131.55	7.006	74 656	1 078 816	24.9
2012	57 465	138.11	2.241	61 586	896 880	19.7
2013	52 999	113.75	1.818	56 384	879 983	18.8
2014	52 668	112.41	2.016	56 079	876 746	17.7
2015	62 494	62.76	4.242	65 327	1 010 607	19.4
2016	62 413	61.56	4.190	65 201	1 020 656	18.5
2017	70 272	73.39	4.310	73 391	1 112 130	19.7

Total GHG emission in 1A4 category increased 8 190 kt CO<sub>2</sub> eq. (12.6% of increase) from 2016 to 2017.

#### 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<sub>2</sub> EF are used when available, otherwise default CO<sub>2</sub> EF are used. Same CO<sub>2</sub> EFs are used from the summary table X.X. (from 1.A Fuel combustion sector) All CH<sub>4</sub> and N<sub>2</sub>O EF are also default. The default CH<sub>4</sub> and N<sub>2</sub>O EF for 1A4 sector are tabulated below.

**Table 3.59 N<sub>2</sub>O and CH<sub>4</sub> emission factors of fuels used in others sector (1A4).**

Sub Sectors	Emission Factors		Source
	CH <sub>4</sub> (kg/TJ)	N <sub>2</sub> O(kg/TJ)	
1A4a sub sector			
Coal products	10	1.5	Table 2.4
LPG	5	0.1	Table 2.4
Other petroleum products	10	0.6	Table 2.4
Wood	300	4	Table 2.4
Natural gas	5	0.1	Table 2.4
1A4b, 1A4c sub sectors			
Coal products	300	1.5	Table 2.5
LPG	5	0.1	Table 2.5
Other petroleum products	10	0.6	Table 2.5
Wood	300	4	Table 2.5
Other primary solid biomass	300	4	Table 2.5
Natural gas	5	0.1	Table 2.5

**Recalculation:**

Due to the revision on the national energy balance tables, the 1A4 sector and its subsectors are recalculated. Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated. The table below shows the effect of the recalculation with respect to 2018 submission.

**Table 3.60 Comparison on OtherSectors (1A4) emissions recalculation in 2018 and 2019 inventory submissions**

<b>Year</b>	<b>Emissions from 1A4 in 2018 submission (kt CO<sub>2</sub>)</b>	<b>Emissions from 1A4 in 2019 submission (kt CO<sub>2</sub>)</b>	<b>Difference in emissions (kt CO<sub>2</sub>)</b>
1990	33 673	33 707	34
1991	34 860	34 887	27
1992	36 982	37 079	96
1993	37 801	37 812	11
1994	33 753	33 775	22
1995	37 706	37 722	16
1996	38 660	38 664	4
1997	41 517	41 515	- 3
1998	37 708	37 704	- 4
1999	35 745	35 753	8
2000	38 233	37 764	- 469
2001	31 784	31 397	- 386
2002	33 363	32 930	- 433
2003	36 541	36 232	- 308
2004	40 039	39 561	- 478
2005	43 101	42 709	- 392
2006	44 642	42 236	- 2 406
2007	47 620	45 279	- 2 341
2008	66 623	64 410	- 2 214
2009	72 660	70 959	- 1 700
2010	70 355	67 773	- 2 582
2011	74 803	74 656	- 147
2012	63 943	61 586	- 2 357
2013	58 539	56 384	- 2 155
2014	53 480	56 079	2 600
2015	65 033	65 327	293
2016	66 540	65 201	- 1 340

**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 until 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<sub>2</sub>eq. from 1.A.4.a in total other sector is 28.1% in 2017.

**Table 3.61 Fuel combustion emissions from 1.A.4.a category, 1990-2017**

Year	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	CO <sub>2</sub> eq. (kt)	Fuel consumption (TJ)	Share in 1.A.4 category (%)
1990-2014	IE	IE	IE	IE	IE	IE
2015	23 217	2.33	0.260	23 353	300 630	35.7
2016	22 004	2.31	0.258	22 139	298 757	34.0
2017	20 540	2.01	0.190	20 647	279 840	28.1

Total GHG emission in 1.A.4.a category decreased 1 492 kt CO<sub>2</sub> eq. (6.7% of decrease) from 2016 to 2017.

#### 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<sub>2</sub> EFs are used for emission estimation. CH<sub>4</sub> and N<sub>2</sub>O 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 Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO<sub>2</sub> and 100% (mid value in the range) for CH<sub>4</sub> and N<sub>2</sub>O.

#### Source-Specific QA/QC and Verification:

Quality control for 1A4a category was performed on the basis of QA/QC plan. Since only 2015 and 2016 estimation is available for this category, emission trends couldn't be analyzed.

IEF for CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O are in the range of 2006 IPCC default EFs.

#### Recalculation:

Due to the revision on the national energy balance tables, the 1A4a sector is recalculated. Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated. The table below shows the effect of the recalculation with respect to 2018 submission.

**Table 3.62 Comparison on commercial/institutional sector (1A4a) emissions recalculation in 2018 and 2019 inventory submissions**

<b>Year</b>	<b>Emissions from 1A4a in 2018 submission (kt CO<sub>2</sub>)</b>	<b>Emissions from 1A4a in 2019 submission (kt CO<sub>2</sub>)</b>	<b>Difference in emissions (kt CO<sub>2</sub>)</b>
1990-2014	IE	IE	
2015	22 351	23 353	1 001
2016	23 075	22 139	- 936

**Planned Improvement**

Prior to 2015 1A4a and 1A4b categories were not separated out in the national energy balance and therefore all of the emissions from these categories were reported under section 1A4b. However, since 2015 they are separated. All relevant institutions are working together in order to overcome this inconsistency problem and allocate 1A4a and 1A4b categories in time series.

**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. After 2015 only residential sector is covered under 1.A.4.b category. Therefore, there is a sharp decrease in 2015 due to the separation of the commercial and institutional category.

The share of GHG emissions as CO<sub>2</sub>eq. from 1.A.4.b category in total other sectors is 58.0% in 2017 while it was 80.8% in 1990.



**Table 3.63 Fuel combustion emissions from residential sector, 1990-2017**

Year	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	CO <sub>2</sub> eq. (kt)	Fuel consumption (TJ)	Share in 1.A.4 category (%)
1990	23 507	132.37	1.452	27 249	566 764	80.8
1991	24 635	133.24	1.457	28 401	578 434	81.4
1992	26 727	136.37	1.475	30 575	604 918	82.5
1993	26 072	131.94	1.447	29 802	602 809	78.8
1994	22 284	121.10	1.384	25 724	567 499	76.2
1995	25 958	125.19	1.408	29 507	611 993	78.2
1996	26 530	122.46	1.381	30 004	627 258	77.6
1997	28 934	127.38	1.411	32 538	660 113	78.4
1998	25 485	117.06	1.342	28 811	626 011	76.4
1999	23 492	109.68	1.281	26 616	602 632	74.4
2000	25 191	107.43	1.246	28 248	620 325	74.8
2001	19 551	95.80	1.158	22 291	539 029	71.0
2002	20 915	97.15	1.140	23 684	540 681	71.9
2003	24 040	98.78	1.125	26 844	572 802	74.1
2004	26 632	100.40	1.108	29 472	601 603	74.5
2005	29 731	98.99	1.082	32 529	646 141	76.2
2006	28 657	93.48	1.034	31 302	635 230	74.1
2007	30 694	94.77	1.022	33 368	651 714	73.7
2008	45 490	138.68	1.219	49 320	800 328	76.6
2009	51 866	156.49	1.294	56 164	847 483	79.1
2010	49 119	151.51	1.241	53 277	793 813	78.6
2011	54 168	130.68	1.045	57 746	869 556	77.3
2012	54 457	137.94	1.064	58 223	855 118	94.5
2013	50 649	113.61	0.934	53 767	846 990	95.4
2014	49 623	112.23	0.908	52 700	833 597	94.0
2015	30 479	59.92	0.601	32 157	587 205	49.2
2016	31 721	58.75	0.572	33 360	600 881	51.2
2017	40 620	70.85	0.604	42 571	705 283	58.0

Total GHG emission in 1.A.4.b category increased 9 211 kt CO<sub>2</sub> eq. (27.6% of increase) from 2016 to 2017.

#### 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<sub>2</sub> EFs are used for emission estimation. CH<sub>4</sub> and N<sub>2</sub>O 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 Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO<sub>2</sub> and 100% (mid value in the range) for CH<sub>4</sub> and N<sub>2</sub>O.

**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<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O IEFs for all fuels are in the range of 2006 IPCC Guidelines.

**Recalculation:**

Due to the revision on the national energy balance tables, the 1A4b sector is recalculated. Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated. The table below shows the effect of the recalculation with respect to 2018 submission.

**Table 3.64 Comparison on residential sector (1A4b) emissions recalculation in 2018 and 2019 inventory submissions**

<b>Year</b>	<b>Emissions from 1A4b in 2018 submission (kt CO<sub>2</sub>)</b>	<b>Emissions from 1A4b in 2019 submission (kt CO<sub>2</sub>)</b>	<b>Difference in emissions (kt CO<sub>2</sub>)</b>
1990	27 215	27 249	34
1991	28 374	28 401	27
1992	30 479	30 575	96
1993	29 791	29 802	11
1994	25 702	25 724	22
1995	29 490	29 507	16
1996	29 999	30 004	4
1997	32 541	32 538	- 3
1998	28 816	28 811	- 4
1999	26 608	26 616	8
2000	28 717	28 248	- 469
2001	22 678	22 291	- 386
2002	24 117	23 684	- 433
2003	27 153	26 844	- 308
2004	29 950	29 472	- 478
2005	32 921	32 529	- 392
2006	33 708	31 302	- 2 406
2007	35 709	33 368	- 2 341
2008	51 534	49 320	- 2 214
2009	57 866	56 164	- 1 702
2010	55 857	53 277	- 2 580
2011	57 892	57 746	- 146
2012	60 309	58 223	- 2 086
2013	55 831	53 767	- 2 064
2014	50 045	52 700	2 655
2015	32 867	32 157	- 711
2016	33 762	33 360	- 402

**Planned Improvement:**

Prior to 2015 1A4a and 1A4b categories were not separated out in the national energy balance and therefore all of the emissions from these categories were reported under section 1A4b. However since 2015 they are separated. Because of that there is a sharp decrease in the amount of emissions in 2015. All relevant institutions are working together in order to overcome this inconsistency problem and allocate 1A4a and 1A4b categories in time series.

### 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 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 modeling the agricultural diesel oil consumption. MENR disaggregated the diesel oil consumption data in agriculture sector by a comparison method in which total crop harvested area and petroleum products consumption data of similar countries are weighted to derive an indicator for Turkey.

More than 90% of GHG emissions from agricultural sector is related to off road vehicles. The share of GHG emissions as CO<sub>2</sub> eq. from 1.A.4.c category in total other sectors is 13.9% in 2017 while it was 19.2% in 1990.

**Table 3.65 Fuel combustion emissions from agriculture sector, 1990-2017**

Year	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	CO <sub>2</sub> eq. (kt)	Fuel consumption (TJ)	Share in 1.A.4 category (%)
1990	5 770	0.33	2.283	6 458	79 826	19.2
1991	5 794	0.33	2.293	6 486	80 167	18.6
1992	5 810	0.33	2.299	6 503	80 383	17.5
1993	7 156	0.41	2.832	8 010	99 010	21.2
1994	7 193	0.41	2.846	8 051	99 515	23.8
1995	7 340	0.42	2.904	8 216	101 548	21.8
1996	7 737	0.44	3.061	8 660	107 045	22.4
1997	8 019	0.46	3.173	8 976	110 950	21.6
1998	7 944	0.46	3.143	8 892	109 909	23.6
1999	8 163	0.47	3.230	9 138	112 943	25.6
2000	8 501	0.49	3.364	9 516	117 623	25.2
2001	8 135	0.47	3.219	9 106	112 553	29.0
2002	8 260	0.47	3.269	9 246	114 286	28.1
2003	8 387	0.48	3.319	9 388	116 039	25.9
2004	9 013	0.52	3.567	10 089	124 705	25.5
2005	9 095	0.52	3.599	10 180	125 832	23.8
2006	9 768	0.56	3.865	10 934	135 149	25.9
2007	10 641	0.61	4.211	11 911	147 224	26.3
2008	13 481	0.77	5.334	15 089	186 511	23.4
2009	13 218	0.78	5.228	14 796	182 869	20.9
2010	12 951	0.74	5.123	14 496	179 194	21.4
2011	15 112	0.87	5.961	16 910	209 260	22.7
2012	3 008	0.17	1.177	3 364	41 762	5.5
2013	2 350	0.14	0.885	2 617	32 992	4.6
2014	3 045	0.18	1.108	3 380	43 149	6.0
2015	8 797	0.51	3.380	9 817	122 772	15.0
2016	8 688	0.51	3.360	9 702	121 018	14.9
2017	9 112	0.53	3.516	10 173	127 007	13.9

Total GHG emission in 1.A.4.c category increased 471 kt CO<sub>2</sub> eq. (4.9% of increase) from 2016 to 2017.

#### 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<sub>2</sub> EFs are used for emission estimation from for both stationary and mobile source categories. CH<sub>4</sub> and N<sub>2</sub>O 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 Guidelines Vol.2 page 2.38. Uncertainty values were considered as 7% for CO<sub>2</sub> and 100% (mid value in the range) for CH<sub>4</sub> and N<sub>2</sub>O.

**Source-Specific QA/QC and Verification:**

Quality control for 1.A.4.c 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<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O IEFs for all fuels are in the range of 2006 IPCC Guidelines.

**Recalculation:**

Due to the revision on the national energy balance tables, the 1A4c sector is recalculated. Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated. The table below shows the effect of the recalculation with respect to 2018 submission.

**Table 3.66 Comparison on residential sector (1A4c) emissions recalculation in 2018 and 2019 inventory submissions**

<b>Year</b>	<b>Emissions from 1A4c in 2018 submission (kt CO<sub>2</sub>)</b>	<b>Emissions from 1A4c in 2019 submission (kt CO<sub>2</sub>)</b>	<b>Difference in emissions (kt CO<sub>2</sub>)</b>
1990	6 458	6 458	0
1991	6 486	6 486	0
1992	6 503	6 503	0
1993	8 010	8 010	0
1994	8 051	8 051	0
1995	8 216	8 216	0
1996	8 660	8 660	0
1997	8 976	8 976	0
1998	8 892	8 892	0
1999	9 138	9 138	0
2000	9 516	9 516	0
2001	9 106	9 106	0
2002	9 246	9 246	0
2003	9 388	9 388	0
2004	10 089	10 089	0
2005	10 180	10 180	0
2006	10 934	10 934	0
2007	11 911	11 911	0
2008	15 089	15 089	0
2009	14 794	14 796	2
2010	14 498	14 496	- 2
2011	16 911	16 910	- 1
2012	3 635	3 364	- 271
2013	2 708	2 617	- 91
2014	3 435	3 380	- 55
2015	9 815	9 817	3
2016	9 703	9 702	- 1

**Planned Improvement:**

MENR worked on agricultural association for modeling the agricultural diesel oil consumption and the disaggregation of diesel oil consumption was achieved in 2015 national energy balance tables. However national energy balance tables are not in time series therefore the allocation problem still exists between 2012 and 2014. All relevant institutions are working together and make planning in order to overcome this inconsistency problem.

**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 1.A.4.b for 1990-2014 periods and 1.A.4.a (for stationary) and 1.A.3 (for mobile) since 2015.

### 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<sub>4</sub> emission from coal mining, CH<sub>4</sub>, CO<sub>2</sub>, N<sub>2</sub>O and NMVOC emissions from exploration, production/processing, transport/transmission, refining and storage of oil and natural gas were covered.

**Table 3.67 Fugitive emissions from fuels, 1990-2017  
(kt)**

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub> eq.
1990	220	160	0.0031	4222
1991	263	153	0.0037	4098
1992	254	153	0.0035	4081
1993	231	150	0.0032	3994
1994	219	146	0.0031	3876
1995	209	144	0.0029	3817
1996	208	143	0.0029	3789
1997	206	157	0.0029	4136
1998	194	174	0.0027	4546
1999	178	215	0.0025	5544
2000	168	229	0.0023	5890
2001	155	213	0.0021	5481
2002	148	195	0.0020	5028
2003	145	189	0.0020	4861
2004	140	184	0.0019	4751
2005	142	211	0.0019	5420
2006	135	226	0.0018	5791
2007	133	302	0.0018	7683
2008	135	321	0.0018	8167
2009	138	311	0.0019	7904
2010	156	314	0.0021	8018
2011	151	345	0.0021	8774
2012	144	355	0.0020	9027
2013	146	315	0.0020	8021
2014	145	386	0.0020	9786
2015	155	198	0.0021	5117
2016	158	320	0.0022	8158
2017	157	246	0.0021	6311

CO<sub>2</sub> and CH<sub>4</sub> are the main fugitive emissions in this category. CH<sub>4</sub> was emitted mainly from coal mining while CO<sub>2</sub> was emitted from venting and flaring. Fugitive emissions as CO<sub>2</sub> eq. have become 6311 ktons in 2017. 48% of fugitive emissions as CO<sub>2</sub> eq. were from oil and gas systems and 52% were from solid fuels in the same year.



**Table 3.68 Fugitive emissions from fuels by subcategory, 1990-2017**  
(kt CO<sub>2</sub> eq.)

<b>Year</b>	<b>Total</b>	<b>Solid fuels</b>	<b>Oil and natural gas</b>
1990	4222	3310	912
1991	4098	3018	1080
1992	4081	3013	1067
1993	3994	2974	1020
1994	3876	2876	1001
1995	3817	2780	1038
1996	3789	2697	1092
1997	4136	2959	1177
1998	4546	3366	1180
1999	5544	4304	1239
2000	5890	4580	1309
2001	5481	4166	1315
2002	5028	3670	1358
2003	4861	3335	1526
2004	4751	3185	1566
2005	5420	3608	1811
2006	5791	3825	1966
2007	7683	5459	2224
2008	8167	5875	2291
2009	7904	5837	2067
2010	8018	5942	2075
2011	8774	6371	2403
2012	9027	6496	2530
2013	8021	5822	2199
2014	9786	6888	2898
2015	5117	2353	2763
2016	8158	5458	2700
2017	6311	3294	3017

#### Methodological Issues:

GHG emissions from 1.B 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 (BOTAS) (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.

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

#### Source Category Description:

This source category covers CH<sub>4</sub> emissions which occur during the surface and underground extraction of solid fuels and post-mining activities as well as abandoned underground mines. The emissions due to combustions of those fuels to support production activities is not included in this section. Under this category only fugitive CH<sub>4</sub> emissions are calculated.

Fugitive emissions from coal mining has decreased to 3294 kt CO<sub>2</sub> eq. in 2017 due to the decrease in the underground mining activities with respect to previous year.

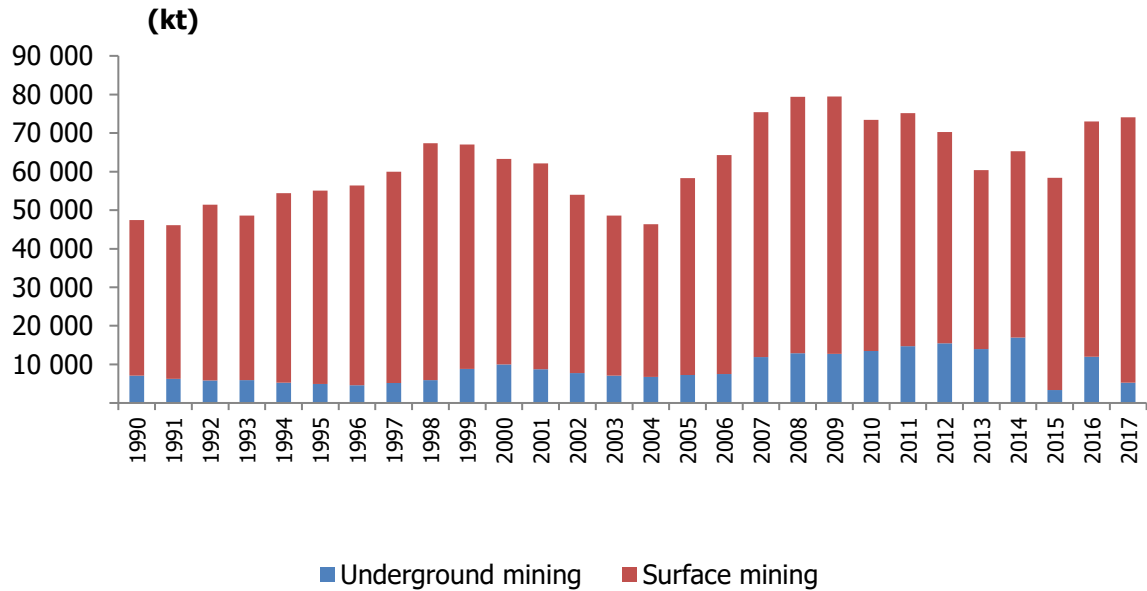
**Table 3.69 Fugitive emissions from solid fuels, 1990-2017**  
(kt)

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub> eq.
1990	NE	132.4	NO,NE	3310
1991	NE	120.7	NO,NE	3018
1992	NE	120.5	NO,NE	3013
1993	NE	119.0	NO,NE	2974
1994	NE	115.0	NO,NE	2876
1995	NE	111.2	NO,NE	2780
1996	NE	107.9	NO,NE	2697
1997	NE	118.3	NO,NE	2959
1998	NE	134.6	NO,NE	3366
1999	NE	172.2	NO,NE	4304
2000	NE	183.2	NO,NE	4580
2001	NE	166.6	NO,NE	4166
2002	NE	146.8	NO,NE	3670
2003	NE	133.4	NO,NE	3335
2004	NE	127.4	NO,NE	3185
2005	NE	144.3	NO,NE	3608
2006	NE	153.0	NO,NE	3825
2007	NE	218.4	NO,NE	5459
2008	NE	235.0	NO,NE	5875
2009	NE	233.5	NO,NE	5837
2010	NE	237.7	NO,NE	5942
2011	NE	254.8	NO,NE	6371
2012	NE	259.9	NO,NE	6496
2013	NE	232.9	NO,NE	5822
2014	NE	275.5	NO,NE	6888
2015	NE	94.1	NO,NE	2353
2016	NE	218.3	NO,NE	5458
2017	NE	131.8	NO,NE	3294

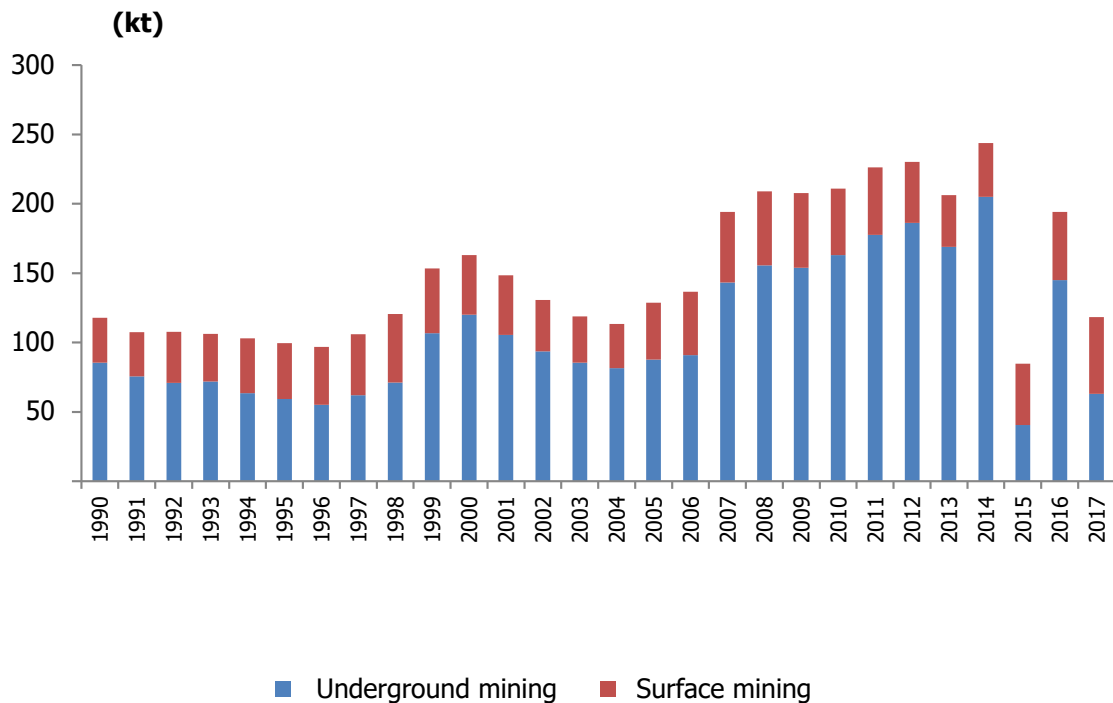
In 2017 the amount of coal mined have been increased by 1.5% and become 74098 ktons. Although the amount of coal mined have been increased, the emissions from mining activities have been

decreased. In 2017, the emissions from coal mining activities have been decreased by 39.6% and become 3294 ktons CO<sub>2</sub> eq. This is due to the decrease in the share of underground mines. In 2016 the share of underground mines was 16.5% whereas it is 7.1% in 2017.

**Figure 3.31 Domestic coal production 1990-2017**



**Figure 3.32 CH<sub>4</sub> emissions from coal mining, 1990-2017**



**Table 3.70 Fugitive emissions from abandoned coal mines,1990-2017**

Year	CO <sub>2</sub>	CH <sub>4</sub>	(kt)
			CO <sub>2</sub> eq.
1990	NE	11.5	288
1991	NE	8.1	201
1992	NE	6.6	164
1993	NE	5.6	140
1994	NE	4.9	122
1995	NE	8.2	205
1996	NE	10.8	271
1997	NE	9.1	229
1998	NE	8.0	199
1999	NE	7.1	177
2000	NE	10.2	256
2001	NE	8.9	222
2002	NE	15.6	389
2003	NE	13.2	329
2004	NE	15.3	384
2005	NE	13.3	332
2006	NE	11.8	295
2007	NE	10.6	266
2008	NE	9.7	243
2009	NE	9.0	224
2010	NE	8.3	208
2011	NE	11.6	291
2012	NE	14.2	355
2013	NE	20.1	503
2014	NE	17.2	430
2015	NE	15.2	380
2016	NE	17.5	438
2017	NE	15.5	387

### Methodological Issues:

GHG emissions from 1.B.1 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.

The fugitive emissions from abandoned underground mines are calculated with tier 2 methodology shown below.

Methane Emissions = (Number of coal mines abandoned remaining unflooded) x (Fraction of gassy mines) x (Average emission rate) x (Emission factor) x (Conversion factor) See eqn. 4.1.11 in 2006 IPCC Guidelines Volume 1. All parameter used in this equation are default values.

Fraction of gassy mines is 100%

Average emission rate is 5.735 m<sup>3</sup>/year

Emission factor is calculated as  $EF = (1+aT)^b$  where a and b are default values for either lignite or hard coal and T is the years elapsed since abandonment. The coefficients used in the calculations is given below.

**Table 3.71 Coefficients used in the calculation of abandoned coal mines methane emission**

Coal type	a	b
Hardcoal	3.72	-0.42
Lignite	0.27	-1

(Source: see eqn 4.1.12 and table 4.1.9 in 2006 IPCC Guidelines Volume 1)

### 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 Guidelines Vol.2 Table 4.1.2 and Table 4.1.4. CH<sub>4</sub>EFs uncertainty value was determined as 557%.

### Source-Specific QA/QC and Verification:

Quality control for 1.B.1 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<sub>4</sub>IEFs are in the range of 2006 IPCC Guidelines.

### Recalculation:

Fugitive methane emissions from abandoned mines were recalculated in this submission. Tier 2 methodology is used with coal rank (bituminous or sub bituminous) specific emission factors. The table below shows the effect of recalculation for abandoned coal mines with respect to 2018 submission.

**Table 3.72 Comparison on ferroalloy production emissions recalculation in 2018 and 2019 inventory submissions**

<b>Year</b>	<b>CH4 Emissions from abandoned mines in 2018 submission (kt CH<sub>4</sub>)</b>	<b>CH4 Emissions from abandoned mines in 2019 submission (kt CH<sub>4</sub>)</b>	<b>Difference in emissions (kt CO<sub>2</sub>)</b>
1990	3.1	11.5	8.4
1991	2.7	8.1	5.4
1992	2.4	6.6	4.2
1993	2.2	5.6	3.4
1994	2.0	4.9	2.9
1995	2.5	8.2	5.7
1996	2.9	10.8	7.9
1997	2.7	9.1	6.4
1998	2.6	8.0	5.4
1999	2.5	7.1	4.6
2000	2.4	10.2	7.8
2001	6.1	8.9	2.7
2002	7.0	15.6	8.5
2003	5.7	13.2	7.5
2004	6.0	15.3	9.4
2005	5.4	13.3	7.9
2006	5.0	11.8	6.8
2007	4.7	10.6	6.0
2008	4.4	9.7	5.3
2009	4.2	9.0	4.7
2010	4.0	8.3	4.3
2011	4.4	11.6	7.2
2012	4.8	14.2	9.4
2013	5.6	20.1	14.5
2014	5.4	17.2	11.8
2015	5.2	15.2	10.0
2016	5.5	17.5	12.0

As you can see from the table above, the emissions of abandoned coal mines have been increased as a result of the recalculation. This is because coal mines are classified according to the coal type in this submission and most of the abandoned mines in Turkey are lignite and lignite have larger EF with respect to Tier 1 default value in overall.

#### **Planned Improvement:**

Since the category is a key category in terms of emission trend of CH<sub>4</sub>, the tiers in CH<sub>4</sub> 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<sub>4</sub>.

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

#### **Source Category Description:**

This source category covers fugitive CO<sub>2</sub>, N<sub>2</sub>O, CH<sub>4</sub> 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 is a key category in terms of emission level and trend of CH<sub>4</sub> emission. CO<sub>2</sub> emissions are mainly coming from oil production. About 95% of CO<sub>2</sub> emissions from oil and gas systems are venting and flaring emissions during oil extraction and production. CH<sub>4</sub> 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 greenhouse gas emissions in 1.B.2 category has increased from 912 kt CO<sub>2</sub> eq. in 1990 to 3017 kt in 2017.

**Table 3.73 Fugitive emissions from oil and natural gas systems, 1990-2017**  
(kt)

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub> eq.
1990	220	27.6	0.0031	912
1991	263	32.6	0.0037	1080
1992	254	32.5	0.0035	1067
1993	231	31.5	0.0032	1020
1994	219	31.2	0.0031	1001
1995	209	33.1	0.0029	1038
1996	208	35.3	0.0029	1092
1997	206	38.8	0.0029	1177
1998	194	39.4	0.0027	1180
1999	178	42.4	0.0025	1239
2000	168	45.6	0.0023	1309
2001	155	46.4	0.0021	1315
2002	148	48.4	0.0020	1358
2003	145	55.2	0.0020	1526
2004	140	57.0	0.0019	1566
2005	142	66.8	0.0019	1811
2006	135	73.2	0.0018	1966
2007	133	83.6	0.0018	2224
2008	135	86.2	0.0018	2291
2009	138	77.1	0.0019	2067
2010	156	76.7	0.0021	2075
2011	151	90.1	0.0021	2403
2012	144	95.4	0.0020	2530
2013	146	82.1	0.0020	2199
2014	145	110.1	0.0020	2898
2015	155	104.3	0.0021	2763
2016	158	101.7	0.0022	2700
2017	157	114.4	0.0021	3017



Figure 3.33 Oil production, 1990–2017

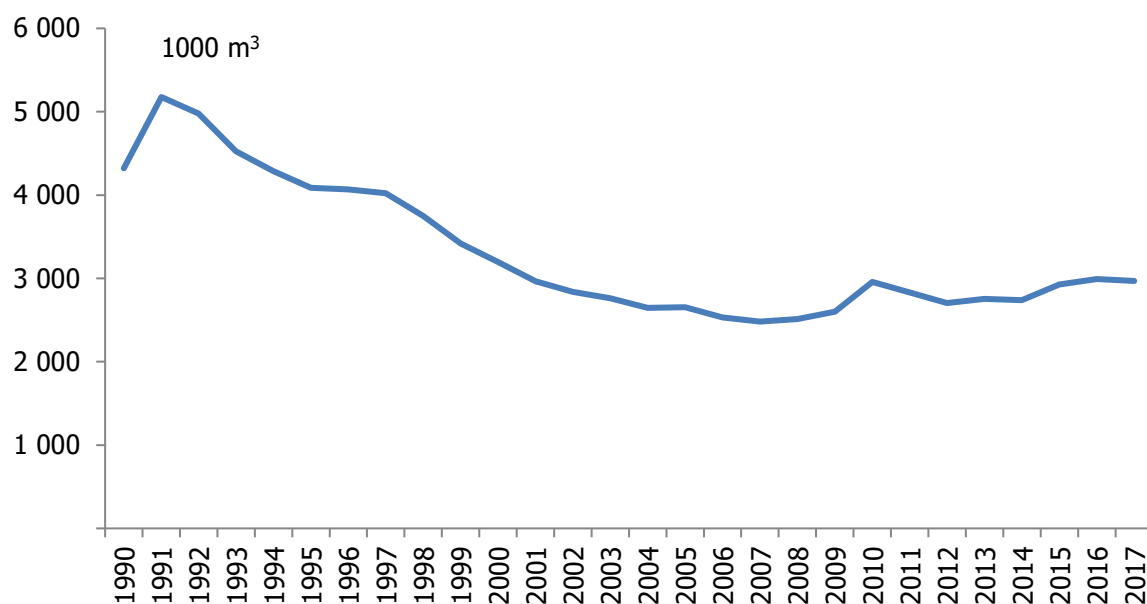
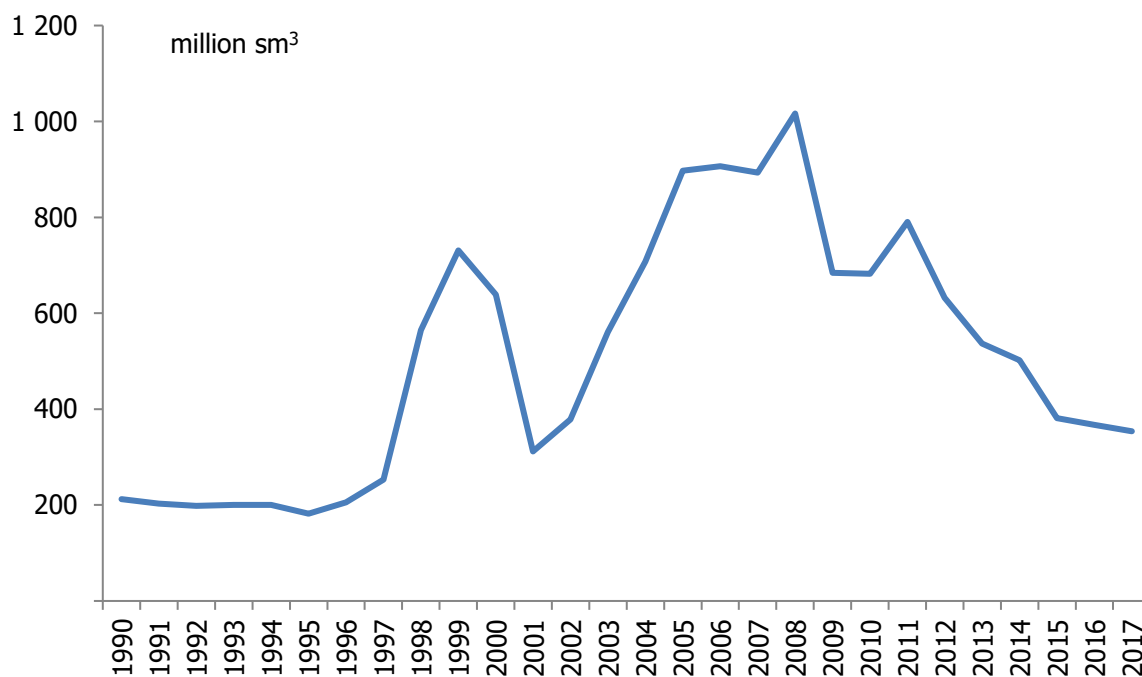
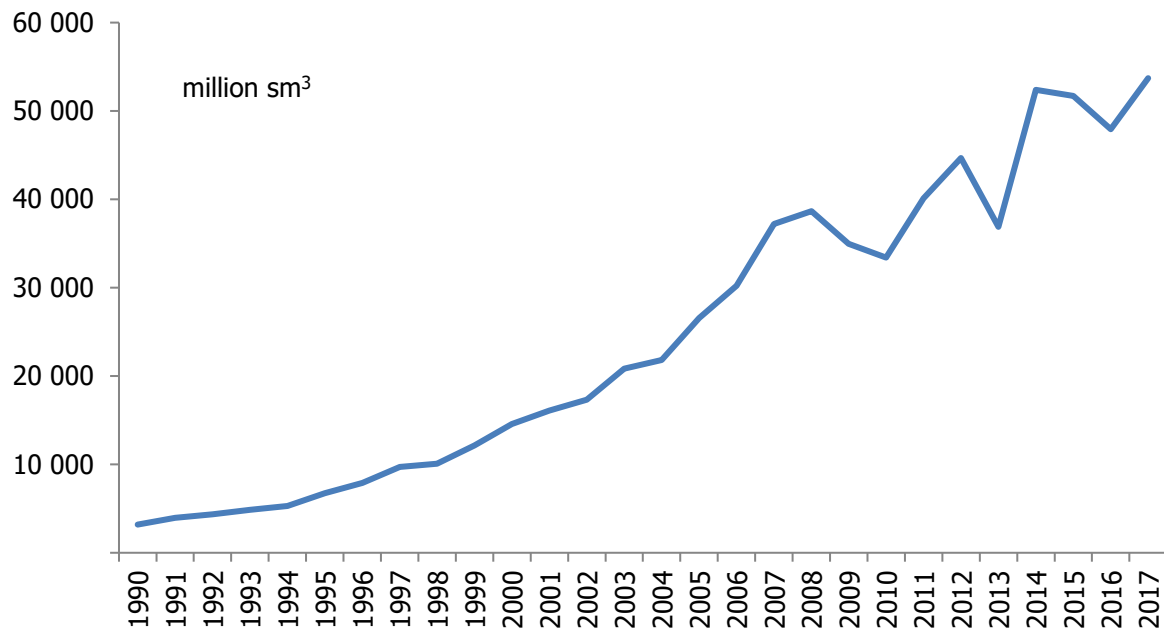
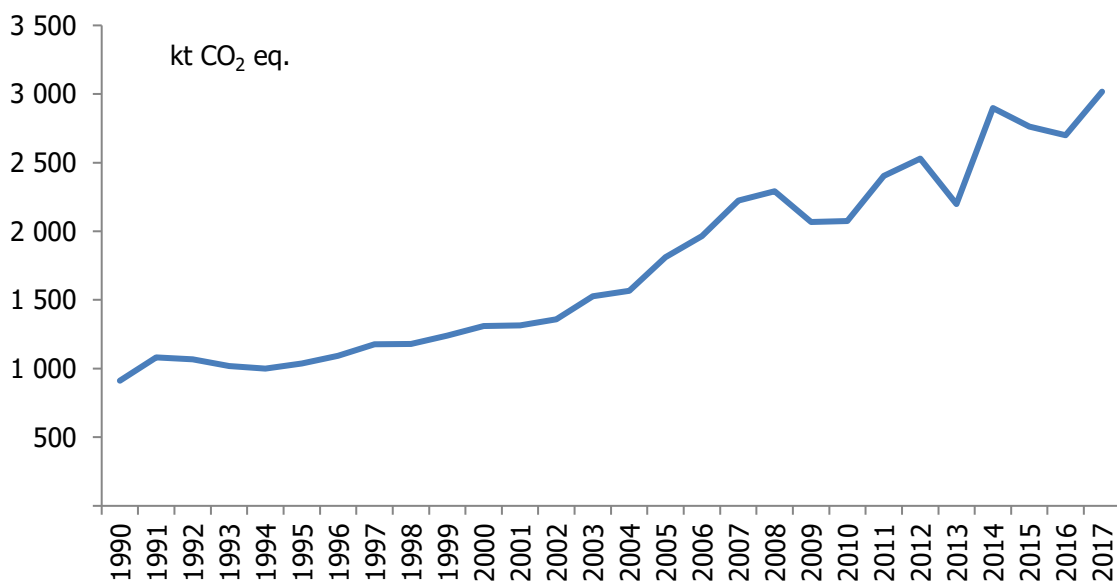


Figure 3.34 Natural gas production, 1990–2017



**Figure 3.35 Natural gas transmission by pipeline, 1990-2017****Figure 3.36 Fugitive emissions from oil and gas system, 1990-2017**

## Methodological Issues:

GHG emissions from 1.B.2 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 Guidelines default EFs. Since the category is a key category in terms of emission level and trend of CH<sub>4</sub>, the tiers in estimating CH<sub>4</sub> emission need 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 Tier 2 estimation of CH<sub>4</sub>. 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 Guidelines Vol.2 Table 4.2.4. Oil and gas systems EFs uncertainty values were determined as 334% for CO<sub>2</sub>, 356% for CH<sub>4</sub>, and 224% for N<sub>2</sub>O.

## Source-Specific QA/QC and Verification:

Quality control for 1.B.2 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<sub>4</sub> 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<sub>2</sub> Transport and Storage (Category 1.C)****Source Category Description:**

This source category covers only fugitive CO<sub>2</sub> from pipeline transportation of CO<sub>2</sub>. This source category is not a key category. CO<sub>2</sub> emissions were calculated on the basis of pipeline length as 0.126 kt for whole 1990-2017 period.

**Methodological Issues:**

CO<sub>2</sub> emissions from 1C sector were calculated by using 2006 IPCC Tier 1 approaches by TurkStat. Pipeline length was obtained from Turkish Petroleum Incorporation. Pipeline length has not changed with respect to the previous inventory year. Fugitive CO<sub>2</sub> emissions from CRF category 1C were estimated by using 2006 IPCC Guidelines 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 Guidelines 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 Guidelines Vol.2 Table 5.2. Uncertainty values were considered as 200% for CO<sub>2</sub>.

**Recalculation:**

There is no recalculation in this category.

**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<sub>2</sub> 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 15.6% to the total anthropogenic GHG emissions in Turkey in 2017 (Table 4.1), in total 66 454 kt CO<sub>2</sub> eq.

**Table 4.1 Industrial processes and product use sector CO<sub>2</sub>eq. emissions, 2017**  
(kt CO<sub>2</sub> eq.)

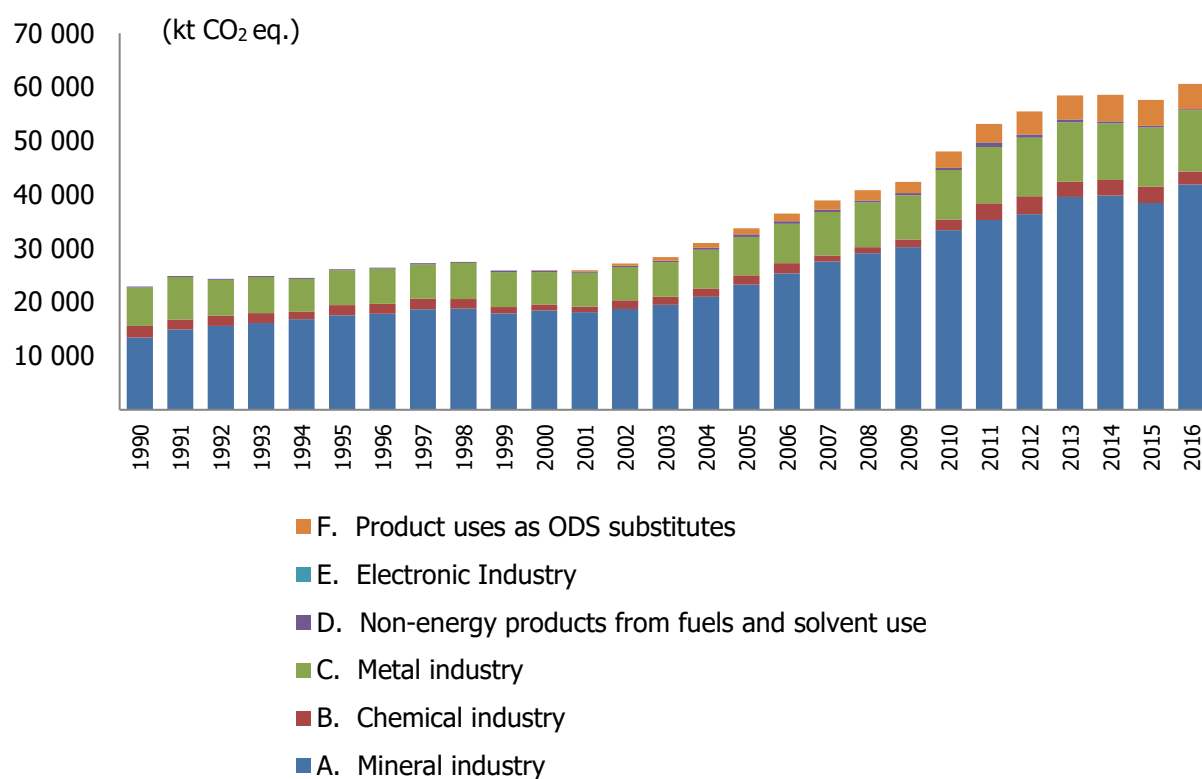
GHG sources and sink categories	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	HFCs /PFCs/SF <sub>6</sub>	Total
<b>Industrial processes and product use</b>	56 980	16	1 263	8 195	66 455
A. Mineral industry	44 274	NA	NA	NA	44 274
B. Chemical industry	2 004	NO,IE,NA	1 263	NA	2 004
C. Metal industry	11 853	16	NA	73	11 903
D. Non-energy products from fuels and solvent use	152	NA,NE	NA,NE	NA	152
E. Electronic Industry	NA	NA	NA	0.1	0.1
F. Product uses as ODS substitutes	NA	NA	NA	8 049	8 049
G. Other product manufacture and use	NA	NA	NA	73	73
H. Other	NE	NE	NA	NE,IE	NE,IE

The most important GHG emission sources of IPPU in 2017 were CO<sub>2</sub> emissions from cement production and iron and steel production, with 7.1% and 2.2% shares of the total national GHG emissions, respectively.

The mineral industry contributed 66.6% of the sector's emissions, the metal industry contributed 17.9%, product uses as ODS substitutes contributed 12.1%, while the chemical industry contributed 3%.

The main gas emitted by the IPPU sector in 2017 was CO<sub>2</sub>, contributing 85.7% (56 980 kt) of the sector emissions in 2017. HFCs, PFCs and SF<sub>6</sub> contributed 12.3% (8 195 kt CO<sub>2</sub> eq.) while the share of N<sub>2</sub>O emissions was 1.9% (1 263 kt CO<sub>2</sub> eq.) and CH<sub>4</sub> emissions was 0.03% (18 kt CO<sub>2</sub> eq.).

**Figure 4.1 Emissions from industrial processes and product use by subsector, 1990–2017**



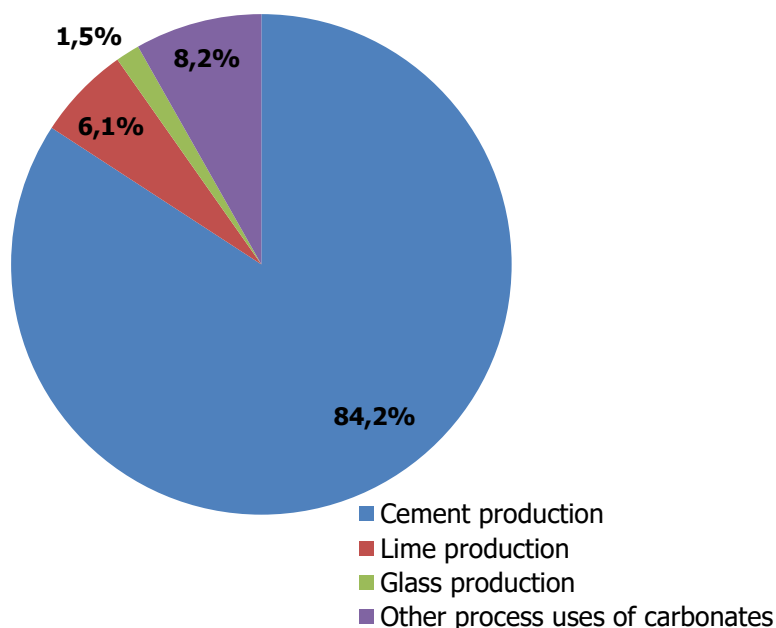
Total emissions from industrial process and product use increased by 191% between 1990 (22 836 kt CO<sub>2</sub> eq.) and 2017, and increased 6.9% between 2016 and 2017. The increases in sectoral emissions observed over the longer term are principally due to growth in emissions associated with the mineral 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 2017 is shown in Figure 4.1.

## 4.2. Mineral Industry (Category 2.A)

Non-fuel CO<sub>2</sub> 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<sub>2</sub> emissions in this category. The major share (84.2%) results from 2A1 cement production, 6.1% from 2A3 lime production and 8.2% from 2A4 other process uses of carbonates. Glass production is responsible for 1.5% of emissions in the mineral industry.

**Figure 4.2 Share of CO<sub>2</sub> emissions from mineral production, 2017**



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

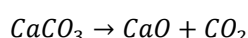
#### Source Category Description:

Cement production causes CO<sub>2</sub> 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.

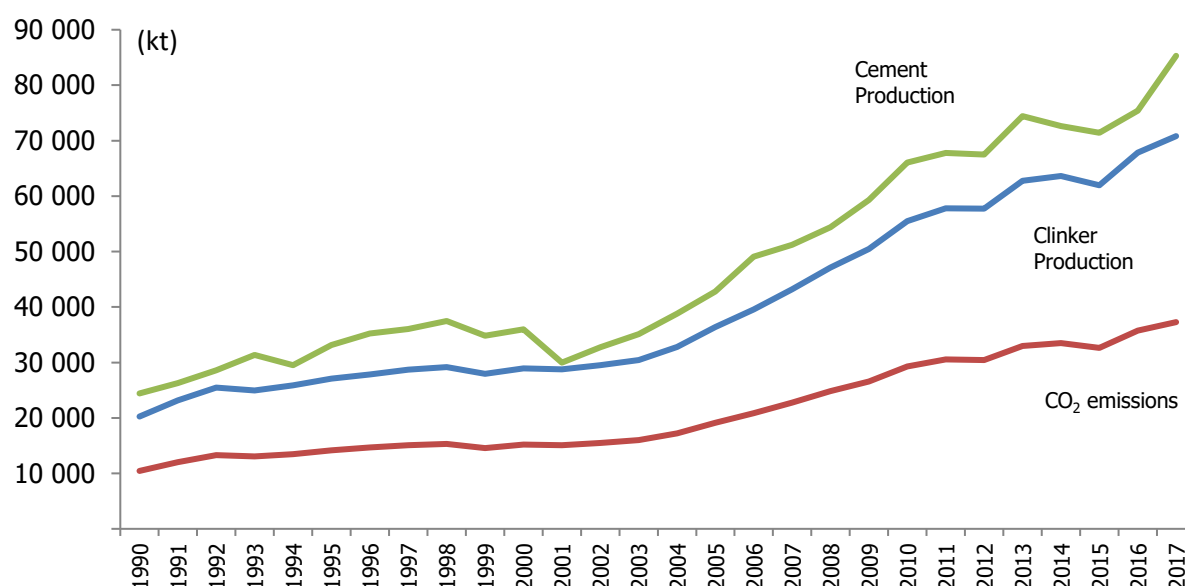
In cement production, limestone is fed to the cement kiln and heated up to 1400-1500 °C to produce lime. At this temperature calcium carbonate ( $\text{CaCO}_3$ ) breaks into lime ( $\text{CaO}$ ) and carbon dioxide ( $\text{CO}_2$ ). The reaction is shown below.



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  $\text{CO}_2$  emissions are released from the kilns during the clinker production step.

Figure 4.3 below shows the trend at clinker production and the related  $\text{CO}_2$  emissions between 1990 and 2017.

**Figure 4.3 Trend at clinker, cement production and related  $\text{CO}_2$  emissions, 1990-2017**



Turkey started cement production in 1911 and Turkey was a cement importer till 1970s. Turkey started exporting cement in 1978. By 2017, Turkey is the Europe's biggest cement producer with its 75 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<sub>2</sub> emissions increased by 257% between 1990 and 2017. Except some minor reductions in 2001 due to Turkey's economic recessions and in 2015 due to conflict 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. In 2015, 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 2017 clinker production was 70 813ktons (94% capacity is used) and it caused 37 272 kt of CO<sub>2</sub> emission.

### Methodological Issues:

Estimation of CO<sub>2</sub> emissions is accomplished by applying a country-specific EF, in tonnes of CO<sub>2</sub> 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.

$$CO_2 \text{ emissions} = M_{Cl} * EF_{Cl} * CF_{CKD}$$

Where:

CO<sub>2</sub> Emissions = emissions of CO<sub>2</sub> from cement production, tonnes

M<sub>cl</sub> = weight (mass) of clinker produced, tonnes

EF<sub>cl</sub> = emission factor for clinker, tonnes CO<sub>2</sub>/tonne clinker

CF<sub>ckd</sub> = emissions correction factor for CKD, dimensionless

### Collection of activity data

There are 54 cement plants in Turkey spread all over Turkey. Most of the cement plants in Turkey are members of Turkish Cement Manufacturers Assembly (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

In the 2016 inventory, 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 65.8% in 2015. The corresponding EF in 2015 is 0.515913. This study reveals that CaO content does not vary thorough out the years and was not iterated again for the latest inventory. 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<sub>2</sub> emissions from clinker production are tabulated.

**Table 4.3 CO<sub>2</sub> emissions from cement production, 1990-2017**

Year	Clinker Production (kt)	Cemet Production (kt)	CaO Content (%)	CO <sub>2</sub> EF	CKD	CO <sub>2</sub> 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
2016	67 856	75 403	65.8	0.516	1.02	35 716
2017	70 813	80 552	65,8	0.516	1.02	37 272

### Uncertainties and Time-Series Consistency:

The uncertainty value of the AD was estimated to be  $\pm 5\%$  with error propagation equations. 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 2017. The uncertainty value of the EF is 2% due to chemical analysis of clinker to determine CaO percentage and default factor used for CKD. Moreover, Monte Carlo analysis has been carried out for the CO<sub>2</sub> emissions from cement production, for the reporting year 2009 and it resulted with -4.97% to +5.02% uncertainty. Further information about Monte Carlo analysis of cement production can be seen in Uncertainty chapter (Annex 2).

### Source-Specific QA/QC and Verification:

Clinker production data is gathered by the 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 is also asked for quality assurance purpose in 2017. Details of this study can be found in inventory submitted in 2018. In this submission emission calculation was done by using two different calculation tools by two people. One is typically Excel based while the other is oracle and software coding based. The results of two different tool was compared to minimize calculation error.

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. In 2018, one of the clinker production plant visited and discussed on CKD data. According to the researches, due to the production system is sealed, it was assumed there is no kiln dust. So, in its emission calculation, plants do not report CKD to the Ministry of Environment and Urbanization. However, there is no enough information for other plant

### Recalculation:

There is no recalculation in this sector for the 2017 inventory year.

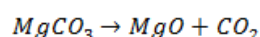
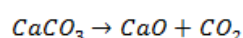
### Planned improvements:

Turkey recently made improvements in the representativeness of the country specific carbonate content of the clinker. In 2018, one of the clinker production plant visited and discussed on CKD data. According to the researches, due to the production system is sealed, it was assumed there is no kiln dust. So, in its emission calculation, plants do not report CKD to the Ministry of Environment and Urbanization. However, there is no enough information for other plants, CKD is still assumed as 2% of the total emissions. 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<sub>2</sub> is generated during the calcination stage, when limestone (CaCO<sub>3</sub>) are burned at high temperature (900-1200°C) in a kiln to produce quicklime (CaO) and CO<sub>2</sub> is released in the atmosphere. Magnesium carbonate (MgCO<sub>3</sub>) breaks into MgO and CO<sub>2</sub> in the same manner. The calcination reactions are shown below in the chemical equations.



Lime production results in CO<sub>2</sub> 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.2.f CRF category. The following table shows allocation of lime production emissions in the CRF categories.

**Table 4.4 Allocation of lime production emissions**

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

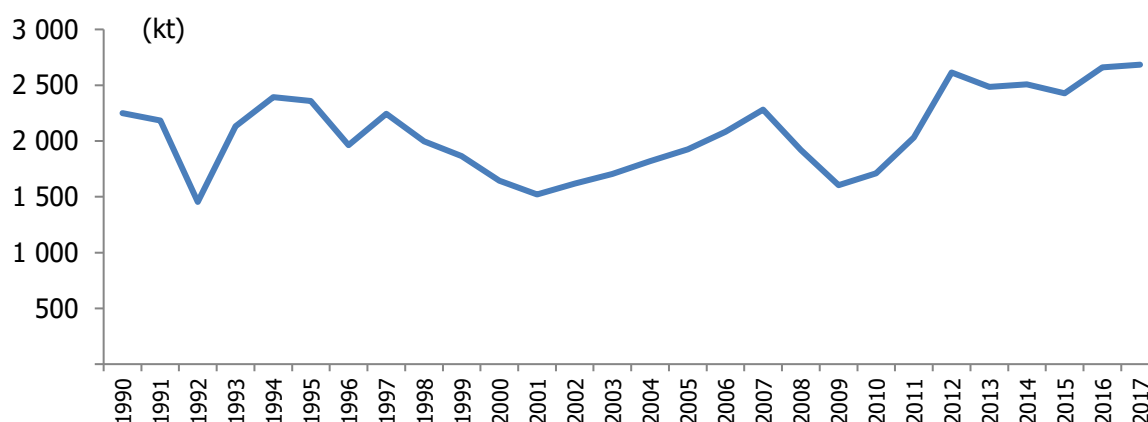
In Turkey lime is produced by a wide range of technology from old fashioned kilns to computer controlled plants. Most of the lime plants in Turkey are technologically new or modified to best available technologies. The old technology lime plants are minority in Turkey and their number is decreasing every 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 use. Sugar refiners and soda ash producers however use the

produced CO<sub>2</sub> in their process steps and CO<sub>2</sub> is absorbed. Therefore, lime production of the sugar refiners and soda ash producers do not contribute to the greenhouse gas inventory.

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

The figure 4.4 shows the trend at lime production and the related CO<sub>2</sub> emissions between 1990 and 2017. The lime produced in Turkey is mostly used in the manufacturing and construction sector. Emissions from lime production are increased by 18.7% between 1990 and 2016. 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<sub>2</sub> emissions from lime production, 1990-2017**



### Methodological Issues:

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

$$CO_2 \text{ emissions} = (M_{ql} - M_{cl}) \times EF_{ql} + M_{dl} \times EF_{dl}$$

Where:

CO<sub>2</sub>emissions = emissions of CO<sub>2</sub> from lime production, tonnes

M<sub>ql</sub> = Production of quick lime

M<sub>cl</sub> = Amount of captive lime (non emissive quick lime production)

M<sub>dl</sub> = Production of dolomitic lime

EF<sub>ql</sub> = Emission factor for quick lime

EF<sub>dl</sub> = Emission factor for dolomitic lime

In sugar industry lime is produced for sugar refining. Both the quick lime and the  $\text{CO}_2$  is used for precipitating the impurities in the sugar. In the Turkish inventory it is assumed that all the  $\text{CO}_2$  produced in lime production for sugar refining is precipitating and no  $\text{CO}_2$  is emitted. Also in the soda ash production with solvay process, lime is produced and the resulting  $\text{CO}_2$  is used in the process as an intermediate product. It is assumed that all the  $\text{CO}_2$  produced from limestone in the soda ash production process is captured and no  $\text{CO}_2$  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 estimated emissions to account for emissions from production of hydrated lime or lime kiln dust.

### **Collection of activity data**

Quick lime ( $\text{CaO}$ ) production data are collected from the Lime Producers Association (KİSAD). KİSAD gathers 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 steel plants and the sum is assumed to be the national dolomitic lime production data.

**Table 4.5 Lime production and CO<sub>2</sub> emissions, 1990-2017**

(kt)				
Year	Quick Lime Production	Quick Lime produced for sugar industry and synthetic soda ash production	Dolomitic lime production	CO <sub>2</sub> Emissions
1990	4 000	233	47	2 249
1991	3 930	280	47	2 183
1992	2 775	286	51	1 454
1993	3 860	297	57	2 133
1994	4 168	298	61	2 394
1995	4 090	334	66	2 359
1996	3 575	350	67	1 961
1997	4 049	360	72	2 245
1998	3 789	427	71	1 997
1999	3 527	465	72	1 864
2000	3 241	473	72	1 645
2001	2 972	477	76	1 520
2002	3 150	485	83	1 620
2003	3 231	491	92	1 704
2004	3 380	497	103	1 819
2005	3 584	506	106	1 925
2006	3 735	536	118	2 083
2007	3 952	575	129	2 280
2008	3 385	578	135	1 920
2009	2 877	558	127	1 605
2010	3 225	703	147	1 711
2011	3 819	747	171	2 031
2012	4 621	666	180	2 615
2013	4 400	715	174	2 486
2014	4 443	704	171	2 507
2015	4 325	683	158	2 429
2016	4 695	713	167	2 660
2017	4 868	863	189	2 684

## Choice of emission factor

Country specific emission factor is used for quick lime whereas default emission factor is used for dolomitic lime (0.77 tonnes CO<sub>2</sub> per tonne lime) from the 2006 IPCC 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 in 2016. By averaging on weight basis, the country specific CaO content of quick lime is calculated. Due to the stable trend in CaO content, this study was not iterated for the latest inventory and the 2015 value was used for the 2016 and 2017 inventories. The table below shows the average CaO content of quicklime and corresponding EF for each year.

**Table 4.6 Quick lime emission factors, 1990-2017**

Year	Turkey's total quick lime production (kt)	Total quick lime production of the plants reporting CaO content (kt)	CaO content (%)	County specific emission factor	Representativeness (%)
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
2016	4 695	1 854	88.3	0.693	42.9
2017	4 868	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  $\pm 10\%$  uncertainty for the activity data is estimated.



The uncertainty value of the EF is estimated to be  $\pm 6\%$  as there is uncertainty in assuming the average CaO in lime with Approach 1.

In this submission, uncertainty in CO<sub>2</sub> emissions from category 2.A.2 was quantified using the Monte Carlo simulation. Uncertainty in CO<sub>2</sub> emissions in 2017 is estimated at -12.29 % to +12.90%. According to the simulation results, most of the uncertainty is related to the activity data for estimating the amount of lime production. Further information about Monte Carlo analysis of cement production can be seen in Uncertainty chapter (Annex).

### Source-Specific QA/QC and Verification:

Plant specific lime production data from KISAD is compared with ILA (International Lime Association) Although ILA report is based on the sales, KISAD data and ILA data are found to be consistent. ILA reports 4 500 kilotons of lime sales in Turkey while KISAD reports 4 868 kilotons of lime production in Turkey in 2017. (<https://www.internationallime.org/world-lime-production/>)

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.

In this submission emission calculation was done by using two different calculation tools by two people. One is typically Excel based while the other is oracle and software coding based. The results of two different tool was compared to minimize calculation error.

### Recalculations:

The amount of dolomitic lime produced in electric arc furnaces was revised due to the change of data source. Previously, the data from General Directorate of Renewable Energy Sources was used. Due to the sustainability problem of the data, it is assumed that lime produced in electric arc furnaces is 5% of total steel production.

**Table 4.7 Comparison on lime production emissions recalculation in the 2018 and 2019 inventory submissions**

Year	CO <sub>2</sub> emissions from lime production in 2018 inventory (kt)	CO <sub>2</sub> emissions from lime production in 2019 inventory (kt)	Difference in emissions (kt)	Percentual difference (%)
1990	2 252	2 249	- 3	-0,1
1991	2 187	2 183	- 3	-0,1
1992	1 457	1 454	- 4	-0,2
1993	2 137	2 133	- 4	-0,2
1994	2 398	2 394	- 4	-0,2
1995	2 363	2 359	- 5	-0,2
1996	1 966	1 961	- 5	-0,2
1997	2 250	2 245	- 5	-0,2
1998	2 002	1 997	- 5	-0,2
1999	1 869	1 864	- 5	-0,3
2000	1 650	1 645	- 5	-0,3
2001	1 525	1 520	- 5	-0,3
2002	1 625	1 620	- 6	-0,4
2003	1 711	1 704	- 6	-0,4
2004	1 826	1 819	- 7	-0,4
2005	1 932	1 925	- 7	-0,4
2006	2 091	2 083	- 8	-0,4
2007	2 289	2 280	- 9	-0,4
2008	1 929	1 920	- 9	-0,5
2009	1 614	1 605	- 9	-0,5
2010	1 721	1 711	- 10	-0,6
2011	2 043	2 031	- 12	-0,6
2012	2 627	2 615	- 12	-0,5
2013	2 494	2 486	- 8	-0,3
2014	2 530	2 507	- 23	-0,9
2015	2 432	2 429	- 4	-0,1
2016	2 673	2 660	- 13	-0,5

## Planned Improvement:

It is planned to obtain a country specific emission factor for dolomitic lime in next submissions.

## 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<sub>2</sub> 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<sub>2</sub> emissions. During glass production carbon based fuels are burnt in order to melt the glass batch and as a result of this CO<sub>2</sub> emissions, which are reported under 1.A.2.f CRF category, are emitted. Table below shows allocation of glass production emissions in the CRF categories.

**Table 4.8 Allocations of glass production emissions**

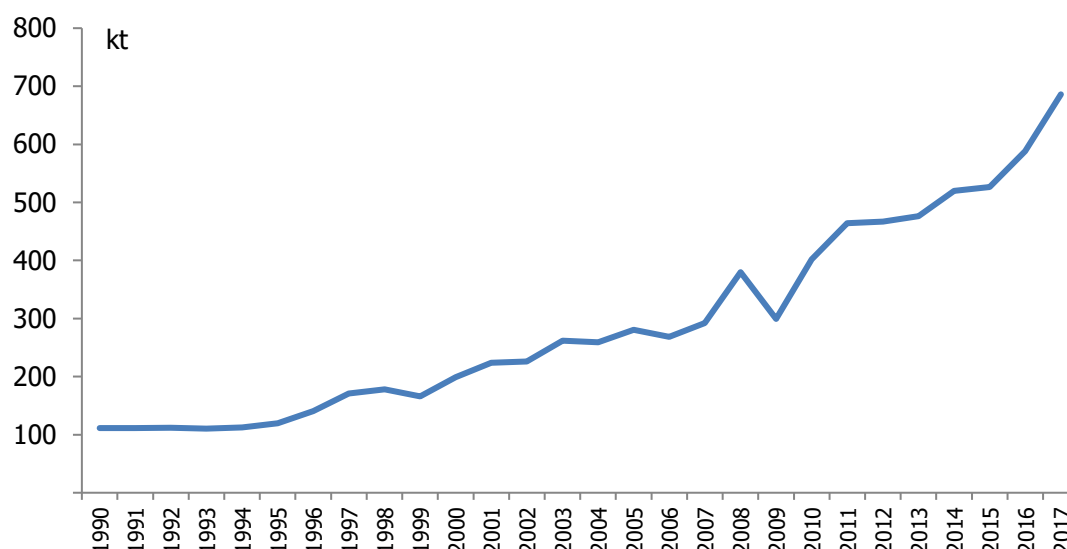
CRF category	Emission source
CRF 2.A.3	Emissions from calcination reactions during production
CRF 1.A.2.f	Emissions from fuel consuming for the energy demand of the production process.

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 Paşabahçe in 1935 with a production capacity of only 3 kt. Turkey glass industry production peaked 4.3Mt in 2017 and it was 3.9 Mt in 2016. 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 (1.13 Mt molten glass produced) and 2017 (4.4 Mt molten glass produced), increasing 288%. By 2017, Turkey is Europe's second and the world's fifth biggest float glass producer.

The trend in CO<sub>2</sub> emissions from glass production is given in the Figure 4.5. The emissions are increasing in general due to increasing glass production in Turkey. The time series shows a considerable decrease in 2009 due to effects of global economic recession in that year.

**Figure 4.5 CO<sub>2</sub> emissions from glass production, 1990-2017**



## Methodological Issues:

Estimation is based on the T3 method described in the 2006 IPCC Guidelines. Specifically, the calculation based on accounting for the carbonate input to the glass melting furnace

$$CO_2 \text{ Emissions} = \sum_i (M_i \cdot EF_i \cdot F_i)$$

Where:

CO<sub>2</sub> Emissions = emissions of CO<sub>2</sub> from glass production, tonnes

EF<sub>i</sub> = emission factor for particular carbonate i, tonnes CO<sub>2</sub>/tonne carbonate

M<sub>i</sub>=weight or mass of the carbonate i consumed (mined), tonnes

F<sub>i</sub> = fraction calcination achieved for the carbonate i, fraction

## Collection of activity data

Turkey produces float glass, container glass (including household glassware) and fiberglass for insulation. Total glass production of Turkey is done by 5 companies. Activity data of molten glass production by glass type and carbonate input directly from the plant for all the years 1990-2017.

In the following table, total CO<sub>2</sub> emissions and glass production by type are given.

**Table 4.9 Molten glass production and CO<sub>2</sub> emissions by type of glass, 1990-2017 (kt)**

Year	Total Glass Production	Float Glass	Container (households + bottles)	Fiberglass	Total CO <sub>2</sub> emissions
1990	1 129	650	146	310	111
1991	1 113	669	134	293	111
1992	1 157	625	162	346	112
1993	1 163	606	174	359	110
1994	1 183	614	194	353	112
1995	1 290	625	267	376	120
1996	1 541	748	324	448	141
1997	1 789	782	436	542	171
1998	1 846	824	429	561	178
1999	1 681	771	361	517	166
2000	1 934	974	433	489	199
2001	1 843	880	389	530	224
2002	1 870	870	386	569	226
2003	2 069	991	426	590	262
2004	2 119	1002	442	605	259
2005	2 175	1016	443	642	280
2006	2 090	938	389	691	269
2007	2 427	1141	418	795	292
2008	2 754	1385	440	859	380
2009	2 174	1075	360	688	299
2010	2 800	1452	433	861	402
2011	3 169	1746	425	923	464
2012	3 106	1525	456	1043	467
2013	3 186	1624	422	1063	476
2014	3 560	1876	407	1211	520
2015	3 444	1661	389	1329	526
2016	3 982	1996	350	1584	588
2017	4 375	2305	287	1736	686

According to the figures in table above, glass production shows a steady increase for the years 2002-2008 after the economic recession years of 1999-2001 of Turkey (1 870 kt in 2002 and 2 754 kt in 2008). The production decreased in the year 2009 (2 174 kt) due to the global economic recession. Then it showed a general trend of growth till 2017 (4 375 kt). In 2017 the growth is continued and total glass production become 4 375 kt, and CO<sub>2</sub> emissions become 686 kt.

## Choice of emission factor

CO<sub>2</sub> emissions are calculated using the 2006 IPCC Guidelines Volume 3 default EFs for the carbonates (Table 2.1). The emission factors for each type of carbonate are given below.

**Table 4.10 EFs for carbonates, 1990-2017**

<b>Carbonate</b>	<b>EF (tonnes CO<sub>2</sub>/tonne carbonates)</b>
Sodium carbonate or soda ash	0.41492
Limestone	0.43971
Dolomite	0.47732

## Uncertainties and Time-Series Consistency:

Due to emissions from glass production are estimated based on the carbonate input (Tier 3), the emission factor uncertainty is relatively low because the emission factor is based on a stoichiometric ratio. There may be some uncertainty associated with assuming that there is 100 percent calcination of the carbonate input (1%). Emission factor uncertainty is assumed as 3% while the emission factor for activity data is assumed %3 under the Tier 3 approach.

## Source-Specific QA/QC and Verification:

Data gathered from companies are compared reported data to the Ministry of Environment and Urbanization under the "Monitoring, Reporting and Verification" regulation. In this submission emission calculation was done by using two different calculation tools by two people. One is typically Excel based while the other is oracle and software coding based. The results of two different tool was compared to minimize calculation error.

## Recalculation:

In this inventory calculation method totally changed from Tier 2 to Tier 3 by using carbonate input to the process. Effect of recalculation can be seen from the table below. During this methodology change, some assumption previously made was changed. Previously, total glass production was estimated by using biggest glass production company. In this submission, other producers were also contacted and their production data was collected in addition to their raw material consumption.

**Table 4.11 Comparison on glass production emissions recalculation in 2018 and 2019 inventory submissions**

					(kt)
Year	Glass production emissions in 2018 Inventory	Glass production emissions in 2019 Inventory	Difference	Percent difference (%)	
1990	198	111	-87	-44	
1991	182	111	-70	-39	
1992	198	112	-86	-44	
1993	201	110	-91	-45	
1994	206	112	-94	-45	
1995	225	120	-106	-47	
1996	267	141	-127	-47	
1997	310	171	-139	-45	
1998	323	178	-145	-45	
1999	287	166	-121	-42	
2000	330	199	-131	-40	
2001	331	224	-107	-32	
2002	317	226	-91	-29	
2003	364	262	-102	-28	
2004	372	259	-113	-30	
2005	387	280	-106	-27	
2006	368	269	-99	-27	
2007	433	292	-141	-33	
2008	490	380	-110	-22	
2009	377	299	-78	-21	
2010	440	402	-38	-9	
2011	497	464	-33	-7	
2012	474	467	-7	-2	
2013	467	476	9	2	
2014	464	520	56	12	
2015	470	526	57	12	
2016	502	588	86	17	

#### Planned Improvements:

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 and bricks and roof tile are reported. Between 1990 (433.7 kt CO<sub>2</sub>eq) and 2017 (3 218 kt CO<sub>2</sub>eq) emissions have increased by over 642%, driven largely by the increase in CO<sub>2</sub> emissions from bricks production (1 279 kt CO<sub>2</sub> increase between 1990 and 2017).

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

### Source Category Description:

Ceramics production is a source of CO<sub>2</sub> 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 4.12 Allocations of ceramic production emissions**

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

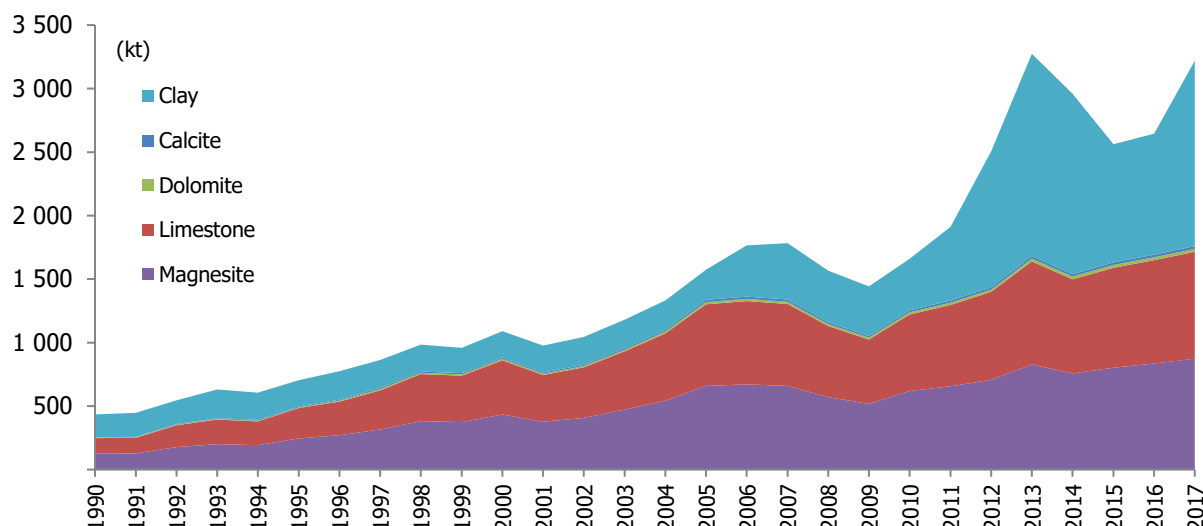
The Turkish ceramics industry, which started production in an industrial sense, has become one of the largest ceramics manufacturers in the world in the last 50 years, which may be deemed quite short. It's becoming the third largest manufacturer in Europe in tiles with a production of 5 280 kilotons 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 include the production of vitrified clay pipes, refractory products, expanded clay products, wall and floor tiles, table and ornamental ware, sanitary ware bricks and tile.

CO<sub>2</sub> emissions from ceramic production show an increasing trend for the years 1990-2017 overall. In 2017, ceramic production and the resulting CO<sub>2</sub> emissions increased by 53% with respect to 2016.



**Figure 4.6 CO<sub>2</sub> emissions, by raw materials type, from ceramics, 1990-2017**



## 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<sub>2</sub> emissions.

$$CO_2 \text{ emissions} = \sum (M_i * EF_i)$$

Where:

CO<sub>2</sub>Emissions = emissions of CO<sub>2</sub> from other process uses of carbonates, tonnes

M<sub>i</sub>= mass of limestone or dolomite respectively (consumption), tonnes.

EF<sub>i</sub>= emission factor for carbonate calcination, tonnes CO<sub>2</sub>/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 the time series 1990-2017. The amount of bricks and tile are gathered by Turkish Statistical Institute for the years 1990-1999 and 2005-2017. Data gaps for the years 2000-2004 is estimated. In this calculation following assumptions are made by using one of the plant data

1 m<sup>3</sup> brick= 600 kg,

1 brick = 4 kg,

1 tile = 3 kg,

Kg clay = 1.3\*kg bricks and tile

**Table 4.13 Raw material consumption and production, 1990-2017**

Year	Raw Material (kt)					Product (kt)			Total Product(kt)
	Calcite	Limestone	Dolomite	Magnesite-hydro magnesite	Clay	Ceramic tile	Sanitary ware	Bricks and tile	
1990	7	278	7	240	5 832	884	47	4 486	5 417
1991	9	282	9	243	6 102	1 020	56	4 694	5 769
1992	10	392	10	338	6 059	1 207	56	4 661	5 924
1993	12	444	12	382	7 342	1 428	59	5 648	7 135
1994	13	426	13	367	6 987	1 576	71	5 375	7 022
1995	15	544	15	469	6 712	1 819	78	5 163	7 060
1996	17	602	17	519	7 275	2 054	87	5 596	7 736
1997	21	701	21	605	7 182	2 514	102	5 524	8 140
1998	22	846	22	729	6 890	2 618	102	5 300	8 021
1999	21	832	21	717	6 474	2 550	106	4 980	7 636
2000	25	968	25	834	6 675	2 975	114	5 135	8 224
2001	22	836	22	720	6 876	2 559	109	5 289	7 957
2002	23	904	23	779	7 077	2 763	124	5 444	8 330
2003	27	1048	27	903	7 278	3 205	141	5 599	8 944
2004	31	1206	31	1 039	7 479	3 672	177	5 753	9 602
2005	37	1464	37	1 262	7 685	4 437	237	5 912	10 585
2006	38	1491	38	1 285	13 118	4 505	254	10 090	14 849
2007	37	1466	37	1 264	14 409	4 420	260	11 084	15 764
2008	32	1270	32	1 095	13 244	3 825	230	10 188	14 243
2009	29	1153	29	994	12 709	3 485	195	9 776	13 456
2010	35	1373	35	1 184	13 211	4 165	220	10 162	14 547
2011	37	1458	37	1 257	18 896	4 420	245	14 535	19 200
2012	40	1572	40	1 355	34 800	4 760	260	26 769	31 789
2013	47	1842	47	1 588	51 733	5 610	270	39 794	45 674
2014	43	1685	43	1 453	46 182	5 100	280	35 525	40 905
2015	46	1786	46	1 540	30 228	5 280	300	23 253	28 833
2016	47	1854	47	1 598	30 920	5 610	310	23 785	29 705
2017	49	1 912	49	1 675	47 388	5 755	352	36 452	42 559

## 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. EF for clay is calculated by using 7% CS carbon content of clay and default emission factor of calcite and limestone. To determine the average carbon content in clay, 11 plants were asked their raw material analysis result. This reveal that average carbon content in clay is around 7%.

**Table 4.14 Carbonate EFs for all years in the time series**

<b>Carbonate</b>	<b>EF (tonnes CO<sub>2</sub>/ton carbonate)</b>
Calcite and limestone	0.43971
Dolomite	0.47732
Magnesite	0.52197
Clay	0.03077

Source: Table 2.1 of the 2006 IPCC Guidelines, Vol. 3

CO<sub>2</sub> emissions from each raw material are given in the table below and Figure 4.6.

**Table 4.15 CO<sub>2</sub> emissions from raw material consumption, 1990-2017**  
(kt)

<b>Year</b>	<b>Calcite</b>	<b>Limestone</b>	<b>Dolomite</b>	<b>Magnesite</b>	<b>Clay</b>	<b>Total</b>
1990	3.3	122.2	3.6	125.1	179.5	433.7
1991	3.8	124.2	4.1	127.0	187.8	446.9
1992	4.4	172.4	4.8	176.4	186.5	544.6
1993	5.2	195.0	5.7	199.6	226.0	631.5
1994	5.8	187.1	6.3	191.5	215.1	605.8
1995	6.7	239.1	7.2	244.7	206.6	704.4
1996	7.5	264.6	8.1	270.8	223.9	774.9
1997	9.2	308.4	10.0	315.6	221.0	864.3
1998	9.6	372.1	10.4	380.7	212.1	984.8
1999	9.3	365.8	10.1	374.4	199.3	959.0
2000	10.9	425.4	11.8	435.4	205.5	1 088.9
2001	9.8	367.4	10.6	376.0	211.6	975.5
2002	10.2	397.5	11.0	406.8	217.8	1 043.3
2003	11.8	460.7	12.8	471.4	224.0	1 180.6
2004	13.5	530.1	14.7	542.5	230.2	1 331.0
2005	16.4	643.6	17.8	658.7	236.6	1 573.1
2006	16.7	655.4	18.2	670.7	403.8	1 764.9
2007	16.5	644.5	17.9	659.6	443.5	1 781.9
2008	14.3	558.4	15.5	571.5	407.7	1 567.3
2009	12.9	506.8	14.1	518.6	391.2	1 443.6
2010	15.4	603.9	16.7	618.0	406.6	1 660.7
2011	16.4	641.0	17.8	656.0	581.6	1 912.8
2012	17.7	691.3	19.2	707.5	1 071.1	2 506.8
2013	20.7	809.8	22.5	828.7	1 592.3	3 273.9
2014	18.9	740.9	20.5	758.2	1 421.5	2 960.1
2015	20.1	785.4	21.8	803.7	930.4	2 561.3
2016	20.8	815.3	22.6	834.3	951.7	2 644.7
2017	21.5	840.7	23.3	874.3	1 458.6	3 218.5

### Uncertainties and Time-Series Consistency:

As the EF is the stoichiometric ratio reflecting the amount of CO<sub>2</sub> 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 ( $\pm 1$ -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. In this submission emission calculation was done by using two different calculation tools by two people. One is typically Excel based while the other is oracle and software coding based. The results of two different tool was compared to minimize calculation error.

### Recalculations

There is no recalculation in this submission.

### Planned Improvements

There are no planned improvements in this sector.

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

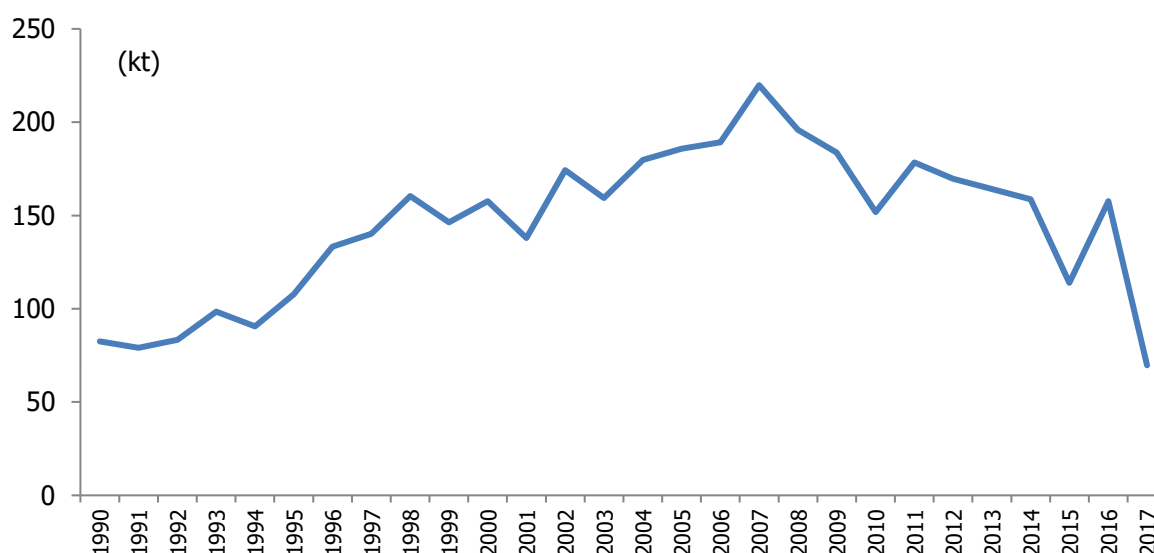
##### Source Category Description:

In this category, emissions from soda ash consumption are considered. CO<sub>2</sub> 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 (314 901 tonnes) and 2017(913 785 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 2017 the GHG release due to the apparent consumption of soda ash is 70 kilotons of CO<sub>2</sub>.

**Figure 4.7 CO<sub>2</sub> emissions from other use of soda ash, 1990-2017**



### 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.

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

$$\text{Apparent Consumption} = \text{Total Consumption} - \text{Use in Glass Industry}$$

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<sub>2</sub> /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<sub>2</sub> emissions from soda ash consumption are given in the following table.

**Table 4.16 Activity data for the other use of soda ash and CO<sub>2</sub> emissions, 1990-2017 (kt)**

Year	Total Consumption in Turkey	Use in Glass Industry	Apparent Consumption	CO <sub>2</sub> emissions
1990	315	116	199	83
1991	307	116	191	79
1992	317	116	201	83
1993	352	115	237	98
1994	336	117	218	91
1995	385	125	259	108
1996	469	148	321	133
1997	519	182	338	140
1998	578	192	387	160
1999	536	184	353	146
2000	601	221	380	158
2001	582	250	332	138
2002	668	248	420	174
2003	668	284	384	159
2004	713	280	433	180
2005	749	301	448	186
2006	747	291	456	189
2007	850	320	530	220
2008	891	419	472	196
2009	772	329	443	184
2010	807	441	366	152
2011	939	509	430	178
2012	918	510	409	170
2013	915	520	395	164
2014	944	561	383	159
2015	897	623	274	114
2016	1 017	637	380	158
2017	914	746	168	70

## Uncertainties and Time-Series Consistency:

AD uncertainty for this source is considered  $\pm 10\%$  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  $\pm 2\%$ .

## 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. In this submission emission calculation was done by using two different calculation tools by two people. One is typically Excel based while the other is oracle and software coding based. The results of two different tool was compared to minimize calculation error.

## Recalculations:

This sector was recalculated due to the methodology change in glass production. Emissions from glass production is recalculated by using raw material input which includes soda ash consumption.

**Table 4.17 Comparison on other use of soda production emissions recalculation in 2018 and 2019 inventory submissions**

(kt)			
Years	Change in the "use in the glass industry"	Change in the apparent consumption of soda ash	Change in terms of emissions
1990	-148.4	-148.4	61.6
1991	-145.7	-145.7	60.5
1992	-154.2	-154.2	64.0
1993	-156.7	-156.7	65.0
1994	-159.9	-159.9	66.4
1995	-178.2	-178.2	73.9
1996	-216.3	-216.3	89.7
1997	-239.8	-239.8	99.5
1998	-242.7	-242.7	100.7
1999	-210.7	-210.7	87.4
2000	-234.8	-234.8	97.4
2001	-181.4	-181.4	75.3
2002	-189.0	-189.0	78.4
2003	-197.0	-197.0	81.8
2004	-211.4	-211.4	87.7
2005	-201.9	-201.9	83.8
2006	-190.3	-190.3	79.0
2007	-241.0	-241.0	100.0
2008	-221.6	-221.6	92.0
2009	-177.2	-177.2	73.5
2010	-127.5	-127.5	52.9
2011	-115.5	-115.5	47.9
2012	-82.1	-82.1	34.1
2013	-80.6	-80.6	33.4
2014	-70.6	-70.6	29.3
2015	11.1	11.1	-4.6
2016	-16.6	-16.6	6.9

## Planned Improvements:

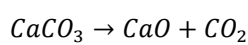
No further improvement is planned at the moment.

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

#### Source Category Description:

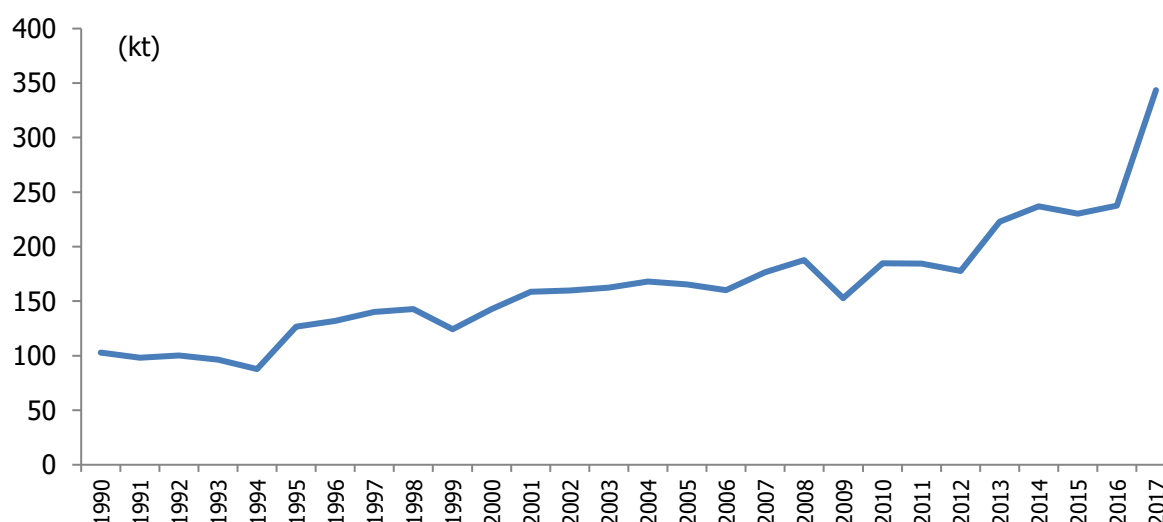
This source category should include emissions from magnesia (MgO) production that are not included elsewhere. Magnesite ( $MgCO_3$ ) is one of the key inputs into the production of magnesia, and ultimately fused magnesia. There are three major categories of magnesia products: calcined magnesia, dead burned 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;



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 2017.

**Figure 4.8  $CO_2$  emissions from magnesia production, 1990-2017**





## Methodological Issues:

Turkey implements Tier 1 method. CO<sub>2</sub> 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 seven plants that are producing magnesia in Turkey. Each of them were asked for their activity data by a questionnaire.

## Choice of Emission Factor

The default IPCC EF (0.52197 tonnes CO<sub>2</sub> / tonne carbonate) taken from Table 2.1 of the 2006 IPCC Guidelines, Volume 3, Chapter 2, is applied for all the time series.

**Table 4.18 Magnesia production and CO<sub>2</sub> emissions, 1990-2017**  
(kt)

Year	Magnesia production	CO <sub>2</sub>
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
2016	455.1	237.6
2017	658.1	343.5

### Uncertainties and Time-Series Consistency:

AD is collected from the companies and all the 6 biggest producers are asked for their activity data. 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  $\pm 2\%$ .

### 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. In this submission emission calculation was done by using two different calculation tools by two people. One is typically Excel based while the other is oracle and software coding based. The results of two different tool was compared to minimize calculation error.

### Recalculation:

There is no recalculation in this sector.

### Planned improvement:

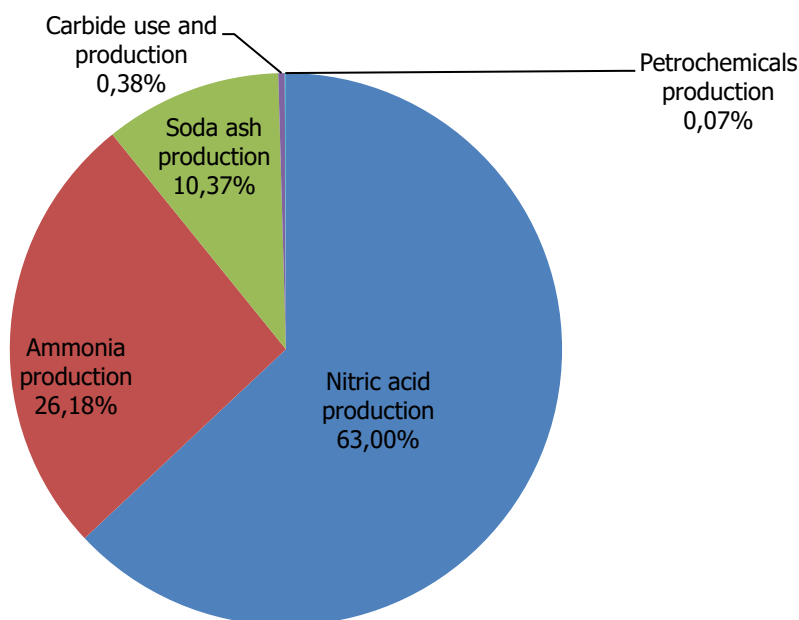
No further improvement is planned at the moment.

## 4.3. Chemical Industry (Category 2.B)

In 2017, the chemical industry was responsible for 3% of the total carbon dioxide equivalent emissions from the industrial processes and product use sector. Between 1990 (1 629 kt CO<sub>2</sub>eq) and 2017 (2 004 kt CO<sub>2</sub>eq), total carbon equivalent emissions increased by 23%. The increase in emissions is driven exclusively by the increase in CO<sub>2</sub> emissions from ammonia production and N<sub>2</sub>O emissions from nitric acid production; emissions from all other sub-categories declined over the reporting period, 1990-2016.

Figure 4.9 depicts the share of CO<sub>2</sub> equivalent emissions from chemical industry. The CO<sub>2</sub>eq. emissions from nitric acid production are (63%), followed by ammonia production and soda ash production (with 26.2% and 10.4% respectively). Carbide use and petrochemical production are much smaller contributors to emissions (0.4% and 0.1%, 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<sub>2</sub> emissions from chemical industry, 2017**



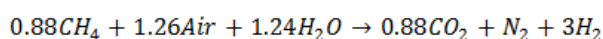
## 4.3.1. Ammonia production (Category 2.B.1)

### Source Category Description:

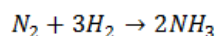
Ammonia is a major industrial chemical and the most important nitrogenous material produced. Ammonia gas is used directly as a fertilizer, in heat treating, paper pulping, nitric acid and nitrates manufacture, nitric acid ester and nitro compound manufacture, explosives of various types, and as a refrigerant. 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<sub>2</sub> 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:



Ammonia synthesis reaction:

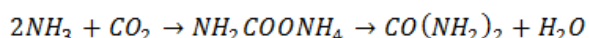


Ammonia production requires the combustion of fuels for the energy demand of the process. Besides being used as feedstock, natural gas is also used for meeting the energy requirement of the process. Both the emissions due to the ammonia production process and the fuel combustion for the energy demand 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 4.19 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.

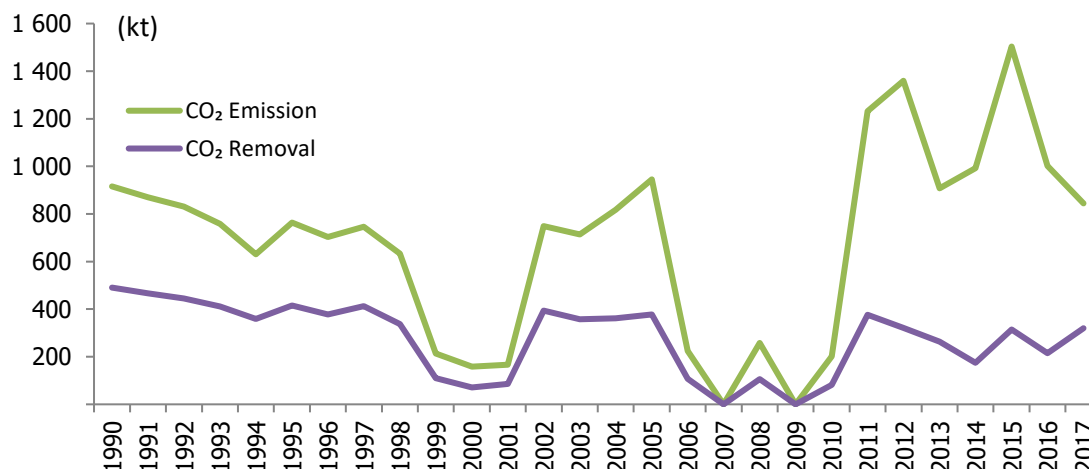
İGSAS is one of two ammonia plants in Turkey which started its operation in 1977. In 1993 a second ammonia plant, GEMLİK GÜBRE, started its operation. İGSAS also produces urea by using CO<sub>2</sub> gas as feedstock. CO<sub>2</sub> is separated from the synthesis gas in the decarbonising step within the ammonia production process. Then, some of the CO<sub>2</sub> gas is used in the urea production process and the remaining gas is released to atmosphere. The chemical reaction that produces urea is:



The figure 4.10 shows the CO<sub>2</sub> emissions from ammonia production as well as the amount of CO<sub>2</sub> recovered.

Overall, between 1990 (425 kt CO<sub>2</sub>eq.) and 2017 (525 kt CO<sub>2</sub>eq.), emissions from ammonia production increased by 24%. There are large inter-annual changes in CO<sub>2</sub> emissions from ammonia production. Rapid increases in emissions can be seen shortly after periods of economic downturns.

**Figure 4.10 CO<sub>2</sub> emissions and removals from ammonia production, 1990-2017**



## 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<sub>2</sub> 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<sub>j</sub> = ammonia production using natural gas in process type *j*, tonnes

FR<sub>j</sub> = fuel requirement per unit of output in process type *j*, GJ/tonne ammonia produced

$$E_{CO_2} = \sum (TFR * CCF * COF * 44/12) - R_{CO_2}$$

where:

E<sub>CO<sub>2</sub></sub> = emissions of CO<sub>2</sub>, 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

$R_{CO_2}$  = CO<sub>2</sub> 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 companies 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<sub>2</sub> are required per tonnes of urea produced. This value is taken from the 2006 IPCC Guidelines.

In Turkey; due to economic factors, 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 4.20 Ammonia production and CO<sub>2</sub> emissions, 1990-2017**

Year	Ammonia Production (1990=100)	Urea Production (1990=100)	CO <sub>2</sub> Emission (kt)	CO <sub>2</sub> Removal (kt)	Net CO <sub>2</sub> Emission (kt)
1990	100	100	915	491	425
1991	95	95	870	466	404
1992	91	91	831	445	385
1993	82	84	759	412	347
1994	73	73	631	359	272
1995	82	85	764	415	348
1996	76	77	703	377	326
1997	81	84	746	413	334
1998	66	69	633	337	296
1999	22	22	213	110	103
2000	15	14	158	70	88
2001	18	17	167	85	82
2002	82	80	749	394	355
2003	79	73	714	358	356
2004	90	74	818	361	456
2005	104	77	945	378	567
2006	25	22	225	108	117
2007	0	0	0	0	0
2008	27	22	257	106	151
2009	0	0	0	0	0
2010	21	17	201	82	119
2011	128	77	1 232	376	856
2012	143	65	1 360	321	1039
2013	97	54	908	263	645
2014	107	35	993	174	818
2015	157	64	1 503	314	1190
2016	105	44	1 002	215	787
2017	82	65	844	319	525

## 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 provided by BOTAŞ (Petroleum Pipeline Corporation) and it 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  $\pm 3\%$  range since 2010. In this submission emission calculation was done by using two different calculation tools by two people. One is typically Excel based while the other is oracle and software coding based. The results of two different tool was compared to minimize calculation error.

### Recalculation:

For the years between 1990-2016, in ammonia production recalculation was made due to two reasons. The carbon content of natural gas is changed by using composition of natural gas. This caused minor changes in emissions. Main recalculation was about recovered CO<sub>2</sub> from urea production. In previous submission total CO<sub>2</sub> emissions and recovered CO<sub>2</sub> emissions were reported separately into CRF by thinking that CRF automatically calculate net emissions (net: total – recovered). It was released that CRF does not calculate automatically the net emissions. For that reason, recovered and net CO<sub>2</sub> emissions entered separately in this submission. Difference in emissions can be seen from the table below.



**Table 4.21 Comparison on emissions from ammonia production emission recalculation in 2018 and 2019 inventory submissions**

Year	CO <sub>2</sub> Emission in 2018 (kt)	CO <sub>2</sub> Emission in 2019 (kt)	Difference
1990	920	491	-429
1991	874	466	-408
1992	835	445	-390
1993	763	412	-351
1994	634	359	-275
1995	768	415	-353
1996	707	377	-330
1997	750	413	-337
1998	636	337	-299
1999	214	110	-104
2000	159	70	-89
2001	168	85	-83
2002	753	394	-359
2003	721	358	-363
2004	825	361	-464
2005	953	378	-575
2006	227	108	-119
2007	0	0	0
2008	259	106	-153
2009	0	0	0
2010	203	82	-121
2011	1223	376	-847
2012	1368	321	-1047
2013	914	263	-651
2014	996	174	-822
2015	1466	314	-1152
2016	983	215	-768

## Planned Improvement

No further improvements are planned at this time.

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

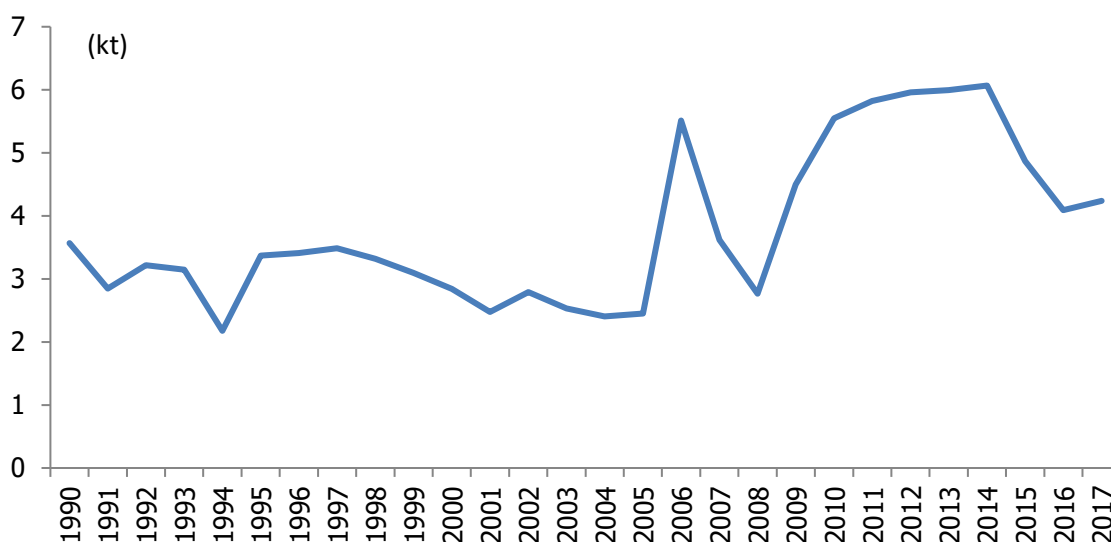
### Source Category Description:

Nitrous oxide (N<sub>2</sub>O) is emitted during the production of nitric acid which is a raw material mainly in the manufacturing of nitrogenous-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<sub>2</sub>O emissions were relatively stable between 1990 (2.33 kt N<sub>2</sub>O) and 2005 (2.45 kt N<sub>2</sub>O), 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<sub>2</sub>O emissions reach its top in 2014 (6.07 kilotons). In 2016 N<sub>2</sub>O emissions was 3.88 kt and it is much less than year 2014 due to production stop in one big capacity nitric acid plant.

**Figure 4.11 N<sub>2</sub>O emissions from nitric acid productions, 1990-2017**



### Methodological Issues:

N<sub>2</sub>O emissions from nitric acid production are not a key category in Turkey. N<sub>2</sub>O emissions are calculated using the T1 method in the 2006 IPCC Guidelines. Total nitric acid production is multiplied by an emission factor as shown below.

$$E_{N_2O} = EF \times \text{Nitric acid production}$$

where:

$E_{N_2O}$  = N<sub>2</sub>O emissions, kg

EF = N<sub>2</sub>O emission factor (default), kg N<sub>2</sub>O/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<sub>3</sub> 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 4.22 Nitric acid production and N<sub>2</sub>O emissions, 1990-2017**

Year	Nitric acid production (1990=100)	Total N <sub>2</sub> O 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	4.87
2016	151.2	4.09
2017	162.6	4.24

### Uncertainties and Time-Series Consistency:

The 2006 IPCC Guidelines recommended default uncertainty value of  $\pm 20\%$  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  $\pm 2\%$ , 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. According to the monitoring, reporting and verifying regulation, nitric acid plants are obliged to report their emissions to the Ministry of Environment and Urbanization by measuring their emissions with N<sub>2</sub>O gas monitoring device. Calculated and reported emissions are compared first time in this submission. In this submission emission calculation was done by using two different calculation tools by two people. One is typically Excel based while the other is oracle and software coding based. The results of two different tool was compared to minimize calculation error.

### Recalculation:

There is no recalculation in this sector.

### Planned Improvements:

There is no further planned improvement

### 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)

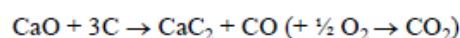
There is no caprolactam, glyoxal and glyoxylic acid production in Turkey during the period 1990-2016.

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

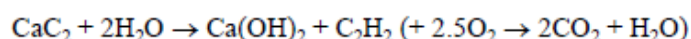
##### Source Category Description:

The production of carbide can result in emissions of CO<sub>2</sub>, CH<sub>4</sub>, CO and SO<sub>2</sub>. 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 and as a reductant in electric arc furnaces. The acetylene is used for welding applications. Therefore, use of acetylene also results in emissions and it is accounted in the IPPU.

Calcium carbide is produced by the reaction of metallurgical coke and lime under electric arc according to the reaction given below.



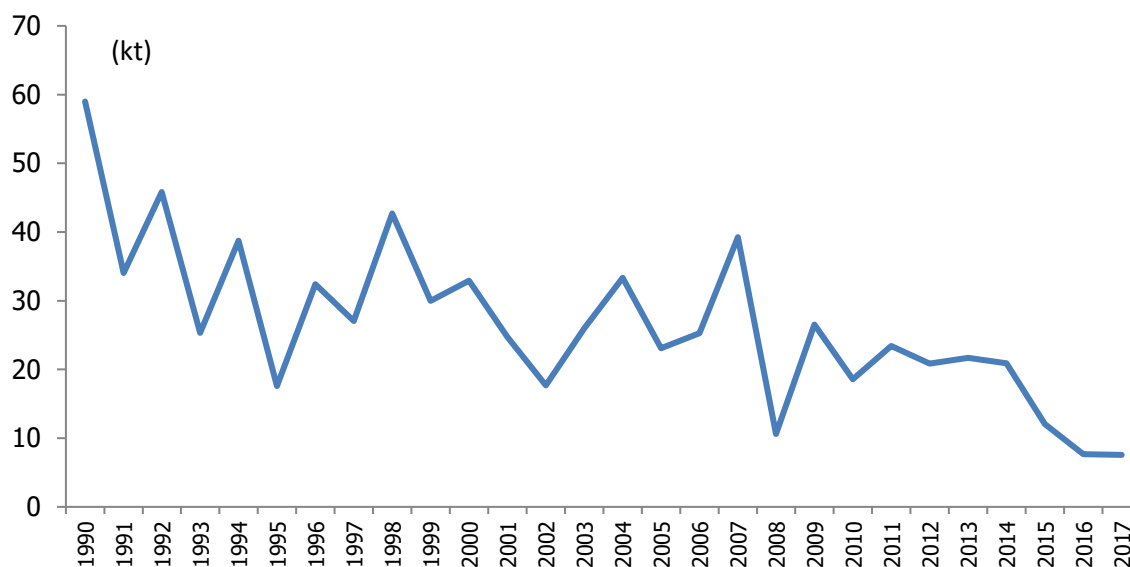
Calcium carbide is used either as a reductant in the steel making process or the feedstock for acetylene production in Turkey. Afterwards acetylene is used as fuel in the welding applications. The combustion of acetylene in welding applications give emissions according to the reaction given below and it is accounted in IPPU sector.



In Turkey there is no silicon carbide production. Calcium carbide has been produced in Turkey till 2015. The amount of coke used is deducted from the Energy part of the NIR to avoid double count.

CO<sub>2</sub> emissions from calcium carbide production and usage of carbide in acetylene was 59 kt CO<sub>2</sub> in 1990. Year by year carbide production decreased and in 2015 the carbide production and usage of carbide in acetylene production emissions was 12.1 kt CO<sub>2</sub>. Finally, in 2016 the production line of carbide was closed due to economic reasons. And use of carbide in acetylene continued and resulted 7.6 kt CO<sub>2</sub> emissions in 2017.

**Figure 4.12 CO<sub>2</sub> emissions due to carbide production, 1990-2017**



## Methodological Issues:

Carbide production is not a key category in Turkey. Calcium carbide was produced in Turkey by a single plant till 2015 and then the production line was closed. The calculation of emissions is based on plant-specific data.

$$E_{CO_2} = AD * EF$$

Where:

ECO<sub>2</sub>= emissions of carbon dioxide

AD = activity data on carbide production

EF = CO<sub>2</sub>emission factor.

The use of calcium carbide also leads to the emissions and it is calculated by the tier 1 methodology suggested in the guideline. The amount calcium carbide used is multiplied with the proper emission factor suggested in the guideline.

## Collection of activity data

The calcium carbide production data 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 carbide production data.

Confidential production data are provided relative to 1990, along with CO<sub>2</sub> emissions from calcium carbide production as can be seen in the table below.

**Table 4.23 Calcium carbide production and CO<sub>2</sub> emissions, 1990-2017**

Years	Calcium Carbide Production (1990=100)	Calcium carbide use (kt)	CO <sub>2</sub> Emissions from carbide production	CO <sub>2</sub> Emissions (kt)
1990	100.0	15.9	41.5	59.0
1991	51.2	11.6	21.3	34.0
1992	65.3	17.0	27.1	45.8
1993	37.5	8.8	15.6	25.3
1994	46.3	17.8	19.2	38.7
1995	24.2	6.9	10.0	17.6
1996	40.6	14.2	16.8	32.4
1997	37.7	10.4	15.6	27.0
1998	56.3	17.6	23.3	42.7
1999	40.7	11.9	16.9	30.0
2000	43.3	13.6	18.0	32.9
2001	33.8	9.7	14.0	24.7
2002	25.7	6.4	10.6	17.7
2003	34.3	10.7	14.2	26.0
2004	40.6	15.0	16.8	33.4
2005	27.1	10.8	11.2	23.1
2006	29.4	11.9	12.2	25.3
2007	50.5	16.7	20.9	39.3
2008	11.9	5.1	4.9	10.6
2009	29.4	13.0	12.2	26.5
2010	19.8	9.4	8.2	18.6
2011	28.0	10.7	11.6	23.4
2012	28.8	8.1	11.9	20.9
2013	27.4	9.4	11.4	21.7
2014	25.9	9.2	10.7	20.9
2015	13.9	5.7	5.8	12.1
2016	0	7.0	0.0	7.7
2017	0	6.9	0.0	7.6

## 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  $\pm 20\%$  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 2009-2017. For the year 2014, the data are found to be different as much as 2% whereas in the other years there found to be no difference.

### Recalculation:

There is no recalculation for this year's inventory.

### 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 1990-2016.

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

#### Source Category Description:

Soda ash (sodium carbonate,  $\text{Na}_2\text{CO}_3$ ) 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.  $\text{CO}_2$  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.  $\text{CO}_2$  is also emitted during production of soda ash, with the quantity emitted dependent on the industrial process used to manufacture soda ash.

Emissions of  $\text{CO}_2$  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



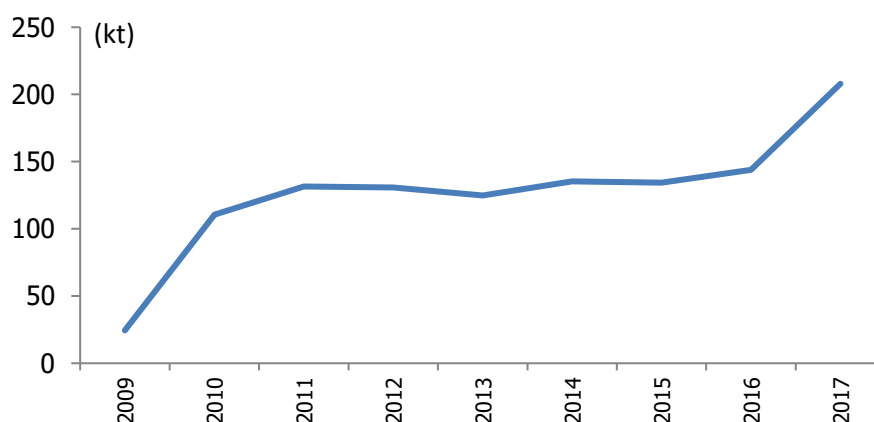
processes. The fourth, the Solvay process, is classified as a synthetic process. Calcium carbonate (limestone) is used as a source of CO<sub>2</sub> in the Solvay process.

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<sub>2</sub> is generated during calcination of limestone. The CO<sub>2</sub> generated is captured, compressed and directed to Solvay precipitating towers for consumption in a mixture of brine (aqueous NaCl) and ammonia. Although CO<sub>2</sub> is generated as a by-product, the CO<sub>2</sub> is recovered and recycled for use in the carbonation stage and in theory the process is neutral, i.e., CO<sub>2</sub> 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<sub>2</sub> emissions from soda ash productions. In the year 2009 a small amount of CO<sub>2</sub> emitted due to plant was not working full capacity due to start up. In 2017 emissions from soda ash increased by 44.4% with respect to previous year and it was 208 kt of CO<sub>2</sub>.

**Figure 4.13 CO<sub>2</sub> Emissions resulting from soda ash production 2009-2017**



## Methodological Issues:

The natural production process of soda ash results in CO<sub>2</sub> emissions. Turkey applies a Tier 1 method, for this non-key category, quantifying emissions based on the plant-specific activity data and default emission factor, and using the following formula:

$$E_{CO_2} = AD * EF$$

Where:

$E_{CO_2}$  = emissions of carbon dioxide in tonnes

AD = quantity of soda ash produced (from trona) in tonnes

EF = emission factor per unit of soda ash produced

## Collection of activity Data

The amount of soda ash produced is the AD and it is directly taken from the plant. Data are acquired on a yearly basis and it is based on a questionnaire which is sent to 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 4.24 Soda ash production and CO<sub>2</sub> emissions, 1990-2017**

Year	Soda ash production by utilizing Trona (2009=100)	CO <sub>2</sub> 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
2016	588	144
2017	850	208

## 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:

On the PRODCOM soda ash production data is available since 2009. PRODCOM data and plant specific data are compared and found consistent. Moreover, according to the 2006 IPCC Guidelines the emission from soda ash production can be calculated by either using the soda ash production data or using the trona consumption data. The emissions are calculated and reported using the soda ash production data. However, for quality control purpose the emissions is also calculated based on the trona consumption. 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. When the two methods are compared 12% difference is found for 2017. In this submission emission calculation was done by using two different calculation tools by two people. One is typically excel based while the other is oracle and software coding based. The results of two different tool was compared to minimize calculation error.

### Recalculation:

There is no recalculation for this year's inventory.

### Planned Improvements

The solvay process is theoretically CO<sub>2</sub> neutral. However no process is 100% efficient in real life. Therefore, it is obvious that the solvay process plants cause some amount of CO<sub>2</sub> emissions under the IPPU category. The soda ash plant which is producing soda ash by solvay process in Turkey is obliged to prepare greenhouse gas emission report under the new regulations of the Ministry of Environment and Urbanization. This report will be accessed in the future and then it would be possible to make CO<sub>2</sub> emission estimation regarding to this plant.

## 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<sub>2</sub> emissions from petrochemicals production. There is a single petrochemical producer in Turkey and the company name is PETKİM. Carbon black was produced by PETKİM till 2001, however it was at a different production site and this production site was closed in 2001.

During the production of petrochemicals various gases are generated. However PETKİM has a closed circuit that collects all the process gases, which includes greenhouses gases and combustible gases, and uses it as fuel. This fuel is named fuel gas and emissions due to the combustion of fuel gas is included in the energy sector. However, some of the fuel gas is combusted in the flare stacks and the emissions from the flare stacks are included in the IPPU category.

The figures below show the CO<sub>2</sub> emissions from flare stacks from the petrochemicals production at main production site of PETKİM between 1990 and 2017 and also carbon black production emissions at Kocaeli production site between 1990 and 2001.

**Table 4.25 CO<sub>2</sub> emissions from flaring in petrochemical sector, 1990-2017**

Year	(kt)		
	CO <sub>2</sub> emissions from carbon black production	CO <sub>2</sub> emissions from flaring	Total CO <sub>2</sub> emissions in petrochemical industry
1990	80.1	1.35	81.5
1991	84.4	1.35	85.8
1992	91.2	1.35	92.6
1993	91.4	1.35	92.7
1994	73.3	1.35	74.6
1995	104.7	1.35	106.1
1996	91.9	1.35	93.2
1997	102.3	1.35	103.7
1998	104.8	1.35	106.2
1999	69.2	1.35	70.6
2000	91.9	1.35	93.2
2001	70.9	1.35	72.2
2002	NO	1.35	1.35
2003	NO	1.35	1.35
2004	NO	1.35	1.35
2005	NO	1.35	1.35
2006	NO	1.35	1.35
2007	NO	1.35	1.35
2008	NO	1.35	1.35
2009	NO	1.35	1.35
2010	NO	1.35	1.35
2011	NO	1.35	1.35
2012	NO	1.35	1.35
2013	NO	1.35	1.35
2014	NO	1.35	1.35
2015	NO	1.35	1.35
2016	NO	1.32	1.32
2017	NO	1.35	1.35

Since PETKİM has a closed system for its stacks, all the methane emissions are assumed to be collected in the fuel gas. Hence it is covered in the energy sector.

### Methodological Issues:

CO<sub>2</sub> emissions are calculated by multiplying the amount of fuel gas burnt with the

$$E_{CO_2} = M_{\text{fuel gas}} \times \text{Carbon content of fuel gas} \times 44/12$$

Where:

$E_{CO_2}$  = CO<sub>2</sub> emissions from production of petrochemical in tonnes

$M_{\text{fuel gas}}$  = Amount of fuel gas combusted as the flare gas in tonnes

44/12 = The molar weight ratio of carbon dioxide to carbon

CO<sub>2</sub> emissions from carbon black production are calculated by Tier 1 methodology. The annual production amount is multiplied by the default CO<sub>2</sub> emission factor.

$$E_{CO_2} = M_{\text{carbon black}} \times \text{Carbon Black CO}_2 \text{ EF}$$

Carbon black production also causes CH<sub>4</sub> emissions. CH<sub>4</sub> emissions are calculated by Tier 1 methodology. The annual production amount is multiplied by the default CH<sub>4</sub> emission factor.

$$E_{CH_4} = M_{\text{carbon black}} \times \text{Carbon Black CH}_4 \text{ EF}$$

### Collection of activity data

In Turkey, there is a single producer of petrochemicals. The amount of fuel gas combusted in the flare stacks is asked to the producer by an annual questionnaire. The amount of fuel gas combusted is confidential since there is one single company producing petrochemicals.

### Choice of emission factor

The fuel gas composition is asked to the producer. The volumetric gas composition data is gathered and it is used to calculate the carbon content of fuel gas. Since there is one single company in Turkey in the field of petrochemical production its fuel gas characteristic is confidential.

### Uncertainties and Time-Series Consistency:

As 2006 IPCC Guidelines recommended default uncertainty values is used as  $\pm 10\%$  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:

A site visit was done to the PETKİM in 2017 by the Turkstat's inventory compilers. During this site visit all the process flow charts were examined and discussed with PETKİM engineers in order to understand emission pathways and ensure all emissions are included and not double counted.

### Recalculation:

There is no recalculation in this sector.

### Planned Improvements

No further improvements are planned at this time.

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

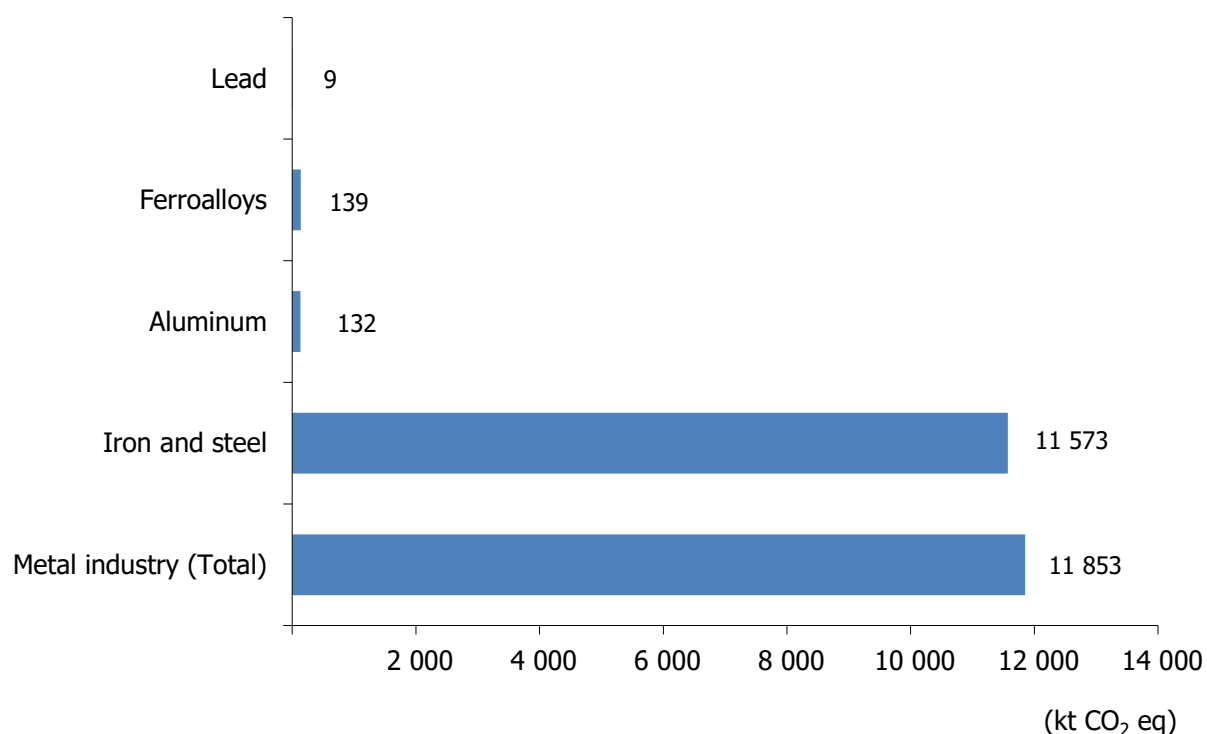
There is no fluorochemical production in Turkey during the period 1990-2017.

## 4.4. Metal Industry (Category 2.C)

In 2017, the metal industry was responsible for 11 903 kt CO<sub>2</sub> eq., 17.9% of total emissions from the industrial processes and product use sector. The vast majority of emissions in the metal industry (97.1%) are from iron and steel production. Aluminum production was responsible for 181.5 kt CO<sub>2</sub> eq., 1.5% of metal emissions, and ferroalloys production 132 kt CO<sub>2</sub> eq., 1.1 % of metal emissions. Lead production was responsible for 9.0 kt CO<sub>2</sub> eq. 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 601kt CO<sub>2</sub> eq.) and 2017 (11 903 kt CO<sub>2</sub> eq.), emissions from the metal industry increased by 56.6%, again driven in large part by the iron and steel industry, which nearly doubled its emissions during the time period, from 6 767 kt CO<sub>2</sub> eq. in 1990 to 11 557 kt CO<sub>2</sub> eq. in 2017. This increase in emissions was partially offset by the elimination of PFC emissions in aluminum production (PFC emissions were 625 kt CO<sub>2</sub> eq. in 1990 and it is 73 in 2017). There is no magnesium production in Turkey.

**Figure 4.14 Emissions from metal industry, 2017**



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

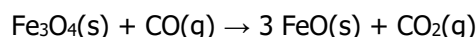
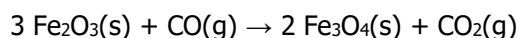
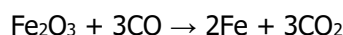
### Source Category Description:

Iron and steel production processes result in CO<sub>2</sub> and CH<sub>4</sub> emissions to be covered under the IPPU category since carbon is used in the reduction process of iron oxides.

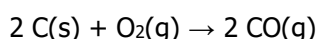
In Turkey currently there are three integrated iron and steel production plants. These facilities include sinter production units, blast furnaces for pig iron production, and basic oxygen furnaces. Besides these plants, there are electric arc furnace mills operating in Turkey. However, there is no direct 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.



Carbon monoxide is generated in the blast furnace from the carbon containing fuels (mainly coke) as can be seen in equation below. Coke provides the necessary carbon for both 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.



Limestone is used in the blast furnaces for removing acidic impurities from the ore. When limestone is heated up to about 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.



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 (i.e. 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<sub>2</sub> release. During the sintering process high temperatures are achieved and limestone is calcined and release CO<sub>2</sub> 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<sub>2</sub>. 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<sub>2</sub>. 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<sub>2</sub> emissions. Metallurgical coke, petroleum coke,



graphite, anthracite, 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 releases CO<sub>2</sub> 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<sub>2</sub> 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 4.26 Categorical allocation of emissions from iron and steel productions in Turkey**

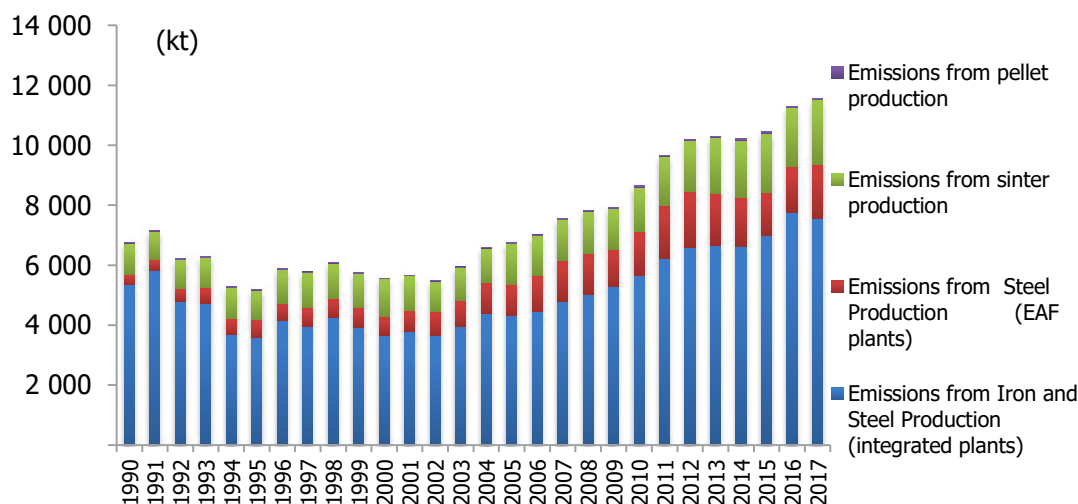
CRF category	Emission source
CRF 1.A.1.a	Public electricity and heat production
CRF 1.A.1.c	Emissions from fuels used in coking plants (coke oven gas and BF gases)
CRF 1.A.2.a	Emissions from fuels used in iron and steel plants' processes and power plants
CRF 2.A.2	Process emissions from lime production 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 28 electric arc furnaces mills operating. The table below presents 2.C.1 category CO<sub>2</sub> emissions between 1990 and 2017, and figure 4.16 shows the 2.C.1 category CO<sub>2</sub> emissions cumulatively revealing the emissions trend in the iron and steel production.

**Table 4.27 CO<sub>2</sub> emissions allocations in 2.C.1 category, 1990-2017 (kt)**

Year	Emissions from Iron and Steel Production (integrated plants)	Emissions from Steel Production (EAF plants)	Emissions from sinter production	Emissions from pellet production	Total emissions in 2.C.1 CRF category
1990	5 356	347	1 033	31	6 767
1991	5 835	349	946	30	7 160
1992	4 796	428	959	29	6 212
1993	4 736	510	1 000	30	6 276
1994	3 684	538	1 030	31	5 283
1995	3 579	595	988	26	5 188
1996	4 155	584	1 118	28	5 884
1997	3 966	624	1 167	22	5 779
1998	4 260	629	1 180	26	6 096
1999	3 930	642	1 149	26	5 747
2000	3 661	637	1 242	28	5 568
2001	3 800	679	1 165	26	5 670
2002	3 659	793	1 017	23	5 492
2003	3 947	878	1 094	23	5 942
2004	4 388	1 025	1 158	23	6 595
2005	4 313	1 039	1 358	34	6 744
2006	4 453	1 208	1 313	34	7 008
2007	4 789	1 355	1 364	39	7 547
2008	5 013	1 384	1 393	34	7 823
2009	5 288	1 242	1 351	41	7 922
2010	5 653	1 463	1 480	45	8 641
2011	6 218	1 769	1 642	45	9 674
2012	6 593	1 859	1 703	46	10 202
2013	6 658	1 731	1 867	44	10 301
2014	6 611	1 663	1 890	47	10 210
2015	6 981	1 434	1 985	46	10 446
2016	7 756	1 529	1 961	47	11 294
2017	7 544	1 817	2 150	45	11 557

**Figure 4.15 CO<sub>2</sub> emissions allocations within the 2.C.1 CRF category, 1990-2017**



CO<sub>2</sub> emissions from iron and steel production in 2017 was 11.6 million tons and it increased by 70.8% 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 37.8 million tons by 2017, it was 17th by 2000. In 2017 steel production was increased by 13.1 % due to increase in steel demand. Turkey's steel production capacity is over 50 million tons.

### Methodological Issues:

For the calculation of CO<sub>2</sub> 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<sub>2</sub> emissions from pig iron production and sinter production in the integrated plants is as follows:

$$E_{CO_2} = \left[ \sum_a (Q_a \times C_a) - \sum_b (Q_b \times C_b) \right] \times \frac{44}{12}$$

where;

$E_{CO_2}$	=	Emissions from pig iron or sinter
$a$	=	Input material a
$b$	=	Output material b
$Q_a$	=	Quantity of input material a
$C_a$	=	Carbon content of material a
$Q_b$	=	Quantity of output material b
$C_b$	=	Carbon content of material b
44/12	=	Stoichiometric ratio of CO <sub>2</sub> to C

For the calculation of CO<sub>2</sub> emissions from pellet production, the 2006 IPCC Tier 1 method is used where total amount of pellet produced is multiplied with the emission factor.

$$E_{CO_2, non-energy} = P \bullet EF_P$$

where;

$E_{CO_2, \text{non-energy}}$  = emissions of CO<sub>2</sub> to be reported in IPPU Sector, tonnes

P = quantity of pellet produced nationally, tonnes

EF<sub>x</sub> = emission factor, tonnes CO<sub>2</sub>/tonne x produced

CO<sub>2</sub> emissions from steel production in EAFs are calculated by applying the Tier 2 method which is the carbon balance calculation on an aggregated national level. The equation is given below:

$$E_{CO_2} = \left[ \sum_a (Q_a \times C_a) - \sum_b (Q_b \times C_b) \right] \times \frac{44}{12}$$

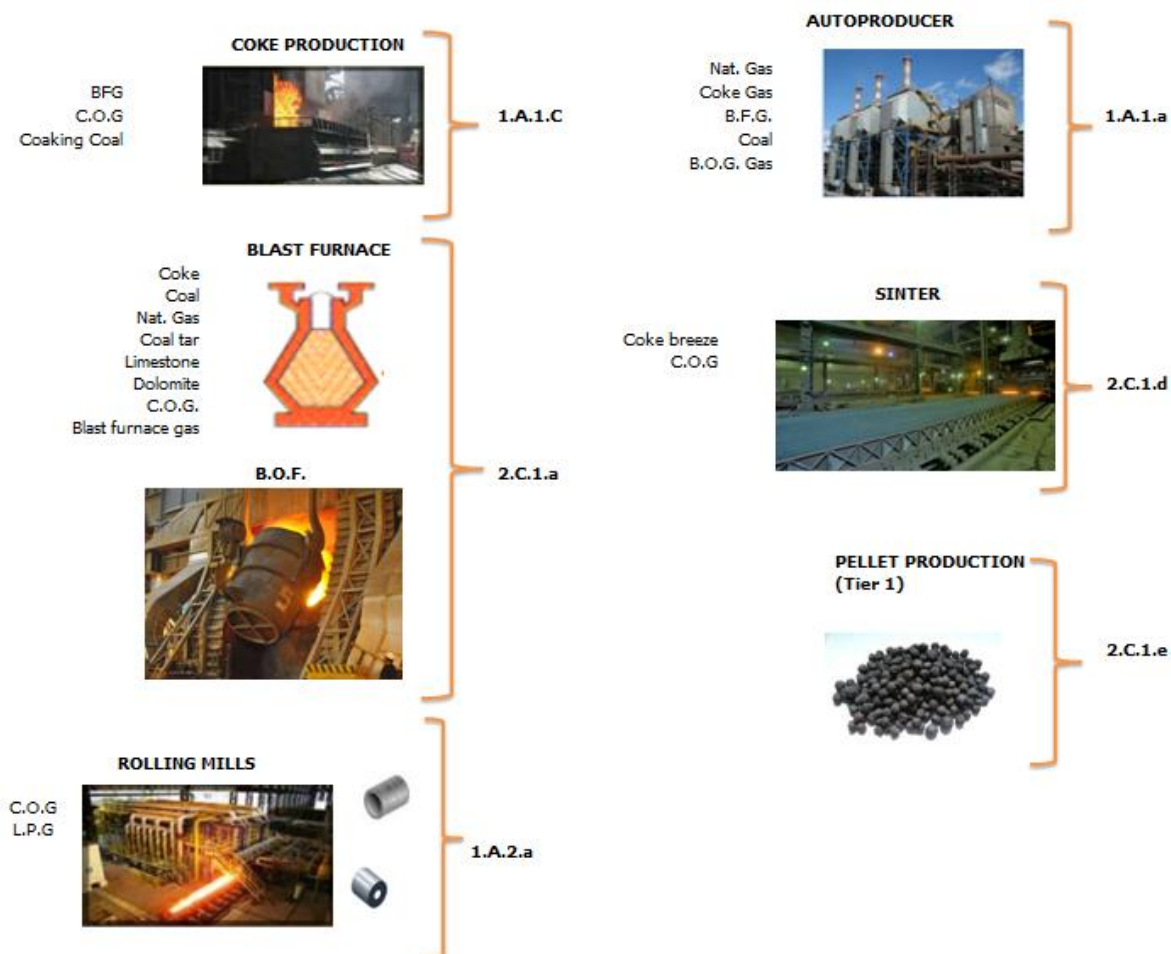
The CH<sub>4</sub> emissions from sinter production are calculated using Tier 1 methodology. This is multiplication of the production data with the default emission factor as suggested in the 2006 IPCC Guidelines, the equations are shown below.

$$E_{CH_4} = SI \times EF_{si}$$

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 4.16 Allocations of the emissions from integrated iron and steel plants**



## Collection of activity data

To estimate CO<sub>2</sub> and CH<sub>4</sub> 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 production and raw material consumption at electric arc furnaces is obtained from Turkish Steel Producers Association and General Directorate of Renewable Energy 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, (e.g. limestone, dolomite), are asked by a questionnaire.

Sinter, pellet production and steel production by plant type are included in the table below.

**Table 4.28 Sinter, pellet and iron & steel production by plant type, 1990-2017**  
(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
2016	1 565	9 834	11 545	21 846	33 392
2017	1 501	9 342	11 795	25 963	37 758

## Choice of emission factor

To estimate CO<sub>2</sub> 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.

In order to estimate CO<sub>2</sub> emissions from EAF (Electric Arc Furnace), Turkey collects raw material consumption and steel production data. These input and output data are aggregated on national level and multiplied by the default carbon contents for each raw material. However, the raw material consumption data is not available before the year 2013. Hence the average implied emission factor found to be 0.0753 t CO<sub>2</sub> / t steel produced between 2013 and 2016, and this factor is applied for the previous years.

To estimate CO<sub>2</sub> emissions from pellet production, Turkey uses the default emission factor from the 2006 IPCC Guidelines (0.03 t CO<sub>2</sub>/ t pellet) for the entire time series.

To estimate CH<sub>4</sub> emissions from sinter production, Turkey applies the default emission factor of 0.07 kg CH<sub>4</sub>/ t sinter.

Default emission factors used in the calculations are provided in the table below.

**Table 4.29 Emission factors**

Activity	CO <sub>2</sub> EF
Pellet production (used in all-time series)	0.03 t/t pellet
EAF steel production (used between 1990-2012)	0.0753 t/t steel

Activity	CH <sub>4</sub> EF
Sinter production (used in all-time series)	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 have been 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, process flow charts and data reporting issues were discussed in order to identify potential inconsistencies and reporting errors. Moreover, 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 each emission categories (1.A.1.a, 1.A.1.c, 1.A.2.a, and 2.C.1) for iron and steel production. The comparison result is given in the below.

Emissions calculated by carbon mass balance over integrated plants= 20 524 kt

Summed up emissions for each CRF category for integrated plants = 21 408 kt

Percentage of equivalence = 96%

The percentage of equivalence is 96% when the data of the three integrated plants are aggregated together, and on the plant basis the percentage of equivalence is at least 94%. The percentage of equivalence shows that the calculated emissions are reliable, but still it can be improved as discussed in the planned improvements.

In this submission emission calculation was done by using two different calculation tools by two people. One is typically excel based while the other is oracle and software coding based. The results of two different tool was compared to minimize calculation error.

### Recalculations:

In this submission report the CO<sub>2</sub> emissions of electric arc furnaces were calculated by Tier 1 methodology. In the previous submission it was calculated by tier 2. During the tier 2 calculation it was revealed that raw material data from electric arc furnaces are not in good quality. For that reason, tier 1 methodology reflects the real situation better.



In the table below iron and steel production emissions are compared for 2017 and 2018 inventory submissions.

**Table 4.30 Comparison on iron and steel production emissions recalculation in 2018 and 2019 inventory submissions**

Year	Iron and steel production emissions in 2018 submission (kt CO <sub>2</sub> )	Iron and steel production emissions in 2019 submission (kt CO <sub>2</sub> )	Difference in emissions (kt CO <sub>2</sub> )	Percentual change (%)
1990	6 300	6 767	-466	-6.9
1991	6 802	7 160	-358	-5.0
1992	5 726	6 212	-486	-7.8
1993	6 161	6 276	-115	-1.8
1994	5 198	5 283	-85	-1.6
1995	5 614	5 188	426	8.2
1996	5 726	5 884	-158	-2.7
1997	5 564	5 779	-215	-3.7
1998	5 858	6 096	-238	-3.9
1999	5 644	5 747	-103	-1.8
2000	5 221	5 568	-347	-6.2
2001	5 598	5 670	-72	-1.3
2002	5 434	5 492	-58	-1.1
2003	5 727	5 942	-215	-3.6
2004	6 449	6 595	-146	-2.2
2005	6 466	6 744	-279	-4.1
2006	6 681	7 008	-327	-4.7
2007	7 267	7 547	-280	-3.7
2008	7 621	7 823	-202	-2.6
2009	7 833	7 922	-89	-1.1
2010	8 525	8 641	-116	-1.3
2011	9 736	9 674	62	0.6
2012	10 359	10 202	158	1.5
2013	10 499	10 301	198	1.9
2014	10 028	10 210	-182	-1.8
2015	10 679	10 446	232	2.2
2016	11 151	11 294	-143	-1.3

As can be seen from the table as a result of the recalculations the emissions from the iron and steel production sector is decreased overall.

## Planned Improvements:

There is no further planned improvement in this sector

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

#### Source Category Description:

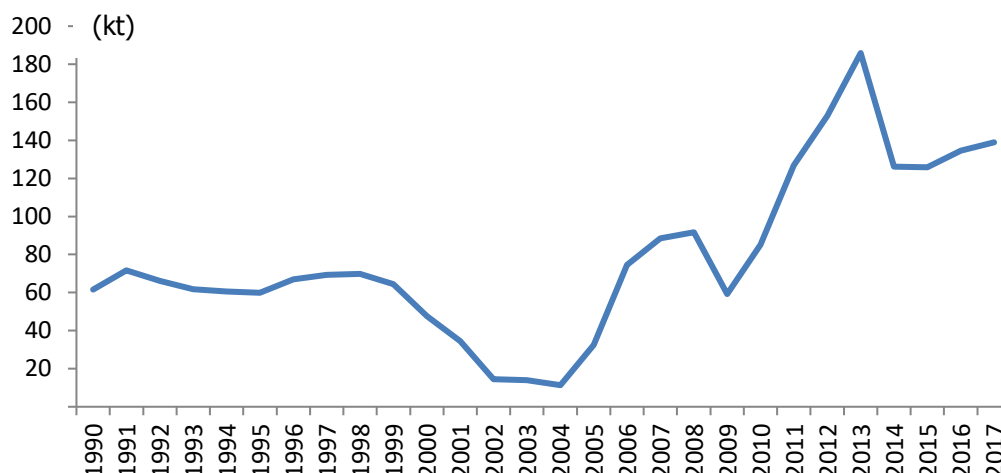
Ferroalloy is the term used to describe concentrated alloys of iron and one or more metals such as silicon, manganese, chromium, molybdenum, vanadium and tungsten. Silicon metal production is usually included in the ferroalloy group because silicon metal production process is quite similar to the ferrosilicon 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<sub>2</sub> emissions. In Turkey there are currently two ferrochrome producer. These two producer are using electric arc furnaces to melt scrap iron and chromite ore in the pot. Some metallurgical coke is added in the pot to reduce chromite and produce ferrochrome.

Between 2011 and 2014 some amount of ferrosilicon manganese was also produced. However, plants are closed due to the high production costs.

In this category; emissions from ferrochromium and ferrosilicon 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<sub>2</sub> emissions from ferroalloys production are driven by mainly ferrochrome production which is strongly depended on the energy prices. There was a decline in emissions between 2000 (47.6 kt CO<sub>2</sub>) and 2004 (11 kt CO<sub>2</sub>) owing to one of the ferrochromium producers was slowed down and finally out of operation during its privatization period. CO<sub>2</sub> emissions generally climbed until 2008 (92 kt CO<sub>2</sub>) with economic growth before decreasing again in 2009 (59 kt CO<sub>2</sub>) due to global economic recession and low demand on steel. There was then a steep increase between 2010 and 2013 (184 kt CO<sub>2</sub>, 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. In 2017, CO<sub>2</sub> emissions from ferroalloy production was 139 kilotons.

**Figure 4.17 CO<sub>2</sub> emissions from ferroalloys production, 1990-2017**



## Methodological Issues:

Turkey reports CO<sub>2</sub> 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<sub>2</sub> emissions from ferroalloys production

$$E_{CO_2} = \sum_i (MP_i * EF_i)$$

where;

$E_{CO_2}$  = CO<sub>2</sub> emissions, tonnes

$MP_i$  = production of ferroalloy type i, tonnes

$EF_i$  = generic emission factor for ferroalloy type i, tonnes CO<sub>2</sub>/ 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 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<sub>2</sub> emission factors from the 2006 IPCC Guidelines, as shown in table below.

**Table 4.31 Ferroalloys emission factors**

<b>Ferro alloy</b>	<b>CO<sub>2</sub> EF (t CO<sub>2</sub>/t product)</b>
Ferrochromium	1.3
Siliconmanganese	1.4

**Table 4.32 Ferroalloys production and emissions, 1990-2016**

<b>Years</b>	<b>Total ferroalloy production (1990=100)</b>	<b>CO<sub>2</sub> emission (kt)</b>
1990	100	62
1991	116	72
1992	107	66
1993	100	62
1994	98	61
1995	97	60
1996	109	67
1997	113	69
1998	113	70
1999	105	64
2000	77	48
2001	56	34
2002	24	15
2003	23	14
2004	18	11
2005	53	32
2006	121	74
2007	144	88
2008	149	92
2009	96	59
2010	138	85
2011	196	127
2012	184	153
2013	298	186
2014	205	126
2015	204	126
2016	219	135
2017	226	139

## Source-Specific QA/QC and Verification:

In this inventory report the ferro alloy production data was gathered directly from the plants. Until last year report Turkstat's PRODCOM data, which is the yearly industrial production survey, have been used to calculate emissions. Therefore, last 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. In this submission emission calculation was done by using two different calculation tools by two people. One is typically excel based while the other is oracle and software coding based. The results of two different tool was compared to minimize calculation error.

There are two ferro chrome producers in Turkey. Both of them supply ferro alloy production and coke consumption data. The production and consumption ratios of the two producers are compared and found consistent.

### **Uncertainties and Time-Series Consistency:**

Since the calculations are based on default Tier 1EFs 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 Guidelines.

### **Recalculation:**

There is no recalculation in this sector.

### **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<sub>2</sub> and PFCs (CF<sub>4</sub> and C<sub>2</sub>F<sub>6</sub>) 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 is 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 primary 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 Alüminyum'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.

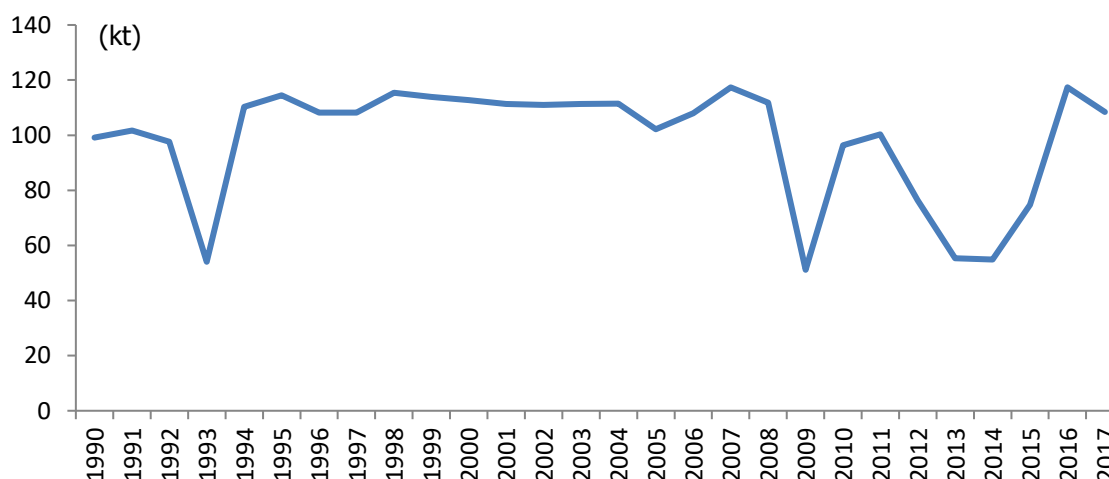
The integrated production process itself consists of five main production phases. These are bauxite mining, alumina production, liquid aluminum production, the alloying and casting of the liquid aluminum,

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 ( $\text{Al}_2\text{O}_3$ ). The consumption of prebaked carbon anodes and Soderberg 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' during liquid aluminum production via electrolysis. Eti Aluminium used Soderberg cells till the modernization of the aluminium production plant in 2015. In 2015 all of the Soderberg cells were replaced with the prebaked cells.

The  $\text{CO}_2$  emissions from aluminum productions is shown in figure 4.18. Overall between 1990 (99 kt  $\text{CO}_2\text{eq.}$ ) and 2017 (108 kt  $\text{CO}_2\text{eq.}$ ) emissions have increased by 9.3%. This is due to increasing 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.  $\text{CO}_2$  emissions remained generally stable until a similar trend was seen in 2008 (111.8 kt), 2009 (51.2 kt) and 2010 (96.4 kt) similarly because of the world economic recession in 2008. In 2017,  $\text{CO}_2$  emissions decreased 7.6% with respect to 2016 due to the decreasing aluminum production of Turkey.

**Figure 4.18  $\text{CO}_2$  emissions from aluminum production, 1990-2017**



$\text{CF}_4$  and  $\text{C}_2\text{F}_6$  emissions are reported in the Table 4.37. Fluctuations in the trend are due to Anode Effect parameter changes as well as primary aluminum production trend.

From the year 2006, PFCs emissions from the aluminum production plant are estimated using T3 methodology.

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 after 2006.

## Methodological Issues:

Aluminum is a key category by the trend analysis due to the cessation of PFC emissions in the industry. CO<sub>2</sub> emissions from primary aluminum production are calculated by the T3 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 Söderberg process was used to produce aluminum. For 1990-2014 CO<sub>2</sub> emissions come from only Söderberg cells. However, in 2015 Söderberg cells were switched to Prebaked cells. In 2016 CO<sub>2</sub> emissions come from only Prebaked cells.

## Formula for CO<sub>2</sub> emissions from Soderberg cells

$$E_{CO_2} = \left( PC \times MP - \frac{CSM \times MP}{1000} - \frac{BC}{100} \times PC \times MP \times \frac{S_p + Ash_p + H_p}{100} - \frac{100 - BC}{100} \times PC \times MP \times \frac{S_c + Ash_c}{100} - MP \times CD \right) \times \frac{44}{12}$$

where;

$E_{CO_2}$  = CO<sub>2</sub> emissions from paste consumption, tonnes CO<sub>2</sub>

MP = total metal production, tonnes Al

PC = paste consumption, tonnes/tonne Al

CSM = emissions of cyclohexane soluble matter, kg/tonne 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 Söderberg cells, tonnes C/tonne Al

44/12 = CO<sub>2</sub>molecular mass: carbon atomic mass ratio, dimensionless

### CO<sub>2</sub> emissions from Prebaked cells

$$E_{CO_2} = NAC \times MP \times \frac{C_a}{100} \times \frac{44}{12}$$

where;

$E_{CO_2}$  = CO<sub>2</sub> emissions from paste consumption, tonnes CO<sub>2</sub>

MP = total metal production, tonnes Al

NAC = net prebaked anode consumption per tonne of aluminum, tonnes C / tonne Al

Ca = carbon content in baked anodes, wt%

44/12 = CO<sub>2</sub> 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<sub>4</sub>, C<sub>2</sub>F<sub>6</sub>), following a T3 IPCC methodology.

In the following Table 4.33, PFCs, CF<sub>4</sub> and C<sub>2</sub>F<sub>6</sub> EF are reported.



**Table 4.33 PFCs, CF<sub>4</sub> and C<sub>2</sub>F<sub>6</sub> EF, 1990-2017**

Year	C <sub>2</sub> F <sub>6</sub> s EFs (kg/t)	CF <sub>4</sub> s EFs (kg/t)
1990	0.0632	1.4348
1991	0.0852	1.9315
1992	0.0743	1.6835
1993	0.0748	1.6959
1994	0.0646	1.4642
1995	0.0536	1.2157
1996	0.0535	1.2131
1997	0.0524	1.2067
1998	0.0534	1.2120
1999	0.0533	1.2082
2000	0.0535	1.2129
2001	0.0534	1.2100
2002	0.0531	1.2026
2003	0.0525	1.1884
2004	0.0522	1.1840
2005	0.0519	1.1771
2006	0.0382	0.9764
2007	0.0504	1.1421
2008	0.0480	1.0883
2009	0.0481	1.0908
2010	0.0474	1.0758
2011	0.0474	1.0747
2012	0.0458	1.0379
2013	0.0468	1.0613
2014	0.0473	1.0733
2015	0.0699	0.0826
2016	0.0852	0.1007
2017	0.0463	0.0547

Due to the process change in Eti Aluminum, the company has switched to the Prebake cells just in 2015 after using Söderberg process for long years. This technology change has led to changing the coefficient numbers and the difference between 2014-2015 has occurred because of this reason. Also PFC, C<sub>2</sub>F<sub>6</sub> and CF<sub>4</sub> emission factors are recalculated in Eti Aluminum Facility in 2015-2016, calculation made by using the current coefficients in the Greenhouse Gas Monitoring Reporting Communiqué.

## Collection of activity data

To estimate CO<sub>2</sub> 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, and 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 is given in table 4.34 below.

**Table 4.34 Aluminum production emissions, 1990-2017**

<b>Year</b>	<b>Aluminium Production (tonnes)</b>	<b>CO<sub>2</sub> emissions (kt)</b>
1990	54 970	99.2
1991	56 377	101.7
1992	54 136	97.7
1993	29 978	54.1
1994	61 161	110.3
1995	63 439	114.4
1996	60 006	108.2
1997	60 001	108.2
1998	64 002	115.5
1999	63 140	113.9
2000	62 501	112.7
2001	61 730	111.4
2002	61 501	110.9
2003	61 705	111.3
2004	61 803	111.5
2005	60 001	102.2
2006	60 006	108.0
2007	63 439	117.3
2008	61 161	111.8
2009	29 978	51.2
2010	54 136	96.4
2011	56 377	100.3
2012	43 635	76.4
2013	32 160	55.3
2014	30 016	54.9
2015	45 870	74.7
2016	78 807	117.3
2017	75 523	108.4

## Choice of emission factor

Some of the CO<sub>2</sub>emission factors are provided by the facility while some are used as default values. In the tables below the emission factors used in the formula for Söderberg cells and Prebaked cells can be found.

**Table 4.35 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%
Cc (Carbon content in calcined coke)	Plant specific	Confidential
Ashc (Ash content is calcined coke)	Plant specific	Confidential
CD (Carbon in skimmed dust from Soderberg 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 4.36 Emission factors for aluminum production with Prebaked cells, 2015-2016**

Emission factor	Type of data	Value
NAC (Net Prebaked Anode Consumption)	Plant specific	Confidential
Ca (Carbon content in baked anodes)	Plant specific	Confidential

Note that the company, Eti Alüminyum, switched to the Prebake cells just in 2015 after using Soderberg 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<sub>4</sub> Slope coefficient;
- C<sub>2</sub>F<sub>6</sub> Slope coefficient;
- CF<sub>4</sub>EF (kg CF<sub>4</sub>/tonnes aluminum);
- C<sub>2</sub>F<sub>6</sub>EF (kg C<sub>2</sub>F<sub>6</sub>/tonnes aluminum).

In the following table, PFCs, CF<sub>4</sub> and C<sub>2</sub>F<sub>6</sub> emissions are reported.

**Table 4.37 PFCs, CF<sub>4</sub> and C<sub>2</sub>F<sub>6</sub> emissions from primary aluminum production, 1990-2017**

Year	(kt CO <sub>2</sub> eq.)		
	PFCs	CF <sub>4</sub>	C <sub>2</sub> F <sub>6</sub>
1990	692 767	645 736	47 030
1991	854 541	796 527	58 013
1992	781 918	728 835	53 083
1993	786 584	733 184	53 400
1994	693 652	646 561	47 090
1995	592 881	552 631	40 249
1996	597 281	556 733	40 548
1997	593 326	553 046	40 279
1998	593 870	553 553	40 316
1999	591 067	550 940	40 126
2000	591 382	551 234	40 148
2001	592 202	551 998	40 203
2002	595 920	555 464	40 456
2003	595 330	554 914	40 416
2004	600 776	559 990	40 785
2005	559 966	521 950	38 015
2006	460 953	432 984	27 968
2007	574 440	535 432	39 007
2008	527 708	491 881	35 826
2009	259 256	241 656	17 600
2010	513 882	478 997	34 885
2011	480 349	447 744	32 605
2012	359 053	334 676	24 376
2013	270 582	252 212	18 369
2014	255 411	238 072	17 339
2015	159 033	122 766	36 267
2016	140 691	58 698	81 992
2017	73 214	30 545	42 699

## Uncertainties and Time-Series Consistency:

For CO<sub>2</sub> emissions, the uncertainty values of the T2 method is considered  $\pm 5\%$  for the EF and  $\pm 1\%$  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<sub>2</sub> 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 Guidelines Volume 3 (page 4.56).

### Source-Specific QA/QC and Verification:

Within the scope of the Turkish National Greenhouse Gas Emission Inventory Improvement Project, Turkey's only primary aluminum producer, Eti Alüminyum A.Ş., was visited on July 2017 and detailed information on production processes and data recording systems were obtained. The emission calculation methodology, the parameters used in the formulation and the data gathered were discussed with sector experts. The methodology, the parameters and the data were also approved by the sector experts.

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:

In the previous inventory, the producer provided the total metal production including the secondary productions for 2005-2013. This year the metal production data of the company revised and only the primary metal production was taken into consideration. Moreover, recalculation was made due to a formulation mistake for 1990 to 2012 for F-gases. Also PFC, C<sub>2</sub>F<sub>6</sub> and CF<sub>4</sub> emission factors are recalculated in Eti Aluminum Facility in 2015-2016, calculation made by using the current coefficients in the Greenhouse Gas Monitoring Reporting Communiqué. The unit of the total emission is CO<sub>2</sub> eq. for PFCs, CF<sub>4</sub> and C<sub>2</sub>F<sub>6</sub> emissions from primary aluminum production.

### 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 1990-2016.

#### 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/smeltering, 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 metallurgical 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<sub>2</sub>.

### 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<sub>2</sub> emissions by multiplying process specified to lead production data, as shown in equation below.

$$E_{CO_2} = Pb * EF_{secondary\ raw\ material\ treatment}$$

where:

E<sub>CO<sub>2</sub></sub> = CO<sub>2</sub> emissions from lead production, tonnes

Pb= quantity of lead produced, tonnes

EF secondary raw material treatment = process specific emission factor, tonnes CO<sub>2</sub> / tonne lead produced

The lead production data is known for only 1990-1996. Besides that, the amount of vehicle batteries recycled is known for the years 2007 and 2016. There is no data between 1997 and 2006. 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 between 1997 and 2006 is estimated by interpolation.

### Collection of activity data

There are many companies in Turkey recycling vehicle batteries for lead recovery. 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 2007-2016. The data is gathered from Ministry of Environment and Urbanization. It is assumed that 60% of the waste battery weight is recycled as lead. This assumption is based on the experts who work in the lead smelting industry. 1990-1996 lead production data is found in the 8<sup>th</sup> five years development plan 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 4.38 Lead production of Turkey and CO<sub>2</sub> emissions from lead production, 1990-2017**

Year	Recycled	Lead	CO <sub>2</sub>
1990	No Data	11.0	2.2
1991	No Data	8.5	1.7
1992	No Data	10.5	2.1
1993	No Data	9.6	1.9
1994	No Data	8.7	1.7
1995	No Data	11.1	2.2
1996	No Data	13.4	2.7
1997	No Data	14.7	2.9
1998	No Data	16.0	3.2
1999	No Data	17.2	3.4
2000	No Data	18.5	3.7
2001	No Data	19.7	3.9
2002	No Data	21.0	4.2
2003	No Data	22.3	4.5
2004	No Data	23.5	4.7
2005	No Data	24.8	5.0
2006	No Data	26.0	5.2
2007	45.5	27.3	5.5
2008	48.5	29.1	5.8
2009	53.0	31.8	6.4
2010	55.0	33.0	6.6
2011	59.4	35.6	7.1
2012	59.5	35.7	7.1
2013	69.0	41.4	8.3
2014	61.3	36.8	7.4
2015	71.4	42.9	8.6
2016	66.4	39.8	8.0
2017	73.9	44.3	8.9

### Choice of emission factor

Emission factor of 0.20 tonne of CO<sub>2</sub> / 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 expert judgment. The process type emission factor has an uncertainty of 20% by default.

### Source-Specific QA/QC and Verification:

The weight data of recycled batteries is gathered from Ministry of Environment and Urbanization (MEU). The same data is also produced by TurkStat. When this two data sets from different sources are compared they are found to be only 3% different.

In order to estimate the amount of lead produced using the amount of batteries recycled data, the biggest two lead smelter company were asked and the production engineers and environmental responsables 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 consistent with the assumption that 60% of lead is recovered by weight. In this submission emission calculation was done by using two different calculation tools by two people. One is typically excel based while the other is oracle and software coding based. The results of two different tool was compared to minimize calculation error.

### Recalculation:

There is no recalculation for this year's inventory.

### Planned Improvements:

Research will be held for decreasing the uncertainty in the activity data.

## 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 (ÇİNKUR), 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<sub>2</sub> emissions.



**Table 4.39 Zinc productions and CO<sub>2</sub> emission, 1990-2017**

Year	Zinc	
	Production (kt)	CO <sub>2</sub> emission (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
2000-2017	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 its primary zinc production line by December 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<sub>2</sub>emissions, the default EF is multiplied with zinc production data as shown in the equation below.

$$E_{CO_2} = ZN * EF_{default}$$

where:

E<sub>CO<sub>2</sub></sub> = CO<sub>2</sub> emissions from zinc production, tonnes

Zn = quantity of zinc produced, tonnes

EF default = Default emission factor, tonnes CO<sub>2</sub>/ tonne zinc produced

## Collection of activity data

The Plant stopped its primary zinc production activities in 1999. And it changed its owners many times from then. The newest owners of the plant have 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<sub>2</sub> / 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 zinc production plant is different in two separate data sources. (33.500 tonnes/year in the 8th Five Years of Development Plan of Turkey and 40.000 tonnes/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 than 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. In this submission emission calculation was done by using two different calculation tools by two people. One is typically excel based while the other is oracle and software coding based. The results of two different tool was compared to minimize calculation error.

### Recalculation:

There is no recalculation for this submission.

### 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<sub>2</sub> 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 Guidelines is used to calculate CO<sub>2</sub> 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<sub>2</sub> emissions, from 1990 to 2017.

**Table 4.40 The Amount of lubricant used and CO<sub>2</sub> emissions, 1990-2017**

Year	Lubricant	(kt) CO <sub>2</sub>
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
2016	229	135.0
2017	243	143.3

## 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, the default uncertainty for EF is 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. In this submission emission calculation was done by using two different calculation tools by two people. One is typically excel based while the other is oracle and software coding based. The results of two different tool was compared to minimize calculation error.

### 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). In this submission emission calculation was done by using two different calculation tools by two people. One is typically excel based while the other is oracle and software coding based. The results of two different tool was compared to minimize calculation error.

#### Methodological Issues:

CO<sub>2</sub> 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 Guidelines is used with default carbon content and ODU factor. The following table shows the amount of paraffin wax used and resulting CO<sub>2</sub> emissions, 1990 to 2017.

**Table 4.41 The Amount of paraffin wax used and CO<sub>2</sub> emissions, 1990-2017 (kt)**

Year	Paraffin wax use	CO <sub>2</sub>
1990	14	8.3
1991	13	7.7
1992	7	4.1
1993	8	4.7
1994	5	2.9
1995	5	2.9
1996	8	4.7
1997	5	2.9
1998	5	2.9
1999	4	2.4
2000	10	5.9
2001	28	16.5
2002	33	19.5
2003	29	17.1
2004	38	22.4
2005	89	52.5
2006	53	31.2
2007	29	17.1
2008	19	11.2
2009	20	11.8
2010	19	11.2
2011	32	18.9
2012	29	17.1
2013	11	6.5
2014	23	13.6
2015	20	11.8
2016	19	11.2
2017	14	8.3

## 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 Guidelines.

## 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 is determined 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  $\text{CF}_4$ ,  $\text{CHF}_3$  and  $\text{SF}_6$  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 was used for each year. This assumption is made by considering the expert judgment.

Table 4.42 shows the consumption amount of each gases which are consumed for the research and development purpose.

**Table 4.42 Consumption of each gases, 2010-2017**

Year	CF <sub>4</sub> (kg)	HFC-23 (kg)	SF <sub>6</sub> (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
2016	1.2	6	1 848
2017	1.28	6.4	1 984.7

### 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 Ministry of Trade.

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 3 % 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 Ozone Layer Division of MoEU and Turkish Fire Protection and Training Foundation – (TUYAK) which is representative of fire sector, 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.

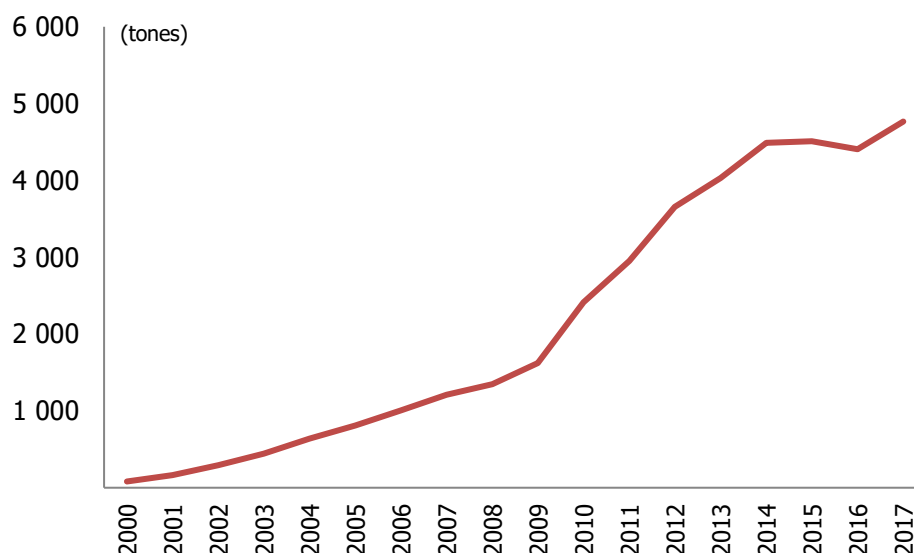
### Uncertainties and Time-Series Consistency:

Table 4.43 and Figure 4.19 present total HFCs emissions from 1997 to 2017. 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 (Values of 1999 has been calculated due to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories).

**Table 4.43 Total HFCs emissions, 2000-2017**

Year	HFCs Emissions (tonnes)	HFCs Emissions (kt CO <sub>2</sub> eq.)
1999	42.7	60.8
2000	81.3	115.66
2001	163.4	232.00
2002	293.9	417.19
2003	443.2	628.80
2004	640.8	909.37
2005	808.6	1 146.88
2006	1 004.4	1 424.19
2007	1 208.4	1 713.19
2008	1 348.1	1 896.14
2009	1 621.3	2 111.28
2010	2 412.4	3 054.19
2011	2 949.9	3 432.55
2012	3 654.4	4 256.75
2013	4 029.9	4 470.16
2014	4 489.2	4 927.46
2015	4 511.9	4 804.95
2016	4 405.7	4 719.53
2017	4 766.3	4 744.55

**Figure 4.19 Total HFCs emissions, 2000-2017**

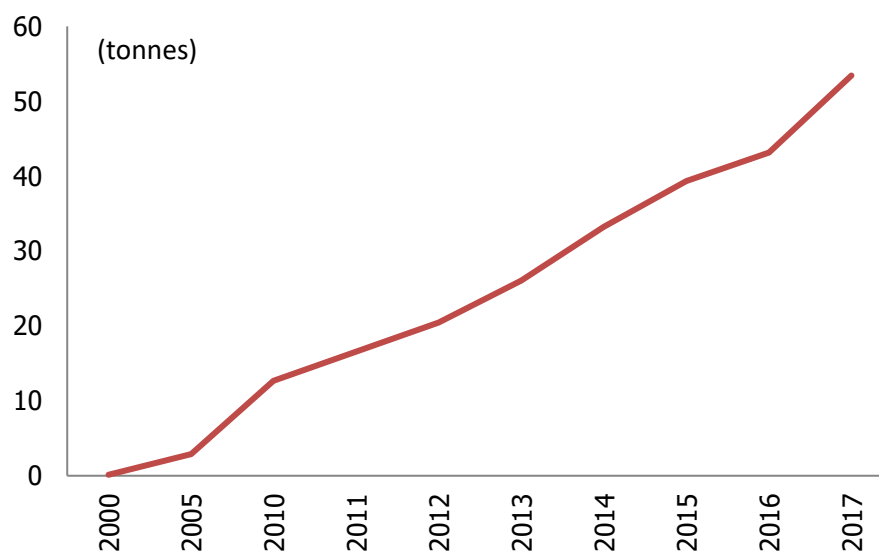


Above presentation shows aggregated emissions caused by HFCs including HFC-23, HFC-32, HFC-41, HFC-43-10mee, HFC-125, HFC-134, HFC-134a, HFC-143, HFC-143a, HFC-152a, HFC-227ea, HFC-236fa, HFC-245ca, and HFC-365mfc. Moreover, table below separately indicates emissions from these gases for specific years. All emission values are presented in tonnes and for each gas emissions are calculated related to Tier 1a/1b method of IPCC.

**Table 4.44 HFCs Emissions**

(tonnes)									Calculation method
Substance	2000	2005	2010	2013	2014	2015	2016	2017	
HFC-23	0.02	0.29	0.56	4.64	4.05	3.61	3.24	2.93	IPCC T1
HFC-32	-	-	-	0.01	0.236	0.201	1.625	4.28	IPCC T1
HFC-41	-	-	0.03	0.03	0.0217	0.6640	0.5644	0.4798	IPCC T1
HFC-43-10mee	-	-	-	0.07	0.1464	0.124	0.330	0.731	IPCC T1
HFC-125	-	-	0.71	6.68	14.180	24.180	30,863	34.724	IPCC T1
HFC-134	-	-	-	0.01	0.0046	0.0039	0.0034	0.0029	IPCC T1
HFC-134a	80.35	791.38	2066.27	2877.47	3056.82	2904.74	3128.67	3192.67	IPCC T1
HFC-143	-	-	0.001	0.001	0.001	0.000	0.000	0.00	IPCC T1
HFC-143a	-	-	-	0.000	0.000	2.83	3.83	3.25	IPCC T1
HFC-152a	0.78	14.07	331.36	1109.14	1139.46	1268.48	1376.52	1466.61	IPCC T1
HFC-236fa	-	-	0.68	4.12	4.105	4.090	4.601	5.56	IPCC T1
HFC-245ca	-	-	0.02	0.82	2.6539	2.2557	1.9174	1.6298	IPCC T1
HFC-245fa	-	-	-	-	10.67	11.81	10.65	0.00	IPCC T1
HFC-365mfc	-	-	0.12	0.92	0.78	0.66	0.56	0.4798	IPCC T1
HFC-227ea	0.13	2.87	12.67	26.06	33.23	39.33	43.17	53.44	IPCC T1

**Figure 4.20 HFC-227ea Emissions, 2001-2017**



### Recalculation:

Recalculation and minor corrections has been made between years 2014-2016.

### Planned Improvements:

For the future inventory submissions, improvements in the sector data will be done within the scope of *Technical Assistance for Increased Capacity for Transposition and Capacity Building on F-Gases Project* which has started in 2017 and will last in 2020.

## 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<sub>6</sub> Emissions from electrical equipment

### Methodological Issues:

It is assumed that SF<sub>6</sub> is used only in electrical instruments, mainly in circuit breakers. Emission results are reported based on the import and export data of SF<sub>6</sub>. However, custom code for this gas was established in 2013 and trade data is available only for 2013, 2014, 2015, 2016 and 2017. Therefore, trend of electricity consumption is used for the prediction of imported gas for previous years.

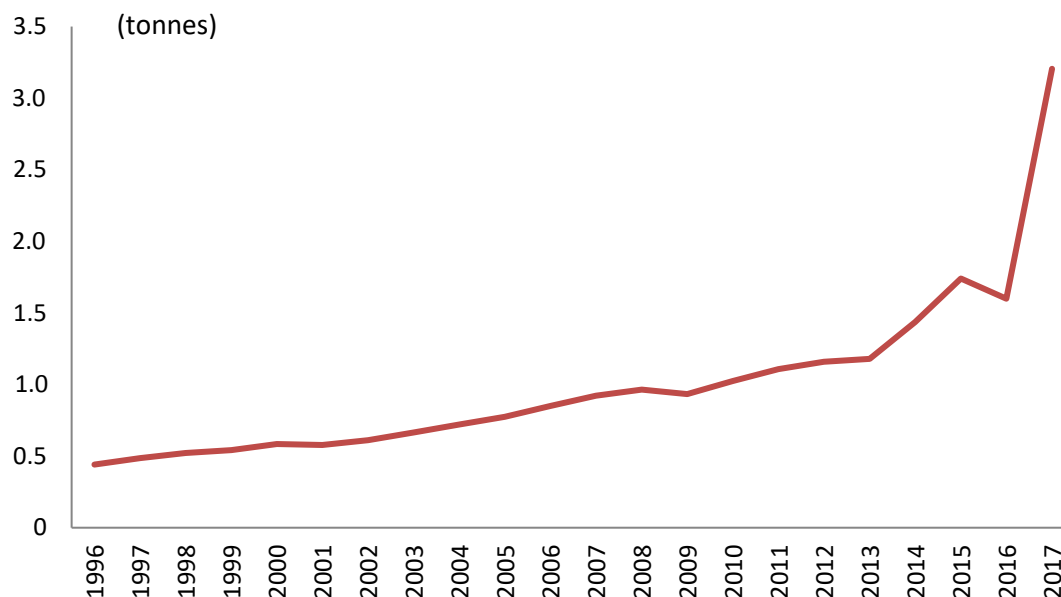
Data for electricity consumption is obtained from the Turkish Electricity Transmission Corporation and the trade data for SF<sub>6</sub> is provided by Ministry of Trade. Table 4.45 shows the distribution of electricity consumption, SF<sub>6</sub> consumption (import and export values) and emissions of SF<sub>6</sub> which is emitted from the circuit breakers used in Electricity industry. The IPCC default values of emission factors (including natural leakage and emissions of operation, maintenance, and disposal) are 2.6% for the EU, 0.7% for Japan, and 2.0% as a global average and calculation made by using the global average value.

**Table 4.45 SF<sub>6</sub> Consumption and Electricity Consumption**

<b>Years</b>	<b>Electricity consumption (GWh)</b>	<b>SF<sub>6</sub> net consumption (tonnes)</b>	<b>SF<sub>6</sub> Emissions (tonnes)</b>
1996	74 157	22.075	0.441
1997	81 885	24.375	0.487
1998	87 705	26.108	0.522
1999	91 202	27.149	0.542
2000	98 296	29.260	0.585
2001	97 070	28.895	0.577
2002	102 948	30.645	0.612
2003	111 766	33.270	0.665
2004	121 142	36.061	0.721
2005	130 263	38.776	0.775
2006	143 071	42.589	0.851
2007	155 135	46.180	0.923
2008	161 948	48.208	0.964
2009	156 894	46.703	0.934
2010	172 051	51.215	1.024
2011	186 100	55.397	1.107
2012	194 923	58.024	1.160
2013	198 045	58.953	1.179
2014	207 375	71.826	1.436
2015	216 233	87.055	1.741
2016	225 495	80.002	1.600
2017	249 020	160.277	3.205

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 2% emitted in related year. Net consumption of SF<sub>6</sub> is almost doubled by year 2017 when comparing with year 2016, import and export data is provided by Ministry of Trade.

**Figure 4.21 SF<sub>6</sub> emissions, 1996-2017**



## Uncertainties and Time-Series Consistency:

Uncertainties of SF<sub>6</sub> 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:

There is no recalculation for this year's inventory.

## Planned Improvements:

For the future inventory submissions, improvements in the sector data will be done within the scope of "Technical Assistance for Increased Capacity for Transposition and Capacity Building on F-Gases" project which has started in June 2017 and will last till May 2020.

## 5. AGRICULTURE (CRF Sector 3)

### 5.1. Sector Overview

Agricultural activities will most likely coexist with the existence of human beings on this planet, and agricultural production is indispensable to the continuance of life. Effects of climate change are observed by concentration of GHGs for many sectors including agriculture which generally comes second in size after the energy sector. The total emission value calculated for the agriculture sector is 62.5 Mt CO<sub>2</sub> eq. for the year 2017 which is 14.7% of the total emission value including LULUCF sector and 11.9% of all emissions excluding LULUCF sector for the Republic of Turkey. The agricultural sector is divided into ten categories from 3.A to 3.J in the CRF tables. These categories are listed in Table 5.1 briefly for GHGs emitted from each of these sources.

**Table 5.1 Categories of the agriculture sector and emitted gases**

CRF Categories	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	NO <sub>x</sub>	CO	NMVOC	SO <sub>x</sub>
3.A Enteric fermentation		x					
3.B Manure management		x	x	x <sup>b</sup>		x <sup>b</sup>	
3.C Rice cultivation		x					
3.D Agricultural soils	x <sup>a</sup>		x	x <sup>b</sup>		x <sup>b</sup>	
3.E Prescribed burning of savannas		x	x	x <sup>c</sup>	x <sup>c</sup>	x <sup>c</sup>	x <sup>c</sup>
3.F Field burning of agricultural residues		x	x	x <sup>b</sup>	x <sup>b</sup>	x <sup>b</sup>	x <sup>b</sup>
3.G Liming	x						
3.H Urea application	x						
3.I Other carbon-containing fertilizers	x						
3.J Other							

<sup>a</sup> to be reported under LULUCF Sector.

<sup>b</sup> Emissions of this gas from this category are likely to be emitted and a methodology is provided in the EMEP/EEA Guidebook.

<sup>c</sup> 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 percentage of total national GHG emissions (excluding LULUCF) gradually declined from 20.8% to 10.5% in most of the years between 1990 and 2009 before levelling off. With the aim to give a clear view on the weights of the categories within the sector, the following Table 5.2 presents emission and percentage values for the year 2017.

**Table 5.2 Agriculture sector emissions and overall percentages by categories, 2017**

	CH <sub>4</sub> (kt CO <sub>2</sub> eq.)	N <sub>2</sub> O (kt CO <sub>2</sub> eq.)	CO <sub>2</sub> (kt)	Total (kt CO <sub>2</sub> eq.)	(%)
<b>3 Agriculture</b>	<b>33 746.8</b>	<b>27 346.2</b>	<b>1 449.6</b>	<b>62 542.6</b>	<b>100.0</b>
A. Enteric fermentation	30 039.2			30 039.2	48.0
B. Manure management	3 347.7	4 190.1		7 537.8	12.1
C. Rice cultivation	233.8			233.8	0.4
D. Agricultural soils		23 117.2		23 117.2	37.0
E. Prescribed Burning of Savannas				NO	
F. Field burning of agricultural residues	126.1	39.0		165.1	0.3
G. Liming				NE	
H. Urea application			1 449.6	1 449.6	2.3
I. Other Carbon-containing fertilizers				NE	
J. Other				NO	
<b>GHG Percentage Shares</b>	<b>54.0</b>	<b>43.7</b>	<b>2.3</b>	<b>100.0</b>	

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 value for the sector increased from approximately 45.7 Mt CO<sub>2</sub> eq. to around 62.5 Mt CO<sub>2</sub> eq. (an increase of 36.9%) during the 28 years period after 1990. The biggest increase among the categories in absolute terms for the emissions is observed in the enteric fermentation category where the emissions increased by around 7.7 Mt CO<sub>2</sub> eq. (34.6%) from 22.3 Mt CO<sub>2</sub> eq. to 30.0 Mt CO<sub>2</sub> eq. for the same period. The primary reason for this increase is the change in activity data. Other significant increases in this twenty-eight years period are seen in agricultural soils, manure management, and urea application where the figures are 6.0 Mt CO<sub>2</sub> eq. (35.2%), 2.2 Mt CO<sub>2</sub> eq. (40.5%), and 1.0 Mt CO<sub>2</sub> eq. (215.2%) respectively. Increases in emissions from enteric fermentation and manure management are largely a result of changes in activity data. Emissions for rice cultivation increased by 0.1 Mt CO<sub>2</sub> eq. (133.3%) whereas the emissions for field burning of agricultural residues of 1990 and 2017 resulted in a decrease of 52.4%.



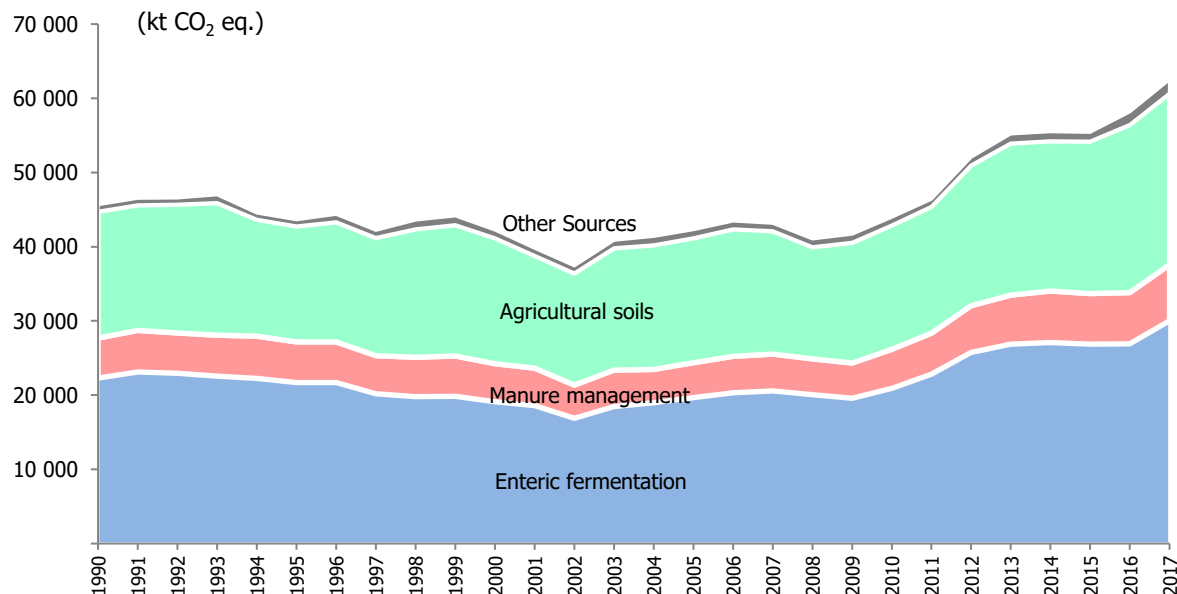
Table 5.3 Overview of agriculture sector emissions, 1990–2017

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 <sub>2</sub> eq.)	Agriculture total (%)
	(kt CO <sub>2</sub> eq.)	(%)	(kt CO <sub>2</sub> eq.)	(%)	(kt CO <sub>2</sub> eq.)	(%)	(kt CO <sub>2</sub> eq.)	(%)	(kt CO <sub>2</sub> eq.)	(%)	(kt CO <sub>2</sub> eq.)	(%)		
1990	22 314	48.8	5 365	11.7	100	0.2	17 093	37.4	347	0.8	460	1.0	45 680	100
1991	23 129	49.7	5 592	12.0	100	0.2	16 930	36.4	359	0.8	436	0.9	46 546	100
1992	22 929	49.2	5 467	11.7	94	0.2	17 302	37.1	341	0.7	459	1.0	46 592	100
1993	22 536	47.9	5 536	11.8	102	0.2	17 864	38.0	367	0.8	627	1.3	47 032	100
1994	22 235	49.9	5 735	12.9	90	0.2	15 721	35.3	321	0.7	453	1.0	44 553	100
1995	21 705	49.7	5 460	12.5	113	0.3	15 633	35.8	332	0.8	426	1.0	43 668	100
1996	21 677	48.9	5 515	12.4	126	0.3	16 176	36.5	344	0.8	534	1.2	44 372	100
1997	20 204	47.8	5 103	12.1	124	0.3	15 933	37.7	347	0.8	532	1.3	42 243	100
1998	19 781	45.4	5 304	12.2	135	0.3	17 326	39.8	382	0.9	658	1.5	43 586	100
1999	19 850	44.9	5 406	12.2	147	0.3	17 709	40.1	342	0.8	733	1.7	44 187	100
2000	19 124	45.3	5 098	12.1	128	0.3	16 953	40.1	340	0.8	617	1.5	42 261	100
2001	18 606	46.7	5 049	12.7	132	0.3	15 169	38.1	318	0.8	527	1.3	39 801	100
2002	16 878	45.1	4 481	12.0	135	0.4	15 098	40.3	328	0.9	527	1.4	37 447	100
2003	18 464	45.2	4 906	12.0	143	0.3	16 466	40.3	325	0.8	565	1.4	40 869	100
2004	18 957	45.8	4 509	10.9	156	0.4	16 788	40.5	359	0.9	632	1.5	41 402	100
2005	19 663	46.5	4 691	11.1	183	0.4	16 854	39.8	302	0.7	613	1.4	42 307	100
2006	20 331	46.7	4 913	11.3	212	0.5	17 150	39.4	294	0.7	592	1.4	43 492	100
2007	20 552	47.6	4 982	11.5	203	0.5	16 618	38.5	256	0.6	566	1.3	43 177	100
2008	20 057	48.9	4 825	11.8	216	0.5	15 122	36.8	259	0.6	565	1.4	41 044	100
2009	19 576	47.0	4 768	11.4	209	0.5	16 262	39.0	288	0.7	593	1.4	41 696	100
2010	20 912	47.6	5 289	12.0	202	0.5	16 709	38.0	219	0.5	645	1.5	43 976	100
2011	22 806	49.2	5 525	11.9	204	0.4	17 074	36.8	233	0.5	558	1.2	46 400	100
2012	25 740	49.4	6 298	12.1	249	0.5	18 930	36.3	224	0.4	640	1.2	52 080	100
2013	26 851	48.6	6 634	12.0	231	0.4	20 452	37.0	240	0.4	807	1.5	55 215	100
2014	27 094	48.8	6 926	12.5	230	0.4	20 256	36.5	215	0.4	788	1.4	55 508	100
2015	26 888	48.5	6 812	12.3	240	0.4	20 504	37.0	174	0.3	811	1.5	55 428	100
2016	26 923	46.3	6 913	11.9	243	0.4	22 643	38.9	164	0.3	1 295	2.2	58 182	100
2017	30 039	48.0	7 538	12.1	234	0.4	23 117	37.0	165	0.3	1 450	2.3	62 543	100

Figures in the table may not add up to the total due to rounding.

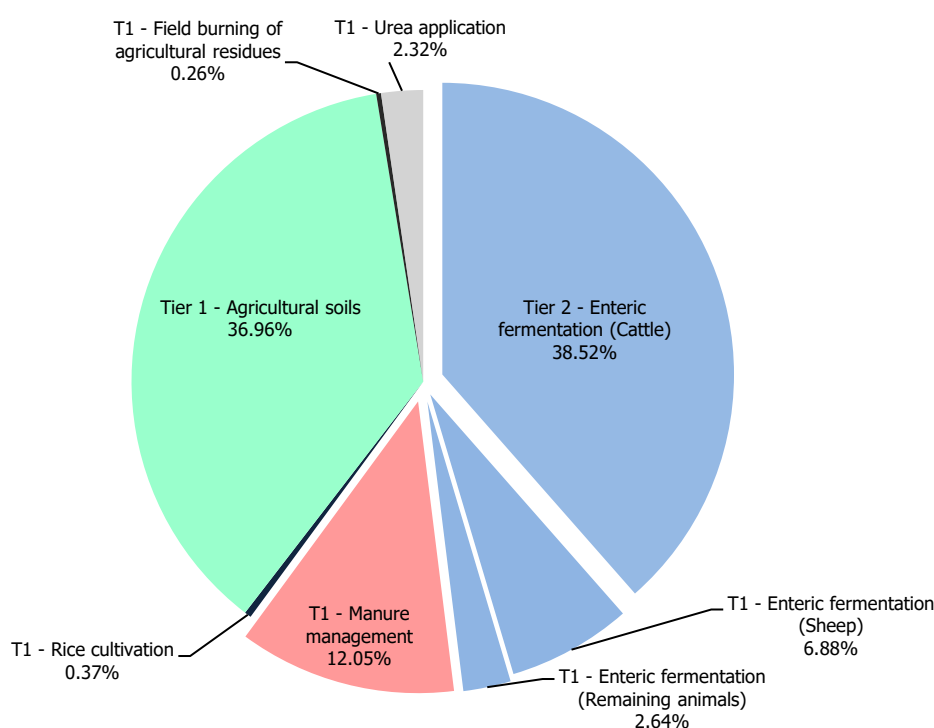
Furthermore, in relative terms, the biggest category in the agriculture sector is enteric fermentation having a 48% share for 2017, so it dominates the sector. In all reported years, 1990-2017, this category had an average share of 47.6% in the agriculture sector, though the trend indicates a slight decline from 48.8% to 48%. The second biggest category is agricultural soils having a proportion of 37% for 2017 decreased from 38.9% in 2016. While having percentage shares of agricultural soils range from 35.3% in 1994 and 40.5% in 2004, its average share for the entire reporting period of twenty-eight years is around 38%. Manure management's share presents somehow a more stable increasing trend, starting from 11.7% in 1990 and reaching 12.1% in 2017 having an average of 12%. The remaining categories, which are rice cultivation, field burning of agricultural residuals, and urea application, had emission shares of 0.4%, 0.3%, and 2.3% respectively for 2017. Though the share increased by around 70.4% for rice cultivation and 130.2% for urea application, the absolute terms were small and relative weights of these two categories were still low for the period 1990-2017. Despite these increasing values, the share for field burning of agricultural residues decreased from 0.8% to 0.3% for the reporting period. A graphical representation is given below in Figure 5.1, which displays the overall cumulative distribution and the trend for the reporting period of the agriculture sector. Other sources are calculated by the addition of emission estimations from rice cultivation, field burning, and urea application.

**Figure 5.1 Cumulative emissions of agricultural categories, 1990–2017**



Additionally, it should be noted that prescribed burning of savannas (CRF Category 3.E) does not occur in Turkey and is therefore not reported in this National Inventory Report whereas liming (CRF Category 3.G) and other carbon-containing fertilizers (CRF Category 3.I) are not reported 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. Figure 5.2 displays an overview of category shares and methods used for the agriculture sector.

**Figure 5.2 Category shares and methods used in the agriculture sector, 2017**



The methods used for the emission estimations in the agriculture sector except for cattle in enteric fermentation are Tier 1 (T1). The only Tier 2 (T2) method used in this sector is for emissions due to enteric fermentation of cattle which has a value of 24 090 kt CO<sub>2</sub> eq. This amount equals to around 38.5% of total emissions in the agriculture sector and 80.2% of total emissions in enteric fermentation which is the biggest subcategory in enteric fermentation as presented in Figure 5.2.

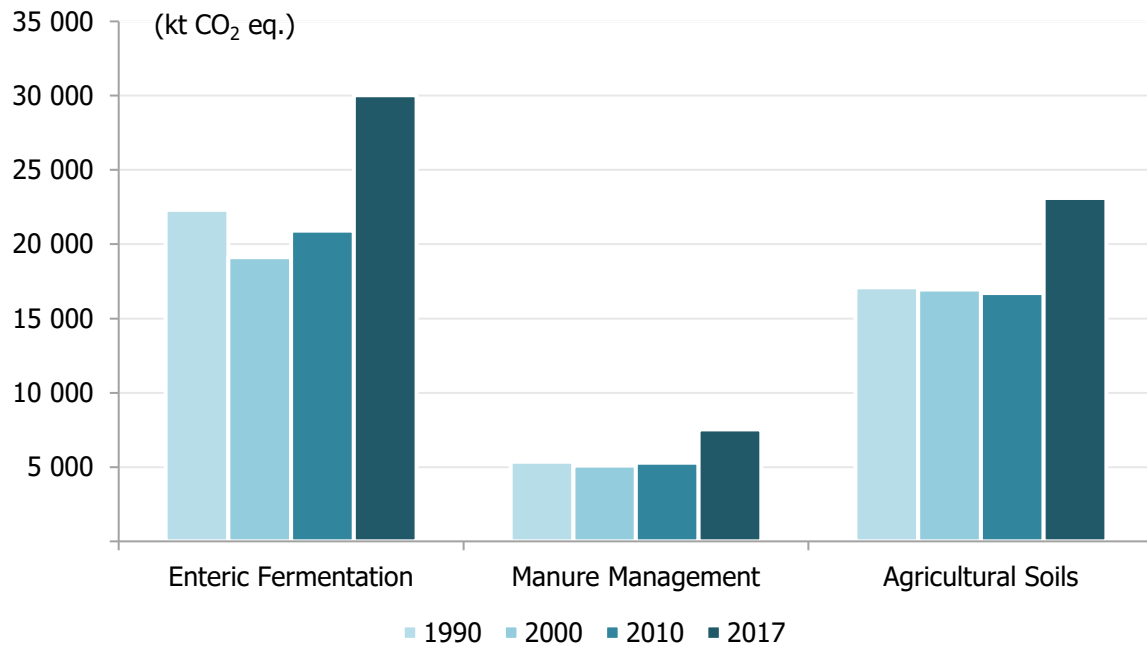
**Table 5.4 Agriculture sector emissions – comparison between 2016 and 2017**

Source Category	2016		2017		Change	
	(kt CO <sub>2</sub> eq.)	(%)	(kt CO <sub>2</sub> eq.)	(%)	(kt CO <sub>2</sub> eq.)	(%)
<b>3. Agriculture Sector</b>	<b>58 182</b>	<b>100</b>	<b>62 543</b>	<b>100</b>	<b>4 361</b>	<b>7.5</b>
3.A Enteric Fermentation	26 923	46.3	30 039	48.0	3 116	11.6
3.B Manure Management	6 913	11.9	7 538	12.1	625	9.0
3.C Rice Cultivation	243	0.4	234	0.4	-9	-3.8
3.D Agricultural Soils	22 643	38.9	23 117	37.0	474	2.1
3.F Field Burning	164	0.3	165	0.3	1	0.3
3.H Urea Application	1 295	2.2	1 450	2.3	154	11.9

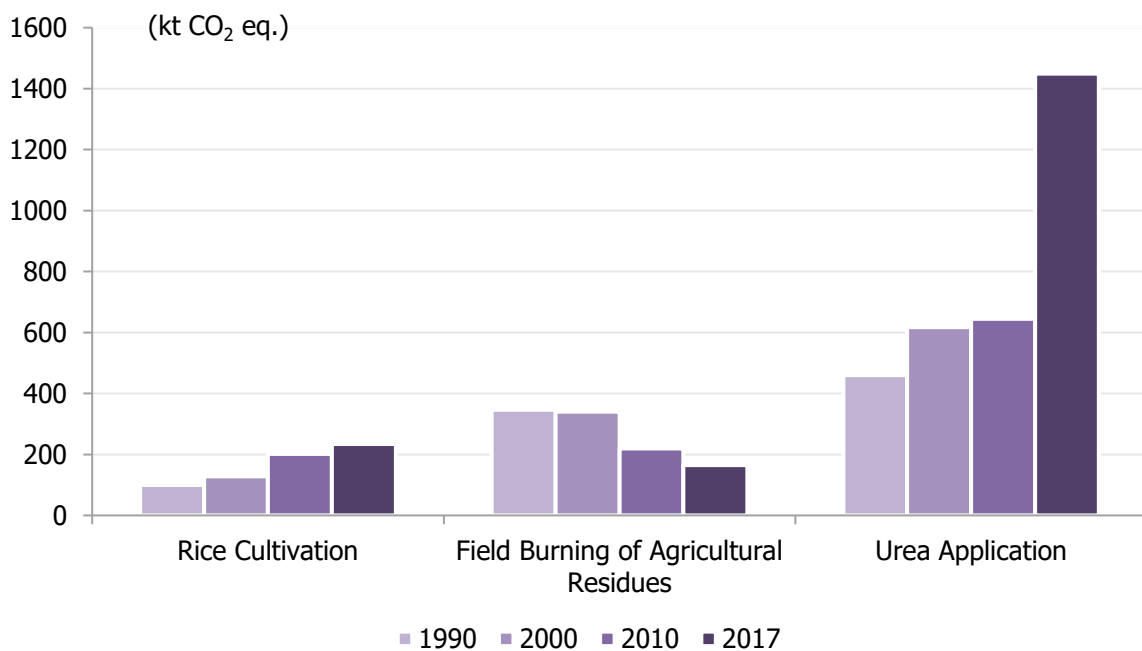
Figures in the table may not add up to the total due to rounding.

The emission values between latest of the two reporting years, 2016 and 2017, are given in Table 5.4 and in order to present a different perspective on the size changes of major agricultural categories, Figure 5.3 is also given. Major agricultural categories, enteric fermentation, manure management, and agricultural soils, are responsible for more than 95% of the emissions in the sector. Additionally, the main changes in minor agricultural categories are given in Figure 5.4.

**Figure 5.3 Trends in major categories of agriculture**



**Figure 5.4 Trends in minor categories of agriculture**



GHG emission values and their shares in the agriculture sector, CH<sub>4</sub>, N<sub>2</sub>O and CO<sub>2</sub>, are given in Table 5.5. After its initial increase in 1991, emission values for CH<sub>4</sub> decrease in the eleven years (except in 1996 and 1999) until 2002. Thereafter, the overall increasing trend could be split into two phases: a moderate one until 2009 and a stronger one after 2009. Overall, the percentage share of CH<sub>4</sub> decreased from 54.8% in 1990 to 54% in 2017.

The average share of N<sub>2</sub>O emissions were around 44.8% with respect to yearly total agricultural emission values. The emission values for N<sub>2</sub>O were 20 189 kt CO<sub>2</sub> eq. (44.2%) in 1990 and increased to an estimated value of 27 346 kt CO<sub>2</sub> eq. while taking a slightly less share of 43.7% of total agricultural emissions in 2017. N<sub>2</sub>O emissions are due to manure management and agricultural soils source categories in the agricultural sector.

CO<sub>2</sub> emissions result only from urea application; have the smallest share in this sector, and ranges between 0.9% and 2.3% for the period 1990-2017. The highest value of CO<sub>2</sub> emissions occurred in 2017 with 1450 kt, while it has the smallest value in 1995 with 426 kt depending on the amount of urea applied. The corresponding value for the latest reporting year accounts for a share of 2.3%.

**Table 5.5 Overview of GHGs in the agriculture sector, 1990–2017**

Year	CH <sub>4</sub>		N <sub>2</sub> O		CO <sub>2</sub>		Total
	(kt CO <sub>2</sub> eq.)	(%)	(kt CO <sub>2</sub> eq.)	(%)	(kt)	(%)	(kt CO <sub>2</sub> eq.)
1990	25 031	54.8	20 189	44.2	460	1.0	45 680
1991	25 944	55.7	20 166	43.3	436	0.9	46 546
1992	25 614	55.0	20 520	44.0	459	1.0	46 592
1993	25 339	53.9	21 066	44.8	627	1.3	47 032
1994	25 230	56.6	18 870	42.4	453	1.0	44 553
1995	24 597	56.3	18 646	42.7	426	1.0	43 668
1996	24 620	55.5	19 218	43.3	534	1.2	44 372
1997	22 901	54.2	18 809	44.5	532	1.3	42 243
1998	22 686	52.0	20 243	46.4	658	1.5	43 586
1999	22 813	51.6	20 641	46.7	733	1.7	44 187
2000	21 845	51.7	19 798	46.8	617	1.5	42 261
2001	21 395	53.8	17 879	44.9	527	1.3	39 801
2002	19 281	51.5	17 639	47.1	527	1.4	37 447
2003	21 086	51.6	19 218	47.0	565	1.4	40 869
2004	21 258	51.3	19 512	47.1	632	1.5	41 402
2005	22 037	52.1	19 657	46.5	613	1.4	42 307
2006	22 818	52.5	20 081	46.2	592	1.4	43 492
2007	23 134	53.6	19 477	45.1	566	1.3	43 177
2008	22 579	55.0	17 900	43.6	565	1.4	41 044
2009	22 143	53.1	18 960	45.5	593	1.4	41 696
2010	23 752	54.0	19 578	44.5	645	1.5	43 976
2011	25 641	55.3	20 202	43.5	558	1.2	46 400
2012	28 997	55.7	22 443	43.1	640	1.2	52 080
2013	30 261	54.8	24 146	43.7	807	1.5	55 215
2014	30 652	55.2	24 069	43.4	788	1.4	55 508
2015	30 292	54.7	24 326	43.9	811	1.5	55 428
2016	30 404	52.3	26 482	45.5	1 295	2.2	58 182
2017	33 747	54.0	27 346	43.7	1 450	2.3	62 543

Figures in the table may not add up to the total due to rounding.

The activity data used for the compilation of the GHG inventory is provided mainly by Turkish Statistical Institute.

Livestock population data are critical activity data for the required calculations. Animal population numbers given in Table 5.6 and Table 5.7 are provided by TurkStat for the entire time series, 1990–2017. There are differences among population sizes (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 old and do not consider 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 have some assumptions on 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 livestock 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 collected and published two times a year. The data, entered into an online database by the district offices, have been analyzed together with the Ministry of Food, Agriculture and Livestock. Prepared data are sent to the Ministry for controlling process. Once again controlled data are analyzed by Agricultural Production Statistics group at TurkStat and will then become ready for publishing after final analysis and controls.

Livestock population numbers are given for livestock species in Table 5.6. As the numbers display, both dairy and non-dairy cattle, domestic sheep, poultry and goats have significantly high population numbers with respect to other livestock species. Four columns, which are dairy cattle, non-dairy cattle, sheep merino, and poultry, have positive differences between 1990 and 2017 with population increasing around 0.08 million (1.3%), 4.5 million (81.9%), 1.6 million (187.4%), and 245.9 million (240.5%) respectively. It is remarkable that poultry numbers had more than tripled in 28 years from around 102 million to over 348 million. Contrary to these developments, the livestock categories given in the remaining columns decreased by having changes ranging from -2.7% (for goats) to -88.7% (for swine) for the period of 1990-2017. Similarly, other changing percentages observed for categories camels, domestic sheep, buffalo, horses, and mules and asses are -14.9%, -21.3%, -56.5%, -77.8%, -85.2% respectively. The figures are also presenting a decreasing trend for many livestock species for the reporting period of 1990-2017. Decreasing livestock population numbers of nearly 8.5 million in domestic sheep, around 0.2 million in buffalo, and more than a quarter million in goats have important consequences for the agriculture sector in our country. During the reporting period of 28 years, our country's population is increasingly living in urban areas rather than in rural areas which reduced the demand for some of the animals in small households living in rural areas. Moreover, some animals used for carrying goods previously in rural areas, are not needed any more extensively for this purpose. Thus the demand for some livestock species decreased as result significantly.



Table 5.6 Livestock population numbers in Turkey, 1990–2017

Year	Dairy Cattle	Non-Dairy Cattle	Sheep		Sheep Merino	Goats			Buffalo			Poultry			Horses			Mules and Asses		Swine	Camels
			Domestic																		
1990	5 893	5 485	39 711		842	10 926		371	102 255		513	1 187		12.0		2.0					
1991	6 119	5 854	39 590		842	10 764		366	145 051		496	1 136		10.3		1.9					
1992	6 070	5 881	38 576		840	10 454		352	158 770		483	1 075		11.8		1.9					
1993	6 032	5 878	36 709		832	10 133		316	184 460		450	1 013		9.0		2.0					
1994	6 082	5 819	34 823		823	9 564		305	190 033		437	978		8.0		2.0					
1995	5 886	5 903	32 985		806	9 111		255	135 251		415	900		5.0		2.0					
1996	5 968	5 918	32 234		838	8 951		235	158 756		391	843		5.0		2.0					
1997	5 597	5 593	29 376		862	8 376		194	175 223		345	782		4.6		1.4					
1998	5 489	5 542	28 560		875	8 057		176	243 914		330	736		5.0		1.4					
1999	5 538	5 516	29 425		831	7 774		165	246 476		309	680		3.4		1.4					
2000	5 280	5 481	27 719		773	7 201		146	264 451		271	588		3.0		1.0					
2001	5 086	5 462	26 213		759	7 022		138	223 141		271	559		2.7		0.9					
2002	4 393	5 411	24 474		700	6 780		121	251 101		249	512		3.6		0.9					
2003	5 040	4 748	24 689		742	6 772		113	283 674		227	490		7.1		0.8					
2004	3 876	6 194	24 438		763	6 610		104	302 799		212	452		4.4		0.9					
2005	3 998	6 528	24 552		752	6 517		105	322 917		208	423		1.9		0.8					
2006	4 188	6 683	24 801		815	6 643		101	349 402		204	404		1.4		1.0					
2007	4 229	6 807	24 491		971	6 286		85	273 548		189	364		1.8		1.1					
2008	4 080	6 780	22 956		1 019	5 594		86	249 044		180	336		1.7		1.0					
2009	4 133	6 591	20 722		1 028	5 128		87	234 082		167	286		1.9		1.0					
2010	4 362	7 008	22 003		1 086	6 293		85	238 973		155	260		1.6		1.3					
2011	4 761	7 625	23 811		1 221	7 278		98	241 499		151	248		1.8		1.3					
2012	5 431	8 484	25 893		1 533	8 357		107	257 505		141	236		3.0		1.3					
2013	5 607	8 808	27 485		1 799	9 226		118	270 202		136	227		3.1		1.4					
2014	5 609	8 614	29 034		2 106	10 345		122	298 030		131	212		2.7		1.4					
2015	5 536	8 458	29 302		2 206	10 416		134	316 332		123	198		1.6		1.5					
2016	5 432	8 648	28 833		2 151	10 345		142	333 541		120	190		1.3		1.6					
2017	5 969	9 975	31 257		2 420	10 635		161	348 144		114	176		1.4		1.7					

Time series for cattle population with its subcategories in our country are given in Table 5.7. Livestock production can result in CH<sub>4</sub> emissions from enteric fermentation and also in CH<sub>4</sub> and N<sub>2</sub>O emissions from livestock manure management systems. Cattle as a livestock category is a significant source of CH<sub>4</sub> in our country because of their large population and high CH<sub>4</sub> emission rate due to their ruminant digestive system.

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 values of hybrid cattle are between them. Hybrid cattle are breeds of culture and domestic dairy cattle. As it is seen in the table, culture dairy cattle population is increasing by years except for the years 1998, 2002 and 2004. But, in general the culture dairy cattle population has a positive trend in the period 1990-2017, which has a percentage increase of 40% from 9% 1990 to 49% in 2017 within dairy cattle population. For hybrid cattle population, which was around 2.4 million in 1990, a big increase or decrease cannot be observed throughout the same period, though the final reporting year identified an increase close to 0.2 million. The share of domestic cattle among dairy cattle was 58.1% in 1990 but this ratio reduced to 10.1% in 2017. Non-dairy cattle number increased by approximately 4.5 million from around 5.5 million in 1990 to more than 9.9 million in 2017 and its share in total number of cattle increased from 48.2% to 62.6% between 1990 and 2017. Furthermore, Figure 5.5 displays three types of dairy cattle as well as non-dairy cattle population numbers for the period of 1990-2017 in a straightforward chart.

**Figure 5.5 Population numbers for cattle categories, 1990–2017**

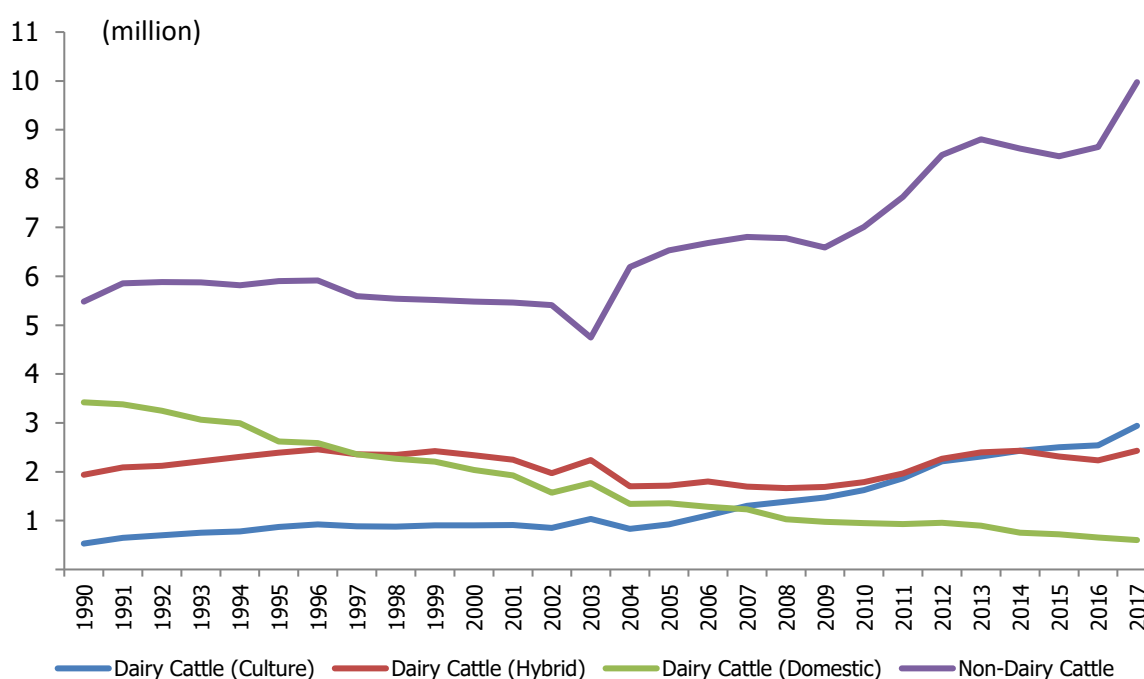


Table 5.7 Subcategories of cattle population, 1990–2017

Year	Culture			Hybrid			Dairy cattle			Domestic			Total			Total			Total Cattle (population)
	(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	650 738	5.4		2 087 018	17.4		3 381 244	28.2		6 119 000	51.1		5 853 923	48.9		11 972 923			
1992	698 224	5.8		2 124 106	17.8		3 247 848	27.2		6 070 178	50.8		5 880 729	49.2		11 950 907			
1993	750 255	6.3		2 214 723	18.6		3 066 974	25.8		6 031 952	50.6		5 878 048	49.4		11 910 000			
1994	779 689	6.6		2 308 310	19.4		2 994 181	25.2		6 082 180	51.1		5 818 820	48.9		11 901 000			
1995	870 246	7.4		2 392 621	20.3		2 622 719	22.2		5 885 586	49.9		5 903 414	50.1		11 789 000			
1996	920 185	7.7		2 457 925	20.7		2 590 101	21.8		5 968 211	50.2		5 917 789	49.8		11 886 000			
1997	882 093	7.9		2 355 540	21.1		2 358 978	21.1		5 596 611	50.0		5 593 326	50.0		11 189 937			
1998	879 840	8.0		2 346 094	21.3		2 263 114	20.5		5 489 048	49.8		5 541 952	50.2		11 031 000			
1999	903 495	8.2		2 424 626	21.9		2 209 762	20.0		5 537 883	50.1		5 516 117	49.9		11 054 000			
2000	904 850	8.4		2 335 119	21.7		2 039 604	19.0		5 279 573	49.1		5 481 427	50.9		10 761 000			
2001	912 411	8.7		2 248 882	21.3		1 924 526	18.2		5 085 819	48.2		5 462 181	51.8		10 548 000			
2002	850 726	8.7		1 971 743	20.1		1 570 105	16.0		4 392 574	44.8		5 410 924	55.2		9 803 498			
2003	1 034 817	10.6		2 236 685	22.9		1 768 868	18.1		5 040 370	51.5		4 747 732	48.5		9 788 102			
2004	832 710	8.3		1 699 803	16.9		1 343 209	13.3		3 875 722	38.5		6 193 624	61.5		10 069 346			
2005	925 613	8.8		1 717 310	16.3		1 355 172	12.9		3 998 095	38.0		6 528 345	62.0		10 526 440			
2006	1 106 679	10.2		1 799 411	16.6		1 281 844	11.8		4 187 934	38.5		6 683 430	61.5		10 871 364			
2007	1 299 750	11.8		1 698 804	15.4		1 230 888	11.2		4 229 442	38.3		6 807 311	61.7		11 036 753			
2008	1 385 727	12.8		1 665 186	15.3		1 029 329	9.5		4 080 242	37.6		6 779 700	62.4		10 859 942			
2009	1 470 885	13.7		1 686 064	15.7		976 201	9.1		4 133 150	38.5		6 590 808	61.5		10 723 958			
2010	1 626 416	14.3		1 787 010	15.7		948 416	8.3		4 361 842	38.4		7 007 958	61.6		11 369 800			
2011	1 868 281	15.1		1 962 711	15.8		930 158	7.5		4 761 150	38.4		7 625 187	61.6		12 386 337			
2012	2 211 245	15.9		2 263 400	16.3		956 758	6.9		5 431 403	39.0		8 483 509	61.0		13 914 912			
2013	2 314 282	16.1		2 395 898	16.6		897 098	6.2		5 607 278	38.9		8 807 979	61.1		14 415 257			
2014	2 427 915	17.1		2 428 709	17.1		752 625	5.3		5 609 249	39.4		8 613 860	60.6		14 223 109			
2015	2 500 881	17.9		2 314 063	16.5		720 835	5.2		5 535 779	39.6		8 458 292	60.4		13 994 071			
2016	2 542 164	18.1		2 235 503	15.9		654 053	4.6		5 431 720	38.6		8 648 435	61.4		14 080 155			
2017	2 940 907	18.4		2 426 764	15.2		601 381	3.8		5 969 052	37.4		9 974 534	62.6		15 943 586			

Figures in the table may not add up to the total due to rounding.

Table 5.3, given previously, presents a detailed perspective on the agriculture sector emissions for the reporting period. GHG emissions from livestock are CH<sub>4</sub> in enteric fermentation and CH<sub>4</sub> and N<sub>2</sub>O in manure management. Rice cultivation leads to CH<sub>4</sub> emissions, agricultural soils to N<sub>2</sub>O emissions, field burning of crop residues to CH<sub>4</sub> and N<sub>2</sub>O emissions. Urea application is the only category directly resulting in CO<sub>2</sub> emissions reported under the agriculture sector in our country.

### **Methane (CH<sub>4</sub>)**

Emissions from enteric fermentation, manure management, rice cultivation and field burning of agricultural residues include methane. The agriculture sector in our country produced 1 349.87 kt CH<sub>4</sub> (33.7 Mt CO<sub>2</sub> eq.) emissions, which equals 54% of agricultural emissions or 62.3% of Turkey's CH<sub>4</sub> emissions (without LULUCF), or 6.4% of Turkey's total emissions in 2017. CH<sub>4</sub> emissions had increased by 8 715 kt CO<sub>2</sub> eq. (34.8%) from its 1990 level of 25 031 kt CO<sub>2</sub> eq. to 33 747 kt CO<sub>2</sub> eq. in 2017. This increase is mainly a result of increases of CH<sub>4</sub> emissions from enteric fermentation of 7 725 kt CO<sub>2</sub> eq., from manure management of 996 kt CO<sub>2</sub> eq., and from rice cultivation of 134 kt CO<sub>2</sub> eq. This total increase as high as 8 715 kt CO<sub>2</sub> eq. is responsible for the 51.7% of 16 863 kt CO<sub>2</sub> eq. overall increase in emissions from the agricultural sector between 1990 and 2017.

Enteric fermentation is the single dominant category leading to 89.1% in 1990 and 89% in 2017 of all CH<sub>4</sub> emissions of agriculture sector. Enteric fermentation was followed by manure management with 9.4% in 1990 and 9.9% in 2017. CH<sub>4</sub> emissions from field burning of agricultural residues are 1.1% in 1990 and 0.4% in 2017 of all CH<sub>4</sub> emissions from the agriculture sector. CH<sub>4</sub> emissions share of rice cultivation is 0.4% and 0.7% for 1990 and 2017, respectively.

### **Nitrous Oxide (N<sub>2</sub>O)**

Nitrous oxide is a GHG with a high global warming potential. Overall, N<sub>2</sub>O emissions accounted for around 7.3% of Turkey's GHG emissions in 2017. Emissions from manure management, agricultural soils, and field burning of agricultural residues include N<sub>2</sub>O gas. Agriculture as a sector produced 81.77 kt N<sub>2</sub>O emissions (27.3 Mt CO<sub>2</sub> eq.), which equals 43.7% of agricultural emissions or 71% of Turkey's N<sub>2</sub>O emissions (excluding LULUCF) or 5.2% of Turkey's total emissions in 2017. N<sub>2</sub>O emissions have increased by 7 158 kt CO<sub>2</sub> eq. (35.5%) from 20 188 kt CO<sub>2</sub> eq. (1990) to 27 346 kt CO<sub>2</sub> eq. (2017).

The agricultural soils source category is the dominant source of N<sub>2</sub>O emissions, responsible for 84.7% and 84.5% of total agricultural N<sub>2</sub>O emissions for the years 1990 and 2017 respectively. Regarding N<sub>2</sub>O emissions, agricultural soils were followed by manure management with 14.9% in 1990 and 15.3% in 2017, and field burning of agricultural residues with 0.4% in 1990 and 0.1% in 2017.

While a percentage as high as 84.2% of the augmentation in nitrous oxide emissions is a result of increases of N<sub>2</sub>O emissions in agricultural soils by 6 023 kt CO<sub>2</sub> eq., manure management is responsible for the remaining increase of 16.4% with 1177 kt CO<sub>2</sub> eq. in N<sub>2</sub>O emissions. N<sub>2</sub>O emissions of field burning of agricultural residues display a decrease of 54.3% (0.6% of Agricultural N<sub>2</sub>O emissions by an amount of 42.5 kt CO<sub>2</sub> eq.) between 1990 and 2017. The net increase of 7 158 kt CO<sub>2</sub> eq. of N<sub>2</sub>O emissions added up to 42.4% of the overall increase of 16 863 kt CO<sub>2</sub> eq. emissions in the agriculture sector between 1990 and 2017.

## 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<sub>4</sub> gas. Animals produce CH<sub>4</sub> during and/or after feed intake. The largest source of CH<sub>4</sub> emissions in the agricultural sector in our country is enteric fermentation. It is the biggest source of total carbon equivalent emissions in the agriculture sector with 48.8% (22.3 Mt CO<sub>2</sub> eq.) in 1990 and with 48% (30 Mt CO<sub>2</sub> eq.) in 2017.

In 2017, enteric fermentation contributed as high as 30 039 kt CO<sub>2</sub> eq., responsible for nearly half of agricultural emissions as stated above and 5.7% of Turkey's total CO<sub>2</sub> eq. emissions. Dairy and non-dairy cattle contributed 24 090 kt CO<sub>2</sub> eq. (80.2%) of emissions from the enteric fermentation category and sheep (domestic and merino) contributed 4 300 kt CO<sub>2</sub> eq. (14.3%) of emissions from this category. Increased emissions from this source category in 2017 resulted in a value of 7 725 kt CO<sub>2</sub> eq. (34.6%) compared to 1990 levels (22 314 kt CO<sub>2</sub> eq.).

CH<sub>4</sub> emissions from enteric fermentation, which are presented by main livestock category sources in Table 5.8, fluctuate over time (also given in Table 5.3). This source category is a key category in terms of methane emissions. Enteric fermentation emissions declined by 24.4% (5.4 Mt CO<sub>2</sub> eq.) between 1990 and 2002. The decline in emissions in the early 1990s was primarily occurred by a fall in cattle and sheep numbers; however, the emissions had begun to increase as the numbers of cattle began to rise by late 2004, reflecting changing relative returns to each industry. Due to governmental support, the numbers of many significant livestock species have been increasing in recent years, thereby resulting also in an increase of CH<sub>4</sub> emissions for these subcategories. Between 2004 and 2017, emissions from enteric fermentation increased by 58.5% (11 Mt CO<sub>2</sub> eq.).

There have been changes in the relative sources of emissions within enteric fermentation (Table 5.8) since 1990. The largest increase occurred from non-dairy cattle emissions due to increase in its

population numbers. In 2017, non-dairy cattle were responsible for 11 869 kt CO<sub>2</sub> eq., increased by 6 010 kt CO<sub>2</sub> eq. (102.6%) from the 1990 level of 5 859 kt CO<sub>2</sub> eq. Despite a slight increase of 1.3% in dairy cattle population for the period of 1990-2017, this subcategory is responsible for 12 221 kt CO<sub>2</sub> eq. in 2017, still an increase of 3 272 kt CO<sub>2</sub> eq. (36.6%) above its 1990 level of 8 949 CO<sub>2</sub> eq. A closer look at the changes of the composition structure of dairy cattle (culture, hybrid, and domestic cattle) revealed a reasonable explanation for the same period. 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 2017 were 6 million in total for dairy cattle consisting of culture cattle (2.94 million), hybrid cattle (2.42 million), and domestic cattle (0.6 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 5.7. Population numbers of other animal types for the period 1990-2017 are given in Table 5.6. Moreover, on the next page, Table 5.8 displays CH<sub>4</sub> emissions of enteric fermentation for livestock categories.

Table 5.8 CH<sub>4</sub> emissions of enteric fermentation in livestock categories, 1990–2017

Year	Dairy Cattle	Non-Dairy Cattle	Sheep Domestic	Sheep Merino	Goats	Buffalo	Horses	Mules & Asses	Swine, Camels	Total
1990	8 949	5 859	4 964	137	1 366	510	231	297	3	22 314
1991	9 398	6 287	4 949	137	1 346	503	223	284	2	23 129
1992	9 373	6 318	4 822	137	1 307	485	217	269	2	22 929
1993	9 384	6 269	4 589	135	1 267	435	203	253	3	22 536
1994	9 503	6 187	4 353	134	1 196	419	197	245	3	22 235
1995	9 323	6 224	4 123	131	1 139	351	187	225	2	21 705
1996	9 475	6 206	4 029	136	1 119	323	176	211	2	21 677
1997	8 895	5 830	3 672	140	1 047	267	155	196	2	20 204
1998	8 750	5 736	3 570	142	1 007	242	149	184	2	19 781
1999	8 842	5 686	3 678	135	972	227	139	170	2	19 850
2000	8 484	5 678	3 465	126	900	201	122	147	1	19 124
2001	8 200	5 676	3 277	123	878	190	122	140	1	18 606
2002	7 134	5 317	3 059	114	848	166	112	128	1	16 878
2003	8 464	5 565	3 086	121	846	156	102	122	1	18 464
2004	7 136	7 464	3 055	124	826	143	96	113	1	18 957
2005	7 401	7 912	3 069	122	815	144	94	106	1	19 663
2006	7 862	8 073	3 100	133	830	138	92	101	1	20 331
2007	8 049	8 205	3 061	158	786	116	85	91	1	20 552
2008	7 875	8 163	2 869	166	699	119	81	84	1	20 057
2009	8 032	7 879	2 590	167	641	120	75	71	1	19 576
2010	8 535	8 411	2 750	177	787	116	70	65	1	20 912
2011	9 390	9 067	2 976	198	910	134	68	62	2	22 806
2012	10 779	10 158	3 237	249	1 045	148	64	59	2	25 740
2013	11 169	10 519	3 436	292	1 153	162	61	57	2	26 851
2014	11 271	10 277	3 629	342	1 293	168	59	53	2	27 094
2015	11 182	10 092	3 663	358	1 302	184	55	49	2	26 888
2016	11 029	10 349	3 604	350	1 293	195	54	47	2	26 923
2017	12 221	11 869	3 907	393	1 329	222	51	44	2	30 039

Figures in the table may not add up to the total due to rounding.

### Methodological Issues:

Turkey applies a T1 method to estimate CH<sub>4</sub> emissions from enteric fermentation for all livestock populations except cattle for which T2 method is applied. The T2 method is applied by using mainly country-specific parameters. The results for cattle in enteric fermentation are presented both in Figure 5.2 and Table 5.8. Moreover, Table 5.9 presents key country-specific parameters regarding T2 calculation; except for methane conversion factor which is a default value given in the 2006 IPCC Guidelines. Although, IPCC (2006) calls for the more detailed T2 method to use in cases in which a country has listed CH<sub>4</sub> emissions from animal husbandry as a key source for its inventories, the detailed data, necessary in order to use T2 approach, cannot be obtained for all related animal categories so far.

The annual population for each livestock category is included in Tables 5.6 and 5.7 above. The AD (the population of livestock species) provider is TurkStat livestock statistics. TurkStat collects livestock data as explained in the Sector Overview.

The CH<sub>4</sub> 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 2017, the average milk production of culture cattle is around of 3 861 kg head<sup>-1</sup> yr<sup>-1</sup>. 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 mean of milk production of Western Europe (6 000 kg head<sup>-1</sup> yr<sup>-1</sup>) and Asia (1 650 kg head<sup>-1</sup> yr<sup>-1</sup>) is 3 825 kg head<sup>-1</sup> yr<sup>-1</sup>. 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 1 307 kg head<sup>-1</sup> yr<sup>-1</sup> and this value is closer to the Asia average milk production value of 1 650 kg head<sup>-1</sup> yr<sup>-1</sup>. The average milk production of Hybrid cattle is 2 728 kg head<sup>-1</sup> yr<sup>-1</sup> and this value is close to the mean of 3 825 and 1 650 kg head<sup>-1</sup> yr<sup>-1</sup> which is 2 737 kg head<sup>-1</sup> yr<sup>-1</sup>. 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 merino and domestic sheep for similar reasons like dairy cattle. For domestic sheep IPCC default EF for developing countries (5.0 kg CH<sub>4</sub> head<sup>-1</sup> year<sup>-1</sup>) is used. The merino sheep are also a kind of domestic sheep fed for its wool. The weight of merino sheep is higher compared to domestic sheep and their feeding rate is also higher than domestic ones. For these reasons, EF for merino sheep is chosen as a higher value compared to domestic sheep. The EF of merino sheep is taken as an average value (6.5 kg CH<sub>4</sub> head<sup>-1</sup> year<sup>-1</sup>) from the IPCC default EF for developing countries (5.0 kg CH<sub>4</sub> head<sup>-1</sup> year<sup>-1</sup>) and developed countries (8.0 kg CH<sub>4</sub>/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 8.59% whereas the EF uncertainty value is 12.08% figured out by using Equation 3.2 in the IPCC Guidelines Vol. 1.

Source category	Gas	Comments on time series consistency
3.A	CH <sub>4</sub>	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 the National GHG emission inventory. The National Inventory System QA/QC Plan prepared by TurkStat is a significant tool for implementing QA/QC procedures 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. Moreover, QA work was conducted by Professor Yusuf Serengil (Member of the UNFCCC Expert Review Team) for this category in December 2017.

## Recalculation:

Recalculations have not occurred in this source category for this reporting year except for rounding errors.

Table 5.9 Key Tier 2 parameters used/calculated and estimated emissions for cattle, 1990–2017

Year	Dairy Cattle						Other Cattle				
	CH <sub>4</sub> Emissions (kt)	Mass (kg)	GE intake (MJ/head /day)	Conversion rates, Y <sub>m</sub> (%)	CH <sub>4</sub> yield (kg/day)	Digestibility of feed (%)	CH <sub>4</sub> Emissions (kt)	Mass (kg)	GE intake (MJ/head /day)	Conversion rates, Y <sub>m</sub> (%)	CH <sub>4</sub> Digestibility of feed (%)
1990	357.9	350.4	142.5	6.50	3.70	64.19	234.4	180.4	100.2	6.50	60.77
1991	375.9	356.6	144.1	6.50	3.86	64.47	251.5	185.1	100.8	6.50	61.13
1992	374.9	360.3	144.9	6.50	3.93	64.65	252.7	186.6	100.8	6.50	61.27
1993	375.4	365.3	146.0	6.50	4.04	64.92	250.8	187.9	100.1	6.50	61.52
1994	380.1	368.1	146.6	6.50	4.11	65.08	247.5	189.9	99.8	6.50	61.80
1995	372.9	377.4	148.6	6.50	4.32	65.54	249.0	192.1	98.9	6.50	62.08
1996	379.0	379.9	148.9	6.50	4.35	65.66	248.3	192.7	98.4	6.50	62.22
1997	355.8	382.1	149.1	6.50	4.37	65.78	233.2	191.8	97.8	6.50	62.23
1998	350.0	383.8	149.6	6.50	4.41	65.88	229.4	191.5	97.1	6.50	62.29
1999	353.7	386.1	149.8	6.50	4.44	66.01	227.4	192.1	96.7	6.50	62.43
2000	339.4	389.0	150.8	6.50	4.53	66.14	227.1	194.3	97.2	6.50	62.54
2001	328.0	391.2	151.3	6.50	4.57	66.22	227.0	195.6	97.5	6.50	62.60
2002	285.3	396.2	152.4	6.50	4.67	66.43	212.7	185.9	92.2	6.50	62.44
2003	338.6	398.7	157.6	6.50	5.17	66.49	222.6	228.7	110.0	6.50	63.66
2004	285.4	400.7	172.7	6.50	6.79	66.53	298.5	251.8	113.1	6.50	64.43
2005	296.0	404.1	173.7	6.50	6.87	66.61	316.5	253.6	113.7	6.50	64.56
2006	314.5	413.3	176.1	6.50	7.11	66.94	322.9	258.9	113.3	6.50	64.84
2007	322.0	421.4	178.6	6.50	7.31	67.09	328.2	265.0	113.1	6.50	65.02
2008	315.0	431.4	181.1	6.50	7.56	67.48	326.5	272.8	113.0	6.50	65.35
2009	321.3	435.9	182.3	6.50	7.68	67.64	315.1	274.1	112.2	6.50	65.53
2010	341.4	440.9	183.6	6.50	7.80	67.83	336.5	278.8	112.6	6.50	65.84
2011	375.6	446.8	185.0	6.50	7.94	68.05	362.7	280.8	111.6	6.50	65.97
2012	431.2	451.5	186.2	6.50	8.06	68.24	406.3	287.0	112.3	6.50	66.23
2013	446.7	454.6	186.9	6.50	8.14	68.40	420.8	288.6	112.1	6.50	66.33
2014	450.8	461.0	188.5	6.50	8.30	68.66	411.1	293.1	111.9	6.50	66.55
2015	447.3	464.2	189.5	6.50	8.38	68.70	403.7	296.0	112.0	6.50	66.61
2016	441.2	467.9	190.5	6.50	8.47	68.80	414.0	297.2	112.3	6.50	66.72
2017	488.8	474.1	192.1	6.50	8.61	68.99	474.8	296.0	111.6	6.50	66.86

## 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 various institutions including the MAF is ongoing in particular on the availability of detailed data on the disaggregation of animals by characteristics such as 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<sub>4</sub> and N<sub>2</sub>O; and for both of these emissions, the source category is a key category according to both level and trend analysis.

In 2017, emissions including CH<sub>4</sub> and N<sub>2</sub>O from the manure management category reached 7 538 kt CO<sub>2</sub> eq. This number represented 12.1% of emissions of the agriculture sector. Emissions from this source category in 2017 increased by 2 173 kt CO<sub>2</sub> eq., nearly 40.5% above its 1990 level of 5 365 kt CO<sub>2</sub> eq. Similarly, the increase is calculated as 996 kt CO<sub>2</sub> eq. for CH<sub>4</sub> emissions and 1 177 kt CO<sub>2</sub> eq. for N<sub>2</sub>O emissions and increasing percentages are 39.1% and 40.5% respectively for the same period, 1990-2017.

### 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<sub>4</sub> 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<sub>4</sub> production including contact with oxygen, water content, pH, and nutrient availability. Climate factors include temperature and rainfall. Optimal conditions for CH<sub>4</sub> 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<sub>4</sub> emissions contributed 3 348 kt CO<sub>2</sub> eq. (44.4% of the manure management category) which constituted 5.35% of agricultural emissions in 2017 whereas the respective share in 1990 was 5.15%, around 0.2 per cent below the current reporting value.

With respect to all CH<sub>4</sub> emissions of the agriculture sector, the second highest CH<sub>4</sub> emission source category was manure management for all reporting years with a share value of 9.40% and 9.92% for 1990 and 2017 respectively, and an average share value of 10% for reporting period, 1990-2017.

### Nitrous Oxide Generation

Production of N<sub>2</sub>O reported in the manure management category occurs during storage and treatment of manure before it is applied to land.

N<sub>2</sub>O emissions contributed 4 190 kt CO<sub>2</sub> eq. (55.6% of the manure management category) which represented 6.7% of agricultural emissions in 2017 whereas the respective share in 1990 was 6.6%, less than the current percentage of 2017.

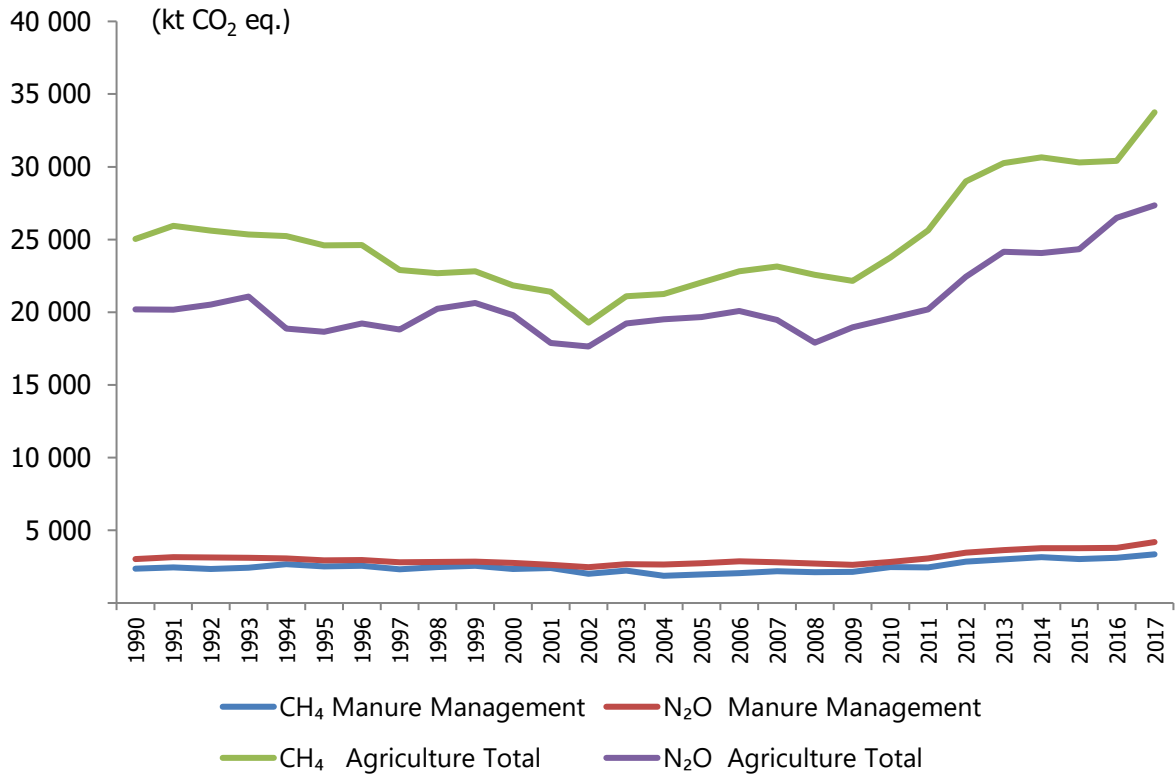
With respect to all N<sub>2</sub>O emissions of the agriculture sector, the second highest N<sub>2</sub>O emission source category was manure management after agricultural soils category for all reporting years. N<sub>2</sub>O emissions of manure management accounted for 14.93% and 15.32% of all N<sub>2</sub>O emissions in the agriculture sector in 1990 and 2017 respectively.

Direct N<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O emissions result from volatile nitrogen losses that occur primarily in the forms of ammonia and NO<sub>x</sub>. 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<sub>4</sub> and N<sub>2</sub>O emissions of manure management and the agriculture sector gives a view on trend inclinations. As indicated above, CH<sub>4</sub> and N<sub>2</sub>O from manure management are only a fraction of total CH<sub>4</sub> and N<sub>2</sub>O emissions from the agriculture sector (9.92% and 15.32%, respectively) and therefore these are not a key driver in the overall trends in the agriculture sector. However, the trends for these gases in this category generally reflect the overall trend of the same gases in the agriculture sector. Figure 5.6 displays a trend comparison of these two gas emissions.

**Figure 5.6 Comparing CH<sub>4</sub> and N<sub>2</sub>O emission trends, 1990–2017**



Typical animal mass values and Nitrogen excretion rates (Nex) are crucial parameters in estimating emissions from manure management. Table 5.10 and Table 5.11 present these values for animal categories for the entire reporting period 1990-2017.

Table 5.10 Typical animal mass values and nitrogen excretion rates per animal 1990–2017

Year	Dairy cattle		Other cattle		Sheep (domestic)		Sheep (merino)		Goats		Buffalo		Poultry	
	(mass)	(Nex)	(mass)	(Nex)	(mass)	(Nex)	(mass)	(Nex)	(mass)	(Nex)	(mass)	(Nex)	(mass)	(Nex)
1990	350.36	60.38	180.43	22.39	50	21.35	60	22.12	45	22.50	380	44.38	2.12	0.63
1991	356.58	61.47	185.11	22.97	50	21.35	60	22.12	45	22.50	380	44.38	2.08	0.62
1992	360.25	62.11	186.58	23.15	50	21.35	60	22.12	45	22.50	380	44.38	2.08	0.62
1993	365.29	62.99	187.92	23.32	50	21.35	60	22.12	45	22.50	380	44.38	2.07	0.62
1994	368.09	63.49	189.92	23.57	50	21.35	60	22.12	45	22.50	380	44.38	2.07	0.62
1995	377.38	65.12	192.08	23.84	50	21.35	60	22.12	45	22.50	380	44.38	2.09	0.62
1996	379.90	65.56	192.67	23.91	50	21.35	60	22.12	45	22.50	380	44.38	2.08	0.62
1997	382.13	65.95	191.79	23.80	50	21.35	60	22.12	45	22.50	380	44.38	2.11	0.63
1998	383.79	66.24	191.49	23.76	50	21.35	60	22.12	45	22.50	380	44.38	2.06	0.61
1999	386.05	66.64	192.15	23.85	50	21.35	60	22.12	45	22.50	380	44.38	2.06	0.61
2000	388.99	67.15	194.31	24.11	50	21.35	60	22.12	45	22.50	380	44.38	2.05	0.61
2001	391.22	67.54	195.64	24.28	50	21.35	60	22.12	45	22.50	380	44.38	2.05	0.61
2002	396.16	68.41	185.89	23.07	50	21.35	60	22.12	45	22.50	380	44.38	2.05	0.61
2003	398.71	68.85	228.67	28.38	50	21.35	60	22.12	45	22.50	380	44.38	2.05	0.61
2004	400.66	69.19	251.76	31.24	50	21.35	60	22.12	45	22.50	380	44.38	2.05	0.61
2005	404.07	69.79	253.61	31.47	50	21.35	60	22.12	45	22.50	380	44.38	2.04	0.61
2006	413.27	71.40	258.90	32.13	50	21.35	60	22.12	45	22.50	380	44.38	2.03	0.61
2007	421.42	72.83	264.97	32.88	50	21.35	60	22.12	45	22.50	380	44.38	2.03	0.61
2008	431.39	74.58	272.78	33.85	50	21.35	60	22.12	45	22.50	380	44.38	2.05	0.61
2009	435.92	75.37	274.12	34.02	50	21.35	60	22.12	45	22.50	380	44.38	2.04	0.61
2010	440.94	76.25	278.75	34.59	50	21.35	60	22.12	45	22.50	380	44.38	2.04	0.61
2011	446.77	77.27	280.78	34.84	50	21.35	60	22.12	45	22.50	380	44.38	2.04	0.61
2012	451.53	78.10	287.04	35.62	50	21.35	60	22.12	45	22.50	380	44.38	2.04	0.61
2013	454.58	78.64	288.55	35.81	50	21.35	60	22.12	45	22.50	380	44.38	2.04	0.61
2014	461.02	79.77	293.07	36.37	50	21.35	60	22.12	45	22.50	380	44.38	2.03	0.61
2015	464.23	80.33	295.96	36.73	50	21.35	60	22.12	45	22.50	380	44.38	2.03	0.61
2016	467.89	80.97	297.15	36.88	50	21.35	60	22.12	45	22.50	380	44.38	2.03	0.61
2017	474.10	82.06	295.96	36.73	50	21.35	60	22.12	45	22.50	380	44.38	2.04	0.61

**Table 5.11 Typical animal mass values and Nex values per animal types 1990–2017 (kg)**

Year	Horses		Mules & asses		Camels		Swine	
	(mass)	(Nex)	(mass)	(Nex)	(mass)	(Nex)	(mass)	(Nex)
1990	238	39.96	130	21.83	217	36.43	28	4.11
1991	238	39.96	130	21.83	217	36.43	28	4.11
1992	238	39.96	130	21.83	217	36.43	28	4.11
1993	238	39.96	130	21.83	217	36.43	28	4.11
1994	238	39.96	130	21.83	217	36.43	28	4.11
1995	238	39.96	130	21.83	217	36.43	28	4.11
1996	238	39.96	130	21.83	217	36.43	28	4.11
1997	238	39.96	130	21.83	217	36.43	28	4.11
1998	238	39.96	130	21.83	217	36.43	28	4.11
1999	238	39.96	130	21.83	217	36.43	28	4.11
2000	238	39.96	130	21.83	217	36.43	28	4.11
2001	238	39.96	130	21.83	217	36.43	28	4.11
2002	238	39.96	130	21.83	217	36.43	28	4.11
2003	238	39.96	130	21.83	217	36.43	28	4.11
2004	238	39.96	130	21.83	217	36.43	28	4.11
2005	238	39.96	130	21.83	217	36.43	28	4.11
2006	238	39.96	130	21.83	217	36.43	28	4.11
2007	238	39.96	130	21.83	217	36.43	28	4.11
2008	238	39.96	130	21.83	217	36.43	28	4.11
2009	238	39.96	130	21.83	217	36.43	28	4.11
2010	238	39.96	130	21.83	217	36.43	28	4.11
2011	238	39.96	130	21.83	217	36.43	28	4.11
2012	238	39.96	130	21.83	217	36.43	28	4.11
2013	238	39.96	130	21.83	217	36.43	28	4.11
2014	238	39.96	130	21.83	217	36.43	28	4.11
2015	238	39.96	130	21.83	217	36.43	28	4.11
2016	238	39.96	130	21.83	217	36.43	28	4.11
2017	238	39.96	130	21.83	217	36.43	28	4.11

**Methodological Issues:**

Turkey applies 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 2006 IPCC Guidelines, in line with the UNFCCC Conference of the Parties decision (24/CP.19). CH<sub>4</sub> 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 5.6 and 5.7 above. The AD (the population of animals) provider is TurkStat livestock statistics for the entire time series 1990-2017.

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 within each of the climate regions, namely cool, temperate and warm, are added up before calculating the weighted average with respect to population numbers of the total animal subcategory.

In order to select appropriate EFs, animal population data, collected from TurkStat databases, are categorized according to their provinces with respective annual temperature figures. CH<sub>4</sub> and N<sub>2</sub>O emission 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 presents 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°C - 14°C) and temperate (15°C - 25°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, Vol.4 of the 2006 IPCC Guidelines). The EF for domestic cattle and non-dairy cattle were assumed to be similar with cattle in Asia, because their milk yield values were similar. The EF for culture cattle was estimated as the mean of the emission factors for dairy cattle from Western Europe and Asia, for the same temperature zone (e.g., at <10°C Turkey estimates that culture cattle have an EF of 15 kg CH<sub>4</sub>/head/year, which is the average of 21 kg CH<sub>4</sub>/head/year and 9 kg CH<sub>4</sub>/head/year from Western Europe and Asia, respectively). The EF for hybrid cattle is the mean 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 of similar body weights.

The EFs for sheep and other livestock, given in the 2006 IPCC Guidelines, are also broken into two climate regions and given in Table 5.13. Turkey has not a single province with an annual average temperature above 25°C; therefore, the warm climate region does not exist.



**Table 5.12 Manure management CH<sub>4</sub> emission factors for cattle and swine**

(kg CH <sub>4</sub> /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
<b>1.Cattle</b>																
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
<b>3.Swine</b>																
	2	2	2	2	2	3	3	3	3	4	4	4	5	5	5	6

**Table 5.13 Manure management CH<sub>4</sub> emission factors for sheep and other livestock**  
(kg CH<sub>4</sub>/head/year)

(°C)	Cool EF (< 15 )	Temperate EF (15-25)
<b>2. Sheep</b>		
Sheep (Domestic)	0.100	0.150
Sheep (Merino)	0.145	0.215
<b>4. Other livestock</b>		
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 according to country-specific values (except for swine which uses default values given in the 2006 IPCC Guidelines Vol.4). These updated figures are able to reflect Turkey's conditions in an improved way leading to improved emission estimations with respect to figures used previously in this regard.

Table 5.14 Manure Management System Distribution, 1990–2017

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		10.0		50.0	6.0	30.0				4.0
Dairy Cattle - Hybrid		10.0		50.0	6.0	30.0				4.0
Dairy Cattle - Domestic		10.0		50.0	6.0	30.0				4.0
Non Dairy Cattle		10.0		50.0	6.0	30.0				4.0
Swine		40.0			54.0					6.0
Sheep - Domestic				40.0		60.0				
Sheep - Merino				40.0		60.0				
Buffalo				60.0	6.0	30.0				4.0
Camels				40.0		60.0				
Horses				25.0	15.0	60.0				
Goats				10.0	10.0	80.0				
Mules and Asses				25.0	15.0	60.0				
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 Guidelines 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<sub>4</sub> and N<sub>2</sub>O gases whereas EF uncertainty values are 30% and 50% for CH<sub>4</sub> and N<sub>2</sub>O gases respectively, as given in the 2006 IPCC Guidelines.

Source category	Gas	Comments on time series consistency
3.B	CH <sub>4</sub> , N <sub>2</sub> O	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 also published 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. Moreover, QA work was conducted by Professor Yusuf Serengil (Member of the UNFCCC Expert Review Team) for this category in December 2017.

## Recalculation:

Better information on country-specific typical animal mass values for sheep (domestic and merino) and goats, a revision of the distribution of the manure management systems resulted all in the recalculation of the entire time series for manure management. For this source category, the recalculation has an increasing effect of 30.5% and 9.5% for the year 1990 and 2016 respectively, and the average recalculation ratio for the period of 1990-2016 is calculated as 17.2%. Our country-specific conditions are better reflected after this improvement accomplished while the recalculation affected all reported years of last year's submission.

Currently, N<sub>2</sub>O estimations for managed soils are estimated at 17 093 kt CO<sub>2</sub> eq. and 23 117 kt CO<sub>2</sub> eq. for the years 1990 and 2017, respectively. Those figures were reported in the National Inventory Report 1990-2016 as 15 085 kt CO<sub>2</sub> eq. for 1990 and 21 561 kt CO<sub>2</sub> eq. for 2016.

### **Planned Improvement:**

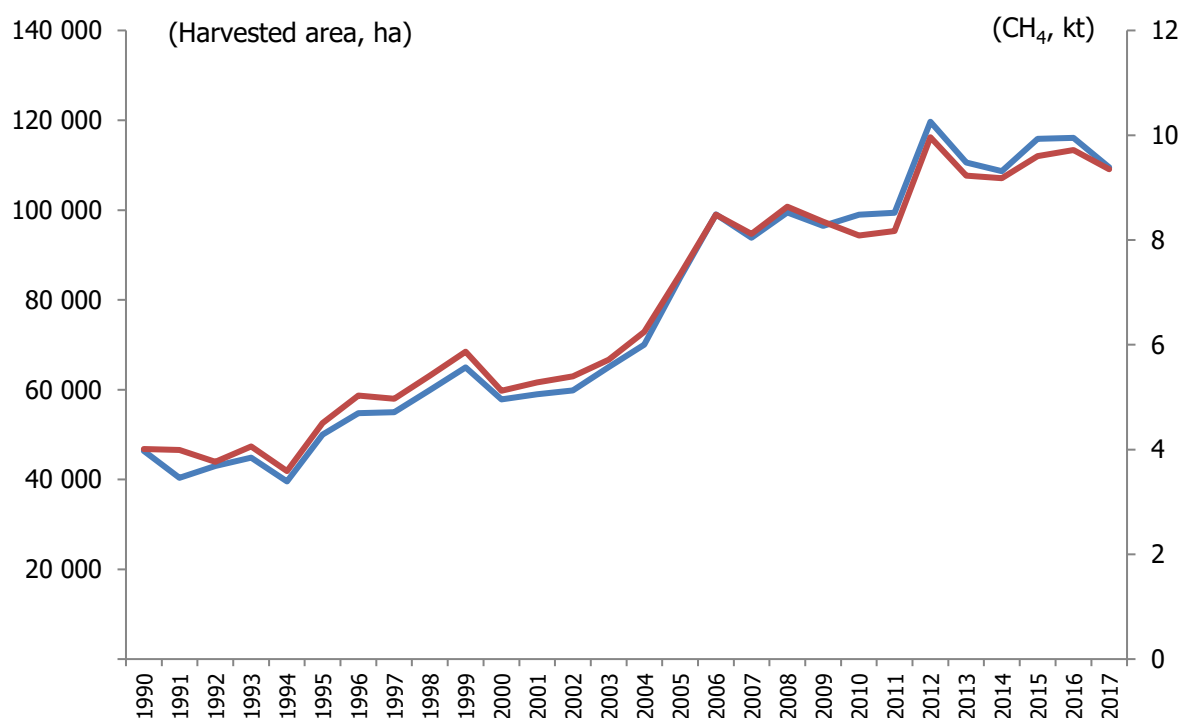
All data and methodologies are kept under review and an upgrade from T1 to T2 will be considered in the future.

## 5.4. Rice Cultivation (Category 3.C)

### Source Category Description:

GHG emissions from rice production are the result of the CH<sub>4</sub> gas released by anaerobic digestion of organic substances in the paddy fields. Aforementioned CH<sub>4</sub> gas emissions are calculated according to the approach given in the 2006 IPCC Guidelines which are estimated by IPCC's default emission factors. The annual amount of CH<sub>4</sub> 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 affects CH<sub>4</sub> emissions. CH<sub>4</sub> emissions from rice cultivation are not a key category. Figure 5.7 presents total annual harvested area in hectare (line drawn in blue - left axis) and total CH<sub>4</sub> emissions emitted in kt (line drawn in dark red - right axis) for rice cultivation covering the period 1990-2017.

**Figure 5.7 Harvested area and emitted CH<sub>4</sub> for rice cultivation, 1990–2017**



Rice cultivation contributed 9.35 kt CH<sub>4</sub> (234 kt CO<sub>2</sub> eq.) emissions or 0.37% of total agricultural emissions in 2017. Emissions have increased by around 14% between the years 2011 and 2017.

Overall, emissions from rice cultivation increased by 133.6 kt CO<sub>2</sub> eq. (133%) for the entire reporting period. Rice cultivation is the lowest contributor to CH<sub>4</sub> emissions in the agriculture sector for each of the reported twenty-eight years, ranging from 0.201% (1994) to 0.526% (2008) respectively. The

respective percentage value for 2017 is calculated as 0.37%. Given below, Table 5.15, presents this sector's activity data and estimated emissions in detail.

**Table 5.15 Irrigated area and estimated emissions for rice cultivation, 1990–2017**

Year	Total		Continuously Flooded		Intermittently Flooded			
	(kt CO <sub>2</sub> eq.)	Area (ha)	(kt CO <sub>2</sub> eq.)	Area (ha)	Single Aeration		Multiple Aeration	
					(kt CO <sub>2</sub> eq.)	Area (ha)	(kt CO <sub>2</sub> eq.)	Area (ha)
1990	100.19	46 348	51.84	17 276	16.30	8 800	32.05	20 272
1991	99.85	40 400	59.98	16 800	14.52	7 811	25.36	15 789
1992	94.11	42 978	48.68	16 351	15.86	8 117	29.57	18 510
1993	101.50	44 842	56.31	18 751	17.79	8 988	27.40	17 103
1994	89.71	39 562	48.48	15 950	16.65	8 321	24.58	15 291
1995	112.60	49 955	62.85	21 203	16.80	8 479	32.95	20 273
1996	125.73	54 779	75.58	25 859	16.65	8 403	33.50	20 517
1997	124.25	54 995	73.35	25 447	17.28	8 902	33.62	20 646
1998	135.19	59 885	79.51	27 566	19.34	10 035	36.34	22 284
1999	146.65	64 983	87.09	30 133	20.97	10 984	38.59	23 866
2000	128.04	57 859	71.20	24 800	20.45	10 706	36.39	22 353
2001	131.99	59 000	75.04	26 085	25.72	13 770	31.23	19 145
2002	134.89	59 809	78.18	27 055	24.74	13 171	31.98	19 583
2003	142.91	65 000	77.70	26 697	27.45	14 757	37.76	23 546
2004	156.16	69 990	88.66	30 326	28.53	15 409	38.97	24 255
2005	183.46	84 909	96.05	32 926	38.01	20 662	49.40	31 321
2006	212.06	99 043	108.95	37 559	42.50	23 211	60.62	38 273
2007	202.87	93 799	110.05	37 841	36.79	20 965	56.03	34 994
2008	215.89	99 493	116.96	40 325	41.44	23 338	57.49	35 830
2009	208.73	96 444	110.30	38 116	41.44	22 996	56.99	35 332
2010	202.13	98 966	86.23	29 856	40.92	22 554	74.98	46 557
2011	204.33	99 383	93.73	32 456	40.30	22 235	70.30	44 692
2012	249.03	119 664	120.32	41 613	44.94	25 027	83.77	53 024
2013	230.66	110 592	111.64	38 670	42.21	23 458	76.81	48 465
2014	229.54	108 649	114.59	39 628	46.26	26 015	68.69	43 006
2015	239.99	115 856	115.71	40 057	42.45	23 865	81.83	51 934
2016	242.97	116 056	120.66	41 763	43.62	24 390	78.69	49 904
2017	233.76	109 505	121.81	42 153	43.20	24 128	68.75	43 225

Figures in the table may not add up to the total due to rounding.

## Methodological Issues:

Rice production data are taken from TurkStat agricultural statistics and area records are available for all districts of Turkey since 1990. T1 method is used for calculation, and the emission factor and scaling factor are taken from the 2006 IPCC Guidelines. The cultivation period of rice production in Turkey is around 130 days. The methods used in our country includes continuously flooded, intermittently flooded with single aeration and intermittently flooded with multiple aeration. Accordingly, disaggregated case parameters are used for these methods from the 2006 IPCC Guidelines. Initially, the required data are gathered from TurkStat's regional offices. With reference to these data, values of scaling factors according to the 2006 IPCC Guidelines are determined for both  $SF_w$  and  $SF_p$  parameters. Due to the large geographical diversity of our country, all values for disaggregated scaling factors are used. Moreover, information on cultivation period for rice production is also obtained from regional offices of TurkStat and all different periods are taken into account. The default  $CH_4$  baseline emission factor ( $EF_c$ ) applied is 1.30  $CH_4/ha/day$  for rice cultivation emission calculations, a non-key category, under T1 method. Scaling factors are used, if any, in negligible amounts. This, in turn, reduces the value of the related scaling factor to 1, a multiplicative identity, given by the Equation 5.3 on page 5.50 of the 2006 IPCC Guidelines Vol.4. Furthermore, scaling factors for other related variables are not available, and as a result not used, which is in line with the information provided on page 5.48 presented in the 2006 IPCC Guidelines Vol.4.

## Uncertainties and Time-Series Consistency:

The AD for this sector are gathered from agricultural statistics of TurkStat, and the information about water regime, water regime prior to rice cultivation and cultivation periods, that are crucial in determining appropriate scaling factors, are obtained from regional offices of TurkStat for all provinces and their districts in Turkey. 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 76.74% according to the information given in the 2006 IPCC Guidelines.

An Approach 2 uncertainty analysis using the Monte Carlo technique was carried out on the methodology used to estimate emissions of methane from rice cultivation category. The Monte Carlo uncertainty range for  $CH_4$  emissions from rice cultivation is similar to Approach 1, the error propagation method and mean estimates of combined MC simulation uncertainty lie within a range of -68.98% to +70.43% in 2017. For more detailed information about Monte Carlo method, please refer to the uncertainty section in the annexes.

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 mainly gathered from the Agricultural Statistics Department of TurkStat. The respective AD, used for calculations, are also published as official statistics by TurkStat which have their own QA/QC procedures. Emission trends are analyzed. Moreover, QA work was conducted by Professor Yusuf Serengil (Member of the UNFCCC Expert Review Team) for this category in December 2017.

**Recalculation:**

There was no recalculation exercised regarding emission estimates from this source category in this submission.

**Planned Improvement:**

All data and methodologies are kept under review. There are no further planned improvements in this source category.

**5.5. Agricultural Soils (Category 3.D)****Source Category Description:**

This source contains N<sub>2</sub>O emissions from synthetic fertilizers, organic fertilizers, and crop residue. This source category is a key category. In this section the N<sub>2</sub>O 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 N<sub>2</sub>O emissions from this source category are key categories in all trend and level assessments except for indirect N<sub>2</sub>O emissions in level assessment (with LULUCF).

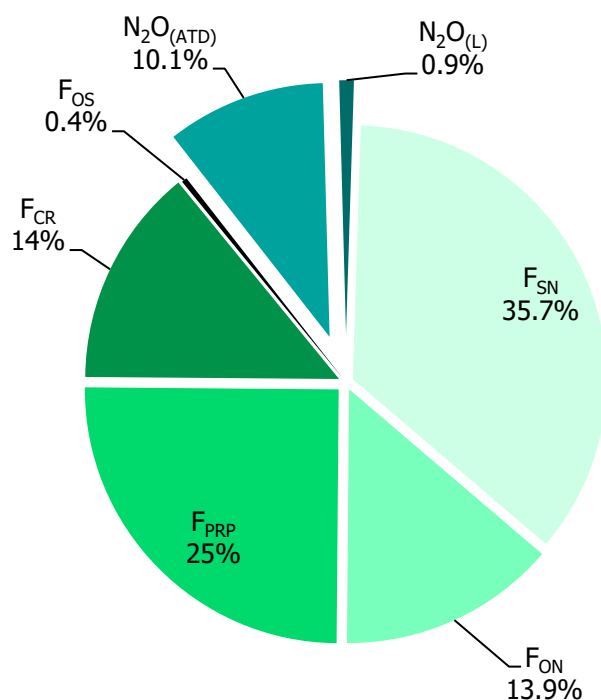
Agriculture soils produced 77.6 kt N<sub>2</sub>O (23.1 Mt CO<sub>2</sub> eq.) emissions in 2017 and agriculture soils is the largest source category of N<sub>2</sub>O emissions in Turkey. This figure represented 84.5% of N<sub>2</sub>O emissions in the Agriculture sector, around 60% of Turkey's N<sub>2</sub>O emissions (without LULUCF), and 37% of agricultural emissions. Emissions were 6 024 kt CO<sub>2</sub> eq. (35.2%) above the 1990 level of 17 093 kt CO<sub>2</sub> eq. in the year 2017. Direct N<sub>2</sub>O emissions increased by 5 577 kt CO<sub>2</sub> eq. whereas indirect N<sub>2</sub>O emissions increased by 447 kt CO<sub>2</sub> eq. for the given period 1990-2017. The increase is a result of the emission



changes of direct and indirect N<sub>2</sub>O emissions from managed soils. The total change of direct N<sub>2</sub>O emissions is a result of increases in the subcategories inorganic N fertilizers, a subcategory of organic N fertilizers, urine and dung deposited by grazing animals, crop residues, and also decreases in cultivation of organic soils and two subcategories of organic N fertilizers. Direct N<sub>2</sub>O 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 5.16, Table 5.17 and Table 5.18). Direct N<sub>2</sub>O 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<sub>3</sub> or NO<sub>x</sub>, or result from leaching and runoff of soil N within water (IPCC, 2006). A precise overview is also given in Figure 5.8 and Table 5.16 for direct and indirect N<sub>2</sub>O emissions. The abbreviations used in Figure 5.8 are listed on the headings of Table 5.17 and 5.18.

**Figure 5.8 Sub-categories of Agricultural Soils Emission Sources, 2017**



**Table 5.16 Overview of N<sub>2</sub>O emissions from managed soils, 1990–2017**

Year	Agriculture Total (kt CO <sub>2</sub> eq.)	Agricultural soils					
		Total		Direct N <sub>2</sub> O		Indirect N <sub>2</sub> O	
		(kt CO <sub>2</sub> eq.)	(%)	(kt CO <sub>2</sub> eq.)	(%)	(kt CO <sub>2</sub> eq.)	(%)
1990	45 680	17 093	37.4	14 985	32.8	2 108	4.6
1991	46 546	16 930	36.4	14 842	31.9	2 088	4.5
1992	46 592	17 302	37.1	15 182	32.6	2 119	4.5
1993	47 032	17 864	38.0	15 712	33.4	2 152	4.6
1994	44 553	15 721	35.3	13 786	30.9	1 935	4.3
1995	43 668	15 633	35.8	13 745	31.5	1 888	4.3
1996	44 372	16 176	36.5	14 243	32.1	1 934	4.4
1997	42 243	15 933	37.7	14 051	33.3	1 882	4.5
1998	43 586	17 326	39.8	15 317	35.1	2 009	4.6
1999	44 187	17 709	40.1	15 634	35.4	2 075	4.7
2000	42 261	16 953	40.1	14 985	35.5	1 968	4.7
2001	39 801	15 169	38.1	13 390	33.6	1 779	4.5
2002	37 447	15 098	40.3	13 364	35.7	1 734	4.6
2003	40 869	16 466	40.3	14 552	35.6	1 914	4.7
2004	41 402	16 788	40.5	14 888	36.0	1 900	4.6
2005	42 307	16 854	39.8	14 965	35.4	1 889	4.5
2006	43 492	17 150	39.4	15 241	35.0	1 909	4.4
2007	43 177	16 618	38.5	14 741	34.1	1 876	4.3
2008	41 044	15 122	36.8	13 414	32.7	1 709	4.2
2009	41 696	16 262	39.0	14 482	34.7	1 780	4.3
2010	43 976	16 709	38.0	14 895	33.9	1 813	4.1
2011	46 400	17 074	36.8	15 206	32.8	1 868	4.0
2012	52 080	18 930	36.3	16 835	32.3	2 095	4.0
2013	55 215	20 452	37.0	18 200	33.0	2 252	4.1
2014	55 508	20 256	36.5	17 988	32.4	2 268	4.1
2015	55 428	20 504	37.0	18 225	32.9	2 279	4.1
2016	58 182	22 643	38.9	20 154	34.6	2 489	4.3
2017	62 543	23 117	37.0	20 562	32.9	2 555	4.1

Figures in the table may not add up to the total due to rounding.

Table 5.17 Categories of Direct N<sub>2</sub>O emissions of agricultural soils, 1990–2017

Direct N <sub>2</sub> O Emissions from Managed Soils												(kt CO <sub>2</sub> eq.)
Year	Total N <sub>2</sub> O Emissions from Managed Soils	Inorganic N Fertilizers (F <sub>SN</sub> )	Organic N Fertilizers (F <sub>ON</sub> )			Urine and Dung Deposited by Grazing Animals (F <sub>PRP</sub> )	Crop Residues (F <sub>CR</sub> )	Mineralization/Immobilization Associated with loss/gain of soil organic matter (F <sub>SOM</sub> )	Cultivation of Organic Soils (F <sub>OS</sub> )			
			Animal Manure Applied to Soils	Sewage Sludge Applied to Soils	Other Organic Fertilizers Applied to Soils							
1990	17 093	5 618	2 494	59	133	5 015	1 585	NO	82			
1991	16 930	5 169	2 586	59	133	5 128	1 687	NO	82			
1992	17 302	5 649	2 565	59	133	5 058	1 638	NO	82			
1993	17 864	6 253	2 527	59	133	4 946	1 713	NO	82			
1994	15 721	4 714	2 473	59	133	4 804	1 523	NO	82			
1995	15 633	4 934	2 341	62	110	4 581	1 635	NO	82			
1996	16 176	5 373	2 352	58	123	4 565	1 689	NO	82			
1997	15 933	5 465	2 211	161	124	4 275	1 732	NO	82			
1998	17 326	6 532	2 238	232	115	4 245	1 874	NO	82			
1999	17 709	6 957	2 273	226	156	4 279	1 660	NO	82			
2000	16 953	6 456	2 196	224	165	4 091	1 771	NO	82			
2001	15 169	5 304	2 077	221	151	3 903	1 653	NO	82			
2002	15 098	5 615	1 949	124	187	3 655	1 752	NO	82			
2003	16 466	6 279	2 093	427	136	3 861	1 674	NO	82			
2004	16 788	6 400	2 032	383	144	3 793	2 055	NO	82			
2005	16 854	6 427	2 092	221	137	3 873	2 134	NO	82			
2006	17 150	6 587	2 181	59	134	4 009	2 189	NO	82			
2007	16 618	6 349	2 118	69	230	3 930	1 964	NO	82			
2008	15 122	5 306	2 035	80	219	3 759	1 933	NO	82			
2009	16 262	6 621	1 944	69	143	3 568	2 055	NO	82			
2010	16 709	6 292	2 069	58	109	3 858	2 427	NO	82			
2011	17 074	5 897	2 244	56	113	4 225	2 589	NO	82			
2012	18 930	6 706	2 508	53	124	4 738	2 625	NO	82			
2013	20 452	7 419	2 642	51	110	5 023	2 874	NO	82			
2014	20 256	6 991	2 754	48	80	5 273	2 759	NO	82			
2015	20 504	6 961	2 778	46	87	5 306	2 965	NO	82			
2016	22 643	8 881	2 781	43	92	5 299	2 976	NO	82			
2017	23 117	8 264	3 050	58	102	5 778	3 228	NO	82			

Figures in the table may not add up to the total due to rounding.

**Table 5.18 Categories of Indirect N<sub>2</sub>O emissions of agricultural soils, 1990–2017**

(kt CO <sub>2</sub> eq.)				
<b>Indirect N<sub>2</sub>O Emissions from Managed Soils</b>				
<b>Year</b>	<b>Total N<sub>2</sub>O Emissions from Managed Soils</b>	<b>Total</b>	<b>Atmospheric Deposition N<sub>2</sub>O<sub>(ATD)</sub></b>	<b>Nitrogen Leaching and Run-off N<sub>2</sub>O<sub>(L)</sub></b>
1990	17 093	2 108	1 949	159
1991	16 930	2 088	1 931	157
1992	17 302	2 119	1 959	160
1993	17 864	2 152	1 986	166
1994	15 721	1 935	1 790	144
1995	15 633	1 888	1 744	144
1996	16 176	1 934	1 784	150
1997	15 933	1 882	1 734	148
1998	17 326	2 009	1 848	162
1999	17 709	2 075	1 910	165
2000	16 953	1 968	1 810	158
2001	15 169	1 779	1 638	141
2002	15 098	1 734	1 593	141
2003	16 466	1 914	1 760	153
2004	16 788	1 900	1 743	157
2005	16 854	1 889	1 732	158
2006	17 150	1 909	1 749	160
2007	16 618	1 876	1 722	155
2008	15 122	1 709	1 569	140
2009	16 262	1 780	1 628	152
2010	16 709	1 813	1 657	156
2011	17 074	1 868	1 710	159
2012	18 930	2 095	1 920	175
2013	20 452	2 252	2 062	190
2014	20 256	2 268	2 080	187
2015	20 504	2 279	2 089	190
2016	22 643	2 489	2 277	212
2017	23 117	2 555	2 341	214

Figures in the table may not add up to the total due to rounding.

Direct N<sub>2</sub>O 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<sub>2</sub>O soil emissions contributed 20 562 kt CO<sub>2</sub> eq. (88.9%) to emissions from the Agricultural soils category and around 32.9% of emissions under the total Agriculture sector in 2017. This is an increase of 5 577 kt CO<sub>2</sub> eq. (37.2%) from the 1990 reported figure of 14 985 kt CO<sub>2</sub> eq.

A major direct source of N<sub>2</sub>O emissions from agricultural soils is an outcome of the use of synthetic fertilizer. Around 47.4% increase in direct emissions from agricultural soils, observed between 1990 and 2017, is a result of an increase in 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 2017, N<sub>2</sub>O emissions from synthetic nitrogen fertilizers contributed 8 264 kt CO<sub>2</sub> eq. (43.9%) to emissions from the managed soils category. This is an increase of 2 646 kt CO<sub>2</sub> eq. (47.1%) from the 1990 level of 5 618 kt CO<sub>2</sub> eq. Nitrogen emissions of synthetic fertilizer contributed 13.2% to the total emissions under the agriculture sector for the last reported year.

In 2017, N<sub>2</sub>O emissions from organic N fertilizers contributed 3 210 kt CO<sub>2</sub> eq. (13.9%) to emissions from the agricultural soils category and 5.1% of emissions under the total agriculture sector. An increase of 525 kt CO<sub>2</sub> eq. (19.5%) is observed from the 1990 level of 2 686 kt CO<sub>2</sub> eq.

N<sub>2</sub>O emissions due to sewage sludge applied to soils has a slightly peculiar trend observable on Table 5.17. Since Turkey applied the Tier 1 methodology, emissions are directly linked to change of activity data. In the initial years, the number of municipal wastewater treatment plants increased in our country leading to an increase of emissions thereof. Thereafter, three factors could be given which resulted in a reduction of these emissions: First, increase in number of landfilling sites affected the trend in sewage sludge applied to soils. Second, new legislations which set criteria on sewage sludge for its use on agricultural soils limited the use of sewage sludge on soils. Third, some wastewater treatment plants using sewage sludge extensively before, changed their treatment methods.

As observed from Table 5.17, N<sub>2</sub>O emissions from urine and dung deposited by grazing animals contributed 5 778 kt CO<sub>2</sub> eq. (25%) to emissions from the agricultural soils category and 9.2% of emissions under the total agriculture sector. This is an increase of 764 kt CO<sub>2</sub> eq. (12.7%) from the 1990 level of 5 015 kt CO<sub>2</sub> eq. Moreover, N<sub>2</sub>O emissions from crop residues contributed 3 228 kt CO<sub>2</sub> eq. (14%) to emissions from the agricultural soils category and 5.2% of emissions under the total agriculture sector. This is a value of more than twofold presenting an increase of 1 643 kt CO<sub>2</sub> eq. (103.6%) from the 1990 level of 1 585 kt CO<sub>2</sub> eq.

Indirect N<sub>2</sub>O emissions were calculated as 2 555 kt CO<sub>2</sub> eq. for 2017. Indirect N<sub>2</sub>O emissions through atmospheric deposition contributed 2 341 kt CO<sub>2</sub> eq. (10.1%) to emissions from the agricultural soils category and 3.7% of emissions under the total agriculture sector in 2017. This is an increase of 392 kt CO<sub>2</sub> eq. (20.1%) from the 1990 level of 1 949 kt CO<sub>2</sub> eq. Indirect N<sub>2</sub>O emissions through leaching and runoff added 214 kt CO<sub>2</sub> eq. (0.9%) to emissions from the agricultural soils category in 2017 and 0.3% of emissions under the total agriculture sector.

Briefly, agricultural soils emissions have increased by 35.2% (around 6 Mt CO<sub>2</sub> eq.) between 1990 and 2017. The increase is a result of the emission changes of direct and indirect N<sub>2</sub>O emissions from managed soils. The former, direct N<sub>2</sub>O emissions increased by around 5.6 Mt CO<sub>2</sub> eq. and the latter, indirect N<sub>2</sub>O emissions, by 0.4 Mt CO<sub>2</sub> eq. for the given period, 1990-2017. The total net increase of 5.6 Mt CO<sub>2</sub> eq. of direct N<sub>2</sub>O emissions is a result of changes in inorganic N fertilizers, organic N fertilizers, urine and dung deposited by grazing animals, crop residues subcategories. The related figures of changes for 1990-2017 concerning these five subcategories mentioned are 2 646 kt (47.1%), 525 kt (19.5%), 764 kt (15.2%), and 1 643 kt (103.6%) respectively. Estimations from cultivation of organic soils are constant 82 kt CO<sub>2</sub> eq. Organic N fertilizers are further subdivided into three groups, namely animal manure, sewage sludge, and other organic fertilizers, all applied to soils. Increase in animal manure applied to soils is 556 kt (22.3%) from 2 494 kt to 3 050 kt whereas the two other organic N fertilizer subcategories decreased as given in Table 5.17. On the other hand, the total increase of 0.4 Mt CO<sub>2</sub> eq. of indirect N<sub>2</sub>O emissions is divided into two categories, atmospheric deposition and nitrogen leaching and run-off. The related figures of changes for these subcategories are 392kt (20.1%) and 55 kt (34.8%) for the period of 1990-2017 respectively.

### Methodological Issues:

N<sub>2</sub>O emissions are calculated by using the IPCC T1 approach. The AD used in emission calculation are taken from agricultural statistics of TurkStat. The N<sub>2</sub>O EFs are IPCC T1 default factors.

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<sub>2</sub>O production. Crop residue calculation follows in principle the 2006 IPCC Guidelines with small refinements. N<sub>2</sub>O emissions are now calculated according to all cultivated plants in Turkey. Both aboveground and belowground crop residues are included. Crop yields vary from year to year, as well as cultivated areas, which cause fluctuations in crop residue emissions. Better data for renewal fraction and fraction removed were asked and received from MFA in order to improve estimations of N<sub>2</sub>O emissions from crop residues. The following table summarizes the crop headings for which N<sub>2</sub>O emissions due to crop residues are calculated in our country.

**Table 5.19 Crop data used for crop residue calculations**

Major Crop Types	Individual Crops	
Grains	Maize	Sorghum
Beans & Pulses	Wheat	Soybean
Tubers	Rice	Dry bean
Root crops, other	Barley	Potato
N-fixing forages	Oats	Peanut
Non-N-fixing forages	Millet	Alfalfa
Grass-clover mixtures	Rye	

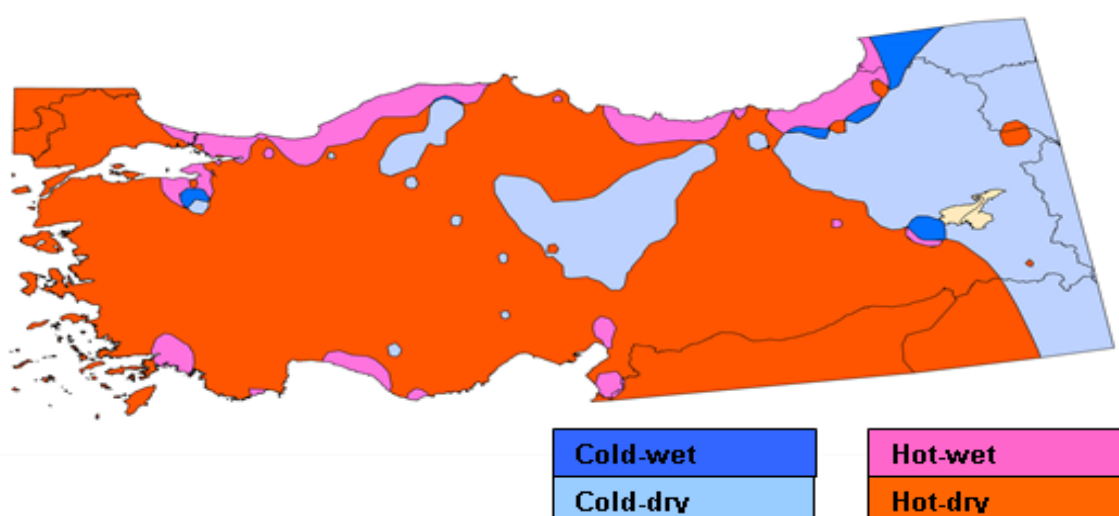
Source category	Gas	Comments on time series consistency
3.D.1	N <sub>2</sub> O	All EFs are constant over the entire time series

N<sub>2</sub>O emissions are calculated by using the IPCC T1 approach. The AD used in emission calculation are taken from agricultural statistics of TurkStat. The N<sub>2</sub>O EFs are IPCC T1 default factors.

In the 2016 Assessment Review Report of Turkey published on 24 April 2017, a recommendation was made by the Expert Review Team to investigate the actual leaching conditions in Turkey and estimate the most likely  $Frac_{LEACH-(H)}$  for its national conditions and include justification of the  $Frac_{LEACH-(H)}$  value used in its NIR. The ERT also noted that taking into account the dry conditions in Turkey and the use of a  $Frac_{LEACH-(H)}$  of 0.3, a likely overestimation is taking place. To address this recommendation and use a more precise  $Frac_{LEACH-(H)}$  value this issue was evaluated. As a result, a revised country-specific  $Frac_{LEACH-(H)}$  value of 0.015 is calculated and used with respect to the footnote of Table 11.3 in the 2006 IPCC Guidelines Volume 4. While calculating this parameter, following steps are implemented: First, the Climate Map (Figure 5.9) was used as a reference data source while keeping in mind that in this data source, the entire 12 months in a year (including also the dry months of June, July and August) are taken into account, not 9 months as mentioned in the footnote of Table 11.3 given in the 2006 IPCC Guidelines Vol.4. Secondly, soil water-holding capacity is assumed to be zero as a conservative approach. In other words, if rainfall exceeds the potential evapotranspiration then it is assumed that surface runoff or leaching occurs. In general conditions there is a soil layer (shallow or deep) that hold water and disable surface runoff but it is not possible to make an assessment on the water capacity of soils for the whole country. Thirdly, it is assumed that leaching/run-off occurs in all wet areas shown in the Climate Map but not occur at the dry areas of the country. Thus, a ratio between wet and dry areas has been determined and multiplied by 0.3 to result in 0.015 as a  $Frac_{LEACH-(H)}$  value. This newly calculated value has been used since the submission of the 1990-2016 Inventory.

According to the 2006 IPCC Guidelines, a climate map of Turkey (Figure 5.9) was prepared before and this map was used to estimate a country-specific  $Frac_{LEACH-(H)}$  value. Four sub-climate types have been identified based on 2006 IPCC Guidelines that use basic climatic parameters of temperature, potential evapotranspiration and precipitation.

**Figure 5.9 Climate Map of Turkey**



### 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 MAF. By using Equation 3.2 in the 2006 IPCC Guidelines Vol. 1, uncertainties for the AD are calculated as 19.50% by TurkStat for  $N_2O$  Emissions from Managed Soils. In a similar manner, the respective EF uncertainty for this category is figured out as 96.00% after taking the default uncertainties in the 2006 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. Moreover, QA work was conducted by Professor Yusuf Serengil (Member of the UNFCCC Expert Review Team) for this category in December 2017.

### **Recalculation:**

Better information on country-specific typical animal mass values for sheep (domestic and merino) and goats, a revision of the distribution of the manure management systems and an update in crop residues, resulted all in the recalculation of the entire time series for agricultural soils. For this source category, the recalculation has an increasing effect of 13.3% and 5% for the year 1990 and 2016 respectively, and the average recalculation ratio for the period of 1990-2016 is calculated as 8.1%. Our country-specific conditions are better reflected after this improvement accomplished while the recalculation affected all reported years of last year's submission.

Currently, N<sub>2</sub>O estimations for managed soils are estimated at 17 093 kt CO<sub>2</sub> eq. and 23 117 kt CO<sub>2</sub> eq. for the years 1990 and 2017, respectively. Those figures were reported in the National Inventory Report 1990-2016 as 15 085 kt CO<sub>2</sub> eq. for 1990 and 21 561 kt CO<sub>2</sub> eq. for 2016.

### **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 in the future.

## **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<sub>4</sub>, N<sub>2</sub>O, CO, and NO<sub>x</sub> emissions of which CO and NO<sub>x</sub> are indirect greenhouse gases. The resulting atmospheric release of agricultural residues is not considered to be a net carbon dioxide source, as carbon is being absorbed again during the growing season. This source category is not a key category. Emission values due to field burning of crop residues are given in Table 5.3 for all twenty-eight reporting years. After consultations with the Ministry of Food, Agriculture and Livestock and our own research, wheat, barley, maize and rice 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 given in detail in Table 5.20, CH<sub>4</sub> and N<sub>2</sub>O emissions contributed 126 kt CO<sub>2</sub> eq. and 39 kt CO<sub>2</sub> eq. respectively to this source category in 2017.

**Table 5.20 Field burning of agricultural residues emissions, 1990 and 2017**

Category	Emissions (kt CO <sub>2</sub> eq.)				Changes from 1990 to 2017		Percentages of agricultural sector (%)	
	1990	(%)	2017	(%)	(kt CO <sub>2</sub> eq.)	(%)	1990	2017
<b>Field burning of agricultural residues</b>	347	100	165	100	-182	-52.4	0.76	0.26
CH <sub>4</sub>	265	76	126	76	-139	-52.4	0.58	0.20
N <sub>2</sub> O	82	24	39	24	-43	-52.4	0.18	0.06

In 2017, field burning of agricultural residues contributed 165 kt CO<sub>2</sub> eq. This emission value represented 0.3% of all agricultural emissions. Total field burning CO<sub>2</sub> eq. emissions presented a decreasing trend because of prohibitive legislative measures undertaken. The emission estimations for the period 1990-2016 had been recalculated. For the base year 1990, this total emission was changed to 347 kt as a result of this recalculation. CH<sub>4</sub> and N<sub>2</sub>O emissions from field burning have mostly a negative trend except for some years. Prohibiting measures and increase of public awareness related to field burning are key in this decreasing trend and relevant authorities impose also fines on misconduct. Additionally, the use of advanced agricultural machinery assists farmers in handling crop residues more easily, could also be considered as another factor leading to the reduction of field burning practices. The respective percentage change from this source category is -52.4% for the period of 1990-2017.

## 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<sub>2</sub> and N<sub>2</sub>O emissions are calculated using the IPCC Tier 1 approach. The values calculated for CH<sub>4</sub> and N<sub>2</sub>O emissions were converted to their CO<sub>2</sub> equivalents by multiplying the values with their respective global warming potential factors. Other emission values under this source category, NO<sub>x</sub>, CO, and NMVOC, are not estimated. Most of the farmers obey the rules, prohibiting stubble burning leaving some farmers still practicing crop residue burning.

## Uncertainties and Time-Series Consistency:

The AD for this sector was gathered from agricultural statistics of TurkStat. Uncertainty values concerning AD for two GHG sources under this source category, namely CH<sub>4</sub> and N<sub>2</sub>O, are each estimated to be 50% whereas uncertainty values concerning EF for these gases are estimated to be 40% as recommended in the 2006 IPCC Guidelines.

Source category	Gas	Comments on time series consistency
3.F	CH <sub>4</sub> , N <sub>2</sub> O	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 also published 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 MAF. Annual checks are done whether new scientific articles for updating emission factors have been published in Turkey. Finally, QA work was conducted by Professor Yusuf Serengil (Member of the UNFCCC Expert Review Team) for this category in December 2017.

**Recalculation:**

Emissions from field burning of agricultural residues are recalculated for the period of 1990-2016 because of the addition of maize burning. The new reported emission value for the year 1990 is 347 kt CO<sub>2</sub> eq. instead of 332 kt CO<sub>2</sub> eq. which was submitted last year. Similarly, the current submitted emission value for the year 2016 is 164 kt CO<sub>2</sub> eq. instead of 151 kt CO<sub>2</sub> eq.

**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)**

Possible data sources are considered for this mandatory category. Three factors are possibly more important than others which explain the use of carbonate limestone applied to soils in our country. First, soils with lower pH values are present mainly in the Black Sea Region and Marmara Region. Second, it is not an inexpensive method to reduce acidity of soils for agricultural producers by using carbonate limestone. Third, there are also non-carbon containing materials available, which are suitable to be applied on soils in order to reduce acidity. Our research is almost decisive in estimating CO<sub>2</sub> emissions amounted to far less than 100 kt for 2015 due to liming applied on soils. Hence, this category is considered as insignificant according to 24/CP.19, annex I, paragraph 37(b). This source category is reported as not estimated in the CRF.

## 5.9. Urea Application (Category 3.H)

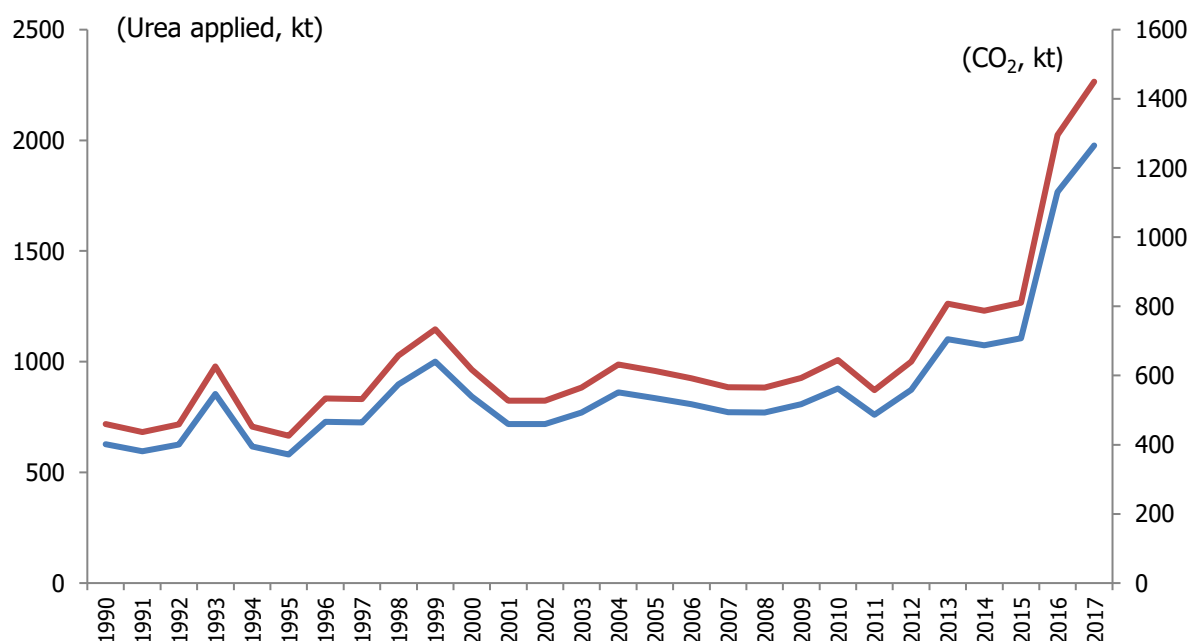
### Source Category Description:

Adding urea to soils for fertilization leads to reduction of the CO<sub>2</sub> gas that was fixed during the industrial production process. Urea (CO(NH<sub>2</sub>)<sub>2</sub>) transforms to (NH<sub>4</sub><sup>+</sup>), hydroxyl ion (OH<sup>-</sup>) and bicarbonate (HCO<sub>3</sub><sup>-</sup>) with the presence of urease and water. Similar to the soil reaction following addition of lime, bicarbonate that is formed evolves into CO<sub>2</sub> and water.

CO<sub>2</sub> emissions from the application of urea produced 1449.6 kt CO<sub>2</sub> in 2017. This is an amount representing 2.3% of agricultural emissions. Emissions from the urea application in 2017 were 990 kt CO<sub>2</sub> (215.2%) above its 1990 level of 460 kt CO<sub>2</sub>. This source category, CO<sub>2</sub> emissions from urea application, is not a key category.

Emissions values due to urea application are given in Table 5.3 for the period of 1990-2017 in the sector overview section. Figure 5.10 presents yearly amount of urea application in kt (line drawn in blue - left axis) and CO<sub>2</sub> emissions emitted in kt (line drawn in dark red - right axis). A direct relationship between the two values is observed on the figure. In addition, a slowly increasing trend can be seen on the figure except for the last two reporting years, 2016 and 2017, which indicate big increases.

**Figure 5.10 Urea application and emitted CO<sub>2</sub>, 1990–2017**



### Methodological Issues:

Emissions associated with the application of urea are calculated by using 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<sub>2</sub>-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 MAF 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<sub>2</sub> 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.

An uncertainty analysis using the Monte Carlo technique was carried out to estimate emissions of CO<sub>2</sub> from urea application in this inventory year. Combined uncertainty in CO<sub>2</sub> emissions in 2017 is estimated at -13.54% to +14.70%. The Monte Carlo uncertainty range for CO<sub>2</sub> emissions from urea application is lower than Approach 1 results. The main reason of this difference is explained in Annex 2.

### 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 MAF. Data used for calculations are a part of official statistics, which have their own QA/QC procedures. Specially, the time series was checked for consistency. As a general QC check, the multiplications of activity data and emission factor were double checked for CO<sub>2</sub> 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. Moreover, QA work was conducted by Professor Yusuf Serengil (Member of the UNFCCC Expert Review Team) for this category in December 2017.

**Recalculation:**

There was no recalculation exercised regarding emission estimates from this source category in this submission.

**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.

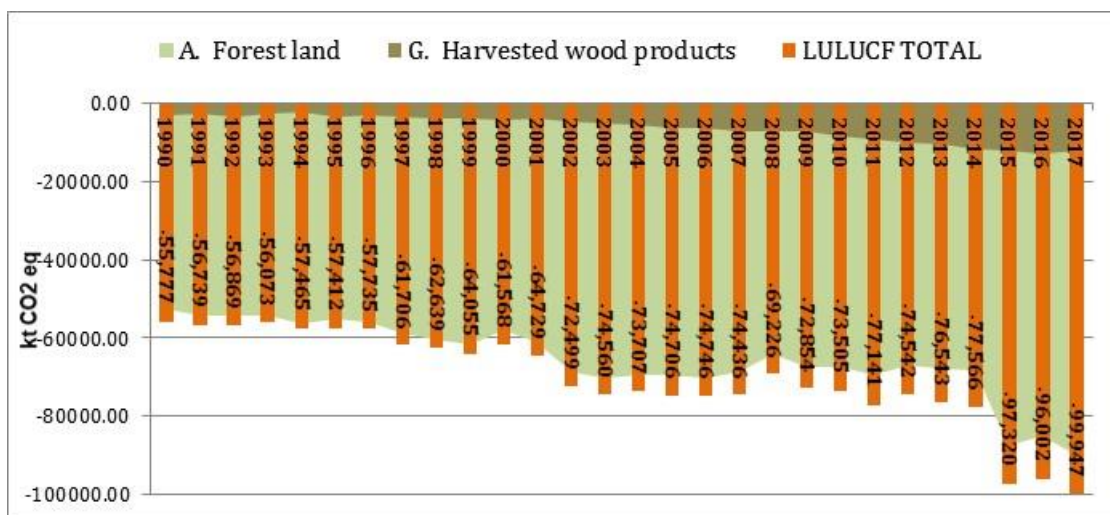


## 6. LULUCF (CRF SECTOR 4)

### 6.1. Sector Overview

The LULUCF sector of Turkey is a net removal dominated by forests. The 22.85 Mha of forest area removed a net 90.19 Mt of CO<sub>2</sub> eq. from the atmosphere in 2017. Other land uses were net emissions while accounting less than 1 percent of forestland removals. The net removal of the sector when HWP was added has been 99.91 Mt of CO<sub>2</sub> eq. representing a 79.2 percent increase compared to 1990. The reason of the increase was increased productivity of the forests reflected by increment values.

**Figure 6.1 The trend of LULUCF sector net removals including HWP, 1990-2017**



The LULUCF sector methodologies related to activity data have entirely been modified with the support of EU funded project entitled "Technical Assistance for Developed Analytical Basis for Land Use, Land Use Change and Forestry (LULUCF) Sector" started in August 2017. The project will be finished in July 2019 but so far provided significant improvements on;

- Developing spatially explicit land use matrices for the land uses and conversions starting from 1990,
- Capacity building in relevant inventory agencies,

- iii. Development of a Program of Works, Annual Work Plan and Compendium,
- iv. A new system to calculate and report GHG emissions/removals in LULUCF sector,
- v. Activity data disaggregated into 8 Ecoregions and 28 Forest Administrative regions for higher level accuracy,
- vi. Updated NIR.

The details of the project can be seen at the project web page <https://www.lulucf-tr.org/>

The new LULUCF reporting system (LRS) of Turkey is composed of below elements:

- A spatially explicit land cover driven AD produced by an experienced international company. The system uses tracks all land cover with satellite images since 1990 and detects all changes on an annual basis. Each 1 hectare unit of land (1 ha) is tracked for the reporting period and calculated for emissions and removals on a consistent approach
- Updated land use definitions
- A new system of reporting that is capable of performing calculations; harmonize spatial data with EF data, archiving, and tools to enhance QA/QC
- Re-assessed EFs by a team of experts
- An EF database and Reference Library developed and used. The system enables experts to update the EFs and coefficients on a continuous basis
- A database has been developed to query all land covers and changes. Thus, land cover data base on Satellite images can be checked and verified anytime

The LRS is managed and used by a group of national experts for different elements. This means that the inventory is prepared by more than 10 experts each focus on a different item. This enables sharing of responsibility and improvement potential

The new system increased the transparency significantly by using AD produced by an international remote sensing company, and a renewed NIR. Furthermore, the new spatially explicit land use tracking system improved completeness, accuracy and consistency because the same methodology has been used for the whole reporting period and for all land uses with around 90 percent accuracy. The new reporting system caused significant changes in emissions and removals. The main categories of removals have been FL-FL and HWPs. The outcome of the key category analysis for 2017 was listed in Table 6.1.

**Table 6.1 Key categories identification in the LULUCF sector (Tier 1)**

	<b>CATEGORIES OF EMISSIONS AND REMOVALS</b>	<b>Gas</b>	<b>2017</b>
4.A.1	Forest Land Remaining Forest Land	CO <sub>2</sub>	Key (L,T)
4.G	Harvested Wood Products	CO <sub>2</sub>	Key (L,T)

Within the new reporting system, a national EF database together with a reference library have been established. They are very similar with the IPCC EF database in structure and includes all data used in the inventory even the default coefficients.

The context and management of the EF database is as follows;

Emission factors are the second set of data, needed for estimation of GHG emissions and removals. An emission factor (EF) is defined as the average emission rate of a given GHG for a given source, relative to units of activity (IPCC 1996). Emission factors can be collected from various sources, from national and international statistics and monitoring, databases, research studies, scientific papers, technical reports etc. The use of appropriate emission factor is essential as wrong selection may lead to under- or overestimation of emissions and removals. In general, the IPCC guidelines include a large list of emission factors, which can be used when Tier 1 methods are selected for estimation. Moreover, there exists emission factor database (EFDB: <https://www.ipcc-nggip.iges.or.jp/EFDB/main.php>) of the IPCC, which also includes large set of emission factors, relevant for the LULUCF.

The following approach is implemented for updating the national EF database:

- Check for improvement of EF database on annual basis (e.g. new EF gathered, higher Tier method selected, category become key source etc.).
- Collect country-specific emission and stock change factors for all key categories.
- Collect all relevant default emission factors of the IPCC for other categories (non-key).
- Assign appropriate specific emission and stock change factors to each corresponding category.
- Add and update EF database when new or improved emission factors are obtained or determined, respectively.
- Store a reference of the EF in the archive (data source, uncertainty, background data etc.).
- Record the person and reason whenever your update the EF database.

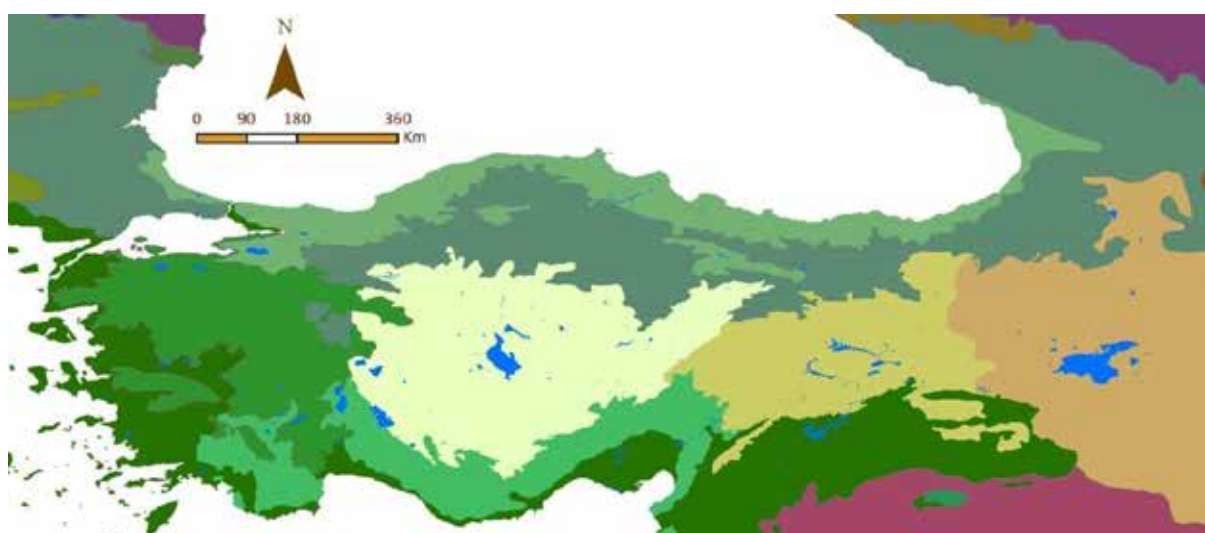
The EF database is embedded in the reporting system on the main computer and has the below table format;

EF ID	GAS DESCRIPTION PRACTICES		CONDITIONS	REGION	VALUE	STD DEV	RANGE	on Coeff (%)	UNIT	REFERENCE	
	Soil										
1	CO <sub>2</sub>	Soil C Stock	native broadleaved forest	grazed forests and shrubs, not	Southeast Anatolia Dec	44.33	12.23	33.64-64.00	27.58	T/ha	BUDAK, M., GÜNAL, H., 2018. Yükan Dicle
											Temel SARINLIOZ (Kastamonu University, Faculty of Forestry, 37100 Kastamonu / Turkey), Gamze SAVACI (Kastamonu University, Faculty of Forestry, 37100 Kastamonu / Turkey), Züleyha MARAL (Kastamonu University, Faculty of Forestry, 37100 Kastamonu / Turkey)
			Mature and young fir stands and adjacent pasture and agriculture	The study area consists of a variation of broadleaf and conifer stands with ages between 40 and 150 year	Mature and Young Fir Stands- Pasture and Agriculture Sites in Kastamonu Northwest Region	Forest (mature fir) 47.4 Forest (young fir) 48.6	Forest (mature fir) ±13.4 SOC Forest (young fir) ±13.8 SOC	the descriptive statistics table is not available		T/ha	
2	CO <sub>2</sub>	soil organic C sites	homogenous soils								Temel SARINLIOZ (Kastamonu University, Faculty of Forestry, 37100 Kastamonu / Turkey), Gamze SAVACI (Kastamonu University, Faculty of Forestry, 37100 Kastamonu / Turkey), Züleyha MARAL (Kastamonu University, Faculty of Forestry, 37100 Kastamonu / Turkey)
			Mature and young fir stands and adjacent pasture and agriculture	The study area consists of a variation of broadleaf and conifer stands with ages between 40 and 150 year	Mature and Young Fir Stands- Pasture and Agriculture Sites in Kastamonu Northwest Region	Forest (mature fir) 4.45 Forest (young fir) 5.61	Forest (mature fir) ±0.48 STN Forest (young fir) ±0.88 STN	the descriptive statistics table is not available		T/ha	
3	N	total nitrogen sites	150 year homogenous soils								Temel SARINLIOZ (Kastamonu University, Faculty of Forestry, 37100 Kastamonu / Turkey), Gamze SAVACI (Kastamonu University, Faculty of Forestry, 37100 Kastamonu / Turkey), Züleyha MARAL (Kastamonu University, Faculty of Forestry, 37100 Kastamonu / Turkey)

## Land-use definitions and the classification systems used and their correspondence to the land use, land-use change and forestry categories

The Land Use definitions of Turkey have been updated with the new land monitoring system. The country has been divided into 8 ecological zones based on international and national literature. The ecoregions assessment has provided the possibility to disaggregate calculations into more homogenous regions and use of more specific EFs and coefficients. The Eco zones identified by Serengil (2018) and relationship with climate types are given below (Figure 6.2. and Table 6.2.)

**Figure 6.2 The ecoregions in Turkey (Serengil, 2018)**



**Table 6.2 Ecozones in Turkey and their relationships with climate classifications (Serengil, 2018)**

	Ecozone	Biome	Climate Type	IPCC Climate Type
1	Euxine-Colchic deciduous forest	Temperate deciduous & mixed forest	Black Sea Coastal Zone	Warm Temp Moist
2	North Anatolian deciduous, coniferous and mixed forest	Temperate deciduous, coniferous and mixed forest	Black Sea Inland Temperate Climate Zone	Warm Temp Dry
3	Mediterranean coastal zone deciduous and coniferous forest	Mediterranean forest, shrubs	Mediterranean Coastal Zone	Warm Temperate Moist-Dry
4	Mediterranean Mountain zone	Mediterranean forest, shrubs	Mediterranean Inland Temperate Mountain Climate	Warm Temp Dry
5	Aegean Inland deciduous and coniferous forest	Mediterranean forest, shrubs	Mediterranean Inland Temperate Climate	Warm Temp Dry
6	Central Anatolian steppe	Temperate deciduous & mixed forest	Semi Dry Steppe Climate	Warm-Cool Temp Dry
7	East Anatolian deciduous forest zone	Temperate deciduous & mixed forest	Temperate Continental Climate	Warm Temp Dry
8	East Anatolian steppe	Temperate grassland, shrubs and steppe	Continental Mountainous Climate	Cool Temp Moist-Dry

The new definitions of land uses have been explained below. The former forest definition in 2018 submission was the national legal definition. The national definition had a threshold just for the minimum area which is 3 ha. The application of the new definition and spatially explicit land tracking system did not change the forest area drastically but the share of productive forest in forestland category increased. The difference between the old and the new systems has been discussed in Forestland category below.

**Forest Land:** Forest Land category has been disaggregated into 2 major subcategories;

**Productive Forest:** Tree and woodland communities more than 1 ha with a crown closure over 10 percent, which are grown by both human efforts and naturally are regarded as Forest.

**Other Wooded Forest (OWF):** The same definition applies except the crown closure. The crown closure for OWF is between 1 to 10 percent. The wooded land with crown closures less than 1 percent are allocated under grassland.

**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:** All woody/herbaceous vegetation is defined as grassland. The grasslands include shrubs and trees that provide a crown closure of less than 1 percent. The demand for grazing areas is high in the country and a differentiation between managed and unmanaged is not technically possible thus all grasslands are accepted as managed.

**Wetlands:** This category is divided into two as managed and unmanaged. Only flooded land (dams, irrigation dams and reservoirs) and peatlands are included in the managed wetland definition. Natural systems like rivers and lakes classified under unmanaged wetlands.

**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 spaces like parks and cemeteries that are not classified as forest, sport and leisure facilities)

**Other Land:** Open spaces with little or no vegetation are defined under Other Land. These include;

- Beaches, dunes, sands
- Bare rocks,
- Sparsely vegetated areas

### **Information on approaches used for representing land areas and on land-use databases used for the inventory preparation**

In the previous submission there was inconsistency between activity data of forestry and other land uses. The AD related to forestland was collected from a tabular database called ENVANIS. The ENVANIS system is the major data source of forest management in Turkey and provides both area data, increment and other relevant data related to the forests. It bases on 10 years rotation period field measurements that are implemented on 10 percent of the forests in the country. The ENVANIS system provides high

accuracy information on stand parameters but has some disadvantages for GHG inventories. These disadvantages are;

- The forest area in ENVANIS system uses national legal forest definition and is not compatible with land cover maps i.e. CORINE. Thus it is not possible to establish a consistent land use matrix with a combination of ENVANIS and spatial databases that base on land cover.
- As 10 percent of the country forests are sampled and measured every year the data given in ENVANIS represents only this amount of updated data.
- The types of conversions are unknown. The forest area increase or decrease is reported but the land use that forest is converted is not. Thus an assumption was made that these area areas are all grassland.

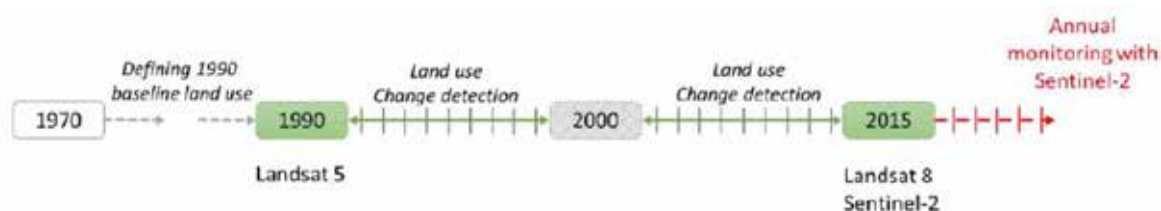
The new system still uses data from ENVANIS such as annual increment but not the area data. Below are the specifications of the satellite based system that has been produced just to be used for GHG calculations.

### **The New Satellite Based Land Cover Monitoring System (SBLMS)**

A satellite Earth Observation based on AD monitoring system for LULUCF for the entire territory of Turkey is developed. The system relies on wall-to-wall spatially explicit mappings to analyze LULUCF activity data and changes for the period from 1990 to 2015. The system delivers complete annual land use and land use change matrices, allowing for consistent spatially explicit assessment in high spatial resolution (30m, 1 ha MMU). The matrices report on land use and land use change between the six IPCC Guidelines land use categories and related 11 subcategories. With this system every unit of land is univocally assigned to only one land use category, eliminating double counting or omissions. By providing consistent information on all land use and land use change categories, inconsistencies in previous submissions in land use representation derived from CORINE Land Cover and ENVANIS have been overcome.



**Figure 6.3 The temporal structure of the SBLMS with the satellites used**



Following similar approaches of other Mediterranean countries, this is achieved through

- a detailed mapping of the selected reference years (here 1990, 2000 and 2015) from time series high-resolution satellite images,
- the determination of changes between these reference years and,
- an assessment of the intermediate years through advanced analyses.

**Table 6.3 Classification approach for all categories and subcategories under SBLMS**

Category	Classification Approach
<b>Forest</b>	The identification of <b>deciduous</b> and <b>coniferous</b> forests is based on time-series analysis, where phenological changes are used to differentiate between these two classes. Copernicus HRL Forest layers 2015 and 2012 are used as ground truth. Following this differentiation a local filter with a size of 1ha will be applied, where areas without dominant tree type are classified as <b>mixed</b> forest.
<b>Cropland</b>	Separation of cropland and grassland is a complex task in image classification and requires multitemporal data analyses and reference ground truth data. <b>Annual</b> crops have been identified due to their vegetation phenology (periodic change of vegetation status). <b>Perennial</b> crops on the other hand are hard to differentiate from forest areas, due to similar spectral characteristics compared to other woody vegetation. Therefore, ancillary information is needed to assist in the identification of perennial croplands (e.g.. LPIS for 2015). The global NASA Crop layer and CORINE are used to prepare samples for both crop sub-categories. A fully automated classification approach for 25 years over entire Turkey cannot reliably detect different crop types, so statistical information (e.g. TUIK) can instead be used to calculate crop type ratios that are then applied to the detected crop areas, assuming the area estimates in the TUIK database are representative for the entire country.
<b>Grassland</b>	Grassland areas are classified by the spectral characteristics detected over time. The differentiation between woody grasslands and herbaceous grasslands base on spectral classification as well a ruleset to improve accuracy. Woody grasslands, for example, are likely to be found around forests, so their proximity to a forest boundary has been taken into consideration. For the consistency woody grasslands that have a crown closure of 1 to 10 percent are merged with Other Forested Areas category.



**Table 6.3 Classification approach for all categories and subcategories under SBLMS (Cont'd)**

<b>Wetland</b>	<i>Open (artificial) waterbodies are readily detectable with satellite data given their sudden appearance at a fixed point in time (e.g. construction of a dam) and their permanence following that date. Different indices (e.g. Normalized Difference Water Index (NDWI)) are used to efficiently delineate wetlands. Auxiliary data on dam constructions is needed to improve detection accuracy.</i>
<b>Settlement</b>	<i>For the identification of settlement areas, indices like the NDVI are used, as they highlight both vegetated and non-vegetated areas. The HRL and CORINE datasets have been used to provide ground truth.</i>
<b>Other land</b>	<i>Areas which are covered by bare soil, sand, rocks, and salt marshes will be classified as other land. Permanent snow and ice will also fall under this category, should they be present in Turkey in any given year.</i>

## Land use baseline establishment

For each of the three reference years (1990, 2000 and 2015) a land cover map has been produced by applying the classification procedures described above. The outputs have further been refined using existing datasets for Turkey especially for the differentiation of perennial crops. Due to the different type and amount of data available for the different time steps, specific methodologies have been applied to achieve consistent outputs over the entire 1990-2015 periods.

2015 is the most recent reference year for mapping and AD reporting in this project. With the Copernicus program, the availability of high resolution satellite imagery has dramatically improved and the monitoring system can utilize this wealth of information by including both Sentinel 2 (10-20m) and Landsat 8 (30m) imagery in the production process. In addition to the high availability of satellite imagery, an extensive list of highly accurate, spatially explicit information products have been used to support the mapping in 2015. These include LPIS, Copernicus High Resolution Layers (HRL) for Forest, Wetlands, Grassland, and Settlements, other global data layers (e.g. USGS Global Crop Maps) and other auxiliary data.

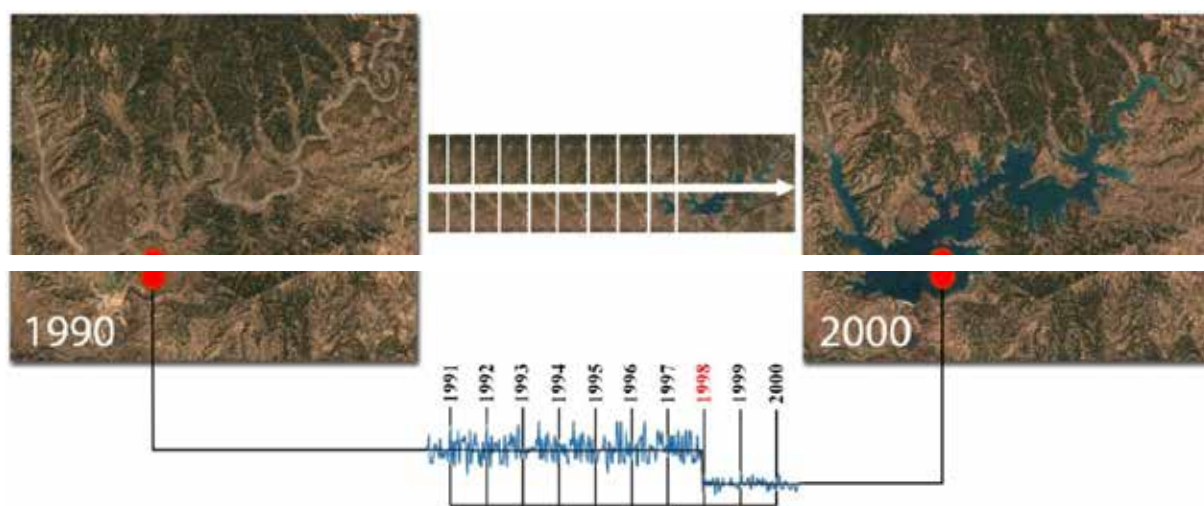
Mapping of the intermediate reference year 2000 is primarily based on Landsat 7 with support from Landsat 5 imagery. CORINE is used as auxiliary data.

The reference year 1990 is the base year for UNFCCC reporting and relies primarily on Landsat 5 imagery for mapping. Considering the 20-year-transition rule, it was anticipated that the time from 1970 until 1990 be reviewed for the definition of the 1990 map (see D4.2.1). The Landsat satellite program started in 1972, however, satellite data is only sparsely available for Turkey until the 1980's and the assessment

of approaches chosen by other Mediterranean countries show that the primary input for 1990 base maps are national forest statistics. The Turkish national forest inventory is available for 1972, however, it is not spatially explicit and uses an incompatible definition for forest which means that it is of very limited use in an assessment of the 1970-1990 period. In order to overcome these high uncertainties, some countries (e.g. Greece) have chosen to report 1990 as is and commence with any land use changes from then on. In our approach we used the 1990 land cover / land use map on Landsat 5 imagery as the base year.

The monitoring system uses an accurate approach by performing change detection for intermediate years through breakpoint analyses of spectral indices calculated from all satellite data available for the intermediate period. This method provides accurate estimates of changes and their change years, and together with the 3 national land cover / land use maps, provides the basis for the annual matrices.

**Figure 6.4 Change detection approach between reference years**



The satellite based land monitoring system is planned to be continued and improved in the coming years.

### Land Use Matrices

Land uses and transitions between the 6 land use types and 11 land use subcategories have been calculated in annual land use / land use change matrices for all 25 years (without any interpolation in between). Further the last 2 years (2016 and 2017) have been extrapolated. All transitions are reported as transitions for 20 years following the transition event. Land categories and subcategories have been

further disaggregated into 8 ecozones and 28 forest regional directorates. The ecozones have been explained above in 6.2. The outline of the core matrix is illustrated in Table 4.

**Table 6.4 A sample land use matrix**

2015		Deciduous Forest	Coniferous Forest	Mixed Forest	Degraded Forest	Annual crops	Perennial crops	Herbaceous grassland	Managed Wetland	Unmanaged Wetland	Settlement	Other Land	Total
		1	2	3	4	5	6	7	8	9	10	11	
Deciduous Forest	1	8,856,545	-	-	4,656	10,074	2,496	13,171	147	14	2,770	3,921	8,881,789
Coniferous Forest	2	-	10,262,529	-	33,600	22,189	3,415	20,124	119	44	3,808	10,481	10,356,542
Mixed Forest	3	-	-	728,488	71	115	21	118	0	0	25	66	728,881
Degraded Forest	4	30,021	33,604	904	3,170,918	8,167	2,960	7,963	66	9	1,788	4,857	3,261,337
Annual crops	5	-	-	-	-	23,461,804	41,055	-	1,545	293	78,035	25,996	23,608,728
Perennial crops	6	1,227	539	11	475	11,597	3,407,874	3,031	11	9	4,626	1,494	3,430,894
Herbaceous grassland	7	12,779	27,236	414	15,006	72,230	13,922	23,574,342	891	166	12,442	26,717	24,171,947
Managed Wetland	8	-	-	-	-	356	-	161	465,649	-	26	80	466,372
Unmanaged Wetland	9	-	-	-	-	10,719	-	7,972	-	1,344,259	1,733	6,272	1,370,955
Settlement	10	-	-	-	-	-	-	-	0	0	821,772	371	822,143
Other Land	11	2,015	3,014	32	2,375	15,248	2,609	7,091	78	179	4,927	1,659,232	1,696,941
<b>Total</b>		<b>8,887,587</b>	<b>10,327,058</b>	<b>729,849</b>	<b>3,227,900</b>	<b>29,625,670</b>	<b>3,476,831</b>	<b>24,093,974</b>	<b>466,501</b>	<b>1,344,979</b>	<b>947,021</b>	<b>1,739,528</b>	

## Accuracy Assessment

For the land cover and land use datasets of the years 1990, 2000 and 2015 a scientifically sound thematic accuracy assessment has been carried out following best-practice standards according to ISO 19157 Geographic information - Data quality, the CEOS guidelines for Calibration and Validation and the QA4EO principles. This involves the following core design principles:

- Sampling design: A probability sampling design is used to generate a stratified random point sample that is statistically viable for all sampled categories and sub-categories at a confidence interval of 95%.
- Response design: The samples are then validated against higher quality data that includes aerial imagery (e.g. Google and Bing maps) for 2015; 15m pan-sharpened Landsat 7 imagery for 2000 and Landsat 5 imagery for 1990, in addition to other independent aerial or very high resolution satellite imagery, other map products or local auxiliary data.
- Analysis: The outcomes are presenting uncertainty measures on the area and area changes of the land use categories in the form of a confusion matrix (Figure 10) that provides information on overall thematic accuracy, class-specific user's and producer's accuracies, and Kappa coefficients at a confidence interval of 95%. User accuracy and Producer accuracy are defined as follows:

User accuracy is a measure of commission error: Represents the probability that a pixel classified into a given category actually represents that category on the ground. Producer accuracy is a measure of omission error. This value represents how well reference pixels of the ground cover type are classified.

## Completeness

As regards the inventory completeness, sinks and sources that has been reported with notation keys NA, NO and NE in the CRF tables are listed below:

**Table 6.5 Completeness Table**

Sink/source category	Pool	GHG	Reported as	Mandatory	Explanation
Forest land remaining forest land	Soil	CO <sub>2</sub>	NO	No	It is assumed that carbon stocks of soils in Forest Land Remaining Forest Land do not change.
Forest land remaining forest land	Dead wood and litter	CO <sub>2</sub>	NO	No	It is assumed that carbon stocks of DOM in Forest Land Remaining Forest Land do not change.
Land converted to Forestland	Dead wood	CO <sub>2</sub>	NO	Yes	The DW carbon stocks in case of land conversion is assumed to be not changing and DW carbon stocks in all land uses is assumed to be zero. The IPCC 2006 does not provide a default value for DW C stocks.
Forest land, Biomass Burning- Controlled Burning	Biomass	CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O	NO	Yes	Controlled Burning is not applied in Forestland.
Forest lands, drained soils	Biomass	Non-CO <sub>2</sub>	NE	Yes	No available data on drainage
Drained wetlands	Biomass	Non-CO <sub>2</sub>	NO	Yes	Wetland drainage is not performed in Turkey.
Limestone application in croplands and grasslands	Soil	CO <sub>2</sub>	NO	No	Limestone application does not occur in the agricultural lands and grasslands.
Croplands, grasslands, wetlands and settlements, biomass burning	Biomass	CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O	NA	Yes	No available data

### 6.2. Forest Land (4.A)

#### Source Category Description:

The forestland category includes CSC from Forestland Remaining Forestland (FL-FL) and Land Converted to Forestland (L-FL) subcategories. Tier 2 methods that are combinations of national EFs and IPCC methods have been applied except some default coefficients (i.e. CF, root to shoot ratio). The AD in these subcategories have entirely been changed. The previous submissions used to base on ENVANIS statistics for AD and increment values. With the spatially explicit land tracking system the increment values are still taken from ENVANIS but AD has entirely been changed. The improvements in this category with the new reporting system and consequences are as follows;

- The forest definition has been changed to one that is more suitable for GHG inventories. The previous national definition was a legal definition that do not include threshold for crown closure. All land uses have been disaggregated into ecozones but forests have also been split into 28 regional forestry directorates. This will enable to implement mitigation actions more effective among forestry directorates.
- Now the forestland has been split into 4 subcategories that are coniferous, deciduous, mixed forest and other forested land (OFL). OFL are forest areas with crown closure between 1 to 10 percent. The previous forest definition included a minimum area of 3 ha. The new system defines all forests with a minimum area of 1 ha.
- As a consequence of changes in definition and AD development methodology the total forest did not change significantly but productive forest areas that have crown closure more than 10 percent increased significantly. As a result of this the removals due to increase in aboveground biomass increased drastically. The increment data taken from ENVANIS puts forward large increases in increment which may be caused by rehabilitation projects in early 2000s. The productivity of the stands increased as the stands reached to the fast growing young ages in 2010s. The changes in increment for forest types are given below;

**Table 6.6 Increment rates of forest types in Turkey (m<sup>3</sup>/ha)**

Year	Coniferous	Deciduous	Mixed	OFL
1990	2.99	2.40	2.62	0.22
1995	3.06	2.46	2.68	0.23
2000	3.26	2.62	2.86	0.24
2005	3.85	2.81	3.05	0.26
2010	3.98	2.94	3.06	0.22
2015	4.37	4.31	3.53	0.23
2016	4.01	4.52	3.52	0.23
2017	4.24	4.43	3.61	0.23

- The previous system was based on ENVANIS that was available since 2002. The period before 2002 was extrapolated basis of 1972 and 1999's forest inventory. With the new system a consistent land use and land use change AD has been available for the whole reporting period. The AD base on satellite images and has 1 ha spatial resolution.
- The previous system was not able to identify land conversions between forests and other land uses (i.e. L-FL, FL-CL, FL-GL) and it was assumed that conversions occur only from and to grasslands. Now all land conversions have been tracked with high accuracy and emissions/removals have been reported.
- The previous system was based on reports from regional forestry districts and was not subject to verification while the new system enables verification of the satellite based maps from other sources (i.e. Land Parcel Identification System, CORINE).
- The crown closure data from ENVANIS was based on subjective observations while the new system enabled objective automatic identification.
- The AD of the previous system was derived from management unit of GDF while AD has been produced by an international remote sensing company. This strengthens the objectiveness of the AD.

### Information on Land Classification and Activity Data

Detailed information has been provided under section 6.3.

## Land-use definitions and the classification systems

In the previous submissions national forest definition was used. With this submission the forest definition has been changed to a definition in line with the definitions of the Food and Agriculture Organization of the United Nations. The EU and FAO compliant forest definition of 10% crown cover, 1 ha MMU and 5m tree height is applied to all sub-categories. The lands below 10 percent crown closure are classified under other forested land (OFL) as a subcategory under forestland. Agriculturally used tree crops are classified under perennial croplands and are not part of the forest definition.

The forests have further been classified as coniferous, deciduous and mixed forests. The mixed forests consist of both coniferous and deciduous trees with neither species clearly dominating the stand.

**Table 6.7 Forest area (kha) changes in Turkey, 1990-2017**

Year	Tabular (old system)			Spatially explicit land tracking (new system)		
	Productive forest	Other Forested Land	Total	Productive forest	Other Forested Land	Total
1990	10 494	10 075	20 569	19 721	3 258	22 979
1995	10 546	10 125	20 672	19 699	3 248	22 955
2000	10 643	10 218	20 861	19 664	3 242	22 908
2005	10 662	10 586	21 248	19 637	3 218	22 865
2010	11 203	10 334	21 537	19 583	3 184	22 783
2015	12 704	9 639	22 343	19 548	3 171	22 726
2017	13 359	9 716	23 075	19 576	3 275	22 851

The increment data is provided by the Management Department of the Forest Service (GDF) via ENVANIS system. The ENVANIS database (Figure 6.8) collects and processes data from forest management plans as the plans are renewed every ten years. Since 2002, 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 species, 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 2002.

The comparison of removals by forestry sector, according to the forest area, annual increment and growing stock changes since 1990 is given in Table 6.5, 6.7 and 6.8.



Table 6.8 The ENVANIS Database

Microsoft Excel (Ürün Etiketini İlemedi) - Envanis 2014.xlsm

	A	B	C	E	F	G	H	I	J	Q	R	S	T	U	AB	AG	AH	AI	AJ	AK	AL	AM	AN							
3																														
4	PLAN CODE NO				Features of management type						Area						TOTAL FOREST AREA Ha				Growing stock						Annual Increment			
5	Forest enterprises		REGION	PLANNING UNIT	Purpose (Function, Statu)	Form of Forest	Manag ement Type	tree species	mixed	Q	R	S	T	U	(a) Age Class high forests Ha	High		Coppices		Productive m3	Degraded m3	Productive Stere	Degraded Stere	Productive m3	Degraded m3	Productive Stere	Coppices			
6	B	C																												
7	1	101	10101	A	1	A	K	63	F	0	0	0	0	0,0	0	0	0	0	0	0	0	0	0	0	0	0	0			
8	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	0	0	0	0			
9	1	101	10101	M	6	A	K	1	C	33	0	0	0	33,0	0	3620	0	0	0	247	0	0	0	0	0	0	0			
10	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	0	0	0	0			
11	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	0	0	0	0			
12	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	0	0	0	0			
13	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	0	0	0	0			
14	1	101	10102	A	1	A	K	51	F	0	0	0	0	0,0	0	0	0	0	0	0	0	0	0	0	0	0	0			
15	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	0	0	0	0			
16	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	0	0	0	0			
17	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	0	0	0	0			
18	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	0	0	0	0			
19	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	0	0	0	0			
20	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	0	0	0	0			
21	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	0	0	0	0			
22	1	101	10103	A	1	A	K	51	F	0	0	0	0	0,0	0	0	0	0	0	0	0	0	0	0	0	0	0			
23	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	0	0	0	0			
24	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	0	0	0	0			
25	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	0	0	0	0			
26	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	0	0	0	0			
27	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	0	0	0	0			
28	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	0	0	0	0			
29	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	0	0	0	0			



### Databases to Identify Forests

There are only two documents (1972 and 1999 inventory) relevant to the national forest inventory results in Turkey before 2002. 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 ten years interval. The data provided by the first inventory (1972) has been shown in Table 6.9. The growing stock and annual increment data since 1990 have been presented in Tables 6.10 and 6.11.

**Table 6.9 Forest inventory, 1972 (Source: GDF)**

<b>Areas</b>						
<b>Type</b>	<b>Productive<sup>a</sup></b>		<b>Degraded<sup>b</sup></b>		<b>Total</b>	
	<b>ha</b>	<b>%</b>	<b>ha</b>	<b>%</b>	<b>ha</b>	<b>%</b>
<b>High Forest</b>	6 176 899	30.58	4 757 708	23.55	10 934 607	54.13
<b>Coppice</b>	2 679 558	13.27	6 585 131	32.60	9 264 689	45.87
<b>Total</b>	8 856 457	43.85	11 342 839	56.15	20 199 296	100.00
<b>Growing stock</b>						
<b>Type</b>	<b>Productive<sup>a</sup></b>		<b>Degraded<sup>b</sup></b>		<b>Total</b>	
	<b>m<sup>3</sup></b>	<b>%</b>	<b>m<sup>3</sup></b>	<b>%</b>	<b>m<sup>3</sup></b>	<b>%</b>
<b>High Forest</b>	758 732 197	81.10	54 349 847	5.81	813 082 044	86.91
<b>Coppice<sup>c</sup></b>	88 300 818	9.44	34 129 288	3.65	122 430 106	13.09
<b>Total</b>	847 033 015	90.54	88 479 135	9.46	935 512 150	100.00
<b>Annual volume increment</b>						
<b>Type</b>	<b>Productive<sup>a</sup></b>		<b>Degraded<sup>b</sup></b>		<b>Total</b>	
	<b>m<sup>3</sup></b>	<b>%</b>	<b>m<sup>3</sup></b>	<b>%</b>	<b>m<sup>3</sup></b>	<b>%</b>
<b>High Forest</b>	20 791 672	74.09	1 343 744	4.79	22 135 416	78.88
<b>Coppice<sup>c</sup></b>	4 813 197	17.15	1 114 592	3.97	5 927 789	21.12
<b>Total</b>	25 604 869	91.24	2 458 336	8.76	28 063 205	100.00

a) Crown closure between 0.11–1.00.

b) Crown closure between 0.01–0.10.

c) 0.75 coefficient was used to convert the stere volume to a m<sup>3</sup> volume.

Table 6.10 Growing stock, 1990-2017 (Source: GDF)

(thousand m<sup>3</sup>)

Year	Productive <sup>1</sup>			Degraded <sup>2</sup>			Total
	High Forest	Coppices <sup>3</sup>	Productive total	High Forest	Coppices <sup>3</sup>	Degraded 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
2016	1 540 723	29 215	1 569 939	60 895	10 377	71 271	1 641 210
2017	1 601 931	13 728	1 615 659	64 991	4 314	69 306	1 684 964

1) Crown closure between 0.11–1.00.

2) Crown closure between 0.01–0.10.

3) 0.75 coefficient was used to convert the stere volume to a m<sup>3</sup> volume.

**Table 6.11 Annual volume increment, 1990-2017 (Source: GDF)**

(m<sup>3</sup>)

Years	Productive <sup>1</sup>			Degraded <sup>2</sup>			Total
	High Forest	Coppices <sup>3</sup>	Productive total	High Forest	Coppices <sup>3</sup>	Degraded 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
2016	43 669 510	1 277 030	44 946 540	1 539 688	487 331	2 027 019	46 973 559
2017	45 516 439	755 697	46 272 136	1 728 694	252 728	1 981 422	48 253 588

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 to convert the stere volume to a m3 volume.

Evaluation of Table 6.9, 6.10, and 6.11 can be outlined as below:

1. The growing stocks and annual volume increments of the coppice forests reduced while high forests increased constantly. The highest amount of decrease in growing stock/annual increment has occurred in degraded coppices due to converting the coppices into high forests.
2. The total amount of growing stocks and annual volume increment in the coniferous and deciduous forests have slightly decreased.

The considerable reasons for these changes can be:

1. The changing approaches on the forestry applications towards multi-functional use of forest resources in the framework of sustainable forest management concept,
2. Converting coppices into the high forests,
3. The reforestation of unstocked areas in and around forests and rehabilitation of degraded forests by the GDF.

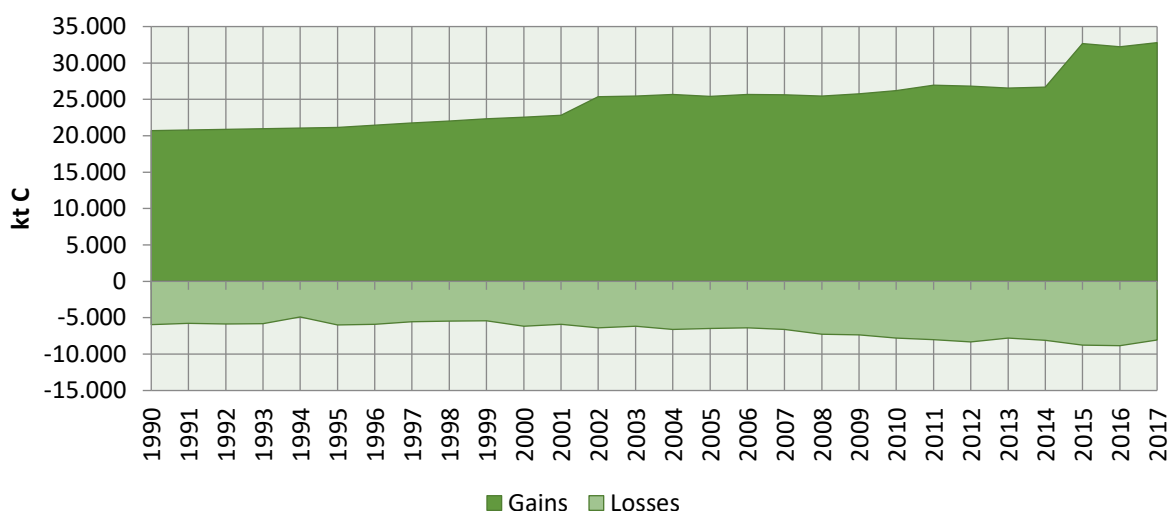
All the factors focused above has been played affecting roles on these changes. Almost entire of Turkish forests can be categorized in the temperate climate zone.

### **CSC in Forest Land Remaining Forest Land**

The carbon stock change in FL-FL subcategory has been net removals during the reporting period. The driver of this situation was the increment of forests. The increment of the forests in the country increased for the reporting period constantly while increased faster for some years. The steep increase in 2015 was due to difference in increment ( $\text{m}^3/\text{ha}$ ) for 2014 ( $I_{\text{dec}}=4.08$ ,  $I_{\text{con}}=2.99$ ,  $I_{\text{mixed}}=2.99$ ,  $I_{\text{deg}}=0.18$ ) and 2015 ( $I_{\text{dec}}=4.37$ ,  $I_{\text{con}}=4.31$ ,  $I_{\text{mixed}}=3.53$ ,  $I_{\text{deg}}=0.23$ ). This might have caused by extensive rehabilitation campaigns during 2000s.

The increment data is derived from all management units of the country as explained in methodology section.

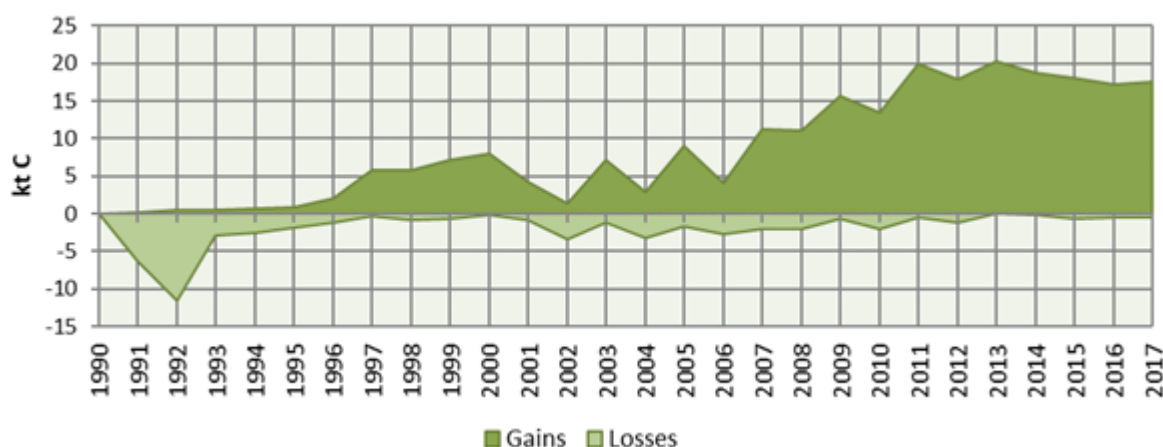
**Figure 6.5 Gains and losses in Forestland Remaining Forestland subcategory (FL-FL)**



### CSC in Land Converted to Forest Land

The CSC in Land Converted to Forestland category is not a key category anymore with the new reporting system. The main reason for the drop in L-FL removals is due to change in forest definition. As explained in the section 6.2 the forest definition has been changed to a physical definition while it used to be a legal national definition. As a consequence of this the AD for land converted to forestland decreased substantially. The CSC in L-FL subcategory moved from net loss to net gain during the reporting period though large fluctuations are observed (Figure 6.6). The large loss in CSC in 1992 was due to a relatively larger conversion from grassland to forest. As explained in methodology section below the conversion from grassland to forestland causes loss in living biomass carbon for the first year.

**Figure 6.6 Gains and losses in Land Converted to Forestland subcategory (L-FL)**

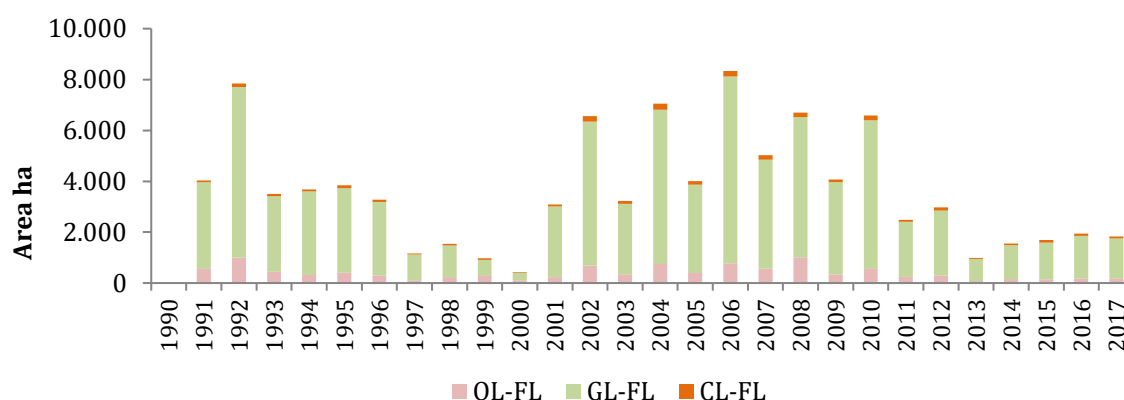


As seen from graph above (Figure 6.6) the L-FL gains increased until 2011 and stabilized since then. There have been 3 type of transitions occurred during the reporting period;

- Grassland Converted to Forestland
- Other land Converted to Forestland
- Cropland (Perennial) Converted to Forestland

Between 1991 and 1996 the conversions were around 4000 ha per year, then dropped below 2000 between 1997 to 2000 and then rise again until 2010. The conversions to Forestland drop to a band around 2000 since then.

**Figure 6.7 Area data for Land Converted to Forestland subcategory**



As seen from the Figure 6.7 the major conversion path in L-FL subcategory is the conversions from Grassland to Forestland. The driver of this conversion type is the afforestation/reforestation of grasslands in or around the forests.

## Methodological Issues:

### Forest Land Remaining Forestland

The calculations in FL category is based on 8 ecozones and 28 forestry regional directorates. In this submission soil C stocks for each ecozones have been calculated by TAGEM (General Directorate of Agricultural Research) based on the soil database.

### Above- and below-ground biomass

Gain-Loss Method (Tier 2) is used to estimate annual change in carbon stocks in living above- and below-ground biomass, considering the country-specific data on mean annual increment, volume of

commercial cutting, fuelwood removal and loss due to disturbances, national biomass expansion factors ( $BCEF_I$ ,  $BCEF_R$ ) and basic wood densities ( $D$ ), and default root-to-shoot ratios ( $R$ ) and carbon fractions ( $CF$ ).

Below equations have been used in estimations;

2006 IPCC equations: Vol 4., Ch. 2: 2.7 / 2.9 / 2.10 / 2.11 / 2.12 / 2.13 / 2.14

Estimation approach was as follows;

- i. Area of each forest stratum with corresponding mean annual increment have been multiplied by national  $BCF_I$  coefficients, IPCC 2006 default root-to-shoot ratios, and IPCC 2006 default CF coefficients to get annual biomass gain ( $\Delta C_G$ ).

The increment data is provided by the Forest Management Department via ENVANIS system and they are updated every year for four forest types;

- Deciduous forest
- Coniferous forest
- Mixed forest
- Degraded forest

The increment data used are given in Table 6.6 for some years.

- ii. Annual carbon loss ( $\Delta C_L$ ) as a sum of wood removals (i.e. commercial cutting), fuelwood removal and disturbance (i.e. forest fires) by each forest stratum has been calculated. In calculation of annual carbon losses in biomass due to disturbances ( $D_{disturbance}$ ) the annual area affected by disturbances has been used (see Equation 2.14).

The data used in this step is received from relevant departments (Production and Marketing, Fire etc.) of the GDF.

The annual biomass loss is a sum of losses from commercial round wood felling's, fuelwood gathering and other losses in forest land was calculated by using the following Equation 2.11 of AFOLU Guidance. Biomass gains and biomass losses are estimated separately. For example, commercial round wood felling's have been calculated in a different column as well as fuelwood 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).

2006 IPCC equations: Vol 4., Ch. 2: 2.11 / 2.12 / 2.13 / 2.14 / 2.17 / 2.24 / 2.27

The FG data in eq. 13 is obtained from the GDF (Forestry Statistic 2018). According to GDF's data, percentage of the illegal cutting is 67, also the fuelwood gathering is 33.

In eq. 2.14 to calculate the losses from wildfires the BW covers the dead organic matter. It is assumed that all dead organic matter is burned in wildfires in this category. It is also assumed that average biomass during wildfires is burned with 44 percent of burning productivity (GDF 2008-2016).

- iii. All biomass gains and losses has been summed up from strata to get estimates for FF.
- iv. Annual change in carbon stock in biomass has been estimated as a difference between  $\Delta C_G$  and  $\Delta C_L$ .

**Table 6.12 The Average basic wood density and national BCEF's factors (Tolunay, 2013)**

<b>Vegetation type</b>	<b>Basic wood density (tonnes/m<sup>3</sup>)</b>	<b>BCEF<sub>I</sub> (tonnes/m<sup>3</sup>)</b>	<b>BCEF<sub>S</sub> (tonnes/m<sup>3</sup>)</b>	<b>BCEF<sub>R</sub> (tonnes/m<sup>3</sup>)</b>
Coniferous	0.446	0.541	0.563	0.612
Deciduous	0.541	0.709	0.717	0.797

### Soil and dead organic matter

Currently, no changes in CSC in deadwood, litter and soil (Tier 1 assumption) are reported due to lack of data related to any change in soil and DOM carbon stocks in FL-FL.

### Land Converted to Forestland

The annual increments and coefficients used for Land Converted to Forest Land were;

**Table 6.13 Coefficients used to calculate CS and CSC in L-FL**

Forest Type	Annual Increment m <sup>3</sup> /ha	BCEF <sub>I</sub>	Root to Shoot Ratio tonnes d.m. below-ground biomass/tonnes above- ground d.m. biomass	CF tonnes C/tonnes dm
Forest Deciduous	0.69 <sup>1</sup>	0.709 <sup>2</sup>	0.46 <sup>3</sup>	0.48 <sup>3</sup>
Forest Coniferous	0.69	0.541 <sup>2</sup>	0.4	0.51
Forest Mixed	0.69	0.625	0.48	0.49
Forest Degraded	0.69	0.625	0.44	0.49

<sup>1</sup>Forest Management Department

<sup>2</sup>Tolunay (2013)

<sup>3</sup>IPCC 2006

The DW C stock has been assumed to be 1 percent of the standing stock. The conversion period is accepted as 20 years.



The DOM C stock is assumed to accumulate in 20 years conversion time to reach a steady state given in Table 6.14 below (Tolunay and Çömez, 2008) :

**Table 6.14 Carbon stocks in DOM used for all forest areas in Turkey**

<b>DOM</b>		
<b>(tonnes/ha)</b>		
Coniferous	7.51	± 6.61 (n=601)
Deciduous	3.09	± 1.58 (n=368)

The below soil C stock values have been applied in case of land use conversions. The stock values have been calculated by the Research Units of Ministry of Agriculture and Forestry.

**Table 6.15 SOC stocks of forests disaggregated for ecozones**

<b>Ecozone</b>	<b>C stock Forestland (tC/ha)</b>	<b>SOC ref</b>
Mediterranean Mountain zone	51.53	46.96
Mediterranean coastal zone deciduous and coniferous forest	46.08	37.77
East Anatolian steppe	48.41	47.99
East Anatolian deciduous forest zone	45.14	41.30
Euxine-Colchic deciduous forest	51.90	49.66
Central Anatolian steppe	49.92	40.41
Aegean Inland deciduous and coniferous forest	50.88	42.53
North Anatolian deciduous, coniferous and mixed forest	55.05	54.57

Reference to the 2006 IPCC equations: Vol 4., Ch. 2: 2.16 / 2.19

### Uncertainties and Time-Series Consistency:

According to para 15 of 24/CP.19 Annex I Parties shall quantitatively estimate the uncertainty of the data used for all source and sink categories using at least Approach 1, and report uncertainties for at least the base year (1990) and last reported year (2017), as well as the trend uncertainty between these two years.

There are two approaches presented in the 2006 IPCC guidelines, which use simple error propagation equations and Monte Carlo or similar techniques, respectively. The first approach has been used with the equations IPCC (2006) equations: Vol. 1, Ch. 3: 3.1 / 3.2.

Uncertainty of input data is provided by underlying systems. Uncertainty of activity data is derived for 11x11 land categories for latest reported year 2015. Under current stage of finalization of land use mapping, still preliminary values of the uncertainty of activity data are estimated in the range of 5% for land remaining in the same category and 10% for land being in conversion among various land categories.

Uncertainty (in %, consistent with 2006 IPCC Guidelines) for CSCs is provided according to various underlying national sources and references.

Uncertainty propagation tracks GHG inventory calculation, i.e. from the most detailed input activity data and CSC/EF to GHG estimates at the land use subcategory and LULUCF sector. Uncertainty is propagated following Tier 1 with Eq. 3.2 of 2006 IPCC Guidelines where uncertain data is added or subtracted, and Eq. 3.1 of 2006 IPCC Guidelines where uncertain data is multiplied or divided.

Estimation of GHG inventory uncertainty cover completely the national territory for year 1990 as the base year and last reported year (2017). Wherever CSC in a C pool is reported as NO or NA such estimates are not included in the Tier 1 propagation of uncertainty.

For all C pools subject to 20 years transition the uncertainty estimation considers aggregation of two terms:

- a) uncertainty associated to the CSC for the area in the first year of the conversion which involves the uncertainty of C stocks in land use from before and after conversion, and the uncertainty of CSC in the first year after the conversion, and,
- b) uncertainty for rest of the area reported under respective conversion cumulated from previous years.

Table 6.16 shows the relative uncertainty for CSC overall for land subcategories.

**Table 6.16 Uncertainty calculation results for the whole LULUCF sector**

Summary	BY (1990)	LRY (2017)
4A1	51%	50%
4A2	0%	57%
4B1	7%	10%
4B2	0%	47%
4C1	0%	0%
4C2	0%	149%
4D1	0%	0%
4D2	0%	86%
4E1	0%	0%
4E2	0%	26%
4F1	0%	0%
4F2	0%	18%
Table 4(I)	0%	0%
Table 4(II)	0%	0%
Table 4(III)	0%	75%
Table 4(IV)	0%	387%
Table 4(V)	54%	54%
<b>LULUCF sector</b>	<b>50.80%</b>	<b>51.14%</b>

The summary table for the uncertainty in Forestland categories (FL-FL and L-FL) is as follows;

**Table 6.17 Uncertainty summary table for Forestland subcategories**

	BY (1990)	LRY (2017)
Forestland Remaining Forestland		
4A1 – FL-FL	51%	50%
$\Delta$ CC in Living Biomass	51%	50%
Annual Loss Living Biomass ( $\Delta$ CL)	33%	34%
Annual Gain Living Biomass ( $\Delta$ CG)	35%	35%
Net C stock change in Litter ( $\Delta$ CC)	NA	NA
Net C stock change in Dead Wood ( $\Delta$ CC)	NA	NA
Net C stock change in SOM ( $\Delta$ CC)	NA	NA
Land Converted to Forestland		
4A2 – L-FL	0%	57.1%
$\Delta$ CC in Living Biomass	NA	4.9%
Annual Loss Living Biomass ( $\Delta$ CL)	NA	22.6%
Annual Gain Living Biomass ( $\Delta$ CG)	NA	4.9%
Net C stock change in Dead Wood ( $\Delta$ CC)	NA	NA
Net C stock change in Litter ( $\Delta$ CC)	NA	300.7%
Net C stock change in SOM ( $\Delta$ CC)	NA	47.0%

Two forest inventories were carried out by the GDF for 1972 and 1999. ENVANIS has been started since 2002. The data on growing stocks and annual increments during 1990-2002 period were calculated by interpolation among data of these three inventories (1972, 1999 and 2002). Thus, the annual increases of growing stocks and volume increments were assumed as linear. The annual ENVANIS table has been obtained annually from the Management and Planning Department of GDF since 2002.

The time series consistency of area data has been significantly increased by using the same satellite images and methods as explained above.

The statistics on the forest fires and commercial round wood production for the same period and fuelwood gathering data were taken from GDF.

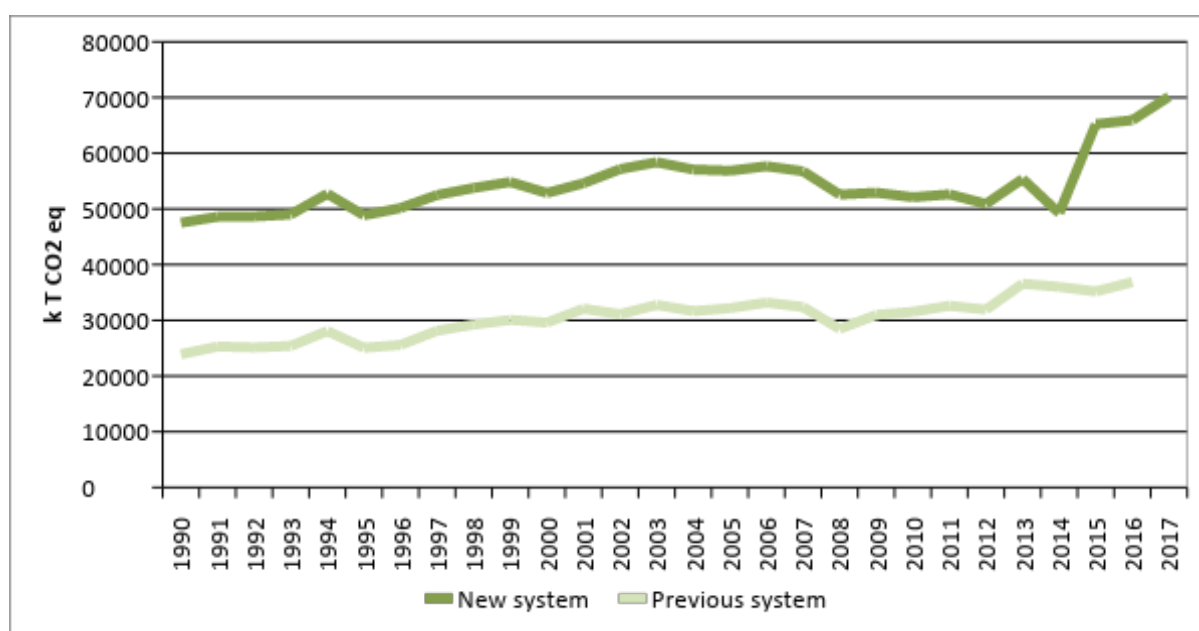
## Source-Specific QA/QC and Verification:

The QA/QC procedure has been realized in the framework of plan developed and carried out by TurkStat the national inventory agency. The sector specific QA/QC has been realized during the LULUCF project activities mentioned above. The calculation procedures have been checked and discussed with the LULUCF experts in and out of the agencies.

## Recalculation:

As explained above the area based AD in the Forestland sector moved from ENVANIS to spatially explicit land tracking system. This enabled the production of a consistent land use matrix that determines the land use and conversions with 1 ha accuracy. The forestland category emissions/removals for the previous and new system are given below;

**Figure 6.8 The comparison of C emissions/removals between the previous and current system estimations**

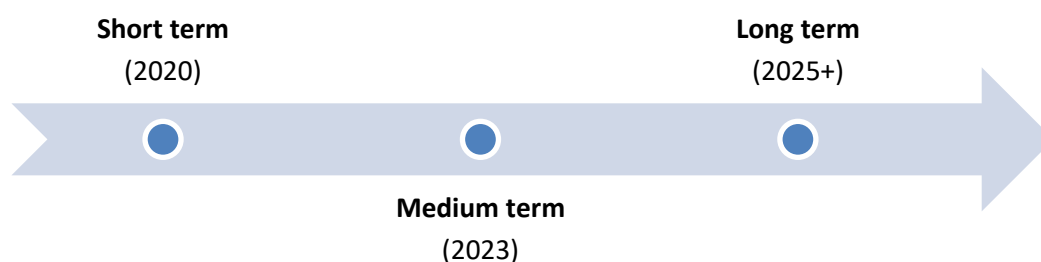


The removals increased significantly as productive forest area has been detected with the new spatially explicit land tracking system as larger compared to previous system. Since the increment data and other coefficients did not change the removals increased.

On the other hand, removals from L-FL decreased significantly with the new system. The reason for this was the change in AD.

### Planned Improvement:

The Forestland is the major category. The removals base on the increment data while emissions on the harvest. An improvement plan has been developed for the sector in the framework of the LULUCF project. The plan has three basic scales; short (ST), medium (MT) and long terms (LT).



The planned improvements for Forestland category are;

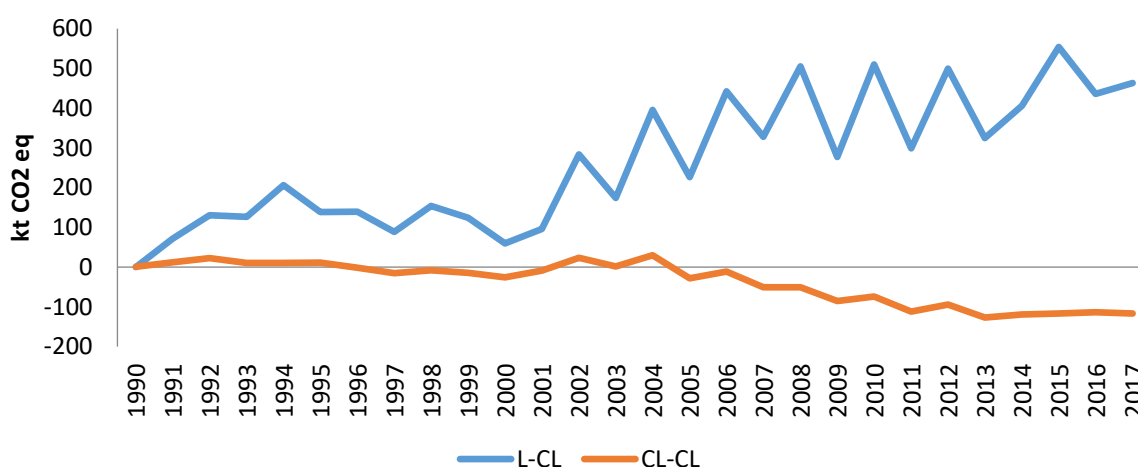
- Re-evaluation of the emission factors used for living biomass, DOM, and mineral soils (ST, MT)
- Estimation of carbon stocks for carbon pools for which emissions are currently not reported, namely deadwood, litter and mineral soil (MT)
- Preparation of input forest data and parameters for some of existing forest models (e.g. CBM) to be able for running simulations and making projections of forest development under different scenarios (MT, LT)
- Development and establishment of national forest inventory (NFI) based on permanent sample plot system (LT)
- Use a higher Tier level in reporting (MT, LT).
- Develop and use algometric equations instead of currently used national BCEF coefficients (MT, LT).

### 6.3. Croplands (4.B)

#### Source Category Description:

Estimation of emissions and removals from cropland follows the 2006 IPCC guidelines (Volume 4, Ch. 5). Currently, there are two strata for different crops in Turkey, namely annual and perennial crops. Besides, emissions are estimated due to cultivation of organic soil and direct N<sub>2</sub>O emission from N mineralization associated with loss of soil organic matter due to land use change or management of mineral soils.

**Figure 6.9 The changes in net emissions and removals in CL-CL and L-CL subcategories**



The cropland category is net emissions due to conversions to cropland. The CL-CL subcategory becomes removals in some years and emissions in others. The main reason for this is the rate of conversions between annual and perennial crops. The perennial crops assumed to have larger C stocks compared to annual crops as explained in methodology section below. Cropland remaining Cropland and Land converted to Cropland has been reported under this category.

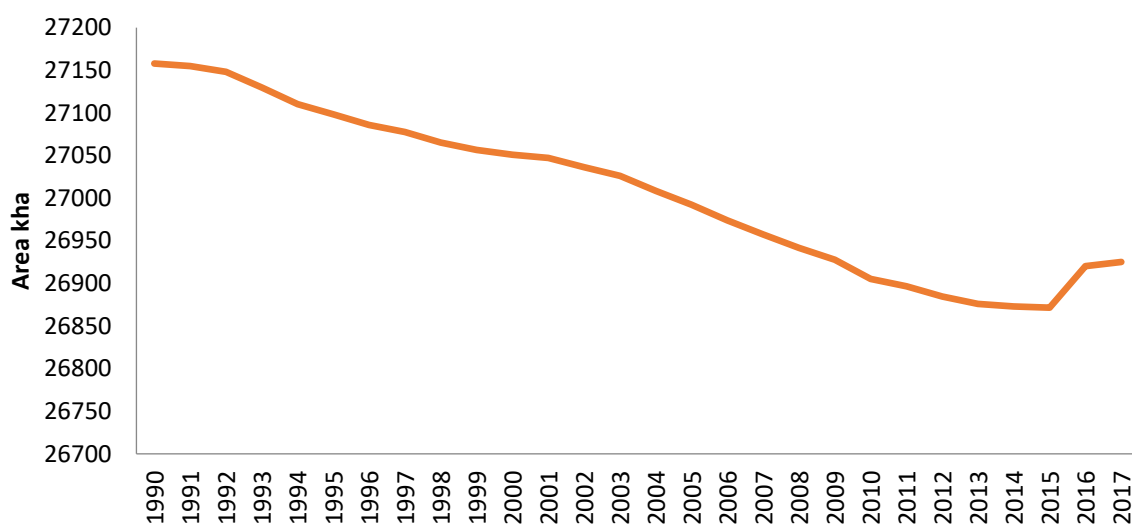
CSC in aboveground, belowground, organic and mineral soil pools have been calculated and reported. The Cropland category was a large source in the last submission but has diminished with the change in emission factors and activity data.

The Cropland covers all perennial and annual crops in agriculture lands. Orchards and poplars are included in this category.

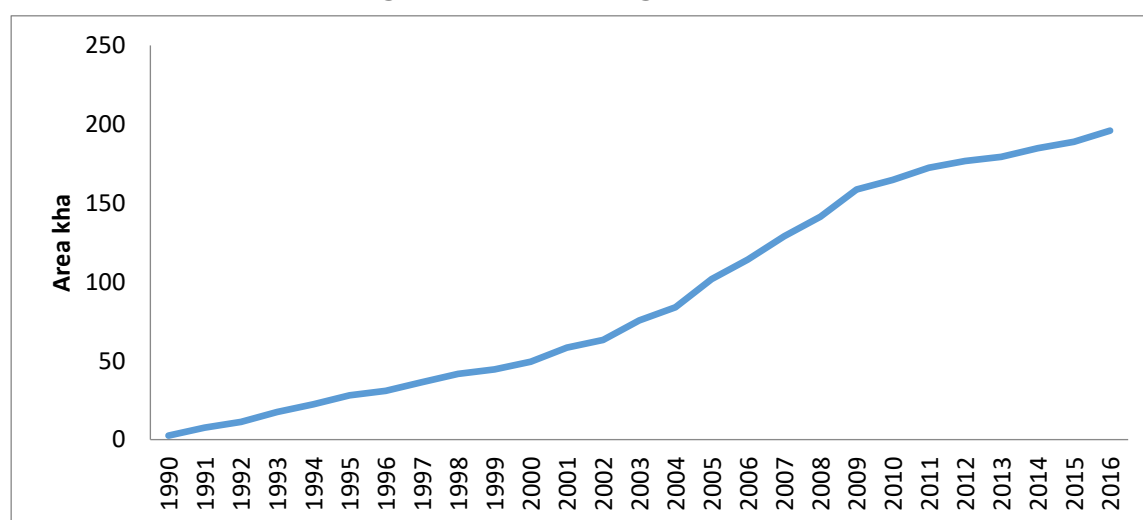
## Information on Land Classification and Activity Data

The CL-CL area decreases during the reporting period due to conversions to other land uses but stabilize after around 2010 and increases after 2015 as lands in L-CL are added after 2010 (20 years transition period).

**Figure 6.10 The change in area of CL-CL**



**Figure 6.11 The change in area of L-CL**



On the other hand, the area of L-CL increases but not with the same ratio as conversions from croplands. Thus the cropland area in total decreases during the reporting period.



### Land-use definitions and the classification systems

Activity data for cropland remaining cropland have been subdivided into annual and perennial crops. Cropland category includes all annual and perennial crops including orchards including olives, vineyards and poplar plantations; the change in all carbon pools has been assumed to be not changing for annual and perennial crops. The increase in biomass stocks in a single year is assumed equal to biomass losses from harvest and mortality in that same year. However, CSC have been calculated in case of conversions between annual and perennial croplands.

### Methodological Issues:

#### Annual cropland remaining annual cropland

##### *Above- and below-ground biomass*

For annual crops increase in biomass stocks in a single year is assumed equal to biomass losses from harvest and mortality in that same year (IPCC 2006).

##### *Dead organic matter*

According to Tier 1 method there is no need to estimate the carbon stock changes for DOM.

##### *Mineral and organic soils*

Currently, there is no specific data on management systems in the country to apply reference carbon stocks and stock change factors. Emissions from organic soil are estimated using default equation and emission factors.

Reference to 2006 IPCC equations: Vol. 4., Ch. 2: 2.24 / 2.25 / 2.26

#### Perennial cropland remaining perennial cropland

##### *Above- and below-ground biomass*

At present, the Gain-Loss method has been applied to estimate CSC in biomass pool. The accumulation rate and rotation period for perennial crops was assumed according to values used by inventory of Italy. If perennial crops, such as vineyards, orchards and olive groves can be disaggregated regarding spatially-explicit activity data, then default values for carbon stocks at maturity, rotation periods, biomass accumulation rates etc. for these crops can be obtained from the MediNet Biomass Report (Canaveira et al., 2018).

Reference to 2006 IPCC equation: Vol. 4., Ch. 2: 2.7

Since the size of loss due to harvesting is usually not available for perennial woody biomass, the CSC in living biomass has been assumed to be compensated with the harvest of the trees. Hence C gains due to the increment of the perennial trees are neutralized by the loss due to cutting of the trees at 100/rotation period of the total perennial crops area. The rotation period of perennial croplands is assumed to be 20 years, with 15 tons C/ha when mature. Thus the increment is 0.75 tons C/ha/yr.

### *Dead organic matter*

According to Tier 1 method the carbon stock changes for DOM has not been estimated. If specific national data on different crop and climate types and management practices or periodic inventories are improved then Gain-Loss or Stock-Difference method, respectively, can be applied.

### *Mineral and organic soils*

Currently, there is no specific data on management systems in the country to apply reference carbon stocks and stock change factors. Tier 1 method can be applied when these data become available. Emissions from organic soil has been estimated using a default equation and emission factor.

Reference to 2006 IPCC equations: Vol. 4., Ch. 2: 2.24 / 2.25 / 2.26

## **Annual cropland converted to perennial cropland**

The 2006 IPCC guidelines do not include any specific method for conversions between annual and perennial cropland. As carbon accumulation rates and soil carbon stocks in these two cropland subcategories are different, more accurate estimation of emissions and removals is needed.

Annual CSC in biomass has been estimated using the equation below:

*Annual change in biomass = conversion area for a transition period of 20 years \*  $\Delta C_{growth}$  + annual area of currently converted land \*  $\Delta C_{conversion}$*

$$\Delta C_{conversion} = C_{after} - C_{before}$$

$C_{after}$  = carbon stock immediately after conversion (at Tier 1 assume  $C_{after} = 0$ )

$C_{before}$  = carbon stock of annual crop before conversion (IPCC default value = 5 t C ha<sup>-1</sup>)

$\Delta C_{growth}$  = carbon accumulation rate of perennial crops (0.75 t C ha<sup>-1</sup> yr<sup>-1</sup>)

The biomass loss is accounted only for the year of conversion, thus  $\Delta C_{conversion}$  must be multiplied by annual area (i.e. area in the year of conversion).

Reference to 2006 IPCC equations: Vol. 4., Ch. 2: 2.15 / 2.16

The calculation spreadsheet for annual-perennial conversion is as follows;

**Table 6.18 Coefficients and CS values used in annual/perennial conversions in cropland category**

Ecozones	NAI $\Delta CG$ (tC/yr/ha)	Y1 Loss $\Delta CL$ (tC/yr/ha)	Y1 BAFTER (tC/yr)	BBEFORE (tC/yr)	CSC (tC/ha/yr)	Y1 NAI (tC/ha/yr)	Y2 NAI (tC/ha/yr)
Mediterranean Mountain zone	0.75	0	0	5	-4.25	0.75	
Mediterranean coastal zone deciduous and coniferous forest	0.75	0	0	5	-4.25	0.75	
East Anatolian steppe	0.75	0	0	5	-4.25	0.75	
East Anatolian deciduous forest zone	0.75	0	0	5	-4.25	0.75	
Euxine-Colchic deciduous forest	0.75	0	0	5	-4.25	0.75	
Central Anatolian steppe	0.75	0	0	5	-4.25	0.75	
Aegean Inland deciduous and coniferous forest	0.75	0	0	5	-4.25	0.75	
North Anatolian deciduous, coniferous and mixed forest	0.75	0	0	5	-4.25	0.75	

As seen from the Table 6.18 CS for annual crops is 5 tC/ha and is lost in the first year of conversion while the planted seedlings grow with 0.75 tC/ha per year for the next 20 years until the land is allocated as CL-CL.

## *Dead organic matter*

According to Tier 1 method carbon stock changes for DOM assumed to be not changing.

## Mineral and organic soil

According to Tier 2 method country-specific carbon stocks have been used to estimate annual change in organic carbon stocks in mineral soil. Country-specific carbon stocks have been calculated by the TAGEM (General Directorate of Agricultural Research) and used for both cropland subcategories in case of conversion, default equation, assuming a transition period of 20 years has been used. Emissions from organic soil should be estimated using a default equation and emission factors.

Reference to 2006 IPCC equations: Vol. 4., Ch. 2: 2.24 / 2.25 / 2.26

The below default coefficients have been employed to calculate CSC in mineral soils in case of conversions (between cropland subcategories or LULUCF land use categories) CS for annual and perennial croplands. The SOC of perennial crops has been assumed to be same as SOC<sub>ref</sub>.

**Table 6.19 Coefficients and soil CS values used in annual/perennial conversions in cropland category**

Ecozone	SOC ref (tC/ha)	CS <sub>annualcrops</sub> (tC/ha)	CS <sub>perennialcrops</sub> (tC/ha)
Mediterranean Mountain zone	46.96	40.22	46.96
Mediterranean coastal zone deciduous and coniferous forest	37.77	29.62	37.77
East Anatolian steppe	47.99	38.90	47.99
East Anatolian deciduous forest zone	41.30	30.44	41.30
Euxine-Colchic deciduous forest	49.66	38.68	49.66
Central Anatolian steppe	40.41	32.14	40.41
Aegean Inland deciduous and coniferous forest	42.53	30.99	42.53
North Anatolian deciduous, coniferous and mixed forest	54.57	34.29	54.57

## Perennial cropland converted to annual cropland

Annual CSC in biomass on areas of conversion from perennial cropland to annual cropland has been estimated by the same equation as for the opposite management change with the difference that only annual area of currently converted land is considered here, because the gains of the annual crop during land use changes to annual cropland are accounted only once.

The estimation of CSC in biomass has been performed using the equation below:

*Annual change in biomass = annual area of currently converted land \* ( $\Delta C_{conversion} + \Delta C_{growth}$ )*

$\Delta C_{conversion} = C_{after} - C_{before}$

$C_{after}$  = carbon stock immediately after conversion (at Tier 1 assume  $C_{after} = 0$ )

$C_{before}$  = carbon stock of annual/perennial crop before conversion (15 t C ha<sup>-1</sup>)

$\Delta C_{growth}$  = carbon accumulation rate of annual/perennial crop (IPCC default value = 5 t C ha<sup>-1</sup>)

### *Dead organic matter*

According to Tier 1 method carbon stock changes for DOM assumed to be not changing.

### *Mineral and organic soil*

According to Tier 2 method country-specific carbon stocks have been used to estimate annual change in organic carbon stocks in mineral soil. Country-specific carbon stocks have been calculated by the TAGEM (General Directorate of Agricultural Research) and used for both cropland subcategories in case of conversion, default equation, assuming a transition period of 20 years has been used. Emissions from organic soil should be estimated using a default equation and emission factors.

Reference to 2006 IPCC equations: Vol. 4., Ch. 2: 2.24 / 2.25 / 2.26

## **Land converted to cropland**

### *Above- and below-ground biomass*

Changes in biomass carbon stocks have been estimated according to Tier 1/Tier 2 method with spatially-explicit activity data. Conversions from all other land uses (e.g. from forest land, grassland etc.) to cropland are likely to occur in the country. The principle of estimating the CSC in biomass in land converted to cropland is same as described in the subcategories annual cropland converted to perennial and vice versa, depending on conversion to which cropland subcategory happened (i.e. annual or perennial cropland).

Below calculation algorithms have been applied for land conversions to Cropland;

In case of forestland converted to annual and perennial cropland;

**Table 6.20 Coefficients and CS values used in L-CL category**

<b>For FL-CLannual</b>								
Ecozone		CF	$\Delta CG$ (tC/yr/ha)	$\Delta CL$ (tC/yr/ha)	B <sub>AFTER</sub> (tC/yr/ha)	B <sub>BEFORE</sub> (tC/ha)	CSC Y1 (tC/ha/yr)	CSC Y2 (tC/ha/yr)
i.e. Mediterranean Mountain zone	Forest Deciduous	0.48	5.00	0	0	41.97	-36.97	0
	Forest Coniferous	0.51	5.00	0	0	64.80	-59.80	0
	Forest Mixed	0.49	5.00	0	0	52.35	-47.35	0
	Forest Degraded	0.49	5.00	0	0	4.051	0.95	0
<b>For FL-CLperennial</b>								
i.e. Mediterranean Mountain zone	Forest Deciduous	0.48	0.75	0	0	41.97	-41.22	0.75
	Forest Coniniferous	0.51	0.75	0	0	64.80	-64.05	0.75
	Forest Mixed	0.49	0.75	0	0	52.35	-51.60	0.75
	Forest Degraded	0.49	0.75	0	0	4.05	-3.30	0.75

In case of grassland converted to annual and perennial cropland;

For GL-CLannual							
Ecozone		$\Delta CG$ (tC/yr/ha)	$\Delta CL$ (tC/yr/ha)	$B_{AFTER}$ (tC/yr/ha)	$B_{BEFORE}$ (tC/ha)	CSC Y1 (tC/ha/yr)	CSC Y2 (tC/ha/yr)
i.e. Mediterranean Mountain zone	GL- CLann	5.00	0	0	1.86	3.14	0
For GL-CLannual							
i.e. Mediterranean Mountain zone	GL-CLper	0.75	0	0	1.86	-1.11	0.75

In case of wetland (managed/unmanaged) converted to annual and perennial cropland;

For WLmanaged/unmanaged-CLannual							
Ecozone		$\Delta CG$ (tC/yr/ha)	$\Delta CL$ (tC/yr/ha)	$B_{AFTER}$ (tC/yr/ha)	$B_{BEFORE}$ (tC/ha)	CSC Y1 (tC/ha/yr)	CSC Y2 (tC/ha/yr)
i.e. Mediterranean Mountain zone	WLman- CLann	5.00	0	0	1.86	3.14	0
i.e. Mediterranean Mountain zone	WLunma- n-CLann	5.00	0	0	1.86	3.14	0
For WLmanaged/unmanaged-CLperennial							
i.e. Mediterranean Mountain zone	WLman- CLper	0.75	0	0	1.86	-1.11	0.75
i.e. Mediterranean Mountain zone	WLunma- n-CLper	0.75	0	0	1.86	-1.11	0.75

In case of settlement converted to annual and perennial cropland;

<b>For SL-CLannual</b>							
Ecozone		$\Delta CG$ (tC/yr/ha)	$\Delta CL$ (tC/yr/ha)	$B_{AFTER}$ (tC/yr/ha)	$B_{BEFORE}$ (tC/ha)	CSC Y1 (tC/ha/yr)	CSC Y2 (tC/ha/yr)
i.e. Mediterranean Mountain zone	SL- CLann	5.00	0	0	5.03	-0.03	0
<b>For SL-CLperennial</b>							
i.e. Mediterranean Mountain zone	SL- CLper	0.75	0	0	5.03	-4.28	0.75

In case of other land converted to annual and perennial cropland;

<b>For OL-CLannual</b>							
Ecozone		$\Delta CG$ (tC/yr/ha)	$\Delta CL$ (tC/yr/ha)	$B_{AFTER}$ (tC/yr/ha)	$B_{BEFORE}$ (tC/ha)	CSC Y1 (tC/ha/yr)	CSC Y2 (tC/ha/yr)
i.e. Mediterranean Mountain zone	OL- CLann	5	0	5	0	0	0
<b>For OL-CLperennial</b>							
i.e. Mediterranean Mountain zone	OL- CLper	0.75	0	0	0	0.75	0.75

## Dead organic matter

A Tier 1 method takes into account the estimation of CSC in dead organic matter only for major conversion categories (e.g. forest land to cropland). It is assumed that all dead organic matter is removed in the year of conversion, so there is no accumulation in land converted to cropland afterwards.

Reference to 2006 IPCC equation: Vol. 4., Ch. 2: 2.23,



**Table 6.21 Coefficients and CS values used in L-CL category**

<b>For FL-CLannual/perennial</b>						
Ecozone		CFlitter	CFdw	CSC LT (tC/ha)	CSC DW (tC/ha)	CSC DOM (tC/ha)
i.e. Mediterranean Mountain zone	Forest Deciduous	0.37	0.50	-3.09	-0.49	-3.58
	Forest Coniferous	0.37	0.50	-7.51	-0.36	-7.87
	Forest Mixed	0.37	0.50	-5.30	-0.42	-5.72
	Forest Degraded	0.37	0.50	0.00	-0.03	-0.03

### *Mineral and organic soil*

The Tier 2 method has been applied here, as country-specific reference carbon stocks were available for all land categories. General approach, assuming the 20-year transition period after which the soil reaches a new equilibrium, has been used for land use changes to cropland. In case that organic soil is subject to this type of land-use change, emissions have been estimated using the default emission factor and method.

Reference to 2006 IPCC equations: Vol. 4., Ch. 2: 2.24 / 2.25 / 2.26

In case of forestland (FL) converted to annual and perennial cropland;

**Table 6.22 Coefficients and soil CS values used in L-CL category**

Ecozone	Forest Type	C stock Forestland (tC/ha)	SOC ref	C stock Cropland (tC/ha)	CSC Y1 (tC/ha/yr)	NAI Y2 (tC/ha/yr)
<b>FL-CLannual</b>						
Mediterranean Mountain zone	FL-CLann	51.53	46.96	40.22	-0.57	-0.57
Mediterranean coastal zone deciduous and coniferous forest	FL-CLann	46.08	37.77	29.62	-0.82	-0.82
East Anatolian steppe	FL-CLann	48.41	47.99	38.90	-0.48	-0.48
East Anatolian deciduous forest zone	FL-CLann	45.14	41.30	30.44	-0.74	-0.74
Euxine-Colchic deciduous forest	FL-CLann	51.90	49.66	38.68	-0.66	-0.66
Central Anatolian steppe	FL-CLann	49.92	40.41	32.14	-0.89	-0.89
Aegean Inland deciduous and coniferous forest	FL-CLann	50.88	42.53	30.99	-0.99	-0.99
North Anatolian deciduous, coniferous and mixed forest	FL-CLann	55.05	54.57	34.29	-1.04	-1.04
<b>FL-CLperennial</b>						
Mediterranean Mountain zone	FL-CLper	51.53	46.96	46.96	-0.23	-0.23
Mediterranean coastal zone deciduous and coniferous forest	FL-CLper	46.08	37.77	37.77	-0.42	-0.42
East Anatolian steppe	FL-CLper	48.41	47.99	47.99	-0.02	-0.02
East Anatolian deciduous forest zone	FL-CLper	45.14	41.30	41.30	-0.19	-0.19
Euxine-Colchic deciduous forest	FL-CLper	51.90	49.66	49.66	-0.11	-0.11
Central Anatolian steppe	FL-CLper	49.92	40.41	40.41	-0.48	-0.48
Aegean Inland deciduous and coniferous forest	FL-CLper	50.88	42.53	42.53	-0.42	-0.42
North Anatolian deciduous, coniferous and mixed forest	FL-CLper	55.05	54.57	54.57	-0.02	-0.02

In case of grassland (GL) converted to annual and perennial cropland;

Ecozone	SOC ref	C stock Grassland (tC/ha)	C stock Cropland (annual) (tC/ha)	CSC Y1 (tC/ha/yr)	NAI Y2 (tC/ha/yr)
<b>GL-CLannual</b>					
Mediterranean Mountain zone	<b>46.96</b>	<b>42.26</b>	<b>40.22</b>	-0.10	-0.10
Mediterranean coastal zone deciduous and coniferous forest	<b>37.77</b>	<b>33.99</b>	<b>29.62</b>	-0.22	-0.22
East Anatolian steppe	<b>47.99</b>	<b>43.19</b>	<b>38.90</b>	-0.21	-0.21
East Anatolian deciduous forest zone	<b>41.30</b>	<b>37.17</b>	<b>30.44</b>	-0.34	-0.34
Euxine-Colchic deciduous forest	<b>49.66</b>	<b>44.69</b>	<b>38.68</b>	-0.30	-0.30
Central Anatolian steppe	<b>40.41</b>	<b>36.37</b>	<b>32.14</b>	-0.21	-0.21
Aegean Inland deciduous and coniferous forest	<b>42.53</b>	<b>38.28</b>	<b>30.99</b>	-0.36	-0.36
North Anatolian deciduous, coniferous and mixed forest	<b>54.57</b>	<b>49.11</b>	<b>34.29</b>	-0.74	-0.74
<b>GL-CLperennial</b>					
Mediterranean Mountain zone	<b>46.96</b>	<b>42.26</b>	<b>46.96</b>	0.23	0.23
Mediterranean coastal zone deciduous and coniferous forest	<b>37.77</b>	<b>33.99</b>	<b>37.77</b>	0.19	0.19
East Anatolian steppe	<b>47.99</b>	<b>43.19</b>	<b>47.99</b>	0.24	0.24
East Anatolian deciduous forest zone	<b>41.30</b>	<b>37.17</b>	<b>41.30</b>	0.21	0.21
Euxine-Colchic deciduous forest	<b>49.66</b>	<b>44.69</b>	<b>49.66</b>	0.25	0.25
Central Anatolian steppe	<b>40.41</b>	<b>36.37</b>	<b>40.41</b>	0.20	0.20
Aegean Inland deciduous and coniferous forest	<b>42.53</b>	<b>38.28</b>	<b>42.53</b>	0.21	0.21
North Anatolian deciduous, coniferous and mixed forest	<b>54.57</b>	<b>49.11</b>	<b>54.57</b>	0.27	0.27

In case of wetland (WL) (Managed/Unmanaged) converted to annual and perennial cropland;

Parameteres /C stock in year (tC/yr/ha)	SOC ref	C stock Wetlands (tC/ha)	C stock Cropland (annual) (tC/ha)	CSC Y1 (tC/ha/yr)	NAI Y2 (tC/ha/yr)
<b>WL-CLannual</b>					
Mediterranean Mountain zone	<b>46.96</b>	<b>42.26</b>	<b>40.22</b>	-0.10	-0.10
Mediterranean coastal zone deciduous and coniferous forest	<b>37.77</b>	<b>33.99</b>	<b>29.62</b>	-0.22	-0.22
East Anatolian steppe	<b>47.99</b>	<b>43.19</b>	<b>38.90</b>	-0.21	-0.21
East Anatolian deciduous forest zone	<b>41.30</b>	<b>37.17</b>	<b>30.44</b>	-0.34	-0.34
Euxine-Colchic deciduous forest	<b>49.66</b>	<b>44.69</b>	<b>38.68</b>	-0.30	-0.30
Central Anatolian steppe	<b>40.41</b>	<b>36.37</b>	<b>32.14</b>	-0.21	-0.21
Aegean Inland deciduous and coniferous forest	<b>42.53</b>	<b>38.28</b>	<b>30.99</b>	-0.36	-0.36
North Anatolian deciduous, coniferous and mixed forest	<b>54.57</b>	<b>49.11</b>	<b>34.29</b>	-0.74	-0.74
<b>WL-CLperennial</b>					
Mediterranean Mountain zone	<b>46.96</b>	<b>42.26</b>	<b>46.96</b>	0.23	0.23
Mediterranean coastal zone deciduous and coniferous forest	<b>37.77</b>	<b>33.99</b>	<b>37.77</b>	0.19	0.19
East Anatolian steppe	<b>47.99</b>	<b>43.19</b>	<b>47.99</b>	0.24	0.24
East Anatolian deciduous forest zone	<b>41.30</b>	<b>37.17</b>	<b>41.30</b>	0.21	0.21
Euxine-Colchic deciduous forest	<b>49.66</b>	<b>44.69</b>	<b>49.66</b>	0.25	0.25
Central Anatolian steppe	<b>40.41</b>	<b>36.37</b>	<b>40.41</b>	0.20	0.20
Aegean Inland deciduous and coniferous forest	<b>42.53</b>	<b>38.28</b>	<b>42.53</b>	0.21	0.21
North Anatolian deciduous, coniferous and mixed forest	<b>54.57</b>	<b>49.11</b>	<b>54.57</b>	0.27	0.27

In case of settlements (SL) converted to annual and perennial cropland;

Ecozones	C stock Settlements (tC/ha)	SOC ref	C stock Cropland (annual) (tC/ha)	CSC Y1 (tC/ha/yr)	NAI Y2 (tC/ha/yr)
<b>SL-CLannual</b>					
Mediterranean Mountain zone	20.14	46.96	40.22	1.00	1.00
Mediterranean coastal zone deciduous and coniferous forest	20.14	37.77	29.62	0.47	0.47
East Anatolian steppe	20.14	47.99	38.90	0.94	0.94
East Anatolian deciduous forest zone	20.14	41.30	30.44	0.51	0.51
Euxine-Colchic deciduous forest	20.14	49.66	38.68	0.93	0.93
Central Anatolian steppe	20.14	40.41	32.14	0.60	0.60
Aegean Inland deciduous and coniferous forest	20.14	42.53	30.99	0.54	0.54
North Anatolian deciduous, coniferous and mixed forest	20.14	54.57	34.29	0.71	0.71
<b>SL-CLperennial</b>					
Mediterranean Mountain zone	20.14	46.96	46.96	1.34	1.34
Mediterranean coastal zone deciduous and coniferous forest	20.14	37.77	37.77	0.88	0.88
East Anatolian steppe	20.14	47.99	47.99	1.39	1.39
East Anatolian deciduous forest zone	20.14	41.30	41.30	1.06	1.06
Euxine-Colchic deciduous forest	20.14	49.66	49.66	1.48	1.48
Central Anatolian steppe	20.14	40.41	40.41	1.01	1.01
Aegean Inland deciduous and coniferous forest	20.14	42.53	42.53	1.12	1.12
North Anatolian deciduous, coniferous and mixed forest	20.14	54.57	54.57	1.72	1.72

In case of otherland (OL) converted to annual and perennial cropland;

Ecozones	C stock Otherland (tC/ha)	SOC ref	C stock Cropland (annual) (tC/ha)	CSC Y1 (tC/ha/yr)	NAI Y2 (tC/ha/yr)
<b>OL-CLannual</b>					
Mediterranean Mountain zone	12.78	46.96	40.22	1.37	1.37
Mediterranean coastal zone deciduous and coniferous forest	12.78	37.77	29.62	0.84	0.84
East Anatolian steppe	12.78	47.99	38.90	1.31	1.31
East Anatolian deciduous forest zone	12.78	41.30	30.44	0.88	0.88
Euxine-Colchic deciduous forest	12.78	49.66	38.68	1.30	1.30
Central Anatolian steppe	12.78	40.41	32.14	0.97	0.97
Aegean Inland deciduous and coniferous forest	12.78	42.53	30.99	0.91	0.91
North Anatolian deciduous, coniferous and mixed forest	12.78	54.57	34.29	1.08	1.08
<b>OL-CLperennial</b>					
Mediterranean Mountain zone	12.78	46.96	46.96	1.71	1.71
Mediterranean coastal zone deciduous and coniferous forest	12.78	37.77	37.77	1.25	1.25
East Anatolian steppe	12.78	47.99	47.99	1.76	1.76
East Anatolian deciduous forest zone	12.78	41.30	41.30	1.43	1.43
Euxine-Colchic deciduous forest	12.78	49.66	49.66	1.84	1.84
Central Anatolian steppe	12.78	40.41	40.41	1.38	1.38
Aegean Inland deciduous and coniferous forest	12.78	42.53	42.53	1.49	1.49
North Anatolian deciduous, coniferous and mixed forest	12.78	54.57	54.57	2.09	2.09

## Uncertainties and Time-Series Consistency:

The time series consistency has been ensured via the new land tracking system as explained in section 6.3.

The same methodology to estimate uncertainty has been employed as 6.4.5 and the below summary table has been produced.

**Table 6.23 Uncertainty summary table for Cropland subcategories**

	BY (1990)	LRV (2017)
Cropland Remaining Cropland		
4B1 – CL-CL	7.3%	9.9%
Net C stock change in Living Biomass ( $\Delta CC$ )	0.0%	12.6%
Net C stock change in DOM ( $\Delta CC$ )	NA	NA
Net C stock change in SOM ( $\Delta CC$ )	7.3%	15.3%
Land Converted to Cropland		
4B2 – L-CL	0%	47%
$\Delta CC$ in Living Biomass	NA	46%
Annual Loss Living Biomass ( $\Delta CL$ )	NA	NA
Annual Gain Living Biomass ( $\Delta CG$ )	NA	NA
Net C stock change in Dead Organic Matter ( $\Delta CC$ )	NA	42%
Net C stock change in SOM ( $\Delta CC$ )	NA	64%

#### Source-Specific QA/QC and Verification:

The QA/QA procedure has been realized in the framework of plan developed and carried out by TurkStat the national inventory agency. The sector specific QA/QC has been realized during the LULUCF project activities mentioned above. The calculation procedures have been checked and discussed with the LULUCF experts in and out of the agencies.

#### Recalculation:

The CL-CL and L-CL subcategories have been recalculated for the entire reporting period. The main reason was the change in area data. In previous submissions the area data was derived from CORINE while a spatially explicit 1 ha resolution system has been used. The use of the new system produced totally different rates of conversions compared to the old system. As an example the CL-CL subcategory was removal for 2016 in the previous submission but it is now emission in the current submission.

The other reason of recalculation was the new CS values disaggregated for ecozones calculated by the Agricultural Research Directorates of the Ministry of Agriculture and Forestry. The new soil carbon stock values are more representative and up to date.

## Planned Improvement:

The planned improvements for Cropland category are;

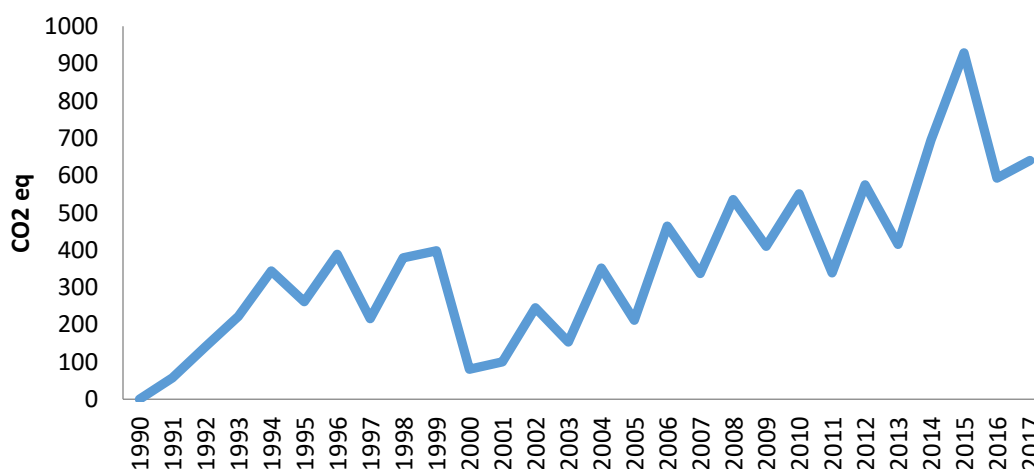
- Increase from Tier 1 to Tier 2 method in estimating the carbon stock change in living biomass in Land converted to cropland (MT)
- Collection, sampling and/or modelling of carbon stocks in mineral soil at larger spatial scale (e.g. consider potential use of National Geospatial Soil Fertility and Soil Organic Carbon Information System) (MT)
- Data collection about management systems (land use, tillage, input) for Cropland remaining cropland, also through use of existing generalised maps of dominant crops in Turkey (MT)

## 6.4. Grassland (4.C)

### Source Category Description:

Grasslands are all lands with non woody vegetation subject to grazing. 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.

**Figure 6.12 The change in net emissions in Grassland category**

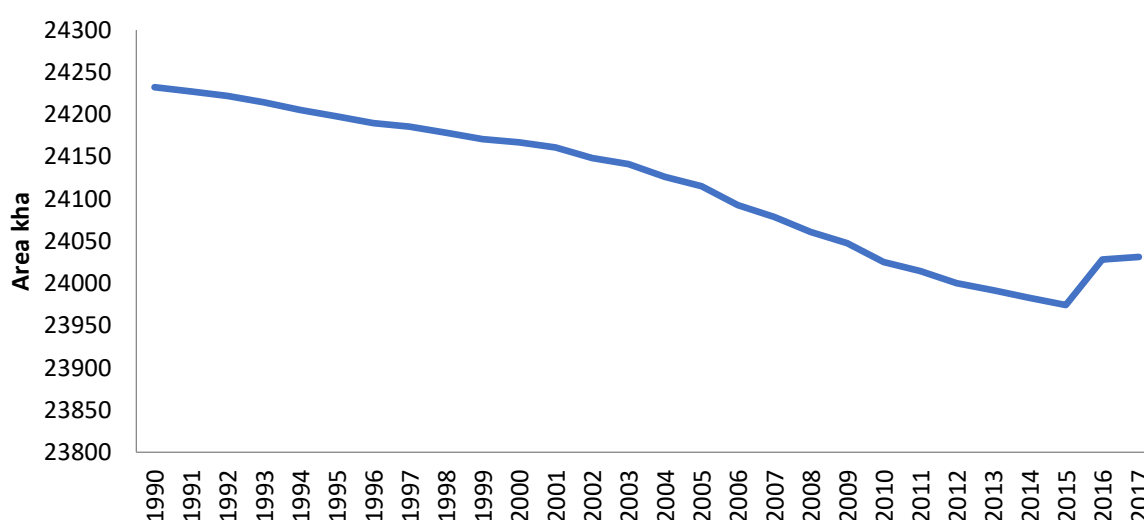




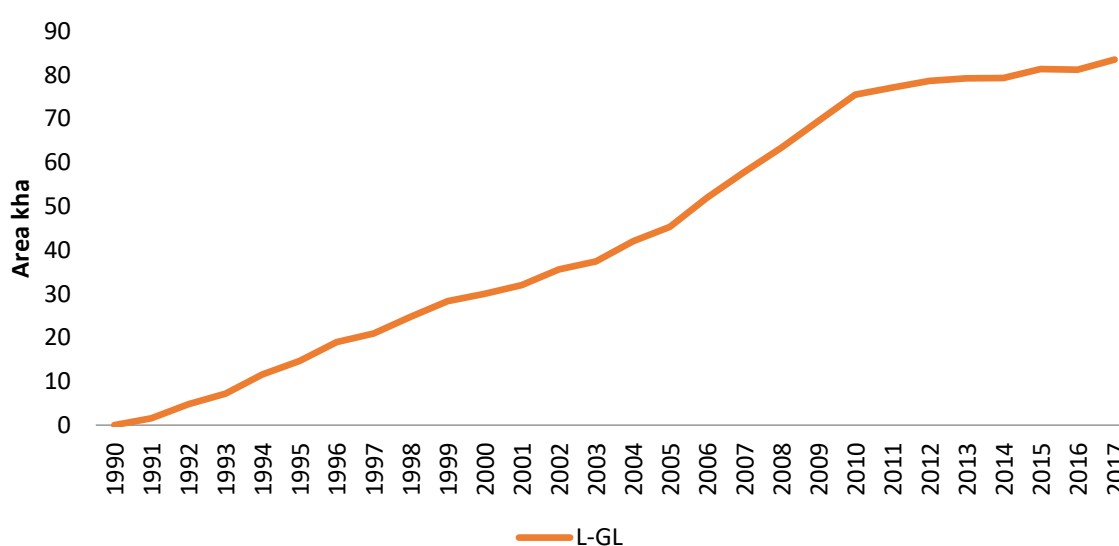
## Information on Land Classification and Activity Data

The grassland areas decrease in Turkey though there are a certain amount of conversions to grasslands. While around a total of 0.08 M ha are added to grasslands during the reporting period the grassland area decreased from 24.23 Mha to 24.03 ha.

**Figure 6.13 The change in area of GL-GL**



**Figure 6.14 The change in area of L-CL**



## Land-use definitions and the classification systems

### Methodological Issues:

#### Grassland remaining grassland (GL-GL)

All carbon pools in GL-GL is assumed to be not changing thus reported as NO except emissions from organic soils. A 3.01 k ha of organic soils have been reported in GL-GL subcategory. This caused a 0.03 k t CO<sub>2</sub> eq. of emissions every year during the reporting period. The management in these areas are not known exactly but considered as managed to be conservative.

#### Land converted to grassland (GL-GL)

*Above- and below-ground biomass*

**Table 6.24 Coefficients and living biomass CS values for L-GL subcategories**

Ecozones	Forest type	NAI Y1 ΔCG (tC/yr/ha)	Loss Y1 ΔCL (tC/yr/ha)	BAFTER (tC/yr/ha)	BBEFORE (tC/yr/ha)	CSC Y1 (tC/ha/yr)
<b>Forestland converted to Grassland</b>						
i.e. Mediterranean Mountain zone	Forest Deciduous	1.86	0	0	41.97	-40.11
	Forest Coniferous	1.86	0	0	64.80	-62.94
	Forest Mixed	1.86	0	0	52.35	-50.49
	Forest Degraded	1.86	0	0	4.05	-2.19
<b>Cropland (annual) converted to Grassland</b>						
	Cropland <sub>annual</sub>	1.86	0	0	5	-3.14
<b>Cropland (perennial) converted to Grassland</b>						
	Cropland <sub>perennial</sub>	1.86	0	0	15	-13.14
<b>Wetland converted to Grassland</b>						
	Grassland	1.86	0	0	1.86	0.00
<b>Settlements converted to Grassland</b>						
	Settlements	1.86	0	0	5.03	-3.17
<b>Otherland converted to Grassland</b>						
	Other land	1.86	0	0	0	1.86

## *Dead organic matter*

CSC converted to wetlands for forestlands are calculated based on the below coefficients and EF. The CSC for other conversions are assumed to be not occurring.

**Table 6.25 Coefficients and DOM CS values for L-GL subcategories**

Ecozones	Forest type	CF litter	CF Dead Wood	CSC LT (tC/ha/yr)	CSC DW (tC/ha/yr)	CSC DOM (tC/ha/yr)
<b>Forestland converted to Grassland</b>						
i.e. Mediterranean Mountain zone	Forest Deciduous	0.37	0.50	-3.09	-0.49	-3.58
	Forest Coniferous	0.37	0.50	-7.51	-0.36	-7.87
	Forest Mixed	0.37	0.50	-5.30	-0.42	-5.72
	Forest Degraded	0.37	0.50	0.00	-0.03	-0.03

## *Mineral and organic soil*

The CSC in mineral soils have been calculated based on national stock values determined by General Directorate of Agricultural Research. The default conversion duration of 20 years has been applied.

**Table 6.26 Coefficients and soil CS values for L-GL subcategories**

Ecozone	SOC ref	C stock Grassland (tC/ha)	Forestland C stock (tC/ha)	Cropland (Annual) C stock (tC/ha)	Cropland (perennial) C stock (tC/ha)	Wetland C stock (tC/ha)	Settl. C stock (tC/ha)	Otherl. C stock (tC/ha)
Mediterranean Mountain zone	46.96	42.26	51.53	40.22	46.96	42.26	20.14	12.78
Mediterranean coastal zone deciduous and coniferous forest	37.77	33.99	46.08	29.62	37.77	33.99	20.14	12.78
East Anatolian steppe	47.99	43.19	48.41	38.90	47.99	43.19	20.14	12.78
East Anatolian deciduous forest zone	41.30	37.17	45.14	30.44	41.30	37.17	20.14	12.78
Euxine-Colchic deciduous forest	49.66	44.69	51.90	38.68	49.66	44.69	20.14	12.78
Central Anatolian steppe	40.41	36.37	49.92	32.14	40.41	36.37	20.14	12.78

**Table 6.26 Coefficients and soil CS values for L-GL subcategories (Cont'd)**

Aegean Inland deciduous and coniferous forest	42.53	38.28	50.88	30.99	42.53	38.28	20.14	12.78
North Anatolian deciduous, coniferous and mixed forest	54.57	49.11	55.05	34.29	54.57	49.11	20.14	12.78

### Uncertainties and Time-Series Consistency:

The time series consistency has been ensured via the new land tracking system as explained in section 6.3.

The same methodology to estimate uncertainty has been employed as 6.4.5 and the below summary table has been produced.

**Table 6.27 Uncertainty summary table for Grassland subcategories**

	BY (1990)	LRV (2017)
Grassland Remaining Grassland		
4C1 – GL-GL	0	0
$\Delta$ CC in Living Biomass	NO	NA
Annual Loss Living Biomass ( $\Delta$ CL)	NA	NA
Annual Gain Living Biomass ( $\Delta$ CG)	NA	NA
Net C stock change in DOM ( $\Delta$ CC)	NO	NA
Net C stock change in SOM ( $\Delta$ CC)	0.00	NA
Land Converted to Grassland		
4C2 – L-GL	0%	149%
$\Delta$ CC in Living Biomass	NA	32%
Annual Loss Living Biomass ( $\Delta$ CL)	NA	NA
Annual Gain Living Biomass ( $\Delta$ CG)	NA	NA
Net C stock change in DOM ( $\Delta$ CC)	NA	190%
Net C stock change in SOM ( $\Delta$ CC)	NA	149%

### Source-Specific QA/QC and Verification:

The Qa/Qc procedure has been realized in the framework of plan developed and carried out by TurkStat the national inventory agency. The sector specific Qa/Qc has been realized during the LULUCF project activities mentioned above. The calculation procedures have been checked and discussed with the LULUCF experts in and out of the agencies.

### Recalculation:

The GL-GL and L-GL subcategories have been recalculated for the entire reporting period. The reasons and consequences of the recalculation is the same as explained in Croplands section.

In the previous submission the emission value was quite high due to L-GL. It was assumed that forestland conversions occurred towards grasslands so this caused high amount of emissions. In the last submission the grassland emission for 2016 was 2.73 M t CO<sub>2</sub> eq. The grassland category is still an emission after recalculation but with a far lower amount of 0.59 M t CO<sub>2</sub> eq. The main reason is the realistic rates of conversion in the new system.

### Planned Improvement:

The planned improvements for Grassland category are;

- Re-evaluation of the estimation of emissions due to drainage of organic soil (MT)
- Check for the size of emission factors for the subcategory Land converted to grassland (MT)
- Verification of assumptions by surveying national research studies and papers (ST, MT)
- Data collection about management systems (land use, management, input) for Grassland remaining grassland (MT, LT)
- Estimation of carbon stock changes in mineral soil for Grassland remaining grassland, using a default method (applying SOCREF and stock change factors) (MT)
- Modelling of carbon stocks in mineral soil at larger spatial scale (e.g. considering potential use of National Geospatial Soil Fertility and Soil Organic Carbon Information System) (MT, LT)

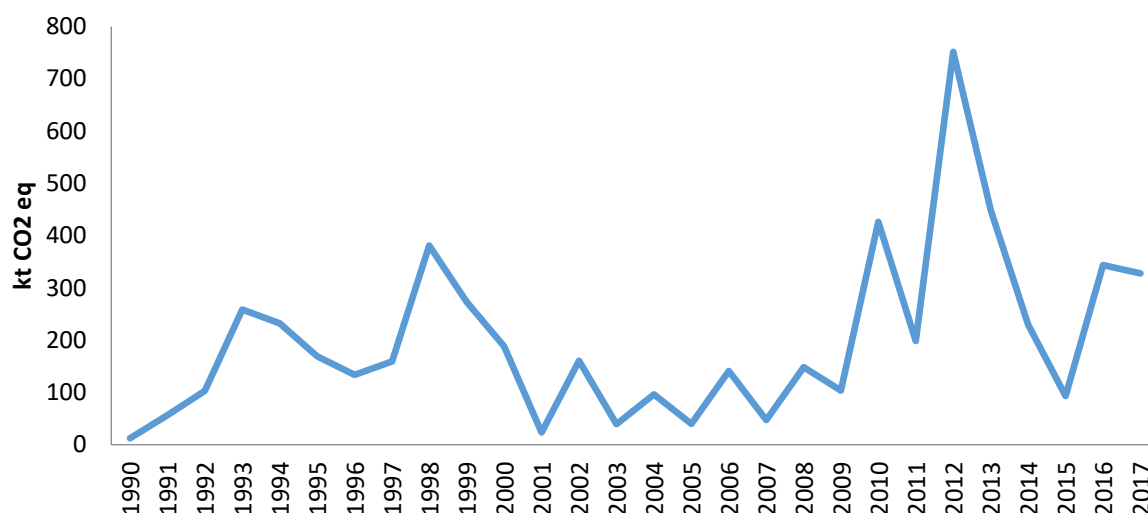
## 6.5. Wetlands (4.D)

### Source Category Description:

Emissions/removals from wetlands remaining wetlands are currently assumed to be not occurring. Two subcategories are currently included under the wetlands remaining wetlands in the CRF table 4.D of Turkey, namely peat extraction remaining peat extraction and flooded land remaining flooded land. The non-official data suggests that peat extraction permission is given for an area that is ignorable in terms of carbon stock changes.

The conversions from and to managed/unmanaged wetlands have been calculated under L-WL subcategory. The emissions and removals calculated were relatively small but had large variations.

**Figure 6.15 The emissions/removals from wetlands category**



As seen from the figure above the emissions in L-WL were around 100 kt CO<sub>2</sub> eq. and stable. In 2013 the emissions peaked and then dropped 2015 and even turned to be a slight removal. In 2016 and 2017 the emissions rise again. The driver of the fluctuations in emissions was caused by emissions from living biomass pool due to land conversions.

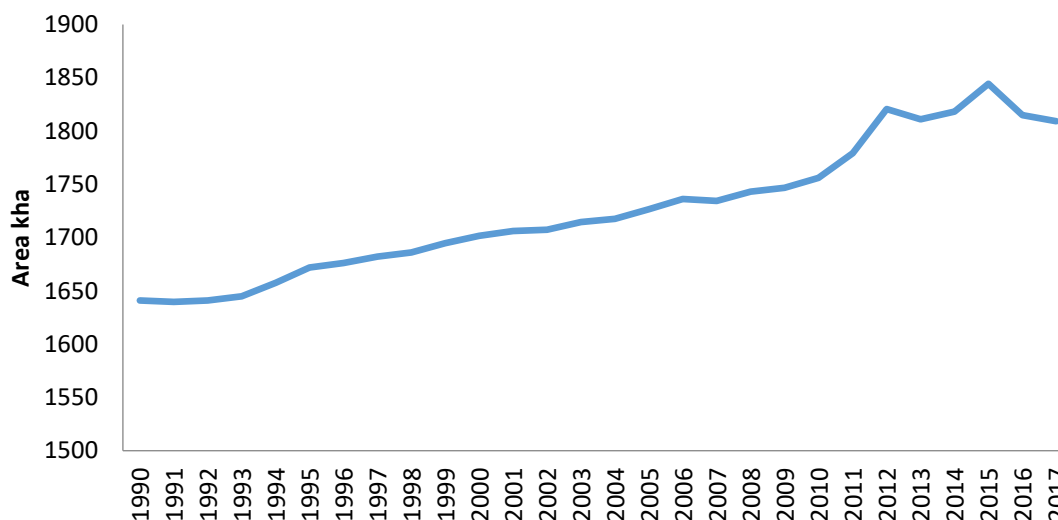
Estimation of emissions and removals from wetlands follows the 2006 IPCC guidelines (Volume 4, Ch. 7) and 2013 Wetlands Supplement. Wetlands include any land that is covered or saturated by water for all or part of the year, and that does not fall into the Forest Land, Cropland, or Grassland categories (IPCC 2006). In wetlands category emissions are estimated only for managed wetlands due to human activity, such as drainage, rewetting, dam construction etc.

At present, the notation key NO has been used for peat extraction. When more detailed data on peat extraction are available, a default methodology can be applied.

## Information on Land Classification and Activity Data

The managed wetland area increased constantly during the reporting period causing mostly emissions.

**Figure 6.16 The change in area of managed and unmanaged wetlands**



## Land-use definitions and the classification systems

All human made reservoirs are included in the managed wetlands category while natural water bodies in the unmanaged wetlands subcategory.

### Methodological Issues:

#### Wetland remaining wetland (WL-WL)

All carbon pools in WL-WL except peat extraction is assumed to be not changing thus reported as NO. The activity data used in peat extraction base on permitted area for extraction by the ministry and depth. We assumed that all permitted area has been subject to production. The on and off site emissions have been estimated in Tier 1 level with default EFs (IPCC Vol. Chapter 7. Table 7.4, 7.5, Temperate zone, nutrient poor).

Reference to 2006 IPCC equations: Vol. 4., Ch. 7: 7.2 / 7.3 /7.4 /7.5

#### Land converted to wetland (L-WL)

*Above- and below-ground biomass*



**Table 6.28 Coefficients and living biomass CS values for L-WL subcategories**

Ecozones	Forest type	NAI Y1 $\Delta$ CG (tC/yr/ha)	Loss Y1 $\Delta$ CL (tC/yr/ha)	BAFTER (tC/yr/ha)	BBEFORE (tC/yr/ha)	CSC Y1 (tC/ha/yr)
<b>Forestland converted to Wetland</b>						
i.e. Mediterranean Mountain zone	Forest Deciduous	1.86	0	0	41.97	-40.11
	Forest Coniferous	1.86	0	0	64.80	-62.94
	Forest Mixed	1.86	0	0	52.35	-50.49
	Forest Degraded	1.86	0	0	4.05	-2.19
<b>Cropland (annual) converted to Wetland</b>						
	Cropland <sub>annual</sub>	1.86	0	0	5	-3.14
<b>Cropland (perennial) converted to Wetland</b>						
		1.86	0	0	15	-13.14
<b>Grassland converted to Wetland</b>						
		0.00	0	1.86	1.86	0.00
<b>Settlements converted to Wetland</b>						
		1.86	0	0	5.03	-3.17
<b>Otherland converted to Wetland</b>						
		1.86	0	0	0	1.86

### Dead organic matter

CSC converted to wetlands for forestlands are calculated based on the below coefficients and EF. The CSC for other conversions are assumed to be not occurring.

**Table 6.29 Coefficients and DOM CS values for L-WL subcategories**

Ecozones	Forest type	CF litter	CF Dead Wood	CSC LT (tC/ha/yr)	CSC DW (tC/ha/yr)	CSC DOM (tC/ha/yr)
<b>Forestland converted to Wetland</b>						
i.e. Mediterranean Mountain zone	Forest Deciduous	0.37	0.50	-3.09	-0.49	-3.58
	Forest Coniferous	0.37	0.50	-7.51	-0.36	-7.87
	Forest Mixed	0.37	0.50	-5.30	-0.42	-5.72
	Forest Degraded	0.37	0.50	0.00	-0.03	-0.03

### Mineral and organic soil

The CSC in mineral soils have been calculated based on national stock values determined by General Directorate of Agricultural Research. The default conversion duration of 20 years has been applied.

**Table 6.30 Coefficients and soil CS values for L-WL subcategories**

Ecozone	SOC ref	C stock Wetlands (tC/ha)	Forestland C stock (tC/ha)	Cropland (Annual) C stock (tC/ha)	Cropland (perennial) C stock (tC/ha)	Grassland C stock (tC/ha)	Settl. C stock (tC/ha)	Otherl. C stock (tC/ha)
Mediterranean Mountain zone	46.96	42.26	51.53	40.22	46.96	42.26	20.14	12.78
Mediterranean coastal zone deciduous and coniferous forest	37.77	33.99	46.08	29.62	37.77	33.99	20.14	12.78
East Anatolian steppe	47.99	43.19	48.41	38.90	47.99	43.19	20.14	12.78
East Anatolian deciduous forest zone	41.30	37.17	45.14	30.44	41.30	37.17	20.14	12.78
Euxine-Colchic deciduous forest	49.66	44.69	51.90	38.68	49.66	44.69	20.14	12.78

**Table 6.30 Coefficients and soil CS values for L-WL subcategories (Cont'd)**

Central Anatolian steppe	40.41	36.37	49.92	32.14	40.41	36.37	20.14	12.78
Aegean Inland deciduous and coniferous forest	42.53	38.28	50.88	30.99	42.53	38.28	20.14	12.78
North Anatolian deciduous, coniferous and mixed forest	54.57	49.11	55.05	34.29	54.57	49.11	20.14	12.78

### Uncertainties and Time-Series Consistency:

The time series consistency has been ensured via the new land tracking system as explained in section 6.3. The same methodology to estimate uncertainty has been employed as 6.4.5 and the below summary table has been produced.

**Table 6.31 Uncertainty summary table for Wetland subcategories**

	BY (1990)	LRY (2017)
Wetland Remaining Wetland		
<b>4D1 – WL-WL</b>	<b>0%</b>	<b>0</b>
ΔCC in Living Biomass	<b>NA</b>	<b>NA</b>
Annual Loss Living Biomass (ΔCL)	NA	NA
Annual Gain Living Biomass (ΔCG)	NA	NA
Net C stock change in DOM (ΔCC)	<b>NA</b>	NA
Net C stock change in SOM (ΔCC)	<b>NA</b>	NA
Land Converted to Wetland		
<b>4D2 – L-WL</b>	<b>0%</b>	<b>86%</b>
ΔCC in Living Biomass	NA	33%
Annual Loss Living Biomass (ΔCL)	NA	NA
Annual Gain Living Biomass (ΔCG)	NA	NA
Net C stock change in DOM (ΔCC)	NA	195%
Net C stock change in SOM (ΔCC)	NA	183%

### Source-Specific QA/QC and Verification:

The QA/QC procedure has been realized in the framework of plan developed and carried out by TurkStat the national inventory agency. The sector specific QA/QC has been realized during the LULUCF project activities mentioned above. The calculation procedures have been checked and discussed with the LULUCF experts in and out of the agencies.

### Recalculation:

The WL-WL and L-WL subcategories have been recalculated for the entire reporting period. The reasons and consequences of the recalculation is the same as explained in Croplands and Grasslands sections.

## Planned Improvement:

The planned improvements for Wetland category are;

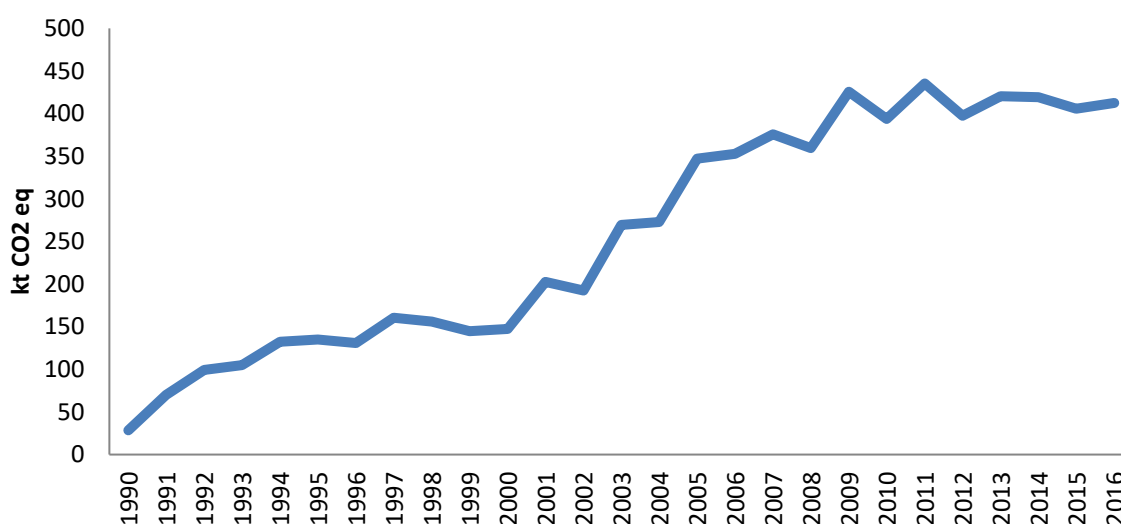
- Use of Wetlands Supplement more effectively (ST, MT)
- Review all existing national and international databases related to wetlands (e.g. Ramsar Convention on Wetlands, FAOSTAT, Wetlands International, NGO data etc.) (MT)
- Expert judgment (e.g. by national soil scientist) about different types of managed wetlands that are likely to occur in Turkey (ST, MT)
- Collection of activity data regarding specific types of managed wetlands (MT)
- Sampling of SOC and estimation of carbon stocks for major soil types of wetlands (MT, LT)

## 6.6. Settlements (4.E)

### Source Category Description:

The carbon stock change in settlements remaining settlements has been estimated to be not changing. Land converted to settlements caused emissions increasing until 2010 and then stabilizing. The major driver of the emissions has been conversions from other land uses that resulted in loss of carbon.

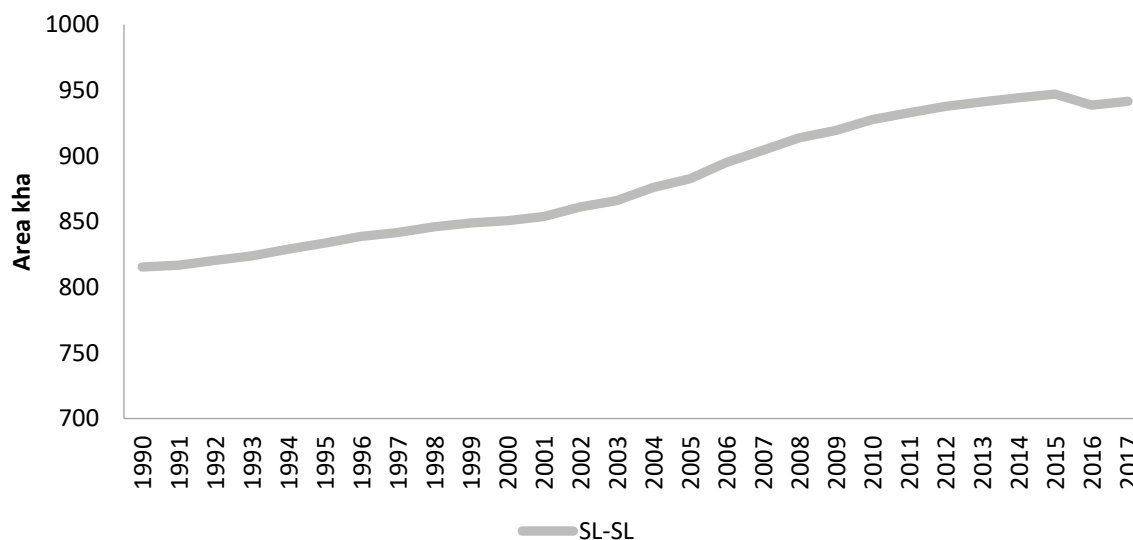
**Figure 6.17 The change in net emissions in settlements**



## Information on Land Classification and Activity Data

The area of settlements is increasing constantly with the conversions mainly from cropland and grassland.

**Figure 6.18 The change in area of settlements**



## Land-use definitions and the classification systems

The emission factors and coefficients for calculation GHG emissions and removals in this category bases on the results of a national research project entitled "*Development of a climate change-ecosystem services software to support sustainable land planning works*" funded by the Scientific and Technical Research Council of Turkey with the Project Number 112Y096.

The method we used to develop EFs for Settlements category bases on a modeling study while representativeness is weak because the study is conducted only 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.

### Methodological Issues:

#### Settlements remaining settlements (SL-SL)

All carbon pools in SL-SL is assumed to be not changing thus reported as NO.

The CS values used in other categories have also been used in this category. The forestland living biomass C stocks have been taken from ENVANIS, croplands from both IPCC 2006 and neighboring countries, grasslands from Serengil et al. (2015). Thus below EFs have been used.

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<sup>2</sup>) 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).

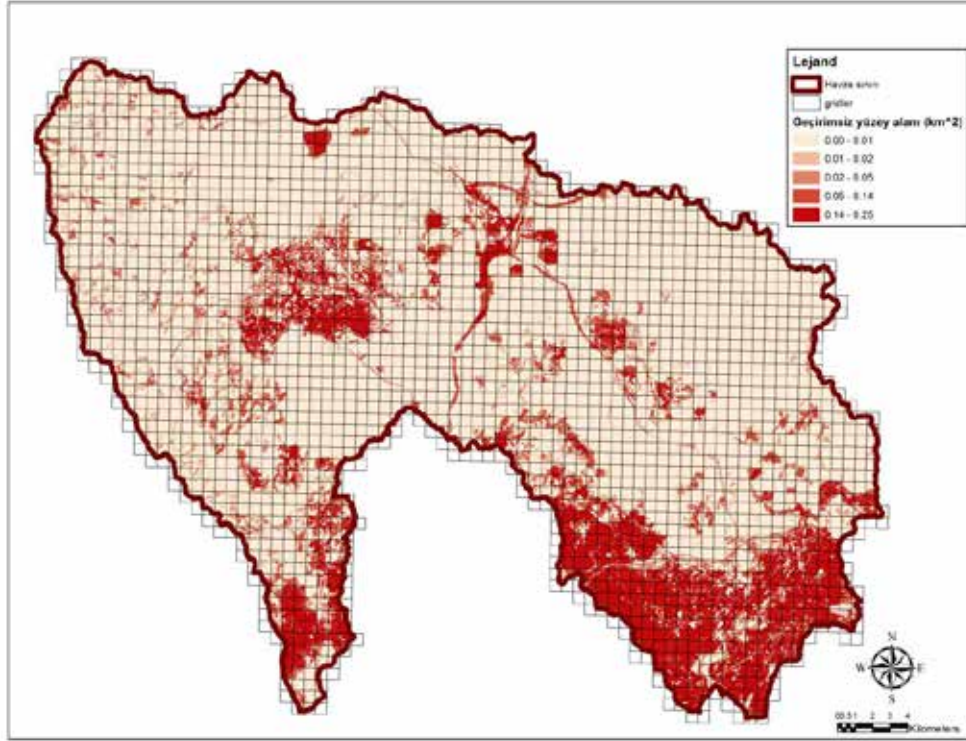
**Table 6.32 Total carbon stocks calculated for various settlements intensity classes (Serengil et al., 2015)**

Settlement class (SC)	Settlement intensity (% imperviousness)	Sample size		
		$\bar{x}$ (t C /ha)	$\sigma$ (t C /ha)	(#)
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

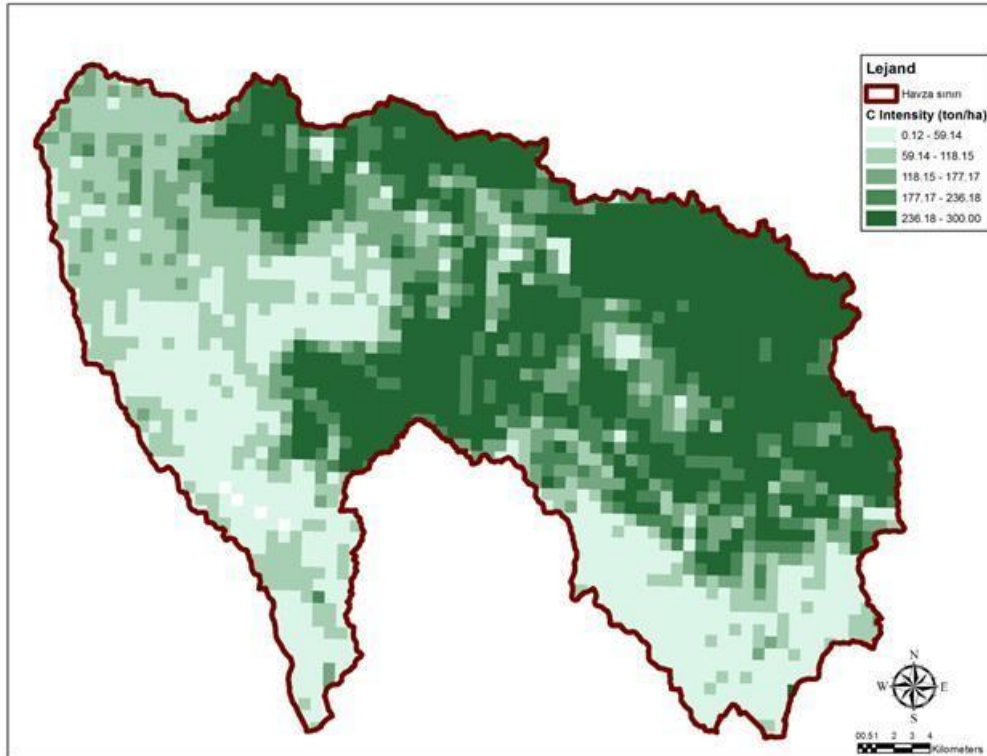
The weighted average for settlement land cover has been calculated as 25.17 t C/ha in total being 20.14 Mg C/ha in biomass, and 5.03 Mg C/ha in soil pools.

The settlement intensity and CS in the study are of the TUBITAK 112Y096 is given in Figure 6.5 and Figure 6.6.

**Figure 6.19 Impervious areas in the study area (Alibeyköy, Sazlıdere and Kağıthane watersheds in Istanbul)**



**Figure 6.20 Carbon intensity in the study area (Alibeyköy, Sazlıdere and Kağıthane watersheds in Istanbul)**



## Land converted to settlements (L-SL)

*Above- and below-ground biomass*

**Table 6.33 Coefficients and living biomass CS values for L-SL subcategories**

Ecozones	Forest type	NAI Y1 $\Delta CG$ (tC/yr/ha)	Loss Y1 $\Delta CL$ (tC/yr/ha)	BAFTER (tC/yr/ha)	BBEFORE (tC/yr/ha)	CSC Y1 (tC/ha/yr)
<b>Forestland converted to Settlements</b>						
i.e. Mediterranean Mountain zone	Forest Deciduous	5.03	0	0	41.97	-36.94
	Forest Coniferous	5.03	0	0	64.80	-59.77
	Forest Mixed	5.03	0	0	52.35	-47.32
	Forest Degraded	5.03	0	0	4.05	0.98

**Table 6.33 Coefficients and living biomass CS values for L-SL subcategories (Cont'd)**

<b>Cropland (annual) converted to Settlements</b>						
	Cropland <sub>annual</sub>	5.03	0	0	5	0.03
<b>Cropland (perennial) converted to Settlements</b>						
		5.03	0	0	15	-9.97
<b>Grassland converted to Settlements</b>						
		5.03	0	0	1.86	3.17
<b>Wetlands converted to Settlements</b>						
		5.03	0	0	1.86	3.17
<b>Otherland converted to Settlements</b>						
		5.03	0	0	0	5.03

*Dead organic matter*

CSC converted to settlements from forestlands are calculated based on the below coefficients and EF. The CSC for other conversions are assumed to be not occurring.



**Table 6.34 Coefficients and DOM CS values for L-SL subcategories**

Ecozones	Forest type	CF litter	CF Dead Wood	CSC LT (tC/ha/yr)	CSC DW (tC/ha/yr)	CSC DOM (tC/ha/yr)
<b>Forestland converted to Wetland</b>						
i.e. Mediterranean Mountain zone	Forest Deciduous	0.37	0.50	-3.09	-0.49	-3.58
	Forest Coniferous	0.37	0.50	-7.51	-0.36	-7.87
	Forest Mixed	0.37	0.50	-5.30	-0.42	-5.72
	Forest Degraded	0.37	0.50	0.00	-0.03	-0.03

#### *Mineral and organic soil*

The CSC in mineral soils have been calculated based on national stock values determined by General Directorate of Agricultural Research. The default conversion duration of 20 years has been applied.

**Table 6.35 Coefficients and soil CS values for L-SL subcategories**

Ecozone	SOC ref	C stock Settl. (tC/ha)	Forestland C stock (tC/ha)	Cropland (Annual) C stock (tC/ha)	Cropland (perennial) C stock (tC/ha)	Grassland C stock (tC/ha)	Wetland C stock (tC/ha)	Otherl. C stock (tC/ha)
Mediterranean Mountain zone	46.96	20.14	51.53	40.22	46.96	42.26	42.26	12.78
Mediterranean coastal zone deciduous and coniferous forest	37.77	20.14	46.08	29.62	37.77	33.99	33.99	12.78
East Anatolian steppe	47.99	20.14	48.41	38.90	47.99	43.19	43.19	12.78
East Anatolian deciduous forest zone	41.30	20.14	45.14	30.44	41.30	37.17	37.17	12.78
Euxine-Colchic deciduous forest	49.66	20.14	51.90	38.68	49.66	44.69	44.69	12.78
Central Anatolian steppe	40.41	20.14	49.92	32.14	40.41	36.37	36.37	12.78
Aegean Inland deciduous and coniferous forest	42.53	20.14	50.88	30.99	42.53	38.28	38.28	12.78
North Anatolian deciduous, coniferous and mixed forest	54.57	20.14	55.05	34.29	54.57	49.11	49.11	12.78

### Uncertainties and Time-Series Consistency:

The time series consistency has been ensured via the new land tracking system as explained in section 6.3.

The same methodology to estimate uncertainty has been employed as 6.4.5 and the below summary table has been produced.

**Table 6.36 Uncertainty summary table for Settlement subcategories**

	BY (1990)	LRY (2017)
Wetland Remaining Wetland		
<b>4E1 – SL-SL</b>	<b>0%</b>	<b>0</b>
$\Delta$ CC in Living Biomass	<b>NA</b>	<b>NA</b>
Annual Loss Living Biomass ( $\Delta$ CL)	NA	NA
Annual Gain Living Biomass ( $\Delta$ CG)	NA	NA
Net C stock change in DOM ( $\Delta$ CC)	<b>NA</b>	NA
Net C stock change in SOM ( $\Delta$ CC)	<b>NA</b>	NA
Land Converted to Wetland		
<b>4E2 – L-SL</b>	<b>0%</b>	<b>26%</b>
$\Delta$ CC in Living Biomass	NA	24%
Annual Loss Living Biomass ( $\Delta$ CL)	NA	NA
Annual Gain Living Biomass ( $\Delta$ CG)	NA	NA
Net C stock change in DOM ( $\Delta$ CC)	NA	97%
Net C stock change in SOM ( $\Delta$ CC)	NA	27%

#### Source-Specific QA/QC and Verification:

The QA/QC procedure has been realized in the framework of plan developed and carried out by TurkStat the national inventory agency. The sector specific QA/QC has been realized during the LULUCF project activities mentioned above. The calculation procedures have been checked and discussed with the LULUCF experts in and out of the agencies.

#### Recalculation:

The SL-SL and L-SL subcategories have been recalculated for the entire reporting period. The reasons and consequences of the recalculation is the same as explained in Croplands and Grasslands sections.

#### Planned Improvement:

The planned improvements for Settlement category are;

- Update carbon stock changes for all relevant carbon pools for each land use conversion to settlements (MT, LT)

- Extend the study mentioned in methodology section to other settlement areas and thus update the CS values (MT, LT)

## 6.7. Other land (4.F)

### Source Category Description:

Other land category is a net emission due to land converted to other land. However, the amount of land converted to Other land is quite low. It is assumed that other land may have organic carbon in soils but not in living biomass.

### Information on Land Classification and Activity Data

The area of other land category decreases during the reporting period from 1.7 Mha in 1990 to 1.3 Mha in 2017. Land conversion to other land is much lower. It has been 0.1 Mha in 2017.

### Methodological Issues:

The same conversion principles apply to Other land category. The coefficients and EFs use are as follows;

**Table 6.37 The coefficients and EF used in Other land category**

EF	Living Biomass	DOM	Soil
Other land	0	0	12.78

The C stocks for living biomass and DOM are assumed to be zero while mineral soil carbon stock is 12.78 based on calculations of General Directorate of Agricultural Research.

### Uncertainties and Time-Series Consistency:

The time series consistency has been ensured via the new land tracking system as explained in section 6.3.

The same methodology to estimate uncertainty has been employed as 6.4.5 and the below summary table has been produced.

**Table 6.38 Uncertainty summary table for Otherland subcategories**

	BY (1990)	LRY (2017)
Other land Remaining Other land		
<b>4F1 – OL-OL</b>	<b>0%</b>	<b>0</b>
$\Delta$ CC in Living Biomass	<b>NA</b>	<b>NA</b>
Annual Loss Living Biomass ( $\Delta$ CL)	NA	NA
Annual Gain Living Biomass ( $\Delta$ CG)	NA	NA
Net C stock change in DOM ( $\Delta$ CC)	<b>NA</b>	NA
Net C stock change in SOM ( $\Delta$ CC)	<b>NA</b>	NA
Land Converted to Wetland		
<b>4F2 – L-OL</b>	<b>0%</b>	<b>18%</b>
$\Delta$ CC in Living Biomass	NA	31%
Annual Loss Living Biomass ( $\Delta$ CL)	NA	NA
Annual Gain Living Biomass ( $\Delta$ CG)	NA	NA
Net C stock change in DOM ( $\Delta$ CC)	NA	139%
Net C stock change in SOM ( $\Delta$ CC)	NA	19%

## 6.8. Direct N<sub>2</sub>O emissions from N inputs to managed soils (4(I))

### Source Category Description:

Emissions and removals from this category as not been calculated since the activity data for N inputs can not be differentiated for the sectors and land uses.

### Methodological Issues:

The NO notation key has been used for wetlands and other land. The IE notation key has been used for forestland and settlements since we presume that N inputs are common in urban areas and some specific forestry applications (i.e. nurseries) but are included in the amount used for croplands.

### Uncertainties and Time-Series Consistency:

The time series consistency has been ensured via the new land tracking system as explained in section 6.3.

The same methodology to estimate uncertainty has been employed as 6.4.5 and the below summary table has been produced.

**Table 6.39 Uncertainty summary table for 4 (I) category**

Summary	BY (1990)	LRY
Table 4(I)	0%	0%

## 6.9. Emissions and removals from drainage and rewetting and other management of organic and mineral soils (4(II))

### Source Category Description:

There is no reliable data for drainage/rewetting and other management of organic and mineral soils. The category has been reported as NO.

### Uncertainties and Time-Series Consistency:

The time series consistency has been ensured via the new land tracking system as explained in section 6.3.

The same methodology to estimate uncertainty has been employed as 6.4.5 and the below summary table has been produced.

**Table 6.40 Uncertainty summary table for 4 (II) category**

Summary	BY (1990)	LRY
Table 4(II)	0%	0%

### 6.10. N<sub>2</sub>O emissions from N mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils (4(III))

#### Source Category Description:

N<sub>2</sub>O emissions from N mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils have been estimated and reported, according to the 2006 IPCC Guidelines, under this category. N<sub>2</sub>O emissions from land use conversions are derived from mineralization of soil organic matter resulting from the conversions that result in C losses.

#### Methodological Issues:

The equation 11.8 in IPCC (2006) has been used to calculate the mineralised N resulting from loss of soil organic C stocks in mineral soils through Land-use Change or Management Practices. The emissions due to loss of soil organic C was calculated and reported for all conversions. Gains have not been calculated since IPCC 2006 Guidelines suggest Tier 3 methods in order to calculate gains.

A default value of 15 as the C:N ratio of the soil organic matter has been used for conversions involving land-use change from forest or grassland to cropland. A default value of 10 has been used for conversions or management changes on cropland remaining cropland.

The parameters used in calculations are;

**Table 6.41 EFs used for N<sub>2</sub>O emissions**

Parameter (for 1 tC lost)	C/N=15 (all)	C/N=10 (CL)
C/N ratio	15	10
EF1 (kgN <sub>2</sub> O-N/kg N )	0.01	0.01
Factor (N <sub>2</sub> O-N) to (N <sub>2</sub> O)	1.57	1.57
<b>Aggregated factor (t N<sub>2</sub>O)</b>	<b>0.001047619</b>	<b>0.001571429</b>

## Uncertainties and Time-Series Consistency:

The time series consistency has been ensured via the new land tracking system as explained in section 6.3.

The same methodology to estimate uncertainty has been employed as 6.4.5 and the below summary table has been produced.

**Table 6.42 Uncertainty summary table for 4 (III) category**

Summary	BY (1990)	LRY
Table 4(I)	0%	75%

## Recalculation:

The category has been recalculated entirely since the AD for conversions between land categories have been available in this submission. In the previous submission the land category forestland converted to was not known. Thus it was assumed that all conversions from forestland was to the grassland.

## 6.11. Indirect N<sub>2</sub>O emissions from managed soils (4(IV))

### Source Category Description:

The estimation of indirect N<sub>2</sub>O emissions follows the 2006 IPCC guidelines (Volume 4, Ch. 11). The indirect N<sub>2</sub>O emissions from N leaching and runoff from managed soils are estimated based on annual amount of N mineralised in mineral soils associated with loss of soil organic matter due to land-use change (i.e. from direct N<sub>2</sub>O emissions). Default emission factors have been used accordingly.

Reference to 2006 IPCC equation: Vol. 4., Ch. 11: 11.10

### Methodological Issues:

The atmospheric deposition as indirect N<sub>2</sub>O Emissions from Managed Soils has been reported as IE in this category as sources of N can not be differentiated from Croplands and Grasslands thus reported



under 3D(b). However, Nitrogen Leaching and Runoff has been estimated by using the default EFs of IPCC 2006.

**Table 6.43 EFs used for N<sub>2</sub>O emissions**

Parameter	Values
Volatilization fraction: Frac GASF ((kg NH <sub>3</sub> -N + NO <sub>x</sub> -N) (kg N applied) -1)	0.2
EF4 (kg N <sub>2</sub> O-N (kg NH <sub>3</sub> -N + NO <sub>x</sub> -N volatilised)-1)	0.01
FracLEACH-(H) [N losses by leaching/runoff for regions]	0.3
EF5 [leaching/runoff], kg N <sub>2</sub> O-N (kg N leaching/runoff)	0.0075

#### Uncertainties and Time-Series Consistency:

The time series consistency has been ensured via the new land tracking system as explained in section 6.3.

The same methodology to estimate uncertainty has been employed as 6.4.5 and the below summary table has been produced.

**Table 6.44 Uncertainty summary table for 4 (IV) category**

Summary	BY (1990)	LRY
Table 4(I)	0%	387%

#### Recalculation:

The category used to be reported as NE in the previous submissions.

## 6.12. Biomass Burning (4(V))

#### Source Category Description:

Several types of country-specific data have been collected to estimate emissions from biomass burning. The most important input variable is activity data (i.e. area burnt) that is collected each year. The

second important variable to be collected is above-ground biomass of lands that were affected by wildfires. In addition, Turkey also collects country-specific data on types of wildfires, carbon pools affected and the fraction of biomass lost in wildfires.

### Methodological Issues:

To calculate emissions from wildfires;

- Average above-ground biomass of those forest types (coniferous, deciduous, mixed and OFL) that were affected by wildfires were calculated on an annual basis.
- Average fraction of biomass lost in wildfires was estimated.

Emission estimation due to biomass burning follows the 2006 IPCC guidelines (Volume 4, Ch. 2 and Ch. 4). Currently, CO<sub>2</sub> emissions from biomass burning are estimated as part of annual carbon loss in biomass (i.e. Ldisturbance). A generic approach for estimating the amount of carbon lost from disturbances is applied, based on area affected by disturbance (i.e. area burnt), average above-ground biomass on area burnt and average fraction of biomass lost in wildfires. Non-CO<sub>2</sub> emissions from biomass burning have also been estimated by applying a generic methodology for each of individual greenhouse gases through use of default emission factors (i.e. for CO, CH<sub>4</sub>, N<sub>2</sub>O, NO<sub>x</sub> and NMVOC).

Field burning of agricultural residues are estimated under the Agriculture sector (CRF table 3.F).

Controlled burning is not a practice used in Turkey. Thus reported as NO. Emissions from FL-FL and L-FL subcategories have been estimated. Other categories have been reported as NE as there is no available activity data.

Reference to the 2006 IPCC equations: Vol. 4., Ch. 2: 2.14 / 2.27

The EFs and coefficients used are as follows;

Table 6.45 EFs used for Biomass burning emissions

Parameters	Year						
	1990	1995	2000	2005	2010	2015	2017
ABG Dec (tDM/ha)	98.50	102.49	107.61	127.34	128.00	112.87	106.88
ABG Con (tDM/ha)	71.09	73.98	77.67	83.75	86.12	85.79	87.88
ABG Mixed (tDM/ha)	84.80	88.23	92.64	105.55	107.06	99.33	97.38
ABG Degraded (tDM/ha)	5.78	6.02	6.32	6.52	5.57	4.64	4.19
R For Dec	0.23	0.23	0.23	0.23	0.23	0.23	0.23
R For Con	0.29	0.29	0.29	0.29	0.29	0.29	0.29
R For Mix	0.26	0.26	0.26	0.26	0.26	0.26	0.26
R For Deg	0.43	0.43	0.43	0.43	0.43	0.43	0.43
LB total Dec (tDM/ha)	127.07	132.22	138.82	164.27	165.12	145.60	137.88
LB total Con (tDM/ha)	87.45	90.99	95.53	103.01	105.93	105.53	108.09
LB total Mixed (tDM/ha)	106.84	111.18	116.73	132.99	134.90	125.16	122.70
LB total Degraded (tDM/ha)	8.27	8.60	9.03	9.32	7.96	6.64	5.99
LT Dec (tDM/ha)	8.35	8.35	8.35	8.35	8.35	8.35	8.35
LT Con (tDM/ha)	20.30	20.30	20.30	20.30	20.30	20.30	20.30
LT Mix (tDM/ha)	14.32	14.32	14.32	14.32	14.32	14.32	14.32
LT Deg (tDM/ha)	0.00	5.00	10.00	15.00	20.00	25.00	27.00
DW Dec (tDM/ha)	0.99	1.02	1.08	1.27	1.28	1.13	1.07
DW Con (tDM/ha)	0.71	0.74	0.78	0.84	0.86	0.86	0.88
DW Mix (tDM/ha)	0.85	0.88	0.93	1.06	1.07	0.99	0.97
DW Deg (tDM/ha)	0.06	0.06	0.06	0.07	0.06	0.05	0.04
Burned share Dec	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Burned share Con	0.90	0.90	0.90	0.90	0.90	0.90	0.90

**Table 6.45 EFs used for Biomass burning emissions (Cont'd)**

Burned share Mix	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Burned share Deg	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total stock available for burning (tDM/ha)	105.00	109.35	115.03	129.25	132.07	125.52	125.41
Cf (combustion factor, Extra tropical forest)	0.44	0.44	0.44	0.44	0.44	0.44	0.44
FLremFL Amount burnt (tDM/ha)	46.20	48.11	50.61	56.87	58.11	55.23	55.18
convFL Amount burnt (tDM/ha)	11.11	8.11	8.11	8.11	8.11	7.96	7.96

### Uncertainties and Time-Series Consistency:

The time series consistency has been ensured via the new land tracking system as explained in section 6.3.

The same methodology to estimate uncertainty has been employed as 6.4.5 and the below summary table has been produced.

**Table 6.46 Uncertainty summary table for 4 (V) category**

Summary	BY (1990)	LRY
Table 4(I)	54%	54%

### Recalculation:

The source of AD for wildfires in forestland has not been changed. The coefficients and EFs remained also unchanged.

### 6.13. Harvested Wood Products (4.G)

#### Source Category Description:

Carbon stock changes of the HWP category calculations have been revised and recalculated in this submission. The previous computation was done in the context of a study by Bouyer and Serengil (2014). The revision involved below changes;

- The approach has been reviewed by international experts and modified based on their suggestions,
- Paper was added as the third product,
- A KP analogical approach has been employed. Export and import amounts have been taken into account,

**Figure 6.21 Emissions and removals in HWP pool**



### Methodological Issues:

The following methodology has been applied in calculations;

The activity data on various forest products (sawnwood, wood panels and paper) variables for HWP has been downloaded from the FAO database: <http://www.fao.org/faostat/en/#data/FO>. It is assumed that paperboard is part of the paper category. The data on production of industrial roundwood (production, import, export) and production of wood pulp (production, import, export) have been obtained from FAO database and annual fraction (i.e. share) of domestic harvest calculated accordingly.

The Approach B has been used for HWP calculations. General method to estimate annual change in carbon stock in "products in use" based on first order decay function and half-life is used. Domestic consumption is computed from production data (domestic harvest) plus imports minus exports. The annual fraction of the feedstock coming from domestic harvest for the HWP categories sawnwood and wood-based panels has been estimated. Also the annual fraction of domestically produced wood pulp as feedstock originating from domestic harvest for the production of the HWP category paper and paperboard (IPCC 2014) is estimated.

Annual carbon stock inflow from domestic wood production for each category was extrapolated backward by applying equation 12.6 to get figures for period before 1961, because FAO statistics start from 1961 (annual rate of increase for industrial roundwood production can be used from table 12.3; for Europe the U value = 0.0151).

Country specific wood density values have been used.

Reference to 2014 IPCC equations: Ch. 2: 2.8.1 / 2.8.2

Reference to 2014 IPCC table: Ch. 2: 2.8.1

Reference to 2006 IPCC equation: Vol. 4., Ch. 12: 12.6

Default half-lives from Table 2.8.2 were used for each HWP category in the FOD constant (k) and the estimation from the year 1900 to present has been performed. Annual CSC in the HWP pool was calculated as difference between subsequent year for the whole reporting period, i.e. base year to present ( $\Delta C_i = C_i - C_{i-1}$ ).

Reference to 2006 IPCC equation: Vol. 4., Ch. 12: 12.1

Reference to 2014 IPCC table: Ch. 2: 2.8.2

### Recalculation:

The category was recalculated because the methodology has been changed and paper has been added to the calculation procedure.

## 7. WASTE (CRF SECTOR 5)

### 7.1. Sector Overview

The waste sector includes CH<sub>4</sub> emissions from solid waste disposal, CH<sub>4</sub> and N<sub>2</sub>O emissions from biological treatment of solid waste, CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions from open burning of waste and, CH<sub>4</sub> and N<sub>2</sub>O 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.

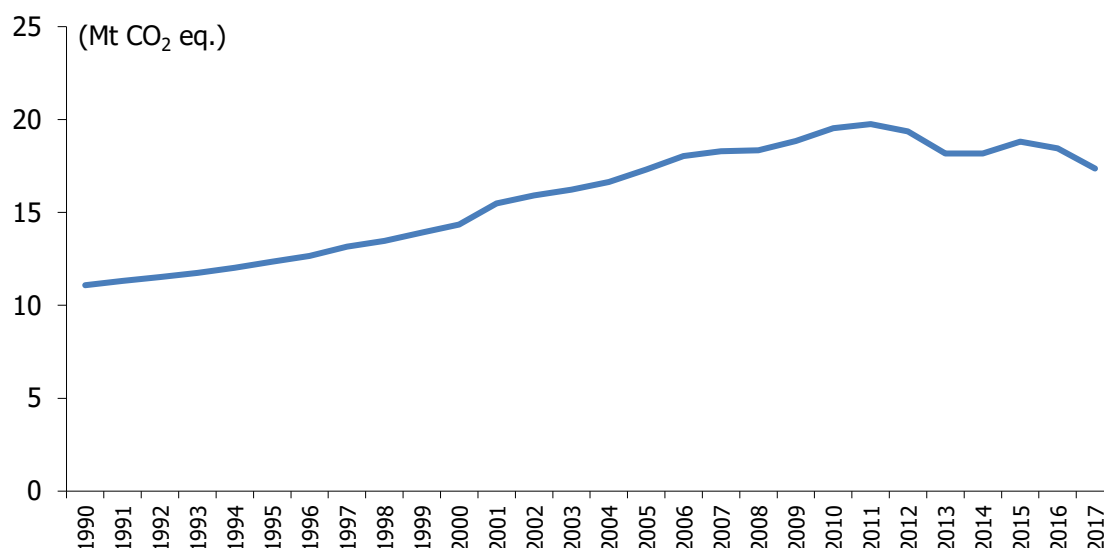
Total waste emissions for the year 2017 are 17.4 Mt CO<sub>2</sub> eq., or 3.3% of total GHG emissions (without LULUCF). Within the sector, 52.3% of the emissions were from solid waste disposal, followed by 47.6% from wastewater treatment and discharge, 0.08% from biological treatment of solid waste and 0.02% from open burning of waste.

The major GHG emissions from the waste sector are CH<sub>4</sub> emissions, which represent 66.5% of total emissions from this sector in 2017, followed by N<sub>2</sub>O emissions with 33.5% and a very small percent of CO<sub>2</sub> as 0.01%.

**Table 7.1 CO<sub>2</sub> equivalent emissions for the waste sector, 2017**

GHG source and sink categories	(kt CO <sub>2</sub> eq.)			
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	Total
<b>5. Waste</b>	1.9	11 538.7	5 814.4	17 355.0
A. Solid waste disposal	NA	9 079.1	NA	9 079.1
B. Biological treatment of solid waste	NA	8.2	5.9	14.0
C. Incineration and open burning of waste	1.9	1.7	0.3	3.9
D. Wastewater treatment and discharge	NA	2 449.8	5 808.3	8 258.1
E. Other	NO	NO	NO	NO

Waste emissions are 56.6% (6.3 Mt CO<sub>2</sub> eq.) higher in 2017 than they were in 1990 and 5.9% (1.09 Mt CO<sub>2</sub> eq.) lower than in 2016 as seen in Figure 7.1.

**Figure 7.1 Total GHG emissions of waste sector, 1990-2017**

Total emissions in the waste sector gradually increased between 1990 (11 084 kt CO<sub>2</sub> eq.) and 2017 (17 355 kt CO<sub>2</sub> 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 after 2011. Emissions from solid waste disposal increased by 78.2% (8 672 kt CO<sub>2</sub> eq.) between 1990 and 2011, before decreasing by 12.2% between 2011 and 2017 (2 401 kt CO<sub>2</sub> eq.), except an increase with 3.5% (644 kt CO<sub>2</sub> eq.) between 2013 and 2015.

Methane recovery in solid waste disposal sites is reported as of 2002 (37 kt CO<sub>2</sub> eq.) and increasing to 8 000 kt CO<sub>2</sub> eq. in 2017. The decline in recent total emissions is mainly due to the increase in methane recovery between 2011 (1 418 kt CO<sub>2</sub> eq.) and 2013 (3 993 kt CO<sub>2</sub> eq.), an increase of 181.6%. There is also an increasing trend in methane recovery with 47.8% from 2013 to 2016, with a significant increase of 35.6% between 2016 and 2017.

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 <sub>2</sub>		CH <sub>4</sub>		N <sub>2</sub> O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
<b>5. Waste</b>	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, T1: Tier 1, T2: Tier 2

## 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<sub>4</sub> emissions from two types of waste in municipal SWDS in Turkey:

- Municipal solid waste (MSW),
- Industrial waste,
- Sewage sludge, and
- Clinical waste.

According to the clinical waste management practices and regulations in Turkey, clinical waste which is collected separately from health institutions is disposed of in SWDS or incinerated. Almost all of the clinical waste is sterilized prior to disposal in SWDS. CH<sub>4</sub> emissions from clinical waste which is collected separately are assumed to be negligible and have not been reported so far. Based on the ERT findings in the latest review, clinical waste emissions were estimated and reported in this submission. Likewise,

the ongoing study to determine the amount of sewage sludge disposed in SWDS from the results of Municipal Wastewater Statistics of Turkish Statistical Institute (TurkStat) have been completed and the emission estimates done for the whole time series. 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<sub>4</sub> emissions from solid waste disposal is a key category according to both a level and a trend assessment. CH<sub>4</sub> emissions of MSW, industrial waste, sewage sludge and clinical waste emissions 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<sub>4</sub> emissions. Closed SWDS continue to emit CH<sub>4</sub>. This is automatically accounted for in the FOD method because historical waste disposal data are used. The CH<sub>4</sub> 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.

$$CH_4 \text{ Emissions} = \left[ \sum_x CH_4 \text{ generated}_{x,T} - R_T \right] \cdot (1 - OX_T)$$

Where:

$\text{CH}_4$  Emissions =  $\text{CH}_4$  emitted in year  $T$ , Gg

$T$  = inventory year

$x$  = waste category or type/material

$R_T$  = recovered  $\text{CH}_4$  in year  $T$ , Gg

$\text{OX}_T$  = oxidation factor in year  $T$ , (fraction)

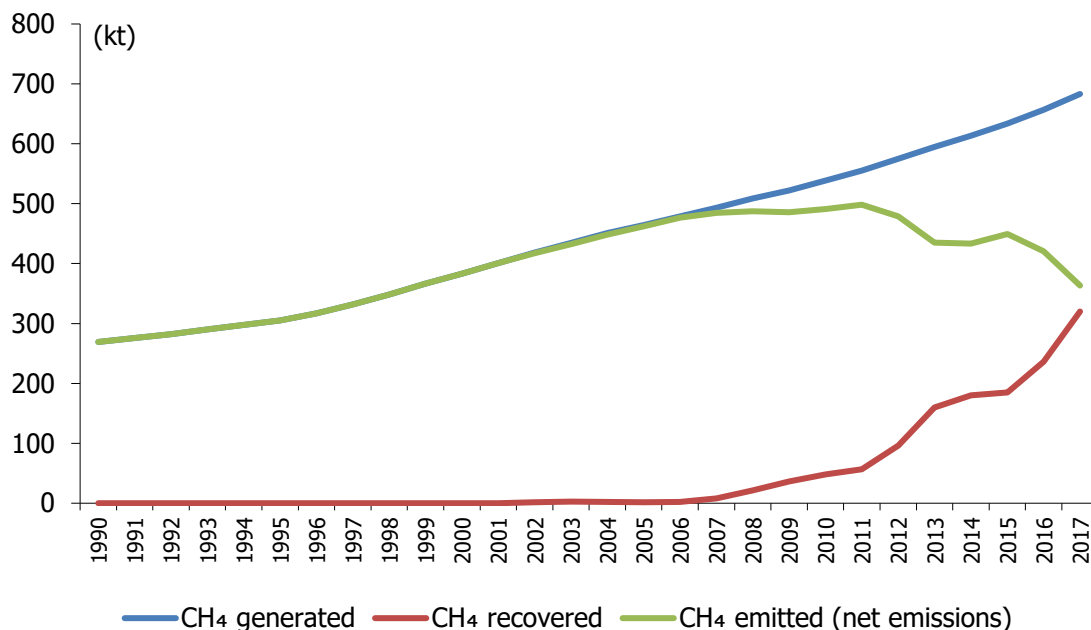
The  $\text{CH}_4$  generated by each category of waste disposed is added to get total  $\text{CH}_4$  generated in each year. Finally, emissions of  $\text{CH}_4$  are calculated by subtracting the  $\text{CH}_4$  gas recovered from the disposal site.

The total amount of  $\text{CH}_4$  generated,  $\text{CH}_4$  recovered and net  $\text{CH}_4$  emissions from solid waste disposal sites are estimated as given in Table 7.3 and Figure 7.2.

**Table 7.3 CH<sub>4</sub> generated, recovered and emitted from SWDS, 1990-2017****(kt)**

Year	CH <sub>4</sub> Generated	CH <sub>4</sub> Recovered	CH <sub>4</sub> Emitted	
			Managed	Unmanaged
1990	269.2	NO	NO	269.2
1991	275.7	NO	NO	275.7
1992	282.4	NO	NO	282.4
1993	290.0	NO	2.2	287.8
1994	297.8	NO	4.0	293.7
1995	305.1	NO	5.6	299.5
1996	317.1	NO	8.6	308.5
1997	331.6	NO	14.5	317.1
1998	348.5	NO	23.5	325.0
1999	366.5	NO	33.9	332.6
2000	383.3	NO	45.9	337.3
2001	400.7	NO	59.5	341.2
2002	418.7	1.5	72.9	344.2
2003	434.6	2.5	83.3	348.8
2004	450.9	2.3	95.0	353.5
2005	464.1	1.7	105.5	357.0
2006	478.8	2.2	114.5	362.2
2007	493.1	8.3	122.2	362.6
2008	508.6	21.4	124.0	363.2
2009	522.2	36.5	124.9	360.8
2010	538.8	47.9	131.5	359.4
2011	555.0	56.7	143.1	355.3
2012	574.9	96.2	126.1	352.7
2013	594.5	159.7	86.4	348.4
2014	613.5	179.8	91.3	342.3
2015	633.9	184.6	111.3	338.0
2016	656.6	236.1	87.5	333.0
2017	683.1	320.0	33.9	329.3

**Figure 7.2 CH<sub>4</sub> emissions from solid waste disposal, 1990-2017**



In Turkey, due to the increased capacity and number of the methane recovery plants producing electrical or thermal energy from the waste gas, net emissions and methane recovery amounts are approaching one another.

### Choice of Activity Data

For calculating CH<sub>4</sub> generated; municipal solid waste AD, industrial waste AD, sewage sludge AD and clinical waste AD are needed. As is described in more detail below, for MSW, industrial waste, sewage sludge and clinical waste, national data are used where possible, depending on availability of all ADs. 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. By the same logic, GDP data and waste generation rate data are used as drivers for estimating industrial waste generation and some missing data imputation methods were implied for sludge and clinical waste data when any year's data is missing.

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<sub>F</sub>), 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, 2014 and 2016 are available. For 2017, the survey data is not 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 2016, the missing data for the remaining years are estimated by linear interpolation. 2017 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 managed SWDS, 1992-2016**

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	2016
12	15	16	18	22	37	52	80	113	134

Source: (1) TurkStat, Municipal Waste Statistics, 1992-2010

(2) TurkStat, Waste Disposal and Recovery Facilities Statistics, 2012-2016

Amount of municipal waste by disposal methods are given in Table 7.5.

**Table 7.5 Amount of municipal waste by disposal methods, 1994-2016****(kt)**

<b>Year</b>	<b>Municipality's dumping site</b>	<b>Controlled landfill site</b>	<b>Composting plant</b>	<b>Burning in an open area</b>	<b>Lake and river disposal</b>	<b>Burial</b>	<b>Other<sup>(1)</sup></b>
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
2016	9 094.9	19 337.9	146.5	10.2	0.5	6.7	41.1

Source: TurkStat, Municipal Waste Statistics

(1) Data refers to disposals by using as filling material and dumping on to land.

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, 1990-2017**

Year	Annual MSW at the SWDS (kt)			Distribution of waste (%)	
	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	18 572.7	8 842.3	67.7	32.3
2016	28 480.5	19 337.9	9 142.6	67.9	32.1
2017	28 837.0	20 103.1	8 733.8	69.7	30.3

**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 2007-2017, the annual results of ABPRS are used.



**Table 7.7 Mid-year population, 1950-2017**

Year	Population	Year	Population
1950	20 807 000	1984	49 070 000
1951	21 351 000	1985	50 307 000
1952	21 952 000	1986	51 480 000
1953	22 569 000	1987	52 370 000
1954	23 204 000	1988	53 268 000
1955	23 857 000	1989	54 192 000
1956	24 540 000	1990	55 120 000
1957	25 250 000	1991	56 055 000
1958	25 981 000	1992	56 986 000
1959	26 733 000	1993	57 913 000
1960	27 506 000	1994	58 837 000
1961	28 227 000	1995	59 756 000
1962	28 931 000	1996	60 671 000
1963	29 652 000	1997	61 582 000
1964	30 391 000	1998	62 464 000
1965	31 149 000	1999	63 364 000
1966	31 936 000	2000	64 269 000
1967	32 750 000	2001	65 166 000
1968	33 586 000	2002	66 003 000
1969	34 443 000	2003	66 795 000
1970	35 321 000	2004	67 599 000
1971	36 215 000	2005	68 435 000
1972	37 133 000	2006	69 295 000
1973	38 073 000	2007	70 158 000
1974	39 037 000	2008	71 052 000
1975	40 026 000	2009	72 039 000
1976	40 916 000	2010	73 142 000
1977	41 769 000	2011	74 224 000
1978	42 641 000	2012	75 176 000
1979	43 531 000	2013	76 148 000
1980	44 439 000	2014	77 182 000
1981	45 540 000	2015	78 218 000
1982	46 688 000	2016	79 278 000
1983	47 864 000	2017	80 313 000

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, 2014 and 2016) are obtained from TurkStat's *Municipal Waste Statistics*. The estimations of TurkStat are used for the years 1999, 2000, 2005, 2007, 2009, 2011, 2013, 2015 and 2017. 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, 1990-2017**

<b>Year</b>	<b>MSW Generated (kt)</b>	<b>Population (millions)</b>	<b>Waste per capita (kg/cap/yr)</b>
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
2016	33 763.5	79.3	425.9
2017	34 173.0	80.3	425.5

**% 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, 2014 and 2016) are obtained from TurkStat's *Municipal Waste Statistics Survey*. The estimations of TurkStat are used for the years 1999, 2000, 2005, 2007, 2009, 2011, 2013, 2015 and 2017. Due to lack of MSW generated data, % to SWDS of 1994 (70.6%) is used for 1990-1993.

% to SWDS obtained by dividing the amount of MSW landfilled by MSW generated are given for 1990-2017 in Table 7.9.

**Table 7.9 Percentage of MSW disposed in the SWDS, 1990-2017**

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
2016	33 763.5	28 480.5	84.4
2017	34 173.0	28 837.0	84.4

**Waste Composition Data:** The waste composition data were available for the years 1993, 2006 and 2014 until this submission. To improve the quality of the inventory, an additional question on waste composition data has been added to the TurkStat's *Municipal Waste Statistics Survey* and, TurkStat's waste composition survey results for the years 2016 and 2017 are used in this submission. For 1993, the source of the data is *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 2006 data was developed under the Solid Waste Master Plan Project of MoEF and published in *Waste Management Action Plan, 2008-2012; MoEF*. The source of the 2014 waste composition data is *National Waste Management and Action Plan, 2016-2023; MoEU*. The source of the 2016 and 2017 waste composition data is TurkStat's *Municipal Waste Statistics Survey* as mentioned above. This survey is conducted biennially, but the waste composition data is planned to compile annually by inquiring about the previous year data.

Due to the lack of waste composition data for the remaining years, the data of 1993, 2006, 2014, 2016 and 2017 are used for imputing waste composition data of missing years by time series analysis methods. For missing value imputation R programming language was used. Two time series analysis methods were found statistically better than others. These are Linear Weighted Moving Average (LWMA) and Exponential Weighted Moving Average (EWMA). An exponential moving average is calculated similarly to a linear weighted moving average, but uses an exponentially weighted multiplier. Both of them are calculated by adding the moving average of a certain share of the current value to the previous value. Thus, they assign more meaning to the recent values and less to the period's beginning.

LWMA: Weights decrease in arithmetical progression. The observations directly next to a central value  $i$ , have weight  $1/2$ , the observations one further away ( $i-2, i+2$ ) have weight  $1/3$ , the next ( $i-3, i+3$ ) have weight  $1/4$ , ...

EWMA: uses weighting factors which decrease exponentially. The observations directly next to a central value  $i$ , have weight  $1/2^1$ , the observations one further away ( $i-2, i+2$ ) have weight  $1/2^2$ , the next ( $i-3, i+3$ ) have weight  $1/2^3$ , ...

(The R Project for Statistical Computing- "Time Series Missing Value Imputation", Package 'imputeTS', Version: 2.7, June 20, 2018)

As a result, LWMA method was preferred because the values of both the first years and the last years were the same in the EWMA method.

In conclusion, based on the ERT findings in the latest review, Turkey re-examined the completeness and accuracy of different data sources and, updated the time series by disseminating the waste composition data along the years 1990-2017 in order to provide a consistent time series.

Table 7.10 contains these statistically estimated data with the official waste composition data.

Table 7.10 Waste composition data

(%)

Year	Food	Garden	Paper	Textile	Plastics	Metal	Glass	Other
1990	58.29	0.95	7.90	3.81	2.81	1.00	2.76	22.48
1991	59.26	0.79	7.58	3.84	2.84	1.00	2.63	22.05
1992	60.47	0.59	7.18	3.88	2.88	1.00	2.47	21.53
1993 <sup>(1)</sup>	64.00	0.00	6.00	4.00	3.00	1.00	2.00	20.00
1994	60.00	0.67	7.33	3.87	2.87	1.00	2.53	21.73
1995	58.00	1.00	8.00	3.80	2.80	1.00	2.80	22.60
1996	56.00	1.33	8.67	3.73	2.73	1.00	3.07	23.47
1997	54.00	1.67	9.33	3.67	2.67	1.00	3.33	24.33
1998	52.00	2.00	10.00	3.60	2.60	1.00	3.60	25.20
1999	50.00	2.33	10.67	3.53	2.53	1.00	3.87	26.07
2000	48.00	2.67	11.33	3.47	2.47	1.00	4.13	26.93
2001	46.00	3.00	12.00	3.40	2.40	1.00	4.40	27.80
2002	44.00	3.33	12.67	3.33	2.33	1.00	4.67	28.67
2003	42.00	3.67	13.33	3.27	2.27	1.00	4.93	29.53
2004	37.15	5.39	14.31	2.98	2.83	1.08	5.44	30.82
2005	36.45	5.31	14.69	2.98	2.64	1.06	5.56	31.31
2006 <sup>(2)</sup>	34.00	5.00	16.00	3.00	2.00	1.00	6.00	33.00
2007	36.94	5.37	14.42	2.98	2.77	1.07	5.48	30.97
2008	38.41	5.55	13.63	2.97	3.16	1.11	5.21	29.95
2009	39.88	5.74	12.84	2.96	3.54	1.15	4.95	28.94
2010	41.35	5.92	12.06	2.95	3.93	1.19	4.69	27.92
2011	46.34	5.98	11.44	2.10	6.23	1.52	4.51	21.88
2012	51.11	6.41	9.52	1.81	7.80	1.71	3.88	17.77
2013	50.84	6.45	9.36	1.93	7.58	1.67	3.82	18.33
2014 <sup>(3)</sup>	48.70	6.84	8.11	2.90	5.86	1.37	3.38	22.84
2015	52.37	5.67	10.47	1.09	9.17	1.95	4.34	14.94
2016 <sup>(4)</sup>	55.13	5.68	11.87	0.00	11.02	2.28	4.70	9.32
2017 <sup>(5)</sup>	53.75	3.91	11.91	0.00	11.36	2.33	5.22	11.53

(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 and Action Plan, 2016-2023

(4), (5) TurkStat, Municipal Waste Statistics Survey Results

## 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, 2014 and 2016. The missing data for the remaining years between 1994 and 2016 were estimated by linear interpolation. 2017 data was assumed the same as in 2016.

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, 1990-2017**

Year	Annual IW at the SWDS (kt)			Distribution of waste (%)	
	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	4.0	NO	4.0	0.0	100.0
2016	2.1	NO	2.1	0.0	100.0
2017	2.1	NO	2.1	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 1998-2017, 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, 1950-2017**

(million USD)			
Year	GDP	Year	GDP
1950	3 469	1984	58 643
1951	4 167	1985	66 408
1952	4 793	1986	75 018
1953	5 585	1987	85 638
1954	5 700	1988	90 495
1955	6 854	1989	106 123
1956	7 909	1990	149 195
1957	10 518	1991	149 156
1958	12 552	1992	156 656
1959	15 687	1993	177 332
1960	9 932	1994	131 639
1961	5 512	1995	168 080
1962	6 402	1996	181 077
1963	7 402	1997	188 735
1964	7 872	1998	277 468
1965	8 419	1999	253 622
1966	9 997	2000	271 768
1967	11 144	2001	200 998
1968	18 008	2002	236 338
1969	20 128	2003	313 776
1970	18 825	2004	402 952
1971	16 847	2005	499 874
1972	21 319	2006	547 832
1973	26 854	2007	677 438
1974	36 985	2008	776 643
1975	46 300	2009	646 893
1976	52 996	2010	772 365
1977	60 613	2011	831 696
1978	66 277	2012	871 125
1979	80 960	2013	950 355
1980	67 457	2014	934 857
1981	70 419	2015	861 879
1982	63 485	2016	862 746
1983	60 373	2017	851 492

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, 2014 and 2016) 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 2017, waste generation rate is calculated assuming that IW generated in 2017 is the same as in 2016. 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, 2014 and 2016) are obtained from TurkStat's *Manufacturing Industry Establishments Water, Wastewater and Waste Statistics Survey*. 2017 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 are given in detail in Table 7.13.

**Table 7.13 Industrial waste activity data, 1990-2017**

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	861 879.3	0.02	15 377.8	0.03	4.0
2016	862 745.6	0.02	16 266.7	0.01	2.1
2017	851 492.3	0.02	16 266.7	0.01	2.1

### Methane Correction Factor (MCF)

Due to the assumption that all managed SWDS are categorized under anaerobic managed SWDS, the default MCF from the 2006 IPCC Guidelines for anaerobic managed SWDS (1.0) is taken for managed SWDS. Since there is no information about classification of deep ( $\geq 5$  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  $\text{CH}_4$  emissions from solid waste disposal sites. Calculated values for the MCF are given in Table 7.14.

**Table 7.14 Weighted averages of MCF, 1990-2017****(weighted average fraction)**

<b>Year</b>	<b>MCF for MSW</b>	<b>MCF for IW</b>	<b>MCF for SS</b>	<b>MCF for CW</b>
1990	0.60	0.60	0.60	0.00
1991	0.60	0.60	0.60	0.00
1992	0.62	0.60	0.60	0.00
1993	0.62	0.60	0.60	0.00
1994	0.62	0.60	0.60	0.00
1995	0.63	0.60	0.60	0.00
1996	0.65	0.60	0.60	0.00
1997	0.68	0.60	0.60	0.00
1998	0.69	0.60	0.74	0.00
1999	0.71	0.60	0.81	0.00
2000	0.72	0.60	0.82	0.00
2001	0.74	0.60	0.83	0.00
2002	0.71	0.60	0.77	0.00
2003	0.72	0.60	0.79	0.71
2004	0.71	0.60	0.85	0.72
2005	0.71	0.60	0.79	0.78
2006	0.75	0.60	0.75	0.82
2007	0.76	0.60	0.76	0.85
2008	0.78	0.60	0.77	0.88
2009	0.79	0.60	0.75	0.89
2010	0.82	0.60	0.74	0.88
2011	0.82	0.60	0.74	0.90
2012	0.84	0.60	0.75	0.92
2013	0.86	0.60	0.75	0.91
2014	0.86	0.60	0.76	0.90
2015	0.87	0.60	0.77	0.91
2016	0.87	0.60	0.77	0.92
2017	0.88	0.60	0.76	0.90

### 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 7.15. For sewage sludge 0.05 is taken and for clinical waste 0.15 is used according to *Table 2.6 in the 2006 IPCC, Volume 5, Chapter 2*.

**Table 7.15 DOC values by individual waste type****(weight fraction, wet basis)**

<b>Waste Type</b>	<b>Food waste</b>	<b>Garden</b>	<b>Paper</b>	<b>Textiles</b>
<b>DOC</b>	0.15	0.20	0.40	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, Chapter 2*.

$$\% \text{ DOC (by net weight) } = (0.15 \times A) + (0.20 \times B) + (0.40 \times C) + (0.24 \times D)$$

Where:

- A = fraction of food waste in MSW
- B = fraction of garden waste in MSW
- C = fraction of paper in MSW
- D = fraction of textiles in MSW

The calculated values of DOC by weight for the inventory years of 1990-2017 are listed below in Table 7.16.

**Table 7.16 DOC by weight, 1990-2017**

<b>Year</b>	<b>%DOC</b>	<b>Year</b>	<b>%DOC</b>
1990	13.01	2004	13.09
1991	13.00	2005	13.12
1992	12.99	2006	13.22
1993	12.96	2007	13.10
1994	12.99	2008	13.04
1995	13.01	2009	12.98
1996	13.03	2010	12.92
1997	13.05	2011	13.23
1998	13.06	2012	13.19
1999	13.08	2013	13.13
2000	13.10	2014	12.61
2001	13.12	2015	13.44
2002	13.13	2016	14.15
2003	13.15	2017	13.61

**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 <sup>-1</sup> )			
Waste Type	Food waste	Garden	Paper	Textiles
<b>k</b>	0.06	0.05	0.04	0.04

**Fraction of Methane in Generated Landfill Gas (*F*):** Most waste in SWDS generates a gas with approximately 50% CH<sub>4</sub>. The IPCC default value for the fraction of CH<sub>4</sub> in landfill gas (0.5) is used for the entire time series.

**Oxidation Factor (*OX*):** The oxidation factor reflects the amount of CH<sub>4</sub> 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 is 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, 2016*) etc. The emissions from energy production from the recovered CH<sub>4</sub> 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, 1990-2017**

<b>Year</b>	<b>Number of SWDS with landfill gas recovery</b>	<b>Recovered methane (kt)</b>
1990-2001	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	16	159.7
2014	19	179.8
2015	25	184.6
2016	34	236.1
2017	36	320.0

An additional question about landfill gas flaring has been added to the *Waste Disposal and Recovery Facilities Survey, 2014* and been also asked via *Waste Disposal and Recovery Facilities Survey, 2016*. There is still no official data on landfill gas flaring in response to the *Waste Disposal and Recovery Facilities Survey, 2016*. It will be also considered in the upcoming inventory in the case that new information is obtained.

### **Sewage Sludge**

In this submission sewage sludge is estimated by TurkStat with official data. This sludge is domestic wastewater treatment sludge from municipal wastewater treatment plants. Data on sludge quantity are compiled on wet basis and converted to dry matter by using the coefficients included in the guidelines of the European Union Statistical Office (EUROSTAT). And for the emissions calculations dry basis is used.

Methane emissions from sewage sludge are listed below in Table 7.19.

**Table 7.19 CH<sub>4</sub> generated from SS at SWDS, 1990-2017**

<b>Year</b>	<b>(kt)</b>		
	<b>Total</b>	<b>Managed</b>	<b>Unmanaged</b>
1990	NO	NO	NO
1991	0.001	NO	0.001
1992	0.002	NO	0.002
1993	0.003	NO	0.003
1994	0.003	NO	0.003
1995	0.004	NO	0.004
1996	0.005	NO	0.005
1997	0.006	0.000	0.006
1998	0.007	0.000	0.007
1999	0.021	0.006	0.014
2000	0.055	0.029	0.026
2001	0.098	0.058	0.040
2002	0.149	0.094	0.055
2003	0.240	0.143	0.097
2004	0.317	0.190	0.127
2005	0.419	0.269	0.151
2006	0.537	0.339	0.198
2007	0.669	0.403	0.266
2008	0.806	0.472	0.334
2009	0.947	0.546	0.401
2010	1.087	0.613	0.474
2011	1.227	0.673	0.554
2012	1.358	0.731	0.627
2013	1.479	0.787	0.693
2014	1.576	0.834	0.742
2015	1.650	0.875	0.776
2016	1.711	0.908	0.802
2017	1.757	0.936	0.821

**Table 7.20 Annual SS and distribution of waste by management type, 1990-2017**

Year	Annual SS at the SWDS (kt)			Distribution of waste (%)	
	Total	Managed	Unmanaged	Managed	Unmanaged
1990-94	1.5	NO	1.5	0.0	100.0
1995	2.4	NO	2.4	0.0	100.0
1996	2.0	0.0	2.0	1.0	99.0
1997	3.0	0.0	3.0	0.8	99.2
1998	19.6	6.6	12.9	33.9	66.1
1999	45.2	23.5	21.6	52.1	47.9
2000	58.0	32.0	26.0	55.1	44.9
2001	70.8	40.4	30.4	57.1	42.9
2002	133.2	55.8	77.4	41.9	58.1
2003	118.4	57.5	60.9	48.6	51.4
2004	145.5	92.1	53.4	63.3	36.7
2005	184.6	88.8	95.7	48.1	51.9
2006	223.7	85.6	138.1	38.3	61.7
2007	238.1	95.2	142.9	40.0	60.0
2008	252.6	104.8	147.7	41.5	58.5
2009	268.0	101.8	166.1	38.0	62.0
2010	283.3	98.8	184.5	34.9	65.1
2011	280.2	100.0	180.2	35.7	64.3
2012	277.0	101.1	175.9	36.5	63.5
2013	250.5	96.3	154.1	38.5	61.5
2014	223.9	91.5	132.4	40.9	59.1
2015	210.0	87.3	122.7	41.6	58.4
2016	196.1	83.0	113.1	42.3	57.7
2017	316.7	125.4	191.3	39.6	60.4

## Clinical Waste

In this submission, clinical waste emissions are calculated for the first time. Data have been collected according to the manual for the implementation of regulation (EC) no 2150/2002 on waste statistics and to the framework of the OECD/EUROSTAT core set of environmental data and indicators. For the reference year 2016 and before, data was produced based on the results of the survey conducted by Turkish Statistical Institute which was applied to the health institutions listed in Medical Waste Control Regulation as producers of large quantities of waste (university hospitals and their clinics, general purpose hospitals and their clinics, maternity hospitals and their clinics and military hospitals and their clinics) as Waste Statistics of Health Institutions. On the other hand, Medical Waste Statistics 2017 was produced based on the administrative registers of the Ministry of Environment and Urbanization covering the same scope for the first time.

Also, "Zero Waste" project is expected to come into force. The Zero Waste Project is aimed at managing waste and leaving future generations a clean and developed Turkey. Carried out by the Ministry of Environment and Urbanization, the project will initially be implemented in public bodies. With this



project, the collection and processing of all wastes including medical wastes might change. Hence a recalculation is likely to be inevitable.

Methane emissions caused by clinical waste are quite small as seen in Table 7.21.

**Table 7.21 CH<sub>4</sub> generated from CW at SWDS, 1990-2017**

	(kt)		
Year	Total	Managed	Unmanaged
1990-2003	NO	NO	NO
2004	0.1	0.0	0.1
2005	0.2	0.1	0.1
2006	0.3	0.1	0.1
2007	0.3	0.2	0.2
2008	0.4	0.2	0.2
2009	0.5	0.3	0.2
2010	0.6	0.4	0.2
2011	0.7	0.5	0.2
2012	0.8	0.6	0.2
2013	0.9	0.7	0.2
2014	1.0	0.8	0.2
2015	1.1	0.8	0.3
2016	1.2	0.9	0.3
2017	1.3	1.0	0.3

As can be seen from Table 7.22, values before 2003 were entered as "IE". The reason why those years were entered as "Included Elsewhere" is the clinical waste data were gathered by TurkStat in those years included in SWDS statistics via Municipal Waste Statistics Survey prior to 2003 because clinical waste was not collected separately before 2003. After 2003, clinical waste was collected separately by municipalities.

**Table 7.22 Annual CW and distribution of waste by management type, 1990-2017**

Year	Annual CW at the SWDS (kt)			Distribution of waste (%)	
	Total	Managed	Unmanaged	Managed	Unmanaged
1990-2002	IE	IE	IE	NA	NA
2003	48.9	14.0	34.9	28.7	71.3
2004	52.6	15.7	36.8	29.9	70.1
2005	47.7	21.1	26.6	44.3	55.7
2006	48.0	26.5	21.4	55.3	44.7
2007	51.2	32.3	18.8	63.2	36.8
2008	49.9	35.2	14.7	70.5	29.5
2009	57.1	41.6	15.5	72.9	27.1
2010	54.4	38.1	16.3	70.1	29.9
2011	58.8	44.6	14.2	75.8	24.2
2012	63.2	51.0	12.2	80.7	19.3
2013	65.1	50.8	14.3	78.1	21.9
2014	67.0	50.7	16.3	75.6	24.4
2015	67.7	52.5	15.2	77.6	22.4
2016	68.5	54.4	14.0	79.5	20.5
2017	75.3	56.3	19.0	74.8	25.2

### 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 municipal solid waste, industrial waste, sewage sludge and clinical 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. 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, Chapter3*.

Besides, in this year's submission Monte Carlo simulation is applied to waste sector entirely. The uncertainty estimate was performed by integrating the Monte Carlo simulation straight to the FOD model. According to Approach 2 (Monte Carlo method) results, the combined uncertainty range for CH<sub>4</sub> emissions from managed SWDS is -34.93% to +34.82% while for unmanaged SWDS is -46.85% to +47.31% in 2017. Detailed information is in Annex 2.

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:**

After the latest *Municipal Waste Statistics Survey* conducted by TurkStat, the results for the years 2016 and 2017 have been added to the waste composition data set. Additionally, the ERT's findings in the latest review are taken into account for the current submission. As a result of the review of the data sources, some minor revisions have been made to the waste components and the data gaps have been resolved by applying splicing techniques for the remaining years.

Waste composition data is estimated with R statistical software. So, emission estimates from Solid Waste Disposal (CRF Category 5.A) are recalculated over the 1990-2016 time series due to new comprehensive data. Besides in this submission, estimates of sewage sludge and clinical waste are included to the inventory. Also, methane recovery for energy purposes increased by 3.13 kt (1.3%) in 2016. Compared to the previous inventory submission, total CH<sub>4</sub> emissions from Solid Waste Disposal in 2016 decreased by 10 percent (1 169 kt CO<sub>2</sub> eq.).

**Planned Improvement:**

As noted above, Turkey has asked a question on flaring of landfill gas to its *Waste Disposal and Recovery Facilities Survey, 2016*. 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, 2018*) 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<sub>4</sub> and N<sub>2</sub>O 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 27% (5.2 kt CO<sub>2</sub> eq.) between 1990 (19.2 kt CO<sub>2</sub> eq.) and 2017 (14.0 kt CO<sub>2</sub> eq.).

### Methodological Issues:

To estimate both CH<sub>4</sub> and N<sub>2</sub>O emissions for composting, Turkey multiplies 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<sub>4</sub> and N<sub>2</sub>O 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.

$$CH_4 \text{ Emissions} = \sum_i (M_i \cdot EF_i) \cdot 10^{-3} - R$$

Where:

CH<sub>4</sub> Emissions = total CH<sub>4</sub> emissions in inventory year, Gg CH<sub>4</sub>

M<sub>i</sub> = mass of organic waste treated by biological treatment type i, Gg

EF = emission factor for treatment i, g CH<sub>4</sub>/kg waste treated

i = composting or anaerobic digestion

R = total amount of CH<sub>4</sub> recovered in inventory year, Gg CH<sub>4</sub>

$$N_2O \text{ Emissions} = \sum_i (M_i \cdot EF_i) \cdot 10^{-3}$$

Where:

N<sub>2</sub>O Emissions = total N<sub>2</sub>O emissions in inventory year, Gg N<sub>2</sub>O

M<sub>i</sub> = mass of organic waste treated by biological treatment type i, Gg

EF = emission factor for treatment i, g N<sub>2</sub>O/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, 2014 and 2016) are available in TurkStat's *Municipal Waste Statistics* as provided in Table 7.5. The estimations of TurkStat are also available for the years not surveyed (1999, 2000, 2005, 2007, 2009, 2011, 2013, 2015 and 2017). 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, as recommended in 2006 IPCC Guidelines, Turkey uses the "amount of waste treated by composting plants" as AD in emission estimations instead of the "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, 2014 and 2016. 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 of "fraction of waste composted" is used to estimate the amount of waste treated by composting plants for providing a complete time series. The fractions of waste composted are calculated as the "amount of waste treated by composting plants" divided by the "amount of waste delivered to composting plants" for the years of 2005, 2006, 2008, 2010, 2012, 2014 and 2016. The average value of "fraction of waste composted" is calculated as 58.4%. Due to lack of historical waste data treated by composting plants, the AD of 1994 (112.1kt) is used for 1990-1993.

As of 2015, the official data on the amount of waste treated by composting plants were started to be compiled directly from the relevant facilities. Therefore, the emission estimates made using the above-mentioned fraction are used for verification purposes only. The amount of waste composted for 2017 was compiled by official letters sent directly to four composting plants operating in 2017.

Number of composting plants in Turkey is listed below as a supplementary information.

**Table 7.23 Number of composting plants with installed capacity, 1994-2016**

<b>1994-1998</b>	<b>2006</b>	<b>2008</b>	<b>2010</b>	<b>2012</b>	<b>2014</b>	<b>2016</b>
2	4	4	5	6	4	7

Source: (1) TurkStat, Municipal Waste Statistics, 1994-2010

(2) TurkStat, Waste Disposal and Recovery Facilities Statistics, 2012-2016

In Turkey, the capacity of each facility is different and there is only one dominant facility (representing 99.9% of the composted waste for 2015, 93.0% of the composted waste for 2016 and 87.3% of the composted waste for 2017). Others are very small facilities established in different regions within the scope of several projects. The largest composting plant is located in Istanbul, which is the largest city

in terms of population of Turkey. These figures in Table 7.23 indicate the number of facilities with installed capacity in that year, and are not providing the number of facilities operating. For example, the number of composting plants in operation is 5 in 2016 actually. The number of composting plants with installed capacity is 5 in 2017, while the number of those in operation is 4 in 2017 as mentioned above. Because, one of the small plants responded that it did not compost waste in 2017.

### Choice of Emission Factor

EFs of 4.0 g CH<sub>4</sub>/kg waste treated (on a wet weight basis) and 0.24 g N<sub>2</sub>O/kg waste treated (on a wet weight basis) are selected for the estimates of CH<sub>4</sub> and N<sub>2</sub>O emissions respectively, based on *Table 4.1 in the 2006 IPCC Guidelines, Volume 5, Chapter 4*.

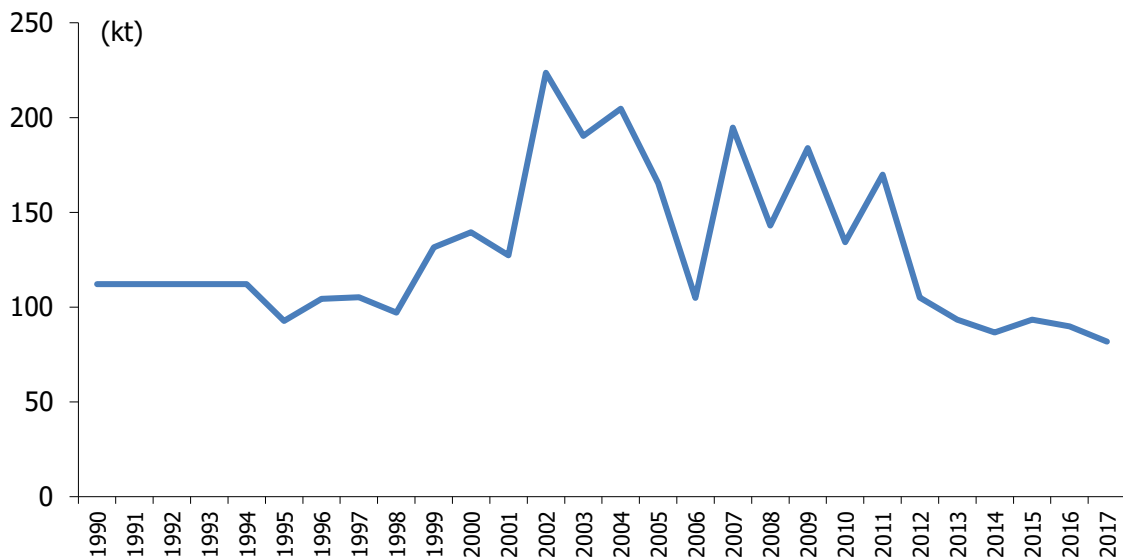
The total annual amount of waste treated (as wet weight) by composting plants and emissions from composting are provided in Table 7.24.

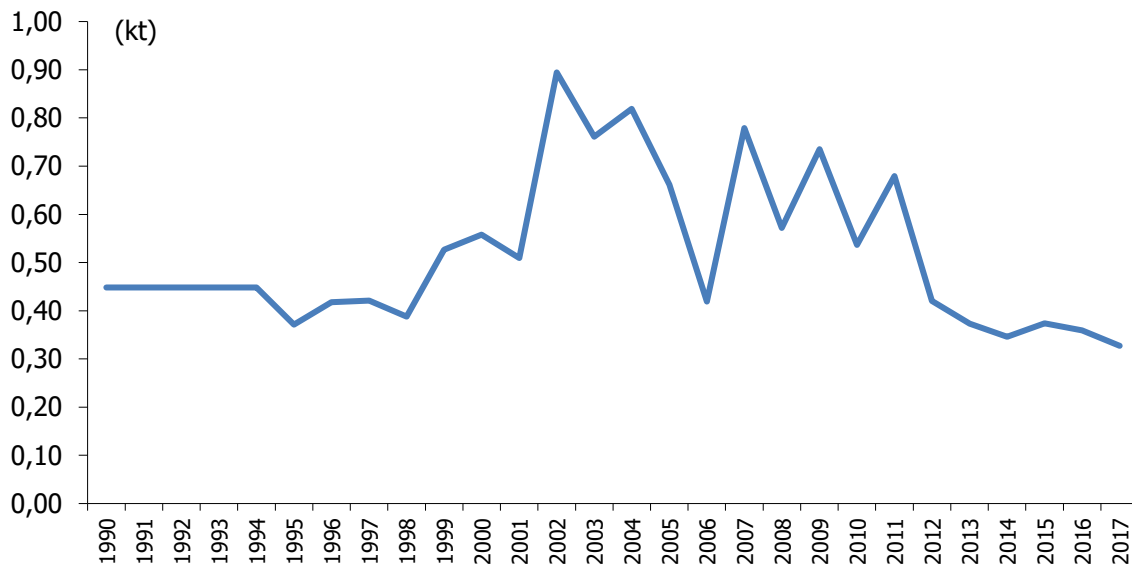
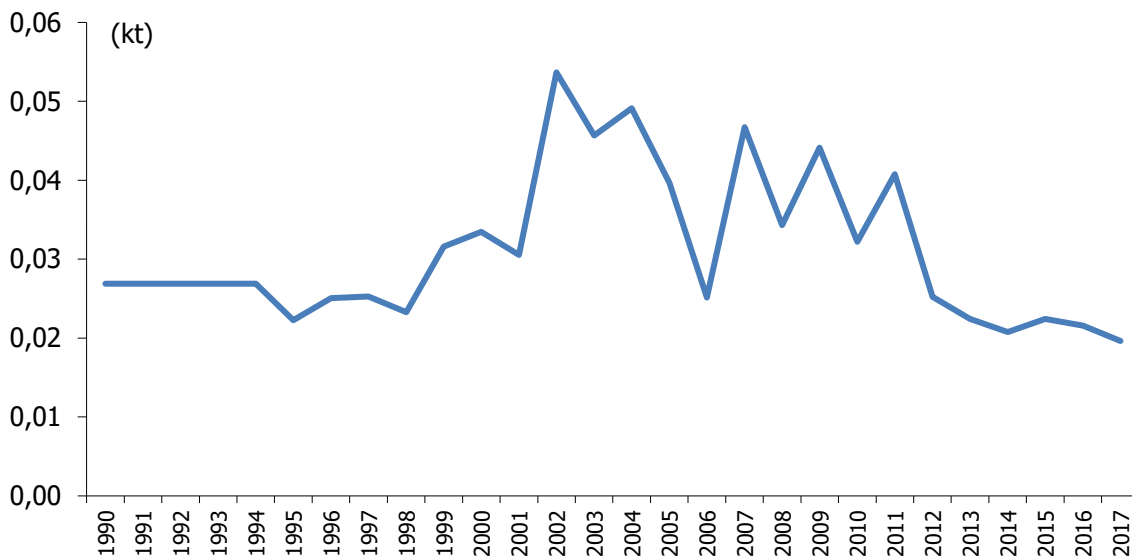
**Table 7.24 Activity data, CH<sub>4</sub> and N<sub>2</sub>O emissions from composting, 1990-2017 (kt)**

Year	Amount of waste treated by composting plants	CH <sub>4</sub> Emissions	N <sub>2</sub> O Emissions
1990-94	112.1	0.45	0.027
1995	92.8	0.37	0.022
1996	104.4	0.42	0.025
1997	105.3	0.42	0.025
1998	97.0	0.39	0.023
1999	131.6	0.53	0.032
2000	139.5	0.56	0.033
2001	127.3	0.51	0.031
2002	223.6	0.89	0.054
2003	190.2	0.76	0.046
2004	204.7	0.82	0.049
2005	165.4	0.66	0.040
2006	104.8	0.42	0.025
2007	194.7	0.78	0.047
2008	143.0	0.57	0.034
2009	183.9	0.74	0.044
2010	134.2	0.54	0.032
2011	169.9	0.68	0.041
2012	105.1	0.42	0.025
2013	93.4	0.37	0.022
2014	86.6	0.35	0.021
2015	93.4	0.37	0.022
2016	89.9	0.36	0.022
2017	81.8	0.33	0.020

As seen in Figure 7.3, Figure 7.4 and Figure 7.5, the fluctuations of CH<sub>4</sub> and N<sub>2</sub>O emissions from composting depend mainly on the fluctuations of the amount of waste treated by composting plants (AD). The reasons for fluctuations in AD observed specifically between 2001 and 2013 could be explained by different capacities of the facilities and having one dominant facility in Turkey. In addition, the AD was verified by the statistical data on the amount of waste delivered to composting plants for the each corresponding year according to the TurkStat's *Municipal Waste Statistics*. Emissions were relatively stable between 1990 and 1999, before demonstrating larger interannual fluctuations in recent years. CH<sub>4</sub> emissions have a maximum value of 0.89 kt in 2002 while having a minimum value of 0.33 kt in 2017. Likewise, N<sub>2</sub>O emissions have a maximum value of 0.054 kt in 2002 while having a minimum value of 0.020 kt in 2017.

**Figure 7.3 Amount of waste treated by composting plants, 1990-2017**



**Figure 7.4 CH<sub>4</sub> emissions from composting, 1990-2017****Figure 7.5 N<sub>2</sub>O emissions from composting, 1990-2017****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<sub>4</sub> and N<sub>2</sub>O EFs since there is no sufficient information in 2006 IPCC.



The Biological treatment of solid waste category employed a Monte Carlo uncertainty analysis which causes a combined uncertainty range  $\pm 22.2\%$  for CH<sub>4</sub> emissions and +50% for N<sub>2</sub>O emissions. Detailed explanation of Approach 2 method is in Uncertainty part of this inventory report (Annex 2).

The estimates are calculated in a consistent manner over time series.

### Source-Specific QA/QC and Verification:

QA/QC procedures implemented for each category in order to verify and improve the inventory under the Turkey's QA/QC plan.

The data used in Biological Treatment of Solid Waste (CRF Category 5.B) are derived from waste statistics database of TurkStat. TurkStat is producing all its statistics according to the European Code of Practice Principles. Therefore, high quality data are used in the emission estimates of this category.

### Recalculation:

There is no recalculation in this subsector.

### Planned Improvement:

Emissions and amount of CH<sub>4</sub> 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<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O 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<sub>2</sub> emissions from waste of biogenic origin are reported but not counted as part of the national total GHG emissions. Unlike CO<sub>2</sub>, emissions of CH<sub>4</sub> and N<sub>2</sub>O 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 96.3% (101.3 kt CO<sub>2</sub> eq.) between 1990 to 2017, including an increase of 0.08 kt between 2016 and 2017. The main reason of this negative 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<sub>2</sub> 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<sub>4</sub> and N<sub>2</sub>O emissions, IPCC default emission factors are multiplied by the amount of waste open-burned (the IPCC T1 method in the 2006 IPCC Guidelines).

### CO<sub>2</sub> Emissions

The CO<sub>2</sub> 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*.

$$CO_2 \text{ Emissions} = MSW \cdot \sum_j (WF_j \cdot dm_j \cdot CF_j \cdot FCF_j \cdot OF_j) \cdot 44/12$$

Where:

CO<sub>2</sub> Emissions = CO<sub>2</sub> emissions in inventory year, Gg/yr

MSW = total amount of municipal solid waste as wet weight open-burned, Gg/yr

WF<sub>j</sub> = fraction of waste type/material of component j in the MSW (as wet weight open-burned)

dm<sub>j</sub> = 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)

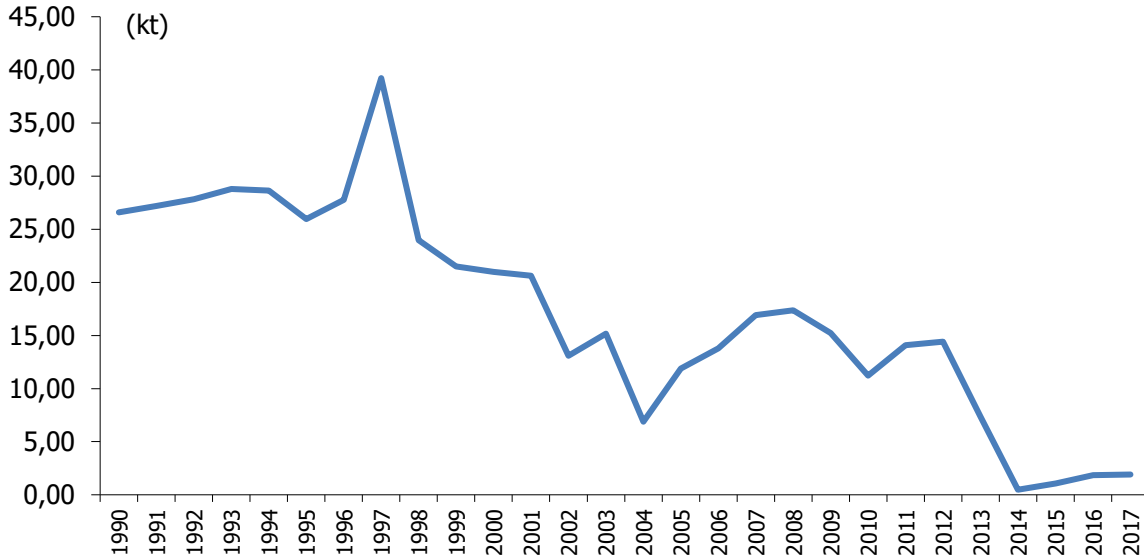
44/12 = conversion factor from C to CO<sub>2</sub>

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<sub>2</sub> 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 7.25. Total CO<sub>2</sub> emissions from open burning fluctuate between 1990-2017 as shown in Figure 7.6.

**Table 7.25 CO<sub>2</sub> emissions from open burning of waste, 1990-2017**  
(kt)

Year	Total	Biogenic	Non-biogenic
1990	26.59	0.288	26.59
1991	27.18	0.281	27.18
1992	27.81	0.271	27.81
1993	28.78	0.230	28.78
1994	28.64	0.285	28.64
1995	25.96	0.285	25.96
1996	27.77	0.334	27.77
1997	39.22	0.514	39.22
1998	23.97	0.340	23.97
1999	21.51	0.329	21.51
2000	20.98	0.345	20.98
2001	20.62	0.363	20.62
2002	13.09	0.246	13.09
2003	15.17	0.303	15.17
2004	6.90	0.128	6.90
2005	11.87	0.235	11.87
2006	13.80	0.347	13.80
2007	16.91	0.320	16.91
2008	17.38	0.287	17.38
2009	15.24	0.220	15.24
2010	11.21	0.142	11.21
2011	14.09	0.123	14.09
2012	14.42	0.088	14.42
2013	7.37	0.045	7.37
2014	0.48	0.003	0.48
2015	1.07	0.006	1.07
2016	1.84	0.011	1.84
2017	1.91	0.011	1.91

**Figure 7.6 CO<sub>2</sub> emissions from open burning of waste, 1990-2017**

#### CH<sub>4</sub> Emissions

The calculation of CH<sub>4</sub> 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*.

$$CH_4 \text{ Emissions} = \sum_i (IW_i \cdot EF_i) \cdot 10^{-6}$$

Where:

CH<sub>4</sub> Emissions = CH<sub>4</sub> emissions in inventory year, Gg/yr

IW<sub>i</sub> = amount of solid waste of type i open-burned, Gg/yr

EF<sub>i</sub> = aggregate CH<sub>4</sub> emission factor, kg CH<sub>4</sub>/Gg of waste

10<sup>-6</sup> = conversion factor from kilogram to gigagram

i = category or type of waste open-burned, specified as follows:

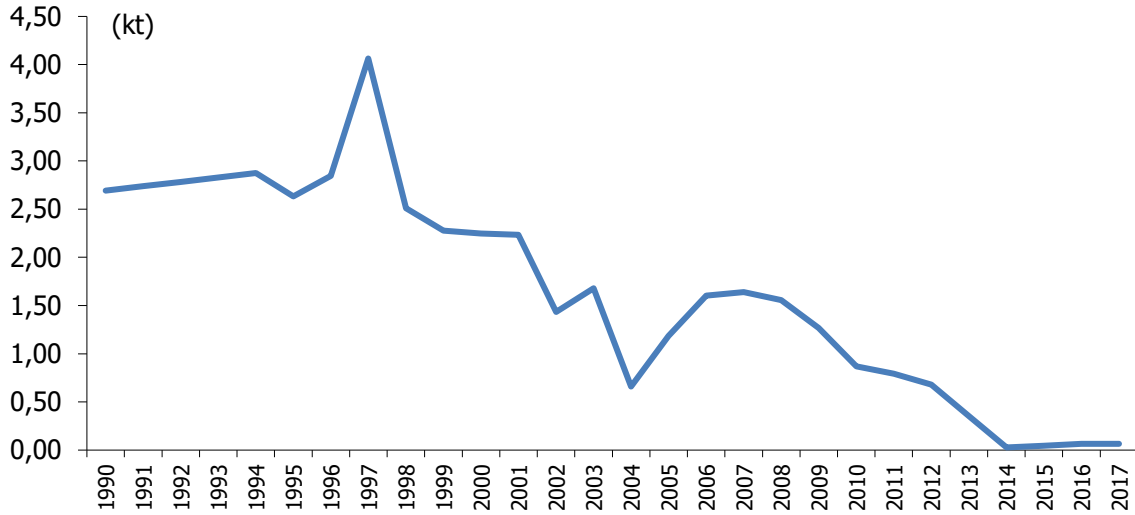
MSW: municipal solid waste, ISW: industrial solid waste, HW: hazardous waste,

CW: clinical waste, SS: sewage sludge, others (that must be specified)

Estimated results of CH<sub>4</sub> emissions are given in Table 7.26 and Figure 7.7. The CH<sub>4</sub> emissions show a decreasing trend with the same fluctuations as with AD between 1990 and 2017 as can be seen in Figure 7.9 below.

**Table 7.26 CH<sub>4</sub> emissions from open burning of waste, 1990-2017**  
(kt)

<b>Year</b>	<b>Total</b>	<b>Biogenic</b>	<b>Non-biogenic</b>
1990	2.69	1.81	0.88
1991	2.74	1.85	0.89
1992	2.78	1.90	0.88
1993	2.83	1.98	0.85
1994	2.87	1.95	0.92
1995	2.63	1.76	0.87
1996	2.85	1.88	0.97
1997	4.06	2.64	1.42
1998	2.51	1.61	0.90
1999	2.28	1.43	0.84
2000	2.25	1.39	0.85
2001	2.23	1.36	0.87
2002	1.43	0.86	0.57
2003	1.68	0.99	0.69
2004	0.66	0.38	0.29
2005	1.18	0.67	0.52
2006	1.60	0.88	0.72
2007	1.64	0.93	0.71
2008	1.56	0.90	0.66
2009	1.27	0.74	0.53
2010	0.87	0.52	0.35
2011	0.79	0.51	0.29
2012	0.68	0.46	0.22
2013	0.36	0.24	0.12
2014	0.03	0.02	0.01
2015	0.04	0.03	0.01
2016	0.07	0.05	0.02
2017	0.07	0.05	0.02

**Figure 7.7 CH<sub>4</sub> emissions from open burning of waste, 1990-2017**

### N<sub>2</sub>O Emissions

The calculation of N<sub>2</sub>O 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*.

$$N_2O \text{ Emissions} = \sum_i (IW_i \cdot EF_i) \cdot 10^{-6}$$

Where:

N<sub>2</sub>O Emissions = N<sub>2</sub>O emissions in inventory year, Gg/yr

IW<sub>i</sub> = amount of open-burned waste of type i , Gg/yr

EF<sub>i</sub> = N<sub>2</sub>O emission factor (kg N<sub>2</sub>O/Gg of waste) for waste of type i

10<sup>-6</sup> = conversion from kilogram to gigagram

i = category or type of waste open-burned, specified as follows:

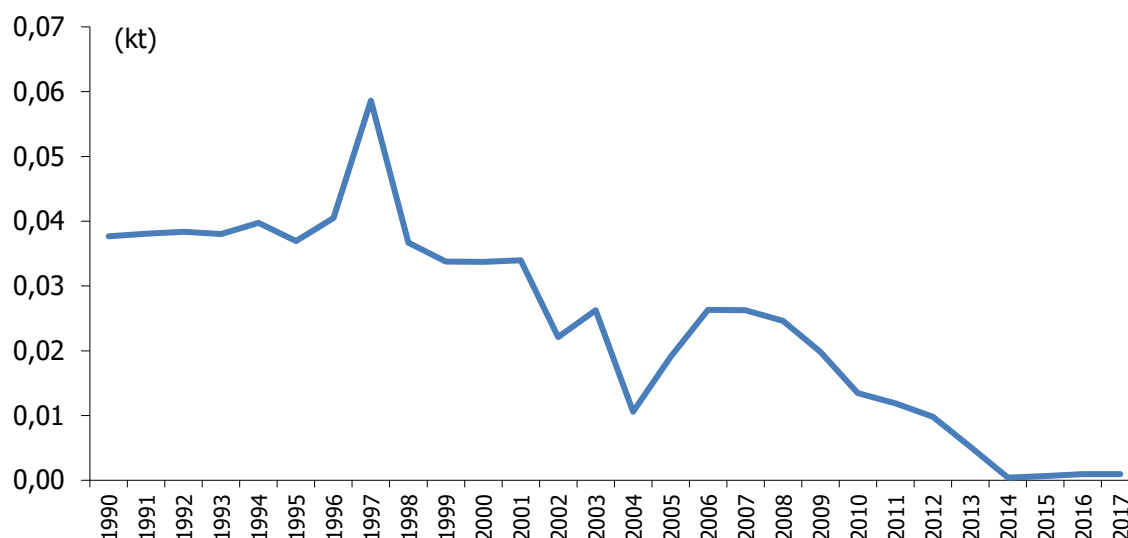
MSW: municipal solid waste, ISW: industrial solid waste, HW: hazardous waste,

CW: clinical waste, SS: sewage sludge, others (that must be specified)

Estimated results of N<sub>2</sub>O emissions from open burning of waste are given in Table 7.27 and Figure 7.8. As with CH<sub>4</sub> emissions, N<sub>2</sub>O emissions have a decreasing trend with the same fluctuations as of AD between 1990 and 2017 as can be seen in Figure 7.9 below.

Table 7.27 N<sub>2</sub>O emissions from open burning of waste, 1990-2017

(kt)			
Year	Total	Biogenic	Non-biogenic
1990	0.0377	0.0191	0.0185
1991	0.0381	0.0195	0.0186
1992	0.0384	0.0198	0.0185
1993	0.0380	0.0202	0.0178
1994	0.0397	0.0205	0.0193
1995	0.0369	0.0187	0.0182
1996	0.0405	0.0202	0.0203
1997	0.0586	0.0288	0.0299
1998	0.0367	0.0177	0.0190
1999	0.0337	0.0160	0.0177
2000	0.0337	0.0158	0.0179
2001	0.0340	0.0157	0.0183
2002	0.0221	0.0100	0.0121
2003	0.0262	0.0117	0.0145
2004	0.0106	0.0046	0.0060
2005	0.0190	0.0082	0.0109
2006	0.0263	0.0111	0.0152
2007	0.0263	0.0113	0.0150
2008	0.0246	0.0107	0.0139
2009	0.0198	0.0087	0.0111
2010	0.0135	0.0060	0.0075
2011	0.0119	0.0057	0.0062
2012	0.0098	0.0050	0.0048
2013	0.0051	0.0026	0.0026
2014	0.0004	0.0002	0.0002
2015	0.0006	0.0003	0.0003
2016	0.0009	0.0005	0.0004
2017	0.0010	0.0005	0.0004

**Figure 7.8 N<sub>2</sub>O emissions from open burning of waste, 1990-2017**

### Collection of Activity Data

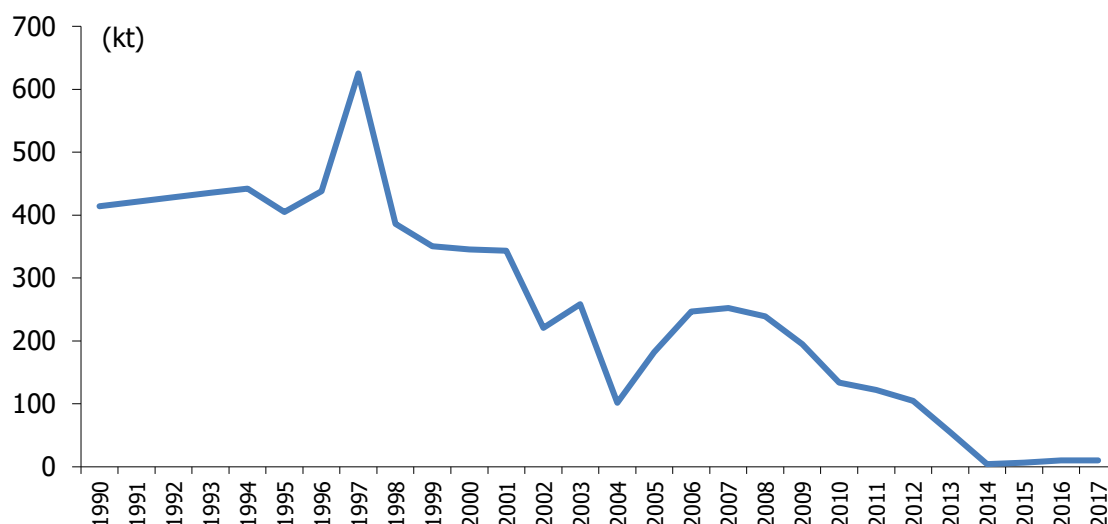
Activity data for open burning of MSW are estimated using the total amount of MSW open-burned (1994-1998, 2001-2004, 2006, 2008, 2010, 2012, 2014 and 2016) as obtained from TurkStat's *Municipal Waste Statistics Survey* as given in Table 7.5 and applying an estimate of the composition of MSW.

To calculate the total amount of MSW open-burned for the years not surveyed (1999, 2000, 2005, 2007, 2009, 2011, 2013, 2015 and 2017) 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 and 2015 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. As a result, the total amount of MSW open-burned is calculated for the entire time-series and provided in Table 7.28 and Figure 7.9.



**Table 7.28 The fraction and amount of MSW open-burned, 1990-2017**

<b>Year</b>	<b>Fraction of MSW open-burned (%)</b>	<b>Amount of MSW open-burned (kt)</b>
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	0.02	6.86
2016	0.03	10.17
2017	0.03	10.17

**Figure 7.9 Total amount of MSW open-burned, 1990-2017**

Country-specific values on the total waste amount (Table 7.28) and the waste fraction for each component for MSW are needed to apply Tier 2a. To calculate the country-specific waste fraction, updated time series of MSW composition data (see Table 7.10) are used as given in Table 7.29. Default dry matter content, total carbon content and fossil carbon fraction of different MSW components are given in Table 7.30 which is based on *Table 2.4 in the 2006 IPCC Guidelines, Volume 5, Chapter 2*.

**Table 7.29 MSW composition data by type of origin, 1990-2017**

		(%)									
MSW Component	Origin	1990	1991	1992	1993 <sup>(1)</sup>	1994	1995	1996	1997	1998	
Paper/cardboard	Biogenic	7.9	7.6	7.2	6.0	7.3	8.0	8.7	9.3	10.0	
Textiles	Non-biogenic	3.8	3.8	3.9	4.0	3.9	3.8	3.7	3.7	3.6	
Food waste	Biogenic	58.3	59.3	60.5	64.0	60.0	58.0	56.0	54.0	52.0	
Garden and park waste	Biogenic	1.0	0.8	0.6	0.0	0.7	1.0	1.3	1.7	2.0	
Plastics	Non-biogenic	2.8	2.8	2.9	3.0	2.9	2.8	2.7	2.7	2.6	
Metal	Non-biogenic	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Glass	Non-biogenic	2.8	2.6	2.5	2.0	2.5	2.8	3.1	3.3	3.6	
Other, inert waste	Non-biogenic	22.5	22.1	21.5	20.0	21.7	22.6	23.5	24.3	25.2	

(1) TurkStat, Environmental Statistics, Household Solid Waste Composition and Tendency Survey Results, 1993

**Table 7.29 MSW composition data by type of origin, 1990-2017 (Cont.)**

(%)

MSW Component	Origin	1999	2000	2001	2002	2003	2004	2005	2006 <sup>(2)</sup>	2007
Paper/cardboard	Biogenic	10.7	11.3	12.0	12.7	13.3	14.3	14.7	16.0	14.4
Textiles	Non-biogenic	3.5	3.5	3.4	3.3	3.3	3.0	3.0	3.0	3.0
Food waste	Biogenic	50.0	48.0	46.0	44.0	42.0	37.2	36.5	34.0	36.9
Garden and park waste	Biogenic	2.3	2.7	3.0	3.3	3.7	5.4	5.3	5.0	5.4
Plastics	Non-biogenic	2.5	2.5	2.4	2.3	2.3	2.8	2.6	2.0	2.8
Metal	Non-biogenic	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.0	1.1
Glass	Non-biogenic	3.9	4.1	4.4	4.7	4.9	5.4	5.6	6.0	5.5
Other, inert waste	Non-biogenic	26.1	26.9	27.8	28.7	29.5	30.8	31.3	33.0	31.0

(2) MoEF, Waste Management Action Plan, 2008-2012

**Table 7.29 MSW composition data by type of origin, 1990-2017 (Cont.)**

(%)

MSW Component	Origin	2008	2009	2010	2011	2012	2013	2014 <sup>(3)</sup>	2015	2016 <sup>(4)</sup>	2017 <sup>(5)</sup>
Paper/cardboard	Biogenic	13.6	12.8	12.1	11.4	9.5	9.4	8.1	10.5	11.9	11.9
Textiles	Non-biogenic	3.0	3.0	3.0	2.1	1.8	1.9	2.9	1.1	0.0	0.0
Food waste	Biogenic	38.4	39.9	41.4	46.3	51.1	50.8	48.7	52.4	55.1	53.8
Garden and park waste	Biogenic	5.6	5.7	5.9	6.0	6.4	6.5	6.8	5.7	5.7	3.9
Plastics	Non-biogenic	3.2	3.5	3.9	6.2	7.8	7.6	5.9	9.2	11.0	11.4
Metal	Non-biogenic	1.1	1.1	1.2	1.5	1.7	1.7	1.4	1.9	2.3	2.3
Glass	Non-biogenic	5.2	5.0	4.7	4.5	3.9	3.8	3.4	4.3	4.7	5.2
Other, inert waste	Non-biogenic	30.0	28.9	27.9	21.9	17.8	18.3	22.8	14.9	9.3	11.5

(3) MoEU, National Waste Management and Action Plan, 2016-2023

(4), (5) TurkStat, Municipal Waste Statistics Survey Results

**Table 7.30 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
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*. All different waste fractions (WF) are given in Table 7.29 and the fractions of carbon content given in Table 7.30 above are used related to CO<sub>2</sub> 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<sub>4</sub> emissions from open burning of waste are estimated using an EF of 6500 g CH<sub>4</sub> / 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<sub>2</sub>O emissions from open burning of waste are estimated using an EF of 150 g N<sub>2</sub>O / 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<sub>2</sub> EF is considered as 40.0%. Since default values for CH<sub>4</sub> and N<sub>2</sub>O EFs are used, the uncertainty values of  $\pm 100\%$  are estimated for both EFs as recommended in the *2006 IPCC Guidelines, Volume 5, Chapter 5, Section 5.7.1*.

An uncertainty analysis using the Monte Carlo technique was carried out to estimate emissions of CO<sub>2</sub> for 5.C category and also to other waste categories in this inventory year. Combined uncertainty in CO<sub>2</sub> emissions in 2017 is estimated at  $\pm 41.88\%$ , CH<sub>4</sub> emissions is estimated as  $-85.71\%$  to  $+114.29\%$  and in N<sub>2</sub>O emissions is estimated as  $-72.73\%$  to  $+100\%$ . Further information is given in Uncertainty part at the end of this inventory report (Annex 2).

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:

Due to the updated time series of waste composition data, Incineration and Open Burning of Waste (CRF Category 5.C) has also been affected by the updated component. In addition, garden and park waste was mistakenly considered as non-biologic in the previous submission. With the ERT's pointing out this matter, that minor mistake was corrected and the garden and park waste was considered as biogenic by this submission. Therefore, GHG emissions for the entire time series have been recalculated accordingly. For all three gases, there has been a slight change in almost all years because of the change in waste composition data.

Compared to previous inventory submission; in 2016, CO<sub>2</sub> increased by 62.35% (0.71 kt CO<sub>2</sub> eq.) and N<sub>2</sub>O decreased by 0.25% (0.0007 kt CO<sub>2</sub> eq.), while there is no recalculation for CH<sub>4</sub>. In 1990, CO<sub>2</sub> decreased by 2.93% (0.80 kt) and N<sub>2</sub>O increased by 4.22% (0.45 kt CO<sub>2</sub> eq.), while there is a negligible recalculation for CH<sub>4</sub>.

### Planned Improvement:

There are no planned improvements in this category.

## 7.5. Wastewater Treatment and Discharge (Category 5.D)

### Source Category Description:

This category includes CH<sub>4</sub> and N<sub>2</sub>O 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 sewerage to plants. For uncollected systems; septic system is considered as treated and sea, river and lake discharge as untreated practices in Turkey.

CH<sub>4</sub> emissions are estimated for both domestic wastewater (5.D.1) and industrial wastewater (5.D.2). N<sub>2</sub>O emissions from 5.D.2 are also reported in 5.D.1.

Wastewater treatment and discharge emissions increased by 95.2% (4 028.1 kt CO<sub>2</sub> eq.) for the period 1990-2017, also increased by 4.4% (349 kt CO<sub>2</sub> eq.) between 2016 and 2017. Methane recovery in domestic wastewater treatment increased by 633% (868.6 kt CO<sub>2</sub> eq.) between 1998 (137.2 kt CO<sub>2</sub> eq.) and 2017 (1005.9 kt CO<sub>2</sub> 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<sub>4</sub> emissions from domestic wastewater. CH<sub>4</sub> emissions are estimated using *Equation 6.1 in the 2006 IPCC Guidelines, Volume 5, Chapter 6*.

$$CH_4 \text{ Emissions} = \left[ \sum_{i,j} (U_i \cdot T_{i,j} \cdot EF_j) \right] (TOW - S) - R$$

Where:

$\text{CH}_4$  Emissions =  $\text{CH}_4$  emissions in inventory year, kg  $\text{CH}_4/\text{yr}$

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 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  $\text{CH}_4$  / kg BOD

R = amount of  $\text{CH}_4$  recovered in inventory year, kg  $\text{CH}_4/\text{yr}$

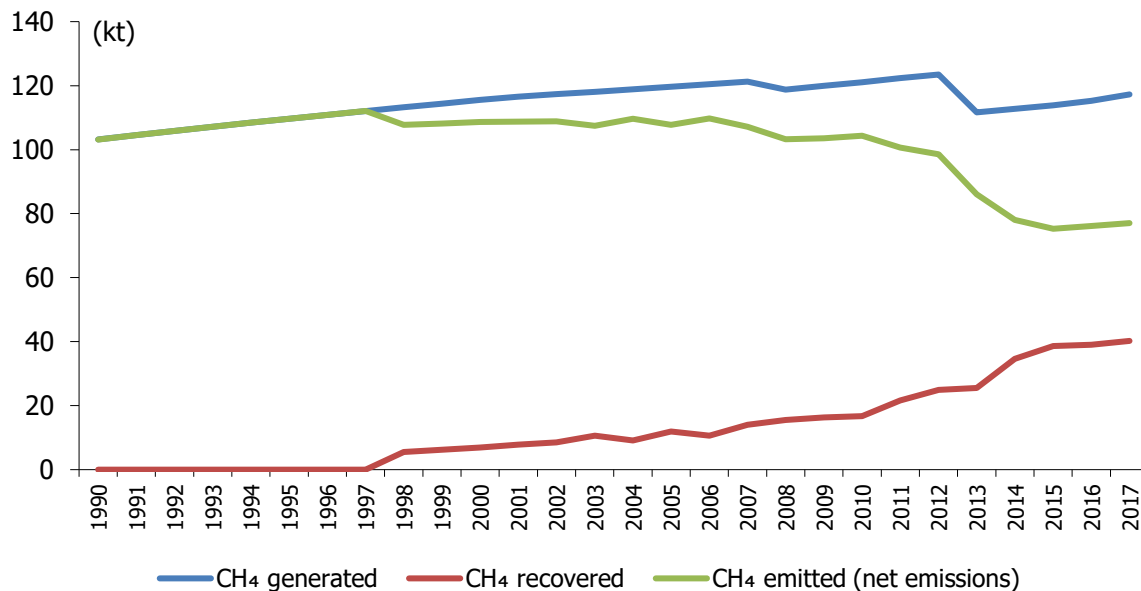
Total  $\text{CH}_4$  emissions are estimated based on country-specific information on the total organics in wastewater minus the total amount of sludge and multiplying by the IPCC default emission factor, corrected for country-specific fractions of urban/rural populations and the fraction of the wastewater utilizing the various discharge pathways. The amount of methane generated, methane recovered and net methane emissions are estimated as given in Table 7.31 and Figure 7.10.

**Table 7.31 CH<sub>4</sub> generated, recovered and emitted from domestic wastewater, 1990-2017**

<b>(kt)</b>			
<b>Year</b>	<b>CH<sub>4</sub> Generated</b>	<b>CH<sub>4</sub> Recovered</b>	<b>CH<sub>4</sub> Emitted</b>
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	21.7	100.7
2012	123.5	25.0	98.5
2013	111.6	25.5	86.1
2014	112.7	34.7	78.1
2015	113.9	38.6	75.3
2016	115.2	39.1	76.2
2017	117.3	40.2	77.0



**Figure 7.10 CH<sub>4</sub> emissions from domestic wastewater, 1990-2017**



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<sub>4</sub> 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*.

$$TOW = P \cdot BOD \cdot 0.001 \cdot I \cdot 365$$

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 2017 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 7.32.

**Table 7.32 Fraction of population and total, rural, urban population, 1990-2017**

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
2016	7.7	92.3	79 278 000	6 101 802	73 176 198
2017	7.5	92.5	80 810 525	6 049 393	74 761 132

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, 92.1% in 2015, 92.3% in 2016, and 92.5% in 2017 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 7.33.

**Table 7.33 Total organics in wastewater (TOW) and organic component removed as sludge (S) for domestic wastewater, 1990-2017**

Year	(kt BOD/yr)	
	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
2016	1 533.6	810.2
2017	1 563.3	825.9

### Choice of Emission Factor

As given in *Equation 6.2 in the 2006 IPCC Guidelines, Volume 5, Chapter 6*, CH<sub>4</sub> EFs for each domestic wastewater treatment/discharge pathway or system are calculated by multiplying the default maximum CH<sub>4</sub> producing capacity (B<sub>0</sub>) for domestic wastewater (0.6 kg CH<sub>4</sub>/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*.

$$EF_j = B_o \cdot MCF_j$$

Where:

EF<sub>j</sub> = emission factor, kg CH<sub>4</sub>/kg BOD

j = each treatment/discharge pathway or system

B<sub>0</sub> = maximum CH<sub>4</sub> producing capacity, kg CH<sub>4</sub>/kg BOD

MCF<sub>j</sub> = 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 7.34.

**Table 7.34 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<sub>4</sub> EFs are calculated using CH<sub>4</sub> EFs by each type of treatment and discharge pathway or system and the fractional usage of different treatment systems by population class. Weighted CH<sub>4</sub> EFs for domestic wastewater with background data are given in Table 7.35.

**Table 7.35 MCF, EFs, utilization degrees and weighted EFs by population class**

<b>Type of treatment and discharge path way or system</b>	<b>MCF</b>	<b>CH<sub>4</sub> EF</b>	<b>T (Rural)</b>	<b>T (Urban)</b>
<b>Untreated system</b>				
Sea, river, lake discharge	0.10	0.06	0.0043	0.1543
<b>Treated system</b>				
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
<b>Total</b>			<b>0.12</b>	<b>0.88</b>
<b>Weighted CH<sub>4</sub> EFs (kg CH<sub>4</sub>/kg BOD)</b>			<b>0.29</b>	<b>0.15</b>

### 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 is 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, 2016*) etc. The emissions of energy production from the recovered CH<sub>4</sub> gas in biogas facilities were included in the category of Public Electricity and Heat Production (1.A.1.a).

The number of biogas facilities and the amount of recovered methane by year are given in Table 7.36.

**Table 7.36 Methane recovery, 1990-2017**

Year	Number of biogas facilities	Recovered methane (kt)
1990-97	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	13	21.7
2012	14	25.0
2013	18	25.5
2014	19	34.7
2015	20	38.6
2016	23	39.1
2017	23	40.2

### Methane Emissions from Industrial Wastewater

This section deals with estimating CH<sub>4</sub> emissions from on-site industrial wastewater treatment. The IPCC T2 method of the 2006 IPCC Guidelines is applied to estimate CH<sub>4</sub> emissions from industrial wastewater. CH<sub>4</sub> emissions are estimated using *Equation 6.4 in the 2006 IPCC Guidelines, Volume 5, Chapter 6*.

$$CH_4 \text{ Emissions} = \sum_i [(TOW_i - S_i) EF_i - R_i]$$

Where:

CH<sub>4</sub> Emissions = CH<sub>4</sub> emissions in inventory year, kg CH<sub>4</sub>/yr

TOW<sub>i</sub> = total organically degradable material in wastewater from industry i in inventory year, kg COD/yr

i = industrial sector

S<sub>i</sub> = organic component removed as sludge in inventory year, kg COD/yr

$EF_i$  = emission factor for industry  $i$ , kg CH<sub>4</sub>/kg COD

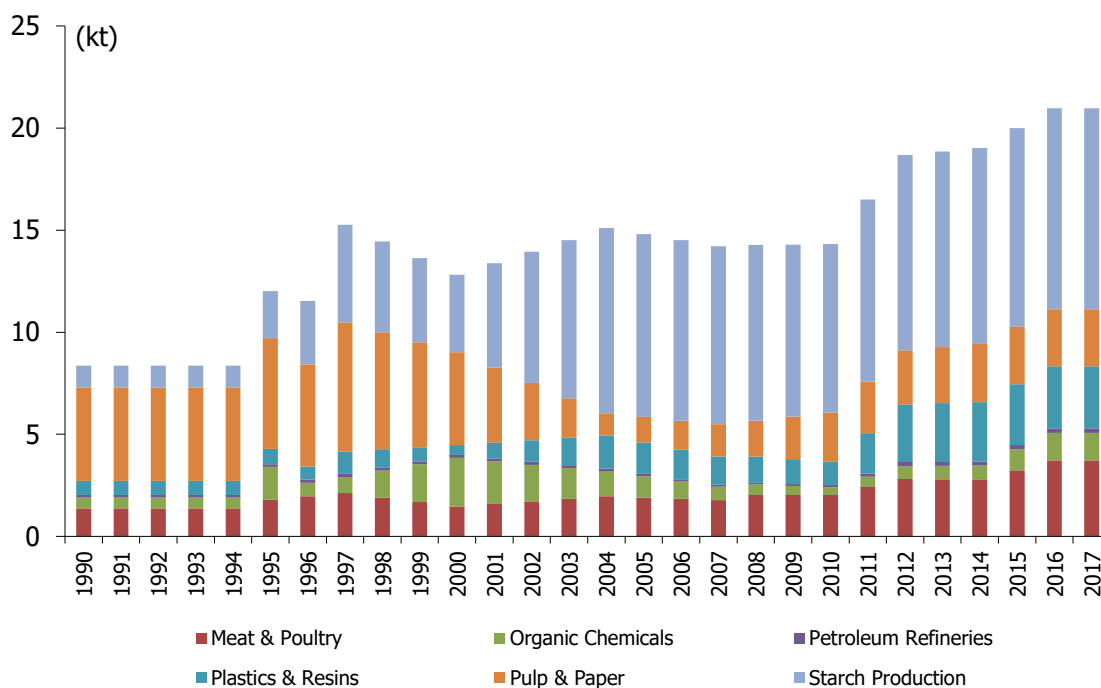
for treatment/discharge pathway or system(s) used in inventory year

$R_i$  = amount of CH<sub>4</sub> recovered in inventory year, kg CH<sub>4</sub>/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 7.37 and Figure 7.11.

**Table 7.37 CH<sub>4</sub> emissions from industrial wastewater by sector, 1990-2017**

							(kt)
Year	Total	Meat & poultry	Organic chemicals	Petroleum refineries	Plastics & resins	Pulp & paper (combined)	Starch production
1990-94	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	20.00	3.24	1.03	0.20	2.98	2.82	9.72
2016	20.97	3.72	1.34	0.22	3.05	2.79	9.84
2017	20.97	3.72	1.34	0.22	3.05	2.79	9.84

**Figure 7.11 CH<sub>4</sub> emissions from industrial wastewater, 1990-2017**

### Collection of Activity Data

To calculate CH<sub>4</sub> emissions from industrial wastewater, total organically degradable material in wastewater for each industry (TOW<sub>i</sub>) is used as AD and calculated by applying *Equation 6.6 in the 2006 IPCC Guidelines, Volume 5, Chapter 6*.

$$TOW_i = P_i \cdot W_i \cdot COD_i$$

Where:

TOW<sub>i</sub> = total organically degradable material in wastewater for industry i, kg COD/yr

i = industrial sector

P<sub>i</sub> = total industrial product for industrial sector i, t/yr

W<sub>i</sub> = wastewater generated, m<sup>3</sup>/t<sub>product</sub>

COD<sub>i</sub> = chemical oxygen demand (industrial degradable organic component in wastewater), kg COD/m<sup>3</sup>



Organic component removed as sludge (S) is assumed to be 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, 2014 and 2016. Missing data for the years not surveyed (1998, 1999, 2001-2003, 2005-2007, 2009, 2011, 2013 and 2015) are estimated by linear interpolation. In the current inventory, TOW<sub>i</sub> and emissions for 2017 were assumed the same as in 2016 due to the lack of data.

The amount of industrial wastewater treated by industrial sectors are given in Table 7.38.

**Table 7.38 Amount of industrial wastewater discharged by sector, 1990-2017**

(thousand m <sup>3</sup> /yr)							
Year	Total	Meat & poultry	Organic chemicals	Petroleum refineries	Plastics & resins	Pulp & paper (combined)	Starch production
1990-94	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	264 574	61 040	26 429	15 670	62 250	24 180	75 005
2016	285 035	70 059	34 516	16 887	63 655	23 961	75 956
2017	285 035	70 059	34 516	16 887	63 655	23 961	75 956

TOW<sub>i</sub> is calculated by applying COD values for each industrial sector as given in Table 7.39, that are based on *Table 6.9 in the 2006 IPCC Guidelines, Volume 5, Chapter 6* and the results are given in Table 7.40.

**Table 7.39 COD values by industry type**

Industry type	COD (kg/m <sup>3</sup> )
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 7.40 TOW<sub>i</sub> in wastewater by industry sector, 1990-2017****(kt COD/yr)**

Year	Total	Meat & poultry	Organic chemicals	Petroleum refineries	Plastics & resins	Pulp & paper (combined)	Starch production
1990-94	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	1 543.2	250.3	79.3	15.7	230.3	217.6	750.1
2016	1 618.4	287.2	103.5	16.9	235.5	215.7	759.6
2017	1 618.4	287.2	103.5	16.9	235.5	215.7	759.6

### Choice of Emission Factor

As given in *Equation 6.5 in the 2006 IPCC Guidelines, Volume 5, Chapter 6*, CH<sub>4</sub>EFs for each industrial wastewater treatment/discharge pathway or system are calculated by multiplying the default maximum CH<sub>4</sub> producing capacity (B<sub>0</sub>) for industrial wastewater (0.25 kg CH<sub>4</sub>/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.* ,

$$EF_j = B_o \cdot MCF_j$$

Where:

$EF_j$  = emission factor for each treatment/discharge pathway or system, kg CH<sub>4</sub>/kg COD,

$j$  = each treatment/discharge pathway or system

$B_o$  = maximum CH<sub>4</sub> producing capacity, kg CH<sub>4</sub>/kg COD

$MCF_j$  = methane correction factor (fraction)

Weighted CH<sub>4</sub> EFs are calculated by multiplying CH<sub>4</sub> EFs for each type of treatment and discharge pathway or system and fractional usage of the different treatment systems. Weighted CH<sub>4</sub> EF for industrial wastewater with background data are given in Table 7.41.

**Table 7.41 MCF, EFs, fractional usages and weighted EF for industrial wastewater**

Type of treatment and discharge pathway or system	MCF	CH <sub>4</sub> EF	Fractional usage
<b>Untreated system</b>			
Sea, river, lake discharge	0.10	0.03	0.173
<b>Treated system</b>			
Aerobic treatment plant, well managed	0.00	0.00	0.668
Aerobic treatment plant, not wellmanaged	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
<b>Total</b>			<b>1.00</b>
<b>Weighted CH<sub>4</sub> EF (kg CH<sub>4</sub>/kg COD)</b>			<b>0.01</b>

### Nitrous Oxide Emissions from Wastewater

Turkey applies the default method from the 2006 IPCC Guidelines to estimate N<sub>2</sub>O emissions from domestic wastewater. N<sub>2</sub>O emissions from domestic wastewater effluent are estimated using *Equation 6.7 in the 2006 IPCC Guidelines, Volume 5, Chapter 6*. Specifically, N<sub>2</sub>O emissions are assumed to equal the amount of nitrogen discharged to aquatic environments, multiplied by an emission factor.

$$N_2O \text{ Emissions} = N_{EFFLUENT} \cdot EF_{EFFLUENT} \cdot 44/28$$

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*.

$$N_2O_{PLANTS} = P \cdot T_{PLANT} \cdot F_{IND-COM} \cdot EF_{PLANT}$$

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

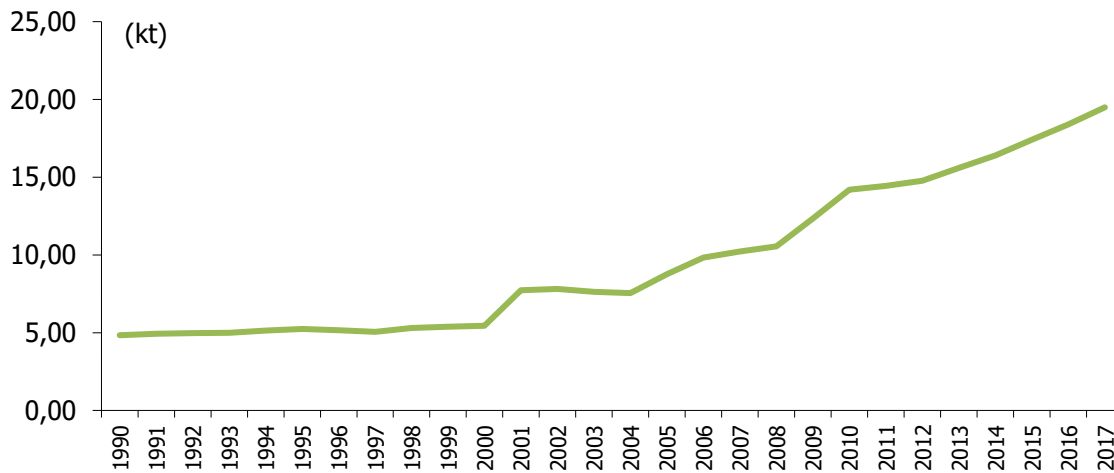
The estimation results are given in Table 7.42 and Figure 7.12.

In this submission, Turkey has developed  $T_{PLANT}$  values for each inventory year since 1990. So, there has been a significant increase in  $N_2O$  emissions from wastewater during the period 1990-2017, as shown in Figure 7.12.  $N_2O$  emissions increase of 95.2% since 1990 especially after 2001, because new wastewater treatment plants doing nitrogen removal have been started in operation in 2001.

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 7.42 N<sub>2</sub>O emissions from wastewater, 1990-2017****(kt)**

<b>Year</b>	<b>N<sub>2</sub>O emissions from wastewater effluent</b>	<b>N<sub>2</sub>O emissions from centralized WWT plants</b>	<b>Total N<sub>2</sub>O emissions</b>
1990	4.84	NO	4.84
1991	4.92	NO	4.92
1992	4.97	NO	4.97
1993	4.99	NO	4.99
1994	5.13	NO	5.13
1995	5.24	NO	5.24
1996	5.16	NO	5.16
1997	5.05	NO	5.05
1998	5.31	NO	5.31
1999	5.38	NO	5.38
2000	5.44	NO	5.44
2001	5.39	2.33	7.72
2002	5.47	2.35	7.82
2003	5.50	2.12	7.62
2004	5.58	1.96	7.54
2005	5.66	3.10	8.76
2006	5.71	4.11	9.82
2007	5.76	4.46	10.22
2008	5.71	4.83	10.54
2009	5.79	6.54	12.34
2010	6.04	8.17	14.20
2011	6.18	8.25	14.44
2012	6.45	8.32	14.77
2013	6.57	9.02	15.59
2014	6.69	9.70	16.39
2015	6.81	10.58	17.39
2016	6.94	11.45	18.39
2017	7.11	12.38	19.49

**Figure 7.12 N<sub>2</sub>O emissions from wastewater, 1990-2017**

### Collection of Activity Data

The activity data that are needed for estimating N<sub>2</sub>O 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*.

$$N_{EFFLUENT} = (P \cdot Protein \cdot N_{PR} \cdot F_{NON-CON} \cdot F_{IND-COM}) - N_{SLUDGE}$$

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. Based on the ERT findings in the latest review; 2014, 2015, 2016 and 2017 data were extrapolated due to the lack of data in this submission.

Population data is available from the TurkStat ([http://www.turkstat.gov.tr/PreTablo.do?alt\\_id=1027](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 7.43.

**Table 7.43 Population and per capita protein consumption, 1990-2017**

Year	Population <sup>(1)</sup> (1000's persons)	Per capita protein consumption <sup>(2)</sup> (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	39.68
2015	78 218	39.89
2016	79 278	40.11
2017	80 811	40.33

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 7.44. 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 7.44 Parameters for estimation of nitrogen in effluent, 2017**

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, the country-specific values of the degree of utilization of modern, centralized WWT plants ( $T_{PLANT}$ ) are calculated for the whole time series.

### 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.

Monte Carlo analysis has been carried out for the  $CH_4$  and  $N_2O$  emissions from Wastewater treatment and discharge, for the reporting year 2017. Combined uncertainty in  $CH_4$  emissions is was estimated at -40.16% to +40.77% for Domestic water sub-category and -32.71% to 41.28% for Industrial water sub-



category while N<sub>2</sub>O combined uncertainty range is -24.38% to +25.56%. More detailed information is in Annex 2.

## 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.

Wherefore Turkey made QC checks in order to provide more accurate data, methane recovery data of some biogas facilities in 2016 are rechecked.

## Recalculation:

Based on the ERT findings in the latest review, Turkey started to investigate T<sub>PLANT</sub> values for each year between 1990-2017. Required activity data are generated except 1990-2000 period. Because nitrogen removal process was not available before 2001 in wastewater treatment plants in Turkey.

Likewise, since the protein data of FAO used in the calculation of N<sub>2</sub>O emissions are not available after 2013, it is estimated by extrapolation method for 2014, 2015, 2016 and 2017. Thus, this part of the subsector has been recalculated for 2014, 2015 and 2016.

Corrections in methane recovery data of some biogas facilities for 2011-2016 are resulted in minor recalculations. So, CH<sub>4</sub> emissions from Wastewater Treatment and Discharge (CRF Category 5.D) have been recalculated for the years 2011-2016. For instance, this recalculation caused 7.29 kt CO<sub>2</sub> eq. (0.30%) increase in 2016 CH<sub>4</sub> emissions.

Total Wastewater Treatment and Discharge (CRF Category 5.D) N<sub>2</sub>O emissions have been changed for entire time series consequently. While in 1990, the difference is -6.25 kt CO<sub>2</sub> eq. (-0.43%), in 2016 there is a significant rise for N<sub>2</sub>O emissions. This difference is calculated as 3420 kt CO<sub>2</sub> eq. (166%) for 2016.

## Planned Improvement:

Turkey is planning to improve the CH<sub>4</sub> emission parameters both for the degree of treatment utilization by population class (domestic wastewater) and for the fractional usage for different types of waste treatment and discharge pathways (industrial wastewater) for the whole time series by applying the results achieved from the ongoing study, which is being carried out to determine specific values for

those parameters. After the study is completed, the emission and activity data time series will be recalculated accordingly.

## **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 report on 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 2017 inventory.

Also the ERT recommendations are one of the most important reasons for recalculations. A centralized review of the 2018 inventory submission of Turkey was organized by the UNFCCC Secretariat from 24 to 29 September 2018. The *Report on the individual review of the inventory submission of Turkey submitted in 2018* have not been finalized yet. However, many recalculations have been made based on the ERT findings in some categories in addition to Turkey's own improvements. 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;

Due to the revision of the national energy balance table, all the categories that use the national energy balance tables as data source are recalculated.

The CO<sub>2</sub> emissions from coke oven gas for the 1.A.1.a category are recalculated due to a changing CO<sub>2</sub> emission factor as 37.47 which are average of three integrated iron and steel plants in Turkey instead of 107.067 that was used in 2000-2017 submissions.

Since the changing the assumption of asphaltite as sub-bituminous coal instead of Petrocokethe CO<sub>2</sub> emissions from asphaltite is recalculated due to a changing emission factor as 96.46 instead of 97.53 that was used in 2000-2017 submissions for the 1.A.1.a category. For this period the emission factors of CH<sub>4</sub> and N<sub>2</sub>O are changing due to revision fuel assumption.

For the fuel of Pyrolytic oil emission factor is corrected for the 1.A.1.a category. It was mistyped in the previous three years calculation sheet. The emissions are recalculated accordingly.

For manufacture of solid fuels; the fuel consumption data of coke production units within the integrated iron and steel plants are revised. Another issue is that town gas and brown coal briquettes have been produced in Turkey until 1994 and 2008 respectively. In this submission, emissions from the production of these two fuels are covered in the inventory for the first time.

In manufacturing industries and construction; Major revision was done on the national energy balance tables in 04.05.2017 and this revision is reflected in this inventory. In this revision sectoral allocation of

the fuels were elaborated, new fuels were added to the table and historical fuel consumption data were revised. In the previous submissions, the process gas combustion emissions of integrated iron and steel plants under 1A2a category were not covered, in this submission it is calculated and added into the 1A2a category. (See section 3.2.5.1 for details) Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated. As a result, there are recalculations in all the sub sectors of 1A2 category. The minor revisions of sub categories in the time series are due to the revision of the natural gas CO<sub>2</sub> emission factor.

In iron and steel industry due to the revision on the national energy balance tables, the 1A2a sector is recalculated. Moreover, the process gases of integrated iron and steel plants (BFG, Coke oven gas and BOF gas) are used for heating the rolling mills and for other miscellaneous combustion and their emissions should be reported under 1A2a category. However, in the previous submissions these fuels were excluded and not estimated. Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated. In this submission they are estimated and reported. The table below shows the effect of the recalculations with respect to 2018 submission.

In non-ferrous metals sector; due to the revision on the national energy balance tables, the 1A2b sector is recalculated. Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated.

For chemicals due to the revision on the national energy balance tables, the 1A2c sector is recalculated. Moreover, the manufacture of rubber and plastic products sector was separated in the national energy balance tables in 2015 and since then these sector emissions were reported under others (1A2g) category. However, in this submission this sector is covered under 1A2c and because of that 2015 and 2016 emissions were recalculated. Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated.

For pulp and paper industry; due to the revision on the national energy balance tables, the 1A2d sector is recalculated. Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated.

In food processing, beverages and tobacco; due to the revision on the national energy balance tables, the 1A2d sector is recalculated. Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated.

In nonmetallic minerals; due to the revision on the national energy balance tables, the 1A2f sector is recalculated. Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated.

For other industries; due to the revision on the national energy balance tables, the 1A2g sector is recalculated. Moreover, the manufacture of rubber and plastic products sector was separated in the national energy balance tables in 2015 and since then this sector emission were reported under others (1A2g) category. However, in this submission this sector is covered under 1A2c and because of that

2015 and 2016 emissions were recalculated. Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated.

For other sectors; due to the revision on the national energy balance tables, the 1A4 sector and its subsectors are recalculated. Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated.

For commercial/institutional, residential, Agriculture/Forestry/Fisheries sectors due to the revision on the national energy balance tables, the 1A4a sector is recalculated. Besides that, the CO<sub>2</sub> emission factor of natural gas was recalculated.

Fugitive methane emissions from abandoned mines were recalculated in this submission. Tier 2 methodology is used with coal rank (bituminous or sub bituminous) specific emission factors.

### **In IPPU sector;**

For lime production the amount of dolomitic lime produced in electric arc furnaces was revised due to the change of data source. Previously, the data from General Directorate of Renewable Energy Sources was used. Due to the sustainability problem of the data, it is assumed that lime produced in electric arc furnaces is 5% of total steel production.

For the glass production; In this inventory calculation method totally changed from Tier 2 to Tier 3 by using carbonate input to the process. Effect of recalculation can be seen from the table below. During this methodology change, some assumption previously made was changed. Previously, total glass production was estimated by using biggest glass production company. In this submission, other producers were also contacted and their production data was collected in addition to their raw material consumption.

For other uses of soda ash; there is recalculation due to the methodology change in glass production. Emissions from glass production are recalculated by using raw material input which includes soda ash consumption.

In ammonia production; for the years between 1990-2016, in ammonia production recalculation was made due to two reasons. The carbon content of natural gas is changed by using composition of natural gas. This caused minor changes in emissions. Main recalculation was about recovered CO<sub>2</sub> from urea production. In previous submission total CO<sub>2</sub> emissions and recovered CO<sub>2</sub> emissions were reported separately into CRF by thinking that CRF automatically calculate net emissions (net: total – recovered). It was released that CRF does not calculate automatically the net emissions. For that reason, recovered and net CO<sub>2</sub> emissions entered separately in this submission. Difference in emissions can be seen from the table below.

In iron and steel production category, in this submission report the CO<sub>2</sub> emissions of electric arc furnaces were calculated by Tier 1 methodology. In the previous submission it was calculated by tier 2. During the tier 2 calculation it was revealed that raw material data from electric arc furnaces are not in good quality. For that reason, tier 1 methodology reflects the real situation better.

In aluminum production; in the previous inventory, the producer provided the total metal production including the secondary productions for 2005-2013. This year the metal production data of the company revised and only the primary metal production was taken into consideration. Moreover, recalculation was made due to a formulation mistake for 1990 to 2012 for F-gases.

### **In agriculture sector;**

Availability of country-specific typical animal mass values for sheep (domestic and merino) and goats and a revision of the distribution of the manure management systems are the two reasons for the recalculations in the manure management source category. Emission calculations have improved considerably by the use of country-specific liveweight values and country-specific MMS distribution figures (except for swine).

Once again availability of country-specific typical animal mass values for sheep (domestic and merino) and goats, a revision of the distribution of the manure management systems are two out of the three reasons because of linkages in emission source accounts, in addition to an update in crop residues resulting in the recalculation of the entire time series for agricultural soils.

Moreover, emissions from field burning of agricultural residues are recalculated for the period of 1990-2016 because of the addition of maize burning in the current inventory.

### **In LULUCF sector;**

The whole activity data has been changed in the sector. The area data for land uses and conversions have been changed to a spatially explicit monitoring system performed by an international remote sensing company. The whole calculation system has been reviewed and when necessary modified with the support of three international LULUCF experts. The modifications involved fine tune ups in EFs and coefficients and also calculation algorithms explained in more detail below.

The soil carbon stock values have been changed based on a national study conducted by research units of the Ministry of Agriculture and Forestry.

Forest Land: In addition to changes in AD mentioned above the emission factors have been reviewed and corrected where necessary. The largest change occurred in forestland remaining forestland subcategory due to increase in productive forest area. The increase in area of forestland remaining

forestland was for both base year and the whole time series however increased the removals substantially due to increased productivity and thus increment. The forest definition has been changed from national one to an international. This caused decrease in removals in land converted to forestland category since in the previous submissions the lands legally converted to forestland was considered as afforested even if not stocked yet.

In previous submissions the conversions from/to forestland was not known thus it was assumed that they occurred from/to grasslands. With the spatially explicit land monitoring system all conversions have been tracked and estimated.

The emission derived from forest fires has been recalculated due to developing activity data.

Cropland, Grassland, Settlements, Wetland, Other land: Activity data and emission factors have been changed. New soil carbon stock values have been used.

HWP: The data from FAO have been used to enable transparency but also national wood density values have been updated. The paper has been added in this submission.

Other Gases: The wildfires in Forest Land Remaining Forest Land and Land Converted Forest Land are calculated separately due to developing activity data.

### **In waste sector;**

Emission estimates from Solid Waste Disposal (CRF Category 5.A) are recalculated over the 1990-2016 time series due to new comprehensive and collaborative study with data providers at TurkStat; Waste composition data is improved for all years, Sewage Sludge and Clinical Waste data included for the first time in this submission, and also methane recovery data is recalculated for previous year.

CO<sub>2</sub> and N<sub>2</sub>O emissions arising from Incineration and Open Burning of Waste (CRF Category 5.C) have been recalculated depending on waste composition data for entire time series. Moreover, garden and park waste category was considered as biogenic by this submission.

N<sub>2</sub>O emissions from Wastewater Treatment and Discharge (CRF Category 5.D) have been recalculated for the years 1990-2016. Because  $T_{PLANT}$  values for each year between 1990-2017 have been improved in this submission. Besides, due to the lack of FAO's protein data used in the calculation of N<sub>2</sub>O emissions after 2013, this required data is estimated by extrapolation method for 2014, 2015, 2016 and 2017. Thus, this part of the subsector has been recalculated for 2014, 2015 and 2016. Minor corrections are done in methane recovery data of some biogas facilities for 2011-2016. Therefore, CH<sub>4</sub> emissions from Wastewater Treatment and Discharge (CRF Category 5.D) have been recalculated for the years 2011-2016.



The reasons and the implications of recalculations by CRF category are given in the below table for 1990 and 2016.

**Table 10.1 Recalculations made in 2017 inventory and implications to the emission level, 1990 and 2016**

CRF category	Reasons for recalculation	Implication to the CRF category level (kt CO <sub>2</sub> eq.)		Implication to the total emission w/o LULUCF (%)	
		1990	2016	1990	2016
<b>Total (net emissions)</b>		<b>-18 355</b>	<b>-25 450</b>	<b>-8.37</b>	<b>-5.11</b>
<b>1. Energy</b>		<b>5 273</b>	<b>-1 307</b>	<b>2.41</b>	<b>-0.26</b>
A.1 Energy industries	Revision on AD and EF	249	-647	0.11	-0.13
A.2. Manufacturing industries and construction	Revision on AD and EF	4 781	380	2.18	0.08
A.4. Other sectors	Revision on AD and EF	34	-1 340	0.02	-0.27
B.1 Fugitive emissions from solid fuels	Change of methodology from T1 to T2	210	300	0.10	0.06

**Table 10.1 Recalculations made in 2017 inventory and implications to the emission level, 1990 and 2016 (cont'd)**

CRF category	Reasons for recalculation	Implication to the CRF category level (kt CO <sub>2</sub> eq.)		Implication to the total emission w/o LULUCF (%)	
		1990	2016	1990	2016
<b>2. Industrial Processes</b>		<b>-57</b>	<b>-247</b>	<b>-0.03</b>	<b>-0.05</b>
A. Mineral industry	Change of data source	-28	80	-0.01	0.02
B. Chemical industry	Change in captured CO <sub>2</sub> in ammonia production	-495	-196	-0.23	-0.04
C. Metal industry	Change of methodology	466	259	0.21	0.05
F. Product uses as ODS substitutes	Revision on AD	NO	1 397	NO	0.28
G. Other product manufacture and use	Revision on EF	NO	-1 788	NO	-0.36
<b>3. Agriculture</b>		<b>3 278</b>	<b>1 696</b>	<b>1.50</b>	<b>0.34</b>
B. Manure management	Revision of MMS and use of country-specific typical animal mass values for sheep (domestic and merino) and goats	1 254	601	0.57	0.12
D. Agricultural soils	Revision of MMS and use of country-specific typical animal mass values for sheep (domestic and merino) and goats, and updates of crop residues	2 008	1 082	0.92	0.22
F. Field burning of agricultural residues	Addition of maize burning	16	13	0.01	0.00

**Table 10.1 Recalculations made in 2017 inventory and implications to the emission level, 1990 and 2016 (cont'd)**

CRF category	Reasons for recalculation	Implication to the CRF category level (kt CO <sub>2</sub> eq.)		Implication to the total emission w/o LULUCF (%)	
		1990	2016	1990	2016
<b>4. Land use, land-use change and forestry</b>		<b>-26 842</b>	<b>-27 852</b>	<b>-12.2</b>	<b>-5.59</b>
A. Forest land	Activity data and emission factors have changed.	-25 789	-24 863	-11.8	-4.99
B. Cropland	Activity data and emission factors have changed.	38	388	0.02	0.08
C. Grassland	Activity data and emission factors have changed.	-99	2 321	-0.05	-0.47
D. Wetlands	Activity data and emission factors have changed.	-1 729	NO	-0.79	NO
E. Settlements	Activity data and emission factors have changed.	NO	361	NO	0.07
G. Harvested wood products	Activity data and emission factors have changed.	1 420	-2 378	0.65	-0.48
<b>5. Waste</b>		<b>-6.59</b>	<b>2 260</b>	<b>0.00</b>	<b>0.45</b>
A. Solid waste disposal	Waste composition data is improved and updated. Sewage Sludge and Clinical Waste added to calculations. Minor correction in 2016 data for methane recovery.	0.00	-1 169	0.00	-0.23
C. Incineration and open burning of waste	Updating waste composition data. Garden waste is considered as biogenic.	-0.35	0.71	0.00	0.00
D. Wastewater treatment and discharge	T <sub>PLANT</sub> data is revised for entire time series. FAO protein data is extrapolated. Minor corrections in methane recovery data.	-6.25	3 428	0.00	0.69
<b>Total CO<sub>2</sub> equivalent emissions without land use, land-use change and forestry</b>		<b>8 487</b>	<b>2 402</b>	<b>3.87</b>	<b>0.48</b>
<b>Total CO<sub>2</sub> equivalent emissions with land use, land-use change and forestry</b>		<b>-18 355</b>	<b>-25 450</b>	<b>-8.37</b>	<b>-5.11</b>

### Planned Improvements:

Considerable improvements have been made in the 2017 inventory (2019 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 sector;**

Emissions from petroleum refining are calculated both plant specific and from national energy balance tables. However, there are some differences in the results. Plant specific results are reported. However, there is a continuous work in order to understand the reasons of the differences.

Prior to 2011 several manufacturing sectors that have their own categories (Pulp, Paper & Print; Non-metallic minerals; Food processing, beverages & tobacco) were not fully separated out in the national energy balance and therefore some or all of the emissions from these categories were reported under section 1A2g. This is because in the calculation of 1A2 subcategories the national energy balance tables are used and national energy balance tables are not created as time series. All relevant institutions are working together in order to overcome this inconsistency problem.

Prior to 2015 1A4a and 1A4b categories were not separated out in the national energy balance and therefore all of the emissions from these categories were reported under section 1A4b. However, since 2015 they are separated. All relevant institutions are working together in order to overcome this inconsistency problem and allocate 1A4a and 1A4b categories in time series.

MENR worked on agricultural association for modeling the agricultural diesel oil consumption and the disaggregation of diesel oil consumption was achieved in 2015 national energy balance tables. However national energy balance tables are not in time series therefore the allocation problem still exists between 2012 and 2014. All relevant institutions are working together and make planning in order to overcome this inconsistency problem.

Since the 1.B.1 category is a key category in terms of emission trend of CH<sub>4</sub>, the tiers in CH<sub>4</sub> 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<sub>4</sub>.

For 1.B.2 In order to increase the tiers for CH<sub>4</sub> 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.

### **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 a country specific emission factor for dolomitic lime.

In nitric acid production; as a legislative obligation nitric acid producers should install a N<sub>2</sub>O gas monitoring device. These devices measure the N<sub>2</sub>O content of the flue gas instantaneously. Using the instant measurements and the working hours, companies estimated their own annual N<sub>2</sub>O 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 soda ash production; the solvay process is theoretically CO<sub>2</sub> neutral. However, no process is 100% efficient in real life. Therefore, it is obvious that the solvay process plants cause some amount of CO<sub>2</sub> emissions under the IPPU category. The soda ash plant which is producing soda ash by solvay process in Turkey is obliged to prepare greenhouse gas emission report under the new regulations of the Ministry of Environment and Urbanization. This report will be accessed in the future and then it would be possible to make CO<sub>2</sub> emission estimation regarding to this plant.

In iron and steel production; integrated iron and steel plants produce coke from coal and during this process some oils are obtained as by-product (i.e. benzene, toluene, xylene). The coke plant by products should be included in the general carbon mass balance calculations. Moreover, next year a material balance will be done on lime and limestone in the integrated iron and steel production plants.

For Product Use as Substitutes for ODS, improvements in the sector data will be done within the scope of "*Technical Assistance for Increased Capacity for Transposition and Capacity Building on F-Gases*" project which has started in June 2017 and will last in May 2020.

For Other Product Manufacture and Use (2.G) improvements in the sector data will be done within the scope of "*Technical Assistance for Increased Capacity for Transposition and Capacity Building on F-Gases*" project which has started in June 2017 and will last in May 2020.

### **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;**

In Forestland category the increment data is planned to be disaggregated for ecozones in the short term. The soil and dead organic matter carbon stocks will be updated as more national studies are available.

In Cropland category perennial crops is planned to be disaggregated for major species including olives, vineyards etc. if a method that can be embedded into the current system can be developed. Related to management of annual croplands there are area data available but has not been estimated in this submission. The removals/emissions from cropland management including reduced tillage is planned to be reported not in the short term but in medium or long term.

In Grassland category it will be possible to estimate CSC in soils when range rehabilitation data is available. There are several studies going on in grasslands in the country. The results will be incorporated into estimates as they become available.

Turkey is a partner of ICP Forests program. The ICP forest project's soil analysis in Turkey was initiated in January 2015 and planned to be finished by 2019. The results of this project may enable us to improve soil and litter carbon stocks.

The EU funded project entitled "The Technical Assistance for Developed an Analytical Basis for the LULUCF Sector Project" has been started in 2017 and finish in July in 2019. The project provided a spatially explicit land use tracking system so far. The project is also working on a reporting system that will be finalized this year. Thus the 2020 submission is expected to be done with the new reporting system.

### **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.

In Wastewater Treatment and Discharge (CRF Category 5.D), Turkey is planning to improve the CH<sub>4</sub> emission parameters both for the degree of treatment utilization by population class (domestic wastewater) and for the fractional usage for different types of waste treatment and discharge pathways (industrial wastewater) for the whole time series by applying the results achieved from the ongoing study, which is being carried out to determine specific values for those parameters. After the study is completed, the emission and activity data time series will be recalculated accordingly.

## 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 (2006 IPCC Guidelines) 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" (2006 IPCC Guidelines); 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 (2006 IPCC Guidelines). 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 Guidelines while trend assessment is calculated according to the Equation 4.2. and 4.3.

In 2017 inventory key source analysis, there were 30 key source categories shown in Table A1 below.



Table A1 Key category analysis summary, 2017

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 Fuel combustion - Energy Industries - Liquid Fuels	CO2	X	X	X	X
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO2	X	X	X	X
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO2	X	X	X	X
1.A.3.a Domestic Aviation	CO2	X	X	X	X
1.A.3.b Road Transportation	CO2	X	X	X	X
1.A.4 Other Sectors - Liquid Fuels	CO2	X	X	X	X
1.A.4 Other Sectors - Solid Fuels	CO2	X	X	X	X
1.A.4 Other Sectors - Gaseous Fuels	CO2	X	X	X	X
1.A.4 Other Sectors - Biomass	CH4		X	X	X
1.B.1 Fugitive emissions from Solid Fuels	CH4	X	X	X	X
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH4		X	X	
2.A.1 Cement Production	CO2	X	X	X	X
2.A.2 Lime Production	CO2	X	X	X	X
2.A.4 Other Process Uses of Carbonates	CO2	X	X	X	X
2.C.1 Iron and Steel Production	CO2	X	X	X	X
2.F.6 Other Applications	Aggregate F-gases	X	X	X	X
3.A Enteric Fermentation	CH4	X	X	X	X
3.B Manure Management	CH4	X	X	X	X
3.B Manure Management	N2O	X	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
4.A.1 Forest Land Remaining Forest Land	CO2	X	X		X
4.G Harvested Wood Products	CO2	X	X		X
4(V) Biomass Burning	CO2		X		X
5.A Solid Waste Disposal	CH4	X	X	X	X
5.D Wastewater Treatment and Discharge	CH4		X	X	X
5.D Wastewater Treatment and Discharge	N2O	X	X	X	X

Table A2 Key category analysis level assessment with LULUCF, 2017

Sector	Fuel	GAS	2017 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.1.	Energy industries	CO2	100 465	100 465	15.91	15.91
4.A.1.	Forest Land Remaining Forest Land	CO2	- 89 961	89 961	14.25	30.16
1.A.3.b.	Road Transportation	CO2	77 094	77 094	12.21	42.37
1.A.1.	Energy industries	CO2	47 364	47 364	7.50	49.87
2.A.1.	Cement Production (Mineral Products)	CO2	37 272	37 272	5.90	55.77
1.A.4.	Other sectors	CO2	33 351	33 351	5.28	61.06
3.A.	Enteric fermentation	CH4	30 039	30 039	4.76	65.81
1.A.4.	Other sectors	CO2	24 784	24 784	3.93	69.74
1.A.2.	Manufacturing industries and construction	CO2	21 059	21 059	3.34	73.08
1.A.2.	Manufacturing industries and construction	CO2	20 663	20 663	3.27	76.35
3.D.a.	Direct N2O emissions from managed soils	N2O	20 562	20 562	3.26	79.60
1.A.2.	Manufacturing industries and construction	CO2	16 763	16 763	2.65	82.26
1.A.4.	Other sectors	CO2	12 137	12 137	1.92	84.18
4.G.	Harvested Wood Products	CO2	- 12 115	12 115	1.92	86.10
2.C.1.	Iron and Steel Production	CO2	11 557	11 557	1.83	87.93
5.A.	Solid waste disposal	CH4	9 079	9 079	1.44	89.37
2.F.6.	Other applications	HFC	7 877	7 877	1.25	90.62
5.D.	Wastewater treatment and discharge	N2O	5 808	5 808	0.92	91.54
1.A.1.	Energy industries	CO2	5 364	5 364	0.85	92.39
3.B.	Manure management	N2O	4 190	4 190	0.66	93.05
1.A.3.a.	Domestic Aviation	CO2	3 798	3 798	0.60	93.65
1.B.1	Solid fuels	CH4	3 681	3 681	0.58	94.23
2.A.4.	Other process uses of carbonates	CO2	3 632	3 632	0.58	94.81
3.B.	Manure management	CH4	3 348	3 348	0.53	95.34
2.A.2.	Lime Production (Mineral Products)	CO2	2 684	2 684	0.43	95.76
3.D.b.	Indirect N2O Emissions from managed soils	N2O	2 555	2 555	0.40	96.17
5.D.	Wastewater treatment and discharge	CH4	2 450	2 450	0.39	96.56
1.B.2.b	Natural Gas	CH4	2 067	2 067	0.33	96.89
1.A.2.	Manufacturing industries and construction	CO2	1 472	1 472	0.23	97.12

Table A2 Key category analysis level assessment with LULUCF, 2017 (cont'd)

Sector	Fuel	GAS	2017 Emission	ABS (Emission)	Cont. (%)	Cumulative
3.H.	Urea application	CO2	1 450	1 450	0.23	97.35
2.B.2.	Nitric acid production	N2O	1 263	1 263	0.20	97.55
1.A.3.b.	Road Transportation	N2O	1 231	1 231	0.20	97.74
1.A.4.	Other sectors	CH4	1 099	1 099	0.17	97.92
1.A.4.	Other sectors	N2O	1 051	1 051	0.17	98.08
1.A.3.d.	Domestic Navigation	CO2	823.6	823.6	0.13	98.21
1.A.3.e.	Other transportation	CO2	757.1	757.1	0.12	98.33
1.A.1.	Energy industries	N2O	691.5	691.5	0.11	98.44
2.A.3.	Glass Production	CO2	686.0	686.0	0.11	98.55
1.A.1.	Energy industries	N2O	656.5	656.5	0.10	98.66
4.F.2.	Land Converted to Other Land	CO2	653.1	653.1	0.10	98.76
1.A.4.	Other sectors	CH4	640.9	640.9	0.10	98.86
4.C.2.	Land Converted to Grassland	CO2	630.8	630.8	0.10	98.96
2.B.1.	Ammonia Production	CO2	524.8	524.8	0.08	99.04
1.B.2.c	Venting and flaring	CH4	485.8	485.8	0.08	99.12
4.B.2.	Land Converted to Cropland	CO2	463.1	463.1	0.07	99.19
4.E.2.	Land Converted to Settlements	CO2	412.6	412.6	0.07	99.26
1.A.3.b.	Road Transportation	CH4	379.8	379.8	0.06	99.32
1.A.3.c.	Railways	CO2	369.0	369.0	0.06	99.38
1.A.1.	Energy industries	CO2	363.4	363.4	0.06	99.44
4.A.2.	Land Converted to Forest Land	CO2	-328.9	328.9	0.05	99.49
1.B.2.a	Oil	CH4	306.4	306.4	0.05	99.54
4.D.2.	Land Converted to Wetlands	CO2	284.0	284.0	0.04	99.58
3.C.	Rice cultivation	CH4	233.8	233.8	0.04	99.62
2.B.7.	Soda ash production	CO2	207.9	207.9	0.03	99.65
2.F.3.	Fire protection	HFC	172.1	172.1	0.03	99.68
1.B.2.c	Venting and flaring	CO2	150.2	150.2	0.02	99.70
2.D.1.	Lubricant Use	CO2	143.3	143.3	0.02	99.72
2.C.2.	Ferroalloys Production	CO2	139.3	139.3	0.02	99.75
3.F.	Field burning of agricultural residues	CH4	126.1	126.1	0.02	99.77
4.B.1.	Cropland Remaining Cropland	CO2	-116.8	116.8	0.02	99.79

Table A2 Key category analysis level assessment with LULUCF, 2017 (cont'd)

	Sector	Fuel	GAS	2017 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.4.	Other sectors	Solid fuels	N2O	114.0	114.0	0.02	99.80
1.A.3.d.	Domestic Navigation	Residual fuel oil	CO2	110.9	110.9	0.02	99.82
2.C.3.	Aluminium Production		CO2	108.4	108.4	0.02	99.84
1.A.4.	Other sectors	Biomass	N2O	101.9	101.9	0.02	99.85
1.A.2.	Manufacturing industries and construction	Solid fuels	N2O	87.4	87.4	0.01	99.87
1.A.4.	Other sectors	Gaseous fuels	CH4	74.9	74.9	0.01	99.88
2.C.3.	Aluminium Production		PFC	73.1	73.1	0.01	99.89
2.G.1.	Electrical equipment		SF6	73.1	73.1	0.01	99.90
4.A.1.	Forest Land Remaining Forest Land		CH4	57.2	57.2	0.01	99.91
1.A.2.	Manufacturing industries and construction	Solid fuels	CH4	49.0	49.0	0.01	99.92
1.A.3.c.	Railways		N2O	43.5	43.5	0.01	99.93
4.D.1.1.	Peat Extraction Remaining Peat Extraction		CO2	39.6	39.6	0.01	99.93
3.F.	Field burning of agricultural residues		N2O	39.0	39.0	0.01	99.94
1.A.3.a.	Domestic Aviation		N2O	38.5	38.5	0.01	99.95
4.A.1.	Forest Land Remaining Forest Land		N2O	37.7	37.7	0.01	99.95
1.A.2.	Manufacturing industries and construction	Liquid fuels	N2O	31.1	31.1	0.00	99.96
1.A.1.	Energy industries	Gaseous fuels	CH4	29.3	29.3	0.00	99.96
4.B.2.	Land Converted to Cropland		N2O	22.2	22.2	0.00	99.96
1.A.4.	Other sectors	Liquid fuels	CH4	20.3	20.3	0.00	99.97
1.A.4.	Other sectors	Gaseous fuels	N2O	17.9	17.9	0.00	99.97
1.A.1.	Energy industries	Solid fuels	CH4	17.7	17.7	0.00	99.97
2.C.1.	Iron and Steel Production		CH4	16.3	16.3	0.00	99.98
1.A.2.	Manufacturing industries and construction	Liquid fuels	CH4	13.1	13.1	0.00	99.98
1.A.2.	Manufacturing industries and construction	Other fossil fuels	N2O	12.6	12.6	0.00	99.98
1.A.2.	Manufacturing industries and construction	Gaseous fuels	N2O	11.3	11.3	0.00	99.98
4.C.2.	Land Converted to Grassland		N2O	9.5	9.5	0.00	99.98
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CH4	9.5	9.5	0.00	99.98
2.C.5.	Lead Production		CO2	8.9	8.9	0.00	99.99
2.D.2.	Paraffin Wax Use		CO2	8.3	8.3	0.00	99.99
5.B.	Biological treatment of solid waste		CH4	8.2	8.2	0.00	99.99
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CH4	7.9	7.9	0.00	99.99
2.B.5.	Carbide production		CO2	7.6	7.6	0.00	99.99

Table A2 Key category analysis level assessment with LULUCF, 2017 (cont'd)

Sector	Fuel	GAS	2017 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.3.d. Domestic Navigation	Gas/diesel oil	N2O	6.8	6.8	0.00	99.99
1.A.1. Energy industries	Biomass	N2O	6.5	6.5	0.00	99.99
5.B. Biological treatment of solid waste		N2O	5.9	5.9	0.00	99.99
1.A.1. Energy industries	Liquid fuels	N2O	5.1	5.1	0.00	100.00
4.D.2. Land Converted to Wetlands		N2O	4.0	4.0	0.00	100.00
1.B.2.a Oil		CO2	4.0	4.0	0.00	100.00
1.A.1. Energy industries	Other fossil fuels	N2O	3.0	3.0	0.00	100.00
1.B.2.b Natural Gas		CO2	2.8	2.8	0.00	100.00
1.A.1. Energy industries	Liquid fuels	CH4	2.3	2.3	0.00	100.00
1.A.3.d. Domestic Navigation	Gas/diesel oil	CH4	2.0	2.0	0.00	100.00
5.C. Incineration and open burning of waste		CO2	1.9	1.9	0.00	100.00
1.A.1. Energy industries	Other fossil fuels	CH4	1.9	1.9	0.00	100.00
5.C. Incineration and open burning of waste		CH4	1.7	1.7	0.00	100.00
1.A.3.a. Domestic Aviation		CH4	1.5	1.5	0.00	100.00
2.B.8. Petrochemical and carbon black production		CO2	1.3	1.3	0.00	100.00
1.A.3.d. Domestic Navigation	Residual fuel oil	N2O	0.9	0.9	0.00	100.00
1.B.2.c Venting and flaring		N2O	0.6	0.6	0.00	100.00
1.A.1. Energy industries	Biomass	CH4	0.6	0.6	0.00	100.00
1.A.3.c. Railways		CH4	0.5	0.5	0.00	100.00
1.A.3.e. Other transportation		N2O	0.4	0.4	0.00	100.00
4.A.2. Land Converted to Forest Land		CH4	0.4	0.4	0.00	100.00
1.A.3.e. Other transportation		CH4	0.3	0.3	0.00	100.00
5.C. Incineration and open burning of waste		N2O	0.3	0.3	0.00	100.00
4.A.2. Land Converted to Forest Land		N2O	0.3	0.3	0.00	100.00
1.A.3.d. Domestic Navigation	Residual fuel oil	CH4	0.3	0.3	0.00	100.00
1.C. CO2 Transport and storage		CO2	0.1	0.1	0.00	100.00
2.E.5. Other		HFC	0.1	0.1	0.00	100.00
2.E.5. Other		SF6	0.0	0.0	0.00	100.00
4.C.1. Grassland Remaining Grassland		CO2	0.0	0.0	0.00	100.00
1.A.2. Manufacturing industries and construction	Biomass	N2O	0.0	0.0	0.00	100.00
1.A.2. Manufacturing industries and construction	Biomass	CH4	0.0	0.0	0.00	100.00
2.E.5. Other		PFC	0.0	0.0	0.00	100.00
<b>Total</b>				<b>631 389.57</b>		

Table A3 Key category analysis level assessment without LULUCF, 2017

Sector	Fuel	GAS	2017 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.1. Energy industries	Solid fuels	CO2	100 465	100 465	19.09	19.09
1.A.3.b. Road Transportation		CO2	77 094	77 094	14.65	33.74
1.A.1. Energy industries	Gaseous fuels	CO2	47 364	47 364	9.00	42.74
2.A.1. Cement Production (Mineral Products)		CO2	37 272	37 272	7.08	49.82
1.A.4. Other sectors	Gaseous fuels	CO2	33 351	33 351	6.34	56.16
3.A. Enteric fermentation		CH4	30 039	30 039	5.71	61.87
1.A.4. Other sectors	Solid fuels	CO2	24 784	24 784	4.71	66.58
1.A.2. Manufacturing industries and construction	Gaseous fuels	CO2	21 059	21 059	4.00	70.58
1.A.2. Manufacturing industries and construction	Solid fuels	CO2	20 663	20 663	3.93	74.51
3.D.a. Direct N2O emissions from managed soils		N2O	20 562	20 562	3.91	78.41
1.A.2. Manufacturing industries and construction	Liquid fuels	CO2	16 763	16 763	3.19	81.60
1.A.4. Other sectors	Liquid fuels	CO2	12 137	12 137	2.31	83.91
2.C.1. Iron and Steel Production		CO2	11 557	11 557	2.20	86.10
5.A. Solid waste disposal		CH4	9 079	9 079	1.73	87.83
2.F.6. Other applications		HFC	7 877	7 877	1.50	89.32
5.D. Wastewater treatment and discharge		N2O	5 808	5 808	1.10	90.43
1.A.1. Energy industries	Liquid fuels	CO2	5 364	5 364	1.02	91.45
3.B. Manure management		N2O	4 190	4 190	0.80	92.24
1.A.3.a. Domestic Aviation		CO2	3 798	3 798	0.72	92.96
1.B.1. Solid fuels		CH4	3 681	3 681	0.70	93.66
2.A.4. Other process uses of carbonates		CO2	3 632	3 632	0.69	94.35
3.B. Manure management		CH4	3 348	3 348	0.64	94.99
2.A.2. Lime Production (Mineral Products)		CO2	2 684	2 684	0.51	95.50
3.D.b. Indirect N2O Emissions from managed soils		N2O	2 555	2 555	0.49	95.99
5.D. Wastewater treatment and discharge		CH4	2 450	2 450	0.47	96.45
1.B.2.b. Natural Gas		CH4	2 067	2 067	0.39	96.84
1.A.2. Manufacturing industries and construction	Other fossil fuels	CO2	1 472	1 472	0.28	97.12
3.H. Urea application		CO2	1 450	1 450	0.28	97.40
2.B.2. Nitric acid production		N2O	1 263	1 263	0.24	97.64
1.A.3.b. Road Transportation		N2O	1 231	1 231	0.23	97.87

Table A3 Key category analysis level assessment without LULUCF, 2017 (cont'd)

Sector	Fuel	GAS	2017 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.4.	Other sectors	CH4	1 099	1 099	0.21	98.08
1.A.4.	Other sectors	N2O	1 051	1 051	0.20	98.28
1.A.3.d.	Domestic Navigation	CO2	823.6	823.6	0.16	98.44
1.A.3.e.	Other transportation	CO2	757.1	757.1	0.14	98.58
1.A.1.	Energy industries	N2O	691.5	691.5	0.13	98.71
2.A.3.	Glass Production	CO2	686.0	686.0	0.13	98.84
1.A.1.	Energy industries	N2O	656.5	656.5	0.12	98.97
1.A.4.	Other sectors	CH4	640.9	640.9	0.12	99.09
2.B.1.	Ammonia Production	CO2	524.8	524.8	0.10	99.19
1.B.2.c	Venting and flaring	CH4	485.8	485.8	0.09	99.28
1.A.3.b.	Road Transportation	CH4	379.8	379.8	0.07	99.35
1.A.3.c.	Railways	CO2	369.0	369.0	0.07	99.42
1.A.1.	Energy industries	CO2	363.4	363.4	0.07	99.49
1.B.2.a	Oil	CH4	306.4	306.4	0.06	99.55
3.C.	Rice cultivation	CH4	233.8	233.8	0.04	99.60
2.B.7.	Soda ash production	CO2	207.9	207.9	0.04	99.64
2.F.3.	Fire protection	HFC	172.1	172.1	0.03	99.67
1.B.2.c	Venting and flaring	CO2	150.2	150.2	0.03	99.70
2.D.1.	Lubricant Use	CO2	143.3	143.3	0.03	99.72
2.C.2.	Ferroalloys Production	CO2	139.3	139.3	0.03	99.75
3.F.	Field burning of agricultural residues	CH4	126.1	126.1	0.02	99.77
1.A.4.	Other sectors	N2O	114.0	114.0	0.02	99.80
1.A.3.d.	Domestic Navigation	CO2	110.9	110.9	0.02	99.82
2.C.3.	Aluminium Production	CO2	108.4	108.4	0.02	99.84
1.A.4.	Other sectors	N2O	101.9	101.9	0.02	99.86
1.A.2.	Manufacturing industries and construction	N2O	87.4	87.4	0.02	99.87
1.A.4.	Other sectors	CH4	74.9	74.9	0.01	99.89
2.C.3.	Aluminium Production	PFC	73.1	73.1	0.01	99.90
2.G.1.	Electrical equipment	SF6	73.1	73.1	0.01	99.92
1.A.2.	Manufacturing industries and construction	CH4	49.0	49.0	0.01	99.93

Table A3 Key category analysis level assessment without LULUCF, 2017 (cont'd)

Sector	Fuel	GAS	2017 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.3.C. Railways		N2O	43.5	43.5	0.01	99.93
3.F. Field burning of agricultural residues		N2O	39.0	39.0	0.01	99.94
1.A.3.a. Domestic Aviation		N2O	38.5	38.5	0.01	99.95
1.A.2. Manufacturing industries and construction	Liquid fuels	N2O	31.1	31.1	0.01	99.95
1.A.1. Energy industries	Gaseous fuels	CH4	29.3	29.3	0.01	99.96
1.A.4. Other sectors	Liquid fuels	CH4	20.3	20.3	0.00	99.96
1.A.4. Other sectors	Gaseous fuels	N2O	17.9	17.9	0.00	99.97
1.A.1. Energy industries	Solid fuels	CH4	17.7	17.7	0.00	99.97
2.C.1. Iron and Steel Production		CH4	16.3	16.3	0.00	99.97
1.A.2. Manufacturing industries and construction	Liquid fuels	CH4	13.1	13.1	0.00	99.98
1.A.2. Manufacturing industries and construction	Other fossil fuels	N2O	12.6	12.6	0.00	99.98
1.A.2. Manufacturing industries and construction	Gaseous fuels	N2O	11.3	11.3	0.00	99.98
1.A.2. Manufacturing industries and construction	Gaseous fuels	CH4	9.5	9.5	0.00	99.98
2.C.5. Lead Production		CO2	8.9	8.9	0.00	99.98
2.D.2. Paraffin Wax Use		CO2	8.3	8.3	0.00	99.99
5.B. Biological treatment of solid waste		CH4	8.2	8.2	0.00	99.99
1.A.2. Manufacturing industries and construction	Other fossil fuels	CH4	7.9	7.9	0.00	99.99
2.B.5. Carbide production		CO2	7.6	7.6	0.00	99.99
1.A.3.d. Domestic Navigation	Gas/diesel oil	N2O	6.8	6.8	0.00	99.99
1.A.1. Energy industries	Biomass	N2O	6.5	6.5	0.00	99.99
5.B. Biological treatment of solid waste		N2O	5.9	5.9	0.00	99.99
1.A.1. Energy industries	Liquid fuels	N2O	5.1	5.1	0.00	99.99
1.B.2.a. Oil		CO2	4.0	4.0	0.00	100.00
1.A.1. Energy industries	Other fossil fuels	N2O	3.0	3.0	0.00	100.00
1.B.2.b. Natural Gas		CO2	2.8	2.8	0.00	100.00
1.A.1. Energy industries	Liquid fuels	CH4	2.3	2.3	0.00	100.00
1.A.3.d. Domestic Navigation	Gas/diesel oil	CH4	2.0	2.0	0.00	100.00
5.C. Incineration and open burning of waste		CO2	1.9	1.9	0.00	100.00
1.A.1. Energy industries	Other fossil fuels	CH4	1.9	1.9	0.00	100.00
5.C. Incineration and open burning of waste		CH4	1.7	1.7	0.00	100.00
1.A.3.a. Domestic Aviation		CH4	1.5	1.5	0.00	100.00



Table A3 Key category analysis level assessment without LULUCF, 2017 (cont'd)

Sector	Fuel	GAS	2017 Emission	ABS (Emission)	Cont. (%)	Cumulative
2.B.8.	Petrochemical and carbon black production	CO2	1.3	1.3	0.00	100.00
1.A.3.d.	Domestic Navigation	N2O	0.9	0.9	0.00	100.00
1.B.2.c	Venting and flaring	N2O	0.6	0.6	0.00	100.00
1.A.1.	Energy industries	CH4	0.6	0.6	0.00	100.00
1.A.3.c.	Railways	CH4	0.5	0.5	0.00	100.00
1.A.3.e.	Other transportation	N2O	0.4	0.4	0.00	100.00
1.A.3.e.	Other transportation	CH4	0.3	0.3	0.00	100.00
5.C.	Incineration and open burning of waste	N2O	0.3	0.3	0.00	100.00
1.A.3.d.	Domestic Navigation	CH4	0.3	0.3	0.00	100.00
1.C.	CO2 Transport and storage	CO2	0.1	0.1	0.00	100.00
2.E.5.	Other	HFC	0.1	0.1	0.00	100.00
2.E.5.	Other	SF6	0.0	0.0	0.00	100.00
1.A.2.	Manufacturing industries and construction	N2O	0.0	0.0	0.00	100.00
1.A.2.	Manufacturing industries and construction	CH4	0.0	0.0	0.00	100.00
2.E.5.	Other	PFC	0.0	0.0	0.00	100.00
<b>Total</b>			<b>526</b>	<b>252.99</b>		

Table A4 Key category analysis trend assessment with LULUCF, 2017

Sector	Fuel	Gas	2017	1990	Trend	Cont	Cum.
4.A.1. Forest Land Remaining Forest Land		CO2	-89 961.36	-52 977.05	0.318	19.08	19.08
1.A.1. Energy industries	Solid fuels	CO2	100 464.74	26 160.40	0.179	10.75	29.83
1.A.1. Energy industries	Gaseous fuels	CO2	47 364.42	5 024.67	0.136	8.18	38.01
1.A.4. Other sectors	Gaseous fuels	CO2	33 351.09	93.89	0.120	7.23	45.24
3.A. Enteric fermentation		CH4	30 039.21	22 314.09	0.109	6.55	51.78
1.A.3.b. Road Transportation		CO2	77 094.40	24 142.97	0.109	6.51	58.30
1.A.2. Manufacturing industries and construction	Solid fuels	CO2	20 663.43	22 199.68	0.075	4.50	62.80
3.D.a. Direct N2O emissions from managed soils		N2O	20 561.83	14 985.32	0.075	4.48	67.28
1.A.2. Manufacturing industries and construction	Gaseous fuels	CO2	21 059.47	1 557.79	0.065	3.93	71.21
2.A.1. Cement Production (Mineral Products)		CO2	37 272.44	10 444.54	0.061	3.67	74.88
1.A.4. Other sectors	Liquid fuels	CO2	12 136.69	14 433.04	0.058	3.50	78.38
4.G. Harvested Wood Products		CO2	-12 115.04	-2 947.74	0.044	2.61	81.00
1.A.2. Manufacturing industries and construction	Liquid fuels	CO2	16 763.25	13 246.53	0.033	1.99	82.99
5.A. Solid waste disposal		CH4	9 079.05	6 729.60	0.033	1.98	84.96
2.F.6. Other applications		HFC	7 876.57		0.029	1.72	86.68
1.A.1. Energy industries	Liquid fuels	CO2	5 364.48	5 945.25	0.023	1.36	88.04
5.D. Wastewater treatment and discharge		N2O	5 808.31	1 440.99	0.021	1.27	89.31
3.B. Manure management		N2O	4 190.08	3 013.18	0.015	0.91	90.22
1.A.4. Other sectors	Solid fuels	CO2	24 783.85	14 749.94	0.015	0.88	91.11
1.B.1. Solid fuels		CH4	3 681.41	3 598.18	0.013	0.80	91.91
3.B. Manure management		CH4	3 347.70	2 352.09	0.012	0.73	92.64
3.D.b. Indirect N2O Emissions from managed soils		N2O	2 555.35	2 108.14	0.009	0.56	93.19
5.D. Wastewater treatment and discharge		CH4	2 449.79	2 789.04	0.009	0.53	93.73
2.A.4. Other process uses of carbonates		CO2	3 631.70	618.97	0.009	0.53	94.26
1.B.2.b. Natural Gas		CH4	2 067.50	143.70	0.008	0.45	94.71
1.A.3.a. Domestic Aviation		CO2	3 798.42	913.74	0.007	0.44	95.14
2.A.2. Lime Production (Mineral Products)		CO2	2 683.98	2 248.84	0.006	0.37	95.52
2.C.1. Iron and Steel Production		CO2	11 556.54	6 766.59	0.006	0.36	95.88
1.A.2. Manufacturing industries and construction	Other fossil fuels	CO2	1 472.19		0.005	0.32	96.20
2.B.2. Nitric acid production		N2O	1 262.81	1 063.63	0.005	0.28	96.48
1.A.3.b. Road Transportation		N2O	1 231.33	537.71	0.004	0.27	96.75
1.A.4. Other sectors	Solid fuels	CH4	1 098.68	1 023.23	0.004	0.24	96.99
1.A.4. Other sectors	Liquid fuels	N2O	1 050.84	692.17	0.004	0.23	97.22
1.A.3.c. Railways		CO2	369.00	651.19	0.003	0.20	97.41

Table A4 Key category analysis trend assessment with LULUCF, 2017 (cont'd)

Sector	Fuel	Gas	2017	1990	Trend	Cont	Cum.
1.A.1. Energy industries	Solid fuels	N2O	691.53	96.75	0.003	0.15	97.56
1.A.3.e. Other transportation		CO2	757.05	39.29	0.002	0.15	97.71
1.A.1. Energy industries	Gaseous fuels	N2O	656.45	2.57	0.002	0.14	97.85
4.F.2. Land Converted to Other Land		CO2	653.05		0.002	0.14	98.00
1.A.4. Other sectors	Biomass	CH4	640.86	2 263.35	0.002	0.14	98.14
4.C.2. Land Converted to Grassland		CO2	630.79		0.002	0.14	98.27
3.H. Urea application		CO2	1 449.63	459.95	0.002	0.12	98.39
1.B.2.c Venting and flaring		CH4	485.77	126.99	0.002	0.11	98.50
2.A.3. Glass Production		CO2	686.01	111.30	0.002	0.10	98.60
4.B.2. Land Converted to Cropland		CO2	463.07		0.002	0.10	98.70
1.A.3.d. Domestic Navigation	Residual fuel oil	CO2	110.89	282.87	0.002	0.10	98.80
4.E.2. Land Converted to Settlements		CO2	412.62		0.001	0.09	98.89
1.A.3.d. Domestic Navigation	Gas/diesel oil	CO2	823.60	220.75	0.001	0.09	98.97
4.A.2. Land Converted to Forest Land		CO2	- 328.85	20.70	0.001	0.08	99.05
1.A.1. Energy industries	Other fossil fuels	CO2	363.45		0.001	0.08	99.13
1.B.2.a Oil		CH4	306.38	419.87	0.001	0.07	99.20
2.B.1. Ammonia Production		CO2	524.83	424.76	0.001	0.07	99.27
4.D.2. Land Converted to Wetlands		CO2	283.98		0.001	0.06	99.33
1.B.2.c Venting and flaring		CO2	150.24	217.58	0.001	0.06	99.39
3.C. Rice cultivation		CH4	233.76	100.19	0.001	0.05	99.44
2.B.7. Soda ash production		CO2	207.94		0.001	0.05	99.49
2.D.1. Lubricant Use		CO2	143.27	175.11	0.001	0.04	99.53
1.A.3.b. Road Transportation		CH4	379.81	96.49	0.001	0.04	99.57
2.F.3. Fire protection		HFC	172.0768		0.001	0.04	99.61
2.B.8. Petrochemical and carbon black production		CO2	1.35	81.49	0.001	0.03	99.64
3.F. Field burning of agricultural residues		CH4	126.09	265.12	0.000	0.03	99.67
4.B.1. Cropland Remaining Cropland		CO2	- 116.81	0.69	0.000	0.03	99.70
1.A.4. Other sectors	Solid fuels	N2O	113.96	61.00	0.000	0.02	99.72
2.B.5. Carbide production		CO2	7.57	58.99	0.000	0.02	99.74
1.A.4. Other sectors	Biomass	N2O	101.85	359.72	0.000	0.02	99.77
1.A.2. Manufacturing industries and construction	Solid fuels	N2O	87.44	72.60	0.000	0.02	99.78
2.C.3. Aluminium Production		CO2	108.42	99.16	0.000	0.02	99.80
1.A.4. Other sectors	Gaseous fuels	CH4	74.95	0.21	0.000	0.02	99.82
2.C.6. Zinc Production		CO2		37.84	0.000	0.02	99.84

Table A4 Key category analysis trend assessment with LULUCF, 2017 (cont'd)

Sector	Fuel	Gas	2017	1990	Trend	Cont	Cum.
2.C.3. Aluminium Production		PFC	73.10	625.30	0.000	0.02	99.85
2.G.1. Electrical equipment		SF6	73.074		0.000	0.02	99.87
4.A.1. Forest Land Remaining Forest Land		CH4	57.24	74.60	0.000	0.01	99.88
5.C. Incineration and open burning of waste		CO2	1.91	26.59	0.000	0.01	99.89
1.A.3.c. Railways		N2O	43.51	68.71	0.000	0.01	99.90
3.F. Field burning of agricultural residues		N2O	38.97	81.93	0.000	0.01	99.91
1.A.3.a. Domestic Aviation		N2O	38.51	8.88	0.000	0.01	99.92
4.A.1. Forest Land Remaining Forest Land		N2O	37.75	49.19	0.000	0.01	99.93
1.A.2. Manufacturing industries and construction	Liquid fuels	N2O	31.08	30.11	0.000	0.01	99.93
1.A.2. Manufacturing industries and construction	Solid fuels	CH4	49.05	40.84	0.000	0.01	99.94
1.A.1. Energy industries	Gaseous fuels	CH4	29.34	2.16	0.000	0.01	99.94
4.B.2. Land Converted to Cropland		N2O	22.19		0.000	0.00	99.95
1.A.4. Other sectors	Liquid fuels	CH4	20.26	30.81	0.000	0.00	99.95
2.C.2. Ferroalloys Production		CO2	139.32	61.56	0.000	0.00	99.96
1.A.4. Other sectors	Gaseous fuels	N2O	17.87	0.05	0.000	0.00	99.96
2.C.1. Iron and Steel Production		CH4	16.35	7.89	0.000	0.00	99.97
4.D.1.1. Peat Extraction Remaining Peat Extraction		CO2	39.60	12.35	0.000	0.00	99.97
1.A.2. Manufacturing industries and construction	Other fossil fuels	N2O	12.61		0.000	0.00	99.97
1.A.2. Manufacturing industries and construction	Liquid fuels	CH4	13.13	12.66	0.000	0.00	99.97
1.A.2. Manufacturing industries and construction	Gaseous fuels	N2O	11.28	0.84	0.000	0.00	99.98
4.C.2. Land Converted to Grassland		N2O	9.50		0.000	0.00	99.98
2.C.5. Lead Production		CO2	8.86	2.20	0.000	0.00	99.98
2.D.2. Paraffin Wax Use		CO2	8.25	8.25	0.000	0.00	99.98
5.B. Biological treatment of solid waste		CH4	8.18	11.21	0.000	0.00	99.98
1.A.2. Manufacturing industries and construction	Gaseous fuels	CH4	9.47	0.70	0.000	0.00	99.99
1.A.2. Manufacturing industries and construction	Other fossil fuels	CH4	7.93		0.000	0.00	99.99
1.A.3.d. Domestic Navigation	Gas/diesel oil	N2O	6.79	1.79	0.000	0.00	99.99
1.A.1. Energy industries	Biomass	N2O	6.50		0.000	0.00	99.99
1.A.1. Energy industries	Solid fuels	CH4	17.70	5.74	0.000	0.00	99.99
5.B. Biological treatment of solid waste		N2O	5.85	8.02	0.000	0.00	99.99
1.A.1. Energy industries	Liquid fuels	N2O	5.06	12.59	0.000	0.00	99.99
4.D.2. Land Converted to Wetlands		N2O	4.03	0.00	0.000	0.00	100.00
1.A.1. Energy industries	Liquid fuels	CH4	2.31	3.05	0.000	0.00	100.00
1.A.1. Energy industries	Other fossil fuels	N2O	3.02		0.000	0.00	100.00

Table A4 Key category analysis trend assessment with LULUCF, 2017 (cont'd)

Sector	Fuel	Gas	2017	1990	Trend	Cont	Cum.
1.B.2.b	Natural Gas	CO2	2.81	0.25	0.000	0.00	100.00
1.A.1.	Energy industries	CH4	1.90		0.000	0.00	100.00
5.C.	Incineration and open burning of waste	CH4	1.65	67.31	0.000	0.00	100.00
1.A.3.c.	Railways	CH4	0.53	0.86	0.000	0.00	100.00
1.A.3.d.	Domestic Navigation	CH4	0.25	0.63	0.000	0.00	100.00
1.A.3.d.	Domestic Navigation	CH4	1.99	0.53	0.000	0.00	100.00
1.A.3.a.	Domestic Aviation	CH4	1.49	0.31	0.000	0.00	100.00
1.A.3.d.	Domestic Navigation	N2O	0.86	2.15	0.000	0.00	100.00
1.B.2.a	Oil	CO2	3.99	2.38	0.000	0.00	100.00
1.B.2.c	Venting and flaring	N2O	0.63	0.91	0.000	0.00	100.00
1.A.1.	Energy industries	CH4	0.57		0.000	0.00	100.00
1.A.3.e.	Other transportation	N2O	0.41	0.02	0.000	0.00	100.00
4.A.2.	Land Converted to Forest Land	CH4	0.40	1.55	0.000	0.00	100.00
1.A.3.e.	Other transportation	CH4	0.34	0.02	0.000	0.00	100.00
5.C.	Incineration and open burning of waste	N2O	0.29	11.23	0.000	0.00	100.00
4.A.2.	Land Converted to Forest Land	N2O	0.26	1.02	0.000	0.00	100.00
1.C.	CO2 Transport and storage	CO2	0.13	0.13	0.000	0.00	100.00
2.E.5.	Other	HFC	0.09		0.000	0.00	100.00
2.E.5.	Other	SF6	0.04		0.000	0.00	100.00
4.C.1.	Grassland Remaining Grassland	CO2	0.03	0.03	0.000	0.00	100.00
1.A.2.	Manufacturing industries and construction	N2O	0.02		0.000	0.00	100.00
1.A.2.	Manufacturing industries and construction	CH4	0.01		0.000	0.00	100.00
2.E.5.	Other	PFC	0.01		0.000	0.00	100.00
2.B.8.	Petrochemical and carbon black production	CH4		0.05	0.000	0.00	100.00
<b>Total</b>			<b>426 345.50</b>	<b>163 437.03</b>	<b>1.67</b>	<b>100.00</b>	

Table A5 Key category analysis trend assessment without LULUCF, 2017

Sector	Fuel	Gas	2017	1990	Trend	Cont	Cum.
1.A.1. Energy industries	Solid fuels	CO2	100 464.74	26 160.40	0.179	13.84	13.84
1.A.1. Energy industries	Gaseous fuels	CO2	47 364.42	5 024.67	0.136	10.54	24.38
1.A.4. Other sectors	Gaseous fuels	CO2	33 351.09	93.89	0.120	9.31	33.69
3.A. Enteric fermentation		CH4	30 039.21	22 314.09	0.109	8.43	42.12
1.A.3.b. Road Transportation		CO2	77 094.40	24 142.97	0.109	8.39	50.51
1.A.2. Manufacturing industries and construction	Solid fuels	CO2	20 663.43	22 199.68	0.075	5.80	56.31
3.D.a. Direct N2O emissions from managed soils		N2O	20 561.83	14 985.32	0.075	5.77	62.08
1.A.2. Manufacturing industries and construction	Gaseous fuels	CO2	21 059.47	1 557.79	0.065	5.06	67.14
2.A.1. Cement Production (Mineral Products)		CO2	37 272.44	10 444.54	0.061	4.73	71.87
1.A.4. Other sectors	Liquid fuels	CO2	12 136.69	14 433.04	0.058	4.51	76.38
1.A.2. Manufacturing industries and construction	Liquid fuels	CO2	16 763.25	13 246.53	0.033	2.56	78.95
5.A. Solid waste disposal		CH4	9 079.05	6 729.60	0.033	2.55	81.50
2.F.6. Other applications		HFC	7 876.57		0.029	2.21	83.71
1.A.1. Energy industries	Liquid fuels	CO2	5 364.48	5 945.25	0.023	1.76	85.46
5.D. Wastewater treatment and discharge		N2O	5 808.31	1 440.99	0.021	1.63	87.09
3.B. Manure management		N2O	4 190.08	3 013.18	0.015	1.18	88.27
1.A.4. Other sectors	Solid fuels	CO2	24 783.85	14 749.94	0.015	1.14	89.41
1.B.1. Solid fuels		CH4	3 681.41	3 598.18	0.013	1.03	90.44
3.B. Manure management		CH4	3 347.70	2 352.09	0.012	0.94	91.38
3.D.b. Indirect N2O Emissions from managed soils		N2O	2 555.35	2 108.14	0.009	0.72	92.10
5.D. Wastewater treatment and discharge		CH4	2 449.79	2 789.04	0.009	0.69	92.79
2.A.4. Other process uses of carbonates		CO2	3 631.70	618.97	0.009	0.68	93.47
1.B.2.b. Natural Gas		CH4	2 067.50	143.70	0.008	0.58	94.05
1.A.3.a. Domestic Aviation		CO2	3 798.42	913.74	0.007	0.56	94.61
2.A.2. Lime Production (Mineral Products)		CO2	2 683.98	2 248.84	0.006	0.48	95.09
2.C.1. Iron and Steel Production		CO2	11 556.54	6 766.59	0.006	0.47	95.56
1.A.2. Manufacturing industries and construction	Other fossil fuels	CO2	1 472.19		0.005	0.41	95.97
2.B.2. Nitric acid production		N2O	1 262.81	1 063.63	0.005	0.35	96.33
1.A.3.b. Road Transportation		N2O	1 231.33	537.71	0.004	0.35	96.67
1.A.4. Other sectors	Solid fuels	CH4	1 098.68	1 023.23	0.004	0.31	96.98
1.A.4. Other sectors	Liquid fuels	N2O	1 050.84	692.17	0.004	0.29	97.28
1.A.3.c. Railways		CO2	369.00	651.19	0.003	0.25	97.53
1.A.1. Energy industries	Solid fuels	N2O	691.53	96.75	0.003	0.19	97.72
1.A.3.e. Other transportation		CO2	757.05	39.29	0.002	0.19	97.92
1.A.1. Energy industries	Gaseous fuels	N2O	656.45	2.57	0.002	0.18	98.10
1.A.4. Other sectors	Biomass	CH4	640.86	2 263.35	0.002	0.18	98.28
3.H. Urea application		CO2	1 449.63	459.95	0.002	0.15	98.43

Table A5 Key category analysis trend assessment without LULUCF, 2017 (cont'd)

Sector	Fuel	Gas	2017	1990	Trend	Cont	Cum.
1.B.2.c	Venting and flaring	CH4	485.77	126.99	0.002	0.14	98.57
2.A.3.	Glass Production	CO2	686.01	111.30	0.002	0.13	98.70
1.A.3.d.	Domestic Navigation	CO2	110.89	282.87	0.002	0.12	98.83
1.A.3.d.	Domestic Navigation	CO2	823.60	220.75	0.001	0.11	98.94
1.A.1.	Energy industries	CO2	363.45		0.001	0.10	99.04
1.B.2.a	Oil	CH4	306.38	419.87	0.001	0.09	99.12
2.B.1.	Ammonia Production	CO2	524.83	424.76	0.001	0.09	99.21
1.B.2.c	Venting and flaring	CO2	150.24	217.58	0.001	0.08	99.29
3.C.	Rice cultivation	CH4	233.76	100.19	0.001	0.07	99.35
2.B.7.	Soda ash production	CO2	207.94		0.001	0.06	99.41
2.D.1.	Lubricant Use	CO2	143.27	175.11	0.001	0.06	99.47
1.A.3.b.	Road Transportation	CH4	379.81	96.49	0.001	0.05	99.52
2.F.3.	Fire protection	HFC	172.0768		0.001	0.05	99.57
2.B.8.	Petrochemical and carbon black production	CO2	1.35	81.49	0.001	0.04	99.61
3.F.	Field burning of agricultural residues	CH4	126.09	265.12	0.000	0.04	99.65
1.A.4.	Other sectors	N2O	113.96	61.00	0.000	0.03	99.68
2.B.5.	Carbide production	CO2	7.57	58.99	0.000	0.03	99.71
1.A.4.	Other sectors	N2O	101.85	359.72	0.000	0.03	99.74
1.A.2.	Manufacturing industries and construction	N2O	87.44	72.60	0.000	0.02	99.76
2.C.3.	Aluminium Production	CO2	108.42	99.16	0.000	0.02	99.79
1.A.4.	Other sectors	CH4	74.95	0.21	0.000	0.02	99.81
2.C.6.	Zinc Production	CO2		37.84	0.000	0.02	99.83
2.C.3.	Aluminium Production	PFC	73.10	625.30	0.000	0.02	99.85
2.G.1.	Electrical equipment	SF6	73.074		0.000	0.02	99.87
5.C.	Incineration and open burning of waste	CO2	1.91	26.59	0.000	0.01	99.89
1.A.3.c.	Railways	N2O	43.51	68.71	0.000	0.01	99.90
3.F.	Field burning of agricultural residues	N2O	38.97	81.93	0.000	0.01	99.91
1.A.3.a.	Domestic Aviation	N2O	38.51	8.88	0.000	0.01	99.92
1.A.2.	Manufacturing industries and construction	N2O	31.08	30.11	0.000	0.01	99.93
1.A.2.	Manufacturing industries and construction	CH4	49.05	40.84	0.000	0.01	99.94
1.A.1.	Energy industries	CH4	29.34	2.16	0.000	0.01	99.94
1.A.4.	Other sectors	CH4	20.26	30.81	0.000	0.01	99.95
2.C.2.	Ferroalloys Production	CO2	139.32	61.56	0.000	0.01	99.95
1.A.4.	Other sectors	N2O	17.87	0.05	0.000	0.01	99.96
2.C.1.	Iron and Steel Production	CH4	16.35	7.89	0.000	0.00	99.96

Table A5 Key category analysis trend assessment without LULUCF, 2017 (cont'd)

Sector	Fuel	Gas	2017	1990	Trend	Cont	Cum.
1.A.2.	Manufacturing industries and construction	N2O	12.61		0.000	0.00	99.97
1.A.2.	Manufacturing industries and construction	CH4	13.13	12.66	0.000	0.00	99.97
1.A.2.	Manufacturing industries and construction	N2O	11.28	0.84	0.000	0.00	99.97
2.C.5.	Lead Production	CO2	8.86	2.20	0.000	0.00	99.98
2.D.2.	Paraffin Wax Use	CO2	8.25	8.25	0.000	0.00	99.98
5.B.	Biological treatment of solid waste	CH4	8.18	11.21	0.000	0.00	99.98
1.A.2.	Manufacturing industries and construction	CH4	9.47	0.70	0.000	0.00	99.98
1.A.2.	Manufacturing industries and construction	CH4	7.93		0.000	0.00	99.99
1.A.3.d.	Domestic Navigation	N2O	6.79	1.79	0.000	0.00	99.99
1.A.1.	Energy industries	N2O	6.50		0.000	0.00	99.99
1.A.1.	Energy industries	CH4	17.70	5.74	0.000	0.00	99.99
5.B.	Biological treatment of solid waste	N2O	5.85	8.02	0.000	0.00	99.99
1.A.1.	Energy industries	N2O	5.06	12.59	0.000	0.00	99.99
1.A.1.	Energy industries	CH4	2.31	3.05	0.000	0.00	100.00
1.A.1.	Energy industries	N2O	3.02		0.000	0.00	100.00
1.B.2.b	Natural Gas	CO2	2.81	0.25	0.000	0.00	100.00
1.A.1.	Energy industries	CH4	1.90		0.000	0.00	100.00
5.C.	Incineration and open burning of waste	CH4	1.65	67.31	0.000	0.00	100.00
1.A.3.c.	Railways	CH4	0.53	0.86	0.000	0.00	100.00
1.A.3.d.	Domestic Navigation	CH4	0.25	0.63	0.000	0.00	100.00
1.A.3.d.	Domestic Navigation	CH4	1.99	0.53	0.000	0.00	100.00
1.A.3.a.	Domestic Aviation	CH4	1.49	0.31	0.000	0.00	100.00
1.A.3.d.	Domestic Navigation	N2O	0.86	2.15	0.000	0.00	100.00
1.B.2.a	Oil	CO2	3.99	2.38	0.000	0.00	100.00
1.B.2.c	Venting and flaring	N2O	0.63	0.91	0.000	0.00	100.00
1.A.1.	Energy industries	CH4	0.57		0.000	0.00	100.00
1.A.3.e.	Other transportation	N2O	0.41	0.02	0.000	0.00	100.00
1.A.3.e.	Other transportation	CH4	0.34	0.02	0.000	0.00	100.00
5.C.	Incineration and open burning of waste	N2O	0.29	11.23	0.000	0.00	100.00
1.C.	CO2 Transport and storage	CO2	0.13	0.13	0.000	0.00	100.00
2.E.5.	Other	HFC	0.09		0.000	0.00	100.00
2.E.5.	Other	SF6	0.04		0.000	0.00	100.00
1.A.2.	Manufacturing industries and construction	N2O	0.02		0.000	0.00	100.00
1.A.2.	Manufacturing industries and construction	CH4	0.01		0.000	0.00	100.00
2.E.5.	Other	PFC	0.01		0.000	0.00	100.00
2.B.8.	Petrochemical and carbon black production	CH4		0.05	0.000	0.00	100.00
Total			526 252.99	219 201.69	1.29	100.00	



## Annex 2: Uncertainty

In this submission, on the recommendation of the UNFCCC expert review team (ERT) in 2018 Turkey has undertaken a tier 2 uncertainty analysis. Therefore, Turkey has estimated uncertainties both with Approach 1 and Approach 2 (Monte Carlo Simulation) methods. Approach 1, based on the error propagation equations, and Approach 2, corresponding to the application of Monte Carlo analysis. In the IPCC Good Practice Guidance, two methodologies (Tier 1 and Tier 2) for combining uncertainties are defined. Tier 1 uses error propagation equations. The equations are appropriate, when uncertainties are relatively small, have normal distributions and have no significant covariance. Tier 2 is more sophisticated method using Monte Carlo simulation, and it is the main method used in this study. However, according to the IPCC Good Practice Guidance (Penman et al. 2000), countries performing an uncertainty analysis according to Tier 2 should also report the Tier 1 results.

Table A6 shows Approach 1 results.

Approach 2 was implemented in previous years' submissions to estimate uncertainty of some specific categories, for 2017 emission levels with SPSS Modeler 18.2 software. Those specific categories are shown at the summary table below in Table A7. Also the comparisons between Approach 1 and Approach 2 can easily be seen there. The main reasons of selected categories are their large shares of in total emissions and it is thought that first uncertainty method calculations require quality control for some of them primarily. In next year's submissions all sectors and their sub-sectors will be added to Approach 2 calculations and more details will be provided in the next NIR. The results show that uncertainty values are generally lower than those derived from the application of Approach 1.

In Monte Carlo simulation, random numbers are selected from each distribution (for example, from probability distributions of activity data and emission factors) with means of uncertainties of Approach 1, and the total emissions are calculated ten thousand to one hundred thousand of times to obtain the probability distribution of total emissions. So the selected precisions were obtained after about 100.000 trials.

Monte Carlo simulation allows the use of asymmetrical distributions. Normal distribution is the most widely used distribution in this study. It is symmetrical around the mean, and defined for all values. However, because emissions cannot be negative, normal distribution is used only in the cases where uncertainty is lower than  $\pm 100\%$ . Normal distribution is a two-parametrical distribution, and can therefore be completely described with the 95% confidence interval. Moreover, some sub-categories

are defined with the PDF of lognormal distribution. E.g.: Urea application and Biological treatment of solid waste because of single-sided uncertainty distribution of ADs or EFs. Lognormal distribution is positively skewed, and it is defined only for positive values, which makes it very useful in describing emissions. Lognormal distribution is a transformation of normal distribution, and is therefore also a two-parametric distribution. A combination of Monte Carlo and Bootstrap simulation was applied also some categories, in consideration of the specific data availability assuming a normal distribution for activity data and for the emission factor of natural gas.

According to the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Emission Inventories is “a system of routine technical activities, to measure and control the quality of the inventory as it is being developed”. The QC system is designed to provide routine and consistent checks to ensure data integrity, correctness and completeness, to identify and address errors and emissions and to document and archive inventory material and record all QC activities. Therefore, Monte Carlo is a way of QC procedure. And, for the categories with a high uncertainty, generally, further improvements are planned whenever sectoral studies can be carried out.

Throughout the entire time series, the uncertainties associated with annual estimates are expressed as a 95% confidence interval, bound by 2.5th and 97.5th percentiles of the Monte Carlo run outputs.

Table A6 Approach 1 Uncertainty assessment

Source Category	Fuel	Gas	Emissions in 1990		Emissions in 2017		AD Unc.		EF Unc.		A <sup>(1)</sup>		B <sup>(2)</sup>		C <sup>(3)</sup>		D <sup>(4)</sup>		E <sup>(5)</sup>		F <sup>(6)</sup>		G <sup>(7)</sup>	
			Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1.A.1.a. Public Electricity and Heat Production	Liquid fuels	CO2	3 650.2	1.0	1 232.2	4.1	1.0	4.1	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.0	0.0
1.A.1.a. Public Electricity and Heat Production	Solid fuels	CO2	24 147.7	1.0	98 081.6	3.4	1.0	3.4	3.5	0.6	0.4	0.8	0.7	1.1	1.2	0.0	0.8	0.7	1.1	1.1	1.1	1.1	1.2	1.2
1.A.1.a. Public Electricity and Heat Production	Gaseous fuels	CO2	5 024.7	1.0	45 136.8	1.1	1.0	1.1	1.5	0.0	0.0	0.4	0.2	0.4	0.2	0.0	0.4	0.2	0.4	0.4	0.4	0.4	0.2	0.2
1.A.1.a. Public Electricity and Heat Production	Other fossil fuels	CO2			363.4	9.6	18.0	9.6	20.4	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.0
1.A.1.b. Petroleum Refining	Liquid fuels	CO2	2 280.4	2.0	4 132.2	7.0	2.0	7.0	7.3	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
1.A.1.b. Petroleum Refining	Gaseous fuels	CO2			2 227.7	7.0	2.0	7.0	7.3	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0
1.A.1.c. Manufacture of solid fuels	Solid fuels	CO2	2 012.7	2.0	2 383.1	7.0	2.0	7.0	7.3	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0
1.A.2.a. Iron and Steel Production	Liquid fuels	CO2	1 823.3	10.0	44.8	7.0	10.0	7.0	12.2	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.0	0.0
1.A.2.a. Iron and Steel Production	Solid fuels	CO2	4 854.8	10.0	1 353.8	7.0	10.0	7.0	12.2	0.0	0.0	0.1	0.5	0.5	0.2	0.0	0.1	0.5	0.5	0.5	0.5	0.5	0.2	0.2
1.A.2.a. Iron and Steel Production	Gaseous fuels	CO2			2 923.7	7.0	10.0	7.0	12.2	0.0	0.0	0.3	0.1	0.3	0.1	0.0	0.3	0.1	0.3	0.1	0.3	0.1	0.1	0.1
1.A.2.b. Non-Ferrous Metals	Liquid fuels	CO2	927.8	15.1	15.1	21.2	21.2	7.0	22.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0
1.A.2.b. Non-Ferrous Metals	Solid fuels	CO2	156.3	259.9	259.9	21.2	21.2	7.0	22.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.b. Non-Ferrous Metals	Gaseous fuels	CO2			858.7	21.2	21.2	7.0	22.3	0.0	0.0	0.2	0.0	0.2	0.0	0.0	0.2	0.0	0.2	0.0	0.2	0.2	0.0	0.0
1.A.2.c. Chemicals	Liquid fuels	CO2	2 588.1	27.9	27.9	15.8	15.8	7.0	17.3	0.0	0.0	0.0	0.3	0.3	0.1	0.0	0.1	0.3	0.3	0.3	0.3	0.3	0.1	0.1
1.A.2.c. Chemicals	Solid fuels	CO2	1 342.6	992.8	992.8	15.8	15.8	7.0	17.3	0.0	0.0	0.1	0.1	0.2	0.0	0.0	0.1	0.1	0.2	0.1	0.2	0.2	0.0	0.0
1.A.2.c. Chemicals	Gaseous fuels	CO2	944.6	4 266.4	4 266.4	15.8	15.8	7.0	17.3	0.0	0.0	0.6	0.1	0.6	0.3	0.0	0.6	0.1	0.6	0.1	0.6	0.1	0.3	0.3
1.A.2.c. Chemicals	Other fossil fuels	CO2			18.8	2.0	2.0	7.0	7.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.d. Pulp, Paper and Print	Liquid fuels	CO2	24.2	18.0	24.2	18.0	18.0	7.0	19.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.d. Pulp, Paper and Print	Solid fuels	CO2	441.0	18.0	441.0	18.0	18.0	7.0	19.3	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.0
1.A.2.d. Pulp, Paper and Print	Gaseous fuels	CO2	473.5	18.0	473.5	18.0	18.0	7.0	19.3	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.0
1.A.2.e. Food Processing, Beverages and Tobacco	Liquid fuels	CO2	420.7	91.6	91.6	5.0	5.0	7.0	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.e. Food Processing, Beverages and Tobacco	Solid fuels	CO2	2 471.7	2 435.1	2 435.1	18.0	18.0	7.0	19.3	0.0	0.0	0.4	0.2	0.4	0.2	0.0	0.4	0.2	0.4	0.2	0.4	0.3	0.1	0.1
1.A.2.e. Food Processing, Beverages and Tobacco	Gaseous fuels	CO2			2 375.3	14.1	14.1	7.0	15.8	0.0	0.0	0.3	0.1	0.3	0.1	0.0	0.3	0.1	0.3	0.1	0.3	0.3	0.1	0.1
1.A.2.f. Non metallic minerals	Liquid fuels	CO2	2 626.3	15 296.7	15 296.7	27.8	27.8	7.0	28.7	1.1	1.1	3.7	0.4	3.7	13.7	0.0	3.7	0.4	3.7	0.4	3.7	0.4	13.7	13.7
1.A.2.f. Non metallic minerals	Solid fuels	CO2	5 587.5	11 538.7	11 538.7	25.5	25.5	7.0	26.4	0.5	0.3	2.5	0.1	2.5	6.5	0.0	2.5	0.1	2.5	0.1	2.5	0.1	6.5	6.5
1.A.2.f. Non metallic minerals	Gaseous fuels	CO2	1.9	4 141.7	4 141.7	29.2	29.2	7.0	30.0	0.1	0.0	1.0	0.2	1.1	1.1	0.0	1.0	0.2	1.1	0.2	1.1	1.1	1.1	1.1
1.A.2.f. Non metallic minerals	Other fossil fuels	CO2			1 453.4	2.0	2.0	7.0	7.3	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0
1.A.2.g. Other Industries	Liquid Fuels	CO2	4 860.3	1 262.9	1 262.9	70.7	70.7	7.0	71.1	0.0	0.0	0.8	0.5	0.9	0.8	0.0	0.8	0.5	0.9	0.5	0.9	0.8	0.8	0.8
1.A.2.g. Other Industries	Solid Fuels	CO2	7 786.9	3 642.2	3 642.2	70.7	70.7	7.0	71.1	0.4	0.1	2.2	0.7	2.3	5.5	0.0	2.2	0.7	2.3	0.7	2.3	5.5	5.5	5.5
1.A.2.g. Other Industries	Gaseous Fuels	CO2	611.2	6 020.2	6 020.2	70.7	70.7	7.0	71.1	1.0	1.0	3.7	0.2	3.7	13.6	0.0	3.7	0.2	3.7	0.2	3.7	13.6	13.6	13.6
1.A.3.a. Domestic Aviation	Jet kerosene	CO2	913.7	3 798.4	3 798.4	5.5	5.5	5.0	7.4	0.0	0.0	0.2	0.0	0.2	0.0	0.0	0.2	0.0	0.2	0.0	0.2	0.0	0.0	0.0
1.A.3.b. Road Transportation	Gasoline	CO2	8 377.4	6 894.3	6 894.3	10.1	10.1	5.0	11.2	0.0	0.0	0.6	0.5	0.8	0.6	0.0	0.6	0.5	0.8	0.5	0.8	0.6	0.6	0.6
1.A.3.b. Road Transportation	Diesel oil	CO2	15 765.5	60 740.4	60 740.4	10.1	10.1	5.0	11.2	2.6	6.5	5.3	0.6	5.3	28.3	0.0	5.3	0.6	5.3	0.6	5.3	28.3	28.3	28.3
1.A.3.b. Road Transportation	Liquefied petroleum gases (LPG)	CO2		9 299.0	9 299.0	10.1	10.1	5.0	11.2	0.1	0.0	0.8	0.3	0.9	0.7	0.0	0.8	0.3	0.9	0.3	0.9	0.7	0.7	0.7
1.A.3.b. Road Transportation	Gaseous fuels	CO2		160.7	160.7	10.0	10.0	7.0	12.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.c. Railways	Liquid fuels	CO2	589.5	369.0	369.0	2.0	2.0	1.5	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A6 Approach 1 Uncertainty assessment

Source Category	Fuel	Gas	Emissions in 1990 Gg CO <sub>2</sub> eq	Emissions in 2017 Gg CO <sub>2</sub> eq	AD Unc.	EF Unc.	A <sup>(1)</sup> %	B <sup>(2)</sup> %	C <sup>(3)</sup> %	D <sup>(4)</sup> %	E <sup>(5)</sup> %	F <sup>(6)</sup> %	G <sup>(7)</sup> %
1.A.3.c. Railways	Solid fuels	CO <sub>2</sub>	61.7		0.0	14.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.d. Domestic Navigation	Residual fuel oil	CO <sub>2</sub>	282.9	110.9	15.0	3.0	15.3	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.d. Domestic Navigation	Gas/diesel oil	CO <sub>2</sub>	220.8	823.6	15.0	1.5	15.1	0.0	0.0	0.1	0.0	0.1	0.0
1.A.3.e. Pipeline Transportation	Gaseous fuels	CO <sub>2</sub>	39.3	757.1	5.0	7.0	8.6	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.a. Commercial/institutional	Liquid fuels	CO <sub>2</sub>		2 598.1	7.1	7.0	10.0	0.0	0.0	0.2	0.1	0.2	0.0
1.A.4.a. Commercial/institutional	Solid fuels	CO <sub>2</sub>		10 783.5	14.1	7.0	15.7	0.2	0.0	1.3	0.5	1.4	1.9
1.A.4.a. Commercial/institutional	Gaseous fuels	CO <sub>2</sub>	8 663.4	653.0	5.0	7.0	8.6	0.0	0.0	0.3	0.3	0.4	0.2
1.A.4.b. Residential	Liquid fuels	CO <sub>2</sub>		14 749.9	7.1	7.0	10.0	0.0	0.0	0.0	0.9	0.9	0.9
1.A.4.b. Residential	Solid fuels	CO <sub>2</sub>		14 000.4	14.1	7.0	15.7	0.3	0.1	1.7	1.0	2.0	4.0
1.A.4.b. Residential	Gaseous fuels	CO <sub>2</sub>	93.9	25 966.4	5.0	7.0	8.6	0.3	0.1	1.1	1.1	1.6	2.5
1.A.4.c. Agriculture/Forestry/Fisheries	Liquid fuels	CO <sub>2</sub>	5 769.6	8 885.6	14.1	5.0	15.0	0.1	0.0	1.1	0.2	1.1	1.2
1.A.4.c. Agriculture/Forestry/Fisheries	Gaseous fuels	CO <sub>2</sub>		226.4	7.0	7.0	9.9	0.0	0.0	0.0	0.0	0.0	0.0
1.B.2.a. Oil		CO <sub>2</sub>	2.4	4.0	7.0	50.0	50.5	0.0	0.0	0.0	0.0	0.0	0.0
1.B.2.b. Natural gas		CO <sub>2</sub>	0.3	2.8	7.0	50.0	50.5	0.0	0.0	0.0	0.0	0.0	0.0
1.B.2.c. Venting and flaring		CO <sub>2</sub>	217.6	150.2	7.0	50.0	50.5	0.0	0.0	0.0	0.1	0.1	0.0
1.C. Transport of CO <sub>2</sub>		CO <sub>2</sub>	0.1	0.1	2.0	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0
2.A.1. Cement Production (Mineral Products)		CO <sub>2</sub>	10 444.5	37 272.4	5.0	2.0	5.4	0.2	0.0	1.6	0.1	1.6	2.6
2.A.2. Lime Production (Mineral Products)		CO <sub>2</sub>	2 248.8	2 684.0	10.0	10.0	14.1	0.0	0.0	0.2	0.2	0.3	0.1
2.A.3. Glass Production		CO <sub>2</sub>	111.3	686.0	5.0	2.0	5.4	0.0	0.0	0.0	0.0	0.0	0.0
2.A.4. Other process uses of carbonates		CO <sub>2</sub>	619.0	3 631.7	30.0	2.0	30.1	0.1	0.0	0.9	0.0	0.9	0.9
2.B.1. Ammonia Production		CO <sub>2</sub>	424.8	524.8	2.0	5.0	5.4	0.0	0.0	0.0	0.0	0.0	0.0
2.B.5. Carbide production		CO <sub>2</sub>	59.0	7.6	5.0	20.0	20.6	0.0	0.0	0.0	0.0	0.0	0.0
2.B.7. Soda ash production		CO <sub>2</sub>		207.9	5.0	1.0	5.1	0.0	0.0	0.0	0.0	0.0	0.0
2.B.8. Petrochemical and carbon black production		CO <sub>2</sub>	81.5	1.3	10.0	10.0	14.1	0.0	0.0	0.0	0.0	0.0	0.0
2.C.1. Iron and Steel Production		CO <sub>2</sub>	6 766.6	11 556.5	10.0	25.0	26.9	0.5	0.3	1.0	0.9	1.4	1.9
2.C.2. Ferroalloys Production		CO <sub>2</sub>	61.6	139.3	5.0	25.0	25.5	0.0	0.0	0.0	0.0	0.0	0.0
2.C.3. Aluminium Production		CO <sub>2</sub>	99.2	108.4	1.0	5.0	5.1	0.0	0.0	0.0	0.0	0.0	0.0
2.C.5. Lead Production		CO <sub>2</sub>	2.2	8.9	25.0	20.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0
2.C.6. Zinc Production		CO <sub>2</sub>	37.8		20.0	50.0	53.9	0.0	0.0	0.0	0.0	0.0	0.0
2.D.1. Lubricant Use		CO <sub>2</sub>	175.1	143.3	25.0	50.0	55.9	0.0	0.0	0.0	0.1	0.1	0.0
2.D.2. Paraffin Wax Use		CO <sub>2</sub>	8.3	8.3	25.0	100.0	103.1	0.0	0.0	0.0	0.0	0.0	0.0
3.H. Urea application		CO <sub>2</sub>	459.9	1 449.6	10.0	50.0	51.0	0.0	0.0	0.1	0.1	0.1	0.0
4.A. Forestland		CO <sub>2</sub>	-52 956.4	-90 290.2	75.9	4.5	76.0	259.3	67225.1	59.3	1.3	59.3	3518.7
4.B. Cropland		CO <sub>2</sub>	0.7	346.3	48.0	4.5	48.2	0.0	0.0	0.1	0.0	0.1	0.0
4.C. Grassland		CO <sub>2</sub>	0.0	630.8	149.0	4.5	149.1	0.0	0.0	0.8	0.0	0.8	0.7
4.D. Wetlands		CO <sub>2</sub>	12.4	323.6	86.0	4.5	86.1	0.0	0.0	0.2	0.0	0.2	0.1

Table A6 Approach 1 Uncertainty assessment (cont'd)

Source Category	Fuel	Gas	Emissions in 1990 Gg CO <sub>2</sub> eq	Emissions in 2017 Gg CO <sub>2</sub> eq	AD Unc.	EF Unc.	A <sup>(1)</sup> %	B <sup>(2)</sup> %	C <sup>(3)</sup> %	D <sup>(4)</sup> %	E <sup>(5)</sup> %	F <sup>(6)</sup> %	G <sup>(7)</sup> %
4.E. Settlements		CO2		412.6	26.0	4.5	26.4	0.0	0.0	0.1	0.0	0.1	0.0
4.F. Other land		CO2		653.1	18.0	4.5	18.6	0.0	0.0	0.1	0.0	0.1	0.0
4.G. Harvested wood products		CO2	-2 947.7	-12 115.0	23.5	4.5	23.9	0.5	0.2	2.5	0.1	2.5	6.1
5.C. Incineration and open burning of waste		CO3	26.6	1.9	30.4	40.0	50.2	0.0	0.0	0.0	0.0	0.0	0.0
<b>TOTAL</b>	<b>TOTAL CO2</b>		<b>95 602.7</b>	<b>325 290.7</b>				<b>16.4</b>				<b>60.1281</b>	
1.A.1.a. Public Electricity and Heat Production	Liquid fuels	CH4	1.2	0.4	6.0	25.0	25.7	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.a. Public Electricity and Heat Production	Solid fuels	CH4	5.3	17.3	1.0	25.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.a. Public Electricity and Heat Production	Gaseous fuels	CH4	2.2	28.3	3.0	25.0	25.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.a. Public Electricity and Heat Production	Other fossil fuels	CH4		1.9	0.9	25.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.a. Public Electricity and Heat Production	Biomass	CH4		0.6	0.9	25.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.b. Petroleum Refining	Liquid fuels	CH4	1.8	2.0	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.b. Petroleum Refining	Gaseous fuels	CH4		1.0	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.c. Manufacture of solid fuels	Solid fuels	CH4	0.4	0.3	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.a. Iron and Steel Production	Liquid fuels	CH4	1.8	0.0	10.0	100.0	100.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.a. Iron and Steel Production	Solid fuels	CH4	0.7	0.7	10.0	100.0	100.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.a. Iron and Steel Production	Gaseous fuels	CH4		1.3	10.0	100.0	100.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.b. Non-Ferrous Metals	Liquid fuels	CH4	0.9	0.0	21.2	100.0	102.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.b. Non-Ferrous Metals	Solid fuels	CH4	0.3	0.6	21.2	100.0	102.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.b. Non-Ferrous Metals	Gaseous fuels	CH4		0.4	21.2	100.0	102.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.c. Chemicals	Liquid fuels	CH4	2.5	0.0	15.8	100.0	101.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.c. Chemicals	Solid fuels	CH4	2.9	2.5	15.8	100.0	101.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.c. Chemicals	Gaseous fuels	CH4	0.4	1.9	15.8	100.0	101.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.c. Chemicals	Other fossil fuels	CH4		0.1	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.d. Pulp, Paper and Print	Liquid fuels	CH4		0.0	18.0	100.0	101.6	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.d. Pulp, Paper and Print	Solid fuels	CH4		1.1	18.0	100.0	101.6	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.d. Pulp, Paper and Print	Gaseous fuels	CH4		0.2	18.0	100.0	101.6	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.e. Food Processing, Beverages and Tobacco	Liquid fuels	CH4	0.4	0.1	5.0	100.0	100.1	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.e. Food Processing, Beverages and Tobacco	Solid fuels	CH4	5.5	5.9	18.0	100.0	101.6	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.e. Food Processing, Beverages and Tobacco	Gaseous fuels	CH4		1.1	14.1	100.0	101.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.f. Non metallic minerals	Liquid fuels	CH4	2.4	11.9	27.8	100.0	103.8	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.f. Non metallic minerals	Solid fuels	CH4	13.6	29.7	25.5	100.0	103.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.f. Non metallic minerals	Gaseous fuels	CH4	0.0	1.9	29.2	100.0	104.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.f. Non metallic minerals	Other fossil fuels	CH4		7.8	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A6 Approach 1 Uncertainty assessment (cont'd)

Source Category	Fuel	Gas	Emissions in 1990 Gg CO <sub>2</sub> eq	Emissions in 2017 Gg CO <sub>2</sub> eq	AD Unc.	EF Unc.	A <sup>(1)</sup> %	B <sup>(2)</sup> %	C <sup>(3)</sup> %	D <sup>(4)</sup> %	E <sup>(5)</sup> %	F <sup>(6)</sup> %	G <sup>(7)</sup> %
1.A.2.f. Non metallic minerals	Biomass	CH <sub>4</sub>		0.0	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.g. Other Industries	Liquid Fuels	CH <sub>4</sub>	4.7	1.0	70.7	100.0	122.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.g. Other Industries	Solid Fuels	CH <sub>4</sub>	17.7	8.7	70.7	100.0	122.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.g. Other Industries	Gaseous Fuels	CH <sub>4</sub>	0.3	2.7	70.7	100.0	122.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.a. Domestic Aviation	Jet kerosene	CH <sub>4</sub>	0.3	1.5	5.5	80.0	80.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.b. Road Transportation	Gasoline	CH <sub>4</sub>	75.6	62.2	10.0	250.0	250.2	0.0	0.0	0.0	0.2	0.2	0.0
1.A.3.b. Road Transportation	Diesel oil	CH <sub>4</sub>	20.9	81.9	10.0	250.0	250.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.b. Road Transportation	Liquefied petroleum gases (LPG)	CH <sub>4</sub>		228.5	10.0	250.0	250.2	0.0	0.0	0.0	0.3	0.4	0.1
1.A.3.b. Road Transportation	Gaseous fuels	CH <sub>4</sub>		6.6	10.0	250.0	250.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.b. Road Transportation	Biomass	CH <sub>4</sub>		0.5	10.0	250.0	250.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.c. Railways	Liquid fuels	CH <sub>4</sub>	0.8	0.5	5.0	105.0	105.1	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.c. Railways	Solid fuels	CH <sub>4</sub>	0.0	0.0	5.0	135.0	135.1	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.d. Domestic Navigation	Residual fuel oil	CH <sub>4</sub>	0.6	0.3	15.0	50.0	52.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.d. Domestic Navigation	Gas/diesel oil	CH <sub>4</sub>	0.5	2.0	15.0	50.0	52.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.e. Pipeline Transportation	Gaseous fuels	CH <sub>4</sub>	0.0	0.3	5.0	100.0	100.1	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.a. Commercial/institutional	Liquid fuels	CH <sub>4</sub>		6.1	7.1	100.0	100.3	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.a. Commercial/institutional	Solid fuels	CH <sub>4</sub>		28.0	14.1	100.0	101.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.a. Commercial/institutional	Gaseous fuels	CH <sub>4</sub>		16.1	5.0	100.0	100.1	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.b. Residential	Liquid fuels	CH <sub>4</sub>	22.5	1.4	7.1	100.0	100.3	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.b. Residential	Solid fuels	CH <sub>4</sub>	1 023.2	1 070.6	14.1	100.0	101.0	0.1	0.0	0.1	1.0	1.0	1.0
1.A.4.b. Residential	Gaseous fuels	CH <sub>4</sub>	0.2	58.4	5.0	100.0	100.1	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.b. Residential	Biomass	CH <sub>4</sub>	2 263.4	640.9	300.0	100.0	316.2	0.2	0.1	1.7	3.2	3.6	13.1
1.A.4.c. Agriculture/Forestry/Fisheries	Liquid fuels	CH <sub>4</sub>	8.3	12.8	200.0	250.0	320.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.c. Agriculture/Forestry/Fisheries	Gaseous fuels	CH <sub>4</sub>		0.5	7.0	100.0	100.2	0.0	0.0	0.0	0.0	0.0	0.0
1.B.1.a. Coal mining and handling		CH <sub>4</sub>	3 598.2	3 681.4	16.6	150.0	150.9	1.7	2.9	0.5	5.2	5.3	27.7
1.B.2.a. Oil		CH <sub>4</sub>	419.9	306.4	7.0	100.0	100.2	0.0	0.0	0.0	0.5	0.5	0.2
1.B.2.b. Natural gas		CH <sub>4</sub>	143.7	2 067.5	7.0	100.0	100.2	0.2	0.1	0.1	1.0	1.0	1.1
1.B.2.c. Venting and flaring		CH <sub>4</sub>	127.0	485.8	7.0	100.0	100.2	0.0	0.0	0.0	0.1	0.1	0.0
2.B.8. Petrochemical and carbon black production		CH <sub>4</sub>	0.0		10.0	30.0	31.6	0.0	0.0	0.0	0.0	0.0	0.0
2.C.1. Iron and Steel Production		CH <sub>4</sub>	7.9	16.3	10.0	5.0	11.2	0.0	0.0	0.0	0.0	0.0	0.0
3.A. Enteric fermentation		CH <sub>4</sub>	22 314.1	30 039.2	8.6	12.1	14.8	1.1	1.2	2.2	2.1	3.1	9.3
3.B. Manure management		CH <sub>4</sub>	2 352.1	3 347.7	14.1	30.0	33.1	0.1	0.0	0.4	0.5	0.7	0.4
3.C. Rice cultivation		CH <sub>4</sub>	100.2	233.8	5.0	76.7	76.9	0.0	0.0	0.0	0.0	0.0	0.0
3.F. Field burning of agricultural residues		CH <sub>4</sub>	265.1	126.1	50.0	40.0	64.0	0.0	0.0	0.1	0.1	0.1	0.0
4.A. Forest land		CH <sub>4</sub>	76.1	57.6	23.5	1.7	23.6	0.0	0.0	0.0	0.0	0.0	0.0
5.A.1. Managed waste disposal		CH <sub>4</sub>		846.8	10.0	30.8	32.4	0.0	0.0	0.1	0.2	0.2	0.0

Table A6 Approach 1 Uncertainty assessment (cont'd)

Source Category	Fuel	Gas	Emissions in 1990		Emissions in 2017		AD Unc.		EF Unc.		A <sup>(1)</sup> %		B <sup>(2)</sup> %		C <sup>(3)</sup> %		D <sup>(4)</sup> %		E <sup>(5)</sup> %		F <sup>(6)</sup> %		G <sup>(7)</sup> %	
			Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%	Unc.	%	Unc.	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
5.A.2.	Unmanaged waste disposal sites	CH <sub>4</sub>	6 729.6		8 232.2		30.0		38.1		48.5		0.9		0.8		2.1		2.2		3.0		9.3	
5.B.	Biological treatment of solid waste	CH <sub>4</sub>	11.2		8.2		10.0		20.0		22.4		0.0		0.0		0.0		0.0		0.0		0.0	
5.C.	Incineration and open burning of waste	CH <sub>4</sub>	67.3		1.7		30.4		100.0		104.5		0.0		0.0		0.0		0.1		0.1		0.0	
5.D.1	Domestic wastewater	CH <sub>4</sub>	2 579.8		1 925.5		5.0		37.7		38.0		0.0		0.0		0.1		1.1		1.1		1.2	
<b>Total</b>	<b>Total CH<sub>4</sub></b>		<b>42 483.0</b>		<b>54 251.0</b>								<b>2.1</b>										<b>8.0</b>	
<b>Cumulative</b>	<b>Cumulative CO<sub>2</sub> and CH<sub>4</sub></b>		<b>138 085.8</b>		<b>379 541.7</b>																		<b>46.3</b>	
1.A.1.a.	Public Electricity and Heat Production	N <sub>2</sub> O	8.5		1.7		6.0		75.0		75.2		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.1.a.	Public Electricity and Heat Production	N <sub>2</sub> O	95.2		691.1		1.0		75.0		75.0		0.0		0.0		0.0		0.2		0.2		0.0	
1.A.1.a.	Public Electricity and Heat Production	N <sub>2</sub> O	2.6		655.3		3.0		75.0		75.1		0.0		0.0		0.0		0.3		0.3		0.1	
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels			3.0		0.9		75.0		75.0		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.1.a.	Public Electricity and Heat Production	Biomass			6.5		0.9		75.0		75.0		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.1.b.	Petroleum Refining	Liquid fuels	4.1		3.3		2.0		100.0		100.0		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.1.b.	Petroleum Refining	Gaseous fuels			1.2		2.0		100.0		100.0		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.1.c.	Manufacture of solid fuels	Solid fuels	1.6		0.4		2.0		100.0		100.0		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.2.a.	Iron and Steel Production	Liquid fuels	4.2		0.1		10.0		100.0		100.5		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.2.a.	Iron and Steel Production	Solid fuels	0.8		1.0		10.0		100.0		100.5		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.2.a.	Iron and Steel Production	Gaseous fuels			1.6		10.0		100.0		100.5		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	2.1		0.0		21.2		100.0		102.2		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.2.b.	Non-Ferrous Metals	Solid fuels	0.6		1.1		21.2		100.0		102.2		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels			0.5		21.2		100.0		102.2		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.2.c.	Chemicals	Liquid fuels	6.1		0.1		15.8		100.0		101.2		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.2.c.	Chemicals	Solid fuels	5.3		4.4		15.8		100.0		101.2		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.2.c.	Chemicals	Gaseous fuels	0.5		2.3		15.8		100.0		101.2		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.2.c.	Chemicals	Other fossil fuels			0.2		2.0		100.0		100.0		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.2.d.	Pulp, Paper and Print	Liquid fuels			0.1		18.0		100.0		101.6		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.2.d.	Pulp, Paper and Print	Solid fuels			1.9		18.0		100.0		101.6		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.2.d.	Pulp, Paper and Print	Gaseous fuels			0.3		18.0		100.0		101.6		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.2.e.	Food Processing, Beverages and Tobacco	Liquid fuels	1.0		0.2		5.0		100.0		100.1		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.2.e.	Food Processing, Beverages and Tobacco	Solid fuels	9.9		10.5		18.0		100.0		101.6		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.2.e.	Food Processing, Beverages and Tobacco	Gaseous fuels			1.3		14.1		100.0		101.0		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.2.f.	Non metallic minerals	Liquid fuels	5.6		28.4		27.8		100.0		103.8		0.0		0.0		0.0		0.0		0.0		0.0	
1.A.2.f.	Non metallic minerals	Solid fuels	24.3		53.1		25.5		100.0		103.2		0.0		0.0		0.0		0.0		0.0		0.0	

Table A6 Approach 1 Uncertainty assessment (cont'd)

Source Category	Fuel	Gas	Emissions In 1990 Gg CO <sub>2</sub> eq	Emissions In 2017 Gg CO <sub>2</sub> eq	AD Unc.	EF Unc.	A <sup>(1)</sup> %	B <sup>(2)</sup> %	C <sup>(3)</sup> %	D <sup>(4)</sup> %	E <sup>(5)</sup> %	F <sup>(6)</sup> %	G <sup>(7)</sup> %
1.A.2.f. Non metallic minerals	Gaseous fuels	N2O	0.0	2.2	29.2	100.0	104.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.f. Non metallic minerals	Other fossil fuels	N2O		12.4	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.f. Non metallic minerals	Biomass	N2O		0.0	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.g. Other Industries	Liquid Fuels	N2O	11.1	2.2	70.7	100.0	122.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.g. Other Industries	Solid Fuels	N2O	31.7	15.5	70.7	100.0	122.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.g. Other Industries	Gaseous Fuels	N2O	0.3	3.2	70.7	100.0	122.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.a. Domestic Aviation	Jet kerosene	N2O	8.9	38.5	5.5	85.0	85.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.b. Road Transportation	Gasoline	N2O	288.2	237.2	10.0	250.0	250.2	0.0	0.0	0.0	0.8	0.8	0.6
1.A.3.b. Road Transportation	Diesel oil	N2O	249.5	976.7	10.0	250.0	250.2	0.3	0.1	0.1	0.5	0.5	0.3
1.A.3.b. Road Transportation	Liquefied petroleum gases (LPG)	N2O		8.8	10.0	250.0	250.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.b. Road Transportation	Gaseous fuels	N2O		2.6	10.0	250.0	250.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.b. Road Transportation	Biomass	N2O		6.1	10.0	250.0	250.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.c. Railways	Liquid fuels	N2O	68.4	43.5	5.0	142.0	142.1	0.0	0.0	0.0	0.1	0.1	0.0
1.A.3.c. Railways	Solid fuels	N2O	0.3		5.0	150.0	150.1	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.d. Domestic Navigation	Residual fuel oil	N2O	2.1	0.9	15.0	140.0	140.8	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.d. Domestic Navigation	Gas/diesel oil	N2O	1.8	6.8	15.0	140.0	140.8	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.e. Pipeline Transportation	Gaseous fuels	N2O	0.0	0.4	5.0	100.0	100.1	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.a. Commercial/institutional	Liquid fuels	N2O		2.7	7.1	100.0	100.3	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.a. Commercial/institutional	Solid fuels	N2O		50.1	14.1	100.0	101.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.a. Commercial/institutional	Gaseous fuels	N2O		3.8	5.0	100.0	100.1	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.b. Residential	Liquid fuels	N2O	11.8	0.4	7.1	100.0	100.3	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.b. Residential	Solid fuels	N2O	61.0	63.8	14.1	100.0	101.0	0.0	0.0	0.0	0.1	0.1	0.0
1.A.4.b. Residential	Gaseous fuels	N2O	0.1	13.9	5.0	100.0	100.1	0.0	0.0	0.0	0.0	0.0	0.0
1.A.4.b. Residential	Biomass	N2O	359.7	101.9	300.0	100.0	316.2	0.0	0.0	0.3	0.5	0.6	0.3
1.A.4.c. Agriculture/Forestry/Fisheries	Liquid fuels	N2O	680.3	1 047.8	14.1	250.0	250.4	0.4	0.1	0.1	1.1	1.1	1.3
1.A.4.c. Agriculture/Forestry/Fisheries	Gaseous fuels	N2O		0.1	7.0	100.0	100.2	0.0	0.0	0.0	0.0	0.0	0.0
1.B.2.c. Venting and flaring		N2O		0.6	7.0	100.0	100.2	0.0	0.0	0.0	0.0	0.0	0.0
2.B.2. Nitric acid production		N2O	1 063.6	1 262.8	2.0	20.0	20.1	0.0	0.0	0.0	0.2	0.2	0.0
3.B. Manure management		N2O	3 013.2	4 190.1	14.1	50.0	52.0	0.3	0.1	0.5	1.1	1.2	1.5
3.D. Agricultural soils		N2O	17 093.5	23 117.2	19.5	96.0	98.0	28.2	796.0	3.9	12.6	13.2	174.1
4.A. Field burning of agricultural residues		N2O	81.9	39.0	50.0	40.0	64.0	0.0	0.0	0.0	0.0	0.0	0.0
4.B. Forest land		N2O	50.2	38.0	23.5	0.9	23.5	0.0	0.0	0.0	0.0	0.0	0.0
4.C. Cropland		N2O		22.2	23.5	4.5	23.9	0.0	0.0	0.0	0.0	0.0	0.0
4.D. Grassland		N2O		9.5	23.5	4.5	23.9	0.0	0.0	0.0	0.0	0.0	0.0
4.D. Wetlands		N2O		4.0									



Table A6 Approach 1 Uncertainty assessment (cont'd)

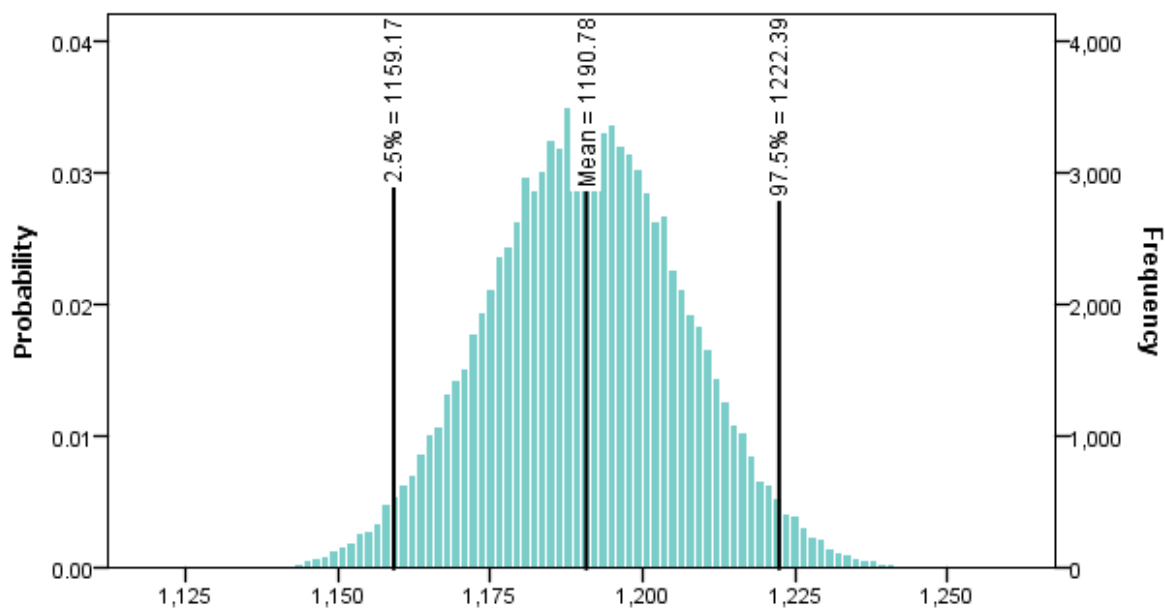
Source Category	Fuel	Gas	Emissions in 1990 Gg CO <sub>2</sub> eq	Emissions in 2017 Gg CO <sub>2</sub> eq	AD Unc.	EF Unc.	A <sup>(1)</sup> %	B <sup>(2)</sup> %	C <sup>(3)</sup> %	D <sup>(4)</sup> %	E <sup>(5)</sup> %	F <sup>(6)</sup> %	G <sup>(7)</sup> %
5.C.	Incineration and open burning of waste	N <sub>2</sub> O	11.2	0.3	30.4	100.0	104.5	0.0	0.0	0.0	0.0	0.0	0.0
5.D.1	Wastewater treatment and discharge	N <sub>2</sub> O	1 441.0	5 808.3	30.0	42.4	51.9	0.5	0.3	1.5	0.5	1.6	2.6
<b>Total N<sub>2</sub>O</b>			<b>24 711.2</b>	<b>38 608.8</b>				<b>5.5</b>					<b>13.4</b>
<b>Cumulative CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFC</b>			<b>162 797.0</b>	<b>418 150.5</b>									<b>66.4</b>
2.C.3.	Aluminium Production	PFC	625.3	73.1	25.0	5.0	25.5	0.0	0.0	0.0	0.0	0.1	0.0
2.E.5.	Other	HFC		0.1	25.0	5.0	25.5	0.0	0.0	0.0	0.0	0.0	0.0
2.E.5.	Other	PFC		0	25.0	5.0	25.5	0.0	0.0	0.0	0.0	0.0	0.0
2.E.5.	Other	SF <sub>6</sub>		0.0	25.0	5.0	25.5	0.0	0.0	0.0	0.0	0.0	0.0
2.F.3.	Fire protection	HFC		172.1	25.0	5.0	25.5	0.0	0.0	0.0	0.0	0.0	0.0
2.F.6.	Other applications	HFC		7876.6	25.0	5.0	25.5	0.2	0.0	1.7	0.2	1.7	3.0
2.G.1.	Electrical equipment	SF <sub>6</sub>		73.1	25.0	5.0	25.5	0.0	0.0	0.0	0.0	0.0	0.0
<b>Total</b>	<b>Total HFC, PFC &amp; SF<sub>6</sub></b>		<b>625.3</b>	<b>8 195.0</b>				<b>0.5</b>	<b>0.2</b>				<b>1.7</b>
<b>Total all gases with LULUCF</b>			<b>163 422.3</b>	<b>426 345.4</b>		<b>13.8</b>			<b>Trend Unc.</b>		<b>48.3</b>		<b>2329.3</b>
<b>Total all gases with LULUCF</b>			<b>219 187.0</b>	<b>526 253.0</b>		<b>5.3</b>			<b>Trend Unc.</b>		<b>12.4</b>		<b>153.3</b>

**Table A7 Approach 2 Uncertainty assessment (Monte Carlo Simulation Method)**

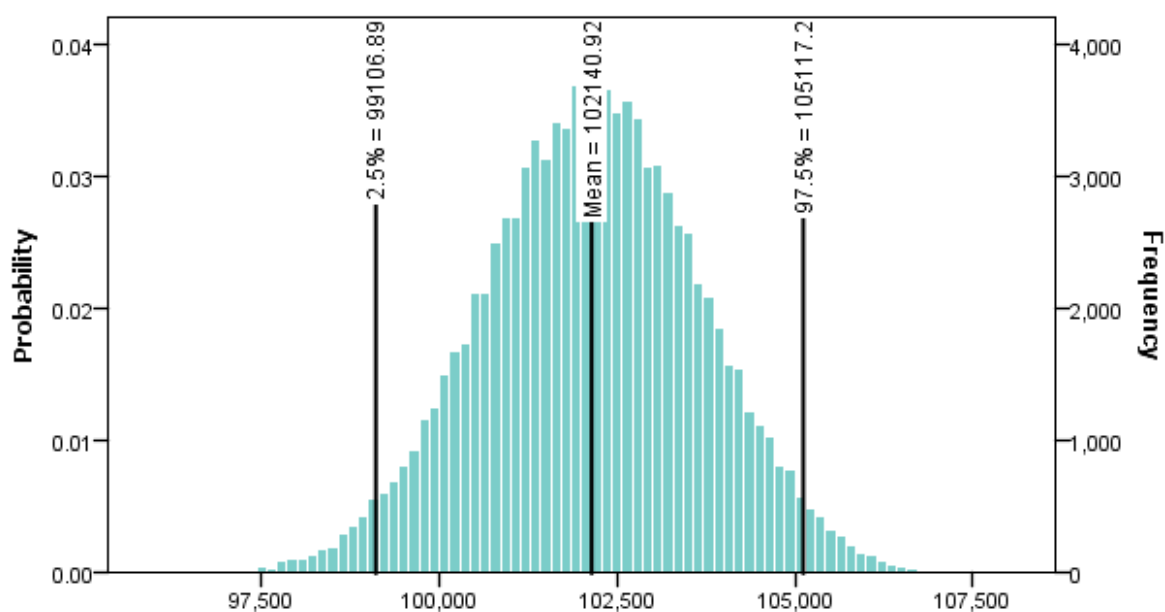
<i>Selected Sources</i>		2017 Emissions (kt)	Estimates of 2017 Emissions (Means) with MC (kt)	Combined Uncertainty (%) Approach 1 (±)	Combined Uncertainty (%) Approach 2
1.A.1.a.	Public Electricity and Heat Production	1232.24	1190.78	4.24	±2.65
1.A.1.a.	Public Electricity and Heat Production	98081.63	102140.92	3.50	-2.97, +2.91
1.A.1.a.	Public Electricity and Heat Production	45136.77	44124.70	1.50	-1.46, +1.47
2.A.1.	Cement Production (Mineral Products)	37272.44	37270.42	5.39	-4.97, +5.02
2.A.2.	Lime Production (Mineral Products)	2683.98	2684.52	14.14	-12.29, +12.90
3.H.	Urea application	1449.63	1451.54	50.99	-13.54, +14.70
5.C.	Incineration and open burning of waste	1.91	1.91	50.24	±41.88
3.C.	Rice cultivation	9.35	9.47	76.9	-68.95, +70.43
5.A.1.	Managed waste disposal	33.87	34.64	32.38	-34.93, +34.82
5.A.2.	Unmanaged waste disposal sites	329.29	327.05	48.49	-46.85, +47.31
5.B.	Biological treatment of solid waste	0.33	0.36	22.36	±22.22
5.C.	Incineration and open burning of waste	0.07	0.07	104.52	-85.71, +114.29
5.D.1	Domestic wastewater	77.02	77.04	38.03	-40.16, +40.77
5.D.2	Industrial wastewater	20.97	24.15	40.67	-32.71, +41.28
5.B.	Biological treatment of solid waste	0.02	0.02	22.36	+50
5.C.	Incineration and open burning of waste	0.00	0.00	104.52	-72.73, +100
5.D.1	Wastewater treatment and discharge	19.49	19.48	51.94	-24.38, +25.56

The probability density functions resulting from the Monte Carlo assessment are shown below:

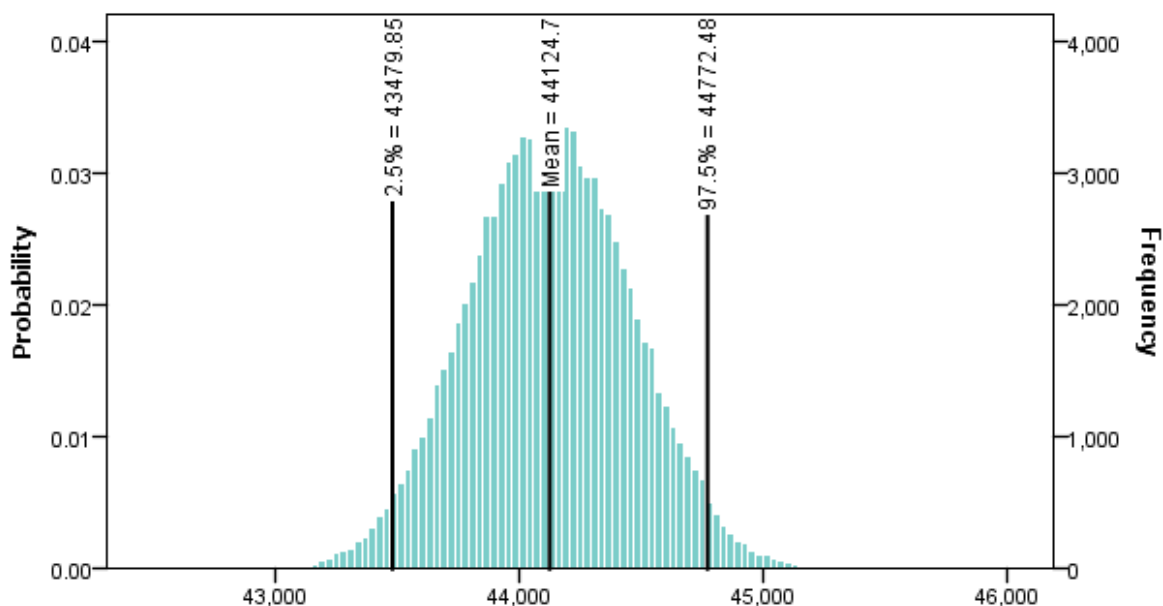
**Figure A1 Probability density function resulting from Monte Carlo analysis for CO<sub>2</sub> emissions from Public Electricity and Heat Production- Liquid fuels, 2017**



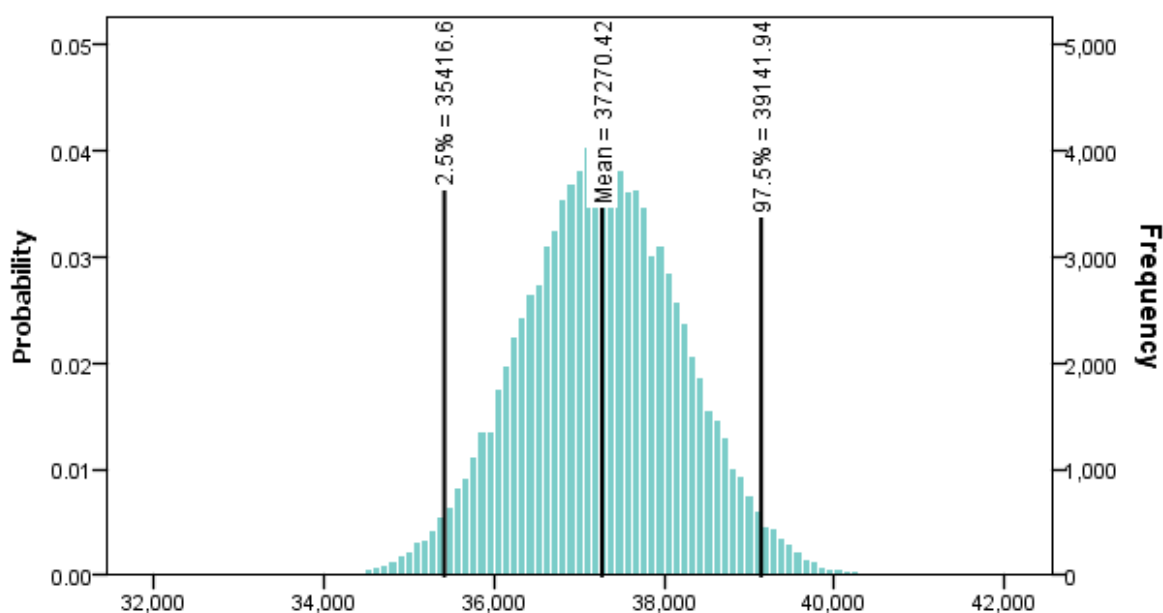
**Figure A2 Probability density function resulting from Monte Carlo analysis for CO<sub>2</sub> emissions from Public Electricity and Heat Production- Solid fuels, 2017**



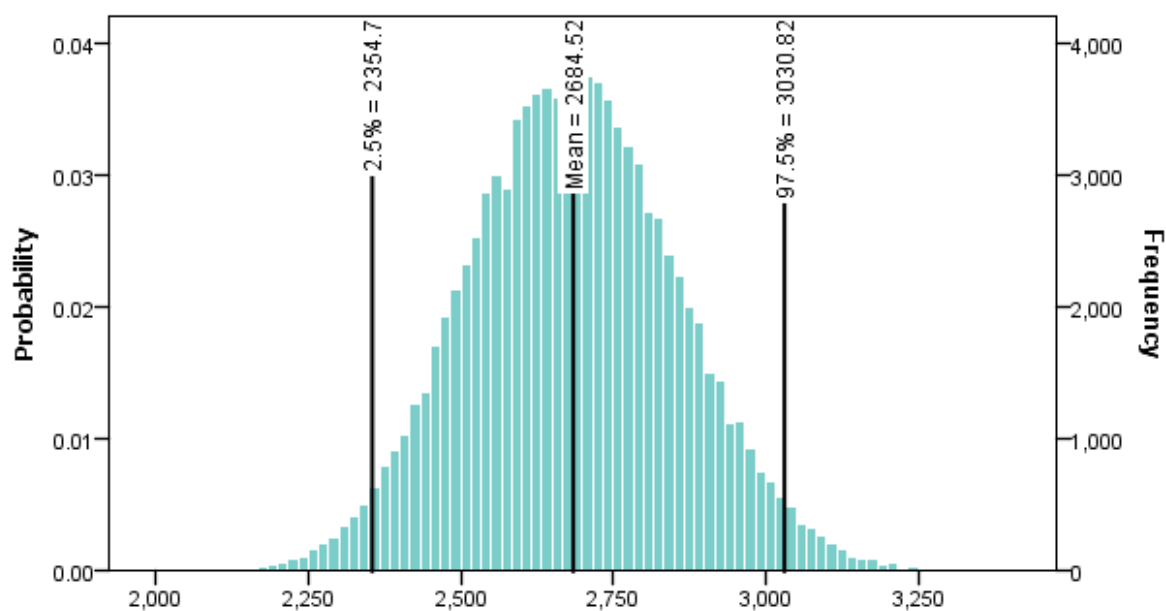
**Figure A3 Probability density function resulting from Monte Carlo analysis for CO<sub>2</sub> emissions from Public Electricity and Heat Production- Gaseous fuels, 2017**



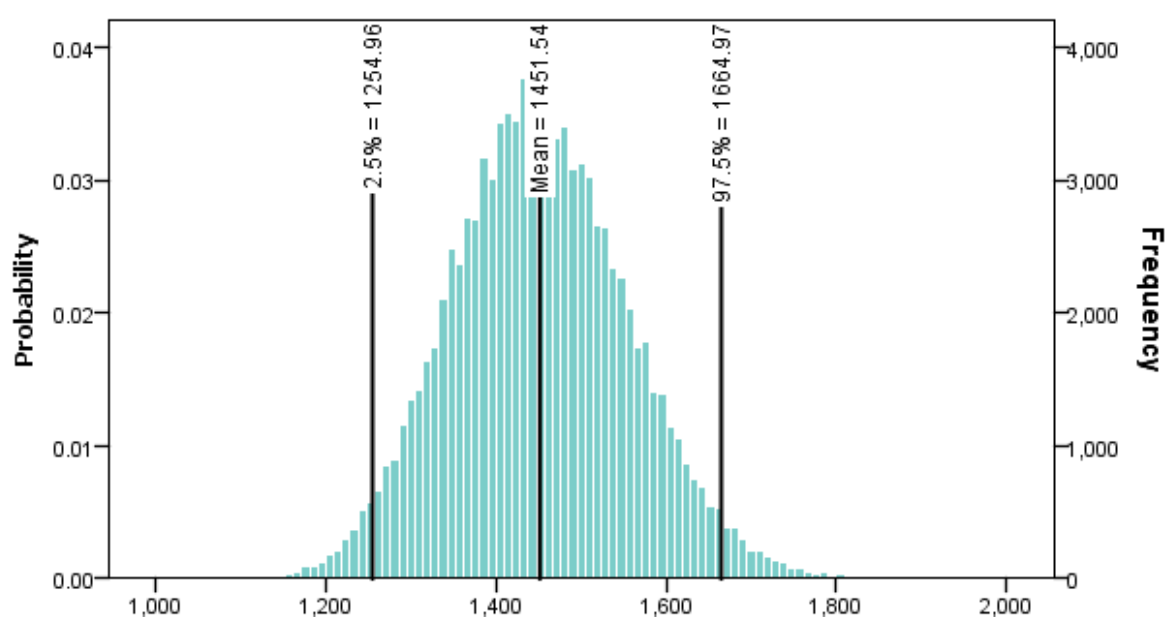
**Figure A4 Probability density function resulting from Monte Carlo analysis for CO<sub>2</sub> emissions from Cement Production, 2017**



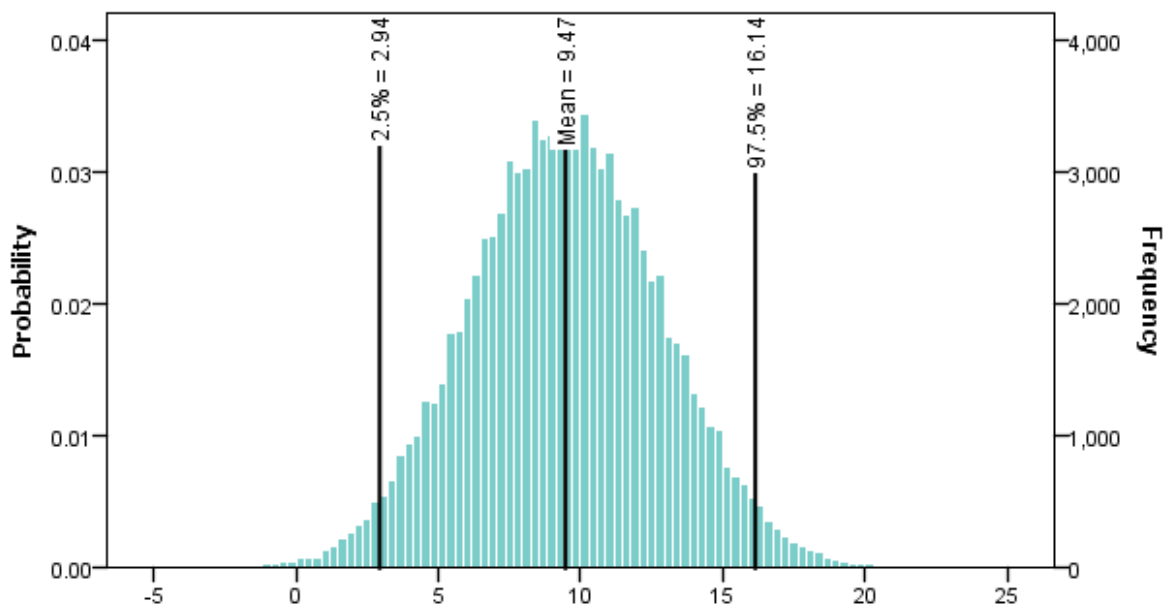
**Figure A5 Probability density function resulting from Monte Carlo analysis for CO<sub>2</sub> emissions from Lime Production, 2017**



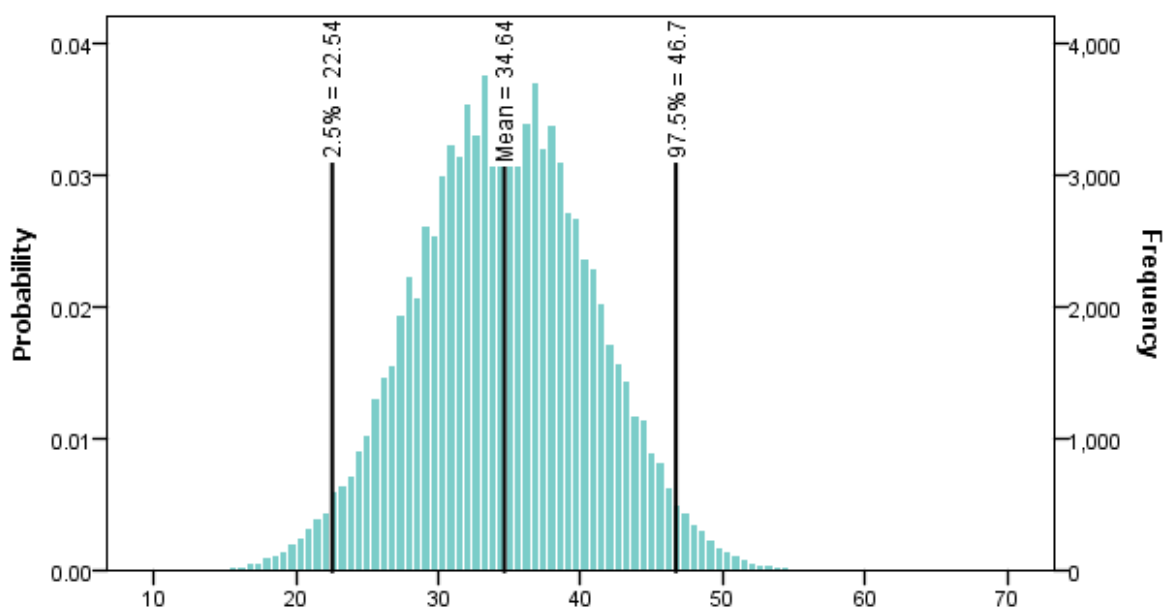
**Figure A6 Probability density function resulting from Monte Carlo analysis for CO<sub>2</sub> emissions from Urea Application, 2017**



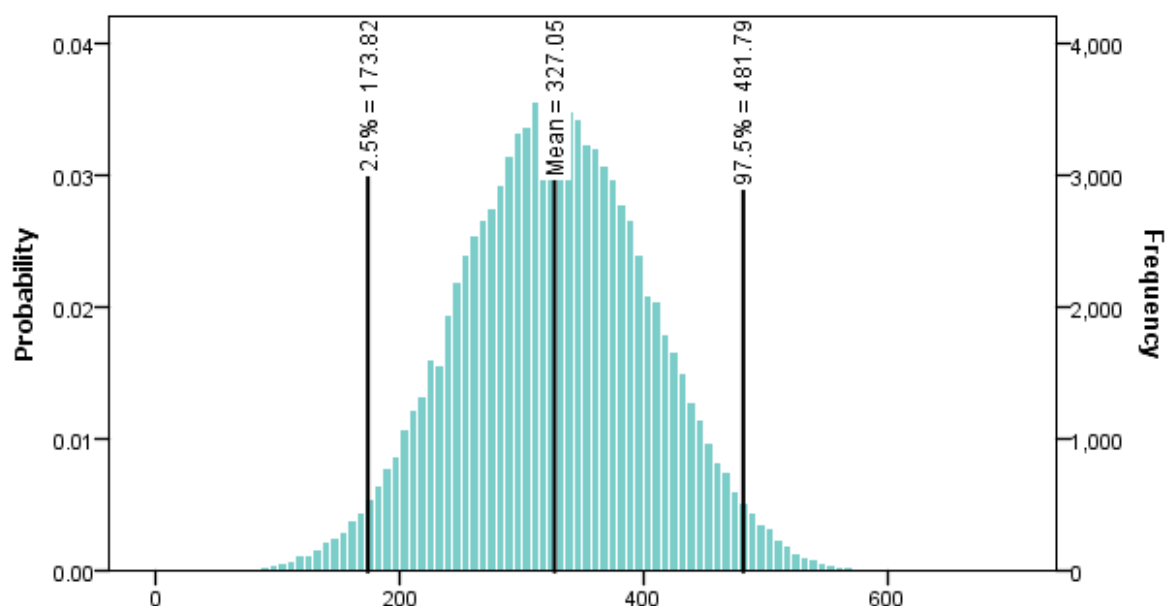
**Figure A7 Probability density function resulting from Monte Carlo analysis for CH<sub>4</sub> emissions from Rice Cultivation, 2017**



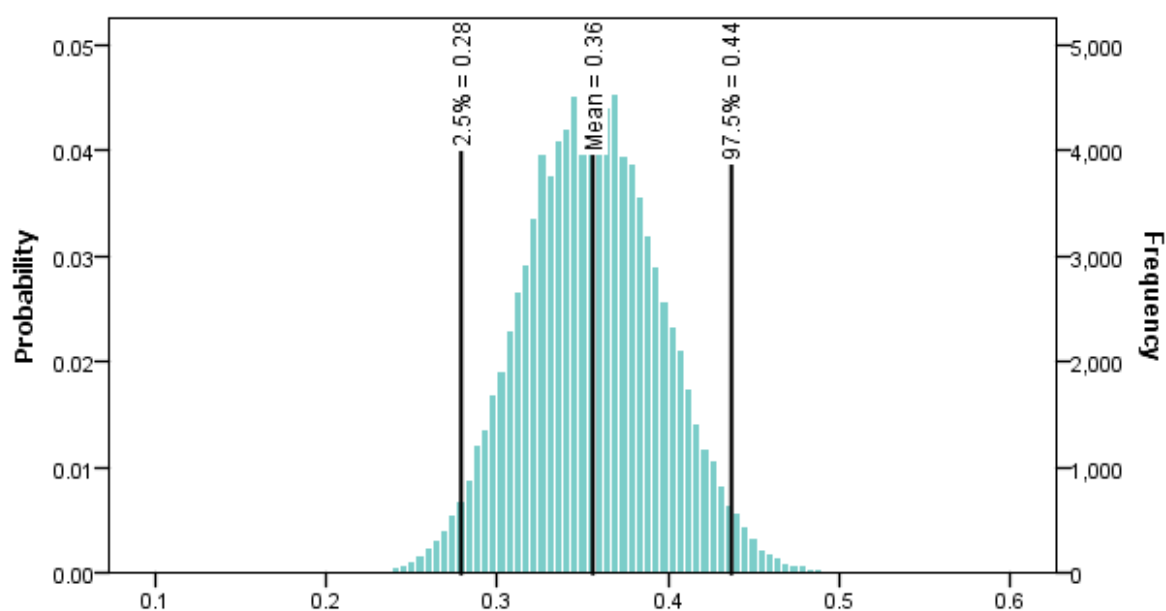
**Figure A8 Probability density function resulting from Monte Carlo analysis for CH<sub>4</sub> emissions from Managed SWDS, 2017**



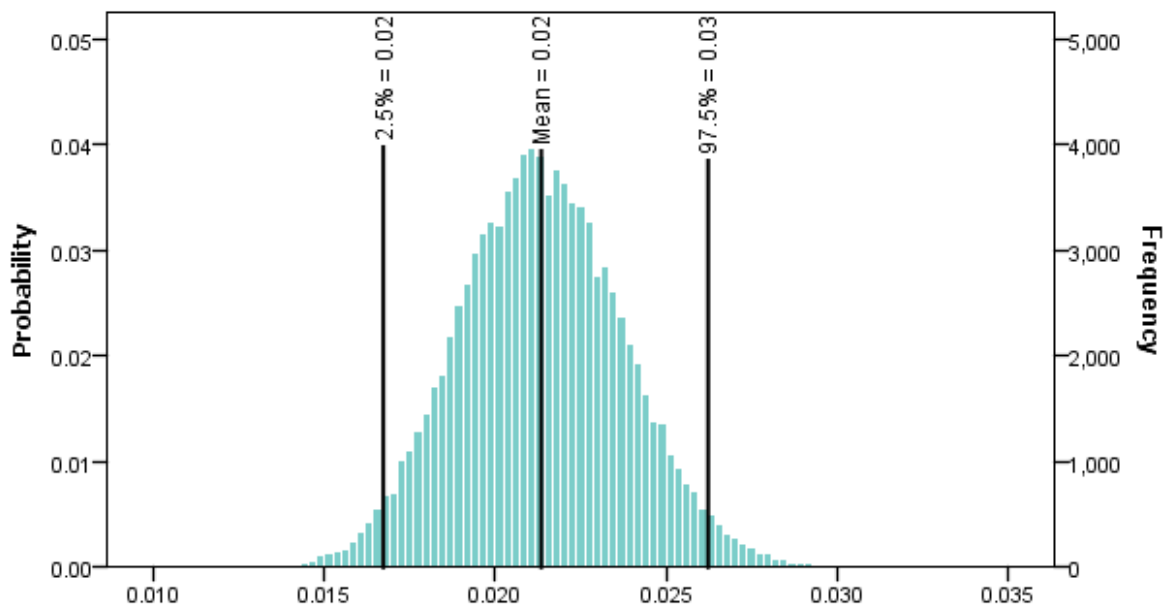
**Figure A9 Probability density function resulting from Monte Carlo analysis for CH<sub>4</sub> emissions from Unmanaged SWDS, 2017**



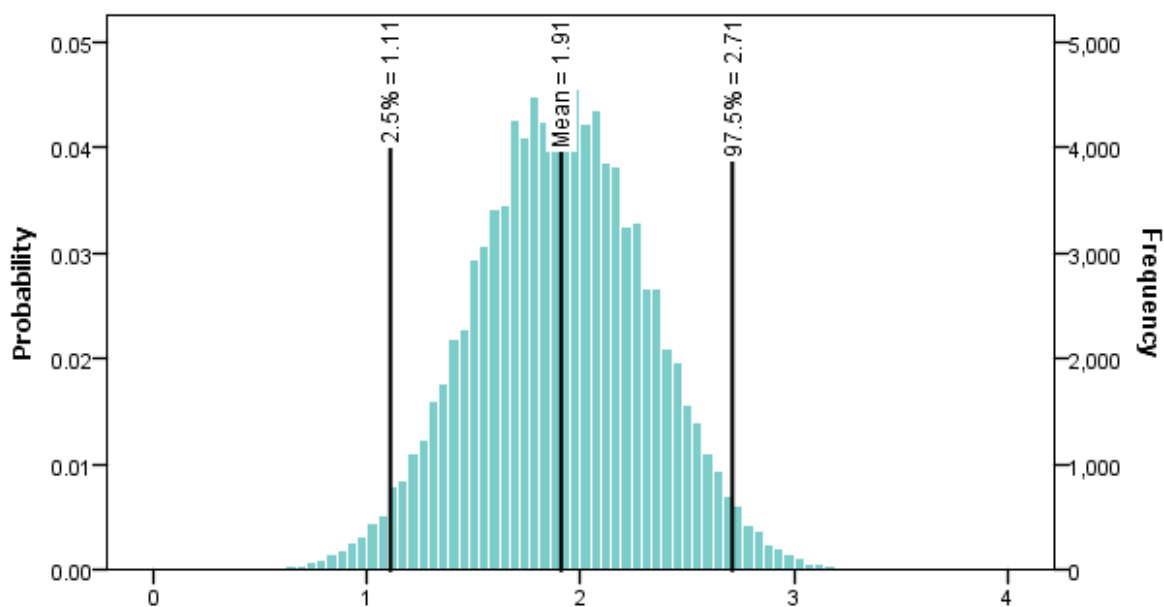
**Figure A10 Probability density function resulting from Monte Carlo analysis for CH<sub>4</sub> emissions from Biological treatment of solid waste- Composting, 2017**



**Figure A11 Probability density function resulting from Monte Carlo analysis for N<sub>2</sub>O emissions from Biological treatment of solid waste- Composting, 2017**

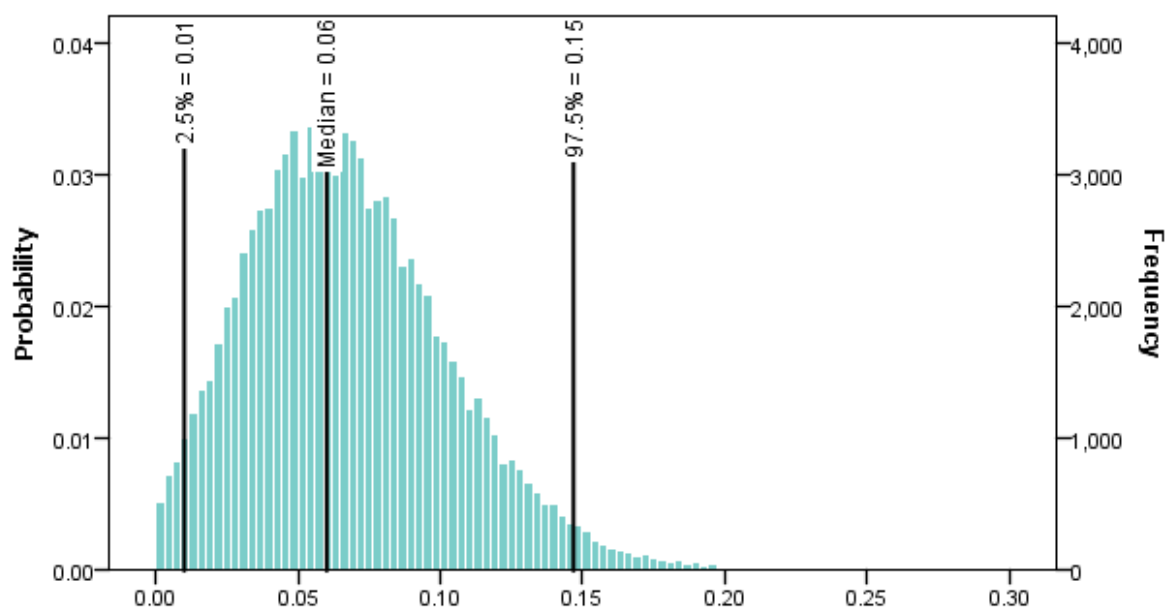


**Figure A12 Probability density function resulting from Monte Carlo analysis for CO<sub>2</sub> emissions from Incineration and open burning of waste, 2017**

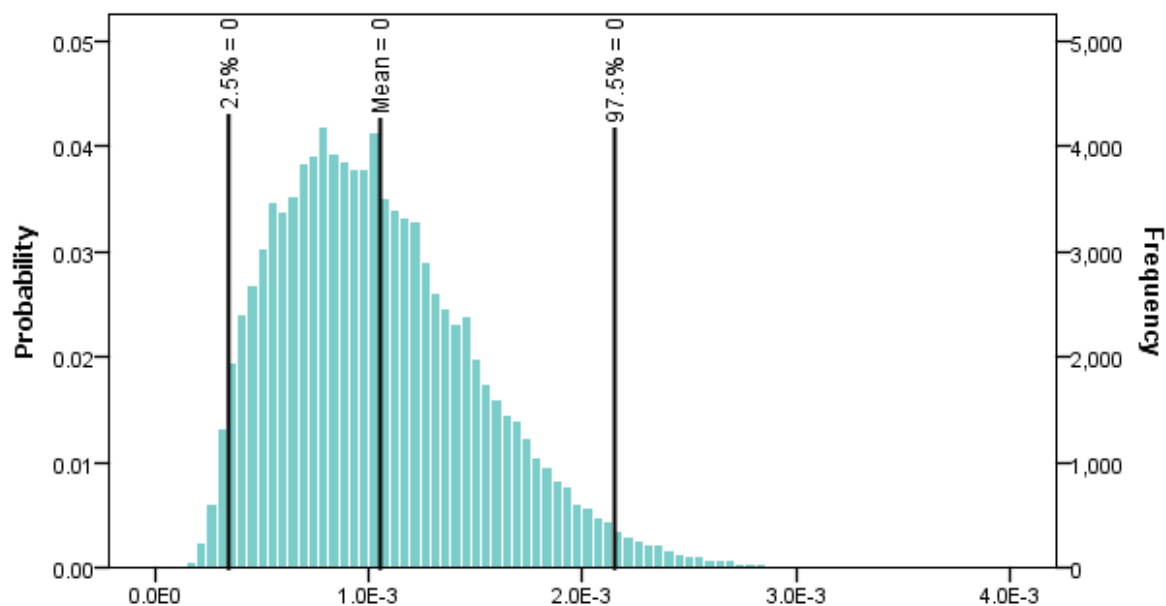




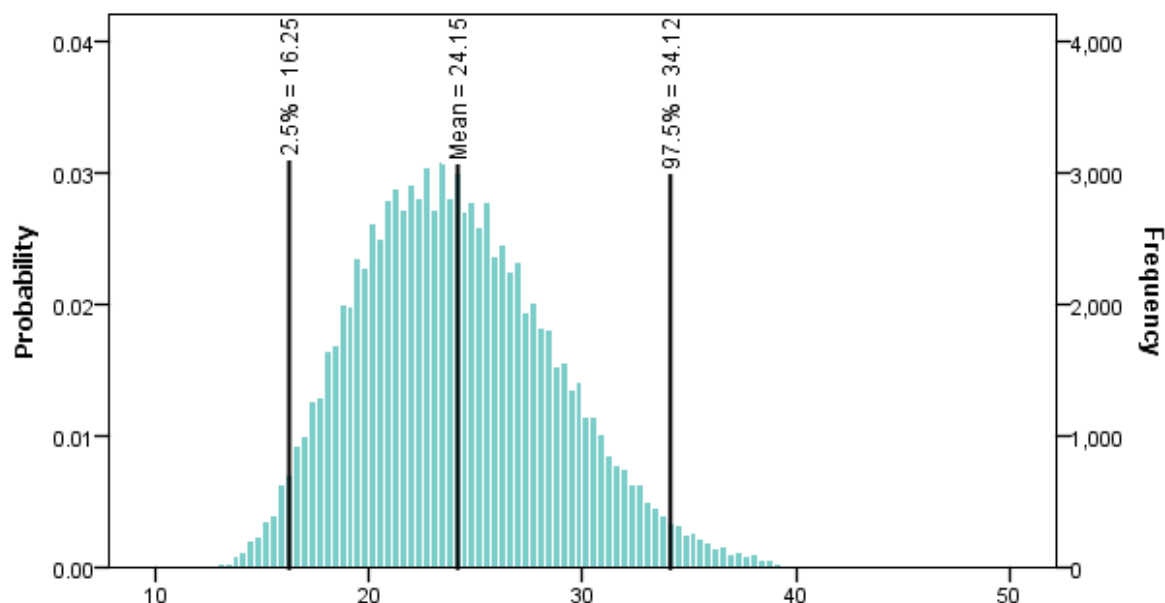
**Figure A13 Probability density function resulting from Monte Carlo analysis for CH<sub>4</sub> emissions from Incineration and open burning of waste, 2017**



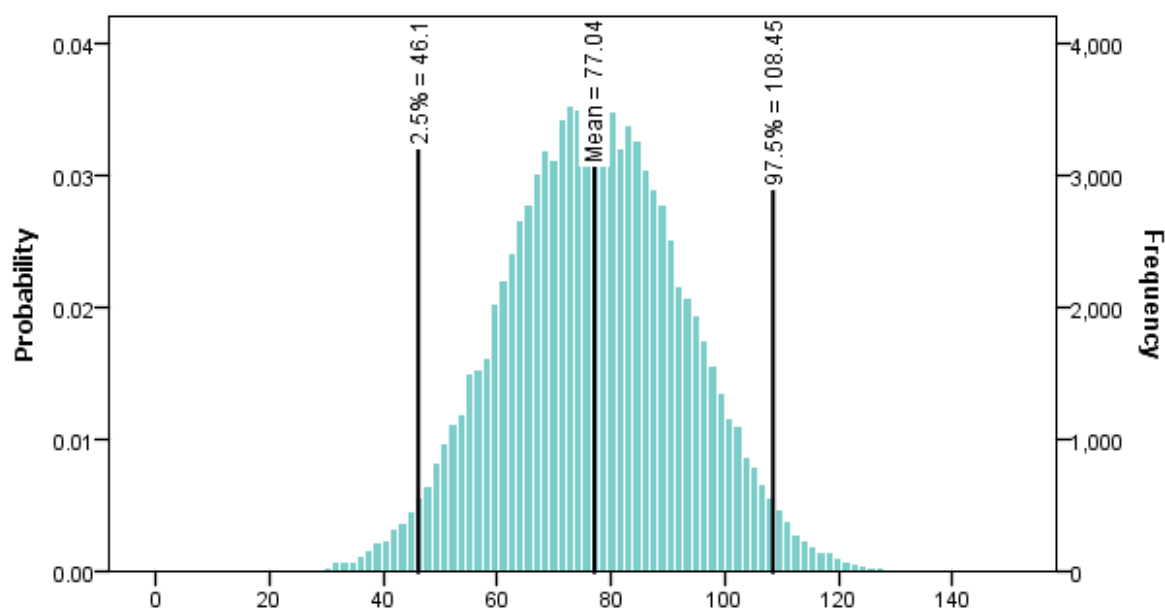
**Figure A14 Probability density function resulting from Monte Carlo analysis for N<sub>2</sub>O emissions from Incineration and open burning of waste, 2017**



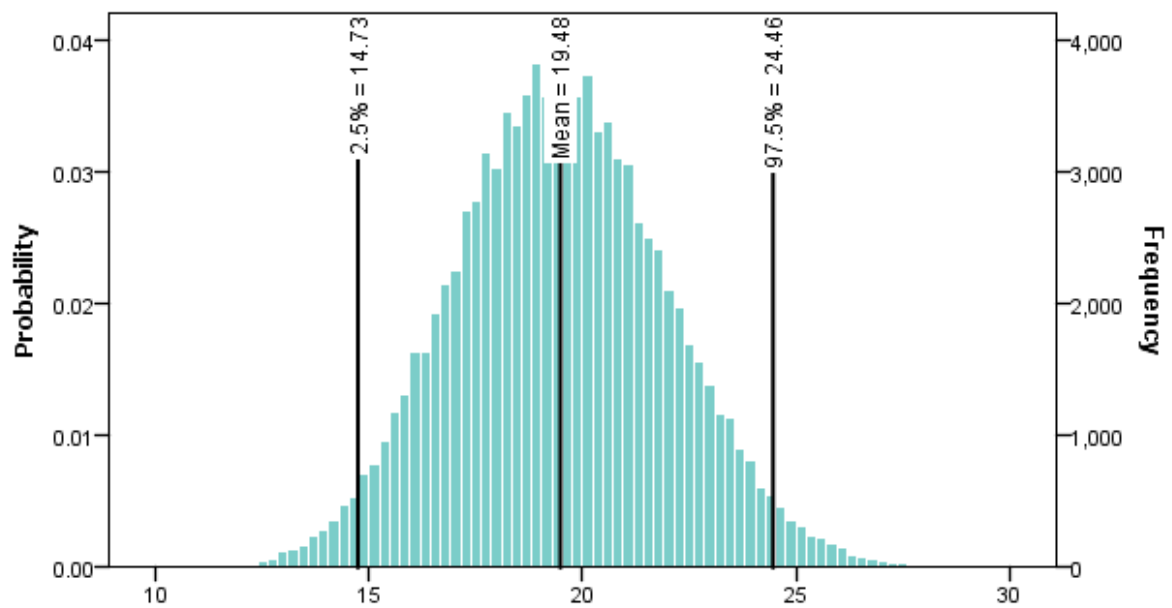
**Figure A15 Probability density function resulting from Monte Carlo analysis for CH<sub>4</sub> emissions from Wastewater treatment and discharge- Industrial wastewater, 2017**



**Figure A16 Probability density function resulting from Monte Carlo analysis for CH<sub>4</sub> emissions from Wastewater treatment and discharge- Domestic wastewater, 2017**



**Figure A17 Probability density function resulting from Monte Carlo analysis for N<sub>2</sub>O emissions from Wastewater treatment and discharge- Domestic wastewater, 2017**



### Annex 3: Country Specific Carbon Content Determination and Emission Factors

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 coal firing plants, BOTAS and some public university laboratories. Those analyses are the basis of country specific Carbon Contents.

#### 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.

Volumetric fractions of gas concentrations were obtained through gas chromatography analysis from Petroleum Pipeline Company (BOTAS). 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. For 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. In order to calculate the oxidation rate of gaseous fuels (natural gas), CO concentration measured in the stack gas of the related plants were obtained from the Ministry of Environment and Urbanization.

#### Turkey Lignite

Ultimate analysis results, which were obtained from coal firing plants, were used to calculate carbon content of the related coal types. In the analysis results 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.

Oxidation rate of solid fuels was calculated by using the mass percentage of carbon in ash-slag analysis reports which were obtained from coal firing plants.

#### 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 1.A 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<sub>2</sub> 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 (average) D	NCV GJ/kg (average) E	C mass/kg fuel F (C/100)	C content kg C/GJ G (F/E)
<b>Diesel</b>	639/06-1106	86.261	10233	0.0428435	0.86261	20.133975
<b>Fuel Oil</b>	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.

		<b>Fuel oil density (kg/m3)</b>	0.9757
<b>CO (average v/v %)</b>	3.25	<b>C inlet (m/m) %</b>	86.611
<b>C (outlet v/v %) (*12/28)</b>	1.39	<b>C inlet (v/v) %</b>	88.768

**Oxidation rate, %:**  $((C \text{ inlet} - C \text{ outlet})/C \text{ inlet}) * 100 = 98.43$

### 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.

## Emissions Factors

### Emission Factors used for Energy Sector

Years	Country Specific CO <sub>2</sub> Emission Factor						(kg/TJ)
	Hard Coal	Lignite	Coke	BFG	COG	BOF Gas	Natural Gas
1990	93.37	114.16	110.29	258.85	40.46	176.53	55.61
1991	101.38	114.01	110.29	258.85	40.46	176.53	55.61
1992	101.35	113.85	110.29	258.85	40.46	176.53	55.61
1993	100.54	113.70	110.29	258.85	40.46	176.53	55.61
1994	99.12	113.54	110.29	258.85	40.46	176.53	55.61
1995	102.17	113.39	110.29	258.85	40.46	176.53	55.61
1996	102.50	113.23	110.29	258.85	40.46	176.53	55.61
1997	103.34	113.08	110.29	258.85	40.46	176.53	55.61
1998	102.81	112.92	110.29	255.17	40.25	176.53	55.61
1999	93.39	112.77	110.29	255.17	40.27	176.53	55.61
2000	95.52	110.05	110.29	260.85	40.27	176.53	55.61
2001	99.28	110.58	110.29	261.55	40.90	176.53	55.61
2002	96.27	111.30	110.29	261.55	40.60	176.53	55.61
2003	100.90	112.00	110.70	261.55	41.51	176.53	55.65
2004	90.34	112.72	110.62	261.55	41.76	176.53	55.61
2005	94.23	113.50	112.25	256.64	43.40	176.53	55.60
2006	88.71	114.18	110.29	261.55	40.88	176.53	55.61
2007	88.52	113.62	111.97	264.06	41.41	176.53	55.62
2008	93.35	112.51	110.29	257.53	40.91	176.53	55.62
2009	96.03	111.39	111.58	259.33	41.85	175.60	55.68
2010	98.56	110.26	109.79	257.31	41.22	179.97	55.74
2011	95.10	109.48	110.05	257.81	39.36	174.71	56.31
2012	96.65	109.29	111.01	256.94	40.05	174.81	55.66
2013	96.18	109.09	112.45	252.27	42.12	176.39	55.66
2014	93.15	107.63	110.71	251.92	42.03	173.73	55.68
2015	92.38	107.63	110.38	258.70	40.78	175.09	55.75
2016	85.32	107.41	108.37	265.09	39.02	182.31	55.39
2017	94.50	107.24	112.22	264.12	37.45	190.08	55.62

Default CO<sub>2</sub> Emission Factors

<b>Fuels</b>	<b>1990-2017</b>
Sub bituminous coal	96.1
Coal tar	80.7
Crude oil	73.3
Petroleum Coke	97.4
Fuel Oil	77.0
Diesel Oil	72.3
Gasoline	69.3
LPG	63.1
Refinery gas	57.6
Jet kerosene	71.5
Kerosene	71.9
Naphtha	72.7
By products	73.3
Basic oil	73.3
White spirit	73.3
Bitumen	80.7
Other petroleum products	73.3
Navigation diesel oil	72.3
Navigation fuel	77.0
Wood	111.8
Biofuels and Waste	100.1

CH<sub>4</sub> and N<sub>2</sub>O Emission Factors

Sub Sectors	Emission Factors		Source
	CH <sub>4</sub> (kg/TJ)	N <sub>2</sub> O(kg/TJ)	
1A1b sector			
Fuel oil	3	0.6	2006 IPCC Guideline Vol2 Table 2.3 page 2.18
Diesel oil	3	0.6	2006 IPCC Guideline Vol2 Table 2.3 page 2.18
Natural gas	1	0.1	2006 IPCC Guideline Vol2 Table 2.3 page 2.18
Refinery gas	1	0.1	2006 IPCC Guideline Vol2 Table 2.3 page 2.18
FCC coke	3	0.6	2006 IPCC Guideline Vol2 Table 2.3 page 2.18

Sub Sectors	Emission Factors		Source
	CH <sub>4</sub> (kg/TJ)	N <sub>2</sub> O(kg/TJ)	
1A1c sector			
Derived gases	1	0.1	2006 IPCC Guideline Vol2 Table 2.3 page 2.18



## CH<sub>4</sub> and N<sub>2</sub>O Emission Factors (cont'd)

Sub Sectors	Emission Factors		Source
	CH <sub>4</sub> (kg/TJ)	N <sub>2</sub> O(kg/TJ)	
1A2 sector			
Coal products	10	1.5	2006 IPCC Guideline Vol2 Table 2.3 page 2.18
LPG	1	0.1	2006 IPCC Guideline Vol2 Table 2.3 page 2.18
Other Petroleum products	3	0.6	2006 IPCC Guideline Vol2 Table 2.3 page 2.18
Derived gases	1	0.1	2006 IPCC Guideline Vol2 Table 2.3 page 2.18
Wood	30	4	2006 IPCC Guideline Vol2 Table 2.3 page 2.18
Natural gas	1	0.1	2006 IPCC Guideline Vol2 Table 2.3 page 2.18

Sub Sectors	Emission Factors		Source
	CH <sub>4</sub> (kg/TJ)	N <sub>2</sub> O(kg/TJ)	
1A4a sector			
Coal products	10	1.5	2006 IPCC Guideline Vol2 Table 2.4 page 2.20
LPG	5	0.1	2006 IPCC Guideline Vol2 Table 2.4 page 2.20
Other petroleum products	10	0.6	2006 IPCC Guideline Vol2 Table 2.4 page 2.20
Wood	300	4	2006 IPCC Guideline Vol2 Table 2.4 page 2.20
Natural gas	5	0.1	2006 IPCC Guideline Vol2 Table 2.4 page 2.20
1A4b, 1A4c sectors			
Coal products	300	1.5	2006 IPCC Guideline Vol2 Table 2.5 page 2.22
LPG	5	0.1	2006 IPCC Guideline Vol2 Table 2.5 page 2.22
Other petroleum products	10	0.6	2006 IPCC Guideline Vol2 Table 2.5 page 2.22
Wood	300	4	2006 IPCC Guideline Vol2 Table 2.5 page 2.22
Other primary solid biomass	300	4	2006 IPCC Guideline Vol2 Table 2.5 page 2.22
Natural gas	5	0.1	2006 IPCC Guideline Vol2 Table 2.5 page 2.22

## Emission factors used for IPPU

Category		EF	Reference
Cement Production	CKD	1.02	IPCC Default
	EF	0.52	CS
Lime Production	EF high calcium lime ((tonnes CO <sub>2</sub> /tonne carbonate)	0.69	CS
	EF dolomitic lime (tonnes CO <sub>2</sub> /tonne carbonate)	0.77	Default
Glass production/Ceramics/ Roof and Tiles/ Soda ash use	Soda (tonnes CO <sub>2</sub> /tonne carbonate)	0.41	IPCC Vol 2. Table 2.1. <a href="https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf">https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf</a>
	Dolomit (tonnes CO <sub>2</sub> /tonne carbonate)	0.48	IPCC Vol 2. Table 2.1. <a href="https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf">https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf</a>
	Kalker (tonnes CO <sub>2</sub> /tonne carbonate)	0.44	IPCC Vol 2. Table 2.1. <a href="https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf">https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf</a>
Magnesia Production	Magnesia (tonnes CO <sub>2</sub> /tonne carbonate)	0.52	IPCC Vol 2. Table 2.1. <a href="https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf">https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf</a>
Ammonia Production	Natural Gas NCV (kcal/sm <sup>3</sup> )	8396	BOTAŞ
	Natural Gas NCV (GJ/sm <sup>3</sup> )	0.0352	BOTAŞ
	Nat Gas. Car. Cont. (kgC/GJ)	15.1	BOTAŞ
	Carbon Oxidation Factor	1	Default
Nitric Acid Production	Middle pressure plant (kg N <sub>2</sub> O/tonne nitric acid)	7	IPCC VOL 2. Table 3.3. <a href="https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf">https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf</a>
	with abatement technology(kg N <sub>2</sub> O/tonne nitric acid)	2.5	IPCC VOL 2. Table 3.3. <a href="https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf">https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf</a>
Carpide Production	Carpide (tonnes CO <sub>2</sub> /tonne carbide produced)	1.09	IPCC VOL 2. Table 3.8. <a href="https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf">https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf</a>
	Asetilen (tonnes CO <sub>2</sub> /tonne carbide produced)	1.1	IPCC VOL 2. Table 3.8. <a href="https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf">https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf</a>
Soda Ash Production	Soda ash (tonnes CO <sub>2</sub> /tonne of Trona)	0.097	IPCC VOL 2. Equation 3.4. <a href="https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf">https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf</a>
Petrochemicals	Fuel gas	0.67227	CS, Petkim
Iron and Steel Production			PS, confidential
Ferro chrome production		1.3	IPCC VOL 2. Table 4.5 <a href="https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_4_Ch4_Metal_Industry.pdf">https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_4_Ch4_Metal_Industry.pdf</a>
Aluminium production	Net prebaked anode consumption (ton/ ton alüminyum)	0.412	PS
	Carbon content wt %	98.56	PS
Lead production		0.2	IPCC VOL 2. Table 4.21 <a href="https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_4_Ch4_Metal_Industry.pdf">https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_4_Ch4_Metal_Industry.pdf</a>
Lubricant and paraffin wax use	Carbon content	20	IPCC VOL 2. Table 5.2 <a href="https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf">https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf</a>
	Oxidation rate	0.2	IPCC VOL 2. Equation 5.4 <a href="https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf">https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf</a>

## Emission factors used in the agriculture sector

<b>3.A Enteric Fermentation</b>		<b>EF</b> (kg CH <sub>4</sub> /head/yr)	<b>Method</b>	<b>Note</b>
3.A.1 Cattle	Dairy Cattle	81.9	T2	Latest Inventory year figure
	Non-Dairy Cattle	47.6	T2	Latest Inventory year figure
3.A.2 Sheep	Domestic	5.0	T1	2006 IPCC Guidelines Vol.4 Table 10.10
	Merino	6.5	T1	2006 IPCC Guidelines Vol.4 Table 10.10 (developing + developed)/2
3.A.3 Swine		1.0	T1	2006 IPCC Guidelines Vol.4 Table 10.10
3.A.4 Other livestock	Buffalo	55.0	T1	2006 IPCC Guidelines Vol.4 Table 10.10
	Camels	46.0	T1	2006 IPCC Guidelines Vol.4 Table 10.10
	Goats	5.0	T1	2006 IPCC Guidelines Vol.4 Table 10.10
	Horses	18.0	T1	2006 IPCC Guidelines Vol.4 Table 10.10
	Mules and Asses	10.0	T1	2006 IPCC Guidelines Vol.4 Table 10.10
	Poultry	NA	-	

<b>3.B(a) Manure Management CH<sub>4</sub> Emissions</b>		<b>EF</b> (kg CH <sub>4</sub> /head/yr)	<b>Method</b>	<b>Note</b>
3.A.1 Cattle	Dairy Cattle	*	T1	* Given on Table 5.12 of the latest Inventory Report
	Non-Dairy Cattle	*	T1	* Given on Table 5.12 of the latest Inventory Report
3.A.2 Sheep	Domestic	*	T1	* Given on Table 5.13 of the latest Inventory Report
	Merino	*	T1	* Given on Table 5.13 of the latest Inventory Report
3.A.3 Swine		*	T1	* Given on Table 5.12 of the latest Inventory Report
3.A.4 Other livestock	Buffalo	*	T1	* Given on Table 5.13 of the latest Inventory Report
	Camels	*	T1	* Given on Table 5.13 of the latest Inventory Report
	Goats	*	T1	* Given on Table 5.13 of the latest Inventory Report
	Horses	*	T1	* Given on Table 5.13 of the latest Inventory Report
	Mules and Asses	*	T1	* Given on Table 5.13 of the latest Inventory Report
	Poultry	*	T1	* Given on Table 5.13 of the latest Inventory Report

## Emission factors used in the agriculture sector (cont'd)

3.B(b) Manure Management		EF			
Direct N <sub>2</sub> O Emissions		(kg N <sub>2</sub> O-N / kg N excreted)	Method	Note	
Liquid system		0.005	T1	2006 IPCC Guidelines Vol.4 Table 10.21	
Solid storage		0.005	T1	2006 IPCC Guidelines Vol.4 Table 10.21	
Dry lot		0.02	T1	2006 IPCC Guidelines Vol.4 Table 10.21	
Pasture, range and paddock		-	T1	Reported under 3.D agricultural soils category	
Burned for fuel or as waste		-	T1	Reported under the energy sector	
Other (Poultry manure with/without litter)		0.001	T1	2006 IPCC Guidelines Vol.4 Table 10.21	
3.B(b) Manure Management		EF			
Indirect N <sub>2</sub> O Emissions		[kg N <sub>2</sub> O-N / (kg NH <sub>3</sub> -N + NO <sub>x</sub> -N volatilised)]	Method	Note	
All related manure management systems		0.01	T1	2006 IPCC Guidelines Vol.4 Table 11.3	
3.C Rice Cultivation		Value	Unit	Method	Note
EF <sub>c</sub>	(on Table 5.11, Vol.4 of the 2006 IPCC Guidelines)	1.30	kg CH <sub>4</sub> /ha/ day	T1	Baseline emission factor for all types of water regimes
SF <sub>w</sub>	(on Table 5.12, Vol.4 of the 2006 IPCC Guidelines)	1.00		T1	For continuously flooded water regime
SF <sub>w</sub>	(on Table 5.12, Vol.4 of the 2006 IPCC Guidelines)	0.60		T1	For intermittently flooded (single aeration) water regime
SF <sub>w</sub>	(on Table 5.12, Vol.4 of the 2006 IPCC Guidelines)	0.52		T1	For intermittently flooded (multiple aeration) water regime
SF <sub>p</sub>	(on Table 5.13, Vol.4 of the 2006 IPCC Guidelines)	1.00		T1	Non-flooded pre-season less than 180 days
SF <sub>p</sub>	(on Table 5.13, Vol.4 of the 2006 IPCC Guidelines)	0.68		T1	Non-flooded pre-season more than 180 days
SF <sub>p</sub>	(on Table 5.13, Vol.4 of the 2006 IPCC Guidelines)	1.90		T1	For flooded pre-season over 30 days

## Emission factors used in the agriculture sector (cont'd)

3.D.a Agricultural Soils			
Direct N <sub>2</sub> O Emissions			
	EF	Method	Note (Table 11.1, Vol.4, 2006 IPCC Guidelines)
3.D.a.1 Inorganic N fertilizers	0.01	T1	0.003 is taken for flooded rice
3.D.a.2 Organic N fertilizers	0.01	T1	
3.D.a.3 Urine and dung deposited by grazing animals	**	T1	** 0.02 for cattle, buffalo, pigs, poultry and 0.01 for sheep and other animals
3.D.a.4 Crop residues	0.01	T1	
3.D.a.6 Cultivation of organic soils	8	T1	EF2, CG, Temp
3.D.b Agricultural Soils			
Indirect N <sub>2</sub> O Emissions			
	Value	Method	Note
EF <sub>4</sub> (on Table 11.3, Vol.4 of the 2006 IPCC Guidelines)	0.010	T1	N volatilisation and re-deposition
EF <sub>5</sub> (on Table 11.3, Vol.4 of the 2006 IPCC Guidelines)	0.0075	T1	Leaching/runoff
Frac <sub>GASF</sub> (on Table 11.3, Vol.4 of the 2006 IPCC Guidelines)	0.10	T1	Volatilisation from synthetic fertiliser
Frac <sub>GASM</sub> (on Table 11.3, Vol.4 of the 2006 IPCC Guidelines)	0.20	T1	Volatilisation from all organic N fertilisers applied, and dung and urine deposited by grazing animals
Frac <sub>LEACH-(H)</sub>	0.015	T1	Country-specific value

## Emission factors used in the agriculture sector (cont'd)

3.F Field Burning of agricultural residues	$G_{ef}$ (g /kg)		$C_f$		Note
	CH <sub>4</sub>	N <sub>2</sub> O	CH <sub>4</sub> and N <sub>2</sub> O	Method	
3.F.1.1 Wheat	2.7	0.07	0.9	T1	2006 IPCC Guidelines Vol.4, Table 2.5 for $G_{ef}$ and Table 2.6 for $C_f$
3.F.1.2 Barley	2.7	0.07	0.9	T1	the value given for wheat was taken
3.F.1.3 Maize	2.7	0.07	0.8	T1	2006 IPCC Guidelines Vol.4, Table 2.5 for $G_{ef}$ and Table 2.6 for $C_f$
3.F.1.4 Rice	2.7	0.07	0.8	T1	2006 IPCC Guidelines Vol.4, Table 2.5 for $G_{ef}$ and Table 2.6 for $C_f$
3.H Urea Application					
			EF (tonne of C/ tonne of urea)	Method	Note
Applied amount of urea			0.20	T1	2006 IPCC Guidelines Vol.4 page 11.34

## Emission Factors Used for Waste Sector

	EF	AD Source
5.A Solid waste disposal	Default values in 2006 IPCC Guidelines Waste Sector Table 3.1	TurkStat's surveys and database
5.B Biological treatment of solid waste	CH <sub>4</sub> : 4, N <sub>2</sub> O: 0.24 wet weight basis)	TurkStat's surveys and database
5.B.1 Composting	in 2006 IPCC Guidelines	
5.B.1.a Municipal Solid Waste		
5.C Incineration and open burning of waste	CO <sub>2</sub> : OF= 0.58 for MSW (Table 5.2)	TurkStat's surveys and database
5.C.2 Open Burning of Waste	CH <sub>4</sub> & N <sub>2</sub> O: Defaults (Table 5.6) in	
5.C.2.1 Biogenic	2006 IPCC Guidelines	
5.C.2.1.a Municipal Solid Waste		
5.D Wastewater treatment and discharge	Default values (Table 6.11 & 6.3) in	TurkStat's surveys and database
5.D.1 Domestic Wastewater	2006 IPCC Guidelines	
	CS BODs for TOW calculation	
	(Table 1) & Tij values (Table 2)	
5.D.2 Industrial Wastewater	Default values (Table 6.8 & 6.9) in	TurkStat's surveys and database
	2006 IPCC Guidelines	

### Country-specific BOD values

BOD (g/person/day)	I
Country-specific per capita BOD for wastewater collected by sewers	Correction factor for additional industrial BOD discharged into sewers
53	1

BOD (g/person/day)	BOD (g/person/day)
Country-specific per capita BOD for receiving bodies	Country-specific per capita BOD for sludge removed
25	28

Country specific values for degrees of treatment utilization (T) by income groups		
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

## Annex 4: National Energy Balance Sheets, 2017

Distribution of Energy Supply	Hard Coal	Lignite	Asphaltite	Coke	Derivative Gases	BFG	Coke Oven Gas	BOF Gas	Coal Tar	Oil	Oil Products	Petroleum Coke
Domestic Production (+)	723	13,752	611							2,681		
Import (+)	24,347			537					1	27,055	26,668	3,235
Export (-)	60			2					110		6,876	356
Bunkers (-)											4,575	
Stock Change (+/-)	-304	39	-55	-31					11	-245	-431	102
Primary Energy Supply	24,707	13,791	555	504	0	0	0	0	-98	29,491	14,786	2,981
Statistical Difference (+/-)--	126	-3	-6	-127	0	0	0	0	13	0	222	55
Transformation Sector	-15,823	-10,734	-551	2,780	407	34	324	48	137	-29,491	28,352	719
Electricity and Heat Production	-11,141	-10,462	-551		-868	-546	-255	-66			-373	
Main Activity Producer Plants	-10,038	-10,340	-551		0						-255	
Autoproductors	-1,103	-123			-868	-546	-255	-66			-119	
Heat Production	-221	-262			-99	-18	-34	-47			-136	
Coke ovens	-4,276			2,780	832		832		137			
Blast Furnaces					1,457	1,265		192				
Petroleum Refinery										-29,354	33,163	719
Own use and losses	-185	-9			-916	-667	-219	-30		-138	-4,301	
Total Final Energy consumption	8,883	3,057	5	3,284	407	34	324	48	40	0	43,139	3,700
Sectors Total	8,757	3,060	11	3,411	407	34	324	48	26	0	42,916	3,645
Industry Consumption	3,974	1,765	0	3,411	407	34	324	48	26	0	4,293	3,645
Mining and Quarrying (07,08,09)	2	89									157	5
Manufacture of Food,beverage ,tobacco products(10,11,12)	179	336		46							29	3
Manufacture of food products	179	332		8							25	3
Manufacture of beverage products											1	
Manufacture of tobacco products											0	
Sugar Production (10)		4		38							3	
Manufacture of Textile and Leather Products (13,14,15)	130	567									11	5
Manufacture of textile products	101	532									8	5
Manufacture of clothing articles	28	34									2	
Manufacture of leather and related products	1	0									1	
Manufacture of wood and products(16)	5	5									5	
Manufacture of paper and products(17,18)	20	81									7	3
Manufacture of chemical, petrochemical products(20,21,22)	115	109		9							9	
Manufacture of chemical products	112	52		9							2	
Fertilizer(20)											0	
Manufacture of pharmaceutical products(21)	3	3									1	
Manufacture of rubber , plastic products(22)	1	55									5	
Manufacture of non-metallic mineral products-23	2,273	551		15	3		3				3,795	3,629
Manufacture of glass products(23)											1	
Manufacture of ceramic products(23)	22	116									52	42
Manufacture of cement products(23)	2,250	435		15	3		3				3,742	3,587
Basic metal industry(24,25)	1,250	22		3,341	404	34	321	48	26		23	
Manufacture of iron and steel products(24)	1,239			3,292	404	34	321	48	26		15	
Manufacture of non-ferrous metal products(24)	11			46							5	
Manufacture of fabricated metal products(25)	0	22		2							3	
Manufacture of Machine, Electrical, Electronic Products(26,27,28)	0										8	
Production of Transportation Equipment(29,30)	6										14	
Manufacture of Motorized Land Vehicles(29)	0										5	
Manufacture of Other Transportation Vehicles(30)		6									9	
Furniture and Other Manufacturing(31,32)	0										1	
Construction(41,42,43)	0	0									81	
Other industry	0	0		0							153	0
TRANSPORT	0	0	0	0	0	0	0	0	0	0	27,757	0
Rail											122	
Domestic Navigation											393	
Domestic Aviation											1,272	
Pipeline Transportation												
Road											25,970	
OTHER SECTORS	4,784	1,295	11	0	0	0	0	0	0	0	4,061	0
Residential	2,444	955	11								245	
Commercial and Public Services	2,340	340									880	
Agriculture and farming											2,936	
NON ENERGY USE	0	0	0	0	0	0	0	0	0	0	6,804	0
Petrochemical feedstock											2,179	



# National Energy Balance Sheets, 2017

Distribution of Energy Supply	Fuel Oil	Gas Diesel Oil	Gasoline	LPG	Refinery Gas	Jet Kerosene	Kerosen	Naphta	By Products	Base Oil	White Spirit	Bitumen
<b>Domestic Production (+)</b>												
<b>Import (+)</b>	2,019	14,876		3,826		210		1,948	205	248	35	5
<b>Export (-)</b>	1,523	236	3,389	301		337		44	436	156	5	9
<b>Bunkers (-)</b>	821	74				3,679						
<b>Stock Change (+/-)</b>	-66	-182	34	-46	14	-73	-4	-15	-54	-35	5	-60
<b>Primary Energy Supply</b>	<b>-391</b>	<b>14,384</b>	<b>-3,355</b>	<b>3,479</b>	<b>14</b>	<b>-3,880</b>	<b>-4</b>	<b>1,890</b>	<b>-284</b>	<b>56</b>	<b>35</b>	<b>-64</b>
<b>Statistical Difference (+/-)---</b>	<b>0</b>	<b>72</b>	<b>0</b>	<b>15</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>81</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>Transformation Sector</b>	<b>655</b>	<b>9,613</b>	<b>5,735</b>	<b>1,147</b>	<b>-14</b>	<b>5,152</b>	<b>20</b>	<b>370</b>	<b>524</b>	<b>187</b>	<b>7</b>	<b>3,356</b>
Electricity and Heat Production	-169	-204										
Main Activity Producer Plants	-52	-203										
Autoproducers	-118	-1										
Heat Production	-136											
Coke ovens												
Blast Furnaces												
Petroleum Refinery	2,687	10,821	5,735	1,147	1,556	5,152	20	370	524	187	7	3,356
Own use and losses	-1,727	-1,004	0		-1,570							
<b>Total Final Energy consumption</b>	<b>264</b>	<b>23,997</b>	<b>2,380</b>	<b>4,626</b>	<b>0</b>	<b>1,272</b>	<b>16</b>	<b>2,260</b>	<b>241</b>	<b>244</b>	<b>42</b>	<b>3,292</b>
<b>Sectors Total</b>	<b>264</b>	<b>23,924</b>	<b>2,380</b>	<b>4,611</b>	<b>0</b>	<b>1,272</b>	<b>16</b>	<b>2,179</b>	<b>241</b>	<b>244</b>	<b>42</b>	<b>3,292</b>
<b>Industry Consumption</b>	<b>38</b>	<b>435</b>	<b>4</b>	<b>171</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
Mining and Quarrying (07,08,09)	16	136	0	1								
Manufacture of Food,beverage ,tobacco products(10,11,12)	5	20	0	1								
Manufacture of food products	2	19	0	0								
Manufacture of beverage products	0	0	0	0								
Manufacture of tobacco products		0	0	0								
Sugar Production (10)	3	1	0	0								
Manufacture of Textile and Leather Products (13,14,15)	0	4	1	0								
Manufacture of textile products	0	2	0	0								
Manufacture of clothing articles		2	0	0								
Manufacture of leather and related products		1	1									
Manufacture of wood and products(16)	0	4	0									
Manufacture of paper and products(17,18)	0	3	0	0								
Manufacture of chemical, petrochemical products(20,21,22)	0	7	0	2								
Manufacture of chemical products	0	2	0	0								
Fertilizer(20)	0	0										
Manufacture of pharmaceutical products(21)	0	1	0	0								
Manufacture of rubber , plastic products(22)	0	4	0	1								
Manufacture of non-metallic mineral products-23	16	148	1	1								
Manufacture of glass products(23)		1		1								
Manufacture of ceramic products(23)	0	10	0	0								
Manufacture of cement products(23)	16	137	1	0								
Basic metal industry(24,25)	0	21	0	2								
Manufacture of iron and steel products(24)	0	14	0	1								
Manufacture of non-ferrous metal products(24)	0	5	0	0								
Manufacture of fabricated metal products(25)	0	3	0	1								
Manufacture of Machine, Electrical, Electronic Products(26,27)	0	3	0	4								
Production of Transportation Equipment(29,30)	0	5	1	8								
Manufacture of Motorized Land Vehicles(29)	0	4	1	0								
Manufacture of Other Transportation Vehicles(30)		1	0	8								
Furniture and Other Manufacturing(31,32)	0	1	0	0								
Construction(41,42,43)	0	81	0									
Other industry	0	0	0	153								
<b>TRANSPORT</b>	<b>34</b>	<b>20,553</b>	<b>2,376</b>	<b>3,522</b>	<b>0</b>	<b>1,272</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
Rail		122										
Domestic Navigation	34	359										
Domestic Aviation						1,272						
Pipeline Transportation												
Road		20,072	2,376	3,522								
<b>OTHER SECTORS</b>	<b>192</b>	<b>2,936</b>		<b>918</b>	<b>0</b>	<b>0</b>	<b>16</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
Residential				229			16					
Commercial and Public Services	192			688								
Agriculture and farming		2,936										
<b>NON ENERGY USE</b>			<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>2,179</b>	<b>241</b>	<b>244</b>	<b>42</b>	<b>3,292</b>
Petrochemical feedstock								2,179				

# National Energy Balance Sheets, 2017

Distribution of Energy Supply	Others	Natural Gas	Biofuels and Waste	Wood	Hay,Bit.Artık	Biofuel	Hydro	Wind	Electricity	Other heat	Geothermal	Solar	Total
Domestic Production (+)		292	2.531	1.356	1.050	125	5.007	1.540			7.128	1.091	35.357
Import (+)	61	45.581							235				124.425
Export (-)	85	520							284				7.853
Bunkers (-)													4.575
Stock Change (+/-)	-50	-1.034											-2.050
Primary Energy Supply	-74	44.319	2.531	1.356	1.050	125	5.007	1.540	-49	0	7.128	1.091	145.305
Statistical Difference (+/-)-	0	65	-1	0	-1	0	0	0	0	0	0	0	289
Transformation Sector	880	-19.887	-367	0	-367	0	-5.007	-1.540	21.306	2.281	-5.268	-248	-33.654
Electricity and Heat Production		-18.057	-342		-342		-5.007	-1.540	25.566	1.034	-5.268	-248	-27.258
Main Activity Producer Plants		-15.713	-320		-320		-4.924	-1.535	23.821	538	-5.268	-185	-24.770
Autoproducers		-2.344	-22		-22		-83	-5	1.744	496		-63	-2.488
Heat Production		-880	-25		-25					1.663			40
Coke ovens													-526
Blast Furnaces													1.457
Petroleum Refinery	880	-630							-159	-417			2.603
Own use and losses		-320							-4.100				-9.970
Total Final Energy consumption	806	24.432	2.165	1.356	683	125	0	0	21.257	2.281	1.860	843	111.650
Sectors Total	806	24.367	2.166	1.356	685	125	0	0	21.257	2.280	1.860	843	111.362
Industry Consumption	0	9.043	0	0	0	0	0	0	9.858	2.246	0	295	35.318
Mining and Quarrying (07,08,09)		119							121	4			491
Manufacture of Food,beverage ,tobacco products(10,11,12)		1.020							644	462			2.715
Manufacture of food products		948							526	462			2.480
Manufacture of beverage products		28							48				76
Manufacture of tobacco products		9							16				25
Sugar Production (10)		35							54				134
Manufacture of Textile and Leather Products (13,14,15)		936							1.464	84			3.192
Manufacture of textile products		858							1.236	84			2.819
Manufacture of clothing articles		70							183				317
Manufacture of leather and related products		9							45				56
Manufacture of wood and products(16)		161							200	64			441
Manufacture of paper and products(17,18)		203							302	156			768
Manufacture of chemical, petrochemical products(20,21,22)		1.832							1.071	225			3.371
Manufacture of chemical products		1.223							447	216			2.062
Fertilizer(20)		407							34				442
Manufacture of pharmaceutical products(21)		41							46				94
Manufacture of rubber , plastic products(22)		161							543	8			774
Manufacture of non-metallic mineral products-23		1.778							1.114	45			9.574
Manufacture of glass products(23)		669							187				856
Manufacture of ceramic products(23)		901							197				1.287
Manufacture of cement products(23)		209							731	45			7.430
Basic metal industry(24,25)		1.787							2.721	160			9.733
Manufacture of iron and steel products(24)		1.255							2.194	115			8.541
Manufacture of non-ferrous metal products(24)		369							323	44			798
Manufacture of fabricated metal products(25)		163							204				395
Manufacture of Machine, Electrical, Electronic Products(26,27,28)		60							248	7			323
Production of Transportation Equipment(29,30)		144							227	6			396
Manufacture of Motorized Land Vehicles(29)		129							188	6			327
Manufacture of Other Transportation Vehicles(30)		15							39				69
Furniture and Other Manufacturing(31,32)		39							73				113
Construction(41,42,43)		504							320	1			906
Other industry		458							1.355	1.034		295	3.295
TRANSPORT	0	436	125	0	0	125	0	0	111	0	0	0	28.429
Rail									85				207
Domestic Navigation									0				393
Domestic Aviation									0				1.272
Pipeline Transportation		367							27				393
Road		69	125			125			0				26.164
OTHER SECTORS	0	14.321	2.041	1.356	685	0	0	0	11.287	34	1.860	548	40.242
Residential		11.150	2.041	1.356	685				4.666		777	548	22.836
Commercial and Public Services		3.074							6.037	34	475		13.179
Agriculture and farming		97							585		609		4.227
NON ENERGY USE	806	568	0	0	0	0	0	0	0	0	0	0	7.372
Petrochemical feedstock													2.179

Energy balance sheets for 1972-2017 are available on the MENR website (<http://www.eigm.gov.tr/en-US/Balance-Sheets?page=1>).

## Annex 5: Completeness

Table A8.1 Completeness, Sources and sinks not estimated ("NE")

GHG	Sector <sup>(2)</sup>	Source/sink category <sup>(2)</sup>
CH4	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.b Solid Fuel Transformation
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
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
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	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.b Solid Fuel Transformation
CO2	Energy	1.C CO2 Transport and Storage/Injection and Storage/Injection
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
N2O	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.b Solid Fuel Transformation
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

**Table A8.2 Completeness, Sources and sinks reported elsewhere ("IE")**

<b>GHG</b>	<b>Source/sink category</b>	<b>Explanation</b>
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars	Included under "1.A.3.e Other Transportation"
CH4	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	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars	Included under "1.A.3.e Other Transportation"
CH4	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	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	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	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	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	Included under "1.A.3.e Other Transportation"
CH4	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	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	Included under "1.A.3.e Other Transportation"
CH4	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.4.c.i
CH4	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	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	4.B Cropland/4.B.1 Cropland Remaining Cropland/4(V) Biomass Burning/Wildfires	Report in "agriculture sector"
CH4	4.B Cropland/4.B.2 Land Converted to Cropland/4(V) Biomass Burning/Wildfires	Report in "agriculture sector"
CH4	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	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	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	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	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars	Included under "1.A.3.e Other Transportation"
CO2	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"

**Table A8.2 Completeness, Sources and sinks reported elsewhere ("IE") (cont'd)**

GHG	Source/sink category	Explanation
CO2	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	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	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	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"
CO2	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	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	1.AD Feedstocks, reductants and other non-energy use of fuels/Liquid Fuels/Lubricants	Included under 2D
CO2	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 Report in "agriculture sector"
CO2	4.B Cropland/4.B.1 Cropland Remaining Cropland/4(V) Biomass Burning/Wildfires	Report in "agriculture sector"
CO2	4.B Cropland/4.B.2 Land Converted to Cropland/4(V) Biomass Burning/Wildfires	Report in "agriculture sector"
CO2	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	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	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	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	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.

**Table A8.2 Completeness, Sources and sinks reported elsewhere ("IE") (cont'd)**

GHG	Source/sink category	Explanation
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars	Included under "1.A.3.e Other Transportation"
N2O	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	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars	Included under "1.A.3.e Other Transportation"
N2O	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	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"
N2O	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	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	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	No data available
N2O	4(IV) Indirect N2O Emissions from Managed Soils/Atmospheric Deposition	No data available
N2O	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	No data available
N2O	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	No data available
N2O	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	not estimated due to lack of activity data
N2O	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	not estimated due to lack of activity data
N2O	4.B Cropland/4.B.1 Cropland Remaining Cropland/4(V) Biomass Burning/Wildfires	Report in "agriculture sector"
N2O	4.B Cropland/4.B.2 Land Converted to Cropland/4(V) Biomass Burning/Wildfires	Report in "agriculture sector"
N2O	4.E Settlements/4.E.1 Settlements Remaining Settlements/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Inorganic N Fertilizers	i.e. included in "agriculture sector"
N2O	4.E Settlements/4.E.1 Settlements Remaining Settlements/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Organic N Fertilizers	i.e. included in "agriculture sector"
N2O	4.E Settlements/4.E.2 Land Converted to Settlements/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Inorganic N Fertilizers	i.e. included in "agriculture sector"
N2O	4.E Settlements/4.E.2 Land Converted to Settlements/4(I) Direct N2O Emissions from N Inputs to Managed Soils/Organic N Fertilizers	i.e. included in "agriculture sector"
N2O	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
N2O	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

**Table A8.2 Completeness, Sources and sinks reported elsewhere ("IE") (cont'd)**

GHG	Source/sink category	Explanation
N2O	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	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	5.D Wastewater Treatment and Discharge/5.D.2 Industrial Wastewater	Emissions from 5.D.2 are included in 5.D.1
SF6	2.G Other Product Manufacture and Use/2.G.1 Electrical Equipment/SF6	Due to lack of data, NE is entered

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