TURKISH GREENHOUSE GAS INVENTORY 1990 - 2020

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

TURKISH STATISTICAL INSTITUTE

April 2022

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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. Türkiye 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.

National inventory of Türkiye 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.

Türkiye, 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 1990-2020.

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, Türkiye submits a National Inventory Report (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. GHG inventory of Türkiye 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 Türkiye by the decision taken by CBCC in 2009.

The Official Statistics Programme (OSP), based on the Turkish Statistics Law 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, Urbanization and Climate Change (MoEUCC),
- Ministry of Agriculture and Forestry (MoAF).

The National GHG emissions/removals are calculated by using 2006 IPCC Guidelines. The GHG Inventory includes direct GHGs as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), fluorinated gases (F-gases); hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6), nitrogen trifluoride (NF_3) and indirect GHGs as nitrogen oxides (NO_x), carbon monoxide (CO), non-methane volatile organic compounds (NMVOC), sulphur dioxide (SO_2) and ammonia (NH_3) 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

Total GHG emissions, excluding the LULUCF sector, were estimated to be 523.9 Mt of CO_2 equivalent (CO_2 eq.) in 2020. This represents an increase of 15.8 Mt, or 3.1%, in emissions compared to 2019, and a 138.4% increase compared to 1990 (Table ES 1).

Table ES 1 Greenhouse gas emissions, 1990-2020

	1990	2000	2005	2010	2015	2016	2017	2018	2019	2020
Total emissions ($Mt CO_2$ eq. excluding LULUCF)	219.7	299.0	337.0	398.7	474.5	500.8	528.3	524.0	508.1	523.9
Change compared to 1990 (%)	-	36.1	53.4	81.4	115.9	127.9	140.4	138.5	131.2	138.4
Net emissions ($Mt CO_2$ eq. including LULUCF)	164.0	237.4	262.5	325.1	376.9	404.8	428.5	429.6	424.0	466.9
Change compared to 1990 (%)	-	44.8	60.0	98.2	129.9	146.8	161.3	162.0	158.6	184.8

Total GHG emissions, including the LULUCF sector, were 466.9 Mt CO_2 eq. in 2020. Thus, LULUCF included total emissions decreased by 10.1% compared to 2019 emissions. There is a 184.8% increase from 1990 to 2020 (Table ES 1).

Table ES 2 Overview of GHG emissions and removals, 1990-2020

($Mt CO_2$ eq.)

GHG emissions	1990	2000	2005	2010	2015	2016	2017	2018	2019	2020
CO_2 (excluding LULUCF)	151.7	229.9	264.8	316.0	384.3	405.3	430.2	422.6	401.7	413.4
CO_2 (including LULUCF)	95.8	168.0	190.2	242.3	286.7	309.1	330.2	328.0	317.5	356.2
CH_4 (excluding LULUCF)	42.5	43.7	45.2	51.6	52.8	55.6	56.8	60.3	63.1	64.0
CH_4 (including LULUCF)	42.6	43.8	45.2	51.6	52.8	55.6	56.8	60.4	63.2	64.1
N_2O (excluding LULUCF)	25.0	24.8	25.3	27.4	32.3	34.4	35.6	35.5	37.0	40.5
N_2O (including LULUCF)	25.0	24.9	25.4	27.5	32.4	34.6	35.7	35.6	37.1	40.7
HFCs	NO	0.1	1.1	3.1	4.8	5.3	5.5	5.5	6.1	5.9
PFCs	0.6	0.6	0.6	0.5	0.2	0.1	0.1	0.0	0.1	0.0
SF_6	NO	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total (excluding LULUCF)	219.7	299.0	337.0	398.7	474.5	500.8	528.3	524.0	508.1	523.9
Total (including LULUCF)	164.0	237.4	262.5	325.1	376.9	404.8	428.5	429.6	424.0	466.9

Note that 0.0 kt figures refer to values smaller than 0.05 but greater than zero.

Total GHG emissions as CO_2 eq. for the year 2020 were 523.9 Mt (excluding LULUCF). Overall in 2020, the energy sector had the largest portion with a 70.2% share of total emissions. The energy sector was followed by the sectors of agriculture with 14%, IPPU with 12.7% and waste with 3.1%. GHG emissions by sectors are presented in Table ES 3 for 1990-2020.

Table ES 3 Greenhouse gas emissions by sectors, 1990-2020

(Mt CO_2 eq.)

Year	Energy	IPPU	Agriculture	LULUCF	Waste	Total (Excluding LULUCF)	Total (Including LULUCF)
1990	139.6	23.0	46.1	-55.7	11.1	219.7	164.0
1991	144.0	24.9	46.9	-56.7	11.3	227.1	170.4
1992	150.3	24.5	47.0	-56.9	11.5	233.3	176.4
1993	156.8	24.7	47.4	-56.1	11.8	240.6	184.6
1994	153.3	24.3	44.9	-57.6	12.0	234.6	177.0
1995	166.3	25.9	44.1	-57.4	12.3	248.6	191.2
1996	184.0	26.3	44.8	-57.6	12.7	267.7	210.1
1997	196.1	27.1	42.5	-61.7	13.2	278.9	217.2
1998	195.8	27.5	43.7	-62.7	13.5	280.4	217.7
1999	193.8	25.9	44.3	-64.1	13.9	277.9	213.8
2000	216.0	26.3	42.3	-61.6	14.3	299.0	237.4
2001	199.2	25.9	39.9	-64.9	14.8	279.8	214.9
2002	205.9	26.9	37.6	-72.6	15.2	285.7	213.1
2003	220.4	28.3	40.6	-74.6	15.6	304.9	230.2
2004	226.3	30.8	41.3	-73.7	16.1	314.5	240.8
2005	244.4	33.7	42.4	-74.5	16.4	337.0	262.5
2006	260.5	36.7	43.9	-74.8	16.8	358.0	283.2
2007	291.5	39.3	43.4	-74.5	17.1	391.3	316.8
2008	288.3	41.1	41.3	-69.5	17.2	387.9	318.4
2009	292.9	43.0	42.0	-73.2	17.2	395.1	322.0
2010	287.8	49.0	44.4	-73.6	17.4	398.7	325.1
2011	309.9	53.9	46.9	-77.5	17.8	428.5	351.0
2012	321.6	56.2	52.7	-74.8	17.6	448.0	373.2
2013	308.3	59.2	55.9	-76.9	16.7	440.0	363.1
2014	326.8	59.9	56.2	-77.9	16.5	459.4	381.5
2015	342.0	59.2	56.1	-97.5	17.1	474.5	376.9
2016	361.7	63.5	58.9	-96.0	16.7	500.8	404.8
2017	382.4	66.4	63.3	-99.8	16.3	528.3	428.5
2018	374.1	68.0	65.3	-94.4	16.6	524.0	429.6
2019	365.4	58.6	68.0	-84.0	16.1	508.1	424.0
2020	367.6	66.8	73.2	-56.9	16.4	523.9	466.9

IPPU: Industrial Processes and Product Use
LULUCF: Land Use, Land Use Change and Forestry

As shown in Table ES 3, emissions from energy increased by 0.6% to 367.6 Mt CO_2 eq. in 2020 compared to 2019. However, there is a 163.3% increase compared to 1990. Emissions in the IPPU sector increased to 66.8 Mt CO_2 eq. in 2020 which is 14% higher than the emissions in 2019. Emissions in the agriculture and waste sectors were 73.2 Mt CO_2 eq. and 16.4 Mt CO_2 eq. respectively in 2020.

ES.3 Overview of Emission Estimates and Trends

In 2020, the highest portion of total CO_2 emissions originated from the energy sector with 85.4%. The remaining 14.2% originated from IPPU, 0.4% from agriculture and a percentage close to zero from waste. CO_2 emissions from energy increased by 0.8% compared to 2020 while increased by 171.8% as compared to 1990. CO_2 emissions from IPPU increased by 16.8% compared to 2019 and increased by 175.9% compared to 1990.

The largest portion of CH_4 emissions originated from agriculture with 61% while a share of 22.1% is from waste, and 16.9% from energy and industrial processes and product use. CH_4 emissions from agriculture increased by 3.8% compared to 2019 and it increased by 55.3% compared to 1990. Though CH_4 emissions from waste increased by 2.2% compared to 2019, it increased by 47.2% compared to 1990.

While 80.3% of N_2O emissions was from agriculture, 9.1% was from energy, 5.6% was from waste, and 5% was from IPPU. There is a 9.4% increase and 62.2% increase in total N_2O emissions compared to 2019 and 1990, respectively. GHG emissions by sectors are shown in Table ES 4.

Table ES 4 GHG emissions, 1990-2020

(kt)

Emission sources	1990	2000	2005	2010	2015	2016	2017	2018	2019	2020
CO_2										
Total	151 665	229 858	264 769	316 036	384 330	405 305	430 220	422 569	401 720	413 433
Energy	129 891	204 494	232 907	271 645	330 815	347 273	369 365	360 850	350 127	353 038
IPPU	21 287	24 726	31 237	43 735	52 704	56 734	59 404	60 461	50 302	58 735
Agriculture	460	617	613	645	811	1 295	1 450	1 257	1 288	1 657
Waste	27	21	12	11	1.1	1.8	1.5	1.2	2.4	3.6
CH_4										
Total	1 699	1 746	1 806	2 064	2 111	2 222	2 271	2 414	2 525	2 560
Energy	310	360	337	490	295	419	355	382	469	434
IPPU	0.3	0.4	0.4	0.4	0.6	0.7	0.7	0.7	0.6	0.6
Agriculture	1 005	878	882	951	1 214	1 219	1 353	1 456	1 503	1 560
Waste	384	507	587	623	601	584	563	575	553	565
N_2O										
Total	84	83	85	92	108	115	119	119	124	136
Energy	6.5	8.5	10.5	13.3	12.7	13.3	14.0	12.6	12.0	12.4
IPPU	3.6	2.8	2.4	5.5	4.9	4.1	4.2	6.1	6.8	6.7
Agriculture	69	66	66	67	84	91	94	93	98	109
Waste	4.9	5.5	5.8	6.3	7.1	7.1	7.3	7.4	7.5	7.6

IPPU: Industrial Processes and Product Use. The LULUCF sector is not included.
Figures in the table may not add up to the totals due to rounding.

ES.4 Indirect GHG Emissions

Emissions of NO_x, CO, NMVOC, SO_2 and NH_3 were also included in the report because they influence climate change indirectly. Table ES 5 shows indirect GHG emissions. 99.4% of total NO_x emissions which was 0.86 Mt, comes from energy sector. Similarly, 98.2% of total CO emissions as high as 1.89 Mt in 2020 was due to the energy sector. NMVOC emissions was 1.16 Mt in 2020. The largest portion of NMVOC emissions came from agriculture with 44.5% which is followed by IPPU with 31.8% and almost all SO_2 emissions close to 2.2 Mt was from the energy sector in 2020.

Table ES 5 Indirect GHG emissions, 1990-2020

(kt)

Emission sources	1990	2000	2005	2010	2015	2016	2017	2018	2019	2020
NO_x										
Total	**253**	**1490**	**1297**	**998**	**857**	**870**	**855**	**860**	**888**	**866**
Energy	250	1 480	1 293	994	853	866	851	856	883	860
IPPU	0.95	7.62	3.60	2.77	3.70	3.52	3.80	4.06	4.20	4.33
LULUCF	0.51	1.05	0.12	0.14	0.13	0.41	0.60	0.33	0.68	0.91
Waste	0.93	1.14	0.55	0.43	0.02	0.03	0.03	0.03	0.03	0.06
CO										
Total	**2 040**	**8 762**	**3 745**	**3 454**	**2 522**	**2 332**	**2 164**	**1 643**	**1 762**	**1 930**
Energy	1 997	8 696	3 723	3 435	2 508	2 306	2 132	1 625	1 733	1 895
IPPU	8.60	8.54	8.12	7.33	8.40	10.76	10.56	10.56	10.55	10.83
LULUCF	18.36	37.59	4.27	5.10	4.65	14.60	21.47	6.35	18.42	23.14
Waste	16.41	19.99	9.74	7.48	0.39	0.56	0.56	0.56	0.70	1.06
NMVOC										
Total	**896**	**1 607**	**1 110**	**1 104**	**1 110**	**1 087**	**1 114**	**1 092**	**1 118**	**1 161**
Energy	283	905	428	409	306	277	255	203	213	234
IPPU	252	317	314	328	346	351	358	362	366	369
Agriculture	356	354	336	332	414	419	461	487	499	517
Waste	4.92	30.25	32.55	35.55	44.01	39.87	39.87	40.47	40.47	40.95
SO_2										
Total	**1 683**	**2 237**	**2 000**	**2 554**	**1 939**	**2 244**	**2 351**	**2 515**	**2 521**	**2 166**
Energy	1 682	2 237	2 000	2 554	1 939	2 243	2 350	2 514	2 521	2 165
IPPU	0.73	0.70	0.63	0.54	0.69	0.82	0.85	0.85	0.85	0.91
Waste	0.03	0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
NH_3										
Total	**85**	**97**	**84**	**62**	**59**	**45**	**46**	**41**	**43**	**46**
Energy	1.03	1.51	3.32	2.73	9.21	5.71	4.54	3.34	3.67	4.14
IPPU	5.76	3.54	3.85	3.98	4.13	3.24	3.70	5.10	6.38	6.50
Waste	78.32	91.91	77.04	55.22	45.34	36.36	38.08	32.45	32.45	35.71

Note that 0.00 kt figures refer to values smaller than 0.005 kt but greater than zero.
Figures in the table may not add up to the totals due to rounding.
IPPU: Industrial Processes and Product Use

CONTENTS

Page

TABLES

Page

FIGURES

Page

ABBREVIATIONS AND ACRONYMS

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
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 Corporation
BWD	Basic wood density
C	Carbon
°C	Degree centigrade
C_2F_6	Hexafluoroethane
$CaCO_3$	Calcium carbonate
CAGR	Compound annual growth rate
$CaMg(CO_3)_2$	Dolomite
CaO	Calcium oxide
CBCC	Coordination Board on Climate Change
CBCCAM	Coordination Board on Climate Change and Air Management
CF	Carbon fraction of dry matter
CF	Carbon fraction
CF_4	Carbon tetrafluoride
CFCs	Chlorofluorocarbons
CH_4	Methane
CITEPA	Technical Reference Center for Air Pollution and Climate Change
CKD	Cement kiln dust
CL-SL	Cropland converted to settlements

cm	Centimeter
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2 eq.	Carbon dioxide equivalent
COD	Chemical oxygen demand
CORINAIR	Core Inventory of Air Emissions in Europe
CORINE	Coordinate Information on the Environment
CRF	Common Reporting Format
CS	Country specific
CSC	Carbon stock change
D	Default
DG	Directorate of General
dm	Dry matter content
DOC	Degradable organic carbon
DOM	Dead Organic Matter
DOCF	Fraction of degradable organic carbon
EAF	Electric arc furnace
EF	Emission factor
EF_c	Baseline emission factor for continuously flooded fields without organic amendments
EHCIP	Environmental Heavy Cost Investment Planning
EMEP	European Monitoring and Evaluation Programme
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
FAOSTAT	Statistical database of the FAO
FCF	Fossil carbon content
F-gas	Fluorinated gas
FOD	First Order Decay
$Frac_{GASF}$	Fraction of synthetic fertiliser N that volatilises as NH_3 and NO_x
$Frac_{GASMS}$	Percent of managed manure nitrogen that volatilises as NH_3 and NO_x in the manure management system S

$Frac_{GASM}$	Fraction of applied organic N fertiliser materials and of urine and dung N deposited by grazing animals that volatilises as NH_3 and NO_x
$Frac_{LEACH-(H)}$	Fraction of all N added to/mineralised in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff
$Frac_{LEACHMS}$	Percent of managed manure nitrogen losses due to runoff and leaching during solid and liquid storage of manure
F_{comp}	Annual amount of total compost N applied to soils
F_{sew}	Annual amount of total sewage N that is applied to soils
g	gram
GDF	General Directorate of Forestry
GDP	Gross Domestic Product
GE	Gross energy intake
Gg	Gigagram
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
HFC	Hydrofluorocarbon
HWP	Harvested wood product
ICP	International Cooperative Programme
IE	Included elsewhere
IEA	International Energy Agency
IEF	Implied emission factor
IFA	International Fertilizer Association
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial processes and product use
IW	Industrial Waste
k	Methane generation rate constant
kha	Kilo hectare
KISAD	Lime Producers Association
km	kilometer

kt	Kilo tonnes
ktoe	Kilo tonnes of oil equivalent
kW	Kilowatt
kWh	Kilowatt hour
L	Litter
LPG	Liquefied petroleum gas
LRS	LULUCF reporting system
LTO	Landing and take-off
LULUCF	Land Use, Land Use Change and Forestry
MAPEG	General Directorate of Mining and Petroleum Affairs
MC	Monte Carlo
MCF	Methane correction factor
ME	Main engine
MENR	Ministry of Energy and Natural Resources
$MgCO_3$	Magnesium carbonate
MgO	Magnesium oxide
MJ	Megajoule
MMS	Manure Management System(s)
MoAF	Ministry of Agriculture and Forestry
MoEF	Ministry of Environment and Forestry
MoEU	Ministry of Environment and Urbanization
MoEUCC	Ministry of Environment, Urbanization and Climate Change
MoT	Ministry of Trade
MoTI	Ministry of Transport and Infrastructure
MRV	Monitoring, Reporting, Verification
MS	Manure Management System Usage
MSm^3	Million standard cubic meter
MSW	Municipal solid waste
Mt	Million tonnes
MW	Megawatt
N	Nitrogen
N_2O	Nitrous oxide
NA	Not applicable

Na_2CO_3	Sodium carbonate
NaCl	Sodium cloride
NCV	Net calorific value
NE	Not estimated
NES	EU Integrated Environmental Adaptation Strategy
Nex	Annual nitrogen excretion
NF_3	Nitrogen trifluoride
NH_3	Ammonia
NIR	National Inventory Report
NMVOC	Non-methane volatile organic compounds
NO	Not occurring
NO_x	Nitrogen oxides
ODS	Ozone-depleting substances
ODU	Oxidised During Use
OHF	Open hearth furnace
OSP	Official Statistics Programme
OX	Oxidation factor
PFC	Perfluorocarbon
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_6	Sulphur hexafluoride
SFOC	Specific Fuel Oil Consumption
SF_o	Scaling factor regarding organic amendment type and amount applied
SF_p	Scaling factor regarding water regime before the cultivation period
$SF_{s,r}$	Scaling factor for soil type, rice cultivar, etc., if available
SF_w	Scaling factor regarding water regime during the cultivation period
SO_2	Sulphur dioxide
SO_x	Sulphur oxide
SOM	Soil Organic Matter

SWDS	Solid waste disposal sites
t	Tonnes
T	Degrees of treatment utilization
T_{PLANT}	Degree of utilization of modern, centralized wastewater treatment plants
T1	Tier 1
T2	Tier 2
T3	Tier 3
TACCC	Transparency, accuracy, comparability, consistency, and completeness
TADPK	Tobacco and Alcohol Market Regulatory Authority
TurkCimento	Turkish Cement Manufacturer's Association
TEİAŞ	Turkish Electricity Transmission Company
TJ	Terajoule
TOBB	The Union of Chambers and Commodity Exchanges of Türkiye
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 Türkiye
TUBITAK	Scientific and Technical Research Council of Türkiye
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 Türkiye in 2004 and 2009 respectively. As an Annex I party to Convention, Türkiye 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 Türkiye 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_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3 and indirect gases as NO_x, CO, NMVOC, SO_2 and NH_3 emissions originated from energy, IPPU, agriculture, and waste. The emissions and removals from LULUCF are also included in the inventory. Indirect CO_2 emissions that are a consequence of the activities of the reporting entity, but available at sources owned or controlled by another entity are not occur.

In this report, the national GHG emissions and removals from 1990 to 2020, 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, Urbanization and Climate Change (MoEUCC) is the National Focal Point of the UNFCCC, and is responsible for climate change and air pollution policies and measures. Türkiye 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 Türkiye on climate change. Under the chairmanship of Minister of Environment, Urbanization and Climate Change, 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 Türkiye through the Official Statistics Programme (OSP). The OSP is based on the Statistics Law of Türkiye 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, Urbanization and Climate Change (MoEUCC),
- Ministry of Agriculture and Forestry (MoAF).

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

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

Table 1.1 Institutions by responsiblities for national GHG inventory

Sector	CRF category	Collection of 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	MoEUCC	MoEUCC	MoEUCC	MoEUCC	MoEUCC
Agriculture	3 – Agriculture	TurkStat	TurkStat	TurkStat	TurkStat	TurkStat
Land use, land-use change and forestry	4 – LULUCF	MoAF	MoAF	MoAF	MoAF	MoAF
Waste	5 – Waste	TurkStat	TurkStat	TurkStat	TurkStat	TurkStat
Cross cutting issues						
Key category analysis			TurkStat			
Uncertainty analysis						

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 latest press release of Greenhouse Gas Emissions Statistics can be found on *https://data.tuik.gov.tr/Bulten/Index?p=Greenhouse-Gas-Emissions-Statistics-1990-2020-45862&dil=2* as scheduled on National Data Publishing Calendar. Subsequently, The MoEUCC 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 Türkiye 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 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, Urbanization and Climate Change. Emissions and removals from land use, land-use change and forestry are estimated by the Ministry of Agriculture and Forestry.

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 Türkiye. 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 and revised and updated in 2017. 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). Türkiye 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, as well as a training package for newcomers and periodic refreshment trainings for existing inventory experts.

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 IPPU, agriculture, and waste sectors are obtained from industrial production statistics, agricultural 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 Türkiye, 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.

The QA/QC plan (approved in 2017) including above mentioned annexes can be found at *https://biruni.tuik.gov.tr/yayin/views/visitorPages/english/index.zul*.

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

Table 1.2 Criteria for assessing achievement of quality objectives

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

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

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

General QC Procedures

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

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

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

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

Category-Specific QC Procedures

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

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

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

- Assumptions for AD, EFs and other parameters are compared with IPCC values and significant differences are noted,
- National and regional comparability and trends of AD, EF or other assumptions are checked against alternative data sources,
- Conduct of an in-depth review of the background data used to develop a country-specific EF, including the adequacy of any plant-level measurement programmes upon which the country-specific EF was developed. Such an in-depth review may also involve an assessment of any national literature used in support of the development of the country-specific factor,
- Evaluate any peer reviewed literature evaluating national or plant level statistics and suitability for the use in the GHG inventory,
- Hand-checking the accuracy of random calculations,
- To the extent possible, are the only hardwired data in the spreadsheets the basic input data (e.g., AD, EFs and assumptions) with all other spreadsheets using spreadsheet tools to link and calculate emissions,
- Reviewing the time series consistency of emissions calculations for any outliers and compare whether the values are within the minimum – maximum interval of other Parties,
- Checking a random sampling of conversion factors to ensure proper calculation from input data to emissions calculations,
- Is the IEF calculated reasonable compared with the previous annual submission and with the 2006 IPCC Guidelines,
- Is the time series of the IEF reasonable- are any large changes explainable,
- Checking that confidentiality is assured by Statistics Law of Türkiye,
- 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.

In 2019 submission, emissions from energy, IPPU and agriculture sectors were calculated on SAS (Statistical Analysis System) and it was double checked by the calculations on the Excel sheets by two different experts and any findings were corrected.

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.

Our 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 Türkiye, 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 Türkiye 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 Türkiye's GHG Emissions, project period was January 2015 - April 2017, aimed to strengthen existing capacities in Türkiye and assist the country to:

- Fully implement a monitoring mechanism of GHG emissions in Türkiye, 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 was 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 2017. Likewise, another QA work was conducted for the energy sector in 2018.

"Technical Assistance for New Era for Statistics Programme" which is co-funded by the European Union and the Republic of Türkiye, has been started since March 2019. Within the scope of this project, under sub-activity "National Greenhouse Gas Inventory", the experts from CITEPA – Technical Reference Center for Air Pollution and Climate Change – provided QA works for the energy, IPPU, agriculture and waste sectors of the Turkish GHG Inventory between December 2019 and February 2020.

In addition, GHG inventory submission of Türkiye 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, Türkiye 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 Türkiye. Findings in the annual review reports are considered feedback for improvement of the GHG inventory, and as such are included in inventory improvement plan of Türkiye.

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 Türkiye, some level of verification happens on an annual basis, as Türkiye estimates and reports CO_2 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 Tier 1 method.

In current situation, in Türkiye, 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 report their verified GHG emissions to the MoEUCC from 2017 onwards. GHG emissions from most of the IPCC categories are compared with those emissions reported under the MRV Regulation.

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. 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

Inventory preparation of Türkiye 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_2 emissions from energy are calculated by using Tier 2 (T2) approach except for biomass and other fossil fuels. CH_4 and N_2O emissions from all subcategories of energy excepting 1A1a category are calculated by using Tier 1 (T1). Technology specific EFs are used for CH_4 and N_2O emissions from 1A1a category. For the emissions from coke production, due to plant specific data are gathered, Tier 3 (T3) methodology are used.

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

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

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

In waste sector; for the CO_2 emissions from open burning of waste, which is only CO_2 emission source for waste sector is calculated by using T2 method. For CH_4 emissions from solid waste disposal and wastewater treatment and discharge, T2 methodology was used while T1 was used for the other non-key categories. For N_2O emissions, T1 methodology was used for all relevant categories.

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

Table 1.4 Summary for methods and emission factors used, 2020

Greenhouse Gas Source and Sink Categories	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
1. Energy	T1,T2,T3	CS,D,PS	T1,T2,T3	CS,D,PS	T1,T2,T3	CS,D,PS
A. Fuel combustion	T1,T2,T3	CS,D,PS	T1,T2,T3	CS,D,PS	T1,T2,T3	CS,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	CS,D	T1,T2	CS,D
4. Other sectors	T1,T2	CS,D	T1	D	T1	D
B. Fugitive emissions from fuels	T1	D	T1	D	T1	D
1. Solid fuels	NE	NE	T1	D	NE	NE
2. Oil and natural gas	T1	D	T1	D	T1	D
C. CO_2 transport and storage	T1	D				
2. Industrial processes and product use	T1,T2,T3	CS,D,PS	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,PS	T1	D	NE	NE
D. Non-energy products from fuels and solvent use	T1	D	NE	NE	NE	NE
E. Electronic industry						
F. Product uses as ODS substitutes						
G. Other product manufacture and use	NA	NA	NA	NA	NA	NA
H. Other	NA	NA	NA	NA	NA	NA
3. Agriculture	T1	D	T1,T2	CS,D	T1	D
A. Enteric fermentation			T1,T2	CS,D		
B. Manure management			T1	D	T1	D
C. Rice cultivation			T1	D		
D. Agricultural soils					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	NO	NO				
J. Other	NO	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry	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
5. Waste	T2	CS,D	T1,T2	CS,D	T1	D
A. Solid waste disposal	NA	NA	T2	CS,D		
B. Biological treatment of solid waste			T1	D	T1	D
C. Incineration and open burning of waste	T2	CS,D	T1	D	T1	D
D. Waste water treatment and discharge			T2	CS	T1	D

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

Table 1.5 Activity data sources for GHG 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) Directorate of Energy Efficiency and Environment 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, MAPEG - fuel consumption by transport mode MoTI/DG of State Airports Authority - air traffic data
Industrial Process and Product Use	2.A.1.Cement	Turkish Cement Manufacturer's Association- production data, Producers- production data and EF
	2.A.2. Lime	Turkish Lime Association- production data, Producers- production data and EF, Steel plants- production data
	2.A.3 Glass	Producers- glass production data and parameters
	2.A.4 Other process uses of carbonates	Turkish Ceramics Federation- production data, Producers- production and raw material consumption data, TurkStat- Industrial production and foreign trade statistics
	2.B.1. Ammonia Prod.	Producers- production and fuel consumption data BOTAS (Petroleum Pipeline Corporation)- Carbon content of natural gas
	2.B.2 Nitric Acid Prod.	Producers- production data and technology
	2.B.5. Carbide Prod.	TurkStat-Foreign trade statistics and industrial production statistics,
	2.B.7. Soda ash prod.	Producers- production and raw material data
	2.B.8. Petrochemical and carbon black prod.	Producers- production data
	2.C.2. Iron and Steel Prod.	Producers- production data and other parameters Turkish Steel Producers Association- production data
	2.C.2. Ferroalloy prod.	Producers- production data TurkStat- Industrial production statistics
	2.C.3 Aluminium Prod.	Producer- production data and other parameters
	2.C.5. Lead Prod.	TurkStat- production data
	2.C.6. Zinc Prod.	Producers- production data
	2.D.1. Lubricant Use	MENR- consumption data
	2.D.2. Paraffin wax use	MENR- consumption data
	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.)

Sector	Category	Activity data source
Agriculture	Agriculture – 3	TurkStat - Livestock population Crop production data Waste disposal and treatment statistics General Directorate of Meteorology - Temperature data MoAF- Inorganic N Fertilizers application data, urea application data
Land Use, Land Use Change and Forestry	LULUCF - 4	MoAF (General Directorate of Forestry) - Landsat Satellite Images Copernicus HRL for Forest (Sentinel) The ENVANIS (Inventory Statistical System for Forests) The annual commercial cutting and fuel wood data The annual forest fire information The annual illegal cutting and wood gathering information MoAF (General Directorate of Agricultural Reform) - Landsat Satellite Images 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 estimations and projections 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 1990-2020 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 2020.

Table 1.6 Key categories for GHG inventory, 2020

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_2	X	X	X	X
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO_2	X	X	X	X
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO_2		X	X	X
1.A.3.b Road Transportation	CO_2	X	X	X	X
1.A.4 Other Sectors - Liquid Fuels	CO_2	X	X	X	X
1.A.4 Other Sectors - Solid Fuels	CO_2	X	X	X	X
1.A.4 Other Sectors - Gaseous Fuels	CO_2	X	X	X	X
1.A.4 Other Sectors - Biomass	CO_2		X	X	X
1.B.1 Fugitive emissions from Solid Fuels	CH_4	X	X	X	X
1.B.2.b Fugitive emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4		X	X	X
2.A.1 Cement Production	CO_2	X	X	X	X
2.A.2 Lime Production	CO_2	X	X	X	X
2.A.4 Other Process Uses of Carbonates	CO_2	X	X	X	X
2.C.1 Iron and Steel Production	CO_2	X	X	X	X
2.C.3 Aluminium Production	F-gases		X	X	
2.F.6 Other Applications	F-gases	X	X	X	X
3.A Enteric Fermentation	CH_4	X	X	X	X
3.B Manure Management	CH_4	X	X	X	X
3.B Manure Management	N_2O	X	X	X	X
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	X	X	X	X
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	X	X	X	X
4.A.1 Forest Land Remaining Forest Land	CO_2	X	X		X
4.G Harvested Wood Products	CO_2	X	X		X
5.A Solid Waste Disposal	CH_4	X	X	X	X
5.D Wastewater Treatment and Discharge	CH_4	X	X	X	X
5.D Wastewater Treatment and Discharge	N_2O		X		X

Note: L: Level assessment; T: Trend assessment

Based on the results of the key category analysis, it is tried to increase the Tiers in emissions/removals estimation. However due to resource restrictions, Tier 1 approaches have to be used for some key categories, such as CH_4 emissions from other sectors, solid fuels and oil and gas systems in energy sectors, CH_4 emissions from manure management, N_2O emissions from agricultural soils and wastewater treatment and discharge. Efforts to increase the tiers for all key categories is continuing.

1.6. General Uncertainty Evaluation

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_2, CH_4, N_2O, HFCs, PFCs and SF_6) gases,
- The uncertainties for industrial processes data are estimated by TurkStat,
- The uncertainties of F-gases data are estimated by MoEUCC,
- 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 MoAF.

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 10.4%, and 6.0% 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 Türkiye.

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

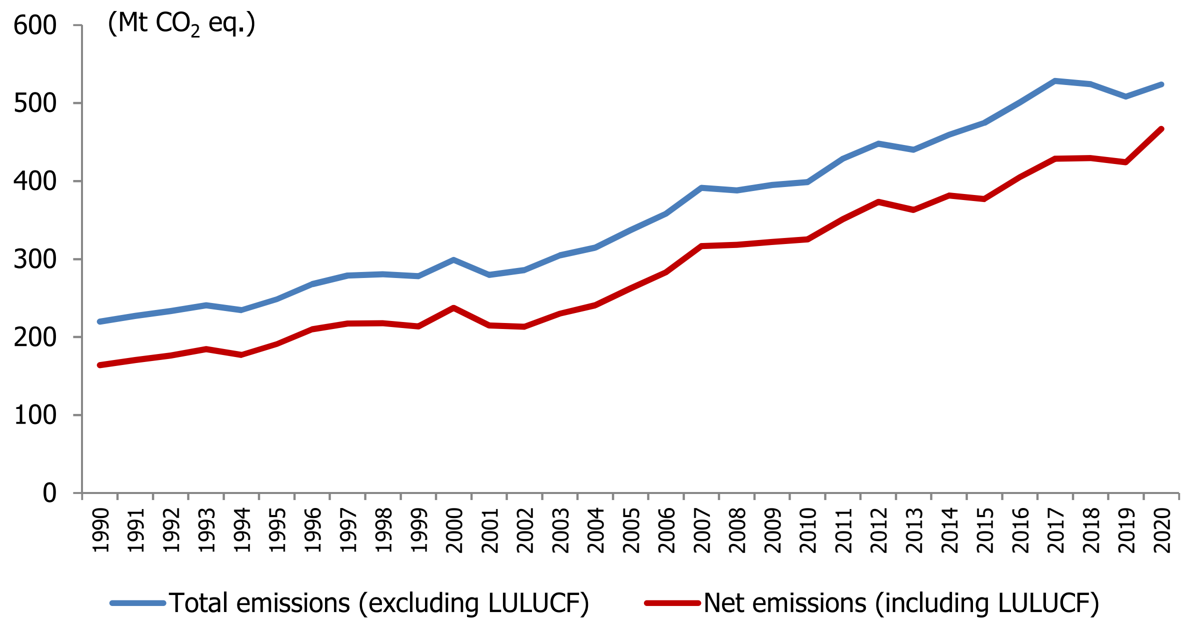
2.1. Emission Trends for Aggregated Greenhouse Gas Emissions

Total GHG emissions, excluding the LULUCF sector, were 523.9 Mt CO_2 eq. in 2020. This represents an increase of 304.2 Mt CO_2 eq. (138.4%) on total emissions in 1990 and an increase of 15.8 Mt CO_2 eq. (3.1%) in 2019.

Net GHG emissions, including the LULUCF sector, were 466.9 Mt CO_2 eq. in 2020. This represents an increase of 303 Mt CO_2 eq. (184.8%) on net emissions in 1990 and an increase of 42.9 Mt CO_2 eq. (10.1%) in 2019.

Figure 2.1 presents total and net GHG emissions from 1990 to 2020.

Figure 2.1 Emission trend for aggregated GHG emissions, 1990-2020



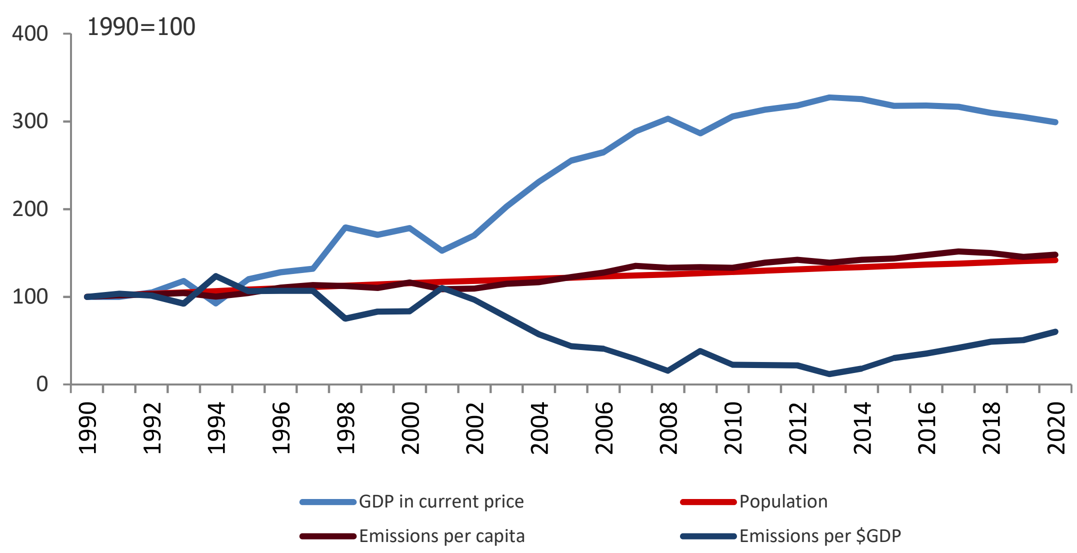
There is a positive trend in the total emissions over the period 1990-2020. However, economic recessions had directly caused reductions in the total GHG emissions in 1994, 1999, 2001 and 2008. In these years, total emissions are decreased by 2.5%, 0.9%, 6.4% and 0.9% as compared to the previous year's emissions respectively. Although there is no economic recession, total emissions are slightly decreased by 1.8% in 2013, 0.8% in 2018 and 3.0% in 2019.

The fluctuations in the emission trends are mainly due to the trends in economic activities. Therefore, GDP can be thought as the main driver of the GHG emissions in Türkiye. It has nearly the same pattern as total GHG emissions for the period 1990-2020. It reached 717 billion USD in 2020 from 149 billion USD in 1990. While the Real GDP figures of the World Bank until 2019 were used for comparison, the official GDP ($) figures of TurkStat started to be used in 2020.

Population data is another driver of the emission trends in national inventories. The mid-year population of Türkiye increased about 51.3% for the period 1990-2020. While it was 55.1 million in 1990, it reached 83.4 million in 2020. Accordingly, CO_2 eq. emissions per capita are 6.3 t in 2020, while it was 4.0 t in 1990.

Figure 2.2 shows trends on various statistics related to Turkish greenhouse gas emissions normalized to 1990 as a baseline year. These values represent the relative change (in comparison with previous year for every year) in each statistic since 1990. The direction of the emissions per $ of GDP trend started to change after 2002, when GDP (in current price) began to peak, while population and emissions per capita continued to increase slightly.

Figure 2.2 Trends in emissions per capita and dollar of GDP relative to 1990



Source: https://data.tuik.gov.tr/Bulten/Index?p=Yillik-Gayrisafi-Yurt-Ici-Hasila-2020-37184

Table 2.1 gives summary data for GHG emissions for some selected years between 1990 and 2020.

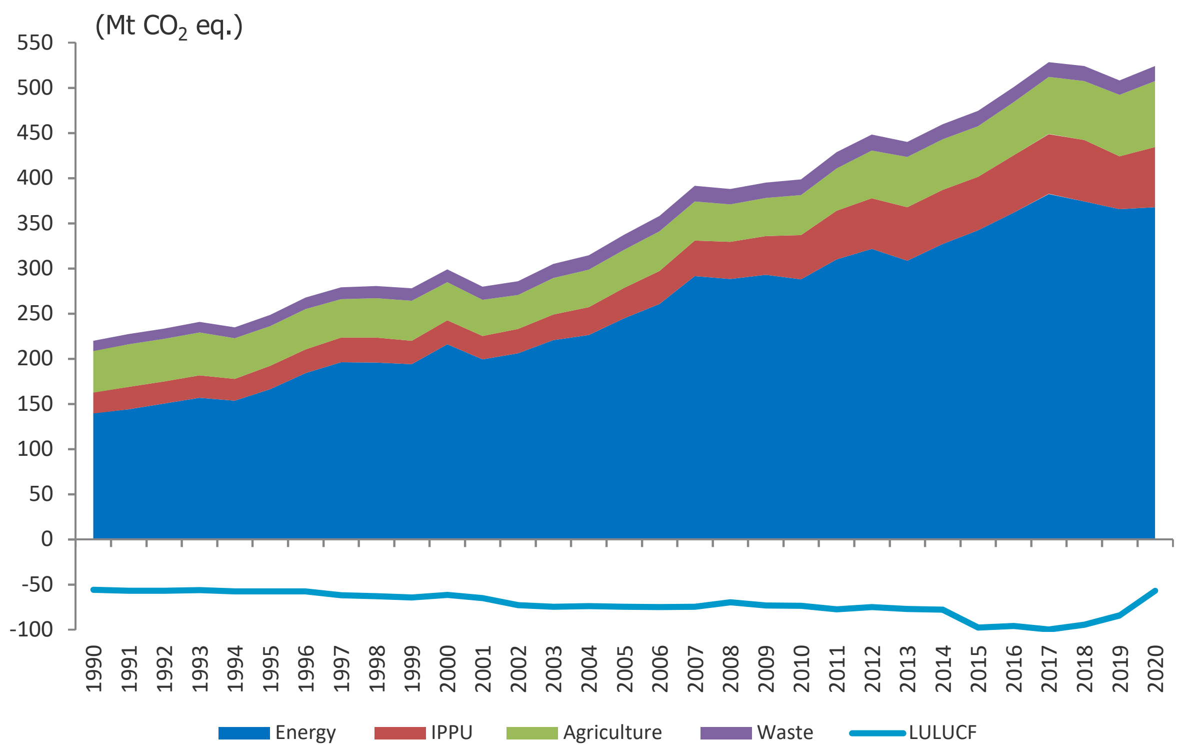
Table 2.1 Aggregated GHG emissions by sectors

($Mt\ CO_2$ eq.)

Sector	**1990**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Total (exc. LULUCF)	219.72	299.01	336.99	398.68	474.47	500.75	528.31	524.04	508.08	523.90
Energy	139.60	216.02	244.45	287.84	341.98	361.69	382.39	374.14	365.41	367.58
IPPU	22.98	26.31	33.70	48.98	59.21	63.45	66.41	67.97	58.58	66.76
Agriculture	46.05	42.33	42.44	44.41	56.13	58.89	63.26	65.34	68.02	73.16
Waste	11.08	14.34	16.40	17.45	17.14	16.72	16.25	16.59	16.07	16.40
LULUCF	-55.74	-61.57	-74.54	-73.62	-97.54	-95.97	-99.83	-94.41	-84.03	-56.95
Comp. to 1990 (%)	-	36.09	53.37	81.45	115.94	127.90	140.45	138.50	131.24	138.44

In overall 2020 emissions excluding LULUCF, the energy sector had the largest portion with 70.2%. The energy sector was followed by the sectors of agriculture with 14%, IPPU with 12.7% and waste with 3.1%. In Figure 2.3 fluctuations of whole sectors can easily be seen for the entire period starting with 1990.

Figure 2.3 GHG Emissions and sinks by sector, 1990-2020



2.2. Emission Trends by Gas

Total CO_2 emissions (excluding LULUCF) increased by 172.6% from 1990 to 2020. CH_4 emissions (excluding LULUCF) increased by 50.6% and N_2O emissions (excluding LULUCF) increased by 62.2%.

Total CO_2 emissions (including LULUCF) increased by 271.8% from 1990 to 2019. There are no significant changes in other GHGs by taking into account the LULUCF sector. CH_4 emissions (including LULUCF) increased by 50.6% and N_2O emissions (including LULUCF) increased by 62.6%.

As shown in Figure 2.4, the CO_2 emissions show a general increasing trend, while N_2O and CH_4 emissions are not changing considerably.

Figure 2.4 Emission trend of main GHGs, 1990-2020

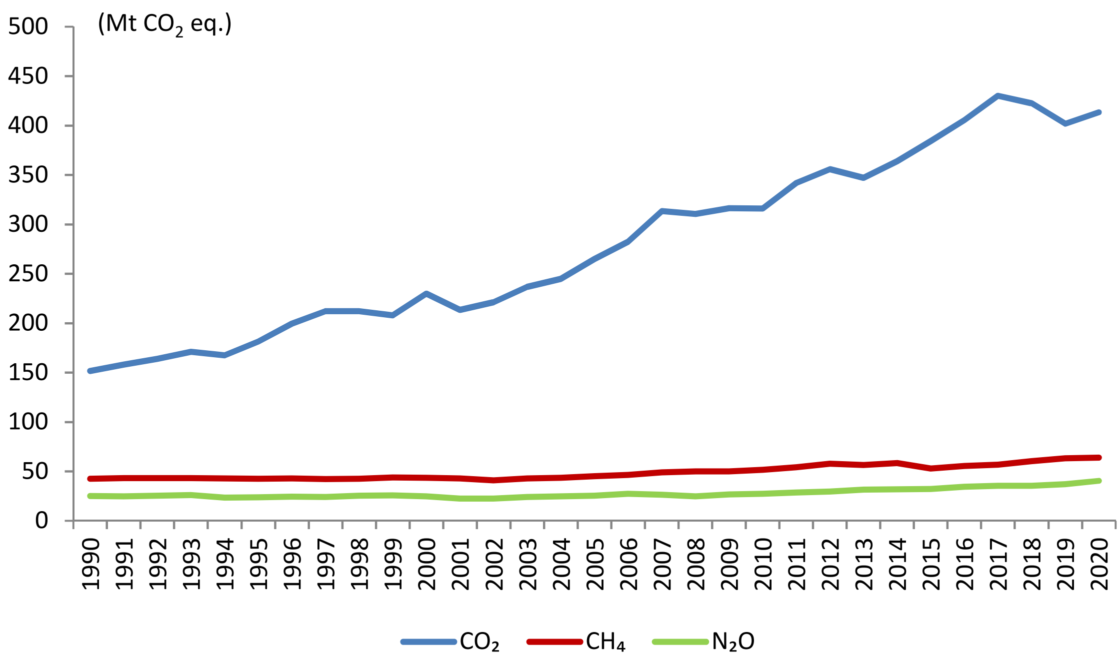


Table 2.2 gives summary data for GHG emissions by gas for some selected years between 1990 and 2020.

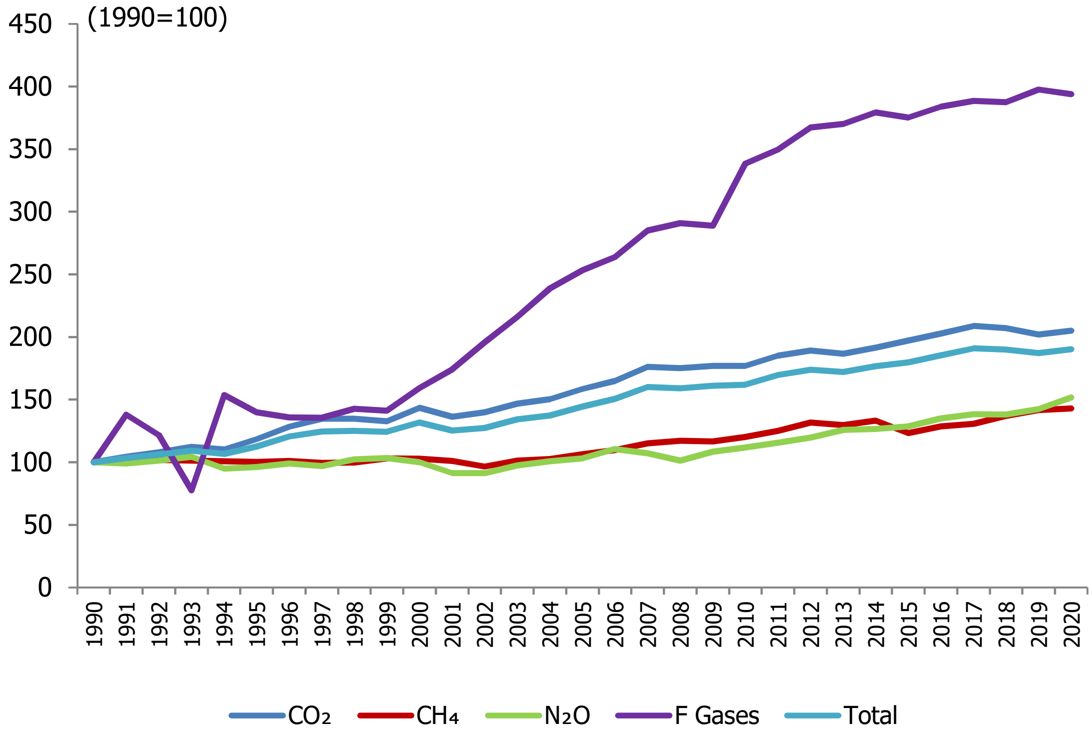
Table 2.2 Aggregated GHG emissions excluding LULUCF

($Mt\ CO_2$ eq.)

Gas	1990	2000	2005	2010	2015	2016	2017	2018	2019	2020
Total	219.72	299.01	336.99	398.68	474.47	500.75	528.31	524.04	508.08	523.9
CO_2	151.66	229.86	264.77	316.04	384.33	405.30	430.22	422.57	401.72	413.43
CH_4	42.48	43.66	45.15	51.61	52.78	55.56	56.78	60.35	63.14	63.99
N_2O	24.95	24.77	25.34	27.45	32.32	34.41	35.59	35.46	36.98	40.47
HFCs	NO	0.12	1.15	3.05	4.80	5.26	5.53	5.50	6.06	5.85
PFCs	0.63	0.60	0.56	0.46	0.16	0.14	0.07	0.04	0.06	0.04
SF_6	NO	0.01	0.02	0.07	0.08	0.08	0.12	0.13	0.12	0.12

Figure 2.5 shows trends in the index for each year compared to previous year by gas for the 1990-2020 period. 1990 is assumed as "100" for indexing. All gases are showing an increasing trend compared to 1990 and also to previous years in general. The sharpest trend belongs to F-gases since they increased by 861% in proportion to 1990.

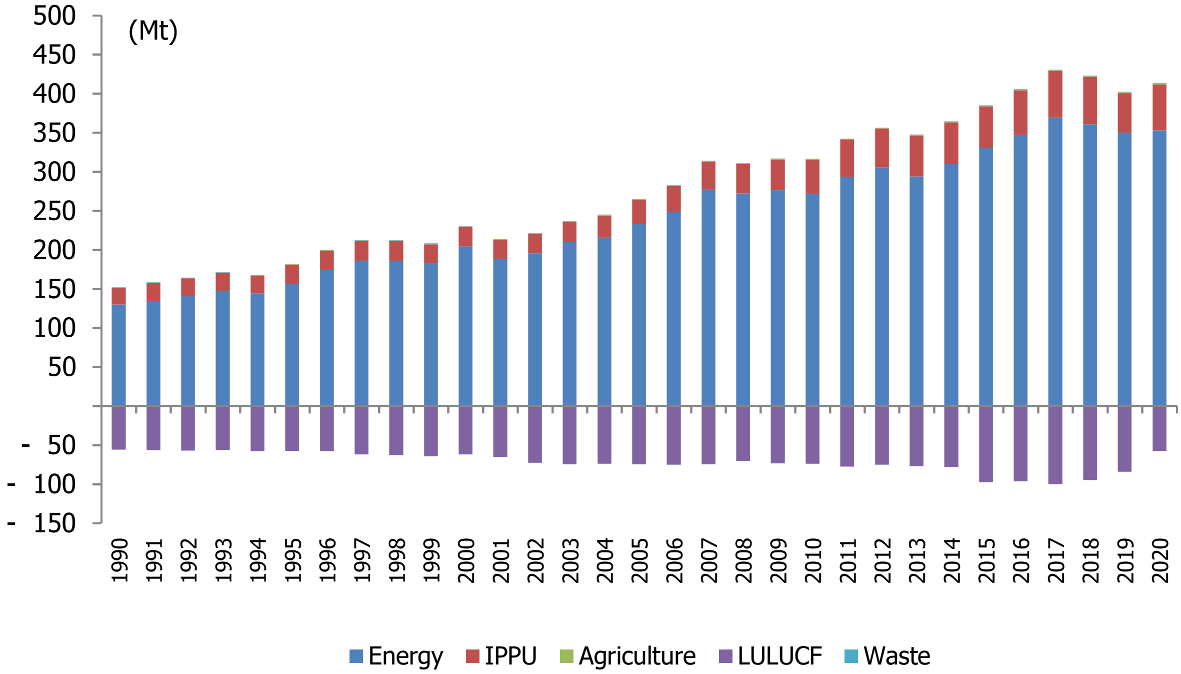
Figure 2.5 Trends in emissions by gas relative to 1990



Carbon Dioxide (CO_2)

In 2020, CO_2 emissions are 413.4 Mt (excluding LULUCF), 2.9% above the 2019 level and 172.6% above the 1990 level. Figure 2.6 illustrates the trend in CO_2 emissions. It is seen that CO_2 emissions are dominated by the energy sector which is the main driver for the rising trend in emissions. This situation is caused by the growing industrial sector and population in Türkiye. In 2020 excluding the LULUCF, the energy sector is responsible for 85.4% of the total CO_2 emissions while IPPU is responsible for 14.2%. The Agriculture and waste sectors do not cause a significant amount of CO_2 emission.

Figure 2.6 CO_2 emissions by sector, 1990-2020

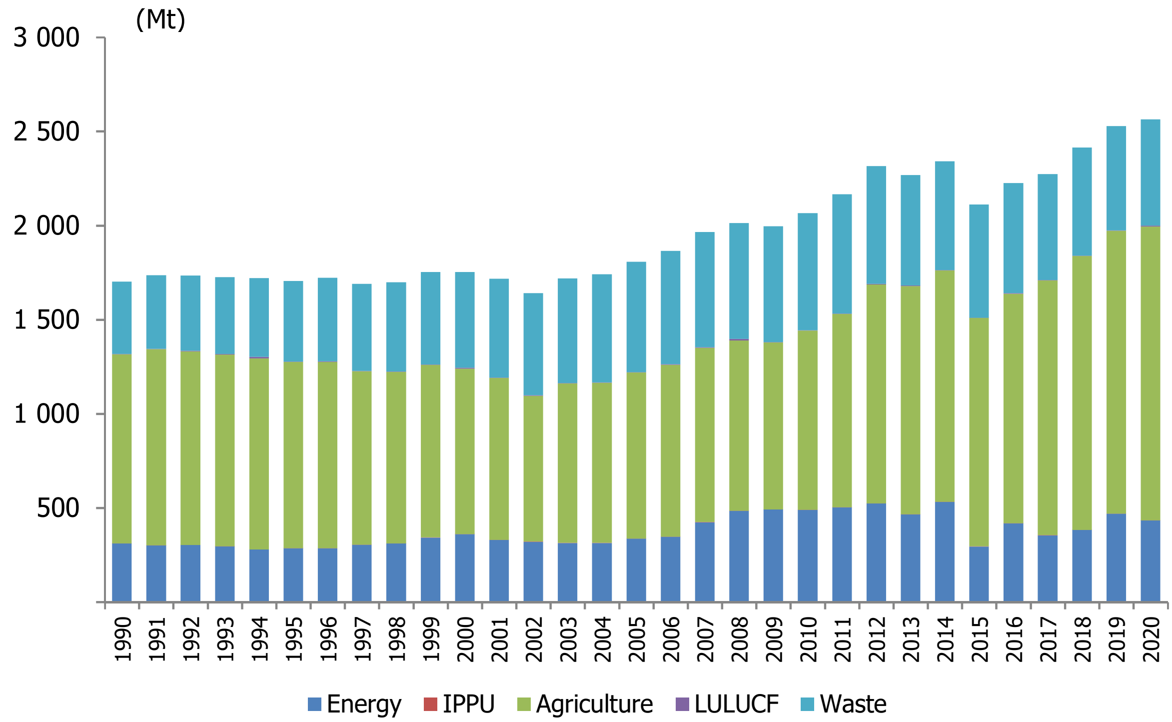


Methane (CH_4)

The trend in emissions of CH_4 is broken down by source in Figure 2.7, CH_4 is the second most significant GHG after CO_2 in Türkiye since 1990. Emissions of CH_4 have increased by 50.6% since the base year 1990 and have increased by 1.4% compared to 2019. In 2020, CH_4 emissions were 2 560 kt excluding the LULUCF.

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

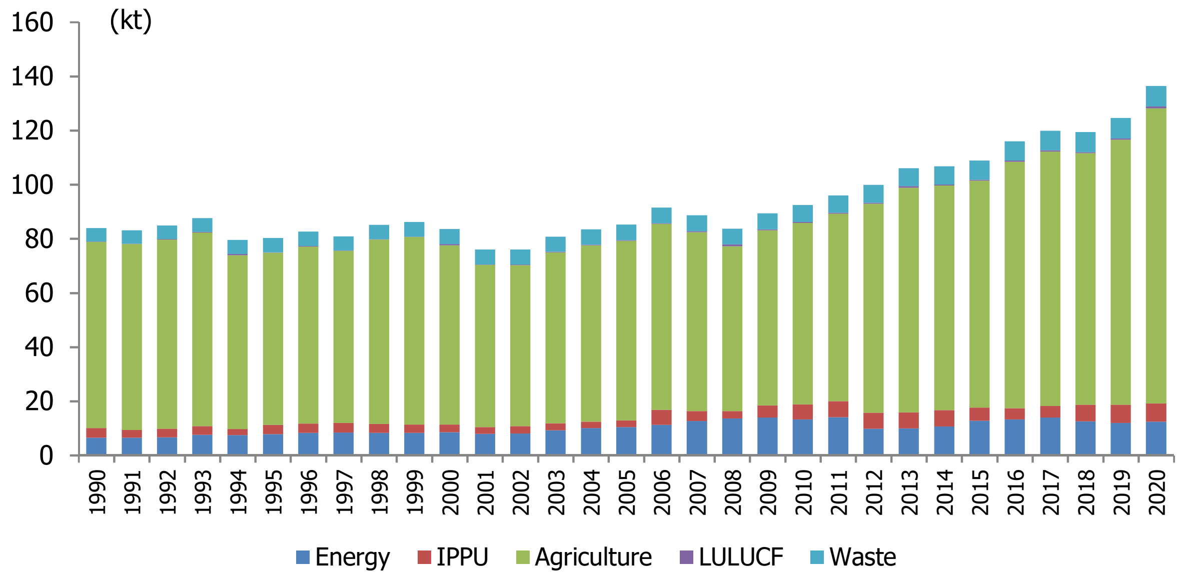
Figure 2.7 CH_4 emissions by sector, 1990-2020



Nitrous Oxide (N_2O)

In 2020, N_2O emissions are 136 kt without LULUCF and it slightly increased from the level of 2019 (11.7 kt) but 62.2% above the 1990 level. As it is seen from Figure 2.8, the agriculture sector is the main contributor of N_2O emissions in all the years and the share is 80.3% in 2020. The waste sector is responsible for 5.6% and the energy sector is responsible for 9.1% of all N_2O emissions. IPPU has a minor share of the N_2O emissions by 5%.

Figure 2.8 N_2O emissions by sector, 1990-2020



Fluorinated Gases (HFCs, PFCs, SF_6)

The F-gases are only caused by the IPPU sector. In 2020, 6 007 kt CO_2 eq. of F-gases released to the atmosphere. It is seen from Table 2.3 that total F-gas emissions increased by 861% since 1990. The main contributor to total F-gas emissions is HFCs emissions and it is mainly due to the increasing demand of refrigerant and air conditioning sector in Türkiye.

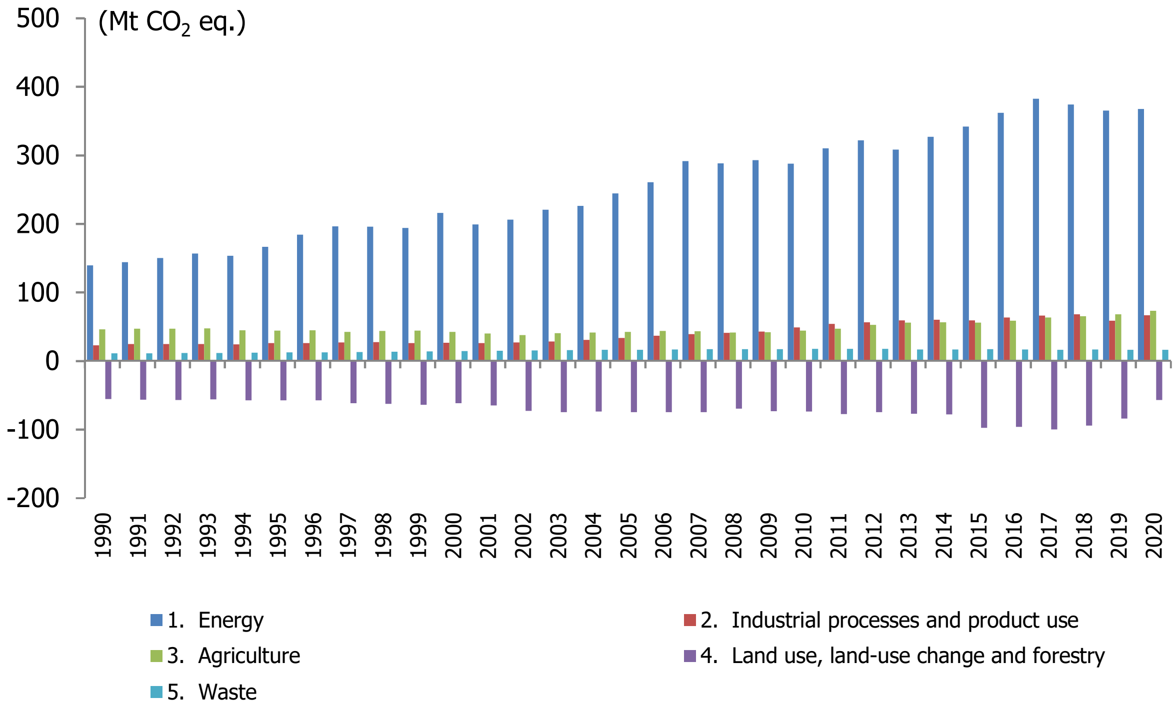
Table 2.3 Fluorinated gases emissions by sector, 1990-2020

(kt CO_2 eq.)

Year	HFCs	PFCs	SF_6
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	65.48
2011	3 432.64	480.36	67.37
2012	4 256.83	359.06	68.58
2013	4 470.24	270.60	69.02
2014	4 927.46	255.42	74.88
2015	4 802.87	158.99	81.83
2016	5 262.92	140.67	78.61
2017	5 534.60	73.11	118.33
2018	5 502.39	36.62	128.39
2019	6 064.07	62.18	115.71
2020	5 853.16	37.83	115.78

2.3. Emission Trends by Sector

Figure 2.9 GHG emission trend by sectors, 1990-2020



1990-2020: All sectors have an increasing trend from 1990 to 2020 including energy (163%), IPPU (190%), waste (48%), LULUCF (2.2%) and agriculture (59%).

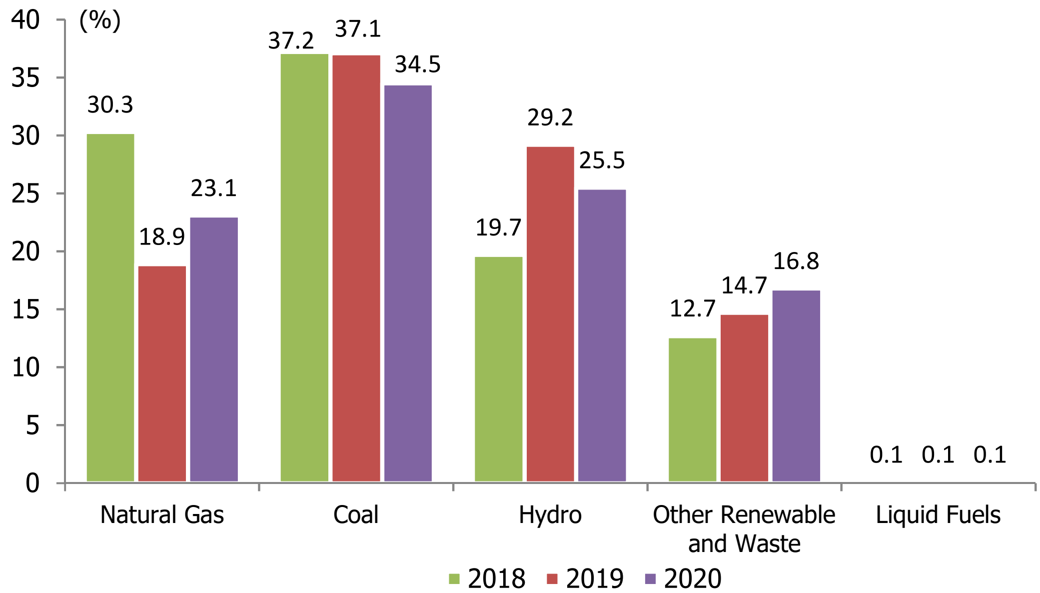
The main reasons for the increase for all sectors are population growth, a growing economy and an increase in energy demand.

The main reasons for 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. the year 2008; 29 749 ha forest area burned), deforestation, conversions to wetlands (flooded land) and settlements.

2019-2020: There are increasing trends in the annual change almost for each sector from 2019 to 2020. The sectors having increasing trends are energy (0.6%), IPPU (14%), agriculture (7.5%) and waste (2.1%), the decreasing trend is LULUCF (-32.2%)

In the energy sector; manufacturing industries and construction and other sectors show 10.3% and 8.6% increase respectively while the transport sector 2.12% and energy industries show 4.4% decrease in 2020. Figure 2.10 shows electricity production from different energy sources for the period, 2018-2020.

Figure 2.10 Electricity generation and shares by energy resources, 2018-2020



The increase in emissions from the 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 a contribution of sectors to the net GHG emissions by sectors for some selected years between 1990 and 2020, Table 2.5 shows the same shares for the GHG emissions without LULUCF.

Table 2.4 Contribution of sectors to the net GHG emissions

(%)

Sectors	1990	2000	2005	2010	2015	2016	2017	2018	2019	2020
Energy	85.13	90.98	93.14	88.55	90.73	89.35	89.24	87.09	86.17	78.72
IPPU	14.02	11.08	12.84	15.07	15.71	15.68	15.50	15.82	13.81	14.30
Agriculture	28.08	17.83	16.17	13.66	14.89	14.55	14.76	15.21	16.04	15.67
Waste	6.76	6.04	6.25	5.37	4.55	4.13	3.79	3.86	3.79	3.51
LULUCF	-33.99	-25.93	-28.40	-22.65	-25.88	-23.71	-23.30	-21.98	-19.82	-12.20

Table 2.5 Contribution of sectors to the GHG emissions without LULUCF

(%)

Sectors	1990	2000	2005	2010	2015	2016	2017	2018	2019	2020
Energy	63.54	72.25	72.54	72.20	72.08	72.23	72.38	71.40	71.92	70.16
IPPU	10.46	8.80	10.00	12.29	12.48	12.67	12.57	12.97	11.53	12.74
Agriculture	20.96	14.16	12.59	11.14	11.83	11.76	11.97	12.47	13.39	13.96
Waste	5.04	4.80	4.87	4.38	3.61	3.34	3.08	3.17	3.16	3.13

Energy

As in most countries, the energy system in Türkiye is largely driven by fuel combustion, followed by fugitive emissions from fuels and then CO_2 transport and storage. In 2019, emissions from the energy sector are 70.2% of total emissions, excluding LULUCF. Emissions in CO_2 eq. from the energy sector are reported in Table 2.6 and shown in Figure 2.11.

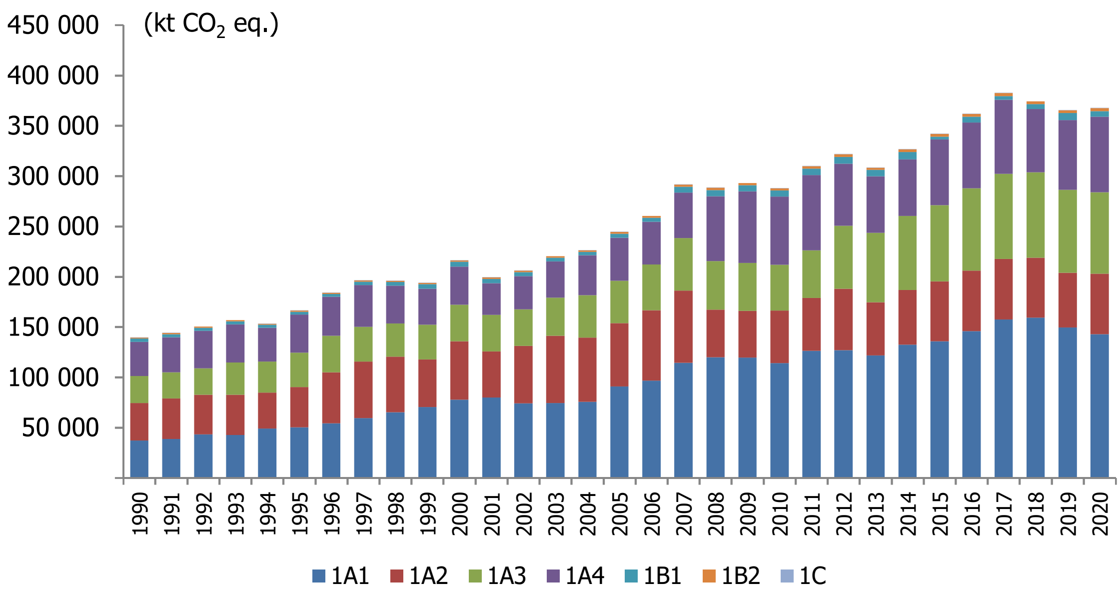
CO_2 emissions, 96% of the total energy sector emissions, showed an increase of 171.8% from 1990 to 2020. CH_4 emissions are just 2.9% of the total, increased by 39.7% in comparison with 1990. N_2O emissions, with a 1% contribution to total emissions of the energy sector, show an 89.7% increase in proportion to the year 1990.

Table 2.6 Total emissions from the energy sector by source

(kt CO_2 eq.)

	1990	2000	2005	2010	2015	2016	2017	2018	2019	2020
Total	139 602	216 025	244 446	287 840	341 981	361 686	382 389	374 145	365 410	367 577
1.A Fuel combustion	135 092	209 879	238 693	279 614	336 485	353 091	375 690	366 483	355 734	358 995
1.A.1 Energy industries	37 262	77 725	90 957	114 151	135 736	145 940	157 331	159 409	149 489	142 927
1.A.2 Manufacturing industries and construction	37 153	57 925	62 987	52 298	59 554	60 039	60 152	59 576	54 535	60 150
1.A.3 Transport	26 969	36 465	42 041	45 392	75 798	81 841	84 770	84 617	82 428	80 680
1.A.4 Other sectors	33 707	37 764	42 709	67 773	65 397	65 270	73 437	62 881	69 282	75 238
1.B Fugitive emissions from fuels	4 510	6 145	5 752	8 226	5 496	8 596	6 699	7 662	9 676	8 581
1.B.1 Solid fuels	3 598	4 836	3 941	6 151	2 733	5 896	3 681	4 885	6 770	5 558
1.B.2 Oil and natural gas	912	1 309	1 811	2 075	2 763	2 700	3 017	2 777	2 906	3 023
1.C CO_2 transport and storage	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13

Figure 2.11 Trend of total emissions from the energy sector, 1990-2020



GHG emissions of the energy sector, in CO_2 eq., show an increase of 163% from 1990 to 2020. Generally, an upward trend is noted from 1990 to 2020.

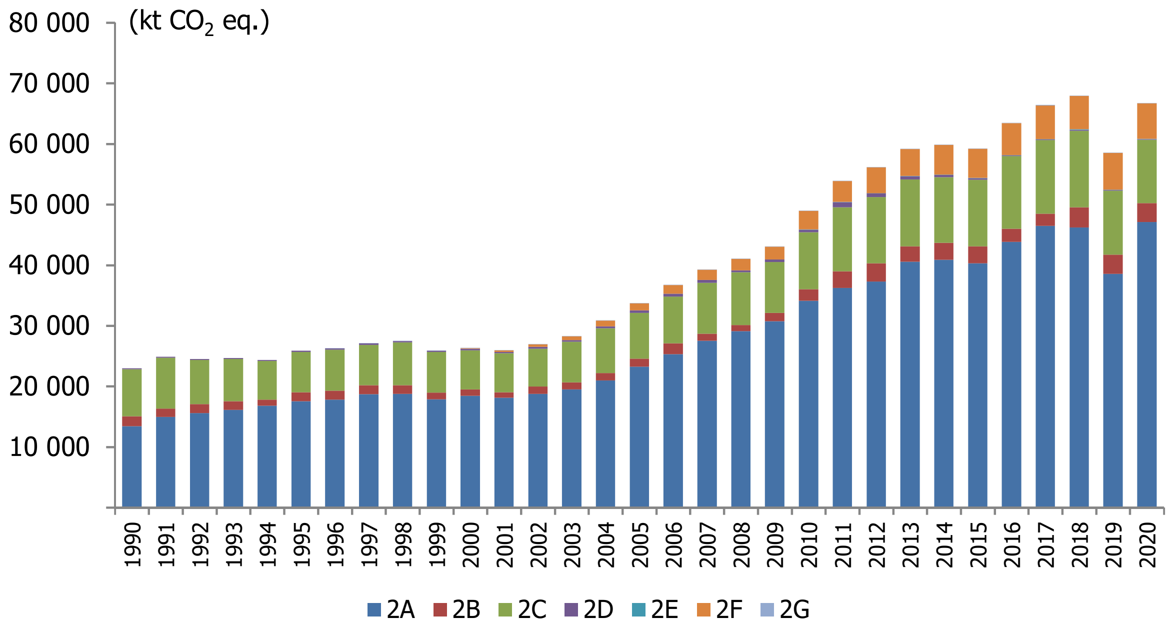
IPPU

Emissions from the industrial process and product use sector have a share of 12.7% of total emissions excluding LULUCF in 2020. CO_2 emissions are 88% of total IPPU emissions in 2020. N_2O and CH_4 have a minor impact on IPPU emissions and N_2O increased by 88.6% compared to 1990. Emissions by each subsector of IPPU are tabulated in Table 2.7 for the 1990-2020 period. Figure 2.12 shows the trend for the IPPU related emissions by cumulating its subsectors.

Table 2.7 Total emissions from the industrial process and product use sector by source (kt CO_2 eq.)

	1990	2000	2005	2010	2015	2016	2017	2018	2019	2020
Total	22 983	26 312	33 700	48 980	59 213	63 453	66 409	67 968	58 577	66 763
2.A Mineral industry	13 424	18 418	23 246	34 087	40 301	43 816	46 470	46 207	38 564	47 109
2.B Chemical industry	1 629	1 061	1 321	1 903	2 788	2 159	2 004	3 335	3 129	3 091
2.C Metal industry	7 748	6 427	7 523	9 439	10 973	11 990	12 130	12 589	10 567	10 460
2.D Non-energy products from fuels and solvent use	183	277	446	432	266	146	152	206	138	134
2.E Electronic industry	NO	NO	NO	42.23	42.23	42.23	45.36	57.11	58	59
2.F Product uses as ODS substitutes	NO	116	1 147	3 054	4 803	5 263	5 535	5 502	6 064	5 853
2.G Other product manufacture and use	NO	13	18	23	40	36	73	71	58	57

Figure 2.12 Trend of total emissions from IPPU sector, 1990-2020



IPPU related emissions increased by 190.5% from 1990 to 2020. Due to the growth of population and production especially for the recent decade, emissions from the IPPU sector are increased.

Agriculture

Enteric fermentation is by far the largest source of GHG emissions of agriculture in Türkiye since 1990. The agriculture sector includes emissions from enteric fermentation, manure management, rice cultivation, agricultural soils, field burning of agricultural residues and urea application. In 2020, the agriculture sector accounted for 14% of total emissions in Türkiye. Enteric fermentation and agricultural soils dominate the trends in this sector between 1990 and 2020 as seen in Table 2.8 and they have an increase of 54.6% and 58.2% compared to 1990 respectively.

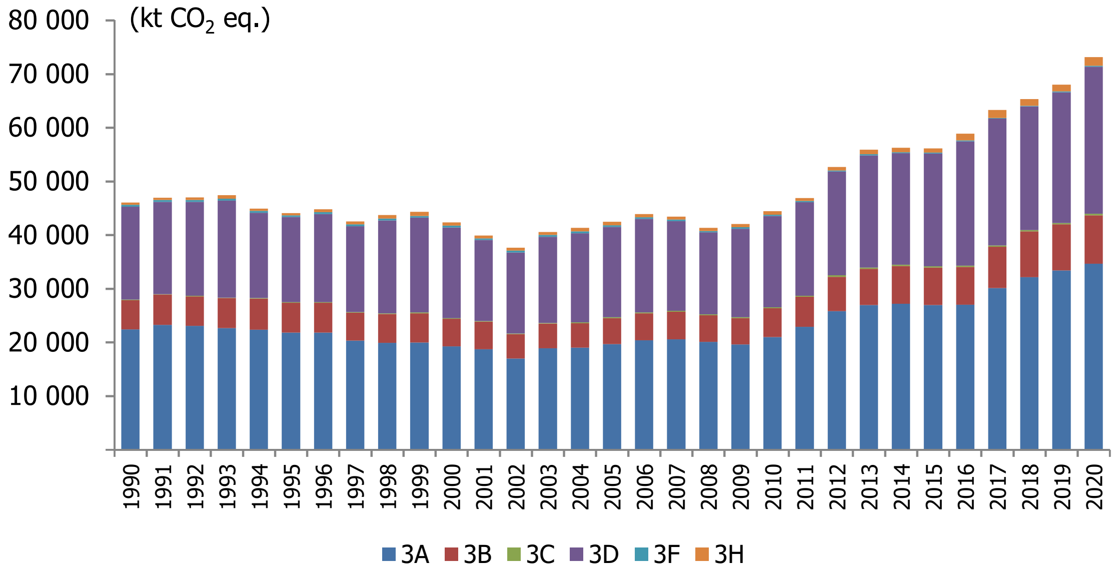
The most important portion in each gas is CH_4 with 53.3%, then comes N_2O with 44.4% share in the agriculture sector emissions. CO_2 has the lowest contribution with 2.3%.

Table 2.8 Total emissions from the agriculture sector by source

(kt CO_2 eq.)

	1990	2000	2005	2010	2015	2016	2017	2018	2019	2020
Total	46 054	42 332	42 439	44 409	56 133	58 894	63 262	65 338	68 023	73 155
3.A Enteric fermentation	22 397	19 234	19 680	20 946	26 947	26 984	30 110	32 136	33 368	34 615
3.B Manure management	5 436	5 142	4 781	5 391	6 956	7 060	7 697	8 508	8 597	9 060
3.C Rice cultivation	100	128	183	202	240	243	234	252	263	262
3.D Agricultural soils	17 314	16 870	16 880	17 006	21 006	23 147	23 607	23 022	24 342	27 389
3.F Field burning of agricultural residues	347	340	302	219	174	164	165	163	165	173
3.H Urea application	460	617	613	645	811	1 295	1 450	1 257	1 288	1 657

Figure 2.13 Trend of total emissions from agriculture sector, 1990-2020



LULUCF

GHG emissions of the 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.

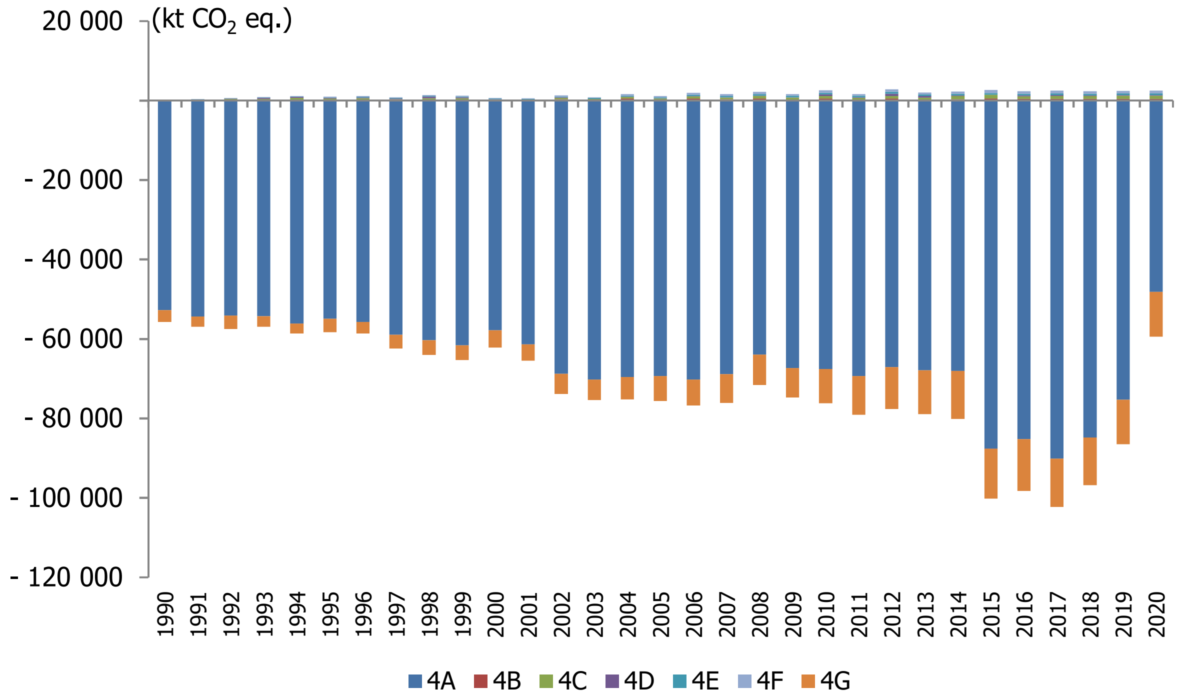
In 2020, total CO_2 eq. emissions and removals of the LULUCF sector have decreased by 32.2% compared to 2019. Table 2.9 reports emissions and removals from the LULUCF sector by source.

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

(kt CO_2 eq.)

	1990	2000	2005	2010	2015	2016	2017	2018	2019	2020
Total	-55 736	-61 566	-74 535	-73 620	-97 538	-95 972	-99 830	-94 413	-84 032	-56 948
4.A Forest land	-52 830	-57 890	-69 356	-67 614	-87 669	-85 233	-90 195	-84 849	-75 311	-48 220
4.B Cropland	0.69	38	207	453	457	344	368	352	381	395
4.C Grassland	0.03	97	259	636	983	656	705	708	768	777
4.D Wetlands	0.01	176	28	413	- 20	271	288	222	188	189
4.E Settlements	NO,IE	145	273	426	419	406	413	407	413	419
4.F Other land	NO,NE,IE	187	310	601	764	617	653	650	671	696
4.G Harvested wood products	-2 907	-4 337	-6 285	-8 587	-12 541	-13 102	-12 133	-11 973	-11 215	-11 281

Figure 2.14 Trend of total emissions from the LULUCF sector, 1990-2020



LULUCF emissions or removals, in CO_2 equivalent, are variable over the reporting period 1990-2020 as seen in Figure 2.14. 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, 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 the inventory however it is reported under the energy sector. The waste sector GHG emissions are tabulated in Table 2.10. Total waste emissions for the year 2020 are 3.1% of total GHG emissions (without LULUCF). Considering emissions by gas, the most important GHG is CH_4 which accounts for 86.1% of the total and shows an increase of 47.2% from 1990 to 2020. N_2O levels have increased by 55.9% whereas CO_2 decreased by 86.4% from 1990 to 2020; these gases account for 13.9% and 0.02% share in the waste sector.

Table 2.10 Total emissions from the waste sector by source

(kt CO_2 eq.)

	1990	2000	2005	2010	2015	2016	2017	2018	2019	2020
Total	11 081	14 341	16 401	17 446	17 142	16 720	16 251	16 588	16 068	16 402
5.A Solid waste disposal	6 730	9 582	11 562	12 564	12 578	12 113	11 524	11 578	11 002	11 237
5.B Biological treatment of solid waste	16	17	28	30	23	24	23	20	22	21
5.C Incineration and open burning of waste	105	87	47	37	2	4	3	2	5	7
5.D Wastewater treatment and discharge	4 230	4 656	4 764	4 815	4 539	4 579	4 701	4 987	5 039	5 138

Figure 2.15 Trend of total emissions from the waste sector, 1990-2020

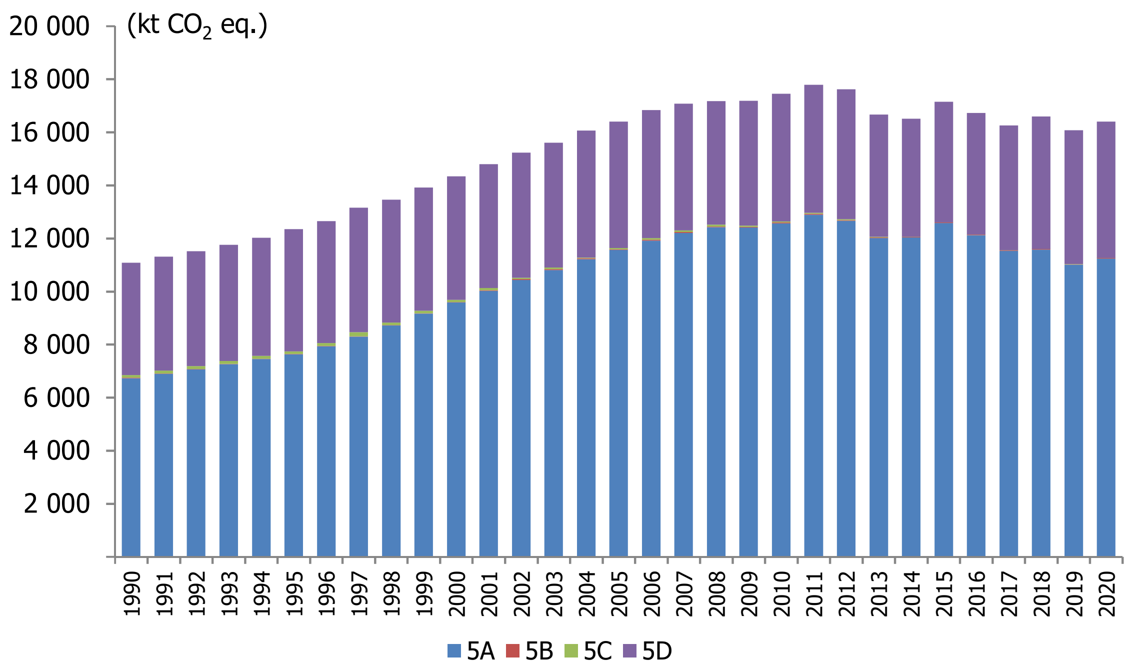


Figure 2.15 shows trends in the waste sector between 1990-2020. The trend is mainly driven by solid waste disposal with 68.5% of the emissions were from, followed by wastewater treatment and discharge 31.3% from, 0.12% from biological treatment of solid waste and 0.04% from open burning of waste. Total emissions, in CO_2 equivalent, increased by 2.1% from 2019 to 2020.

2.4. Emission Trends for Indirect Greenhouse Gases

Emission trends of NO_X, CO, NMVOC and SO_2 from 1990 to 2020 are given in Table 2.11.

Table 2.11 Total emissions for indirect greenhouse gases, 1990-2020

(kt)

Gas	1990	2000	2005	2010	2015	2016	2017	2018	2019	2020
NO_X	253	1490	1297	998	857	870	855	860	888	866
CO	2 040	8 762	3 745	3 454	2 522	2 332	2 164	1 643	1 762	1 930
NMVOC	896	1 607	1 110	1 104	1 110	1 087	1 114	1 092	1 118	1 161
SO_2	1 683	2 237	2 000	2 554	1 939	2 244	2 351	2 515	2 521	2 166
NH_3	85	97	84	62	59	45	46	41	43	46

1990-2020: While three indirect gases have an increasing trend from 1990 to 2020 including NO_X (242.7%), SO_2 (28.7%) and NMVOC (29.5%), two gases have a decreasing trend including CO (5.4%) and NH_3 (45.5%).

2019-2020: There are both increasing and decreasing trends in the annual change for each gas from 2019 to 2020. The gases having increasing trends are CO (9.5%), NMVOC (3.8%) and NH_3 (9.1%). The gases that have decreasing trends are SO_2 (14.1%) and NO_X (2.5%).

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_2 transportation and storage (1.C).

Energy sector is the major source of Turkish anthropogenic GHG emissions. In overall 2020 GHG emissions (excluding LULUCF), the energy sector had the largest portion with 70%.

Energy sector CO_2 emissions constituted 85.4% of total CO_2 emissions in 2020. The non-CO_2 emissions from energy-related activities represented rather small portion of the total national emissions. CH_4 emissions are 16.9% of total national CH_4 emissions and N_2O emissions are 9.1% of total N_2O emissions in 2020.

Total emissions from the energy sector for 2020 were estimated to be 368 Mt CO_2 eq. (Table 3.1) Energy industries were the main contributor, accounting for 38.9% of emissions from the energy sector. It is followed by transport sector with 20.5%, other sector with 21.9% and manufacturing industries with 16.4% (Table 3.2).

Energy sector GHG emissions increased by 163.3% between 1990 and 2020 whereas annual emissions from 2019 to 2020 decreased by 0.6% (2 167 Kt CO_2 eq.).

Table 3.1 Energy sector emissions by gas, 1990-2020

(kt)

Year	CO_2	CH_4	N_2O	CO_2 eq.
1990	129 891	310	6.5	139 602
1991	134 517	301	6.5	143 991
1992	140 772	303	6.7	150 322
1993	147 151	296	7.6	156 800
1994	144 099	279	7.5	153 317
1995	156 801	286	7.8	166 281
1996	174 372	286	8.3	183 994
1997	186 002	304	8.4	196 127
1998	185 560	311	8.3	195 804
1999	182 742	343	8.3	193 781
2000	204 494	360	8.5	216 025
2001	188 587	330	7.9	199 186
2002	195 541	320	8.0	205 941
2003	209 829	314	9.3	220 432
2004	215 444	313	10.1	226 278
2005	232 907	337	10.5	244 446
2006	248 483	347	11.2	260 497
2007	277 130	424	12.7	291 504
2008	272 156	484	13.6	288 319
2009	276 415	491	14.0	292 872
2010	271 645	490	13.3	287 840
2011	293 135	503	14.1	309 922
2012	305 544	524	9.8	321 568
2013	293 760	465	9.9	308 339
2014	310 274	533	10.6	326 754
2015	330 815	295	12.7	341 981
2016	347 273	419	13.3	361 686
2017	369 365	355	14.0	382 389
2018	360 850	382	12.6	374 145
2019	350 127	469	12.0	365 410
2020	353 038	434	12.4	367 577

Table 3.2 Energy sector GHG emissions, 1990-2020

(kt CO_2 eq.)

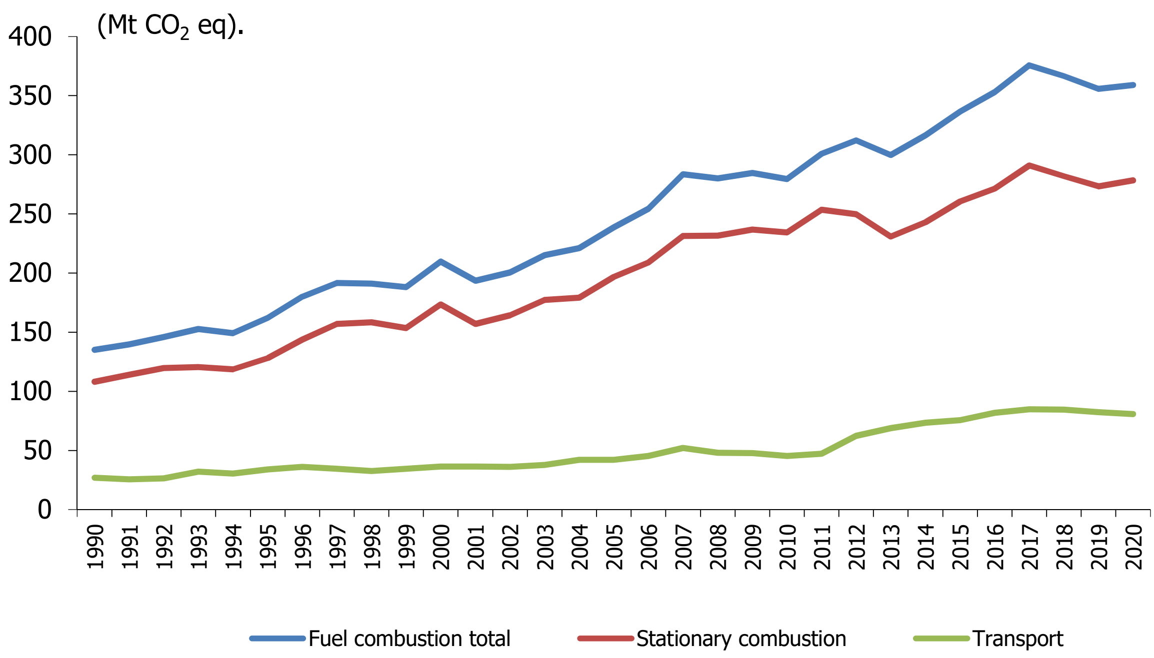
		Fuel combustion					Fugitive emissions from fuels			
Year	Energy	Fuel combustion total	Energy industries	Manufacturing industries and construction	Transport	Other sectors	Total fugitive emissions	Solid fuels	Oil and natural gas	CO_2 transport and storage
1990	139 602	135 092	37 262	37 153	26 969	33 707	4 510	3 598	912	0.13
1991	143 991	139 691	38 808	40 324	25 673	34 887	4 300	3 219	1 080	0.13
1992	150 322	146 078	43 321	39 313	26 366	37 079	4 245	3 177	1 067	0.13
1993	156 800	152 667	42 733	39 978	32 143	37 812	4 133	3 114	1 020	0.13
1994	153 317	149 318	49 040	35 863	30 640	33 775	3 999	2 998	1 001	0.13
1995	166 281	162 258	50 440	39 983	34 113	37 722	4 023	2 985	1 038	0.13
1996	183 994	179 934	54 425	50 573	36 271	38 664	4 060	2 967	1 092	0.13
1997	196 127	191 762	59 544	56 014	34 690	41 515	4 364	3 187	1 177	0.13
1998	195 804	191 059	65 115	55 459	32 782	37 704	4 745	3 565	1 180	0.13
1999	193 781	188 060	70 339	47 351	34 617	35 753	5 720	4 481	1 239	0.13
2000	216 025	209 879	77 725	57 925	36 465	37 764	6 145	4 836	1 309	0.13
2001	199 186	193 483	79 986	45 645	36 455	31 397	5 702	4 387	1 315	0.13
2002	205 941	200 523	74 258	57 102	36 234	32 930	5 418	4 059	1 358	0.13
2003	220 432	215 242	74 516	66 668	37 825	36 232	5 190	3 664	1 526	0.13
2004	226 278	221 143	75 695	63 839	42 048	39 561	5 134	3 568	1 566	0.13
2005	244 446	238 693	90 957	62 987	42 041	42 709	5 752	3 941	1 811	0.13
2006	260 497	254 411	96 686	70 064	45 424	42 236	6 086	4 119	1 966	0.13
2007	291 504	283 555	114 326	71 852	52 099	45 279	7 949	5 725	2 224	0.13
2008	288 319	279 910	120 000	47 334	48 166	64 410	8 410	6 118	2 291	0.13
2009	292 872	284 744	119 674	46 204	47 907	70 959	8 128	6 061	2 067	0.13
2010	287 840	279 614	114 151	52 298	45 392	67 773	8 226	6 151	2 075	0.13
2011	309 922	300 857	126 265	52 550	47 386	74 656	9 065	6 662	2 403	0.13
2012	321 568	312 186	127 058	61 017	62 525	61 586	9 381	6 851	2 530	0.13
2013	308 339	299 816	121 620	52 946	68 865	56 384	8 524	6 324	2 199	0.13
2014	326 754	316 538	132 490	54 409	73 559	56 079	10 216	7 318	2 898	0.13
2015	341 981	336 485	135 736	59 554	75 798	65 397	5 496	2 733	2 763	0.13
2016	361 686	353 091	145 940	60 039	81 841	65 270	8 596	5 896	2 700	0.13
2017	382 389	375 690	157 331	60 152	84 770	73 437	6 699	3 681	3 017	0.13
2018	374 145	366 483	159 409	59 576	84 617	62 881	7 662	4 885	2 777	0.13
2019	365 410	355 734	149 489	54 535	82 428	69 282	9 676	6 770	2 906	0.13
2020	367 577	358 995	142 927	60 150	80 680	75 238	8 581	5 558	3 023	0.13

Energy sector GHG emissions mainly are coming from stationary combustion. Total emissions from stationary combustion are 278 Mt CO_2 eq. in 2020, equal to 53% of total national GHG emissions (excluding LULUCF).

The energy industries subsector (1.A.1) contributed 143 Mt CO_2 eq. in 2020 while the GHG emissions from manufacturing industries and construction subsector (1.A.2) emissions were 60.2 Mt CO_2 eq. and GHG emissions from other sectors (1.A.4) were 75.2 Mt. The transport sector GHG emissions were 80.7 Mt in the same year.

GHG emissions from stationary combustion increased by 157% (170.1 Mt CO_2 eq.) between 1990 and 2020, and increased by 1.8% (5.0 Mt CO_2 eq.) between 2019 and 2020.

Figure 3.1 GHG emissions from fuel combustion, 1990-2020



In 2020, transport contributed 80.7 Mt CO_2 eq., which is 15.4% of total GHG emissions (excluding LULUCF). The major source of transport emissions in Türkiye is road transportation. It accounts for 94.9% of transport emissions. It is followed by domestic aviation while other sources are far smaller: domestic aviation with 2.7% and domestic navigation with 1.6%. Pipeline transport contribution was 0.4% and railway contribution was 0.4%.

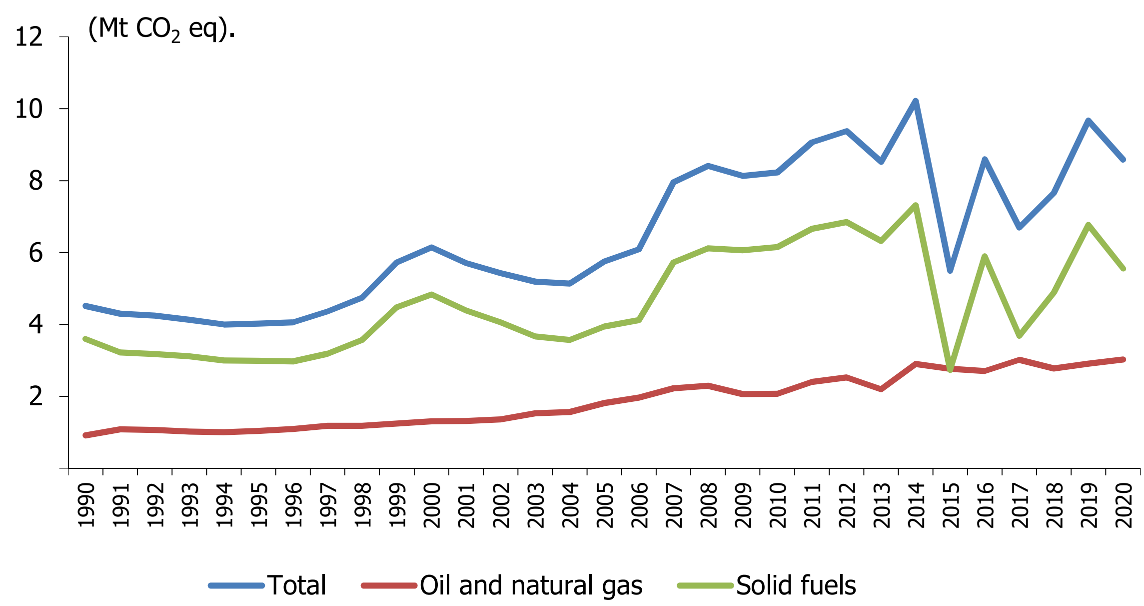
Fuel used in international aviation and marine bunkers is reported separately from the national total. In 2020, international bunker GHG emissions were 7.6 Mt CO_2 eq.

Emissions from transport sector increased 199.2% (53.7 Mt CO_2 eq.) in 2020 compared to 1990. In the same period increase in road transportation emissions was 209.2%, in domestic aviation it was 280.2% and in domestic navigation it was 148.5%. Emissions from railway transport decreased by 55.2% between 1990 and 2020.

Total fugitive emissions for 2020 were 8.6 Mt CO_2 eq., representing 1.6% of total GHG emissions (excluding LULUCF). Oil and natural gas systems contributed 30%, solid fuels account for the remaining 70% of fugitive emissions.

Overall fugitive emissions increased 90.3% between 1990 and 2020. 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 2020, the underground coal production activity decreased and therefore in 2020 fugitive emissions from solid fuels were decreased. In overall, from 1990 to 2020, fugitive emissions from oil and natural gas systems increased by 231.6%. Emissions from solid fuels increased by 88.2% in the same period.

Figure 3.2 Fugitive emissions, 1990-2020



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

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

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

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

Sector QA/QC and Verification

Quality control for energy category was performed on the basis of QA/QC plan of Türkiye. 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 in NIR submitted in 2018. Another QA process was also conducted in 2020 by an expert from CITEPA for this sector.

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 Türkiye 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_4 and N_2O emission factors from 2006 IPCC Guidelines are used for 1.A.1.a category for since 2003 and 2006 IPCC Guidelines default CH_4 and N_2O EFs are used for 1990-2002 period since combustion technology data is available from 2003 onward for this category.

For petroleum refining sector (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_4 and N_2O 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_2 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_4 and N_2O 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_2 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_2 emissions from pipeline transportation. 2006 IPCC Guidelines default EFs are used for CH_4 and N_2O 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, MTA, MAPEG 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_2 emissions. NCVs can be found Annex 3.

Table 3.5 Country specific carbon contents of fuels

Fuel types	Unit	1990	2000	2010	2015	2017	2018	2019	2020
Hard coal	t/TJ	25.79	26.38	27.28	26.16	26.43	26.08	26.87	25.56
Lignite	t/TJ	32.79	31.61	31.57	30.57	30.05	30.51	30.09	29.80
Coke	t/TJ	30.14	30.14	29.95	30.10	30.61	29.48	29.59	30.19
Petrocoke	t/TJ	26.55	26.55	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	21.33	21.33
Diesel	t/TJ	20.03	20.03	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	20.13	20.13
Natural gas	t/TJ	15.13	15.13	15.17	15.19	15.18	15.08	14.64	15.19

The following table shows the country specific oxidation factors of fuels used in calculating the CO_2 emissions factors.

Table 3.6 Country specific oxidation factor of fuels

Fuel types	1990	2000	2010	2015	2016	2017	2018	2019	2020
Hard coal	0.988	0.988	0.985	0.963	0.963	0.975	0.975	0.983	0.979
Lignite	0.950	0.950	0.953	0.960	0.960	0.973	0.973	0.966	0.959
Fuel oil	0.984	0.984	0.984	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	0.984	0.984	0.984

The following table shows the CO_2 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_2 EFs are calculated by the formula below.

CO_2 EF = C content of fuel x Oxidation factor of fuel x (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_2 emission factors of fuels

Fuel types	Unit	1990	2000	2010	2016	2017	2018	2019	2020
Hard coal	t/TJ	93.4	95.5	98.6	85.3	94.5	94.1	96.9	91.8
Lignite	t/TJ	114.2	110.1	110.3	107.4	107.2	107.5	106.6	104.8
Asphaltite	t/TJ	96.1	96.1	96.1	96.1	96.1	96.1	96.1	96.1
Coke	t/TJ	110.5	110.5	109.8	108.3	112.2	108.1	108.5	110.7
Coal tar	t/TJ	80.7	80.7	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	73.7	73.7
Petrocoke	t/TJ	97.4	97.4	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	77.0	77.0
Diesel	t/TJ	72.3	72.3	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	69.3	69.3
LPG	t/TJ	63.1	63.1	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	57.6	57.6
Aviation fuel	t/TJ	71.5	71.5	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	71.9	71.9
Naphta	t/TJ	72.7	72.7	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	73.3	73.3
Base oils	t/TJ	73.3	73.3	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	73.3	73.3
Bitumen	t/TJ	80.7	80.7	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	73.3	73.3
Natural gas	t/TJ	55.5	55.5	55.6	55.7	55.6	55.6	53.7	53.7
Fuel wood	t/TJ	111.8	111.8	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	100.1	100.1
Biofuels	t/TJ	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8

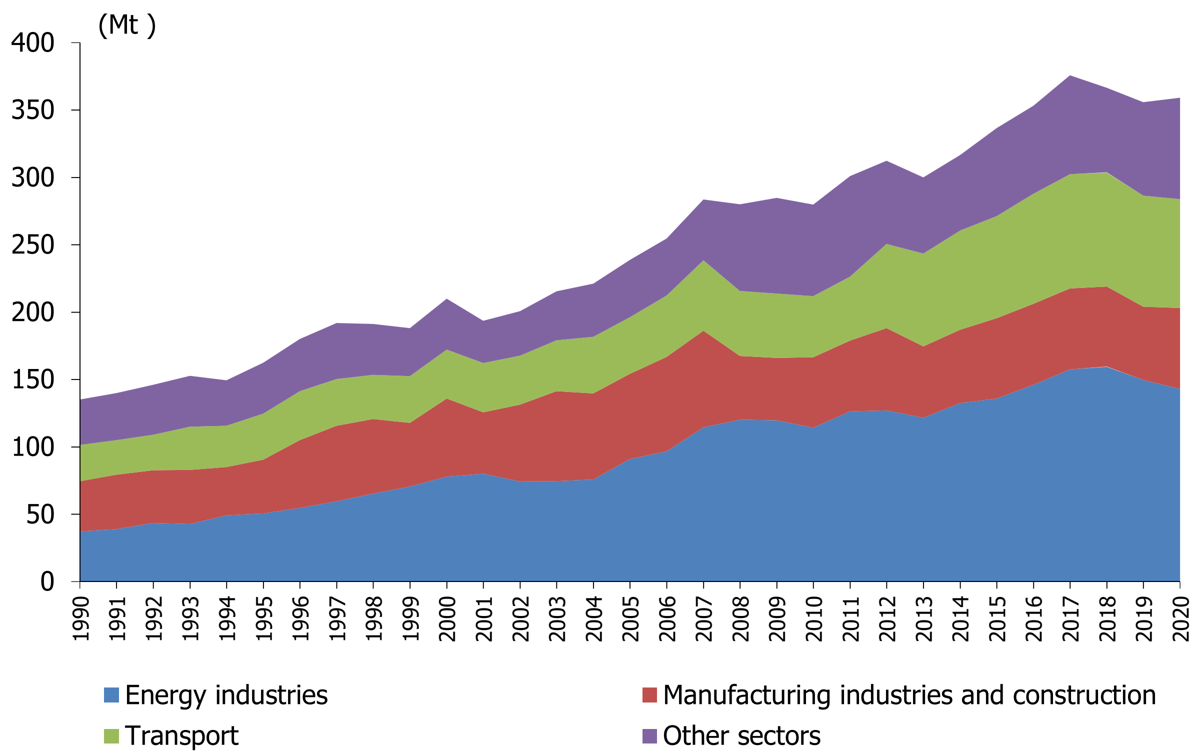
CO_2, CH_4 and N_2O Emissions from fuel combustion were calculated for the period 1990-2020

Table 3.8 Emissions from fuel combustion (1A), 1990-2020

(kt)

Year	CO_2	CH_4	N_2O	CO_2 eq.
1990	129 671	138.9	6.5	135 092
1991	134 253	139.8	6.5	139 691
1992	140 518	143.0	6.7	146 078
1993	146 920	139.6	7.6	152 667
1994	143 880	128.3	7.5	149 318
1995	156 592	133.3	7.8	162 258
1996	174 164	131.8	8.3	179 934
1997	185 795	138.2	8.4	191 762
1998	185 366	128.8	8.3	191 059
1999	182 564	121.1	8.3	188 060
2000	204 326	121.2	8.5	209 879
2001	188 432	107.9	7.9	193 483
2002	195 393	109.6	8.0	200 523
2003	209 683	111.9	9.3	215 242
2004	215 304	113.7	10.1	221 143
2005	232 765	112.4	10.5	238 693
2006	248 348	108.5	11.2	254 411
2007	276 997	111.5	12.7	283 555
2008	272 021	153.4	13.6	279 910
2009	276 277	171.8	14.0	284 744
2010	271 489	167.1	13.2	279 614
2011	292 984	146.5	14.1	300 857
2012	305 400	154.5	9.8	312 186
2013	293 615	130.2	9.9	299 816
2014	310 129	129.7	10.6	316 538
2015	330 660	81.3	12.7	336 485
2016	347 115	81.0	13.3	353 091
2017	369 208	92.9	14.0	375 690
2018	360 675	82.4	12.6	366 483
2019	349 944	89.1	12.0	355 734
2020	352 843	98.3	12.4	358 995

Figure 3.3 CO_2 emissions from fuel combustion, 1990-2020



Energy industry has the highest share in total CO_2 emission from fuel combustion in 2020. It is followed by transport, other sectors, and manufacturing industries and construction.

Figure 3.4 CO_2 emissions from fuel combustion by sectors, 1990 and 2020

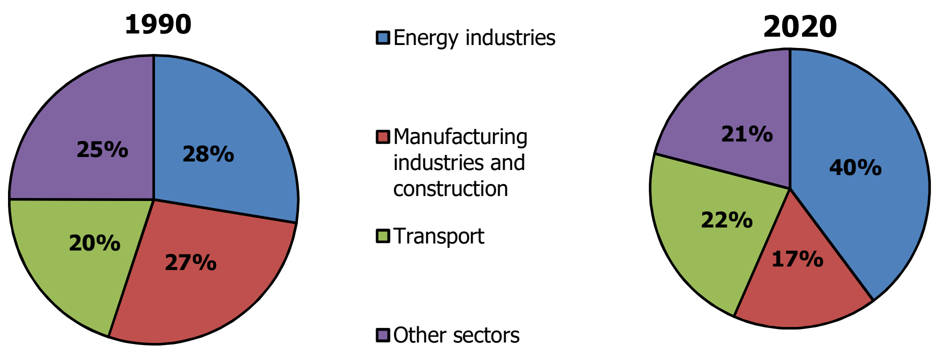


Figure 3.5 CH_4 emissions from fuel combustion, 1990-2020

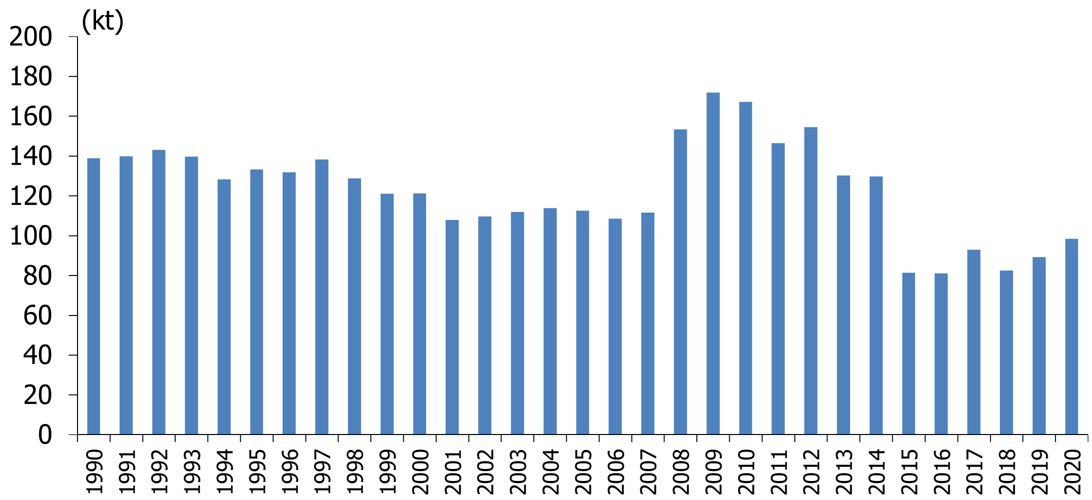
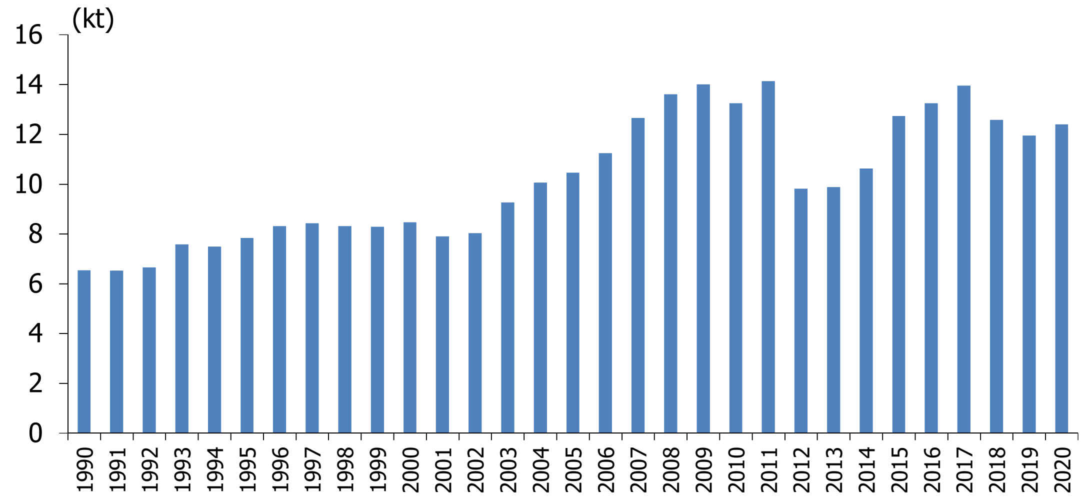


Figure 3.6 N_2O emissions from fuel combustion, 1990-2020



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_2 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:

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

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

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

Fuel allocated under national energy balance table	Fuel allocated under CRF 1AB sector
Hard coal	Coking coal
Lignite	Lignite
Asphaltite	Sub bitiminous 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
Rafinery 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_2 emissions from fuel combustion, 1990-2020

(kt)

	Reference Approach					Sectoral Approach				
Year	Liquid fuels (excluding international bunkers)	Solid fuels (excluding international bunkers)	Gaseous fuels	Other fossil fuels	Total	Liquid fuels (excluding international bunkers)	Solid fuels (excluding international bunkers)	Gaseous fuels	Other fossil fuels	Total
1990	66 028	63 511	5 538	66 028	135 077	59 784	63 172	6 716	NO	129 671
1991	63 928	68 588	7 090	63 928	139 606	58 450	67 539	8 265	NO	134 253
1992	68 820	69 341	7 888	68 820	146 048	62 930	68 552	9 036	NO	140 518
1993	79 456	64 342	8 849	79 456	152 646	72 851	63 995	10 074	NO	146 920
1994	76 788	65 295	9 582	76 788	151 665	70 301	62 993	10 585	NO	143 880
1995	83 270	68 610	12 363	83 270	164 243	77 694	65 272	13 626	1	156 592
1996	89 069	79 578	14 681	89 069	183 328	81 735	76 505	15 918	5	174 164
1997	88 669	88 954	18 378	88 669	196 001	81 478	84 429	19 879	9	185 795
1998	83 850	91 464	19 596	83 850	194 910	77 090	87 610	20 655	12	185 366
1999	85 127	81 165	24 329	85 127	190 621	78 463	78 236	25 848	17	182 564
2000	91 665	94 125	28 572	91 665	214 362	82 142	92 771	29 371	42	204 326
2001	86 964	78 869	30 951	86 964	196 784	77 784	78 707	31 937	4	188 432
2002	89 278	81 163	32 934	89 278	203 376	79 825	81 652	33 877	39	195 393
2003	90 895	91 964	40 026	90 895	222 885	81 460	85 950	42 262	11	209 683
2004	93 976	86 589	41 909	93 976	222 474	85 339	86 660	43 268	37	215 304
2005	94 669	89 275	50 823	94 669	234 767	83 824	95 196	53 671	75	232 765
2006	88 099	103 599	59 200	88 099	250 898	82 456	104 396	61 448	48	248 348
2007	90 542	117 154	69 921	90 542	277 616	87 157	118 279	71 425	136	276 997
2008	89 110	118 647	70 129	89 110	277 885	86 235	114 783	70 829	175	272 021
2009	77 819	123 172	68 337	77 819	269 328	82 971	122 257	70 750	299	276 277
2010	86 236	126 348	72 623	86 236	285 207	79 519	120 683	70 847	441	271 489
2011	85 800	130 463	85 643	85 800	301 906	82 652	125 204	84 582	545	292 984
2012	88 700	135 973	84 926	88 700	309 599	88 192	131 041	85 364	803	305 400
2013	93 760	118 580	86 085	93 760	298 425	92 556	114 701	85 191	1 166	293 615
2014	93 634	128 608	92 030	93 634	314 272	97 263	119 749	91 878	1 238	310 129
2015	103 508	131 236	90 528	103 508	325 273	106 454	128 006	94 388	1 812	330 660
2016	110 646	139 291	87 954	110 646	337 891	116 047	139 842	89 719	1 508	347 115
2017	115 623	152 470	101 863	115 623	369 956	118 618	145 912	102 843	1 836	369 208
2018	111 761	157 027	93 420	111 761	370 737	115 004	150 431	93 028	2 211	360 675
2019	108 087	168 373	82 157	108 087	367 388	112 098	154 384	81 119	2 343	349 944
2020	108 860	158 904	91 445	108 860	368 822	112 903	148 138	89 835	1 966	352 843

Figure 3.7 CO_2 emissions from fuel combustion, 1990-2020

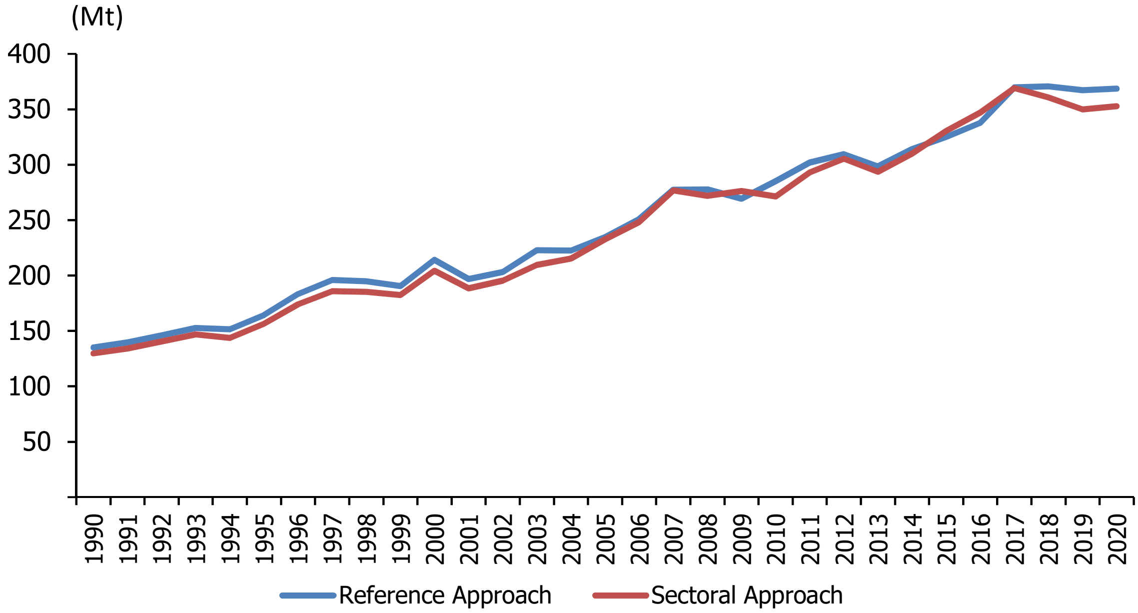


Table 3.11 Comparison of CO_2 from fuel combustion between reference and sectoral approach, 1990-2020

	Reference approach		Sectoral approach		Difference in emissions (%)
Year	Apparent consumption (PJ)	Emissions (kton CO_2)	Apparent consumption (PJ)	Emissions (kton CO_2)	
1990	1 795	135 077	1 794	135 092	-0.01
1991	1 826	139 606	1 839	139 691	-0.06
1992	1 914	146 048	1 922	146 078	-0.02
1993	2 047	152 646	2 035	152 667	-0.01
1994	2 007	151 665	1 997	149 318	1.55
1995	2 188	164 243	2 174	162 258	1.21
1996	2 410	183 328	2 365	179 934	1.85
1997	2 562	196 001	2 506	191 762	2.16
1998	2 580	194 910	2 497	191 059	1.98
1999	2 581	190 621	2 524	188 060	1.34
2000	2 891	214 362	2 778	209 879	2.09
2001	2 686	196 784	2 602	193 483	1.68
2002	2 796	203 376	2 682	200 523	1.40
2003	3 043	222 885	2 885	215 242	3.43
2004	3 138	222 474	2 992	221 143	0.60
2005	3 293	234 767	3 209	238 693	-1.67
2006	3 601	250 898	3 427	254 411	-1.40
2007	3 966	277 616	3 792	283 555	-2.14
2008	3 918	277 885	3 719	279 910	-0.73
2009	3 804	269 328	3 720	284 744	-5.72
2010	4 005	285 207	3 657	279 614	1.96
2011	4 300	301 906	3 962	300 857	0.35
2012	4 404	309 599	4 117	312 186	-0.84
2013	4 320	298 425	4 004	299 816	-0.47
2014	4 532	314 272	4 269	316 538	-0.72
2015	4 750	325 273	4 528	336 485	-3.45
2016	4 978	337 891	4 723	353 091	-4.50
2017	5 361	369 956	5 030	375 690	-1.55
2018	5 271	370 737	4 910	366 483	1.15
2019	5 146	367 388	4 716	355 734	3.17
2020	5 260	368 822	4 819	358 995	2.66

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:

There is no recalculation in this sector.

3.2.2. International bunker fuels

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

3.2.2.1. International aviation

The fuel type used in international aviation is jet kerosene. Table 3.12 shows the trend in emissions of CO_2, CH_4, and N_2O from international aviation between 1990 and 2020.

GHG emissions from international aviation have an increasing trend in consistent with the growth in international aviation sector. CO_2 eq. emissions were 5.89 Mt in 2020 (Figure 3.8) 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 Türkiye because aircraft operational use data are not available.

Energy balance tables were used for AD. To estimate emissions, Türkiye applies the default emission factors from the 2006 IPCC Guidelines as follows: CO_2 (71500 kg/TJ), CH_4 (0.5 kg/TJ) and N_2O (2 kg/TJ).

Figure 3.8 GHG emissions from international aviation, 1990-2020

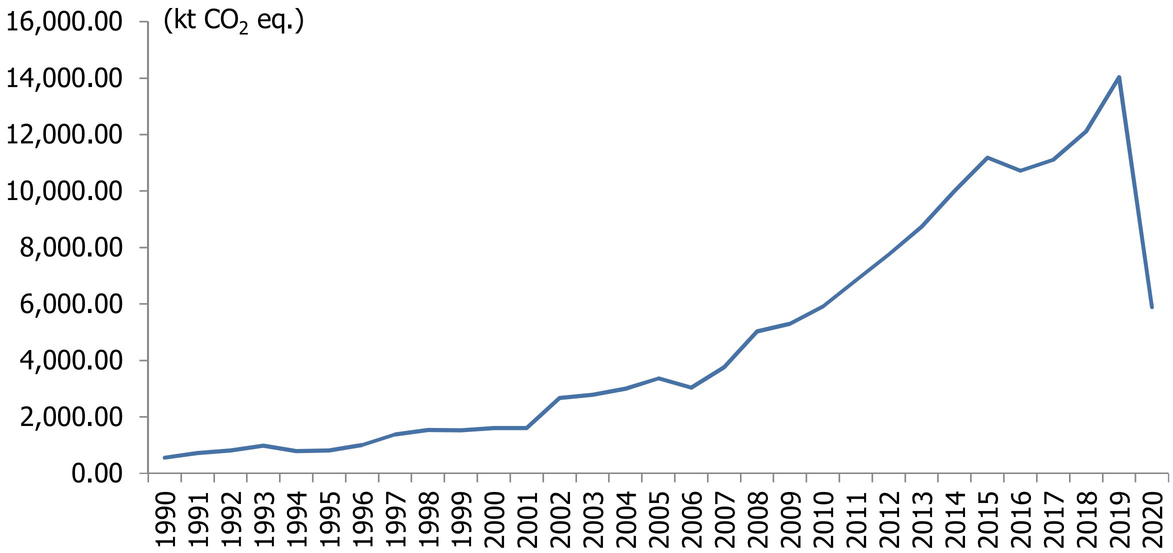


Table 3.12 Emissions and fuel for international aviation, 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq (kt)	Aviation bunkers (TJ)
1990	552	0.004	0.02	556	7 718
1991	716	0.005	0.02	722	10 011
1992	804	0.006	0.02	811	11 246
1993	977	0.007	0.03	986	13 671
1994	788	0.006	0.02	795	11 025
1995	807	0.006	0.02	814	11 290
1996	1 003	0.007	0.03	1 011	14 024
1997	1 368	0.010	0.04	1 380	19 139
1998	1 523	0.011	0.04	1 536	21 300
1999	1 514	0.011	0.04	1 526	21 168
2000	1 599	0.011	0.04	1 612	22 359
2001	1 592	0.011	0.04	1 606	22 271
2002	2 649	0.019	0.07	2 671	37 044
2003	2 762	0.019	0.08	2 786	38 632
2004	2 977	0.021	0.08	3 002	41 630
2005	3 330	0.023	0.09	3 358	46 570
2006	3 014	0.021	0.08	3 040	42 160
2007	3 731	0.026	0.10	3 762	52 177
2008	4 991	0.035	0.14	5 034	69 810
2009	5 255	0.037	0.15	5 299	73 493
2010	5 858	0.041	0.16	5 908	81 937
2011	6 769	0.047	0.19	6 827	94 671
2012	7 684	0.054	0.21	7 750	107 473
2013	8 661	0.061	0.24	8 734	121 129
2014	9 922	0.069	0.28	10 007	138 775
2015	11 085	0.078	0.31	11 180	155 037
2016	10 630	0.074	0.30	10 720	148 668
2017	11 015	0.077	0.31	11 109	154 053
2018	12 006	0.084	0.34	12 108	167 911
2019	13 917	0.097	0.39	14 036	194 649
2020	5 842	0.041	0.16	5 892	81 712

3.2.2.2. International navigation

The fuel type used in international navigation is diesel oil and residual fuel oil. Table 3.13 shows the trend in emissions of CO_2, CH_4 and N_2O from international navigation between 1990 and 2020.

GHG emissions from international navigation have an increasing trend corresponding to the growth in the international navigation sector. CO_2 emissions were 1.73 Mt in 2020 (Figure 3.9) 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_2 emission estimation. 2006 IPCC default

EFs are used for CH_4 and N_2O emissions. The following equation is used. Activity data in international navigation provided by the EMRA were compared with those of DG of Mining and Petroleum Affairs, reported to IEA.

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

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)

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

Figure 3.9 GHG emissions from international navigation, 1990-2020

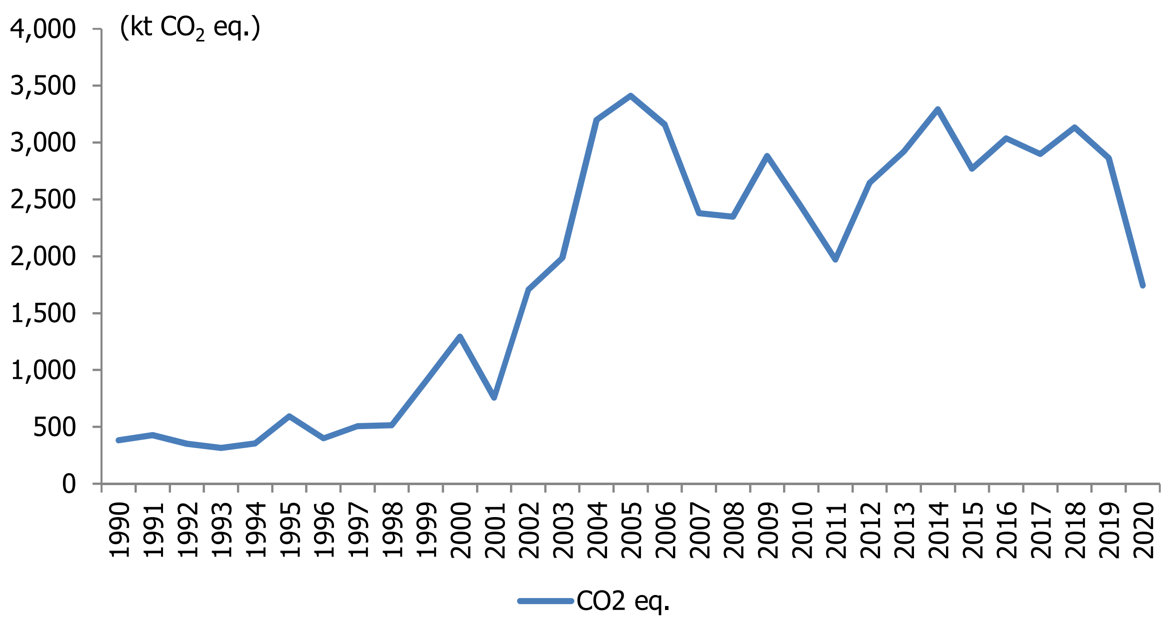


Table 3.13 Emissions and fuel for international navigation, 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Navigation bunkers (TJ)
1990	379	0.035	0.01	383	5 035
1991	423	0.039	0.01	428	5 622
1992	347	0.032	0.01	351	4 626
1993	313	0.029	0.01	316	4 148
1994	351	0.033	0.01	354	4 656
1995	587	0.055	0.02	593	7 819
1996	395	0.037	0.01	399	5 248
1997	502	0.047	0.01	507	6 658
1998	509	0.047	0.01	514	6 689
1999	894	0.083	0.02	903	11 810
2000	1 279	0.118	0.03	1 292	16 861
2001	749	0.069	0.02	756	9 848
2002	1 690	0.156	0.04	1 707	22 334
2003	1 964	0.183	0.05	1 984	26 127
2004	3 168	0.294	0.08	3 200	41 988
2005	3 376	0.312	0.09	3 411	44 586
2006	3 127	0.287	0.08	3 159	41 059
2007	2 355	0.212	0.06	2 379	30 323
2008	2 325	0.211	0.06	2 348	30 114
2009	2 854	0.257	0.07	2 882	36 737
2010	2 407	0.217	0.06	2 431	31 058
2011	1 951	0.176	0.05	1 971	25 160
2012	2 618	0.237	0.07	2 645	33 786
2013	2 892	0.261	0.07	2 921	37 316
2014	3 260	0.294	0.08	3 292	41 958
2015	2 742	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
2018	3 101	0.284	0.08	3 132	40 520
2019	2 833	0.260	0.07	2 862	37 186
2020	1 726	0.162	0.05	1 744	23 145

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 3.14 Summary table for use of feedstock, reductants and other non energy use of

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 in2.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_2 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 rafinery 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:

There is no recalculation in this sector.

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 Türkiye. This category is one of the main emission sources in Türkiye. The share of GHG emissions as CO_2 eq**.** from energy industries in total fuel combustion was 39.8% in 2020 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_2 from liquid, solid and gaseous fuels in 2020.

Table 3.15 GHG emissions from energy industries, 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)
1990	37 139	0.4	0.4	37 262	395 856
1991	38 679	0.5	0.4	38 808	411 244
1992	43 174	0.5	0.5	43 321	456 727
1993	42 590	0.5	0.4	42 733	455 875
1994	48 873	0.6	0.5	49 040	519 646
1995	50 272	0.6	0.5	50 440	545 725
1996	54 243	0.6	0.6	54 425	584 018
1997	59 346	0.7	0.6	59 544	647 072
1998	64 899	0.8	0.7	65 115	712 882
1999	70 116	0.9	0.7	70 339	802 036
2000	77 486	1.0	0.7	77 725	906 993
2001	79 743	1.0	0.7	79 986	942 482
2002	74 045	1.0	0.6	74 258	895 197
2003	73 976	1.0	1.7	74 516	927 231
2004	75 039	1.0	2.1	75 695	936 466
2005	90 164	1.2	2.6	90 957	1 115 256
2006	95 797	1.3	2.9	96 686	1 184 557
2007	113 152	1.6	3.8	114 326	1 406 230
2008	118 765	1.6	4.0	120 000	1 484 961
2009	118 287	1.7	4.5	119 674	1 474 100
2010	112 917	1.7	4.0	114 151	1 414 803
2011	124 958	1.9	4.2	126 265	1 562 958
2012	125 865	1.9	3.8	127 058	1 597 608
2013	120 366	1.8	4.1	121 620	1 526 230
2014	131 143	1.9	4.4	132 490	1 698 737
2015	134 536	1.9	3.9	135 736	1 704 217
2016	144 655	2.0	4.1	145 940	1 787 203
2017	155 914	2.1	4.6	157 331	1 954 726
2018	158 360	2.0	3.4	159 409	1 936 301
2019	148 637	1.8	2.7	149 489	1 722 019
2020	142 026	1.8	2.9	142 927	1 728 330

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_2 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_4 and N_2O emissions from CRF category 1A1a, have been estimated by using plant specific fuel consumption and NCVs. For the years 2000-2020 technology information of power plants were obtained. According to type of technology, using 2006 IPCC Guidelines for National Greenhouse Gas Inventories, emission factors were chosen in order for CH_4 and N_2O to be estimated with Tier 3.

Emissions from petroleum refining (CRF 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_2 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_4 and N_2O 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_2 emissions from 1.A.1.c were calculated by using plant specific AD, carbon contents of fuels and IPCC default oxidation rates. CH_4 and N_2O emissions from CRF category 1.A.1.c, have been estimated by using plant specific fuel consumption and NCVs and IPCC default EFs.

Recalculation:

There is no recalculation in this sector.

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

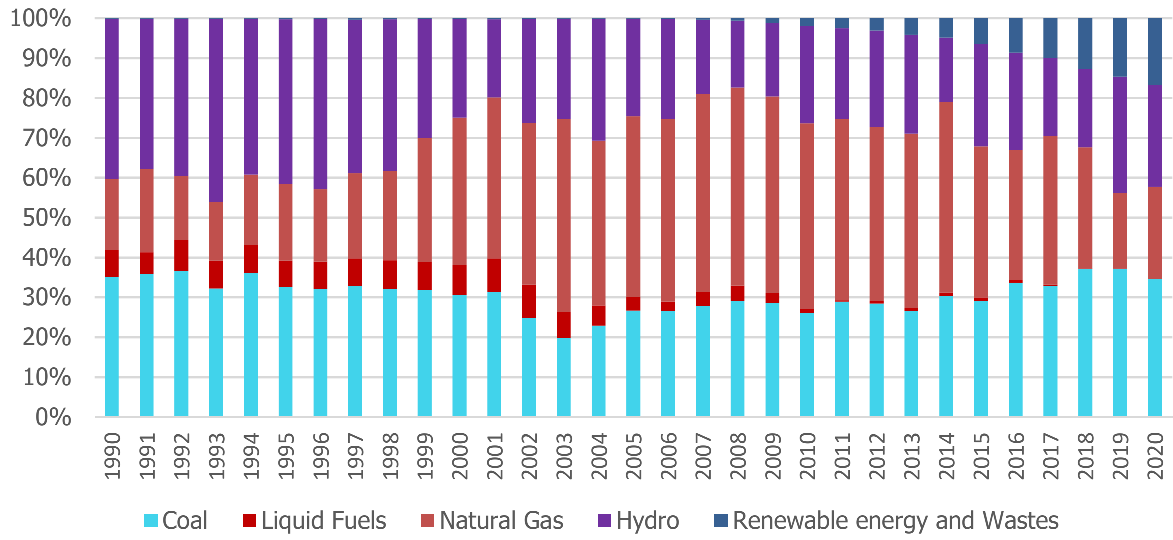
Source Category Description:

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 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 avoid double-counting for the whole time series. For 1.A.1.a sector, plant-specific AD's are gathered from Turkish Electricity Transmission Company (TEİAŞ).

Total installed capacity reached 95,891 MW with a 5% increase from the previous year and nearly 5.9 times higher than the 1990 values. The total gross electricity consumption increased by 0.9% in 2020 compared to the previous year. In 2020, gross consumption was 306,109 GWh; meanwhile, in 2019, this figure was realized as 303,320 GWh. Above mentioned installed capacities, and consumption amounts belong to electricity production companies and auto producers as well. In 2020, hydro had a high share of 25.5% in all electricity production, which was followed by natural gas (23.1%), other bituminous coal (22.1%), Turkish lignite (12.4%), other renewable and wastes (16.8%) and oil (0.11%). From 2019 to 2020, electricity production from hydropower plants decreased by 12.1%. The amount of electricity produced from Turkish lignite has decreased from 46.87 TWh to 37.94 TWh . On the other hand, electricity production from other bituminous coal increased from 66.02 TWh to 67.87 TWh and natural gas from 57.29 TWh to 70.93 TWh.

In 2020 electricity production from fossil-fueled thermal power plants has accounted for 177.066 TWh of 306.703 TWh production, while in 2019, electricity production from fossil-fueled thermal power plants had accounted for 170.518 TWh of a total of 303.898 TWh production. Fossil fueled thermal share in electricity production increased from 56.11% in 2019 to 57.73% in 2020.

Figure 3.10 Energy mix of category 1.A.1.a, 1990-2020[1]



There was an increase in wind installed capacity from 7,591 MW in 2019 to 8,832 MW in 2020. Renewable Law, which came into force in 2005 later revised in 2011, provided some supporting mechanisms for purchasing electricity from solar, biomass, geothermal, wind, and hydraulic energy. In the year 2020, solar power plants installed capacity raised to 6,667 MW. The voluntary carbon market's role is important to mention, as many wind projects in the country generate and sell the voluntary carbon credits.

Electricity generation from animal and yard waste has increased by 24% compared to the previous year, reaching 1,485 MW of installed power, generating 5,737 GWh of power in 2020.

In 2020, Total Primary Energy Supply (TPES) of Türkiye was 6 161 637.93 TJ, a 2 % increase compared to 2019. Oil had a share of 1 766 395.16 TJ while hard coal and natural gas accounted for 1 065 510.94 TJ and 1 666 582.38 TJ, respectively.

[1] Electricity Statistics, TEİAŞ (https://www.teias.gov.tr/tr-TR/turkiye-elektrik-uretim-iletim-istatistikleri)

Figure 3.11 Electricity generation and shares by energy resources, 2019 - 2020[2]

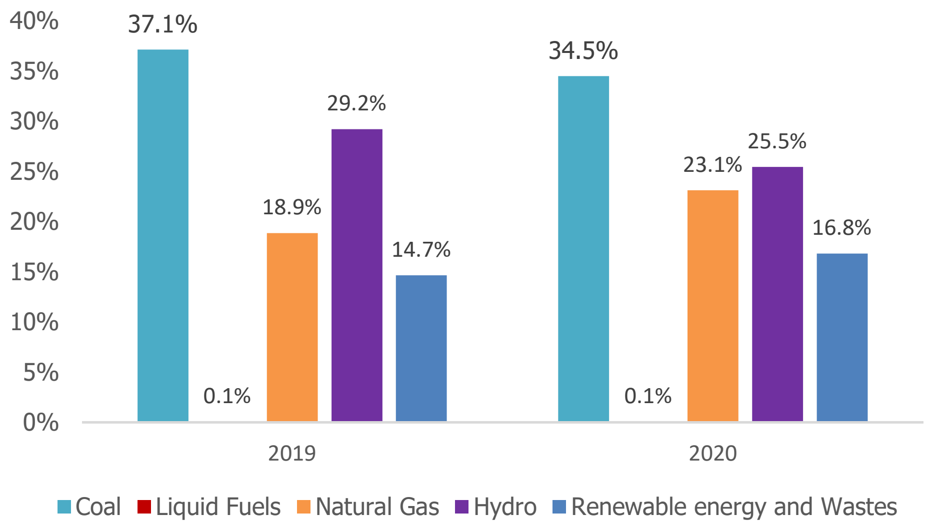
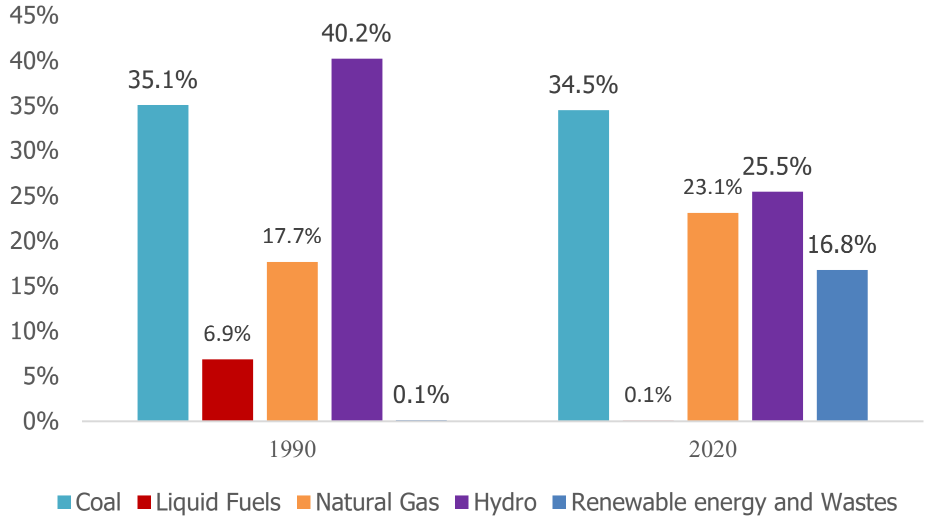


Figure 3.12 Electricity generation and shares by energy resources, 1990 - 2020[3]



Primary energy (domestic) production was 1 845 086.77 TJ in 2020 and provided 30% of the overall energy supply. The share of imports in TPES decreased from 80% in 2019 to 78% in 2020.

[2]Electricity Statisticts, TEİAŞ (https://www.teias.gov.tr/tr-TR/turkiye-elektrik-uretim-iletim-istatistikleri)
[3]Electricity Statisticts, TEİAŞ (https://www.teias.gov.tr/tr-TR/turkiye-elektrik-uretim-iletim-istatistikleri)

The production of solid fossil fuels, excluding animal & yard waste, has decreased from 726 382.56 TJ in 2019 to 658 188.76 TJ in 2020. The main domestic energy source remains as Turkish lignite, with production decreased from 83.69 Mt in 2019 to 71 637.40 Mt in 2020, which represented a decline by about %14,41

GHG emissions from public electricity and heat production in total fuel combustion were 36.7% in 2020, and even it was 24.4% in 1990. According to Table 3.16, fuel consumption increased from 1 580 085 TJ in 2019 to 1 585 675 TJ in 2020 when the CO_2 emissions decreased from 138 273 kt in 2019 to 130 770 kt in 2020. In other words, fuel consumption increased by 0.4% compared to the previous year, while CO_2 emissions decreased by 5.4%. The main reason for this situation is that the coal share in electricity generation decreased from 37.1% in 2019 to 34.5% in 2020, while natural gas share in electricity generation increased in 2020 (23.1%) compared to the previous year (18.9%).

Table 3.16 Emissions from category 1A1a, 1990-2020

Year	CO_2	CH_4	N_2O	CO_2 eq.	Fuel
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	1 591 475
2016	134 280	1.9	4.1	135 554	1 644 763
2017	144 814	1.9	4.6	146 220	1 804 038
2018	148 992	1.9	3.3	150 032	1 791 670
2019	138 273	1.7	2.7	139 116	1 580 085
2020	130 770	1.7	2.9	131 662	1 585 675

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 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 literature. Cross checks, including fuel capacity factor controls, and examining outliers give some opinion about data consistency. Suspicious data are corrected by getting in 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, the 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 Table 3.17.

Table 3.17 Average NCVs of fuels used in category 1.A.1.a

(TJ/kt)

Fuel Type	Weighted average	Default
Sub-Bituminous Coal	14.53	18.90
Natural gas	53.37	48.00
Residual Fuel Oil	47.82	40.40
Other bituminous coal	23.82	25.80
Turkish lignite	6.82	11.90
Gas\Diesel Oil	43.25	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 obtained from coal-fired power plants were used to calculate the related coal types' carbon content. The same procedure was applied for liquid fuels 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 the gases and some stoichiometry density, each gas compound's carbon mass amount was calculated and summed up to reach an overall carbon amount. The oxidation rate of solid fuels was calculated 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 the mass percentage of the unoxidized carbon and then the 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_2 EFs used for source category 1.A.1.a were listed in Table 3.18 for the whole time series on a fuel basis.

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

EFs for CH_4 and N_2O were listed in Table 3.19 for the whole time series on a fuel basis.

Table 3.18 CO_2 emission factors used for source category 1.A.1.a, 1990-2020

(t/TJ)

Year	Turkish Lignite	Sub-Bituminous Coal	Other Bituminous Coal	Natural Gas	Residual Fuel Oil	Diesel Oil	LPG	Biogas	Industrial Waste	Wood-wood waste	Coke Oven Gas	Black Liquor	Blast Furnace Gas	Petroleum Coke	Oxygen Steel Furnace Gas	Coal Tar	Refinery Gas
1990	114.16	93.37	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	57.57
1991	114.01	101.38	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	57.57
1992	113.85	101.35	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	57.57
1993	113.70	100.54	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	57.57
1994	113.54	99.12	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	57.57
1995	113.39	102.17	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	57.57
1996	113.23	102.50	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	57.57
1997	113.08	103.34	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	57.57
1998	112.92	102.81	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	57.57
1999	112.77	93.39	NO	58.23	76.97	72.28	63.07	NO	NO	NO	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2000	110.05	95.52	88.62	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2001	110.58	99.28	88.62	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2002	111.30	96.27	88.62	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2003	112.00	100.90	79.88	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2004	112.72	90.34	84.02	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2005	113.50	94.23	85.24	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2006	114.18	88.71	90.07	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2007	113.62	88.52	91.17	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2008	112.51	93.35	83.29	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2009	111.39	96.03	90.35	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2010	110.26	98.56	90.01	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2011	109.48	95.10	89.11	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2012	109.29	96.65	88.89	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2013	109.09	96.18	93.57	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2014	107.63	93.15	87.70	58.23	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	57.57
2015	107.63	92.38	92.64	58.66	76.97	72.28	63.07	54.63	143.00	111.83	37.46	95.33	259.60	97.53	181.87	80.67	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	57.57
2017	107.24	94.50	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	57.57
2018	107.55	94.12	92.75	55.74	76.97	72.28	63.07	54.63	143.00	111.83	37.35	95.33	259.60	97.53	181.87	80.67	57.57
2019	106.62	96.89	94.58	55.50	76.97	72.28	63.07	54.63	143.00	111.83	38.87	95.33	259.60	97.53	181.87	80.67	57.57
2020	104.44	91.76	94.50	53.77	76.97	72.28	63.07	54.63	143.00	111.83	39.74	95.33	259.60	97.53	181.87	80.67	57.57

Table 3.19 CH_4 and N_2O emission factors used for source category 1.A.1.a

(kg/TJ)

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

Comparability and Accuracy through Nomenclature Change:

NCV of Turkish lignite differs significantly from that of the Energy Statistics Handbook and general fuel literature. It is even lower than the lowest value of lignite in all reports of the Parties. Analysis reports support this NCV data of Turkish lignite. Its average carbon content in 2020 is 29.8 kg/GJ, approaches the upper limit of 2006 IPCC Guidelines (31.3 kg/GJ). To recategorize our local lignite, we renamed it as "Turkish Lignite" to separate it from literature lignite and avoid misleading comparisons.

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

CO_2 capture from flue gases and CO_2 storage is not occurring in Türkiye, 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.

Table 3.20 IEFs of fuels used for category 1.A.1.a, 1990-2020

	CO_2						CH_4		N_2O	
	Solid Fuels		Liquid Fuels		Gaseous Fuels		Biomass		Biomass	
Years	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	110.51	74.03	75.55	58.23	58.23	4.80	2.92	2.13	1.65
2001	117.56	111.08	65.95	74.80	58.23	58.23	4.84	3.78	2.14	1.48
2002	123.56	112.39	75.38	76.50	58.23	58.23	4.80	4.73	2.13	1.59
2003	128.20	109.22	75.75	76.57	58.23	58.23	3.13	2.57	2.08	1.85
2004	130.18	108.85	75.99	76.48	58.23	58.23	3.00	1.89	2.00	1.44
2005	125.53	109.76	76.05	76.09	58.23	58.23	2.37	1.11	1.68	1.06
2006	140.06	110.54	76.95	75.96	58.23	58.23	2.61	1.44	1.81	1.22
2007	137.25	110.10	76.96	76.05	58.23	58.23	2.28	1.37	1.64	1.18
2008	136.91	107.98	76.94	76.05	58.23	58.23	2.83	1.41	2.02	1.22
2009	138.78	109.37	73.76	76.07	58.23	58.23	3.52	1.33	2.44	1.18
2010	130.35	107.83	70.62	76.10	58.23	58.23	4.57	1.44	3.06	1.25
2011	134.30	105.10	69.63	75.41	58.23	58.23	2.41	1.08	1.82	1.05
2012	132.06	102.89	60.18	73.23	58.23	58.23	1.11	1.10	1.03	1.05
2013	132.06	105.23	61.41	73.84	58.23	58.23	1.54	1.10	1.31	1.05
2014	111.14	100.49	64.07	75.79	58.23	58.23	2.29	1.09	1.74	1.05
2015	105.74	101.35	69.34	73.52	58.66	58.66	1.40	1.07	1.23	1.04
2016	120.84	101.98	76.97	74.00	56.04	56.04	1.38	1.04	1.22	1.02
2017	107.77	102.26	76.97	73.24	56.02	56.02	1.25	1.02	1.14	1.01
2018	119.49	101.49	76.97	76.24	55.75	55.75	1.76	1.31	1.45	1.19
2019	117.31	102.14	76.97	75.73	55.50	55.50	1.93	1.81	1.56	1.49
2020	112.17	100.79	76.97	76.36	53.77	53.77	1.63	2.98	1.38	2.18

IEFs of CO_2 ranges from 101 to 140 t/TJ. It is mainly because of local Turkish lignite and its share in solid fuels. Unlike literature lignite of statistics manual, Turkish lignite has a very low NCV, about one-fifth of literature. 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.

IEFs of gaseous fuels do not change considerably over time; for example, IEFs of CO_2 ranges from 53.77 to 58 t CO_2/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. Rising in the trend, however, due to the share of black liquor. "Other Fossil Fuels" node is used for industrial wastes data reporting consisting of the clinic and hazardous wastes.

Emission estimation with T2, T3 approach using plant-specific data is 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 3.21.

Table 3.21 Comparison of GHG emissions from 1.A.1.a category ,1990-2020

	GHG emissions with plant-specific data		GHG emissions with national energy balance data		Difference	
Year	GHG Emission (kt CO_2 eq.)	Fuel consumption (TJ)	GHG Emission (kt CO_2 eq.)	Fuel consumption (TJ)	GHG emission (kt CO_2 eq.)	Fuel consumption (TJ)
1990	32 938	346 707	35 135	360 733	2 197	14 026
1991	34 550	362 934	36 671	374 744	2 121	11 810
1992	39 186	408 249	41 384	423 770	2 198	15 521
1993	38 390	403 148	40 872	418 681	2 482	15 533
1994	44 721	466 134	47 350	484 105	2 629	17 971
1995	46 020	490 230	48 744	509 424	2 724	19 194
1996	49 919	529 408	53 090	551 496	3 171	22 088
1997	55 000	590 895	58 085	612 189	3 085	21 294
1998	60 544	656 466	63 520	680 233	2 976	23 767
1999	65 993	749 301	68 479	763 845	2 486	14 544
2000	73 371	854 300	80 991	956 721	7 620	102 421
2001	75 586	888 392	83 151	990 341	7 565	101 949
2002	69 578	834 375	77 176	943 244	7 598	108 869
2003	69 501	862 965	81 320	990 602	11 819	127 637
2004	70 485	866 064	77 478	969 140	6 993	103 076
2005	85 407	1036 864	84 970	1 067 718	- 437	30 854
2006	90 994	1103 265	92 884	1 148 644	1 890	45 379
2007	108 595	1323 995	108 573	1 352 507	- 22	28 512
2008	113 633	1389 232	118 630	1 471 363	4 997	82 131
2009	115 222	1413 335	112 112	1 396 319	-3 110	-17 016
2010	108 892	1344 379	113 798	1 424 965	4 906	80 586
2011	120 031	1478 115	125 560	1 552 324	5 529	74 209
2012	120 889	1 512 807	126 359	1 581 762	5 470	68 955
2013	116 110	1 451 358	119 945	1 519 612	3 835	68 254
2014	127 006	1 624 731	136 476	1 726 147	9 470	101 416
2015	127 958	1 591 475	127 582	1 561 850	- 376	-29 625
2016	135 554	1 644 763	135 622	1 647 281	68	2 518
2017	146 220	1 804 038	150 275	1 812 282	4 055	8 244
2018	150 032	1 791 671	156 740	1 829 058	6 708	37 387
2019	139 116	1 580 085	147 507	1 620 581	8 391	40 496
2020	131 662	1 585 675	139 561	1 621 157	7 899	35 482

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 Turkish lignite's character, 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 causes 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 NCV in the national balance table 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 results in a 12.1% decrease in lignite consumption in TJ (Table 3.22). 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, but there was an increase 1.0% in 2020.

Table 3.22 Comparison of solid fuel consumption, 1990-2020

	Plant specific data				National energy balance data			
	Hard coal consumption		Lignite consumption		Hard coal consumption		Lignite consumption	
Year	(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
2018	23 437	555 837	71 990	482 560	23 437	555 596	71 990	487 535
2019	23 321	548 539	74 397	505 425	23 320	547 944	74 396	512 511
2020	24 235	553 834	61 471	407 980	23 653	555 774	59 835	412198

Uncertainties and Time-Series Consistency

AD's 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 the activity data source, no bias in total electricity production was published in the 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 the amount of fuel used. Experts of MENR determined uncertainties. For hard coal and Turkish lignite, there is no bias for AD. There is no bias in 2020.

CO_2 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 2019 submission combined uncertainty estimates of solid fuels are quantified using the Monte Carlo simulation. Uncertainty in Solid fuels CO_2 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. The combined uncertainty for these liquid fuels was calculated as 4.24% with the Approach 1 method. In 2019 submission combined uncertainty estimates of Liquid fuels are quantified using the Monte Carlo simulation. Uncertainty in Liquid fuels CO_2 emissions in 2017 are estimated at ±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 the Approach 1 method. In 2019 submission combined uncertainty estimates of Gaseous fuels are quantified using the Monte Carlo simulation. Uncertainty in Gaseous fuels CO_2 emissions in 2017 are estimated at -1.46% to +1.47% with the 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. The 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. The 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 a weighted average according to the generated heat amount. So the combined uncertainty for biomass is 9.57%.

Other Fossil Fuels: Default EFs were taken from 2006 IPCC Guidelines for Industrial wastes (mainly composed of hazardous and clinic waste) and waste oils. On the other hand, there was no default uncertainty value for industrial waste EF throughout the guideline.

EFs uncertainty for CH_4 and N_2O were taken from 2006 IPCC Guidelines Vol.2 page 2.38 Table 2.12 and considered 100% (mid-value in the range).

Recalculation

There is no recalculation for this category.

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_2 eq. from petroleum refining in energy industries sector (1A1) was 6.4% in 2020 and it was also 6.2% in 1990.

Table 3.23 Emissions from petroleum refining, 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1A1 category (%)
1990	2 289	0.07	0.014	2 295	32 091	6.2
1991	2 216	0.07	0.013	2 222	31 079	5.7
1992	2 312	0.07	0.013	2 318	33 474	5.4
1993	2 655	0.08	0.014	2 662	38 946	6.2
1994	2 889	0.09	0.016	2 896	42 342	5.9
1995	2 984	0.09	0.016	2 991	43 872	5.9
1996	2 932	0.09	0.016	2 940	42 422	5.4
1997	3 000	0.09	0.016	3 007	44 520	5.1
1998	3 059	0.10	0.017	3 066	44 866	4.7
1999	2 873	0.09	0.016	2 880	41 464	4.1
2000	2 914	0.09	0.017	2 922	41 749	3.8
2001	2 994	0.09	0.017	3 001	43 607	3.8
2002	3 342	0.10	0.017	3 350	50 707	4.5
2003	3 526	0.10	0.018	3 534	53 136	4.8
2004	3 723	0.11	0.019	3 731	56 999	5.0
2005	4 265	0.12	0.019	4 273	66 632	4.7
2006	4 311	0.12	0.019	4 320	68 480	4.5
2007	4 475	0.12	0.019	4 483	70 498	4.0
2008	5 016	0.13	0.019	5 025	82 039	4.2
2009	3 147	0.09	0.014	3 154	48 778	2.7
2010	3 531	0.08	0.012	3 537	58 930	3.1
2011	4 326	0.09	0.012	4 331	73 409	3.5
2012	4 210	0.09	0.012	4 216	72 549	3.3
2013	3 549	0.08	0.010	3 554	60 957	3.0
2014	3 424	0.07	0.009	3 429	59 412	2.6
2015	5 503	0.12	0.015	5 510	96 958	4.1
2016	8 347	0.16	0.022	8 358	129 038	5.8
2017	8 717	0.16	0.019	8 727	136 691	5.6
2018	7 044	0.14	0.016	7 053	131 107	4.5
2019	7 972	0.14	0.015	7 980	128 096	5.4
2020	9 029	0.14	0.015	9 037	128 401	6.4

Total emissions from petroleum refining were increased by 1 057 kt CO_2 eq. from 2019 to 2020 (13% of increase).

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_2 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_4 and N_2O 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_2 and 100% (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1.A.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:

Activity data and newly added and other fuel’s emissions factor have been revised. This recalculation caused 13.5% change in 2019 emissions as CO_2 eq.

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. Under the MRV framework, emissions from this category will be replaced with the emissions from plant reported to Ministry of Environment, Urbanisation and Climate Change in next submission

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_2 eq. from manufacture of solid fuels category in 1A1 category was 1.6% in 2020 while it was 5.4% in 1990.

Table 3.24 Emissions from category 1.A.1.c, 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1A1 Category (%)
1990	2 027	0.017	0.005	2 029	17 058	5.4
1991	2 034	0.017	0.005	2 036	17 232	5.2
1992	1 815	0.015	0.005	1 817	15 004	4.2
1993	1 680	0.014	0.003	1 681	13 782	3.9
1994	1 422	0.011	0.001	1 423	11 170	2.9
1995	1 429	0.012	0.001	1 429	11 623	2.8
1996	1 567	0.012	0.001	1 567	12 188	2.9
1997	1 536	0.012	0.001	1 537	11 657	2.6
1998	1 504	0.012	0.001	1 505	11 550	2.3
1999	1 465	0.011	0.001	1 466	11 271	2.1
2000	1 432	0.011	0.001	1 433	10 944	1.8
2001	1 399	0.010	0.001	1 399	10 483	1.7
2002	1 329	0.010	0.001	1 329	10 115	1.8
2003	1 480	0.012	0.002	1 481	11 129	2.0
2004	1 477	0.017	0.004	1 478	13 403	2.0
2005	1 276	0.013	0.003	1 277	11 761	1.4
2006	1 371	0.015	0.004	1 372	12 812	1.4
2007	1 247	0.013	0.002	1 248	11 737	1.1
2008	1 341	0.014	0.002	1 342	13 690	1.1
2009	1 298	0.012	0.001	1 299	11 988	1.1
2010	1 721	0.011	0.001	1 722	11 494	1.5
2011	1 903	0.011	0.001	1 903	11 433	1.5
2012	1 953	0.012	0.001	1 954	12 251	1.5
2013	1 956	0.014	0.001	1 956	13 916	1.6
2014	2 054	0.015	0.001	2 055	14 593	1.6
2015	2 267	0.016	0.002	2 267	15 784	1.7
2016	2 028	0.013	0.001	2 028	13 402	1.4
2017	2 383	0.014	0.001	2 384	13 996	1.5
2018	2 323	0.014	0.001	2 324	13 524	1.5
2019	2 393	0.014	0.002	2 393	13 838	1.6
2020	2 226	0.014	0.001	2 227	14 254	1.6

Total emissions from manufacture of solid fuels and other energy industries were decreased by 166 kt CO_2 eq. from 2019 to 2020 (6.9% of decrease) due to decrease 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_2 emissions from 1.A.1.c were calculated by using plant specific AD, carbon contents of fuels and 2006 IPCC default oxidation rates. CH_4 and N_2O emissions from CRF category 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_2 and 100% (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1.A.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:

No recalculation in this sector.

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 3.25 Fuel combustion emissions from manufacturing industry and construction, 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in fuel combustion (1A) category (%)
1990	37 004	1.84	0.35	37 153	386 908	27.5
1991	40 162	1.96	0.38	40 324	421 807	28.9
1992	39 168	1.69	0.34	39 313	422 604	26.9
1993	39 832	1.78	0.34	39 978	441 625	26.2
1994	35 741	1.30	0.30	35 863	394 963	24.0
1995	39 843	1.60	0.34	39 983	452 068	24.6
1996	50 376	2.37	0.46	50 573	553 552	28.1
1997	55 794	2.65	0.52	56 014	613 749	29.2
1998	55 221	3.01	0.55	55 459	597 667	29.0
1999	47 158	2.28	0.46	47 351	530 985	25.2
2000	57 657	3.44	0.61	57 925	629 742	27.6
2001	45 470	2.16	0.41	45 645	504 554	23.6
2002	56 856	3.17	0.56	57 102	633 369	28.5
2003	66 388	3.59	0.64	66 668	748 880	31.0
2004	63 558	3.48	0.65	63 839	750 894	28.9
2005	62 731	3.13	0.59	62 987	743 394	26.4
2006	69 749	3.96	0.73	70 064	846 725	27.5
2007	71 521	4.16	0.76	71 852	867 730	25.3
2008	47 169	1.82	0.40	47 334	578 884	16.9
2009	46 034	1.85	0.42	46 204	550 987	16.2
2010	52 120	1.66	0.46	52 298	639 363	18.7
2011	52 380	1.53	0.44	52 550	662 028	17.5
2012	60 821	1.88	0.50	61 017	760 755	19.5
2013	52 772	1.65	0.45	52 946	648 612	17.7
2014	54 233	1.75	0.44	54 409	680 149	17.2
2015	59 359	2.02	0.49	59 554	765 682	17.7
2016	59 840	2.03	0.50	60 039	785 911	17.0
2017	59 958	2.05	0.48	60 152	780 500	16.0
2018	59 311	3.22	0.62	59 576	814 062	16.3
2019	54 277	3.30	0.59	54 535	754 558	15.3
2020	59 869	3.48	0.65	60 150	814 780	16.8

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 60.1 Mt CO_2 eq. in 2020 which is 16.8% of total fuel combustion and 11.5% of total national emissions (excluding LULUCF), whereas GHG emissions from 1.A.2 category was 37.2 Mt CO_2 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 decrease by 5.6 Mt CO_2 eq. (10.3%) from 2019 to 2020.

Table 3.26 GHG emissions from manufacturing industry and construction, 1990-2020

(kt CO_2 eq.)

Year	Total	Iron and steel	Non-ferrous metals	Chemicals	Pulp, paper and print	Food processing beverages and tobacco	Non-metallic minerals	Other industries
1990	37 153	6 686	1 088	4 893	NO,IE	2 909	8 253	13 324
1991	40 324	6 549	1 016	4 458	NO,IE	2 910	9 389	16 001
1992	39 313	7 066	1 069	4 926	NO,IE	2 340	8 186	15 726
1993	39 978	6 406	980	4 811	NO,IE	2 139	8 156	17 486
1994	35 863	6 236	1 307	4 244	NO,IE	1 573	9 498	13 005
1995	39 983	5 591	1 756	4 962	NO,IE	1 685	8 782	17 207
1996	50 573	6 333	1 359	4 881	NO,IE	2 235	10 339	25 426
1997	56 014	6 348	1 248	4 945	NO,IE	2 188	9 487	31 797
1998	55 459	6 152	1 167	4 086	NO,IE	2 641	8 384	33 030
1999	47 351	5 576	1 700	3 592	NO,IE	2 025	10 748	23 710
2000	57 925	6 566	1 952	3 762	NO,IE	2 143	9 237	34 263
2001	45 645	6 732	1 989	5 074	NO,IE	3 979	8 835	19 035
2002	57 102	6 461	2 142	4 561	NO,IE	3 910	8 901	31 127
2003	66 668	6 185	1 938	4 393	NO,IE	2 698	10 141	41 312
2004	63 839	5 057	2 188	6 857	NO,IE	2 341	13 201	34 194
2005	62 987	5 482	2 225	5 346	NO,IE	2 119	14 865	32 949
2006	70 064	4 524	2 489	4 491	NO,IE	2 011	14 881	41 670
2007	71 852	4 640	2 400	2 058	NO,IE	1 384	13 473	47 896
2008	47 334	4 223	239	945	NO,IE	1 371	18 574	21 983
2009	46 204	2 042	988	2 452	NO,IE	459	16 493	23 770
2010	52 298	3 657	1 153	2 900	NO,IE	880	21 325	22 383
2011	52 550	3 990	755	3 139	776	3 378	25 310	15 200
2012	61 017	4 380	1 173	4 646	743	3 529	27 904	18 643
2013	52 946	4 638	760	3 942	766	3 603	26 343	12 894
2014	54 409	4 992	989	3 705	888	3 322	28 228	12 285
2015	59 554	5 287	1 199	6 689	963	4 359	29 925	11 133
2016	60 039	4 190	1 407	6 071	1 076	4 962	31 601	10 733
2017	60 152	4 327	1 136	5 317	942	4 921	32 550	10 959
2018	59 576	4 215	809	7 032	982	5 080	30 193	11 266
2019	54 535	4 620	773	6 404	1 024	5 180	25 431	11 103
2020	60 150	5 633	694	6 840	1 270	5 866	29 593	10 255

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 49.2%.

Table 3.27 Contribution of subsectors of manufacturing industries and construction, 2019-2020

	Emissions ($kt\ CO_2$ eq.)		Changes from 2019 to 2020		Share in manufacturing industry (%)	
	2019	2020	($kt\ CO_2$ eq.)	(%)	2019	2020
1.A.2 Total	54 535	60 150	5 614	10.3	100.0	100.0
Iron and steel	4 620	5 633	1 013	21.9	8.5	9.4
Non-ferrous metals	773	694	- 79	-10.2	1.4	1.2
Chemicals	6 404	6 840	435	6.8	11.7	11.4
Pulp, paper and print	1 024	1 270	247	24.1	1.9	2.1
Food processing, beverages and tobacco	5 180	5 866	685	13.2	9.5	9.8
Non-metallic minerals	25 431	29 593	4 161	16.4	46.6	49.2
Other industries	11 103	10 255	-848	-7.6	20.4	17.0

GHG emissions from 1.A.2 category have been decreased by 1% between 2017 and 2018.

Manufacturing industry and construction category is a key category in terms of emission level and emission trend of CO_2 emissions from liquid, solid and gaseous fuels in 2020. It is also a key category in terms of emission level of CO_2 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_2 EFs are used when available, otherwise default CO_2 EFs are used. All CO_2 EFs are given in table 3.18 under 3.2 Fuel Combustion Sector. All CH_4 and N_2O EFs are default. The default CH_4 and N_2O EFs for 1A2 sector are tabulated below.

Table 3.28 Defualt CH_4 and N_2O EFs for 1A2 sector

	Emission Factors		Source
Sub Sectors	**CH_4 (kg/TJ)**	**N_2O(kg/TJ)**	
1A2 sector			
Coal products	10	1.5	Table 2.3
LPG	1	0.1	Table 2.3
Other Petroluem 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 Directorate of Energy Efficiency and Environment. The list of all waste incineration facilities having waste incineration licenses was determined from the MoEU. Then the amount of waste incinerated and NCVs as MJ/kg by waste types were compiled from all facilities listed by the MoEU. Plant specific waste incineration data and NCVs were used in the GHG estimation. But, 2006 IPCC default EFs were used for CO_2, CH_4 and N_2O emission estimation.

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_2 and 100% (mid value in the range) for CH_4 and N_2O. The same uncertainties were used for all subcategories of 1A2 except 1A2a.

Source-Specific QA/QC and Verification:

Quality control for 1A2 category was performed on the basis of QA/QC plan. 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_2 IEFs in the time series for liquid and solid fuels.

Table 3.29 CO_2 implied emission factors for 1A2 category

Year	Liquid	Solid	Gaseous
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
2018	94.3	97.4	55.3
2019	93.8	99.1	53.7
2020	94.3	97.2	55.7

It can be seen on the table that CO_2 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_2 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:

1.A.2.a, 1.A.2.c, 1.A.2.f and 1.A.2.g sectors were recalculated due to the revision AD for the year 2019. Recalculation effected 2019 emission as 0.88% for 1.A.2

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 Türkiye. The share of GHG emissions as CO_2 eq. from 1A2a in total 1A2 was 9.4% in 2020 while it was 18.0% in 1990

Table 3.30 Fuel combustion emissions from iron and steel industry, 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1.A.2 (%)
1990	6 678	0.099	0.017	6 686	51 756	18.0
1991	6 541	0.102	0.018	6 549	52 848	16.2
1992	7 057	0.112	0.019	7 066	57 620	18.0
1993	6 397	0.111	0.020	6 406	53 175	16.0
1994	6 228	0.103	0.018	6 236	50 715	17.4
1995	5 584	0.095	0.017	5 591	46 104	14.0
1996	6 325	0.105	0.018	6 333	51 497	12.5
1997	6 341	0.101	0.018	6 348	50 825	11.3
1998	6 145	0.097	0.017	6 152	48 952	11.1
1999	5 569	0.085	0.015	5 576	43 873	11.8
2000	6 559	0.092	0.016	6 566	49 855	11.3
2001	6 726	0.090	0.015	6 732	50 208	14.7
2002	6 455	0.086	0.014	6 461	47 941	11.3
2003	6 179	0.083	0.014	6 185	46 012	9.3
2004	5 052	0.066	0.011	5 057	37 403	7.9
2005	5 478	0.059	0.009	5 482	37 766	8.7
2006	4 521	0.044	0.006	4 524	30 178	6.5
2007	4 637	0.041	0.006	4 640	30 080	6.5
2008	4 220	0.053	0.006	4 223	45 251	8.9
2009	2 040	0.020	0.002	2 042	19 606	4.4
2010	3 652	0.077	0.012	3 657	47 148	7.0
2011	3 987	0.058	0.006	3 990	56 485	7.6
2012	4 377	0.051	0.005	4 380	50 211	7.2
2013	4 635	0.061	0.006	4 638	59 556	8.8
2014	4 989	0.062	0.006	4 992	61 286	9.2
2015	5 282	0.073	0.011	5 287	71 979	8.9
2016	4 186	0.065	0.008	4 190	63 997	7.0
2017	4 322	0.072	0.009	4 327	71 184	7.2
2018	4 207	0.124	0.016	4 215	70 018	7.1
2019	4 615	0.081	0.010	4 620	75 977	8.5
2020	5 627	0.086	0.010	5 633	83 337	9.4

Total emissions from iron and steel subcategory was increased by 1 013 kt CO_2 eq. from 2019 to 2020 (22% 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_2 EF are used when available, otherwise default CO_2 EF are used. All CH_4 and N_2O 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_2. EFs uncertainty for CH_4 and N_2O 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:

There is recalculation for the year 2019 due to the revision of AD. Recalculation effected 2019 emission as 0.9%.

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_2 eq. from 1.A.2.b in total manufacturing industry fuel combustion was 1.2% in 2020 while it was 2.9% in 1990.

Table 3.31 Fuel combustion emissions from non-ferrous metals, 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1.A.2 category (%)
1990	1 084	0.049	0.009	1 088	13 187	2.9
1991	1 013	0.049	0.009	1 016	12 422	2.5
1992	1 065	0.053	0.010	1 069	12 967	2.7
1993	976	0.049	0.009	980	11 829	2.4
1994	1 302	0.064	0.012	1 307	15 676	3.6
1995	1 750	0.084	0.014	1 756	22 300	4.4
1996	1 355	0.058	0.010	1 359	18 282	2.7
1997	1 244	0.061	0.011	1 248	15 854	2.2
1998	1 162	0.062	0.011	1 167	14 014	2.1
1999	1 695	0.073	0.012	1 700	23 842	3.6
2000	1 945	0.099	0.016	1 952	25 668	3.4
2001	1 982	0.100	0.016	1 989	26 110	4.3
2002	2 134	0.106	0.017	2 142	28 721	3.7
2003	1 932	0.079	0.013	1 938	27 655	2.9
2004	2 182	0.087	0.014	2 188	32 282	3.4
2005	2 219	0.084	0.013	2 225	33 266	3.5
2006	2 482	0.089	0.014	2 489	38 255	3.5
2007	2 393	0.099	0.014	2 400	37 010	3.3
2008	239	0.004	0.000	239	4 256	0.5
2009	987	0.020	0.002	988	17 086	2.1
2010	1 151	0.025	0.003	1 153	20 089	2.2
2011	754	0.016	0.002	755	13 016	1.4
2012	1 171	0.027	0.003	1 173	20 393	1.9
2013	759	0.017	0.002	760	13 379	1.4
2014	987	0.022	0.002	989	17 371	1.8
2015	1 197	0.033	0.004	1 199	20 103	2.0
2016	1 404	0.046	0.006	1 407	22 925	2.3
2017	1 134	0.040	0.005	1 136	18 034	1.9
2018	807	0.032	0.004	809	12 650	1.4
2019	771	0.027	0.003	773	13 016	1.4
2020	693	0.024	0.003	694	11 410	1.2

The decrease in total emissions of 1.A.2.b category from 2019 to 2020 is 79 kt CO_2 eq. (10.2% 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_2 EFs are used for emission estimation.CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs. GHG emissions from biomass were estimated by using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

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

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

Source-Specific QA/QC and Verification:

Quality control for 1.A.2.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_2, CH_4 and N_2O IEFs for all fuels are in the range of 2006 IPCC Guidelines but are changing based on fuel mix used in the sector

Recalculation:

There is recalculation for the year 2018 due to the revision of the country specific emission factor for solid fuels. Recalculation effected 2018 emission as 0.9%.

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_2 eq. from 1.A.2.c in total manufacturing industry was 11.3% in 2020 while it was 13.1% in 1990.

Table 3.32 Fuel combustion emissions from chemicals, 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1.A.2 category (%)
1990	4 875	0,237	0,040	4 893	62 789	13,1
1991	4 444	0,178	0,031	4 458	61 951	11,0
1992	4 912	0,179	0,031	4 926	70 629	12,5
1993	4 799	0,170	0,028	4 811	70 578	12,0
1994	4 233	0,153	0,026	4 244	61 162	11,8
1995	4 948	0,174	0,030	4 962	71 612	12,4
1996	4 868	0,169	0,029	4 881	70 777	9,6
1997	4 933	0,166	0,028	4 945	73 001	8,8
1998	4 073	0,159	0,028	4 086	56 268	7,3
1999	3 581	0,140	0,025	3 592	49 495	7,6
2000	3 751	0,146	0,027	3 762	51 629	6,5
2001	5 059	0,194	0,036	5 074	69 258	11,1
2002	4 549	0,163	0,028	4 561	65 875	8,0
2003	4 382	0,142	0,025	4 393	64 521	6,6
2004	6 838	0,237	0,044	6 857	97 606	10,7
2005	5 334	0,157	0,026	5 346	82 163	8,5
2006	4 481	0,133	0,023	4 491	68 710	6,4
2007	2 056	0,044	0,005	2 058	36 059	2,9
2008	944	0,023	0,003	945	16 381	2,0
2009	2 445	0,101	0,014	2 452	37 259	5,3
2010	2 889	0,137	0,023	2 900	40 314	5,5
2011	3 132	0,121	0,016	3 139	49 224	6,0
2012	4 635	0,164	0,023	4 646	74 005	7,6
2013	3 929	0,195	0,027	3 942	57 487	7,4
2014	3 692	0,189	0,026	3 705	54 713	6,8
2015	6 672	0,260	0,034	6 689	106 985	11,2
2016	6 054	0,257	0,035	6 071	97 036	10,1
2017	5 306	0,180	0,023	5 317	87 051	8,8
2018	7 010	0,330	0,044	7 032	111 968	11,8
2019	6 385	0,297	0,040	6 404	101 747	11,7
2020	6 820	0,299	0,041	6 840	107 599	11,3

The increase in total emissions of 1.A.2.c category from 2019 to 2020 is 435 kt CO_2 eq. (6.8% 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_2 EFs are used for emission estimation. GHG emissions from waste incineration were estimated by using 2006 IPCC default EFs. CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

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

For other fossil fuels it was considered 2% as indicated in table 2.15 of 2006 IPCC 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_2 and 100% was taken (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1A2c category was performed on the basis of QA/QC plan. Emission trends are analyzed. If there is a high fluctuation in the series, then AD and emission calculation are re-examined. Also country specific carbon content of fuels is checked with IPCC default values to ensure they are in the range. Reasonability of IEFs is compared with the previous annual submission and with the 2006 IPCC Guidelines.

Recalculation:

There is recalculation for the year 2019 due to the revision of wate inceneration data. Recalculation effected 2019 emission as 0.2%.

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_2 eq. from 1.A.2.d in total manufacturing industry fuel combustion was 2.1% in bo 2020.

Table 3.33 Fuel combustion emissions from pulp, paper and print, 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 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	0.036	0.005	776	11 127	1.5
2012	740	0.041	0.006	743	9 972	1.2
2013	764	0.037	0.005	766	11 118	1.4
2014	885	0.050	0.007	888	12 315	1.6
2015	960	0.057	0.008	963	12 946	1.6
2016	1 072	0.058	0.008	1 076	15 156	1.8
2017	939	0.051	0.007	942	13 014	1.6
2018	977	0.072	0.010	982	13 303	1.6
2019	1 019	0.064	0.009	1 024	14 181	1.9
2020	1 264	0.084	0.012	1 270	17 481	2.1

The increase in total emissions of 1.A.2.d category from 2019 to 2020 is 245 kt CO_2 eq. (24.1% of increase).

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_2 EFs are used for emission estimation. CH_4 and N_2O 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_2 and 100% (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1.A.2.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:

There is no recalculation in this sector.

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_2 eq. from 1.A.2.e in total 1.A.2 GHG emissions was 7.8% in 1990 while it was 9.8% in 2020.

Table 3.34 Fuel combustion emissions from 1A2e category, 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1.A.2 category (%)
1990	2 892	0.238	0.037	2 909	27 656	7.8
1991	2 894	0.235	0.036	2 910	27 243	7.2
1992	2 327	0.186	0.029	2 340	22 194	6.0
1993	2 127	0.169	0.026	2 139	20 484	5.4
1994	1 564	0.123	0.019	1 573	15 217	4.4
1995	1 676	0.128	0.020	1 685	16 894	4.2
1996	2 223	0.165	0.025	2 235	23 019	4.4
1997	2 176	0.164	0.025	2 188	22 416	3.9
1998	2 626	0.210	0.032	2 641	25 636	4.8
1999	2 014	0.160	0.025	2 025	20 370	4.3
2000	2 130	0.188	0.028	2 143	20 673	3.7
2001	3 960	0.258	0.042	3 979	44 605	8.7
2002	3 892	0.243	0.040	3 910	44 296	6.8
2003	2 685	0.188	0.030	2 698	29 055	4.0
2004	2 330	0.156	0.025	2 341	26 249	3.7
2005	2 108	0.158	0.024	2 119	22 373	3.4
2006	2 001	0.142	0.022	2 011	22 391	2.9
2007	1 377	0.102	0.015	1 384	14 436	1.9
2008	1 365	0.069	0.012	1 371	17 717	2.9
2009	456	0.036	0.006	459	4 622	1.0
2010	877	0.047	0.007	880	12 244	1.7
2011	3 364	0.206	0.030	3 378	43 421	6.4
2012	3 515	0.208	0.030	3 529	46 695	5.8
2013	3 591	0.188	0.027	3 603	50 942	6.8
2014	3 310	0.187	0.027	3 322	46 330	6.1
2015	4 342	0.257	0.037	4 359	58 490	7.3
2016	4 943	0.277	0.040	4 962	69 245	8.3
2017	4 902	0.281	0.040	4 921	67 426	8.2
2018	5 047	0.495	0.068	5 080	77 611	8.5
2019	5 156	0.357	0.050	5 180	75 449	9.5
2020	5 838	0.407	0.058	5 866	83 228	9.8

Total GHG emission in 1.A.2.e category increased 682 kt CO_2 eq. (13.2% of increase) from 2019 to 2020.

Methodological Issues:

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

Country specific CO_2 EFs are used for emission estimation. CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

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

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

Source-Specific QA/QC and Verification:

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

Recalculation:

There is no recalculation in this sector.

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 Türkiye, 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_2 eq. from 1.A.2.f in total manufacturing industry GHG emission was 49.2% in 2020 while it was 22.2% in 1990.

Table 3.35 Fuel combustion emissions from non-metallic minerals, 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1.A.2 category (%)
1990	8 216	0.306	0.100	8 253	85 781	22.2
1991	9 348	0.294	0.112	9 389	97 120	23.3
1992	8 155	0.146	0.093	8 186	84 425	20.8
1993	8 127	0.200	0.082	8 156	84 789	20.4
1994	9 463	0.132	0.106	9 498	95 240	26.5
1995	8 750	0.150	0.097	8 782	86 732	22.0
1996	10 301	0.176	0.110	10 339	102 402	20.4
1997	9 452	0.116	0.109	9 487	93 114	16.9
1998	8 354	0.128	0.091	8 384	82 232	15.1
1999	10 708	0.170	0.121	10 748	110 905	22.7
2000	9 204	0.158	0.100	9 237	94 531	15.9
2001	8 804	0.150	0.093	8 835	88 560	19.4
2002	8 870	0.160	0.093	8 901	90 270	15.6
2003	10 105	0.152	0.110	10 141	100 807	15.2
2004	13 152	0.205	0.147	13 201	136 689	20.7
2005	14 810	0.277	0.158	14 865	152 922	23.6
2006	14 824	0.260	0.169	14 881	156 317	21.2
2007	13 419	0.184	0.167	13 473	141 561	18.8
2008	18 497	0.530	0.213	18 574	192 996	39.2
2009	16 430	0.295	0.185	16 493	165 653	35.7
2010	21 240	0.318	0.258	21 325	209 775	40.8
2011	25 214	0.450	0.283	25 310	273 446	48.2
2012	27 797	0.601	0.309	27 904	298 718	45.7
2013	26 240	0.615	0.292	26 343	277 274	49.8
2014	28 122	0.708	0.295	28 228	309 282	51.9
2015	29 810	0.825	0.315	29 925	332 379	50.2
2016	31 482	0.828	0.330	31 601	360 842	52.6
2017	32 430	0.934	0.323	32 550	362 747	54.1
2018	30 048	1.401	0.370	30 193	351 235	50.7
2019	25 292	1.505	0.342	25 431	303 022	46.6
2020	29 440	1.536	0.382	29 593	351 842	49.2

The increase in total GHG emission of 1.A.2.f category is 4 148 kt CO_2 eq. (16.4% of increase) from 2019 to 2020.

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_2 EFs are used for emission estimation. GHG emissions from waste incineration and biomass were estimated by using 2006 IPCC default EFs. CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

The AD 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_2 and 100% (mid value in the range) for CH_4 and N_2O.

Source-Specific QA/QC and Verification:

Quality control for 1.A.2.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_2, CH_4 and N_2O IEFs for all fuels are in the range of 2006 IPCC guidelines but are changing based on fuel mix used in the sector.

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:

There is recalculation for the year 1990-2019 due to the revision of AD. Recalculation effected 2019 emission as 0.08%.

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_2 eq. from 1.A.2.g in total manufacturing industry fuel combustion was 17% in 2020 while it was 35.9% in 1990.

Table 3.36 Fuel combustion emissions from other industries, 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1.A.2 category (%)
1990	13 258	0.907	0.145	13 324	145 738	35.9
1991	15 922	1.103	0.175	16 001	170 223	39.7
1992	15 652	1.010	0.163	15 726	174 768	40.0
1993	17 407	1.084	0.176	17 486	200 769	43.7
1994	12 951	0.721	0.119	13 005	156 954	36.3
1995	17 135	0.973	0.158	17 207	208 427	43.0
1996	25 304	1.696	0.268	25 426	287 576	50.3
1997	31 649	2.046	0.324	31 797	358 538	56.8
1998	32 862	2.360	0.365	33 030	370 563	59.6
1999	23 591	1.653	0.259	23 710	282 500	50.1
2000	34 068	2.755	0.422	34 263	387 385	59.2
2001	18 940	1.366	0.206	19 035	225 814	41.7
2002	30 957	2.410	0.367	31 127	356 265	54.5
2003	41 104	2.948	0.450	41 312	480 830	62.0
2004	34 004	2.730	0.410	34 194	420 665	53.6
2005	32 781	2.400	0.364	32 949	414 903	52.3
2006	41 441	3.291	0.493	41 670	530 874	59.5
2007	47 639	3.694	0.555	47 896	608 583	66.7
2008	21 905	1.139	0.166	21 983	302 283	46.4
2009	23 674	1.376	0.207	23 770	306 760	51.4
2010	22 310	1.052	0.158	22 383	309 794	42.8
2011	15 154	0.641	0.101	15 200	215 309	28.9
2012	18 587	0.789	0.123	18 643	260 761	30.6
2013	12 854	0.540	0.087	12 894	178 856	24.4
2014	12 248	0.531	0.080	12 285	178 853	22.6
2015	11 097	0.518	0.076	11 133	162 800	18.7
2016	10 699	0.498	0.072	10 733	156 710	17.9
2017	10 925	0.495	0.070	10 959	161 044	18.2
2018	11 215	0.769	0.106	11 266	177 276	18.9
2019	11 039	0.967	0.135	11 103	171 165	20.4
2020	10 185	1.045	0.145	10 255	159 883	17.0

Total GHG emission in 1.A.2.g category decreased 853 kt CO_2 eq. (7.7% of increase) from 2019 to 2020.

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_2 EFs are used for emission estimation. CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

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

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

Source-Specific QA/QC and Verification:

Quality control for 1.A.2.g category was performed on the basis of QA/QC plan.CO_2, CH_4 and N_2O IEFs for all fuels are in the range of 2006 IPCC Guidelines.

Recalculation:

There is recalculation for the year 2019 due to the revision of AD. Recalculation effected 2019 emission as 0.12%.

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 199.2% higher in 2020 than in 1990, and on average emissions increased by more than 6.4% annually.

In 2020, transport sector contributed to 80.7 Mt CO_2 eq. emissions (Figure 3.13). GHG emissions (in CO_2 eq.) from transport sector as a share of total fuel combustion was 22.5% in 2020 while it was 20% in 1990.

GHG emissions by transport sector and transport modes are given in Table 3.37 and 3.38 respectively. As shown in Figure 3.14, road transportation is the major CO_2 source contributing to 94.9% of transport emissions in 2020. Contribution of domestic aviation is 2.7%, domestic water-borne navigation is 1.6%, and railways are 0.4% in 2020. The share of pipeline transportation is 0.4%.

Figure 3.13 GHG emissions for transportation sector, 1990-2020

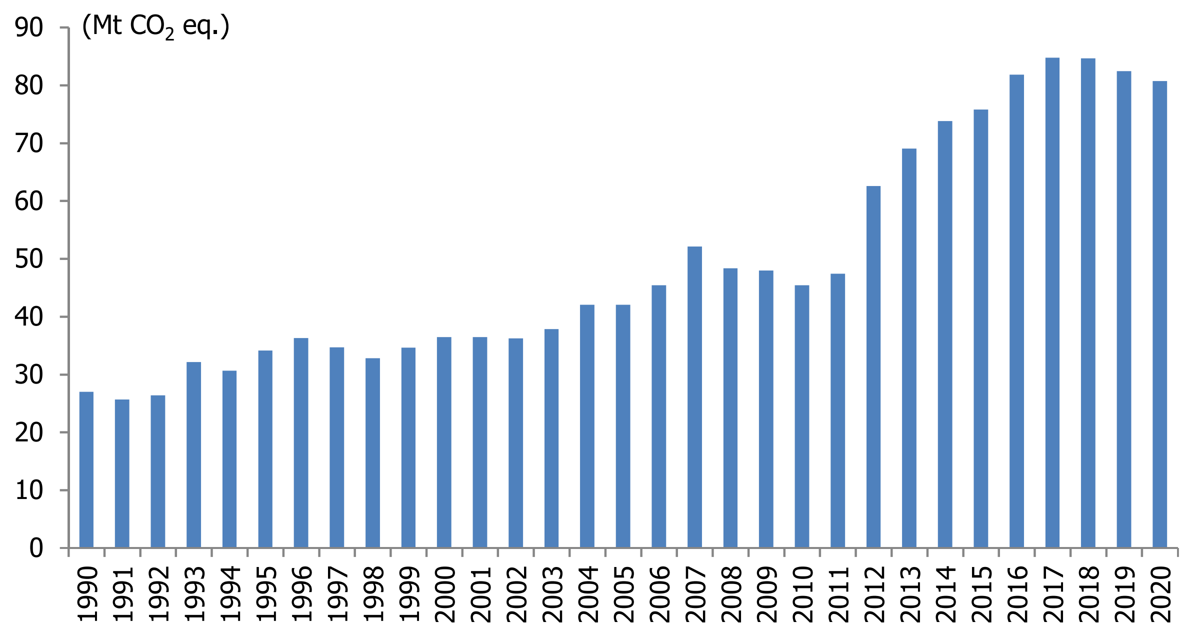


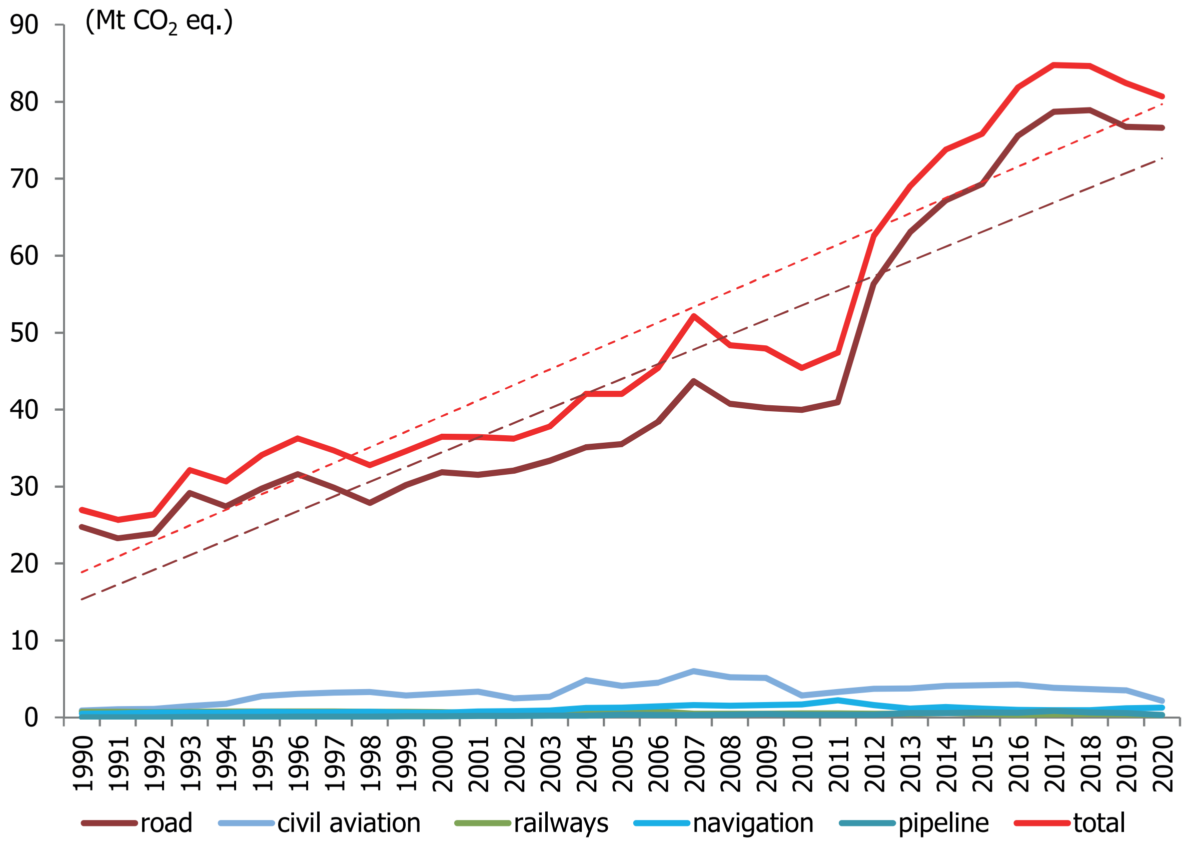
Table 3.37 GHG emissions from transport sector, 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ
1990	26 251	4.0	2.1	26 969	364 617
1991	24 982	3.8	2.0	25 673	347 164
1992	25 640	4.2	2.1	26 366	356 995
1993	31 269	5.0	2.5	32 143	435 401
1994	29 789	4.9	2.4	30 640	415 493
1995	33 180	5.5	2.7	34 113	463 044
1996	35 277	5.9	2.8	36 271	492 752
1997	33 702	7.0	2.7	34 690	474 602
1998	31 817	7.5	2.6	32 782	450 289
1999	33 635	7.8	2.6	34 617	475 418
2000	35 490	8.9	2.5	36 465	503 352
2001	35 534	8.4	2.4	36 455	503 006
2002	35 316	7.9	2.4	36 234	498 404
2003	36 893	8.1	2.4	37 825	520 124
2004	41 061	8.3	2.6	42 048	578 405
2005	41 044	8.6	2.6	42 041	578 712
2006	44 377	9.2	2.7	45 424	625 285
2007	50 989	10.4	2.8	52 099	718 824
2008	47 117	10.5	2.6	48 166	668 762
2009	46 871	11.0	2.6	47 907	664 439
2010	44 383	11.4	2.4	45 392	630 304
2011	46 367	11.5	2.5	47 386	657 982
2012	61 249	12.6	3.2	62 525	862 220
2013	67 478	13.0	3.6	68 865	948 734
2014	72 084	13.6	3.8	73 559	1 013 762
2015	74 263	14.5	3.9	75 789	1 047 749
2016	80 208	15.4	4.2	81 841	1 129 546
2017	82 954	15.4	4.4	84 659	1 182 246
2018	82 788	15.9	4.4	84 502	1 182 683
2019	80 745	16.0	4.3	82 427	1 153 518
2020	79 033	15.2	4.3	80 680	1 124 064

Table 3.38 GHG emissions by transport mode, 1990-2020

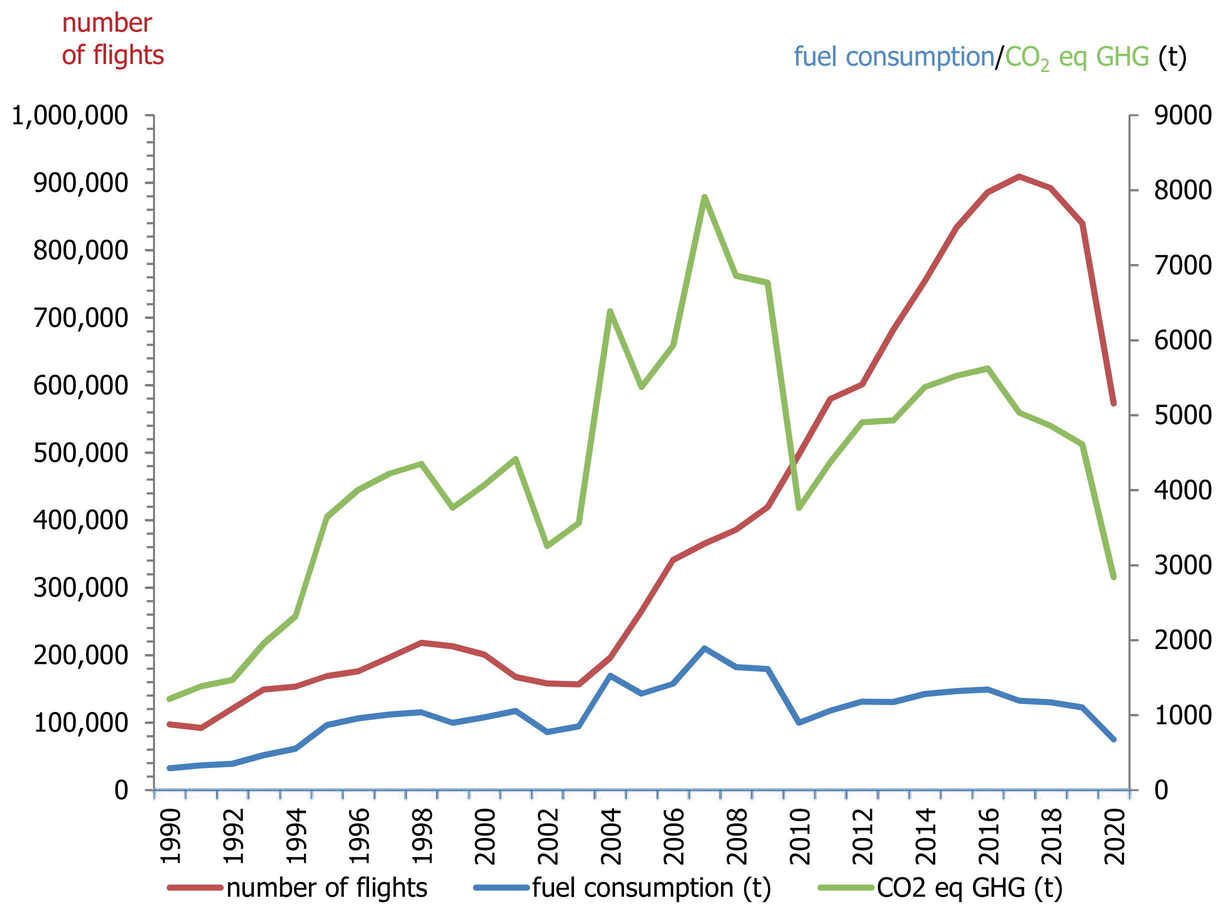
Year	Road transportation	Domestic aviation	Railways	Domestic navigation	Other transportation	Total
1990	24 777	923	721	509	39	26 969
1991	23 288	1 053	740	543	49	25 673
1992	23 871	1 118	685	638	54	26 366
1993	29 178	1 489	751	664	60	32 143
1994	27 419	1 764	768	623	65	30 640
1995	29 760	2 775	768	726	83	34 113
1996	31 628	3 048	799	699	97	36 271
1997	29 858	3 215	799	698	120	34 690
1998	27 881	3 311	740	726	124	32 782
1999	30 219	2 868	722	658	150	34 617
2000	31 850	3 099	713	623	180	36 465
2001	31 512	3 358	587	800	198	36 455
2002	32 084	2 503	612	822	213	36 234
2003	33 347	2 713	629	891	245	37 825
2004	35 090	4 859	629	1 228	242	42 048
2005	35 532	4 089	757	1 299	364	42 041
2006	38 370	4 512	761	1 464	317	45 424
2007	43 674	6 019	470	1 598	338	52 099
2008	40 559	5 218	499	1 543	348	48 166
2009	40 204	5 149	484	1 632	437	47 907
2010	39 941	2 862	517	1 682	390	45 392
2011	40 899	3 344	532	2 242	370	47 386
2012	56 310	3 727	492	1 614	381	62 525
2013	62 889	3 754	505	1 154	563	68 865
2014	66 967	4 090	562	1 348	593	73 559
2015	69 309	4 205	480	1 147	647	75 789
2016	75 595	4 281	374	970	621	81 841
2017	78 706	3 838	413	944	869	84 770
2018	78 907	3 688	435	931	657	84 617
2019	76 720	3 509	400	1 217	581	82 428
2020	76 601	2 164	323	1 264	328	80 680

Figure 3.14 GHG emission trend by transport mode, 1990-2020



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 3.15), there are different factors influencing GHG emissions resulting from domestic aviation. Fuel consumption rose steadily in domestic aviation sector up to year 1999. Because 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. The number of flights and fuel consumption decreased in 2020 due to pandemic conditions. As a result GHG emissions declined by approximately 40% compared to 2019.

Figure 3.15 Comparison of number of flights, fuel consumption and GHG emissions of civil aviation, 1990-2020



The other transportation mode needed to be analyzed is road transportation (Figure 3.16). 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_2 eq.) and 2020 (59 736 kt. CO_2 eq.), an increase of 121%.

Figure 3.16 Emission distributions by fuel types in road transportation, 1990-2020

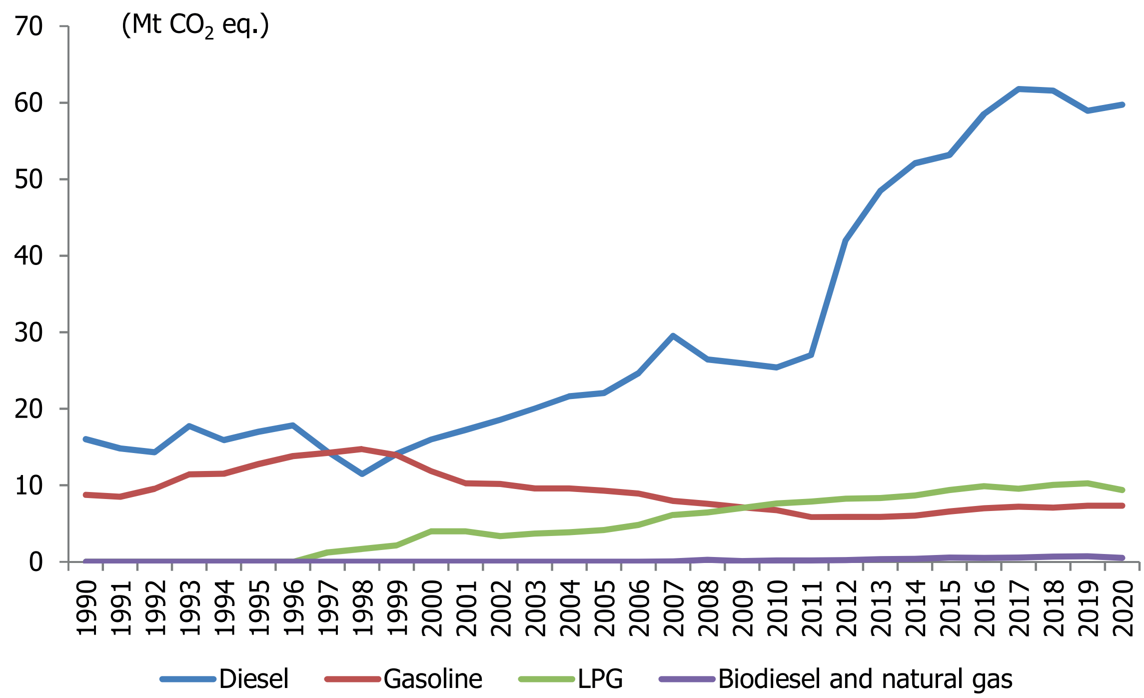
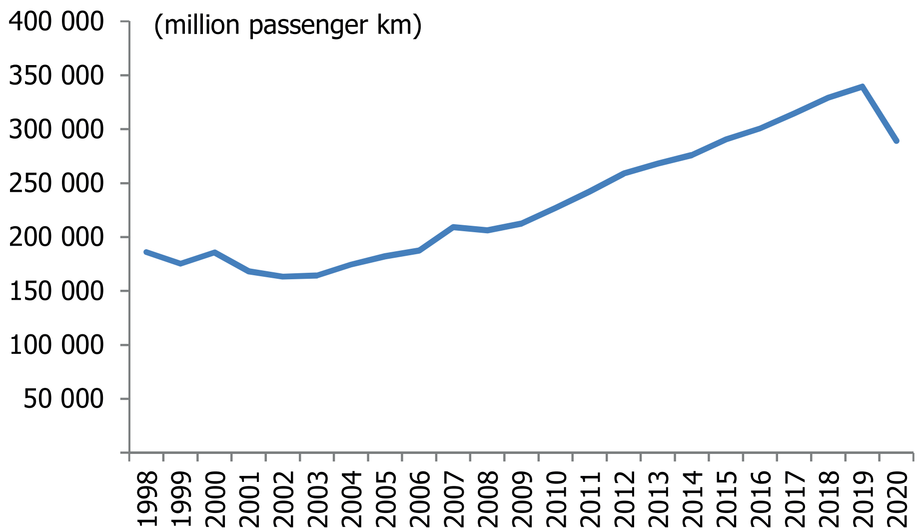


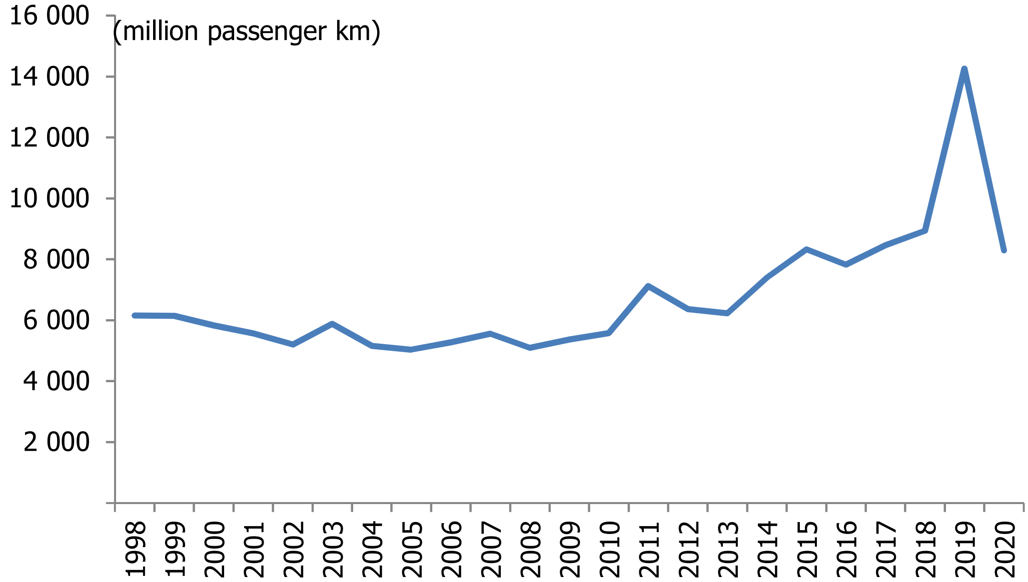
Figure 3.17 Passenger-km by road, 1998-2020 (1)



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

As seen from the figure 3.17, 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 reason behind this is the number of cars has increased which leads to increase in the number of people traveling by road. This trend reversed due to pandemic conditions in 2020.

Figure 3.18 Passenger-km by railway, 1998-2020 (2)



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

Figure 3.18 represents million passenger kilometers by rail. In recent years, Türkiye 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. But in 2020 the number of passenger kilometers decreased significantly in railway sector which is affected by the covid-19 pandemic.

The modernization of the rail infrastructure requires a temporary stoppage of railway transport until the infrastructure construction is complete. That is the reason of the fluctuation in emissions from 2011 to 2020.

Source Category Description:

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

- Domestic aviation in terms of CO_2 emissions from jet fuel (level and trend),

- Road transportation in terms of CO_2 emissions from diesel fuel, LPG, gasoline and other ones (biofuel and natural gas) (level and trend),
- Domestic navigation in terms of CO_2 emissions from diesel fuel and fuel oil,

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

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

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

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

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

Methodological Issues:

Türkiye implements Tier 1 and Tier 2 methodologies to estimate GHG emissions of mobile sources for the time series 1990-2019, 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_2 (kg)
$Fuel_a$ = fuel sold (TJ)
EF_a = emission factor (kg/TJ). This is equal to the carbon content of the fuel multiplied by 44/12.
a = type of fuel (e.g. petrol, diesel, natural gas, LPG etc.)

All EFs were taken from the 2006 IPCC Guidelines.

The IPCC methods used in transport sector calculations are listed in Table 3.39.

Table 3.39 Method used in the calculation of GHG emissions by transport modes

Modes of transport	CO_2	CH_4	N_2O	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, MAPEG 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 Türkiye. 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 2020, in terms of both the level and trend analysis of CO_2 emissions from the jet fuel. In domestic aviation only jet fuel is consumed.

Figure 3.19 and Figure 3.20 illustrate the total emissions and the emissions of CH_4 and N_2O increasing trends as CO_2 eq. CO_2 eq. emissions have increased approximately 348% since 1990 and reached to 2.16 Mt CO_2 in 2020. The calculated amounts of CH_4 and N_2O emissions were 0.99 kt. CO_2 eq. and 22.06 kt. CO_2 eq. in 2020 respectively. There was a relatively large decrease in CO_2 emissions observed between 2009 and 2010 (44% decline) owing to the global economic crisis.

Figure 3.19 GHG emissions for domestic aviation, 1990-2020

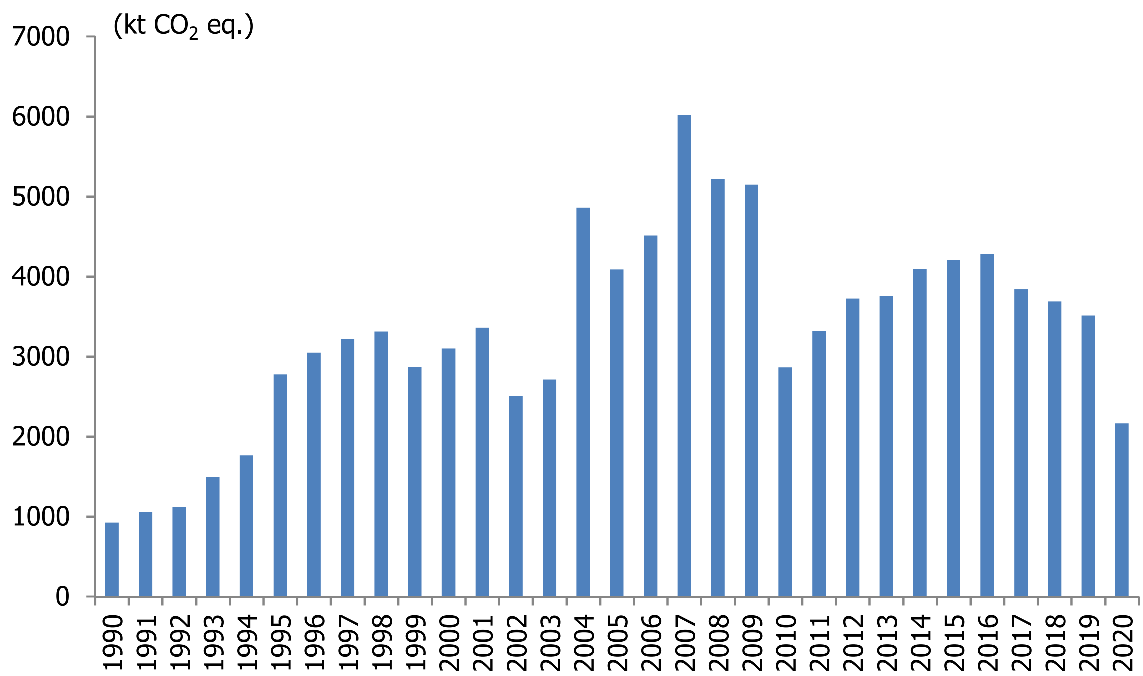
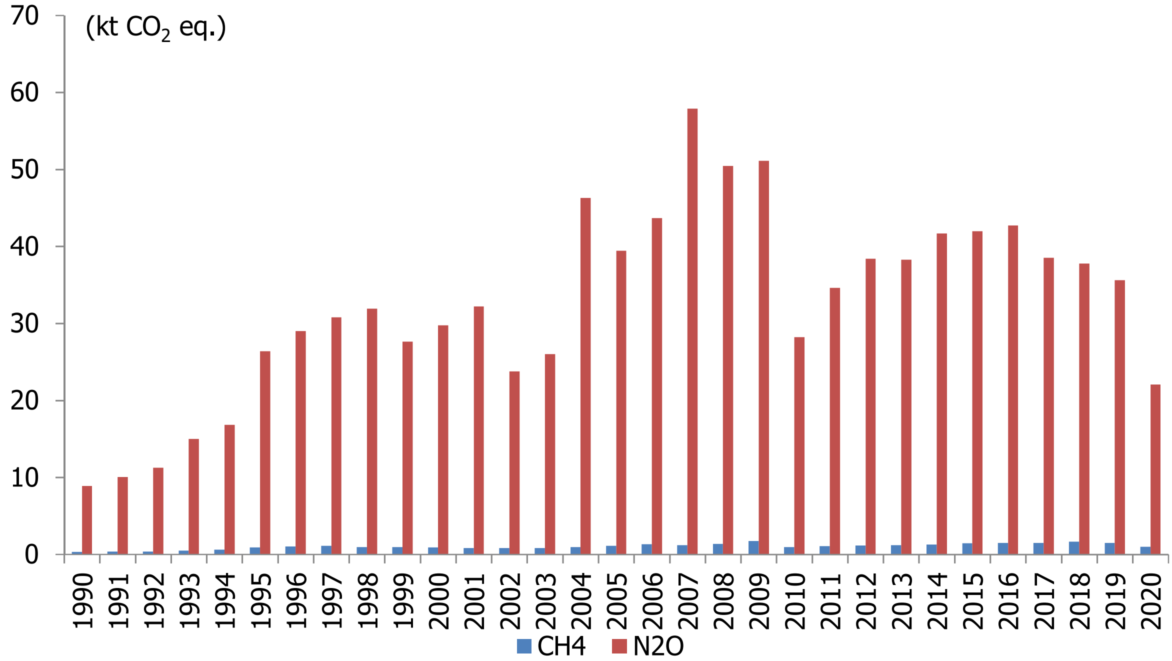


Figure 3.20 CH_4 and N_2O emissions for domestic aviation, 1990-2020



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.

$$Total\ emissions = LTOemissions + cruiseemissions$$

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

$$LTOfuelconsumption = NumberofLTOs * FuelconsumptionperLTO$$

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

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 Türkiye. 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 2020 total number of LTO’s in domestic travel for all aircraft types is 572 994. Passenger and freight traffic from 2006 to 2020 is also given in Figure 3.21 and Figure 3.22 respectively. Figure 3.23 shows the number of domestic LTOs for Turkish airports from 1990 to 2020.

Figure 3.21 Passenger traffic, 2006-2020

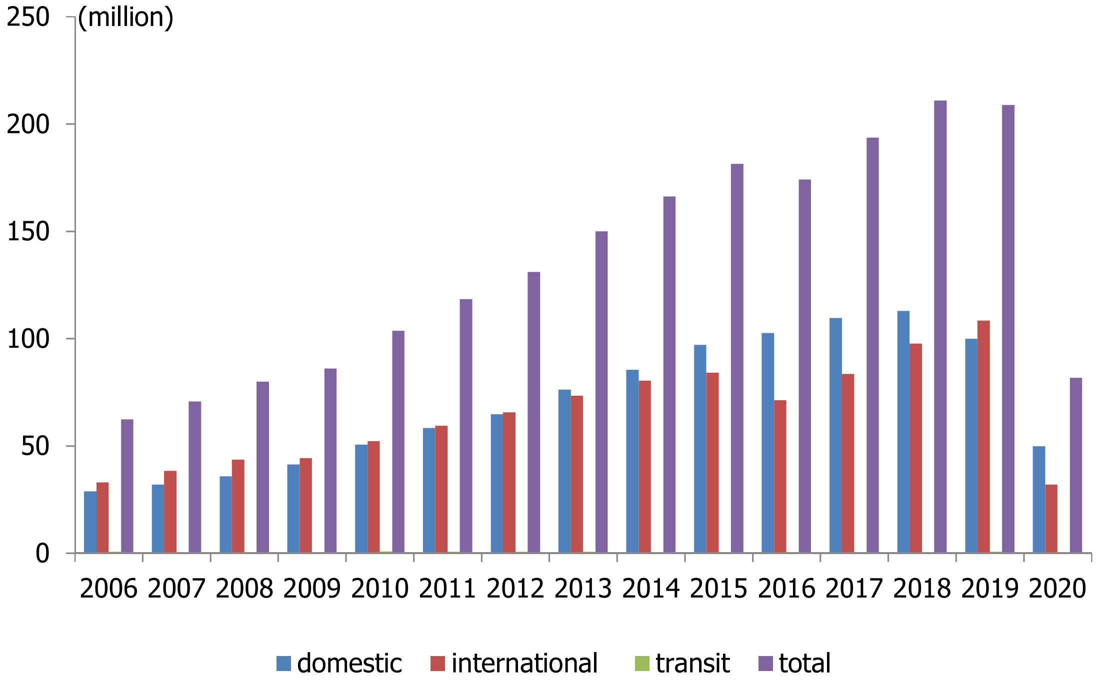
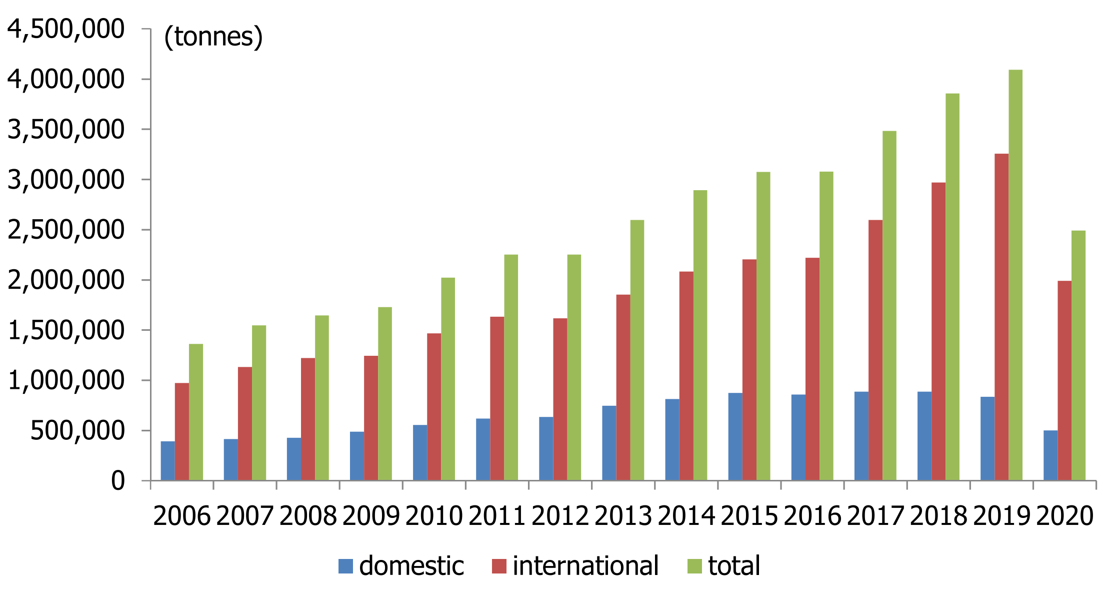
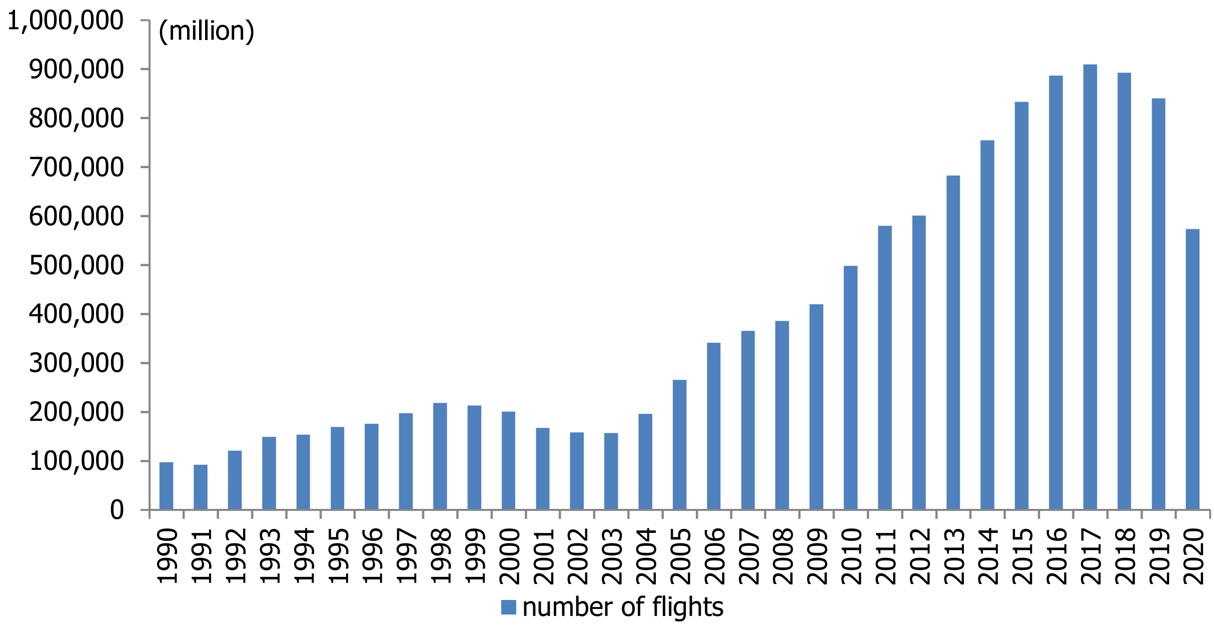


Figure 3.22 Freight traffic, 2006-2020



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 0.68 Mt. To calculate the LTO fuel consumption, Türkiye multiplied the number of LTOs by the relevant LTO fuel consumption factors. The calculated total LTO fuel consumption is 0.37 Mt. To estimate cruise fuel consumption, Türkiye subtracts LTO fuel consumption from total fuel consumption for each year of the time series. In 2020, cruise fuel consumption is 0.31 Mt.

Figure 3.23 Number of domestic LTO, 1990-2020



Choice of Emission Factor:

LTO fuel consumption factors, as well as default CO_2, CH_4 and N_2O emission factors for all aircraft types were obtained from the 2006 IPCC Guidelines (Table 3.6.9). Default emission factor values were applied for aircrafts where specific data are not available. The resulting CO_2 emission values of 1.18 Mt and 0.96 Mt were reported for LTO and cruise respectively. CO_2, CH_4 and N_2O emission values are given in Table 3.40.

Table 3.40 GHG emissions from domestic aviation, 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ
1990	914	0.01	0.03	923	13 030
1991	1 043	0.01	0.03	1 053	14 755
1992	1 107	0.02	0.04	1 118	15 648
1993	1 474	0.02	0.05	1 489	20 875
1994	1 747	0.02	0.06	1 764	24 653
1995	2 748	0.04	0.09	2 775	38 670
1996	3 018	0.04	0.10	3 048	42 642
1997	3 183	0.04	0.10	3 215	45 028
1998	3 278	0.04	0.11	3 311	46 302
1999	2 840	0.04	0.09	2 868	40 106
2000	3 068	0.04	0.10	3 099	43 296
2001	3 325	0.03	0.11	3 358	47 044
2002	2 478	0.03	0.08	2 503	35 266
2003	2 686	0.03	0.09	2 713	37 923
2004	4 811	0.04	0.16	4 859	68 082
2005	4 048	0.05	0.13	4 089	57 276
2006	4 467	0.05	0.15	4 512	63 194
2007	5 960	0.05	0.19	6 019	84 334
2008	5 166	0.06	0.17	5 218	73 201
2009	5 096	0.07	0.17	5 149	72 049
2010	2 833	0.04	0.09	2 862	40 043
2011	3 308	0.04	0.12	3 344	47 199
2012	3 688	0.05	0.13	3 727	52 686
2013	3 715	0.05	0.13	3 754	52 467
2014	4 047	0.05	0.14	4 090	57 243
2015	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
2018	3 648	0.07	0.13	3 688	52 217
2019	3 472	0.06	0.12	3 509	49 140
2020	2 141	0.04	0.07	2 164	30 233

Table 3.41 GHG emissions for LTO and cruise in domestic aviation, 2020

(kt)

	CO_2	CH_4	N_2O	Jet kerosene
Total	2 141	0.04	0.074	678
LTO	1 177	0.04	0.043	372
Cruise	964	-	0.031	306

Table 3.42 IEFs of domestic aviation 1990-2020

		IEFs		
	Activity	CO_2	CH_4	N_2O
Year	TJ	t/TJ	kg/TJ	kg/TJ
1990	13 030	70.13	0.96	2.29
1991	14 755	70.67	0.96	2.28
1992	15 648	70.72	0.98	2.42
1993	20 875	70.60	0.99	2.41
1994	24 653	70.84	0.98	2.29
1995	38 670	71.06	0.95	2.29
1996	42 642	70.77	0.99	2.28
1997	45 028	70.69	0.98	2.30
1998	46 302	70.79	0.84	2.31
1999	40 106	70.80	0.94	2.31
2000	43 296	70.86	0.86	2.31
2001	47 044	70.69	0.70	2.30
2002	35 266	70.28	0.96	2.26
2003	37 923	70.82	0.88	2.30
2004	68 082	70.67	0.57	2.28
2005	57 276	70.68	0.80	2.31
2006	63 194	70.68	0.84	2.32
2007	84 334	70.68	0.57	2.30
2008	73 201	70.57	0.76	2.31
2009	72 049	70.74	0.97	2.38
2010	40 043	70.75	0.95	2.36
2011	47 199	70.09	0.92	2.46
2012	52 686	69.99	0.88	2.45
2013	52 467	70.81	0.92	2.45
2014	57 243	70.70	0.90	2.44
2015	58 824	70.75	0.98	2.39
2016	59 884	70.75	0.99	2.39
2017	53 259	71.32	1.12	2.43
2018	52 217	69.86	1.27	2.43
2019	49 140	70.66	1.22	2.43
2020	30 233	70.81	1.31	2.45

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 5.48% liquid fuels.

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

Recalculation:

There is no recalculation 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)

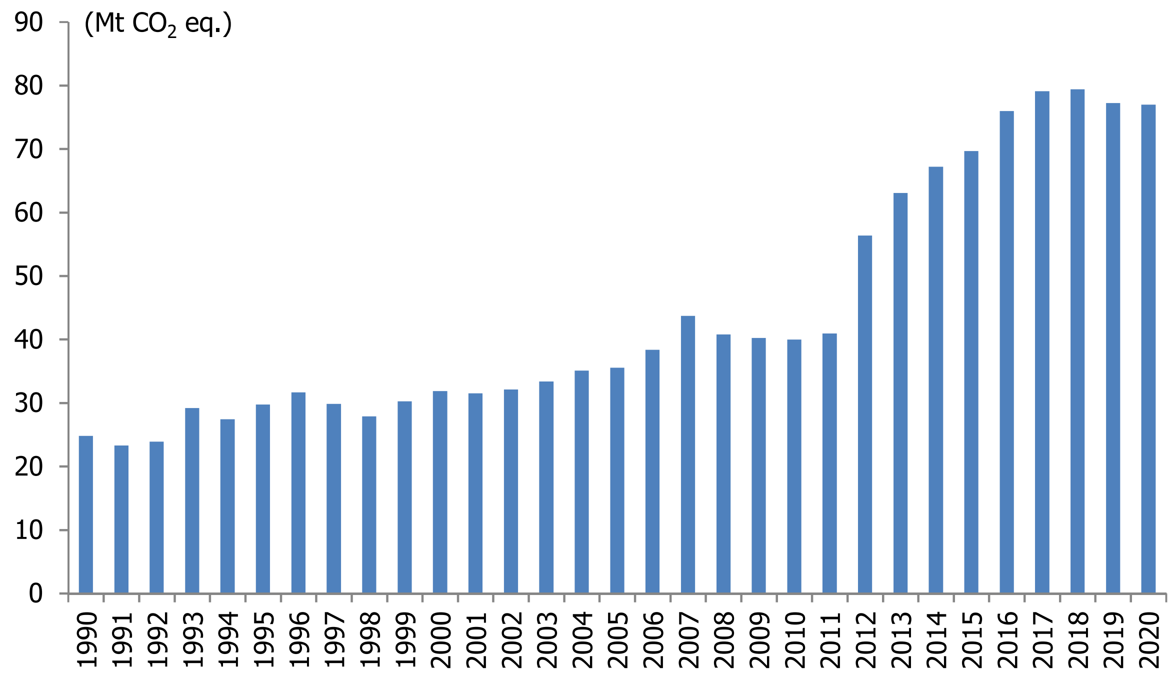
Road Transportation source category was a key category, in terms of emission level of CO_2 from diesel oil, LPG and gasoline in 2020. This category was also a key category in terms of emission trend of CO_2 from LPG, gasoline and diesel oil. The results according to IPCC Tier 1&2 were in Table 3.43.

Table 3.43 GHG emissions from road transportation, 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ
1990	24 143	3.9	1.804	24 777	335 589
1991	22 686	3.7	1.712	23 288	315 543
1992	23 232	4.0	1.804	23 871	323 808
1993	28 403	4.9	2.192	29 178	395 708
1994	26 672	4.8	2.105	27 419	372 206
1995	28 942	5.3	2.301	29 760	404 093
1996	30 753	5.7	2.458	31 628	429 564
1997	28 993	6.9	2.329	29 858	408 624
1998	27 033	7.3	2.233	27 881	383 300
1999	29 346	7.6	2.287	30 219	415 241
2000	30 988	8.8	2.158	31 850	439 986
2001	30 694	8.3	2.050	31 512	434 724
2002	31 264	7.7	2.106	32 084	441 038
2003	32 517	7.9	2.119	33 347	458 427
2004	34 230	8.2	2.203	35 090	482 069
2005	34 668	8.4	2.195	35 532	488 494
2006	37 463	9.0	2.289	38 370	527 725
2007	42 689	10.2	2.447	43 674	601 495
2008	39 630	10.3	2.253	40 559	562 707
2009	39 289	10.7	2.170	40 204	556 696
2010	39 033	11.2	2.106	39 941	554 362
2011	39 995	11.2	2.093	40 899	567 688
2012	55 142	12.4	2.882	56 310	775 067
2013	61 607	12.8	3.224	62 889	864 602
2014	65 608	13.4	3.434	66 967	921 018
2015	67 889	14.3	3.561	69 309	955 968
2016	74 055	15.2	3.887	75 595	1 041 071
2017	77 094	15.2	4.132	78 706	1 095 446
2018	77 289	15.7	4.116	78 907	1 100 570
2019	75 131	15.8	4.005	76 720	1 072 046
2020	75 024	15.0	4.035	76 600	1 066 461

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 76.6 Mt of CO_2 eq in 2020 (Figure 3.24). Emissions of CH_4 reached 0.37 Mt CO_2 eq. and N_2O reached 1.20 Mt CO_2 eq. in 2020 (Figure 3.25). Emissions from the consumption of biofuels were taken into consideration for CH_4 and N_2O emissions.

Figure 3.24 GHG emissions for road transportation, 1990-2020



CO_2 emissions according to fuel types are illustrated in Figure 3.26. Most important portion of CO_2 emission is occurred from diesel fuel consumption, which is about 78% of total emissions of road transportation.

Figure 3.25 CH_4 and N_2O emissions for road transportation, 1990-2020

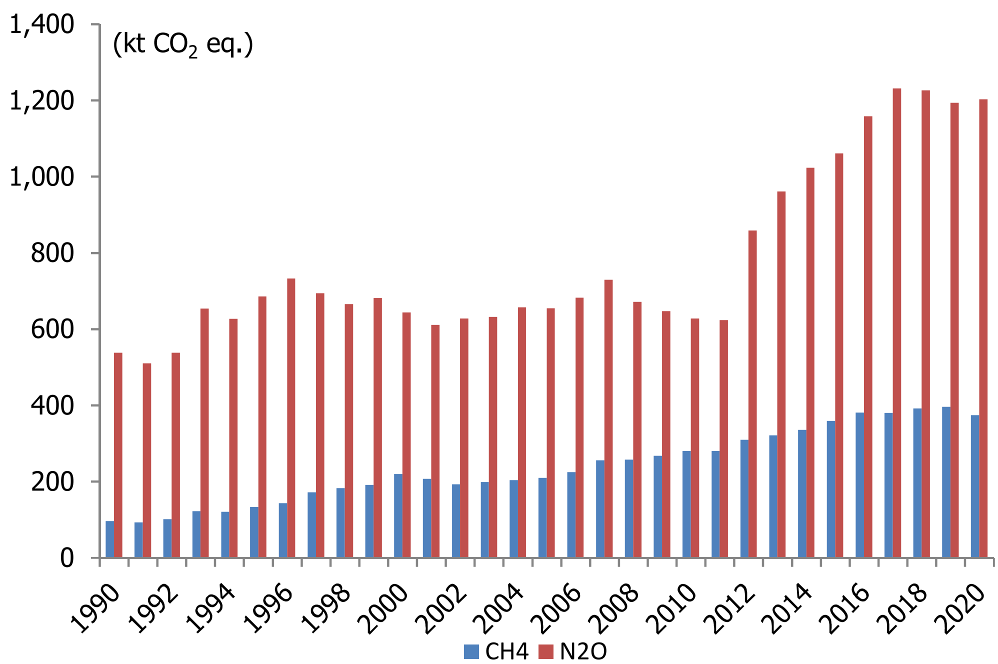
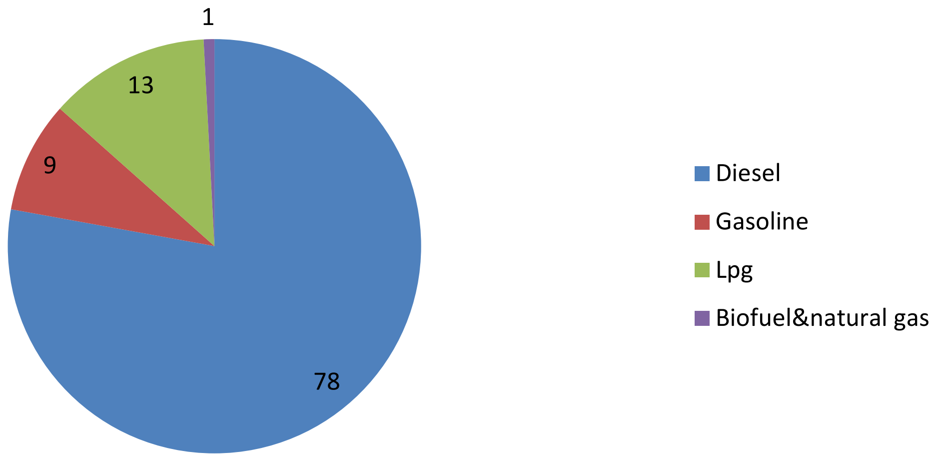


Figure 3.26 CO_2 emission distributions by fuel types (%), 2020



Methodological issues:

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

Collection of Activity Data:

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

Choice of Emission Factor:

To estimate CO_2 emissions, Türkiye 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 data in road transportation provided by the MENR were compared with those of DG of Mining and Petroleum Affairs, reported to IEA.

To verify 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, 2017 and 2018. COPERT V results were compared with the results regarding current methodology (Tier 1, Tier 2) and in terms of CH_4, 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 3.44 Comparison of COPERT and current methodology for GHG emissions from road transportation, 2016-2018

	CO_2 (kt)		CH_4 (kt)		N_2O (kt)		CO_2 eq. (kt)	
Year	**Tier 2**	**COPERT**	**Tier 1**	**COPERT**	**Tier 1**	**COPERT**	**Tier 1&2**	**COPERT**
2016	74 055	74 663	15.2	4.952	3.9	2.637	75 595	75 573
2017	77 094	78 701	15.2	5.677	4.1	2.807	78 706	79 679
2018	77 289	79 015	15.7	5.230	4.1	2.866	78 907	80 000

With this calculation results obtained from COPERT for the years 2016-2018.

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 10.05% for liquid fuels.

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

Recalculations:

There is no recalculation for this category.

Planned Improvement:

There is no planned improvement for this sector.

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

The railways source category was not a key category in 2020. Figure 3.27 and Figure 3.28 show the total, CH_4 and N_2O emissions as CO_2 eq. respectively. CO_2 eq. emissions have declined 55.2% since 1990. The emissions calculated for railways is 0.323 Mt CO_2 eq. in 2020.

Table 3.45 GHG emissions from railway, 1990-2020

Year	CO_2	CH_4	N_2O	CO_2 eq.	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
2018	388	0.02	0.15	435	5 373
2019	358	0.02	0.14	400	4 946
2020	289	0.02	0.11	323	3 995

Figure 3.27 GHG emissions for railways, 1990-2020

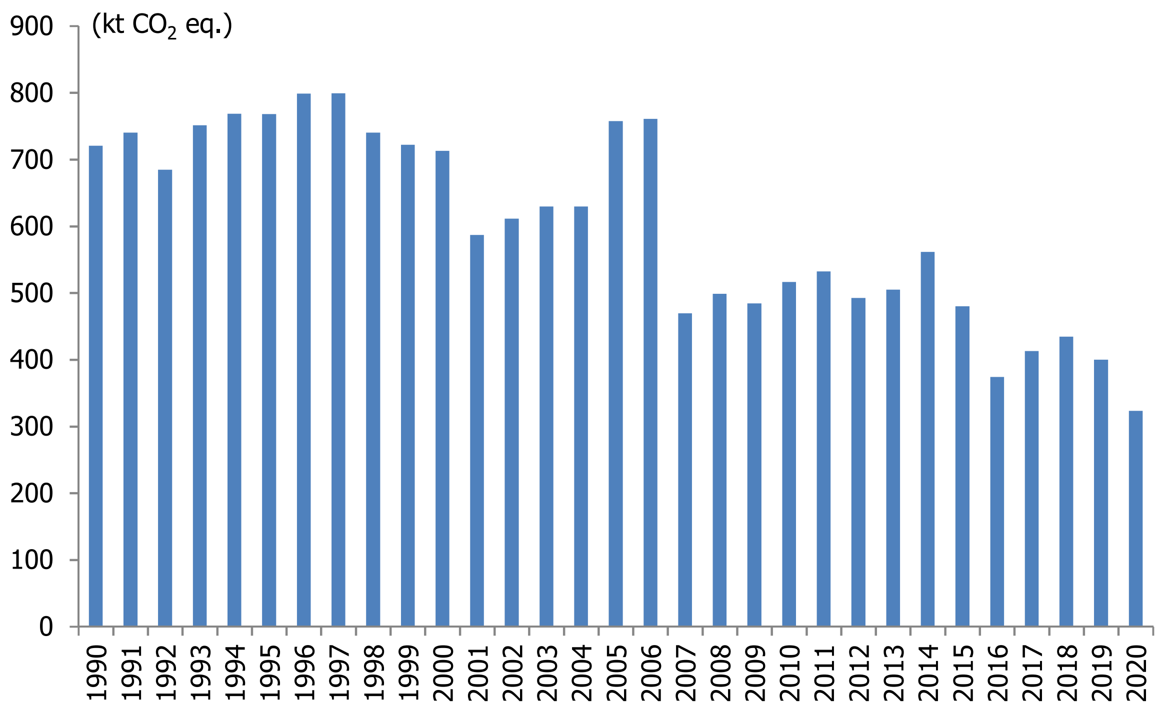
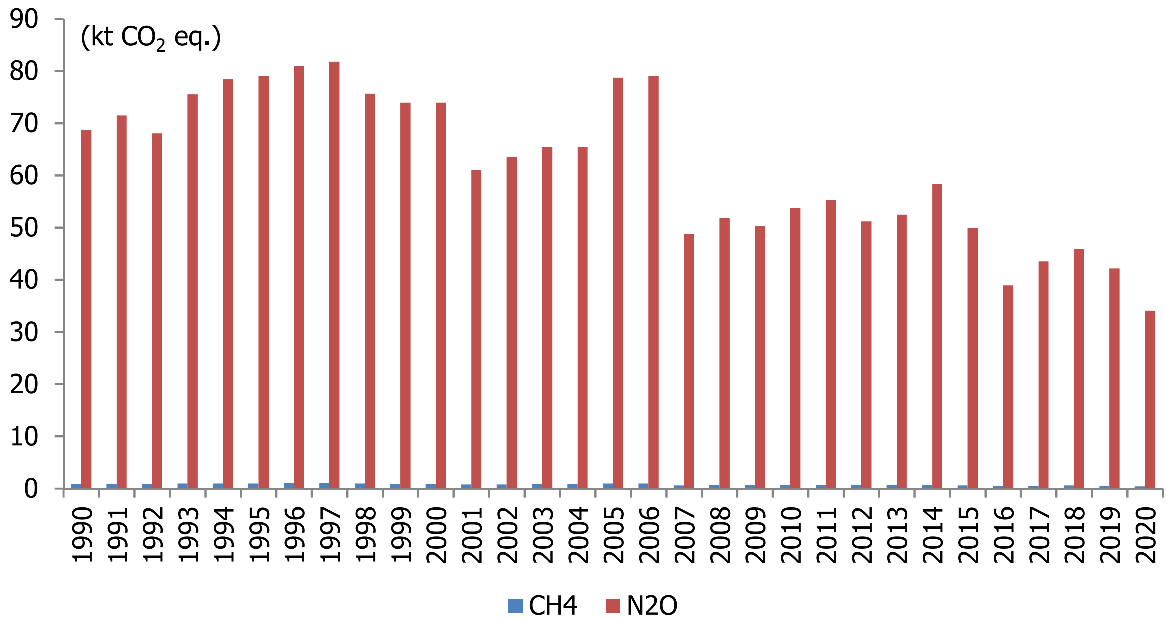


Figure 3.28 CH_4 and N_2O emissions from railways, 1990-2020



Methodological issues:

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

Collection of Activity Data:

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

Choice of Emission Factor:

To estimate CO_2 emissions, Türkiye applies the country specific carbon content. Türkiye does not modify the emission factors for CH_4 and N_2O to consider 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 was 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_2 was derived from 2006 IPCC Guidelines Vol. 2 table 3.4.1 as 1.5% for liquid fuels. For CH_4, EF uncertainties were derived as 105% for liquid fuels. For N_2O 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 2020. 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 1.26 Mt of CO_2 in 2020 while CH_4 3.02 kt. CO_2 eq. and N_2O emissions were 10.29 kt. CO_2 eq. (Figure 3.29 and 3.30). Overall, between 1990 and 2020 emissions from water-borne navigation increased by 148.2%.

Table 3.46 GHG emissions from domestic navigation, 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ
1990	504	0.05	0.01	509	6 624
1991	537	0.05	0.01	543	7 068
1992	632	0.06	0.02	638	8 290
1993	657	0.06	0.02	664	8 632
1994	617	0.06	0.02	623	8 129
1995	719	0.07	0.02	726	9 444
1996	692	0.06	0.02	699	9 104
1997	691	0.06	0.02	698	9 090
1998	718	0.07	0.02	726	9 466
1999	652	0.06	0.02	658	8 610
2000	617	0.06	0.02	623	8 167
2001	792	0.07	0.02	800	10 535
2002	813	0.08	0.02	822	10 821
2003	881	0.08	0.02	891	11 732
2004	1 215	0.11	0.03	1228	16 266
2005	1 286	0.12	0.03	1299	17 225
2006	1 449	0.14	0.04	1464	19 436
2007	1 581	0.15	0.04	1598	21 241
2008	1 527	0.14	0.04	1543	20 561
2009	1 615	0.15	0.04	1632	21 991
2010	1 664	0.16	0.05	1682	22 658
2011	2 218	0.21	0.06	2242	30 058
2012	1 598	0.15	0.04	1614	21 670
2013	1 142	0.11	0.03	1154	15 486
2014	1 334	0.13	0.04	1348	18 083
2015	1 136	0.11	0.03	1147	15 369
2016	960	0.09	0.03	970	12 958
2017	934	0.09	0.03	944	12 836
2018	921	0.09	0.03	931	12 650
2019	1 204	0.12	0.03	1 217	15 696
2020	1 251	0.12	0.03	1 264	16 653

Figure 3.29 GHG emissions from domestic water-borne navigation, 1990-2020

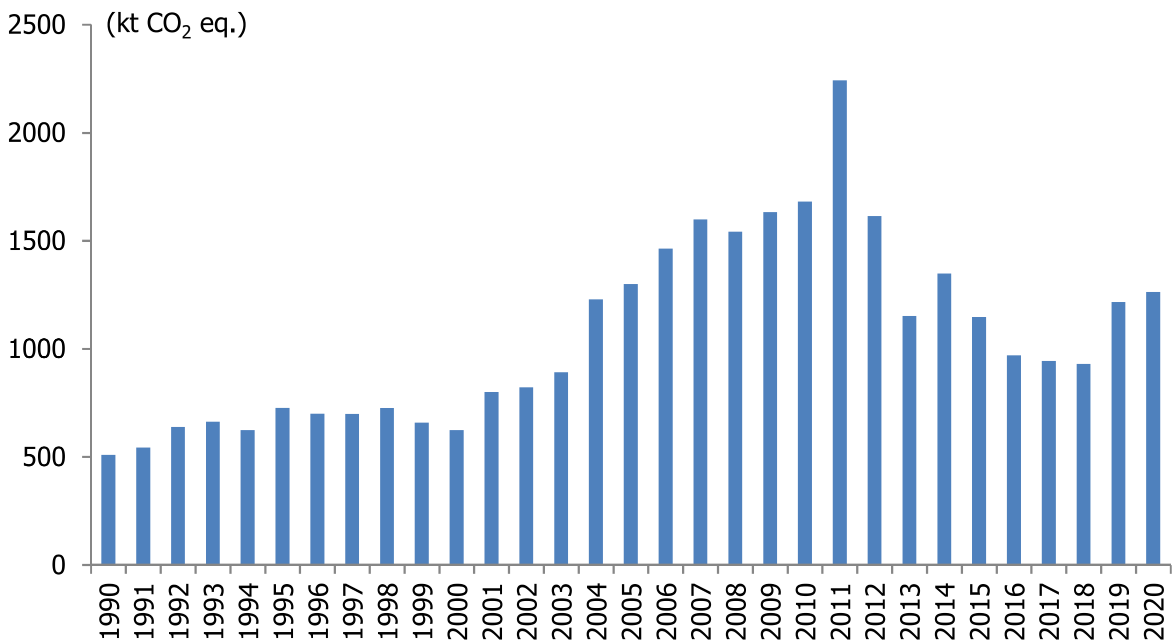
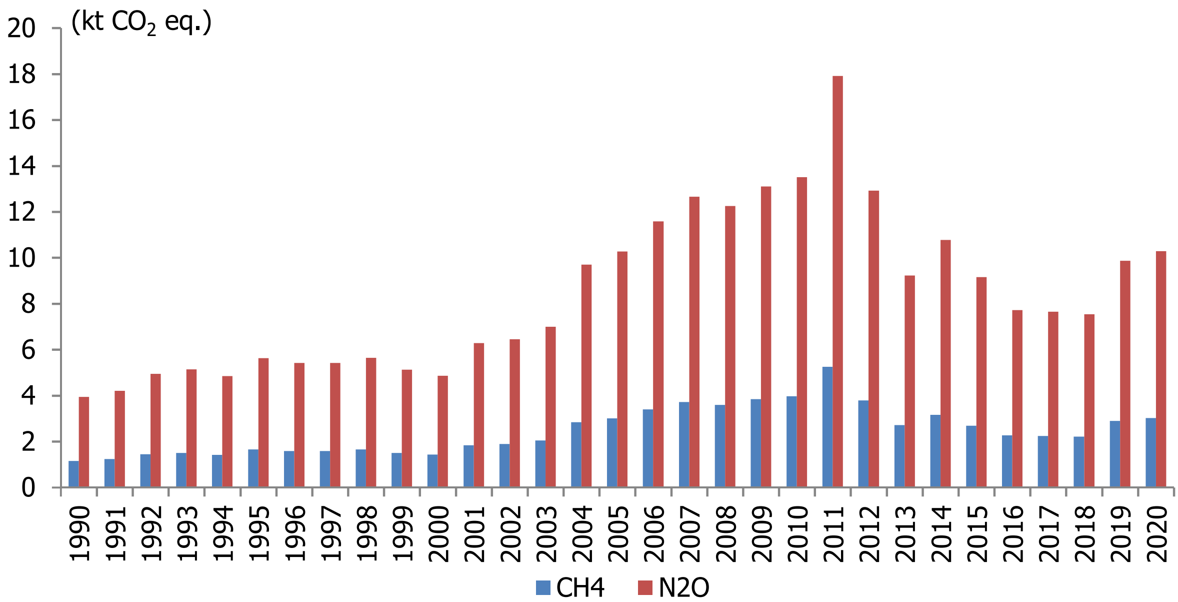


Figure 3.30 CH_4 and N_2O emissions from domestic water-borne navigation, 1990-2020



Methodological issues:

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

Collection of Activity Data:

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

Choice of emission factor:

For CO_2 estimation, country-specific carbon contents were used. The EFs for CH_4 and N_2O are taken from IPCC 2006/CORINAIR and set to 7 and 2 kg per TJ respectively.

Source-Specific QA/QC and Verification:

On the energy balance table provided by the MENR, diesel and fuel oil consumption values were compared with the values provided by MoTI DG of Maritime, as well as the Annual Activity Report results of Energy Market Regulatory Authority and 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 was taken from MENR. AD uncertainties were determined as 15% for liquid fuels.

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

Recalculations:

There is no recalculation for this category.

Planned Improvement:

There is no planned improvement for this category.

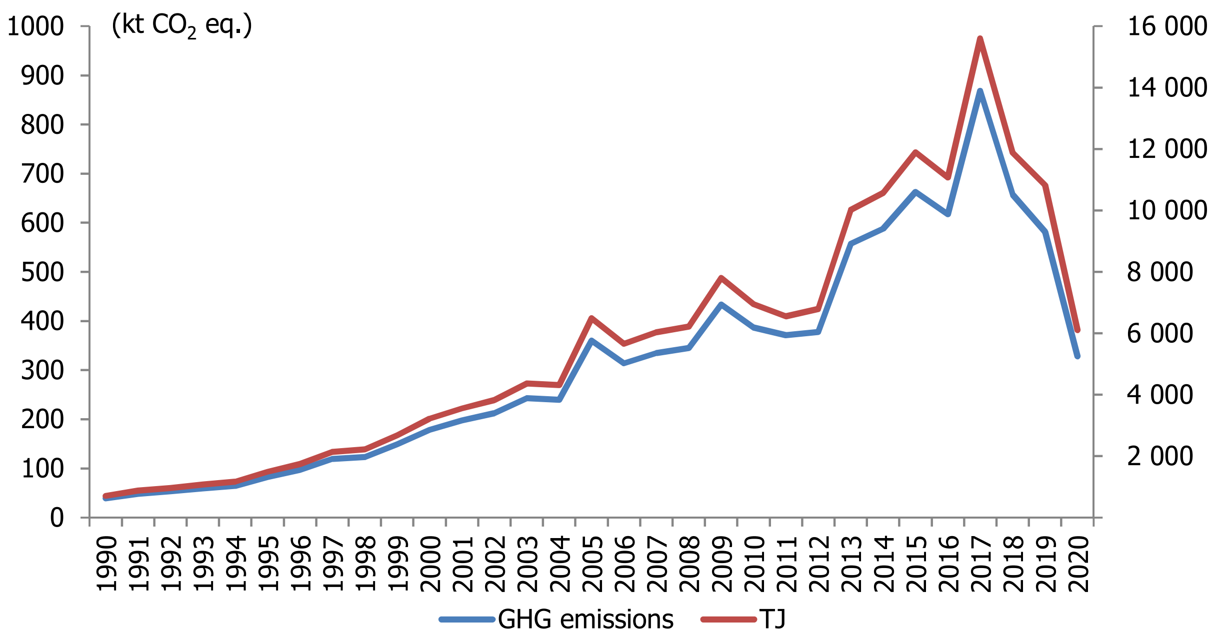
3.2.6.5. Pipeline transport (Category 1.A.3.e.i)

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 Türkiye, natural gas is used to carry out operations mentioned above. Pipeline Transport contributed 0.33 Mt of CO_2 in 2020. Table 3.47 shows the trend in GHG emissions from pipeline transport.

Table 3.47 The trend in GHG emissions from pipeline transport, 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	TJ
1990	39	0.0007	0.00007	39	705
1991	49	0.0009	0.00009	49	875
1992	54	0.0010	0.00010	53	962
1993	60	0.0011	0.00011	60	1 075
1994	65	0.0012	0.00012	65	1 167
1995	83	0.0015	0.00015	83	1 489
1996	97	0.0017	0.00017	97	1 745
1997	119	0.0021	0.00021	119	2 143
1998	123	0.0022	0.00022	123	2 221
1999	149	0.0027	0.00027	149	2 682
2000	178	0.0032	0.00032	179	3 217
2001	197	0.0036	0.00036	197	3 553
2002	212	0.0038	0.00038	212	3 826
2003	243	0.0044	0.00044	243	4 372
2004	240	0.0043	0.00043	240	4 317
2005	360	0.0065	0.00065	360	6 487
2006	314	0.0057	0.00057	314	5 658
2007	335	0.0060	0.00060	335	6 030
2008	345	0.0062	0.00062	345	6 216
2009	433	0.0078	0.00078	434	7 803
2010	386	0.0069	0.00069	387	6 945
2011	371	0.0066	0.00066	371	6 552
2012	377	0.0068	0.00068	378	6 796
2013	557	0.0100	0.00100	557	10 025
2014	587	0.0106	0.00106	588	10 575
2015	662	0.0117	0.00117	663	11 897
2016	617	0.0111	0.00111	617	11 073
2017	868	0.0156	0.00156	869	15 601
2018	656	0.0119	0.00119	657	11 873
2019	581	0.0108	0.00108	582	10 824
2020	328	0.0061	0.00061	328	6 109

Figure 3.31 GHG emissions from pipeline transport, 1990-2020



Methodological issues:

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

Collection of Activity Data:

Fuel consumption data for pipeline transport were provided by energy balance table provided by the MENR.

Choice of emission factor:

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

Source-Specific QA/QC and Verification:

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

Recalculations:

There has been a recalculation from 2017 to 2019 for changing the source of activity data to improve the time series consistency. Table 3.48 shows the recalculation results based on those years.

Table 3.48 The recalculation results in terms of GHG emissions from pipeline transport

Years	Previous CO_2 Emissions	Recalculated CO_2 Emissions	% Difference
2017	757.05	867.77	14.62
2018	541.39	655.97	21.16
2019	580.77	580.90	0.02

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_2 from solid, liquid and gaseous fuels in 2020. The source category is also a key category in terms of emission trend of CH_4 from solid fuels and biomass.

The share of GHG emissions as CO_2 eq. from other sectors in total fuel combustion was 21% in 2020 while it was 25.0% in1990. It was 19.5% of total GHG emissions in 2019.

Table 3.49 Fuel combustion emissions from other sectors (1A4), 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in fuel combustion (1A) category (%)
1990	29 277	133	3.7	33 707	646 591	25.0
1991	30 430	134	3.7	34 887	658 600	25.0
1992	32 537	137	3.8	37 079	685 301	25.4
1993	33 228	132	4.3	37 812	701 819	24.8
1994	29 477	122	4.2	33 775	667 014	22.6
1995	33 297	126	4.3	37 722	713 541	23.2
1996	34 267	123	4.4	38 664	734 303	21.5
1997	36 953	128	4.6	41 515	771 063	21.6
1998	33 429	118	4.5	37 704	735 920	19.7
1999	31 655	110	4.5	35 753	715 575	19.0
2000	33 693	108	4.6	37 764	737 948	18.0
2001	27 686	96	4.4	31 397	651 581	16.2
2002	29 176	98	4.4	32 930	654 967	16.4
2003	32 427	99	4.4	36 232	688 840	16.8
2004	35 645	101	4.7	39 561	726 309	17.9
2005	38 826	100	4.7	42 709	771 973	17.9
2006	38 425	94	4.9	42 236	770 378	16.6
2007	41 335	95	5.2	45 279	798 938	16.0
2008	58 971	139	6.6	64 410	986 839	23.0
2009	65 084	157	6.5	70 959	1 030 352	24.9
2010	62 070	152	6.4	67 773	973 007	24.2
2011	69 279	132	7.0	74 656	1 078 816	24.8
2012	57 465	138	2.2	61 586	896 880	19.7
2013	52 999	114	1.8	56 384	879 983	18.8
2014	52 668	112	2.0	56 079	876 746	17.7
2015	62 494	63	4.5	65 397	1 010 607	19.4
2016	62 413	62	4.4	65 270	1 020 656	18.5
2017	70 272	73	4.5	73 437	1 112 130	19.5
2018	60 102	61	4.2	62 881	977 068	17.2
2019	66 284	68	4.4	69 282	1 085 732	19.5
2020	71 915	78	4.6	75 238	1 152 101	21.0

Total GHG emission in 1A4 category increase 5 631 kt CO_2 eq. (8.5% of increase) from 2019 to 2020.

Methodological Issues:

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

Country specific CO_2 EF are used when available, otherwise default CO_2 EF are used. Same CO_2 EFs are used from the summary table 3.8. (from 1.A Fuel combustion sector) All CH_4 and N_2O EF are also default. The default CH_4 and N_2O EF for 1A4 sector are tabulated below.

Table 3.50 N_2O and CH_4 emission factors of fuels used in others sector (1A4).

Sub Sectors	Emission Factors CH_4 (kg/TJ)	Emission Factors N_2O(kg/TJ)	Source
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:

There is no recalculation in this sector.

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_2eq. from 1.A.4.a in total other sector is 21.2% in 2019

Table 3.51 Fuel combustion emissions from 1.A.4.a category, 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1.A.4 category (%)
1990-2014	IE	IE	IE	IE	IE	IE
2015	23 217	2.33	0.50	23 423	300 630	35.8
2016	22 004	2.31	0.49	22 208	298 757	34.0
2017	20 540	2.01	0.35	20 693	279 840	28.2
2018	13 484	1.26	0.12	13 551	208 743	21.6
2019	14 620	1.39	0.12	14 691	231 304	21.2
2020	13 581	1.28	0.13	13 651	209 304	18.1

Total GHG emission in 1.A.4.a category decreased 1 039 kt CO_2 eq. (7.1% of decrease) from 2019 to 2020.

Methodological Issues:

GHG emissions from 1.A.4.a sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

Country specific CO_2 EFs are used for emission estimation. CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

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

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

Source-Specific QA/QC and Verification:

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

IEF for CO_2, CH_4, and N_2O are in the range of 2006 IPCC default EFs.

Recalculation:

There is no recalculation in this sector.

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_2 eq. from 1.A.4.b category in total other sectors is 63.1% in 2019 while it was 80.8% in 1990.

Table 3.52 Fuel combustion emissions from residential sector, 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1.A.4 category (%)
1990	23 507	132	1.45	27 249	566 764	80.8
1991	24 635	133	1.46	28 401	578 434	81.4
1992	26 727	136	1.47	30 575	604 918	82.5
1993	26 072	132	1.45	29 802	602 809	78.8
1994	22 284	121	1.38	25 724	567 499	76.2
1995	25 958	125	1.41	29 507	611 993	78.2
1996	26 530	122	1.38	30 004	627 258	77.6
1997	28 934	127	1.41	32 538	660 113	78.4
1998	25 485	117	1.34	28 811	626 011	76.4
1999	23 492	110	1.28	26 616	602 632	74.4
2000	25 191	107	1.25	28 248	620 325	74.8
2001	19 551	96	1.16	22 291	539 029	71.0
2002	20 915	97	1.14	23 684	540 681	71.9
2003	24 040	99	1.12	26 844	572 802	74.1
2004	26 632	100	1.11	29 472	601 603	74.5
2005	29 731	99	1.08	32 529	646 141	76.2
2006	28 657	93	1.03	31 302	635 230	74.1
2007	30 694	95	1.02	33 368	651 714	73.7
2008	45 490	139	1.22	49 320	800 328	76.6
2009	51 866	156	1.29	56 164	847 483	79.1
2010	49 119	152	1.24	53 277	793 813	78.6
2011	54 168	131	1.04	57 746	869 556	77.3
2012	54 457	138	1.06	58 223	855 118	94.5
2013	50 649	114	0.93	53 767	846 990	95.4
2014	49 623	112	0.91	52 700	833 597	94.0
2015	30 479	60	0.60	32 157	587 205	49.2
2016	31 721	59	0.57	33 360	600 881	51.1
2017	40 620	71	0.60	42 571	705 283	58.0
2018	37 192	59	0.49	38 826	636 194	61.7
2019	41 922	66	0.53	43 729	717 860	63.1
2020	48 240	76	0.59	50 313	802 223	66.9

Total GHG emission in 1.A.4.b category increased 6 317 kt CO_2 eq. (15.1% of decrease) from 2019 to 2020.

Methodological Issues:

GHG emissions from 1.A.4.b sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

Country specific CO_2 EFs are used for emission estimation. CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs. GHG emissions from biomass were estimated by using 2006 IPCC default EFs.

Uncertainties and Time-Series Consistency:

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

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

Source-Specific QA/QC and Verification:

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

CO_2, CH_4 and N_2O IEFs for all fuels are in the range of 2006 IPCC Guidelines.

Recalculation:

There is no recalculation in this sector

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 Türkiye.

More than 90% of GHG emissions from agricultural sector is related to off road vehicles. The share of GHG emissions as CO_2 eq. from 1.A.4.c category in total other sectors is 15% in 2020 while it was 19.2% in 1990.

Table 3.53 Fuel combustion emissions from agriculture sector, 1990-2020

Year	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	CO_2 eq. (kt)	Fuel consumption (TJ)	Share in 1.A.4 category (%)
1990	5 770	0.33	2.28	6 458	79 826	19.2
1991	5 794	0.33	2.29	6 486	80 167	18.6
1992	5 810	0.33	2.30	6 503	80 383	17.5
1993	7 156	0.41	2.83	8 010	99 010	21.2
1994	7 193	0.41	2.85	8 051	99 515	23.8
1995	7 340	0.42	2.90	8 216	101 548	21.8
1996	7 737	0.44	3.06	8 660	107 045	22.4
1997	8 019	0.46	3.17	8 976	110 950	21.6
1998	7 944	0.46	3.14	8 892	109 909	23.6
1999	8 163	0.47	3.23	9 138	112 943	25.6
2000	8 501	0.49	3.36	9 516	117 623	25.2
2001	8 135	0.47	3.22	9 106	112 553	29.0
2002	8 260	0.47	3.27	9 246	114 286	28.1
2003	8 387	0.48	3.32	9 388	116 039	25.9
2004	9 013	0.52	3.57	10 089	124 705	25.5
2005	9 095	0.52	3.60	10 180	125 832	23.8
2006	9 768	0.56	3.87	10 934	135 149	25.9
2007	10 641	0.61	4.21	11 911	147 224	26.3
2008	13 481	0.77	5.33	15 089	186 511	23.4
2009	13 218	0.78	5.23	14 796	182 869	20.9
2010	12 951	0.74	5.12	14 496	179 194	21.4
2011	15 112	0.87	5.96	16 910	209 260	22.7
2012	3 008	0.17	1.18	3 364	41 762	5.5
2013	2 350	0.14	0.88	2 617	32 992	4.6
2014	3 045	0.18	1.11	3 380	43 149	6.0
2015	8 797	0.51	3.38	9 817	122 772	15.0
2016	8 688	0.51	3.36	9 702	121 018	14.9
2017	9 112	0.53	3.52	10 173	127 007	13.9
2018	9 426	0.55	3.57	10 504	132 130	16.7
2019	9 742	0.57	3.71	10 862	136 568	15.7
2020	10 095	0.59	3.91	11 274	140 574	15.0

Total GHG emission in 1.A.4.c category increased 353 kt CO_2 eq. (3.6% of increase) from 2019 to 2020.

Methodological Issues:

GHG emissions from 1.A.4.c sector were calculated by using 2006 IPCC T1 and T2 approaches by TurkStat. Fuel consumption data were taken from the national energy balance tables in both kt and ktoe units.

Country specific CO_2 EFs are used for emission estimation from for both stationary and mobile source categories. CH_4 and N_2O emissions from liquid, solid and gaseous fuels have been estimated by using 2006 IPCC default EFs for both stationary and mobile source categories.

Uncertainties and Time-Series Consistency:

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

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

Source-Specific QA/QC and Verification:

Quality control for 1.A.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_2, CH_4 and N_2O IEFs for all fuels are in the range of 2006 IPCC Guidelines.

Recalculation:

There is no recalculation in this sector

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_4 emission from coal mining, CH_4, CO_2, N_2O and NMVOC emissions from exploration, production/processing, transport/transmission, refining and storage of oil and natural gas were covered.

Table 3.54 Fugitive emissions from fuels, 1990-2020

(kt)

Year	CO_2	CH_4	N_2O	CO_2 eq.
1990	220	172	0.0031	4 510
1991	263	161	0.0037	4 300
1992	254	160	0.0035	4 245
1993	231	156	0.0032	4 133
1994	219	151	0.0030	3 999
1995	209	153	0.0029	4 023
1996	208	154	0.0029	4 060
1997	206	166	0.0029	4 364
1998	194	182	0.0027	4 745
1999	178	222	0.0025	5 720
2000	168	239	0.0023	6 145
2001	155	222	0.0021	5 702
2002	148	211	0.0020	5 418
2003	145	202	0.0020	5 190
2004	140	200	0.0019	5 134
2005	142	224	0.0019	5 752
2006	135	238	0.0018	6 086
2007	133	313	0.0018	7 949
2008	135	331	0.0018	8 410
2009	138	320	0.0019	8 128
2010	156	323	0.0021	8 226
2011	151	357	0.0020	9 065
2012	144	369	0.0019	9 381
2013	146	335	0.0020	8 524
2014	145	403	0.0020	10 216
2015	155	214	0.0021	5 496
2016	158	337	0.0021	8 596
2017	157	262	0.0021	6 699
2018	174	299	0.0024	7 662
2019	183	380	0.0025	9 676
2020	195	335	0.0027	8 581

CO_2 and CH_4 are the main fugitive emissions in this category. CH_4 was emitted mainly from coal mining while CO_2 was emitted from venting and flaring. Fugitive emissions as CO_2 eq. have become 8 581 ktons in 2020. 30% of fugitive emissions as CO_2 eq. were from oil and gas systems and 70% were from solid fuels in the same year.

Table 3.55 Fugitive emissions from fuels by subcategory, 1990-2020

(kt CO_2 eq.)

Year	Total	Solid fuels	Oil and natural gas
1990	4 510	3 598	912
1991	4 300	3 219	1 080
1992	4 245	3 177	1 067
1993	4 133	3 114	1 020
1994	3 999	2 998	1 001
1995	4 023	2 985	1 038
1996	4 060	2 967	1 092
1997	4 364	3 187	1 177
1998	4 745	3 565	1 180
1999	5 720	4 481	1 239
2000	6 145	4 836	1 309
2001	5 702	4 387	1 315
2002	5 418	4 059	1 358
2003	5 190	3 664	1 526
2004	5 134	3 568	1 566
2005	5 752	3 941	1 811
2006	6 086	4 119	1 966
2007	7 949	5 725	2 224
2008	8 410	6 118	2 291
2009	8 128	6 061	2 067
2010	8 226	6 151	2 075
2011	9 065	6 662	2 403
2012	9 381	6 851	2 530
2013	8 524	6 324	2 199
2014	10 216	7 318	2 898
2015	5 496	2 733	2 763
2016	8 596	5 896	2 700
2017	6 699	3 681	3 017
2018	7 662	4 885	2 777
2019	9 676	6 770	2 906
2020	8 581	5 558	3 023

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 (BOTAŞ) (which is state own enterprise and authority for crude oil and natural gas transportation and pipeline operation). Petroleum refining data were taken from Turkish Petroleum Refineries Co. (TÜPRAŞ). For LPG and gasoline distribution, consumption values presented in the national energy balance tables were used as AD.

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

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

Source Category Description:

This source category covers CH_4 emissions which occur during the surface and underground extraction of solid fuels and post-mining activities 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_4emissions are calculated.

Fugitive emissions from coal mining has decreased to 1 212 t CO_2 eq. in 2020 due to the decrease in the underground mining activities with respect to previous year.

Table 3.56 Fugitive emissions from solid fuels, 1990-2020

(kt)

Year	CO_2	CH_4	N_2O	CO_2 eq.
1990	NE	144	NO,NE	3 598
1991	NE	129	NO,NE	3 219
1992	NE	127	NO,NE	3 177
1993	NE	125	NO,NE	3 114
1994	NE	120	NO,NE	2 998
1995	NE	119	NO,NE	2 985
1996	NE	119	NO,NE	2 967
1997	NE	127	NO,NE	3 187
1998	NE	143	NO,NE	3 565
1999	NE	179	NO,NE	4 481
2000	NE	193	NO,NE	4 836
2001	NE	175	NO,NE	4 387
2002	NE	162	NO,NE	4 059
2003	NE	147	NO,NE	3 664
2004	NE	143	NO,NE	3 568
2005	NE	158	NO,NE	3 941
2006	NE	165	NO,NE	4 119
2007	NE	229	NO,NE	5 725
2008	NE	245	NO,NE	6 118
2009	NE	242	NO,NE	6 061
2010	NE	246	NO,NE	6 151
2011	NE	266	NO,NE	6 662
2012	NE	274	NO,NE	6 851
2013	NE	253	NO,NE	6 324
2014	NE	293	NO,NE	7 318
2015	NE	109	NO,NE	2 733
2016	NE	236	NO,NE	5 896
2017	NE	147	NO,NE	3 681
2018	NE	195	NO,NE	4 885
2019	NE	271	NO,NE	6 770
2020	NE	222	NO,NE	5 558

In 2020 the amount of coal mined have been increased by 3.8% and become 87 089 ktons. In 2020, the emissions from coal mining activities have been decreased by 18% and become 5 558 ktons CO_2 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 3.32 Domestic coal production 1990-2020

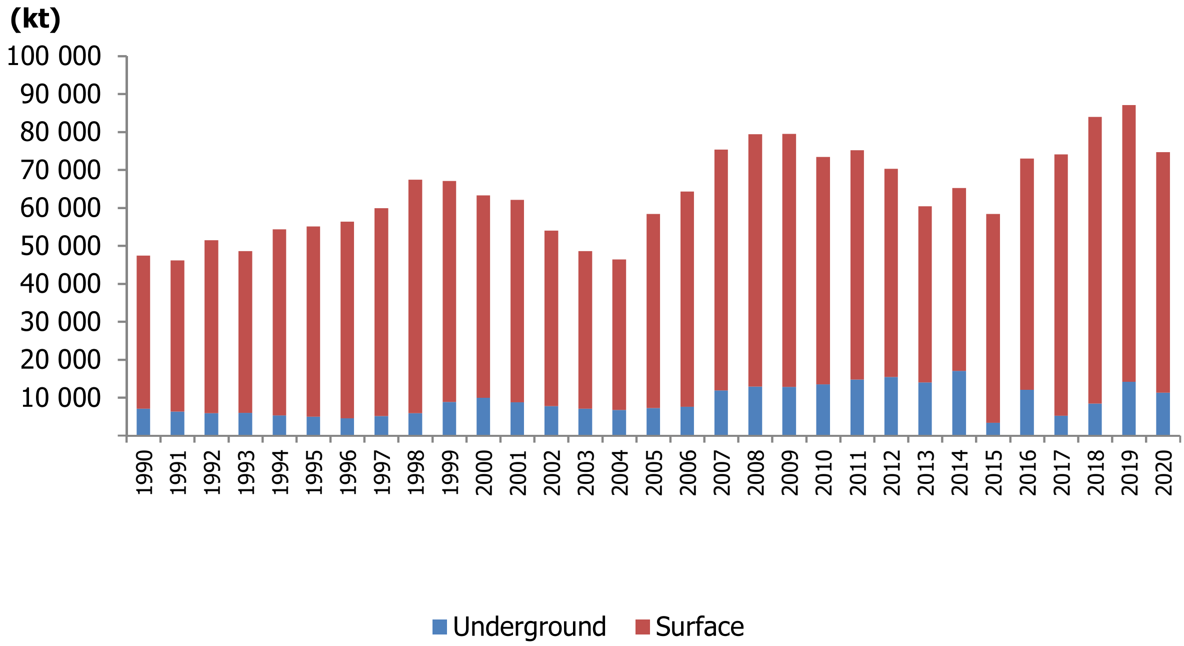


Figure 3.33 CH_4 emissions from coal mining, 1990-2020

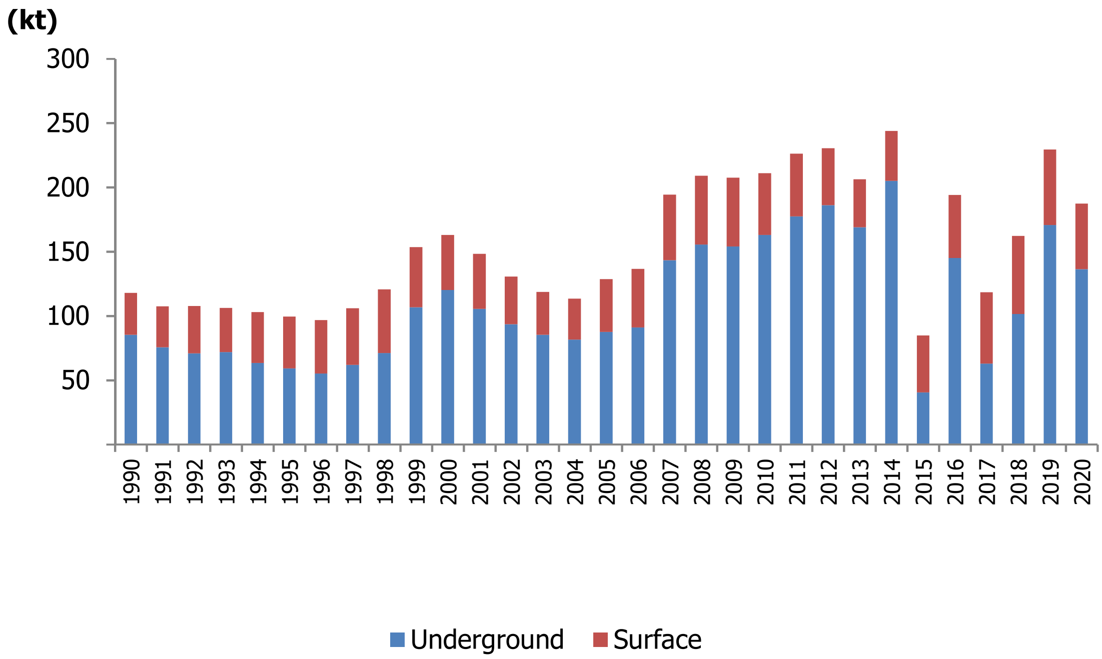


Table 3.57 Fugitive emissions from abandoned coal mines,1990-2020

(kt)

Year	CO_2	CH_4	CO_2 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
2018	NE	14.0	350
2019	NE	12.8	320
2020	NE	11.9	296

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^3/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 3.58 Coefficients used in the calculation of abandoned coal mines methane emission

Coal type	a	b
Hard coal	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_4EFs 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_4IEFs are in the range of 2006 IPCC Guidelines.

Recalculation:

There is no recalculation in this sector

Planned Improvement:

Since the category is a key category in terms of emission trend of CH_4, the tiers in CH_4 estimation needs to be increased. Detailed investigation has been performed to find out the availability of country specific or basin specific EFs within both general directorates for lignite and hard coal structured under the

MENR, namely, DG Turkish Lignite Enterprises and DG Turkish Hard Coal Enterprises. However, information for the generation of country-specific EFs are not available centrally in those coal authorities. Therefore, it is necessary to communicate and cooperate with mining enterprises directly to search the availability of required information for T2 estimation of CH_4.

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

Source Category Description:

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

This source category is a key category in terms of emission level and trend of CH_4emission. CO_2 emissions are mainly coming from oil production. About 95% of CO_2 emissions from oil and gas systems are venting and flaring emissions during oil extraction and production. CH_4 emissions are mainly coming from oil production and pipeline transmission and distribution of natural gas. In parallel to the increase in natural gas transmission and distribution, the greenhouse gas emissions in 1.B.2 category has increased from 912 kt CO2 eq. in 1990 to 3 023 kt in 2020.

Table 3.59 Fugitive emissions from oil and natural gas systems,1990-2020

(kt)

Year	CO_2	CH_4	N_2O	CO_2 eq.
1990	220	27.6	0.0031	912
1991	263	32.6	0.0037	1 080
1992	254	32.5	0.0035	1 067
1993	231	31.5	0.0032	1 020
1994	219	31.2	0.0030	1 001
1995	209	33.1	0.0029	1 038
1996	208	35.3	0.0029	1 092
1997	206	38.8	0.0029	1 177
1998	194	39.4	0.0027	1 180
1999	178	42.4	0.0025	1 239
2000	168	45.6	0.0023	1 309
2001	155	46.4	0.0021	1 315
2002	148	48.4	0.0020	1 358
2003	145	55.2	0.0020	1 526
2004	140	57.0	0.0019	1 566
2005	142	66.8	0.0019	1 811
2006	135	73.2	0.0018	1 966
2007	133	83.6	0.0018	2 224
2008	135	86.2	0.0018	2 291
2009	138	77.1	0.0019	2 067
2010	156	76.7	0.0021	2 075
2011	151	90.1	0.0020	2 403
2012	144	95.4	0.0019	2 530
2013	146	82.1	0.0020	2 199
2014	145	110.1	0.0020	2 898
2015	155	104.3	0.0021	2 763
2016	158	101.7	0.0021	2 700
2017	157	114.4	0.0021	3 017
2018	174	104.1	0.0024	2 777
2019	183	108.9	0.0025	2 906
2020	195	113.1	0.0027	3 023

Figure 3.34 Oil production, 1990–2020

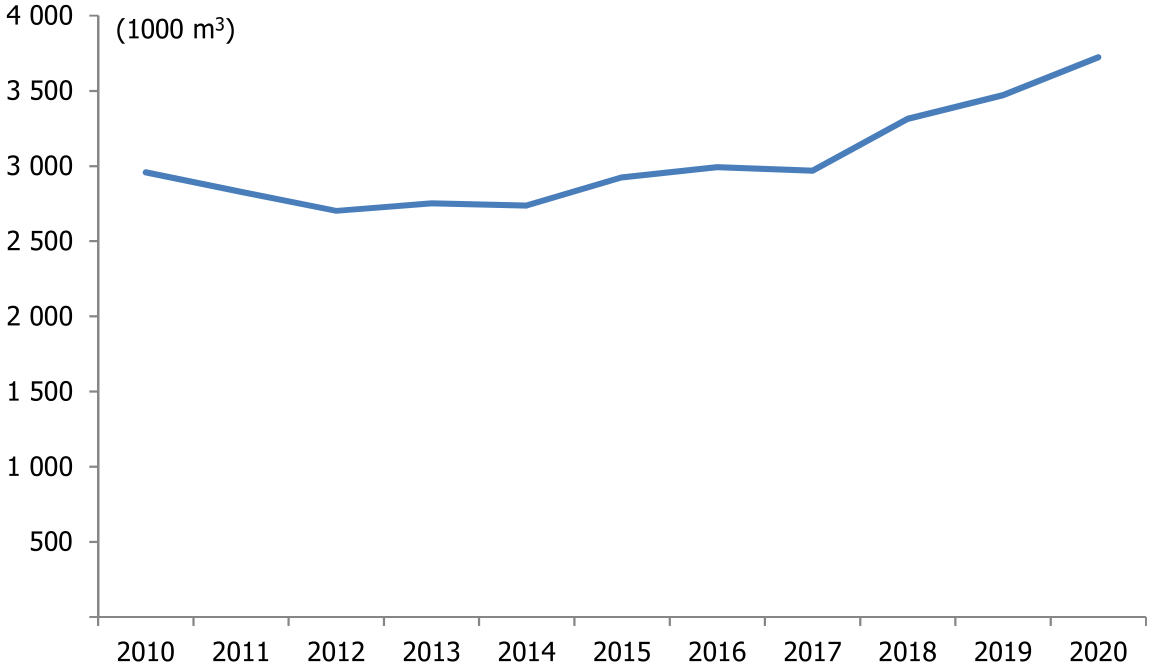


Figure 3.35 Natural gas production, 1990-2020

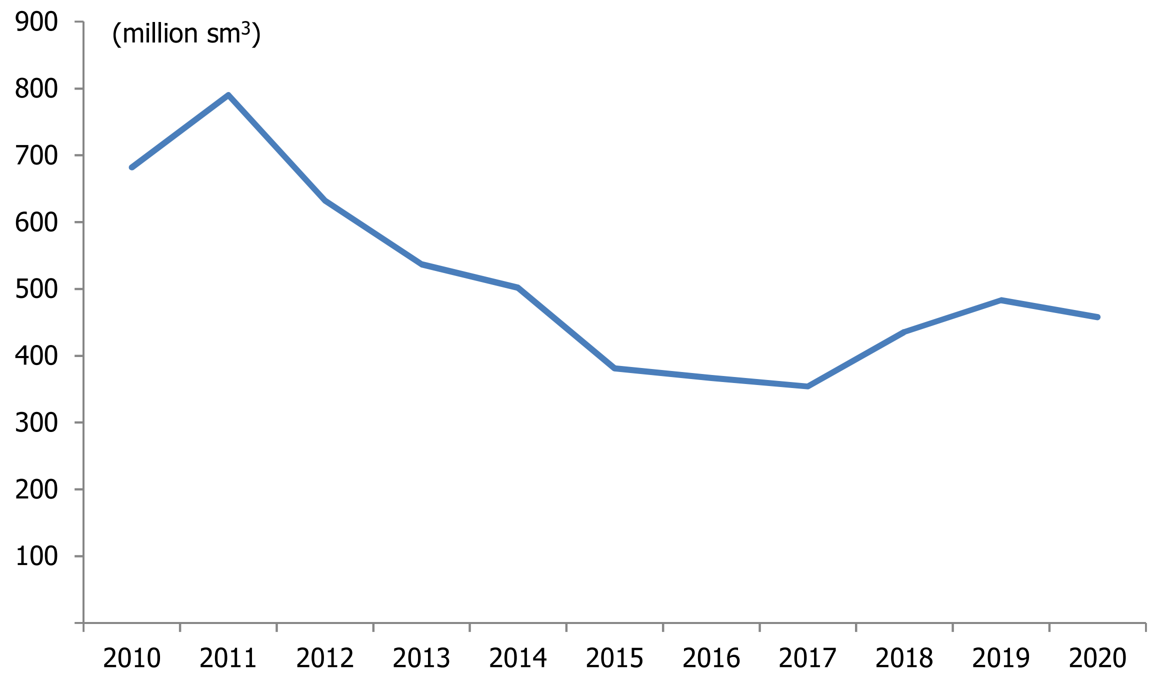


Figure 3.36 Natural gas transmission by pipeline, 1990-2020

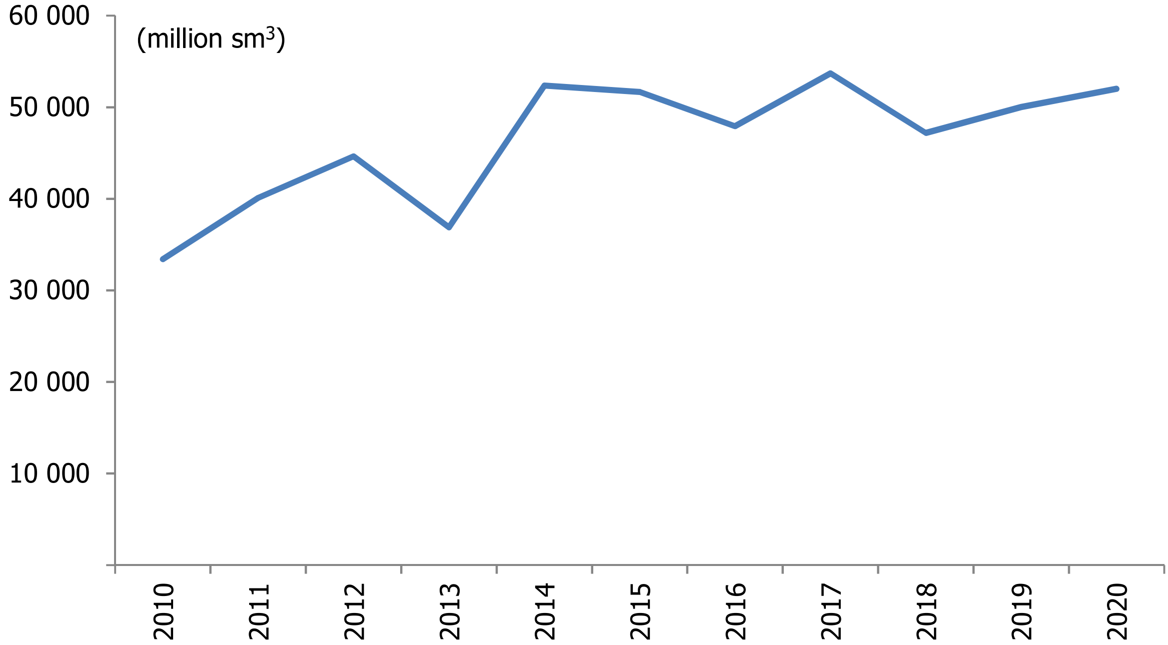
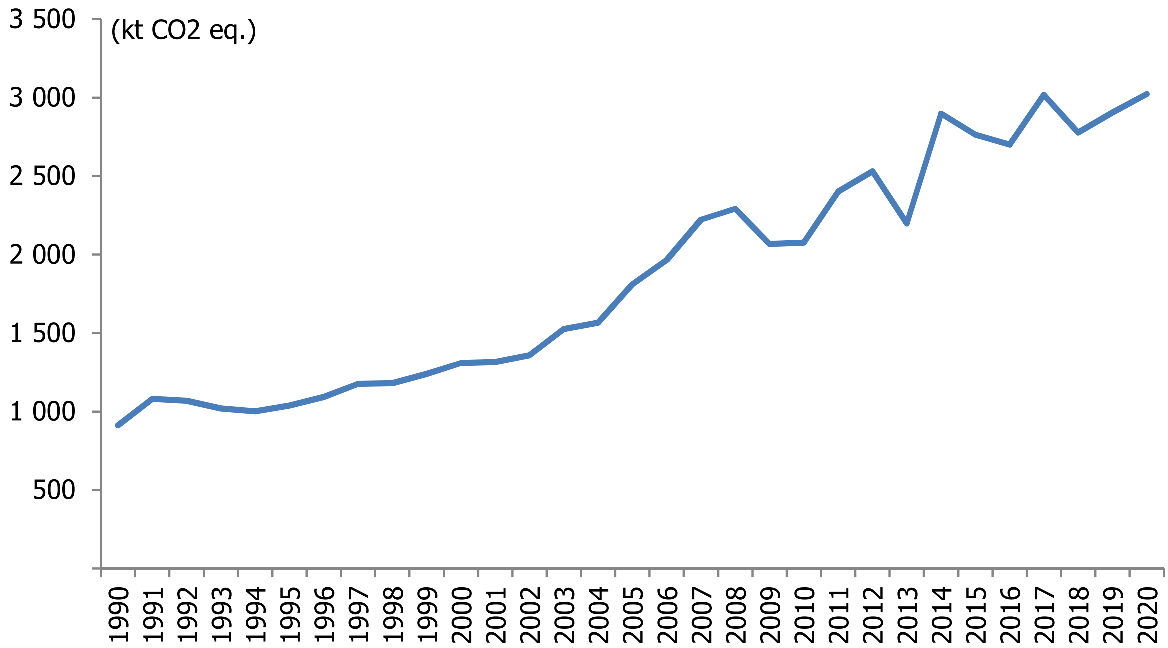


Figure 3.37 Fugitive emissions from oil and gas system, 1990-2020



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_4, the tiers in estimating CH_4 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_4. It is planned to continue with investigations.

Uncertainties and Time-Series Consistency:

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

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

Source-Specific QA/QC and Verification:

Quality control for 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_4 emission estimation, availability of detailed information have been searched. It is planned to continue the investigation to find out the availability or possibility of availability of appropriate data for higher tiers.

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

Source Category Description:

This source category covers only fugitive CO_2 from pipeline transportation of CO_2. This source category is not a key category. CO_2 emissions were calculated on the basis of pipeline length as 0.126 kt for whole 1990-2017 period.

Methodological Issues:

CO_2 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_2 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_2.

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_2 emissions were identified as key category are production of cement, lime and iron and steel, as well as other process uses of carbonates in different industrial activities. PFC emissions from aluminium production and HFCs from product uses as ODS substitutes are also considered key categories.

The total GHG emissions from industrial processes and product use is 66 762.6 CO_2 eq. for the year 2020 which is 14.3% of the total emissions including LULUCF sector and 12.7% of all emissions excluding LULUCF in Türkiye.

The most important GHG emission sources of IPPU in 2020 were cement production with 8.7% and iron and steel production 2.2% shares of the total national GHG emissions excluding LULUCF.

Table 4.1 Industrial processes and product use sector emissions, 2020

(kt CO_2 eq.)

GHG sources and sink categories	CO_2	CH_4	N_2O	HFCs/ PFCs/SF_6	Total
Industrial processes and product use	58 735	16	2 006	6 007	66 763
A. Mineral industry	47 109				47 109
B. Chemical industry	1 085	NO,NA	2 006	NO	3 091
C. Metal industry	10 406	16	NO	38	10 460
D. Non-energy products from fuels and solvent use	134	NA	NA		134
E. Electronic Industry				59	59
F. Product uses as ODS substitutes				5 853	5 853
G. Other product manufacture and use	NA	NA	NA	57	57
H. Other	NE,NA	NE,NA	NA	NA	NE,NA

The main gas emitted by the IPPU sector in 2020 was CO_2, contributing 88% (58 735 kt) of the sector emissions in 2020. HFCs, PFCs and SF_6 contributed 9% (6 007 kt CO_2 eq.) while the share of N_2O emissions was 3% (2 006 CO_2 eq.) and CH_4 emissions was 0.02% (16 kt CO_2 eq.).

Table 4.2 presents the development of the emissions for the IPPU sector. Total emissions from industrial process and product use increased by 190.5% between 1990 (22 983.5 kt CO_2 eq.) and 2020 (66 762.6).

Table 4.2 Overview of industrial processes and product use sector emissions, 1990-2020

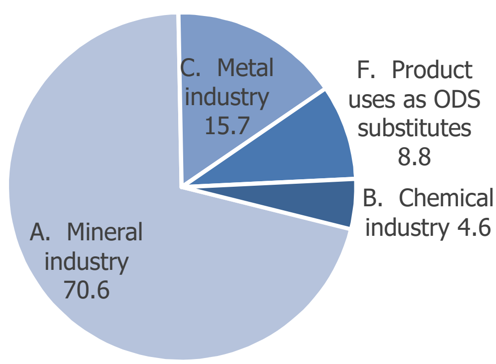
Year	A. Mineral industry		B. Chemical industry		C. Metal industry		D. Non-energy products from fuels and solvent use		Industrial Processes and Product Use Total	
	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)
1990	13 424	58.4	1 629	7.1	7 748	33.7	183	0.8	22 983	100.0
1991	14 940	60.0	1 373	5.5	8 378	33.7	190	0.8	24 881	100.0
1992	15 559	63.5	1 483	6.1	7 287	29.8	163	0.7	24 492	100.0
1993	16 118	65.3	1 403	5.7	6 981	28.3	174	0.7	24 676	100.0
1994	16 783	68.9	1 034	4.2	6 356	26.1	174	0.7	24 347	100.0
1995	17 549	67.9	1 476	5.7	6 623	25.6	203	0.8	25 852	100.0
1996	17 804	67.8	1 467	5.6	6 755	25.7	223	0.9	26 260	100.0
1997	18 665	68.9	1 504	5.6	6 675	24.6	242	0.9	27 098	100.0
1998	18 755	68.3	1 434	5.2	7 047	25.7	203	0.7	27 452	100.0
1999	17 850	68.9	1 126	4.3	6 670	25.7	250	1.0	25 908	100.0
2000	18 418	70.0	1 061	4.0	6 427	24.4	277	1.1	26 312	100.0
2001	18 102	69.8	916	3.5	6 454	24.9	214	0.8	25 932	100.0
2002	18 736	69.6	1 206	4.5	6 267	23.3	283	1.1	26 923	100.0
2003	19 490	69.0	1 137	4.0	6 716	23.8	275	1.0	28 262	100.0
2004	20 964	68.0	1 207	3.9	7 379	23.9	359	1.2	30 836	100.0
2005	23 246	69.0	1 321	3.9	7 523	22.3	446	1.3	33 700	100.0
2006	25 306	68.9	1 786	4.9	7 726	21.0	472	1.3	36 733	100.0
2007	27 530	70.1	1 119	2.9	8 429	21.5	449	1.1	39 262	100.0
2008	29 101	70.9	986	2.4	8 708	21.2	360	0.9	41 073	100.0
2009	30 725	71.4	1 392	3.2	8 391	19.5	396	0.9	43 037	100.0
2010	34 087	69.6	1 903	3.9	9 439	19.3	432	0.9	48 980	100.0
2011	36 225	67.2	2 747	5.1	10 557	19.6	854	1.6	53 882	100.0
2012	37 307	66.4	2 968	5.3	10 952	19.5	606	1.1	56 158	100.0
2013	40 536	68.5	2 579	4.4	10 999	18.6	534	0.9	59 187	100.0
2014	40 881	68.3	2 784	4.6	10 817	18.1	399	0.7	59 883	100.0
2015	40 301	68.1	2 788	4.7	10 973	18.5	266	0.5	59 213	100.0
2016	43 816	69.1	2 159	3.4	11 990	18.9	146	0.2	63 453	100.0
2017	46 470	70.0	2 004	3.0	12 130	18.3	152	0.2	66 409	100.0
2018	46 207	68.0	3 335	4.9	12 589	18.5	206	0.3	67 968	100.0
2019	38 564	65.8	3 129	5.3	10 567	18.0	138	0.2	58 577	100.0
2020	47 109	70.6	3 091	4.6	10 460	15.7	134	0.2	66 763	100.0

Table 4.2 Overview of industrial processes and product use sector emissions, 1990-2020 (cont.)*

Year	E. Electronic industry		F. Product uses as ODS substitutes		G. Other product manufacture and use		Industrial Processes and Product Use Total	
	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)
1990	-	0.0	-	0.0	-	0.0	22 983	100.0
1991	-	0.0	-	0.0	-	0.0	24 881	100.0
1992	-	0.0	-	0.0	-	0.0	24 492	100.0
1993	-	0.0	-	0.0	-	0.0	24 676	100.0
1994	-	0.0	-	0.0	-	0.0	24 347	100.0
1995	-	0.0	-	0.0	-	0.0	25 852	100.0
1996	-	0.0	-	0.0	10	0.0	26 260	100.0
1997	-	0.0	-	0.0	11	0.0	27 098	100.0
1998	-	0.0	-	0.0	12	0.0	27 452	100.0
1999	-	0.0	-	0.0	12	0.0	25 908	100.0
2000	-	0.0	116	0.4	13	0.1	26 312	100.0
2001	-	0.0	232	0.9	13	0.1	25 932	100.0
2002	-	0.0	417	1.5	14	0.1	26 923	100.0
2003	-	0.0	629	2.2	15	0.1	28 262	100.0
2004	-	0.0	909	2.9	16	0.1	30 836	100.0
2005	-	0.0	1 147	3.4	18	0.1	33 700	100.0
2006	-	0.0	1 424	3.9	19	0.1	36 733	100.0
2007	-	0.0	1 713	4.4	21	0.1	39 262	100.0
2008	-	0.0	1 896	4.6	22	0.1	41 073	100.0
2009	-	0.0	2 111	4.9	21	0.0	43 037	100.0
2010	42	0.1	3 054	6.2	23	0.0	48 980	100.0
2011	42	0.1	3 433	6.4	25	0.0	53 882	100.0
2012	42	0.1	4 257	7.6	26	0.0	56 158	100.0
2013	42	0.1	4 470	7.6	27	0.0	59 187	100.0
2014	42	0.1	4 927	8.2	33	0.1	59 883	100.0
2015	42	0.1	4 803	8.1	40	0.1	59 213	100.0
2016	42	0.1	5 263	8.3	36	0.1	63 453	100.0
2017	45	0.1	5 535	8.3	73	0.1	66 409	100.0
2018	57	0.1	5 502	8.1	71	0.1	67 968	100.0
2019	58	0.1	6 064	10.4	58	0.1	58 577	100.0
2020	59	0.1	5 853	8.8	57	0.1	66 763	100.0

*The icon "-" indicates notation keys "NO, NA, IE" as shown in the table 4.1

Figure 4.1 Emissions from industrial processes and product use by subsector, 2020



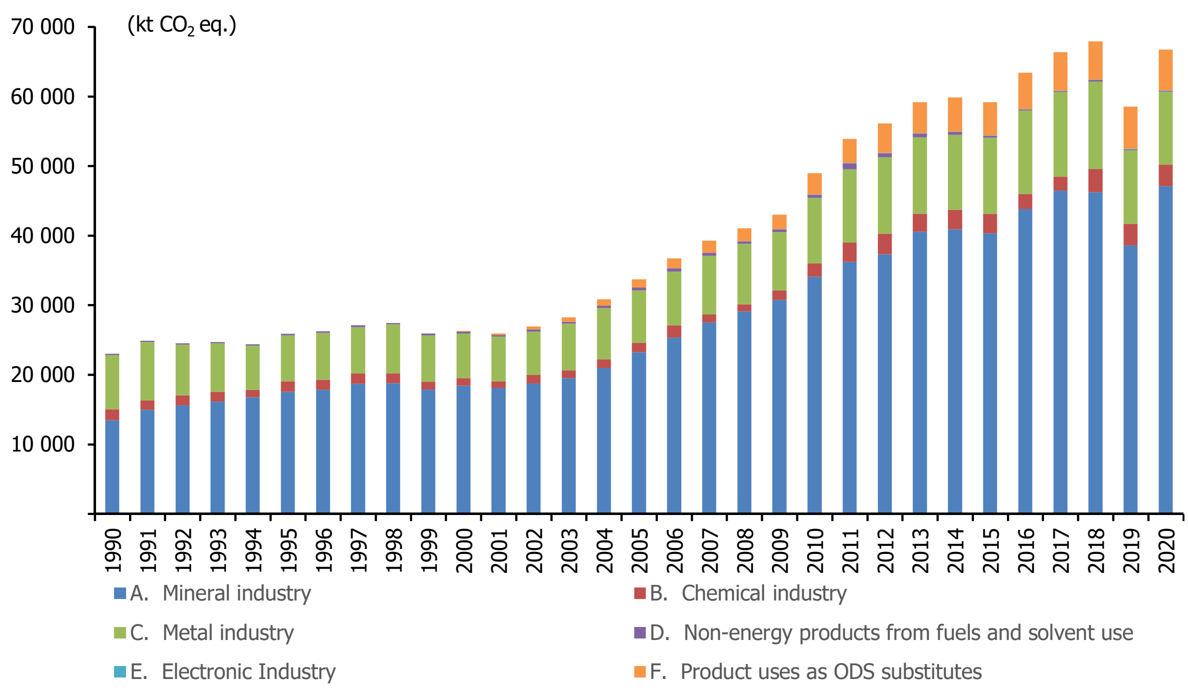
The mineral industry contributed 70.6% of the IPPU sector's emissions, the metal industry contributed 15.7%, product uses as ODS substitutes contributed 8.8%, while the chemical industry contributed 4.6% in 2020.

The average shares of the mineral industry, metal industry and chemical industry between the years 1990-2020 are 67.9%, 22.8% and 4.6%, respectively.

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 2020 is shown in Figure 4.2.

Figure 4.2 Emissions from industrial processes and product use by subsector, 1990–2020

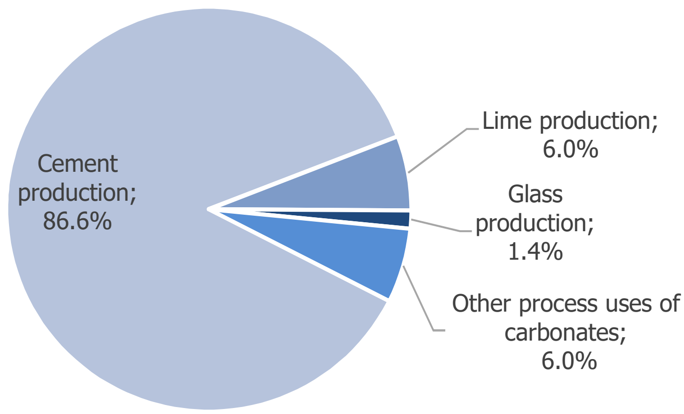


4.2. Mineral Industry (Category 2.A)

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

Figure 4.3 presents the share of CO_2 emissions in this category for the year 2020. The dominant sector is cement production having a 86.6% share of CO_2 emissions in the mineral industry. The second and third sectors are other process uses of carbonates and lime production each having 6% share of CO_2 emissions. Glass production is responsible for 1.4% of emissions in the mineral industry.

Figure 4.3 Share of CO_2 emissions from mineral production, 2020



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

Source Category Description:

Cement production causes CO_2 emissions due to calcination reaction of limestone during production and these emissions are reported under 2.A.1 CRF category. Moreover, cement production is an energy intensive process. Heating up the kiln with its load to such a high temperature is extremely energy consuming. Most of the kilns in Türkiye 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.

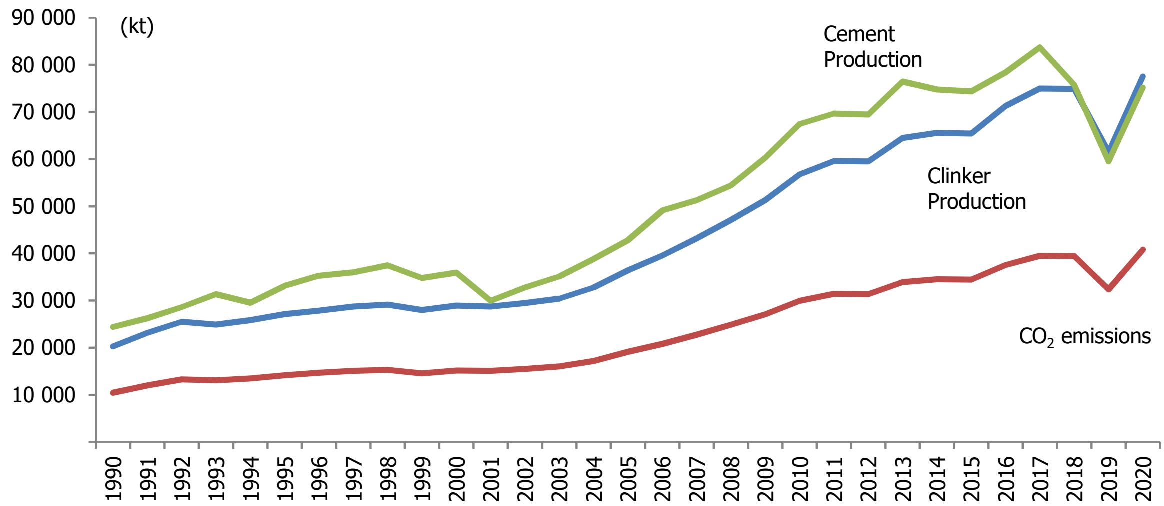
In cement production, limestone is fed to the cement kiln and heated up to 1400-1500 °C to produce lime. At this temperature calcium carbonate ($CaCO_3$) breaks into lime (CaO) and carbon dioxide (CO_2). The reaction is shown below.

$$CaCO_3 \rightarrow CaO + CO_2$$

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

Figure 4.4 below shows the trend at clinker production and the related CO_2 emissions between 1990 and 2020.

Figure 4.4 Trend at clinker, cement production and related CO_2 emissions, 1990-2020



Türkiye started cement production in 1911 and Türkiye was a cement importer till 1970s. Türkiye started exporting cement in 1978. By 2020, Türkiye is the Europe's biggest cement producer with its 77 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 Türkiye mostly portland cement is produced. Slag cement, puzzolan added cement and their modifications are also produced.

As can be seen from the figures above, CO_2 emissions increased by 291% between 1990 and 2020. Construction sector and cement export are the strongest drivers in the cement sector. Except some minor reductions in 2001 due to Türkiye's economic recessions and in 2015 due to conflict at Türkiye's southern neighborhood (Syria and Iraq), cement industry showed a continuous growth untill 2018. In 2018 and 2019 cement production decreased due to contraction in domestic demand. In 2020 clinker production was 77 539 kt and it caused 40 813 kt of CO_2 emission. By 2020 despite the negative effects of COVID-19, Türkiye construction industry recover and cement production increased by 26.3% with respect to 2019. Total housing sales in Türkiye increased by 11.2% compared to 2019, rising to approximately 150 000 housing units.

Methodological Issues:

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

$$CO_2\,emissions = M_{Cl} \cdot EF_{Cl} \cdot CF_{CKD}$$

Where:

CO_2 *Emissions* = emissions of CO_2 from cement production, tonnes
M_{Cl} = weight (mass) of clinker produced, tonnes
EF_{Cl} = emission factor for clinker, tonnes CO_2/tonne clinker
CF_{CKD} = emissions correction factor for CKD, dimensionless

Collection of activity data

There are 54 cement plants in Türkiye, one new plant launced operation in 2020 and included in calculations. Most of the cement plants are members of Turkish Cement Manufacturers' Association (TurkCimento) and they report their activity data to TurkCimento on monthly basis and TurkCimento publish the data as industry specific statistics on their website. Annual amount of national clinker production of Türkiye is gathered from the clinker production statistics of the TurkCimento website. The activity data of plants that are not member of TurkCimento, are collected with questionnaire.

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. Türkiye applies the IPCC default CKD correction factor of 1.02. In the following table, all the activity data and emission factors used for the emission calculation in the time series are shown. In addition, annual CO_2 emissions from clinker production are tabulated.

Table 4.3 CO_2 emissions from cement production, 1990-2020

Year	Clinker Production (kt)	Cemet Production (kt)	Cao Content (%)	CO_2 EF	CKD	CO_2 Emission (kt)
1990	20 252	24 416	64.4	0.506	1.02	10 445
1991	23 153	26 261	64.9	0.509	1.02	12 021
1992	25 489	28 607	65.0	0.510	1.02	13 265
1993	24 941	31 366	65.4	0.513	1.02	13 049
1994	25 880	29 515	65.1	0.511	1.02	13 493
1995	27 094	33 140	65.2	0.511	1.02	14 133
1996	27 852	35 233	65.8	0.516	1.02	14 662
1997	28 706	36 007	65.7	0.516	1.02	15 105
1998	29 148	37 488	65.4	0.514	1.02	15 292
1999	27 966	34 817	65.1	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	47 120	54 386	65.9	0.517	1.02	24 850
2009	51 351	60 358	65.8	0.516	1.02	27 040
2010	56 798	67 447	65.9	0.517	1.02	29 977
2011	59 579	69 643	66.0	0.518	1.02	31 454
2012	59 508	69 466	65.9	0.517	1.02	31 372
2013	64 482	76 484	65.7	0.516	1.02	33 913
2014	65 594	74 768	65.7	0.516	1.02	34 498
2015	65 433	74 401	65.8	0.516	1.02	34 441
2016	71 298	78 437	65.8	0.516	1.02	37 528
2017	74 985	83 735	65.8	0.516	1.02	39 469
2018	74 880	75 746	65.8	0.516	1.02	39 413
2019	61 458	59 511	65.8	0.516	1.02	32 349
2020	77 539	75 172	65.8	0.516	1.02	40 813

Uncertainties and Time-Series Consistency:

The uncertainty value of the AD was estimated to be ±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 TurkCimento supplied and it is found that they are close for 2015. The uncertainty value of the EF is 2% due to chemical analysis of clinker to determine CaO percentage and default factor used for CKD.

Moreover, Monte Carlo analysis has been carried out for the CO_2 emissions from cement production for 2020 submission and it resulted with -5.35% to +5.37% combined 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 TurkCimento and reported monthly on their website. The activity data of plants that are not member of TurkCimento, are collected with questionnaire. However, TurkCimento 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.

Moreover, the clinker production data gathered from the TurkCimento and 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, Urbanization and Climate Change. However, there is not enough information for other plants.

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

A QA work was conducted by an external reviewer from CITEPA (Technical Reference Center for Air Pollution and Climate Change) for this category in January 2020.

Recalculation:

In 2020 activity data from three cement plants, which did not report their activity data to TurkCimento, are gathered with questionnaire and included in calculations. For this source category, the recalculation has increased the cement emissions by the average 3.6% (1 260 kt CO_2 emissions) for the period of 2008-2019 and 6.0% (1 926 kt CO_2 emissions) for 2019.

Planned improvements:

Türkiye made improvements in the representativeness of the country specific carbonate content of the clinker in 2017.

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, Urbanization and Climate Change in MRV (Monitoring, Reporting, Verification) system. However, there is no 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_2 is generated during the calcination stage, when limestone ($CaCO_3$) are burned at high temperature (900-1200°C) in a kiln to produce quicklime (CaO) and CO_2 is released in the atmosphere. Magnesium carbonate ($MgCO_3$) breaks into MgO and CO_2 in the same manner. The calcination reactions are shown below in the chemical equations.

$$CaCO_3 \rightarrow CaO + CO_2$$

$$MgCO_3 \rightarrow MgO + CO_2$$

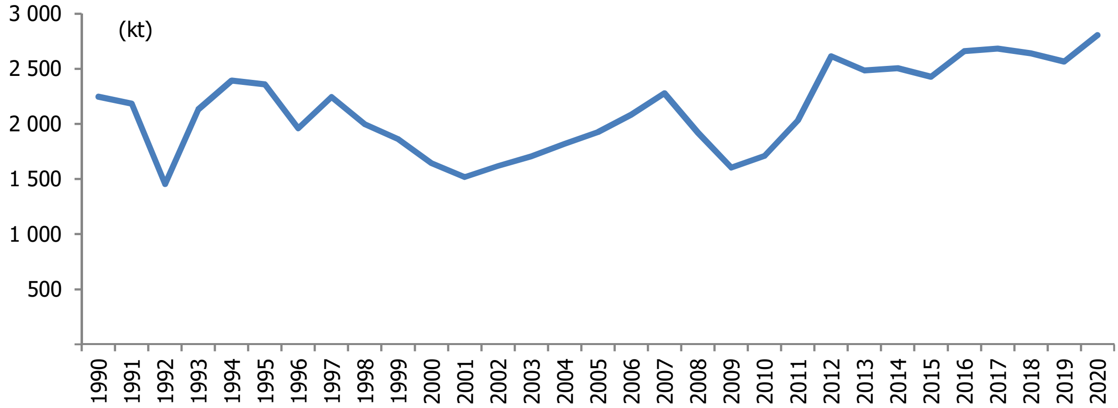
Lime production results in CO_2 emissions due to calcination reaction of limestone during production and these emissions are reported under 2.A.1 CRF category. Moreover, lime production is an energy intensive process. Heating up the kiln with its load to such a high temperature is extremely energy consuming. Most of the kilns in Türkiye 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.

In Türkiye lime is produced by a wide range of technology from old fashioned kilns to computer controlled plants. Most of the lime plants in Türkiye are technologically new or modified to best available technologies. The old technology lime plants are minority in Türkiye 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_2 in their process steps and CO_2 is absorbed. Therefore, lime production of the sugar refiners and soda ash producers do not contribute to the greenhouse gas inventory.

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

The figure 4.5 shows the trend at lime production and the related CO_2 emissions between 1990 and 2020. The lime produced in Türkiye is mostly used in the manufacturing and construction sector. Emissions from lime production are increased by 24.8% between 1990 and 2020. 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 4.5 CO_2 emissions from lime production, 1990-2020



Methodological Issues:

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

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

Where:

- CO_2 *emissions* = emissions of CO_2 from lime production, tonnes
- M_{ql} = Production of quick lime
- M_{cl}= Amount of captive lime (non emissive quick lime production)
- M_{dl}= Production of dolomitic lime
- EF_{ql} = Emission factor for quick lime
- EF_{dl}= Emission factor for dolomitic lime

In sugar industry lime is produced for sugar refining. Both the quick lime and the CO_2 is used for precipitating the impurities in the sugar. In the Turkish inventory it is assumed that all the CO_2 produced in lime production for sugar refining is precipitating and no CO_2 is emitted. Also in the soda ash production with solvay process, lime is produced and the resulting CO_2 is used in the process as an intermediate product. It is assumed that all the CO_2 produced from limestone in the soda ash production process is captured and no CO_2 emitted. Therefore, the lime produced for sugar industry and the soda ash production industry is deducted from the national lime production data and the emissions are calculated accordingly. Consistent with the use of the Tier 1 method, Türkiye 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 (CaO) production data are collected from the Lime Producers Association (KISAD). KISAD 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 KISAD using the lime import and export data and related activity data in the industry. In addition, sectoral lime consumption data is also taken from KISAD 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 4.4 Lime production and CO_2 emissions, 1990-2020

(kt)

Year	Quick Lime Production	Quick Lime produced for synthetic soda ash production	Quick Lime produced for sugar industry	Dolomitic lime production	County specific emission factor	CO2 Emissions
1990	4 000	233	182	47	0.617	2 249
1991	3 930	280	192	47	0.621	2 183
1992	2 775	286	199	51	0.618	1 454
1993	3 860	297	205	57	0.622	2 133
1994	4 168	298	157	61	0.632	2 394
1995	4 090	334	140	66	0.638	2 359
1996	3 575	350	205	67	0.632	1 961
1997	4 049	360	273	72	0.641	2 245
1998	3 789	427	340	71	0.643	1 997
1999	3 527	465	251	72	0.643	1 864
2000	3 241	473	272	72	0.637	1 645
2001	2 972	477	183	76	0.632	1 520
2002	3 150	485	237	83	0.641	1 620
2003	3 231	491	187	92	0.640	1 704
2004	3 380	497	204	103	0.649	1 819
2005	3 584	506	224	106	0.646	1 925
2006	3 735	536	224	118	0.670	2 083
2007	3 952	575	134	129	0.672	2 280
2008	3 385	578	125	135	0.677	1 920
2009	2 877	558	110	127	0.682	1 605
2010	3 225	703	195	147	0.687	1 711
2011	3 819	747	301	171	0.685	2 031
2012	4 621	666	356	180	0.688	2 615
2013	4 400	715	300	174	0.695	2 486
2014	4 443	704	315	171	0.694	2 507
2015	4 325	683	313	158	0.693	2 429
2016	4 695	713	328	167	0.693	2 660
2017	4 868	863	342	189	0.693	2 684
2018	4 984	871	300	188	0.693	2 642
2019	4 750	917	320	170	0.693	2 565
2020	4 964	790	320	177	0.693	2 807

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_2 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 2016-2020 inventories.

Uncertainties and Time-Series Consistency:

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

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

Monte Carlo simulation was carried out to estimate uncertainty in CO_2 emissions from lime category. Combined uncertainty in CO_2 emissions in 2018 is estimated at -16.87% to +17.92%. Further information about Monte Carlo analysis can be seen in Uncertainty chapter (Annex 2).

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 4 700 kt of lime sales in Türkiye while KISAD reports 4 750 kt of lime production in Türkiye in 2019[4].

In addition, Türkiye'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 Türkiye 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.

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

[4] https://www.internationallime.org/world-lime-production/

Moreover, a QA work was conducted by an external reviewer from CITEPA (Technical Reference Center for Air Pollution and Climate Change) for this category in January 2020.

Recalculations:

A correction to the activity data for lime in 2019 results in a reduction in emissions of 222 kt CO_2.With respect to previous year, the currently submitted values show an increase of 8% for the year 2019.

Planned Improvement:

It is planned to obtain a country specific emission factor for dolomitic lime and emissions from lime production in sugar factories in next submissions.

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

Source Category Description:

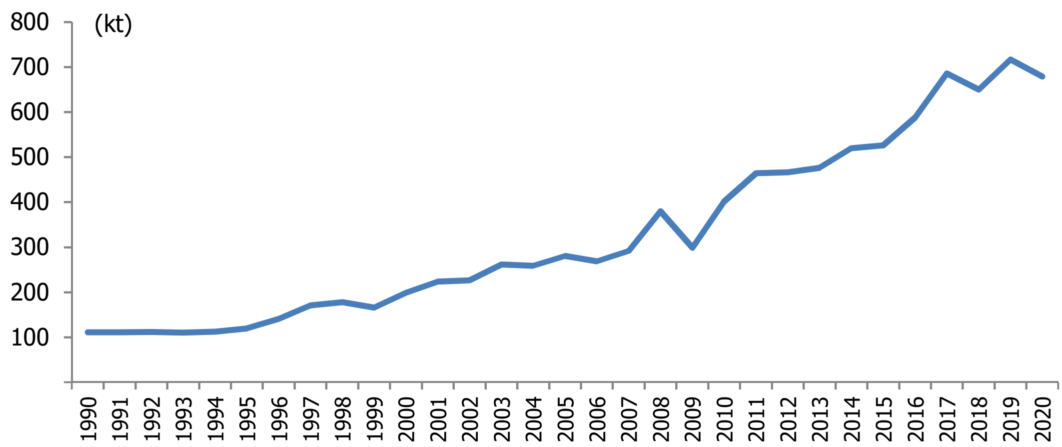
A variety of raw materials are involved during glass production. Limestone, dolomite and soda ash are the carbonates that compose the majority of raw materials. These carbonates emit CO_2 when heated (calcined) during the glass production and it is reported under 2.A.3 CRF category. Glass makers also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

Turkish glass industry produces various type of glasses with different chemical and physical properties. Türkiye'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. Türkiye glass industry production reached 4.3 Mt in 2020 and it was 3.4 Mt in 2015. Since the Turkish glass industry does not have an advantage in terms of raw material and energy costs compared to its European peers, capacity utilization rates of the industry are the key indicator of the competitive edge and profitability. The industry depicted a tremendous growth trend either through capacity additions or through new product initiations between 1990 (1.13 Mt molten glass produced) and 2020 (4.2 Mt molten glass produced), increasing 277%.

The trend in CO_2 emissions from glass production is given in the Figure 4.6. The emissions are increasing in general due to increasing glass production in Türkiye. The time series shows a considerable decrease in 2009 due to effects of global economic recession in that year.

Figure 4.6 CO_2 emissions from glass production, 1990-2020



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

$$CO_2\ emissions = \sum_i (M_i \cdot EF_i \cdot F_i)$$

Where:

> *CO_2 emissions* = emissions of CO_2 from glass production, tonnes
> *EF_i* = emission factor for particular carbonate i,tonnes CO_2/tonne carbonate
> *M_i* =weight or mass of the carbonate i consumed (mined), tones
> *Fi* = fraction calcination achieved for the carbonate i, fraction

Collection of activity data

Türkiye produces float glass, container glass (including household glassware) and fiberglass for insulation. Total glass production of Türkiye 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 1990-2020.

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

Table 4.5 Molten glass production and CO_2 emissions by type of glass, 1990-2020

(kt)

Year	Total Glass Production	Float Glass	Container (households +bottles)	Fiberglass	CO_2 emission from glass
1990	1 129	650	456	23	111
1991	1 113	669	427	17	111
1992	1 157	625	508	24	112
1993	1 163	606	533	24	110
1994	1 183	614	547	22	112
1995	1 290	625	643	22	120
1996	1 541	748	772	21	141
1997	1 789	782	978	29	171
1998	1 846	824	990	32	178
1999	1 681	771	878	32	166
2000	1 934	974	922	38	199
2001	1 843	880	919	44	224
2002	1 870	870	955	45	226
2003	2 069	991	1 016	62	262
2004	2 119	1 002	1 047	70	259
2005	2 175	1 016	1 085	74	280
2006	2 090	938	1 080	72	269
2007	2 427	1 141	1 213	73	292
2008	2 754	1 385	1 299	70	380
2009	2 174	1 075	1 048	51	299
2010	2 800	1 452	1 294	54	402
2011	3 169	1 746	1 348	75	464
2012	3 106	1 525	1 499	82	467
2013	3 186	1 624	1 485	77	476
2014	3 560	1 876	1 618	66	520
2015	3 444	1 661	1 718	65	526
2016	3 982	1 996	1 934	52	588
2017	4 375	2 305	2 023	48	686
2018	4 427	2 253	2 140	34	650
2019	4 396	2 102	2 228	66	717
2020	4 255	1 856	2 338	60	679

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 Türkiye (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 2018 (4 427 kt). In 2019 and 2020 total glass production slightly decrease and become 4 255 kt in 2020. The CO_2 emissions from glass production is 679 kt in 2020.

Choice of emission factor

CO_2 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 4.6 EFs for carbonates, 1990-2020

Carbonate	EF (tonnes CO_2/tonne carbonates)
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.

Uncertainty for CO_2 emissions from category 2.A.3 was quantified using the Monte Carlo simulation for 2020 submission. The Monte Carlo analysis resulted with (-9.63%,+9.82%) combined uncertainty. Further information about Monte Carlo analysis can be seen in Uncertainty chapter (Annex 2).

Source-Specific QA/QC and Verification:

The data used in Glass Production category is collected directly from these plants by questionaire for all the years 1990-2020.

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye. A QA work was conducted by an external reviewer from CITEPA (Technical Reference Center for Air Pollution and Climate Change) for this category in January 2020.

Recalculation:

No recalculations have been made to emissions from this category.

Planned Improvements:

No further improvements are planned regarding this source.

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, bricks and roof tile production, other uses of soda ash and non-metallurgical magnesia production are reported.

Figure 4.7 CO_2 emissions from other uses of carbonates, 1990-2020

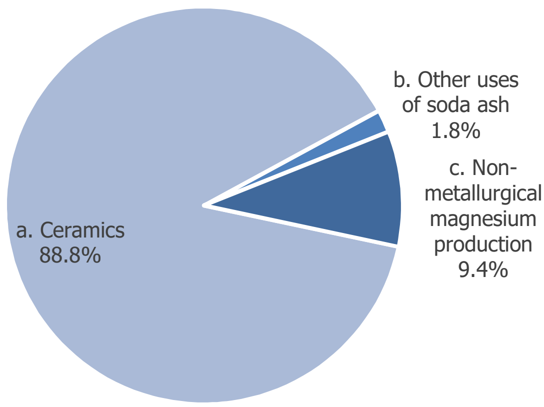


Figure 4.7 shows the share of CO_2 emissions in other uses of carbonates for 2020. The major sector is ceramics production having a 88.8% (2 494 kt) share of CO_2 emissions of other uses of carbonates. The second sector is non-metallurgical magnesium production shares 9.4% (264 kt) and third other uses of soda ash sector shares 1.8% (52 kt) of CO_2 emissions of other uses of carbonates.

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

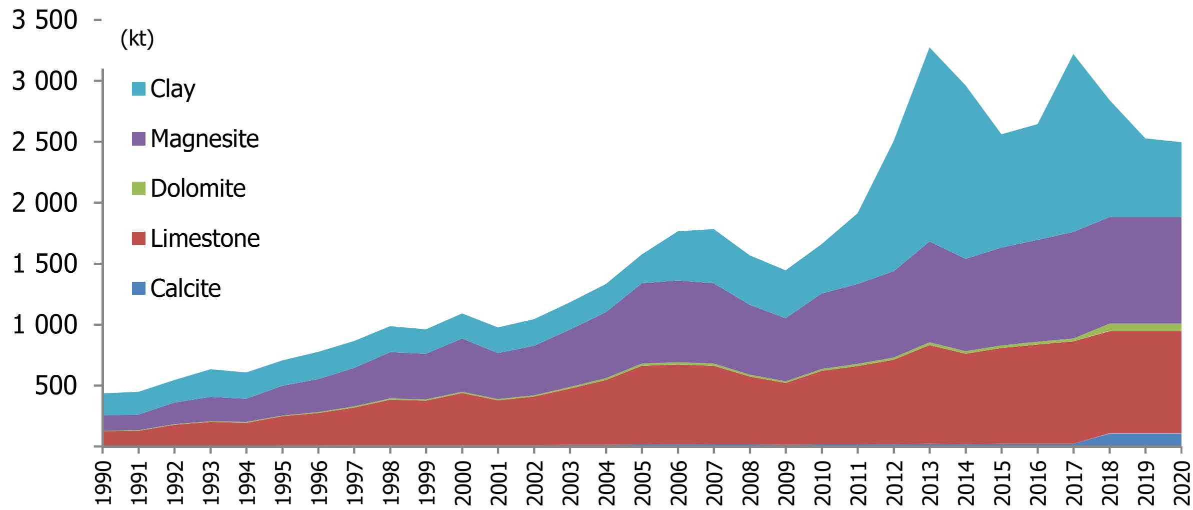
Source Category Description:

Ceramics production is a source of CO_2 emissions since raw materials like limestone and magnesite are calcined during manufacturing. Moreover, ceramic production is an energy intensive process. Heating up the ceramics to such a high temperature for calcination is extremely energy consuming. Most of the ceramic manufacturers in Türkiye use natural gas for this purpose. The emissions due to combusting of fuels to heat up the ceramics are included in 1.A.2.f CRF category.

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_2 emissions from ceramic production show an increasing trend for the years 1990-2017 overall. In 2020, ceramic production and the resulting CO_2 emissions decreased by 22.5% with respect to 2017.

Figure 4.8 CO_2 emissions, by raw materials type, from ceramics, 1990-2020



Methodological Issues:

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

$$CO_2\ emission = \sum(M_i \cdot EF_i)$$

Where:

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

Collection of activity data

Calcite, limestone, dolomite, magnesite and hydro-magnesite are consumed as raw materials in the ceramics industry. Production of ceramic tile and sanitary ware and carbonate consumption data (see the following table) are gathered from the Turkish Ceramics Federation for the time series 1990-2018. The amount of bricks and tile are gathered by Turkish Statistical Institute for the years 1990-1999 and 2005-2020. Data gaps for the years 2000-2004 is estimated. In this calculation following assumptions are made by using one of the plant data

$$1\ m^3\ brick = 600\ kg,$$
$$1\ brick = 4\ kg,$$
$$1\ tile = 3\ kg,$$
$$Kg_{\ clay} = 1.3 * kg_{\ bricks\ and\ tile}$$

Table 4.7 Raw material consumption and production, 1990-2020

	Raw Material (kt)					Product (kt)			Total Product (kt)
Year	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
2018	241	1 912	127	1 675	31 169	6 030	350	23 976	30 356
2019	241	1 912	127	1 675	20 922	6 030	350	16 094	22 474
2020	241	1 912	127	1 675	19 899	6 030	350	15 307	21 687

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 4.8 Carbonate EFs for all years in the time series

Carbonate	EF (tonnes CO_2/ton carbonate)
Calcite and limestone	0.43971
Dolomite	0.47732
Magnesite	0.52197
Clay	0.03077

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

CO_2 emissions from each raw material are given in the table below and in Figure 4.8.

Table 4.9 CO_2 emissions from raw material consumption, 1990-2020

(kt)

Year	Calcite	Limestone	Dolomite	Magnesite	Clay	Total
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
2018	106.1	840.7	60.6	874.3	959.4	2 841.1
2019	106.1	840.7	60.6	874.3	644.0	2 525.7
2020	106.1	840.7	60.6	874.3	612.5	2 494.2

Uncertainties and Time-Series Consistency:

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

AD uncertainties are greater than the uncertainties associated with EFs. Although there is a significant amount of roof tiles and bricks production in Türkiye, 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).

Category 2.A.4.a employed a Monte Carlo uncertainty analysis which causes a combined uncertainty range (-19.24%, +20.79%) for CO_2 emissions in 2020 submission. Detailed explanation of Approach 2 method is in Uncertainty part of this inventory report (Annex 2).

Source-Specific QA/QC and Verification:

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

Additionally, a QA work was conducted by an external reviewer from CITEPA (Technical Reference Center for Air Pollution and Climate Change) for this category in January 2020.

Recalculations

No recalculations have been made to emissions from this category.

Planned Improvements

Ceramic production data were gathered from Turkish Ceramics Federation until the federation had judicial issues regarding data collection from its members in 2020. As a result of this situation, TurkStat launched studies for estimating emissions of ceramics sector from other data sources. Calculations will be examined in next submissions.

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

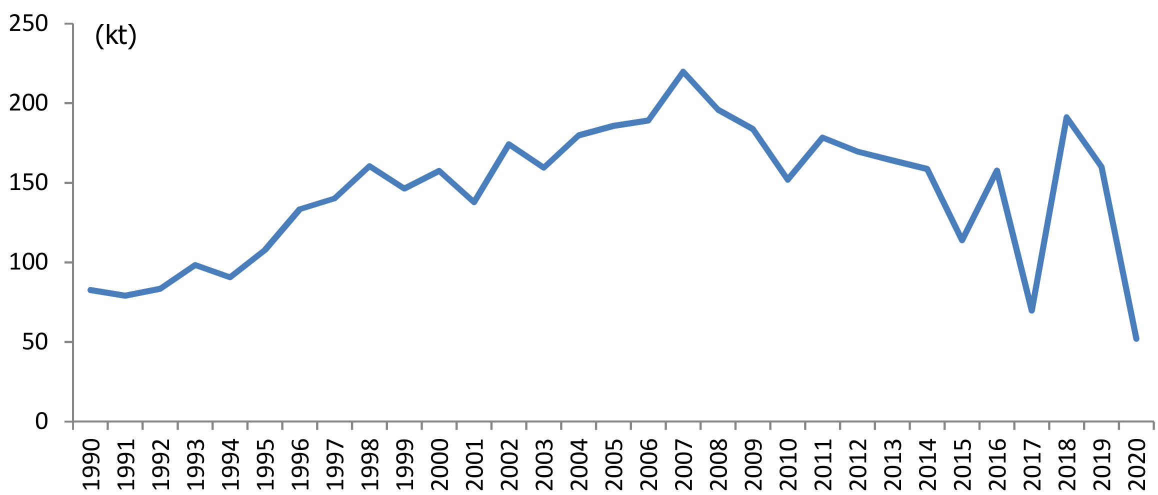
Source Category Description:

In this category, emissions from soda ash consumption are considered. CO_2 emissions from soda ash used in glass manufacturing industry are included in Glass Production. There are no other uses of soda ash included elsewhere in the Turkish Inventory.

Since soda ash is an important intermediate product primarily for the glass industry and detergent industry and it is used in many other industries. Soda ash consumption increased dramatically between 1990 (315 kt) and 2020 (848 kt) as the Turkish industry grew. During the 2001 and 2008 economic recessions, soda ash consumption decreased remarkably. Since 2009 consumption has increased driven by the growth of the glass industry in particular and the growth of Turkish industry in general.

In 2020 the GHG release due to the apparent consumption of soda ash is 52 kt of CO_2.

Figure 4.9 CO_2 emissions from other use of soda ash, 1990-2020



Methodological Issues:

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

Collection of activity data

Apparent consumption is calculated by the following formula.

Total Consumption = Soda ash production +Imports – Exports

Apparent Consumption = Total Consumption – Use in Glass Industry

Total production values are gathered from the two soda ash producer plants while foreign trade statistics are provided by TurkStat. The data for the amount of soda ash used in the glass sector is estimated from the glass production data which was obtained from glass producer plants.

Choice of emission factor

The default EF (0.41492 tonnes CO_2 /tonnes product) taken from Table 2.1 of the 2006 IPCC Guidelines, Volume 3, Chapter 2 is applied for the full time series.

Total consumption, use in glass industry, apparent consumption and CO_2 emissions from soda ash consumption are given in the following table.

Table 4.10 Activity data for the other use of soda ash and CO_2 emissions, 1990-2020

(kt)

Year	Total Consumption	Use in Glass Industry	Apparent Consumption	CO_2 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
2018	1 180	719	461	191
2019	1 168	782	386	160
2020	848	724	124	52

Uncertainties and Time-Series Consistency:

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

Moreover, Monte Carlo analysis has been carried out for the CO_2 emissions from other uses of soda ash production for 2020 submission and it resulted with a range of -30.14% to +29.94% combined uncertainty. Further information about Monte Carlo analysis of other uses of soda ash production can be seen in Uncertainty chapter (Annex 2).

Source-Specific QA/QC and Verification:

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

There are three plants in Türkiye 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.

A QA work was conducted by an external reviewer from CITEPA (Technical Reference Center for Air Pollution and Climate Change) for this category in January 2020.

Recalculations:

No recalculations have been made to emissions from this category.

Planned Improvements:

No further improvements are planned regarding this source.

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

Source Category Description:

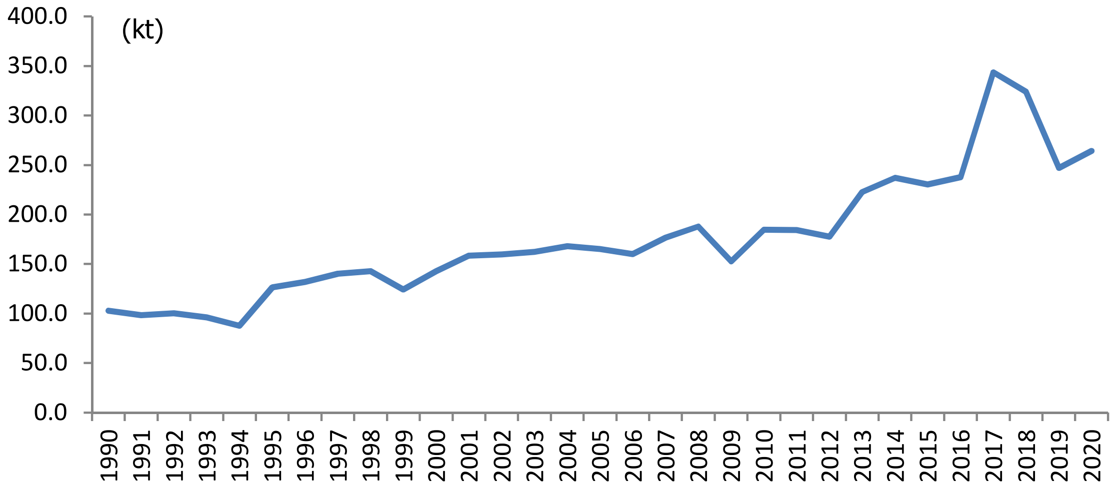
This source category should include emissions from magnesia (MgO) production that are not included elsewhere. Magnesite ($MgCO_3$) is one of the key inputs into the production of magnesia, and ultimately fused magnesia. There are three major categories of magnesia products: calcined magnesia, dead burned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

$$MgCO_3 \rightarrow MgO + CO_2$$

Depending on the calcination temperature, calcined magnesia or deadburned magnesia is produced. Deadburned magnesia requires higher temperatures and its purity is higher than calcined magnesia in terms of MgO. Fused magnesia is produced in the electrical arc furnaces at very high temperatures and it is the purest among all. The figure below shows the CO_2 emissions from total magnesia production between 1990 and 2020.

Figure 4.10 CO_2 emissions from magnesia production, 1990-2020



Methodological Issues:

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

Collection of Activity Data

The magnesia production data are collected from the magnesia producers. There are seven plants that are producing magnesia in Türkiye. Each of them were asked for their activity data by a questionnaire.

Choice of Emission Factor

The default IPCC EF (0.52197 tonnes CO_2 / tonne carbonate) taken from Table 2.1 of the 2006 IPCC Guidelines, Volume 3, Chapter 2, is applied for all the time series.

Table 4.11 Magnesia production and CO_2 emissions, 1990-2020

(kt)

Year	Magnesia production	CO_2
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
2018	621.0	324.1
2019	473.1	247.0
2020	506.5	264.4

Uncertainties and Time-Series Consistency:

AD is collected from the companies and all the 7 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 ±2%.

Additionally, an uncertainty analysis using the Monte Carlo technique was carried out to estimate emissions of CO_2 for 2.A.4.c category (Non metallurgical magnesia production) in 2020 submission.

Combined uncertainty in CO_2 emissions in 2018 is estimated at the range of (-30.14%,+30.29%). For more detailed explanations please refer to Annex 2.

Source-Specific QA/QC and Verification:

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

Furthermore, a QA work was conducted by an external reviewer from CITEPA (Technical Reference Center for Air Pollution and Climate Change) for this category in January 2020.

Recalculation:

A correction to the activity data for magnesia production in 2019 results increase in emissions of 33.2 kt CO_2. With respect to previous year, the currently submitted values show an increase of 15.5% for the year 2019.

Planned improvement:

No further improvements are planned regarding this source.

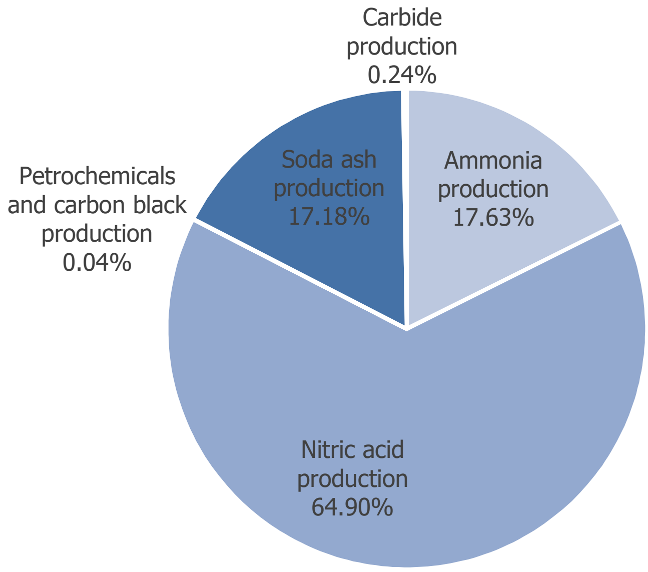
4.3. Chemical Industry (Category 2.B)

In 2020, the chemical industry was responsible for 4.6% of the total carbon dioxide equivalent emissions from the industrial processes and product use sector. Between 1990 (1 629 kt CO_2 eq) and 2020 (3 091 kt CO_2 eq.), total carbon equivalent emissions increased by 89.7%. The increase in emissions is driven exclusively by the increase in CO_2 emissions from ammonia production, soda ash production and N_2O emissions from nitric acid production; emissions from all other sub-categories declined over the reporting period, 1990-2020.

Figure 4.11 depicts the share of CO_2 equivalent emissions from chemical industry. The CO_2 eq. emissions from nitric acid production are (64.9%), followed by ammonia production and soda ash production (with 17.63% and 17.18% respectively). Carbide use and petrochemical production are much smaller contributors to emissions (0.24% and 0.04%, respectively).

There is no production of adipic acid, caprolactam, glyoxal, glyoxylic acid, or titanium dioxide produced in Türkiye, therefore emissions are reported as "NO" for these subcategories.

Figure 4.11 CO_2 emissions from chemical industry, 2020



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

Source Category Description:

Ammonia is a major industrial chemical and the most important nitrogenous material produced. Ammonia gas is used directly as a fertilizer, in heat treating, paper pulping, nitric acid and nitrates manufacture, nitric acid ester and nitro compound manufacture, explosives of various types, and as a refrigerant. Amines, amides, and miscellaneous other organic compounds, such as urea, are made from ammonia.

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

Overall reforming reaction:

$$0.88\,CH_4 + 1.26\,Air + 1.24\,H_2O \rightarrow 0.88\,CO_2 + N_2 + 3H_2$$

Ammonia synthesis reaction:

$$N_2 + 3H_2 \rightarrow 2NH_3$$

Ammonia production requires the combustion of fuels for the energy demand of the process. Besides being used as feedstock, natural gas is also used for meeting the energy requirement of the process. Both the emissions due to the ammonia production process and the fuel combustion for the energy demand are included in 2.B.1 CFR category. To avoid double counting, the total quantities of natural gas used in ammonia production is subtracted from the quantity reported under energy use in the energy sector.

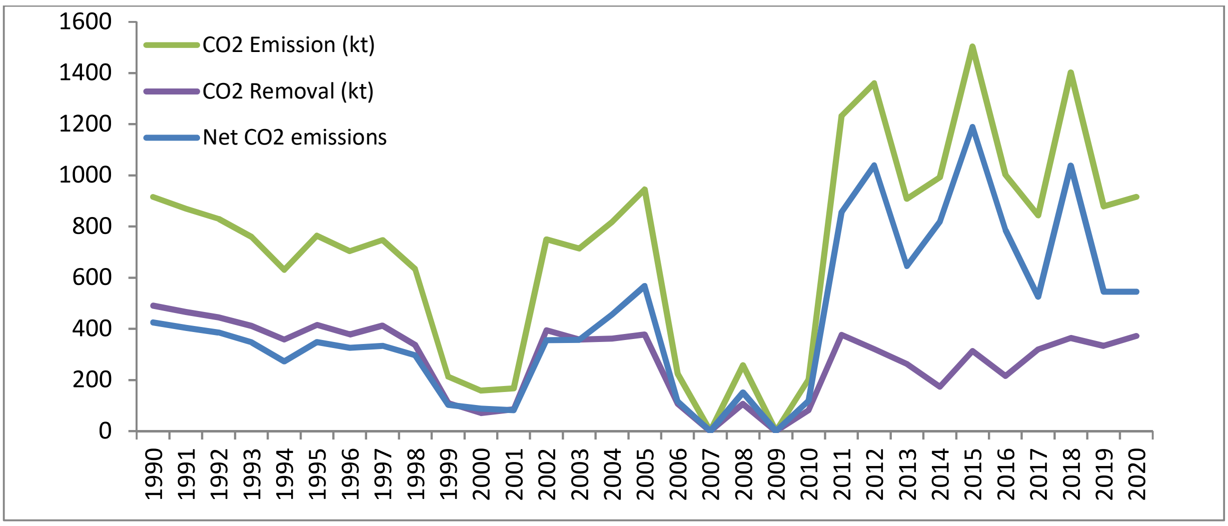
IGSAS is one of three ammonia plants in Türkiye which started its operation in 1977. In 1993 second ammonia plant Gemlik Gubre and in 2020 third ammonia plant ETI Gubre started its operations. IGSAS also produces urea by using CO_2 gas as feedstock. CO_2 is separated from the synthesis gas in the decarbonising step within the ammonia production process. Then, some of the CO_2 gas is used in the urea production process and the remaining gas is released to atmosphere. The chemical reaction that produces urea is:

$$2NH_3 + CO_2 \rightarrow NH_3COONH_4 \rightarrow CO(NH_2)_2 + H_2O$$

The figure 4.12 shows the CO_2 emissions from ammonia production as well as the amount of CO_2 recovered.

Overall, between 1990 (425 kt CO_2 eq.) and 2020 (545 kt CO_2 eq.), emissions from ammonia production increased by 28.3%. There are large inter-annual changes in CO_2 emissions from ammonia production. Rapid increases in emissions can be seen shortly after periods of economic downturns.

Figure 4.12 CO_2 emissions and removals from ammonia production, 1990-2020



Methodological Issues:

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

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

Where:

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

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

Where:

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

Collection of activity data

Ammonia production and fuel requirement data are obtained from producers on annual basis. The survey on ammonia production is sent to the 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 three ammonia producers in Türkiye, 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 shown in the following table where 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. Türkiye assumes 0.733 tonnes of CO_2 are required per tonnes of urea produced. This value is taken from the 2006 IPCC Guidelines.

In Türkiye; 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 4.12 Ammonia production and CO_2 emissions, 1990-2020

Year	Ammonia Production (1990=100)	Urea Production (1990=100)	CO_2 Emission (kt)	CO_2 Removal (kt)	Net CO_2 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
2018	150	74	1 402	364	1 038
2019	97	68	878	333	545
2020	97	76	916	371	545

Choice of emission factor

Türkiye 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 BOTAS (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%.

In 2020 submission, uncertainty for CO_2 emissions from category 2.B.1 was quantified using the Monte Carlo simulation. The MC analysis resulted with (-7.46%,+7.54%) combined uncertainty. Detailed information is in Annex 2.

Source-Specific QA/QC and Verification:

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

There are three ammonia producers in the Turkish market. All producers utilize natural gas to produce ammonia and use the same process. Hence their implied emission factors are comparable. When compared they are found consistent. Furthermore, total ammonia production data of Türkiye obtained from the producers is checked with data from PRODCOM every year.

Moreover, a QA work was conducted by an external reviewer from CITEPA (Technical Reference Center for Air Pollution and Climate Change) for this category in January 2020.

Recalculation:

No recalculations have been made to emissions from this category.

Planned Improvement

No further improvements are planned regarding this source.

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

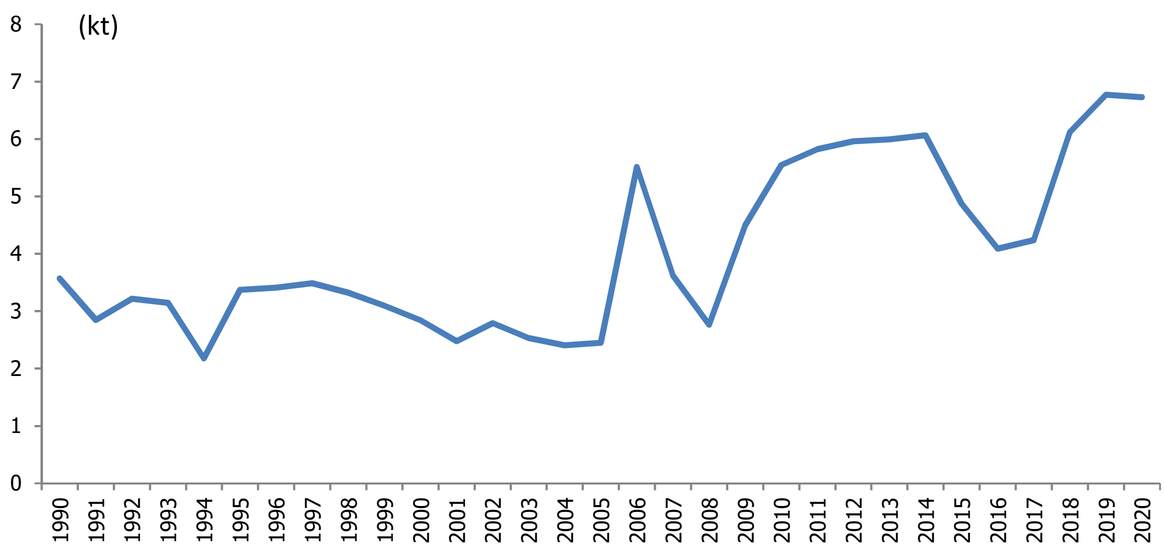
Source Category Description:

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

In Türkiye; these are four nitric acid plants, IGSAS is in operation since 1961, Toros Tarım since 1972, Gemlik Gubre since 2006 and BAGFAS since 2015. These are medium pressure combustion plants. Some of these plants indicate their use of a selective catalytic reduction system.

N_2O emissions were relatively stable between 1990 (3.57 kt N_2O) and 2005 (2.45 kt N_2O). Emissions from nitric acid production is not stable between 2005 and 2009 as can be seen from the figure 4.11, this is due to a new nitric acid plant starts production in 2006 but stops its production in the same year and restarts production again in 2009. Moreover, one of the nitric acid plants starts using an abatement technology in 2008 which decreases its emission factor. N_2O emissions reached in 2020 (6.73 kt N_2O). In 2016 N_2O emissions was 4.09 kt and it is much less than year 2014 due to production stop in one big capacity nitric acid plant.

Figure 4.13 N_2O emissions from nitric acid productions, 1990-2020



Methodological Issues:

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

$$E_{N2O} = EF \cdot NAP$$

Where:

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

Collection of activity data

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

Choice of emission factor

There are four nitric acid production plants, IGSAS, Toros Tarım, Gemlik Gubre and BAGFAS. 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 in the table below.

Table 4.13 Nitric acid production and N_2O emissions, 1990-2020

Year	Nitric acid production	Total N_2O emission (kt)
1990	C	3.57
1991	C	2.85
1992	C	3.22
1993	C	3.15
1994	C	2.18
1995	C	3.37
1996	C	3.41
1997	C	3.49
1998	C	3.32
1999	C	3.10
2000	C	2.84
2001	C	2.47
2002	C	2.79
2003	C	2.53
2004	C	2.40
2005	C	2.45
2006	C	5.51
2007	C	3.62
2008	C	2.76
2009	C	4.50
2010	C	5.55
2011	C	5.82
2012	C	5.96
2013	C	5.99
2014	C	6.07
2015	861	4.87
2016	771	4.09
2017	829	4.24
2018	1 066	6.12
2019	1 303	6.77
2020	1 300	6.73

Uncertainties and Time-Series Consistency:

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

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

Category 2.B.2 (Nitric acid production) employed a Monte Carlo uncertainty analysis which causes a combined uncertainty as ±20.59% for N_2O emissions in 2020 submission. Detailed explanation of Approach 2 method is in Uncertainty part of this inventory report (Annex 2).

Source-Specific QA/QC and Verification:

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

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, Urbanization and Climate Change by measuring their emissions with N_2O gas monitoring device. Calculated and reported emissions are compared.

Furthermore, a QA work was conducted by an external reviewer from CITEPA (Technical Reference Center for Air Pollution and Climate Change) for this category in January 2020.

Recalculation:

A correction to the activity data for nitric asit production in 2019 results increase in emissions of 2.77 kt N_2O. With respect to previous year, the currently submitted values show an increase of 69.1% for the year 2019.

Planned Improvements:

No further improvement are planned regarding this source.

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

There is no adipic acid production in Türkiye during the period 1990-2020.

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

There is no caprolactam, glyoxal and glyoxylic acid production in Türkiye during the period 1990-2020.

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

Source Category Description:

The production of carbide can result in emissions of CO_2, CH_4, CO and SO_2. Silicon carbide is a significant artificial abrasive. It is produced from silica sand or quartz and petroleum coke. Calcium carbide is used in the production of acetylene 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.

$$CaO + 3C \rightarrow CaC_2 + CO \ (+ \tfrac{1}{2} O_2 \rightarrow CO_2)$$

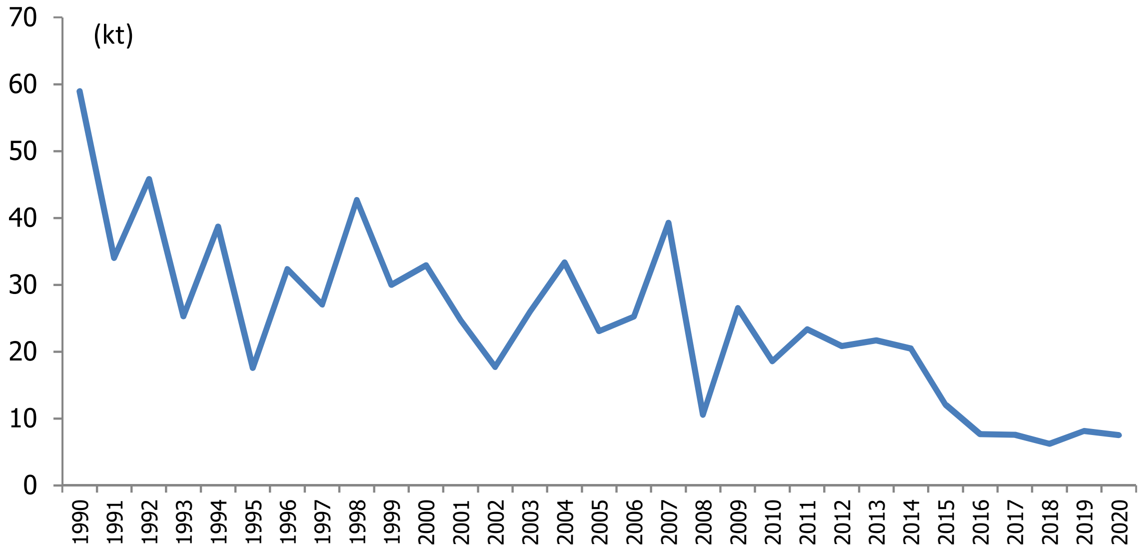
Calcium carbide is used either as a reductant in the steel making process or the feedstock for acetylene production in Türkiye. Afterwards acetylene is used as fuel in the welding applications. The combustion of acetylene in welding applications give emissions according to the reaction given below and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

$$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2 \ (+ 2.5\ O_2 \rightarrow 2CO_2 + H_2O)$$

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

CO_2 emissions from calcium carbide production and usage of carbide in acetylene was 59 kt CO_2 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_2. Finally, in 2016 the production line of carbide was closed due to economic reasons. And use of carbide in acetylene continued and resulted 7.5 kt CO_2 emissions in 2020.

Figure 4.14 CO_2 emissions due to carbide production, 1990-2020



Methodological Issues:

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

$$E_{CO2} = AD \bullet EF$$

Where:

E_{CO2} = emissions of carbon dioxide
AD = activity data on carbide production
EF = CO_2 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 period of a single plant which finalize its production in 2015, the calcium carbide production data was 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 were obtained. However, emissions were calculated by using the carbide production data.

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

Table 4.14 Calcium carbide production and CO_2 emissions, 1990-2020

Years	Calcium Carpide Production (1990=100)	Calcium carpide use (kt)	CO_2 Emissions from carbide production	CO_2 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	27.5	9.4	11.4	21.7
2014	25.4	9.0	10.5	20.5
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
2018	0	5.7	0.0	6.2
2019	0	7.4	0.0	8.2
2020	0	6.9	0.0	7.5

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 judgement the uncertainty value of the EF is taken ±20% while the default uncertainty value of the activity data is taken as 5% consistent with the 2006 IPCC Guidelines. (Volume 3 Page 3.45).

In 2020 submission combined uncertainty estimates of Carbide production (Category 2.B.5) are quantified using the Monte Carlo simulation. Uncertainty in Category 2.B.5 CO_2 emissions in 2018 are estimated at -20.55% to +20.87% with Approach 2 method. For more details, please refer to the Uncertainty chapter at the end of the Inventory report in Annex 2.

Source-Specific QA/QC and Verification:

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

Plant-specific production data are compared with national statistics data available from PRODCOM (National Industrial Production Statistics) and found consistent.

Moreover, a QA work was conducted by an external reviewer from CITEPA (Technical Reference Center for Air Pollution and Climate Change) for this category in January 2020.

Recalculation:

Due to minor changes observed in PRODCOM (National Industrial Production Statistics) data set, emission from carpide production reduced 0.4 kt CO_2 in 2014.

Planned Improvements

No further improvements are planned regarding this source.

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

There is no titanium dioxide production in Türkiye during the period 1990-2020.

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

Source Category Description:

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

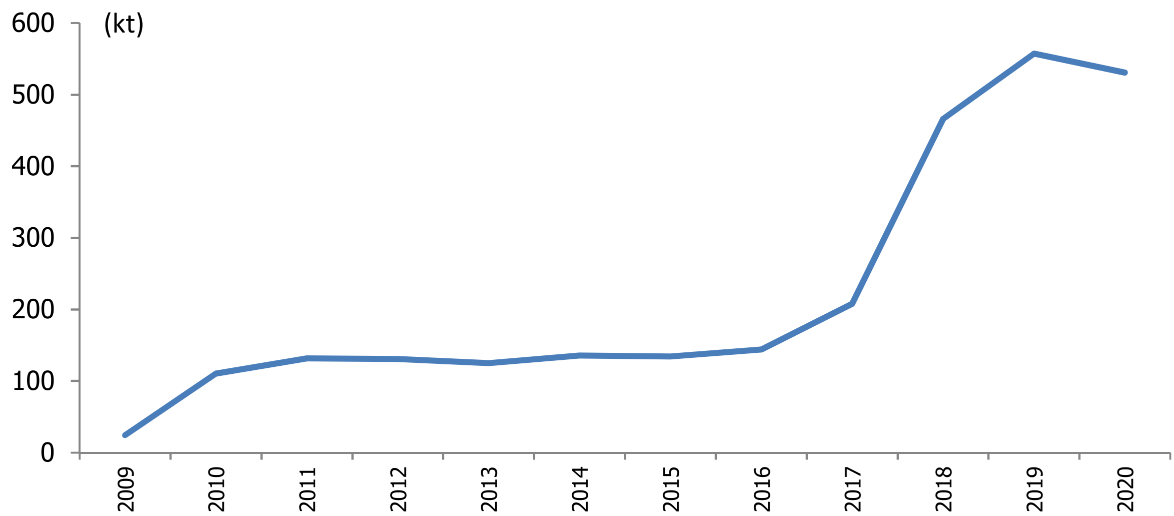
Emissions of CO_2 from the production of soda ash vary substantially with the manufacturing process. Four different processes may be used commercially to produce soda ash. Three of these processes, monohydrate, sodium sesquicarbonate (trona) and direct carbonation, are referred to as natural processes.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

There are three soda ash plants in Türkiye. 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. Third one started production in 2018.

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

Soda ash production by utilizing trona started in 2009 while emissions from soda ash production using the solvay process are not estimated due to the carbon neutral characteristic of the process. Therefore; for the years 1990-2008, emissive soda ash production is reported as not occurring. In the figure below you can see the trend of the CO_2 emissions from soda ash productions. In the year 2009 a small amount of CO_2 emitted due to plant was not working full capacity due to start up. In 2020 emissions from soda ash decreased by 4.7% with respect to previous year and it was 531 kt of CO_2.

Figure 4.15 CO_2 Emissions resulting from soda ash production 2009-2020



Methodological Issues:

The natural production process of soda ash results in CO_2 emissions. Türkiye 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:

$$E_{CO2} = AD \cdot EF$$

Where:

E_{CO2} = 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 is directly taken from the plants. Data are acquired on a yearly basis and it is based on a questionnaire which is sent to the plants.

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 4.15 Soda ash production and CO_2 emissions, 1990-2020

Year	Soda ash production by utilizing Trona (2009=100)	CO_2 Emissions (kt)
1990-2008	NO	NO
2009	100	24
2010	451	110
2011	538	132
2012	535	131
2013	511	125
2014	554	135
2015	549	134
2016	588	144
2017	850	208
2018	1 905	466
2019	2 278	557
2020	2 170	531

Uncertainties and Time-Series Consistency:

Türkiye 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).

Moreover, Monte Carlo analysis has been carried out for the CO_2 emissions from soda ash production for 2020 submission and it resulted with -5.10% to +5.15% combined uncertainty. Further information about Monte Carlo analysis of soda ash production can be seen in Uncertainty chapter (Annex 2).

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.

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

In addition, a QA work was conducted by an external reviewer from CITEPA (Technical Reference Center for Air Pollution and Climate Change) for this category in January 2020.

Recalculation:

No recalculations have been made to emissions from this category.

Planned Improvements

No further improvements are planned regarding this source.

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).

Türkiye reports CO_2 emissions from petrochemicals production. There is a single petrochemical producer in Türkiye and the company name is PETKIM. Carbon black was produced by PETKIM 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 PETKIM 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_2 emissions from flare stacks from the petrochemicals production at main production site of PETKIM between 1990 and 2020 and also carbon black production emissions at Kocaeli production site between 1990 and 2001.

Since PETKIM 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.

Table 4.16 CO_2 emissions from flaring in petrochemical sector, 1990-2020

(kt)

Year	CO_2 emissions from carbon black production	CO_2 emissions from flaring	Total CO_2 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
2018	NO	1.19	1.19
2019	NO	1.35	1.35
2020	NO	1.35	1.35

Methodological Issues:

CO_2 emissions are calculated by multiplying the amount of fuel gas burnt with the

$$E_{CO2} = M_{fuel\ gas}\ x\ Carbon\ content\ of\ fuel\ gas\ x\ 44/12$$

Where:

E_{CO2}= CO_2 emissions from production of petrochemical in tonnes
$M_{fuel\ gas}$ = Amount of fuel gas combusted as the flare gas in tonnes
44/12 = The molar weight ratio of carbondioxide to carbon

CO_2 emissions from carbon black production are calculated by Tier 1 methodology. The annual production amount is multiplied by the default CO_2 mission factor.

$$E_{CO2} = M_{carbon\ black} \times \text{Carbon Black } CO_2 \text{ EF}$$

Carbon black production also causes CH4 emissions. CH_4 emissions are calculated by Tier 1 methodology. The annual production amount is multiplied by the default CH_4 emission factor.

$$E_{CH4} = M_{carbon\ black} \times \text{Carbon Black } CH_4 \text{ EF}$$

Collection of activity data

There is a single producer of petrochemicals in Türkiye. 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 Türkiye 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 ±10% for EF and AD based on expert judgement and table 3.27 in the 2006 IPCC Guidelines, Volume 3.

Uncertainty in CO_2 emissions from category 2.B.8 was quantified using the Monte Carlo simulation in 2020 submission. Combined uncertainty in CO_2 emissions in 2018 is estimated with a symmetrical normal distribution as ±14.29%. Further information about Monte Carlo analysis of petrochemical and carbon black production can be seen in Uncertainty chapter (Annex 2).

Source-Specific QA/QC and Verification:

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

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

A QA work was conducted by an external reviewer from CITEPA (Technical Reference Center for Air Pollution and Climate Change) for this category in January 2020.

Recalculation:

No recalculations have been made to emissions from this category.

Planned Improvements

No further improvements are planned regarding this source.

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

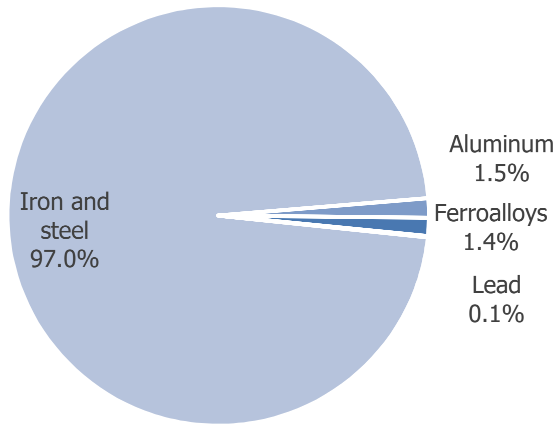
There is no fluorochemical production in Türkiye during the period 1990-2020.

4.4. Metal Industry (Category 2.C)

In 2020, the metal industry was responsible for 10 459.8 kt CO_2 eq., 15.7% of total emissions from the industrial processes and product use sector. The vast majority of emissions in the metal industry (97%) are from iron and steel production. Aluminum production was responsible for 155.3 kt CO_2 eq., 1.5% of metal emissions, and ferroalloys production 147.7 kt CO_2 eq., 1.4% of metal emissions. Lead production was responsible for 9.4 kt CO_2 eq. contributed 0.1% of sector emissions (see Figure 4.16). Zinc was produced in Türkiye till 1999, however zinc has not been produced since.

Between 1990 (7 747.6 kt CO_2 eq.) and 2020 (10 459.8 kt CO_2 eq.), emissions from the metal industry increased by 35%, again driven in large part by the iron and steel industry, which increased by 46.6% during the time period, from 6 921.5 kt CO_2 eq. in 1990 to 10 147.2 kt CO_2 eq. in 2020. This increase in emissions was partially offset by the elimination of PFC emissions in aluminum production (PFC emissions were 625.3 kt CO_2 eq. in 1990 and it is 37.8 kt CO_2 eq. in 2020). There is no magnesium production in Türkiye.

Figure 4.16 Emissions from metal industry, 2020



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

Source Category Description:

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

In Türkiye 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 Türkiye. However, there is no direct reduced iron (DRI) production in Türkiye. 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 Türkiye there is currently one plant producing pellet iron in order to supply the iron ore demand of the integrated steel plants.

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

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

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

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

Carbon monoxide is generated in the blast furnace from the carbon containing fuels (mainly coke) as can be seen in equation below. Coke 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.

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

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.

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

Sinter production is also an emissive process within the iron and steel industry. Sinter plants in Türkiye 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_2 release. During the sintering process high temperatures are achieved and limestone is calcined and release CO_2 emissions.

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

Electric Arc Furnaces (EAF) is another process unit for producing steel. Unlike BOF, only scrap iron and steel is used in the EAF to produce steel. The scrap metal is melted using high voltage electric arcs. There would be iron oxides in the feed of the EAF. Therefore, these iron oxides should be reduced to iron with the same reactions given above that cause CO_2 emissions. Metallurgical coke, petroleum coke, 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_2 emissions due to reaction of oxygen and carbon.

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

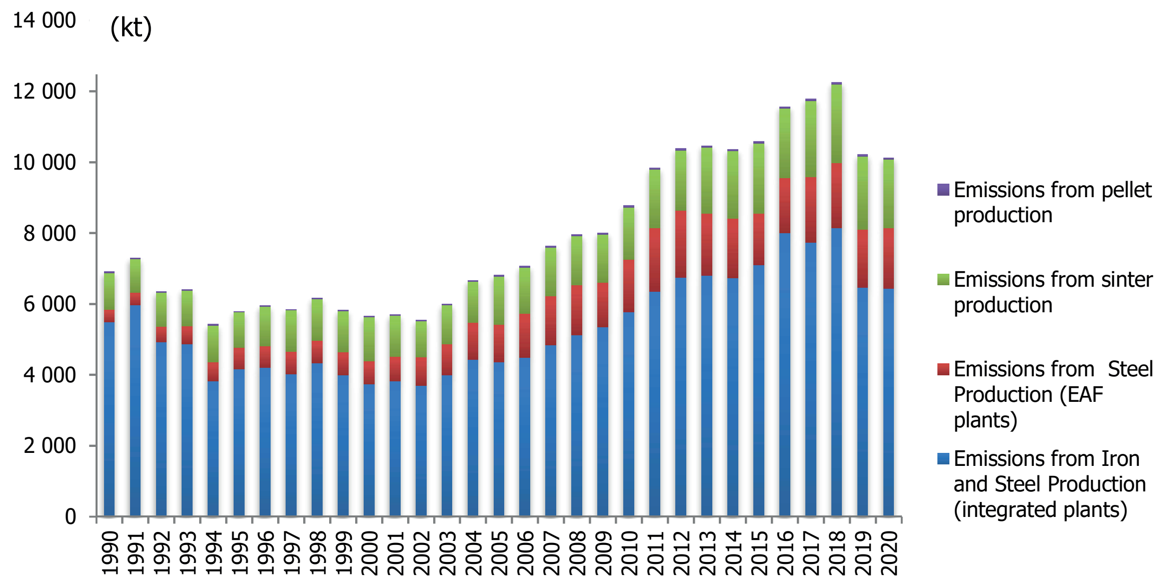
In Türkiye there are currently 3 integrated iron and steel plants and 26 electric arc furnaces mills operating. The table below presents 2.C.1 category CO_2 emissions between 1990 and 2020, and figure 4.17 shows the 2.C.1 category CO_2 emissions cumulatively revealing the emissions trend in the iron and steel production.

Table 4.17 CO_2 emissions allocations in 2.C.1 category, 1990-2020

(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	5 497	353	1 033	31	6 914
1991	5 971	355	946	30	7 303
1992	4 932	435	959	29	6 355
1993	4 869	519	1 000	30	6 417
1994	3 822	547	1 030	31	5 430
1995	4 173	605	988	26	5 793
1996	4 217	594	1 118	28	5 956
1997	4 024	635	1 167	22	5 848
1998	4 328	640	1 180	26	6 175
1999	3 994	653	1 149	26	5 822
2000	3 735	648	1 242	28	5 653
2001	3 823	691	1 165	26	5 704
2002	3 696	807	1 017	23	5 543
2003	3 986	893	1 094	23	5 996
2004	4 439	1043	1 158	23	6 663
2005	4 365	1057	1 358	34	6 814
2006	4 493	1228	1 313	34	7 069
2007	4 852	1379	1 364	39	7 634
2008	5 128	1408	1 393	34	7 962
2009	5 351	1263	1 351	41	8 006
2010	5 766	1488	1 480	45	8 779
2011	6 351	1800	1 642	45	9 838
2012	6 743	1891	1 703	46	10 383
2013	6 796	1760	1 867	44	10 468
2014	6 732	1691	1 890	47	10 359
2015	7 100	1458	1 985	46	10 590
2016	8 008	1555	1 961	47	11 572
2017	7 740	1849	2 150	45	11 784
2018	8 148	1837	2 220	45	12 250
2019	6 471	1629	2 067	46	10 214
2020	6 437	1713	1 936	46	10 132

Figure 4.17 CO_2 emissions allocations within the 2.C.1 CRF category, 1990-2020



CO_2 emissions from iron and steel production in 2020 was 10.1 million tons and it increased by 46% since 1990. Beginning by the year 2000 steel production have increased and Türkiye became the world's 7th biggest[5] crude steel producer reaching 35 million tons by 2020 In 2020 steel production increased by 4.3%. Steel production capacity of Türkiye is over 50 million tons.

Methodological Issues:

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

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

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

Where:

E_{CO2} = emissions of CO_2 to be reported in IPPU Sector, tonnes

a = input material a

b = output material b

[5] https://worldsteel.org/media-centre/press-releases/2021/global-crude-steel-output-decreases-by-0-9-in-2020/

Qa = quantity of input material a

Ca = carbon content of material a

Qb = quantity of output material b

Cb = carbon content of material b

44/12 = stoichiometric ratio of CO_2 to C

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

$$E_{CO2,\ non\text{-}energy} = P \cdot EF_p$$

Where:

$E_{CO2,\ non\text{-}energy}$ = emissions of CO_2 to be reported in IPPU Sector, tonnes

P = quantity of pellet produced nationally, tonnes

EF_p = emission factor, tonnes CO_2/tonne pellet produced

CO_2 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:

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

The CH_4 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.

$$E_{CH4,\ non\text{-}energy} = SI \cdot EF_{SI}$$

Where:

$E_{CH4,\ non\text{-}energy}$ = emissions of CH_4 to be reported in IPPU Sector, kg

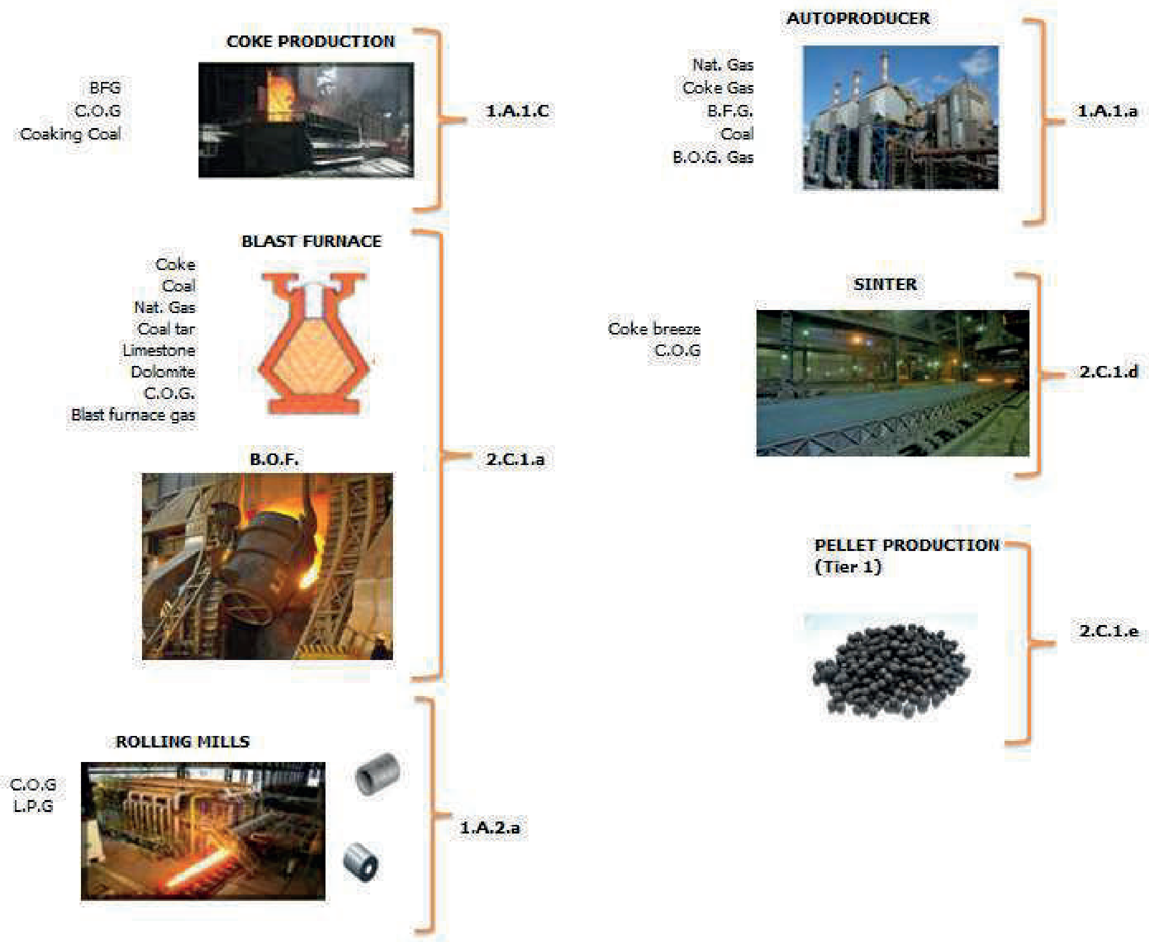
SI = quantity of sinter produced nationally, tonnes

EF_{SI} = emission factor, kg CH_4/tonne sinter produced

In Türkiye 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 4.18 shows the allocations of the emissions from integrated iron and steel plants between Energy and IPPU sectors.

Figure 4.18 Allocations of the emissions from integrated iron and steel plants



Collection of activity data

To estimate CO_2 and CH_4 emissions at integrated facilities, Türkiye 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 Türkiye. 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 by an annual basis questionnaire.

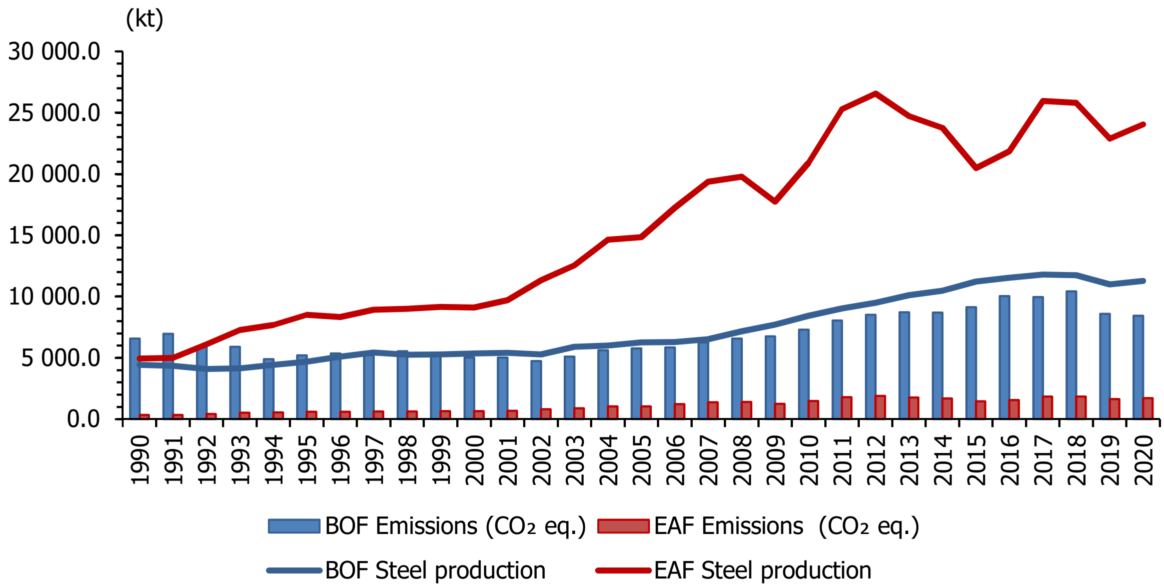
Each of the integrated facility keeps an energy balance table where all the fuel consumptions and generations are recorded annually. These tables are the main data source for the fuel consumptions. The consumption of non-fuel materials, (e.g. limestone, dolomite), are asked by a questionnaire.

Sinter, pellet production and steel production by plant type are included in the table below.

Table 4.18 Sinter, pellet and iron & steel production by plant type, 1990-2020 (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
2018	1 513	9 798	11 734	25 799	37 533
2019	1 547	9 101	11 002	22 884	33 887
2020	1 524	8 866	11 283	24 056	35 338

Figure 4.19 Comparing emissions (kt CO_2 eq.) and steel production (kt) from BOFs anf EAFs



The CO_2 eq. emissions and total steel production (kt) of integrated plants (BOF) and Electric Arc Furnaces (EAF) are shown in the figure 4.19. In 2020, the BOFs produced 31.9% and EAFs produced 68.1% of total iron and steel whereas the BOFs contributed 83.1% and EAFs contributed 16.9% of total emissions from iron and steel production.

Choice of emission factor

To estimate CO_2 emissions from integrated facilities, Türkiye 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_2 emissions from EAFs, Türkiye 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 0.0712 t CO_2 /t steel produced between 2013 and 2016, and this factor is applied for the previous years.

To estimate CO_2 emissions from pellet production, the default emission factor (0.03 t CO_2/t pellet) from the 2006 IPCC Guidelines used for the entire time series.

To estimate CH_4 emissions from sinter production, the default emission factor (0.07 kg CH_4/t sinter) from the 2006 IPCC Guidelines applied.

Emission factors used in the calculations are provided in the table below.

Table 4.19 Emission factors iron and steel production

Activity	CO_2 EF
Pellet production (used in all-time series)	0.03 t/t pellet
EAF steel production	0.0712 t/t steel
Activity	**CH_4 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 8%, 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.

An uncertainty analysis using the Monte Carlo technique was carried out to estimate emissions of CO_2 and CH_4 for 2.C.1 category and also to other IPPU categories in 2020 inventory year. Combined uncertainty in CO_2 emissions in 2018 is estimated at the range of -29.05% to +29.32%, CH_4 emissions is estimated as -13.04% to +11.59% in 2020 submission. Further information is given in Uncertainty part at the end of this inventory report (Annex 2).

Source-Specific QA/QC and Verification:

There are three integrated iron and steel plants in Türkiye 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.

In addition, 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 = 21 203 kt,

Summed up emissions for each CRF category for integrated plants = 19 884 kt,

Percentage of equivalence = 93.3%.

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.

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

Furthermore, a QA work was conducted by an external reviewer from CITEPA (Technical Reference Center for Air Pollution and Climate Change) for this category in January 2020.

Recalculations:

Türkiye finalized studies about CO_2 emission factor used in steel production in EAF (Electric Arc Furnace) for increasing estimations from Tier 1 to Tier 2. In order to estimate CO_2 emissions from EAF (Electric Arc Furnace), raw material consumption and steel production data are collected. Tier 2 emission factor applied for the entire time series.

Furthermore, carbon content of BOF gas data updated from two of three integrated plants this year and included in calculations.

These changes results, average recalculation calculated as 191.86 kt CO_2 increase for the period of 1990-2019 and 343.51 kt CO_2 reduction for 2019. With respect to previous year, the currently submitted values for the years 1990-2019 show an increase of 1.94% average recalculation rate.

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_2 emissions.

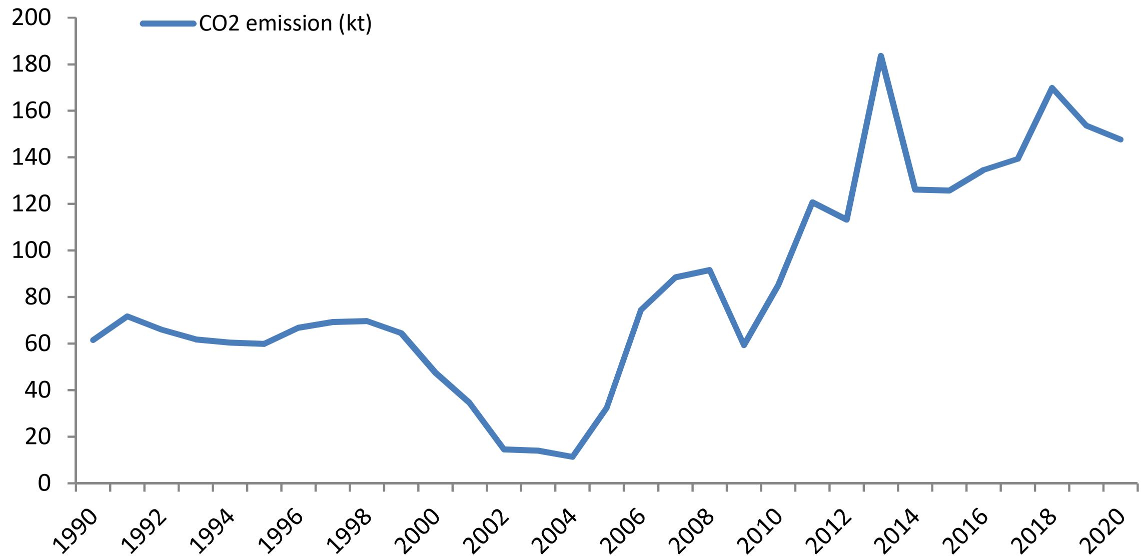
In Türkiye there are currently two ferrochrome producer. These two producer are using electric arc furnaces to melt scrap iron and chromite ore in the pot. Some metallurgical coke is added in the pot to reduce chromite and produce ferrochrome.

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 Türkiye on industrial scale.

Although Türkiye is rich in terms of chrome mines, ferrochrome production is relatively low. This is due to high prices of energy in Türkiye. CO_2 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_2) and 2004 (11 kt CO_2) owing to one of the ferrochromium producers was slowed down and finally out of operation during its privatization period. CO_2 emissions generally climbed until 2008 (92 kt CO_2) with economic growth before decreasing again in 2009 (59 kt CO_2) due to global economic recession and low demand on steel. There was then a steep increase between 2009 and 2013 (184 kt CO_2, an increase in emissions of 210%) 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 2020, CO_2 emissions from ferroalloy production was 148 kt.

Figure 4.20 CO_2 emissions from ferroalloys production, 1990-2020



Methodological Issues:

Türkiye reports CO_2 emissions from ferroalloys production following the IPCC Tier 1 approach, as shown in equation below. Ferroalloys production is not a key category.

CO_2 emissions from ferroalloys production

$$E_{CO2} = \sum_i (MP_i \cdot EF_i)$$

Where:

E_{CO2} = CO_2 emissions, tonnes
MP_i = production of ferroalloy type i, tonnes
EF_i = generic emission factor for ferroalloy type i, tonnes CO_2/ tonne specific ferroalloy product

Collection of activity data

Activity data are obtained from the two ferrochrome producers by a production survey on the yearly basis by TurkStat. Both the ferro-chromium production data and the reductant agent consumption data are gathered for all the time series. The coke used in the ferro chromium production is deducted from the total coke consumption of Türkiye in the energy sector to avoid a double counting.

Choice of emission factor

Türkiye applies the default CO_2 emission factors for ferro-chromium (1.3 t CO_2/t product) from the 2006 IPCC Guidelines.

Table 4.20 Ferroalloys production and emissions, 1990-2020

Years	Total ferroalloy production (1990=100)	CO_2 Emission (kt)
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	121
2012	184	113
2013	298	184
2014	205	126
2015	204	126
2016	219	135
2017	226	139
2018	276	170
2019	250	154
2020	240	148

Source-Specific QA/QC and Verification:

Ferro alloy production data was gathered directly from the plants. There are two ferro chrome producers in Türkiye. 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. Furthermore, PRODCOM data for ferro alloy production compared every year and found consistent.

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

Moreover, a QA work was conducted by an external reviewer from CITEPA (Technical Reference Center for Air Pollution and Climate Change) for this category in January 2020.

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.

Moreover, Monte Carlo analysis has been carried out for the CO_2 emissions from ferroalloys production in 2020 submission and it resulted with a range of -25.15% to +25.52% combined uncertainty with means of recommended Approach 1 uncertainties. Further information about Monte Carlo analysis of other uses of ferroalloys production can be seen in Uncertainty chapter (Annex 2).

Recalculation:

There is no recalculation in this sector in this submission.

Planned Improvements:

There are no planned improvements in this category.

4.4.3. Aluminum production (Category 2.C.3)

Source Category Description:

Türkiye estimates CO_2 and PFCs (CF_4 and C_2F_6) emissions from primary aluminum production. Primary aluminum is aluminum tapped from electrolytic cells or pots during the electrolytic reduction of metallurgical alumina (aluminum oxide). It thus excludes alloying additives and recycled aluminum.

Primary aluminum 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 Türkiye’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.

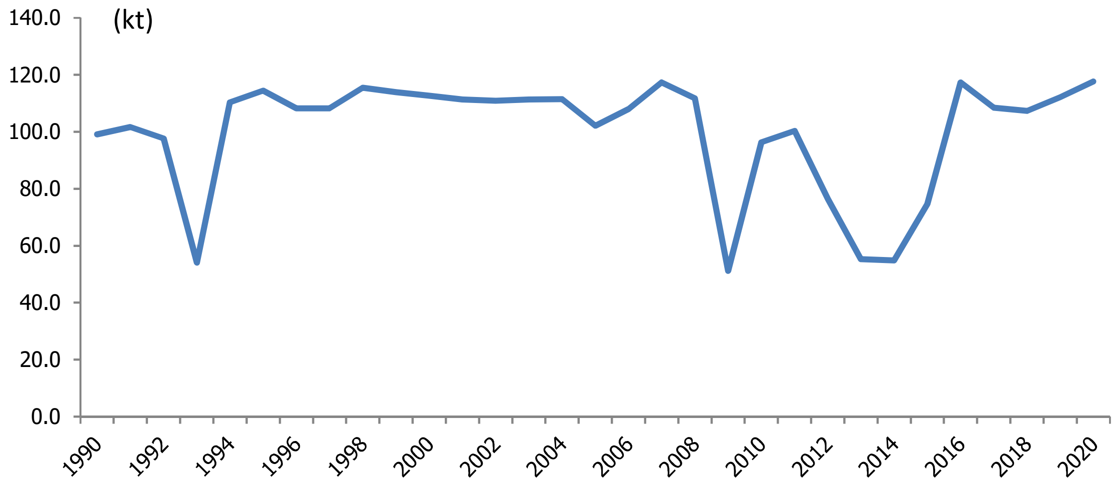
Eti Aluminyum's Seydişehir Aluminum Plant, located in the Central Anatolia region of Türkiye, is an integrated primary aluminum production plant. From here the company is able to convert aluminum ore into metallic aluminum by first processing the ore and then shaping it through the use of casting, rolling 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 (Al_2O_3). The consumption of prebaked carbon anodes and Søderberg paste is the principal source of process related carbon dioxide emissions from primary aluminium production. PFCs are formed during a phenomenon known as the 'anode effect' during liquid aluminum production via electrolysis. Eti Aluminium used Søderberg cells till the modernization of the aluminium production plant in 2015. In 2015 all of the Søderberg cells were replaced with the prebaked cells.

The CO_2 emissions from aluminum productions is shown in figure 4.21. Overall between 1990 (99 kt CO_2 eq) and 2020 (117.7 kt CO_2 eq.) emissions have increased by 18.7% due to increasing aluminum production of Türkiye. In 1993 aluminum production decreased remarkably because of the excessive world aluminum stocks prior to the world economic recession of 1994. CO_2 emissions remained generally stable until a similar trend was seen in 2008 (111.8 kt), 2009 (51.2 kt) and 2010 (96.4 kt) similarly because of the world economic recession in 2008. In 2020, CO_2 emissions increased 5% with respect to 2019 due to the increasing aluminum production of Türkiye.

Figure 4.21 CO_2 emissions from aluminum production, 1990-2020



CF_4 and C_2F_6 emissions are reported in the Table 4.21. 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_2 emissions from primary aluminum production are calculated by the T3 method for the entire time series. Eti Aluminum, the only primary aluminum producer in Türkiye, switched its production process in the mid of 2015. The company is now using Prebaked smelters. Before that Søderberg process was used to produce aluminum. For 1990-2014 CO_2 emissions come from only Søderberg cells. However, in 2015 Søderberg cells were switched to Prebaked cells. In 2016 CO_2 emissions come from only Prebaked cells.

Formula for CO_2 emissions from Søderberg cells

$$E_{CO2} = \left(PC \times MP - \frac{CSM \times MP}{1000} - \frac{BC}{100} \times PC \times MP \times \frac{S_p + Ash_p + H_p}{100} - \frac{100 - BC}{100} \times PC \times MP \times \frac{S_c + Ash_c}{100} - MP \times CD\right) \times \frac{44}{12}$$

Where:

E_{CO2} = CO_2 emissions from paste consumption, tonnes CO_2
MP = total metal production, tonnes Al
PC = paste consumption, tonnes/tonne Al
CSM = emissions of cyclohexane soluble matter, kg/tonne Al
BC = binder content in paste, wt %
S_p = sulphur content in pitch, wt %
Ash_p = ash content in pitch, wt %
H_p = hydrogen content in pitch, wt %
S_p = sulphur content in calcined coke, wt %
Ash_c = ash content in calcined coke, wt %
CD = carbon in skimmed dust from Søderberg cells, tonnes C/tonne Al
$44/12$ = CO_2 molecular mass: carbon atomic mass ratio, dimensionless

CO_2 emissions from Prebaked cells

$$E_{CO_2} = NAC \times MP \times \frac{C_a}{100} \times \frac{44}{12}$$

Where:

E_{CO2} = CO_2 emissions from paste consumption, tonnes CO_2

MP = total metal production, tonnes Al

NAC = net prebaked anode consumption per tonne of aluminum, tonnes C / tonne Al

C_a = carbon content in baked anodes, wt %

44/12 = CO_2 molecular mass: carbon atomic mass ratio, dimensionless

PFC emissions

PFCs are formed during a phenomenon known as the ‘anode effect’. PFCs emissions have been estimated from the primary aluminum production multiplied for the relative EF (CF_4, C_2F_6), following a T3 IPCC methodology.

Due to the process change in Eti Aluminum, the company has switched to the Prebake cells just in 2015 after using Søderberg process for long years. This technology change has leaded to changing the coefficient numbers and the difference between 2014-2015 has occurred because of this reason. Also PFC, C_2F_6 and CF_4 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 of MoEUCC and it can be seen from the table that there is a decrease trend between years 2016-2018. In the same years, total production value has also decreased. In 2020 EF values have decreased for both gasses, compared to the previous year.

In the following table PFCs, CF_4 and C_2F_6 EF are reported.

Table 4.21 PFCs, CF_4 and C_2F_6 EF, 1990-2020

Year	C_2F_6s EFs (kg/t)	CF_4s 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
2018	0.0238	0.0281
2019	0.0380	0.0449
2020	0.0225	0.0266

Collection of activity data

To estimate CO_2 emissions, the parameters below are obtained from the single producer. The data are obtained from the producer company by an annual questionnaire. However, plant specific data can only be obtained for the years 2005-2015, 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 4.22 below.

Table 4.22 Aluminum production emissions, 1990-2020

Year	Aluminium Production (tonnes)	CO_2 emissions (kt)
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
2018	73 291	107.3
2019	78 110	112.1
2020	80 184	117.7

Choice of emission factor

Some of the CO_2 emission factors are provided by the facility while some are used as default values. In the tables below the emission factors used in the formula for Søderberg cells and Prebaked cells can be found.

Table 4.23 Emission factors for aluminum production with Søderberg 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 Søderberg cells)	Plant specific	Confidential

Note: For 1990-2004 PC value assumed to be constant and same with the 2005 data. All other parameters are default for the years 1990-2004

Table 4.24 Emission factors for aluminum production with Prebaked cells, 2015-2020

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 Aluminyum, switched to the Prebake cells just in 2015 after using Søderberg process for long years. The system is not fully developed yet. NAC value is not measured but it is estimated by the process engineers of the company.

For the calculation of PFCs emissions, the company yearly supply data for the following parameters, from 1990:

- Primary aluminum production (tonnes);
- Anode effect (minute/day);
- CF_4 Slope coefficient;
- C_2F_6 Slope coefficient;
- CF_4EF (kg CF_4/tonnes aluminum);
- C_2F_6EF (kg C_2F_6/tonnes aluminum).

In the following table, PFCs, CF_4 and C_2F_6 emissions are reported.

Table 4.25 PFCs, CF_4 and C_2F_6 emissions from primary aluminum production, 1990-2020

(kt CO_2 eq.)

Year	PFCs	CF_4	C_2F_6
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
2018	36 574	15 257	21 316
2019	62 217	25 958	36 259
2020	37 819	15 779	22 039

As shown in the table, since EF values decreased in 2020, compared to the previous year, as a result emission values of PFCs, CF_4 and C_2F_6 are decreased in the same year. In 2020, total production value has increased.

Uncertainties and Time-Series Consistency:

For CO_2 emissions, the uncertainty values of the T2 method is considered ±5% for the EF and ±1% for AD, as recommended in 2006 IPCC Guidelines Volume 3 (page 4.56). AD are relatively low as there is very little uncertainty in the data on annual production of aluminum and information is provided directly from the single producer. The CO_2 emission factor is also low as the mechanisms leading to emissions are well known. On the other hand, for F-gases, uncertainty values of T3 are considered 5% for EF and 2% for AD as recommended in 2006 IPCC Guidelines Volume 3 (page 4.56).

Category 2.C.3 employed a Monte Carlo uncertainty analysis which causes a combined uncertainty range (-5.15%,+5.16%) for CO_2 emissions in 2020 submission. Detailed explanation of Approach 2 method is in Uncertainty part of this inventory report (Annex 2).

Source-Specific QA/QC and Verification:

Within the scope of the Turkish National Greenhouse Gas Emission Inventory Improvement Project, Türkiye'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.

The production data is gathered from the producer and aggregated national implied emission factors are compared with IPCC default values. Due to the data confidentiality the IEFs cannot be tabulated in here.

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

A QA work was conducted by an external reviewer from CITEPA (Technical Reference Center for Air Pollution and Climate Change) for this category in January 2020.

Recalculation:

There is no recalculation for this submission.

Planned Improvements:

No further improvements are planned.

4.4.4. Magnesium production (Category 2.C.4)

There is no magnesium production in Türkiye during period 1990-2020.

4.4.5. Lead production (Category 2.C.5)

Source Category Description

There are two primary processes for the production of rough lead bullion from lead concentrates. The first type is sintering/smelting, which consists of sequential sintering and smelting steps and constitutes roughly 78% of world-wide primary lead production. The second type is direct smelting, which eliminates the sintering step and constitutes the remaining 22% of primary lead production in the developed world. However, in Türkiye there is no primary lead production. Türkiye is producing lead by only smelting the recycled lead from vehicles' old batteries. There are over 25 million registered road motor vehicles and there is huge amount of vehicle batteries to be recycled every year in Türkiye. Therefore, there are many lead batteries recycling companies in Türkiye.

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_2.

Methodological Issues:

Lead production is not a key category in Türkiye, and due to lack of data, the Tier 1 is applied to calculate CO_2 emissions by multiplying process specified to lead production data, as shown in equation below.

$$E_{CO2} = S \cdot EF_s$$

Where:

E_{CO2} = CO_2 emissions from lead production, tonnes
S= quantity of lead produced from secondary materials, tonnes
EF_S = emission factor for secondary materials, tonne CO_2 / 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 2020. There is no data between 1997 and 2006. The specialists from the production field indicated 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 Türkiye recycling vehicle batteries for lead recovery. Since old batteries are classified as dangerous waste, it is statistically overseen. The amount of vehicle batteries recycled is known for the years 2007-2020. The data is gathered from TurkStat data bases and Ministry of Environment, Urbanization and Climate Change. 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 8th five years development plan of Türkiye. 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 4.26 Lead production and CO_2 emissions from lead production, 1990-2020

Year	Recycled waste batteries (kt)	Lead production from waste batteries (kt)	CO_2 emissions (kt)
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
2018	72.6	43.5	8.7
2019	73.5	44.1	8.8
2020	78.5	47.1	9.4

Choice of emission factor

Emission factor of 0.20 tonne of CO_2 / tonne of lead produced is used in the calculations. This is the process type specific emission factor for the treatment of secondary raw materials in the 2006 IPCC Guidelines, Table 4.21.

Uncertainties and Time-Series Consistency:

National production data for the amount of vehicle batteries are used as the activity data and it is estimated that 60% by weight of the amount of batteries recycled is recovered as lead. Due to this assumption the activity data has an uncertainty of 25% relying on the expert judgement. The process type emission factor has an uncertainty of 20% by default.

In 2020 submission, uncertainty in CO_2 emissions from category 2.C.5 was quantified using the Monte Carlo simulation for other IPPU sub-categories. Combined uncertainty in CO_2 emissions from lead production in 2018 is estimated at -22.87% to +24.60%. Further information about Monte Carlo analysis of lead production can be seen in Uncertainty chapter (Annex 2).

Source-Specific QA/QC and Verification:

The weight data of recycled batteries is gathered from Ministry of Environment, Urbanization and Climate Change (MoEUCC). The same data is also produced by TurkStat. When this two data sets from different sources are compared they are found consistent.

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 responsibles 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.

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

A QA work was conducted by an external reviewer from CITEPA (Technical Reference Center for Air Pollution and Climate Change) for this category in January 2020.

Recalculation:

There is no recalculation for this year's inventory.

Planned Improvements:

Research will be held for decreasing the uncertainty in the activity data. The activities of recently established plants will be examined in next submissions.

4.4.6. Zinc production (Category 2.C.6)

Source Category Description:

In Türkiye currently there is no zinc production. In the past, there was a single primary production plant (CINKUR), located in Kayseri, produced zinc until 1999, starting from 1968. The company was closed in 1999. The plant produced zinc by utilizing zincoxide ore by pyrometallurgical (Imperial Smelting Furnace) process. The table below shows the amount of zinc production and CO_2 emissions.

Table 4.27 Zinc productions and CO_2 emission, 1990-2020

Year	Zinc Production (kt)	CO_2 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
2000-2020	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 Türkiye, and due to lack of data Tier 1 is applied. In order to calculate CO_2emissions, the default EF is multiplied with zinc production data as shown in the equation below.

$$E_{CO2} = Zn \cdot EF_{default}$$

Where:

E_{CO2} = CO_2 emissions from zinc production, tonnes

Zn = quantity of zinc produced, tonnes

EF default = Default emission factor, tonnes CO_2/ 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_2 / tonne of zinc produced is used in the calculations. This is the default emission factor in the 2006 IPCC Guidelines, Table 4.24 based on weighting of 60% Imperial Smelting and 40% Waelz Kiln.

Uncertainties and Time-Series Consistency:

Uncertainty value for EF is considered 50% as recommended in the 2006 IPCC Guidelines Volume 3 Table 4.25 due to the use of default EF. The capacity data of zinc production plant is different in two separate data sources. (33.500 tonnes/year in the 8th five years development plan of Türkiye 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 then the Guideline recommends. Uncertainty value for AD is considered 20% based on the expert judgement.

Source-Specific QA/QC and Verification:

Experts from zinc trader and waelz oxide producer companies in Türkiye are personally communicated and by this way it is verified that Türkiye's only zinc producer was CINKUR and it was closed in 1999. CINKUR's zinc production data is also found in the 8th five years development plan of Türkiye (2001) and it is stated that CINKUR is roughly producing 20.000 tons zinc/year which is in line with our calculated production data for the years between 1990 and 1996.

A QA work was conducted by an external reviewer from CITEPA (Technical Reference Center for Air Pollution and Climate Change) for this category in January 2020.

Recalculation:

There is no recalculation for this submission.

Planned Improvements:

The activities of recently established plants will be examined in next submissions.

4.5. Non-Energy Products from Fuels and Solvent Use (Category 2.D)

4.5.1. Lubricant use (Category 2.D.1)

Source Category Description:

Lubricants are mostly used in industrial and transportation applications. Lubricants are produced either at refineries through separation from crude oil or at petrochemical facilities. They can be subdivided into (a) motor oils and industrial oils, and (b) greases, which differ in terms of physical characteristics (e.g., viscosity), commercial applications, and environmental fate.

The use of lubricants in engines is primarily for their lubricating properties and associated emissions are therefore considered as non-combustion emissions and reported in the IPPU Sector.

Methodological Issues:

CO_2 emissions calculation is based on the amount of lubricant consumption in a country which is obtained from IEA - Eurostat - UNECE Energy Questionnaire - Oil table of Türkiye. 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_2 emission. The amount of lubricant consumed in terms of kt converted to in terms of TJ by multiplying it with a factor (40.2). The following table shows the amount of lubricant used and the CO_2 emissions, from 1990 to 2020.

Table 4.28 The Amount of lubricant used and CO_2 emissions, 1990-2020

(kt)

Year	Lubricant use	CO_2
1990	297	175.1
1991	310	182.8
1992	270	159.2
1993	287	169.2
1994	290	171.0
1995	339	199.9
1996	371	218.7
1997	406	239.4
1998	340	200.5
1999	420	247.6
2000	460	271.2
2001	335	197.5
2002	447	263.6
2003	437	257.7
2004	571	336.7
2005	667	393.3
2006	747	440.4
2007	733	432.2
2008	591	348.5
2009	652	384.4
2010	713	420.4
2011	1 416	834.9
2012	998	588.4
2013	894	527.1
2014	654	385.6
2015	432	254.7
2016	229	135.0
2017	243	143.3
2018	328	193.4
2019	211	124.4
2020	203	119.5

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%.

An uncertainty analysis using the Monte Carlo technique was carried out to estimate emissions of CO_2 for 2.D.1 category and also to other IPPU categories in 2020 inventory year. Combined uncertainty of CO_2 emissions in 2018 is estimated at the range of -51.96% to +59.43%. Please refer to Annex 2 for more detailed information.

Source-Specific QA/QC and Verification:

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

A QA work was conducted by an external reviewer from CITEPA (Technical Reference Center for Air Pollution and Climate Change) for this category in January 2020.

Recalculation:

A correction to the activity data for lubricant use in 2019 results decrease in emissions of 78.7 kt CO_2. With respect to previous year, the currently submitted values show an decrease of 38.7% for the year 2019.

Planned Improvements:

No further improvements are planned at this time.

4.5.2. Paraffin wax use (Category 2.D.2)

Source Category Description:

The category, as defined here, includes such products as petroleum jelly, paraffin waxes and other waxes, including ozokerite (mixtures of saturated hydrocarbons, solid at ambient temperature). Paraffin waxes are separated from crude oil during the production of light (distillate) lubricating oils. Paraffin waxes are categorized by oil content and the amount of refinement.

Waxes are used in a number of different applications. Paraffin waxes are used in applications such as: candles, corrugated boxes, paper coating, board sizing, food production, wax polishes, surfactants (as used in detergents) and many others. Emissions from the use of waxes derive primarily when the waxes or derivatives of paraffin are combusted during use (e.g., candles), and when they are incinerated with or without heat recovery or in wastewater treatment (for surfactants).

Methodological Issues:

CO_2 emissions calculation is based on the amount of paraffin waxes consumed in a country which is obtained from IEA - Eurostat - UNECE Energy Questionnaire - Oil table of Türkiye. 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_2 emissions, 1990 to 2020.

Table 4.29 The Amount of paraffin wax used and CO_2 emissions, 1990-2020

(kt)

Year	Paraffin wax use	CO_2
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
2018	22	13.0
2019	23	13.6
2020	25	14.6

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.

Additionally, an uncertainty analysis using the Monte Carlo technique was carried out to estimate emissions of CO_2 for 2.D.2 category (Paraffin wax use) in 2020 inventory year. Combined uncertainty in CO_2 emissions in 2018 is estimated at the range of (-98.46%,+107.31%). For more detailed information please refer to Annex 2.

Source-Specific QA/QC and Verification:

QA/QC procedures are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

Moreover, a QA work was conducted by an external reviewer from CITEPA (Technical Reference Center for Air Pollution and Climate Change) for this category in January 2020.

Recalculation:

A correction to the activity data for paraffin wax use in 2019 results decrease in emissions of 1.2 kt CO_2. With respect to previous year, the currently submitted values show an decrease of 8% for the year 2019.

Planned Improvements:

No further improvements are planned.

4.6. Electronics Industry (Category 2.E)

A research for this category, has been done by taking into consideration of relevant sectors and gases. According to the results, it has been appeared that F-gases have not been used in the manufacturing processes of these sectors. However, it is founded that some gases have been used with the aim of research and development.

Source category description

The sub-sector only consists of the following sub-application: 2.E.5- Other, other electronic uses.

Methodological issues

This section is composed of results of the research which has been conducted by the Ministry of Environment, Urbanization and Climate Change. As it is stated above, results show that F-gases are not used in the manufacturing of flat panel display, photovoltaic products and semiconductors. This information has been gathered by contacting with largest companies within the relevant sectors.

However, it is observed that CF_4, CHF_3 and SF_6 are used for the research and development in the area of semiconductor products. Therefore, these gases are reported under the category of 2.E.5 "other electronic uses".

According to the research, these gases were started to be used in 2010. For reporting of emission, it is assumed that same amount of gas was used for each year. This assumption is made by considering the expert judgement. MoEUCC has made survey with the leading company of Türkiye, which has R&D department in electronic industry and the numbers assessed due to the results of survey.

Table 4.30 shows the consumption amount of each gases which are consumed for the research and development purpose.

Table 4.30 Consumption of each gases, 2010-2020 (kg)

	CF_4	HFC-23	SF_6
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
2018	1.31	6.56	2 501.7
2019	1.32	6.61	2 524.2
2020	1.34	6.72	2 569.6

Türkiye's economy grew 1.8 percent in 2020 and the value of consumption of each gas has determined for 2020 by using the value of economic grew.

Recalculation:

There is no recalculation for this submission

Planned Improvements:

No further improvements are planned.

4.7. Product Use as Substitutes for ODS (Category 2.F)

Source Category Description:

Production of fluorochemicals does not exist in Türkiye. 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 years period.

For calculation of HFC-227ea, expert judgements are considered. According to the information which is obtained from discussion with experts who are working under the Protection of Ozon Layer Division of

MoEUCC and Turkish Fire Protection and Training Foundation (TUYAK) which is representative of fire sector, HFC-227ea is mostly consumed in fire protection application in Türkiye. 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.

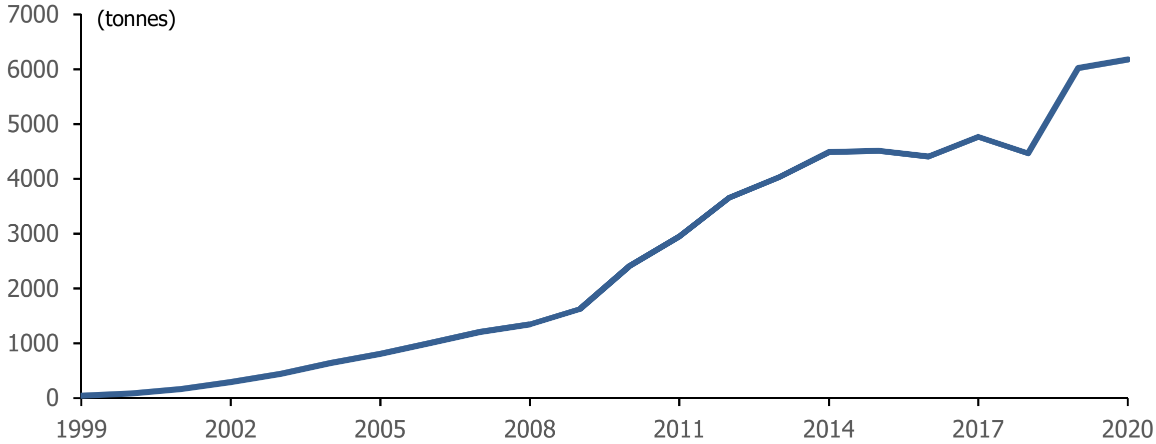
Uncertainties and Time-Series Consistency:

Table 4.31 and Figure 4.22 present total HFCs emissions from 1999 to 2020. 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 4.31 Total HFCs emissions, 1999-2020

Year	HFCs Emissions (tonnes)	HFCs Emissions (kt CO_2 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	4 488.9	4 517.17
2015	4 508.7	4 412.43
2016	4 887.1	4 838.34
2017	5 101.0	5 095.21
2018	5 125.7	5 073.77
2019	6 021.8	5 606.63
2020	6 177.5	5 475.75

Figure 4.22 Total HFCs emissions, 1999-2020



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-365 mfc. 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. Inventory calculations have been based on the raw trade data (import and export) provided for each gas by Ministry of Trade and the change in graph is consistent with number of import and export.

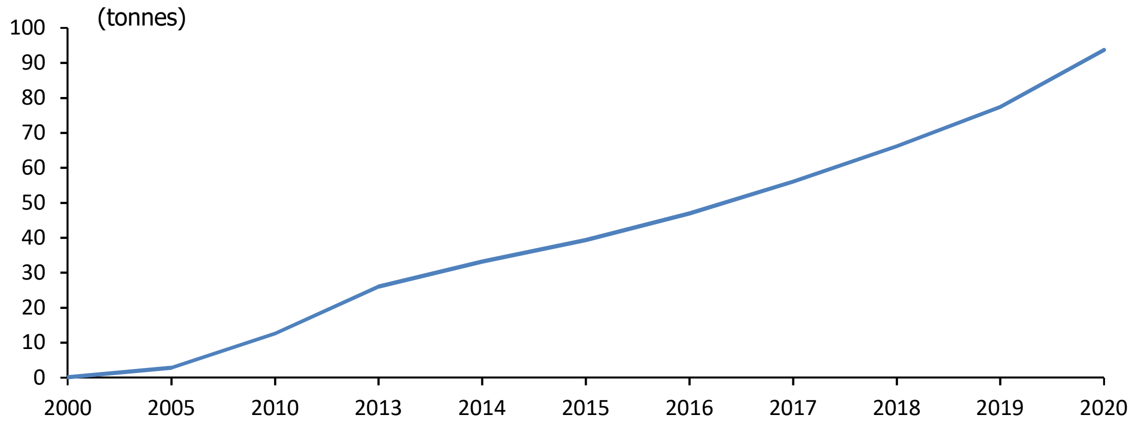
Table 4.32 HFCs Emissions

Substance	2000	2005	2010	2015	2016	2017	2018	2019	2020
HFC-23	0.02	0.29	0.56	3.617	3.30	3.025	2.248	2.041	1.911
HFC-32	-	-	-	0.201	22.763	71.278	139.281	223.813	421.084
HFC-41	-	-	0.03	0.12	0.02	1.14	0.97	0.82	0.0
HFC-43-10mee	-	-	-	0.124	0.02	1.14	0.97	0.82	0.67
HFC-125	-	-	0.71	25.530	33.50	39.45	45.42	48.39	26.366
HFC-134	-	-	-	0.0039	0.04	1.14	0.97	0.82	0.0
HFC-134a	80.35	791.38	2 066.27	3 000	3 260.17	3 384.77	3 277	3 557.65	3 307.715
HFC-143	-	-	0.001	0.000	0.000	0.00	0.00	0.00	0.00
HFC-143a	-	-	-	2.83	5.55	7	6.915	5.619	4.786
HFC-152a	0.78	14.07	331.36	1 418.2	1 499.5	1 528	1 575	2 093.81	2 228.66
HFC-236fa	-	-	0.68	4.090	4.71	5.84	8.81	9	8.099
HFC-245ca	-	-	0.02	2.26	0.02	1.14	0.97	0.82	0.99
HFC-245fa	-	-	-	11.81	10.65	0.00	0.00	0.00	36.12
HFC-365mfc	-	-	0.12	0.66	0.02	1.14	0.97	0.82	0.19
HFC-227ea	0.13	2.87	12.67	39.33	46.99	56.01	66.18	77.43	93.755

The calculation method is IPCC T1 for all substances given above.

Inventory calculations have been based on the raw trade data (import and export) provided for each gas by Ministry of Trade and the change in emission values are consistent with number of import and export.

Figure 4.23 HFC-227ea Emissions, 2000-2020



Recalculation:

There is no recalculation for this submission.

Planned Improvement:

No further improvements are planned.

4.8. Other Product Manufacture and Use (Category 2.G)

Source Category Description:

The sub-sector other product manufacture and use consists of the following sub- applications:

- 2.G.1- SF_6 Emissions from electrical equipment

Methodological Issues:

It is assumed that SF_6 is used only in electrical instruments, mainly in circuit breakers. Emission results are reported based on the import and export data of SF_6. However, custom code for this gas was established in 2013 and trade data is available only for 2013- 2019. Therefore, trend of electricity consumption is used for the prediction of imported gas for previous years.

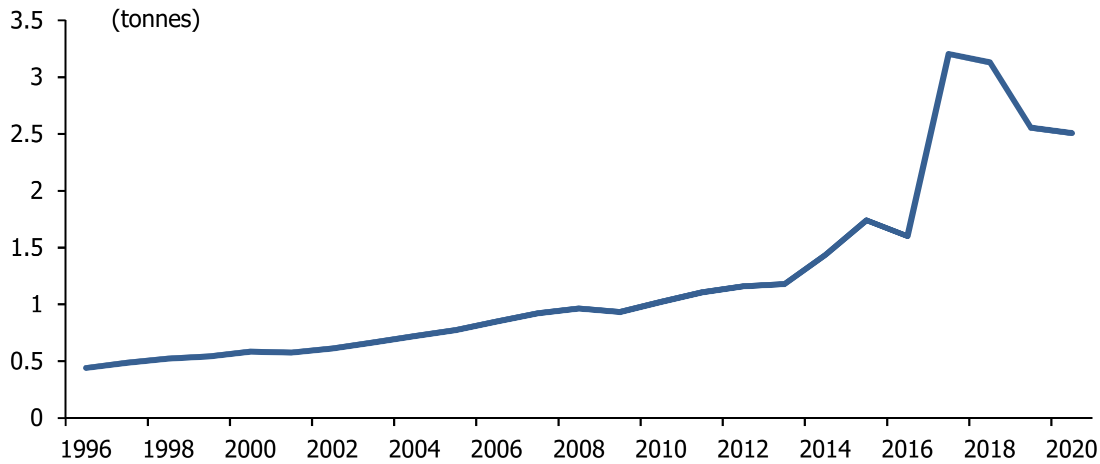
Data for electricity consumption is obtained from the Turkish Electricity Transmission Corporation and the trade data for SF_6 is provided by Ministry of Trade. Table 4.33 shows the distribution of electricity consumption, SF_6 consumption (import and export values) and emissions of SF_6 which is emitted 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 4.33 SF_6 Consumption and Electricity Consumption

Years	Electricity consumption (GWh)	SF_6 net consumption (tonnes)	SF_6 Emissions (tonnes)
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
2018	254 863	156.591	3.131
2019	257 273	127.775	2.555
2020	261 193	125.466	2.509

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. Import and export data is provided by Ministry of Trade. By year 2020 SF_6 net consumption decreased in an almost downward trend, comparing with previous year and the emission also decreased.

Figure 4.24 SF_6 emissions, 1996-2020



Uncertainties and Time-Series Consistency:

Uncertainties of SF_6 was estimated using expert judgement 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. Aggregated national EFs are compared with IPCC default values.

Recalculation:

There is no recalculation for this submission.

Planned Improvement:

No further improvements are planned.

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 73 Mt CO_2 eq. for the year 2020 which is 15.7% of the total emission value including the LULUCF sector and 14% of all emissions excluding the LULUCF sector for Türkiye. 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 gases emitted from each of these sources.

Table 5.1 Categories of the agriculture sector and emitted gases

CRF Categories		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
3.A	Enteric fermentation		x					
3.B	Manure management		x	x	x[b]		x[b]	
3.C	Rice cultivation		x					
3.D	Agricultural soils	x[a]		x	x[b]		x[b]	
3.E	Prescribed burning of savannas		x	x	x[c]	x[c]	x[c]	x[c]
3.F	Field burning of agricultural residues		x	x	x[b]	x[b]	x[b]	x[b]
3.G	Liming	x						
3.H	Urea application	x						
3.I	Other carbon-containing fertilizers	x						
3.J	Other							

[a] to be reported under LULUCF Sector.
[b] Emissions of this gas from this category are likely to be emitted and a methodology is provided in the EMEP/EEA Guidebook.
[C] Emissions of this air pollutant from this category are likely to be emitted and the methodology may be included in the EMEP/EEA Guidebook in the future.

The percentage of emissions from this sector as percentage of total national GHG emissions (excluding LULUCF) gradually declined from around 21% to 10.6% in most of the years between 1990 and 2009 before levelling off and thereafter gaining momentum. 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 2020.

Table 5.2 Agriculture sector emissions and overall percentages by categories, 2020

	CH_4 (kt CO_2 eq.)	N_2O (kt CO_2 eq.)	CO_2 (kt)	Total (kt CO_2 eq.)	(%)
3 Agriculture	**39 007**	**32 491**	**1 657**	**73 155**	**100.0**
A. Enteric fermentation	34 615			34 615	47.3
B. Manure management	3 999	5 062		9 060	12.4
C. Rice cultivation	262			262	0.4
D. Agricultural soils		27 389		27 389	37.4
E. Prescribed burning of savannas				NO	
F. Field burning of agricultural residues	132	41		173	0.2
G. Liming				NE*	
H. Urea application			1 657	1 657	2.3
I. Other carbon-containing fertilizers				NO	
J. Other				NO	
GHG Percentage Shares	53.3	44.4	2.3	100.0	

*The emission level from source category 3.G Liming is considered to be insignificant according to Paragraph 37(b) of 24/CP.19.
Figures in the table may not add up to the totals 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 46.1 Mt CO_2 eq. to around 73 Mt CO_2 eq. (an increase of 58.4%) during the 31 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 12 Mt CO_2 eq. (54%) from 22.4 Mt CO_2 eq. to 34.6 Mt CO_2 eq. for the same period. The primary reason for this increase is the change in activity data (AD). Other significant increases in this thirty-one years period are seen in agricultural soils, manure management, and urea application where the figures are 10 Mt CO_2 eq. (58.6%), 3.6 Mt CO_2 eq. (66.7%), and 1.2 Mt CO_2 eq. (260%), 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 around 0.2 Mt CO_2 eq. (161.3%) whereas the emissions for field burning of agricultural residues between 1990 and 2020 resulted in a decrease of 50.1%.

Table 5.3 Overview of the agriculture sector emissions, 1990–2020

Year	A. Enteric fermentation (kt CO_2 eq.)	A. Enteric fermentation (%)	B. Manure management (kt CO_2 eq.)	B. Manure management (%)	C. Rice cultivation (kt CO_2 eq.)	C. Rice cultivation (%)	Agriculture total (kt CO_2 eq.)	Agriculture total (%)
1990	22 397	48.6	5 436	11.8	100	0.2	46 054	100
1991	23 221	49.5	5 657	12.1	100	0.2	46 928	100
1992	23 025	49.0	5 533	11.8	94	0.2	46 979	100
1993	22 636	47.7	5 597	11.8	101	0.2	47 407	100
1994	22 339	49.7	5 793	12.9	90	0.2	44 926	100
1995	21 815	49.5	5 523	12.5	113	0.3	44 080	100
1996	21 792	48.7	5 570	12.4	126	0.3	44 757	100
1997	20 313	47.8	5 166	12.2	124	0.3	42 505	100
1998	19 890	45.5	5 348	12.2	135	0.3	43 720	100
1999	19 963	45.1	5 448	12.3	147	0.3	44 276	100
2000	19 234	45.4	5 142	12.1	128	0.3	42 332	100
2001	18 714	46.9	5 096	12.8	132	0.3	39 894	100
2002	16 975	45.1	4 540	12.1	135	0.4	37 608	100
2003	18 874	46.5	4 596	11.3	143	0.4	40 558	100
2004	18 969	45.9	4 590	11.1	156	0.4	41 298	100
2005	19 680	46.4	4 781	11.3	183	0.4	42 439	100
2006	20 352	46.4	5 027	11.5	212	0.5	43 900	100
2007	20 575	47.4	5 081	11.7	203	0.5	43 421	100
2008	20 084	48.6	4 929	11.9	216	0.5	41 302	100
2009	19 606	46.6	4 863	11.6	208	0.5	42 032	100
2010	20 946	47.2	5 391	12.1	202	0.5	44 409	100
2011	22 847	48.7	5 639	12.0	204	0.4	46 901	100
2012	25 790	49.0	6 425	12.2	249	0.5	52 662	100
2013	26 906	48.2	6 769	12.1	231	0.4	55 858	100
2014	27 154	48.3	7 068	12.6	229	0.4	56 219	100
2015	26 947	48.0	6 956	12.4	240	0.4	56 133	100
2016	26 984	45.8	7 060	12.0	243	0.4	58 894	100
2017	30 110	47.6	7 697	12.2	234	0.4	63 262	100
2018	32 136	49.2	8 508	13.0	252	0.4	65 338	100
2019	33 368	49.1	8 597	12.6	263	0.4	68 023	100
2020	34 615	47.3	9 060	12.4	262	0.4	73 155	100

Figures in the table may not add up to the totals due to rounding.

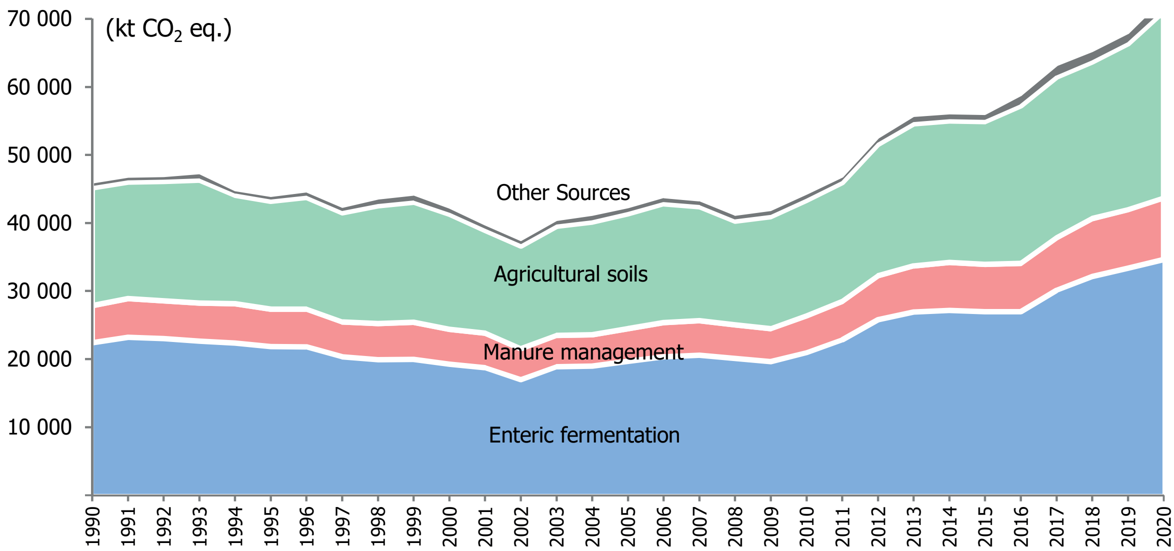
Table 5.3 Overview of the agriculture sector emissions, 1990–2020 (continued)

Year	D. Managed soils		F. Field burning		H. Urea application		Agriculture total	
	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)
1990	17 314	37.6	347	0.8	460	1.0	46 054	100
1991	17 155	36.6	359	0.8	436	0.9	46 928	100
1992	17 527	37.3	341	0.7	459	1.0	46 979	100
1993	18 078	38.1	367	0.8	627	1.3	47 407	100
1994	15 931	35.5	321	0.7	453	1.0	44 926	100
1995	15 871	36.0	332	0.8	426	1.0	44 080	100
1996	16 391	36.6	344	0.8	534	1.2	44 757	100
1997	16 023	37.7	347	0.8	532	1.3	42 505	100
1998	17 306	39.6	382	0.9	658	1.5	43 720	100
1999	17 643	39.8	342	0.8	733	1.7	44 276	100
2000	16 870	39.9	340	0.8	617	1.5	42 332	100
2001	15 107	37.9	318	0.8	527	1.3	39 894	100
2002	15 103	40.2	328	0.9	527	1.4	37 608	100
2003	16 054	39.6	325	0.8	565	1.4	40 558	100
2004	16 591	40.2	359	0.9	632	1.5	41 298	100
2005	16 880	39.8	302	0.7	613	1.4	42 439	100
2006	17 422	39.7	294	0.7	592	1.3	43 900	100
2007	16 740	38.6	256	0.6	566	1.3	43 421	100
2008	15 250	36.9	259	0.6	565	1.4	41 302	100
2009	16 474	39.2	288	0.7	593	1.4	42 032	100
2010	17 006	38.3	219	0.5	645	1.5	44 409	100
2011	17 421	37.1	233	0.5	558	1.2	46 901	100
2012	19 334	36.7	224	0.4	640	1.2	52 662	100
2013	20 905	37.4	240	0.4	807	1.4	55 858	100
2014	20 764	36.9	215	0.4	788	1.4	56 219	100
2015	21 006	37.4	174	0.3	811	1.4	56 133	100
2016	23 147	39.3	164	0.3	1 295	2.2	58 894	100
2017	23 607	37.3	165	0.3	1 450	2.3	63 262	100
2018	23 022	35.2	163	0.2	1 257	1.9	65 338	100
2019	24 342	35.8	165	0.2	1 288	1.9	68 023	100
2020	27 389	37.4	173	0.2	1 657	2.3	73 155	100

Figures in the table may not add up to the totals due to rounding.

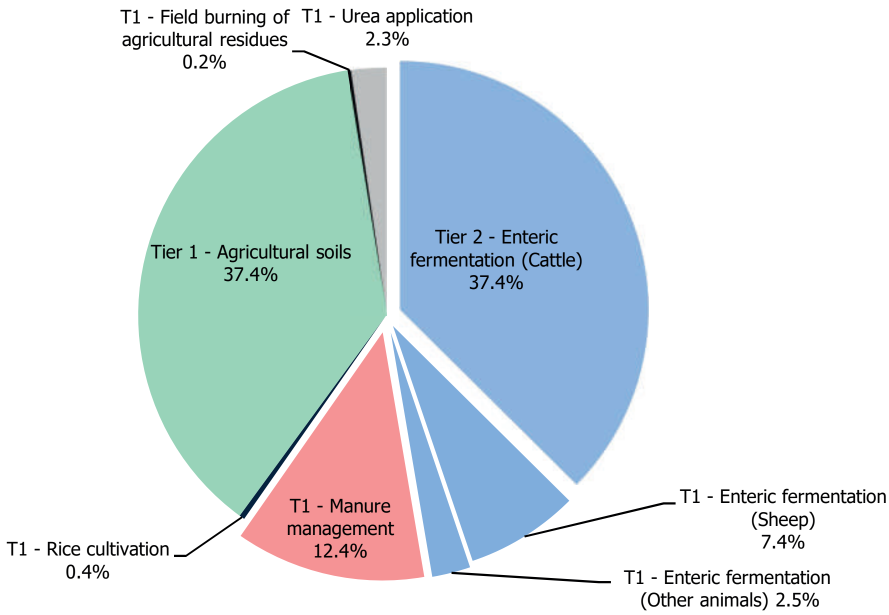
Furthermore, in relative terms, the biggest category in the agriculture sector is enteric fermentation having a 47.3% share for 2020, so it dominates the sector. In all reported years, 1990-2020, this category had an average share of 47.6% in the agriculture sector, starting with a share of 48.6% in 1990. The second biggest category is agricultural soils having a proportion of 37.4% for 2020 increased from 35.8% in 2019. While having a percentage share of agricultural soils of 40.2% in 2004, its average share for the entire reporting period of thirty-one years is around 37.9%. Manure management's share presents somehow a more stable increasing trend, starting from 11.8% in 1990 and reaching 12.4% in 2020 while having an average of 12.1% for all reporting years. For 2020, remaining categories, which are rice cultivation, field burning of agricultural residuals, and urea application, had emission shares of 0.4%, 0.2%, and 2.3%, respectively. Though the share increased by around 65% for rice cultivation and 127% for urea application, the absolute terms were small and relative weights of these two categories were low for the period 1990-2020. Despite these increasing values, the share for field burning of agricultural residues decreased from 0.8% to 0.2% for the reporting period. A graphical representation is given below in Figure 5.1, which presents the overall cumulative distribution and the trend for the reporting period of the agriculture sector. Other sources are calculated by the summation of emission figures from rice cultivation, field burning, and urea application.

Figure 5.1 Cumulative emissions of agricultural categories, 1990–2020



Additionally, it should be noted that prescribed burning of savannas (CRF Category 3.E) does not occur in Türkiye and is therefore not reported in this National Inventory Report whereas liming (CRF Category 3.G) is considered to be insignificant according to Paragraph 37(b) of 24/CP.19. Other carbon-containing fertilizers (CRF Category 3.I) are not occurring while the final category, other (CRF Category 3.J) in the agriculture sector, is an option to be used only if necessary. Figure 5.2 shows an overview of category shares and methods used for the agriculture sector.

Figure 5.2 Category shares and methods used in the agriculture sector, 2020



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 27 377 kt CO_2 eq. This amount equals to around 37.4% of total emissions in the agriculture sector and 79.1% of total emissions in enteric fermentation which is the biggest subcategory in enteric fermentation as presented in Figure 5.2.

Table 5.4 Agriculture sector emissions – comparison between 2019 and 2020

Source Category		2019		2020		Change	
		(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)
3. Agriculture Sector		**68 023**	**100**	**73 155**	**100**	**5 133**	**7.5**
3.A	Enteric Fermentation	33 368	49.1	34 615	47.3	1 246	3.7
3.B	Manure Management	8 597	12.6	9 060	12.4	464	5.4
3.C	Rice Cultivation	263	0.4	262	0.4	-1	-0.5
3.D	Agricultural Soils	24 342	35.8	27 389	37.4	3 047	12.5
3.F	Field Burning	165	0.2	173	0.2	9	5.2
3.H	Urea Application	1 288	1.9	1 657	2.3	369	28.7

Figures in the table may not add up to the totals due to rounding. Note that two source categories, CRF 3.E and 3.I, are not occurring (NO), while another source category, CRF 3.G Liming, is not estimated (NE) because it is considered to be insignificant.

The emission values between the latest of two reporting years, 2019 and 2020, are presented 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 shown in Figure 5.4.

Figure 5.3 Trends in major agriculture categories

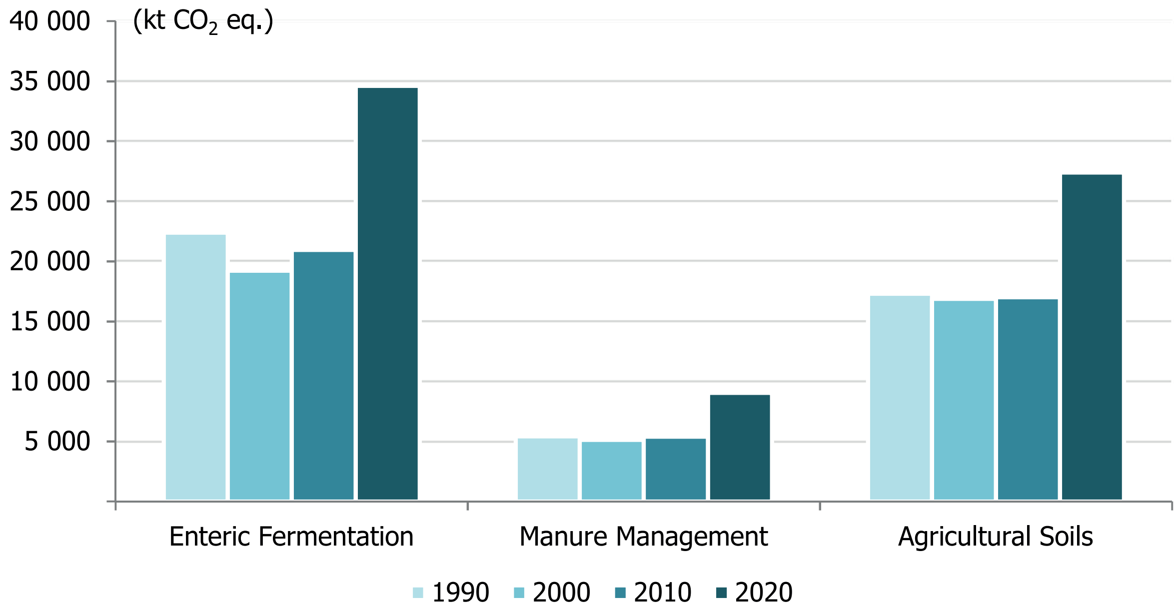
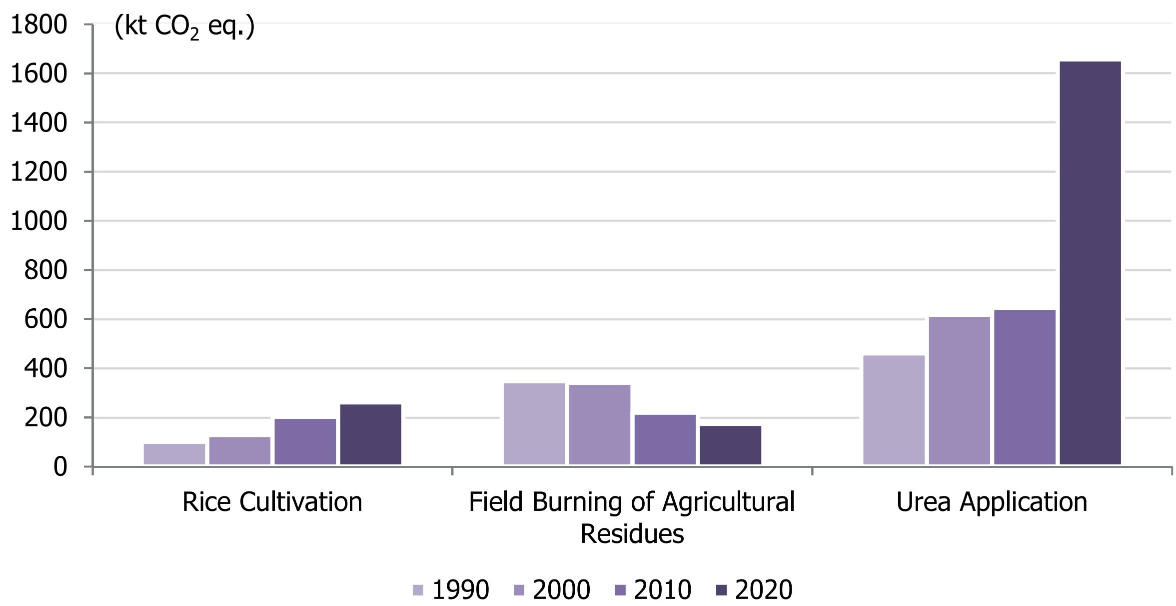


Figure 5.4 Trends in minor agriculture categories



GHG emission values and their percentage shares in the agriculture sector, CH_4, N_2O and CO_2, are presented in Table 5.5. After its initial increase in 1991, emission values for CH_4 decreased 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_4 decreased from 54.5% in 1990 to 53.3% in 2020.

The average share of N_2O emissions were around 44.8% with respect to yearly total agricultural emission values. The emission values for N_2O were 20 480 kt CO_2 eq. (44.5%) in 1990 and increased to an estimated value of 32 491 kt CO_2 eq. while taking a smaller share of 44.4% of total agricultural emissions in 2020. N_2O emissions are due to manure management and agricultural soils source categories in the agricultural sector.

CO_2 emissions result only from urea application; have the smallest share in this sector, and ranges between 0.9% and 2.3% for the period 1990-2020. The highest absolute value of CO_2 emissions occurred in 2020 with 1657 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, 1990–2020

Year	CH_4 (kt CO_2 eq.)	CH_4 (%)	N_2O (kt CO_2 eq.)	N_2O (%)	CO_2 (kt)	CO_2 (%)	Total (kt CO_2 eq.)
1990	25 114	54.5	20 480	44.5	460	1.0	46 054
1991	26 036	55.5	20 456	43.6	436	0.9	46 928
1992	25 709	54.7	20 811	44.3	459	1.0	46 979
1993	25 439	53.7	21 342	45.0	627	1.3	47 407
1994	25 335	56.4	19 139	42.6	453	1.0	44 926
1995	24 707	56.1	18 947	43.0	426	1.0	44 080
1996	24 735	55.3	19 488	43.5	534	1.2	44 757
1997	23 011	54.1	18 962	44.6	532	1.3	42 505
1998	22 795	52.1	20 267	46.4	658	1.5	43 720
1999	22 925	51.8	20 618	46.6	733	1.7	44 276
2000	21 955	51.9	19 759	46.7	617	1.5	42 332
2001	21 502	53.9	17 864	44.8	527	1.3	39 894
2002	19 377	51.5	17 704	47.1	527	1.4	37 608
2003	21 179	52.2	18 813	46.4	565	1.4	40 558
2004	21 270	51.5	19 396	47.0	632	1.5	41 298
2005	22 053	52.0	19 773	46.6	613	1.4	42 439
2006	22 839	52.0	20 468	46.6	592	1.3	43 900
2007	23 156	53.3	19 699	45.4	566	1.3	43 421
2008	22 605	54.7	18 132	43.9	565	1.4	41 302
2009	22 172	52.7	19 267	45.8	593	1.4	42 032
2010	23 786	53.6	19 978	45.0	645	1.5	44 409
2011	25 681	54.8	20 662	44.1	558	1.2	46 901
2012	29 048	55.2	22 975	43.6	640	1.2	52 662
2013	30 316	54.3	24 734	44.3	807	1.4	55 858
2014	30 712	54.6	24 720	44.0	788	1.4	56 219
2015	30 351	54.1	24 972	44.5	811	1.4	56 133
2016	30 464	51.7	27 134	46.1	1 295	2.2	58 894
2017	33 818	53.5	27 995	44.3	1 450	2.3	63 262
2018	36 399	55.7	27 682	42.4	1 257	1.9	65 338
2019	37 578	55.2	29 157	42.9	1 288	1.9	68 023
2020	39 007	53.3	32 491	44.4	1 657	2.3	73 155

Figures in the table may not add up to the totals due to rounding. Source categories for CH_4 and N_2O emissions are presented in Table 5.9 and 5.10, respectively, whereas the only source category for CO_2 emissions is urea application (CRF category 3.H) which emits carbon dioxide reported under the agriculture sector.

The activity data used for the compilation of the GHG inventory are provided mainly by TurkStat's databases distributed by its Central Dissemination System on the following website accessible on https://biruni.tuik.gov.tr/medas/?kn=101&locale=en which is also accessible at www.turkstat.gov.tr.

Livestock population data are critical activity data for the required calculations. Animal population numbers shown in Table 5.6 are provided by TurkStat for the entire time series, 1990-2020. 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 are more recent and accurate compared to FAO. Moreover, FAO has some assumptions on TurkStat data. Although the data are updated each year by TurkStat, FAO has still continued to use its assumptions. Therefore, the data sent by TurkStat, which are also used for GHG inventory, are the most accurate data available for inventory calculations.

Data on livestock production have been collected from District Offices of the Ministry of Agriculture and Forestry 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 Agriculture and Forestry. 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 show, both dairy and non-dairy cattle, domestic sheep, poultry and goats have significantly high population numbers with respect to other livestock species. Five columns, which are dairy cattle, non-dairy cattle, sheep merino, goats, and poultry, have positive differences between 1990 and 2020 with population increasing around 0.9 million (13%), 5.7 million (104%), 2.7 million (321%), 1 million (9.7%) and 284 million (278%), respectively. It is remarkable that poultry numbers had more than tripled in 31 years from around 102 million to over 385 million. Contrary to these developments, the change for the reporting period of 31 years was as much as -92% for the swine population and -89% for mules and asses. Similarly, other changing percentages observed for camels, domestic sheep, buffalo, and horses are -35%, -2.8%, -48.1%, -82.5%, respectively. The figures also presents a decreasing trend for few livestock species for the reporting period of 1990-2020. During the reporting period, 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, a few animal categories used for carrying goods previously in rural areas, are not needed any more extensively for this purpose. Thus the demand for a few livestock species decreased.

Table 5.6 Livestock population numbers in Türkiye, 1990–2020

(thousand)

Year	Dairy Cattle	Non-Dairy Cattle	Sheep Domestic	Sheep Merino	Goats	Buffalo	Horses	Mules and Asses	Swine, Camels	Poultry
1990	5 893	5 485	39 711	842	10 926	371	513	1 187	14.0	102 255
1991	6 119	5 854	39 590	842	10 764	366	496	1 136	12.2	145 051
1992	6 070	5 881	38 576	840	10 454	352	483	1 075	13.7	158 770
1993	6 032	5 878	36 709	832	10 133	316	450	1 013	11.0	184 460
1994	6 082	5 819	34 823	823	9 564	305	437	978	10.0	190 033
1995	5 886	5 903	32 985	806	9 111	255	415	900	7.0	135 251
1996	5 968	5 918	32 234	838	8 951	235	391	843	7.0	158 756
1997	5 597	5 593	29 376	862	8 376	194	345	782	6.0	175 223
1998	5 489	5 542	28 560	875	8 057	176	330	736	6.4	243 914
1999	5 538	5 516	29 425	831	7 774	165	309	680	4.8	246 476
2000	5 280	5 481	27 719	773	7 201	146	271	588	4.0	264 451
2001	5 086	5 462	26 213	759	7 022	138	271	559	3.6	223 141
2002	4 393	5 411	24 474	700	6 780	121	249	512	4.5	251 101
2003	4 134	5 654	24 689	742	6 772	113	227	490	7.9	283 674
2004	3 876	6 194	24 438	763	6 610	104	212	452	5.3	302 799
2005	3 998	6 528	24 552	752	6 517	105	208	423	2.7	322 917
2006	4 188	6 683	24 801	815	6 643	101	204	404	2.4	349 402
2007	4 229	6 807	24 491	971	6 286	85	189	364	2.9	273 548
2008	4 080	6 780	22 956	1 019	5 594	86	180	336	2.7	249 044
2009	4 133	6 591	20 722	1 028	5 128	87	167	286	2.9	234 082
2010	4 362	7 008	22 003	1 086	6 293	85	155	260	2.8	238 973
2011	4 761	7 625	23 811	1 221	7 278	98	151	248	3.1	241 499
2012	5 431	8 484	25 893	1 533	8 357	107	141	236	4.3	257 505
2013	5 607	8 808	27 485	1 799	9 226	118	136	227	4.5	270 202
2014	5 609	8 614	29 034	2 106	10 345	122	131	212	4.1	298 030
2015	5 536	8 458	29 302	2 206	10 416	134	123	198	3.2	316 332
2016	5 432	8 648	28 833	2 151	10 345	142	120	190	2.9	333 541
2017	5 969	9 975	31 257	2 420	10 635	161	114	176	3.1	348 144
2018	6 338	10 705	32 513	2 682	10 922	178	108	165	3.3	359 218
2019	6 581	11 107	34 199	3 077	11 205	184	102	156	3.1	348 785
2020	6 775	11 190	38 580	3 547	11 986	192	90	133	2.0	386 081

Note that dairy cattle population for the year 2003 is taken as the average of population figures for 2002 and 2004 after carefully discussed/scrutinized with the Agricultural Statistics Department at TurkStat in order to ensure comparability for the entire time series. This was necessary because of a different methodology applied regarding dairy cattle for the year 2003. Non-dairy cattle figures were adjusted accordingly.

Time series for cattle population with its subcategories in our country are presented in Table 5.7. Livestock production can result in CH_4 emissions from enteric fermentation and also in CH_4 and N_2O emissions from livestock manure management systems. Cattle as a livestock category is a significant source of CH_4 in our country because of their large population and high CH_4 emission rate due to their ruminant digestive system.

In Türkiye there are three dairy cattle types categorized as culture cattle, hybrid cattle and domestic cattle as shown in Table 5.8. 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 1997, 1998 and 2002-2004. But, in general, the culture dairy cattle population has a positive trend in the period 1990-2020, which has a percentage increase of 41.2% from 9% in 1990 to 50.2% in 2020 within dairy cattle population. For hybrid cattle population, which was around 2.8 million in 2020 despite being 1.9 million in 1990, a big increase or decrease cannot be observed throughout the same period, though the final three reporting years identified a total increase of around 0.4 million. The share of domestic cattle among dairy cattle was 58.1% in 1990 but this ratio reduced to 8.4% in 2020. As seen in Table 5.7, non-dairy cattle number increased by approximately 5.7 million from around 5.5 million in 1990 to more than 11.2 million in 2020 and its share in total number of cattle increased from 48.2% to 62.3% between 1990 and 2020. Furthermore, Figure 5.5 presents three types of dairy cattle as well as non-dairy cattle population numbers for the period of 1990-2020 in a straightforward chart.

Figure 5.5 Population numbers for cattle categories, 1990–2020

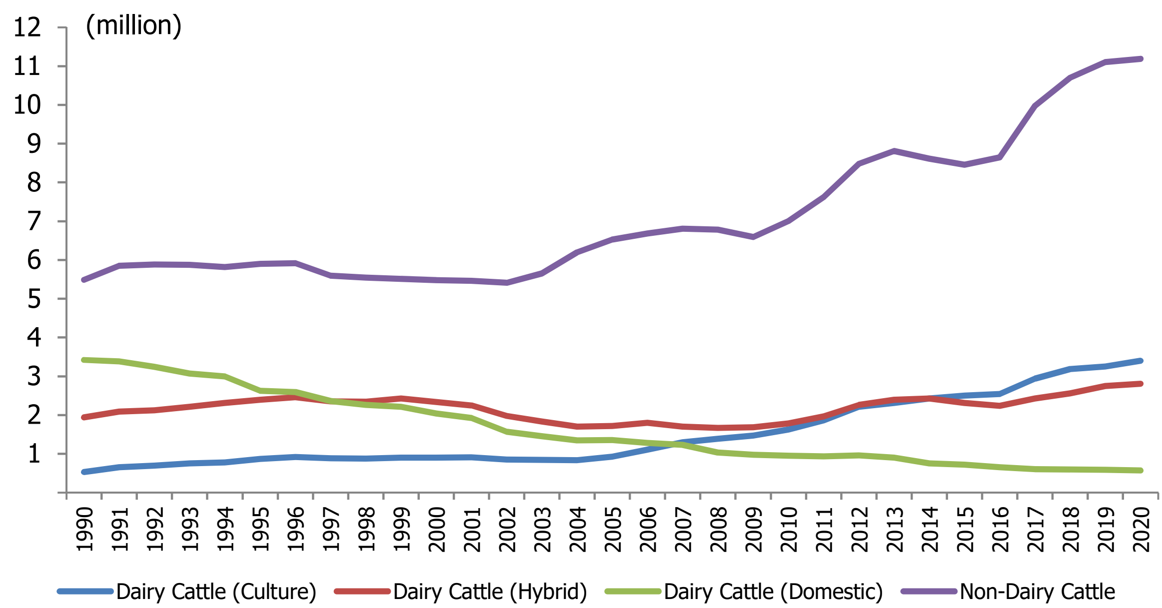


Table 5.7 Subcategories of cattle population, 1990–2020

Year	Total Cattle	Dairy Cattle		Non-Dairy Cattle	
	(population)	(population)	(%)	(population)	(%)
1990	11 377 057	5 892 550	51.8	5 484 507	48.2
1991	11 972 923	6 119 000	51.1	5 853 923	48.9
1992	11 950 907	6 070 178	50.8	5 880 729	49.2
1993	11 910 000	6 031 952	50.6	5 878 048	49.4
1994	11 901 000	6 082 180	51.1	5 818 820	48.9
1995	11 789 000	5 885 586	49.9	5 903 414	50.1
1996	11 886 000	5 968 211	50.2	5 917 789	49.8
1997	11 189 937	5 596 611	50.0	5 593 326	50.0
1998	11 031 000	5 489 048	49.8	5 541 952	50.2
1999	11 054 000	5 537 883	50.1	5 516 117	49.9
2000	10 761 000	5 279 573	49.1	5 481 427	50.9
2001	10 548 000	5 085 819	48.2	5 462 181	51.8
2002	9 803 498	4 392 574	44.8	5 410 924	55.2
2003	9 788 102	4 134 148	42.2	5 653 954	57.8
2004	10 069 346	3 875 722	38.5	6 193 624	61.5
2005	10 526 440	3 998 095	38.0	6 528 345	62.0
2006	10 871 364	4 187 934	38.5	6 683 430	61.5
2007	11 036 753	4 229 442	38.3	6 807 311	61.7
2008	10 859 942	4 080 242	37.6	6 779 700	62.4
2009	10 723 958	4 133 150	38.5	6 590 808	61.5
2010	11 369 800	4 361 842	38.4	7 007 958	61.6
2011	12 386 337	4 761 150	38.4	7 625 187	61.6
2012	13 914 912	5 431 403	39.0	8 483 509	61.0
2013	14 415 257	5 607 278	38.9	8 807 979	61.1
2014	14 223 109	5 609 249	39.4	8 613 860	60.6
2015	13 994 071	5 535 779	39.6	8 458 292	60.4
2016	14 080 155	5 431 720	38.6	8 648 435	61.4
2017	15 943 586	5 969 051	37.4	9 974 535	62.6
2018	17 042 506	6 337 906	37.2	10 704 600	62.8
2019	17 688 139	6 580 834	37.2	11 107 305	62.8
2020	17 965 482	6 775 321	37.7	11 190 161	62.3

Figures in the table may not add up to the totals due to rounding. Note also the footnote to Table 5.6.

Table 5.8 Subcategories of dairy cattle population, 1990–2020

Year	Total	Culture		Hybrid		Domestic	
	(population)	(population)	(%)	(population)	(%)	(population)	(%)
1990	5 892 550	530 330	9.0	1 941 170	32.9	3 421 050	58.1
1991	6 119 000	650 738	10.6	2 087 018	34.1	3 381 244	55.3
1992	6 070 178	698 224	11.5	2 124 106	35.0	3 247 848	53.5
1993	6 031 952	750 255	12.4	2 214 723	36.7	3 066 974	50.8
1994	6 082 180	779 689	12.8	2 308 310	38.0	2 994 181	49.2
1995	5 885 586	870 246	14.8	2 392 621	40.7	2 622 719	44.6
1996	5 968 211	920 185	15.4	2 457 925	41.2	2 590 101	43.4
1997	5 596 611	882 093	15.8	2 355 540	42.1	2 358 978	42.2
1998	5 489 048	879 840	16.0	2 346 094	42.7	2 263 114	41.2
1999	5 537 883	903 495	16.3	2 424 626	43.8	2 209 762	39.9
2000	5 279 573	904 850	17.1	2 335 119	44.2	2 039 604	38.6
2001	5 085 819	912 411	17.9	2 248 882	44.2	1 924 526	37.8
2002	4 392 574	850 726	19.4	1 971 743	44.9	1 570 105	35.7
2003	4 134 148	841 718	20.4	1 835 773	44.4	1 456 657	35.2
2004	3 875 722	832 710	21.5	1 699 803	43.9	1 343 209	34.7
2005	3 998 095	925 613	23.2	1 717 310	43.0	1 355 172	33.9
2006	4 187 934	1 106 679	26.4	1 799 411	43.0	1 281 844	30.6
2007	4 229 442	1 299 750	30.7	1 698 804	40.2	1 230 888	29.1
2008	4 080 242	1 385 727	34.0	1 665 186	40.8	1 029 329	25.2
2009	4 133 150	1 470 885	35.6	1 686 064	40.8	976 201	23.6
2010	4 361 842	1 626 416	37.3	1 787 010	41.0	948 416	21.7
2011	4 761 150	1 868 281	39.2	1 962 711	41.2	930 158	19.5
2012	5 431 403	2 211 245	40.7	2 263 400	41.7	956 758	17.6
2013	5 607 278	2 314 282	41.3	2 395 898	42.7	897 098	16.0
2014	5 609 249	2 427 915	43.3	2 428 709	43.3	752 625	13.4
2015	5 535 779	2 500 881	45.2	2 314 063	41.8	720 835	13.0
2016	5 431 720	2 542 164	46.8	2 235 503	41.2	654 053	12.0
2017	5 969 051	2 940 907	49.3	2 426 763	40.7	601 381	10.1
2018	6 337 906	3 185 954	50.3	2 554 949	40.3	597 003	9.4
2019	6 580 834	3 249 038	49.4	2 745 272	41.7	586 524	8.9
2020	6 775 321	3 398 270	50.2	2 808 168	41.4	568 883	8.4

Figures in the table may not add up to the totals due to rounding. Note also the footnote to Table 5.6.

Table 5.3, given previously, presents a detailed perspective on the agriculture sector emissions for the reporting period. GHG emissions from livestock are CH_4 in enteric fermentation and CH_4 and N_2O in manure management. Rice cultivation leads to CH_4 emissions, agricultural soils to N_2O emissions, field burning of crop residues to CH_4 and N_2O emissions. Urea application is the only category directly resulting in CO_2 emissions reported under the agriculture sector in our country. An overview of emission factors and parameters related to emission calculations from the agriculture sector is shown in Annex 3 of the NIR.

Methane (CH_4)

Emissions from enteric fermentation, manure management, rice cultivation and field burning of agricultural residues include methane. The agriculture sector in our country produced 1560.3 kt CH_4 (39 Mt CO_2 eq.) emissions, which equals 53.3% of agricultural emissions or 61% of Türkiye's CH_4 emissions (without LULUCF), or 7.4% of Türkiye's total emissions in 2020. CH_4 emissions had increased by 13 893 kt CO_2 eq. (55.3%) from its 1990 level of 25 114 kt CO_2 eq. to 39 007 kt CO_2 eq. in 2020. This increase is mainly a result of increases in CH_4 emissions from enteric fermentation of 12 218 kt CO_2 eq., from manure management of 1 647 kt CO_2 eq., and from rice cultivation of 161 kt CO_2 eq. The total increase as high as 13 893 kt CO_2 eq. is responsible for 51.3% of 27 102 kt CO_2 eq. overall increase in emissions from the agricultural sector between 1990 and 2020.

Enteric fermentation is the single dominant category leading to 89.2% in 1990 and 88.7% in 2020 of all CH_4 emissions of the agriculture sector. Enteric fermentation was followed by manure management with 9.4% in 1990 and 10.3% in 2020. CH_4 emissions from field burning of agricultural residues are 1.1% in 1990 and 0.3% in 2020 of all CH_4 emissions from the agriculture sector. CH_4 emissions share of rice cultivation is 0.4% and 0.7% for 1990 and 2020, respectively. An overview of CH_4 emissions are presented in the following table.

Table 5.9 Overview of CH_4 emissions in the agriculture sector, 1990–2020

	CH_4 Emissions								
	3.A		3.B		3.C		3.F		Total
Year	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)
1990	22 397	89.2	2 352	9.4	100	0.4	265	1.1	25 114
1991	23 221	89.2	2 440	9.4	100	0.4	274	1.1	26 036
1992	23 025	89.6	2 330	9.1	94	0.4	261	1.0	25 709
1993	22 636	89.0	2 420	9.5	101	0.4	281	1.1	25 439
1994	22 339	88.2	2 661	10.5	90	0.4	245	1.0	25 335
1995	21 815	88.3	2 526	10.2	113	0.5	254	1.0	24 707
1996	21 792	88.1	2 554	10.3	126	0.5	263	1.1	24 735
1997	20 313	88.3	2 308	10.0	124	0.5	265	1.2	23 011
1998	19 890	87.3	2 478	10.9	135	0.6	292	1.3	22 795
1999	19 963	87.1	2 554	11.1	147	0.6	261	1.1	22 925
2000	19 234	87.6	2 334	10.6	128	0.6	260	1.2	21 955
2001	18 714	87.0	2 414	11.2	132	0.6	243	1.1	21 502
2002	16 975	87.6	2 017	10.4	135	0.7	250	1.3	19 377
2003	18 874	89.1	1 913	9.0	143	0.7	249	1.2	21 179
2004	18 969	89.2	1 871	8.8	156	0.7	274	1.3	21 270
2005	19 680	89.2	1 959	8.9	183	0.8	231	1.0	22 053
2006	20 352	89.1	2 051	9.0	212	0.9	225	1.0	22 839
2007	20 575	88.9	2 183	9.4	203	0.9	195	0.8	23 156
2008	20 084	88.8	2 108	9.3	216	1.0	198	0.9	22 605
2009	19 606	88.4	2 138	9.6	208	0.9	220	1.0	22 172
2010	20 946	88.1	2 471	10.4	202	0.8	167	0.7	23 786
2011	22 847	89.0	2 452	9.5	204	0.8	178	0.7	25 681
2012	25 790	88.8	2 837	9.8	249	0.9	171	0.6	29 048
2013	26 906	88.8	2 996	9.9	231	0.8	184	0.6	30 316
2014	27 154	88.4	3 163	10.3	229	0.7	164	0.5	30 712
2015	26 947	88.8	3 031	10.0	240	0.8	133	0.4	30 351
2016	26 984	88.6	3 112	10.2	243	0.8	126	0.4	30 464
2017	30 110	89.0	3 348	9.9	234	0.7	126	0.4	33 818
2018	32 136	88.3	3 886	10.7	252	0.7	124	0.3	36 399
2019	33 368	88.8	3 820	10.2	263	0.7	126	0.3	37 578
2020	34 615	88.7	3 999	10.3	262	0.7	132	0.3	39 007

Figures in the table may not add up to the totals due to rounding.

Nitrous Oxide (N_2O)

Nitrous oxide is a GHG with a high global warming potential. Overall, excluding LULUCF, N_2O emissions accounted for around 7.7% of Türkiye's GHG emissions in 2020. Emissions from manure management, agricultural soils, and field burning of agricultural residues include N_2O gas. Agriculture as a sector produced 109.03 kt N_2O emissions (32.5 Mt CO_2 eq.), which equals 44.4% of agricultural emissions or 80.3% of Türkiye's N_2O emissions (excluding LULUCF) or 5.6% of Türkiye's total emissions in 2020. N_2O emissions have increased by 12 011 kt CO_2 eq. (58.6%) from 20 480 kt CO_2 eq. (1990) to 32 491 kt CO_2 eq. (2020).

The source category agricultural soils is the dominant source of N_2O emissions, responsible for 84.5% and 84.3% of total agricultural N_2O emissions for the years 1990 and 2020, respectively. Regarding N_2O emissions, agricultural soils were followed by manure management with 15.1% in 1990 and 15.6% in 2020, and field burning of agricultural residues with 0.4% in 1990 and 0.1% in 2020.

While a percentage as high as 84% of the augmentation in nitrous oxide emissions is a result of increases of N_2O emissions in agricultural soils by 10 075 kt CO_2 eq., manure management is responsible for the remaining increase of 16.5% with 1 977 kt CO_2 eq. in N_2O emissions. N_2O emissions of field burning of agricultural residues show a decrease of 50.1% (0.3% of Agricultural N_2O emissions by an amount of 41 kt CO_2 eq.) between 1990 and 2020. The net increase of 12 011 kt CO_2 eq. of N_2O emissions added up to 44.3% of the overall increase of 27 102 kt CO_2 eq. emissions in the agriculture sector between 1990 and 2020. An overview of N_2O emissions is presented in the next table.

Table 5.10 Overview of N_2O emissions in the agriculture sector, 1990–2020

	N_2O Emissions						
	3.B		3.D		3.F		Total
Year	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)
1990	3 084	15.1	17 314	84.5	82	0.4	20 480
1991	3 217	15.7	17 155	83.9	85	0.4	20 456
1992	3 203	15.4	17 527	84.2	81	0.4	20 811
1993	3 177	14.9	18 078	84.7	87	0.4	21 342
1994	3 133	16.4	15 931	83.2	76	0.4	19 139
1995	2 997	15.8	15 871	83.8	78	0.4	18 947
1996	3 016	15.5	16 391	84.1	81	0.4	19 488
1997	2 857	15.1	16 023	84.5	82	0.4	18 962
1998	2 871	14.2	17 306	85.4	90	0.4	20 267
1999	2 894	14.0	17 643	85.6	81	0.4	20 618
2000	2 809	14.2	16 870	85.4	80	0.4	19 759
2001	2 683	15.0	15 107	84.6	75	0.4	17 864
2002	2 523	14.3	15 103	85.3	77	0.4	17 704
2003	2 683	14.3	16 054	85.3	77	0.4	18 813
2004	2 720	14.0	16 591	85.5	85	0.4	19 396
2005	2 822	14.3	16 880	85.4	71	0.4	19 773
2006	2 977	14.5	17 422	85.1	69	0.3	20 468
2007	2 899	14.7	16 740	85.0	60	0.3	19 699
2008	2 821	15.6	15 250	84.1	61	0.3	18 132
2009	2 726	14.1	16 474	85.5	68	0.4	19 267
2010	2 921	14.6	17 006	85.1	52	0.3	19 978
2011	3 187	15.4	17 421	84.3	55	0.3	20 662
2012	3 588	15.6	19 334	84.2	53	0.2	22 975
2013	3 772	15.3	20 905	84.5	57	0.2	24 734
2014	3 905	15.8	20 764	84.0	51	0.2	24 720
2015	3 925	15.7	21 006	84.1	41	0.2	24 972
2016	3 948	14.5	23 147	85.3	39	0.1	27 134
2017	4 349	15.5	23 607	84.3	39	0.1	27 995
2018	4 622	16.7	23 022	83.2	38	0.1	27 682
2019	4 776	16.4	24 342	83.5	39	0.1	29 157
2020	5 062	15.6	27 389	84.3	41	0.1	32 491

Figures in the table may not add up to the totals due to rounding.

5.2. Enteric Fermentation (Category 3.A)

Source Category Description:

Enteric fermentation is a digestive process whereby carbohydrates are broken down by micro-organisms into simple molecules. The main product is CH_4 gas. Animals produce CH_4 during and/or after feed intake. The largest source of CH_4 emissions in the agricultural sector in our country is enteric fermentation. It is the biggest source of total carbon dioxide equivalent emissions in the agriculture sector with 48.6% (22.4 Mt CO_2 eq.) in 1990 and with 47.3% (34.6 Mt CO_2 eq.) in 2020.

In 2020, enteric fermentation contributed as high as 34 615 kt CO_2 eq., responsible for nearly half of agricultural emissions as stated above and 6.6% of Türkiye's total CO_2 eq. emissions. Dairy and non-dairy cattle contributed 27 377 kt CO_2 eq. (79.1%) of emissions to the enteric fermentation category and sheep (domestic and merino) contributed 5 398 kt CO_2 eq. (15.6%) of emissions to this category. This source category in 2020 resulted in a value of 12 218 kt CO_2 eq. (55%) of increased emissions compared to 1990 levels (22 397 kt CO_2 eq).

CH_4 emissions from enteric fermentation, which are presented by main livestock species in Table 5.11, fluctuate over time. This source category is a key category according to level and trend assessment. Enteric fermentation emissions declined by 24.2% (5.4 Mt CO_2 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 in CH_4 emissions for these subcategories. Between 2004 and 2019, emissions from enteric fermentation increased by 82.5% (15.6 Mt CO_2 eq).

There have been changes in the relative sources of emissions within enteric fermentation (Table 5.11) since 1990. The largest increase occurred from non-dairy cattle emissions due to an increase in its population numbers. In 2020, non-dairy cattle were responsible for 13 232 kt CO_2 eq., increased by 7 372 kt CO_2 eq. (126%) from the 1990 level of 5 860 kt CO_2 eq. Despite a slight increase of 15% in dairy cattle population for the period of 1990-2020, this subcategory is responsible for 14 145 kt CO_2 eq. in 2020, still an increase of 5 115 kt CO_2 eq. (56.6%) above its 1990 level of 9 030 CO_2 eq. A closer look at the changes in 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, which consisted of culture cattle (0.53 million), hybrid cattle (1.94 million), and domestic cattle (3.42 million). The respective figures for the year 2020 were 6.78 million in total for dairy cattle consisting of culture cattle (3.4 million), hybrid cattle (2.8 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 presented in Table 5.8. Population numbers of livestock species for the period 1990-2020 are shown in Table 5.6. While Figure 5.6 presents the percentage shares for the subcategories of enteric fermentation emission sources for the latest reporting year, on the next page, Table 5.11 presents CH_4 emissions of enteric fermentation regarding livestock species for the period, 1990-2020.

Figure 5.6 Enteric Fermentation Emission Sources, 2020

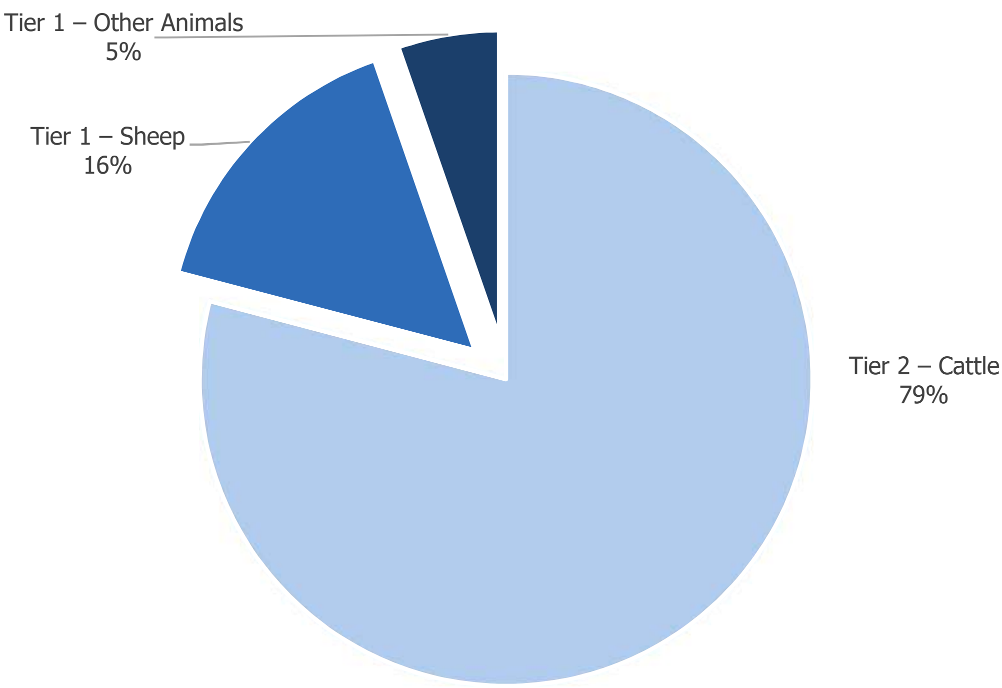


Table 5.11 Enteric fermentation CH_4 emissions, 1990–2020

(kt CO_2 eq.)

Year	Dairy Cattle	Non-Dairy Cattle	Sheep Domestic	Sheep Merino	Goats	Buffalo	Horses	Mules and Asses	Swine, Camels	Total
1990	9 030	5 860	4 964	137	1 366	510	231	297	3	22 397
1991	9 488	6 289	4 949	137	1 346	503	223	284	2	23 221
1992	9 466	6 319	4 822	137	1 307	485	217	269	2	23 025
1993	9 482	6 271	4 589	135	1 267	435	203	253	3	22 636
1994	9 605	6 189	4 353	134	1 196	419	197	245	3	22 339
1995	9 431	6 226	4 123	131	1 139	351	187	225	2	21 815
1996	9 587	6 209	4 029	136	1 119	323	176	211	2	21 792
1997	9 003	5 832	3 672	140	1 047	267	155	196	2	20 313
1998	8 857	5 738	3 570	142	1 007	242	149	184	2	19 890
1999	8 953	5 688	3 678	135	972	227	139	170	2	19 963
2000	8 592	5 680	3 465	126	900	201	122	147	1	19 234
2001	8 306	5 678	3 277	123	878	190	122	140	1	18 714
2002	7 228	5 318	3 059	114	848	166	112	128	1	16 975
2003	7 489	6 950	3 086	121	846	156	102	122	1	18 874
2004	7 221	7 390	3 055	124	826	143	96	113	1	18 969
2005	7 490	7 839	3 069	122	815	144	94	106	1	19 680
2006	7 961	7 995	3 100	133	830	138	92	101	1	20 352
2007	8 152	8 124	3 061	158	786	116	85	91	1	20 575
2008	7 980	8 085	2 869	166	699	119	81	84	1	20 084
2009	8 141	7 799	2 590	167	641	120	75	71	1	19 606
2010	8 653	8 327	2 750	177	787	116	70	65	1	20 946
2011	9 523	8 973	2 976	198	910	134	68	62	2	22 847
2012	10 935	10 053	3 237	249	1 045	148	64	59	2	25 790
2013	11 333	10 410	3 436	292	1 153	162	61	57	2	26 906
2014	11 440	10 168	3 629	342	1 293	168	59	53	2	27 154
2015	11 351	9 983	3 663	358	1 302	184	55	49	2	26 947
2016	11 197	10 241	3 604	350	1 293	195	54	47	2	26 984
2017	12 410	11 751	3 907	393	1 329	222	51	44	2	30 110
2018	13 218	12 716	4 064	436	1 365	245	49	41	2	32 136
2019	13 705	13 147	4 275	500	1 401	253	46	39	2	33 368
2020	14 145	13 232	4 822	576	1 498	265	41	33	2	34 615

Figures in the table may not add up to the totals due to rounding.

Methodological Issues:

Türkiye applies T1 method to estimate CH_4 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. Necessary data for T2 calculations are mainly gathered from TurkStat Agricultural Statistics Department, Ministry of Agriculture and Forestry, academic sources. The results for cattle in enteric fermentation are presented both in Figure 5.6 and Table 5.11. Moreover, Tables 5.12 and 5.13 present key country-specific parameters regarding T2 calculation; except for methane conversion factor which is a default value shown in the 2006 IPCC Guidelines. The annual population numbers for livestock species are included in Table 5.6 above. The AD (the population of livestock species) are obtained from TurkStat livestock statistics. TurkStat collects livestock data as explained in the sector overview. T2 cattle emissions are calculated according to equations 10.3, 10.4, 10.6, 10.8, 10.13, 10.14, 10.15, 10.16 and 10.21 presented in the 2006 IPCC Guidelines, Volume 4, Chapter 10.

Sheep are categorized as merino and domestic sheep in our country. For domestic sheep IPCC default EF for developing countries (5.0 kg CH_4 head^{-1} year^{-1}) is used. Merino sheep are also a kind of domestic sheep fed for their 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_4 head^{-1} year^{-1}) from the IPCC default EF for developing countries (5.0 kg CH_4 head^{-1} year^{-1}) and developed countries (8.0 kg CH_4/head/year). The country-specific typical animal mass values are 50 kg/head and 60 kg/head for domestic sheep and merino sheep, respectively. It is clear that emission levels for merino sheep currently calculated are conservative since the approximate EF for merino sheep is 5.73 kg CH_4/head/year obtained by the quotient of the weight figures (60 kg/50kg) raised to the power of 0.75 and then multiplied by the EF for domestic sheep (5.0 kg CH_4 head^{-1} year^{-1}). As stated clearly in the 2006 IPCC Guidelines (Vol.4, Chapter 10, page 10.24), this approximate figure can only be used to assess the significance of the emissions from a livestock species. The EF value for merino sheep is clearly higher than the calculated approximate EF value.

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 8.67% whereas the EF uncertainty value is 12.03% figured out by using Equation 3.2 in the IPCC Guidelines Vol. 1.

Source category	Gas	Comments on time series consistency
3.A	CH_4	All EFs for cattle are not constant over the entire time series because they are estimated mainly according to the split of culture, hybrid and domestic. Since the population numbers for cattle change over the reporting period, the respective EFs also reflect this change. EFs for all other livestock species are constant.

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 are 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, a QA work was conducted by a Project Engineer from CITEPA for this category in January 2020.

Recalculation:

There was no recalculation exercised regarding emission estimates from this source category in this submission.

Table 5.12 Key T2 parameters and estimated emissions for dairy cattle, 1990–2020

Year	Dairy Cattle					
	CH_4 Emissions (kt)	Mass (kg)	GE intake (MJ/head/day)	CH_4 Conversion rates, Y_m (%)	Milk yield (kg/day)	Digestibility of feed (%)
1990	361.2	350.4	143.8	6.50	3.70	64.19
1991	379.5	356.6	145.5	6.50	3.86	64.47
1992	378.7	360.3	146.3	6.50	3.93	64.65
1993	379.3	365.3	147.5	6.50	4.04	64.92
1994	384.2	368.1	148.2	6.50	4.11	65.08
1995	377.2	377.4	150.3	6.50	4.32	65.54
1996	383.5	379.9	150.7	6.50	4.35	65.66
1997	360.1	382.1	150.9	6.50	4.37	65.78
1998	354.3	383.8	151.4	6.50	4.41	65.88
1999	358.1	386.1	151.7	6.50	4.44	66.01
2000	343.7	389.0	152.7	6.50	4.53	66.14
2001	332.2	391.2	153.2	6.50	4.57	66.22
2002	289.1	396.2	154.4	6.50	4.67	66.43
2003	299.6	398.3	170.0	6.50	6.31	66.48
2004	288.8	400.7	174.8	6.50	6.79	66.53
2005	299.6	404.1	175.8	6.50	6.87	66.61
2006	318.4	413.3	178.4	6.50	7.11	66.94
2007	326.1	421.4	180.8	6.50	7.31	67.09
2008	319.2	431.4	183.5	6.50	7.56	67.48
2009	325.7	435.9	184.8	6.50	7.68	67.64
2010	346.1	440.9	186.1	6.50	7.80	67.83
2011	380.9	446.8	187.7	6.50	7.94	68.05
2012	437.4	451.5	188.9	6.50	8.06	68.24
2013	453.3	454.6	189.6	6.50	8.14	68.40
2014	457.6	461.0	191.4	6.50	8.30	68.66
2015	454.0	464.2	192.4	6.50	8.38	68.70
2016	447.9	467.9	193.4	6.50	8.47	68.80
2017	496.4	474.1	195.1	6.50	8.61	68.99
2018	528.7	476.4	195.7	6.50	8.66	69.06
2019	548.2	475.9	195.4	6.50	8.65	69.11
2020	565.8	477.7	195.9	6.50	8.69	69.16

Table 5.13 Key T2 parameters and estimated emissions for non-dairy cattle, 1990–2020

	Non-dairy Cattle				
Year	CH_4 Emissions (kt)	Mass (kg)	GE intake (MJ/head/ day)	CH_4 Conversion rates, Y_m (%)	Digestibility of feed (%)
1990	234.4	180.6	100.3	6.50	60.77
1991	251.6	185.3	100.8	6.50	61.13
1992	252.8	186.8	100.8	6.50	61.27
1993	250.8	188.1	100.1	6.50	61.52
1994	247.6	190.1	99.8	6.50	61.80
1995	249.0	192.3	99.0	6.50	62.08
1996	248.3	192.9	98.4	6.50	62.22
1997	233.3	192.0	97.8	6.50	62.23
1998	229.5	191.7	97.1	6.50	62.29
1999	227.5	192.4	96.7	6.50	62.43
2000	227.2	194.5	97.2	6.50	62.54
2001	227.1	195.9	97.5	6.50	62.60
2002	212.7	186.1	92.2	6.50	62.44
2003	278.0	244.1	115.3	6.50	64.12
2004	295.6	252.1	112.0	6.50	64.43
2005	313.6	253.9	112.7	6.50	64.56
2006	319.8	259.2	112.2	6.50	64.84
2007	325.0	265.3	112.0	6.50	65.02
2008	323.4	273.2	111.9	6.50	65.35
2009	311.9	274.5	111.0	6.50	65.53
2010	333.1	279.2	111.5	6.50	65.84
2011	358.9	281.2	110.4	6.50	65.97
2012	402.1	287.5	111.2	6.50	66.23
2013	416.4	289.0	110.9	6.50	66.33
2014	406.7	293.6	110.8	6.50	66.55
2015	399.3	296.4	110.7	6.50	66.61
2016	409.6	297.6	111.1	6.50	66.72
2017	470.0	296.4	110.5	6.50	66.86
2018	508.6	300.1	111.5	6.50	66.99
2019	525.9	300.1	111.1	6.50	67.03
2020	529.3	304.5	110.9	6.50	67.09

Planned Improvement:

Türkiye considers the possibility of using Tier 2 method for estimating enteric fermentation emissions from sheep in the next submissions.

5.3. Manure Management (Category 3.B)

Source Category Description:

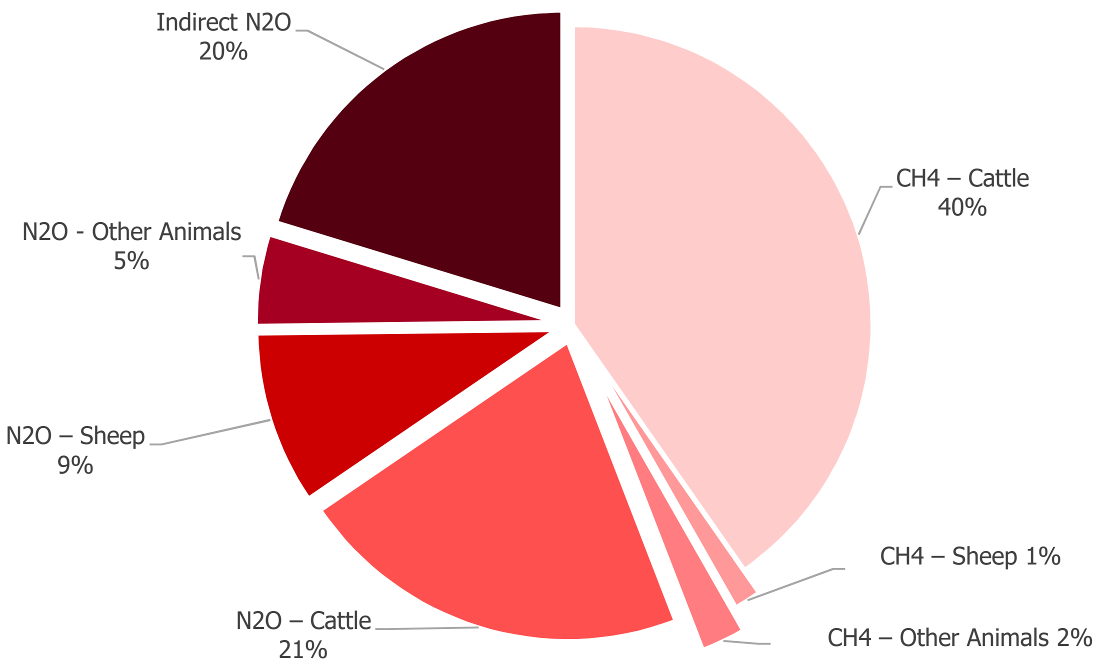
In Türkiye, manure management systems (MMS) distribution data are a result of the combination of various sources, including expert opinions, comparison of countries in the Mediterranean basin, MoAF data, TurkStat data etc. resulting in a country-specific MMS distribution presented in Table 5.19.

This source category contains two types of emissions, CH_4 and N_2O, and for both of these emissions, the source category is a key category according to level assessment. According to trend assessment, while the source category is key category only for N_2O emissions with LULUCF, it is also key category for N_2O and CH_4 emissions without LULUCF.

In 2020, emissions including CH_4 and N_2O from the manure management category reached 9 060 kt CO_2 eq. This number represented 12.4% of emissions of the agriculture sector. Emissions from this source category in 2020 increased by 3 624 kt CO_2 eq., nearly 66.7% above its 1990 level of 5 436 kt CO_2 eq. Similarly, the increase is calculated as 1 647 kt CO_2 eq. for CH_4 emissions and 1 977 kt CO_2 eq. for N_2O emissions and increasing percentages are 70% and 64.1%, respectively, for the period 1990-2020.

Manure management emissions can also be described as direct emissions consisting of CH_4 and N_2O emissions with a share of 79.7% (7223 kt CO_2 eq.) and indirect emissions consisting only of N_2O emissions with a share of 20.3% (1 837 kt CO_2 eq.). It is also significant to note that there are two types of indirect N_2O emissions to be calculated under manure management, which are due to nitrogen volatilization and nitrogen leaching and run-off. The indirect N_2O emissions share of 20.3% is only a result of the amount of manure nitrogen that is lost due to volatilization of NH_3 and NO_x. Indirect emissions due to leaching and run-off from manure are calculated as 154 kt CO_2 eq. for the latest reporting year. This emission level is considered insignificant and reported as NE according to 24/CP.19 paragraph 37(b). While the following Figure 5.7 presents emission shares of manure management subcategories for the latest reporting year, Table 5.11 combines and presents the emission figures from manure management for the entire reporting period.

Figure 5.7 Manure Management Emission Sources, 2020



Regarding MMS, TurkStat has asked academicians for their views on the topic, investigated countries in the Mediterranean Basin whose the agriculture sector would resemble of our country's, searched internally through some of our regional offices, looked for field experiences gained throughout the years within TurkStat and also scrutinized agriculture-related data which have not been published so far in order to come up with a distribution that would reflect our country-specific conditions better.

Table 5.14 Overview of emissions from manure management, 1990–2020

		Manure management source category							
	Agriculture Total	Total		CH_4		Direct N_2O		Indirect N_2O	
Year	(kt CO_2 eq.)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)
1990	46 054	5 436	11.8	2 352	5.1	2 190	4.8	895	1.9
1991	46 928	5 657	12.1	2 440	5.2	2 250	4.8	967	2.1
1992	46 979	5 533	11.8	2 330	5.0	2 225	4.7	978	2.1
1993	47 407	5 597	11.8	2 420	5.1	2 184	4.6	993	2.1
1994	44 926	5 793	12.9	2 661	5.9	2 141	4.8	992	2.2
1995	44 080	5 523	12.5	2 526	5.7	2 072	4.7	925	2.1
1996	44 757	5 570	12.4	2 554	5.7	2 069	4.6	947	2.1
1997	42 505	5 166	12.2	2 308	5.4	1 933	4.5	924	2.2
1998	43 720	5 348	12.2	2 478	5.7	1 903	4.4	968	2.2
1999	44 276	5 448	12.3	2 554	5.8	1 917	4.3	977	2.2
2000	42 332	5 142	12.1	2 334	5.5	1 836	4.3	973	2.3
2001	39 894	5 096	12.8	2 414	6.1	1 769	4.4	913	2.3
2002	37 608	4 540	12.1	2 017	5.4	1 630	4.3	893	2.4
2003	40 558	4 596	11.3	1 913	4.7	1 700	4.2	983	2.4
2004	41 298	4 590	11.1	1 871	4.5	1 705	4.1	1 015	2.5
2005	42 439	4 781	11.3	1 959	4.6	1 754	4.1	1 069	2.5
2006	43 900	5 027	11.5	2 051	4.7	1 829	4.2	1 148	2.6
2007	43 421	5 081	11.7	2 183	5.0	1 828	4.2	1 070	2.5
2008	41 302	4 929	11.9	2 108	5.1	1 778	4.3	1 043	2.5
2009	42 032	4 863	11.6	2 138	5.1	1 717	4.1	1 008	2.4
2010	44 409	5 391	12.1	2 471	5.6	1 851	4.2	1 070	2.4
2011	46 901	5 639	12.0	2 452	5.2	2 033	4.3	1 154	2.5
2012	52 662	6 425	12.2	2 837	5.4	2 296	4.4	1 292	2.5
2013	55 858	6 769	12.1	2 996	5.4	2 418	4.3	1 354	2.4
2014	56 219	7 068	12.6	3 163	5.6	2 500	4.4	1 405	2.5
2015	56 133	6 956	12.4	3 031	5.4	2 503	4.5	1 422	2.5
2016	58 894	7 060	12.0	3 112	5.3	2 501	4.2	1 446	2.5
2017	63 262	7 697	12.2	3 348	5.3	2 759	4.4	1 590	2.5
2018	65 338	8 508	13.0	3 886	5.9	2 929	4.5	1 692	2.6
2019	68 023	8 597	12.6	3 820	5.6	3 044	4.5	1 732	2.5
2020	73 155	9 060	12.4	3 999	5.5	3 224	4.4	1 837	2.5

Indirect N_2O emissions from manure management include only emissions due to atmospheric deposition. Manure management indirect N_2O emissions due to leaching and run-off are considered to be insignificant because of its calculated emission level of 154 kt CO_2 eq. for the latest reporting year. This level is well-below the threshold level specified in Paragraph 37(b) of 24/CP.19. Figures in the table may not add up to the totals due to rounding.

Methane Generation

Livestock manure is primarily composed of organic material and water. Anaerobic and facultative bacteria decompose the organic material under anaerobic conditions. Several biological and chemical factors influence methane generation from manure. The amount of CH_4 produced during decomposition is influenced by the climate and the manner in which the manure is managed. The management system determines key factors that affect CH_4 production including contact with oxygen, water content, pH, and nutrient availability. Climate factors include temperature and rainfall. Optimal conditions for CH_4 production include an anaerobic, water-based environment, a high level of nutrients for bacterial growth, a neutral pH (close to 7.0), warm temperatures, and a moist climate.

Manure management CH_4 emissions contributed 3 999 kt CO_2 eq. (44.1% of the manure management category) which constituted 5.5% of agricultural emissions in 2020 whereas the respective share in 1990 was 5.1%, around 0.4 per cent below the current reporting value.

With respect to all CH_4 emissions of the agriculture sector, the second highest CH_4 emission source category was manure management for all reporting years with a share value of 9.4% and 10.3% for 1990 and 2020, respectively, and an average share value of 9.9% for the reporting period, 1990-2020.

Nitrous Oxide Generation

Production of N_2O reported in the manure management category occurs during storage and treatment of manure before it is applied to land.

N_2O emissions contributed 5 062 kt CO_2 eq. (55.9% of the manure management category) which represented 6.9% of agricultural emissions in 2020 whereas the respective share in 1990 was 6.7%, less than the current percentage of 2020.

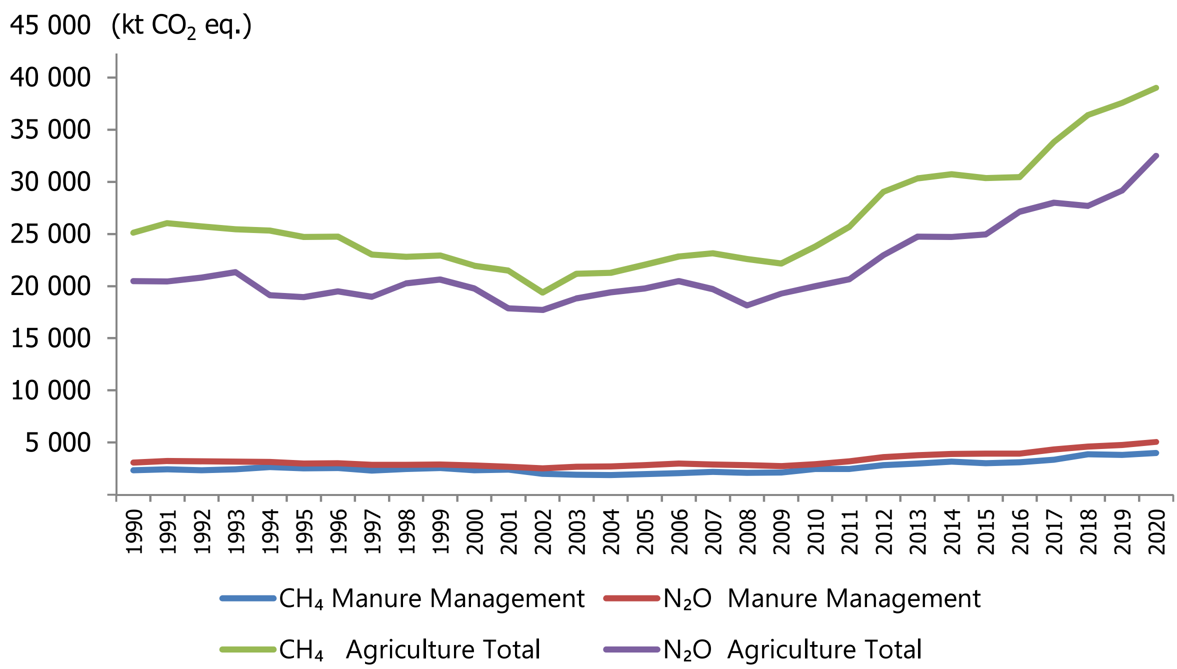
With respect to all N_2O emissions of the agriculture sector, the second highest N_2O emission source category was manure management after agricultural soils category for all reporting years. N_2O emissions of manure management accounted for 15.1% and 15.6% of all N_2O emissions in the agriculture sector in 1990 and 2020, respectively.

Direct N_2O emissions from MMS can occur via combined nitrification (under aerobic conditions) and denitrification (an anaerobic process) of nitrogen contained in the manure. The emission of N_2O from manure during storage and treatment depends on the nitrogen and carbon content of manure, on the duration of the storage and type of treatment.

Indirect N_2O emissions result from volatile nitrogen losses that occur primarily in the forms of ammonia and NO_x. Indirect emissions occur from the deposition of volatilized nitrogen from manure management systems and via runoff and leaching of nitrogen into soils.

The following figure on CH_4 and N_2O emissions of manure management and the agriculture sector gives a view on trendencies. As indicated above, CH_4 and N_2O from manure management are only a fraction of total CH_4 and N_2O emissions from the agriculture sector (10.3% and 15.6%, 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 5.8 shows a trend comparison of these two gas emissions.

Figure 5.8 Comparing CH_4 and N_2O emission trends, 1990–2020



Typical animal mass values, Nrates and Nitrogen excretion rates (Nex) are crucial parameters in estimating emissions from manure management. Table 5.15 and Table 5.16 present these values for animal categories for the entire reporting period 1990-2020.

Table 5.15 Typical animal mass, Nrate and Nex values for cattle and poultry, 1990–2020

Year	Dairy Cattle			Non-dairy Cattle			Poultry		
	Mass (kg)	Nrate[a]	Nex[b]	Mass (kg)	Nrate[a]	Nex[b]	Mass (kg)	Nrate[a]	Nex[b]
1990	350.4	0.47	60.38	180.6	0.34	22.41	2.22	0.81	0.65
1991	356.6	0.47	61.47	185.3	0.34	23.00	2.08	0.81	0.62
1992	360.3	0.47	62.11	186.8	0.34	23.18	2.10	0.81	0.62
1993	365.3	0.47	62.99	188.1	0.34	23.35	2.06	0.81	0.61
1994	368.1	0.47	63.49	190.1	0.34	23.60	2.05	0.81	0.61
1995	377.4	0.47	65.12	192.3	0.34	23.87	2.14	0.81	0.63
1996	379.9	0.47	65.56	192.9	0.34	23.94	2.04	0.81	0.60
1997	382.1	0.47	65.95	192.0	0.34	23.83	2.19	0.81	0.64
1998	383.8	0.47	66.24	191.7	0.34	23.79	2.01	0.81	0.60
1999	386.1	0.47	66.64	192.4	0.34	23.87	2.00	0.81	0.59
2000	389.0	0.47	67.15	194.5	0.34	24.14	2.02	0.81	0.60
2001	391.2	0.47	67.54	195.9	0.34	24.31	2.04	0.81	0.61
2002	396.2	0.47	68.41	186.1	0.34	23.09	2.13	0.81	0.63
2003	398.3	0.47	68.78	244.1	0.34	30.30	2.17	0.81	0.64
2004	400.7	0.47	69.19	252.1	0.34	31.29	2.16	0.81	0.64
2005	404.1	0.47	69.79	253.9	0.34	31.51	2.18	0.81	0.65
2006	413.3	0.47	71.40	259.2	0.34	32.17	2.26	0.82	0.67
2007	421.4	0.47	72.83	265.3	0.34	32.92	2.24	0.82	0.67
2008	431.4	0.47	74.58	273.2	0.34	33.91	2.31	0.81	0.69
2009	435.9	0.47	75.37	274.5	0.34	34.07	2.28	0.81	0.68
2010	440.9	0.47	76.25	279.2	0.34	34.64	2.28	0.81	0.68
2011	446.8	0.47	77.27	281.2	0.34	34.90	2.30	0.82	0.68
2012	451.5	0.47	78.10	287.5	0.34	35.67	2.29	0.82	0.68
2013	454.6	0.47	78.64	289.0	0.34	35.87	2.30	0.82	0.68
2014	461.0	0.47	79.77	293.6	0.34	36.43	2.30	0.82	0.68
2015	464.2	0.47	80.33	296.4	0.34	36.79	2.28	0.82	0.68
2016	467.9	0.47	80.97	297.6	0.34	36.93	2.28	0.82	0.68
2017	474.1	0.47	82.06	296.4	0.34	36.78	2.29	0.81	0.68
2018	476.4	0.47	82.47	300.1	0.34	37.24	2.32	0.81	0.69
2019	475.9	0.47	82.37	300.1	0.34	37.25	2.34	0.81	0.70
2020	477.7	0.47	82.69	304.5	0.34	37.79	2.36	0.81	0.70

All mass values are live weight figures and these figures are country-specific. Country-specific figures for cattle are gathered from a variety of sources including the Ministry for Agriculture and Forestry and TurkStat data. Country-specific poultry mass data ara gathered from the Ministry for Agriculture and Forestry.

[a] Unit for Nrate is kg N/ (1000 kg animal mass × day).

[b] Unit for Nex is kg N/ (head × yr).

Table 5.16 Typical animal mass, Nrate and Nex values for some livestock species

Years	Livestock species	Mass (kg)	Nrate[b]	Nex (kg N/head/yr)
1990 – 2020	Sheep (domestic)	50	1.17	21.35
1990 – 2020	Sheep (merino)	60	1.01	22.12
1990 – 2020	Goats	45	1.37	22.50
1990 – 2020	Buffalo	380	0.32	44.38
1990 – 2020	Horses	238	0.46	39.96
1990 – 2020	Mules & Asses	130	0.46	21.83
1990 – 2020	Swine[a]	28	0.402	4.11
1990 – 2020	Camels	217	0.46	36.43

All mass figures are live weight figures. Mass values given for sheep (domestic and merino) and goats were country-specific values. Mass values given for buffalo, horses, swine, camels, and mules & asses were all default values presented in the 2006 IPCC Guidelines Vol.4.

[a] According to the footnote given on page 10.59, Table 10.19 of the 2006 IPCC Guidelines Vol.4 Chapter 10, nitrogen excretion for swine is based on an estimated country population of 90% market swine and 10% breeding swine. Thus, the Nrate is calculated as given and used in the related Nex calculation: (90% × 0.42)+(10% × 0.24)=0.402 (Nrate value for swine).

[b] Unit for Nrate is kg N/ (1000 kg animal mass × day).

Methodological Issues:

Türkiye applies T1 method according to the 2006 IPCC Guidelines to estimate methane and nitrous oxide emissions from manure management for all livestock types. CH_4 and N_2O emissions from manure management are key category according to level assessment.

The annual population for each livestock category is included in Table 5.6 above. The AD (the population of animals) provider is TurkStat livestock statistics for the entire time series 1990-2020. 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.

The CH_4 EFs are default IPCC T1 factors except for cattle. In Türkiye, there are three dairy cattle types categorized as culture cattle, hybrid cattle and domestic cattle. For 2020, the average milk production of culture cattle is around 3 859 kg head^{-1} yr^{-1}. Hence, the EF for culture cattle is taken as the average of EFs of Western Europe and Asia with respect to milk yield of these cattle, and the mean of milk production of Western Europe (6 000 kg head^{-1} yr^{-1}) and Asia (1 650 kg head^{-1} yr^{-1}) is 3 825 kg head^{-1} yr^{-1}. 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 1 303 kg head^{-1} yr^{-1} and this value is closer to the Asia average milk production value of 1 650 kg head^{-1} yr^{-1}.

The average milk production of Hybrid cattle is 2 721 kg head^{-1} yr^{-1} and this value is close to the mean of 3 825 and 1 650 kg head^{-1} yr^{-1} which is 2 737 kg head^{-1} yr^{-1}. 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.

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_4 and N_2O 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 5.17 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 (0ºC - 14ºC) and temperate (15ºC - 25ºC) 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 for the former and the weight figures were similar for the latter. 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 <10º C Türkiye estimates that culture cattle have an EF of 15 kg CH_4/head/year, which is the average of 21 kg CH_4/head/year and 9 kg CH_4/head/year from Western Europe and Asia, respectively). The EF for hybrid cattle is the 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, shown in the 2006 IPCC Guidelines, are also broken into two climate regions and shown in Table 5.18. Türkiye does not have a province with an annual average temperature above 25°C; therefore, the warm climate region does not exist in the country.

Table 5.17 Manure management CH_4 emission factors for cattle and swine

(kg CH_4/head/year)

	Cool EF (< 15 °C)					Temperate EF (15-25 °C)										
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1. Cattle																
Dairy Cattle (Culture)	15.0	16.5	17.5	19.0	20.5	23.5	25.5	27.5	29.5	32.0	34.5	37.5	40.0	43.5	47.0	50.5
Dairy Cattle (Hybrid)	12.0	13.3	13.8	15.0	16.3	18.3	19.8	21.3	22.8	24.5	26.3	28.8	30.5	33.3	35.5	38.3
Dairy Cattle (Domestic)	9	10	10	11	12	13	14	15	16	17	18	20	21	23	24	26
Non-Dairy Cattle	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3. Swine	2	2	2	2	2	3	3	3	3	4	4	4	5	5	5	6

Table 5.18 Manure management CH_4 emission factors for sheep and other livestock

(kg CH_4/head/year)

	Cool EF (< 15 °C)	Temperate EF (15-25 °C)
2. Sheep		
Sheep (Domestic)	0.100	0.150
Sheep (Merino)	0.145	0.215
4. Other livestock		
Buffalo	1.00	2.00
Camels	1.28	1.92
Goats	0.11	0.17
Horses	1.09	1.64
Mules and asses	0.60	0.90
Poultry	0.01	0.02

Furthermore, Table 5.19 presents the Manure Management System (MMS) used according to country-specific values. These figures are able to reflect Türkiye's conditions in an improved way leading to improved emission estimations. Note also that 50% of burned manure is reported under the Energy sector category 1.A.4.b – fuel combustion activities (residential), while the remaining 50% is calculated and reported under pasture, range and paddock according to the rules given under section 10.5.2 of the 2006 IPCC Guidelines, Vol.4.

Table 5.19 Manure Management System Distribution, 1990–2020

(%)

MS	Liquid system	Solid storage	Dry lot	Pasture, range and paddock	Burned for fuel or as waste	Poultry manure
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				96.0	4.0	
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

Note that "Other" shown in the CRF Tables relates entirely to poultry manure. Anaerobic lagoon, daily spread, composting and digesters (four different MMS types) were considered as either not occurring or negligible. Definite data on MMS are not available and the table was prepared in order to serve the estimations for CRF 3.B source category based on a variety of data sources.

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_4 and N_2O gases whereas EF uncertainty values are 30% and 50% for CH_4 and N_2O gases, respectively, as presented in the 2006 IPCC Guidelines.

Source category	Gas	Comments on time series consistency
3.B	CH_4, N_2O	CH_4 EFs are selected according to the yearly mean temperature values of the 81 provinces. N_2O EFs are mainly constant over the entire time series except for cattle (dairy & other) and poultry which reflect the weighted average of their subcategories over the reporting period.

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 are 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, a QA work was conducted by a Project Engineer from CITEPA for this category in January 2020.

Recalculation:

There was no recalculation exercised regarding emission estimates from this source category in this submission.

Planned Improvement:

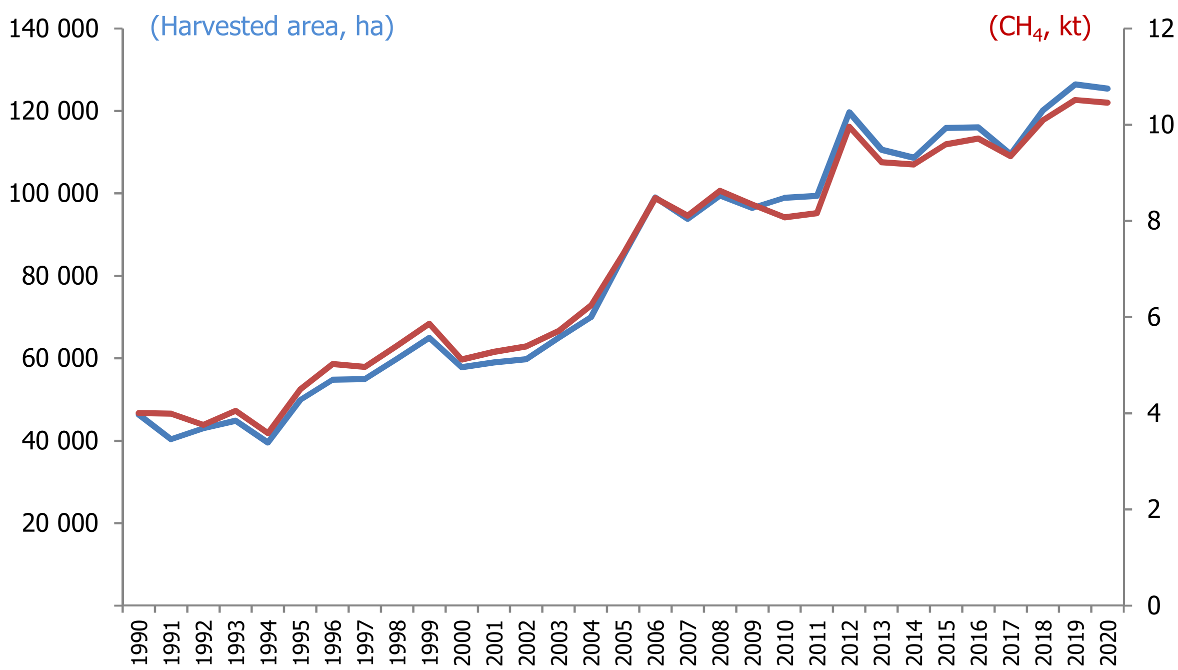
All data and methodologies are kept under review and an upgrade from T1 to T2 will be considered for the future.

5.4. Rice Cultivation (Category 3.C)

Source Category Description:

GHG emissions from rice production are the result of the CH_4 gas released by anaerobic digestion of organic substances in the paddy fields. The aforementioned CH_4 gas emissions are calculated according to the approach shown in the 2006 IPCC Guidelines which are estimated by IPCC's default emission factors. The annual amount of CH_4 emitted from a given area of rice is a function of the number and duration of crops grown, water regimes before and during the cultivation period, and organic and inorganic soil amendments. Soil type, temperature, fertilizer application, rice cultivar also affect CH_4 emissions. CH_4 emissions from rice cultivation are not a key category. Figure 5.9 presents total annual harvested area in hectare (line drawn in blue - left axis) and total CH_4 emissions emitted in kt (line drawn in dark red - right axis) for rice cultivation covering the period 1990-2020.

Figure 5.9 Harvested area and emitted CH_4 for rice cultivation, 1990–2020



Rice cultivation contributed 10.46 kt CH_4 (262 kt CO_2 eq.) emissions or 0.36% of total agricultural emissions in 2020 whereas the respected value for the year 1990 was around 4 kt CH_4 (100 kt CO_2 eq.) emissions or 0.22% of total sector emissions.

Overall, emissions from rice cultivation increased by 161.4 kt CO_2 eq. (161%) for the entire reporting period and the increase was calculated around 28% between the years 2011 and 2020.

Table 5.20, given below, presents the activity data and estimated emissions of this source category in detail.

Table 5.20 Irrigated area and estimated emissions for rice cultivation, 1990–2020

	Total		Continuously Flooded		Intermittently Flooded			
					Single Aeration		Multiple Aeration	
Year	(kt CO_2 eq.)	Area (ha)	(kt CO_2 eq.)	Area (ha)	(kt CO_2 eq.)	Area (ha)	(kt CO_2 eq.)	Area (ha)
1990	100.08	46 348	51.84	17 276	16.08	8 693	32.16	20 379
1991	99.78	40 400	59.98	16 800	14.42	7 764	25.38	15 836
1992	94.01	42 978	48.68	16 351	15.79	8 090	29.54	18 537
1993	101.29	44 842	56.31	18 751	17.01	8 553	27.98	17 538
1994	89.63	39 562	48.48	15 950	16.58	8 294	24.57	15 318
1995	112.51	49 955	62.85	21 203	16.71	8 434	32.95	20 318
1996	125.63	54 779	75.58	25 859	16.59	8 378	33.46	20 542
1997	124.17	54 995	73.35	25 447	17.22	8 878	33.60	20 670
1998	135.06	59 885	79.51	27 566	19.08	9 892	36.47	22 427
1999	146.59	64 983	87.09	30 133	20.95	10 975	38.55	23 875
2000	127.96	57 859	71.20	24 800	20.42	10 694	36.35	22 365
2001	131.92	59 000	75.04	26 085	25.70	13 763	31.18	19 152
2002	134.78	59 809	78.18	27 055	24.65	13 138	31.95	19 616
2003	142.82	65 000	77.70	26 697	27.40	14 731	37.72	23 572
2004	156.08	69 990	88.66	30 326	28.48	15 385	38.93	24 279
2005	182.98	84 909	96.05	32 926	35.04	18 949	51.89	33 034
2006	211.87	99 043	108.95	37 559	41.28	22 506	61.64	38 978
2007	202.71	93 799	110.05	37 841	35.84	20 419	56.81	35 539
2008	215.63	99 493	116.96	40 325	40.44	22 762	58.22	36 407
2009	208.47	96 444	110.30	38 116	40.65	22 539	57.52	35 789
2010	201.88	98 966	86.23	29 856	39.80	21 900	75.86	47 210
2011	204.08	99 383	93.73	32 456	38.95	21 449	71.40	45 479
2012	248.91	119 664	120.32	41 613	44.29	24 647	84.30	53 405
2013	230.53	110 592	111.64	38 670	41.45	23 018	77.44	48 905
2014	229.37	108 649	114.59	39 628	45.20	25 395	69.59	43 626
2015	239.85	115 856	115.71	40 057	41.58	23 355	82.56	52 444
2016	242.83	116 056	120.66	41 763	42.80	23 912	79.38	50 381
2017	233.65	109 505	121.81	42 153	42.60	23 778	69.24	43 575
2018	252.22	120 137	125.12	43 178	45.84	25 606	81.26	51 353
2019	262.86	126 419	127.74	44 053	45.94	25 817	89.17	56 549
2020	261.53	125 398	127.58	43 942	47.08	26 551	86.87	54 905

Figures in the table may not add up to the totals due to rounding.

Methodological Issues:

Harvested area data for rice cultivation are taken from TurkStat agricultural statistics and area records are available for all districts of Türkiye since 1990. T1 method is used for calculation, and the emission factor and scaling factors are taken from the 2006 IPCC Guidelines. The cultivation period of rice production in Türkiye is around 130 days. The methods mainly 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. Mainly based on these data, in addition to data received from the Ministry of Agriculture and Forestry, 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. Organic amendments are not used or, if any, used in negligible amounts. This, in turn, reduces the value of the related scaling factor (SF_o) to 1, a multiplicative identity, given by Equation 5.3 on page 5.50 of the 2006 IPCC Guidelines Vol.4. Furthermore, scaling factors ($SF_{s,r}$) 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. Accordingly, emissions from this source category are calculated and reported taking into account the country-specific conditions.

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, which are crucial in determining appropriate scaling factors, are obtained from regional offices of TurkStat for all provinces and their districts in Türkiye. 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 76.73% according to the information shown 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 were between -68.98% and +70.43% in 2017. For more detailed information about Monte Carlo method, refer to the uncertainty section in the annexes.

Source category	Gas	Comments on time series consistency
3.C	CH_4	EFs reflect the subcategories of the methods applied for rice cultivation. The calculations reflect different types of water regimes applied in the country. A list of EFs and related parameters used for emission calculations are listed in Annex 3 of the National Inventory Report.

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 are 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, a QA work was conducted by a Project Engineer from CITEPA for this category in January 2020.

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, which is a key category, contains N_2O emissions from synthetic fertilizers, organic fertilizers and crop residues. In this section N_2O emissions from pasture, range and paddock manure, cultivation of organic soils, and indirect emissions, which consist 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_2O emissions from this source category are key categories according to the level and trend assessment (with and without LULUCF).

Agriculture soils produced 91.9 kt N_2O (27.4 Mt CO_2 eq.) emissions in 2020 and agriculture soils is the largest source category of N_2O emissions in Türkiye. This figure represented 84.3% of N_2O emissions in the Agriculture sector, around 67.7% of Türkiye's N_2O emissions (without LULUCF), and close to 37% of agricultural emissions. Emissions were 10 075 kt CO_2 eq. (58%) above the 1990 level of 17 314 kt CO_2 eq. in 2020 - the latest reporting year. Direct N_2O emissions increased by 9 121 kt CO_2 eq. (60.1%) whereas indirect N_2O emissions increased by 955 kt CO_2 eq. (44.7%) for the given period 1990-2020. The increase is a result of the emission changes of direct and indirect N_2O emissions from managed soils. The total change of direct N_2O emissions is a result of increases in the subcategories inorganic N fertilizers, 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_2O emissions due to mineralization/immobilization related to loss/gain of soil organic carbon in the agriculture sector did not occur for the entire reporting period.

Several subcategories contribute to emissions from agricultural soils from direct and indirect pathways (Tables 5.21 – 5.24). Direct N_2O emissions occur directly from the soils to which N has been added or released; indirect emissions arise from volatilization (evaporation or sublimation) and subsequent redeposition of NH_3 or NO_x or result from leaching and runoff of soil N within water (IPCC, 2006). A precise overview is also presented in Figure 5.10 and Table 5.21 for direct and indirect N_2O emissions. The abbreviations used in this figure are listed on the headings of Tables 5.22 and 5.24.

Figure 5.10 Sub-categories of Agricultural Soils Emission Sources, 2020

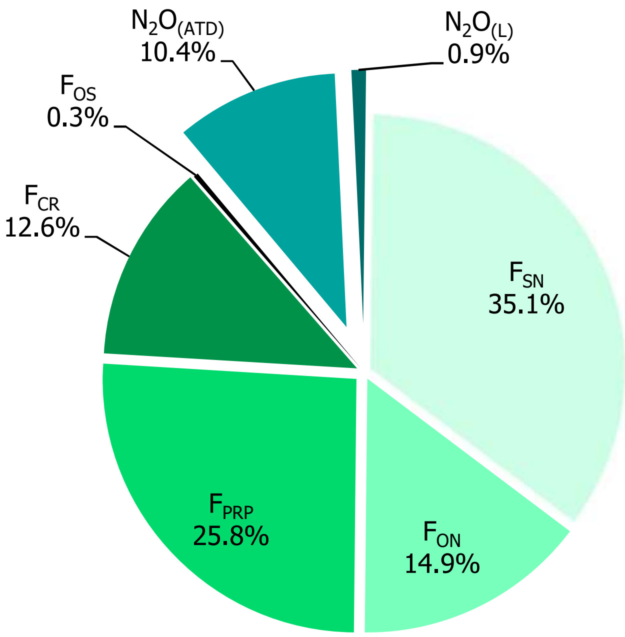


Table 5.21 Overview of N_2O emissions from managed soils, 1990–2020

Year	Agriculture Total	Agricultural soils					
		Total		Direct N_2O		Indirect N_2O	
	(kt CO_2 eq.)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)	(kt CO_2 eq.)	(%)
1990	46 054	17 314	37.6	15 176	33.0	2 138	4.6
1991	46 928	17 155	36.6	15 037	32.0	2 118	4.5
1992	46 979	17 527	37.3	15 378	32.7	2 149	4.6
1993	47 407	18 078	38.1	15 898	33.5	2 180	4.6
1994	44 926	15 931	35.5	13 969	31.1	1 962	4.4
1995	44 080	15 871	36.0	13 951	31.6	1 920	4.4
1996	44 757	16 391	36.6	14 429	32.2	1 962	4.4
1997	42 505	16 023	37.7	14 134	33.3	1 888	4.4
1998	43 720	17 306	39.6	15 309	35.0	1 998	4.6
1999	44 276	17 643	39.8	15 588	35.2	2 055	4.6
2000	42 332	16 870	39.9	14 925	35.3	1 946	4.6
2001	39 894	15 107	37.9	13 347	33.5	1 760	4.4
2002	37 608	15 103	40.2	13 377	35.6	1 727	4.6
2003	40 558	16 054	39.6	14 215	35.0	1 839	4.5
2004	41 298	16 591	40.2	14 735	35.7	1 856	4.5
2005	42 439	16 880	39.8	14 996	35.3	1 883	4.4
2006	43 900	17 422	39.7	15 478	35.3	1 944	4.4
2007	43 421	16 740	38.6	14 854	34.2	1 886	4.3
2008	41 302	15 250	36.9	13 531	32.8	1 718	4.2
2009	42 032	16 474	39.2	14 669	34.9	1 805	4.3
2010	44 409	17 006	38.3	15 153	34.1	1 853	4.2
2011	46 901	17 421	37.1	15 506	33.1	1 915	4.1
2012	52 662	19 334	36.7	17 184	32.6	2 150	4.1
2013	55 858	20 905	37.4	18 590	33.3	2 314	4.1
2014	56 219	20 764	36.9	18 425	32.8	2 340	4.2
2015	56 133	21 006	37.4	18 656	33.2	2 350	4.2
2016	58 894	23 147	39.3	20 587	35.0	2 560	4.3
2017	63 262	23 607	37.3	20 977	33.2	2 631	4.2
2018	65 338	23 022	35.2	20 424	31.3	2 598	4.0
2019	68 023	24 342	35.8	21 593	31.7	2 749	4.0
2020	73 155	27 389	37.4	24 297	33.2	3 092	4.2

Figures in the table may not add up to the totals due to rounding.

Table 5.22 Categories of Direct N_2O emissions of agricultural soils, 1990–2020

(kt CO_2 eq.)

Year	Total N_2O Emissions from Managed Soils	Direct N_2O Emissions from Managed Soils						
		Total	Inorganic N Fertilizers (F_{SN})	Organic N Fertilizers (F_{ON})	Urine and Dung Deposited by Grazing Animals (F_{PRP})	Crop Residues (F_{CR})	Loss/ Gain of soil organic matter (F_{SOM})	Culti-vation of Organic Soils (F_{OS})
1990	17 314	15 176	5 618	2 773	5 118	1 585	NO	82
1991	17 155	15 037	5 169	2 868	5 232	1 687	NO	82
1992	17 527	15 378	5 649	2 845	5 165	1 638	NO	82
1993	18 078	15 898	6 253	2 801	5 050	1 713	NO	82
1994	15 931	13 969	4 714	2 742	4 908	1 523	NO	82
1995	15 871	13 951	4 934	2 609	4 690	1 635	NO	82
1996	16 391	14 429	5 373	2 615	4 670	1 689	NO	82
1997	16 023	14 134	5 465	2 472	4 383	1 732	NO	82
1998	17 306	15 309	6 532	2 483	4 338	1 874	NO	82
1999	17 643	15 588	6 957	2 516	4 372	1 660	NO	82
2000	16 870	14 925	6 456	2 433	4 183	1 771	NO	82
2001	15 107	13 347	5 304	2 312	3 997	1 653	NO	82
2002	15 103	13 377	5 615	2 175	3 752	1 752	NO	82
2003	16 054	14 215	6 279	2 282	3 897	1 674	NO	82
2004	16 591	14 735	6 400	2 295	3 904	2 055	NO	82
2005	16 880	14 996	6 427	2 360	3 994	2 134	NO	82
2006	17 422	15 478	6 587	2 467	4 153	2 189	NO	82
2007	16 740	14 854	6 349	2 394	4 066	1 964	NO	82
2008	15 250	13 531	5 306	2 311	3 900	1 933	NO	82
2009	16 474	14 669	6 621	2 207	3 704	2 055	NO	82
2010	17 006	15 153	6 292	2 351	4 001	2 427	NO	82
2011	17 421	15 506	5 897	2 555	4 382	2 589	NO	82
2012	19 334	17 184	6 706	2 857	4 916	2 625	NO	82
2013	20 905	18 590	7 419	3 008	5 208	2 874	NO	82
2014	20 764	18 425	6 991	3 128	5 465	2 759	NO	82
2015	21 006	18 656	6 961	3 150	5 497	2 965	NO	82
2016	23 147	20 587	8 881	3 156	5 493	2 976	NO	82
2017	23 607	20 977	8 264	3 463	5 993	3 175	NO	82
2018	23 022	20 424	7 153	3 667	6 326	3 195	NO	82
2019	24 342	21 593	7 879	3 800	6 569	3 263	NO	82
2020	27 389	24 297	9 612	4 077	7 061	3 463	NO	82

F_{SOM} refers to mineralization/immobilization associated with loss/gain of soil organic matter and related activity data are taken from CRF Table 4.B. The notation key NO was used for F_{SOM} for the entire reporting period because the related activity data do not show a carbon loss from cropland remaining cropland. Activity data (Area of organic soils) required for the calculation of emissions from F_{OS} are taken from the data available in CRF Table 4.B and CRF Table 4.C. Figures in the table may not add up to the totals due to rounding.

Table 5.23 Subcategories of Organic N fertilizers emissions, 1990–2020

(kt CO_2 eq.)

Year	Total N_2O Emissions from Managed Soils	Total Direct N_2O Emissions from Managed Soils	Organic N Fertilizers (F_{ON})	Organic N Fertilizers (F_{ON})		
				Animal Manure Applied to Soils	Sewage Sludge Applied to Soils	Other Organic Fertilizers Applied to Soils
1990	17 314	15 176	2 773	2 769	3	1
1991	17 155	15 037	2 868	2 863	3	1
1992	17 527	15 378	2 845	2 840	3	1
1993	18 078	15 898	2 801	2 796	3	1
1994	15 931	13 969	2 742	2 738	3	1
1995	15 871	13 951	2 609	2 605	3	1
1996	16 391	14 429	2 615	2 611	3	1
1997	16 023	14 134	2 472	2 463	8	1
1998	17 306	15 309	2 483	2 470	12	1
1999	17 643	15 588	2 516	2 503	12	2
2000	16 870	14 925	2 433	2 419	12	2
2001	15 107	13 347	2 312	2 299	11	2
2002	15 103	13 377	2 175	2 167	6	2
2003	16 054	14 215	2 282	2 259	22	1
2004	16 591	14 735	2 295	2 274	20	1
2005	16 880	14 996	2 360	2 348	11	1
2006	17 422	15 478	2 467	2 462	3	1
2007	16 740	14 854	2 394	2 388	4	2
2008	15 250	13 531	2 311	2 304	4	2
2009	16 474	14 669	2 207	2 202	4	1
2010	17 006	15 153	2 351	2 347	3	1
2011	17 421	15 506	2 555	2 551	3	1
2012	19 334	17 184	2 857	2 853	3	1
2013	20 905	18 590	3 008	3 004	3	1
2014	20 764	18 425	3 128	3 125	2	1
2015	21 006	18 656	3 150	3 147	2	1
2016	23 147	20 587	3 156	3 153	2	1
2017	23 607	20 977	3 463	3 460	2	1
2018	23 022	20 424	3 667	3 663	2	2
2019	24 342	21 593	3 800	3 797	2	1
2020	27 389	24 297	4 077	4 075	1	2

Other organic fertilizers applied to soils consist only of compost applied to soils. There is no data available and no indication for the use of other organic fertilizers other except compost. Figures in the table may not add up to the totals due to rounding.

Table 5.24 Categories of Indirect N_2O emissions of agricultural soils, 1990–2020

(kt CO_2 eq.)

Year	Total N_2O Emissions from Managed Soils	Indirect N_2O Emissions from Managed Soils		
		Total	Atmospheric Deposition $N_2O_{(ATD)}$	Nitrogen Leaching and Run-off $N_2O_{(L)}$
1990	17 314	2 138	1 977	161
1991	17 155	2 118	1 960	158
1992	17 527	2 149	1 987	162
1993	18 078	2 180	2 012	168
1994	15 931	1 962	1 816	146
1995	15 871	1 920	1 774	146
1996	16 391	1 962	1 811	151
1997	16 023	1 888	1 740	148
1998	17 306	1 998	1 837	161
1999	17 643	2 055	1 891	164
2000	16 870	1 946	1 789	157
2001	15 107	1 760	1 620	140
2002	15 103	1 727	1 586	141
2003	16 054	1 839	1 690	149
2004	16 591	1 856	1 702	155
2005	16 880	1 883	1 726	157
2006	17 422	1 944	1 782	162
2007	16 740	1 886	1 731	155
2008	15 250	1 718	1 578	140
2009	16 474	1 805	1 652	153
2010	17 006	1 853	1 695	158
2011	17 421	1 915	1 754	161
2012	19 334	2 150	1 972	178
2013	20 905	2 314	2 121	193
2014	20 764	2 340	2 148	191
2015	21 006	2 350	2 156	194
2016	23 147	2 560	2 345	215
2017	23 607	2 631	2 413	218
2018	23 022	2 598	2 387	211
2019	24 342	2 749	2 526	223
2020	27 389	3 092	2 839	253

Figures in the table may not add up to the totals due to rounding.

Direct N_2O emissions from agricultural soils are a result of addition of nitrogen in the form of inorganic nitrogen fertilizers, organic nitrogen fertilizers (predominantly in the form of animal manure), inputs from above-ground and below-ground crop residues and from forages during pasture renewal, mineralization of cropland soil organic matter loss, urine and dung deposited by grazing animals, and cultivation of organic soils. These combined direct N_2O soil emissions contributed 24 297 kt CO_2 eq. (88.7%) to emissions from the Agricultural soils category and around 33% of emissions under the total Agriculture sector in 2020. This is an increase of 9 121 kt CO_2 eq. (60.1%) from the 1990 reported figure of 15 176 kt CO_2 eq.

A major direct source of N_2O emissions from agricultural soils is an outcome of the use of synthetic fertilizer. Around forty-four per cent (43.8%) of increase in direct emissions from agricultural soils, observed between 1990 and 2020, 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 2020, N_2O emissions from synthetic nitrogen fertilizers contributed 9 612 kt CO_2 eq. (35.1%) to emissions from the managed soils category. This is an increase of 3 995 kt CO_2 eq. (71.1%) from the 1990 level of 5 618 kt CO_2 eq. Nitrogen emissions of synthetic fertilizer contributed 13.1% to the total emissions under the agriculture sector for the latest reported year.

In 2020, N_2O emissions from organic N fertilizers contributed 4 077 kt CO_2 eq. (14.9%) to emissions from the agricultural soils category and 5.6% of emissions under the total agriculture sector. Activity data (as dry matter) for sewage sludge and compost are both received within TurkStat. The country-specific nitrogen content value for sewage sludge is taken as 5.15% calculated as an average according to the values presented in a specific research study (Topaç and Başkaya, 2008), while the nitrogen content for compost is taken as 1%. The only source of emissions due to other organic fertilizers is compost because there are neither activity data available on possibly other organic fertilizers except for compost data nor an indication of such an activity.

An increase of 1 304 kt CO_2 eq. (47%) is observed from the 1990 level of 2 773 kt CO_2 eq. of N_2O emissions due to organic nitrogen fertilisers of which sewage sludge applied to soils marks a slightly peculiar trend observable on Table 5.23. Since Türkiye applied the Tier 1 methodology, emissions are directly linked to activity data changes. In the initial years, the number of municipal wastewater treatment plants increased in our country leading to an increase in 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, changing their treatment methods.

As observed from Table 5.22, N_2O emissions from urine and dung deposited by grazing animals contributed 7 061 kt CO_2 eq. (26%) to emissions from the agricultural soils category and 9.7% of emissions under the total agriculture sector in 2020. This is an increase of 1 943 kt CO_2 eq. (38%) from the 1990 level of 5 118 kt CO_2 eq. Moreover, N_2O emissions from crop residues contributed 3 463 kt CO_2 eq. (12.6%) to emissions from the agricultural soils category and 4.7% of emissions under the total agriculture sector. This is a value of more than twofold presenting an increase of 1 878 kt CO_2 eq. (118.5%) from the 1990 level of 1 585 kt CO_2 eq.

Emission calculations from cultivation of organic soils are directly based on related LULUCF sector data entered into CRF Tables 4.B and 4.C while the related activity data source is the new LULUCF reporting system (LRS) in Türkiye for which further information is presented in the LULUCF sector overview section.

Indirect N_2O emissions were calculated as 3 092 kt CO_2 eq. for 2020. Indirect N_2O emissions through atmospheric deposition amounted to 2 839 kt CO_2 eq. (10.4%) from the agricultural soils category and 3.9% of emissions under the entire agriculture sector for 2020. This is an increase of 862 kt CO_2 eq. (43.6%) from the 1990 level of 1 977 kt CO_2 eq. Indirect N_2O emissions through leaching and runoff added 253 kt CO_2 eq. (0.9%) to emissions from the agricultural soils category in 2020 and 0.3% of emissions under the total agriculture sector.

Briefly, agricultural soils emissions have increased by nearly 58% (around 10 Mt CO_2 eq.) between 1990 and 2020. The increase is a result of the emission changes of direct and indirect N_2O emissions from managed soils. The former, direct N_2O emissions increased by around 9.1 Mt CO_2 eq. and the latter, indirect N_2O emissions, by 1 Mt CO_2 eq. for the given period, 1990-2020. The total net increase of 9.1 Mt CO_2 eq. of direct N_2O 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 1990-2020 concerning these five subcategories mentioned are 3 994 kt (71.1%), 1 304 kt (47%), 1 943 kt (38%), and 1 878 kt (118.5%), respectively. Estimations from cultivation of organic soils are constant at 82 kt CO_2 eq. Organic N fertilizers are further subdivided into three groups, namely animal manure, sewage sludge, and other organic fertilizers (which consists entirely of compost), all applied to soils. The increase in animal manure applied to soils is 1 306 kt (47.2%) from 2 769 kt to 4 075 kt whereas the two other organic N fertilizer subcategories decreased as presented in Table 5.23. On the other hand, the total increase of 1 Mt CO_2 eq. of indirect N_2O emissions is divided into two categories, atmospheric deposition and nitrogen leaching and run-off. The related figures of changes for these subcategories are 862 kt (43.6%) and 92 kt (57.1%) for the period of 1990-2020, respectively.

Methodological Issues:

N_2O emissions are calculated by using the IPCC T1 approach. The AD used in emission calculations are taken from agricultural statistics of TurkStat. The N_2O 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_2O production. Crop residue emission calculations follow the principles shown in the 2006 IPCC Guidelines. N_2O emissions are now calculated according to all cultivated plants in Türkiye. 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. It should be further added that the default EF used for crop residues is 0.01 (kg N_2O–N)/(kg N) except for the EF used for flooded rice which is 0.003 (kg N_2O–N)/(kg N). This difference in EFs used in calculations for crop residues emissions is the reason which leads to inconstant implied emission factors over the reporting period. The following table summarizes the crop headings for which N_2O emissions due to crop residues are calculated in our country.

Table 5.25 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	

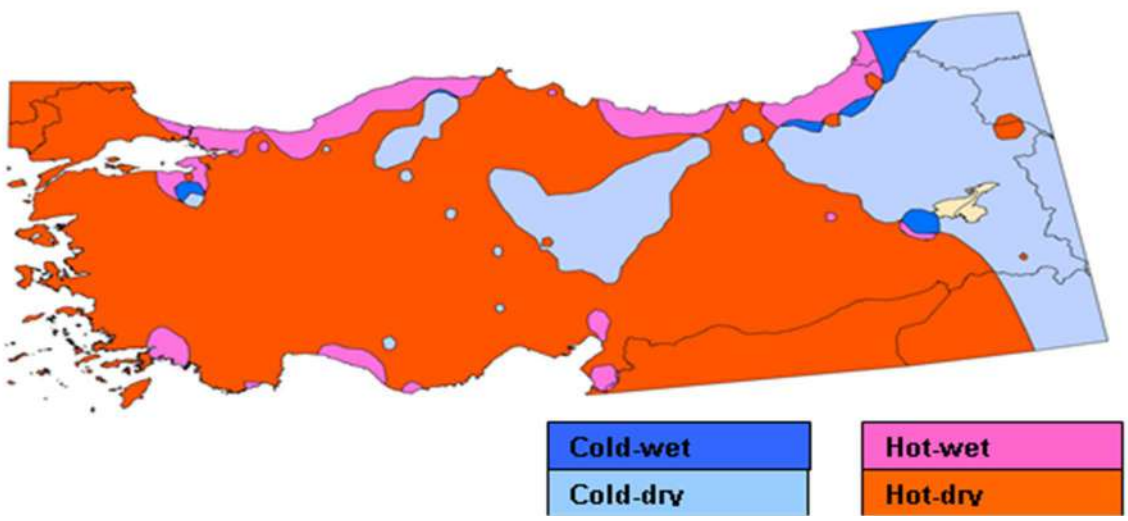
Source category	Gas	Comments on time series consistency
3.D.1	N_2O	All EFs are constant over the entire time series for F_{SN}, F_{OS} and all sub-categories of F_{ON} . The same EF for F_{CR} is used except for flooded rice and the EF for F_{PRP} is chosen according to livestock species.

In the 2016 Assessment Review Report of Türkiye, published on 24 April 2017, a recommendation was made by the Expert Review Team to investigate the actual leaching conditions in Türkiye 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 Türkiye 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 shown in the 2006 IPCC Guidelines Volume 4. While calculating this parameter, following steps are implemented: First, the Climate Map (Figure 5.11) 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 shown 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 deos not occur in 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[6]. 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 Türkiye (Figure 5.11) 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 the 2006 IPCC Guidelines that use basic climatic parameters of temperature, potential evapotranspiration and precipitation. The Climate map given below is taken from the IPCC Climate Zones which is also presented as Figure 3A.5.1 on page 3.38 of the 2006 IPCC Guidelines Volume 4.

Figure 5.11 Climate Map of Türkiye



[6] Please refer to section related to the agriculture sector of Annex 3 in this NIR for calculation details.

Regarding emission calculations from crop residues, TurkStat received country-specific data on renewal fractions and fractions removed from the MoAF. Renewal fraction for a yearly crop is 1 by definition of 1/X (where X is 1 year). This figure is used for most of the crops presented in the classification of Table 11.2 on pages 11.17-11.18 of the 2006 IPCC Guidelines Vol. 4 (since almost all crops are yearly crops). A fraction of 0.25 (as a result of 1/X where X is 4 years) was used only for the following major crop types and individual crops according to the information received from the Ministry of Agriculture and Forestry: perennial grasses, grass-clover mixtures, alfalfa.

Fraction removed values are given for all major crop types and individual crops as received from the Ministry of Agriculture and Forestry as follows: first for major crop types: grains (0.75), beans & pulses (0.80), tubers (0.00), root crops and other (0.00), N-fixing forages (0.80), non-N-fixing forages (1.00), perennial grasses (0.90), grass-clover mixtures (0.90); and second for Individual crop types: alfalfa (0.90), maize, millet, soya bean and dry bean (0.80), wheat, rice, barley, oats, sorghum and rye (0.75), peanuts (0.70); potato (0.00). The use of these data set helped in order to reflect the country-specific conditions in an improved way. It should be further noted that default factor values shown in Table 11.2 of the 2006 IPCC Guidelines Vol.4 were used to calculate emissions from crop residues according to the T1 method. Default factors used for F_{CR} calculations include dry matter fraction of harvested product, N-content of above-ground residues, ratio of below-ground residues to above-ground biomass, and N content of below-ground residues. Additionally, default slope and intercept figures regarding above-ground residue dry matter from the same table are also used in the calculations.

Uncertainties and Time-Series Consistency:

The AD for this sector are gathered from agricultural statistics of TurkStat except for data on synthetic fertilizer consumption amounts, which is obtained from the MoAF. By using Equation 3.1 and 3.2 in the 2006 IPCC Guidelines Vol. 1, uncertainties for the AD are calculated as 18.59% by TurkStat for N_2O Emissions from Managed Soils. In a similar manner, the respective EF uncertainty for this category is figured out as 96.29% 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 are 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.

It should be further noted that the activity data for synthetic fertilizer are also almost entirely consistent with the data available on International Fertilizer Association's (IFA) website. Moreover, a QA work was conducted by a Project Engineer from CITEPA for this category in January 2020.

Recalculation:

Minor revisions are a result of update in activity data for 2019 regarding sewage sludge and crop residues. For this source category, the recalculation has a decreasing effect of -0.005% (1.2 kt CO_2 eq.) for the year 2019.

Planned Improvement:

All data and methodologies are kept under review and further possible improvements are being considered for the future.

5.6. Prescribed Burning of Savannas (Category 3.E)

This source category of agriculture emissions is not relevant to Türkiye.

5.7. Field Burning of Agricultural Residues (Category 3.F)

Source Category Description:

The burning of residual crop material releases CH_4, N_2O, CO, NO_x and NMVOC gases of which CO, NO_x and NMVOC are gases leading to indirect GHG gas emissions. 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 presented in Table 5.3 for all thirty-one reporting years. After consultations with the Ministry of Forestry and Agriculture (MoAF) and our own research, wheat, barley, maize and rice cultivation areas in Türkiye 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 presented in detail in Table 5.26, CH_4 and N_2O emissions amounted to 132 kt CO_2 eq. and 41 kt CO_2 eq., respectively, for this source category in 2020.

Table 5.26 Emissions from field burning of agricultural residues, 1990 and 2020

	Emissions ($kt\ CO_2$ eq.)				Changes from 1990 to 2020		Percentages of the agricultural sector (%)	
Category	1990	(%)	2020	(%)	($kt\ CO_2$ eq.)	(%)	1990	2020
Field burning of agricultural residues	347	100	173	100	-174	-50.1	0.75	0.24
CH_4	265	76	132	76	-133	-50.1	0.58	0.18
N_2O	82	24	41	24	-41	-50.1	0.18	0.06

Figures in the table may not add up to the totals due to rounding.

In 2020, field burning of agricultural residues contributed 173 kt CO_2 eq. This emission value represented 0.24% of all agricultural emissions. Total field burning CO_2 eq. emissions presented a decreasing trend because of prohibitive legislative measures undertaken. CH_4 and N_2O 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 assisting 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 -50.1% for the period of 1990-2020.

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, Volume 4, Equation 2.27 presented in Chapter 2. Crop residue per hectare is multiplied with area of both cereal and then with fraction burned, combustion factor and the related emission factor. Both CO_2 and N_2O emissions are calculated using the IPCC Tier 1 approach. The values calculated for CH_4 and N_2O emissions were converted to their CO_2 equivalents by multiplying the values with their respective global warming potential factors. Other emission values under this source category, NO_x, CO, and NMVOC, are not estimated. Most of the farmers obey the rules, prohibiting stubble burning leaving some farmers still practising crop residue burning.

Uncertainties and Time-Series Consistency:

The AD for this sector were gathered from agricultural statistics of TurkStat. Uncertainty values concerning AD for two GHG sources under this source category, namely CH_4 and N_2O, 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_4, N_2O	All EFs are constant over the entire time series

Source-Specific QA/QC and Verification:

The 2006 IPCC Guidelines are used for the QA/QC procedures of National GHG emission inventory in order to attain quality objectives. A National Inventory System QA/QC Plan prepared by TurkStat is also a significant tool for implementing QA/QC principles for the Inventory. AD for this source category are 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 fractions were received from MoAF. Annual checks are undertaken whether new scientific articles for updating emission factors have been published in Türkiye. Moreover, a QA work was conducted by a Project Engineer from CITEPA for this category in January 2020.

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 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_2 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:

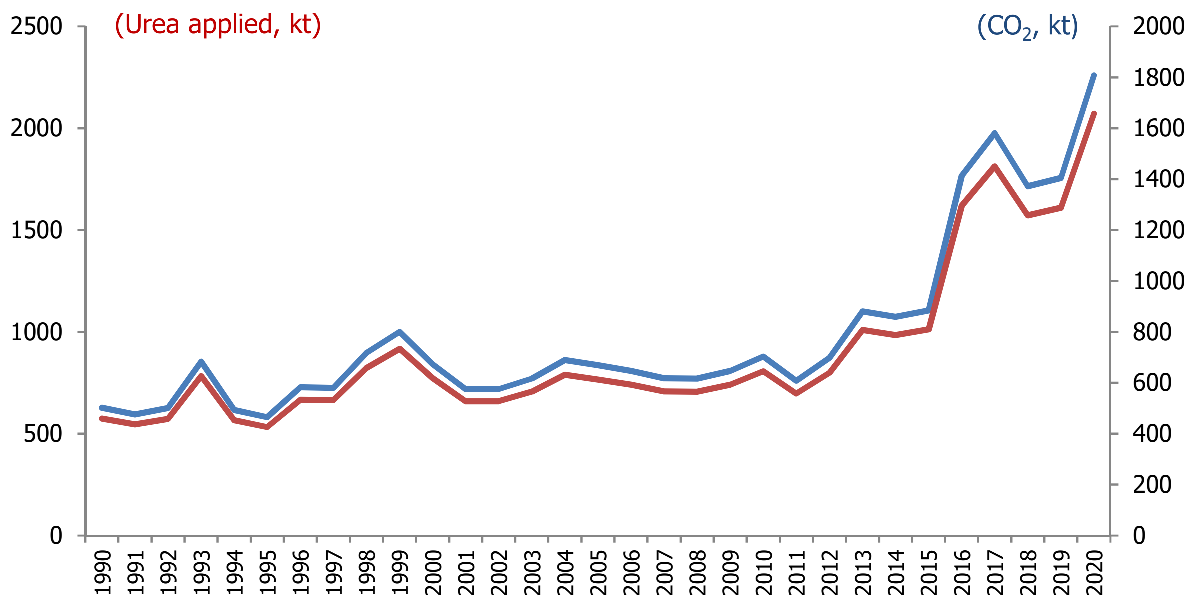
Adding urea to soils during fertilisation leads to a loss of CO_2 that was fixed in the industrial production process (IPCC, Vol.4, 2006). Urea ($CO(NH_2)_2$) is converted into ammonium (NH_4^+), hydroxyl ion (OH^-) and bicarbonate (HCO_3^-), in the presence of water and urease enzymes. Similar to the soil reaction following addition of lime, bicarbonate that is formed evolves into CO_2 and water (IPCC, Vol.4, 2006).

CO_2 emissions from applied urea led to emissions as high as 1657 kt CO_2 in 2020 which is an amount representing 2.3% of agricultural emissions. Emissions from the urea application in 2020 were 1197 kt CO_2 (260%) above its 1990 level of 460 kt CO_2. This source category, CO_2 emissions from urea application, is not a key category.

The observed recent increase (except in 2018) in the use of urea application is a result of its use as a substitute for nitrogen-based fertilizers. Türkiye has limited the use of nitrogen-based fertilizers since June 2016 leading to a shift in farmers' preferences.

Emissions values due to urea application are shown in Table 5.3 for the period of 1990-2020 in the sector overview section. Figure 5.12 presents the annual amount of urea application in kt (line drawn in blue - left axis) and CO_2 emissions emitted in kt (line drawn in dark red - right axis). A direct relationship between the two values is observed in the figure. In addition, a slowly overall increasing trend can be seen in the figure except for the years 2016 and 2020 which reflect sharp increases. Changes in estimations are directly linked to changes in activity data for the consumption of urea.

Figure 5.12 Urea application and emitted CO_2, 1990–2020



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 the atomic weight of urea. In order to calculate CO_2-C emissions resulting from urea application, the annual total amount of urea applied to the soils in the country is determined. Related AD, required for the calculation are taken from the website of MoAF under the title of "Chemical fertilizer production, consumption, import and export statistics" which is updated every year for the subsequent year. The data time series starts from the year 1981 and our country uses directly the consumption data presented as the related activity data which is accessible on the following link: https://www.tarimorman.gov.tr/Konular/Bitkisel-Uretim/Bitki-Besleme-ve-Tarimsal-Teknolojiler/Bitki-Besleme-Istatistikleri#

Uncertainties and Time-Series Consistency:

Under the IPCC (2006) T1 methodologies, the default EFs are used, which assume conservatively that all carbon in the urea is emitted as CO_2 into the atmosphere. The default EF is assumed to be certain under this theoretical assumption. A default 10% uncertainty is applied regarding the AD used in the emission calculation of urea application, whereas the uncertainty of the EF is taken as 50% as presented in the IPCC Guidelines under the related section.

An uncertainty analysis using the Monte Carlo technique was carried out to estimate emissions of CO_2 from urea application in this inventory year. Combined uncertainty in CO_2 emissions in 2017 is estimated between -13.54% and +14.70%. The Monte Carlo uncertainty range for CO_2 emissions from urea application is lower than Approach 1 results and the main reason for 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 are obtained from the MoAF. 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 factors were double-checked for CO_2 emissions from urea application. Emission trends are analyzed. If there is a high fluctuation in the series, then AD and emission calculation are re-examined. It should be further noted that the activity data for urea applied are almost entirely consistent with the data available on the website of the International Fertilizer Industry Association (IFA). Moreover, a QA work was conducted by a Project Engineer from CITEPA for this category in January 2020.

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 source category of agriculture emissions is not relevant to Türkiye.

5.11. Other (Category 3.J)

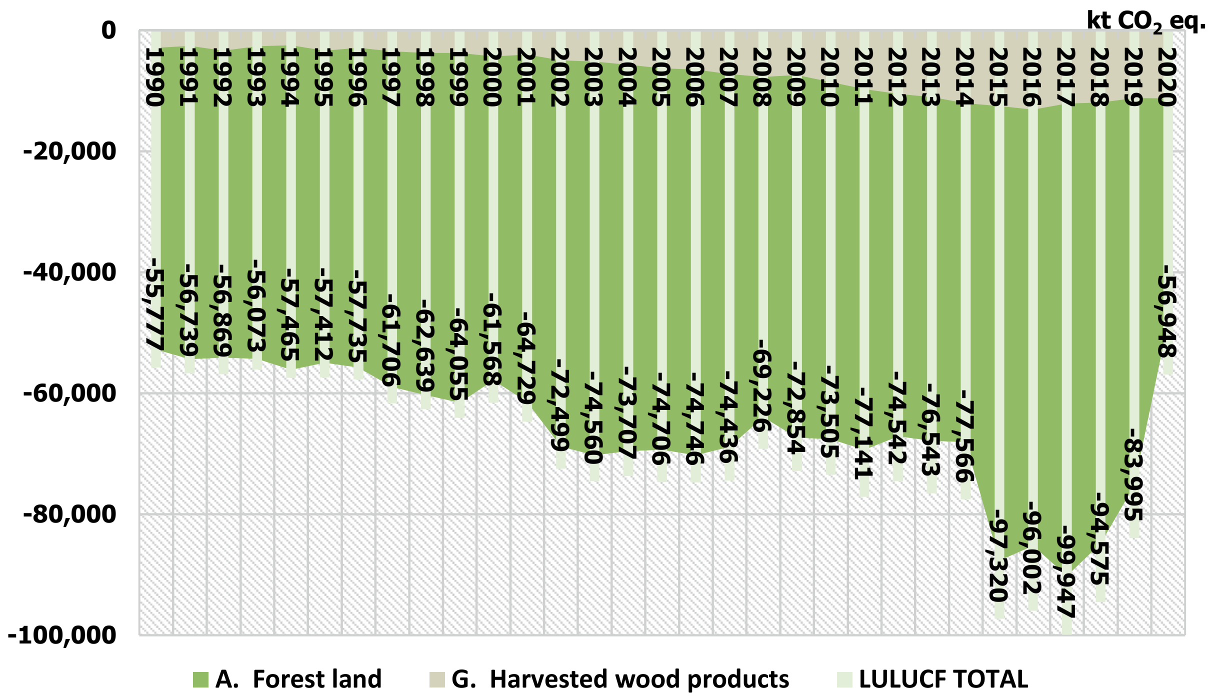
There are no other activities to be considered under this sector.

6. LULUCF (CRF SECTOR 4)

6.1. Sector Overview

The LULUCF sector of Türkiye is a net removal dominated by forests. The 22.8 Mha of forest area removed a net 48.2 Mt of CO_2 eq. from the atmosphere in 2020. Other land uses were net emissions while accounting equals to 5 percent of forest land removals. The total removals of the sector when HWP was added has been 59,5 Mt of CO_2 eq. representing a 3 percent increase compared to 1990. The reason of the decrease in the trend for last 2 years was intense wood harvest policies to meet of demand of the wood industry of Türkiye. This intense harvest policies also caused decreasing of annual increment values per hectare.

Figure 6.1 The trend of LULUCF sector net removals including HWP 1990-2020



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 completed in July 2019 but so far provided significant improvements on;

i. Developing spatially explicit land use matrices for the land uses and conversions starting from 1990,
ii. 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 Türkiye 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 2020 was listed in Table 6.1.

Table 6.1 Key categories identification in the LULUCF sector (Tier 1)

	CATEGORIES OF EMISSIONS AND REMOVALS	Gas	2020
4.A.1	Forest Land Remaining Forest Land	CO_2	Key (L,T)
4.G	Harvested Wood Products	CO_2	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	DESCRIPTIOI	PRACTICES	CONDITIONS	REGION	VALUE	STD DEV	RANGE	on Coeff (%)	UNIT	REFERENCE
Soil											
1	CO2	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. Yukarı Dicle
2	CO2	soil organic ca	Mature and young fir stands and adjacent pasture and agriculture sites	The study area consists of a variation of broadleaf and conifer stands with ages between 40 and 150 year homogenous soils	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) ±13.9 SOC		the descriptive statistics table is not available	T/ha	Temel SARIYILDIZ (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)
3	N	total nitrogen	Mature and young fir stands and adjacent pasture and agriculture sites	The study area consists of a variation of broadleaf and conifer stands with ages between 40 and 150 year homogenous soils	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	Temel SARIYILDIZ (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 Türkiye 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 Türkiye (Serengil, 2018)

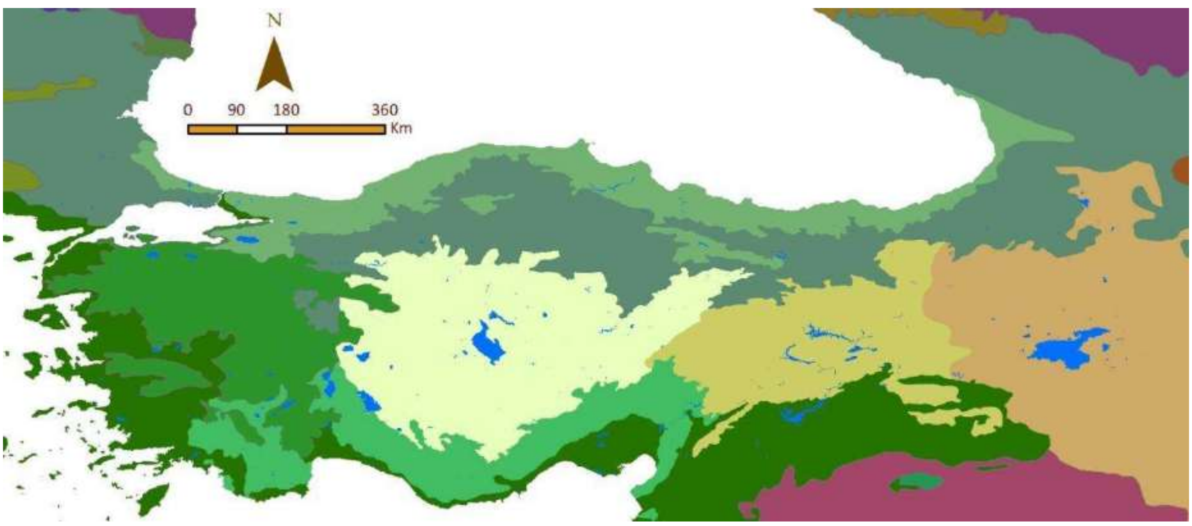


Table 6.2 Ecozones in Türkiye and their relationships with climate classifications (Serengil, 2018)

	Ecozone	Biome	Climate Type	IPCC Climate Type	Map Legend
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 forest land category increased. The difference between the old and the new systems has been discussed in Forest land 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 forest land was collected from a tabular database called ENVANIS. The ENVANIS system is the major data source of forest management in Türkiye 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;

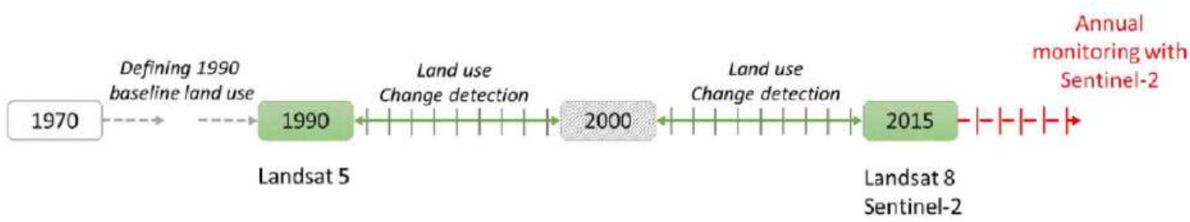
- The forest area in ENVANIS system uses national legal forest definition and is not compatible with land cover maps i.e. CORINE. Thus it is not possible to establish a consistent land use matrix with a combination of ENVANIS and spatial databases that base on land cover.
- As 10 percent of the country 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 Türkiye 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*
Forest	*The identification of **deciduous** and **coniferous** forests is based on time-series analysis, where phonological 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 **mixed** forest.*
Cropland	*Separation of cropland and grassland is a complex task in image classification and requires multitemporal data analyses and reference ground truth data. **Annual** crops have been identified due to their vegetation phenology (periodic change of vegetation status). **Perennial** 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 Türkiye 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.*
Grassland	*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.*

Wetland	*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.*
Settlement	*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.*
Other land	*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 Türkiye in any given year.*

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 Türkiye 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.

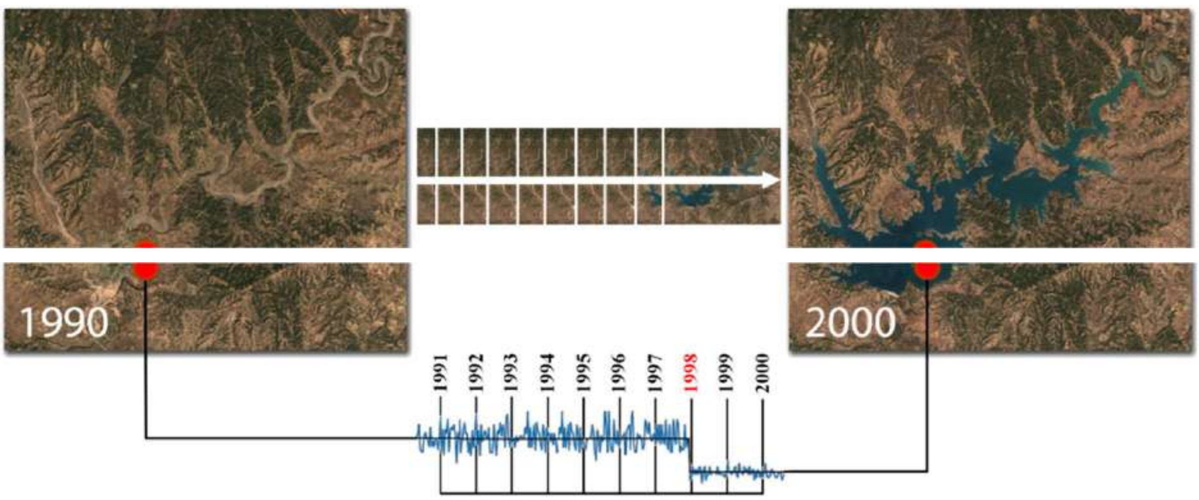
Mapping of the intermediate reference year 2000 is primarily based on Landsat 7 with support from Landsat 5 imagery. CORINE is used as auxiliary data.

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 Türkiye 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 5 years (2016, 2017, 2018, 2019 and 2020) 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 6.4

Table 6.4 A sample land use matrix (2015)

TO: / FROM:	Forest land (managed)	Forest land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetlands (managed)	Wetlands (unmanaged)	Settlements	Other land	Total unmanaged land	Initial area
	(kha)										
Forest land (managed)(2)	22723.46	NO	4.37	4.41	NO	0.39	NO	0.44	2.16	NO	22735.23
Forest land (unmanaged)(2)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Cropland(2)	2.31	NO	26871.50	0.10	NO	1.86	NO	1.63	1.32	NO	26878.71
Grassland (managed)(2)	61.81	NO	5.32	23974.34	NO	1.06	NO	0.70	1.51	NO	24044.74
Grassland (unmanaged)(2)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Wetlands (managed)(2)	NO	NO	0.19	0.09	NO	465.68	NO	0.03	0.24	NO	466.23
Wetlands (unmanaged)(2)	NO	NO	NO	NO	NO	NO	1344.22	NO	NO	NO	1344.22
Settlements(2)	NO	NO	NO	NO	NO	0.00	NO	1383.70	0.01	NO	1383.71
Other land(2)	0.14	NO	0.46	0.18	NO	0.26	NO	0.06	1672.49	NO	1673.60
Total unmanaged land (3)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Final area	22787.72	NO	26881.83	23979.13	NO	469.25	1344.22	1386.55	1677.73	NO	78526.44
Net change(4)	52.50	NO	3.12	-65.61	NO	3.02	0.00	2.84	4.13	NO	0.00

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 6.4a) 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.

Figure 6.4a Confusion Matrix

C.Matrix	1	2	3	4	5	6	ACTUAL	RECALL
1	339	15	5	0	0	0	359	94.43%
2	15	305	14	0	0	0	334	91.32%
3	6	10	242	0	0	0	258	93.80%
4	0	0	0	302	30	0	332	90.96%
5	0	0	0	15	368	0	383	96.08%
6	0	0	0	0	0	394	394	100.00%
PREDICTED	360	330	261	317	398	394	2060	94.43%
PRECISION	94.17%	92.42%	92.72%	95.27%	92.46%	100.00%	94.51%	94.66%

Completeness

As regards the inventory completeness, sinks and sources that has been reported with notation keys NA, NO,IE 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_2	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_2	NO	No	It is assumed that carbon stocks of DOM in Forest Land Remaining Forest Land do not change.
Land converted to Forest land	Dead wood	CO_2	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_2, CH_4 and N_2O	NO	Yes	Controlled Burning is not applied in Forest land.
Forest lands, drained soils	Biomass	Non-CO_2	NE	Yes	No available data on drainage
Drained wetlands	Biomass	Non-CO_2	NO	Yes	Wetland drainage is not performed in Türkiye.
Croplands, grasslands, wetlands and settlements, biomass burning	Biomass	CO_2, CH_4 and N_2O	NA,NO,IE	Yes	No available data

6.2. Forest Land (4.A)

Source Category Description:

The forest land category includes CSC from Forest Land Remaining Forest Land (FL-FL) and Land Converted to Forest Land (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 forest land 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.

- 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. Since 2018 ENVANIS has not been produced by GDF, 2017 values was used for 2018.

- 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.
- 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 Annual increment rates of forest types in Türkiye (m^3/ha)

Year	Deciduous	Coniferous	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
2018	4.24	4.43	3.61	0.23
2019	3.89	4.45	4.17	0.27
2020	3.22	3.53	3.38	0.21

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 before 2019 national forest definition was used. With the 2019 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 forest land. 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 Türkiye, 1990-2020

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	12 983	9 638	22 621	19 583	3 183	22 766
2018	12 983	9 638	22 621	19 602	3 184	22 786
2019	13 083	9 656	22 740	19 610	3 184	22 794
2020	13 264	9 668	22 933	19 603	3 194	22 797

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, growing stock changes and annual increment since 1990 is given in Table 6.7, 6.10 and 6.11.

Table 6.8 The ENVANIS Database

PLAN CODE NO			Features of management type						Area				TOTAL FOREST AREA Ha		Growing stock				Annual Increment			
									High Forests		Coppices				High		Coppices		High		Coppices	
REGION	Forest enterprises	PLANING UNIT	Purpose (Functiion, Statu)		Form of Forest	Management Type	tree species	mixed	Productive Ha.	Degraded Ha.	Productive Ha.	Degraded Ha.		(a) Age Class high forests Ha	Productive m3	Degraded m3	Productive Stere	Degraded Stere	Productive m3	Degraded m3	Productive Stere	Degraded Stere
	B	C				H	I	J	Q	R	S	T	U	AB	AG	AH	AI	AJ	AK	AL	AM	AN
1	101	10101	A	1	A	K	63	F	0	0	0	0	0,0	0	0	0	0	0	0	0	0	0
1	101	10101	M	11	A	K	30	D	11,2	0	0	0	11,2	0	2367	0	0	0	39	0	0	0
1	101	10101	M	6	A	K	1	C	33	0	0	0	33,0	0	3620	0	0	0	247	0	0	0
1	101	10101	M	10	A	K	8	B	830	3310,2	0	0	4140,2	632,8	2539	8330	0	0	187	780	0	0
1	101	10101	T	6	A	K	8	C	2044	137,1	0	0	2181,1	1255,4	40950	274	0	0	2498	14	0	0
1	101	10101	M	3	A	K	1	A	643,4	194,4	0	0	837,8	174,6	4965	1166	0	0	433	224	0	0
1	101	10102	O	1	A	K	1	B	5039,5	238,2	0	0	5277,7	1592,2	97768	925	0	0	8087	69	0	0
1	101	10102	A	1	A	K	51	F	0	0	0	0	0,0	0	0	0	0	0	0	0	0	0
1	101	10102	T	5	A	K	8	A	1281,4	52,6	0	0	1334,0	636,8	16208	210	0	0	867	13	0	0
1	101	10102	F	9	A	K	53	F	0	6741,4	0	0	6741,4	0	0	18447	0	0	0	923	0	0
1	101	10102	M	5	A	K	11	A	26,9	50,4	0	0	77,3	0	1484	132	0	0	45	8	0	0
1	101	10102	M	10	A	K	1	A	19,3	0	0	0	19,3	0	963	0	0	0	54	0	0	0
1	101	10102	M	11	A	K	1	A	8,1	0	0	0	8,1	0	310	0	0	0	26	0	0	0
1	101	10103	O	1	A	K	1	B	1217,4	211,3	0	0	1428,7	322,4	39524	2113	0	0	2596	63	0	0
1	101	10103	O	1	A	K	1	A	6299,8	963,8	0	0	7263,6	505,2	423652	9588	0	0	18407	288	0	0
1	101	10103	A	1	A	K	51	F	0	0	0	0	0,0	0	0	0	0	0	0	0	0	0
1	101	10103	T	5	A	K	8	A	278,9	6,5	0	0	285,4	124	4920	26	0	0	271	1	0	0
1	101	10103	M	10	A	K	1	A	1691,3	1474,1	0	0	3165,4	138,3	59647	12935	0	0	3224	397	0	0
1	101	10103	M	3	A	K	1	A	1528,4	760,8	0	0	2289,2	6,4	67073	7455	0	0	3896	224	0	0
1	101	10103	M	3	A	K	1	A	1611,5	484,6	0	0	2096,1	69,9	144351	4090	0	0	6225	120	0	0

Databases to Identify Forests

There are only two documents (1972 and 1999 inventory) relevant to the national forest inventory results in Türkiye 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 Türkiye, 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)

Areas						
	Productive[a]		**Degraded[b]**		**Total**	
Type	**ha**	**%**	**ha**	**%**	**ha**	**%**
High Forest	6 176 899	30.58	4 757 708	23.55	10 934 607	54.13
Coppice	2 679 558	13.27	6 585 131	32.60	9 264 689	45.87
Total	8 856 457	43.85	11 342 839	56.15	20 199 296	100.00
Growing stock						
	Productive[a]		**Degraded[b]**		**Total**	
Type	**m^3**	**%**	**m^3**	**%**	**m^3**	**%**
High Forest	758 732 197	81.10	54 349 847	5.81	813 082 044	86.91
Coppice[c]	88 300 818	9.44	34 129 288	3.65	122 430 106	13.09
Total	847 033 015	90.54	88 479 135	9.46	935 512 150	100.00
Annual volume increment						
	Productive[a]		**Degraded[b]**		**Total**	
Type	**m^3**	**%**	**m^3**	**%**	**m^3**	**%**
High Forest	20 791 672	74.09	1 343 744	4.79	22 135 416	78.88
Coppice[c]	4 813 197	17.15	1 114 592	3.97	5 927 789	21.12
Total	25 604 869	91.24	2 458 336	8.76	28 063 205	100.00

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^3 volume.

Table 6.10 Growing stock, 1990-2020 (Source: GDF)

(thousand m³)

Year	Productive[1]			Degraded[2]			Total
	High Forest	Coppices[3]	Productive total	High Forest	Coppices[3]	Degraded total	
1990	984 907	64 986	1 049 893	43 622	12 038	19 976	1 105 553
1995	1 028 346	67 957	1 096 303	45 618	12 589	20 890	1 154 509
2000	1 087 582	72 002	1 159 584	48 334	13 338	22 134	1 221 256
2005	1 177 849	71 551	1 249 400	51 045	12 661	23 655	1 313 106
2010	1 328 437	59 097	1 387 534	49 351	12 286	19 415	1 449 171
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
2018	1 601 931	13 728	1 615 659	64 991	4 314	69 306	1 684 964
2019	1 595 828	14 013	1 609 841	64 791	4 723	69 514	1 679 356
2020	1 614 281	14 013	1 628 295	64 037	4 722	68 759	1 697 055

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 m³ volume.

Table 6.11 Annual volume increment, 1990-2020 (Source: GDF)

(m³)

Years	Productive[1]			Degraded[2]			Total
	High Forest	Coppices[3]	Productive total	High Forest	Coppices[3]	Degraded total	
1990	28 263 488	3 594 725	31 858 213	1 292 180	761 076	2 053 256	33 911 468
1995	28 997 951	3 697 360	32 695 311	1 329 099	782 820	2 111 919	34 807 230
2000	31 047 474	3 985 847	35 033 320	1 432 875	843 943	2 276 819	37 310 139
2005	33 282 485	4 025 038	37 307 523	1 495 502	922 183	2 417 685	39 725 208
2010	37 857 085	3 089 208	40 946 293	1 468 070	792 878	2 260 948	43 207 241
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
2018	44 247 096	762 981	45 010 077	1 713 433	276 490	1 989 923	47 000 000
2019	44 447 096	762 981	45 210 077	1 713 433	276 490	1 989 923	47 200 000
2020	44 647 096	762 981	45 410 077	1 713 498	276 425	1 989 923	47 400 000

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 per hectare 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.
4. Intense harvest policies also caused decreasing of annual increment values per hectare.

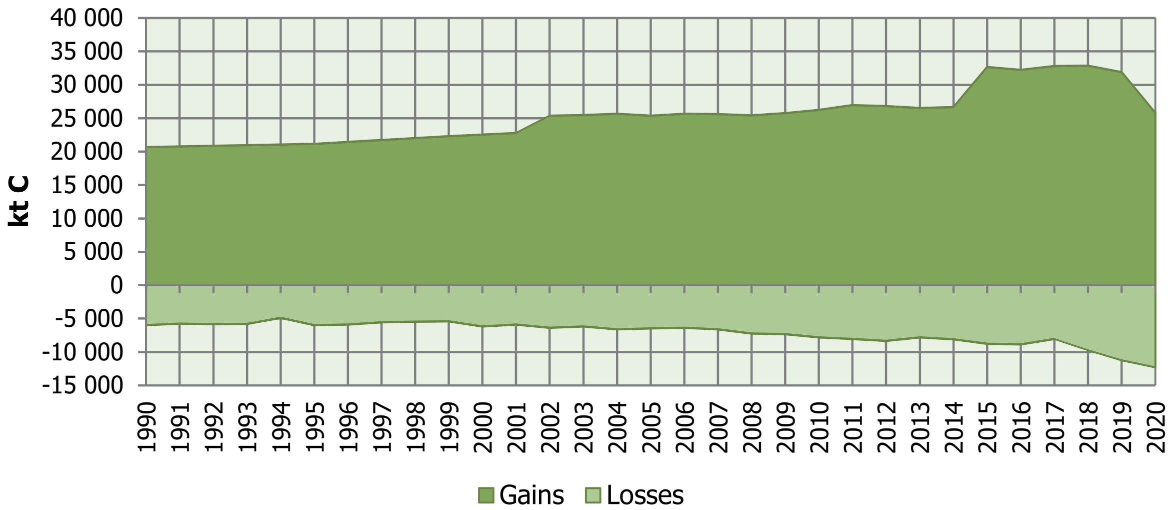
All the factors focused above has been played affecting roles on these changes. Almost entire of Turkish forests can be categorized in the temperate climate zone.

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 between 2015 and 2019 was due to difference in increment (m^3/ha) for 2014 (Iv_{dec}=4.08, Iv_{con}=2.99, Iv_{mixed}=2.99, Iv_{deg}=0.18) and 2015 (Iv_{dec}=4.37, Iv_{con}=4.31, Iv_{mixed}=3.53, Iv_{deg}=0.23). This might have caused by extensive rehabilitation campaigns during 2000s. However, after 2019, annual increases are decreasing due to most of the intensive wood harvesting activities are applied in most productive forests. The increment data is derived from all management units of the country as explained in methodology section.

The removals of the forest land remaining forest land subcategory has been decreased for last 3 years. The main reason is increase of the fellings for industrial roundwood (intense wood harvest policies). The industrial roundwood production amounts has been incrased 15,5 million m^3 for 2017 to 19 million m^3 for 2018, to 22 million m^3 for 2019 and to 30 million m^3 for 2020.

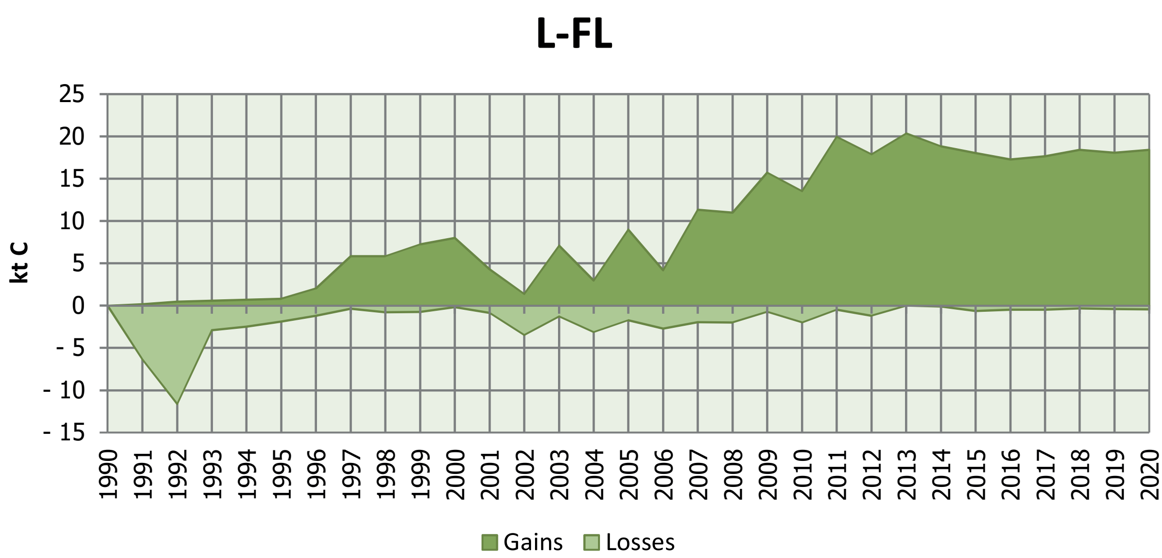
Figure 6.5 Gains and losses in Forest land Remaining Forest land subcategory (FL-FL)



CSC in Land Converted to Forest Land

The CSC in Land Converted to Forest land 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 forest land 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 forest land causes loss in living biomass carbon for the first year.

Figure 6.6 Gains and losses in Land Converted to Forest land subcategory (L-FL)

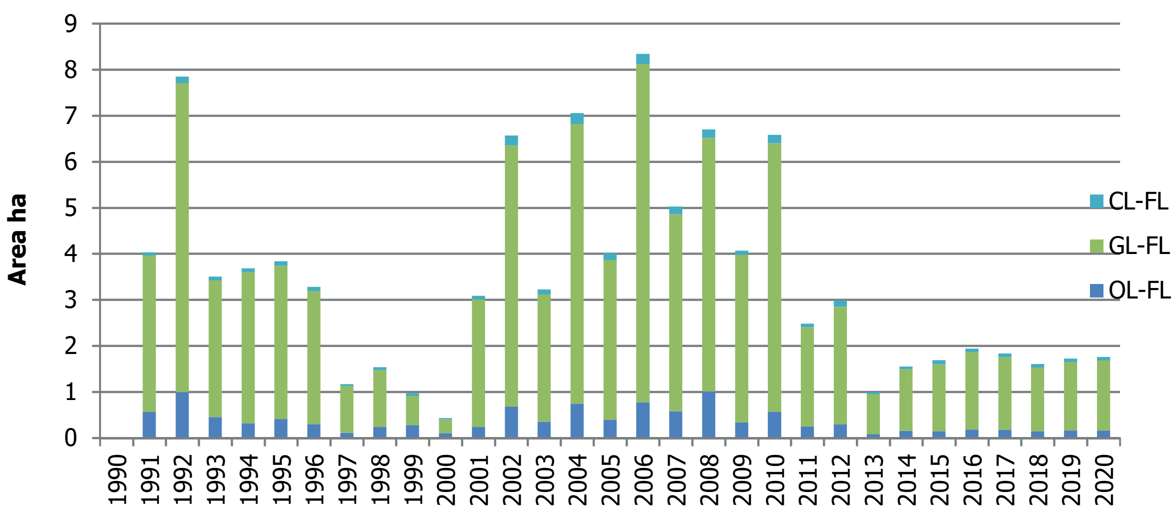


As seen from graph above (Figure 6.6) the L-FL gains increased until 2011 and stabilized since then. There have been 3 type of transitions occurred during the reporting period;

- Grassland Converted to Forest land
- Other land Converted to Forest land
- Cropland (Perennial) Converted to Forest land

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 Forest land drop to a band around 2000 since then.

Figure 6.7 Area data for Land Converted to Forest land subcategory



As seen from the Figure 6.7 the major conversion path in L-FL subcategory is the conversions from Grassland to Forest land. The driver of this conversion type is the afforestation/reforestation of grasslands in or around the forests.

Table 6.12 Area of Land converted to forest land (kha)

Years	*GL-FL*	*CL-FL*	*OL-FL*	*Years*	*GL-FL*	*CL-FL*	*OL-FL*
1990	0.00	0.00	0.00	**2006**	7.35	0.22	0.77
1991	3.40	0.07	0.56	**2007**	4.28	0.17	0.57
1992	6.71	0.14	1.00	**2008**	5.51	0.18	1.01
1993	2.97	0.08	0.45	**2009**	3.63	0.10	0.34
1994	3.28	0.08	0.32	**2010**	5.84	0.18	0.56
1995	3.32	0.10	0.41	**2011**	2.15	0.08	0.25
1996	2.89	0.09	0.30	**2012**	2.56	0.13	0.29
1997	1.02	0.04	0.11	**2013**	0.86	0.05	0.08
1998	1.24	0.06	0.23	**2014**	1.34	0.06	0.15
1999	0.63	0.07	0.28	**2015**	1.45	0.09	0.14
2000	0.30	0.03	0.10	**2016**	1.68	0.08	0.18
2001	2.77	0.07	0.24	**2017**	1.58	0.08	0.17
2002	5.67	0.21	0.68	**2018**	1.38	0.07	0.15
2003	2.77	0.11	0.35	**2019**	1.49	0.08	0.16
2004	6.07	0.24	0.74	**2020**	1.52	0.08	0.16
2005	3.47	0.15	0.40				

Methodological Issues:

Forest Land Remaining Forest land

The calculations in FL category is based on 8 ecozones and 28 forestry regional directorates. The soil C stocks for each ecozones have been calculated by TAGEM (General Directorate of Agricultural Research) based on the soil database since 2019 submission.

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 (ΔC_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 (ΔC_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 ($D_{isturbance}$) 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 2020). 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 ΔC_G and ΔC_L.

Table 6.13 The Average basic wood density and national BCEF's factors (Tolunay, 2013)

Vegetation type	Basic wood density (tonnes/m^3)	$BCEF_I$ (tonnes/m^3)	$BCEF_S$ (tonnes/m^3)	$BCEF_R$ (tonnes/m^3)
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 Forest land

The annual increments and coefficients used for Land Converted to Forest Land were;

Table 6.14 Coefficients used to calculate CS and CSC in L-FL

Forest Type	Annual Increment m^3/ha	$BCEF_I$	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[1]	0.709[2]	0.46[3]	0.48[3]
Forest Coniferous	0.69	0.541[2]	0.40[3]	0.51[3]
Forest Mixed	0.69	0.625[2]	0.48[3]	0.49[3]
Forest Degraded	0.69	0.625[2]	0.44[3]	0.49[3]

[1]Forest Management Department

[2]Tolunay (2013)

[3]IPCC 2006

The conversion period is accepted as 20 years. It is assumed that there is no change in the dead wood carbon stocks for land converted to forest land categories.

The DOM C stock is assumed to accumulate in 20 years conversion time to reach a steady state given in Table 6.15 below (Tolunay and Çömez, 2008) :

Table 6.15 Carbon stocks in DOM used for all forest areas in Türkiye

DOM (tonnes/ha)		
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 6.16 SOC stocks of forests disaggregated for ecozones

Ecozone	C stock Forest land (tC/ha)	SOC ref
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/CP19 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 (2020), 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 (2020). 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 6.17 shows the relative uncertainty for CSC overall for land subcategories.

Table 6.17 Uncertainty calculation results for the whole LULUCF sector

Summary	BY* (1990)	LRY** (2020)
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%
LULUCF sector	**50.80%**	**51.14%**

*BY: Base Year ; ** LRY:Last Reported Year

The summary table for the uncertainty in Forest land categories (FL-FL and L-FL) is as follows;

Table 6.18 Uncertainty summary table for Forest land subcategories

	BY (1990)	LRY (2020)
Forest land Remaining Forest land		
4A1 – FL-FL	51%	50%
ΔCC in Living Biomass	51%	50%
Annual Loss Living Biomass (ΔCL)	33%	34%
Annual Gain Living Biomass (ΔCG)	35%	35%
Net C stock change in Litter (ΔCC)	NA	NA
Net C stock change in Dead Wood (ΔCC)	NA	NA
Net C stock change in SOM (ΔCC)	NA	NA
Land Converted to Forest land		
4A2 – L-FL	0%	57.1%
ΔCC in Living Biomass	NA	4.9%
Annual Loss Living Biomass (ΔCL)	NA	22.6%
Annual Gain Living Biomass (ΔCG)	NA	4.9%
Net C stock change in Dead Wood (ΔCC)	NA	NA
Net C stock change in Litter (ΔCC)	NA	300.7%
Net C stock change in SOM (ΔCC)	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.

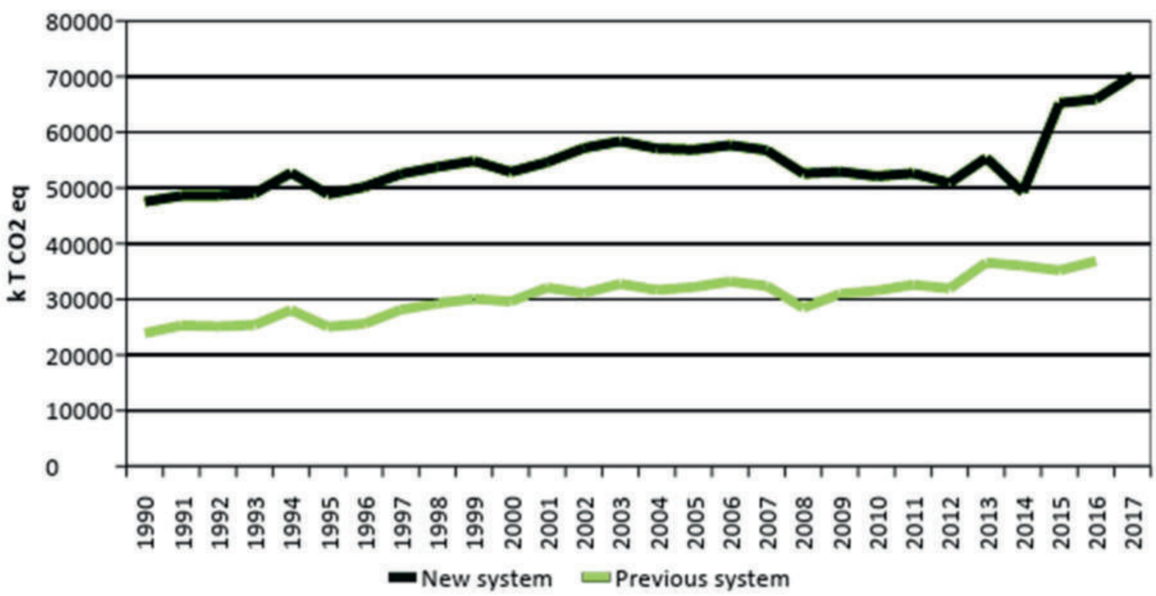
Source-Specific QA/QC and Verification:

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 by the LULUCF experts in and out of the agencies.

Recalculation:

As explained above the area based AD in the Forest land 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 forest land 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

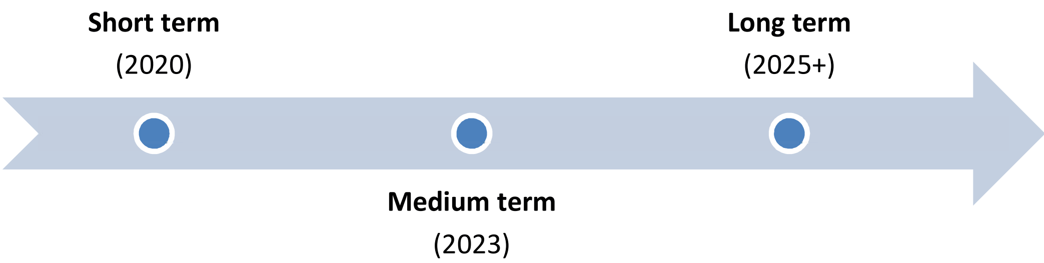


The removals increased significantly as productive forest area has been detected with the new spatially explicit land tracking system as larger compared to previous system. Since the increment data and other coefficients did not change the removals increased.

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 Forest land 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 Forest land category are;

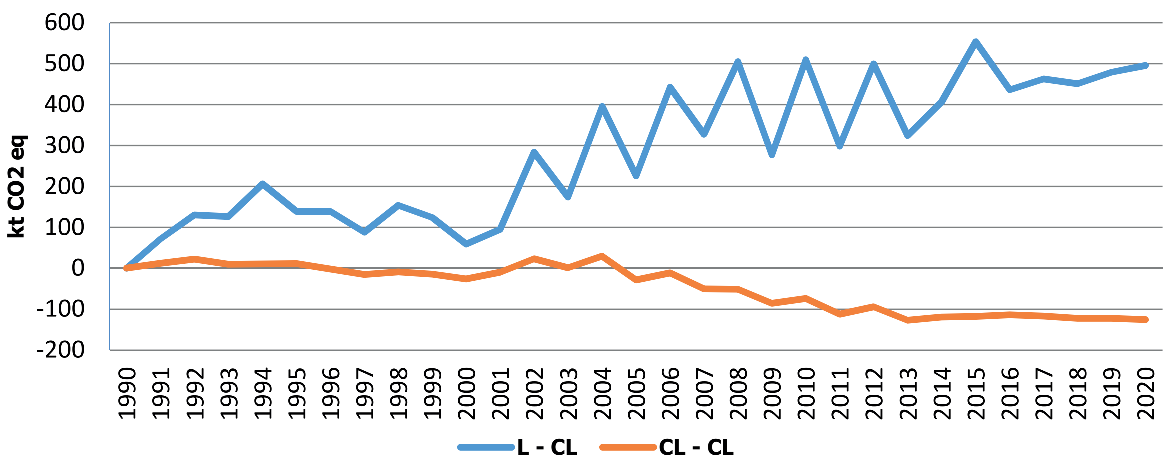
- Re-evaluation of the emission/other factors used for living biomass, DOM, and mineral soils (ST, MT) based on Mediterranean Emission/Other factors Database by the collaboration program of ONF-GDF.
- Estimation of carbon stocks for carbon pools for which emissions are currently not reported, namely 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 allometric equations instead of currently used national BCEF coefficients (MT, LT).
- Preparement of the land use matrix for the 2020 or beyond.

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 Türkiye, namely annual and perennial crops. Besides, emissions are estimated due to cultivation of organic soil and direct N_2O 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

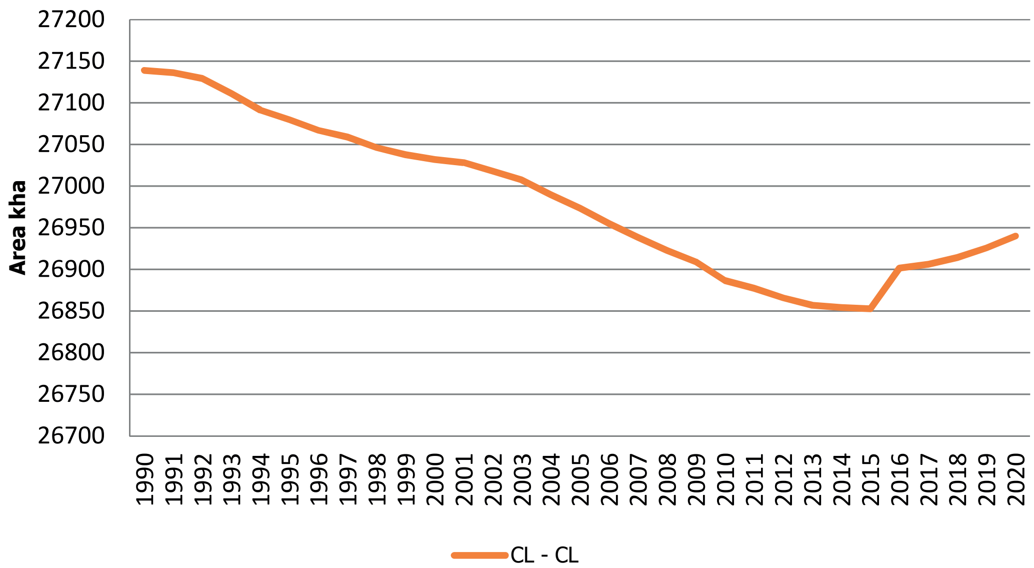
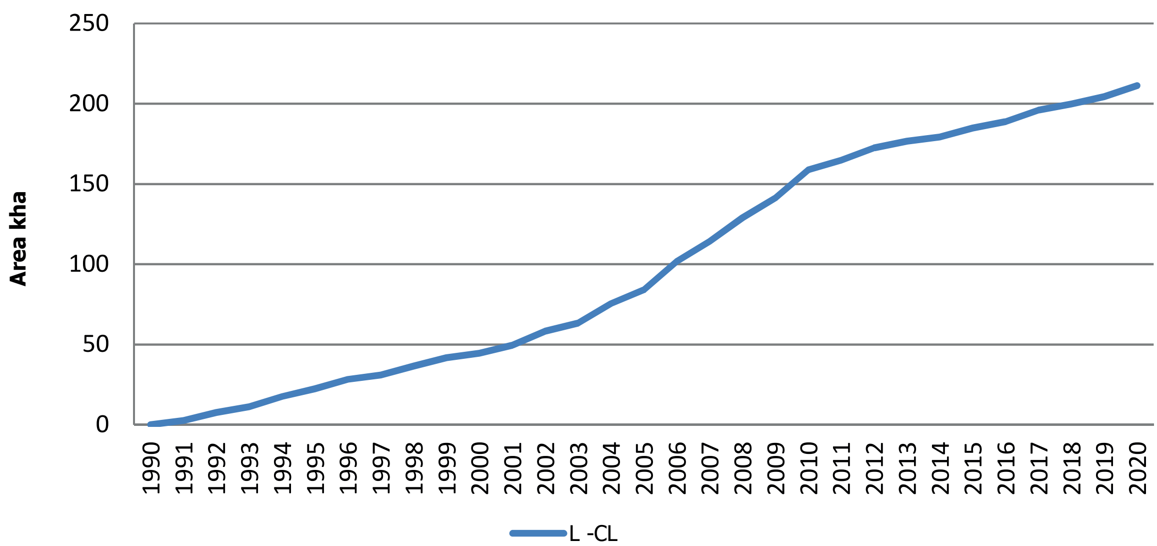


Figure 6.11 The change in area of L-CL



On the other hand, the area of L-CL increases but not with the same ration 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). Canaveira P, Manso S, Pellis G, Perugini L, De Angelis P, Neves R, Papale D, Paulino J, Pereira T, Pina A, Pita G, Santos E, Scarascia-Mugnozza G, Domingos T, and Chiti T (2018). Biomass Data on Cropland and Grassland in the Mediterranean Region. Final Report for Action A4 of Project MediNet. Available at https://www.lifemedinet.com/documents. 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 be estimated using the equation below:

Annual change in biomass = conversion area for a transition period of 20 years * ΔC_{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^{-1})

ΔC_{growth} = carbon accumulation rate of perennial crops (0.75 t C ha^{-1} yr^{-1})

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 6.19 Coefficients and CS values used in annual/perennial conversions in cropland category

Ecozones	NAI Y1 ΔC*G* (tC/yr/ha)	Loss Y1 ΔCL (tC/yr/ha)	BAFTER (tC/yr)	BBEFORE (tC/yr	CSC Y1 (tC/ha/yr)	NAI Y2 (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 6.19 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_{ref}.

Table 6.20 Coefficients and soil CS values used in annual/perennial conversions in cropland category

Ecozone	SOC ref (tC/ha)	$CS_{annualcrops}$ (tC/ha)	$CS_{perennialcrops}$ (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^{-1})

ΔC_{growth} = carbon accumulation rate of annual/perennial crop (IPCC default value = 5 t C ha^{-1})

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 forest land converted to annual and perennial cropland;

Table 6.21 Coefficients and CS values used in L-CL category

For FL-CLannual								
Ecozone		CF	ΔCG (tC/yr/ha)	ΔCL (tC/yr/ha)	BAFTER (tC/yr/ha)	BBEFORE (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
For FL-CLperennial								
i.e. Mediterranean Mountain zone	Forest Deciduous	0.48	0.75	0	0	41.97	-41.22	0.75
	Forest Coninferous	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		ΔCG (tC/yr/ha)	ΔCL (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		ΔCG (tC/yr/ha)	ΔCL (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	WLunman-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	WLunman-CLper	0.75	0	0	1.86	-1.11	0.75

In case of settlement converted to annual and perennial cropland;

For SL-CLannual							
Ecozone		ΔCG (tC/yr/ha)	ΔCL (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
For SL-CLperennial							
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;

For OL-CLannual							
Ecozone		ΔCG (tC/yr/ha)	ΔCL (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
For OL-CLperennial							
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 6.22 Coefficients and CS values used in L-CL category

For FL-CLannual/perennial						
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 Coninferous	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 be 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 forest land (FL) converted to annual and perennial cropland;

Table 6.23 Coefficients and soil CS values used in L-CL category

Ecozone	Forest Type	C stock Forest land (tC/ha)	SOC ref	C stock Cropland (tC/ha)	CSC Y1 (tC/ha/yr)	NAI Y2 (tC/ha/yr)
FL-CLannual						
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
FL-CLperennial						
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)
GL-CLannual					
Mediterranean Mountain zone	**46.96**	**42.26**	**40.22**	-0.10	-0.10
Mediterranean coastal zone deciduous and coniferous forest	**37.77**	**33.99**	**29.62**	-0.22	-0.22
East Anatolian steppe	**47.99**	**43.19**	**38.90**	-0.21	-0.21
East Anatolian deciduous forest zone	**41.30**	**37.17**	**30.44**	-0.34	-0.34
Euxine-Colchic deciduous forest	**49.66**	**44.69**	**38.68**	-0.30	-0.30
Central Anatolian steppe	**40.41**	**36.37**	**32.14**	-0.21	-0.21
Aegean Inland deciduous and coniferous forest	**42.53**	**38.28**	**30.99**	-0.36	-0.36
North Anatolian deciduous, coniferous and mixed forest	**54.57**	**49.11**	**34.29**	-0.74	-0.74
GL-CLperennial					
Mediterranean Mountain zone	**46.96**	**42.26**	**46.96**	0.23	0.23
Mediterranean coastal zone deciduous and coniferous forest	**37.77**	**33.99**	**37.77**	0.19	0.19
East Anatolian steppe	**47.99**	**43.19**	**47.99**	0.24	0.24
East Anatolian deciduous forest zone	**41.30**	**37.17**	**41.30**	0.21	0.21
Euxine-Colchic deciduous forest	**49.66**	**44.69**	**49.66**	0.25	0.25
Central Anatolian steppe	**40.41**	**36.37**	**40.41**	0.20	0.20
Aegean Inland deciduous and coniferous forest	**42.53**	**38.28**	**42.53**	0.21	0.21
North Anatolian deciduous, coniferous and mixed forest	**54.57**	**49.11**	**54.57**	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)
WL-CLannual					
Mediterranean Mountain zone	**46.96**	**42.26**	**40.22**	-0.10	-0.10
Mediterranean coastal zone deciduous and coniferous forest	**37.77**	**33.99**	**29.62**	-0.22	-0.22
East Anatolian steppe	**47.99**	**43.19**	**38.90**	-0.21	-0.21
East Anatolian deciduous forest zone	**41.30**	**37.17**	**30.44**	-0.34	-0.34
Euxine-Colchic deciduous forest	**49.66**	**44.69**	**38.68**	-0.30	-0.30
Central Anatolian steppe	**40.41**	**36.37**	**32.14**	-0.21	-0.21
Aegean Inland deciduous and coniferous forest	**42.53**	**38.28**	**30.99**	-0.36	-0.36
North Anatolian deciduous, coniferous and mixed forest	**54.57**	**49.11**	**34.29**	-0.74	-0.74
WL-CLperennial					
Mediterranean Mountain zone	**46.96**	**42.26**	**46.96**	0.23	0.23
Mediterranean coastal zone deciduous and coniferous forest	**37.77**	**33.99**	**37.77**	0.19	0.19
East Anatolian steppe	**47.99**	**43.19**	**47.99**	0.24	0.24
East Anatolian deciduous forest zone	**41.30**	**37.17**	**41.30**	0.21	0.21
Euxine-Colchic deciduous forest	**49.66**	**44.69**	**49.66**	0.25	0.25
Central Anatolian steppe	**40.41**	**36.37**	**40.41**	0.20	0.20
Aegean Inland deciduous and coniferous forest	**42.53**	**38.28**	**42.53**	0.21	0.21
North Anatolian deciduous, coniferous and mixed forest	**54.57**	**49.11**	**54.57**	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)
SL-CLannual					
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
SL-CLperennial					
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)
OL-CLannual					
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
OL-CLperennial					
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 6.24 Uncertainty summary table for Cropland subcategories

	BY (1990)	LRY (2020)
Cropland Remaining Cropland		
4B1 – CL-CL	7.3%	9.9%
Net C stock change in Living Biomass (ΔCC)	0.0%	12.6%
Net C stock change in DOM (ΔCC)	NA	NA
Net C stock change in SOM (ΔCC)	7.3%	15.3%
Land Converted to Cropland		
4B2 – L-CL	0%	47%
ΔCC in Living Biomass	NA	46%
Annual Loss Living Biomass (ΔCL)	NA	NA
Annual Gain Living Biomass (ΔCG)	NA	NA
Net C stock change in Dead Organic Matter (ΔCC)	NA	42%
Net C stock change in SOM (ΔCC)	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:

There is no recalculation for this submission in this category.

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 Türkiye (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

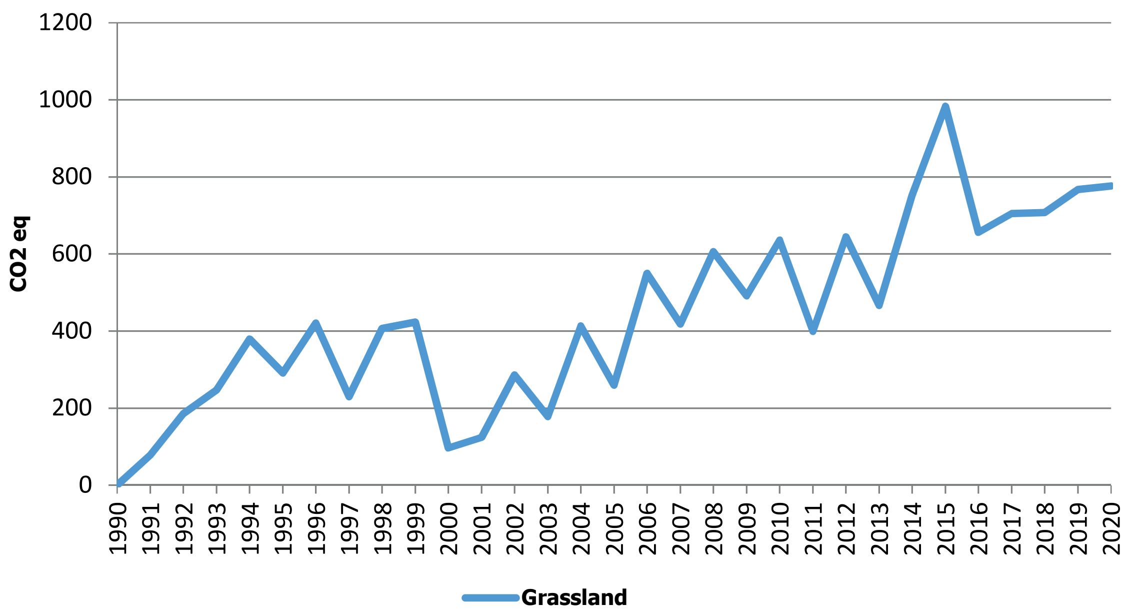


Figure 6.13 The change in area of GL-GL

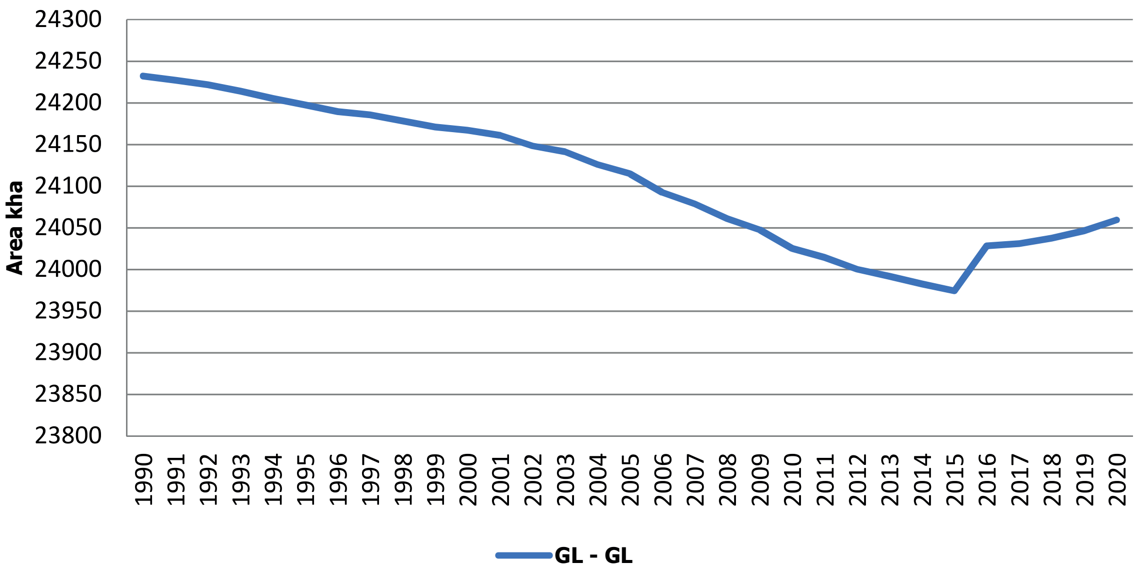
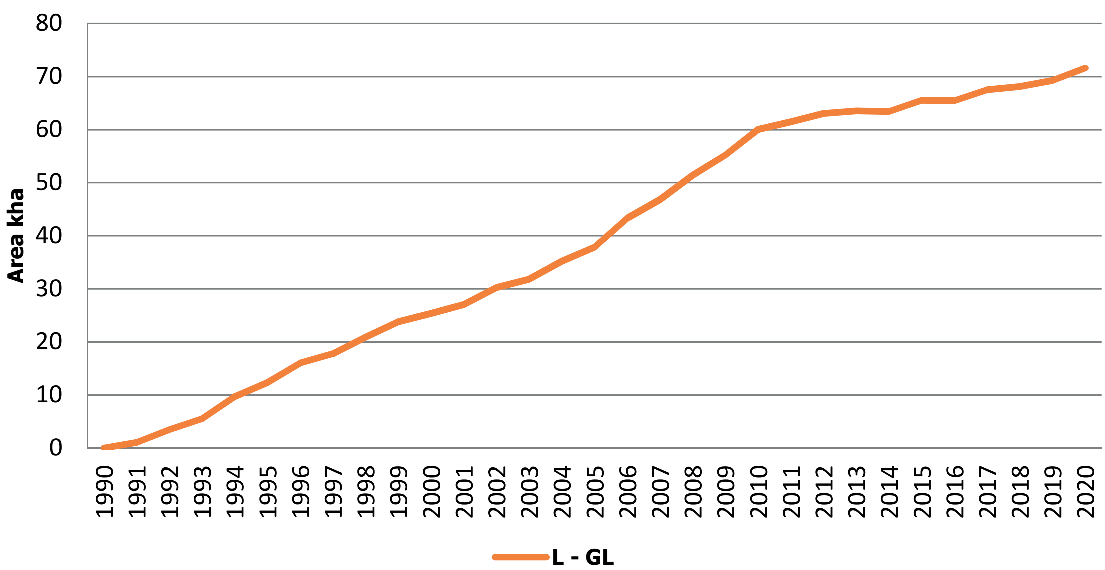


Figure 6.14 The change in area of L-GL



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_2 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 6.25 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)
Forest land converted to Grassland						
i.e. Mediterranean Mountain zone	Forest Deciduous	1.86	0	0	41.97	-40.11
	Forest Coninferous	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
Cropland (annual) converted to Grassland						
	$Cropland_{annual}$	1.86	0	0	5	-3.14
Cropland (perennial) converted to Grassland						
	$Cropland_{perennial}$	1.86	0	0	15	-13.14
Wetland converted to Grassland						
	Grassland	1.86	0	0	1.86	0.00
Settlements converted to Grassland						
	Settlements	1.86	0	0	5.03	-3.17
Otherland converted to Grassland						
	Other land	1.86	0	0	0	1.86

Dead organic matter

CSC converted to wetlands for forest lands are calculated based on the below coefficients and EF. The CSC for other conversions are assumed to be not occurring.

Table 6.26 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)
Forest land converted to Grassland						
i.e. Mediterranean Mountain zone	Forest Deciduous	0.37	0.50	-3.09	-0.49	-3.58
	Forest Coninferous	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 6.27 Coefficients and soil CS values for L-GL subcategories

Ecozone	SOC ref	C stock Grassland (tC/ha)	Forest land 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 6.28 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 6.29 Uncertainty summary table for Grassland subcategories

	BY (1990)	LRY (2020)
Grassland Remaining Grassland		
4C1 – GL-GL	0	0
ΔCC in Living Biomass	NO	NA
Annual Loss Living Biomass (ΔCL)	NA	NA
Annual Gain Living Biomass (ΔCG)	NA	NA
Net C stock change in DOM (ΔCC)	NO	NA
Net C stock change in SOM (ΔCC)	0.00	NA
Land Converted to Grassland		
4C2 – L-GL	0%	149%
ΔCC in Living Biomass	NA	32%
Annual Loss Living Biomass (ΔCL)	NA	NA
Annual Gain Living Biomass (ΔCG)	NA	NA
Net C stock change in DOM (ΔCC)	NA	190%
Net C stock change in SOM (ΔCC)	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:

There is no recalculation for this submission in this category.

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)

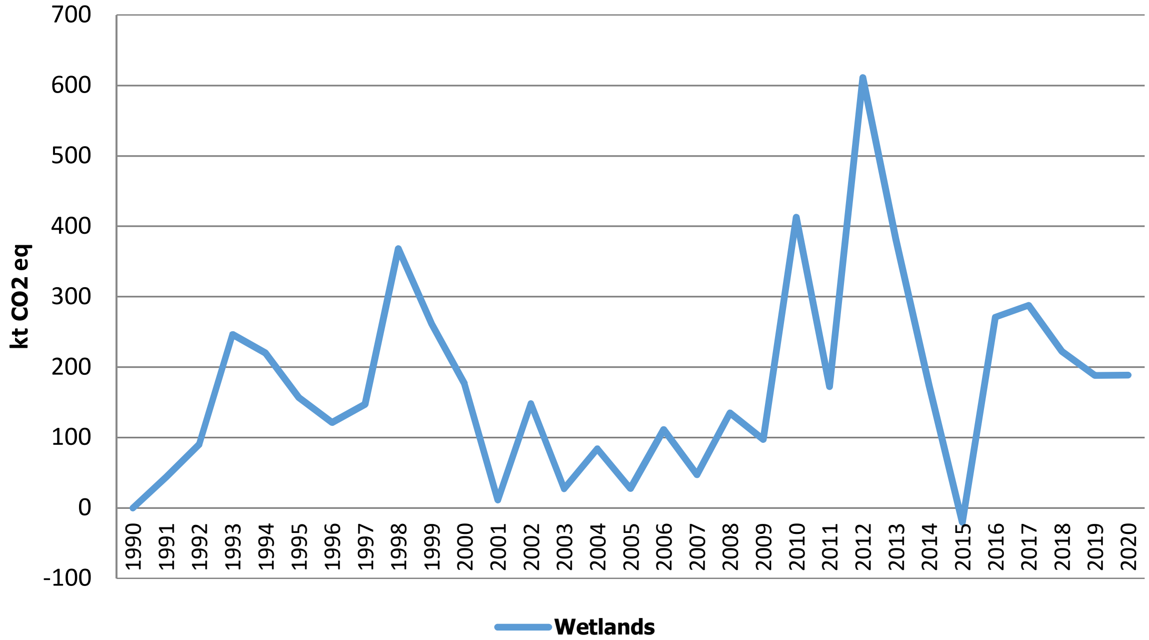
Source Category Description:

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 Türkiye, namely peat extraction remaining peat extraction and flooded land remaining flooded land.

All carbon pools in WL-WL, except peat extraction, are assumed to be unchanged, thus reported as NO. Information is given in Tables 30 and 31. Because OL-WL emissions are calculated at a negligible level, they are reported with the notation key "NE" in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guide.

Since the biomass and soil organic carbon emission coefficients we used in Grassland areas were the same as the biomass and soil organic carbon emission coefficients we used for wetlands areas, it was assumed that there was no gain or loss.Therefore, it is reported as NO. With the biomass and soil organic carbon emission coefficients we used for wetlands areas, it is considered that the gain is relatively low for cropland areas. It is entered as NE in the CRF because it is assumed that the loss is not significant in CL-WL transformations.

Figure 6.15 The emissions/removals from wetlands category



As seen from the figure above the emissions in L-WL were around 100 kt CO2 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. The emission declined again in 2018-2019-2020.

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.

Information on Land Classification and Activity Data

The wetland managed until 2015 has steadily increased, mostly resulting in emissions.

Figure 6.16 a The change in area of managed wetlands

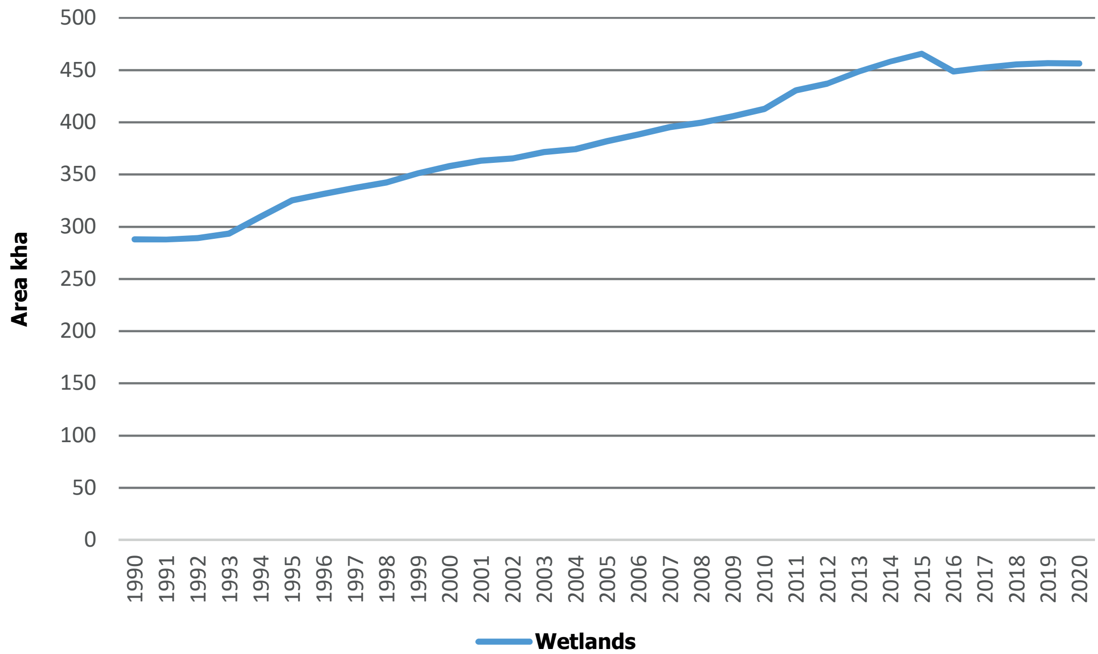
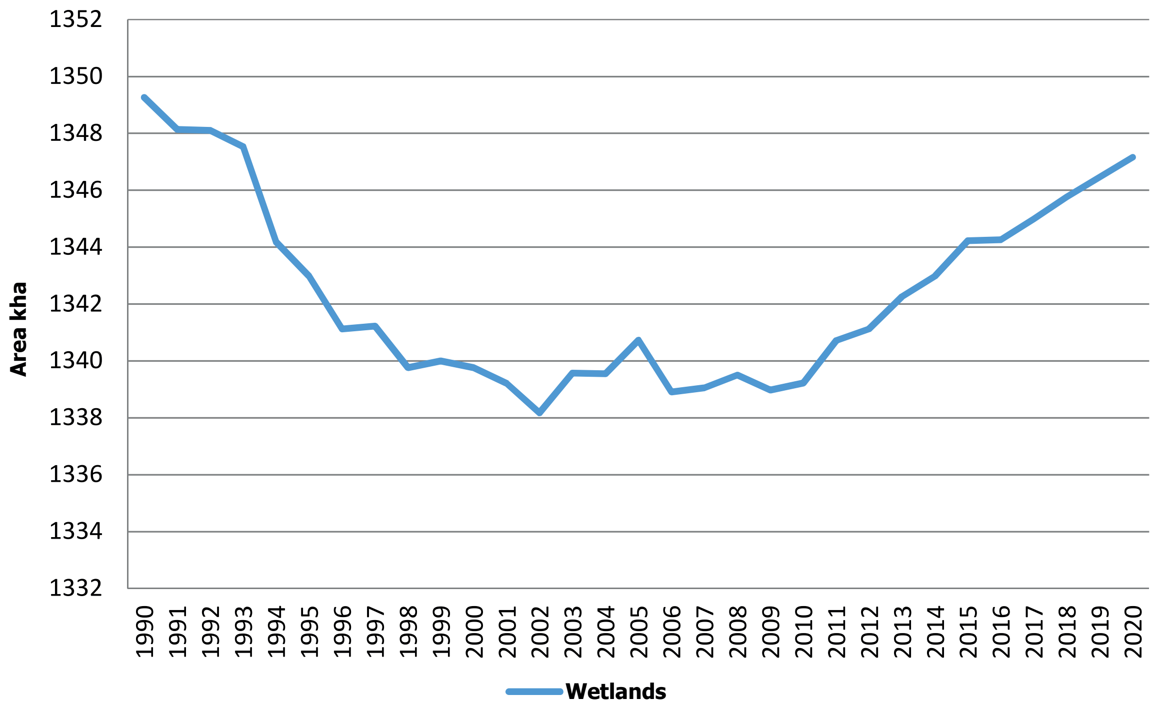


Figure 6.16 b The change in area of unmanaged wetlands



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 6.30 Coefficients and living biomass CS values for L-WL 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)
Forest land converted to Wetland						
i.e. Mediterranean Mountain zone	Forest Deciduous	1.86	0	0	41.97	-40.11
	Forest Coninferous	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
Cropland (annual) converted to Wetland						
	$Cropland_{annual}$	1.86	0	0	5	-3.14
Cropland (perennial) converted to Wetland						
		1.86	0	0	15	-13.14
Grassland converted to Wetland						
		0.00	0	1.86	1.86	0.00
Settlements converted to Wetland						
		1.86	0	0	5.03	-3.17
Otherland converted to Wetland						
		1.86	0	0	0	1.86

Dead organic matter

CSC converted to wetlands for forest lands are calculated based on the below coefficients and EF. The CSC for other conversions are assumed to be not occurring. It is assumed that there is no DOM in non-Forestland.

Table 6.31 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)
Forest land converted to Wetland						
i.e. Mediterranean Mountain zone	Forest Deciduous	0.37	0.50	-3.09	-0.49	-3.58
	Forest Coninferous	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 6.32 Coefficients and soil CS values for L-WL subcategories

Ecozone	SOC ref	C stock Wetlands (tC/ha)	Forest land 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 6.33 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 6.34 Uncertainty summary table for Wetland subcategories

	BY (1990)	LRY (2020)
Wetland Remaining Wetland		
4D1 – WL-WL	**0%**	**0**
ΔCC in Living Biomass	**NA**	**NA**
Annual Loss Living Biomass (ΔCL)	NA	NA
Annual Gain Living Biomass (ΔCG)	NA	NA
Net C stock change in DOM (ΔCC)	**NA**	NA
Net C stock change in SOM (ΔCC)	**NA**	NA
Land Converted to Wetland		
4D2 – L-WL	**0%**	**86%**
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:

There is no recalculation for this submission in this category.

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)

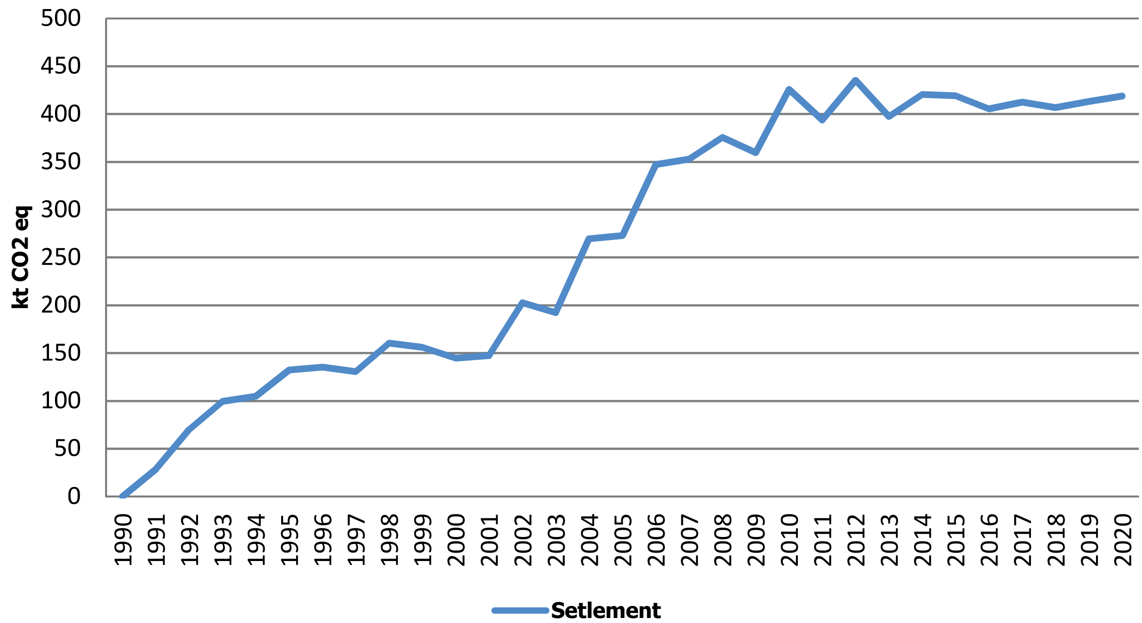
- Expert judgment (e.g. by national soil scientist) about different types of managed wetlands that are likely to occur in Türkiye (ST, MT)
- Collection of activity data regarding specific types of managed wetlands (MT)
- Sampling of SOC and estimation of carbon stocks for major soil types of wetlands (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.

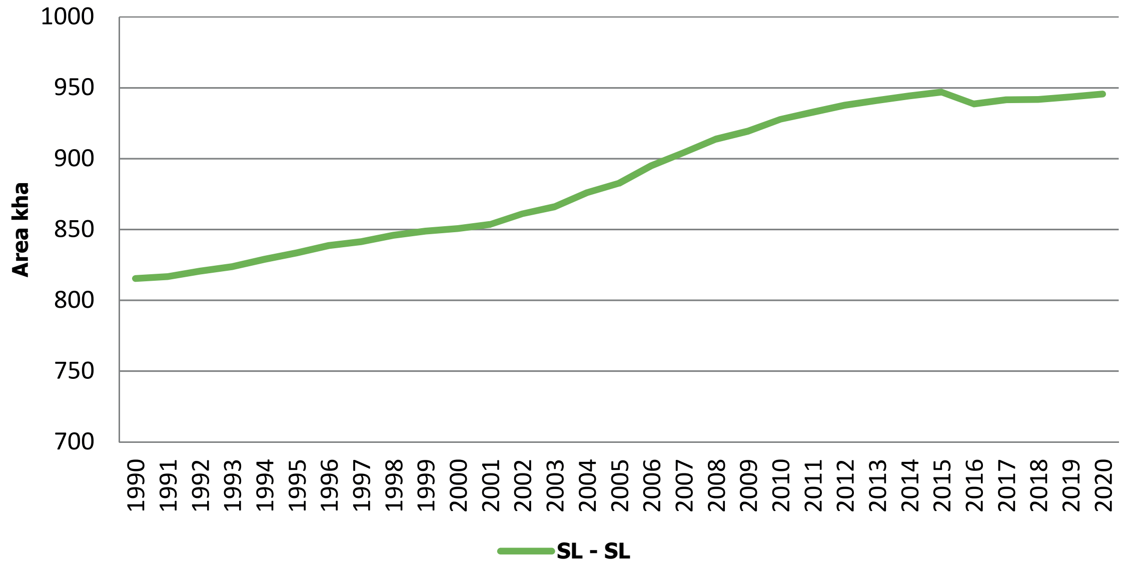
Figure 6.17 The change in net emissions in settlements



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 Türkiye 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 forest land 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^2) has been divided into 500*500 meter grids,
- The land uses in each grid have been determined from SPOT6 2013 satellite image with a 1.5*1.5 meter resolution using supervised classification,
- The accuracy check has been performed with 1000 plots with over 90 percent accuracy,
- The land use in each grid has been multiplied by carbon stocks given in Table 6.20.

- The impervious areas in each grid has been grouped under 5 classes that are >20 percent, >40 percent, >60 percent, and >80 percent. The project area has been classified for 4 settlement intensity classes in this way (Table 6.20).

Table 6.35 Total carbon stocks calculated for various settlements intensity classes (Serengil et al., 2015)

Settlement class (SC)	Settlement intensity (% imperviousness)	$\bar{x}$(t C /ha)	σ(t C /ha)	Sample size (#)
1	>20	85.27	74.19	1 145
2	>40	51.87	41.85	697
3	>60	32.04	25.32	438
4	>80	17.26	13.73	258

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 6.19 and Figure 6.20.

Figure 6.19 Impervious areas in the study area (Alibeyköy, Sazlıdere and Kağıthane watersheds in Istanbul)

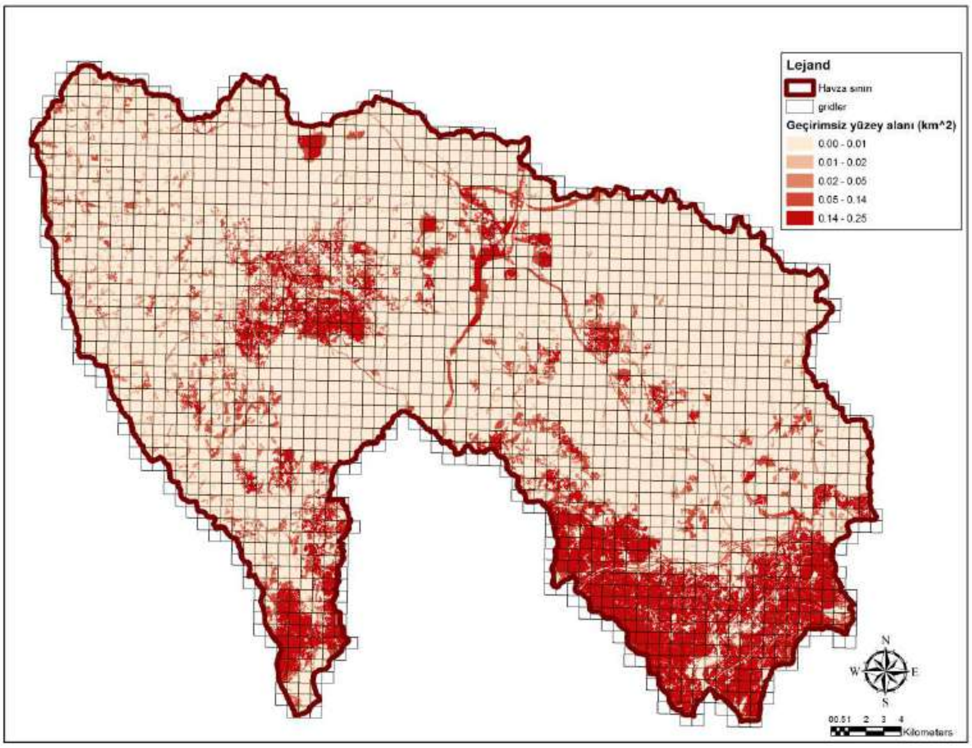
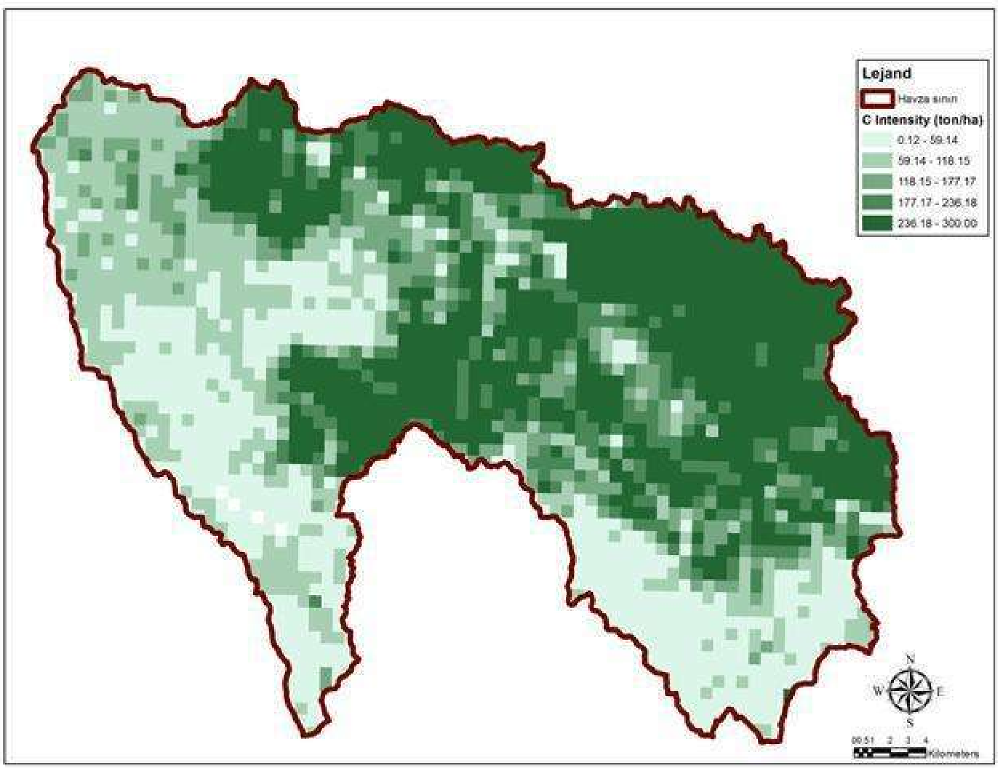


Figure 6.20 Carbon intensity in the study area (Alibeyköy, Sazlıdere and Kağıthane watersheds in Istanbul)



Land converted to settlements (L-SL)

Above- and below-ground biomass

Table 6.36 Coefficients and living biomass CS values for L-SL 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)
Forest land converted to Settlements						
i.e. Mediterranean Mountain zone	Forest Deciduous	5.03	0	0	41.97	-36.94
	Forest Coninferous	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 6.36 Coefficients and living biomass CS values for L-SL subcategories (Cont'd)

Cropland (annual) converted to Settlements						
	$Cropland_{annual}$	5.03	0	0	5	0.03
Cropland (perennial) converted to Settlements						
		5.03	0	0	15	-9.97
Grassland converted to Settlements						
		5.03	0	0	1.86	3.17
Wetlands converted to Settlements						
		5.03	0	0	1.86	3.17
Otherland converted to Settlements						
		5.03	0	0	0	5.03

Dead organic matter

CSC converted to settlements from forest lands are calculated based on the below coefficients and EF. The CSC for other conversions are assumed to be not occurring. It is assumed that there is no DOM in non-Forestland.

Table 6.37 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)
Forest land converted to Wetland						
i.e. Mediterranean Mountain zone	Forest Deciduous	0.37	0.50	-3.09	-0.49	-3.58
	Forest Coninferous	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 6.38 Coefficients and soil CS values for L-SL subcategories

Ecozone	SOC ref	C stock Settl. (tC/ha)	Forest land 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 6.39 Uncertainty summary table for Settlement subcategories

	BY (1990)	LRY (2020)
Wetland Remaining Wetland		
4E1 – SL-SL	0%	0
ΔCC in Living Biomass	NA	NA
Annual Loss Living Biomass (ΔCL)	NA	NA
Annual Gain Living Biomass (ΔCG)	NA	NA
Net C stock change in DOM (ΔCC)	NA	NA
Net C stock change in SOM (ΔCC)	NA	NA
Land Converted to Wetland		
4E2 – L-SL	0%	26%
ΔCC in Living Biomass	NA	24%
Annual Loss Living Biomass (ΔCL)	NA	NA
Annual Gain Living Biomass (ΔCG)	NA	NA
Net C stock change in DOM (ΔCC)	NA	97%
Net C stock change in SOM (ΔCC)	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:

There is no recalculation for this submission in this category.

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)
- Extent 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.

Methodological Issues:

The same conversion principles apply to Other land category. The coefficients and EFs use are as follows;

Table 6.40 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 6.41 Uncertainty summary table for Otherland subcategories

	BY (1990)	LRY (2020)
Other land Remaining Other land		
4F1 – OL-OL	0%	0
ΔCC in Living Biomass	NA	NA
Annual Loss Living Biomass (ΔCL)	NA	NA
Annual Gain Living Biomass (ΔCG)	NA	NA
Net C stock change in DOM (ΔCC)	NA	NA
Net C stock change in SOM (ΔCC)	NA	NA
Land Converted to Wetland		
4F2 – L-OL	0%	18%
ΔCC in Living Biomass	NA	31%
Annual Loss Living Biomass (ΔCL)	NA	NA
Annual Gain Living Biomass (ΔCG)	NA	NA
Net C stock change in DOM (ΔCC)	NA	139%
Net C stock change in SOM (ΔCC)	NA	19%

6.8. Direct N_2O 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 forest land 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 6.42 Uncertainty summary table for 4 (I) category

Summary	BY (1990)	LRY(2020)
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 6.43 Uncertainty summary table for 4 (II) category

Summary	BY (1990)	LRY (2020)
Table 4(II)	0%	0%

6.10. N_2O 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:

N2O 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. N2O emissions from land use conversions are derived from mineralization of soil organic matter resulting from the conversions that result in C losses.

Because N2O emissions from mineralization from other lands in CRF table 4(III) are calculated to be negligible, they are shown with the notation key "NE" in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guide.

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 6.44 EFs used for N_2O emissions

Parameter (for 1 tC lost)	**C/N=15 (all)**	**C/N=10 (CL)**
C/N ratio	15	10
EF1 (kgN2O-N/kg N)	0.01	0.01
Factor (N2O-N) to (N2O)	1.57	1.57
Aggregated factor (t N2O)	**0.001047619**	**0.001571429**

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 6.45 Uncertainty summary table for 4 (III) category

Summary	BY (1990)	LRY (2020)
Table 4(I)	0%	75%

Recalculation:

There is no recalculation for this submission in this category.

6.11. Indirect N_2O emissions from managed soils (4(IV))

Source Category Description:

The estimation of indirect N2O emissions follows the 2006 IPCC guidelines (Volume 4, Ch. 11). The indirect N2O 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 N2O 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 N2O 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 6.46 EFs used for N_2O emissions

Parameter	**Values**
Volatilization fraction: Frac GASF ((kg NH3–N + NOx–N) (kg Napplied) –1)	0.2
EF4 (kg N2O–N (kg NH3–N + NOX–Nvolatilised)-1)	0.01
FracLEACH-(H) [N losses by leaching/runoff for regions	0.3
EF5 [leaching/runoff], kg N2O–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 6.47 Uncertainty summary table for 4 (IV) category

Summary	BY (1990)	LRY (2020)
Table 4(I)	0%	387%

Recalculation:

There is no recalculation for this submission in this category.

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, Türkiye 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, CO2 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-CO2 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_4, N_2O, NOx 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 Türkiye. Thus reported as NO. Wildfires in wetlands are reported as NO. Most of the wildfires in the GL areas are caused by forest fires and they are reported as NA because the activity data cannot be reached clearly.

Reference to the 2006 IPCC equations: Vol. 4., Ch. 2: 2.14 / 2.27

The EFs and coefficients used are as follows;

Table 6.48 EFs used for Biomass burning emissions

Parameters	Years							
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2018**	**2019**
ABG Dec (tDM/ha)	98.50	102.49	107.61	127.34	128.00	112.87	106.88	96.84
ABG Con (tDM/ha)	71.09	73.98	77.67	83.75	86.12	85.79	87.88	90.34
ABG Mixed (tDM/ha)	84.80	88.23	92.64	105.55	107.06	99.33	97.38	93.59
ABG Degraded (tDM/ha)	5.78	6.02	6.32	6.52	5.57	4.64	4.19	5.78
R For Dec	0.23	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	0.29
R For Mix	0.26	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	0.43
LB total Dec (tDM/ha)	127.07	132.22	138.82	164.27	165.12	145.60	137.88	124.92
LB total Con (tDM/ha)	87.45	90.99	95.53	103.01	105.93	105.53	108.09	111.12
LB total Mixed (tDM/ha)	106.84	111.18	116.73	132.99	134.90	125.16	122.70	117.92
LB total Degraded (tDM/ha)	8.27	8.60	9.03	9.32	7.96	6.64	5.99	8.26
LT Dec (tDM/ha)	8.35	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	20.30
LT Mix (tDM/ha)	14.32	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	28.00
DW Dec (tDM/ha)	0.99	1.02	1.08	1.27	1.28	1.13	1.07	0.97
DW Con (tDM/ha)	0.71	0.74	0.78	0.84	0.86	0.86	0.88	0.90
DW Mix (tDM/ha)	0.85	0.88	0.93	1.06	1.07	0.99	0.97	0.94
DW Deg (tDM/ha)	0.06	0.06	0.06	0.07	0.06	0.05	0.04	0.06
Burned share Dec	0.05	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	0.90

Table 6.48 EFs used for Biomass burning emissions (Cont'd)

Parameters	1990	1995	2000	2005	2010	2015	2018	2019
Burned share Mix	0.05	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	0.00
Total stock available for burning (tDM/ha)	105.00	109.35	115.03	129.25	132.07	125.52	125.41	124.27
Cf (combustion factor, Extra tropical forest)	0.44	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	54.68
convFL Amount burnt (tDM/ha)	11.11	8.11	8.11	8.11	8.11	7.96	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 6.49 Uncertainty summary table for 4 (V) category

Summary	BY (1990)	LRY (2020)
Table 4(I)	54%	54%

Recalculation:

There is no recalculation for this submission in this category.

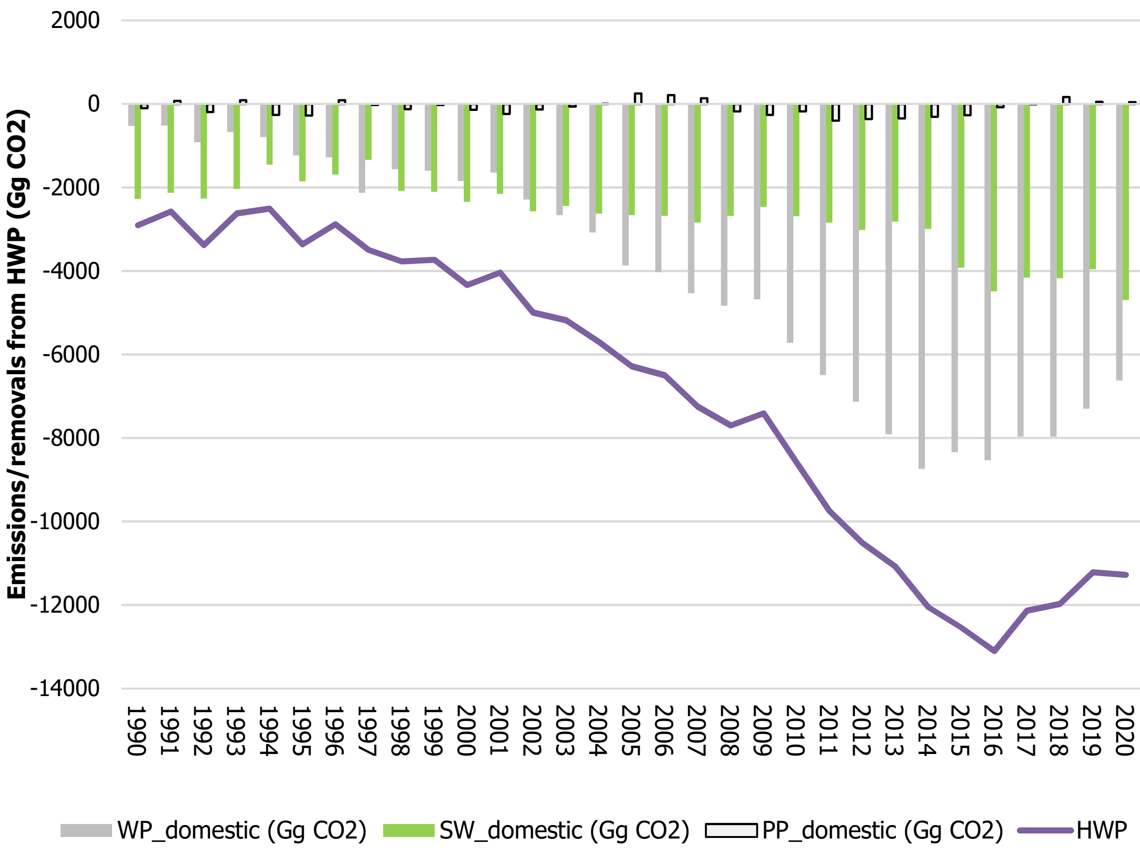
6.13. Harvested Wood Products (4.G)

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 has been added as the third product since 2019 submission (for 1990-2017),
- 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:

Harvested Wood Products category was recalculated because the methodology has been changed and activity data of paper and paperboard has been changed from wood pulp to paper and paperboard category of FAOStat according to the 2021 ARR. The difference derived from recalculation is demonstrated below (Table 6.50):

Table 6.50 Recalculation Table of HWP, 1990-2019

Harvested Wood Products

Year	Without Recalculation (kt CO_2 eq.)	With Recalculation (kt CO_2 eq.)	Difference %
1990	2 948	2 907	-1.4
1991	2 602	2 573	-1.1
1992	3 322	3 380	1.7
1993	2 581	2 620	1.5
1994	2 360	2 507	5.9
1995	3 333	3 361	0.8
1996	3 000	2 883	-4.1
1997	3 449	3 494	1.3
1998	3 651	3 773	3.2
1999	3 626	3 731	2.8
2000	4 305	4 337	0.8
2001	3 811	4 038	5.6
2002	4 835	4 999	3.3
2003	5 072	5 178	2.1
2004	5 643	5 699	1.0
2005	6 379	6 285	-1.5
2006	6 315	6 497	2.8
2007	7 055	7 247	2.6
2008	7 312	7 699	5.0
2009	6 979	7 408	5.8
2010	8 334	8 587	2.9
2011	9 303	9 742	4.5
2012	10 082	10 511	4.1
2013	10 583	11 081	4.5
2014	11 627	12 049	3.5
2015	12 200	12 541	2.7
2016	13 000	13 102	0.8
2017	12 115	12 133	0.2
2018	12 135	11 973	-1.4
2019	11 178	11 215	0.3

7. WASTE (CRF SECTOR 5)

7.1. Sector Overview

The waste sector includes CH_4 emissions from solid waste disposal, CH_4 and N_2O emissions from biological treatment of solid waste, CO_2, CH_4 and N_2O emissions from open burning of waste and, CH_4 and N_2O emissions from wastewater treatment and discharge. Emissions from waste incineration are included in the inventory but reported in the energy sector since the purpose of waste incineration is energy recovery.

Total waste emissions for the year 2020 are 16.4 Mt CO_2 eq., or 3.1% of total GHG emissions (without LULUCF). Within the sector, 68.5% of the emissions were from solid waste disposal, followed by 31.3% from wastewater treatment and discharge, 0.12% from biological treatment of solid waste and 0.04% from open burning of waste.

The major GHG emissions from the waste sector are CH_4 emissions, which represent 86.1% of total emissions from this sector in 2020, followed by N_2O emissions with 13.9% and a very small percent of CO_2 as 0.02%.

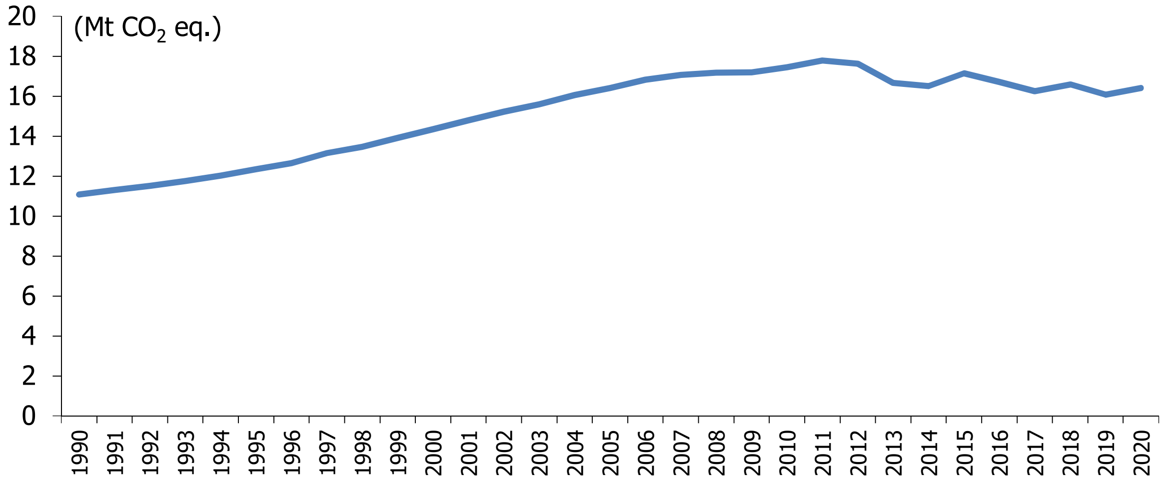
Table 7.1 CO_2 equivalent emissions for the waste sector, 2020

(kt CO_2 eq.)

GHG source and sink categories	CO_2	CH_4	N_2O	Total
5. Waste	3.6	14 123.8	2 274.9	16 402.3
A. Solid waste disposal	NA	11 236.6	NA	11 236.6
B. Biological treatment of solid waste	NA	12.0	8.5	20.5
C. Incineration and open burning of waste	3.6	3.1	0.5	7.3
D. Wastewater treatment and discharge	NA	2 872.2	2 265.8	5 138.0
E. Other	NO	NO	NO	NO

Waste emissions are 48.0% (5.3 Mt CO_2 eq.) higher in 2020 than they were in 1990 and 2.1% (0.3 Mt CO_2 eq.) higher than in 2019 as seen in Figure 7.1.

Figure 7.1 Total GHG emissions of waste sector, 1990-2020



Total emissions in the waste sector gradually increased between 1990 (11 081 kt CO_2 eq.) and 2020 (16 402 kt CO_2 eq.) driven largely by the steady rise in emissions from solid waste disposal between 1990 and 2011 followed by a decrease in emissions since from solid waste disposal after 2011. Emissions from solid waste disposal increased by 91.6% (6 162 kt CO_2 eq.) between 1990 and 2011, before decreasing by 12.8% between 2011 and 2020 (1 655 kt CO_2 eq.). Methane recovery in solid waste disposal sites is reported as of 2002 (37 kt CO_2 eq.) and increasing to 7 573 kt CO_2 eq. in 2020. The decline in recent total emissions is mainly due to the increase in methane recovery between 2011 (985 kt CO_2 eq.) and 2020 (7 573 kt CO_2 eq.), an increase of 669%. 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

	CO_2		CH_4		N_2O	
GHG source and sink categories	**Method applied**	**Emission factor**	**Method applied**	**Emission factor**	**Method applied**	**Emission factor**
5. Waste	T2	CS,D	T1,T2	CS,D	T1	D
A. Solid waste disposal	NA	NA	T2	CS,D	NA	NA
B. Biological treatment of solid waste	NA	NA	T1	D	T1	D
C. Incineration and open burning of waste	T2	CS,D	T1	D	T1	D
D. Wastewater treatment and discharge	NA	NA	T2	CS	T1	D

D: IPCC Default, CS: Country Specific, NA: Not Applicable, 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 Türkiye:

- Managed waste disposal sites,
- Unmanaged waste disposal sites.

There are no semi-aerobic managed waste disposal sites (5.A.1.b) in Türkiye and all managed waste disposal sites are categorized under anaerobic managed waste disposal sites (5.A.1.a). Unmanaged waste disposal sites (5.A.2) cannot be classified into deep and shallow due to lack of knowledge. The category covers CH_4 emissions from two types of waste in municipal SWDS in Türkiye:

- Municipal solid waste (MSW),
- Industrial waste,
- Sewage sludge, and
- Clinical waste.

According to the clinical waste management practices and regulations in Türkiye, 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. 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, Türkiye has carried out many actions related to waste management and regulatory policies. The first legal regulation in this field in Türkiye 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 Türkiye are expected to reduce the share of GHG emissions from the waste sector.

Methodological Issues:

Methane Emissions from Solid Waste Disposal

CH_4 emissions from solid waste disposal is a key category according to both a level and a trend assessment. CH_4 emissions of MSW, industrial waste, sewage sludge and clinical waste emissions are estimated from municipal SWDS in Türkiye. The IPCC T2 First Order Decay (FOD) method recommended in the 2006 IPCC Guidelines for National GHG Inventories is used with default parameters and country-specific AD on current and historical waste disposal at SWDS to estimate CH_4 emissions. Closed SWDS continue to emit CH_4. This is automatically accounted for in the FOD method because historical waste disposal data are used. The CH_4 emissions from solid waste disposal for a single year can be estimated based on *Equation 3.1 in 2006 IPCC, Volume 5, Chapter 3* as given in the equation below.

$$CH_4\ Emissions = \left[\sum_x CH_4 generated_{x,T} - R_T\right] \bullet (1 - OX_T)$$

Where:

CH_4 Emissions = CH_4 emitted in year *T*, Gg

T = inventory year

x = waste category or type/material

R_T = recovered CH_4 in year *T*, Gg

OX_T = oxidation factor in year *T*, (fraction)

The CH_4 generated by each category of waste disposed is added to get total CH_4 generated in each year. Finally, emissions of CH_4 are calculated by subtracting the CH_4 gas recovered from the disposal site.

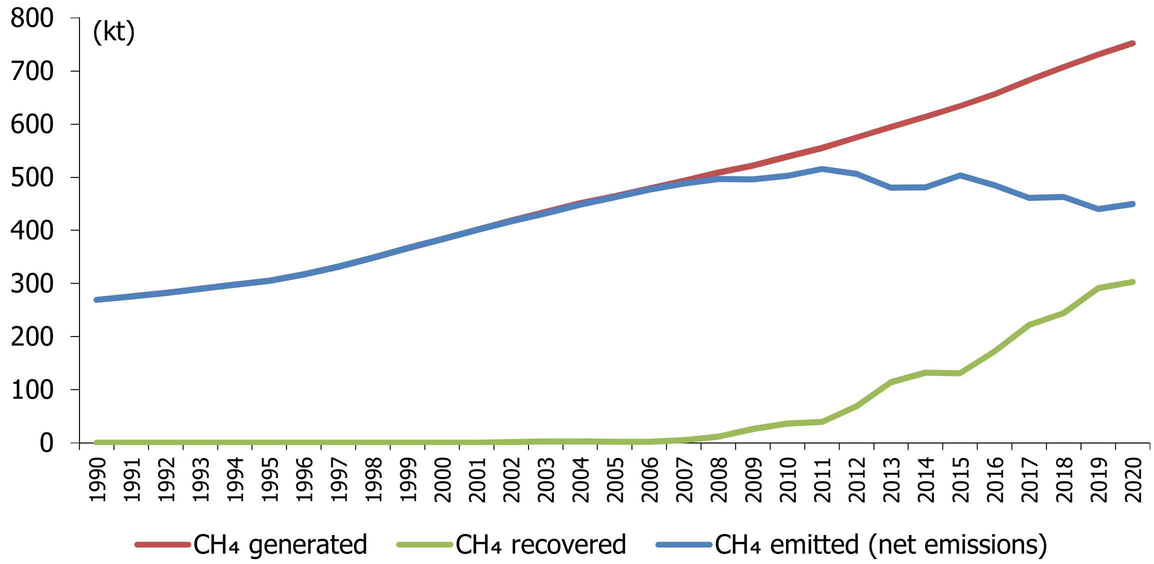
The total amount of CH_4 generated, CH_4 recovered and net CH_4 emissions from solid waste disposal sites are estimated as given in Table 7.3 and Figure 7.2.

Table 7.3 CH_4 generated, recovered and emitted from SWDS, 1990-2020

(kt)

Year	CH_4 Generated	CH_4 Recovered		CH_4 Emitted	
		Managed	Unmanaged	Managed	Unmanaged
1990	269.2	NO	NO	NO	269.2
1991	275.7	NO	NO	NO	275.7
1992	282.4	NO	NO	NO	282.4
1993	290.0	NO	NO	2.2	287.8
1994	297.8	NO	NO	4.0	293.7
1995	305.1	NO	NO	5.6	299.5
1996	317.1	NO	NO	8.6	308.5
1997	331.6	NO	NO	14.5	317.1
1998	348.5	NO	NO	23.5	325.0
1999	366.5	NO	NO	33.9	332.6
2000	383.3	NO	NO	45.9	337.3
2001	400.7	NO	NO	59.5	341.2
2002	418.7	1.5	NO	72.9	344.2
2003	434.6	2.5	NO	83.3	348.8
2004	450.9	2.3	NO	95.0	353.5
2005	464.1	1.7	NO	105.5	357.0
2006	478.8	2.2	NO	114.5	362.2
2007	493.1	4.9	NO	125.6	362.6
2008	508.6	11.8	NO	133.7	363.2
2009	522.2	25.8	NO	135.5	360.8
2010	538.8	36.3	NO	143.2	359.4
2011	555.0	39.4	NO	160.4	355.3
2012	574.9	68.6	NO	153.7	352.7
2013	594.5	109.5	4.4	136.6	344.0
2014	613.5	128.1	4.0	143.0	338.3
2015	633.9	126.8	4.0	169.2	334.0
2016	656.6	169.0	3.0	154.6	330.0
2017	683.1	214.3	7.9	139.6	321.4
2018	707.5	237.9	6.5	145.4	317.7
2019	731.0	284.0	7.0	130.2	309.9
2020	752.4	300.8	2.2	141.9	307.6

Figure 7.2 CH_4 emissions from solid waste disposal, 1990-2020



Net methane emissions tend to decrease with the increase in methane recovery amount due to the increase in the capacity and number of methane recovery facilities producing electricity/heat energy from landfill gas in Türkiye.

Choice of Activity Data

For calculating CH_4 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_F), methane generation rate constant (k), fraction of methane (F) and oxidation factor (OX).

The justification for the selection of parameters by Türkiye 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, 2016, 2018 and 2020 are available. The specific data collected by TurkStat are the amount of MSW is weighed, generally based on waste delivery vehicle capacity. 2005 data of MSW disposed in managed SWDS is gathered via *Waste Disposal and Recovery Facilities Statistics Survey* by TurkStat. In Türkiye, 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 2020, the missing data for the remaining years are estimated by linear interpolation. 2019 data of MSW disposed in managed SWDS has been recalculated by linear interpolation in this inventory submission due to availability of 2020 survey data.

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, Türkiye 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, 1992-2020

	1992	1993	1994	1995	1996	1997	1998	2000	2001	2002
	1	1	2	6	6	8	8	10	12	12

2003	2004	2005	2006	2008	2010	2012	2014	2016	2018	2020
15	16	18	22	37	52	80	113	134	159	174

Source: (1) TurkStat, Municipal Waste Statistics, 1992-2010
(2) TurkStat, Waste Disposal and Recovery Facilities Statistics, 2012-2020

Amount of municipal waste by disposal methods are given in Table 7.5.

Table 7.5 Amount of municipal waste by disposal methods, 1994-2020

(kt)

Year	Municipality's dumping site	Controlled landfill site	Composting plant	Burning in an open area	Lake and river disposal	Burial	Other (1)
1994	14 479.2	809.0	192.1	442.1	557.6	523.4	753.3
1995	17 174.9	1 444.0	158.9	405.0	370.4	828.9	527.3
1996	17 519.5	2 847.0	178.8	437.9	370.3	823.6	303.3
1997	16 805.1	4 363.8	180.4	625.1	384.4	1 446.9	365.8
1998	16 852.8	5 257.9	166.3	386.1	374.9	852.4	1 039.1
2001	14 569.8	8 304.2	218.1	343.6	100.9	481.7	1 115.4
2002	16 310.0	7 047.0	383.1	220.5	196.8	499.9	715.8
2003	16 566.5	7 431.8	325.9	258.5	228.5	597.0	709.3
2004	16 415.8	7 001.5	350.7	101.6	154.7	426.5	562.7
2006	14 941.2	9 428.3	254.9	246.5	69.8	144.5	194.7
2008	12 677.1	10 947.4	275.7	239.3	47.7	100.5	73.1
2010	11 001.2	13 746.9	194.5	133.9	44.0	34.3	122.1
2012	9 771.0	15 484.2	154.7	104.8	33.4	94.3	202.3
2014	9 935.6	17 807.4	126.5	4.3	15.8	7.3	113.8
2016	9 094.9	19 337.9	146.5	10.2	0.5	6.7	41.1
2018	6 520.7	21 643.8	122.9	6.1	0.5	2.0	65.3
2020	5 492.8	22 443.5	117.5	19.0	0.5	6.9	98.0

Source: TurkStat, Municipal Waste Statistics

(1) Data refers to disposals by using as filling material and dumping onto 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, 1990-2020

	Annual MSW at the SWDS (kt)			Distribution of waste (%)	
Year	**Total**	**Managed**	**Unmanaged**	**Managed**	**Unmanaged**
1990	15 518.4	NO	15 518.4	0.0	100.0
1991	15 781.6	NO	15 781.6	0.0	100.0
1992	16 043.7	986.1	15 057.6	6.1	93.9
1993	16 304.7	827.2	15 477.5	5.1	94.9
1994	16 564.8	809.0	15 755.8	4.9	95.1
1995	19 975.1	1 444.0	18 531.1	7.2	92.8
1996	21 493.5	2 847.0	18 646.4	13.2	86.8
1997	22 981.5	4 363.8	18 617.7	19.0	81.0
1998	24 002.3	5 257.9	18 744.3	21.9	78.1
1999	23 256.9	6 273.3	16 983.5	27.0	73.0
2000	23 894.1	7 288.8	16 605.3	30.5	69.5
2001	24 471.1	8 304.2	16 166.9	33.9	66.1
2002	24 572.6	7 047.0	17 525.7	28.7	71.3
2003	25 304.6	7 431.8	17 872.8	29.4	70.6
2004	24 406.4	7 001.5	17 404.9	28.7	71.3
2005	25 947.4	7 078.2	18 869.2	27.3	72.7
2006	24 708.7	9 428.3	15 280.3	38.2	61.8
2007	25 484.4	10 187.9	15 296.5	40.0	60.0
2008	23 798.2	10 947.4	12 850.7	46.0	54.0
2009	25 700.0	12 347.2	13 352.8	48.0	52.0
2010	24 904.4	13 746.9	11 157.5	55.2	44.8
2011	26 319.0	14 615.5	11 703.5	55.5	44.5
2012	25 551.8	15 484.2	10 067.6	60.6	39.4
2013	25 267.0	16 645.8	8 621.2	65.9	34.1
2014	27 864.2	17 807.4	10 056.8	63.9	36.1
2015	27 415.0	18 572.7	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	20 490.9	8 346.1	71.1	28.9
2018	28 231.7	21 643.8	6 587.9	76.7	23.3
2019	28 633.6	22 043.7	6 590.0	77.0	23.0
2020	28 041.2	22 443.5	5 597.7	80.0	20.0

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 2007-2020, the annual results of ABPRS are used.

Table 7.7 Mid-year population, 1950-2020

Year	Population	Year	Population
1950	20 807 000	1986	51 480 000
1951	21 351 000	1987	52 370 000
1952	21 952 000	1988	53 268 000
1953	22 569 000	1989	54 192 000
1954	23 204 000	1990	55 120 000
1955	23 857 000	1991	56 055 000
1956	24 540 000	1992	56 986 000
1957	25 250 000	1993	57 913 000
1958	25 981 000	1994	58 837 000
1959	26 733 000	1995	59 756 000
1960	27 506 000	1996	60 671 000
1961	28 227 000	1997	61 582 000
1962	28 931 000	1998	62 464 000
1963	29 652 000	1999	63 364 000
1964	30 391 000	2000	64 269 000
1965	31 149 000	2001	65 166 000
1966	31 936 000	2002	66 003 000
1967	32 750 000	2003	66 795 000
1968	33 586 000	2004	67 599 000
1969	34 443 000	2005	68 435 000
1970	35 321 000	2006	69 295 000
1971	36 215 000	2007	70 158 000
1972	37 133 000	2008	71 052 000
1973	38 073 000	2009	72 039 000
1974	39 037 000	2010	73 142 000
1975	40 026 000	2011	74 224 000
1976	40 916 000	2012	75 176 000
1977	41 769 000	2013	76 148 000
1978	42 641 000	2014	77 182 000
1979	43 531 000	2015	78 218 000
1980	44 439 000	2016	79 278 000
1981	45 540 000	2017	80 313 000
1982	46 688 000	2018	81 407 000
1983	47 864 000	2019	82 579 000
1984	49 070 000	2020	83 385 000
1985	50 307 000		

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, 2016, 2018 and 2020) 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, 2017 and 2019. 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, 1990-2020

Year	MSW Generated (kt)	Population (millions)	Waste per capita (kg/cap/yr)
1990	21 966.7	55.1	398.5
1991	22 339.3	56.1	398.5
1992	22 710.3	57.0	398.5
1993	23 079.8	57.9	398.5
1994	23 448.0	58.8	398.5
1995	27 234.1	59.8	455.8
1996	29 348.0	60.7	483.7
1997	31 943.8	61.6	518.7
1998	32 972.9	62.5	527.9
1999	30 470.0	63.4	480.9
2000	30 617.0	64.3	476.4
2001	31 030.9	65.2	476.2
2002	30 999.3	66.0	469.7
2003	31 081.4	66.8	465.3
2004	29 736.2	67.6	439.9
2005	31 351.9	68.4	458.1
2006	30 081.8	69.3	434.1
2007	30 365.6	70.2	432.8
2008	28 454.0	71.1	400.5
2009	30 196.0	72.0	419.2
2010	29 733.0	73.1	406.5
2011	30 862.0	74.2	415.8
2012	30 786.0	75.2	409.5
2013	30 920.0	76.1	406.1
2014	31 230.0	77.2	404.6
2015	31 283.0	78.2	399.9
2016	33 763.5	79.3	425.9
2017	34 173.0	80.3	425.5
2018	34 532.6	81.4	424.2
2019	35 017.4	82.6	424.0
2020	34 757.8	83.4	416.8

% 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, 2016, 2018 and 2020) 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, 2017 and 2019. Due to lack of MSW generated data, % to SWDS of 1994 (70.6%) is used for 1950-1993.

% to SWDS obtained by dividing the amount of MSW landfilled by MSW generated are given for 1990-2020 in Table 7.9.

Table 7.9 Percentage of MSW disposed in the SWDS, 1990-2020

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
2018	34 532.6	28 231.7	81.8
2019	35 017.4	28 633.6	81.8
2020	34 757.8	28 041.2	80.7

Waste Composition Data: The waste composition data was previously only available for 1993, 2006 and 2014. To improve the quality of the inventory, an additional question on waste composition data was added to the TurkStat's *Municipal Waste Statistics Survey,* and the results of the survey as of 2016 were used in the calculations. 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, 2017, 2018, 2019 and 2020 waste composition data is TurkStat's *Municipal Waste Statistics Survey* as mentioned above. This survey is conducted biennially, but the waste composition data is compiled annually by inquiring the previous year’s data.

Waste composition data for the remaining years were estimated by time series analysis methods. For missing value imputation R programming language was used. Since, it is not possible to generate missing years before 1993 with interpolation. Thus, for providing time series consistency, time series analysis methods were tried and compared with splicing techniques of IPCC guidelines. After the comprehensive study carried out for imputation of missing years, two of the time series analysis methods were found statistically better than the 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. 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.

Table 7.10 contains these statistically estimated data with the official waste composition data.

Table 7.10 Waste composition data, 1990-2020

(%)

Year	Food	Garden	Paper	Wood	Textile	Plastics	Metal	Glass	Other
1990	58.29	0.95	7.90	0.00	3.81	2.81	1.00	2.76	22.48
1991	59.26	0.79	7.58	0.00	3.84	2.84	1.00	2.63	22.05
1992	60.47	0.59	7.18	0.00	3.88	2.88	1.00	2.47	21.53
1993 (1)	64.00	0.00	6.00	0.00	4.00	3.00	1.00	2.00	20.00
1994	60.00	0.67	7.33	0.00	3.87	2.87	1.00	2.53	21.73
1995	58.00	1.00	8.00	0.00	3.80	2.80	1.00	2.80	22.60
1996	56.00	1.33	8.67	0.00	3.73	2.73	1.00	3.07	23.47
1997	54.00	1.67	9.33	0.00	3.67	2.67	1.00	3.33	24.33
1998	52.00	2.00	10.00	0.00	3.60	2.60	1.00	3.60	25.20
1999	50.00	2.33	10.67	0.00	3.53	2.53	1.00	3.87	26.07
2000	48.00	2.67	11.33	0.00	3.47	2.47	1.00	4.13	26.93
2001	46.00	3.00	12.00	0.00	3.40	2.40	1.00	4.40	27.80
2002	44.00	3.33	12.67	0.00	3.33	2.33	1.00	4.67	28.67
2003	42.00	3.67	13.33	0.00	3.27	2.27	1.00	4.93	29.53
2004	37.15	5.39	14.31	0.00	2.98	2.83	1.08	5.44	30.82
2005	36.45	5.31	14.69	0.00	2.98	2.64	1.06	5.56	31.31
2006 (2)	34.00	5.00	16.00	0.00	3.00	2.00	1.00	6.00	33.00
2007	36.94	5.37	14.42	0.00	2.98	2.77	1.07	5.48	30.97
2008	38.41	5.55	13.63	0.00	2.97	3.16	1.11	5.21	29.95
2009	39.88	5.74	12.84	0.00	2.96	3.54	1.15	4.95	28.94
2010	41.35	5.92	12.06	0.00	2.95	3.93	1.19	4.69	27.92
2011	46.34	5.98	11.44	0.00	2.10	6.23	1.52	4.51	21.88
2012	51.11	6.41	9.52	0.00	1.81	7.80	1.71	3.88	17.77
2013	50.84	6.45	9.36	0.00	1.93	7.58	1.67	3.82	18.33
2014 (3)	48.70	6.84	8.11	0.00	2.90	5.86	1.37	3.38	22.84
2015	52.37	5.67	10.47	0.00	1.09	9.17	1.95	4.34	14.94
2016 (4)	55.13	5.68	11.87	0.00	0.00	11.02	2.28	4.70	9.32
2017 (4)	53.75	3.91	11.91	0.00	0.00	11.36	2.33	5.22	11.53
2018 (4)	54.62	4.96	10.89	0.00	0.00	12.32	2.15	5.13	9.93
2019 (4)	52.71	3.44	9.77	1.24	1.86	11.09	2.09	4.92	12.86
2020 (4)	52.09	2.43	10.26	1.07	1.75	11.30	2.74	5.74	12.62

(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) TurkStat, Municipal Waste Statistics Survey Results, 2016-2020

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, 2016, 2018 and 2020. The missing data for the remaining years between 1994 and 2020 were estimated by linear interpolation.

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, Türkiye 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), Türkiye 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, 1990-2020

	Annual IW at the SWDS (kt)			Distribution of waste (%)	
Year	**Total**	**Managed**	**Unmanaged**	**Managed**	**Unmanaged**
1990	12.9	NO	12.9	0.0	100.0
1991	12.9	NO	12.9	0.0	100.0
1992	13.6	NO	13.6	0.0	100.0
1993	15.4	NO	15.4	0.0	100.0
1994	11.4	NO	11.4	0.0	100.0
1995	6.7	NO	6.7	0.0	100.0
1996	8.8	NO	8.8	0.0	100.0
1997	0.8	NO	0.8	0.0	100.0
1998	4.8	NO	4.8	0.0	100.0
1999	7.3	NO	7.3	0.0	100.0
2000	10.4	NO	10.4	0.0	100.0
2001	5.6	NO	5.6	0.0	100.0
2002	4.4	NO	4.4	0.0	100.0
2003	3.3	NO	3.3	0.0	100.0
2004	1.6	NO	1.6	0.0	100.0
2005	2.7	NO	2.7	0.0	100.0
2006	3.3	NO	3.3	0.0	100.0
2007	4.0	NO	4.0	0.0	100.0
2008	3.9	NO	3.9	0.0	100.0
2009	3.4	NO	3.4	0.0	100.0
2010	4.2	NO	4.2	0.0	100.0
2011	4.5	NO	4.5	0.0	100.0
2012	4.7	NO	4.7	0.0	100.0
2013	5.7	NO	5.7	0.0	100.0
2014	6.1	NO	6.1	0.0	100.0
2015	4.0	NO	4.0	0.0	100.0
2016	2.1	NO	2.1	0.0	100.0
2017	2.8	NO	2.8	0.0	100.0
2018	3.4	NO	3.4	0.0	100.0
2019	4.5	NO	4.5	0.0	100.0
2020	5.5	NO	5.5	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 1998-2020, GDP data have been updated by using Annual GDP based on 2009. Compared to the previous submission, 2018 and 2019 GDP data have been revised by the TurkStat. GDP data in current prices used for emission estimations are given in Table 7.12.

Table 7.12 GDP by production approach, 1950-2020

(million USD)

Year	GDP	Year	GDP
1950	3 469	1986	75 018
1951	4 167	1987	85 638
1952	4 793	1988	90 495
1953	5 585	1989	106 123
1954	5 700	1990	149 195
1955	6 854	1991	149 156
1956	7 909	1992	156 656
1957	10 518	1993	177 332
1958	12 552	1994	131 639
1959	15 687	1995	168 080
1960	9 932	1996	181 077
1961	5 512	1997	188 735
1962	6 402	1998	277 668
1963	7 402	1999	254 119
1964	7 872	2000	273 085
1965	8 419	2001	202 503
1966	9 997	2002	238 145
1967	11 144	2003	316 561
1968	18 008	2004	407 021
1969	20 128	2005	504 754
1970	18 825	2006	552 367
1971	16 847	2007	683 020
1972	21 319	2008	782 865
1973	26 854	2009	651 543
1974	36 985	2010	777 461
1975	46 300	2011	837 924
1976	52 996	2012	877 676
1977	60 613	2013	958 125
1978	66 277	2014	939 923
1979	80 960	2015	867 071
1980	67 457	2016	869 241
1981	70 419	2017	859 055
1982	63 485	2018	797 221
1983	60 373	2019	760 355
1984	58 643	2020	716 902
1985	66 408		

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, 2016, 2018 and 2020) 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, 2013, 2015 and 2017) are estimated by linear interpolation. 2019 waste generation rate of previous submission is recalculated by interpolation method due to availability of 2020 IW data. 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, 2016, 2018 and 2020) are obtained from TurkStat's *Manufacturing Industry Establishments Water, Wastewater and Waste Statistics Survey.* 2019 % to SWDS data of previous submission is recalculated by interpolation method due to availability of 2020 IW generated data. 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, 1990-2020

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	277 668.3	0.07	20 159.9	0.02	4.8
1999	254 119.1	0.07	17 162.1	0.04	7.3
2000	273 085.5	0.06	17 058.9	0.06	10.4
2001	202 503.5	0.06	11 663.7	0.05	5.6
2002	238 145.1	0.05	12 557.0	0.03	4.4
2003	316 561.0	0.05	15 150.2	0.02	3.3
2004	407 020.8	0.04	17 497.5	0.01	1.6
2005	504 753.8	0.04	18 286.1	0.01	2.7
2006	552 366.9	0.03	16 276.2	0.02	3.3
2007	683 020.2	0.02	15 507.9	0.03	4.0
2008	782 865.0	0.02	12 481.6	0.03	3.9
2009	651 543.4	0.02	10 794.8	0.03	3.4
2010	777 460.5	0.02	13 366.5	0.03	4.2
2011	837 924.3	0.02	14 086.6	0.03	4.5
2012	877 675.6	0.02	14 420.3	0.03	4.7
2013	958 125.3	0.02	15 890.2	0.04	5.7
2014	939 922.9	0.02	15 733.5	0.04	6.1
2015	867 071.4	0.02	15 370.1	0.03	4.0
2016	869 240.6	0.02	16 266.7	0.01	2.1
2017	859 055.3	0.02	20 366.0	0.01	2.8
2018	797 221.0	0.03	22 881.1	0.01	3.4
2019	760 355.0	0.03	23 568.8	0.02	4.5
2020	716 901.7	0.03	23 867.9	0.02	5.5

Methane Correction Factor (MCF)

Due to the assumption that all managed SWDS are categorized under anaerobic managed SWDS, the default MCF from the 2006 IPCC Guidelines for anaerobic managed SWDS (1.0) is taken for managed SWDS. Since there is no information about classification of deep (>=5 meters waste and/or high water table) or shallow (<5 meters waste) for unmanaged waste disposal sites, Türkiye has used the average of the default MCFs for unmanaged-deep (0.8) and unmanaged-shallow (0.4) in the absence of country-specific information for unmanaged waste disposal practices (0.6).

A weighted average of MCF from the estimated distribution of site types is needed for the calculation CH_4 emissions from solid waste disposal sites. Calculated values for the MCF are given in Table 7.14.

Table 7.14 Weighted averages of MCF, 1990-2020

(weighted average fraction)

Year	MCF for MSW	MCF for IW	MCF for SS	MCF for CW
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	0.79	0.89
2018	0.91	0.60	0.81	0.88
2019	0.91	0.60	0.82	0.89
2020	0.92	0.60	0.83	0.85

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)

Waste Type	Food waste	Garden	Paper	Wood	Textiles
DOC	0.15	0.20	0.40	0.24	0.24

DOC by weight is calculated from the degradable portion of the MSW based on *Equation 3.7 in the 2006 IPCC, Volume 5, Chapter 3* and the IPCC defaults are taken from *Table 2.4 in the 2006 IPCC, Volume 5, Chapter2*.

$$\% \, DOC\ (by\ net\ weight) = (0.15\ x\ A) + (0.20\ x\ B) + (0.40\ x\ C) + (0.24\ x\ D) + (0.24\ x\ E)$$

Where:

A = fraction of food waste in MSW

B = fraction of garden waste in MSW

C = fraction of paper in MSW

D = fraction of wood in MSW

E = fraction of textiles in MSW

The calculated values of DOC by weight for the inventory years of 1990-2020 are listed below in Table 7.16.

Table 7.16 DOC by weight, 1990-2020

Year	%DOC	Year	%DOC
1990	13.01	2006	13.22
1991	13.00	2007	13.10
1992	12.99	2008	13.04
1993	12.96	2009	12.98
1994	12.99	2010	12.92
1995	13.01	2011	13.23
1996	13.03	2012	13.19
1997	13.05	2013	13.13
1998	13.06	2014	12.61
1999	13.08	2015	13.44
2000	13.10	2016	14.15
2001	13.12	2017	13.61
2002	13.13	2018	13.54
2003	13.15	2019	13.49
2004	13.09	2020	13.29
2005	13.12		

Fraction of Degradable Organic Carbon Which Decomposes (DOC_f): In the absence of country-specific information, the recommended IPCC default value for DOC_f (0.5) is used for the entire time series.

Methane Generation Rate Constant (k): IPCC default methane generation rate constants are selected according to the IPCC climate zone definitions in the model. Default k values for dry temperate are listed below and applied for the entire time series.

Table 7.17 Dry temperate k values by waste type

(years^{-1})

Waste Type	Food waste	Garden	Paper	Wood	Textiles
k	0.06	0.05	0.04	0.02	0.04

Fraction of Methane in Generated Landfill Gas (F): Most waste in SWDS generates a gas with approximately 50% CH_4. The IPCC default value for the fraction of CH_4 in landfill gas (0.5) is used for the entire time series.

Oxidation Factor (OX): The oxidation factor reflects the amount of CH_4 from SWDS that is oxidized in the soil or other material covering the waste. The IPCC default value for OX is zero for managed, unmanaged and uncategorized SWDS and this is the value applied by Türkiye 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 Türkiye 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/heat 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/heat 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; such as information obtained from the facility, the information from the most recent (biennial) survey *(i.e. Waste Disposal and Recovery Facilities Survey, 2020)*. The emissions from energy production from the recovered CH_4 gas in SWDS were included in the category of Public Electricity and Heat Production (1.A.1.a).

The number of managed and unmanaged SWDS with landfill gas recovery and the amount of recovered methane, by year, are given in Table 7.18.

Table 7.18 Methane recovery, 1990-2020

Year	Number of managed SWDS with landfill gas recovery	Number of unmanaged SWDS with landfill gas recovery	Recovered methane in managed SWDS (kt)	Recovered methane in unmanaged SWDS (kt)
1990-2001	NA	NA	NO	NO
2002	1	NA	1.5	NO
2003	1	NA	2.5	NO
2004	1	NA	2.3	NO
2005	1	NA	1.7	NO
2006	1	NA	2.2	NO
2007	2	NA	4.9	NO
2008	3	NA	11.8	NO
2009	4	NA	25.8	NO
2010	5	NA	36.3	NO
2011	8	NA	39.4	NO
2012	13	NA	68.6	NO
2013	15	1	109.5	4.4
2014	17	1	128.1	4.0
2015	24	1	126.8	4.0
2016	34	1	169.0	3.0
2017	35	1	214.3	7.9
2018	47	1	237.9	6.5
2019	50	2	284.0	7.0
2020	64	1	300.8	2.2

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, 2020*. In response to the aforementioned survey, there is still no official data on landfill gas flaring. It will be also considered in the upcoming inventory in the case that new information is obtained.

Sewage Sludge

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. The source of sewage sludge is TurkStat's *Municipal Wastewater Statistics Survey.* In this survey, disposal methods named 'Dumping on to land', 'Municipal dumping sites', 'Controlled landfill sites', 'Buried' and 'Other' are added together and assumed as the total sludge that stored in SWDS and each sludge amount can be seen from Table 7.37 in Wastewater Treatment and Discharge part (Category 5.D)

Methane emissions from sewage sludge are listed below in Table 7.19.

Table 7.19 CH_4 generated from SS at SWDS, 1990-2020

(kt)

Year	Total	Managed	Unmanaged
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
2018	1.793	0.963	0.830
2019	1.818	0.990	0.828
2020	1.829	1.010	0.819

Table 7.20 Annual SS and distribution of waste by management type, 1990-2020

	Annual SS at the SWDS (kt)			Distribution of waste (%)	
Year	**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	180.7	84.2	96.5	46.6	53.4
2018	165.2	85.4	79.8	51.7	48.3
2019	147.5	80.5	67.0	54.6	45.4
2020	129.8	75.6	54.2	58.2	41.8

Clinical Waste

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.

Since 2017, Medical Waste Statistics have been prepared and published annually using medical waste data from the health institutions (university, maternity and general purpose hospitals and their clinics) included in the administrative records of the Ministry of Environment, Urbanization and Climate Change.

Methane emissions caused by clinical waste are quite small as seen in Table 7.21.

Table 7.21 CH_4 generated from CW at SWDS, 1990-2020

(kt)

Year	**Total**	**Managed**	**Unmanaged**
1990-2003	IE	IE	IE
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
2018	1.4	1.1	0.3
2019	1.5	1.2	0.3
2020	1.6	1.3	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, 1990-2020

	Annual CW at the SWDS (kt)			Distribution of waste (%)	
Year	**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	78.4	56.3	22.0	71.9	28.1
2018	82.6	58.2	24.3	70.5	29.5
2019	83.0	60.1	22.9	72.4	27.6
2020	99.4	62.0	37.4	62.4	37.6

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 Türkiye 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.*

In 2019 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_4 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 the QA/QC plan of Türkiye.

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.

Moreover, a QA work was conducted by an external reviewer (expert from CITEPA - Technical Reference Center for Air Pollution and Climate Change) for this category in December 2019.

Recalculation:

2019 data of MSW disposed in managed SWDS has been recalculated by linear interpolation due to availability of 2020 survey data. The amount of MSW disposed in unmanaged SWDS for 2019 was also affected by this recalculation.

2019 waste composition data, assumed the same as 2018 data in the previous submission, is revised with the survey data.

2019 waste generation rate of previous submission is recalculated by interpolation method due to availability of 2020 IW data. A minor reason for the recalculation is updating the GDP data for 2018 and 2019. 2019 % to SWDS data of previous submission is also recalculated by interpolation method due to availability of 2020 IW generated data.

Mainly, methane recovery data from some landfill gas recovery facilities (including one of the largest facilities) has been recalculated for the years 2007-2019 as a result of verification and comparison activities for the quantity of methane in the recovered landfill gas.

In summary, total CH_4 emissions from solid waste disposal sites have been recalculated between the years 2007 and 2019. Compared to the previous inventory submission, CH_4 emissions from Solid Waste Disposal increased by 35.7 per cent (2 896 kt CO_2 eq.) in 2019, mainly due to decrease of methane recovery. There is no recalculation for 1990.

Planned Improvement:

As noted above, a question has been asked about the flaring of landfill gas in the *Waste Disposal and Recovery Facilities Survey, 2020.* According to the results of the survey, it has been determined that there is no flaring at the waste disposal sites in Türkiye. The results of the next survey *(Waste Disposal and Recovery Facilities Survey, 2022)* 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. Türkiye reports CH_4 and N_2O emissions from composting of municipal solid waste (5.B.1). Türkiye has no information available on the existence of anaerobic digestion of organic waste. Therefore, consistent with the 2006 IPCC Guidelines, Türkiye 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.

The total biological treatment of solid waste emissions for both gases increased by 27.6% (4.4 kt CO_2 eq.) between 1990 (16.1 kt CO_2 eq.) and 2020 (20.5 kt CO_2 eq.).

Methodological Issues:

To estimate both CH_4 and N_2O emissions for composting, Türkiye multiples the mass of organic waste composted by a default emission factor (the IPCC T1 method), as recommended in the 2006 IPCC Guidelines for National GHG Inventories. The CH_4 and N_2O emissions of biological treatment can be estimated using the default method based on *Equations 4.1 and 4.2 in 2006 IPCC, Volume 5, Chapter 4* as given below.

$$CH_4\ Emissions = \sum_i (M_i \bullet EF_i) \bullet 10^{-3} - R$$

Where:

CH_4 Emissions = total CH_4 emissions in inventory year, Gg CH_4

M_i = mass of organic waste treated by biological treatment type i, Gg

EF = emission factor for treatment i, g CH_4/kg waste treated

i = composting or anaerobic digestion

R = total amount of CH_4 recovered in inventory year, Gg CH_4

$$N_2O\ Emissions = \sum_i (M_i \bullet EF_i) \bullet 10^{-3}$$

Where:

N_2O Emissions = total N_2O emissions in inventory year, Gg N_2O

M_i = mass of organic waste treated by biological treatment type i, Gg

EF = emission factor for treatment i, g N_2O/kg waste treated

i = composting or anaerobic digestion

Collection of Activity Data

The amount of municipal solid waste delivered to composting plants (1994-1998, 2001-2004, 2006, 2008, 2010, 2012, 2014, 2016, 2018 and 2020) are available in TurkStat's *Municipal Waste Statistics* as provided in Table 7.5. Remaining years are estimated with linear interpolation method except 1990-1993 period. For this beginning period, data was considered the same as for 1994. However, this data is the "amount of waste delivered to composting plants" not the "amount of waste treated by composting plants". Using this data directly will cause overestimation problem. On the other hand, the composted waste data are available in TurkStat's *Municipal Waste Statistics* for the years 2006, 2008 and 2010, and in TurkStat's *Waste Disposal and Recovery Facilities Statistics* for the years 2005, 2012, 2014, 2016, 2018 and 2020. For aforementioned years, composted waste amounts are taken into account instead of delivered amounts. The 2005 survey data is the oldest reliable data since it is asked to both municipalities and composting plants. Thus, for 2005, The 'fraction of waste composted' is calculated as the "amount of waste treated by composting plants" divided by the "amount of waste delivered to composting plants" in order to understand the "amount of waste treated by composting plants" is how much smaller than "amount of waste delivered to composting plants" to estimate the earlier years before 2001. Because after 2001, TurkStat has the composted waste data of the composting plant with the largest share. The "amount of waste treated by composting plants" is approximately the half of the "amount of waste delivered to composting plants" in 2005 (0.49). This 'fraction of waste composted' is used as a multiplier for 1990-2000 period with the "amount of waste delivered to composting plants" survey data.

Since 2001, the composting plant with the largest share is located in Istanbul, which is the largest city of Türkiye in terms of population. The data of this composting plant has been collected directly by sending official letters to the facility itself. These data of the biggest composting plant are not used directly for the total amount of waste composted because at that time it would have caused underestimation problem. Those available data are used as surrogate data (as one of the recommended splicing techniques in 2006 IPCC Guidelines) with the survey data mentioned above, to avoid overestimation problem resulting from using the "amount of waste delivered to composting plants" survey data for generating a complete time series.

To summarize the activity data described in detail above, 1990-2000 data were estimated by using the 'fraction of waste composted'. 2001-2013 data were obtained by estimating from surrogate data. However, if available, survey data were used instead of surrogate data estimations (2005 and 2012). 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 for the years without survey (2015, 2017 and 2019). Thus, a complete time series was obtained with the available survey data (2014, 2016, 2018 and 2020).

The number of facilities operating each year and the total capacity of composting plants for each year in Türkiye is indicated below.

Table 7.23 Number and total capacity of composting plants, 1994-2020

Year	# of composting plants with installed capacity	# of operating composting plants	Capacity (thousand tonnes/year)
1994-1998	2	NA	245
2001	3	NA	299
2002	4	NA	664
2003	5	NA	667
2004	5	NA	667
2005	4	NA	606
2006	4	NA	605
2008	4	NA	551
2010	5	NA	556
2012	6	6	389
2014	4	3	310
2015	4	3(3)	310
2016	7	5	424
2017	7	5(3)	424
2018	8	6	483
2019	8	6(3)	483
2020	9	8	646

Source: (1) TurkStat, Municipal Waste Statistics, 1994-2010
(2) TurkStat, Waste Disposal and Recovery Facilities Statistics, 2012-2020
(3) Administrative records obtained by official letters

The number of composting plants with installed capacity and the operating ones are provided separately for available years in Table 7.23. Since the official data (number of facilities) of the survey indicates the number of composting plants with installed capacity, not those active ones in the relevant press releases, precise information on the number of facilities operating by year is not available before 2012. For years without survey (2015, 2017 and 2019), the number and total capacity of composting plants with installed capacity are assumed to be the same as the previous year.

Choice of Emission Factor

EFs of 4.0 g CH_4/kg waste treated (on a wet weight basis) and 0.24 g N_2O/kg waste treated (on a wet weight basis) are selected for the estimates of CH_4 and N_2O emissions respectively, based on *Table 4.1 in the 2006 IPCC Guidelines, Volume 5, Chapter 4.*

The 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_4 and N_2O emissions from composting, 1990-2020

(kt)

Year	Amount of waste treated by composting plants	CH_4 Emissions	N_2O Emissions
1990-94	93.7	0.37	0.022
1995	77.5	0.31	0.019
1996	87.2	0.35	0.021
1997	87.9	0.35	0.021
1998	81.1	0.32	0.019
1999	89.5	0.36	0.021
2000	97.9	0.39	0.023
2001	122.6	0.49	0.029
2002	186.2	0.74	0.045
2003	221.2	0.88	0.053
2004	182.4	0.73	0.044
2005	165.4	0.66	0.040
2006	153.4	0.61	0.037
2007	176.7	0.71	0.042
2008	153.8	0.62	0.037
2009	137.8	0.55	0.033
2010	174.6	0.70	0.042
2011	169.6	0.68	0.041
2012	158.9	0.64	0.038
2013	120.4	0.48	0.029
2014	128.0	0.51	0.031
2015	135.4	0.54	0.032
2016	140.3	0.56	0.034
2017	134.1	0.54	0.032
2018	119.2	0.48	0.029
2019	127.6	0.51	0.031
2020	119.5	0.48	0.029

As seen in Figure 7.3, Figure 7.4 and Figure 7.5, the fluctuations of CH_4 and N_2O emissions from composting depend mainly on fluctuations of the amount of waste treated by composting plants (AD). Emissions were relatively stable between 1990 and 2000 due to the same number of operating facilities during that period. A remarkable increase was observed when the dominant facility became operational after 2001. Fluctuations have been observed in recent years due to the change in the number of facilities operating in those years, as provided in Table 7.23.

CH_4 emissions have a maximum value of 0.88 kt in 2003 while having a minimum value of 0.31 kt in 1995. Likewise, N_2O emissions have a maximum value of 0.053 kt in 2003 while having a minimum value of 0.019 kt in 1995.

Figure 7.3 Amount of waste treated by composting plants, 1990-2020

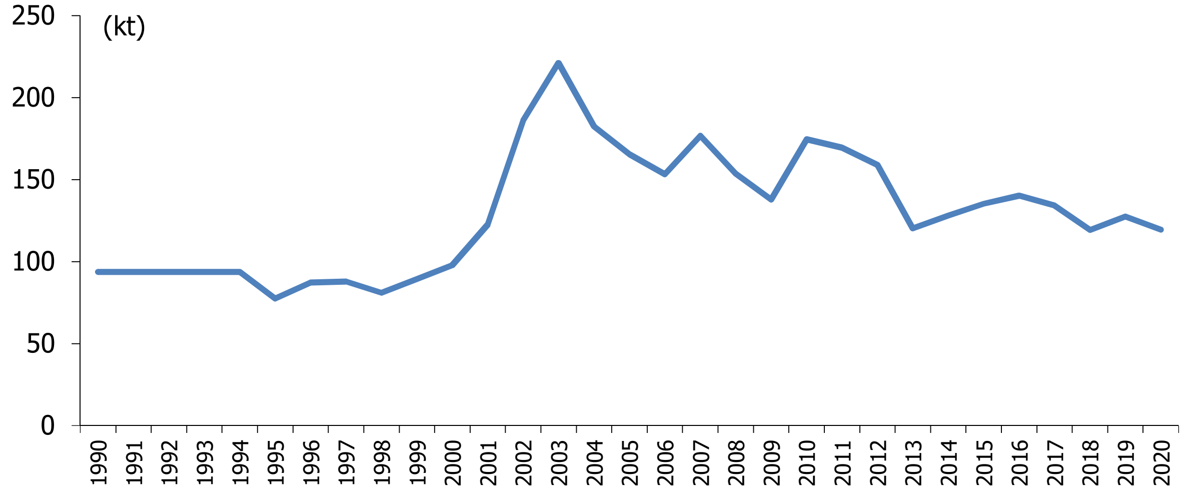


Figure 7.4 CH_4 emissions from composting, 1990-2020

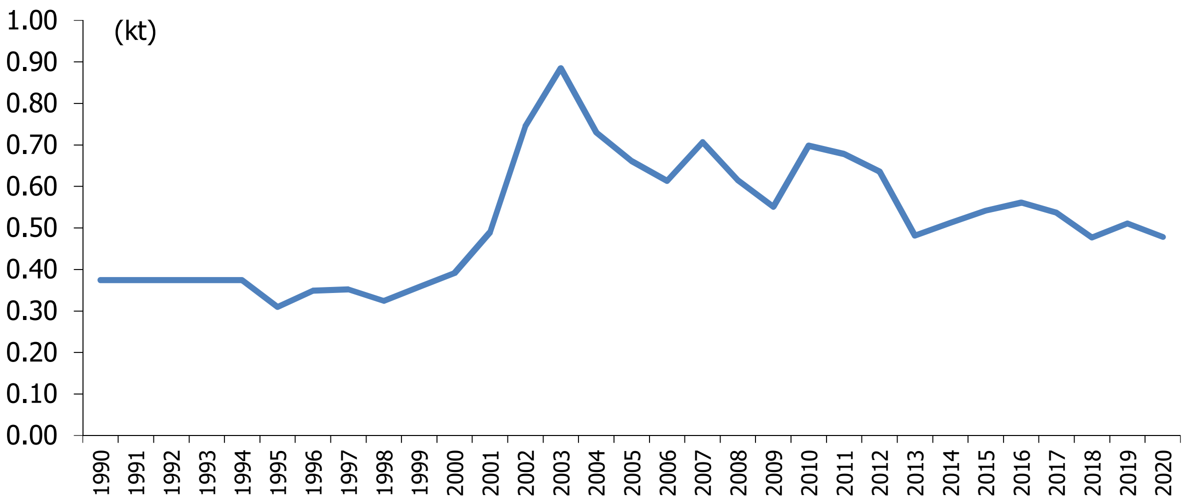
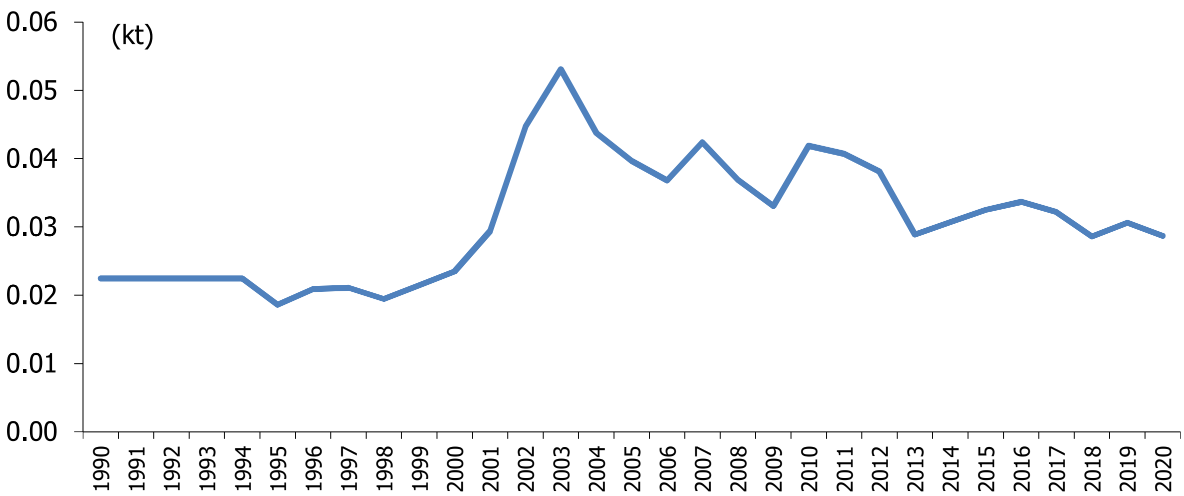


Figure 7.5 N_2O emissions from composting, 1990-2020



Uncertainties and Time-Series Consistency:

The uncertainty value for AD is estimated as 10.0% based on *Table 3.5 in the 2006 IPCC Guidelines, Volume 5, Chapter 3*. The uncertainty value of the EF is considered as 20.0% for both CH_4 and N_2O EFs since there is no sufficient information in 2006 IPCC.

The Biological treatment of solid waste category employed a Monte Carlo uncertainty analysis which causes a combined uncertainty range ±22.2% for CH_4 emissions and +50% for N_2O emissions in 2019 submission. 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 are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

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.

Moreover, a QA work was conducted by an external reviewer (expert from CITEPA - Technical Reference Center for Air Pollution and Climate Change) for this category in December 2019.

Recalculation:

There is no recalculation for this category in this submission.

Planned Improvement:

Emissions and amount of CH_4 for energy recovery from anaerobic digestion at biogas facilities (5.B.2) will be included in next inventory submissions depending on the availability of such treatment processes. Türkiye 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, Türkiye intends to estimate these emissions.

7.4. Incineration and Open Burning of Waste (Category 5.C)

Source Category Description:

This category includes emissions from open burning of waste. The category covers CO_2, CH_4 and N_2O emissions from open burning of waste (5.C.2) which is divided into waste of biogenic origin (5.C.2.1) and waste of non-biogenic origin (5.C.2.2). Only municipal solid waste is open burned in Türkiye (5.C.2.2.a). CO_2 emissions from waste of biogenic origin are reported but not counted as part of the national total GHG emissions. Unlike CO_2, emissions of CH_4 and N_2O from biogenic derived wastes are estimated and accounted for under the waste sector.

Emissions from waste incineration (5.C.1) are included in the inventory but reported in the energy sector since the purpose of waste incineration is for energy recovery. Emissions from MSW of biogenic origin (5.C.1.1.a) and MSW of non-biogenic origin (5.C.1.2.a) are not occurring since MSW is not incinerated in the incineration plants in Türkiye.

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 93.1% (97.9 kt CO_2 eq.) between 1990 to 2020. The main reason of this negative trend is the decreasing amount of waste open-burned by years, especially with a sharp decline in 2014 after the law of Ministry of Environment, Urbanization and Climate Change.

Methodological Issues:

The IPCC Tier 2a method recommended in the 2006 IPCC Guidelines for National GHG Inventories is applied to estimate CO_2 emissions. As elaborated below, Türkiye multiplies the amount of waste types open-burned (wet weight) by the dry matter content, the fossil carbon fraction and an oxidation factor. To estimate CH_4 and N_2O emissions, IPCC default emission factors are multiplied by the amount of waste open-burned (the IPCC T1 method in the 2006 IPCC Guidelines).

CO_2 Emissions

The CO_2 emissions from open burning of waste are estimated on the basis of waste types/material (such as paper, wood, plastics) in the waste open-burned as given in *Equation 5.2 in the 2006 IPCC Guidelines, Volume 5, Chapter 5.*

$$CO_2\ Emissions = MSW \bullet \sum_j \left(WF_j \bullet dm_j \bullet CF_j \bullet FCF_j \bullet OF_j\right) \bullet 44/12$$

Where:

CO_2 Emissions = CO_2 emissions in inventory year, Gg/yr

MSW = total amount of municipal solid waste as wet weight open-burned, Gg/yr

WF_j = fraction of waste type/material of component j in the MSW (as wet weight open-burned)

dm_j = dry matter content in the component j of the MSW open-burned, (fraction)

CF_j = fraction of carbon in the dry matter (i.e., carbon content) of component j

FCF_j = fraction of fossil carbon in the total carbon of component j

OF_j = oxidation factor, (fraction)

44/12 = conversion factor from C to CO_2

j = component of the MSW open-burned such as paper/cardboard, textiles, food waste, wood, garden (yard) and park waste, disposable nappies, rubber and leather, plastics, metal, glass, other inert waste.

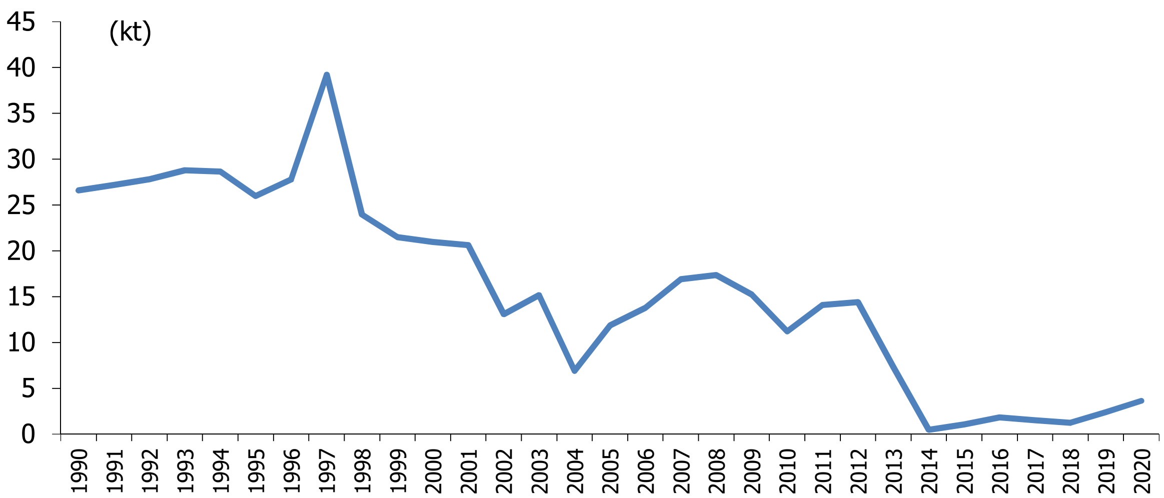
The biogenic CO_2 emissions from open burning should not be included in national total emission estimates according to the information given in *2006 IPCC, Volume 5, Chapter 5, Section 5.1* as in Table 7.25. Total CO_2 emissions from open burning fluctuate between 1990-2020 as shown in Figure 7.6.

Table 7.25 CO_2 emissions from open burning of waste, 1990-2020

(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	1.54	0.009	1.54
2018	1.24	0.006	1.24
2019	2.38	0.011	2.38
2020	3.62	0.017	3.62

Figure 7.6 CO_2 emissions from open burning of waste, 1990-2020



CH_4 Emissions

The calculation of CH_4 emissions is based on the amount of waste open-burned and on the related emission factor as given in *Equation 5.4 in the 2006 IPCC Guidelines, Volume 5, Chapter 5.*

$$CH_4\ Emissions = \sum_i (IW_i \bullet EF_i) \bullet 10^{-6}$$

Where:

CH_4 Emissions = CH_4 emissions in inventory year, Gg/yr

IW_i = amount of solid waste of type i open-burned, Gg/yr

EF_i = aggregate CH4 emission factor, kg CH_4/Gg of waste

10^{-6} = conversion factor from kilogram to gigagram

i = category or type of waste open-burned, specified as follows:

MSW: municipal solid waste, ISW: industrial solid waste, HW: hazardous waste,

CW: clinical waste, SS: sewage sludge, others (that must be specified)

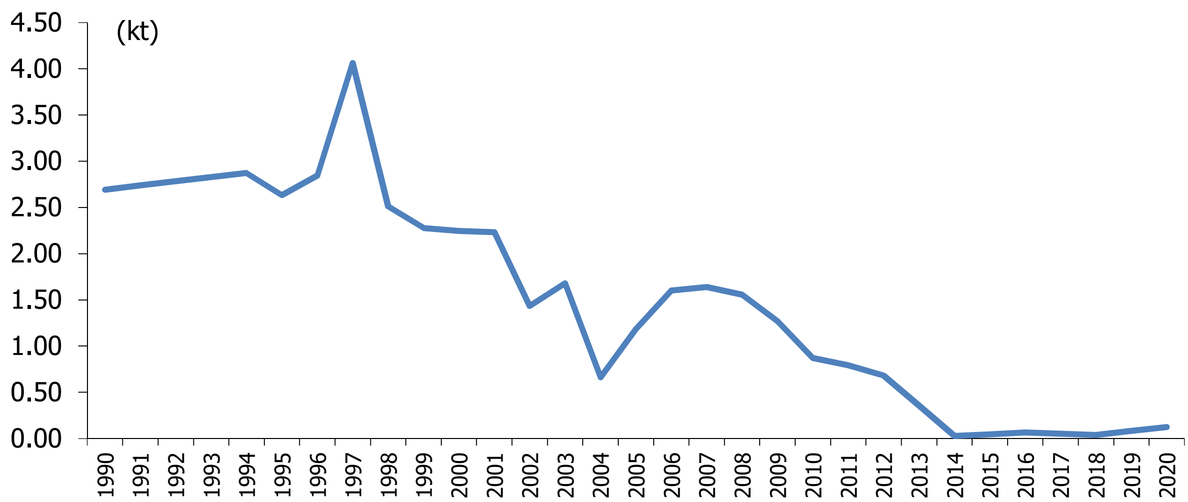
Estimated results of CH_4 emissions are given in Table 7.26 and Figure 7.7. The CH_4 emissions show a decreasing trend with the same fluctuations as with AD between 1990 and 2020 as can be seen in Figure 7.9 below.

Table 7.26 CH_4 emissions from open burning of waste, 1990-2020

(kt)

Year	Total	Biogenic	Non-biogenic
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	0.05	0.04	0.02
2018	0.04	0.03	0.01
2019	0.08	0.06	0.03
2020	0.12	0.08	0.04

Figure 7.7 CH_4 emissions from open burning of waste, 1990-2020



N_2O Emissions

The calculation of N_2O emissions is based on the amount of waste open-burned and a default emission factor as given in *Equation 5.5 in the 2006 IPCC Guidelines, Volume 5, Chapter 5.*

$$N_2O\ Emissions = \sum_i (IW_i \bullet EF_i) \bullet 10^{-6}$$

Where:

N_2O Emissions = N_2O emissions in inventory year, Gg/yr

IW_i = amount of open-burned waste of type i, Gg/yr

EF_i = N_2O emission factor (kg N_2O/Gg of waste) for waste of type i

10^{-6} = conversion from kilogram to gigagram

i = category or type of waste open-burned, specified as follows:

MSW: municipal solid waste, ISW: industrial solid waste, HW: hazardous waste,

CW: clinical waste, SS: sewage sludge, others (that must be specified)

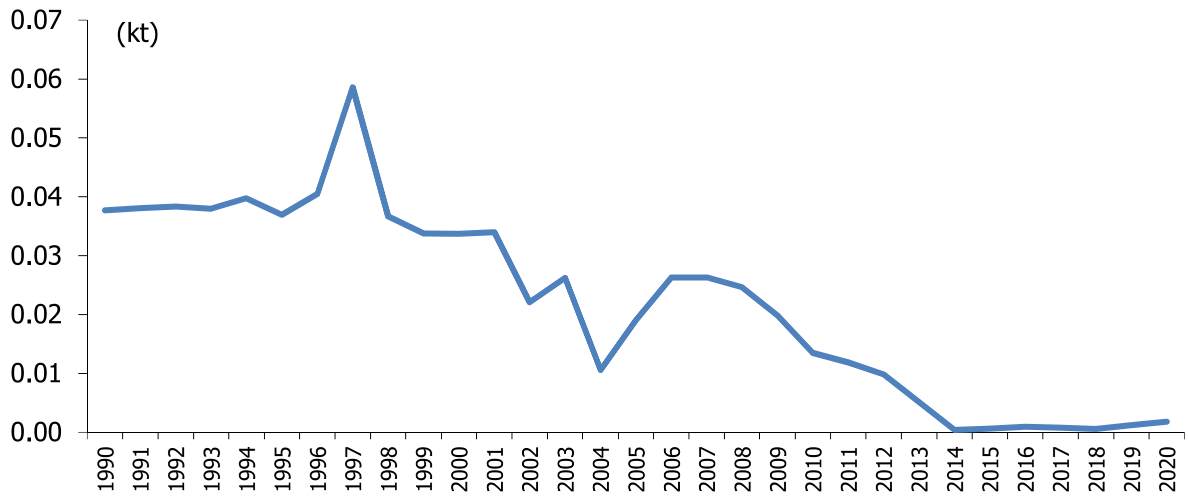
Estimated results of N_2O emissions from open burning of waste are given in Table 7.27 and Figure 7.8. As with CH_4 emissions, N_2O emissions have a decreasing trend with the same fluctuations as of AD between 1990 and 2020 as can be seen in Figure 7.9 below.

Table 7.27 N_2O emissions from open burning of waste, 1990-2020

(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	0.0008	0.0004	0.0004
2018	0.0006	0.0003	0.0003
2019	0.0012	0.0006	0.0006
2020	0.0018	0.0009	0.0009

Figure 7.8 N_2O emissions from open burning of waste, 1990-2020



Collection of Activity Data

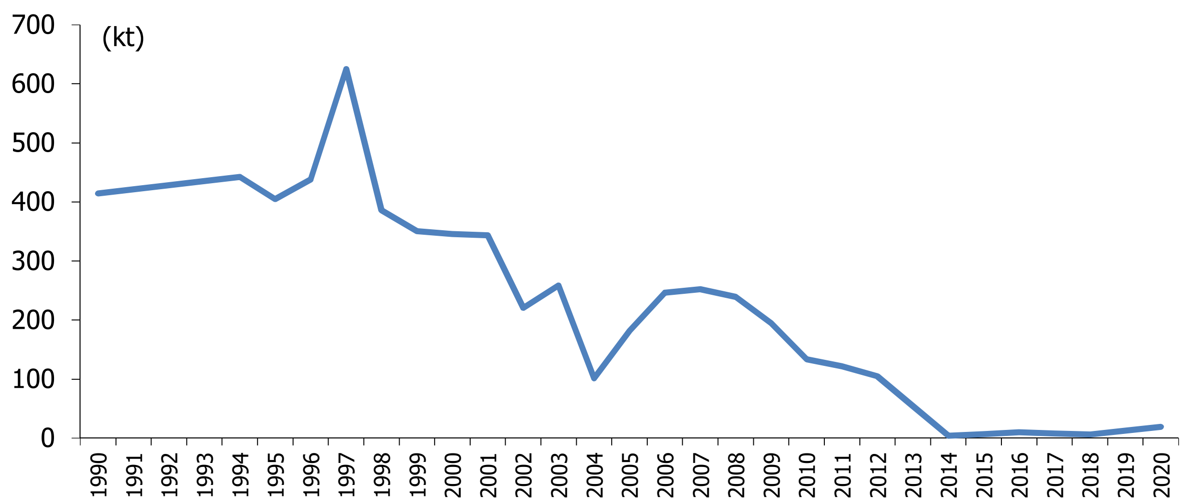
Activity data for open burning of MSW are estimated using the total amount of MSW open-burned (1994-1998, 2001-2004, 2006, 2008, 2010, 2012, 2014, 2016, 2018 and 2020) as obtained from TurkStat's *Municipal Waste Statistics Survey* as given in Table 7.5 and applying an estimate of the composition of MSW.

To calculate the total amount of MSW open-burned for the years not surveyed (1999, 2000, 2005, 2007, 2009, 2011, 2013, 2015, 2017 and 2019) 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, 2013, 2015 and 2017 are estimated by linear interpolation. The open-burned % of 2019 (0.04%) has been recalculated by linear interpolation due to availability of 2020 survey data. 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, 1990-2020

Year	Fraction of MSW open-burned (%)	Amount of MSW open-burned (kt)
1990	1.89	414.22
1991	1.89	421.24
1992	1.89	428.24
1993	1.89	435.21
1994	1.89	442.15
1995	1.49	405.03
1996	1.49	437.90
1997	1.96	625.14
1998	1.17	386.13
1999	1.15	350.34
2000	1.13	345.52
2001	1.11	343.59
2002	0.71	220.55
2003	0.83	258.53
2004	0.34	101.62
2005	0.58	182.05
2006	0.82	246.55
2007	0.83	252.12
2008	0.84	239.29
2009	0.65	194.95
2010	0.45	133.88
2011	0.40	121.98
2012	0.34	104.75
2013	0.18	54.72
2014	0.01	4.28
2015	0.02	6.86
2016	0.03	10.17
2017	0.02	8.18
2018	0.02	6.13
2019	0.04	12.69
2020	0.05	19.02

Figure 7.9 Total amount of MSW open-burned, 1990-2020



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, time series of MSW composition data (see Table 7.10) are used. Default dry matter content, total carbon content and fossil carbon fraction of different MSW components are given in Table 7.29 which is based on *Table 2.4 in the 2006 IPCC Guidelines, Volume 5, Chapter 2.*

Table 7.29 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	-
Wood	Biogenic	85.0	50.0	-
Garden and park waste	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 7.10 and the fractions of carbon content given in Table 7.29 above are used related to CO_2 emission factors*.* A default oxidation factor in % of carbon input (OF) is selected for MSW as 58.0% based on *Table 5.2 in 2006 IPCC, Volume 5, Chapter 5*.

The CH_4 emissions from open burning of waste are estimated using an EF of 6500 g CH_4 / t wet weight for both biogenic and non-biogenic origin of MSW as reported in the *2006 IPCC Guidelines, Volume 5, Chapter 5, Section 5.4.2*.

The N_2O emissions from open burning of waste are estimated using an EF of 150 g N_2O / t dry weight for MSW according to the *2006 IPCC Guidelines, Volume 5, Chapter 5, Table 5.6.* Since the related EF refers to dry weight, the weight of waste open-burned is converted from wet weight to dry weight as reported in the *2006 IPCC Guidelines, Volume 5, Chapter 5, Section 5.3.3* for MSW of both biogenic and non-biogenic origin.

Uncertainties and Time-Series Consistency:

The uncertainty value for AD is estimated as 30.4%. The uncertainty value of the CO_2 EF is considered as 40.0%. Since default values for CH_4 and N_2O EFs are used, the uncertainty values of ± 100% are estimated for both EFs as recommended in the *2006 IPCC Guidelines, Volume 5, Chapter 5, Section 5.7.1.*

An uncertainty analysis using the Monte Carlo technique was carried out to estimate emissions of CO_2 for 5.C category and also to other waste categories in 2019 submission. Combined uncertainty in CO_2 emissions in 2017 is estimated at ±41.88%, CH_4 emissions is estimated as -85.71% to +114.29% and in N_2O 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 the QA/QC plan of Türkiye.

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.

Moreover, a QA work was conducted by an external reviewer (expert from CITEPA - Technical Reference Center for Air Pollution and Climate Change) for this category in December 2019.

Recalculation:

2019 data for the fraction of MSW open-burned has been recalculated by linear interpolation due to availability of 2020 survey data from TurkStat's *Municipal Waste Statistics Survey*. As stated in the "Recalculation" section of Category 5.A above; 2019 waste composition data was revised with the acquisition of survey data. Therefore, Category 5.C emission estimations for 2019 were also affected by this recalculation.

There is only recalculation for 2019. Compared to previous inventory submission; in 2019, CO_2 emissions increased by 91.9% (1.14 kt CO_2 eq.), CH_4 emissions increased by 107% (1.07 kt CO_2 eq.), and N_2O emissions increased by 111.4% (0.19 kt CO_2 eq.).

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_4 and N_2O emissions from wastewater treatment and discharge systems. Wastewater originates from domestic, commercial and industrial sources by treatment and disposal systems. Because of the IPCC methodology, emissions from commercial wastewater are estimated as part of domestic wastewater. Treatment and disposal types for domestic and industrial wastewater are separated into collected and uncollected systems. Each system is divided into untreated and treated systems. For collected systems; sea, river and lake discharge, and stagnant sewer are the untreated systems. Aerobic and anaerobic treatments are the main treated systems of sewered to plants. For uncollected systems; septic system is considered as treated and sea, river and lake discharge as untreated practices in Türkiye.

CH_4 emissions are estimated for both domestic wastewater (5.D.1) and industrial wastewater (5.D.2). N_2O emissions from 5.D.2 are also reported in 5.D.1.

Wastewater treatment and discharge emissions increased by 21.5% (908 kt CO_2 eq.) for the period 1990-2020, also increased by 2% (98.6 kt CO_2 eq.) between 2019 and 2020. Methane recovery in domestic wastewater treatment increased by 463.2% (635.6 kt CO_2 eq.) between 1998 (137.2 kt CO_2 eq.) and 2020 (772.9 kt CO_2 eq.).

Methodological Issues:

Methane Emissions from Wastewater

Methane Emissions from Domestic Wastewater

The IPCC T2 method of the 2006 IPCC Guidelines is applied to estimate CH_4 emissions from domestic wastewater. CH_4 emissions are estimated using *Equation 6.1 in the 2006 IPCC Guidelines, Volume 5, Chapter 6.*

$$CH_4\ Emissions = \left[\sum_{i,j}\left(U_i \bullet T_{i,j} \bullet EF_j\right)\right](TOW - S) - R$$

Where:

CH_4 Emissions = CH_4 emissions in inventory year, kg CH_4/yr

TOW = total organics in wastewater in inventory year, kg BOD/yr

S = organic component removed as sludge in inventory year, kg BOD/yr

U_i = fraction of population in income group in inventory year

$T_{i,j}$= degree of utilisation of treatment/discharge pathway or system, j, for each income group fraction in inventory year

i = income group: rural, urban high income and urban low income

j = each treatment/discharge pathway or system

EF_j = emission factor, kg CH_4 / kg BOD

R = amount of CH_4 recovered in inventory year, kg CH_4/yr

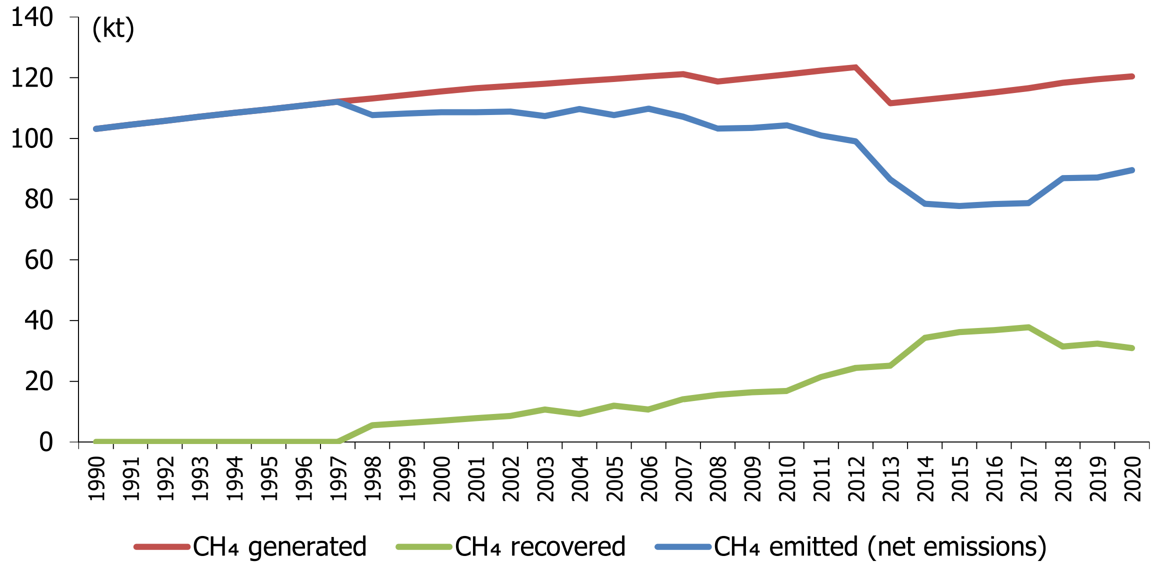
Total CH_4 emissions are estimated based on country-specific information on the total organics in wastewater minus the total amount of sludge and multiplying by the IPCC default emission factor, corrected for country-specific fractions of urban/rural populations and the fraction of the wastewater utilizing the various discharge pathways. The amount of methane generated, methane recovered and net methane emissions are estimated as given in Table 7.30 and Figure 7.10.

Table 7.30 CH_4 generated, recovered and emitted from domestic wastewater, 1990-2020

(kt)

Year	CH_4 Generated	CH_4 Recovered	CH_4 Emitted
1990	103.2	NO	103.2
1991	104.5	NO	104.5
1992	105.8	NO	105.8
1993	107.1	NO	107.1
1994	108.4	NO	108.4
1995	109.7	NO	109.7
1996	110.9	NO	110.9
1997	112.1	NO	112.1
1998	113.2	5.5	107.8
1999	114.4	6.2	108.2
2000	115.6	6.9	108.6
2001	116.5	7.8	108.7
2002	117.4	8.5	108.8
2003	118.1	10.7	107.4
2004	118.8	9.2	109.7
2005	119.6	11.9	107.7
2006	120.4	10.7	109.8
2007	121.2	14.1	107.2
2008	118.8	15.5	103.3
2009	119.9	16.4	103.5
2010	121.1	16.8	104.3
2011	122.4	21.5	100.9
2012	123.5	24.4	99.0
2013	111.6	25.1	86.5
2014	112.7	34.3	78.5
2015	113.9	36.1	77.8
2016	115.2	36.9	78.4
2017	116.5	37.8	78.7
2018	118.4	31.4	87.0
2019	119.5	32.4	87.2
2020	120.5	30.9	89.6

Figure 7.10 CH_4 emissions from domestic wastewater, 1990-2020



The key drivers for the decreasing trend in net emissions are the increasing of methane recovery after the beginning year of 1998. Despite having an increasing trend normally, the main reasons for the sharp decreases in generated methane in the years of 2008 and 2013 are the administrative division changes in the proportion of urban and rural population in 2008 and 2013.

Collection of Activity Data

To calculate CH_4 emissions from domestic wastewater, total organics in wastewater (TOW) and organic component removed as sludge (S) are needed. The TOW is calculated using *Equation 6.3 in the 2006 IPCC Guidelines, Volume 5, Chapter 6.*

$$TOW = P \bullet BOD \bullet 0.001 \bullet I \bullet 365$$

Where:

TOW = total organics in wastewater in inventory year, kg BOD/yr

P = country population in inventory year, (person)

BOD = country-specific per capita BOD in inventory year, g/person/day,

0.001 = conversion from grams BOD to kg BOD

I = correction factor for additional industrial BOD discharged into sewers (for collected the default is 1.25, for uncollected the default is 1.00.)

The total population is used to calculate TOW and S values. For the entire time series, the total population is taken from Turkstat's *Mid-year Population Estimations and Projections*. The total population is then divided into the rural and urban fractions to better characterize the discharge pathways for the domestic wastewater. For the years 1990 and 2000, rural and urban population are available from *General Population Censuses*. The results of *Address Based Population Registration System* are used from 2007 to 2020 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 7.31.

Table 7.31 Fraction of population and total, rural, urban population, 1990-2020

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	80 313 000	6 012 149	74 300 851
2018	7.7	92.3	81 407 000	6 291 257	75 115 743
2019	7.2	92.8	82 579 000	5 962 131	76 616 869
2020	7.0	93.0	83 385 000	5 862 196	77 522 804

The urban population consists of the total population of province and district centers and, rural population consists of the total population of towns and villages. The proportions of the population living in the province and district centers were 91.3% in 2013 and 93.0% in 2020 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 7.32.

Table 7.32 Total organics in wastewater (TOW) and organic component removed as sludge (S) for domestic wastewater, 1990-2020

		(kt BOD/yr)
Year	**TOW**	**S**
1990	1 066.3	563.3
1991	1 084.4	572.9
1992	1 102.4	582.4
1993	1 120.3	591.9
1994	1 138.2	601.3
1995	1 156.0	610.7
1996	1 173.7	620.1
1997	1 191.3	629.4
1998	1 208.4	638.4
1999	1 225.8	647.6
2000	1 243.3	656.8
2001	1 260.6	666.0
2002	1 276.8	674.6
2003	1 292.1	682.6
2004	1 307.7	690.9
2005	1 323.9	699.4
2006	1 340.5	708.2
2007	1 357.2	717.0
2008	1 374.5	726.2
2009	1 393.6	736.2
2010	1 414.9	747.5
2011	1 435.9	758.6
2012	1 454.3	768.3
2013	1 473.1	778.2
2014	1 493.1	788.8
2015	1 513.1	799.4
2016	1 533.6	810.2
2017	1 553.7	820.8
2018	1 574.8	832.0
2019	1 597.5	844.0
2020	1 613.1	852.2

Choice of Emission Factor

As given in *Equation 6.2 in the 2006 IPCC Guidelines, Volume 5, Chapter 6*, CH_4 EFs for each domestic wastewater treatment/discharge pathway or system are calculated by multiplying the default maximum CH_4 producing capacity (B_o) for domestic wastewater (0.6 kg CH_4/kg BOD) by the methane correction factor (MCF) for each type of treatment and discharge pathway or system, which is given in the *2006 IPCC Guidelines, Volume 5, Chapter 6, Table 6.3*.

$$EF_j = B_o \bullet MCF_j$$

Where:

EF_j = emission factor, kg CH_4/kg BOD

j = each treatment/discharge pathway or system

B_o = maximum CH_4 producing capacity, kg CH_4/kg BOD

MCF_j = methane correction factor (fraction)

To calculate country-specific values for the degrees of treatment utilization (T), by population class, the results of TurkStat's *Municipal Wastewater Statistics Survey, 2012* and *Sectoral Water and Wastewater Statistics Survey, 2012* are used. The degrees of utilizations are given in Table 7.33.

Table 7.33 Degrees of treatment utilization (T) by population class

Treatment or discharge system or pathway		T (%)
Rural	To sea, river and lake	0.43
	To aerobic plant, not well managed	0.44
	To septic systems	10.72
Urban	To sea, river and lake	15.43
	To aerobic plant, well managed	44.01
	To aerobic plant, not well managed	1.82
	To anaerobic digester for sludge	20.83
	To septic systems	6.31
Total		100.00

Weighted CH_4 EFs are calculated using CH_4 EFs by each type of treatment and discharge pathway or system and the fractional usage of different treatment systems by population class. Weighted CH_4 EFs for domestic wastewater with background data are given in Table 7.34.

Table 7.34 MCF, EFs, utilization degrees and weighted EFs by population class

Type of treatment and discharge path way or system	MCF	CH_4 EF	T (Rural)	T (Urban)
Untreated system				
Sea, river, lake discharge	0.10	0.06	0.0043	0.1543
Treated system				
Centralized, aerobic, well managed	0.00	0.00		0.4401
Centralized, aerobic, not well managed	0.30	0.18	0.0044	0.0182
Anaerobic digester for sludge	0.80	0.48		0.2083
Septic system	0.50	0.30	0.1072	0.0631
Total			**0.12**	**0.88**
Weighted CH_4 EFs (kg CH_4/kg BOD)			**0.29**	**0.15**

Methane Recovery

The recovery of methane and its subsequent utilization is also considered in the inventory. Methane recovery from biogas started to be implemented in Türkiye 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/heat 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/heat 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; such as information obtained from the facility, the information from the most recent (biennial) survey *(i.e. Municipal Wastewater Statistics Survey, 2020)*. The emissions of energy production from the recovered CH_4 gas in biogas facilities were included in the category of Public Electricity and Heat Production (1.A.1.a).

The number of biogas facilities in wastewater treatment plants and the amount of recovered methane by year are given in Table 7.35.

Table 7.35 Methane recovery, 1990-2020

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	21.5
2012	14	24.4
2013	18	25.1
2014	19	34.3
2015	20	36.1
2016	23	36.9
2017	23	37.8
2018	27	31.4
2019	26	32.4
2020	25	30.9

Sewage Sludge Balance

Sewage sludge is domestic wastewater treatment sludge originating from urban wastewater treatment plants operated by municipalities. Thus, the sewage sludge data are collected by TurkStat from Municipal Wastewater Statistics Survey which is applied to all municipalities. Data on the amount of sludge is compiled on a wet basis and converted to dry matter using coefficients in the guidance documents of the European Union Statistical Office (EUROSTAT). Also, data are compiled in accordance with the OECD / EUROSTAT - Wastewater statistics, environmental data and indicators data set.

As mentioned in Solid Waste Disposal section (Category 5.A), the disposal methods named 'Dumping onto land', 'Municipal dumping sites', 'Controlled landfill sites', 'Buried' and 'Other disposal' are added together and assumed as the total sludge that stored in SWDS.

For the sewage sludge balance, the amount of sewage sludge by disposal and recovery methods, please refer to Table 7.36.

Table 7.36 Amount of sewage sludge by disposal and recovery methods, 1994-2020 (1)

(t)

Year	Agricultural use	Released into sea	Dumping onto land	Municipal dumping sites	Released into lake	Released into river	Incineration with energy recovery	Controlled landfill sites	Buried	Other disposal(2)	Other recovery(3)
1994	12 546	321	0	1 494	0	0	0	0	0	26	0
1995	13 309	10	150	1 783	0	0	0	0	0	56	0
1996	12 322	0	40	1 931	0	0	0	20	10	2	0
1997	34 397	0	0	1 871	0	0	0	26	2	112	0
1998	49 555	0	2 029	10 125	297	0	0	6 627	487	0	0
2001	47 152	54	45	28 356	50	7 300	0	40 431	1 500	467	0
2002	26 445	1 095	274	31 189	4	0	1	55 789	8 378	37 560	0
2003	91 104	0	521	13 218	180	0	0	57 518	10 302	0	0
2004	81 795	0	2 760	12 345	48	1 000	0	92 085	2 154	36 128	0
2006	12 512	0	2 954	65 044	20 000	2 161	0	85 606	38 281	31 772	0
2008	17 118	0	9 480	58 026	0	3 074	2 082	104 846	12 890	67 350	0
2010	12 433	0	10 112	92 741	0	2 018	13 020	98 843	10 243	71 402	0
2012	11 412	0	19 456	107 989	0	22	29 952	101 143	2 517	45 906	0
2014	10 255	0	39 637	41 214	0	105	53 486	91 539	4 670	46 884	0
2016	9 261	0	7 023	62 733	0	0	93 939	83 005	278	43 057	0
2018	10 349	0	6 710	36 135	5	10	143 494	85 382	4 464	31 932	23
2020	3 423	0	14 460	38 971	0	1 040	135 782	75 571	207	29 561	15 310

Source: TurkStat, Municipal Wastewater Statistics

(1) Data on sludge amount is in dry matter.

(2) Includes other disposal operations, temporary storage, land treatment, surface impoundment etc.

(3) Includes other recovery operations.

Methane Emissions from Industrial Wastewater

This section deals with estimating CH_4 emissions from on-site industrial wastewater treatment. The IPCC T2 method of the 2006 IPCC Guidelines is applied to estimate CH_4 emissions from industrial wastewater. CH_4 emissions are estimated using *Equation 6.4 in the 2006 IPCC Guidelines, Volume 5, Chapter 6.*

$$CH_4\ Emissions = \sum_i [(TOW_i - S_i)\ EF_i - R_i]$$

Where:

CH_4 Emissions = CH_4 emissions in inventory year, kg CH_4/yr

TOW_i = total organically degradable material in wastewater from industry i in inventory year, kg COD/yr

i = industrial sector

S_i = organic component removed as sludge in inventory year, kg COD/yr

EF_i = emission factor for industry i, kg CH_4/kg COD

for treatment/discharge pathway or system(s) used in inventory year

R_i = amount of CH_4 recovered in inventory year, kg CH_4/yr

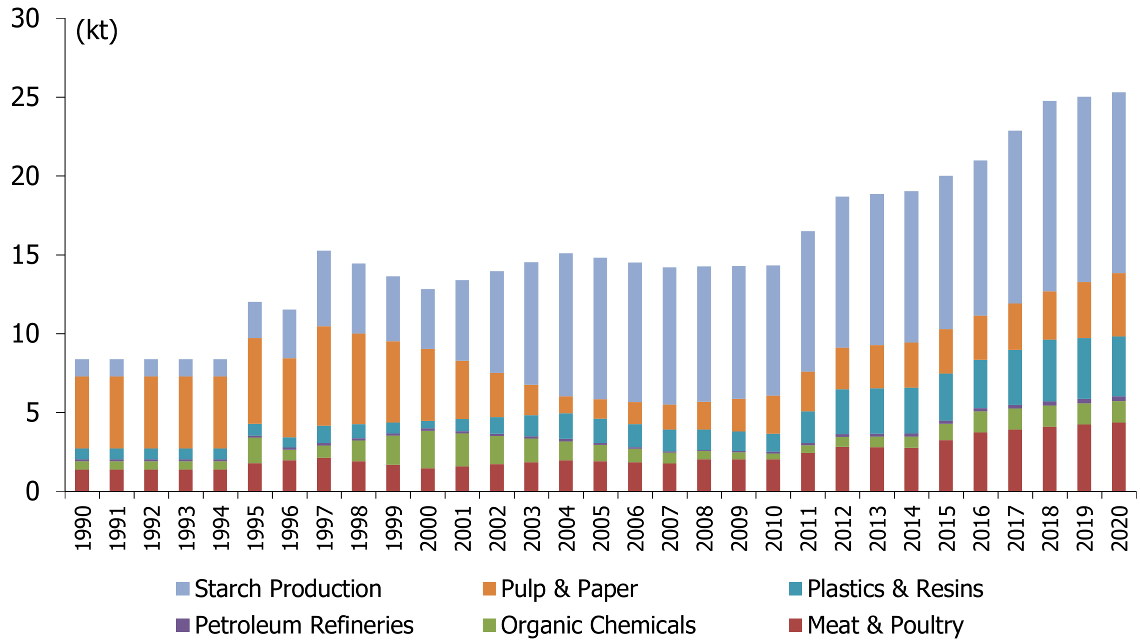
Specifically, the country-specific information on the total organically degradable material in wastewater, by industry, is multiplied by a specific emission factor that takes into account the relative use of various treatment/discharge pathways. There is no recovery of methane from industrial wastewater and sludge removal is assumed to be zero. Amount of methane emissions, by industry, are estimated as given in Table 7.37 and Figure 7.11.

Table 7.37 CH_4 emissions from industrial wastewater by sector, 1990-2020

(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	22.86	3.91	1.34	0.24	3.49	2.93	10.96
2018	24.75	4.10	1.34	0.25	3.93	3.06	12.07
2019	25.02	4.23	1.34	0.28	3.86	3.54	11.76
2020	25.29	4.37	1.35	0.30	3.80	4.02	11.45

Figure 7.11 CH_4 emissions from industrial wastewater, 1990-2020



Collection of Activity Data

To calculate CH_4 emissions from industrial wastewater, total organically degradable material in wastewater for each industry (TOW_i) is used as AD and calculated by applying *Equation 6.6 in the 2006 IPCC Guidelines, Volume 5, Chapter 6.*

$$TOW_i = P_i \bullet W_i \bullet COD_i$$

Where:

TOW_i = total organically degradable material in wastewater for industry i, kg COD/yr

i = industrial sector

P_i = total industrial product for industrial sector i, t/yr

W_i = wastewater generated, $m^3/t_{product}$

COD_i = chemical oxygen demand (industrial degradable organic component in wastewater), kg COD/m^3

Organic component removed as sludge (S) is 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 Survey* for the years 1994-1997, 2000, 2004, 2008, 2010, 2012, 2014, 2016, 2018 and 2020. Missing data for the years not surveyed (1998, 1999, 2001-2003, 2005-2007, 2009, 2011, 2013, 2015 and 2017) are estimated by linear interpolation. For more accurate activity data, 2019 AD of previous submission has been recalculated by interpolation method due to availability of 2020 AD.

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, 1990-2020

(thousand m^3/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	308 713	73 634	34 434	18 197	72 778	25 115	84 556
2018	332 391	77 208	34 351	19 507	81 901	26 268	93 156
2019	337 462	79 707	34 544	21 490	80 607	30 364	90 750
2020	342 533	82 205	34 738	23 474	79 312	34 460	88 345

TOWi 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^3)
Meat & Poultry	4.1
Organic Chemicals	3.0
Petroleum Refineries	1.0
Plastics & Resins	3.7
Pulp & Paper (combined)	9.0
Starch Production	10.0

Table 7.40 TOWi in wastewater by industry sector, 1990-2020

(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	1 764.3	301.9	103.3	18.2	269.3	226.0	845.6
2018	1 910.1	316.6	103.1	19.5	303.0	236.4	931.6
2019	1 930.9	326.8	103.6	21.5	298.2	273.3	907.5
2020	1 951.8	337.0	104.2	23.5	293.5	310.1	883.4

Choice of Emission Factor

As given in *Equation 6.5 in the 2006 IPCC Guidelines, Volume 5, Chapter 6*, CH_4 EFs for each industrial wastewater treatment/discharge pathway or system are calculated by multiplying the default maximum

CH_4 producing capacity (B_o) for industrial wastewater (0.25 kg CH_4/kg COD) by the methane correction factor (MCF) for each type of treatment and discharge pathway or system which is given in the *2006 IPCC Guidelines, Volume 5, Chapter 6, Table 6.8.*,

$$EF_j = B_o \bullet MCF_j$$

Where:

EF_j = emission factor for each treatment/discharge pathway or system, kg CH_4/kg COD,

j = each treatment/discharge pathway or system

B_o = maximum CH_4 producing capacity, kg CH_4/kg COD

MCF_j = methane correction factor (fraction)

Weighted CH_4 EFs are calculated by multiplying CH_4 EFs for each type of treatment and discharge pathway or system and fractional usage of the different treatment systems. Weighted CH_4 EF for industrial wastewater with background data are given in Table 7.41.

Table 7.41 MCF, EFs, fractional usages and weighted EF for industrial wastewater

Type of treatment and discharge pathway or system	MCF	CH_4 EF	Fractional usage
Untreated system			
Sea, river, lake discharge	0.10	0.03	0.173
Treated system			
Aerobic treatment plant, well managed	0.00	0.00	0.668
Aerobic treatment plant, not well managed	0.30	0.08	0.088
Anaerobic digester for sludge	0.80	0.20	0.025
Anaerobic reactor	0.80	0.20	0.030
Septic system	0.50	0.13	0.016
Total			**1.00**
Weighted CH_4 EF (kg CH_4/kg COD)			**0.01**

Nitrous Oxide Emissions from Wastewater

Türkiye applies the default method from the 2006 IPCC Guidelines to estimate N_2O emissions from domestic wastewater. N_2O emissions from domestic wastewater effluent are estimated using *Equation 6.7 in the 2006 IPCC Guidelines, Volume 5, Chapter 6.* Specifically, N_2O emissions are assumed to equal the amount of nitrogen discharged to aquatic environments, multiplied by an emission factor.

$$N_2O\ Emissions = N_{EFFLUENT} \bullet EF_{EFFLUENT} \bullet 44/28$$

Where:

N_2O emissions = N_2O emissions in inventory year, kg N_2O/yr

$N_{EFFLUENT}$ = nitrogen in the effluent discharged to aquatic environments, kg N/yr

$EF_{EFFLUENT}$ = emission factor for N_2O emissions from discharged to wastewater, kg N_2O-N/kg N

The factor 44/28 is the conversion of kg N_2O-N into kg N_2O.

N_2O emissions from centralized wastewater treatment plants with nitrification and denitrification steps are also taken into account by subtracting the amount of nitrogen associated with N_2O emissions from these plants from the total nitrogen discharged in the wastewater effluent. N_2O emissions from such plants are estimated using *Equation 6.9 in 2006 IPCC, Volume 5, Chapter 6.*

$$N_2O_{PLANTS} = P \bullet T_{PLANT} \bullet F_{IND-COM} \bullet EF_{PLANT}$$

Where:

N_2O_{PLANTS} = total N_2O emissions from plants in inventory year, kg N_2O/yr

P = human population

T_{PLANT} = degree of utilization of modern, centralized WWT plants, %

$F_{IND-COM}$ = fraction of industrial and commercial co-discharged protein (default = 1.25),

EF_{PLANT} = emission factor, 3.2 g N_2O/person/year

The estimation results are given in Table 7.42. As can be seen in Figure 7.12, total N_2O emissions increased by 57.2% from 1990 to 2020. N_2O emissions from centralized WWT plants for 1990-2000 period are reported as "NO" because the nitrogen removal is not available before 2001. T_{PLANT} values for 2001-2020 are reported in CRF table 5.D, under additional information.

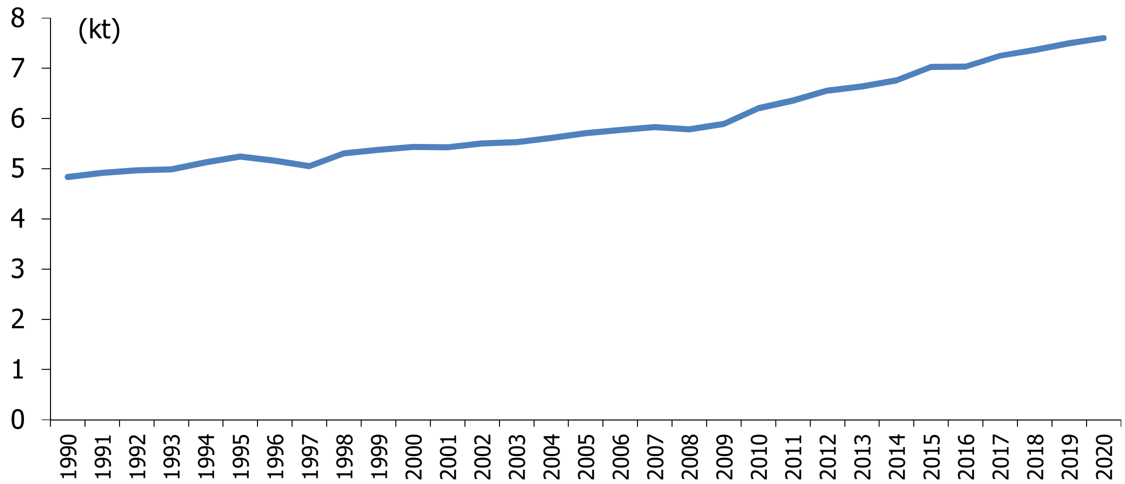
Türkiye reports N_2O emissions from industrial wastewater as "IE" in CRF table 5.D. As discussed further below, N_2O emissions from industrial wastewater (category 5.D.2) discharged into sewers is included in the N_2O emissions from domestic wastewater (category 5.D.1).

Table 7.42 N_2O emissions from wastewater, 1990-2020

(kt)

Year	N_2O emissions from wastewater effluent	N_2O emissions from centralized WWT plants	Total N_2O emissions
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	5.40	0.02	5.42
2002	5.48	0.02	5.51
2003	5.51	0.02	5.53
2004	5.59	0.02	5.61
2005	5.68	0.03	5.71
2006	5.73	0.04	5.77
2007	5.78	0.04	5.83
2008	5.74	0.05	5.78
2009	5.83	0.07	5.89
2010	6.12	0.08	6.21
2011	6.27	0.08	6.36
2012	6.47	0.08	6.56
2013	6.55	0.09	6.64
2014	6.66	0.10	6.76
2015	6.92	0.11	7.03
2016	6.92	0.11	7.03
2017	7.13	0.12	7.25
2018	7.23	0.13	7.36
2019	7.36	0.14	7.50
2020	7.46	0.14	7.60

Figure 7.12 N_2O emissions from wastewater, 1990-2020



Collection of Activity Data

The activity data that are needed for estimating N_2O emissions are nitrogen content in the wastewater effluent, country population and average annual per capita protein generation (kg/person/yr).

The total nitrogen in the effluent is estimated using *Equation 6.8 in the 2006 IPCC Guidelines, Volume 5, Chapter 6.*

$$N_{EFFLUENT} = (P \bullet Protein \bullet {}_{NPR} \bullet F_{NON-CON} \bullet F_{IND-C} \quad) - N_{SLUDGE}$$

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 consumption in Türkiye has been obtained from the FAOSTAT's website *(http://www.fao.org/faostat/en/#data/FBS/visualize)*. The link has re-checked for up-to-date data of recent years, and it is found that the new Food Balances are available after 2010. 2010-2013 and 2018 data have been updated on the link and 2019 data is also available. These revised data are used instead of the data in the previous submission. 2020 data is extrapolated due to lack of data.

Population and annual per capita protein consumption data are given in Table 7.43.

Table 7.43 Population and per capita protein consumption, 1990-2020

Year	Population [1] (1000's persons)	Per capita protein consumption [2] (kg/person/yr)
1990	55 120	39.88
1991	56 055	39.90
1992	56 986	39.62
1993	57 913	39.16
1994	58 837	39.62
1995	59 756	39.89
1996	60 671	38.64
1997	61 582	37.30
1998	62 464	38.64
1999	63 364	38.57
2000	64 269	38.44
2001	65 166	37.68
2002	66 003	37.75
2003	66 795	37.49
2004	67 599	37.60
2005	68 435	37.70
2006	69 295	37.60
2007	70 158	37.47
2008	71 052	36.69
2009	72 039	36.76
2010	73 142	38.06
2011	74 224	38.42
2012	75 176	39.14
2013	76 148	39.11
2014	77 182	39.24
2015	78 218	40.24
2016	79 278	39.66
2017	80 313	40.35
2018	81 407	40.39
2019	82 579	40.54
2020	83 385	40.69

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, Türkiye assumes that there is zero sludge removed. Regarding the fraction of non-consumed protein, Türkiye has applied the value for developed countries using garbage disposals.

Table 7.44 Parameters for estimation of nitrogen in effluent, 2020

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.

In 2019 submission, Monte Carlo analysis has been carried out for the CH_4 and N_2O emissions from Wastewater treatment and discharge, for the year 2017. Combined uncertainty in CH_4 emissions is was estimated at -40.16% to +40.77% for Domestic wastewater sub-category and-32.71% to 41.28% for Industrial wastewater sub-category while N_2O 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 are implemented for each category in order to verify and improve the inventory under the QA/QC plan of Türkiye.

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.

Moreover, a QA work was conducted by an external reviewer (expert from CITEPA - Technical Reference Center for Air Pollution and Climate Change) for this category in December 2019.

Recalculation:

While no recalculations were made for CH_4 emissions from domestic wastewater, recalculations were made for CH_4 emissions from industrial wastewater. Because, 2018 data has been revised in the data source *(Manufacturing Industry Establishments Wastewater Statistics)*. Depending on the revision of the 2018 data, the 2017 data has been recalculated as it is a data obtained by the interpolation method. With the availability of 2020 data, 2019 data has been recalculated using the interpolation method.

With the update of the 2010-2013 and 2018 data and the availability of 2019 data from FAOSTAT, revised protein supply data were used instead of the previous FAOSTAT data and therefore, recalculation was made for per capita protein consumption data.

However, the most important recalculation was made in N_2O emissions after 2001 by correcting the calculation error by entering T_{PLANT} as a percentage into the formula. During the QC, it was noticed that after 2019 submission, T_{PLANT} values are used directly, not as a percentage in the emission calculations.

Total recalculation of CH_4 emissions for Wastewater Treatment and Discharge subsector (CRF Category 5.D) resulted with a decrease of 2.1 kt CO_2 eq. (0.1%) in 2019. For N_2O emissions, the recalculation caused a decrease by 4075.7 kt CO_2 eq. (64.6%) in 2019. There is no recalculation for 1990 for both gases.

Planned Improvement:

Türkiye is planning to improve the CH_4 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

Türkiye does not report any emissions under the category 'Other'.

9. INDIRECT CARBON DIOXIDE AND NITROUS OXIDE EMISSIONS

Türkiye 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, checks the entire time series from 1990 onwards and tries to determine the conditions that are not meet the TACCC criteria. Based on the outcomes of the examination some AD revisions, reallocation of emissions or error corrections are made as compared to previous submission.

Also the ERT recommendations are one of the most important reasons for recalculations. A remote centralized review of the 2021 inventory submission of Türkiye was organized by the UNFCCC Secretariat from 4 to 9 October 2021. The *Report on the individual review of the inventory submission of Turkey submitted in 2021* has not been finalized yet. However, many recalculations have been made based on the ERT findings of the draft report in relevant categories in addition to our own improvements. All kind of recalculations are described in the Chapters 3-7 in detail, and the reasons for recalculations are also summarized below.

In energy sector;

For the sectors, 1.A.1.b, 1.A.2.a, 1.A.2.c, 1.A.2.f, 1.A.2.g, 1.A.4.a, 1.A.4.b were recalculated.

In the pipeline sector, activity source data has been modified for 2017-2019 time series consistency. In addition, the calculations for these years were revised accordingly.

In IPPU sector;

For 2.A.1 cement production sector, activity data from three cement plants, which did not report their activity data to TurkCimento, are gathered with questionnaire and included in calculations.

For the sectors 2.A.2, 2.A.4.c, 2.B.2, 2.D.1, 2.D.2 activity data corrected due to data processing errors for the year 2019.

Due to minor changes observed in PRODCOM (National Industrial Production Statistics) data set, activity data of 2.B.5 carbide production changed between the years 2010-2014.

For iron and steel production, CO_2 emission factor used in steel production in EAF (Electric Arc Furnace) updated with country specific emission factor for increasing estimations from Tier 1 to Tier 2. In order to estimate country specific CO_2 emissions from EAF, raw material consumption and steel production data are collected. Tier 2 emission factor applied for the entire time series.

Carbon content of BOF gas data gathered from two of three integrated plants this year and included in calculations.

In agriculture sector;

Minor revisions in activity data for crop residues and sewage sludge are the reasons for the recalculation of approximately 1 kt CO_2 eq. for 2019.

In LULUCF sector;

Harvested Wood Products category was recalculated because the methodology has been changed and activity data of paper and paperboard has been changed from wood pulp to paper and paperboard category of FAOSTAT according to the 2021 review.

In waste sector;

For Category 5.A, 2019 data of MSW disposed in managed SWDS has been recalculated by linear interpolation due to availability of 2020 survey data. The amount of MSW disposed in unmanaged SWDS for 2019 was also affected by this recalculation. 2019 waste composition data is revised with the survey data. 2019 waste generation rate is recalculated by interpolation method due to availability of 2020 IW data. A minor reason for the recalculation is updating the GDP data for 2018 and 2019. 2019 % to SWDS data is also recalculated by interpolation method due to availability of 2020 IW generated data. Mainly, methane recovery data from some landfill gas recovery facilities (including one of the largest facilities) has been recalculated for the years 2007-2019 as a result of verification and comparison activities for the quantity of methane in the recovered landfill gas.

For Category 5.C, 2019 data for the fraction of MSW open-burned has been recalculated by linear interpolation due to availability of 2020 survey data. 2019 waste composition data is revised with the survey data.

As the 2018 data were revised in the data source, recalculations were made for CH_4 emissions from industrial wastewater for Category 5.D. Depending on the revision of the 2018 data, the 2017 data has been recalculated as it is a data obtained by the interpolation method. With the availability of 2020 data, 2019 data has been recalculated using the interpolation method. With the update of the 2010-2013 and 2018 data and the availability of 2019 data from FAOSTAT, recalculation was made for per capita protein consumption data. However, the most important recalculation was made in N_2O emissions after 2001 by correcting the calculation error by entering T_{PLANT} as a percentage into the formula. During the QC, it was noticed that after 2019 submission, T_{PLANT} values are used directly, not as a percentage in the emission calculations.

The reasons and the implications of recalculations by CRF category are given in the below table for 1990 and 2019.

Table 10.1 Recalculations made in the current submission and their implications to the emission level, 1990 and 2019

CRF category	Reasons for recalculation	Implication to the CRF category level (kt CO_2 eq.)		Implication to the total emission w/o LULUCF (%)	
		1990	2019	1990	2019
1. Energy		**1**	**1 040**	**0.00**	**0.20**
A.1 Energy industries	Change in EF	9	948	0.00	0.19
A.2 Manufacturing industries and construction	Change in AD	-8	-7	0.00	0.00
A.3 Transport	In the pipeline sector, activity source data has been modified for 2017-2019 time series consistency. In addition, the calculations for these years were revised accordingly.	NO	0.14	NO	0.00
A.4 Other sectors	Change in AD	NO	99	0.00	0.02
2. IPPU		**147**	**2 138**	**0.07**	**0.42**
A. Mineral industry	Adding activities of three cement plants. Correction of lime and magnesia production data for the year 2019.	NO	1 737	NO	0.34
B. Chemical industry	Nitric acid production activity data corrected due to data processing errors for the year 2019. Changes reflected to the activity data of 2.B.5 carbide production which observed in PRODCOM (National Industrial Production Statistics) data set between the years 2010-2014.	NO	824	NO	0.16
C. Metal industry	Default emission factor used in steel production in EAF (Electric Arc Furnace) updated with country specific emission factor. Carbon content of BOF gas data updated according to reporting of integrated plants.	147	-344	0.07	-0.07
D. Non-energy products from fuels and solvent use	Activity data of lubricant and parrafin wax use corrected due to data processing errors for the year 2019.	NO	-80	NO	-0.02

Table 10.1 Recalculations made in the current submission and their implications to the emission level, 1990 and 2019 (cont'd)

CRF category	Reasons for recalculation	Implication to the CRF category level (kt CO_2 eq.)		Implication to the total emission w/o LULUCF (%)	
		1990	2019	1990	2019
3. Agriculture		**NO**	**-1**	**NO**	**0.00**
D. Agricultural soils	Due to minor improvements in activity data for crop residues and sewage sludge only for the reporting year 2019	NO	-1	NO	0.00
4. Land use, land-use change and forestry		**41**	**-37**	**0.02**	**-0.01**
G. Harvested wood products	Because the methodology has been changed and activity data of paper and paperboard has been changed from wood pulp to paper and paperboard category of FAOSTAT according to the 2021 review.	41	-37	0.02	-0.01
5. Waste		**NO**	**- 1 179**	**NO**	**-0.23**
A. Solid waste disposal	Change in 2019 AD due to availability of 2020 survey data. Minor revision of GDP data. Correction of methane recovery data for the years 2007-2019.	NO	2 896	NO	0.57
C. Incineration and open burning of waste	Change in 2019 AD due to availability of 2020 survey data.	NO	2	NO	0.00
D. Wastewater treatment and discharge	Change in 2019 AD due to availability of 2020 survey data. Update of per capita protein consumption data due to availability of FAOSTAT data. Correction of calculation error by entering T_{PLANT} as a percentage into the formula.	NO	-4 078	NO	-0.80
Total CO_2 equivalent emissions without land use, land-use change and forestry		**148**	**1 998**	**0.07**	**0.39**

Figures in the table may not add up to the totals due to rounding.

Planned Improvements:

Considerable improvements have been made in this 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;

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_4, the tiers in CH_4 estimation needs to be increased. Detailed investigation has been performed to find out the availability of country specific or basin specific EFs within both general directorates for lignite and hard coal structured under the MENR, namely, DG Turkish Lignite Enterprises and DG Turkish Hard Coal Enterprises. However, information for the generation of country-specific EFs are not available centrally in those coal authorities. Therefore, it is necessary to communicate and cooperate with mining enterprises directly to search the availability of required information for T2 estimation of CH_4.

For 1.B.2 In order to increase the tiers for CH_4 emission estimation, availability of detailed information have been searched. It is planned to continue the investigation to find out the availability or possibility of availability of appropriate data for higher tiers.

In IPPU sector;

For cement production, 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 and emissions from lime production in sugar factories in next submissions.

Ceramic production data were gathered from Turkish Ceramics Federation until the federation had judicial issues regarding data collection from its members in 2020. As a result of this situation, TurkStat launched studies for estimating emissions of ceramics sector from other data sources. Calculations will be examined in next submissions.

For lead and zinc subcategories, the activities of recently established plants will be examined in next submissions.

For Product Use as Substitutes for ODS and Other Product Manufacture and Use (2.G) sectors improvements in the sectors 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 lasted in Aug 2020. After the adaptation of data base system, more detailed data will be collected and improvements in the sector will be done.

Data generated from the Monitoring, reporting, verification (MRV) system for GHG emissions in which more than 700 plants submit their verified annual emissions data in energy and industrial sectors according to the regulations of the Ministry of Environment, Urbanization and Climate Change, will be examined by TurkStat in various quality aspects (coverage, accuracy, completeness, consistency).

In agriculture sector;

Türkiye considers the possibility of using Tier 2 method for estimating enteric fermentation emissions from sheep in the future and also searches 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 medium 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.

Türkiye is a partner of ICP Forests program. The ICP forest project's soil analysis in Türkiye was initiated in January 2015 and planned to be finished by 2019. But it is not completed yet. 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. In this regard it is planned to implement a new project in the long term.

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), Türkiye is planning to improve the CH_4 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 results of Approach 1 key category analysis and results for the latest Turkish GHG 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 objective is to assist inventory agencies in their prioritization efforts to improve overall estimates. A key category is defined as "one that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level of emissions and removals, the trend in emissions and removals, or uncertainty in emissions and removals" (2006 IPCC Guidelines); this term is used in reference to both source and sink categories.

The Approach 1 Level and Trend Assessment described in the 2006 IPCC Guidelines Vol.1, Chapter 4 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 analyses the emission contribution that each category makes to the national total (with and without LULUCF). The trend assessment uses each category's relative contribution to the overall emissions, but assigns greater weight to the categories whose relative trend departs from the overall trend (with and without LULUCF). In this assessment, trends are calculated as the absolute changes between base year and most recent inventory year.

The percent contributions to both levels and trends in emissions are calculated and sorted in descending order. 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. Therefore, when source and sink contributions are sorted in decreasing order of importance, those largest ones that together contribute to 95% of the cumulative total are considered quantitatively to be key categories.

Level contribution of each source or sink is calculated according to Equation 4.1. available in 2006 IPCC Guidelines while trend assessments are calculated according to the Equation 4.2. and 4.3.

In the 2020 inventory key category analysis, there were 30 key categories of emissions and removals shown in Table A1 below.

Table A1 Key category analysis summary, 2020

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.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO2		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	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.C.3 Aluminiium Production	Aggregate F-gases		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	X
4.A.1 Forest Land Remaining Forest Land	CO2	X	X		X
4.G Harvested Wood Products	CO2	X	X		X
5.A Solid Waste Disposal	CH4	X	X	X	X
5.D Wastewater Treatment and Discharge	CH4	X	X	X	X
5.D Wastewater Treatment and Discharge	N2O		X		X

Table A2 Key category analysis level assessment with LULUCF, 2020

	Sector	Fuel	GAS	2020 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.1.	Energy industries	Solid fuels	CO2	104 695	104 695	17.85	17.85
1.A.3.b.	Road Transportation		CO2	75 024	75 024	12.79	30.64
4.A.1.	Forest Land Remaining Forest Land		CO2	-48 070	48 070	8.20	38.83
2.A.1.	Cement Production (Mineral Products)		CO2	40 813	40 813	6.96	45.79
1.A.4.	Other sectors	Gaseous fuels	CO2	38 491	38 491	6.56	52.35
3.A.	Enteric fermentation		CH4	34 615	34 615	5.90	58.26
1.A.1.	Energy industries	Gaseous fuels	CO2	29 779	29 779	5.08	63.33
3.D.a.	Direct N2O emissions from managed soils		N2O	24 297	24 297	4.14	67.47
1.A.2.	Manufacturing industries and construction	Solid fuels	CO2	22 457	22 457	3.83	71.30
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CO2	21 088	21 088	3.60	74.90
1.A.4.	Other sectors	Solid fuels	CO2	20 987	20 987	3.58	78.48
1.A.2.	Manufacturing industries and construction	Liquid fuels	CO2	14 489	14 489	2.47	80.95
1.A.4.	Other sectors	Liquid fuels	CO2	12 437	12 437	2.12	83.07
4.G.	Harvested Wood Products		CO2	-11 281	11 281	1.92	84.99
5.A.	Solid waste disposal		CH4	11 237	11 237	1.92	86.91
2.C.1.	Iron and Steel Production		CO2	10 132	10 132	1.73	88.63
1.A.1.	Energy industries	Liquid fuels	CO2	7 422	7 422	1.27	89.90
1.B.1	Solid fuels		CH4	5 558	5 558	0.95	90.85
2.F.6.	Other applications		HFC	5 551	5 551	0.95	91.79
3.B.	Manure management		N2O	5 062	5 062	0.86	92.66
3.B.	Manure management		CH4	3 999	3 999	0.68	93.34
3.D.b.	Indirect N2O Emissions from managed soils		N2O	3 092	3 092	0.53	93.86
5.D.	Wastewater treatment and discharge		CH4	2 872	2 872	0.49	94.35
2.A.4.	Other process uses of carbonates		CO2	2 810	2 810	0.48	94.83
2.A.2.	Lime Production (Mineral Products)		CO2	2 807	2 807	0.48	95.31
5.D.	Wastewater treatment and discharge		N2O	2 265.8	2 265.8	0.39	95.70
1.A.3.a.	Domestic Aviation		CO2	2 140.9	2 140.9	0.36	96.06
2.B.2.	Nitric acid production		N2O	2 005.8	2 005.8	0.34	96.40
1.B.2.b	Natural Gas		CH4	1 977.6	1 977.6	0.34	96.74
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CO2	1 835.6	1 835.6	0.31	97.05
3.H.	Urea application		CO2	1 657.0	1 657.0	0.28	97.34
1.A.4.	Other sectors	Solid fuels	CH4	1 341.8	1 341.8	0.23	97.57

Table A2 Key category analysis level assessment with LULUCF, 2020 (cont'd)

	Sector	Fuel	GAS	2020 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CO2	1 203.7	1 203.7	0.21	97.77
1.A.3.b.	Road Transportation		N2O	1 202.5	1 202.5	0.21	97.98
1.A.4.	Other sectors	Liquid fuels	N2O	1 166.5	1 166.5	0.20	98.18
4.C.2.	Land Converted to Grassland		CO2	765.0	765.0	0.13	98.31
4.F.2.	Land Converted to Other Land		CO2	696.4	696.4	0.12	98.42
2.A.3.	Glass Production		CO2	679.3	679.3	0.12	98.54
2.B.1.	Ammonia Production		CO2	544.9	544.9	0.09	98.63
2.B.7.	Soda ash production		CO2	531.0	531.0	0.09	98.72
1.A.4.	Other sectors	Biomass	CH4	497.3	497.3	0.08	98.81
4.B.2.	Land Converted to Cropland		CO2	495.7	495.7	0.08	98.89
1.B.2.c	Venting and flaring		CH4	483.1	483.1	0.08	98.98
4.E.2.	Land Converted to Settlements		CO2	418.9	418.9	0.07	99.05
1.A.1.	Energy industries	Solid fuels	N2O	412.9	412.9	0.07	99.12
1.A.1.	Energy industries	Gaseous fuels	N2O	408.3	408.3	0.07	99.19
1.A.3.b.	Road Transportation		CH4	374.2	374.2	0.06	99.25
1.B.2.a	Oil		CH4	366.4	366.4	0.06	99.31
4.A.2.	Land Converted to Forest Land		CO2	-331.1	331.1	0.06	99.37
1.A.3.e.	Other transportation		CO2	327.9	327.9	0.06	99.43
2.F.3.	Fire protection		HFC	301.9	301.9	0.05	99.48
1.A.3.c.	Railways		CO2	288.8	288.8	0.05	99.53
3.C.	Rice cultivation		CH4	261.5	261.5	0.04	99.57
1.B.2.c	Venting and flaring		CO2	188.5	188.5	0.03	99.60
4.D.2.	Land Converted to Wetlands		CO2	184.6	184.6	0.03	99.63
2.C.2.	Ferroalloys Production		CO2	147.7	147.7	0.03	99.66
3.F.	Field burning of agricultural residues		CH4	132.4	132.4	0.02	99.68
1.A.1.	Energy industries	Other fossil fuels	CO2	130.3	130.3	0.02	99.70
4.B.1.	Cropland Remaining Cropland		CO2	-125.2	125.2	0.02	99.73
2.D.1.	Lubricant Use		CO2	119.5	119.5	0.02	99.75
2.C.3.	Aluminium Production		CO2	117.7	117.7	0.02	99.77
4.A.1.	Forest Land Remaining Forest Land		CH4	107.7	107.7	0.02	99.78
1.A.4.	Other sectors	Solid fuels	N2O	97.6	97.6	0.02	99.80
1.A.2.	Manufacturing industries and construction	Solid fuels	N2O	94.5	94.5	0.02	99.82

Table A2 Key category analysis level assessment with LULUCF, 2020 (cont'd)

	Sector	Fuel	GAS	2020 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.4.	Other sectors	Gaseous fuels	CH4	86.4	86.4	0.01	99.83
1.A.4.	Other sectors	Biomass	N2O	79.0	79.0	0.01	99.85
4.(IV).2.	Indirect N2O Emissions from nitrogen leaching and run-off		N2O	78.0	78.0	0.01	99.86
4.A.1.	Forest Land Remaining Forest Land		N2O	71.0	71.0	0.01	99.87
2.E.5.	Other		SF6	58.6	58.6	0.01	99.88
2.G.1.	Electrical equipment		SF6	57.2	57.2	0.01	99.89
1.A.3.d.	Domestic Navigation	Residual fuel oil	CO2	47.1	47.1	0.01	99.90
1.A.2.	Manufacturing industries and construction	Biomass	N2O	45.5	45.5	0.01	99.91
3.F.	Field burning of agricultural residues		N2O	40.9	40.9	0.01	99.91
2.C.3.	Aluminium Production		PFC	37.8	37.8	0.01	99.92
1.A.4.	Other sectors	Gaseous fuels	N2O	34.4	34.4	0.01	99.93
1.A.3.c.	Railways		N2O	34.0	34.0	0.01	99.93
1.A.1.	Energy industries	Biomass	N2O	28.8	28.8	0.00	99.94
1.A.2.	Manufacturing industries and construction	Biomass	CH4	28.7	28.7	0.00	99.94
1.A.2.	Manufacturing industries and construction	Solid fuels	CH4	27.7	27.7	0.00	99.95
1.A.2.	Manufacturing industries and construction	Liquid fuels	N2O	26.9	26.9	0.00	99.95
4.B.2.	Land Converted to Cropland		N2O	24.3	24.3	0.00	99.95
1.A.3.a.	Domestic Aviation		N2O	22.1	22.1	0.00	99.96
1.A.1.	Energy industries	Gaseous fuels	CH4	20.6	20.6	0.00	99.96
1.A.4.	Other sectors	Liquid fuels	CH4	19.8	19.8	0.00	99.97
1.A.1.	Energy industries	Solid fuels	CH4	18.5	18.5	0.00	99.97
1.A.2.	Manufacturing industries and construction	Other fossil fuels	N2O	15.8	15.8	0.00	99.97
2.C.1.	Iron and Steel Production		CH4	15.5	15.5	0.00	99.97
2.D.2.	Paraffin Wax Use		CO2	14.6	14.6	0.00	99.98
5.B.	Biological treatment of solid waste		CH4	12.0	12.0	0.00	99.98
4.C.2.	Land Converted to Grassland		N2O	11.9	11.9	0.00	99.98
1.A.2.	Manufacturing industries and construction	Liquid fuels	CH4	11.3	11.3	0.00	99.98
1.A.2.	Manufacturing industries and construction	Gaseous fuels	N2O	11.3	11.3	0.00	99.98
1.A.3.d.	Domestic Navigation	Gas/diesel oil	N2O	9.9	9.9	0.00	99.99
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CH4	9.9	9.9	0.00	99.99
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CH4	9.5	9.5	0.00	99.99
2.C.5.	Lead Production		CO2	9.4	9.4	0.00	99.99

Table A2 Key category analysis level assessment with LULUCF, 2020 (cont'd)

	Sector	Fuel	GAS	2020 Emission	ABS (Emission)	Cont. (%)	Cumulative
5.B.	Biological treatment of solid waste		N2O	8.5	8.5	0.00	99.99
2.B.5.	Carbide production		CO2	7.5	7.5	0.00	99.99
4.D.2.	Land Converted to Wetlands		N2O	4.2	4.2	0.00	99.99
1.B.2.a	Oil		CO2	4.0	4.0	0.00	99.99
1.A.1.	Energy industries	Liquid fuels	N2O	3.9	3.9	0.00	100.00
5.C.	Incineration and open burning of waste		CO2	3.6	3.6	0.00	100.00
1.A.1.	Energy industries	Biomass	CH4	3.2	3.2	0.00	100.00
5.C.	Incineration and open burning of waste		CH4	3.1	3.1	0.00	100.00
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CH4	2.9	2.9	0.00	100.00
1.B.2.b	Natural Gas		CO2	2.7	2.7	0.00	100.00
1.A.1.	Energy industries	Liquid fuels	CH4	2.6	2.6	0.00	100.00
2.B.8.	Petrochemical and carbon black production		CO2	1.3	1.3	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	N2O	1.3	1.3	0.00	100.00
4.A.2.	Land Converted to Forest Land		CH4	1.0	1.0	0.00	100.00
1.A.3.a.	Domestic Aviation		CH4	1.0	1.0	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	CH4	0.8	0.8	0.00	100.00
1.B.2.c	Venting and flaring		N2O	0.8	0.8	0.00	100.00
4.A.2.	Land Converted to Forest Land		N2O	0.7	0.7	0.00	100.00
5.C.	Incineration and open burning of waste		N2O	0.5	0.5	0.00	100.00
1.A.3.c.	Railways		CH4	0.4	0.4	0.00	100.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	N2O	0.4	0.4	0.00	100.00
1.A.3.e.	Other transportation		N2O	0.2	0.2	0.00	100.00
1.A.3.e.	Other transportation		CH4	0.2	0.2	0.00	100.00
1.C.	CO2 Transport and storage		CO2	0.1	0.1	0.00	100.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	CH4	0.1	0.1	0.00	100.00
2.E.5.	Other		HFC	0.1	0.1	0.00	100.00
4.D.1.1.	Peat Extraction Remaining Peat Extraction		CO2	0.0	0.0	0.00	100.00
4.C.1.	Grassland Remaining Grassland		CO2	0.0	0.0	0.00	100.00
2.E.5.	Other		PFC	0.0	0.0	0.00	100.00
Total				**466 949.58**	**586 563.67**		

Table A3 Key category analysis level assessment without LULUCF, 2020

	Sector	Fuel	GAS	2020 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.1.	Energy industries	Solid fuels	CO2	104 695	104 695	19.98	19.98
1.A.3.b.	Road Transportation		CO2	75 024	75 024	14.32	34.30
2.A.1.	Cement Production (Mineral Products)		CO2	40 813	40 813	7.79	42.09
1.A.4.	Other sectors	Gaseous fuels	CO2	38 491	38 491	7.35	49.44
3.A.	Enteric fermentation		CH4	34 615	34 615	6.61	56.05
1.A.1.	Energy industries	Gaseous fuels	CO2	29 779	29 779	5.68	61.73
3.D.a.	Direct N2O emissions from managed soils		N2O	24 297	24 297	4.64	66.37
1.A.2.	Manufacturing industries and construction	Solid fuels	CO2	22 457	22 457	4.29	70.66
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CO2	21 088	21 088	4.03	74.68
1.A.4.	Other sectors	Solid fuels	CO2	20 987	20 987	4.01	78.69
1.A.2.	Manufacturing industries and construction	Liquid fuels	CO2	14 489	14 489	2.77	81.45
1.A.4.	Other sectors	Liquid fuels	CO2	12 437	12 437	2.37	83.83
5.A.	Solid waste disposal		CH4	11 237	11 237	2.14	85.97
2.C.1.	Iron and Steel Production		CO2	10 132	10 132	1.93	87.91
1.A.1.	Energy industries	Liquid fuels	CO2	7 422	7 422	1.42	89.32
1.B.1	Solid fuels		CH4	5 558	5 558	1.06	90.38
2.F.6.	Other applications		HFC	5 551	5 551	1.06	91.44
3.B.	Manure management		N2O	5 062	5 062	0.97	92.41
3.B.	Manure management		CH4	3 999	3 999	0.76	93.17
3.D.b.	Indirect N2O Emissions from managed soils		N2O	3 092	3 092	0.59	93.76
5.D.	Wastewater treatment and discharge		CH4	2 872	2 872	0.55	94.31
2.A.4.	Other process uses of carbonates		CO2	2 810	2 810	0.54	94.85
2.A.2.	Lime Production (Mineral Products)		CO2	2 807	2 807	0.54	95.38
5.D.	Wastewater treatment and discharge		N2O	2 265.8	2 265.8	0.43	95.82
1.A.3.a.	Domestic Aviation		CO2	2 140.9	2 140.9	0.41	96.22
2.B.2.	Nitric acid production		N2O	2 005.8	2 005.8	0.38	96.61
1.B.2.b	Natural Gas		CH4	1 977.6	1 977.6	0.38	96.99
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CO2	1 835.6	1 835.6	0.35	97.34
3.H.	Urea application		CO2	1 657.0	1 657.0	0.32	97.65
1.A.4.	Other sectors	Solid fuels	CH4	1 341.8	1 341.8	0.26	97.91
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CO2	1 203.7	1 203.7	0.23	98.14
1.A.3.b.	Road Transportation		N2O	1 202.5	1 202.5	0.23	98.37

Table A3 Key category analysis level assessment without LULUCF, 2020 (cont'd)

	Sector	Fuel	GAS	2020 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.4.	Other sectors	Liquid fuels	N2O	1 166.5	1 166.5	0.22	98.59
2.A.3.	Glass Production		CO2	679.3	679.3	0.13	98.72
2.B.1.	Ammonia Production		CO2	544.9	544.9	0.10	98.82
2.B.7.	Soda ash production		CO2	531.0	531.0	0.10	98.92
1.A.4.	Other sectors	Biomass	CH4	497.3	497.3	0.09	99.02
1.B.2.c	Venting and flaring		CH4	483.1	483.1	0.09	99.11
1.A.1.	Energy industries	Solid fuels	N2O	412.9	412.9	0.08	99.19
1.A.1.	Energy industries	Gaseous fuels	N2O	408.3	408.3	0.08	99.27
1.A.3.b.	Road Transportation		CH4	374.2	374.2	0.07	99.34
1.B.2.a	Oil		CH4	366.4	366.4	0.07	99.41
1.A.3.e.	Other transportation		CO2	327.9	327.9	0.06	99.47
2.F.3.	Fire protection		HFC	301.9	301.9	0.06	99.53
1.A.3.c.	Railways		CO2	288.8	288.8	0.06	99.59
3.C.	Rice cultivation		CH4	261.5	261.5	0.05	99.64
1.B.2.c	Venting and flaring		CO2	188.5	188.5	0.04	99.67
2.C.2.	Ferroalloys Production		CO2	147.7	147.7	0.03	99.70
3.F.	Field burning of agricultural residues		CH4	132.4	132.4	0.03	99.72
1.A.1.	Energy industries	Other fossil fuels	CO2	130.3	130.3	0.02	99.75
2.D.1.	Lubricant Use		CO2	119.5	119.5	0.02	99.77
2.C.3.	Aluminium Production		CO2	117.7	117.7	0.02	99.79
1.A.4.	Other sectors	Solid fuels	N2O	97.6	97.6	0.02	99.81
1.A.2.	Manufacturing industries and construction	Solid fuels	N2O	94.5	94.5	0.02	99.83
1.A.4.	Other sectors	Gaseous fuels	CH4	86.4	86.4	0.02	99.85
1.A.4.	Other sectors	Biomass	N2O	79.0	79.0	0.02	99.86
2.E.5.	Other		SF6	58.6	58.6	0.01	99.87
2.G.1.	Electrical equipment		SF6	57.2	57.2	0.01	99.89
1.A.3.d.	Domestic Navigation	Residual fuel oil	CO2	47.1	47.1	0.01	99.89
1.A.2.	Manufacturing industries and construction	Biomass	N2O	45.5	45.5	0.01	99.90
3.F.	Field burning of agricultural residues		N2O	40.9	40.9	0.01	99.91
2.C.3.	Aluminium Production		PFC	37.8	37.8	0.01	99.92
1.A.4.	Other sectors	Gaseous fuels	N2O	34.4	34.4	0.01	99.92
1.A.3.c.	Railways		N2O	34.0	34.0	0.01	99.93

Table A3 Key category analysis level assessment without LULUCF, 2020 (cont'd)

	Sector	Fuel	GAS	2020 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.A.1.	Energy industries	Biomass	N2O	28.8	28.8	0.01	99.94
1.A.2.	Manufacturing industries and construction	Biomass	CH4	28.7	28.7	0.01	99.94
1.A.2.	Manufacturing industries and construction	Solid fuels	CH4	27.7	27.7	0.01	99.95
1.A.2.	Manufacturing industries and construction	Liquid fuels	N2O	26.9	26.9	0.01	99.95
1.A.3.a.	Domestic Aviation		N2O	22.1	22.1	0.00	99.96
1.A.1.	Energy industries	Gaseous fuels	CH4	20.6	20.6	0.00	99.96
1.A.4.	Other sectors	Liquid fuels	CH4	19.8	19.8	0.00	99.96
1.A.1.	Energy industries	Solid fuels	CH4	18.5	18.5	0.00	99.97
1.A.2.	Manufacturing industries and construction	Other fossil fuels	N2O	15.8	15.8	0.00	99.97
2.C.1.	Iron and Steel Production		CH4	15.5	15.5	0.00	99.97
2.D.2.	Paraffin Wax Use		CO2	14.6	14.6	0.00	99.98
5.B.	Biological treatment of solid waste		CH4	12.0	12.0	0.00	99.98
1.A.2.	Manufacturing industries and construction	Liquid fuels	CH4	11.3	11.3	0.00	99.98
1.A.2.	Manufacturing industries and construction	Gaseous fuels	N2O	11.3	11.3	0.00	99.98
1.A.3.d.	Domestic Navigation	Gas/diesel oil	N2O	9.9	9.9	0.00	99.99
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CH4	9.9	9.9	0.00	99.99
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CH4	9.5	9.5	0.00	99.99
2.C.5.	Lead Production		CO2	9.4	9.4	0.00	99.99
5.B.	Biological treatment of solid waste		N2O	8.5	8.5	0.00	99.99
2.B.5.	Carbide production		CO2	7.5	7.5	0.00	99.99
1.B.2.a	Oil		CO2	4.0	4.0	0.00	99.99
1.A.1.	Energy industries	Liquid fuels	N2O	3.9	3.9	0.00	100.00
5.C.	Incineration and open burning of waste		CO2	3.6	3.6	0.00	100.00
1.A.1.	Energy industries	Biomass	CH4	3.2	3.2	0.00	100.00
5.C.	Incineration and open burning of waste		CH4	3.1	3.1	0.00	100.00
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CH4	2.9	2.9	0.00	100.00
1.B.2.b	Natural Gas		CO2	2.7	2.7	0.00	100.00
1.A.1.	Energy industries	Liquid fuels	CH4	2.6	2.6	0.00	100.00
2.B.8.	Petrochemical and carbon black production		CO2	1.3	1.3	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	N2O	1.3	1.3	0.00	100.00
1.A.3.a.	Domestic Aviation		CH4	1.0	1.0	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	CH4	0.8	0.8	0.00	100.00

Table A3 Key category analysis level assessment without LULUCF, 2020 (cont'd)

	Sector	Fuel	GAS	2020 Emission	ABS (Emission)	Cont. (%)	Cumulative
1.B.2.c	Venting and flaring		N2O	0.8	0.8	0.00	100.00
5.C.	Incineration and open burning of waste		N2O	0.5	0.5	0.00	100.00
1.A.3.c.	Railways		CH4	0.4	0.4	0.00	100.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	N2O	0.4	0.4	0.00	100.00
1.A.3.e.	Other transportation		N2O	0.2	0.2	0.00	100.00
1.A.3.e.	Other transportation		CH4	0.2	0.2	0.00	100.00
1.C.	CO2 Transport and storage		CO2	0.1	0.1	0.00	100.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	CH4	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		PFC	0.0	0.0	0.00	100.00
Total				**523 897.19**	**523 897.19**		

Table A4 Key category analysis trend assessment with LULUCF, 2020

	Sector	Fuel	Gas	2020	1990	Trend	Cont	Cum.
4.A.1.	Forest Land Remaining Forest Land		CO2	-48 069.84	-52 977.05	0.193	14.29	14.29
1.A.1.	Energy industries	Solid fuels	CO2	104 694.51	26 160.40	0.181	13.35	27.63
1.A.4.	Other sectors	Gaseous fuels	CO2	38 491.24	93.89	0.139	10.27	37.90
1.A.3.b.	Road Transportation		CO2	75 024.21	24 142.97	0.088	6.53	44.43
1.A.2.	Manufacturing industries and construction	Solid fuels	CO2	22 456.95	22 199.68	0.088	6.47	50.90
1.A.1.	Energy industries	Gaseous fuels	CO2	29 778.85	5 024.67	0.070	5.16	56.05
2.A.1.	Cement Production (Mineral Products)		CO2	40 812.75	10 444.54	0.069	5.06	61.12
1.A.4.	Other sectors	Liquid fuels	CO2	12 437.34	14 433.04	0.065	4.79	65.90
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CO2	21 087.60	1 557.79	0.065	4.78	70.68
1.A.2.	Manufacturing industries and construction	Liquid fuels	CO2	14 488.52	13 246.53	0.048	3.57	74.25
3.A.	Enteric fermentation		CH4	34 614.54	22 396.72	0.045	3.32	77.57
4.G.	Harvested Wood Products		CO2	-11 280.86	-2 906.72	0.042	3.10	80.67
1.A.4.	Other sectors	Solid fuels	CO2	20 986.84	14 749.94	0.036	2.67	83.34
3.D.a.	Direct N2O emissions from managed soils		N2O	24 296.52	15 176.02	0.027	2.02	85.37
2.F.6.	Other applications		HFC	5 551.17		0.020	1.49	86.86
1.A.1.	Energy industries	Liquid fuels	CO2	7 422.29	5 954.30	0.018	1.36	88.22
2.C.1.	Iron and Steel Production		CO2	10 131.73	6 913.61	0.016	1.17	89.39
1.A.4.	Other sectors	Biomass	CH4	497.35	2 263.35	0.015	1.14	90.53
5.D.	Wastewater treatment and discharge		CH4	2 872.20	2 789.04	0.011	0.80	91.33
5.A.	Solid waste disposal		CH4	11 236.59	6 729.60	0.010	0.77	92.10
1.B.1	Solid fuels		CH4	5 558.13	3 598.18	0.007	0.53	92.64
2.A.2.	Lime Production (Mineral Products)		CO2	2 807.17	2 248.84	0.007	0.51	93.15
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CO2	1 835.61		0.007	0.49	93.64
1.B.2.b	Natural Gas		CH4	1 977.59	143.70	0.006	0.45	94.09
2.A.4.	Other process uses of carbonates		CO2	2 810.10	618.97	0.005	0.41	94.50
3.B.	Manure management		N2O	5 061.51	3 084.28	0.005	0.38	94.87
3.D.b.	Indirect N2O Emissions from managed soils		N2O	3 092.04	2 137.50	0.005	0.37	95.25
2.C.3.	Aluminium Production		PFC	37.82	625.30	0.005	0.34	95.59
1.A.3.c.	Railways		CO2	288.75	651.19	0.004	0.29	95.88
3.B.	Manure management		CH4	3 998.92	2 352.09	0.003	0.25	96.13
1.A.4.	Other sectors	Solid fuels	CH4	1 341.82	1 023.23	0.003	0.22	96.35
4.C.2.	Land Converted to Grassland		CO2	765.00		0.003	0.21	96.55
5.D.	Wastewater treatment and discharge		N2O	2 265.79	1 440.99	0.003	0.20	96.75
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CO2	1 203.67	220.75	0.003	0.20	96.95

Table A4 Key category analysis trend assessment with LULUCF, 2020 (cont'd)

	Sector	Fuel	Gas	2020	1990	Trend	Cont	Cum.
4.F.2.	Land Converted to Other Land		CO2	696.38		0.003	0.19	97.14
3.H.	Urea application		CO2	1 657.03	459.95	0.003	0.19	97.32
1.A.4.	Other sectors	Biomass	N2O	79.04	359.72	0.002	0.18	97.51
1.A.3.d.	Domestic Navigation	Residual fuel oil	CO2	47.09	282.87	0.002	0.15	97.65
2.B.7.	Soda ash production		CO2	530.96		0.002	0.14	97.79
1.B.2.a	Oil		CH4	366.44	419.87	0.002	0.14	97.93
4.B.2.	Land Converted to Cropland		CO2	495.71		0.002	0.13	98.07
2.A.3.	Glass Production		CO2	679.28	111.30	0.002	0.12	98.19
3.F.	Field burning of agricultural residues		CH4	132.38	265.12	0.002	0.11	98.30
4.E.2.	Land Converted to Settlements		CO2	418.91		0.002	0.11	98.41
1.A.1.	Energy industries	Gaseous fuels	N2O	408.30	2.57	0.001	0.11	98.52
4.A.2.	Land Converted to Forest Land		CO2	-331.14	20.70	0.001	0.10	98.62
2.B.1.	Ammonia Production		CO2	544.88	424.76	0.001	0.09	98.71
2.F.3.	Fire protection		HFC	301.89		0.001	0.08	98.79
1.A.4.	Other sectors	Liquid fuels	N2O	1 166.52	692.17	0.001	0.08	98.87
1.B.2.c	Venting and flaring		CO2	188.48	217.58	0.001	0.07	98.94
2.D.1.	Lubricant Use		CO2	119.47	175.11	0.001	0.07	99.01
1.A.3.e.	Other transportation		CO2	327.89	39.29	0.001	0.07	99.07
2.B.2.	Nitric acid production		N2O	2 005.78	1 063.63	0.001	0.06	99.13
1.A.3.a.	Domestic Aviation		CO2	2 140.87	913.74	0.001	0.06	99.19
1.B.2.c	Venting and flaring		CH4	483.15	126.99	0.001	0.06	99.25
1.A.1.	Energy industries	Solid fuels	N2O	412.93	96.75	0.001	0.06	99.31
4.D.2.	Land Converted to Wetlands		CO2	184.57		0.001	0.05	99.36
1.A.3.b.	Road Transportation		CH4	374.16	96.49	0.001	0.05	99.40
2.B.8.	Petrochemical and carbon black production		CO2	1.35	81.49	0.001	0.05	99.45
5.C.	Incineration and open burning of waste		CH4	3.09	67.31	0.001	0.04	99.49
3.F.	Field burning of agricultural residues		N2O	40.91	81.93	0.000	0.04	99.52
1.A.1.	Energy industries	Other fossil fuels	CO2	130.29		0.000	0.03	99.56
4.B.1.	Cropland Remaining Cropland		CO2	-125.20	0.69	0.000	0.03	99.59
2.B.5.	Carbide production		CO2	7.54	58.99	0.000	0.03	99.62
1.A.3.c.	Railways		N2O	34.05	68.71	0.000	0.03	99.65
2.C.3.	Aluminium Production		CO2	117.68	99.16	0.000	0.02	99.68
1.A.4.	Other sectors	Gaseous fuels	CH4	86.42	0.21	0.000	0.02	99.70
2.C.6.	Zinc Production		CO2		37.84	0.000	0.02	99.72

Table A4 Key category analysis trend assessment with LULUCF, 2020 (cont'd)

	Sector	Fuel	Gas	2020	1990	Trend	Cont	Cum.
4.(IV).2.	Indirect N2O Emissions from nitrogen leaching and run-off		N2O	77.97		0.000	0.02	99.74
1.A.3.b.	Road Transportation		N2O	1 202.50	537.71	0.000	0.02	99.76
2.E.5.	Other		SF6	58.57		0.000	0.02	99.78
1.A.2.	Manufacturing industries and construction	Solid fuels	N2O	94.54	72.60	0.000	0.02	99.79
2.G.1.	Electrical equipment		SF6	57.21		0.000	0.02	99.81
5.C.	Incineration and open burning of waste		CO2	3.62	26.59	0.000	0.01	99.82
3.C.	Rice cultivation		CH4	261.53	100.08	0.000	0.01	99.84
4.A.1.	Forest Land Remaining Forest Land		CH4	107.75	74.60	0.000	0.01	99.85
1.A.2.	Manufacturing industries and construction	Biomass	N2O	45.54		0.000	0.01	99.86
1.A.4.	Other sectors	Liquid fuels	CH4	19.79	30.81	0.000	0.01	99.87
1.A.2.	Manufacturing industries and construction	Solid fuels	CH4	27.69	32.56	0.000	0.01	99.88
1.A.2.	Manufacturing industries and construction	Liquid fuels	N2O	26.86	30.11	0.000	0.01	99.89
1.A.4.	Other sectors	Gaseous fuels	N2O	34.42	0.05	0.000	0.01	99.90
4.A.1.	Forest Land Remaining Forest Land		N2O	71.05	49.19	0.000	0.01	99.91
1.A.4.	Other sectors	Solid fuels	N2O	97.60	61.00	0.000	0.01	99.92
1.A.1.	Energy industries	Biomass	N2O	28.83		0.000	0.01	99.93
1.A.2.	Manufacturing industries and construction	Biomass	CH4	28.65		0.000	0.01	99.93
4.B.2.	Land Converted to Cropland		N2O	24.33		0.000	0.01	99.94
5.C.	Incineration and open burning of waste		N2O	0.55	11.23	0.000	0.01	99.95
1.A.1.	Energy industries	Liquid fuels	N2O	3.90	12.59	0.000	0.01	99.95
2.C.2.	Ferroalloys Production		CO2	147.66	61.56	0.000	0.00	99.96
1.A.1.	Energy industries	Gaseous fuels	CH4	20.64	2.16	0.000	0.00	99.96
1.A.2.	Manufacturing industries and construction	Other fossil fuels	N2O	15.75		0.000	0.00	99.97
1.A.2.	Manufacturing industries and construction	Liquid fuels	CH4	11.32	12.66	0.000	0.00	99.97
4.C.2.	Land Converted to Grassland		N2O	11.85		0.000	0.00	99.97
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CH4	9.91		0.000	0.00	99.98
1.A.2.	Manufacturing industries and construction	Gaseous fuels	N2O	11.29	0.84	0.000	0.00	99.98
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CH4	9.47	0.70	0.000	0.00	99.98
5.B.	Biological treatment of solid waste		CH4	11.95	9.37	0.000	0.00	99.98
1.A.1.	Energy industries	Solid fuels	CH4	18.51	5.74	0.000	0.00	99.99
1.A.3.d.	Domestic Navigation	Gas/diesel oil	N2O	9.93	1.79	0.000	0.00	99.99
5.B.	Biological treatment of solid waste		N2O	8.55	6.70	0.000	0.00	99.99
2.C.5.	Lead Production		CO2	9.42	2.20	0.000	0.00	99.99
4.D.2.	Land Converted to Wetlands		N2O	4.15		0.000	0.00	99.99

Table A4 Key category analysis trend assessment with LULUCF, 2020 (cont'd)

	Sector	Fuel	Gas	2020	1990	Trend	Cont	Cum.
1.A.3.d.	Domestic Navigation	Residual fuel oil	N2O	0.36	2.15	0.000	0.00	99.99
1.A.1.	Energy industries	Liquid fuels	CH4	2.59	3.05	0.000	0.00	99.99
1.A.3.a.	Domestic Aviation		N2O	22.06	8.88	0.000	0.00	99.99
1.A.1.	Energy industries	Biomass	CH4	3.24		0.000	0.00	99.99
2.D.2.	Paraffin Wax Use		CO2	14.56	8.25	0.000	0.00	100.00
4.A.2.	Land Converted to Forest Land		CH4	1.02	1.55	0.000	0.00	100.00
1.B.2.b	Natural Gas		CO2	2.72	0.25	0.000	0.00	100.00
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CH4	2.91	0.53	0.000	0.00	100.00
4.A.2.	Land Converted to Forest Land		N2O	0.67	1.02	0.000	0.00	100.00
1.A.3.c.	Railways		CH4	0.41	0.86	0.000	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	N2O	1.30		0.000	0.00	100.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	CH4	0.11	0.63	0.000	0.00	100.00
1.B.2.c	Venting and flaring		N2O	0.79	0.91	0.000	0.00	100.00
2.C.1.	Iron and Steel Production		CH4	15.52	7.89	0.000	0.00	100.00
1.B.2.a	Oil		CO2	4.04	2.38	0.000	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	CH4	0.82		0.000	0.00	100.00
1.A.3.a.	Domestic Aviation		CH4	0.99	0.31	0.000	0.00	100.00
1.C.	CO2 Transport and storage		CO2	0.13	0.13	0.000	0.00	100.00
1.A.3.e.	Other transportation		N2O	0.18	0.02	0.000	0.00	100.00
1.A.3.e.	Other transportation		CH4	0.15	0.02	0.000	0.00	100.00
2.E.5.	Other		HFC	0.10		0.000	0.00	100.00
2.B.8.	Petrochemical and carbon black production		CH4		0.05	0.000	0.00	100.00
4.C.1.	Grassland Remaining Grassland		CO2	0.03	0.03	0.000	0.00	100.00
4.D.1.1.	Peat Extraction Remaining Peat Extraction		CO2	0.04	0.01	0.000	0.00	100.00
2.E.5.	Other		PFC	0.01		0.000	0.00	100.00
	Total			**466 949.58**	**163 984.01**	**1.35**	**100.00**	

Table A5 Key category analysis trend assessment without LULUCF, 2020

	Sector	Fuel	Gas	2020	1990	Trend	Cont	Cum.
1.A.1.	Energy industries	Solid fuels	CO2	104 694.51	26 160.40	0.193	12.93	12.93
1.A.4.	Other sectors	Gaseous fuels	CO2	38 491.24	93.89	0.174	11.69	24.62
1.A.2.	Manufacturing industries and construction	Solid fuels	CO2	22 456.95	22 199.68	0.139	9.31	33.93
1.A.4.	Other sectors	Liquid fuels	CO2	12 437.34	14 433.04	0.100	6.71	40.64
3.A.	Enteric fermentation		CH4	34 614.54	22 396.72	0.086	5.74	46.38
1.A.1.	Energy industries	Gaseous fuels	CO2	29 778.85	5 024.67	0.081	5.44	51.81
1.A.3.b.	Road Transportation		CO2	75 024.21	24 142.97	0.079	5.33	57.15
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CO2	21 087.60	1 557.79	0.079	5.31	62.45
1.A.2.	Manufacturing industries and construction	Liquid fuels	CO2	14 488.52	13 246.53	0.078	5.22	67.68
2.A.1.	Cement Production (Mineral Products)		CO2	40 812.75	10 444.54	0.072	4.86	72.54
1.A.4.	Other sectors	Solid fuels	CO2	20 986.84	14 749.94	0.065	4.33	76.87
3.D.a.	Direct N2O emissions from managed soils		N2O	24 296.52	15 176.02	0.054	3.63	80.50
1.A.1.	Energy industries	Liquid fuels	CO2	7 422.29	5 954.30	0.031	2.07	82.57
2.C.1.	Iron and Steel Production		CO2	10 131.73	6 913.61	0.029	1.94	84.51
2.F.6.	Other applications		HFC	5 551.17		0.025	1.70	86.21
1.A.4.	Other sectors	Biomass	CH4	497.35	2 263.35	0.022	1.50	87.70
5.A.	Solid waste disposal		CH4	11 236.59	6 729.60	0.022	1.47	89.17
5.D.	Wastewater treatment and discharge		CH4	2 872.20	2 789.04	0.017	1.15	90.33
1.B.1	Solid fuels		CH4	5 558.13	3 598.18	0.014	0.92	91.25
2.A.2.	Lime Production (Mineral Products)		CO2	2 807.17	2 248.84	0.012	0.78	92.03
3.B.	Manure management		N2O	5 061.51	3 084.28	0.010	0.70	92.73
3.D.b.	Indirect N2O Emissions from managed soils		N2O	3 092.04	2 137.50	0.009	0.61	93.34
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CO2	1 835.61		0.008	0.56	93.90
1.B.2.b	Natural Gas		CH4	1 977.59	143.70	0.007	0.50	94.40
3.B.	Manure management		CH4	3 998.92	2 352.09	0.007	0.49	94.89
2.C.3.	Aluminium Production		PFC	37.82	625.30	0.007	0.44	95.34
2.A.4.	Other process uses of carbonates		CO2	2 810.10	618.97	0.006	0.41	95.75
1.A.3.c.	Railways		CO2	288.75	651.19	0.006	0.39	96.13
5.D.	Wastewater treatment and discharge		N2O	2 265.79	1 440.99	0.005	0.36	96.49
1.A.4.	Other sectors	Solid fuels	CH4	1 341.82	1 023.23	0.005	0.34	96.82
1.A.4.	Other sectors	Biomass	N2O	79.04	359.72	0.004	0.24	97.06
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CO2	1 203.67	220.75	0.003	0.21	97.27
1.B.2.a	Oil		CH4	366.44	419.87	0.003	0.19	97.46
1.A.3.d.	Domestic Navigation	Residual fuel oil	CO2	47.09	282.87	0.003	0.19	97.65
3.H.	Urea application		CO2	1 657.03	459.95	0.003	0.17	97.83
2.B.7.	Soda ash production		CO2	530.96		0.002	0.16	97.99

Table A5 Key category analysis trend assessment without LULUCF, 2020 (cont'd)

	Sector	Fuel	Gas	2020	1990	Trend	Cont	Cum.
2.B.2.	Nitric acid production		N2O	2 005.78	1 063.63	0.002	0.16	98.15
3.F.	Field burning of agricultural residues		CH4	132.38	265.12	0.002	0.15	98.30
1.A.4.	Other sectors	Liquid fuels	N2O	1 166.52	692.17	0.002	0.15	98.45
2.B.1.	Ammonia Production		CO2	544.88	424.76	0.002	0.14	98.59
2.A.3.	Glass Production		CO2	679.28	111.30	0.002	0.13	98.72
1.A.1.	Energy industries	Gaseous fuels	N2O	408.30	2.57	0.002	0.12	98.84
1.B.2.c	Venting and flaring		CO2	188.48	217.58	0.002	0.10	98.94
2.F.3.	Fire protection		HFC	301.89		0.001	0.09	99.04
2.D.1.	Lubricant Use		CO2	119.47	175.11	0.001	0.09	99.13
1.A.3.e.	Other transportation		CO2	327.89	39.29	0.001	0.07	99.20
2.B.8.	Petrochemical and carbon black production		CO2	1.35	81.49	0.001	0.06	99.26
1.A.1.	Energy industries	Solid fuels	N2O	412.93	96.75	0.001	0.06	99.31
1.B.2.c	Venting and flaring		CH4	483.15	126.99	0.001	0.06	99.37
5.C.	Incineration and open burning of waste		CH4	3.09	67.31	0.001	0.05	99.42
3.F.	Field burning of agricultural residues		N2O	40.91	81.93	0.001	0.05	99.46
1.A.3.b.	Road Transportation		CH4	374.16	96.49	0.001	0.04	99.51
2.B.5.	Carbide production		CO2	7.54	58.99	0.001	0.04	99.55
1.A.1.	Energy industries	Other fossil fuels	CO2	130.29		0.001	0.04	99.59
1.A.3.c.	Railways		N2O	34.05	68.71	0.001	0.04	99.63
2.C.3.	Aluminium Production		CO2	117.68	99.16	0.001	0.04	99.66
2.C.6.	Zinc Production		CO2		37.84	0.000	0.03	99.69
1.A.4.	Other sectors	Gaseous fuels	CH4	86.42	0.21	0.000	0.03	99.72
1.A.3.b.	Road Transportation		N2O	1 202.50	537.71	0.000	0.02	99.74
1.A.2.	Manufacturing industries and construction	Solid fuels	N2O	94.54	72.60	0.000	0.02	99.77
5.C.	Incineration and open burning of waste		CO2	3.62	26.59	0.000	0.02	99.78
2.E.5.	Other		SF6	58.57		0.000	0.02	99.80
2.G.1.	Electrical equipment		SF6	57.21		0.000	0.02	99.82
1.A.4.	Other sectors	Liquid fuels	CH4	19.79	30.81	0.000	0.02	99.84
1.A.2.	Manufacturing industries and construction	Solid fuels	CH4	27.69	32.56	0.000	0.02	99.85
1.A.4.	Other sectors	Solid fuels	N2O	97.60	61.00	0.000	0.01	99.87
1.A.2.	Manufacturing industries and construction	Biomass	N2O	45.54		0.000	0.01	99.88
1.A.2.	Manufacturing industries and construction	Liquid fuels	N2O	26.86	30.11	0.000	0.01	99.89
1.A.3.a.	Domestic Aviation		CO2	2 140.87	913.74	0.000	0.01	99.90
1.A.4.	Other sectors	Gaseous fuels	N2O	34.42	0.05	0.000	0.01	99.92
1.A.1.	Energy industries	Biomass	N2O	28.83		0.000	0.01	99.92
1.A.2.	Manufacturing industries and construction	Biomass	CH4	28.65		0.000	0.01	99.93

Table A5 Key category analysis trend assessment without LULUCF, 2020 (cont'd)

	Sector	Fuel	Gas	2020	1990	Trend	Cont	Cum.
5.C.	Incineration and open burning of waste		N2O	0.55	11.23	0.000	0.01	99.94
1.A.1.	Energy industries	Liquid fuels	N2O	3.90	12.59	0.000	0.01	99.95
3.C.	Rice cultivation		CH4	261.53	100.08	0.000	0.01	99.96
1.A.2.	Manufacturing industries and construction	Liquid fuels	CH4	11.32	12.66	0.000	0.01	99.96
1.A.2.	Manufacturing industries and construction	Other fossil fuels	N2O	15.75		0.000	0.00	99.97
1.A.1.	Energy industries	Gaseous fuels	CH4	20.64	2.16	0.000	0.00	99.97
5.B.	Biological treatment of solid waste		CH4	11.95	9.37	0.000	0.00	99.97
1.A.2.	Manufacturing industries and construction	Other fossil fuels	CH4	9.91		0.000	0.00	99.98
1.A.2.	Manufacturing industries and construction	Gaseous fuels	N2O	11.29	0.84	0.000	0.00	99.98
1.A.2.	Manufacturing industries and construction	Gaseous fuels	CH4	9.47	0.70	0.000	0.00	99.98
5.B.	Biological treatment of solid waste		N2O	8.55	6.70	0.000	0.00	99.98
1.A.3.d.	Domestic Navigation	Gas/diesel oil	N2O	9.93	1.79	0.000	0.00	99.99
2.D.2.	Paraffin Wax Use		CO2	14.56	8.25	0.000	0.00	99.99
1.A.1.	Energy industries	Solid fuels	CH4	18.51	5.74	0.000	0.00	99.99
1.A.3.d.	Domestic Navigation	Residual fuel oil	N2O	0.36	2.15	0.000	0.00	99.99
1.A.1.	Energy industries	Liquid fuels	CH4	2.59	3.05	0.000	0.00	99.99
2.C.5.	Lead Production		CO2	9.42	2.20	0.000	0.00	99.99
2.C.1.	Iron and Steel Production		CH4	15.52	7.89	0.000	0.00	99.99
1.A.1.	Energy industries	Biomass	CH4	3.24		0.000	0.00	100.00
1.B.2.b	Natural Gas		CO2	2.72	0.25	0.000	0.00	100.00
1.A.3.d.	Domestic Navigation	Gas/diesel oil	CH4	2.91	0.53	0.000	0.00	100.00
1.A.3.c.	Railways		CH4	0.41	0.86	0.000	0.00	100.00
1.B.2.a	Oil		CO2	4.04	2.38	0.000	0.00	100.00
1.A.3.d.	Domestic Navigation	Residual fuel oil	CH4	0.11	0.63	0.000	0.00	100.00
1.B.2.c	Venting and flaring		N2O	0.79	0.91	0.000	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	N2O	1.30		0.000	0.00	100.00
2.C.2.	Ferroalloys Production		CO2	147.66	61.56	0.000	0.00	100.00
1.A.3.a.	Domestic Aviation		N2O	22.06	8.88	0.000	0.00	100.00
1.A.1.	Energy industries	Other fossil fuels	CH4	0.82		0.000	0.00	100.00
1.A.3.a.	Domestic Aviation		CH4	0.99	0.31	0.000	0.00	100.00
1.C.	CO2 Transport and storage		CO2	0.13	0.13	0.000	0.00	100.00
1.A.3.e.	Other transportation		N2O	0.18	0.02	0.000	0.00	100.00
1.A.3.e.	Other transportation		CH4	0.15	0.02	0.000	0.00	100.00
2.B.8.	Petrochemical and carbon black production		CH4		0.05	0.000	0.00	100.00
2.E.5.	Other		HFC	0.10		0.000	0.00	100.00
2.E.5.	Other		PFC	0.01		0.000	0.00	100.00
	Total			**523 897.19**	**219 720.00**	**1.49**	**100.00**	

Annex 2: Uncertainty

In 2019 submission, on the recommendation of the UNFCCC expert review team (ERT) in 2018, the Turkish Statistical Institute has undertaken a tier 2 uncertainty analysis. Therefore, the country has estimated uncertainties both with Approach 1 and Approach 2 (Monte Carlo Simulation) methods. Approach 1 is based on equations for error propagation, and Approach 2, corresponds to the application of Monte Carlo (MC) 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. 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. The country considered the Uncertainy results in both Approaches for prioritizing category improvements. Especially sectors with large AD or EF uncertainties, even if they are not key categories, have been treated as key categories and more precise information has been collected on those sub-categories primarily. In order to do this, both Approach 1 and Approach 2 results are evaluated together. Table A6 shows Approach 1 results using the Table 3.2 of Volume 1 of the 2006 IPCC Guidelines for the current submission.

In the 2020 submission, Approach 2 was implemented to whole IPPU sector for 2018 emission levels with SPSS Modeler 18.2 software. In the 2019 submission, Approach 2 was implemented to whole waste sector and some specific sub-sectors in energy, IPPU and agriculture sector. *(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 order to provide category improvements.)* MC simulation results are presented in Table A7.1 and A7.2.

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 depending on the opinion of the expert conducting the study. In this MC simulation for emission uncertainties, 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 for uncertainties. 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 ±100%. Normal distribution is a two parametric distribution and can therefore be completely described with the 95% confidence interval. Moreover, some subcategories are defined with the probability density function 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 to some categories, with respect to specific data availability assuming a normal distribution for activity data and for the emission factor of natural gas. In 2020 submission, for entire IPPU sector, all distributions assumed were as normal distribution.

According to the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Emission Inventories, quality control 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 as can be seen at the end of this chapter from uncertainty histograms.

Table A6 Approach 1 Uncertainty assessment

Source Category		Fuel	Gas	Emissions in 1990	Emissions in 2020	AD Unc.	EF Unc.	Combined Unc.	H(1)	I(2)	J(3)	K(4)	L(5)	M(6)
				Gg CO_2 eq	Gg CO_2 eq	%	%	%	%	%	%	%	%	%
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	CO_2	3 650.2	414.4	1.0	4.1	4.2	0.0	0.1	0.0	0.3	0.0	0.1
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	CO_2	24 147.7	102 468.2	1.0	3.4	3.5	0.6	0.2	0.6	0.7	0.9	1.3
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	CO_2	5 024.7	27 757.5	1.0	1.1	1.5	0.0	0.1	0.2	0.1	0.2	0.1
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	CO_2		130.3	18.0	9.6	20.4	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.b.	Petroleum Refining	Liquid fuels	CO_2	2 289.4	7 007.8	2.0	7.0	7.3	0.0	0.0	0.0	0.0	0.1	0.0
1.A.1.b.	Petroleum Refining	Gaseous fuels	CO_2		2 021.4	2.0	7.0	7.3	0.0	0.0	0.0	0.1	0.0	0.0
1.A.1.c.	Manufacture of solid fuels	Liquid fuels	CO_2	14.7		2.0	7.0	7.3	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.c.	Manufacture of solid fuels	Solid fuels	CO_2	2 012.7	2 226.3	2.0	7.0	7.3	0.0	0.0	0.0	0.1	0.0	0.0
1.A.2.a.	Iron and Steel Production	Liquid fuels	CO_2	1 823.3	96.8	10.0	7.0	12.2	0.0	0.0	0.0	0.2	0.0	0.0
1.A.2.a.	Iron and Steel Production	Solid fuels	CO_2	4 854.8	2 156.6	10.0	7.0	12.2	0.0	0.1	0.0	0.5	0.2	0.3
1.A.2.a.	Iron and Steel Production	Gaseous fuels	CO_2		3 374.0	10.0	7.0	12.2	0.0	0.0	0.0	0.1	0.3	0.1
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	CO_2	927.8	15.3	21.2	7.0	22.3	0.0	0.0	0.0	0.1	0.0	0.0
1.A.2.b.	Non-Ferrous Metals	Solid fuels	CO_2	156.3	129.7	21.2	7.0	22.3	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.b.	Non-Ferrous Metals	Gaseous fuels	CO_2		547.7	21.2	7.0	22.3	0.0	0.0	0.0	0.0	0.1	0.0
1.A.2.c.	Chemicals	Liquid fuels	CO_2	2 588.1	38.4	15.8	7.0	17.3	0.0	0.0	0.0	0.3	0.0	0.1
1.A.2.c.	Chemicals	Solid fuels	CO_2	1 342.6	1 973.5	15.8	7.0	17.3	0.0	0.0	0.0	0.1	0.3	0.1
1.A.2.c.	Chemicals	Gaseous fuels	CO_2	944.6	4 802.3	15.8	7.0	17.3	0.0	0.0	0.0	0.1	0.7	0.4
1.A.2.c.	Chemicals	Other fossil fuels	CO_2		5.9	2.0	7.0	7.3	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.d.	Pulp, Paper and Print	Liquid fuels	CO_2		18.0	18.0	7.0	19.3	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.d.	Pulp, Paper and Print	Solid fuels	CO_2		668.7	18.0	7.0	19.3	0.0	0.0	0.0	0.0	0.1	0.0
1.A.2.d.	Pulp, Paper and Print	Gaseous fuels	CO_2		577.7	18.0	7.0	19.3	0.0	0.0	0.0	0.0	0.1	0.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Liquid fuels	CO_2	420.7	83.4	5.0	7.0	8.6	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Solid fuels	CO_2	2 471.7	2 924.1	18.0	7.0	19.3	0.0	0.0	0.0	0.2	0.5	0.2
1.A.2.e.	Food Processing, Beverages and Tobacco	Gaseous fuels	CO_2		2 830.9	14.1	7.0	15.8	0.0	0.0	0.0	0.1	0.3	0.1
1.A.2.f.	Non-metallic minerals	Liquid fuels	CO_2	2 626.3	13 489.8	27.8	7.0	28.7	0.7	0.0	0.1	0.3	3.2	10.5
1.A.2.f.	Non-metallic minerals	Solid fuels	CO_2	5 587.5	10 057.2	25.5	7.0	26.4	0.3	0.0	0.1	0.2	2.2	5.0
1.A.2.f.	Non-metallic minerals	Gaseous fuels	CO_2	1.9	4 063.6	29.2	7.0	30.0	0.1	0.0	0.0	0.2	1.0	1.1
1.A.2.f.	Non-metallic minerals	Other fossil fuels	CO_2		1 829.7	2.0	7.0	7.3	0.0	0.0	0.0	0.1	0.0	0.0
1.A.2.g.	Other Industries	Liquid Fuels	CO_2	4 860.3	746.7	70.7	7.0	71.1	0.0	0.1	0.0	0.6	0.5	0.5
1.A.2.g.	Other Industries	Solid Fuels	CO_2	7 786.9	4 547.2	70.7	7.0	71.1	0.5	0.1	0.0	0.8	2.8	8.3
1.A.2.g.	Other Industries	Gaseous Fuels	CO_2	611.2	4 891.4	70.7	7.0	71.1	0.6	0.0	0.0	0.1	3.0	8.9
1.A.3.a.	Domestic Aviation	Jet kerosene	CO_2	913.7	2 140.9	5.5	5.0	7.4	0.0	0.0	0.0	0.0	0.1	0.0
1.A.3.b.	Road Transportation	Gasoline	CO_2	8 377.4	7 016.7	10.1	5.0	11.2	0.0	0.1	0.0	0.5	0.6	0.6
1.A.3.b.	Road Transportation	Diesel oil	CO_2	15 765.5	58 712.3	10.1	5.0	11.2	2.0	0.1	0.4	0.4	5.1	26.1
1.A.3.b.	Road Transportation	Liquefied petroleum gases (LPG)	CO_2		9 145.8	10.1	5.0	11.2	0.0	0.1	0.1	0.3	0.8	0.7
1.A.3.b.	Road Transportation	Gaseous fuels	CO_2		149.5	10.0	7.0	12.2	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	Emissions in 2020	AD Unc.	EF Unc.	Combined Unc.	H(1)	I(2)	J(3)	K(4)	L(5)	M(6)
				Gg CO_2 eq	Gg CO_2 eq	%	%	%	%	%	%	%	%	%
1.A.3.c.	Railways	Liquid fuels	CO_2	589.5	288.8	2.0	1.5	2.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.c.	Railways	Solid fuels	CO_2	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_2	282.9	47.1	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_2	220.8	1 203.7	15.0	1.5	15.1	0.0	0.0	0.0	0.0	0.2	0.0
1.A.3.e.	Pipeline Transportation	Gaseous fuels	CO_2	39.3	327.9	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_2		1 356.1	7.1	7.0	10.0	0.0	0.0	0.0	0.1	0.1	0.0
1.A.4.a.	Commercial/institutional	Solid fuels	CO_2		3 977.9	14.1	7.0	15.7	0.0	0.0	0.0	0.2	0.5	0.3
1.A.4.a.	Commercial/institutional	Gaseous fuels	CO_2		8 246.9	5.0	7.0	8.6	0.0	0.1	0.1	0.4	0.4	0.3
1.A.4.b.	Residential	Liquid fuels	CO_2	8 663.4	1 205.5	7.1	7.0	10.0	0.0	0.1	0.0	1.0	0.1	1.0
1.A.4.b.	Residential	Solid fuels	CO_2	14 749.9	17 008.9	14.1	7.0	15.7	0.3	0.2	0.1	1.1	2.1	5.4
1.A.4.b.	Residential	Gaseous fuels	CO_2	93.9	30 025.1	5.0	7.0	8.6	0.3	0.2	0.2	1.3	1.3	3.3
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	CO_2	5 769.6	9 875.8	14.1	5.0	15.0	0.1	0.0	0.1	0.2	1.2	1.5
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	CO_2		219.2	7.0	7.0	9.9	0.0	0.0	0.0	0.0	0.0	0.0
1.B.2.a.	Oil		CO_2	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_2	0.3	2.7	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_2	217.6	188.5	7.0	50.0	50.5	0.0	0.0	0.0	0.1	0.0	0.0
1.C	Transport of CO2		CO_2	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_2	10 444.5	40 812.8	5.0	2.0	5.4	0.2	0.1	0.2	0.1	1.8	3.1
2.A.2.	Lime Production (Mineral Products)		CO_2	2 248.8	2 807.2	10.0	10.0	14.1	0.0	0.0	0.0	0.2	0.2	0.1
2.A.3.	Glass Production		CO_2	111.3	679.3	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_2	619.0	2 810.1	30.0	2.0	30.1	0.0	0.0	0.0	0.0	0.7	0.5
2.B.1.	Ammonia Production		CO_2	424.8	544.9	2.0	5.0	5.4	0.0	0.0	0.0	0.0	0.0	0.0
2.B.5.	Carbide production		CO_2	59.0	7.5	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_2		531.0	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_2	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_2	6 913.6	10 131.7	10.0	8.0	12.8	0.1	0.1	0.1	0.5	0.9	1.0
2.C.2.	Ferroalloys Production		CO_2	61.6	147.7	5.0	25.0	25.5	0.0	0.0	0.0	0.0	0.0	0.0
2.C.3.	Aluminium Production		CO_2	99.2	117.7	1.0	5.0	5.1	0.0	0.0	0.0	0.0	0.0	0.0
2.C.5.	Lead Production		CO_2	2.2	9.4	25.0	20.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0
2.C.6.	Zinc Production		CO_2	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_2	175.1	119.5	25.0	50.0	55.9	0.0	0.0	0.0	0.1	0.0	0.0
2.D.2.	Paraffin Wax Use		CO_2	8.3	14.6	25.0	100.0	103.1	0.0	0.0	0.0	0.0	0.0	0.0
3.H.	Urea application		CO_2	459.9	1 657.0	10.0	50.0	51.0	0.0	0.0	0.0	0.1	0.1	0.0
4.A.	Forest land		CO_2	-52 956.4	-48 401.0	75.7	4.5	75.8	61.8	0.6	0.3	2.8	31.6	1005.9
4.B.	Cropland		CO_2	0.7	370.5	47.9	4.2	48.0	0.0	0.0	0.0	0.0	0.2	0.0
4.C.	Grassland		CO_2	0.0	765.0	148.7	10.2	149.0	0.1	0.0	0.0	0.0	1.0	1.0

Table A6 Approach 1 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	Emissions in 1990 Gg CO_2 eq	Emissions in 2020 Gg CO_2 eq	AD Unc. %	EF Unc. %	Combined Unc. %	H(1) %	I(2) %	J(3) %	K(4) %	L(5) %	M(6) %
4.D.	Wetlands		CO_2	0.0	184.6	85.9	3.9	86.0	0.0	0.0	0.0	0.0	0.1	0.0
4.E.	Settlements		CO_2		418.9	25.7	4.0	26.0	0.0	0.0	0.0	0.0	0.1	0.0
4.F.	Other land		CO_2		696.4	15.6	3.8	16.0	0.0	0.0	0.0	0.0	0.1	0.0
4.G.	Harvested wood products		CO_2	-2 906.7	-11 280.9	23.3	3.2	23.5	0.3	0.0	0.1	0.1	2.3	5.1
5.C.	Incineration and open burning of waste		CO_2	26.6	3.6	30.4	40.0	50.2	0.0	0.0	0.0	0.0	0.0	0.0
	Total CO_2			**95 802.2**	**356 186.7**									
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	CH_4	1.2	0.1	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	CH_4	5.3	18.2	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	CH_4	2.2	19.7	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	CH_4		0.8	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	CH_4		3.2	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	CH_4	1.8	2.5	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	CH_4		0.9	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	Liquid fuels	CH_4	0.0		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	CH_4	0.4	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	CH_4	1.8	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	CH_4	0.7	0.5	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	CH_4		1.5	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	Biomass	CH_4		0.0	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	CH_4	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	CH_4	0.3	0.3	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	CH_4		0.2	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	CH_4	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	CH_4	2.9	5.2	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	CH_4	0.4	2.2	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	CH_4		0.0	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.c.	Chemicals	Biomass	CH_4		0.1	15.8	100.0	101.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.d.	Pulp, Paper and Print	Liquid fuels	CH_4		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	CH_4		1.7	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	CH_4		0.3	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	Biomass	CH_4		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	CH_4	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	CH_4	5.5	7.3	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	Gaseous fuels	CH_4		1.3	14.1	100.0	101.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Biomass	CH_4		1.5	5.0	100.0	100.1	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_2 eq	Emissions in 2020 Gg CO_2 eq	AD Unc. %	EF Unc. %	Combined Unc. %	H(1) %	I(2) %	J(3) %	K(4) %	L(5) %	M(6) %
1.A.2.f.	Non-metallic minerals	Liquid fuels	CH_4	2.4	10.5	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	CH_4	5.3	1.3	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	CH_4	0.0	1.8	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	CH_4		9.9	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	CH_4		14.9	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_4	4.7	0.6	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_4	17.7	11.4	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_4	0.3	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	Biomass	CH_4		11.9	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.a.	Domestic Aviation	Jet kerosene	CH_4	0.3	1.0	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_4	75.6	63.3	10.0	250.0	250.2	0.0	0.0	0.0	0.2	0.0	0.1
1.A.3.b.	Road Transportation	Diesel oil	CH_4	20.9	79.2	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_4		224.8	10.0	250.0	250.2	0.0	0.0	0.0	0.3	0.0	0.1
1.A.3.b.	Road Transportation	Gaseous fuels	CH_4		6.4	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_4		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_4	0.8	0.4	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_4	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_4	0.6	0.1	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_4	0.5	2.9	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_4	0.0	0.2	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_4		3.2	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_4		10.2	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_4		18.5	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_4	22.5	2.4	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_4	1 023.2	1 331.6	14.1	100.0	101.0	0.1	0.0	0.0	1.0	0.2	1.0
1.A.4.b.	Residential	Gaseous fuels	CH_4	0.2	67.4	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_4	2 263.4	497.3	300.0	100.0	316.2	0.1	0.0	0.0	3.6	1.3	14.8
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	CH_4	8.3	14.2	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_4		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_4	3 598.2	5 558.1	16.6	150.0	150.9	3.2	0.0	0.0	4.3	0.8	19.0
1.B.2.a.	Oil		CH_4	419.9	366.4	7.0	100.0	100.2	0.0	0.0	0.0	0.5	0.0	0.3
1.B.2.b.	Natural gas		CH_4	143.7	1 977.6	7.0	100.0	100.2	0.2	0.0	0.0	1.0	0.1	0.9
1.B.2.c.	Venting and flaring		CH_4	127.0	483.1	7.0	100.0	100.2	0.0	0.0	0.0	0.1	0.0	0.0
2.B.8.	Petrochemical and carbon black production		CH_4	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_4	7.9	15.5	10.0	5.0	11.2	0.0	0.0	0.0	0.0	0.0	0.0
3.A.	Enteric fermentation		CH_4	22 396.7	34 614.5	8.7	12.0	14.8	1.2	0.2	0.2	2.1	2.6	11.3

Table A6 Approach 1 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	Emissions in 1990	Emissions in 2020	AD Unc.	EF Unc.	Combined Unc.	H(1)	I(2)	J(3)	K(4)	L(5)	M(6)
				Gg CO_2 eq	Gg CO_2 eq	%	%	%	%	%	%	%	%	%
3.B.	Manure management		CH_4	2 352.1	3 998.9	14.1	30.0	33.1	0.1	0.0	0.0	0.5	0.5	0.5
3.C.	Rice cultivation		CH_4	100.1	261.5	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_4	265.1	132.4	50.0	40.0	64.0	0.0	0.0	0.0	0.2	0.1	0.0
4.A.	Forest land		CH_4	76.1	108.8	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_4		3 547.0	10.0	30.8	32.4	0.1	0.0	0.0	0.7	0.3	0.5
5.A.2.	Unmanaged waste disposal sites		CH_4	6 729.6	7 689.6	30.0	38.1	48.5	0.6	0.1	0.0	2.7	2.0	11.1
5.B.	Biological treatment of solid waste		CH_4	9.4	12.0	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_4	67.3	3.1	30.4	100.0	104.5	0.0	0.0	0.0	0.1	0.0	0.0
5.D.1	Domestic wastewater		CH_4	2 579.8	2 239.9	5.0	37.7	38.0	0.0	0.0	0.0	1.2	0.1	1.4
5.D.2	Industrial wastewater		CH_4	209.2	632.3	11.2	39.1	40.7	0.0	0.0	0.0	0.0	0.1	0.0
	Total CH_4			**42 555.5**	**64 097.7**									
1.A.1.a.	Public Electricity and Heat Production	Liquid fuels	N_2O	8.5	0.5	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	Solid fuels	N_2O	95.2	412.5	1.0	75.0	75.0	0.0	0.0	0.0	0.1	0.0	0.0
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	N_2O	2.6	407.2	3.0	75.0	75.1	0.0	0.0	0.0	0.2	0.0	0.0
1.A.1.a.	Public Electricity and Heat Production	Other fossil fuels	N_2O		1.3	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	N_2O		28.8	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	N_2O	4.1	3.4	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	N_2O		1.1	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	Liquid fuels	N_2O	0.0		10.0	100.0	100.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.c.	Manufacture of solid fuels	Solid fuels	N_2O	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	N_2O	4.2	0.2	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	N_2O	0.8	0.9	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	N_2O		1.8	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	Biomass	N_2O		0.0	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.b.	Non-Ferrous Metals	Liquid fuels	N_2O	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	N_2O	0.6	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	N_2O		0.3	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	N_2O	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	N_2O	5.3	9.2	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	N_2O	0.5	2.6	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	N_2O		0.1	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.c.	Chemicals	Biomass	N_2O		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	N_2O		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	N_2O		3.0	18.0	100.0	101.6	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	Emissions in 2020	AD Unc.	EF Unc.	Combined Unc.	H(1)	I(2)	J(3)	K(4)	L(5)	M(6)
				Gg CO_2 eq	Gg CO_2 eq	%	%	%	%	%	%	%	%	%
1.A.2.d.	Pulp, Paper and Print	Gaseous fuels	N_2O		0.3	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	Biomass	N_2O		0.3	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Liquid fuels	N_2O	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	N_2O	9.9	13.1	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	N_2O		1.5	14.1	100.0	101.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.e.	Food Processing, Beverages and Tobacco	Biomass	N_2O		2.4	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	Liquid fuels	N_2O	5.6	25.0	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	N_2O	24.3	47.3	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	N_2O	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	N_2O		15.7	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	N_2O		23.7	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	N_2O	11.1	1.3	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	N_2O	31.7	20.3	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	N_2O	0.3	2.6	70.7	100.0	122.5	0.0	0.0	0.0	0.0	0.0	0.0
1.A.2.g.	Other Industries	Biomass	N_2O		19.0	2.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.a.	Domestic Aviation	Jet kerosene	N_2O	8.9	22.1	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	N_2O	288.2	241.4	10.0	250.0	250.2	0.0	0.0	0.0	0.9	0.0	0.8
1.A.3.b.	Road Transportation	Diesel oil	N_2O	249.5	944.1	10.0	250.0	250.2	0.3	0.0	0.0	0.4	0.1	0.1
1.A.3.b.	Road Transportation	Liquefied petroleum gases (LPG)	N_2O		8.6	10.0	250.0	250.2	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.b.	Road Transportation	Gaseous fuels	N_2O		2.5	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	N_2O		5.9	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	N_2O	68.4	34.0	5.0	142.0	142.1	0.0	0.0	0.0	0.1	0.0	0.0
1.A.3.c.	Railways	Solid fuels	N_2O	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	N_2O	2.1	0.4	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	N_2O	1.8	9.9	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	N_2O	0.0	0.2	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	N_2O		1.4	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	N_2O		18.2	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	N_2O		18.2	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	N_2O	11.8	0.6	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	N_2O	61.0	79.4	14.1	100.0	101.0	0.0	0.0	0.0	0.1	0.0	0.0
1.A.4.b.	Residential	Gaseous fuels	N_2O	0.1	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	Biomass	N_2O	359.7	79.0	300.0	100.0	316.2	0.0	0.0	0.0	0.6	0.2	0.4
1.A.4.c.	Agriculture/Forestry/Fisheries	Liquid fuels	N_2O	680.3	1 164.5	14.1	250.0	250.4	0.4	0.0	0.0	1.2	0.1	1.4
1.A.4.c.	Agriculture/Forestry/Fisheries	Gaseous fuels	N_2O		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		N_2O	0.9	0.8	7.0	100.0	100.2	0.0	0.0	0.0	0.0	0.0	0.0
2.B.2.	Nitric acid production		N_2O	1 063.6	2 005.8	2.0	20.0	20.1	0.0	0.0	0.0	0.1	0.0	0.0
3.B.	Manure management		N_2O	3 084.3	5 061.5	14.1	50.0	52.0	0.3	0.0	0.0	1.1	0.6	1.7

Table A6 Approach 1 Uncertainty assessment (cont'd)

Source Category		Fuel	Gas	Emissions in 1990 Gg CO_2 eq	Emissions in 2020 Gg CO_2 eq	AD Unc. %	EF Unc. %	Combined Unc. %	H(1) %	I(2) %	J(3) %	K(4) %	L(5) %	M(6) %
3.D.	Agricultural soils		N_2O	17 313.5	27 388.6	18.6	96.3	98.1	33.1	0.1	0.2	12.9	4.4	184.5
3.F.	Field burning of agricultural residues		N_2O	81.9	40.9	50.0	40.0	64.0	0.0	0.0	0.0	0.0	0.0	0.0
4.A.	Forest land		N_2O	50.2	71.7	23.5	0.9	23.5	0.0	0.0	0.0	0.0	0.0	0.0
4.B.	Cropland		N_2O		24.3	23.5	4.5	23.9	0.0	0.0	0.0	0.0	0.0	0.0
4.C.	Grassland		N_2O		11.9	23.5	4.5	23.9	0.0	0.0	0.0	0.0	0.0	0.0
4.D.	Wetlands		N_2O		4.2	23.5	4.5	23.9	0.0	0.0	0.0	0.0	0.0	0.0
4.(IV).	Indirect N2O Emissions		N_2O		78.0	166.0	350.0	387.4	0.0	0.0	0.0	0.2	0.1	0.0
5.B.	Biological treatment of solid waste		N_2O	6.7	8.5	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		N_2O	11.2	0.5	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_2O	1 441.0	2 265.8	30	42.4	51.9	0.1	0.0	0.0	0.5	0.6	0.6
	Total N_2O			**25 001.1**	**40 658.4**									
2.C.3.	Aluminium Production		PFC	625.3	37.8	25.0	5.0	25.5	0.0	0.0	0.0	0.1	0.0	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		0.0	25.0	5.0	25.5	0.0	0.0	0.0	0.0	0.0	0.0
2.E.5.	Other		SF_6		58.6	25.0	5.0	25.5	0.0	0.0	0.0	0.0	0.0	0.0
2.F.3.	Fire protection		HFC		301.9	25.0	5.0	25.5	0.0	0.0	0.0	0.0	0.1	0.0
2.F.6.	Other applications		HFC		5551.2	25.0	5.0	25.5	0.1	0.0	0.0	0.2	1.2	1.5
2.G.1.	Electrical equipment		SF_6		57.2	25.0	5.0	25.5	0.0	0.0	0.0	0.0	0.0	0.0
	Total HFCs, PFCs and SF_6			**625.3**	**6 006.8**									
Total all gases with LULUCF				**163 984.0**	**466 949.6**		**Overall Unc.**	**10.4**		**Trend Unc.**		**36.7**		
Total all gases without LULUCF				**219 720.0**	**523 897.2**		**Overall Unc.**	**6.0**		**Trend Unc.**		**10.8**		

(1) Contribution to Variance by Category in Year t
(2) Type A sensitivity
(3) Type B sensitivity
(4) Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty
(5) Uncertainty in trend in national emissions introduced by activity data uncertainty
(6) Uncertainty introduced into the trend in total national emissions

Table A7.1 Approach 2 Uncertainty assessment (Monte Carlo Simulation Method) for 2017

Selected Sources				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	Liquid fuels	CO2	1232.24	1190.78	4.24	±2.65
1.A.1.a.	Public Electricity and Heat Production	Solid fuels	CO2	98081.63	102140.92	3.50	-2.97, +2.91
1.A.1.a.	Public Electricity and Heat Production	Gaseous fuels	CO2	45136.77	44124.70	1.50	-1.46, +1.47
2.A.1.	Cement Production (Mineral Products)		CO2	37272.44	37270.42	5.39	-4.97, +5.02
2.A.2.	Lime Production (Mineral Products)		CO2	2683.98	2684.52	14.14	-12.29, +12.90
3.H.	Urea application		CO2	1449.63	1451.54	50.99	-13.54, +14.70
5.C.	Incineration and open burning of waste		CO2	1.91	1.91	50.24	±41.88
3.C.	Rice cultivation		CH4	9.35	9.47	76.9	-68.95, +70.43
5.A.1.	Managed waste disposal		CH4	33.87	34.64	32.38	-34.93, +34.82
5.A.2.	Unmanaged waste disposal sites		CH4	329.29	327.05	48.49	-46.85, +47.31
5.B.	Biological treatment of solid waste		CH4	0.33	0.36	22.36	±22.22
5.C.	Incineration and open burning of waste		CH4	0.07	0.07	104.52	-85.71, +114.29
5.D.1	Domestic wastewater		CH4	77.02	77.04	38.03	-40.16, +40.77
5.D.2	Industrial wastewater		CH4	20.97	24.15	40.67	-32.71, +41.28
5.B.	Biological treatment of solid waste		N2O	0.02	0.02	22.36	+50
5.C.	Incineration and open burning of waste		N2O	0.00	0.00	104.52	-72.73, +100
5.D.1	Wastewater treatment and discharge		N2O	19.49	19.48	51.94	-24.38, +25.56

Source: Ulusoy, G., 2019. Investigation of Sectoral Uncertainties in Turkish Greenhouse Gas Inventory and Application of Monte Carlo Simulation. TurkStat Expertness Thesis, Ankara.

Table A7.2 Approach 2 Uncertainty assessment (Monte Carlo Simulation Method) for 2018

IPPU Sector			2018 Emissions (kt)	Estimates of 2018 Emissions (Means) with MC (kt)	Combined Uncertainty (%) Approach 1 (±)	Combined Uncertainty (%) Approach 2
2.A.1.	Cement Production (Mineral Products)	CO_2	37 025.7	37 027.0	5.39	-5.35, +5.37
2.A.2.	Lime Production (Mineral Products)	CO_2	2 786.7	2 789.5	14.14	-16.87, +17.92
2.A.3.	Glass Production	CO_2	650.0	650.1	5.39	-9.63, +9.82
2.A.4.	Other process uses of carbonates	CO_2	3 356.3	3 354.3	30.07	-16.68, +17.81
2.B.1.	Ammonia Production	CO_2	1 038.4	1 038.3	5.39	-7.46, +7.54
2.B.5.	Carbide production	CO_2	6.2	6.2	20.62	-20.55, +20.87
2.B.7.	Soda ash production	CO_2	224.4	224.4	5.10	-5.10, +5.15
2.B.8.	Petrochemical and carbon black production	CO_2	1.2	1.2	14.14	±14.29
2.C.1.	Iron and Steel Production	CO_2	12 536.6	12 599.2	26.93	-29.05, +29.32
2.C.2.	Ferroalloys Production	CO_2	169.8	169.9	25.50	-25.15, +25.52
2.C.3.	Aluminium Production	CO_2	107.3	107.4	5.10	-5.15, +5.16
2.C.5.	Lead Production	CO_2	8.1	8.1	32.02	-22.87, +24.60
2.D.1.	Lubricant Use	CO_2	193.4	193.4	55.90	-51.96, +59.43
2.D.2.	Paraffin Wax Use	CO_2	13.0	13.0	103.08	-98.46, +107.31
2.C.1.	Iron and Steel Production	CH_4	17.1	17.3	11.18	-13.04, +11.59
2.B.2.	Nitric acid production	N_2O	1 823.2	1 823.8	20.10	±20.59

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_2 emissions from Public Electricity and Heat Production - Liquid fuels in ENERGY sector, 2017

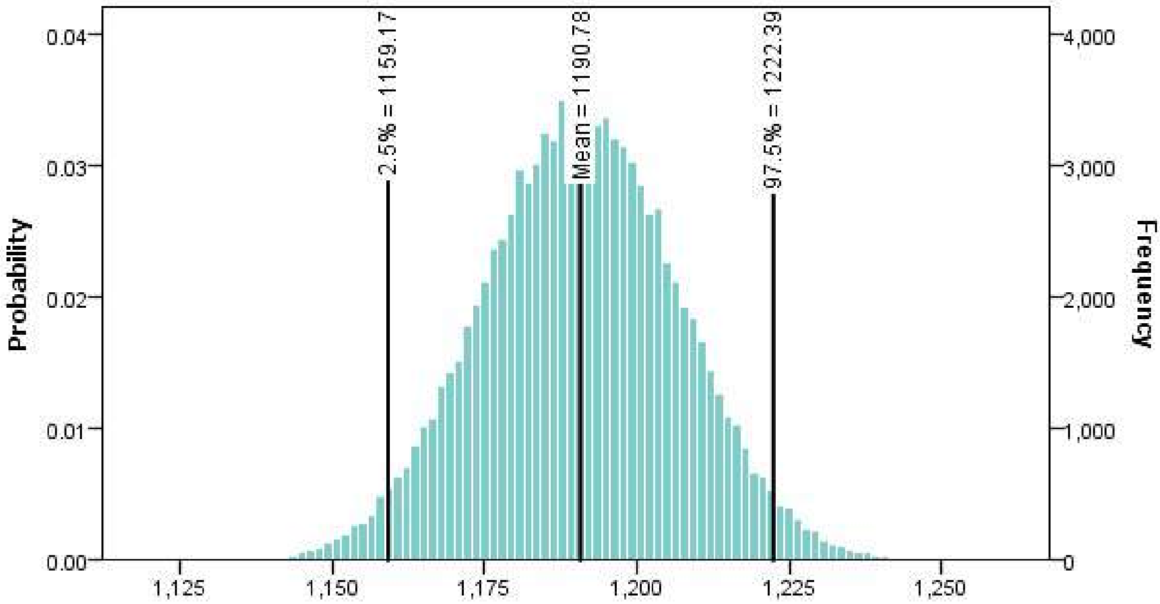


Figure A2 Probability density function resulting from Monte Carlo analysis for CO_2 emissions from Public Electricity and Heat Production - Solid fuels in ENERGY sector, 2017

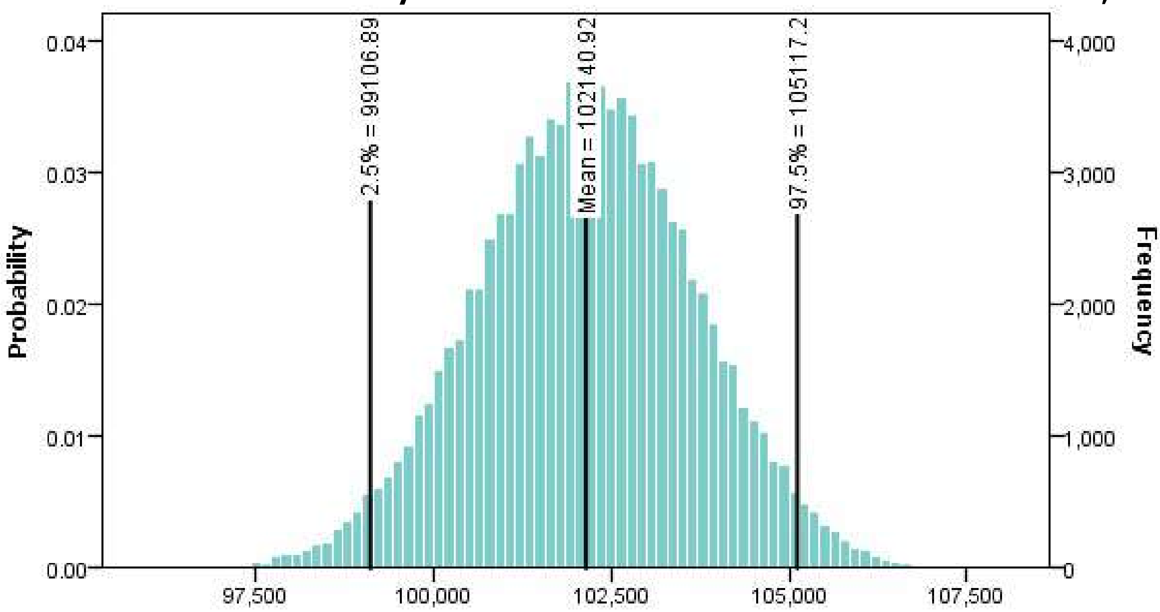


Figure A3 Probability density function resulting from Monte Carlo analysis for CO_2 emissions from Public Electricity and Heat Production- Gaseous fuels in ENERGY sector, 2017

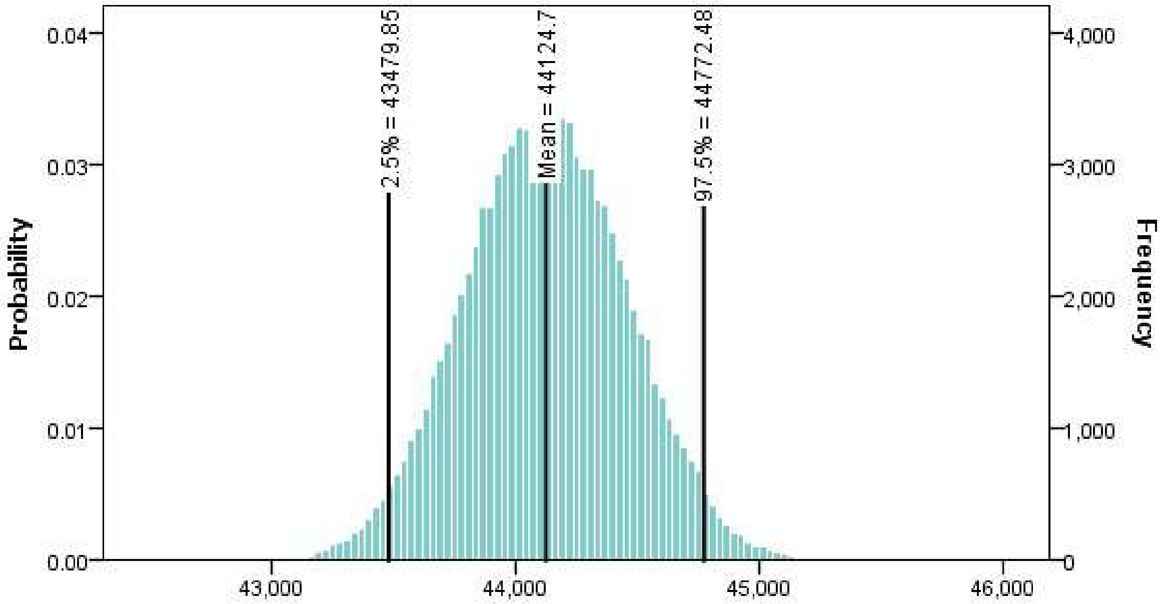


Figure A4 Probability density function resulting from Monte Carlo analysis for CO_2 emissions from Cement Production in IPPU sector, 2018

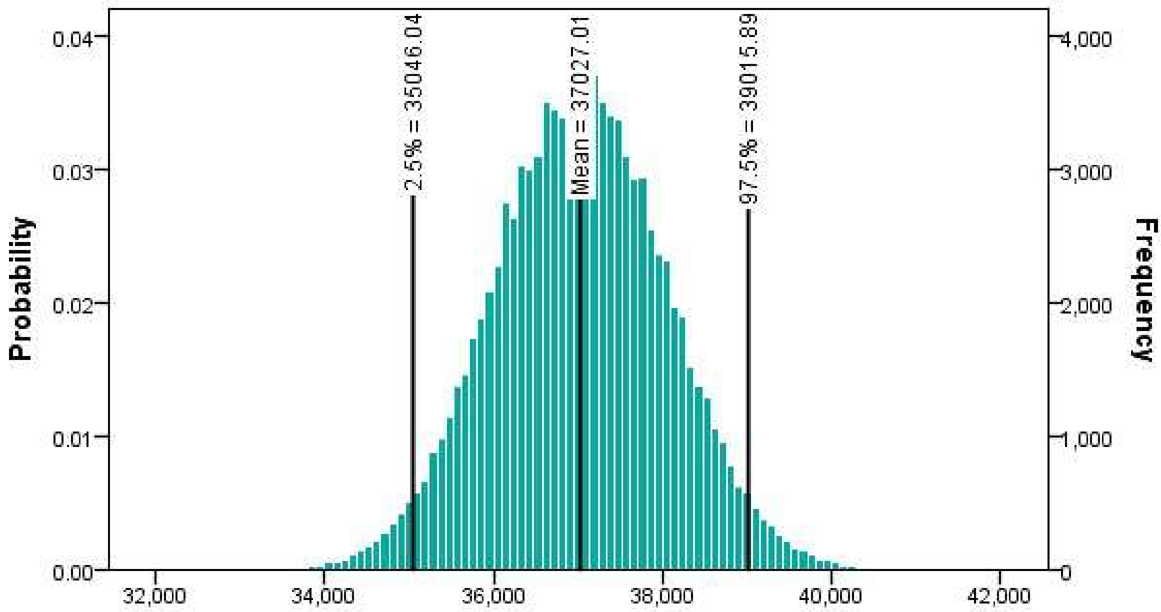


Figure A5 Probability density function resulting from Monte Carlo analysis for CO_2 emissions from Lime Production in IPPU sector, 2018

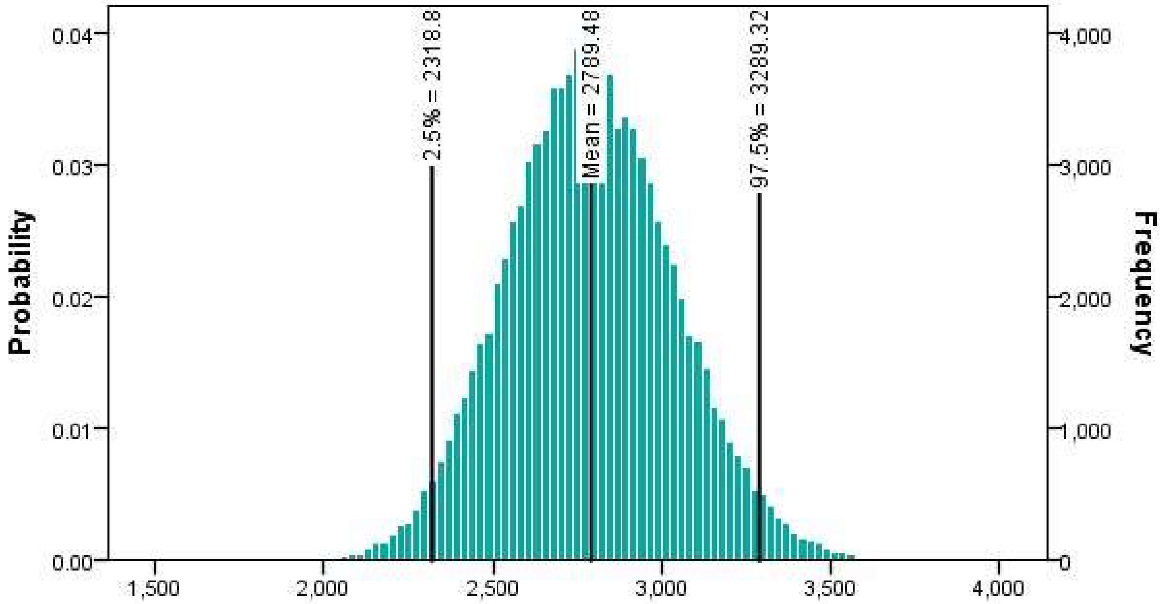


Figure A6 Probability density function resulting from Monte Carlo analysis for CO_2 emissions from Glass Production in IPPU sector, 2018

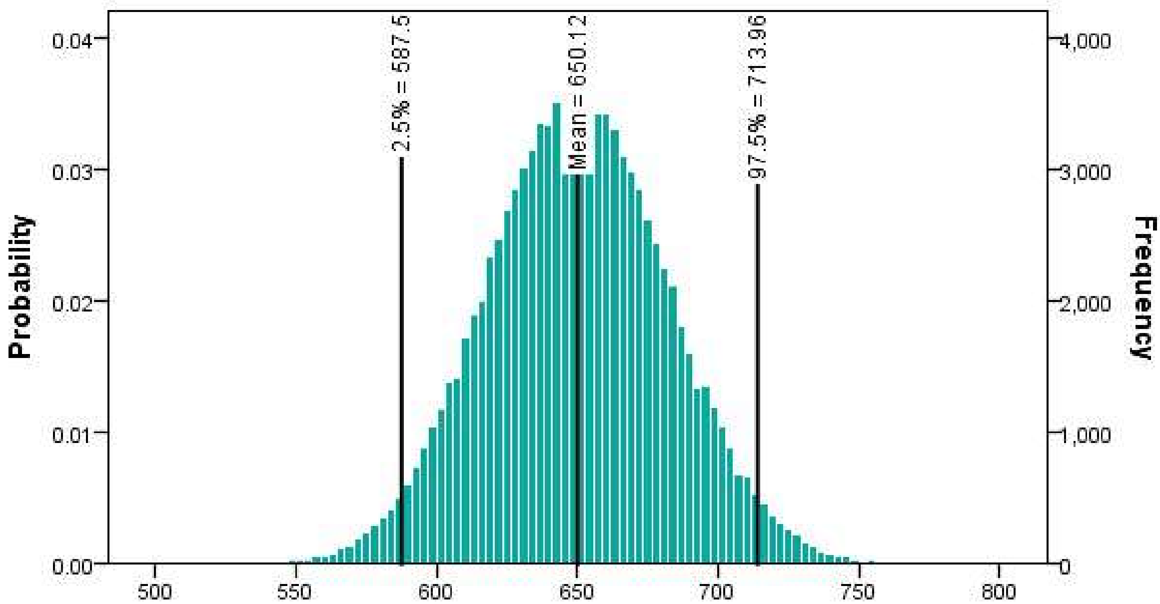


Figure A7 Probability density function resulting from Monte Carlo analysis for CO_2 emissions from Ceramics in IPPU sector, 2018

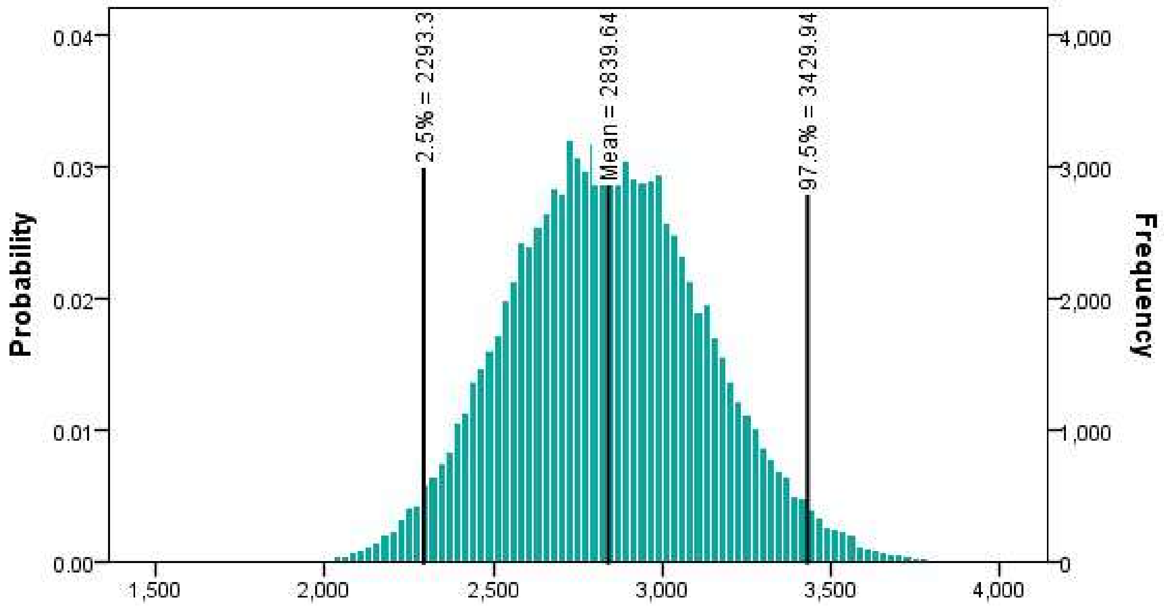


Figure A8 Probability density function resulting from Monte Carlo analysis for CO_2 emissions from Other Uses of Soda Ash in IPPU sector, 2018

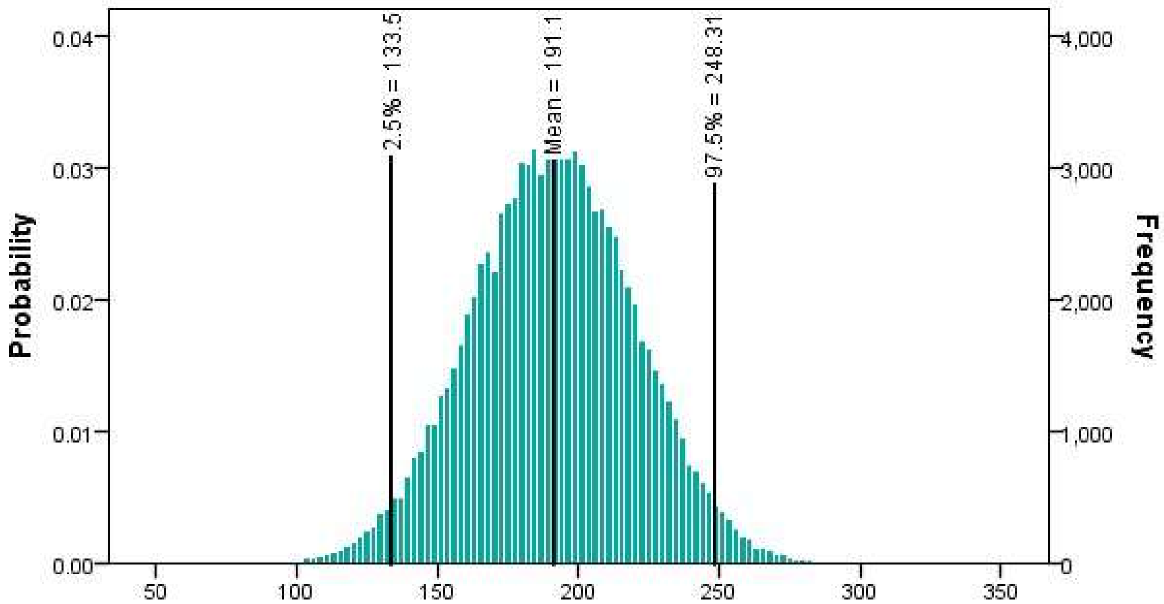


Figure A9 Probability density function resulting from Monte Carlo analysis for CO_2 emissions from Non-Metallurgical Magnesia Production in IPPU sector, 2018

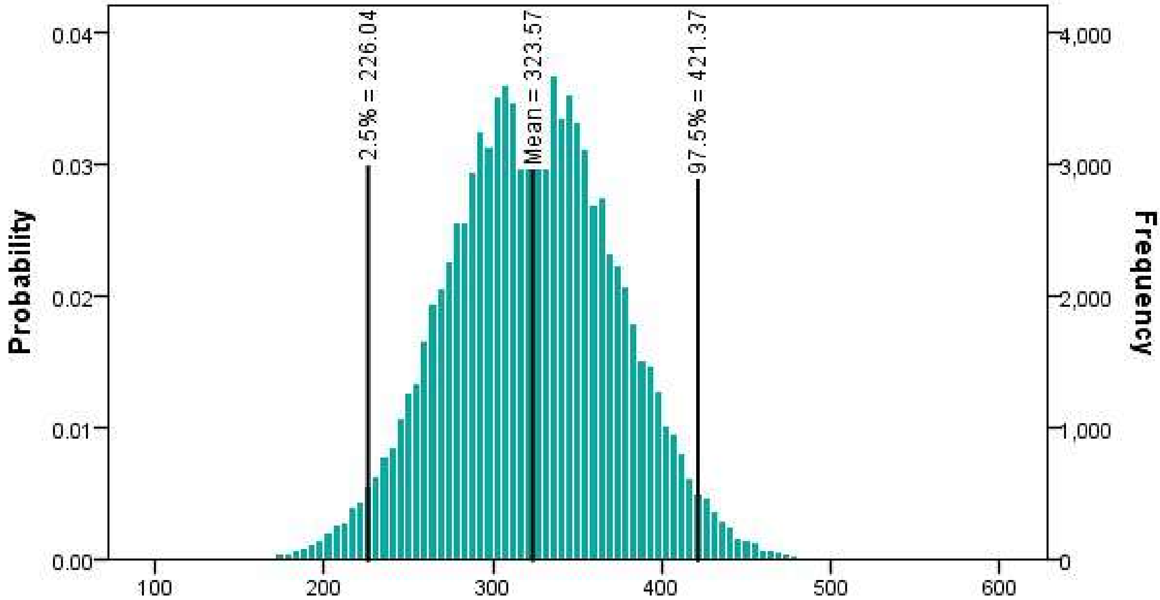


Figure A10 Probability density function resulting from Monte Carlo analysis for CO_2 emissions from Ammonia Production in IPPU sector, 2018

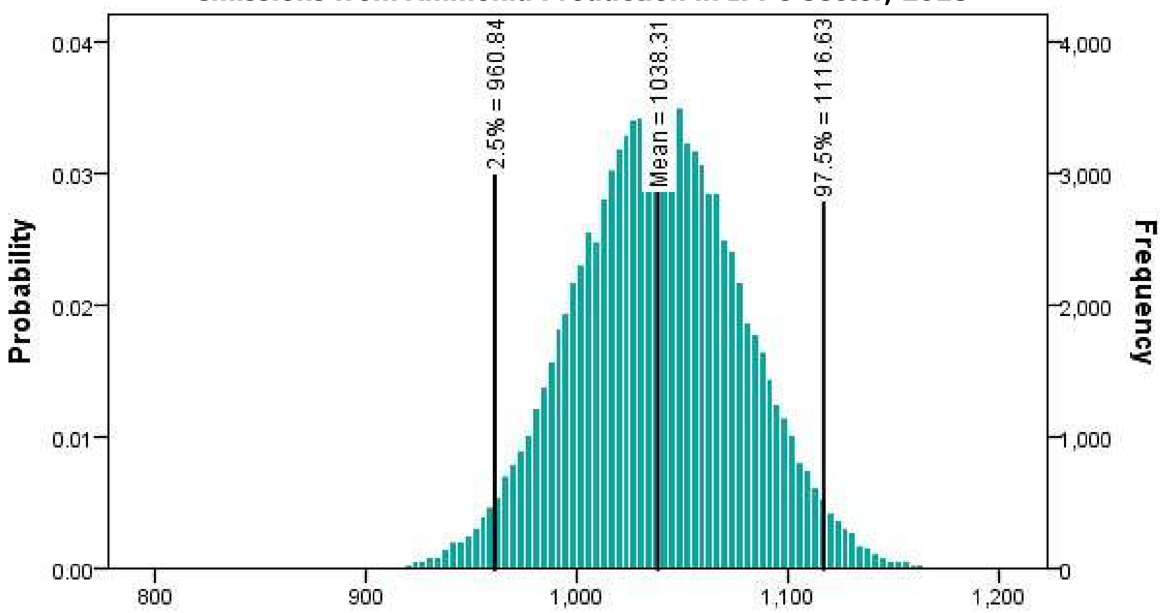


Figure A11 Probability density function resulting from Monte Carlo analysis for N_2O emissions from Nitric Acid Production in IPPU sector, 2018

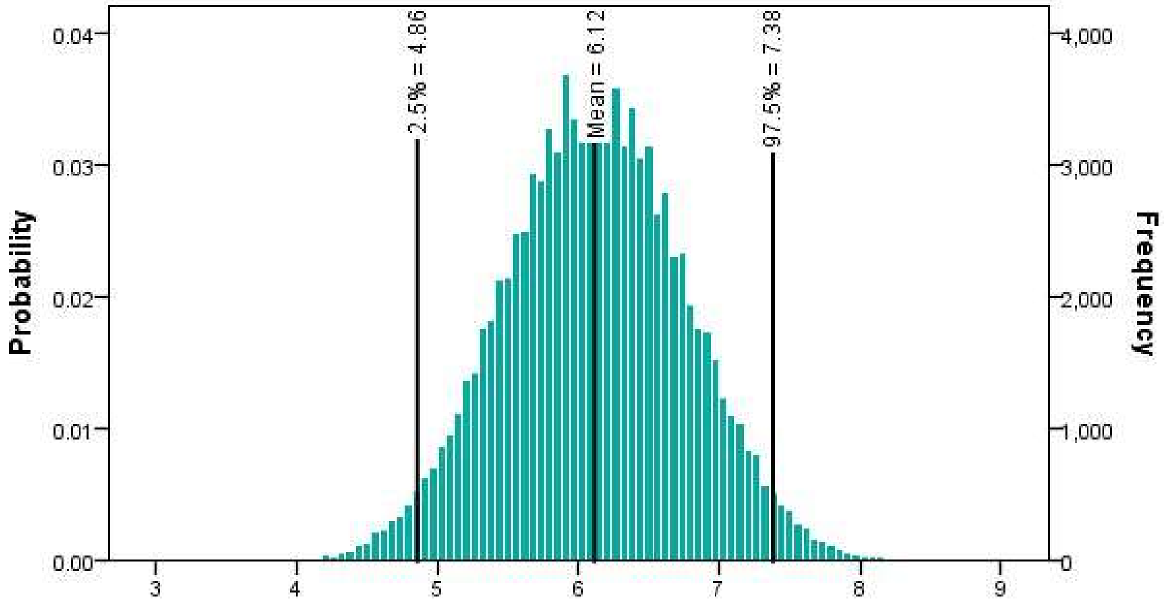


Figure A12 Probability density function resulting from Monte Carlo analysis for CO_2 emissions from Carpide Production in IPPU sector, 2018

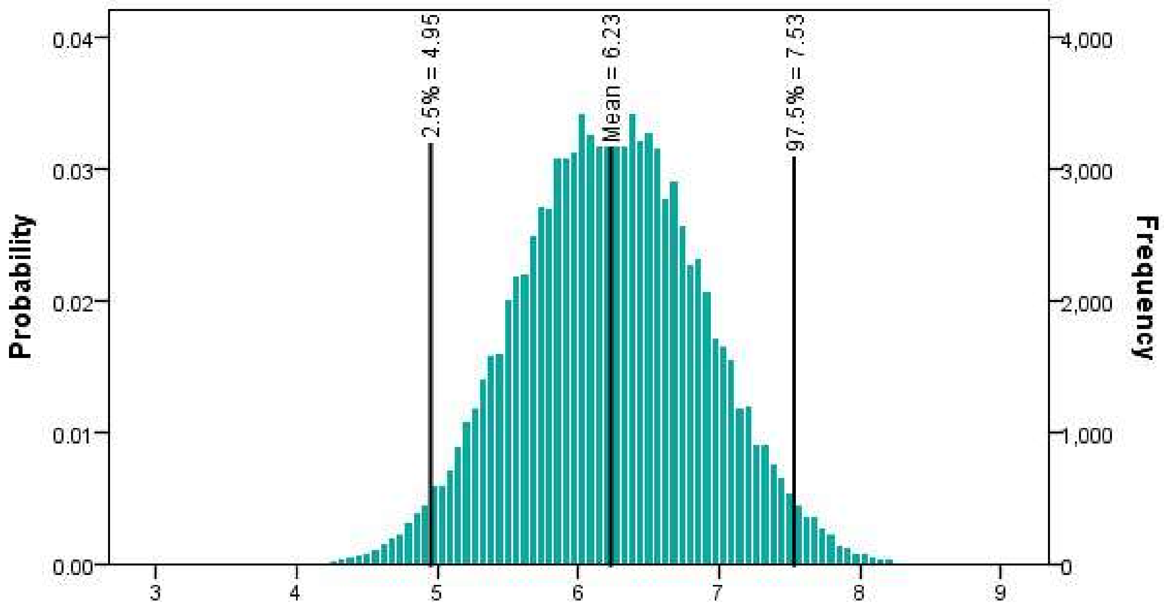


Figure A13 Probability density function resulting from Monte Carlo analysis for CO_2 emissions from Soda Ash Production in IPPU sector, 2018

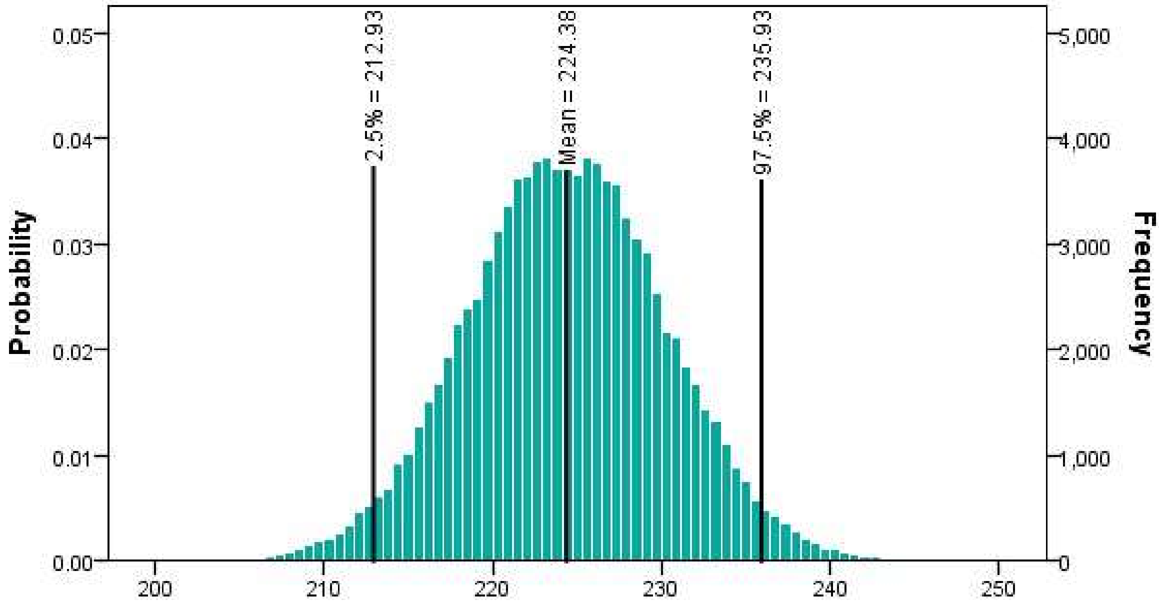


Figure A14 Probability density function resulting from Monte Carlo analysis for CO_2 emissions from Petrochemical and Carbon Black Production in IPPU sector, 2018

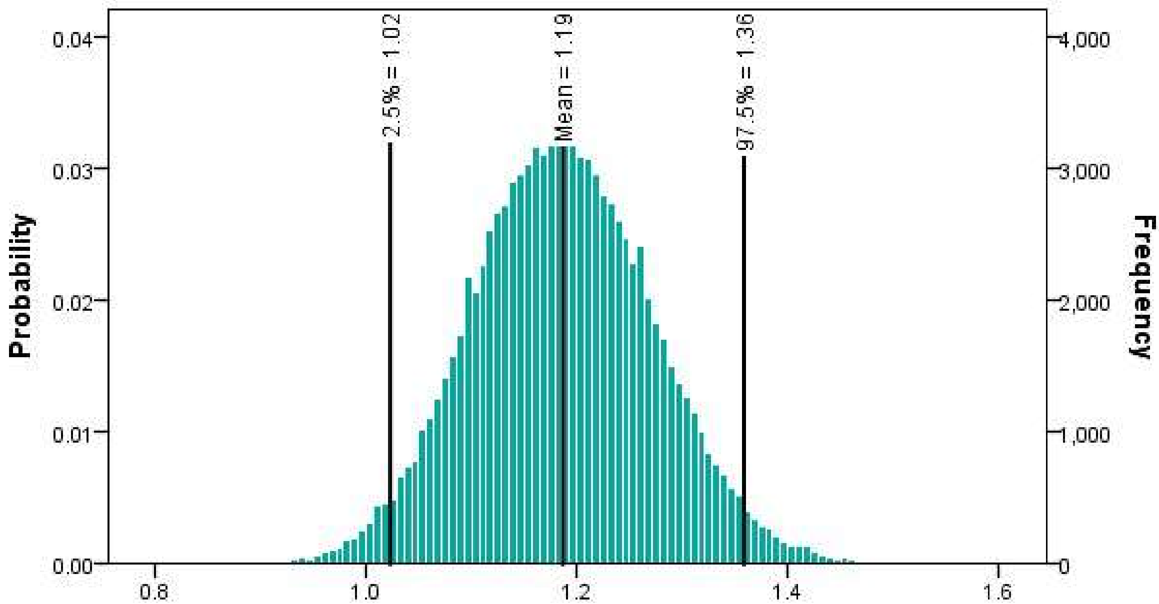


Figure A15 Probability density function resulting from Monte Carlo analysis for CO_2 emissions from Iron and Steel Production in IPPU sector, 2018

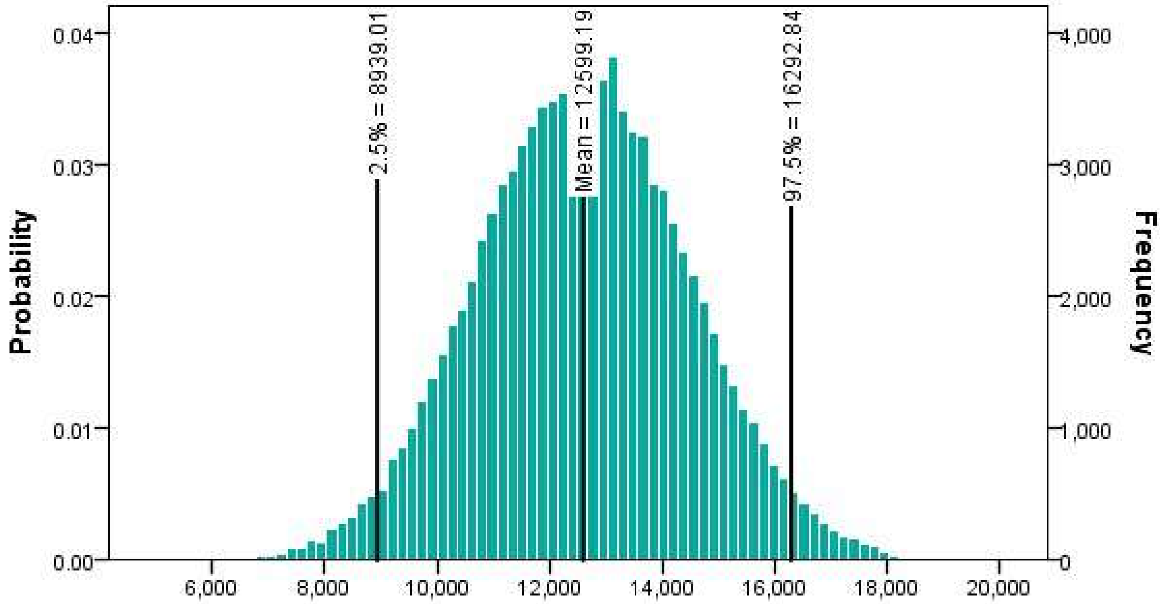


Figure A16 Probability density function resulting from Monte Carlo analysis for CH_4 emissions from Iron and Steel Production in IPPU sector, 2018

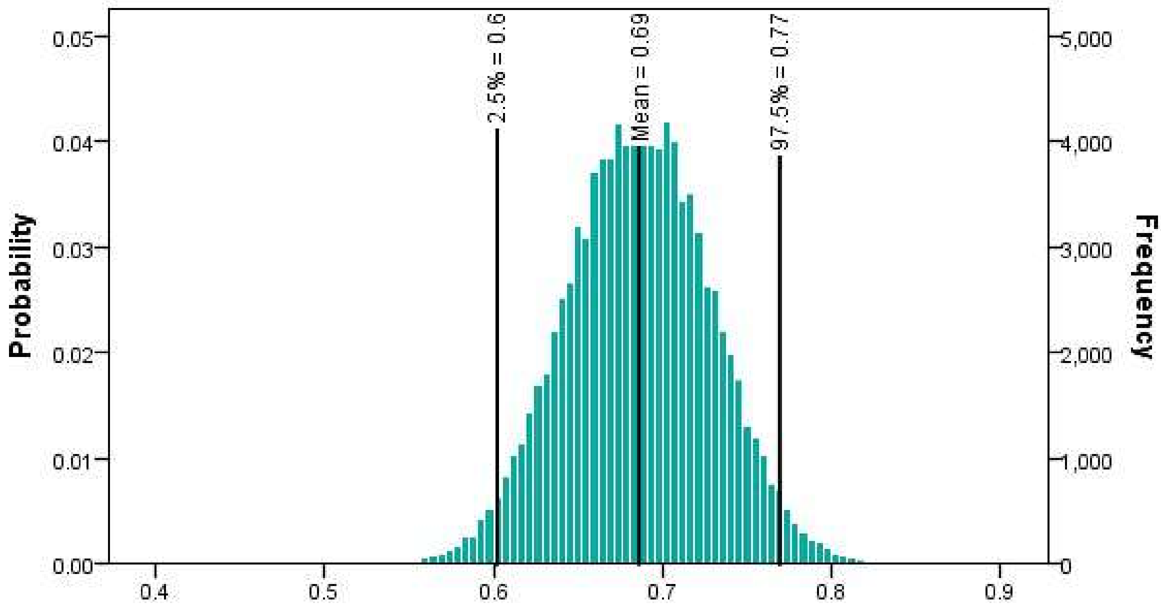


Figure A17 Probability density function resulting from Monte Carlo analysis for CO_2 emissions from Ferroalloys Production in IPPU sector, 2018

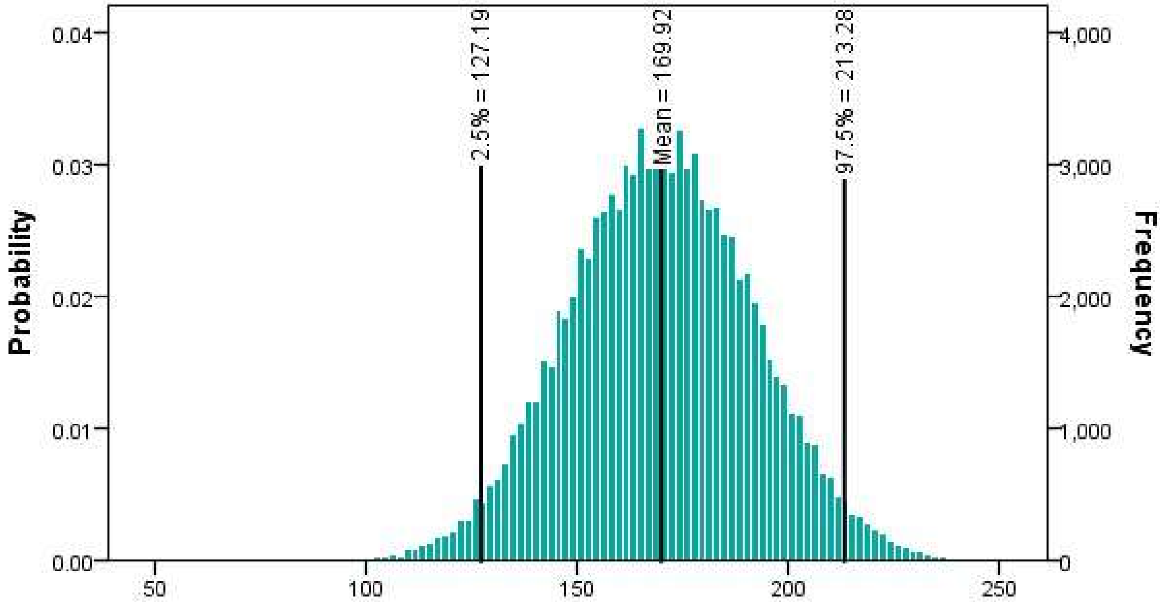


Figure A18 Probability density function resulting from Monte Carlo analysis for CO_2 emissions from Aluminum Production in IPPU sector, 2018

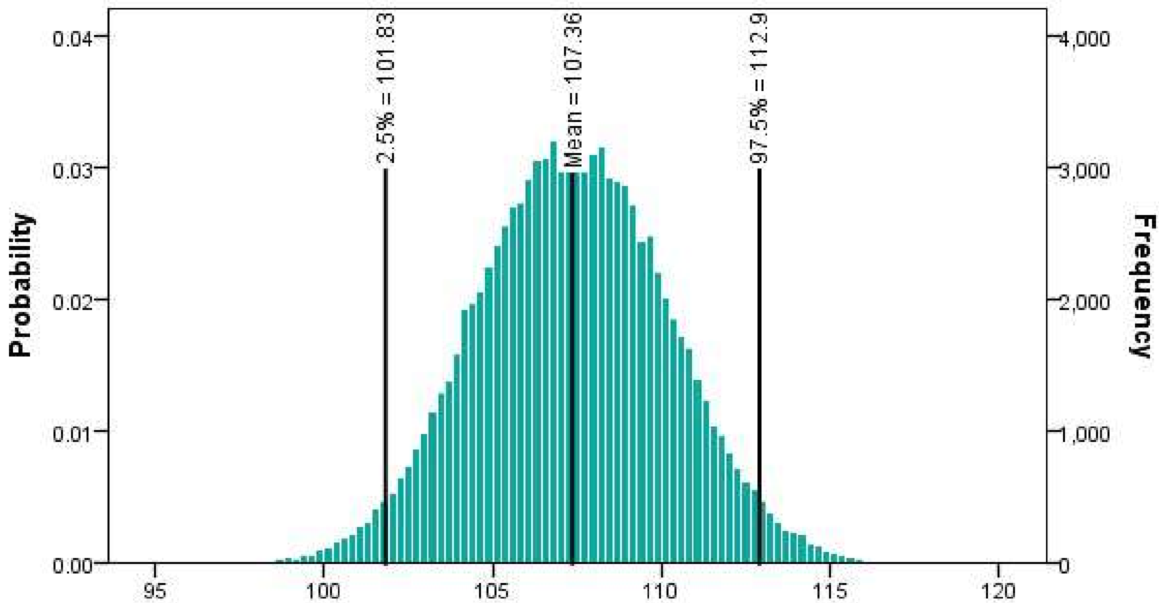


Figure A19 Probability density function resulting from Monte Carlo analysis for CO_2 emissions from Lead Production in IPPU sector, 2018

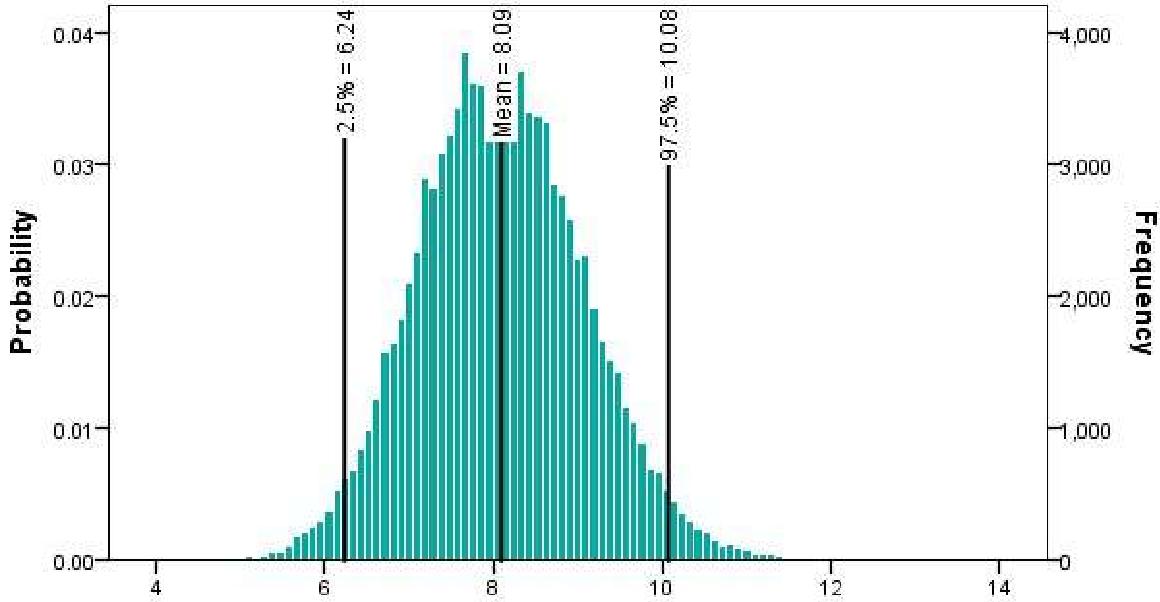


Figure A20 Probability density function resulting from Monte Carlo analysis for CO_2 emissions from Lubricant Use in IPPU sector, 2018

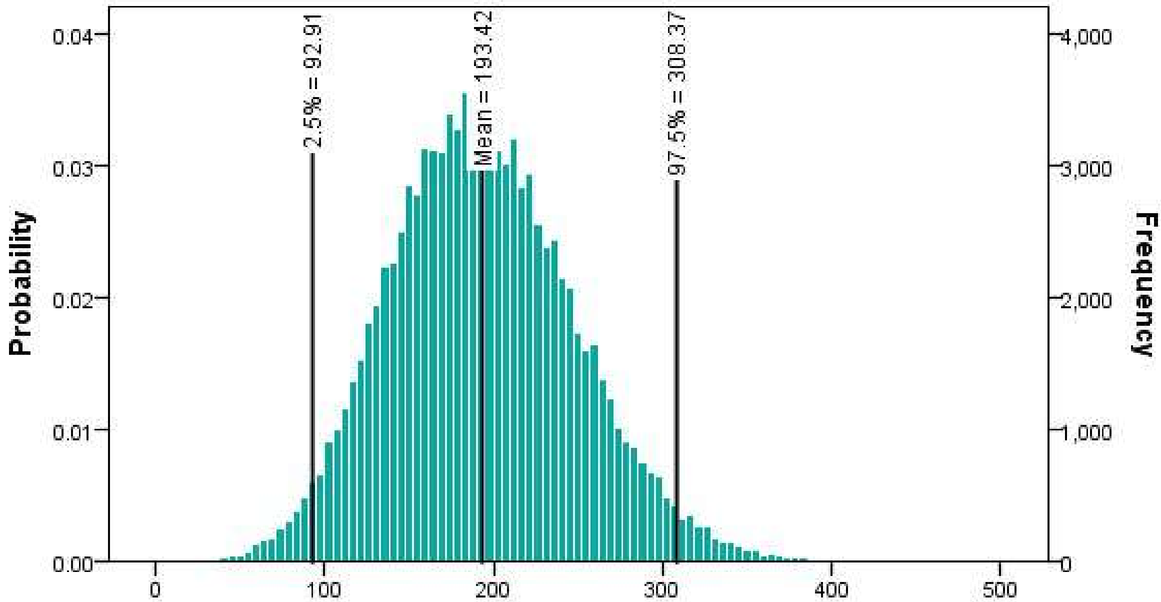


Figure A21 Probability density function resulting from Monte Carlo analysis for CO_2 emissions from Paraffin Wax Use in IPPU sector, 2018

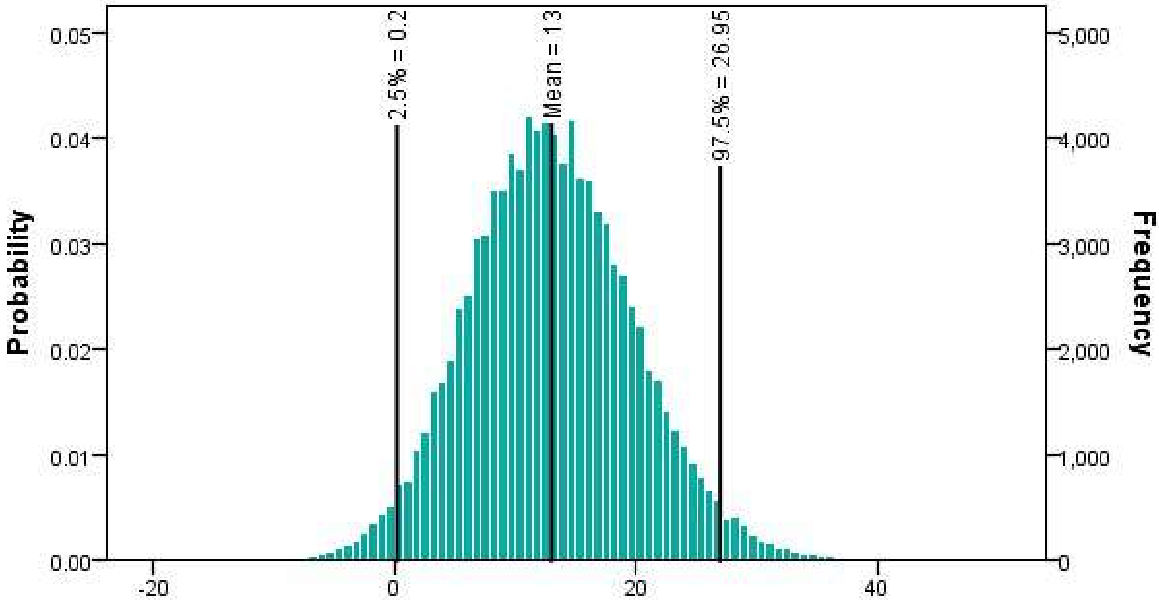


Figure A22 Probability density function resulting from Monte Carlo analysis for CO_2 emissions from Urea Application in AGRICULTURE sector, 2017

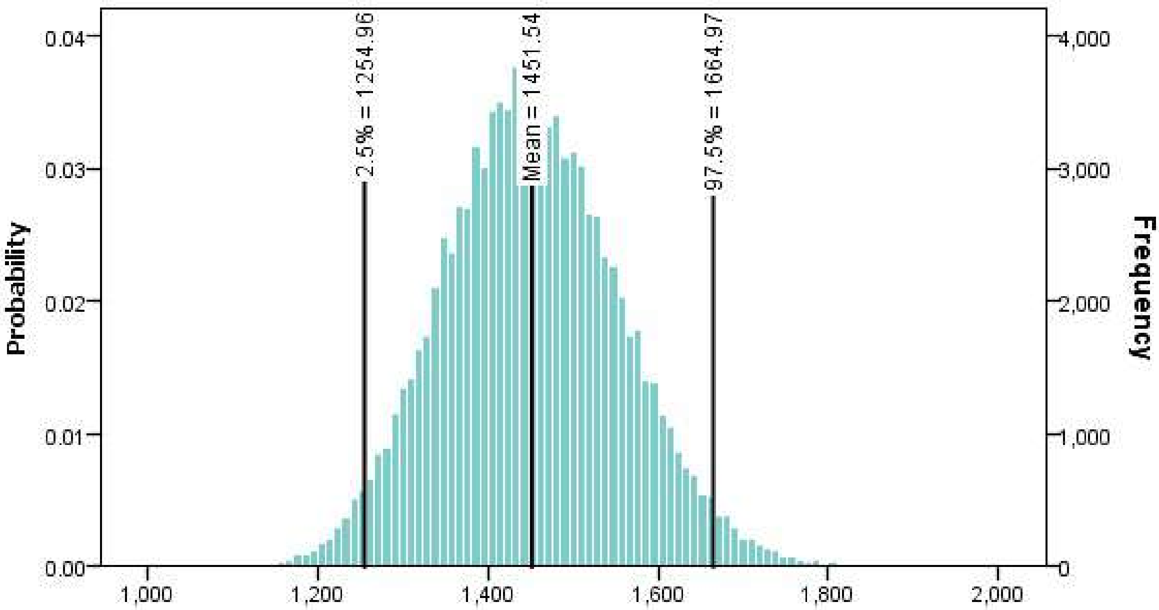


Figure A23 Probability density function resulting from Monte Carlo analysis for CH_4 emissions from Rice Cultivation in AGRICULTURE sector, 2017

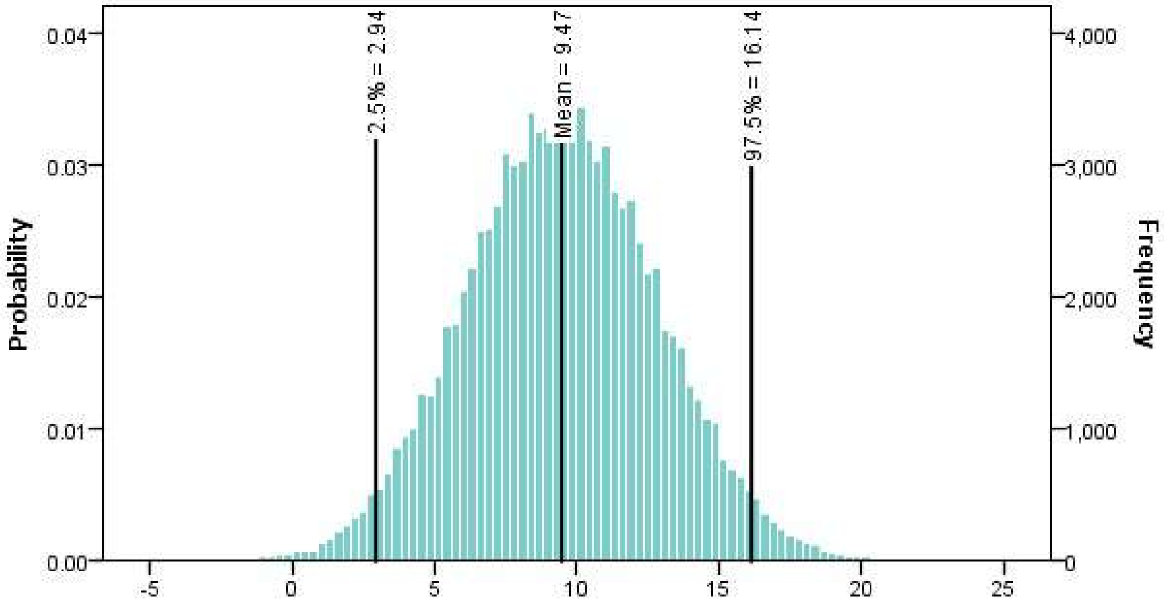


Figure A24 Probability density function resulting from Monte Carlo analysis for CH_4 emissions from Managed SWDS in WASTE sector, 2017

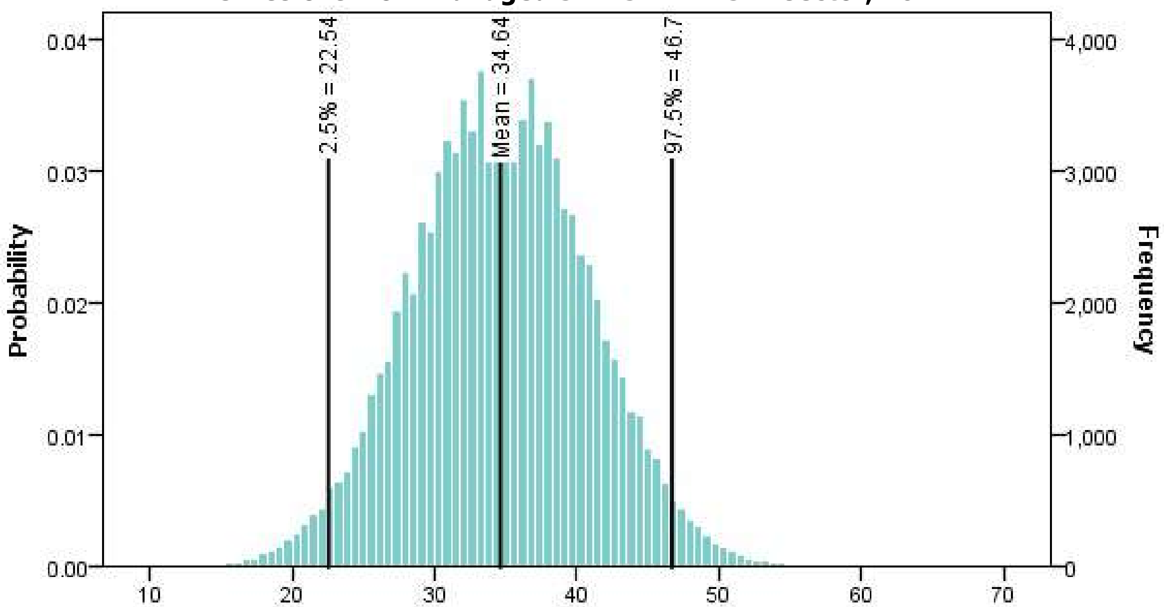


Figure A25 Probability density function resulting from Monte Carlo analysis for CH_4 emissions from Unmanaged SWDS in WASTE sector, 2017

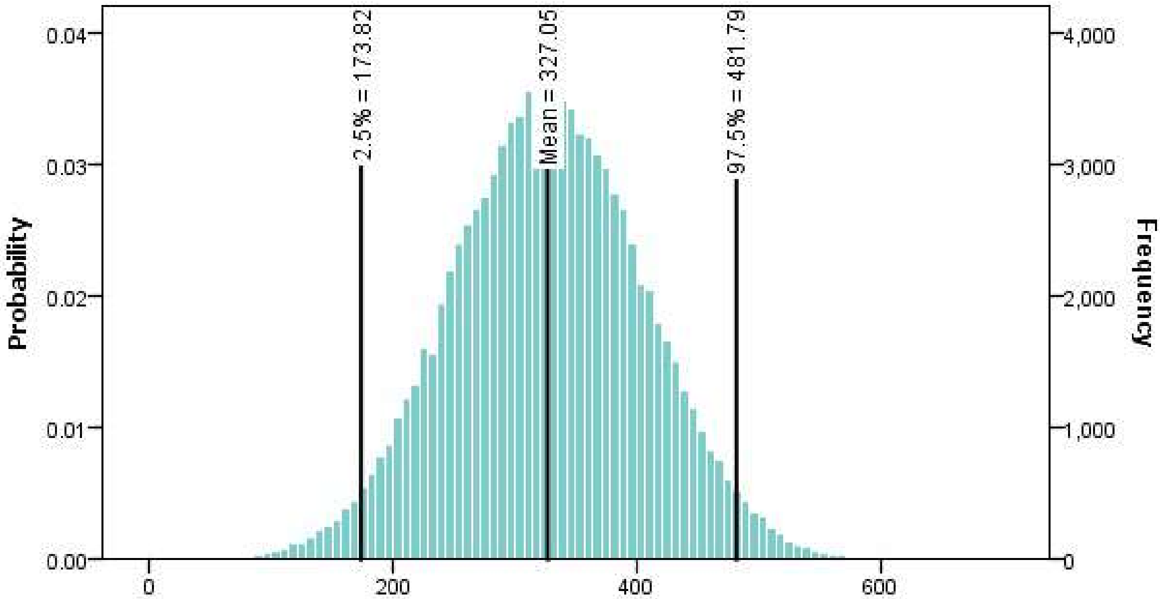


Figure A26 Probability density function resulting from Monte Carlo analysis for CH_4 emissions from Biological Treatment of Solid Waste - Composting in WASTE sector, 2017

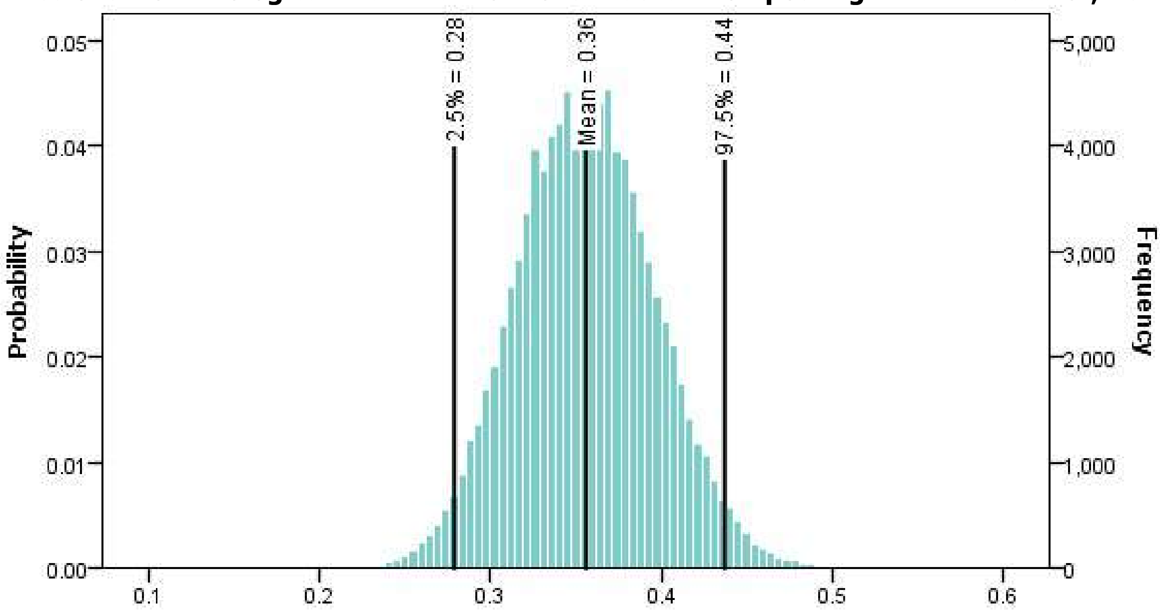


Figure A27 Probability density function resulting from Monte Carlo analysis for N_2O emissions from Biological Treatment of Solid Waste - Composting in WASTE sector, 2017

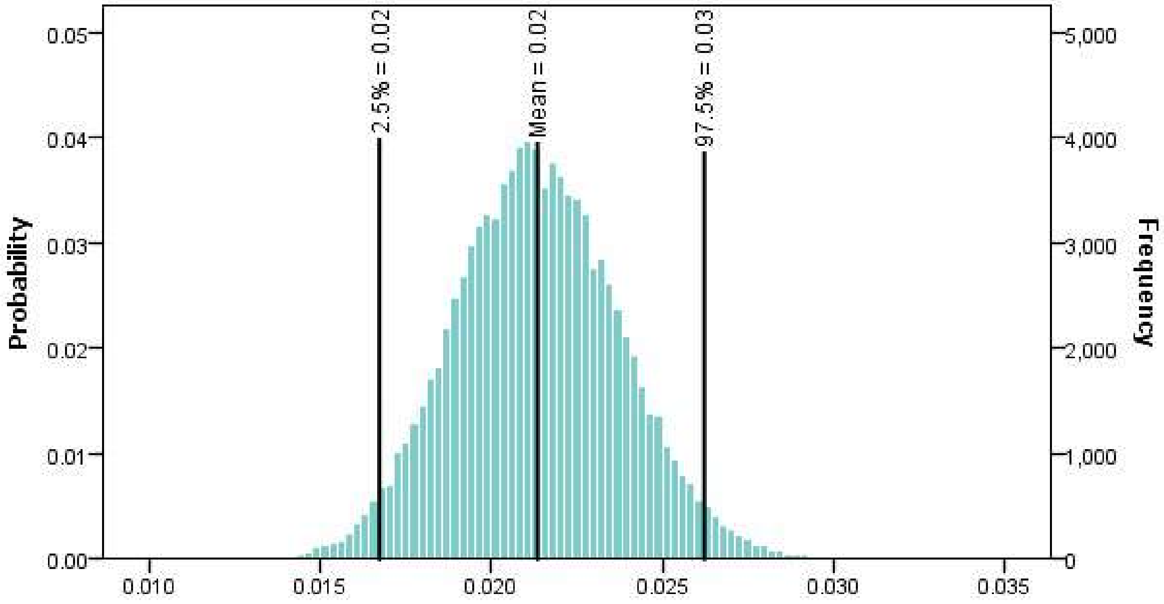


Figure A28 Probability density function resulting from Monte Carlo analysis for CO_2 emissions from Incineration and Open Burning Of Waste in WASTE sector, 2017

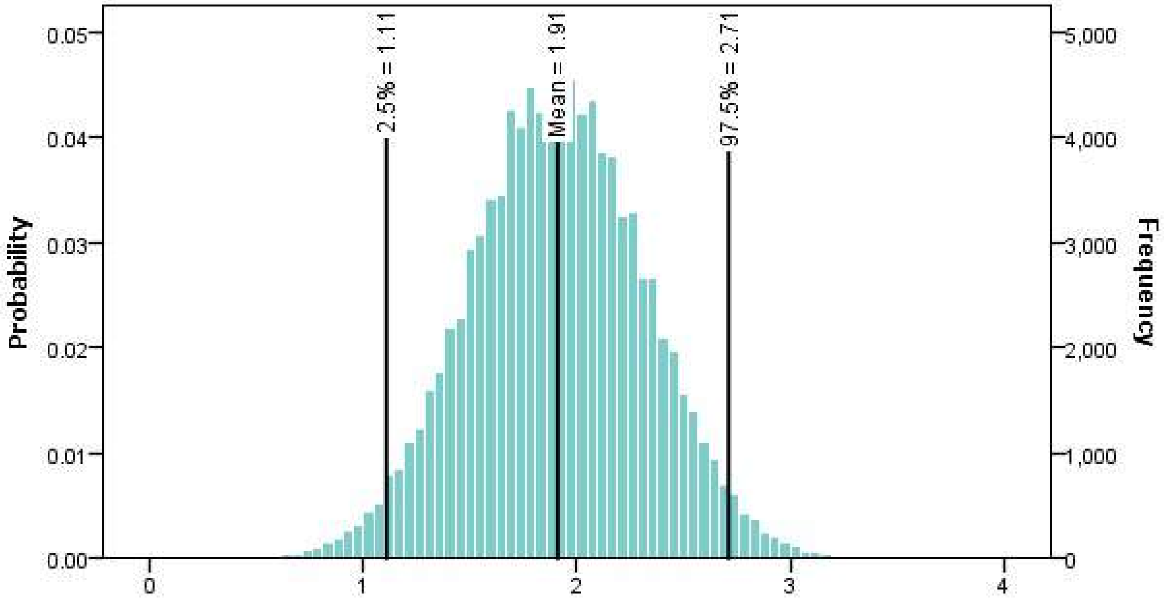


Figure A29 Probability density function resulting from Monte Carlo analysis for CH_4 emissions from Incineration and Open Burning Of Waste in WASTE sector, 2017

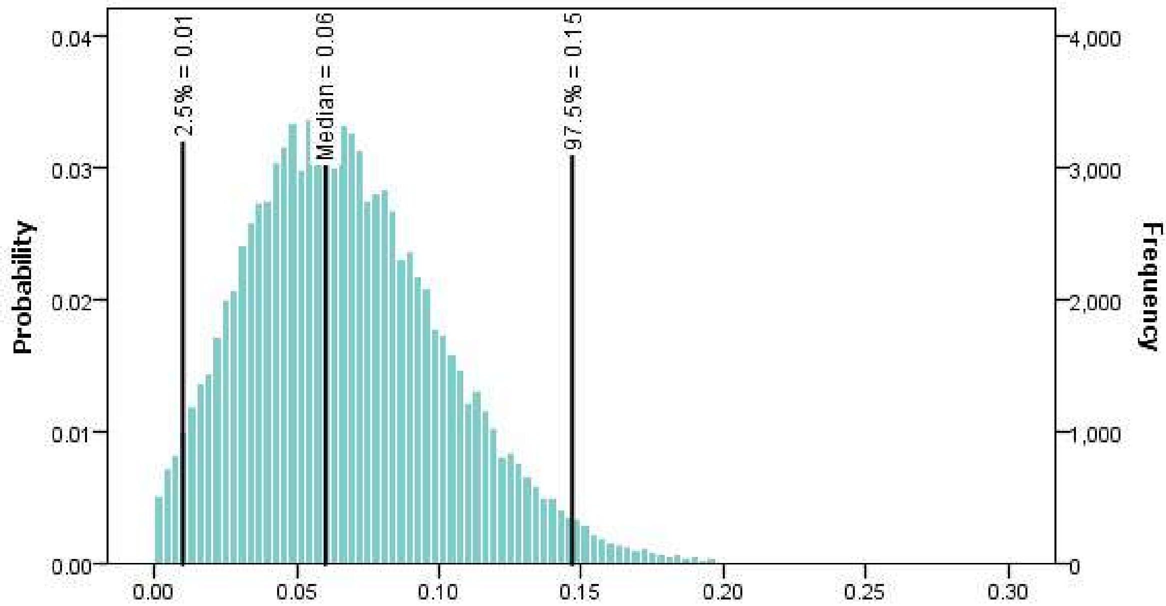


Figure A30 Probability density function resulting from Monte Carlo analysis for N_2O emissions from Incineration and Open Burning of Waste in WASTE sector, 2017

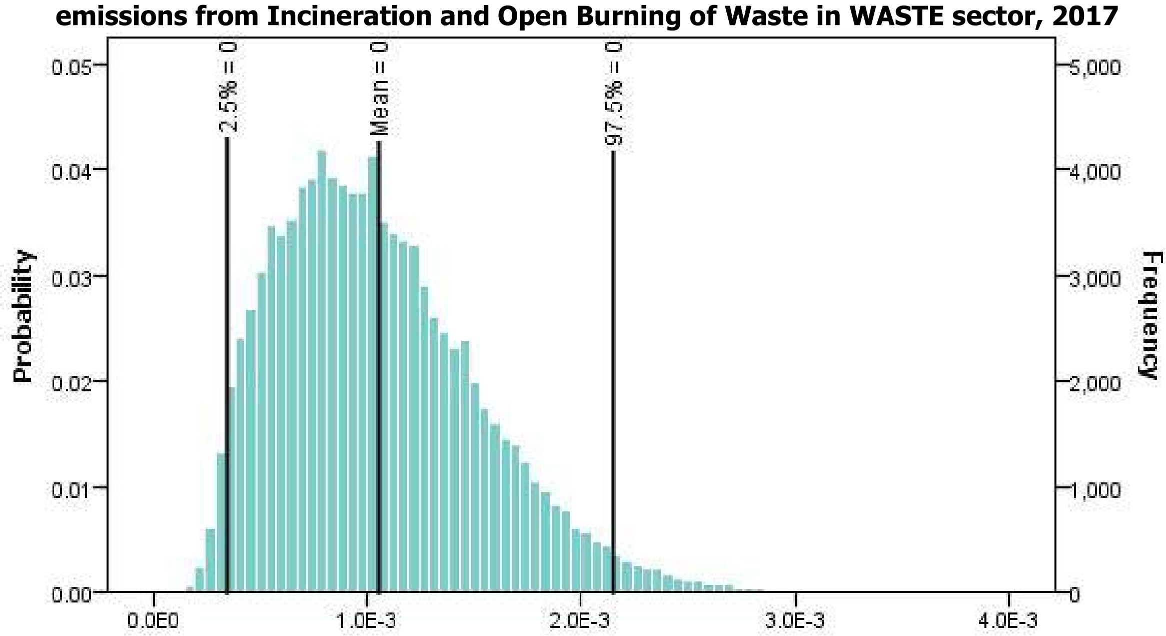


Figure A31 Probability density function resulting from Monte Carlo analysis for CH_4 emissions from Wastewater Treatment and Discharge- Industrial Wastewater in WASTE sector, 2017

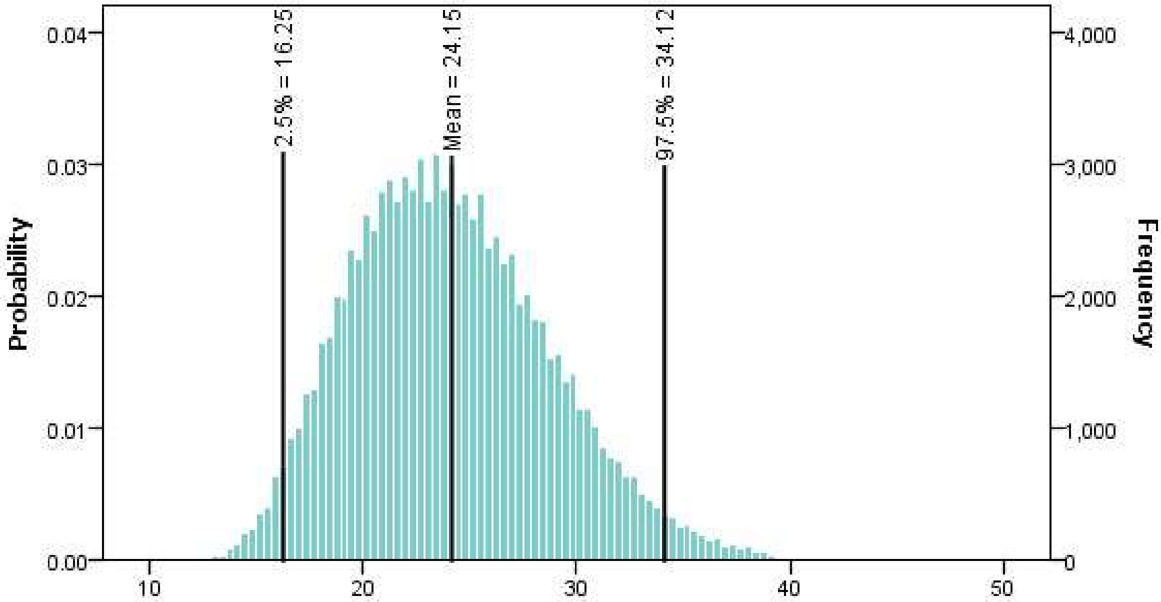


Figure A32 Probability density function resulting from Monte Carlo analysis for CH_4 emissions from Wastewater Treatment and Discharge- Domestic Wastewater in WASTE sector, 2017

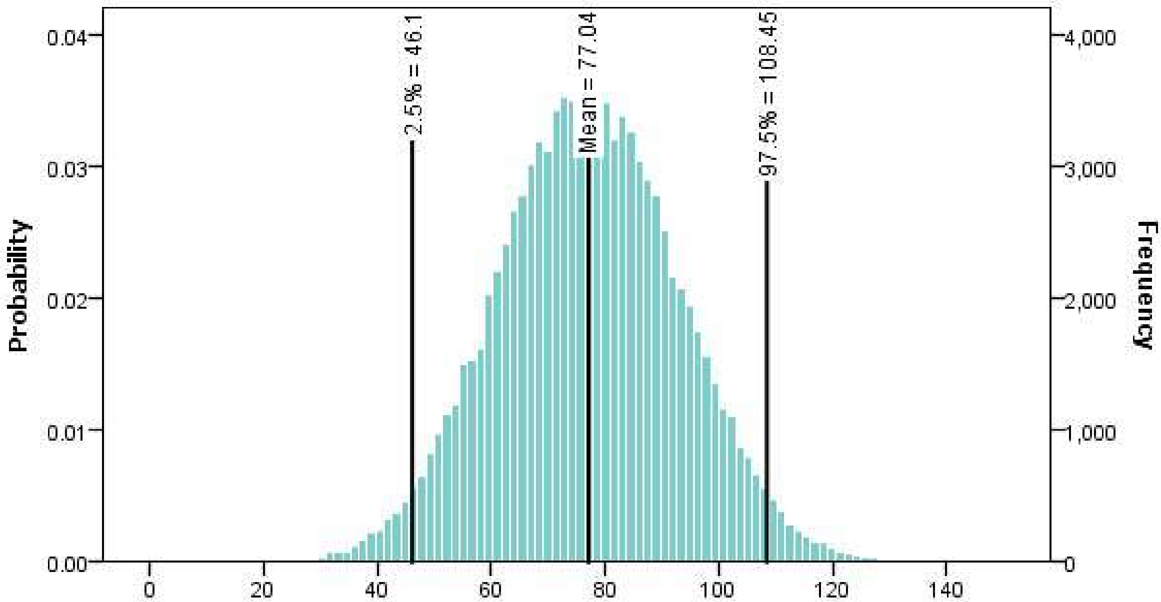
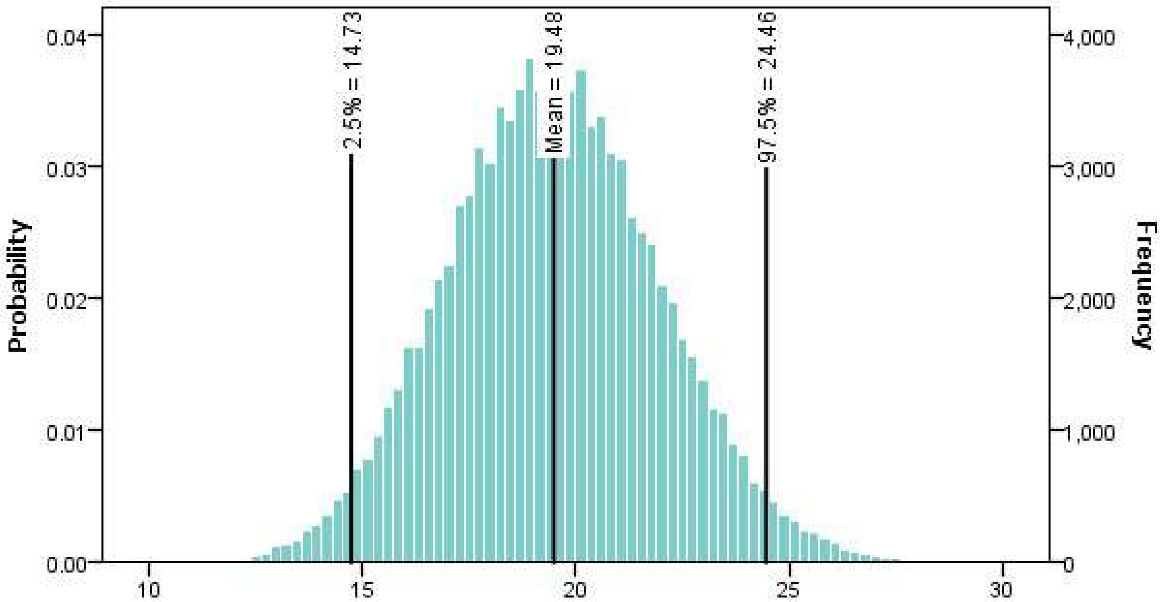


Figure A33 Probability density function resulting from Monte Carlo analysis for N_2O emissions from Wastewater Treatment and Discharge- Domestic Wastewater in WASTE sector, 2017



Annex 3: Country Specific Carbon Content Determination and Emission Factors

In Türkiye 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, BOTAŞ 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 Corporation (BOTAŞ). 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, Urbanization and Climate Change.

Turkish 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 Turkish 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 Turkish 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 Türkiye. There are 3 integrated iron&steel facilities in Türkiye and there are coke production plants in all of them. Carbon contents of all carbonaceous material used for iron and steel production is measured by all the facilities. Carbon content of coke oven coke is also measured since it is used as reducing agent in pig iron production. Annual average carbon content of coke oven coke as kg C/ton of coke and net calorific values are compiled from integrated facilities. The mass of carbon is divided by net calorific values of coke oven coke and the result is the carbon content as kg C/GJ of coke. Calculated country specific carbon content is used for estimation of CO_2 emissions from coke combustion of all other sectors using coke as a fuel.

Gas/diesel oil and Residual fuel oil

Carbon content of gas/diesel oil and residual fuel oil is calculated based on fuel analysis made by Petroleum Research Centre at Middle East Technical University (METU) in Ankara. The Research Center was founded by METU Petroleum Engineering Department and General Directorate of Petroleum Affairs (under the Ministry of Energy and Natural Resources). The main objective of the Center is to make research on the oil and gas exploration and production, refining and transportation and to conduct projects on topics requested by public and private organizations.

Based on the fuel analysis of Petroleum Research Center, an example for calculation of carbon content of gas diesel oil and residual fuel oil is given below.

Sample A	Number of Sample B	C, normalized (%) C	NCV kcal/kg (average) D	NCV GJ/kg (average) E	C mass/kg fuel F (C/100)	C content kg C/GJ G (F/E)
Diesel	639/06-1106	86.261	10233	0.0428435	0.86261	20.133975
Fuel Oil	255/06-330	86.611	9901	0,0414535	0.86611	20.893530

Source: METU, Petroleum Research Laboratory, 2006.

An example for oxidation rate for gas diesel oil and residual fuel oil;

Oxidation rate of gas/diesel oil and residual fuel oil is calculated based on stack gas analysis of oil fired power plants. In stack gas analysis, CO percentage in stack gas is measured. Based on the inlet carbon already provided in fuel analysis report and outlet C derived from stack gas analysis, oxidation rates are calculated.

An example calculation is given below.

		Fuel oil density (kg/m3)	0.9757
CO (average v/v %)	3.25	**C inlet (m/m) %**	86.611
C (outlet v/v %) (*12/28)	1.39	**C inlet (v/v) %**	88.768

Oxidation rate, %: ((C inlet - C outlet)/C inlet)*100 = 98.43

Petroleum coke

Petroleum coke is used in mostly in cement factories. There are around 54 cement factories in Türkiye. 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

NCV of Fuels

	2020	**Unit**
Hard coal	26.03	TJ/kton
Lignite	8.27	TJ/kton
Asphaltite	19.51	TJ/kton
Coke	24.94	TJ/kton
BFG	729	Kcal/kg
Coke oven gas	4 181	Kcal/kg
BOF gas	1 520	Kcal/kg
Oil	43.96	TJ/kton
Coal tar	37.25	TJ/kton
Petroleum Coke	32.24	TJ/kton
Fuel oil	39.39	TJ/kton
Diesel oil	43.33	TJ/kton
Gasoline	44.80	TJ/kton
LPG	47.31	TJ/kton
Refinery gas	48.15	TJ/kton
Jet Kerosene	44.59	TJ/kton
Kerosene	43.75	TJ/kton
Naphtha	45.01	TJ/kton
By products	40.19	TJ/kton
Basic oil	42.00	TJ/kton
White spirit	43.50	TJ/kton
Bitumen	40.19	TJ/kton
Other petroleum products	40.19	TJ/kton
Natural gas	34.54	TJ/10^6m3
Wood	12.56	TJ/kton
Crop and animal residue	11.19	TJ/kton
Biofuels	36.05	TJ/kton

(TJ/kt) = (1000 TOE)/(kt) * 41.868

(TJ/10^6m3) = (1000 TOE)/(10^6m3) * 41.868

		Country Specific CO_2 Emission Factor					(t/TJ)
Years	**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
2018	93.25	108.88	108.08	268.30	37.35	194.38	55.27
2019	96.89	106.62	108.48	285.82	38.87	194.80	53.67
2020	91.76	104.75	110.70	260.32	39.74	196.53	55.67

Default CO_2 Emission Factors

Fuels	1990-2020
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_4 and N_2O Emission Factors

	Emission Factors		Source
Sub Sectors	**CH_4 (kg/TJ)**	**N_2O(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
Rafinery 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

	Emission Factors		Source
Sub Sectors	**CH_4 (kg/TJ)**	**N_2O(kg/TJ)**	
1A1c sector			
Derived gases	1	0.1	2006 IPCC Guideline Vol2 Table 2.3 page 2.18

CH_4 and N_2O Emission Factors (cont'd)

	Emission Factors		Source
Sub Sectors	**CH_4 (kg/TJ)**	**N_2O(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

	Emission Factors		Source
Sub Sectors	**CH_4 (kg/TJ)**	**N_2O(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_2/tonne carbonate)	0.69	CS
	EF dolomitic lime (tonnes CO_2/tonne carbonate)	0.77	Default
Glass production/Ceramics/Roof and Tiles/ Soda ash use	Soda (tonnes CO_2/tonne carbonate)	0.41	IPCC Vol 2. Table 2.1. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf
	Dolomit (tonnes CO_2/tonne carbonate)	0.48	IPCC Vol 2. Table 2.1. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf
	Kalker (tonnes CO_2/tonne carbonate)	0.44	IPCC Vol 2. Table 2.1. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf
Magnesia Production	Magnesia (tonnes CO_2/tonne carbonate)	0.52	IPCC Vol 2. Table 2.1. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf
Ammonia Production	Natural Gas NCV (kcal/sm3)	8453.7	BOTAŞ
	Natural Gas NCV (GJ/sm3)	0.0354	BOTAŞ
	Nat Gas. Car. Cont. (kgC/GJ)	15.2	BOTAŞ
	Carbon Oxidation Factor	1	Default
Nitric Acid Production	Middle pressure plant (kg N2O/tonne nitric acid)	7	IPCC VOL 2. Table 3.3. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf
	with abatement technology(kg N_2O/tonne nitric acid)	2.5	IPCC VOL 2. Table 3.3. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf
Carpide Production	Carpide (tonnes CO_2/tonne carbide produced)	1.09	IPCC VOL 2. Table 3.8. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf
	Asetilen (tonnes CO_2/tonne carbide produced)	1.1	IPCC VOL 2. Table 3.8. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf
Soda Ash Production	Soda ash (tonnes CO_2/tonne of Trona)	0.097	IPCC VOL 2. Equation 3.4. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf
Petrochemicals	Fuel gas	0.67227	CS, Petkim
Iron and Steel Production	EAF	0.0712	CS
	Integrated Plants		PS, confidential
Ferro chrome production		1.3	IPCC VOL 2. Table 4.5 https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_4_Ch4_Metal_Industry.pdf
Aluminium production	Net prebaked anode consumption (ton/ ton alüminyum)	0.412	PS
	Carbon content wt %	98.83	PS
Lead production		0.2	IPCC VOL 2. Table 4.21 https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_4_Ch4_Metal_Industry.pdf
Lubricant and paraffin wax use	Carbon content	20	IPCC VOL 2. Table 5.2 https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf
	Oxidation rate	0.2	IPCC VOL 2. Equation 5.4 https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_5_Ch5_Non_Energy_Products.pdf

Emission factors/parameters used in the agriculture sector

3.A Enteric Fermentation	EF (kg CH_4/head/yr)	Method	Note
3.A.1 Cattle			
Dairy Cattle	83.5	T2	Latest Inventory year figure
Non-Dairy Cattle	47.3	T2	Latest Inventory year figure
3.A.2 Sheep			
Domestic	5.0	T1	Table 10.10
Merino	6.5	T1	Table 10.10, value is derived as follows: (developing EF + developed EF)/2
3.A.3 Swine	1.0	T1	Table 10.10
3.A.4 Other livestock			
Buffalo	55.0	T1	Table 10.10
Camels	46.0	T1	Table 10.10
Goats	5.0	T1	Table 10.10
Horses	18.0	T1	Table 10.10
Mules and Asses	10.0	T1	Table 10.10
Poultry	NA		

All table references given above refer to the 2006 IPCC Guidelines Volume 4 except for EFs given for cattle.

3.B(a) Manure Management CH_4 Emissions	EF (kg CH_4/head/yr)	Method	Note
3.A.1 Cattle			
Dairy Cattle	a	T1	Table 5.17
Non-Dairy Cattle	a	T1	Table 5.17
3.A.2 Sheep			
Domestic	b	T1	Table 5.18
Merino	b	T1	Table 5.18
3.A.3 Swine	a	T1	Table 5.17
3.A.4 Other livestock			
Buffalo	b	T1	Table 5.18
Camels	b	T1	Table 5.18
Goats	b	T1	Table 5.18
Horses	b	T1	Table 5.18
Mules and Asses	b	T1	Table 5.18
Poultry	b	T1	Table 5.18

[a] Given on Table 5.17 of this Inventory Report.

[b] Given on Table 5.18 of this Inventory Report.

Emission factors/parameters used in the agriculture sector (continued)

3.B(b) Manure Management Direct N_2O Emissions	**EF_3 (kg N_2O-N / kg N excreted)**	**Method**	**Note**
Liquid system	0.005	T1	Table 10.21
Solid storage	0.005	T1	Table 10.21
Dry lot	0.02	T1	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)	0.001	T1	Table 10.21

All table references given above refer to the 2006 IPCC Guidelines Volume 4.

3.B(b) Manure Management Indirect N_2O Emissions	**Value**	**Method**	**Note**
All related manure management systems	0.01	T1	Table 11.3, EF_4 [kg N2O-N / (kg NH3-N + NOx-N volatilised)]
$Frac_{GASMS}$	***	T1	***Default values given on Table 10.22
$Frac_{LEACHMS}$	4.5%	T1	Mid-value between 3% and 6% given for drier climates on page 10.56

All value, table and page references given above refer to the 2006 IPCC Guidelines Volume 4.

3.C Rice Cultivation	**Value**	**Unit**	**Method**	**Note**
EF_c	1.30	kg CH4 /ha/ day	T1	Baseline emission factor for all types of water regimes, Table 5.11
SF_w	1.00		T1	Scaling factor for continuously flooded water regime, Table 5.12
SF_w	0.60		T1	Scaling factor for intermittently flooded (single aeration) water regime, Table 5.12
SF_w	0.52		T1	Scaling factor for intermittently flooded (multiple aeration) water regime, Table 5.12
SF_p	1.00		T1	Scaling factor for non-flooded pre-season less than 180 days, Table 5.13
SF_p	0.68		T1	Scaling factor for non-flooded pre-season more than 180 days, Table 5.13
SF_p	1.90		T1	Scaling factor for flooded pre-season over 30 days, Table 5.13

All table references given above refer to the 2006 IPCC Guidelines Volume 4.

Emission factors/parameters used in the agriculture sector (continued)

3.D.a Agricultural Soils Direct N_2O Emissions		**EF**	**Unit**	**Note**
3.D.a.1	Inorganic N fertilizers	0.01	kg N_2O–N / (kg N)	-
3.D.a.2	Organic N fertilizers	0.01	kg N_2O–N / (kg N)	-
3.D.a.3	Urine and dung deposited by grazing animals	**	kg N_2O–N / (kg N)	**0.02 for cattle, buffalo, pigs, poultry and 0.01 for sheep and other animals
3.D.a.4	Crop residues	0.01	kg N_2O–N / (kg N)	0.003 is taken for flooded rice & 0.01 for crop residues except flooded rice
3.D.a.5	Loss/Gain of soil organic matter	0.01	kg N_2O–N / (kg N)	Note that this particular source category is currently reported as not occurring (NO).
3.D.a.6	Cultivation of organic soils	8	kg N_2O–N / ha	$EF_{2\ CG,\ Temp}$ for temperate organic crop and grassland soils

All EF values given above refer to Table 11.1 of the 2006 IPCC Guidelines Volume 4. The method used for 3.D.a is T1.

3.D.b Agricultural Soils Indirect N_2O Emissions	**Value**	**Unit**	**Note**
EF_4	0.01	kg N2O-N / (kg NH3-N + NOx-N volatilised)	N volatilisation and re-deposition
EF_5	0.0075	kg N2O-N / (kg N leaching/runoff)	Leaching/runoff
$Frac_{GASF}$	0.10	kg NH3-N + NOx-N / (kg N applied)	Volatilisation from synthetic fertiliser
$Frac_{GASM}$	0.20	kg NH3-N + NOx-N / (kg N applied or deporsited)	Volatilisation from all organic N fertilisers applied, and dung and urine deposited by grazing animals
$Frac_{LEACH-(H)}$	0.015	kg N / (kg N additions or deposition by grazing animals)	Country-specific value*

All values given above refer to Table 11.3 of the 2006 IPCC Guidelines Volume 4 except for the $Frac_{LEACH-(H)}$ value. The T1 method was applied for 3.D.b.
* Calculations on the country-specific FracLEACH-(H) value of 0.015:
Equation 11.10 is given below;
N2O(L)–N = (FSN + FON + FPRP + FCR + FSOM) • FracLEACH –(H) • EF5
Where F=(Fsn+Fon+Fprp+Fcr+Fsom),
N2O(L)-N = F * FracLEACH-(H) * EF5
and
N2O(L) = N2O-N * (44/12)
Applying this equation for two different factors of FracLEACH-(H) would result in
for 95% of the total area according to the map given as
N2O(L)-N = F * 0.95 * FracLEACH-(H) * EF5 (where FracLEACH-(H) is 0.00)
and
for 5% of the total area according to the map given as
N2O(L)-N = F * 0.05 * FracLEACH-(H) * EF5 (where FracLEACH-(H) is 0.30)
Please note that FracLEACH-(H) (for 95% of the land area) equals **0.00** and
FracLEACH-(H) (for 5% of the land area) equals **0.30**.

Finding a new weighted average rate for FracLEACH-(H) is as straightforward as follows:
F * FracLEACH-(H)new * EF5 = {[F *0.95] * FracLEACH-(H) * EF5} + {[F * 0.05] * FracLEACH-(H)* EF5}

F * FracLEACH-(H)new * EF5 = {[F *0.95] * **0.00** * EF5} + {[F * 0.05] * **0.30** * EF5}

F * FracLEACH-(H)new * EF5 = { 0.00 } + { [F * 0.05] * 0.30 * EF5}

F * FracLEACH-(H)new * EF5 = { F * 0.015 * EF5 }

FracLEACH-(H)new = 0.015

Emission factors/parameters used in the agriculture sector (continued)

3.F Field Burning of agricultural residues	G_{ef} (g /kg) CH$_4$	G_{ef} (g /kg) N_2O	C_f CH_4 and N_2O	Method	Note
3.F.1.1 Wheat	2.7	0.07	0.9	T1	
3.F.1.2 Barley	2.7	0.07	0.9	T1	C_f value for wheat is used
3.F.1.3 Maize	2.7	0.07	0.8	T1	
3.F.1.4 Rice	2.7	0.07	0.8	T1	

All values given above refer to Table 2.5 for G_{ef} and Table 2.6 for C_f of the 2006 IPCC Guidelines Volume 4.

3.H Urea Application	EF (tonne of C/ tonne of urea)	Method	Note
Urea fertilisation	0.20	T1	Information given on page 11.32 of the 2006 IPCC Guidelines Volume 4.

Emission factors/parameters used in the waste sector

Category	EF	AD Source
5.A Solid waste disposal	Default values in IPCC 2006, Vol 5, Chp 3	
5.B Biological treatment of solid waste 5.B.1 Composting 5.B.1.a Municipal Solid Waste	CH_4: 4, N_2O: 0.24 (IPCC 2006, Vol 5, Chp 4, Table 4.1	
5.C Incineration and open burning of waste 5.C.2 Open Burning of Waste 5.C.2.1 Biogenic 5.C.2.1.a Municipal Solid Waste	CO_2: OF= 0.58 for MSW (IPCC 2006, Vol 5, Chp 5, Table 5.2) CH_4 & N_2O: Defaults (IPCC 2006, Vol 5, Chp 5, Section 5.4.2 & Table 5.6)	TurkStat's surveys and database
5.D Wastewater treatment and discharge 5.D.1 Domestic Wastewater	Default values (IPCC 2006, Vol 5, Chp 6, Table 6.11 & 6.3) CS BOD values for TOW calculation (as provided below)	
5.D.2 Industrial Wastewater	Default values (IPCC 2006, Vol 5, Chp 6, Table 6.8 & 6.9)	

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, 2020

Distribution of Energy Supply	Hard Coal	Lignite	Asphaltite	Coke	Derivative Gases	BFG	COG	BOF Gas	Coal Tar	Oil	Oil Products	Petroleum Coke	Fuel Oil
Domestic Production (+)	634	14.148	938							3.363			
Import (+)	24.962			432					9	30.838	18.179	2.441	1.943
Export (-)	86	1		2					134		7.930	10	133
Bunkers (-)											2.504		271
Stock Change (+/-)	-61	-285	41						20	192	51	79	-119
Primary Energy Supply	**25.449**	**13.863**	**979**	**430**	**0**	**0**	**0**	**0**	**-105**	**34.393**	**7.797**	**2.510**	**1.421**
Statistical Difference (+/-)--	**71**	**168**	**-1**	**113**	**0**	**0**	**0**	**0**	**16**	**0**	**316**	**435**	**-205**
Transformation Sector	**-18.017**	**-10.125**	**-609**	**2.715**	**500**	**109**	**350**	**41**	**136**	**-34.393**	**33.834**	**1.182**	**-1.467**
Electricity and Heat Production[4]	-13.274	-9.845	-609		-712	**-411**	**-227**	**-74**			-119		**-110**
Main activity producer plants	-11.978	-9.760	-609								-15		-6
Autoproducers	-1.296	-85			-712	-411	-227	-74			-104		-104
Heat Production	-326	-269			-161	-84	-34	-43			-63		-63
Coke ovens	-4.209			2.715	867		867		136				
Blast Furnaces					1.429	1.242		187					
Petroleum Refineries										-34.034	37.236	1.182	437
Own use and loses	-207	-11			-924	-638	-257	-29		-358	-3.219		-1.730
Total final energy consumption	**7.432**	**3.738**	**370**	**3.145**	**500**	**109**	**350**	**41**	**32**	**0**	**41.631**	**3.692**	**-46**
Sectors Total	**7.361**	**3.570**	**371**	**3.031**	**500**	**109**	**350**	**41**	**16**	**0**	**41.315**	**3.257**	**159**
Industry Consumption	**3.972**	**1.860**	**256**	**3.031**	**500**	**109**	**350**	**41**	**16**	**0**	**3.669**	**3.257**	**23**
Mining and Quarrying (07,08,09)	**0**	**1**									**108**	**15**	**0**
Manufacture of Food, beverage, tobacco products 10,11,12)	**287**	**381**		**33**							**25**	**6**	**5**
Food(10)	287	367		0							19	6	3
Beverages(11)											2		0
Tobacco (12)											2		
Sugar(10.81)		13		33							2		2
Manufacture of textile and leather (13,14,15)	**225**	**565**		**2**							**17**		**1**
Textile13)	151	524		2							15		0
Clothing (14)	73	41									2		1
Leather and related (15)	1										0		
Manufacture of wood products (16)	**9**	**5**									**8**		**0**
Manufacture of paper (17,18)	**55**	**104**									**5**	**3**	**0**
Manufacture of chemicals and petro chemicals (20,21,22)	**347**	**146**		**0**							**13**		**5**
Chemicals(20)	344	95		0							5		1
Fertilizer (20)											2		0
Pharmaceutical (21)	3	0									4		3
Rubberi plastics (22)	0	51									2		0
Manufacture of non-metalic minerals (23)	**1.906**	**624**									**3.341**	**3.219**	**11**
Glass (23)											3		
Ceramics (23)	42	167									33	22	0
Cement (23)	1.863	457									3.305	3.197	11
Basic Metal Industry (24,25)	**1.141**	**32**		**2.996**	**500**	**109**	**350**	**41**	**16**		**33**	**15**	**0**
Iron and steel (24)	1.114	12		2.990	500	109	350	41	16		27	15	0
Non-ferrous metals (24)	26			6							5		
Fabricated metal products 25)	0	19									1		0
Manufacture of machine, electrical and electronical products (2	**0**	**1**									**4**		**0**
Manufacture of transportation Equipment(29,30)	**0**	**1**									**10**		**0**
Motorized land vehicles 29)	0										9		0
Other transportation vehicles (30)		1									2		
Furniture and other production(31)	**0**										**10**		**0**
Construction(41,42,43)	**1**										**14**		
Otherr industry			**256**								**80**		
TRANSPORT	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**26.514**	**0**	**15**
Rail											95		
Domestic Navigation											412		15
Domestic Aviation											722		
Pipelines													
Road											25.284		
Other Sectors	**3.389**	**1.711**	**115**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4.206**	**0**	**121**
Residential	2.846	1.280	115								455		
Commercial and Public services	543	431									487		121
Agriculture and farming											3.264		
Non Energy Use	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6.927**	**0**	**0**
Petrochemicals Feedstock											**2.082**		

Distribution of Energy Supply	Gas Diesel Oil	Gasoline	LPG	Refinery Gas	Jet Kerosene	Kerosene	Naphta	By Products	Base oil	White Spirit	Bitumen	Others
Domestic Production (+)												
Import (+)	9.151		3.395		135		565	136	292	54	4	63
Export (-)	2.711	1.998	134		638		82	896	186	6	592	544
Bunkers (-)	282				1.952							
Stock Change (+/-)	-140	19	79	-1	66	2	4	-60	21	-12	-23	135
Primary Energy Supply	**6.018**	**-1.979**	**3.340**	**-1**	**-2.389**	**2**	**487**	**-821**	**128**	**37**	**-610**	**-346**
Statistical Difference (+/-)--	**0**	**0**	**65**	**0**	**0**	**0**	**21**	**0**	**0**	**0**	**0**	**0**
Transformation Sector	**17.428**	**4.402**	**1.097**	**1**	**3.111**	**7**	**1.616**	**1.146**	**76**	**14**	**2.654**	**2.567**
Electricity and Heat Production[4]	**-9**											
Main activity producer plants	-9											
Autoproducers												
Heat Production												
Coke ovens												
Blast Furnaces												
Petroleum Refineries	17.563	4.457	1.097	1.304	3.111	7	1.616	1.151	76	14	2.654	2.567
Own use and loses	-127	-55		-1.303				-5				
Total final energy consumption	**23.447**	**2.423**	**4.437**	**0**	**722**	**9**	**2.103**	**325**	**203**	**51**	**2.044**	**2.221**
Sectors Total	**23.447**	**2.423**	**4.372**	**0**	**722**	**9**	**2.082**	**325**	**203**	**51**	**2.044**	**2.221**
Industry Consumption	**288**	**4**	**96**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Mining and Quarrying (07,08,09)	**93**	**0**	**0**									
Manufacture of Food, beverage, tobacco products 10,11,12)	**12**	**2**	**1**									
Food(10)	11	0	0									
Beverages(11)	1	0	1									
Tobacco (12)	0	2										
Sugar(10.81)	0	0	0									
Manufacture of textile and leather (13,14,15)	**15**	**0**	**1**									
Textile13)	14		0									
Clothing (14)	1		0									
Leather and related (15)	0	0										
Manufacture of wood products (16)	**8**		**0**									
Manufacture of paper (17,18)	**2**	**0**	**0**									
Manufacture of chemicals and petro chemicals (20,21,22)	**5**	**0**	**3**									
Chemicals(20)	2		2									
Fertilizer (20)	1											
Pharmaceutical (21)	0	0	0									
Rubberi plastics (22)	2	0	0									
Manufacture of non-metalic minerals (23)	**105**	**1**	**5**									
Glass (23)	0	0	3									
Ceramics (23)	10	0	1									
Cement (23)	95	1	1									
Basic Metal Industry (24,25)	**18**	**0**	**0**									
Iron and steel (24)	11	0	0									
Non-ferrous metals (24)	5	0	0									
Fabricated metal products 25)	1	0	0									
Manufacture of machine, electrical and electronical products (2	**2**	**0**	**1**									
Manufacture of transportation Equipment(29,30)	**4**	**1**	**5**									
Motorized land vehicles 29)	2	1	5									
Other transportation vehicles (30)	2	0	0									
Furniture and other production(31)	**10**	**0**	**0**									
Construction(41,42,43)	**14**											
Otherr industry			**80**									
TRANSPORT	**19.895**	**2.418**	**3.464**	**0**	**722**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Rail	95											
Domestic Navigation	398											
Domestic Aviation					722							
Pipelines												
Road	19.402	2.418	3.464									
Other Sectors	**3.264**	**0**	**812**	**0**	**0**	**9**	**0**	**0**	**0**	**0**	**0**	**0**
Residential			446			9						
Commercial and Public services			365									
Agriculture and farming	3.264											
Non Energy Use	**0**	**0**	**0**	**0**	**0**	**0**	**2.082**	**325**	**203**	**51**	**2.044**	**2.221**
Petrochemicals Feedstock							**2.082**					

Distribution of Energy Supply	Nat. Gas	Biofuels and Waste	Wood	Crop and animal residue	Biofuels	Hydro	Wind	Electricty	Other Heat	Jeothermal	Solar	Total
Domestic Production (+)	378	3.396	**1.152**	**2.123**	**122**	6.716	2.135			10.576	1.784	44.069
Import (+)	39.704							162				114.286
Export (-)	476							214				8.842
Bunkers (-)												2.504
Stock Change (+/-)	201											160
Primary Energy Supply	**39.806**	**3.396**	**1.152**	**2.123**	**122**	**6.716**	**2.135**	**-51**	**0**	**10.576**	**1.784**	**147.168**
Statistical Difference (+/-)--	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**683**
Transformation Sector	**-13.382**	**-779**	**0**	**-779**	**0**	**-6.716**	**-2.135**	**22.288**	**2.648**	**-8.622**	**-942**	**-33.597**
Electricity and Heat Production[4]	-11.493	-778		**-778**		-6.716	-2.135	26.376	1.089	-8.622	-942	-27.779
Main activity producer plants	-9.031	-762		-762		-6.628	-2.127	24.168	437	-8.622	-733	-25.658
Autoproducers	-2.462	-16		-16		-88	-9	2.208	652		-209	-2.121
Heat Production	-1.071	-1		-1					1.889			-3
Coke ovens												-490
Blast Furnaces												1.429
Petroleum Refineries	-775							-225	-330			1.872
Own use and loses	-44							-3.863				-8.626
Total final energy consumption	**26.423**	**2.618**	**1.152**	**1.344**	**122**	**0**	**0**	**22.237**	**2.648**	**1.954**	**843**	**113.571**
Sectors Total	**26.423**	**2.618**	**1.152**	**1.344**	**122**	**0**	**0**	**22.237**	**2.648**	**1.954**	**843**	**112.888**
Industry Consumption	**9.047**	**912**	**0**	**912**	**0**	**0**	**0**	**10.266**	**2.603**	**0**	**295**	**36.425**
Mining and Quarrying (07,08,09)	**142**							**166**	**2**			**419**
Manufacture of Food, beverage, tobacco products 10,11,12)	**1.214**	**47**		**47**				**695**	**545**			**3.228**
Food(10)	1.139	47		47				574	545			2.978
Beverages(11)	28							44				73
Tobacco (12)	15							19				35
Sugar(10.81)	33							60				141
Manufacture of textile and leather (13,14,15)	**1.001**	**41**		**41**				**1.586**	**91**			**3.529**
Textile13)	903	1		1				1.307	91			2.994
Clothing (14)	92	41		41				235				484
Leather and related (15)	6							43				50
Manufacture of wood products (16)	**27**	**298**		**298**				**185**	**65**			**597**
Manufacture of paper (17,18)	**248**	**5**		**5**				**326**	**194**			**937**
Manufacture of chemicals and petro chemicals (20,21,22)	**2.060**	**3**		**3**				**1.156**	**239**			**3.964**
Chemicals(20)	1.320	2		2				511	221			2.498
Fertilizer (20)	526							49				577
Pharmaceutical (21)	59							50				115
Rubberi plastics (22)	156	1		1				546	18			775
Manufacture of non-metalic minerals (23)	**1.743**	**475**		**475**				**1.046**	**43**			**9.178**
Glass (23)	746							171				919
Ceramics (23)	770							189				1.201
Cement (23)	227	475		475				686	43			7.058
Basic Metal Industry (24,25)	**1.832**	**37**		**37**				**2.731**	**322**			**9.639**
Iron and steel (24)	1.447	1		1				2.196	271			8.574
Non-ferrous metals (24)	235							345	51			669
Fabricated metal products 25)	149	36		36				189				396
Manufacture of machine, electrical and electronical products (2	**118**	**2**		**2**				**226**	**5**			**356**
Manufacture of transportation Equipment(29,30)	**256**	**0**		**0**				**247**	**8**			**523**
Motorized land vehicles 29)	235	0		0				209				454
Other transportation vehicles (30)	21							38	8			70
Furniture and other production(31)	**35**	**3**		**3**				**57**				**105**
Construction(41,42,43)	**324**							**360**	**0**			**699**
Otherr industry	**46**							**1.485**	**1.090**		**295**	**3.251**
TRANSPORT	**212**	**122**	**0**	**0**	**122**	**0**	**0**	**131**	**0**	**0**	**0**	**26.979**
Rail								106				201
Domestic Navigation												412
Domestic Aviation												722
Pipelines	146							25				171
Road	67	122			122							25.472
Other Sectors	**16.513**	**1.584**	**1.152**	**432**	**0**	**0**	**0**	**11.840**	**46**	**1.954**	**548**	**41.905**
Residential	12.881	1.584	1.152	432				5.154		853	548	25.715
Commercial and Public services	3.538							5.707	46	475		11.226
Agriculture and farming	94							980		627		4.964
Non Energy Use	**651**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**7.578**
Petrochemicals Feedstock												**2.082**

Energy balance sheets for 1972-2020 are available on the MENR website (https://www.eigm.gov.tr/tr-TR/Denge-Tablolari/Denge-Tablolari).

Annex 5: Completeness

Table A8.1 Completeness, Sources and sinks not estimated ("NE")

GHG	Sector	Source/sink category
CH4	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.b Solid Fuel Transformation
CO2	Agriculture	3.G Liming/3.G.1 Limestone CaCO3
CO2	Agriculture	3.G Liming/3.G.2 Dolomite CaMg(CO3)2
CO2	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.a Coal Mining and Handling/1.B.1.a.1 Underground Mines/1.B.1.a.1.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
N2O	Agriculture	3.1 Livestock/3.B Manure Management/3.B.2 N2O and NMVOC Emissions/3.B.2.5 Indirect N2O Emissions
N2O	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.a Coal Mining and Handling
N2O	Energy	1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.b Solid Fuel Transformation
N2O	Industrial Processes and Product Use	2.G Other Product Manufacture and Use/2.G.3 N2O from Product Uses/2.G.3.a Medical Applications
N2O	LULUCF	4.F Other Land/4(III) Direct N2O Emissions from N Mineralization/Immobilization 4.F Other Land
no gas	LULUCF	4.D Wetlands/4.D.2 Land Converted to Wetlands/Carbon stock change/4.D.2.2 Land Converted to Flooded Land/4.D.2.2.2 Cropland converted to flooded land/Carbon stock change in living biomass

Table A8.2 Completeness, Sources and sinks reported elsewhere ("IE")

GHG	Source/sink category	Explanation
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Biomass	Included under "1.A.3.e Other Transportation"
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Diesel Oil	Included under "1.A.3.e Other Transportation"
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Gasoline	Included under "1.A.3.e Other Transportation"
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Liquefied Petroleum Gases (LPG)	Included under "1.A.3.e Other Transportation"
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks/Gasoline	Included under "1.A.3.e Other Transportation"
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks	Included under "1.A.3.e Other Transportation"
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 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 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses/Biomass	Included under "1.A.3.e Other Transportation"
CH4	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"

Table A8.2 Completeness, Sources and sinks reported elsewhere ("IE")(Cont'd)

GHG	Source/sink category	Explanation
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Gasoline	Included under "1.A.3.e Other Transportation"
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles	Included under "1.A.3.e Other Transportation"
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Diesel Oil 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles	Included under "1.A.3.e Other Transportation"
CH4	1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing 1.AA Fuel Combustion - Sectoral approach/1.A.4 Other Sectors/1.A.4.c Agriculture/Forestry/Fishing/1.A.4.c.iii Fishing/Gas/Diesel Oil	Included under 1.A.4.c.i
CH4	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	4.E Settlements/4.E.1 Settlements Remaining Settlements	included in "agriculture sector"
CH4	4.F Other Land/4.F.2 Land Converted to Other Land	included 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 ar 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 an 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 ar 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 an 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 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Biomass	Included under "1.A.3.e Other Transportation"
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Diesel Oil	Included under "1.A.3.e Other Transportation"

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/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks	Included under "1.A.3.e Other Transportation"
CO2	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/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses	Included under "1.A.3.e Other Transportation"
CO2	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.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Gasoline	Included under "1.A.3.e Other Transportation"
CO2	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles	Included under "1.A.3.e Other Transportation"

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.iv Motorcycles/Diesel Oil 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles	Included under "1.A.3.e Other Transportation"
CO2	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.B Chemical Industry/2.B.8 Petrochemical and Carbon Black Production/2.B.8.b Ethylene	Included in 2.B.8.g
CO2	2.B Chemical Industry/2.B.8 Petrochemical and Carbon Black Production/2.B.8.c Ethylene Dichloride and Vinyl Chloride Monomer	Included in 2.B.8.g
CO2	2.B Chemical Industry/2.B.8 Petrochemical and Carbon Black Production/2.B.8.e Acrylonitrile	Included in 2.B.8.g
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
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 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Biomass	Included under "1.A.3.e Other Transportation"
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Diesel Oil	Included under "1.A.3.e Other Transportation"
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.i Cars/Liquefied Petroleum Gases (LPG)	Included under "1.A.3.e Other Transportation"
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks/Gasoline	Included under "1.A.3.e Other Transportation"
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.ii Light duty trucks	Included under "1.A.3.e Other Transportation"
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iii Heavy duty trucks and buses/Biomass	Included under "1.A.3.e Other Transportation"
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Gasoline	Included under "1.A.3.e Other Transportation"
N2O	1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles/Biomass 1.AA Fuel Combustion - Sectoral approach/1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.iv Motorcycles	Included under "1.A.3.e Other Transportation"
N2O	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

Table A8.2 Completeness, Sources and sinks reported elsewhere ("IE")(Cont'd)

GHG	Source/sink category	Explanation
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	Direct N2O Emissions from N Inputs to Managed Soils in Forest Land is included in the Agriculture Sector
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	Direct N2O Emissions from N Inputs to Managed Soils in Forest Land is included in the Agriculture Sector
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	Direct N2O Emissions from N Inputs to Managed Soils in Forest Land is included in the Agriculture Sector
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	4.F Other Land/4.F.2 Land Converted to Other Land	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
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	
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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