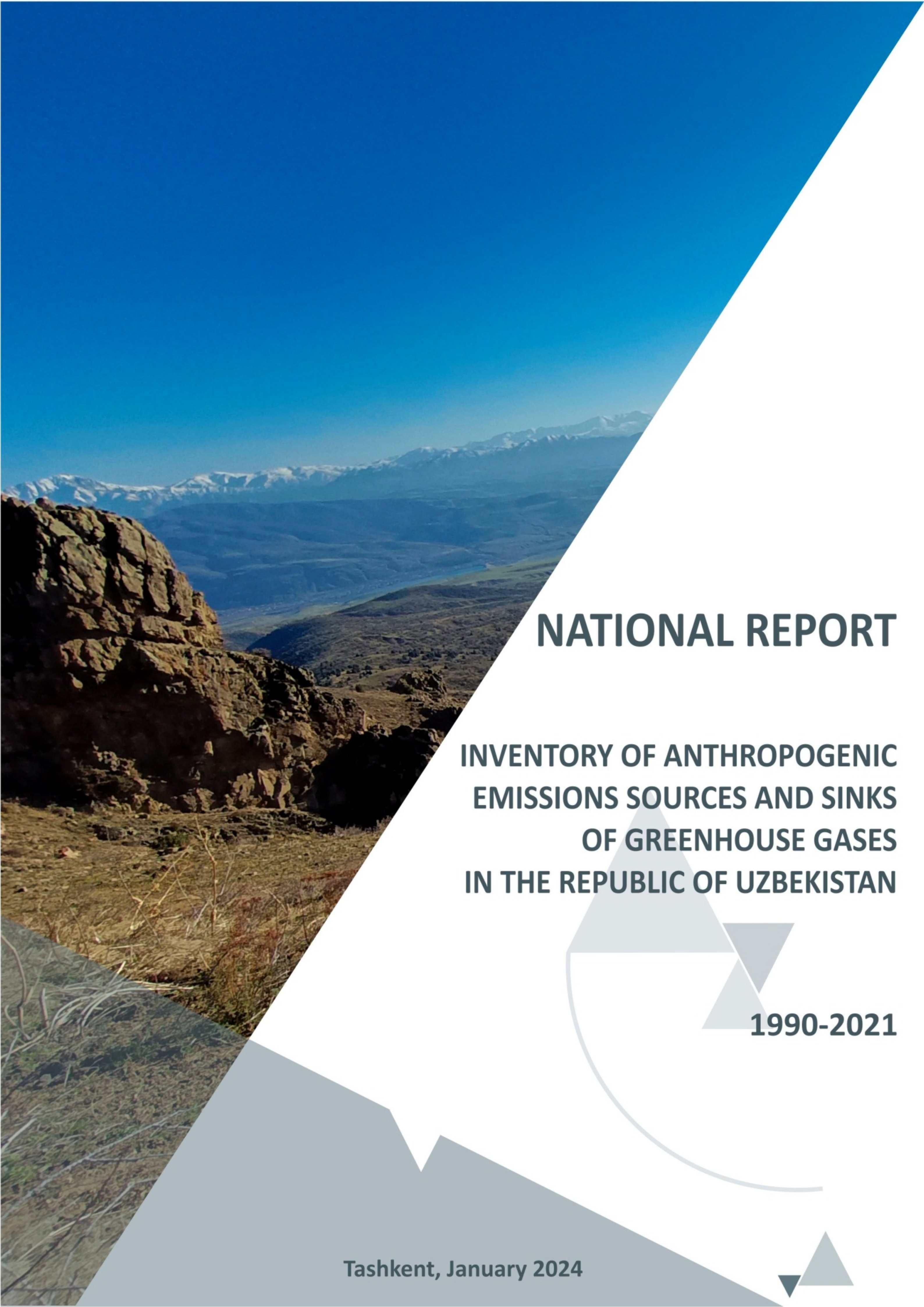

NATIONAL REPORT

INVENTORY OF ANTHROPOGENIC EMISSIONS SOURCES AND SINKS OF GREENHOUSE GASES IN THE REPUBLIC OF UZBEKISTAN

1990-2021

Tashkent, January 2024

GEF/UNEP Project "Uzbekistan: Preparation of the Fourth National Communication under UN Framework Convention on Climate Change (UNFCCC)"

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Prepared in accordance with the obligations of the Republic of Uzbekistan under the UNFCCC and the Paris Agreement

Tashkent, January 2024

Inventory of Anthropogenic Emissions Sources and Sinks of Greenhouse Gases in the Republic of Uzbekistan. National Report
GEF/UNEP Project "Uzbekistan: Preparation of the Fourth National Communication and First Biennial Update Report to the UN Framework Convention on Climate Change"

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LIST OF ABBREVIATIONS

AWMS	– Animal waste management system
BOM	– biodegradable organic matter
DOC	– degradable organic carbon
MCF	– methane correction factor
MSW	– municipal solid waste
UNEP	– United Nations Environment Program
UNFCCC	– United Nations Framework Convention on Climate Change

HFCs	– hydrofluorocarbons
NMVOCs	– Non-Methane Volatile Organic Compounds
FOLU	– Forestry and other land use sector
IPCC	– Intergovernmental Panel on Climate Change
IEA	– International Energy Agency
QA/QC	– Quality Assurance/Quality Control
UN	– United Nations Organization
GHG	– Greenhouse Gases
GWP	– Global Warming Potential
FBR	– First biennial update report
PFC	– perfluorocarbon
FCCC	– Framework Convention on Climate Change
FAO	– Food and Agriculture Organization of the United Nations
COD	– Chemical Oxygen Demand
cap.	– capita
FNC	– Fourth National Communication
eq.	– equivalent

Units

g	– gram	kcal	– kilocalory
Gg	– gigagram (10^9 g or 1000 tons)	m^2	– square meter
ha	– hectar	m^3	– cubic meter
GJ	– gigajoule (10^9 joule)	mg	– milligram
hectoliter	– 100 litres	PJ	– petajoule (10^{15} joule)
dal	– decalitre	TJ	– terajoule (10^{12} joule)
decalitre	– 10 litres	t	– ton
kg	– kilogram	c	– centner
		Mt	– million tons

Chemical formula

C	– carbon	H_2SO_4	– sulphuric acid
CH_4	– methane	N	–nitrogen
CH_2F_2	– HFC-32	NH_3	– ammonia
C_2HF_5	– HFC-125	N_2O	– nitrogen oxide
CH_2FCF_3	– HFC-134a	NOx	– nitrogen oxides
$C_2H_3F_3$	– HFC-143a	S	– sulphur
CO	– carbon monoxide	SF_6	– sulphur hexafluoride
CO_2	– carbon dioxide	SO_2	– sulphur dioxide
HNO_3	– nitric acid		

CONTENT

EXECUTIVE SUMMARY

ES.1 Background

In the presented National report on the Inventory of Anthropogenic Emissions Sources and Sinks of Greenhouse Gases not controlled by the Montreal Protocol for 1990-2021 (hereinafter referred to as the National Inventory for 2021), the inventory was conducted in four sectors in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories:

- Energy (CO_2, CH_4, N_2O, CO, NOx, SO_2, NMVOCs);
- Industrial Processes and Product Use (CO_2, CH_4, N_2O,HFCs , CO, NOx, SO_2, NMVOCs);
- Agriculture, Forestry and Other Land Use (CO_2, CH_4, N_2O, CO, NOx);
- Waste (CH_4, N_2O).

The report contains an Introduction and 6 special chapters.

The Introduction describes the institutional structure and inventory process.

The special chapters present emission estimates for 1990-2021 for all IPCC sectors.

The Annexes provide inventory summary tables, key source analysis, and quantitative estimates of uncertainties by gas and sector.

The report was prepared by the Agency of Hydrometeorological Service under the Ministry of Ecology, Environmental Protection and Climate Change of the Republic of Uzbekistan as part of the preparation of the Fourth National Communication of the Republic of Uzbekistan on Climate Change for the UNFCCC.

ES.2 Review of estimates and trends for various source and sink categories

The total GHG emissions of the Republic of Uzbekistan amounted to 206.94 million tons of CO_2 equivalent without taking into account sinks the FOLU sector in 2021, and 200.59 million tons of CO_2 equivalent taking them into account.

The total GHG emissions increased by 32.5% between 1990 and 2021, including a 20.6% increase between 2010 and 2021 – by 20.6%. The largest emission increases were observed in the Agriculture and Industrial Processes and Product Use sectors.

The contribution of greenhouse gases to total emissions in 2021 was as follows (Mt of CO_2-eq):

- CO_2 – 139.4 (67.1%);
- CH_4 – 52.8 (25.4%);
- N_2O – 14.4 (7.0%);
- HFC – 0.99 (0.5%).

Table ES.1 GHG emissions, Mt of CO_2-eq (not accounting for FOLU sector)

Year	1990	1995	2000	2005	2010	2015	2018	2019	2020	2021	$\Delta_{(1990-2021)}$
CO_2	119.94	105.51	114.96	111.41	114.09	102.96	116.88	115.79	118.58	139.41	+16.2%
CH_4	29.42	39.15	42.09	43.77	48.47	47.71	52.82	53.38	50.43	52.81	+79.5%
N_2O	7.07	6.69	6.69	7.73	9.03	11.98	12.96	13.29	13.17	13.73	+94.2%
HFCs	-	-	0.00	0.01	0.02	0.09	0.44	0.73	0.91	0.99	919-fold increase
Total	**156.44**	**151.35**	**163.75**	**162.92**	**171.61**	**162.73**	**183.10**	**183.20**	**183.09**	**206.94**	**+32.3%**

Between 1990 and 2021, carbon dioxide emissions increased by 16.2%; methane emissions by 79.5%; and nitrous oxide emissions by 94.2%. HFCs emissions increased 919 times between 2000 and 2021 (table ES.1).

The largest contribution to CO_2 emissions comes from the Energy sector (fuel combustion) (80%) and from the Industrial Processes and Product Use sector (production of glass, cement, ammonia, and other products) 20%.

Methane emissions are distributed by inventory sectors as follows: the Energy sector accounts for 41% (mainly due to methane leaks from gas systems in the oil and gas industry); the Agriculture sector (livestock) – for 40%; and the Waste sector (decomposition of solid waste in landfills, formation in wastewater) – for 19%.

The main contributor to nitrous oxide emissions (76%) is the Agriculture sector (manure management and emissions from managed land with nitrogen fertilizers applied, and decomposition of plant residues in soils); the Industrial Processes and Product Use sector (nitric acid production) accounts for 15%; and the Waste sector (formation in domestic wastewater) – for 6% (table ES 2).

HFCs emissions occur in the Industrial Processes and Product Use sector. HFCs emissions are associated with the use of refrigerants in air conditioning and refrigeration systems.

In 2021, GHG emissions from the Energy sector amounted to 136.32 Mt of CO_2 equivalent, or 65.9% of total national emissions excluding the FOLU sector. Overall, from 1990-2021, emissions in the Energy sector increased by 7.4%. From 2010-2021, emissions in the sector increased by 10.5%.

GHG emissions in the Industrial Processes and Product Use sector amounted to 29.21 Mt of CO_2 equivalent, or 14.1% of total national emissions. Compared to 1990, emissions from the sector increased by 121%, compared to 2010 - by 54.1%.

Emissions from the Agriculture sector in 2021 amounted to 32.25 Mt of CO_2 equivalent (15.6% of total national emissions). It is the second largest GHG emitting sector. Emissions from the Agriculture sector have increased by 172.7% between 1990 and 2021, and by 43.3% between 2010 and 2021.

GHG emissions from the Waste sector amounted to 9.15 Mt of CO_2 equivalent, (4.4% of total national emissions). Compared to 1990, emissions from the sector increased by 107%, compared to 2010 - by 34.2%.

In the Forestry and Other Land Use (FOLU) sector, there is a decrease in removals for the period 1990-2021, while there is a trend for a gradual increase in removals for the period 2010-2021, but the value achieved is lower than in 1990.

Table ES.2 Greenhouse gas emissions by sector, Mt CO_2-eq.

IPCC Sectors	1990	1995	2000	2005	2010	2015	2018	2019	2020	2021	$\Delta_{(1990-2021)}$
Energy	126.97	124.32	135.27	125.36	123.32	111.96	125.33	122.27	120.84	136.32	**+7.4%**
Industrial Processes	13.22	7.94	8.87	15.00	18.95	15.73	18.86	21.06	21.56	29.21	**+121.0%**
Agriculture	11.83	14.10	14.17	16.54	22.51	27.21	30.52	31.25	31.83	32.25	**+172.7%**
Waste	4.42	5.00	5.43	6.01	6.82	7.83	8.39	8.62	8.86	9.15	**+107.1%**
Total (excluding FOLU)	**156.44**	**151.35**	**163.75**	**162.92**	**171.61**	**162.73**	**183.10**	**183.20**	**183.09**	**206.94**	**+32.3%**
FOLU	-15.38	-11.69	-3.66	2.95	2.44	-3.28	-2.37	-4.12	-4.89	-6.35	**-58.7%**
Total (including FOLU)	**141.05**	**139.66**	**160.08**	**165.86**	**174.05**	**159.46**	**180.73**	**179.08**	**178.20**	**200.59**	**+42.4%**

Emissions of gases with an indirect greenhouse effect (CO, NOx, SO_2, NMVOCs) calculated in accordance with the IPCC methodologies in the estimated inventory categories for 1990-2021 (table ES.3). Their trends are related to the specifics of emission sources.

Table ES.3 Emissions of gases with indirect greenhouse effect, Gg gas (including FOLU)

Year	1990	1995	2000	2005	2010	2015	2018	2019	2020	2021	$\Delta_{(1990-2021)}$
CO	1940.73	952.88	1114.10	944.42	1226.34	956.02	1163.27	1000.84	1279.75	1687.96	-29.9%
NOx	413.28	284.21	284.14	251.99	256.57	299.20	346.05	343.19	352.19	505.35	+22.3%
NMVOCs	524.89	446.15	434.44	316.35	464.46	358.05	534.26	517.56	555.35	541.33	+3.1%
SO_2	142.98	75.58	61.94	37.88	72.45	98.27	108.82	109.02	108.45	109.92	-23.12%

1. BRIEF ON CLIMATE CHANGE AND THE NATIONAL GREENHOUSE GAS INVENTORY SYSTEM IN THE REPUBLIC OF UZBEKISTAN

Country and climate change

Geographical location. Uzbekistan is located in Central Asia, between the Amudarya and Syrdarya rivers. Uzbekistan is landlocked. The area of the territory is 448.9 thousand km2. It borders with Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Afghanistan.

The territory of the Republic has a complex surface and relief. Deserts account for 78.8% of the country's total area, including the Kyzylkum and Aralkum deserts. In the east and southeast, the plains turn into spurs of the Tien Shan and Gissar-Alai mountain systems with dissected relief, which account for 21.2% of the country's territory.

Uzbekistan's **climate** is sharply continental, with large seasonal and daily air temperature amplitudes, hot and long summers, relatively wet spring and unstable winter.

The country's territory from the north and west is open to the penetration of various air masses, and at the same time is located in the zone of seasonal movement of the planetary high-altitude frontal zone. In winter and spring months, cyclonic activity intensifies, cyclones cross the territory of the country, and cold intrusions are accompanied by winds and heavy precipitation, so precipitation falls mainly from November to May (about 90% of the annual average in Uzbekistan), the maximum is observed in March. The distribution of precipitation over the territory is uneven, closely related to the location of mountain systems, the altitude and slope exposure. An increase in precipitation is observed in the foothill and mountain zones, especially on windward slopes. However, in general, the entire territory of Uzbekistan belongs to the arid zone. In some years, cold air masses freely penetrate into the southernmost regions of the country. The absolute minimum air temperature since 1990 at Termez meteorological station was -19.7°C (2008)

In the northern part of Uzbekistan (Ustyurt Plateau), the absolute minimum recorded since 1990 was -34.2°C (2006). The absolute maximum air temperature in summer in desert areas of Uzbekistan reach 45-49°C and more. Heavily heated air over the plains of Uzbekistan is characterized by a high moisture deficit, therefore, in the summer, conditions for the formation of droughts are often created.

The average annual air temperature over the plains of the country at present (1990-2018) averages 14.9°C, the warmest month is July (28.8°C), the coldest month is January (0.9°C).

Current climatic changes and adopted scenarios. Analysis of long-term changes in average annual air temperature in Uzbekistan shows a steady warming trend since the early 30s of the last century against the background of significant interannual fluctuations. At the vast majority of stations in Uzbekistan, the increase in *average annual air temperatures* from 1950 to 2019 is statistically significant, the trend increment is 1.5-2 times or more higher than the natural variability. The highest rates of warming are observed in Karakalpakstan (Ustyurt and Aral Sea region: 0.41-0.43°C over 10 years), followed by the plains of Tashkent region and Zeravshan valley (0.36 and 0.32°C over 10 years). In the southern part of Uzbekistan (Surkhandarya region), the rate of warming is lower (0.21°C in 10 years), the lowest rates are observed in the mountain zone (0.12-0.18°C in 10 years)

Analysis of *annual precipitation* totals for stations with long observation series located in different parts of Uzbekistan shows multidirectional trends against the background of high variability. All changes are statistically insignificant. However, it can be noted that the stations located in the northern parts of the country show increasing trends of precipitation, while in the southern and central parts - decreasing trends.

The average *number of days with maximum temperature* ($Tx \geq 39°C$) increased more than 2 times. Accordingly, the *number of days with heat waves* has increased; at present, there are 17 days with heat waves on average per year, while in the beginning and middle of the last century their number did not exceed 8-10 days.

Climatic features and ongoing changes in Uzbekistan, such as increase in average annual temperatures, variability, increase in the number of days with extreme temperatures, increase in the number of extreme precipitation, shifting seasons, changes in their duration clearly affect the ecosystem and impact on the health of the country's population. The impact of climate on health is especially felt by the most vulnerable segments of the population - women, children, the elderly, and people with concomitant health conditions.

Estimates made based on *CMIP5 scenarios* show that according to the worst-case scenario (RCP 8.5), the increase in average annual air temperatures across the territory of Uzbekistan by the end of this century may reach 5°C and more, while under the moderate (RCP 4.5) and soft target scenario (RCP2.6), the increase may be only 2.5 and 1.3°C, respectively. In the short term (2020-2039), the observed trends of increasing air temperatures are assumed to continue: the possible increase in summer air temperatures is 1.3-1.6°C. Further, the differences between the scenarios increase, reaching a range of 1.4-5.7°C in the long term (2080-2099). According to the scenarios, the highest increases in average annual air temperatures are possible in Karakalpakstan and the desert part of Navoi region, the lowest - in mountainous areas of Tashkent and Kashkadarya regions.

The calculated changes in annual precipitation amounts do not exceed 5%. However, by season and area, changes can be significantly greater, both in precipitation and air temperature. The assessments showed that in the short term (2020-2039), regardless of the scenario, a slight increase in precipitation is expected in all seasons (within 5% of the baseline) both in the spurs of the western Tien Shan and in the spurs of the Gissar-Alai. In the medium term (2040-2059), a possible increase in precipitation in winter months is expected to be within 5-10%; in summer and autumn months, model estimates show a slight decrease in precipitation (within 5%). In the long term (2080-2099), in the spurs of the Western Tien Shan, a possible increase in precipitation in winter may reach 16%, a decrease in summer to -10%. In the spurs of the Gissar-Alai, the winter increase in precipitation does not exceed 6%, and the summer decrease can reach -14%.

On a regional scale, in the Syrdarya river runoff formation zone, the increase in precipitation in winter and spring may amount to 15-18%, in summer season - a decrease by 9%, and in the Amudarya river runoff formation zone, insignificant changes in precipitation are expected - an increase by 2-8% in winter and spring, and a slight decrease in summer and fall, regardless of the greenhouse gas emissions scenario.

Natural resources. Uzbekistan has a large production and mineral resource potential. There are deposits of noble, non-ferrous and rare metals, all types of organic fuel - oil, natural gas and gas condensate, lignite and semi-coke coal, oil shale, uranium, many types of raw materials for construction materials. The list of mineral resources includes about 100 types of minerals, of which 60 are already used in the national economy.

In terms of confirmed reserves of such minerals as gold, uranium, copper, natural gas, tungsten, potassium salts, phosphorites, kaolins, Uzbekistan occupies leading positions not only in the CIS, but also in the whole world.

Demography. Uzbekistan is the most populous country in Central Asia. The total population is 35.3 million (as of 1.01.2022). The urban population accounts for 50.5% of the total population, while the rural population accounts for 49.5%. The population of the country is steadily increasing. Annual population growth averages about 1.9% (600-700 thousand people). According to expert forecasts, the population in 2030 will reach 39-40 million people. The average population density in the country is 75.5 people/km^2. The highest population density is characteristic of the Fergana Valley (Andijan region - 727.4 people/km2); the lowest - in Navoi region 9.3 people/km^2 and in Karakalpakstan 11.7 people/km^2.

Economy. Uzbekistan is a developing country with a rapidly growing economy. Currently, the country's economy is in a period of reform.

Economic growth until 2017 was the result of extensive factors associated with the targeted programs aimed at new construction, technical and technological renewal in sectors of strategic importance.

The main objectives of economic reforms are to strengthen macroeconomic stability and maintain high rates of economic growth, increase competitiveness through deepening structural reforms, modernization and diversification of its leading industries.

The average annual GDP growth for the period 2010-2021 was 6.3%. 6,3%. By the end of 2021, the country's GDP reached 734,587.7 billion Uzbek soums or $69.239 billion against $49.765 billion in 2010.

The sectoral structure of GDP is dominated by the Services and Agriculture sectors. For the period 2015-2021. There is a gradual increase in the contribution of the Manufacturing sector. The growth in the Manufacturing sector is mainly driven by increased value added in the mining and manufacturing industries.

1.1 National greenhouse gas inventory system. Institutional mechanism of inventory preparation

The GHG inventory is conducted as part of the preparation of National Communications. The first GHG inventory for the period 1990-1994 was conducted as part of the first phase of the First National Communication; while the second phase assessed GHG emissions for the period 1990-1999.

During 2003-2006, the Republic of Uzbekistan participated in the Regional Project “Capacity Building for Improving the Quality of National Inventories” (Eastern Europe / CIS Region).

In 2004-2005, the UNEP Project "Implementation of UNFCCC Article 6 in Uzbekistan"; and in 2005-2006, the UNEP/ Uzbekistan Project "Education, Training and Public Awareness" was implemented in the country.

In the Second National Communication (2005-2008), an inventory of greenhouse gases was conducted for the period 1990-2005.

In the Third National Communication (2012-2018), an inventory of greenhouse gases was conducted for the period 1990-2012.

As part of the Fourth National Communication, the First Biennial Update Report was prepared, which included an inventory for 1990-2017.

This inventory was also prepared as part of the Fourth National Communication. The document provides estimates of anthropogenic emissions and removals of greenhouse gases not controlled by the Montreal Protocol, calculated in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The inventory includes revised emission estimates for the period 1990-2017, as well as new estimates of GHG emissions for the period 2018-2021. The inventory includes information on the following greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and hydrofluorocarbons (HFCs).

In accordance with the 2006 IPCC Guidelines, the inventory was conducted for the following sectors:

- Energy;
- Industrial Processes and Product Use (IPPU);
- Agriculture, Forestry and Other Land Use (AFOLU);
- Waste.

GHG emission/removal calculations were mainly performed using the IPCC Software, 2006 (version V.2800). For individual categories, calculations were performed using supporting Excel spreadsheets based on the Annexes to the 2006 IPCC Guidelines.

National factors have been used for calculations in individual source categories to better suit national circumstances and to reduce uncertainty.

This inventory has benefited from the positive experience gained during the implementation of this inventory as a result of:

- preparation of previous greenhouse gas inventories of the Republic of Uzbekistan;
- participation in international trainings and workshops on conducting national inventories;
- peer review obtained under the ICA procedure of the First Biennial Update Report;
- recommendations on improvement of the emission inventory obtained during the voluntary assessment of the inventory organized by the UNFCCC Secretariat in 2021;
- familiarization with GHG inventories of other countries.

GHG emission estimates were converted to CO_2eq units using their global warming potentials (GWPs), the values of which are presented in the IPCC Fourth Assessment Report on Climate Change (Table 1.1).

The inventory also includes estimates of emissions of precursor gases: carbon monoxide (CO), nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO_2), calculated in the corresponding inventory categories according to the methodologies of the 1996 and 2006 IPCC Guidelines [1, 2].

Table 1.1 Global warming potentials used in the preparation of the GHG inventory for the period 1990-2021

Greenhouse gas	GWP	Greenhouse gas	GWP
CO_2	1	HFC-125	3500
CH_4	25	HFC-134a	1430
N_2O	298	HFC-152a	124
HFC-32	675	HFC-143a	4470

This GHG inventory has been prepared in accordance with the following principles:

- using the methodologies and structure of the 2006 IPCC Guidelines;
- prioritizing the use of national activity data and emission factors;
- using the international databases in work.

GHG emission estimates were conducted primarily using IPCC Tier 1 methodologies and, in some categories, Tier 2 methodologies. National factors were applied, to the extent possible, in key categories to obtain more accurate GHG emission estimates.

Tier 2 methodologies were used to estimate emissions/removals in the following key inventory categories:

- in the Ammonia Production, Nitric Acid Production and Cement Production categories of the Industrial Processes and Product Use sector;
- in the Solid Waste Management category of the Waste sector for the assessment of municipal solid waste;
- in the Forest Land Remaining Forest Land category of the Agriculture, Forestry and Other Land Use (AFOLU) sector.

The GHG inventory for the period 1990-2021 was conducted at the Agency of Hydrometeorological Service under the Ministry of Ecology, Environmental Protection and Climate Change of the Republic of Uzbekistan

1 Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Greenhouse Gas Inventory Workbook, Part 2.
2 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

(Uzhydromet), which is responsible for the preparation of reporting documents on climate change for the UN Framework Convention on Climate Change.

A robust institutional framework has been created in the country for the regular preparation of GHG inventories. All major ministries/departments/organizations were involved in the preparation of the inventory, which provided the necessary activity data and other information necessary for the inventory, participated in the development of national emission factors, performed calculations and developed documentation.

In preparing the GHG Inventory, the interaction of interested organizations in the country was carried out according to the scheme shown in Figure 1.1.

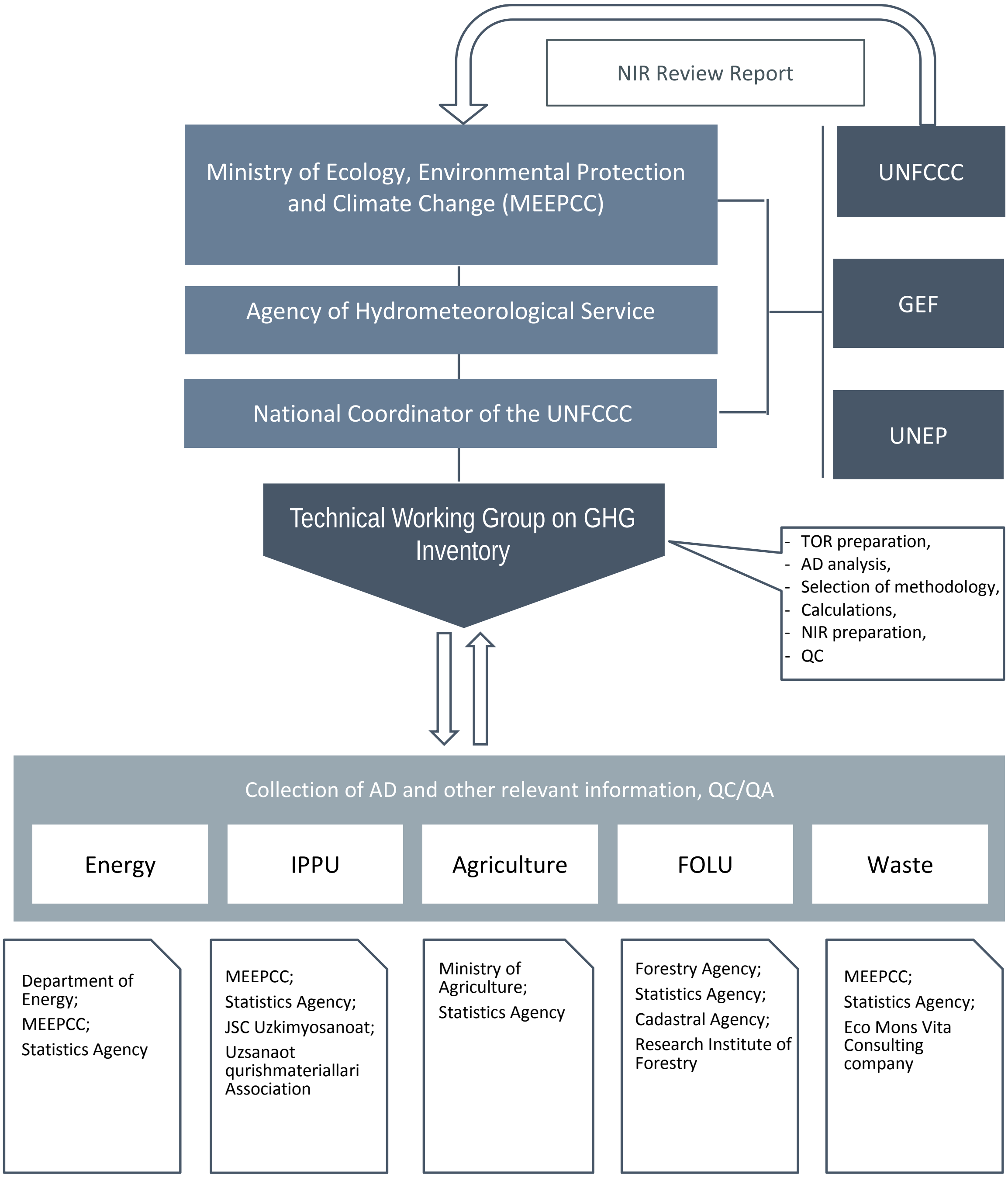

Figure 1.1 Organizational Structure of the National Inventory System

The national greenhouse gas inventory is organized according to a hierarchical principle, is centralized and consists of several levels of structural organization.

During the period of preparation of this GHG inventory, the institutional structure has changed due to the administrative reform of government bodies in 2022-2023. Until 2022, Uzhydromet had the status of the Center of Hydrometeorological Service of the Republic of Uzbekistan. After the reform (from January 2023), it changed its status and was transformed into the *Agency of Hydrometeorological Service under the Ministry of Ecology,* *Environmental Protection and Climate Change*. The State Committee on Ecology and Environmental Protection was transformed into a new Ministry of Ecology, Environmental Protection and Climate Change (MEEPCC). The State Committee on Forestry was transformed into the Forestry Agency under the Ministry of Ecology, Environmental Protection and Climate Change. The State Committee on Statistics was transformed into the Agency of Statistics. The Ministry of Agriculture and Water Resources was split into two separate ministries. The Cadastral Agency under the State Tax Committee changed its subordination and was transformed into the Cadastral Agency under the Ministry of Economy and Finance.

Forming a stable team of experts enables to preserve "institutional memory" and ensure continuity, consistency and continuous improvement in the quality of GHG inventory preparation. Uzhydromet has created and maintained databases and archives of GHG inventories since 1990s.

In accordance with IPCC recommendations, quality control is conducted at all stages of GHG inventory preparation by the technical team for inventory preparation.

Reports on GHG emissions/removals undergo quality assessment and coordination with all involved ministries and agencies. Then, according to the approved regulations, an international expert assessment of the prepared GHG emissions inventory by the UNFCCC bodies, as well as multilateral assessment is conducted.

Issues related to the implementation of the provisions of Articles 4 and 12 of the UN Climate Change Convention regarding greenhouse gas emission inventories are directly or indirectly regulated by the current legislation of the Republic of Uzbekistan.

The list of regulations that directly regulate this issue includes:

- Law of the Republic of Uzbekistan No. O'RQ-491 dated 10/02/2018 "On the ratification of the Paris Agreement";
- Resolutions of the President of the Republic of Uzbekistan:
  - PR-4477 dated 04.10.2019 "On approval of the Strategy for the transition of the Republic of Uzbekistan to a Green Economy in the period of 2019-2030". This Strategy considers the creation of a greenhouse gas emission MRV system as a prerequisite for continuous monitoring of the country's quantitative commitments under the Paris Agreement and ensuring reporting on greenhouse gas emissions.
  - PR-4896 dated 17.11.2020 "On measures to further improve the activities of the Center of Hydrometeorological Service of the Republic of Uzbekistan." This resolution defined Uzhydromet as an authorized state body in the field of hydrometeorology, as well as monitoring of climate change and environmental pollution in the Republic of Uzbekistan. Uzhydromet was entrusted with the implementation of relevant international commitments, including those under the UN Framework Convention on Climate Change;
  - PR-4796 dated 08.03.2020 "On measures to further improve and develop the national statistical system of the Republic of Uzbekistan." The resolution provides for the development and improvement of the state statistical system in accordance with modern international requirements, including those related to climate data;
  - PR-436 dated 02.12.2022 "On measures to improve the effectiveness of reforms aimed at the transition of the Republic of Uzbekistan to a "green" economy until 2030". In particular, it plans to develop a draft law of the Republic of Uzbekistan "On limiting greenhouse gas emissions", phased creation of infrastructure for state regulation of GHG emissions (state MRV system) in 2022-2026, which will provide for state accounting of greenhouse gas emissions and maintenance of *their cadastre*;
  - PD-81 dated 31.05.2023 "On measures to transform the sphere of ecology and environmental protection and organize the activities of the authorized body." In accordance with this decree, in the course of large-scale administrative state reform, a new Ministry of Ecology, Environmental Protection and Climate Change was organized on the basis of the State Committee on Ecology and Environmental Protection, with Uzhydromet (formerly the Center of Hydrometeorological Service) coming under its jurisdiction as the Agency of Hydrometeorological Service.
  - PR-171 dated 31.05.2023 "On measures for the effective organization of the activities of the Ministry of Ecology, Environmental Protection and Climate Change". According to this resolution, the Ministry of Ecology, Environmental Protection and Climate Change is responsible for the development and implementation of a unified state policy in the above areas, including climate change.

1.2 Description of methodologies and data sources used

Emissions/removals of greenhouse gases and indirect greenhouse gases in this inventory were estimated in accordance with the requirements of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

The scheme of the national inventory preparation process is shown in Figure 1.2

Preparation of the inventory includes the stages presented in Figure 1.2.

Uzhydromet develops and sends requests to relevant organizations to provide baseline information for inventory preparation.

Official statistical data, data from some large state-owned companies, expert assessments, as well as information from international statistical databases of the International Energy Agency (IEA), Food and Agriculture Organization of the United Nations (FAO) were used as activity data. The limited access information used in the preparation of the GHG inventory is not provided in the inventory.

In most cases, default emission factors have been used in the calculations. National factors were used where possible to estimate emissions in key categories. The limited use of national emission factors is due to insufficient detail of activity data. Further research and involvement of dedicated experts is required to develop national factors in key categories.

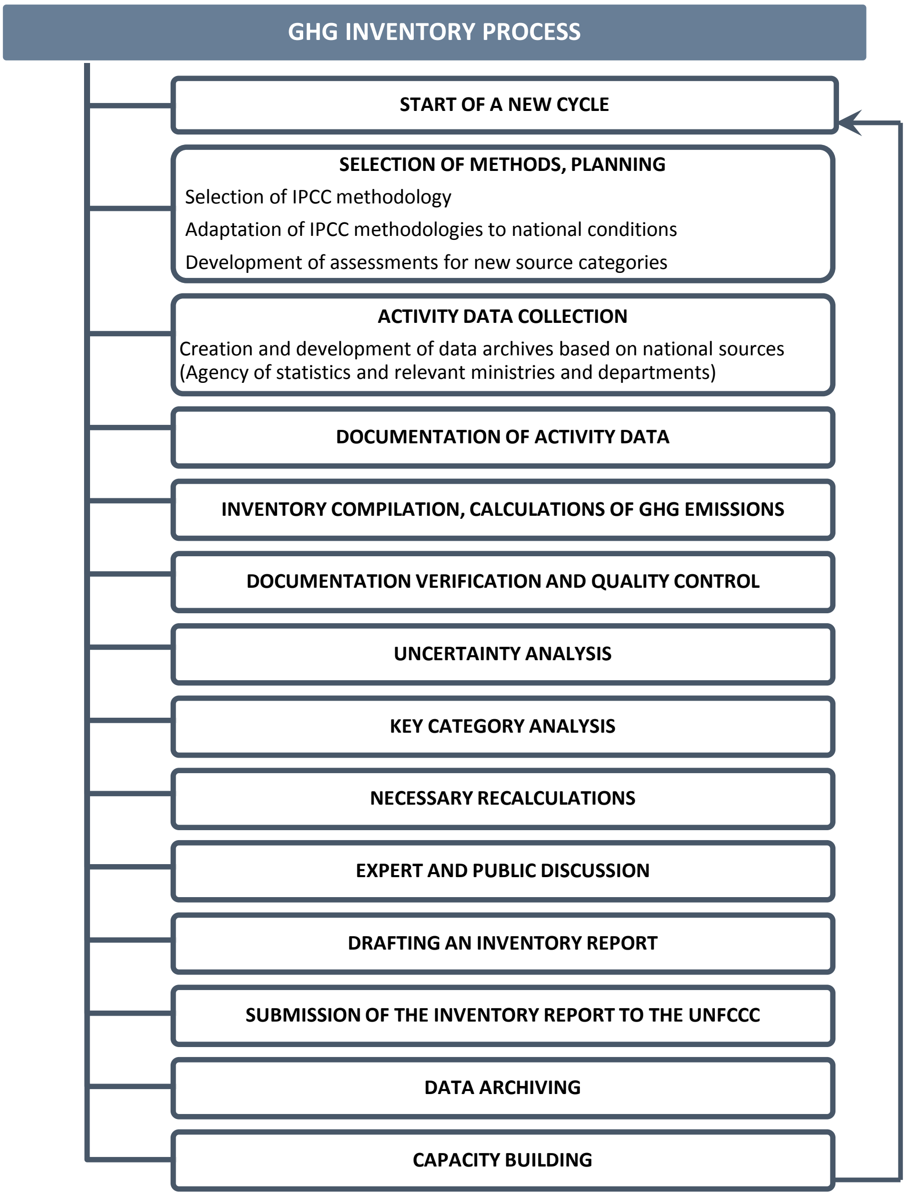

Figure 1.2 GHG inventory program and process

Emissions were calculated using the IPCC 2006 Software (version V.2800). For individual categories, calculations were performed using supporting Excel spreadsheets based on the Annexes to the 2006 IPCC Guidelines.

In preparing the GHG inventory, scientific, technical and economic publications containing information used to estimate GHG emissions in the relevant calculation categories are collected and analyzed.

In some categories, expert estimates were used, as well as information from international statistical databases of the International Energy Agency (IEA) and the Food and Agriculture Organization of the United Nations (FAO).

1.3 Quality Assurance and Quality Control (QA/QC)

Quality Assurance/Quality Control procedures are conducted as an element of good practice to improve the quality of national inventories at all stages of GHG inventory preparation. Quality control was conducted according to Tier 1 - general procedures, by the experts of the technical group on GHG inventory preparation at all stages.

Ministries, agencies, organizations and public-private companies by source category, not directly involved in the preparation of the inventory, participated in the quality assessment of the national GHG inventory.

Quality control procedures

Quality control procedures were conducted at all stages of GHG inventory preparation. Changes and corrections made are entered into the appropriate inventory quality control table.

The following quality control procedures were conducted for all sectors:

- Verification of the received activity data for mechanical errors.
- Verification of the entered data for mechanical errors.
- Verification of calculations to fill activity data gaps using mathematical methods.
- Verification of the entry of emission units, parameters or conversion factors.
- Verification of greenhouse gas emission calculations.
- Verification of consistency of input and calculations in time series in changing method, emission factors/other parameters or data.
- Verification of the correctness of entering formulas, calculations, etc. in modified worksheets according to national worksheet conditions.
- Verification of calculations in the development of national factors.
- Verification of emission source documentation (suppositions, assumptions and criteria for selection of calculation method, activity data, emission factors and other multipliers).
- Verification of all references related to data, factors.
- Cross verification of data.

The overall coordination of activities on quality control of the national greenhouse gas inventory is conducted by the UzHydromet's technical group on preparation of the inventory.

Quality assessment procedures

The quality assessment was conducted after completion of all inventory calculations. The quality assessment was conducted by sending official letters to the relevant organizations and receiving official responses with the results of the assessments. The resulting assessments are taken into account in preparing the final version of the National Inventory Report (NIR).

To assess the quality of the inventory, a draft National Inventory Report was provided to the external assessment organizations, which includes all the necessary information for verification of:

- calculation method;
- activity data;
- factors and other parameters;
- emission data;
- information on quality control conducted.

The following organizations and agencies were provided with information GHG emission/removal estimates obtained for quality assessment:

- Ministry of Ecology, Environmental Protection and Climate Change;
- Ministry of Economy and Finance;
- Ministry of Energy;
- Ministry of Agriculture;
- Uzbekneftegaz JSC;
- Uztransgaz JSC;
- Uzkimyosanoat State Joint Stock Company;
- Uzsanoatqurilishmateriallari Association;

– Forestry Agency;
– Statistics Agency.

An important element of quality assurance of the GHG inventory is its review by UNFCCC expert groups. The results of the review and recommendations of international experts are used to improve the inventory on an ongoing basis.

In January 2021, a voluntary assessment of the inventory system of the Republic of Uzbekistan by the UNFCCC international experts was additionally conducted. Based on the results of the inventory quality assessment, a Technical Review containing detailed recommendations for further improvement of the inventory for the short and long term was provided to the Uzhydromet's Technical Group for inventory preparation. The recommendations obtained were implemented to the extent possible in the preparation of this inventory.

1.4 Key categories

In this inventory, key categories were analyzed using the Tier 1 methodology by level and trend in accordance with the 2006 IPCC Guidelines.
According to the IPCC definition, a *key category* is the one that is prioritized within the national inventory system because its estimate has a significant impact on the overall national greenhouse gas inventory in terms of absolute level, trend in emissions and removals, or both.
Key sources for the GHG inventory are those that total 95% of at least one of the criteria (level or trend), arranged in descending order of their percentage contribution to total cumulative emissions. Key source categories by emission level are identified for the beginning and end of the time period under study.
Key category analysis included:

- greenhouse gases: CO_2, CH_4, N_2O, HFCs (PFCs and SF_6 were not included as there is no data to estimate emissions of these gases);
- all estimated source categories, not accounting for emissions and removals in the FOLU sector;
- all estimated source categories, accounting for emissions and removals in the FOLU sector.

Emission levels and trends were estimated for 1990 and 2021. The detailed Key Source Analysis are presented in Annex 2 to this report.
Key categories in 1990
Tables 1.4.1 and 1.4.2 show key sources of GHG emissions by emission level in 1990 accounting and not accounting for the FOLU sector.
In 1990, 26 emission sources were identified as key categories not accounting for the FOLU sector. Of these, the Energy sector accounts for 16 key sources; the Industrial Processes and Product Use sector – for 4 sources; the Agriculture sector – for 4 sources; and the Waste sector – for 2 sources. The following GHG emission sources made the largest contribution to total emissions in 1990:

– 1.A.1. Energy production. Gaseous fuel – 24%;
– 1.B.2.b. Natural gas. Fugitive methane emissions – 9%;
– 1.A.4. Other sectors. Gaseous fuel – 7%;
– 1.A.3.b. Motor transport. Liquid fuel – 6%;
– 1.A.1. Energy production. Liquid fuel – 6%;
– 1.A.1. Energy production. Solid fuel – 6%;
– 1.A.4. Other sectors. Liquid fuel – 5%;
– 3.A.1. Enteric fermentation. Methane emissions – 5%.

In total, these sources accounted for 69% of total GHG emissions.
In 1990, 28 categories were identified as *key categories, accounting for the FOLU sector*. Among them are 16 categories of the Energy sector, 4 categories of the Industrial Processes and Product Use sector; 6 categories of the AFOLU sector; and 2 categories of the Waste sector. The following categories made the largest contribution to emissions, accounting for removals in the FOLU sector.

– 1.A.1. Energy production. CO_2 emissions from combustion of gaseous fuels – 22%;
– 1.B.2.b. Natural gas. Fugitive methane emissions – 8%;
– 1.A.4. Other Sectors. CO_2 emissions from gaseous fuel combustion – 7%;
– 1.A.3.b. Motor transport. CO_2 emissions from liquid fuel combustion – 6%;
– 1.A.1. Energy production. CO_2 emissions from liquid fuel combustion – 6%;
– 1.A.1. Energy production. CO_2 emissions from solid fuel combustion – 5%;
– 3.B.2.a. Cropland. CO_2 removals – 5%
– 1.A.4. Other sectors. CO_2 emissions from liquid fuel combustion – 5%;
– 3.A.1. Enteric fermentation. Methane emissions – 4%.

In total, these sources accounted for 68% of total GHG emissions.

Key categories in 2021
In 2021, the largest 17 key categories by GHG emissions, which in total account for 67% of all emissions, *not accounting for the FOLU sector*, were:

- 1.A.1 Energy and Heat Production. CO_2 emissions from gaseous fuel combustion – 18%;
- 1.A.4 Other sectors. CO_2 emissions from gaseous fuel combustion – 16%;
- 3.A.1. Enteric fermentation. Methane emissions – 10%;
- 1.B.2.b. Natural gas. Fugitive methane emissions – 9%;
- 2.A.3. Glass production. CO_2 emissions – 8%;
- 1.A.2. Manufacturing and construction. CO_2 emissions from gaseous fuel combustion – 6%.

The 17 key sources were distributed by inventory sector as follows:

- 10 in the Energy sector;
- 4 in the Industrial Processes and Product Use sector;
- 2 in the Agriculture sector;
- 2 in the Waste sector.

Seventeen key sources were identified *by emission trend* for the period 1990-2021 *not accounting for the FOLU sector*.
The following key categories contributed the most to the trend:

- 1.A.4 Other sectors. CO_2 emissions from gaseous fuel combustion –13%;
- 1.A.1. Energy production. CO_2 emissions from gaseous fuel combustion – 12%;
- 2.A.3. Glass production. CO_2 emissions – 10%;
- 1.A.4. Other sectors. CO_2 emissions from solid fuel combustion – 9%;
- 3.A.1. Enteric fermentation. Methane emissions – 9%;
- 1.A.4. Other sectors. CO_2 emissions from liquid fuel combustion – 7%;
- 1.A.3.b. Motor transport. CO_2 emissions from gaseous fuel combustion – 6%;
- 1.A.4. Other sectors. CO_2 emissions from solid fuel combustion – 5%;
- 1.A.3.b. Motor transport. CO_2 emissions from liquid fuel combustion – 5%.

In 2021, the largest 19 key categories by level, which in total account for 68% of all emissions, *accounting for the FOLU sector*, were:

- 1.A.1 Energy and heat production. CO_2 emissions from gaseous fuel combustion – 17%;
- 1.A.4 Other sectors. CO_2 emissions from gaseous fuel combustion – 15%;
- 3.A.1. Enteric fermentation. Methane emissions – 9%;
- 1.B.2.b. Natural gas. Fugitive methane emissions – 9%;
- 2.A.3. Glass production. CO_2 emissions – 8%;
- 1.A.2. Manufacturing and construction. CO_2 emissions from gaseous fuel combustion – 5%.
- 1.A.1 Energy and heat production. CO_2 emissions from solid fuel combustion – 5%.

The 19 key sources were distributed by inventory sector as follows:

- 9 in the Energy sector;
- 3 in the Industrial Processes and Product Use sector;
- 5 in the Agriculture, Forestry and Other Land Use sector;
- 2 in the Waste sector.

Fifteen key categories have been identified *by emission trend* for the 1990-2021, *accounting for the FOLU sector*.
The following categories contributed the most to the trend:

- 1.A.1. Energy production. CO_2 emissions from gaseous fuel combustion – 16%;
- 1.A.4 Other sectors. CO_2 emissions from gaseous fuel combustion –13%;
- 2.A.3. Glass production. CO_2 emissions – 11%;
- 3.A.1. Enteric fermentation. Methane emissions – 9%;
- 1.A.3.b. Motor transport. CO_2 emissions from gaseous fuel combustion – 7%;
- 1.A.4. Other sectors. CO_2 emissions from solid fuel combustion – 6%;
- 1.A.4. Other sectors. CO_2 emissions from liquid fuel combustion – 6%;
- 1.A.2. Manufacturing and construction. CO_2 emissions from gaseous fuel combustion – 5%.

The results of the key category analysis are used in the process of preparing the next inventory in order to reduce uncertainty in the estimates and optimize resource allocation. It is planned to improve GHG emission/removal estimates in key categories as a priority by using higher level IPCC methodologies, detailing and refining activity data, and developing national emission factors.

1.5 Uncertainty assessment

Uncertainty has been estimated for all sectors and categories included in the inventory, as well as for total greenhouse gas emissions accounting and not accounting for the FOLU sector.

Calculations were performed in accordance with the IPCC Tier 1 methodology for a 95% confidence interval. Uncertainty of greenhouse gas emissions is determined by uncertainties in activity data and emission factors.

The overall inventory uncertainty was estimated for 2021.

The combined uncertainty of the national greenhouse gas inventory accounting for the contribution of the FOLU sector was ±25.62%, the uncertainty of the GHG emission trend ±11.85%.

The combined uncertainty of the national greenhouse gas inventory not accounting for the contribution of the FOLU sector was ±24.57%, uncertainty of the GHG emission trend ±9.14%.

The following source and sink categories contributed most to the combined uncertainty:

– 2.B.1. Fugitive emissions from fuels;

– 3.A. Livestock;

– 3.C.4. Direct N_2O emissions from managed soils;

– 3.C.5. Indirect N_2O emissions from managed soils.

Details of the uncertainty are given in Annex 3 of this report.

The results of uncertainty estimates are used to further improve GHG emission/sink calculations. For those source and sink categories that have the greatest influence on the overall uncertainty, the use of higher tier GHG emission estimation methodologies and refinement and detailing of activity data are planned.

1.6 Inventory improvement plan

Following the Voluntary Inventory Assessment (2021), the UNFCCC Secretariat provided technical support to Uzbekistan, as a developing country, to create/improve its National Inventory Improvement Plan to support the implementation of the transparency framework. The updated Inventory Improvement Plan (NIIP) was developed in 2023 with the participation of international experts based on the Technical Review of the Voluntary Inventory Assessment, inventory results of the Republic of Uzbekistan for the period 1990-2017 and the transparency requirements of the Paris Agreement. The was prepared in Excel format.

The content of the NIIP has been developed in collaboration with the UNFCCC National Focal Point and key national sectoral working groups and experts. The Inventory Improvement Plan (NIIP) consists of the following main parts: “Institutional circumstances”, “Reporting and QA/QC”, “Cross-cutting objectives”, “Energy”, “IPPU”, “Agriculture”, “FOLU”, “Waste”, “Key category analysis”, “Uncertainty analysis”, “Improvement planning/projects”, “Management”, “Progress Tracking”.

The plan identifies improvements by individual inventory category for the immediate, medium and long term in line with current IPCC requirements, taking into account the enhanced transparency framework.

The NIIP will facilitate the development of specific resource mobilization and implementation projects to continuously improve the quality of national greenhouse gas inventories in accordance with the reporting requirements set out in the Modalities, Procedures and Guidelines (MPG) for the Preparation of the First Biennial Transparency Report.

This inventory has been prepared on the basis of the developed NIIP.

It is envisaged that the Inventory Improvement Plan will be reviewed and updated prior to the development of each subsequent emission inventory of the Republic of Uzbekistan.

1.7 Overall completeness assessment

In accordance with the IPCC requirements, the inventory must provide a completeness assessment of source data, as well as emissions and removals of greenhouse gases, and coverage of the country's territory.

The inventory covers the entire territory of Uzbekistan, the main sources of emissions and removals in the country (about 90% of sources according to expert estimates). Natural (non-anthropogenic) emissions/removals are not taken into account in the inventory.

The inventory does not include those IPCC categories for which there are no economic or other activities leading to GHG emissions/removals. The inventory includes the following greenhouse gases: CO_2, CH_4, N_2O, hydrofluorocarbons (HFCs).

SF_6 - sulphur hexafluoride and PFCs - perfluorocarbons are not included in the inventory due to the lack of statistical reporting on their consumption at the moment.

The inventory also includes information on emissions of other gases with indirect greenhouse effect in the relevant inventory categories: NOx, CO, non-methane volatile hydrocarbon compounds (NMVHCs), SO_2.

Table 1.3 indicates categories of greenhouse gas sources (classification presented in accordance with the Revised Guidelines for National Greenhouse Gas Inventories, IPCC, 1996 [3]) not covered by inventories for one reason or another.

The Use of Solvents and Other Products sector is not included in the inventory due to the need for additional research to inventory existing industries that use solvents and lubricating oils and to collect data on the use of nitrous oxide for medical purposes.

The following IPCC categories are included in this inventory for the first time:

In the Energy sector:

- in the Fugitive Emissions from Fuels. Natural Gas category - 1.B.2.b.iii.4 Gas Storage category.

In the IPPU sector:

- in the Mineral Products category - 2.A.3 Glass Production and 2.A.4.a Ceramics Production categories;
- in the Chemical Industry category - 2.B.5 Calcium Carbide Production category;
- in the Metallurgical Industry category - 2.C.2 Ferroalloy Production and 2.C.6 Lead Production categories.

In the Waste sector:

- in 4.A Solid Waste Management category, methane emissions from industrial waste were estimated.

2. TRENDS IN GREENHOUSE GAS EMISSIONS

2.1 Trends in greenhouse gas emissions

According to the inventory in Uzbekistan, the total greenhouse gas emissions in 2021 amounted to:

– 206.9 Mt of CO_2-eq not accounting for removals in the FOLU sector;
– 200.6 Mt of CO_2-eq accounting for removals in the FOLU sector.

Compared to the baseline 1990 level, total greenhouse gas emissions in 2021 increased by 32.3%.

The contribution of greenhouse gases to total emissions in 2021 was as follows (Mt CO_2-eq):

– CO_2 – 139.4 (67.4%);
– CH_4 – 52.8 (25.5%);
– N_2O – 14.4 (6.6%);
– HFC – 0.99 (0.5%).

Table 2.1 and Figure 2.1 show the individual GHG emissions and the values of total emissions for the period 1990-2021, as well as the change in total national GHG emissions for each year compared to the baseline 1990 level.

Table 2.1 Greenhouse gas emissions, Mt CO_2-eq. (not accounting for removals in the FOLU sector)

Year	CO_2	CH_4	N_2O	HFC	Total	Year	CO_2	CH_4	N_2O	HFC	Total
1990	119.94	29.42	7.07	-	156.44	2008	115.32	48.59	9.20	0.02	173.13
1991	120.21	30.81	7.74	-	158.765	2009	115.30	48.48	8.71	0.02	172.50
1992	112.52	32.25	7.74	-	152.51	2010	114.09	48.47	9.03	0.02	171.61
1993	110.98	34.91	7.29	-	153.18	2011	110.03	48.41	9.50	0.03	167.97
1994	106.39	36.69	6.75	-	149.83	2012	106.00	49.01	9.96	0.04	165.01
1995	105.51	39.15	6.69	-	151.35	2013	107.49	47.36	11.19	0.05	166.08
1996	108.82	39.23	6.49	-	154.54	2014	105.98	46.72	11.62	0.06	164.37
1997	107.65	39.94	6.78	-	154.37	2015	102.96	47.71	11.98	0.09	162.73
1998	106.49	41.23	6.88	-	154.59	2016	105.68	48.97	12.30	0.17	167.12
1999	110.33	41.93	6.70	-	158.96	2017	104.17	50.37	12.54	0.27	167.36
2000	114.96	42.09	6.69	0.00	163.75	2018	116.88	52.82	12.96	0.44	183.10
2001	117.86	42.16	6.73	0.00	166.75	2019	115.79	53.38	13.29	0.73	183.20
2002	119.49	43.22	6.75	0.00	169.46	2020	118.58	50.43	13.17	0.91	183.09
2003	115.46	43.36	7.00	0.00	165.82	2021	139.41	52.81	13.73	0.99	206.94
2004	115.86	44.15	7.32	0.01	167.34	$\Delta_{(1990-2021)}$	**16.2%**	**79.5%**	**94.2 %**	**919-fold increase**	**32.3%**
2005	111.41	43.77	7.73	0.01	162.92	**%.** $_{2021}$	**67.4 %**	**25.5%**	**6.6%**	**0.5%**	**100.00%**
2006	114.29	45.58	8.05	0.01	167.94	$\Delta_{(2010-2021)}$	**+22.2%**	**+8.9%**	**+52.0%**	**51.6-fold increase**	**+20.6%**
2007	112,45	46,76	8,61	0,01	167,84						

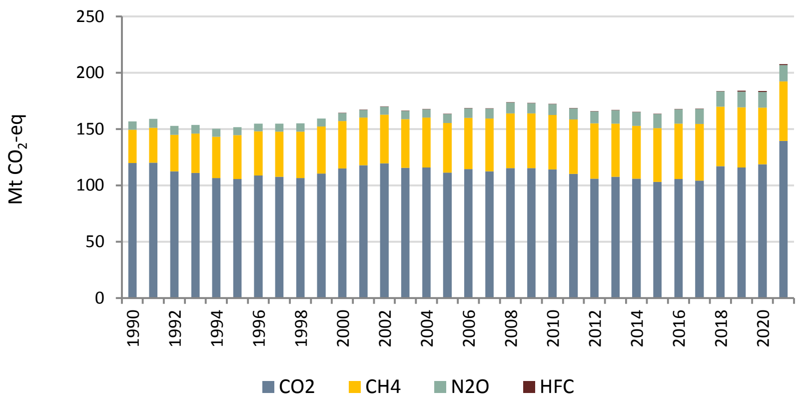

Figure 2.1 Greenhouse gas emissions from 1990 to 2021

The maximum value of total emissions (206.9 Mt CO_2-eq.) were recorded in 2021, the lowest (149.8 Mt CO_2-eq.) in 1994.

HFCs emissions are given for the period 2000-2021, since there are no data on HFC consumption in the country before 2000.

Over the period 1990-2021, the following changes were observed:

- increase in CO_2 emissions by 16.2%;
- increase in CH_4 emissions by 79.5%;
- increase in N_2O emissions by 94.2%;
- increase in HFC emissions over the period 2000-2021 was 919-fold.

Since 2010 was adopted as the baseline year for the NDC of the Republic of Uzbekistan, changes in GHG emissions for the period 2010-2021 were estimated (Table 2.1). During this period, total emissions of all GHGs increased by 20.6%, including CO_2 emissions - by 22.2%; CH_4 - by 8.9%; N_2O - by 51.6%; and HFCs - by 49.5 times.

Changes in the contributions of individual gases to the structure of total national GHG emissions during the period 1990-2021 are given in Figure 2.2. During this period, the share of CO_2 in the total GHG emissions decreased from 77% to 67%, the share of methane increased from 19% to 26%. The share of nitrous oxide increased from 4% to 7%. The contribution of HFCs to the total emission increased to 0.5% since 2000.

The largest contribution to CO_2 emissions (80%) comes from the Energy sector (fuel combustion) and 20% from the Industrial Processes and Product Use sector (production of glass, cement, ammonia and other products).

Methane emissions are distributed by inventory sectors as follows: the Energy sector accounts for 41% (mainly due to methane leaks from gas systems in the oil and gas industry); the Agriculture sector – for 40% (livestock); the Waste sector – for 19% (decomposition of municipal solid waste in landfills, formation in domestic wastewater).

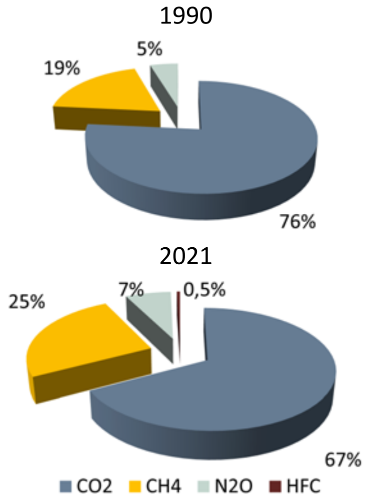

Figure 2.2 Changes in the structure of greenhouse gas emissions for 1990-2021

The main contribution to nitrous oxide emissions (76%) comes from the Agriculture sector (manure management and emissions from managed land through applying nitrogen fertilizers, from decomposition of plant residues in soils); 15% - from Industrial Processes and Product Use sector (nitric acid production); 6% - from Waste sector (formation in domestic wastewater).

HFCs emitter is the Industrial Processes and Product Use sector. HFCs emissions are associated with the use of refrigerants in air conditioning and refrigeration systems.

2.2 Trends in greenhouse gas emissions by sector

Figures 2.3 and 2.4 and Table 2.2 show greenhouse gas emissions by sector for the period 1990-2021 and total national emission values:

- accounting for CO_2 emissions/removals in the FOLU sector;
- not accounting for CO_2 emissions/removals in the FOLU sector.

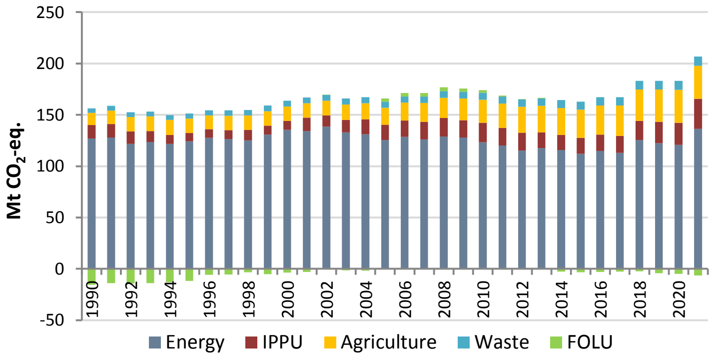

Figure 2.3 Greenhouse gas emissions by sector from 1990 to 2021

For the period 1990-2021, GHG emissions by sector changed as follows:

- there was an increase in emissions in the following sectors:
  - Energy by 7.4%;
  - IPPU by 121.0%;
  - Agriculture by 172.7%;
  - Waste by 107.1%.
- CO_2 removals in the FOLU sector decreased by 58.7% due to increase in emissions in the Grassland Remaining Grassland category.

Changes in the contributions of individual sectors to the structure of total national GHG emissions over the period 1990-2021 are given in Figure 2.4. During this period, the share of the Energy sector in total greenhouse gas emissions decreased from 81% to 66%, while the shares of other sectors increased: IPPU from 8% to 14%, Agriculture from 8% to 16%, Waste from 3% to 4%. The main increase in emissions was observed over the period 2018-2021.

For the period 2010-2021 (relative to the baseline year under the Paris Agreement), GHG emissions by inventory sector changed as follows:

- in the Energy sector - increased by 10.5%;
- in the IPPU sector - increased by 54.1%;
- in the Agriculture sector - increased by 43.3%;
- in the Waste sector - increased by 34.2%.

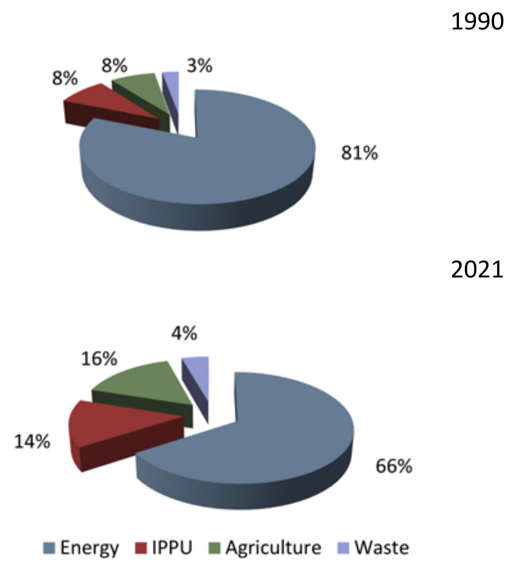

Figure 2.4 Change in the structure of greenhouse gas emissions for 1990-2021 by sector

Table 2.2 Greenhouse gas emissions by sector, Mt of CO_2-eq.

Year	Energy	IPPU	Agriculture	Waste	Total	FOLU	Total (excluding FOLU)	Year	Energy	IPPU	Agriculture	Waste	Total	FOLU	Total (excluding FOLU)
1990	126.97	13.22	11.83	4.42	**156.44**	-15.38	**141.05**	2008	128.87	18.09	19.75	6.41	**173.13**	3.76	**176.89**
1991	127.97	12.96	13.29	4.54	**158.76**	-13.95	**144.81**	2009	128.05	16.76	21.10	6.59	**172.51**	3.18	**175.69**
1992	121.81	11.92	14.12	4.66	**152.51**	-14.30	**138.22**	2010	123.32	18.95	22.51	6.82	**171.61**	2.44	**174.05**
1993	123.48	10.59	14.33	4.79	**153.18**	-13.97	**139.21**	2011	120.29	16.85	23.77	7.06	**167.97**	0.74	**168.71**
1994	121.84	8.68	14.41	4.89	**149.82**	-13.07	**136.75**	2012	115.26	17.43	25.08	7.25	**165.01**	0.08	**165.09**
1995	124.32	7.94	14.10	5.00	**151.35**	-11.69	**139.66**	2013	117.51	15.51	25.65	7.42	**166.08**	0.43	**166.52**
1996	127.68	8.31	13.44	5.11	**154.54**	-5.96	**148.58**	2014	115.89	14.66	26.19	7.62	**164.37**	-2.73	**161.65**
1997	126.25	8.98	13.95	5.19	**154.37**	-5.64	**148.73**	2015	111.96	15.73	27.21	7.83	**162.73**	-3.28	**159.46**
1998	125.28	10.05	13.97	5.29	**154.59**	-3.42	**151.17**	2016	114.69	16.03	28.36	8.04	**167.12**	-3.16	**163.96**
1999	130.59	8.87	14.11	5.39	**158.96**	-5.22	**153.74**	2017	113.04	16.46	29.62	8.24	**167.36**	-2.68	**164.68**
2000	135.27	8.87	14.17	5.43	**163.75**	-3.66	**160.08**	2018	125.33	18.86	30.52	8.39	**183.10**	-2.37	**180.73**
2001	134.32	12.83	14.05	5.54	**166.75**	-3.11	**163.64**	2019	122.27	21.06	31.25	8.62	**183.20**	-4.12	**179.08**
2002	138.52	10.95	14.28	5.70	**169.46**	0.08	**169.53**	2020	120.84	21.56	31.8 3	8.86	**183.09**	-4.89	**178.21**
2003	132.91	12.10	15.00	5.81	**165.82**	-1.38	**164.44**	2021	136.32	29.21	32.25	9.15	**206.94**	-6.35	**200.59**
2004	131.11	14.62	15.70	5.91	**167.34**	-1.83	**165.51**	**$\Delta_{(1990-2021)}$**	**+7.4%**	**+121.0%**	**+172.7%**	**+107.1%**	**+32.3%**	**-58.7%**	**+42.4%**
2005	125.36	15.00	16.54	6.01	**162.92**	2.95	**165.86**	**%, 2021**	**65.9%**	**14.1%**	**15.6 %**	**4.4%**	**100.0%**		
2006	128.47	15.98	17.35	6.13	**167.94**	3.26	**171.19**	**$\Delta_{(2010-2021)}$**	**+10.5%**	**+54.1%**	**+43.3%**	**+34.2%**	**+20.6%**		**+15.3%**
2007	126.19	17.02	18.36	6.26	**167.84**	3.56	**171.39**								

Industrial Processes and Product Use sector mainly due to the growth of industrial production in the Production of Mineral Products category, the lowest - in the Energy sector due to the introduction of new technologies and resource and energy saving policies.

2.3 Trends in emissions of gases with indirect greenhouse effect

The inventory estimated emissions of gases with an indirect greenhouse effect - CO, NOx, NMVOC (non-methane volatile organic compounds) and SO_2 using the 1996 IPCC methodology and default factors from the calculation categories.

The Energy sector is the largest contributor to indirect greenhouse gas emissions.

Table 2.3 and Figure 2.5 show annual emissions of gases with indirect greenhouse effect for the period 1990-2021.

Carbon monoxide accounts for the largest emissions.

During the entire period under review, there has been a decrease in emissions of gases with indirect greenhouse effect: CO by 29.9%; SO2 by 21.3%. At the same time, NOx and NMVOCs increased by 22.3% and 3.1% respectively.

Trends in indirect greenhouse gas emissions are related to the specifics of emission sources.

Table 2.3 Emissions of gases with indirect greenhouse effect, Gg gas

Year	CO	NOx	NMVOCs	SO_2	Year	CO	NOx	NMVOCs	SO_2
1990	1940.73	413.28	524.89	142.98	2007	1013.66	251.15	312.35	45.25
1991	1774.42	392.27	775.38	131.39	2008	1050.22	265.20	326.34	57.15
1992	1404.07	346.41	610.47	109.76	2009	1036.82	260.21	319.42	61.61
1993	1234.79	319.29	512.47	95.48	2010	1226.34	256.57	464.46	72.45
1994	1096.90	294.01	459.33	86.65	2011	971.41	259.20	309.49	84.82
1995	952.88	284.21	446.15	75.58	2012	1029.74	271.19	344.76	89.08
1996	924.40	277.34	382.79	61.78	2013	947.86	277.11	368.29	93.65
1997	1052.72	282.29	462.45	65.69	2014	954.13	291.20	362.13	92.95
1998	1026.30	271.28	420.77	65.99	2015	956.02	299.20	358.05	98.27
1999	1108.06	278.16	420.04	64.68	2016	909.19	305.13	366.58	98.33
2000	1114.10	284.14	434.44	61.94	2017	1002.35	316.03	385.21	108.87
2001	1150.25	282.32	398.85	59.56	2018	1163.27	346.05	534.26	108.82
2002	1077.98	282.28	397.72	52.03	2019	1000.84	343.19	517.56	109.02
2003	965.44	264.31	362.94	45.10	2020	1279.75	352.19	555.35	108.45
2004	982.68	265.42	356.99	41.50	2021	1687.96	505.35	541.33	109.92
2005	944.42	251.99	316.35	37.88	$\Delta_{(1990-2021)}$	**-29.90%**	**+22.3%**	**+3.1%**	**-23.12 %**
2006	988.02	259.03	342.13	40.04					

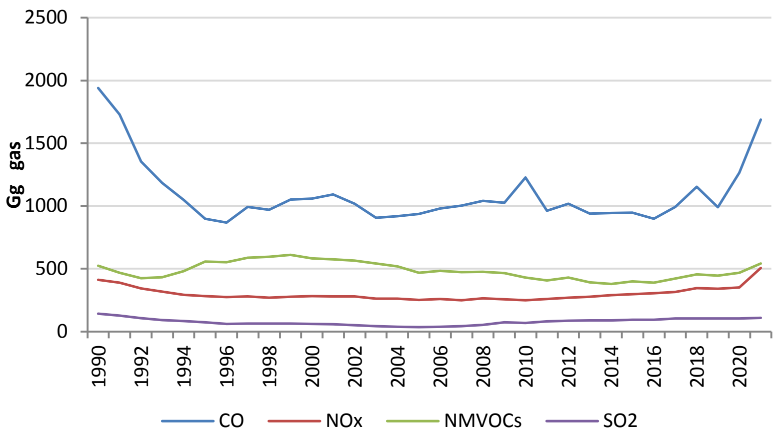

Figure 2.5 Trends in emissions of gases with indirect greenhouse effect

2.4 Fulfillment of Uzbekistan's quantitative commitments under the Paris Agreement

Uzbekistan's quantitative commitments under the Paris Agreement (updated Nationally Determined Contribution, 2021) are: *to reduce specific greenhouse gas emissions per unit of GDP by 35% by 2030 relative to the 2010 level.*

The value of specific greenhouse gas emissions per unit of GDP or GDP carbon intensity is calculated using the following formula:

GDP carbon intensity (kgCO_2-eq/ USD) = GHG emissions (MtCO_2-eq) / GDP (USD)

The numerator in this formula is the annual value of total GHG emissions; the denominator is the value of annual GDP (expressed in constant 2015 international dollars). Calculation of the GDP carbon intensity uses national estimates of total GHG emissions and GDP from the World Bank database for the Republic of Uzbekistan (www.worldbank.org).

Table 2.4 shows the change in the carbon intensity of GDP from the 2010 level.

Table 2.4 Change in GDP carbon intensity from the 2010 level

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
GHG emissions, MtCO_2-eq	171.61	167.97	165.01	166.08	164.37	162.73	167.12	167.36	183.10	183.20	183.09	206.94
GDP, billion USD $_{2015}$	60.88	65.46	70.11	75.22	80.39	86.20	91.31	95.32	100.93	106.96	109.10	117.18
GDP carbon intensity, kg GHG/USD	2.83	2.57	2.36	2.22	2.05	1.89	1.84	1.76	1.82	1.72	1.68	1.77
Reduction in GDP carbon intensity, % of 2010	-	-9.2	-16.0	-21.6	-27.7	-33.0	-35.1	-37.9	-35.7	-39.4	-40.4	-37.2

Thus, over the period 2010-2021, the value of the carbon intensity of GDP decreased by 37.2%.

The fulfillment of quantitative commitments as of 2021 is carried out due to the faster growth rates of GDP relative to the growth rates of GHG emissions.

2.5 Trends in specific emission indicators – GHG emissions per capita

To ensure comparability of emissions from different countries, it is customary to calculate the indicator of annual per capita emissions of the main greenhouse gases.

GHG emissions per capita for the period from 1990 to 2021 changed as follows (Fig. 2.6):

- total emissions decreased from 7.6 to 5.9 t CO_2-eq./cap.;
- CO_2 emissions decreased from 5.8 to 4.0 t CO_2-eq./cap.;
- CH_4 emissions increased from 1.4 to 1.5 t CO_2-eq./cap.;
- N_2O emissions increased from 0.36 to 0.41 t CO_2-eq./cap..

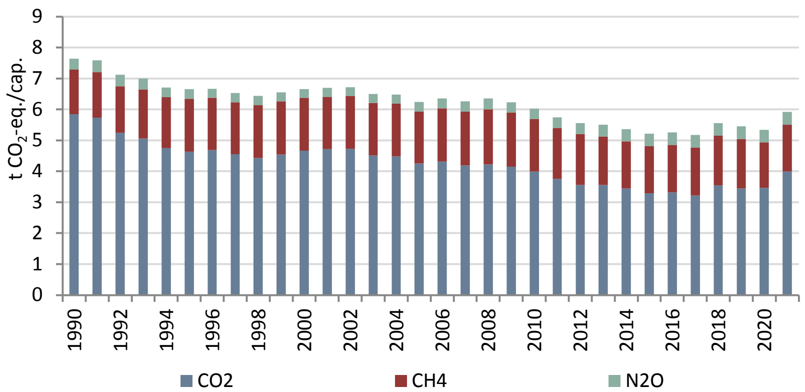

Figure 2.6 GHG trends per capita by individual GHGs

Decrease in specific greenhouse gas emissions per capita for the period 1990-2021 is explained by the outpacing population growth rates relative to the GHG emission growth rates.

The main measures taken in the country to curb the growth of GHG emissions are included in a number of strategic and program documents listed below:

- Strategy for the transition of the Republic of Uzbekistan to a green economy for the period 2019-2030;
- Concept of environmental protection until 2030;
- Biodiversity conservation strategy for the period of 2019-2028;

- Solid waste management strategy for the period 2019-2028;
- Concept Note for ensuring electricity supply in Uzbekistan in 2020-2030;
- Agriculture development strategy for 2020-2030;
- Water sector development concept of Uzbekistan for 2020-2030;
- Concept of forestry system development of the Republic of Uzbekistan until 2030.

2.6 Change in the contribution of GHG emissions of the Republic of Uzbekistan to Global Emissions

Over the period from 1990 to 2020, Uzbekistan's contribution to Global GHG emissions decreased from 0.5 to 0.4% (Fig. 2.7). This is due to outpacing growth rates of global emissions. The minimum contribution value was reached in 2015 and amounted to 0.35%, then due to the increasing rate of annual emission growth in the country, the contribution of Uzbekistan's GHG emissions to Global emissions increased to 0.4%.

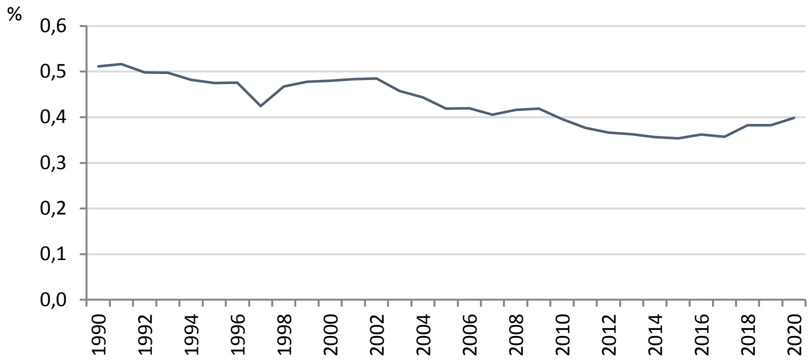

Figure 2.7 Change in the contribution of Uzbekistan's GHG emissions to Global emissions

2.7 Recalculation of total GHG emissions relative to the First Biennial Report estimates

This inventory recalculated emission estimates relative to previous estimates from the First Biennial Update Report (1990-2017). The basis for the recalculation was:

- results of the peer review of the inventory obtained as part of the First Biennial Report assessment;
- recommendations of international experts given in the final review of the voluntary inventory assessment conducted in January 2021 as technical assistance for developing countries from the UNFCCC Secretariat to ensure the quality of national GHG inventories;
- Inventory Improvement Plan (NIIP) prepared in 2023 with technical support from the UNFCCC Secretariat.

The recalculation was related to:

- planned activities included in the Inventory Improvement Plan (NIIP);
- refinement of emission factors in the Energy sector categories;
- refinement of the activity data in selected categories for the period 1990-2017;
- inclusion of new categories in the inventory.

The results of the recalculation are given in Tables 2.5. and 2.6.

Table 2.5 Results of recalculation of total GHG emissions relative to estimates from the First Biennial Update Report (excluding FOLU), $MtCO_2$-eq.

Year	FBUR	FNC	Difference	Year	FBUR	FNC	Difference	Year	FBUR	FNC	Difference	Year	FBUR	FNC	Difference
1990	177.40	156.44	20.96	1997	188.76	154.37	34.39	2004	207.34	167.34	40.00	2011	201.98	167.97	34.01
1991	181.49	158.76	22.73	1998	183.65	154.59	29.06	2005	204.92	162.92	42.00	2012	202.71	165.01	37.70
1992	175.95	152.51	23.44	1999	192.76	158.96	33.80	2006	213.20	167.94	45.26	2013	190.28	166.08	24.20
1993	205.70	153.18	52.52	2000	208.46	163.75	44.71	2007	215.04	167.84	47.20	2014	192.86	164.37	28.49
1994	188.41	149.82	38.59	2001	207.63	166.75	40.88	2008	227.01	173.13	53.88	2015	185.33	162.73	22.60
1995	192.48	151.35	41.13	2002	211.85	169.46	42.39	2009	207.29	172.51	34.78	2016	182.85	167.12	15.73
1996	197.90	154.54	43.36	2003	209.80	165.82	43.98	2010	200.07	171.61	28.46	2017	189.21	167.36	21.85

Table 2.6 Results of recalculation of total GHG emissions relative to the estimates from the First Biennial Update Report (including FOLU), $MtCO_2$-eq.

Year	FBUR	FNC	Difference	Year	FBUR	FNC	Difference	Year	FBUR	FNC	Difference	Year	FBUR	FNC	Difference
1990	163.33	141.05	22.28	1997	172.09	148.73	23.36	2004	213.95	165.51	48.44	2011	188.64	168.71	19.93
1991	168.97	144.81	24.16	1998	166.26	151.17	15.09	2005	208.20	165.86	42.34	2012	189.83	165.09	24.74
1992	163.13	138.22	24.91	1999	179.14	153.74	25.40	2006	210.70	171.19	39.51	2013	178.95	166.52	12.43
1993	192.23	139.21	53.02	2000	202.08	160.08	42.00	2007	206.91	171.39	35.52	2014	179.83	161.65	18.18
1994	172.95	136.75	36.20	2001	207.32	163.64	43.68	2008	213.12	176.89	36.23	2015	173.15	159.46	13.69
1995	175.45	139.66	35.79	2002	220.90	169.53	51.37	2009	193.95	175.69	18.26	2016	172.31	163.96	8.35
1996	183.82	148.58	35.24	2003	222.73	164.44	58.29	2010	187.12	174.05	13.07	2017	180.58	164.68	15.90

The updated total emission estimates are generally lower than the previous ones, mainly due to the refinement of GHG emission estimates in the Fugitive Emissions from Fuels category in the Energy Sector, as well as in other inventory sectors. The reasons for the differences in each of the recalculated categories are explained in the relevant sections of this report.

3. "ENERGY" SECTOR

3.1 Sector overview

The Energy sector occupies a special place in the country's economy. It is the largest consumer of fuel and energy and, accordingly, the main source of greenhouse gases.

The inventory covers the following in the sector:

- greenhouse gases: carbon dioxide, methane, nitrous oxide;
- other gases: carbon monoxide (II), nitrogen oxides, non-methane volatile organic compounds (NMVOCs), sulphur dioxide.

The Energy sector provides calculations of greenhouse gas emissions from activities covering extraction, processing, storage, distribution and use (combustion) of fossil fuels. In this sector, greenhouse gas emissions are divided into 2 main categories:

- Category 1A - Activities related to Fuel Combustion;
- Category 1B - Fugitive Emissions from Fuels.

Category 1A Activities related to Fuel Combustion includes the following subcategories:
1.A.1.a Energy and Heat Production;
1.A.2 Manufacturing Industries and Construction;
1.A.3 Transport;
1.A.4 Other sectors (Commercial, Residential, Agriculture).

Category 1B Fugitive Emissions from Fuels includes the subcategories:
1B.1a Coal Mining and Processing;
1B.2a Oil;
1B.2b Natural Gas.

3.1.1 Emission trends in the Energy sector by gas

Greenhouse gases. In 2021, the share of the Energy sector in total GHG emissions (not accounting for removals) was 65.6% (81% in 1990). The main contributors to sectoral emissions are carbon dioxide and methane. In the Energy sector, CO_2 emissions accounted for 83.1%; methane - 16.7% and nitrous oxide - 0.3%.

Figure 3.1.1.1 and Table 3.1.1.1 show the trends in GHG emissions in the Energy sector for the period 1990-2021.

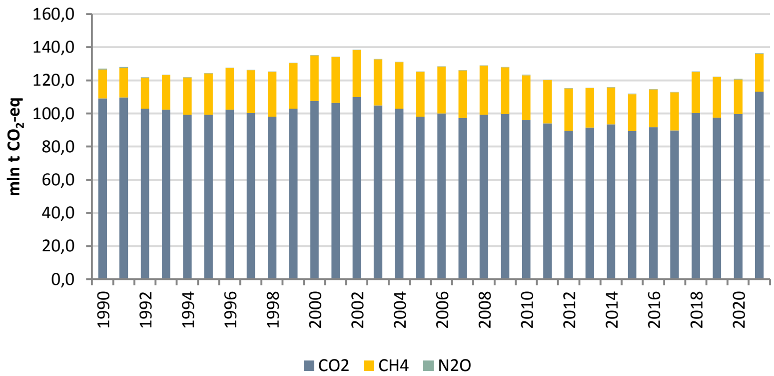

Figure 3.1.1.1 GHG emission trends in the Energy sector from 1990 to 2021

Over the period 1990-2021, total emissions from the Energy sector increased by 7.4%, including CO_2 emissions increased by 3.8%, CH_4 emissions - by 31%; N_2O emissions decreased by 31%.
The most significant sources of greenhouse gas emissions in the Energy sector are:

- for CO_2 – fuel combustion processes in energy production, manufacturing and in the Residential sector;
- for CH_4 – fugitive emissions from gas systems;
- for N_2O – fuel combustion processes in energy production and from motor vehicles.

Table 3.1.1.1 GHG emissions in the Energy sector in the period 1990-2021, Mt CO_2-eq.

Year	CO_2	CH_4	N_2O	Total	Year	CO_2	CH_4	N_2O	Total
1990	109.10	17.36	0.51	**126.97**	2007	97.36	28.61	0.22	**126.19**
1991	109.67	17.80	0.49	**127.97**	2008	99.24	29.40	0.23	**128.87**
1992	102.94	18.47	0.40	**121.81**	2009	99.57	28.24	0.23	**128.04**
1993	102.41	20.76	0.31	**123.48**	2010	96.01	27.09	0.22	**123.32**
1994	99.26	22.33	0.25	**121.84**	2011	94.02	26.05	0.22	**120.28**
1995	99.19	24.90	0.23	**124.31**	2012	89.46	25.56	0.23	**115.25**
1996	102.24	25.21	0.22	**127.67**	2013	91.44	23.80	0.26	**115.5**
1997	100.18	25.85	0.22	**126.25**	2014	93.34	22.29	0.26	**115.89**
1998	98.02	27.04	0.22	**125.27**	2015	89.29	22.40	0.27	**111.96**
1999	102.84	27.53	0.22	**130.59**	2016	91.71	22.71	0.27	**114.68**
2000	107.49	27.55	0.22	**135.27**	2017	89.67	23.09	0.28	**113.04**
2001	106.47	27.62	0.22	**134.31**	2018	100.18	24.84	0.31	**125.33**
2002	109.92	28.37	0.22	**138.52**	2019	97.44	24.52	0.31	**122.26**
2003	104.81	27.89	0.21	**132.91**	2020	99.60	20.92	0.31	**120.84**
2004	102.80	28.08	0.22	**131.10**	2021	113.22	22.75	0.35	**136.32**
2005	98.06	27.09	0.21	**125.36**	$\Delta_{(1990–2021)}$	**3.80%**	**31.00%**	**-31.00%**	**7.40%**
2006	100.01	28.23	0.23	**128.47**	%. $_{2021}$	**83.10%**	**16.70%**	**0.30%**	**100.00%**

Gases with indirect greenhouse effect. The Energy sector accounts for 99% of all CO, NOx and SO_2 emissions estimated in the current inventory and about 93% of NMVOCs emissions.

Trends in indirect greenhouse gas emissions for the period 1990-2021 in the Energy sector are given in Table 3.1.1.2 and Figure 3.1.1.2. CO emissions are associated with fuel combustion. Both fugitive emissions from fuels and emissions from fuel combustion contribute to NOx, NMVOCs and SO_2 emissions. There is a decreasing trend for all gases estimated, including: CO by 29%, NOx and NMVOCs by 3%, and SO_2 by 42%.

The decrease in the emission of gases with indirect greenhouse effect for 1990-2021 can be explained by the implementation of measures to reduce emissions of pollutants into the atmosphere. At the same time, some growth for 2018-2021 is associated with an increase in GHG emissions from fuel combustion.

Table 3.1.1.2 Indirect GHG emissions in the Energy sector in the period 1990-2021, Gg

Gas	CO	NOx	NMVOCs	SO_2	Gas	CO	NOx	NMVOCs	SO_2
1990	1896	410	837	134	2007	1004	250	290	42
1991	1730	390	747	126	2008	1040	264	298	54
1992	1354	344	586	106	2009	1026	259	292	58
1993	1184	317	486	92	2010	1032	250	277	69
1994	1049	292	440	84	2011	961	258	277	81
1995	898	282	425	73	2012	1019	270	312	85
1996	867	275	361	59	2013	938	276	335	89
1997	993	280	440	63	2014	944	290	326	89
1998	969	269	398	64	2015	946	298	313	94
1999	1052	276	397	62	2016	899	304	320	94
2000	1059	282	414	60	2017	993	315	336	104
2001	1091	280	379	58	2018	1154	345	499	104
2002	1018	280	374	50	2019	990	342	475	104
2003	905	262	340	43	2020	1266	351	518	103
2004	920	263	335	39	2021	1347	397	594	104
2005	936	251	296	35	$\Delta_{(1990-2021)}$	**-29%**	**-3%**	**-3%**	**-42%**
2006	979	258	322	37					

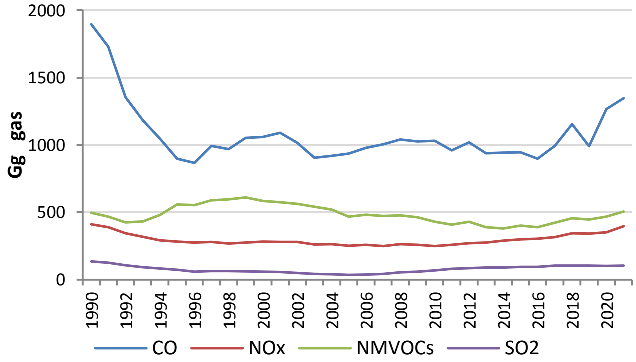

Figure 3.1.1.2 Trends in indirect GHG emissions in the Energy sector

3.1.2 Emission trends in the Energy sector by main categories

The Energy sector consists of two main categories: Fuel Combustion Activities and Fugitive Emissions from Fuels. There has been a significant change in the contribution of these categories to sectoral emissions between 1990 and 2021. The contribution of Fuel Combustion Activities category increased from 65% to 83.1%, while the contribution of the Fugitive Emissions from Fuels category decreased from 35% to 16.9%.

Figure 3.1.2.1 and Table 3.1.2.1 show the distribution of GHG emissions (including CO_2, CH_4, and N_2O emissions) in the Energy sector for the two main categories –Fuel Combustion Activities and Fugitive Emissions from Fuels (Leaks) for 1990- 2021.

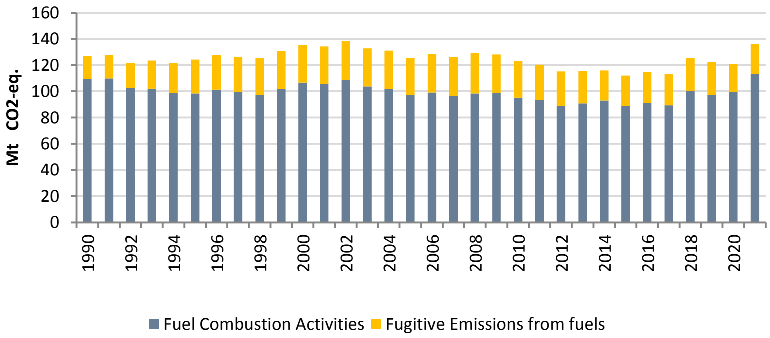

Figure 3.1.2.1 Change in the contribution of fugitive GHG emissions and fuel combustion to sectoral emissions

Table 3.1.2.1 GHG emissions in the Energy sector by main categories, Mt CO_2-eq.

Category	Fuel Combustion	Fugitive Emissions	Total	Category	Fuel combustion	Fugitive emissions	Total
1990	109.3	17.7	**127.0**	2007	96.5	29.7	**126.2**
1991	109.8	18.2	**128.0**	2008	98.4	30.6	**129**
1992	102.9	19.0	**121.8**	2009	98.8	29.3	**128**
1993	102.1	21.4	**123.5**	2010	95.3	28.1	**123.3**
1994	98.7	23.1	**121.8**	2011	93.4	26.9	**120.3**
1995	98.3	26.0	**124.3**	2012	88.8	26.4	**115.3**
1996	101.3	26.3	**127.7**	2013	90.9	24.6	**115.5**
1997	99.3	27.0	**126.2**	2014	92.9	23	**115.9**
1998	97.1	28.2	**125.3**	2015	88.9	23.1	**112**
1999	101.9	28.7	**130.6**	2016	91.3	23.3	**114.7**
2000	106.6	28.7	**135.3**	2017	89.4	23.7	**113**
2001	105.5	28.8	**134.3**	2018	100	25.3	**125.3**
2002	109.0	29.6	**138.5**	2019	97.3	24.9	**122.3**
2003	103.8	29.1	**132.9**	2020	99.6	21.3	**120.8**
2004	101.8	29.3	**131.1**	2021	113.3	23	**136.3**
2005	97.1	28.2	**125.4**	$\Delta_{(1990-2017)}$	**3.7%**	**29.9%**	**7.4%**
2006	99.1	29.3	**128.5**	**%.** $_{2021}$	**83.1%**	**16.9%**	**100.0%**

In 2021, GHG emissions for main categories of the Energy sector amounted to:

- 1A - Fuel Combustion Activities – 113.3 Mt CO_2-eq;
- 1B - Fugitive Emissions from Fuels - 23.0 Mt CO_2-eq.

As can be seen from Table 3.3, increase in GHG emissions in the Energy sector for the period 1990 and 2021, including a 3.7% increase in emissions from fuel combustion and a 29.9% increase in emissions from GHG leaks.

3.1.3 Recalculations for the Energy sector

In this inventory, recalculations for all Energy sector categories have been made due to moving to default factors in accordance with the 2006 IPCC Guidelines for all subcategories included in the Energy sector, as well as the refinement of activity data for the entire period.
Previously, in the First Biennial Update Report (FBUR, 2021), categories 1.A Fuel Combustion Activities and 1.B Fugitive Emissions from Fuels used national emission factors that had not been formally adopted. In this regard, during the independent voluntary assessment of the national GHG emissions inventory (2022), the international expert commission recommended to move to IPCC default factors and continue national research to refine and validate national factors for all categories of the Energy sector.
Research to establish values of national emission factors is included in the Inventory Improvement Plan.

Table 3.1.3.1 shows the differences in GHG emission estimates in the Energy sector obtained in the FBUR and in the current inventory.

Table 3.1.3.1 Recalculation of GHG emissions for the Energy sector for the period 1990-2017, Mt CO_2-eq.

Year	FNC	FBUR	Difference	Year	FNC	FBUR	Difference
1990	127.0	167.2	-40.2	2004	131.1	199.4	-68.3
1991	128.0	169.6	-41.6	2005	125.4	175.8	-50.4
1992	121.8	163.1	-41.3	2006	128.5	184.4	-55.9
1993	123.5	198	-74.5	2007	126.2	192.5	-66.3
1994	121.8	178.9	-57.1	2008	129.0	203.9	-74.9
1995	124.3	183.2	-58.9	2009	128.0	179.7	-51.7
1996	127.7	186.0	-58.3	2010	123.3	162	-38.7
1997	126.2	178.1	-51.9	2011	120.3	140.6	-20.3
1998	125.3	171.6	-46.3	2012	115.3	139.2	-23.9
1999	130.6	182.3	-51.7	2013	115.5	150.3	-34.8
2000	135.3	200.5	-65.2	2014	115.9	207.3	-91.4
2001	134.3	203.0	-68.7	2015	112	204.2	-92.2
2002	138.5	207.3	-68.8	2016	114.7	199.4	-84.7
2003	132.9	204.2	-71.3	2017	113.0	175.8	-62.8

Table 3.1.3.2 shows the differences in GHG emission estimates for the main categories of the Energy sector obtained in the FBUR and the current inventory (FNC). The largest difference in emission estimates was obtained for the Fugitive Emissions from Fuels category due to the use of default emission factors instead of national factors, as well as to the refinement of activity data.

Table 3.1.3.2 Recalculation of GHG emissions for main categories of the Energy sector for the period 1990-2017, Mt CO_2-eq.

Years	Fuel Combustion Activities			Fugitive emissions from fuels			Years	Fuel Combustion Activities			Fugitive emissions from fuels		
	FNC	FBUR	Difference	FNC	FBUR	Difference		FNC	FUR	Difference	FNC	FBUR	Difference
1990	109.3	108.4	0.9	17.7	58.7	-41	2004	101.8	101.1	0.6	29.3	98.4	-69.1
1991	109.8	108.3	1.5	18.2	61.4	-43.2	2005	97.1	96.5	0.2	28.2	79.4	-51.2
1992	102.9	101.3	1.6	19	61.8	-42.8	2006	99.1	99.5	0.6	29.3	84.8	-55.5
1993	102.1	102.3	-0.2	21.4	95.8	-74.4	2007	96.5	98.9	0.6	29.7	93.5	-63.8
1994	98.7	97.7	1.0	23.1	81.2	-58.1	2008	98.4	108.5	0.8	30.6	95.4	-64.8
1995	98.3	98.0	0.3	26	85.1	-59.1	2009	98.8	102.7	0.7	29.3	77.0	-47.7

Table 3.1.3.2 continuation

Years	Fuel Combustion Activities			Fugitive emissions from fuels			Years	Fuel Combustion Activities			Fugitive emissions from fuels		
	FNC	FBUR	Difference	FNC	FBUR	Difference		FNC	FUR	Difference	FNC	FBUR	Difference
1996	101.3	100.9	0.4	26.3	85.1	-58.8	2010	95.3	95.7	-0.3	28.1	66.2	-38.1
1997	99.3	99.2	0.1	27	78.8	-51.8	2011	93.4	99.1	-0.3	26.9	41.3	-14.4
1998	97.1	97.0	0.1	28.2	74.6	-46.4	2012	88.8	98.9	-1.0	26.4	40.2	-13.8
1999	101.9	101.4	0.5	28.7	80.8	-52.1	2013	90.9	90.3	-1.0	24.6	59.9	-35.3
2000	106.6	105.9	0.7	28.7	94.6	-65.9	2014	92.9	93.1	-0.2	23	58.2	-35.2
2001	105.5	105.1	0.4	28.8	97.8	-69	2015	88.9	89.5	-0.6	23.1	52.7	-29.6
2002	109.0	108.2	0.7	29.6	99.1	-69.5	2016	91.3	94.4	-3.1	23.3	49.8	-26.5
2003	103.8	103.5	0.4	29.1	100.7	-71.6	2017	89.4	95.0	-5.6	23.7	49.4	-25.7

3.2 Fuel Combustion Activities (1.A category)

Category overview

In category 1.A Fuel Combustion Activities, emissions of CO_2, CH_4, N_2O, CO, NOx, NMVOCs, and SO_2 were estimated.

Emissions were estimated for the following subcategories:

- 1.A.1.a Electricity and Heat Production;
- 1.A.2 Manufacturing Industries and Construction;
- 1.A.3 Transport (by mode of transport);
- 1.A.4.a Commercial/Institutional sector;
- 1.A.4.b Residential sector;
- 1.A.4.c Agriculture (i и ii).

CO_2 emissions from fuel combustion were also estimated using the Reference Approach, and the Reference and Sectoral approach for estimating CO_2 emissions from fuel combustion were compared (further Section 3.2.1).

Electricity and heat production. The Electricity and Heat Production category accounts for 42.1% (2021) of total GHG emissions from fuel combustion. This category includes GHG emissions from both electricity and heat production.

Energy management in Uzbekistan is entrusted to the Ministry of Energy. In 2019, there was a restructuring in the energy management. The purpose of the reorganization is the transition to modern methods of organization of production, transportation, distribution and sales of electricity while maintaining centralized management. The Ministry of Energy includes three joint stock companies: Thermal Power Plants, National Electric Networks of Uzbekistan and Regional Electric Networks [3].

In 2021, the thermal power plants of Thermal Power Plants JSC generated 56.3 billion kW of electricity, supplied 7.5 million Gcal of thermal energy, and the total installed capacity of power plants in Uzbekistan is more than 14 thousand MW.

Thermal Power Plants JSC is the main producer and supplier of electricity in the country. Thermal Power Plants JSC includes 7 thermal power plants (TPPs) and 3 cogeneration power plants. The share of departmental power plants in the structure of generating capacities is about 3.8%.

In the structure of primary energy resources used at TPPs to produce electricity and heat, gas fuel accounts for 75.8%, fuel oil - 3.2%, coal - 21.1% [4].

Manufacturing Industries and Construction. This category accounts for 11.25% of total greenhouse gas emissions from fuel combustion. In this category, greenhouse gas emissions from fuel use in industry were considered. The main energy-intensive industries in Uzbekistan are:

- Mining Industry;
- Ferrous and Non-Ferrous Metallurgy;
- Construction Materials Industry (production of cement, lime, glass);

3 PD-5646 dated 01.02.2019 «On measures to radically improve the management system of the fuel and energy industry of the Republic of Uzbekistan»

4 Official website of the Ministry of Energy of the Republic of Uzbekistan http:/minenergy.uz

- Chemical Industry;
- Processing Industry, etc.

Greenhouse gases are produced as a result of fuel combustion in technological processes to produce high-temperature heat.

Transport. Uzbekistan has a developed transport complex, which includes road, rail, air and pipeline modes of transport. Transport accounts for 15.03% of the total GHG emissions in the Activities related to Fuel Combustion category. The functioning of the transport complex is accompanied by emissions of CO_2, CO, CH_4, N_2O, NOx and NMVOCs.

Road and pipeline transport (gas pipeline maintenance) are the largest emitters in the category.

Pipeline transport is included in the Activities related to Fuel Combustion category, since during pumping at gas compressor stations natural gas is burned as fuel and carbon dioxide is emitted into the atmosphere. Leaks of natural gas during its transportation through pipelines are accounted for under Fugitive Emissions from Fuels section. The total length of main gas pipelines in Uzbekistan is 13.9 thousand kilometers.

According to the Statistics Agency, the total length of the republic's road network at the beginning of 2022 was 42,869 km. The length of public railroads was 4.7 thousand km, of which electrified sections accounted for 40.8%. Uzbekistan Airways JSC National Air Company provides international air transportation to dozens of countries around the world, and also operates domestic airlines. Today, the fleet of Uzbekistan Airways JSC consists of modern Boeing-757/767, Boeing-787-8 Dreamliner, Airbus A320 aircraft, as well as Boeing-767-300BCF cargo aircraft. The fleet of Uzbekistan Airways JSC consists of 29 Western-made aircraft.

In order to reduce GHG emissions from transport, since 2007, as part of the Environment Action Programs, the state has been taking measures to renew the fleet of cars, railway locomotives, aircraft, improve the quality of motor fuel, use alternative fuels (liquefied petroleum and compressed natural gas), convert certain sections of the railway to electric traction [5]. По данным According to the Ministry of Ecology, Environmental Protection and Climate Change, over 181.3 thousand vehicles were converted to gas fuel by enterprises, organizations and individuals in the period from 2013-2021. In 2017 alone, more than 35 thousand vehicles were converted to gas fuel in the country. The railroad line on the Karshi - Termez section was electrified. The programs for the construction and reconstruction of public roads of international and national importance implemented in the country also make a certain contribution to the reduction of GHG emissions [6].

Residential and Commercial Sector. The Residential and Commercial sectors account for 23.3% and 7.6% of emissions from fuel combustion, respectively. Due to the deterioration of a significant part of the building stock, engineering communications, poor thermal insulation and a number of other problems, energy consumption in buildings is 2-2.5 times higher than in developed countries.

Low energy efficiency and energy saving indicators in the residential sector are associated with the use of a significant share of non-energy-efficient home appliances, certain shortcomings in the system of accounting and consumption of energy resources [7].

Agriculture. Agriculture accounts for 0.7% of GHG emissions from fuel combustion in the Energy sector. At the same time, according to expert estimates, stationary fuel combustion accounts for 95% of total fuel consumption in this category. Stationary sources of GHG emissions include greenhouses, irrigation pumps, grain drying, livestock keeping and other types of agricultural activities. Mobile sources include specialized agricultural machinery (tractors, etc.).

Emissions from biomass combustion. In this category, carbon dioxide emissions from solid biomass combustion were estimated. Emissions from biomass combustion are not included in the total GHG emissions and are provided for information. The main source of emissions in this category is the use of firewood (fuelwood) by the population. Since there are no national statistics on fuelwood consumption by the population, expert estimates were used for calculations. Another component of emissions in this category - stubble burning - is included in the calculations

5 RCM No.142 dated May 27, 2013 "On approval of the Environment Action programme"

6 Resolution of the Cabinet of Ministers of the Republic of Uzbekistan RCM No.142 dated 27.05.2013 "On approval of the Environment Action Program for 2013-2017".

7 D. Abdusalamov. National report on the Republic of Uzbekistan/UNECE Project "Scaling up the synergetic effect of the CIS member-states` national programs on energy efficiency and energy saving for energy security". Tashkent, Uzbekenergo SJSC, 2013. - 54 p.

only for the period 1990-2004, since the burning of grain stubble has been legally prohibited in the country since 2005. According to the estimated data, in 2021, CO_2 emissions in this category amounted to 19.37 Gg.

International bunker. Total GHG emissions do not include CO_2 emissions from the international bunker. In Uzbekistan, there is only an international aviation bunker. In 2021, GHG emissions from the international aviation bunker amounted to 321.82 Gg CO_2-eq.

3.2.1 Comparison of Reference and Sectoral approaches to assess CO_2 emissions from Fuel Combustion

In accordance with the IPCC Guidelines (2006), the reference and sectoral approaches were used to estimate CO_2 emissions from fuel combustion activities as a cross-check of total CO_2 emissions from fuel combustion.

The Reference Approach is a calculation of emissions based on the total consumption of primary and secondary fuels in the country. Calculations were conducted according to the IPCC 2006 [8], Tier 1 methodology in accordance with Equation 6.1, using the values of the net calorific value of fuels and their carbon content similar to those used in sectoral approach calculations.

Fuel balance data provided by the Agency of Statistics of the Republic of Uzbekistan (confidential data) were used in calculations. Apparent consumption was calculated as the sum of data on primary fuel production and fuel imports less fuel exports, bunker fuels (estimated data) and stock changes.

In calculations according to the reference approach, non-energy natural gas consumption (as a raw material in the chemical industry, for the cycling process in the oil and gas industry) was deducted from the values of natural gas production. The use of oil bitumen is also not accompanied by CO_2 emissions.

The sectoral approach involves calculation of emissions using information on the final consumption of fuels in economic sectors, based on fuel balance data (Section 3.2.6 of this chapter).

The results of estimation of CO_2 emissions from fuel combustion obtained based on reference and sectoral approaches are given in Table 3.2.1.1.

In 2021, the CO_2 emission estimates were as follows:

- according to the reference approach amounted to 123,774 Gg,
- according to the sectoral approach – 113,327 Gg.

Table 3.2.1.1 CO_2 emissions from activities related to fuel combustion, calculated by the Reference and Sectoral Approach, Gg CO_2

Years	Reference Approach	Sectoral Approach	Difference, %	Years	Reference Approach	Sectoral Approach	Difference, %
1990	112715	108214	4.0	2006	115533	98676	14.6
1991	113302	108753	4.0	2007	115860	96050	17.1
1992	106455	102009	4.2	2008	118768	97907	17.6
1993	105863	101417	4.2	2009	112294	98289	12.5
1994	102709	98161	4.4	2010	114951	94789	17.5
1995	102839	97890	4.8	2011	116549	92834	20.3
1996	105296	100938	4.1	2012	106925	88249	17.5
1997	106536	98867	7.2	2013	107165	90254	15.8
1998	111000	96678	12.9	2014	103838	92212	11.2
1999	116504	101491	12.9	2015	100578	88184	12.3
2000	121081	106142	12.3	2016	102651	90647	11.7
2001	120335	105098	12.7	2017	99967	88617	11.4
2002	124989	108540	13.2	2018	110017	99162	9.9
2003	119080	103425	13.1	2019	113262	96478	14.8
2004	117657	101444	13.8	2020	114887	98733	14.1
2005	112897	96762	14.3	2021	123774	112341	9.2

The difference between the annual emission volumes in 2021, calculated using different approaches, amounted to 9.2%.

8 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 2

The most significant differences between the Reference and Sectoral approaches in calculating CO_2 emissions were observed in the period after 1997. The maximum deviation in the calculated values was obtained for 2011. Differences in the obtained estimates of CO_2 emissions are mainly associated with the quality of data on the non-energy use of gaseous fuels.

Differences in CO_2 emission calculations in the Reference and Sectoral approaches by primary fuel types are given in Table 3.2.1.2. The greatest differences in CO_2 emission estimates are observed for natural gas. This is due to insufficient accuracy of data on non-energy fuel use, as well as technical losses.

Table 3.2.1.2 CO_2 emissions from primary fuels calculated based on Reference and Sectoral approaches

Year	Reference approach			Sectoral approach			Difference		
	Mt CO_2			Mt CO_2			%		
	Oil	Coal	Natural Gas	Oil	Coal	Natural Gas	Oil	Coal	Natural Gas
1990	34.22	16.64	61.86	32.43	16.71	59.08	1.80	-0.07	2.78
1991	29.84	16.10	67.36	27.97	16.19	64.59	1.87	-0.09	2.78
1992	24.23	12.92	69.30	22.08	12.92	67.02	2.16	0.01	2.28
1993	21.29	7.75	76.83	19.90	7.80	73.71	1.38	-0.05	3.12
1994	19.99	6.32	76.40	18.35	6.38	73.43	1.63	-0.06	2.97
1995	20.10	5.57	77.17	18.09	5.60	74.20	2.01	-0.04	2.97
1996	18.94	6.23	80.12	17.85	6.30	76.79	1.09	-0.07	3.33
1997	19.98	5.13	81.43	18.65	5.20	75.01	1.33	-0.08	6.42
1998	18.88	4.97	87.16	16.88	4.67	75.13	2.00	0.30	12.02
1999	20.38	4.79	91.34	18.65	4.87	77.97	1.73	-0.09	13.37
2000	20.59	5.76	94.73	19.32	5.86	80.96	1.28	-0.11	13.77
2001	18.77	4.83	96.73	17.29	4.92	82.89	1.48	-0.08	13.84
2002	18.59	5.11	101.29	17.58	5.18	85.78	1.00	-0.07	15.52
2003	17.55	3.94	97.59	16.28	4.01	83.14	1.27	-0.07	14.46
2004	16.83	5.24	95.58	15.32	5.24	80.88	1.52	-0.01	14.70
2005	15.12	4.59	93.19	13.56	4.48	78.72	1.56	0.11	14.47
2006	16.55	5.87	93.12	14.61	5.71	78.36	1.93	0.16	14.76
2007	14.63	7.13	94.10	13.10	4.82	78.13	1.53	2.30	15.97
2008	15.41	7.00	96.35	13.23	6.03	78.65	2.19	0.97	17.70
2009	14.25	7.53	90.51	13.15	5.78	79.36	1.10	1.75	11.15
2010	12.91	8.37	93.67	11.86	4.80	78.13	1.05	3.57	15.54
2011	11.73	8.77	96.05	9.61	5.08	78.15	2.12	3.69	17.90
2012	10.70	6.98	89.24	9.62	6.63	71.99	1.08	0.35	17.25
2013	11.09	10.49	85.59	9.84	10.49	69.93	1.25	0.00	15.66
2014	10.21	9.76	83.86	8.97	9.76	73.48	1.25	0.00	10.38
2015	10.67	7.85	82.05	9.85	8.01	70.33	0.83	-0.15	11.72
2016	10.80	9.34	82.52	9.87	9.54	71.24	0.92	-0.20	11.28
2017	11.43	8.79	79.75	9.66	8.99	69.96	1.76	-0.20	9.79
2018	11.58	12.77	85.66	10.30	12.68	76.19	1.28	0.10	9.47
2019	13.72	10.96	88.58	9.41	11.38	75.69	4.32	-0.42	12.89
2020	14.61	15.23	85.05	10.61	11.86	76.26	4.00	3.37	8.79
2021	13.53	13.55	96.69	11.47	13.30	87.57	2.06	0.25	9.12

Table 3.2.1.3 shows the emission factors used in the calculations using the Reference Approach.

Table 3.2.1.3 Factors applied to calculate CO_2 emissions using the Reference Approach

Fuel	Net calorific value, TJ/thousand tons (mln cubic meters)	Carbon content factor, t C/TJ	Source
Gasoline	44.3	18.9	IPCC 2006, Table 1.3
Aviation kerosene	44.1	19.5	
Other kerosene	43.8	19.6	
Diesel fuel	43.0	20.2	
Heating oil	40.15	21.1	
Domestic heating oil	42.49*	20.2	
Liquefied petroleum gas	47.3	17.2	
Subbituminous (Brown) coal	18.9	26.2	
Bituminous coal	25.8	25.8	
Coal briquettes	20.7	26.6	
Natural gas	33.99*	15.3	
Biomass	15.6	30.5	

Note: * - national approved characteristics (Resolution of the State Committee on Statistics No. 11 dated April 4, 2020)

3.2.2 International Aviation Bunker

In Uzbekistan, there is only International Aviation Bunker. GHG emissions from International Aviation Bunker are not included in the national inventory and are provided for information purposes only.

Emissions in this category are entirely determined by aviation kerosene consumption. Emissions were calculated using IPCC default factors for aviation kerosene (Table 3.2.3).

Activity data was provided by Uzbekistan Airways JSC and the Statistics Agency. The data is confidential and is therefore not included in the report.

Due to the lack of separate statistical data on the consumption of aviation kerosene for international flights, the assumption of experts from Uzbekistan Airways JSC was used that in the 1990s, international aviation bunker accounted for about 95% of the total volume of aviation kerosene used (5% - domestic aviation), and by 2017 this ratio in aviation kerosene consumption amounted to 88% and 12%, respectively, and remained at this level until 2021. In the calculations for the period 1990-2021, the distribution of aviation kerosene consumption between international and domestic aviation was determined using interpolation method.

In 2021, GHG emissions from international aviation bunker totaled 321.82 Gg CO_2-eq.

Table 3.2.2.1 and Figure 3.2.2.2.1 show GHG emissions from the International Aviation Bunker for the period 1990-2021.

Table 3.2.2.1 GHG emissions from International Aviation Bunker, Gg CO_2-eq.

Years	CO_2	CH_4	N_2O	Total	Year	CO_2	CH_4	N_2O	Total
1990	2064.02	0.36	17.20	**2081.58**	2007	710.93	0.12	5.93	**716.98**
1991	1278.13	0.22	10.65	**1289.01**	2008	837.13	0.15	6.98	**844.25**
1992	823.92	0.14	6.87	**830.93**	2009	843.16	0.15	7.03	**850.33**
1993	790.12	0.14	6.59	**796.84**	2010	913.87	0.16	7.62	**921.65**
1994	705.61	0.12	5.88	**711.62**	2011	755.27	0.13	6.30	**761.70**
1995	659.13	0.12	5.50	**664.74**	2012	685.96	0.12	5.72	**691.8**
1996	648.57	0.11	5.41	**654.09**	2013	653.46	0.11	5.45	**659.02**
1997	580.97	0.10	4.84	**585.91**	2014	443.41	0.08	3.7	**447.18**
1998	716.17	0.13	5.97	**722.27**	2015	433.97	0.08	3.62	**437.67**
1999	758.43	0.13	6.32	**764.88**	2016	503.62	0.09	4.2	**507.91**
2000	835.88	0.15	6.97	**843.00**	2017	402.34	0.07	3.35	**405.76**
2001	796.80	0.14	6.64	**803.58**	2018	531.65	0.09	4.43	**536.17**
2002	895.04	0.16	7.46	**902.66**	2019	446.06	0.08	3.72	**449.85**
2003	784.91	0.14	6.54	**791.59**	2020	353.02	0.06	2.94	**356.02**
2004	789.30	0.14	6.58	**796.01**	2021	319.1	0.06	2.66	**321.82**
2005	742.88	0.13	6.19	**749.20**	Δ (1990-2021)	**-84.5%**	**-84.5%**	**-84.5%**	**-84.5%**
2006	830.86	0.15	6.93	**837.93**	%. 2021	**99.2%**	**0.02%**	**0.8%**	**100.0%**

Between 1990 and 2021, there was an 84.5% decrease in GHG emissions from international aviation bunker.

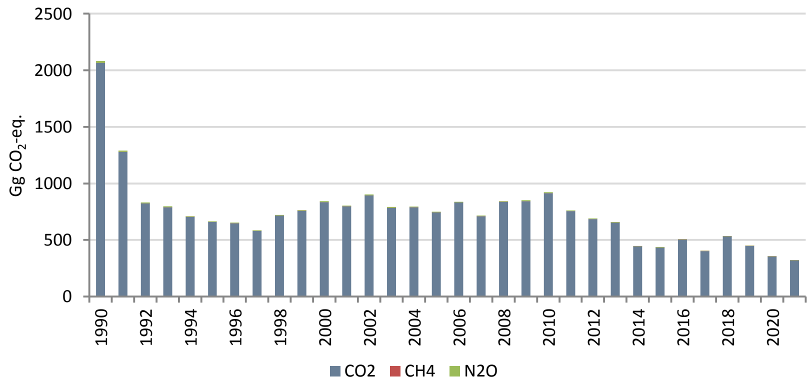

Figure 3.2.2.1 Trends in GHG emissions from International Aviation Bunker

Table 3.2.2.2.2 shows the indirect greenhouse gas emissions from International Aviation Bunker, calculated using default emission factors in accordance with the 1996 IPCC Guidelines [9].

Table 3.2.2.2 Emissions of gases with indirect greenhouse effect from International Aviation Bunker, Gg

Years	NOx	CO	NMVOCs	SO_2	Years	NOx	CO	NMVOCs	SO_2
1990	11.9	4.0	2.0	2.0	2017	2.5	0.5	0.2	0.2
1995	3.8	1.3	0.6	0.6	2018	3.2	1.1	0.5	0.5
2000	4.7	1.6	0.8	0.7	2019	1.9	0.6	0.3	0.3
2005	3.7	1.2	0.6	0.6	2020	1.5	0.5	0.3	0.2
2010	4.1	1.4	0.7	0.6	2021	1.3	0.5	0.2	0.2
2015	1.8	0.6	0.3	0.3	Δ (1990-2021)	**-89.1%**	**-87.5%**	**-90.0%**	**-90.0%**
2016	2,1	0,7	0,3	0,3					

For the period 1990-2021, there was a decrease in indirect GHG emissions from International Aviation Bunker: NOx by 89%; CO by 88%, NMVOCs and SO_2 by 90%, which is due to a decrease in consumption of aviation kerosene.

3.2.3 CO_2 Emissions from Biomass Combustion

In the CO_2 Emissions from Biomass Combustion category, carbon dioxide emissions from the combustion of solid biomass are estimated. Emissions from biomass combustion are not included in total GHG emissions and are provided in this report for information.

The main source of emissions in this category is the use of firewood (fuelwood) by the population. Data for the period 1990-2021 on the amount of fuelwood is provided by the Forestry Agency.

Another component of emissions in this category - stubble burning - is included in the calculations only for the period 1990-2004, since the burning of grain stubble has been legally prohibited in the country since 2005 [10,11].

There is insufficient data to estimate emissions from burning manure and biofuels, which are part of this category. Default emission factors for biomass from the 2006 IPCC Guidelines were used in the calculations:

- **Fuel conversion factor** from natural to energy values (calorific value) - **15.6 TJ/** thousand tons;
- **Carbon emission factor -30.5 tC/TJ,** Table 1.4, p.1.26, Solid Biomass.
- **Fraction of oxidized carbon – 1,** Table 1.4, page 1.26.

9 Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Greenhouse Gas Inventories Workbook, Part 2
10 Resolution of the President of the Republic of Uzbekistan No. PP-76 dated May 16, 2005 “On organizational measures for the harvesting of cereal crops”
11 Resolution of the President of the Republic of Uzbekistan No. PP-865 dated May 13, 2008 “On measures to organize plowing of lands freed from the sowing of cereal crops”

Table 3.2.3.1 CO_2 emissions from biomass combustion, Gg

Years	CO_2	Years	CO_2	Years	CO_2
1990	9990.57	2001	3880.85	2012	23.73
1991	11108.12	2002	4462.74	2013	24.74
1992	11175.48	2003	4934.57	2014	24.95
1993	11392.28	2004	5151.73	2015	24.69
1994	11799.26	2005	72.89	2016	21.77
1995	22327.87	2006	72.89	2017	22.70
1996	22790.96	2007	33.51	2018	25.87
1997	33066.97	2008	28.37	2019	19.87
1998	33273.10	2009	28.66	2020	19.19
1999	33385.20	2010	29.20	2021	19.37
2000	3435.83	2011	24.23	Δ (1990-2021)	**51.1-fold decrease**

Table 3.2.3.1 shows the results of estimates of CO_2 emissions from biomass combustion for 1990-2021.

According to the estimated data in 2021, CO_2 emissions in this category amounted to 19.37 Gg.

A significant decrease in CO_2 emissions from biomass combustion after 2004 is associated with a ban on burning of grain stubble.

It is planned to further refine the estimates of CO_2 emissions from this category and collect data on the use of biomass for energy purposes.

3.2.4 Sectoral Approach

Emission trends for GHG and other gases in category 1.A Fuel Combustion Activities

The section provides estimates of emissions of greenhouse gases (CO_2, CH_4 and N_2O) and gases with indirect greenhouse effect (CO, NOx, SO_2 and NMVOCs), which accompany fuel combustion processes.

Greenhouse gases. Direct greenhouse gas emissions from fuel combustion in category 1.A Activities related to Fuel Combustion are given in Table 3.2.4.1 and Figure 3.2.4.1.

Table 3.2.4.1 Greenhouse gas emissions from Fuel Combustion Activities, Gg CO_2-eq.

Years	CO_2	CH_4	N_2O	Total	Years	CO_2	CH_4	N_2O	Total
1990	108214	549	510	**109273**	2007	96050	227	218	**96495**
1991	108753	543	492	**109787**	2008	97907	244	227	**98378**
1992	102009	451	397	**102857**	2009	98289	245	227	**98762**
1993	101417	337	309	**102063**	2010	94789	261	217	**95267**
1994	98161	284	253	**98697**	2011	92834	315	217	**93365**
1995	97890	189	224	**98303**	2012	88249	336	233	**88818**
1996	100938	186	219	**101343**	2013	90254	375	257	**90886**
1997	98867	185	217	**99269**	2014	92212	403	257	**92872**
1998	96678	179	214	**97071**	2015	88184	407	266	**88857**
1999	101491	192	216	**101899**	2016	90647	424	269	**91340**
2000	106142	194	221	**106557**	2017	88617	461	276	**89354**
2001	105098	193	217	**105508**	2018	99162	574	310	**100046**
2002	108540	191	220	**108951**	2019	96478	536	305	**97319**
2003	103425	184	209	**103818**	2020	98733	531	313	**99576**
2004	101444	177	213	**101834**	2021	112341	635	351	**113327**
2005	96762	178	207	**97147**	Δ(1990-2021)	**+3,8%**	**+15,6%**	**-31,2%**	**+3,7%**
2006	98676	225	224	**99125**	%, 2021	**99,1%**	**0,6%**	**0,3%**	**100,0%**

In total GHG emissions from fuel combustion, carbon dioxide emissions account for 99.1%, methane - 0.6%, and nitrous oxide - 0.3%.

For the period 1990-2021, there was 3.7% increase in total direct GHG emissions from fuel combustion, while CO_2 emissions also increased by 3.8%, CH_4 emissions by 15.6%, and N_2O emissions by 31.2%. The downward trend in N_2O emissions is associated with an increase in the share of gaseous fuel consumption in all sectors of the economy.

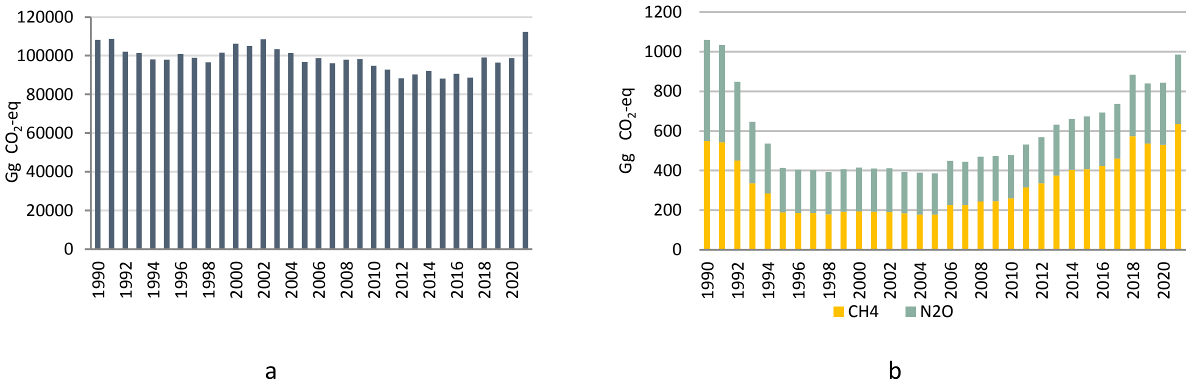

Figure 3.2.4.1 Trends in GHG emissions from Fuel Combustion Activities: (a) CO_2; (b) CH_4; N_2O

Gases with indirect greenhouse effect. Indirect greenhouse gas emissions from fuel combustion in all categories, obtained by calculation in accordance with the 1996 IPCC Guidelines.

Table 3.2.4.2 and Figure 3.2.4.2 shows that there is a decrease in indirect GHG emissions from fuel combustion for the period 1990-2021, including: CO - by 29%, NOx - by 3%, NMVOCs - by 4%, SO_2 - by 72%.

The decrease in indirect GHG emissions from fuel combustion relative to the 1990 level is due to the increase in the share of natural gas in the structure of fuel consumed.

Table 3.2.4.2 Indirect greenhouse gas emissions from Fuel Combustion Activities, Gg

Years	CO	NO_x	NMVOCs	SO_2	Years	CO	NO_x	NMVOCs	SO_2
1990	1896	410	337	0,5	2007	1004	250	181	108
1991	1730	390	306	0,4	2008	1040	264	187	111
1992	1354	344	243	0,3	2009	1026	259	187	106
1993	1184	317	215	0,3	2010	1032	250	191	86
1994	1049	292	192	0,2	2011	961	258	186	91
1995	898	282	168	257	2012	1019	270	205	107
1996	867	275	162	270	2013	938	276	197	138
1997	993	280	183	257	2014	944	290	206	120
1998	969	269	178	220	2015	946	298	215	98
1999	1052	276	192	205	2016	899	304	209	111
2000	1059	282	191	223	2017	993	315	233	103
2001	1091	280	197	182	2018	1154	345	265	234
2002	1018	280	183	191	2019	990	342	251	224
2003	905	262	164	176	2020	1266	351	292	226
2004	920	263	166	169	2021	1347	397	322	272
2005	936	251	169	132	$\Delta_{(1990-2021)}$	-29%	-3%	-4%	-72%
2006	979	258	178	144					

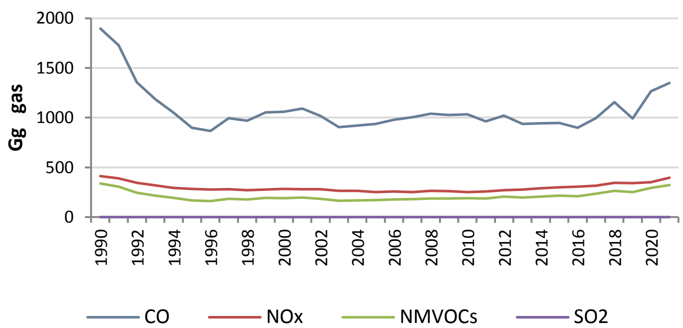

Figure 3.2.4.2 Trends in indirect greenhouse gas emissions from Fuel Combustion

Trends in greenhouse and other gas emissions in the category 1.A Fuel Combustion Activities by subcategories

Greenhouse gases. This report reviews greenhouse gas emissions by main subcategories of the category 1.A Activities related to Fuel Combustion.

Category 1.A.1 Energy Industries covers emissions from stationary combustion of fuels in the production of electricity and heat (1.A.1.a), as well as in the processing of oil and coal into other fuels. This inventory does not estimate separately GHG emissions from oil refining and solid fuel production. In accordance with the structure of the country's fuel balance, the total GHG emissions from energy enterprises producing heat and electricity are included in this category. Data is currently being collected for a separate assessment of GHG emissions for 1.A.1.b Oil Refining and 1.A.1.c Solid Fuel Production and Other Energy Sectors categories.

Category 1.A.2 Manufacturing Industries and Construction covers GHG emissions from stationary combustion of fossil fuels in all industries, emissions from industrial enterprises producing energy for their own needs, as well as in construction. The most energy-intensive industries in Uzbekistan are mining, oil and gas refining, chemical, construction materials, ferrous and non-ferrous metallurgy, food processing, textile, etc.

Category 1. A.3 Transport covers GHG emissions from individual modes of transport. It is discussed in more detail in the relevant section of this chapter.

Category 1.A.4.a Commercial sector covers emissions from fuel combustion in commercial and administrative buildings and social institutions. The main types of fuel used in this category are natural gas, diesel fuel, heating oil, brown coal, and hard coal.

Category 1.A.4.b Residential sector includes emissions from residential fuel combustion. The main types of fuel used in this category are natural gas, diesel fuel, heating oil, brown coal, hard coal, and liquefied petroleum gas.

Category 1.A.4.c Agriculture sector covers emissions from fuel combustion in agriculture. Stationary sources of GHG emissions include greenhouses, pumps, grain drying, livestock keeping, etc. Mobile sources include emissions from specialized agricultural machinery (tractors, combines). The main types of fuel used in this category are natural gas, diesel fuel, brown coal, hard coal, and liquefied petroleum gas.

Table 3.2.4.3 and Figure 3.2.4.3 show the total GHG emissions from fuel combustion for individual subcategories of the Activities related to Fuel Combustion category for the period 1990-2021.

Table 3.2.4.3 Total GHG emissions from Fuel Combustion Activities by category, Gg CO_2-eq.

Years	Electricity and Heat Production	Construction	Manufacturing industries	Transport	Commercial sector	Residential sector	Agriculture	Total
1990	57337.80	1711.21	5577.94	18127.81	7292.99	13413.34	5812.24	**109273.33**
1991	56089.83	1478.16	5764.14	16423.60	10136.30	14262.83	5632.62	**109787.47**
1992	52657.11	1235.59	5162.03	12179.28	11140.75	15097.04	5385.17	**102856.96**
1993	47813.05	1083.59	4810.09	10592.09	14959.60	18205.43	4598.86	**102062.71**
1994	46257.72	985.83	4076.53	9399.55	10759.15	23244.83	3973.56	**98697.16**
1995	46433.89	782.25	3873.52	8739.26	9714.59	24772.53	3986.90	**98302.94**
1996	45012.52	769.73	3399.35	8941.63	10131.32	29223.09	3865.54	**101343.19**
1997	44608.44	805.37	3133.31	9148.31	7835.51	30015.23	3722.79	**99268.95**
1998	42476.02	657.97	2855.19	9740.26	8054.56	30526.04	2761.21	**97071.26**
1999	42651.81	689.90	2821.53	11054.37	8763.13	32680.25	3237.69	**101898.69**
2000	46376.86	639.09	2661.30	11809.94	9343.28	32961.24	2765.21	**106556.92**
2001	43968.37	511.09	3001.78	13598.50	9382.70	31959.79	3086.11	**105508.34**
2002	46749.40	616.71	3194.88	13221.86	8341.72	34107.42	2719.21	**108951.22**
2003	43252.26	456.85	3532.55	11715.70	8488.12	34177.95	2194.92	**103818.36**
2004	45403.52	339.02	3654.73	10691.27	9960.86	29712.49	2072.46	**101834.35**
2005	38335.78	371.74	4151.95	10116.23	10867.90	31234.77	2068.82	**97147.19**
2006	36882.71	353.92	4376.38	13177.60	10733.28	31831.30	1769.95	**99125.14**
2007	33882.91	350.11	4425.77	13504.98	10618.45	32302.89	1409.88	**96494.98**
2008	35457.80	445.21	4387.14	14436.00	10743.13	31571.17	1337.28	**98377.74**
2009	34892.84	468.03	4427.77	13840.97	10675.58	33020.45	1435.89	**98761.53**
2010	33042.01	415.98	4462.02	13323.58	10219.52	32382.51	1421.22	**95266.85**

Table 3.2.4.3 continuation

Years	Electricity and Heat Production	Construction	Manufacturing industries	Transport	Commercial sector	Residential sector	Agriculture	Total
2011	33543.74	384.79	4444.96	12621.46	12905.82	28144.91	1319.65	**93365.33**
2012	33830.02	421.87	4466.42	12147.90	12122.36	24492.65	1336.66	**88817.87**
2013	32823.51	2072.65	15428.38	12487.78	5800.18	22183.98	89.37	**90885.86**
2014	34720.81	2156.10	16473.18	12034.83	3164.09	24238.03	85.13	**92872.16**
2015	34058.35	2125.37	15286.48	13746.11	3169.48	20413.45	58.16	**88857.40**
2016	35075.22	2213.37	15661.05	12631.80	6842.98	18855.17	60.07	**91339.67**
2017	34396.17	2207.28	14294.64	13981.81	3926.78	20492.57	54.90	**89354.14**
2018	39622.81	2050.55	14473.78	14660.36	7111.34	22042.82	84.35	**100046.00**
2019	41484.29	12.62	13114.05	14496.39	7152.69	20948.77	109.99	**97318.81**
2020	39373.83	12.62	11547.75	15574.18	6939.06	25417.74	711.30	**99576.47**
2021	47696.45	49.83	12700.98	17033.51	8604.28	26408.13	833.78	**113326.97**
Δ (1990-2021)	**-17%**	**-97%**	**+128%**	**-6%**	**+18%**	**+97%**	**-86%**	**+4%**
%, 2021	**42.1 %**	**0.04%**	**11.2%**	**15.0%**	**7.6 %**	**23.3%**	**0.7%**	**100.0%**

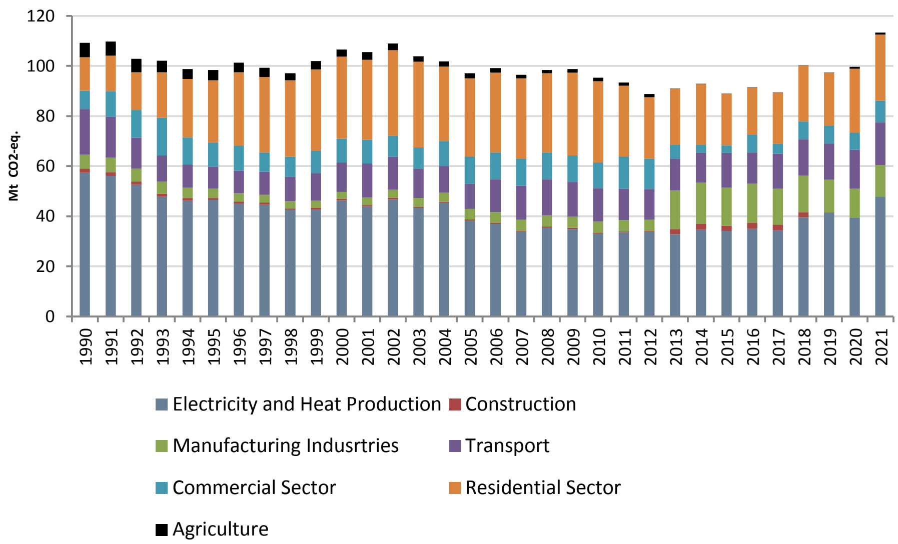

Figure 3.2.4.3 Trends in GHG emissions by subcategories of the Fuel Combustion Activities category

The largest contribution to GHG emissions from fuel combustion in 2021 comes from the Electricity and Heat Production (42.09%), Residential (23.3%) and Transport (15.03%) categories.

For the period 1990-2021, total emissions from fuel combustion increased by 4%.

Whereas, GHG emissions decreased in the following categories:

- Electricity and Heat Production by 17%,
- Construction by 97%,
- Transport by 6%,
- Agriculture by 86%.

GHG emissions increased in the following categories:

- Manufacturing industries by 128%,
- Commercial sector by 18%,
- Residential sector by 97%.

Table 3.2.4.4 shows CO_2 emissions from fuel combustion for individual subcategories of the Activities related to Fuel Combustion category for the period 1990-2021.

Table 3.2.4.4 CO_2 emissions from Fuel Combustion Activities by category, Gg

Years	Electricity and Heat Production	Construction	Manufacturing industries	Transport	Commercial sector	Residential sector	Agriculture	Total
1990	57223	1705	5568	17666	7258	13048	5746	**108214**
1991	55984	1473	5754	15982	10092	13902	5566	**108753**
1992	52564	1231	5154	11833	11099	14811	5316	**102009**
1993	47734	1080	4804	10321	14913	18003	4563	**101417**
1994	46184	982	4072	9183	10722	23070	3947	**98161**
1995	46356	780	3869	8557	9682	24685	3962	**97890**
1996	44933	767	3395	8771	10096	29134	3842	**100938**
1997	44531	803	3130	8967	7808	29927	3701	**98867**
1998	42406	656	2852	9555	8026	30439	2746	**96678**
1999	42577	688	2818	10869	8733	32587	3219	**101491**
2000	46293	637	2658	11626	9310	32869	2749	**106142**
2001	43895	509	2999	13407	9350	31869	3069	**105098**
2002	46671	615	3191	13036	8312	34012	2704	**108540**
2003	43180	455	3529	11537	8460	34081	2183	**103425**
2004	45327	338	3651	10511	9929	29628	2061	**101444**
2005	38274	370	4147	9931	10833	31148	2057	**96762**
2006	36819	353	4371	12965	10699	31710	1760	**98676**
2007	33827	349	4420	13285	10585	32181	1402	**96050**
2008	35397	443	4382	14206	10709	31439	1330	**97907**
2009	34833	466	4423	13601	10642	32897	1428	**98289**
2010	32990	414	4457	13073	10186	32254	1413	**94789**
2011	33496	383	4441	12352	12866	27984	1312	**92834**
2012	33776	420	4462	11835	12084	24343	1329	**88249**
2013	32766	2071	15411	12148	5770	21999	89	**90254**
2014	34661	2154	16455	11670	3148	24041	85	**92212**
2015	34002	2123	15270	13335	3155	20240	58	**88184**
2016	35017	2211	15644	12222	6811	18681	60	**90647**
2017	34338	2205	14279	13531	3909	20300	55	**88617**
2018	39548	2049	14456	14160	7085	21780	84	**99162**
2019	41414	13	13092	13970	7126	20759	105	**96478**
2020	39301	13	11529	15044	6915	25230	702	**98733**
2021	47607	50	12682	16416	8576	26184	826	**112341**
Δ (1990-2021)	**-17%**	**-97%**	**+128%**	**-7%**	**+18%**	**+101%**	**-86%**	**+4%**
%, 2021	**42,4%**	**0,00%**	**11,3%**	**14,6%**	**7,6%**	**23,3%**	**0,7%**	**100,0%**

The largest contribution to carbon dioxide emissions from fuel combustion in 2021 comes from the Energy and Heat Production (42.4%), Residential (23.3%) and Transport (14.6%) categories.

For the period 1990-2021, total CO_2 emissions from fuel combustion increased by 4%.

Whereas, CO_2 emissions decreased in the following categories:

- Electricity and Heat Production by 17%,
- Construction by 97%,
- Transport by 7%,
- Agriculture by 86%.

Emissions increased in the following categories:

- Manufacturing Industries by 128%,

- Commercial sector by 18%,
- Residential sector by 101%.

Reduction of CO_2 emissions in Electricity and Heat Production is due to the replacement of solid and liquid fuels with natural gas, and the transition to new energy generation technologies (CCGT).

Reduction of emissions in Transport sector is due to the technical renewal of the fleet, increased use of gas fuel in motor vehicles, electrification of railroads, and reduction of fuel losses.

A significant increase in CO_2 emissions in the Manufacturing Industries and Construction category is associated with an increase in production capacity and construction scale.

The increase in CO_2 emissions in the Residential sector is due to population growth, increased housing construction, and gasification of rural settlements.

Methane emissions from fuel combustion for individual subcategories of the Activities related to Fuel Combustion category for the period 1990-2021are given in Table 3.2.4.5.

The largest share of methane emissions in 2021 comes from the Transport (59.79%) and Residential Sector (31.42%) categories.

Between 1990 and 2021, total CH_4 emissions from fuel combustion increased by 16%. The following change by subcategory was observed.

Methane emissions decreased in the following categories:

- Electricity and Heat Production by 30%;
- Construction by 94%;
- Residential sector by 41%,
- Agriculture by 86%.

Methane emissions increased in the following categories:

- Manufacturing Industries by 91%;
- Transport by 266%;
- Commercial sector by 6%.

Table 3.2.4.5 CH_4 emissions from Fuel Combustion Activities by category, Gg CO_2-eq.

Years	Electricity and Heat Production	Construction	Manufacturing Industries	Transport	Commercial sector	Residential sector	Agriculture	Total
1990	28.66	1.83	4.15	103.69	19.10	339.91	51.97	**549.31**
1991	27.37	1.52	4.12	95.81	25.09	335.59	53.07	**542.57**
1992	24.76	1.27	3.31	74.35	26.98	264.36	56.2	**451.22**
1993	23.55	1.11	2.83	64.92	34.36	183.97	25.79	**336.54**
1994	22.99	1.01	2.18	58.34	25.09	156.3	17.96	**283.88**
1995	23.5	0.80	2.09	50.12	22.63	73.32	16.07	**188.54**
1996	22.82	0.79	1.73	48.53	23.80	72.69	15.22	**185.59**
1997	22.77	0.82	1.59	56.45	18.64	71.47	13.53	**185.27**
1998	21.30	0.66	1.43	56.09	19.31	71.08	9.14	**179**
1999	21.97	0.70	1.40	60.31	21.01	75.74	11.13	**192.26**
2000	23.93	0.65	1.34	61.16	22.62	74.83	9.29	**193.81**
2001	22.06	0.52	1.45	62.72	22.18	73.49	10.38	**192.79**
2002	23.66	0.62	1.55	58.80	20.08	77.27	9.01	**190.99**
2003	22.09	0.46	1.67	53.74	20.16	78.57	7.26	**183.96**
2004	22.34	0.35	1.73	54.41	23.45	68.3	6.87	**177.43**
2005	18.33	0.39	2.15	55.25	25.31	69.91	6.85	**178.2**
2006	17.82	0.37	2.45	70.97	25.03	102.99	5.85	**225.48**
2007	16.12	0.37	2.42	76.19	24.49	102.47	4.64	**226.69**
2008	16.59	0.59	2.23	82.57	24.9	112.49	4.39	**243.77**
2009	16.35	0.64	2.18	92.54	24.79	104.05	4.73	**245.28**
2010	15.30	0.53	2.05	105.57	23.74	109.06	4.68	**260.93**
2011	14.68	0.46	2.02	122.22	29.67	141.39	4.34	**314.78**
2012	14.54	0.55	2.02	154.06	27.91	132.25	4.4	**335.72**
2013	13.66	0.93	7.63	171.81	15.12	165.52	0.31	**374.97**

Table 3.2.4.5 continuation

Years	Electricity and Heat Production	Construction	Manufacturing Industries	Transport	Commercial sector	Residential sector	Agriculture	Total
2014	14.43	0.96	8.13	195.34	8.19	175.98	0.26	**403.29**
2015	14.14	0.95	7.34	220.79	8.25	155.11	0.18	**406.76**
2016	14.62	0.99	7.43	227.5	17.64	155.2	0.19	**423.56**
2017	14.29	0.98	6.94	255.91	9.93	172.98	0.15	**461.17**
2018	16.53	0.91	7.51	292.36	16.74	239.3	0.20	**573.55**
2019	17.52	0.03	9.07	318.28	17.13	169.26	4.30	**535.59**
2020	16.22	0.03	7.81	315.85	16.46	166.1	8.07	**530.54**
2021	20.11	0.12	7.94	379.75	20.25	199.53	7.42	**635.12**
$\Delta_{(1990–2021)}$	**-30%**	**-94%**	**91%**	**266%**	**6%**	**-41%**	**-86%**	**16%**
%, 2021	**3.17%**	**0.02%**	**1.25%**	**59.79%**	**3.19%**	**31.42%**	**1.17%**	**100.00%**

Nitrous oxide emissions from fuel combustion for individual subcategories of the Activities related to Fuel Combustion category for the period 1990-2021 are given in Table 3.2.4.6.

The largest contribution to nitrous oxide emissions comes from the Transport (67.75%) and Energy and Heat Production (19.72%) categories.

For the period 1990-2021, total nitrous oxide emissions from fuel combustion decreased by 31%. A decrease in N_2O emissions from fuel combustion was observed in the following subcategories:

- Electricity and Heat Production by 19%;
- Construction by 95%;
- Transport by 34%;
- Commercial sector by 54%;
- Residential sector by 6%;
- Agriculture by 95%.

Table 3.2.4.6 N_2O emissions from Fuel Combustion Activities by category, Gg CO_2-eq.

Years	Electricity and Heat Production	Construction	Manufacturing Industries	Transport	Commercial sector	Residential sector	Agriculture	Total
1990	85.75	4.16	5.69	358.15	16.33	25.74	13.95	**509.76**
1991	78.10	3.58	5.60	346.12	19.25	25.68	13.51	**491.85**
1992	68.34	3.01	4.31	271.78	14.86	21.43	12.97	**396.71**
1993	55.48	2.65	3.75	205.98	12.58	18.08	10.24	**308.76**
1994	50.33	2.41	2.80	158.15	11.63	18.27	8.93	**252.52**
1995	54.37	1.91	2.72	131.72	10.32	14.29	8.92	**224.25**
1996	56.81	1.88	2.23	122.01	11.64	15.98	8.57	**219.13**
1997	54.72	1.97	2.03	125.07	8.41	16.29	8.66	**217.15**
1998	49.22	1.55	1.77	129.51	9.07	16.46	6.42	**213.99**
1999	52.47	1.66	1.76	125.03	9.48	17.61	7.56	**215.58**
2000	59.59	1.54	1.67	122.90	10.87	17.65	6.44	**220.65**
2001	51.08	1.23	1.78	128.62	10.06	17.24	7.22	**217.24**
2002	54.72	1.48	1.93	127.35	10.12	18.29	6.34	**220.25**
2003	50.09	1.10	2.06	124.95	7.66	18.44	5.10	**209.40**
2004	54.61	0.83	2.12	125.54	8.56	16.08	4.83	**212.57**
2005	43.35	0.92	2.79	129.62	9.25	16.73	4.81	**207.47**
2006	46.01	0.87	3.28	141.62	9.45	18.79	4.10	**224.13**
2007	39.79	0.86	3.22	143.31	8.46	18.97	3.23	**217.84**
2008	44.16	1.27	2.87	147.30	9.26	19.20	3.05	**227.11**
2009	43.87	1.36	2.75	147.71	8.95	19.36	3.30	**227.30**
2010	36.59	1.15	2.50	144.84	9.42	19.39	3.26	**217.16**

Table 3.2.4.6 continuation

Years	Electricity and Heat Production	Construction	Manufacturing Industries	Transport	Commercial sector	Residential sector	Agriculture	Total
2011	33.36	1.02	2.42	147.13	10.46	19.44	3.02	**216.85**
2012	39.01	1.19	2.42	159.00	10.70	17.52	3.07	**232.91**
2013	43.44	1.11	9.72	167.99	15.44	19.14	0.05	**256.89**
2014	45.84	1.15	10.33	169.79	8.21	21.32	0.05	**256.69**
2015	41.99	1.13	9.21	190.07	5.78	17.94	0.03	**266.15**
2016	43.27	1.18	9.24	181.96	14.49	18.79	0.04	**268.97**
2017	44.07	1.17	8.75	195.07	7.47	19.18	0.03	**275.74**
2018	57.87	1.09	9.79	208.00	9.60	23.71	0.05	**310.10**
2019	53.08	0.06	13.28	207.97	9.63	20.79	0.28	**305.09**
2020	56.89	0.06	11.37	214.63	7.69	21.86	0.73	**313.23**
2021	69.20	0.20	11.28	237.69	7.57	24.17	0.75	**350.86**
$\Delta_{(1990-2021)}$	**-19%**	**-95%**	**+98%**	**-34%**	**-54%**	**-6%**	**-95%**	**-31%**
%, 2021	**19.72%**	**0.06%**	**3.21%**	**67.75%**	**2.16%**	**6.89%**	**0.21%**	**100.00%**

In the Manufacturing Industries subcategory, there was a 98% increase in nitrous oxide emissions over the period.

The downward trend in N_2O emissions is associated with an increase in the share of gaseous fuel consumption in all sectors of the economy.

Gases with indirect greenhouse effect. Tables 3.2.4.7 to 3.2.4.10 show emissions of other gases from fuel combustion by category for the period 1990-2021, calculated using default factors according to the methodology of the 1996 IPCC Guidelines.

Table 3.2.5.5 show the time series of CO emissions for subcategories of the Activities related to Fuel Combustion category.

Table 3.2.4.7 CO emissions from Fuel Combustion Activities by category, Gg

Years	Electricity and Heat Production	Manufacturing Industries and Construction	Transport	Commercial sector	Residential sector	Agriculture	Total
1990	9.2	5.7	1567.6	41.1	78.6	193.6	**1895.8**
1991	9.1	5.2	1399.6	52.0	76.7	187.2	**1729.8**
1992	8.6	4.4	1090.0	31.2	58.9	160.6	**1353.7**
1993	8.0	4.1	970.7	25.1	43.9	132.4	**1184.2**
1994	7.7	3.1	854.4	26.2	40.7	116.9	**1049**
1995	7.6	3.3	721.4	22.7	25.4	117.1	**897.5**
1996	7.3	3.0	693.4	25.6	27.4	109.9	**866.6**
1997	7.3	2.9	832.9	16.2	27.5	106	**992.8**
1998	7.0	2.7	843.3	17.0	27.7	70.8	**968.5**
1999	6.9	2.6	912.7	16.2	29.5	84.1	**1052.0**
2000	7.5	2.6	928.6	18.7	29.5	72.1	**1059.0**
2001	7.2	2.7	953.2	18.8	28.8	80.0	**1090.7**
2002	7.6	2.7	887.5	18.6	30.5	71.1	**1018.0**
2003	7.1	2.8	796.2	11.0	30.7	57.5	**905.3**
2004	7.4	2.9	817.0	12.2	26.7	53.7	**919.9**
2005	6.3	2.9	825.4	15.9	30.2	55.3	**936.0**
2006	6.0	3.4	872.7	16.5	33.6	46.3	**978.5**
2007	5.6	3.7	908.9	15.9	33.8	36.5	**1004.4**
2008	5.8	3.8	933.9	24.8	35.1	36.7	**1040.1**
2009	5.7	4.1	925.8	18.0	34.4	37.5	**1025.5**
2010	5.4	4.2	937.7	14.8	32.9	37.1	**1032.1**
2011	5.8	4.1	862.8	19.8	33.8	34.4	**960.7**
2012	5.7	4.4	921.4	23.3	29.2	34.8	**1018.8**

Table 3.2.4.7 continuation

Years	Electricity and Heat Production	Manufacturing Industries and Construction	Transport	Commercial sector	Residential sector	Agriculture	Total
2013	5.1	10.3	865.4	24.6	32.8	0.1	**938.3**
2014	5.5	11.0	875.3	15.1	37.0	0.1	**944.0**
2015	5.5	10.3	886.3	10.4	33.1	0.1	**945.7**
2016	5.6	12.0	822.9	26.7	31.9	0.1	**899.2**
2017	5.4	11.9	925.5	16.2	34.1	0.1	**993.2**
2018	12.6	9.28	1033.9	29.6	68.7	0.1	**1154.1**
2019	13.49	8.44	888.9	28.9	49.4	1.2	**990.4**
2020	12.58	7.33	1173.3	19.6	50.2	2.3	**1265.5**
2021	15.22	7.79	1248.3	14.3	59.2	2.2	**1347.2**
Δ (1990-2021)	**65%**	**37%**	**-20.40%**	**-65.20%**	**-24.70%**	**-99%**	**-28.90%**
%, 2021	**1.1**	**0.6**	**92.6**	**1.1**	**4.4**	**0.1**	**100.0**

Table 3.2.4.7 show that there was a 28.9% decrease in CO emissions between 1990 and 2021, including in the following categories:

- Transport by 20,4%;
- Commercial sector by 65,2%;
- Residential sector by 24,7%;
- Agriculture by 99%.

An increase in emissions in this category was observed in the Electricity and Heat Production (by 65%) and Manufacturing Industries and Construction (by 37%) categories.

The largest CO emissions come from the Transport category, mainly road transport. An increase in the vehicle fleet and, at the same time, constant monitoring of the environmental condition of vehicles led to further growth and stabilization of the emission level.

Table 3.2.4.8 show the time series of NOx emissions for subcategories of the Activities related to Fuel Combustion category.

Table 3.2.4.8 NOx emissions from Fuel Combustion Activities by category, Gg gas

Years	Electricity and Heat Production	Manufacturing Industries and Construction	Transport	Commercial sector	Residential sector	Agriculture	Total
1990	151.0	29.4	158.12	7.3	12.1	51.7	**409.62**
1991	147.7	26.9	144.2	9.6	12.7	49.0	**390.1**
1992	137.8	23.8	112.5	10.5	13.2	45.8	**343.6**
1993	127.2	22.0	97.1	13.6	16.1	41.1	**317.1**
1994	121.5	17.0	86.1	9.8	20.5	37.0	**291.9**
1995	121.5	17.7	74.4	8.8	22.0	37.8	**282.2**
1996	117.4	16.6	69.4	9.2	26.0	36.8	**275.4**
1997	116.8	15.9	75.6	7.3	26.7	38.0	**280.3**
1998	111.0	15.0	79.7	7.6	27.2	28.7	**269.2**
1999	110.9	14.4	79.8	8.3	29.1	33.6	**276.1**
2000	120.4	14.3	79.9	8.9	29.3	28.7	**281.5**
2001	114.8	14.6	81.4	8.7	28.5	32.3	**280.3**
2002	121.9	14.6	76.6	7.9	30.4	28.3	**279.7**
2003	112.7	15.1	72.4	8.1	30.4	22.8	**261.5**
2004	117.8	15.1	72.9	9.5	26.5	21.4	**263.2**
2005	99.6	14.8	76.5	10.4	27.9	21.6	**250.8**
2006	95.3	17.4	87.5	10.8	28.2	18.4	**257.6**
2007	87.9	18.8	88.8	11.7	28.7	14.4	**250.3**
2008	91.7	19.5	91.7	18.9	27.8	14.6	**264.2**
2009	90.1	20.6	91.4	13.2	29.3	14.7	**259.3**
2010	83.7	21.5	91.5	9.7	28.6	14.6	**249.6**

Table 3.2.4.8 continuation

Years	Electricity and Heat Production	Manufacturing Industries and Construction	Transport	Commercial sector	Residential sector	Agriculture	Total
2011	89.8	21.1	93.5	15.5	24.6	13.5	**258.0**
2012	88.8	23.1	105.4	18.0	21.3	13.7	**270.3**
2013	79.1	51.2	121.5	4.61	19.3	0.1	**275.81**
2014	84.6	54.5	126.7	2.6	21.5	0.1	**290.0**
м2015	84.7	51.4	140.4	3.4	18.0	0.1	**298.0**
2016	86.5	59.8	134.1	6.2	17.0	0.1	**303.7**
2017	84.1	59.0	148.1	6.4	17.5	0.1	**315.2**
2018	109.4	44.4	164.2	7.1	20.4	0.1	**345.4**
2019	113.8	36.0	165.6	6.9	19.7	0.1	**341.8**
2020	108.7	31.4	180.4	6.6	23.5	0.6	**351.4**
2021	131.5	34.5	197.9	8.1	24.4	0.8	**397.3**
Δ (1990–2021)	**-12.9%**	**+17.3%**	**+25.2%**	**+11.0%**	**+202%**	**-98.5%**	**-3.00%**
%, 2021	**33.1**	**8.7**	**49.8**	**2.0**	**6.2**	**0.2**	**100.0**

There was a decrease in emissions overall in category 1.A Activities related to Fuel Combustion, including in the following subcategories:

- Electricity and Heat Production by 12,9%;
- Agriculture на 98,5%.

NOx emissions increased in the following subcategories:

- Manufacturing Industries and Construction by 17,3%;
- Transport by 25,2%;
- Commercial sector by 11%;
- Residential sector by 202%.

Table 3.2.4.9 show the change in NMVOCs emissions from fuel combustion for the period 1990-2021.

Table 3.2.4.9 NMVOCs emissions from Fuel Combustion Activities by category, Gg gas

Years	Electricity and Heat Production	Manufacturing Industries and Construction	Transport	Commercial sector	Residential sector	Agriculture	Total
1990	4.4	1.0	272.4	4.2	7.9	46.7	**336.6**
1991	4.4	0.9	243.2	5.3	7.7	44.7	**306.2**
1992	4.2	0.8	189.3	3.2	5.9	39.8	**243.2**
1993	3.9	0.7	169.2	2.5	4.4	34.3	**215.0**
1994	3.8	0.6	150.7	2.6	4.1	30.7	**192.5**
1995	3.7	0.6	128.2	2.3	2.5	31.0	**168.3**
1996	3.6	0.5	122.5	2.6	2.7	29.6	**161.5**
1997	3.6	0.5	144.7	1.7	2.8	29.7	**183.0**
1998	3.4	0.5	148.7	1.7	2.8	21.1	**178.2**
1999	3.4	0.5	158.5	1.7	3.0	24.9	**192.0**
2000	3.6	0.5	161.0	1.9	3.0	21.3	**191.3**
2001	3.5	0.5	164.7	1.9	2.9	23.9	**197.4**
2002	3.7	0.5	153.3	1.9	3.1	21.0	**183.5**
2003	3.4	0.5	138.9	1.2	3.1	17.0	**164.1**
2004	3.6	0.5	141.8	1.3	2.7	15.9	**165.8**
2005	3.1	0.5	144.4	1.6	3.0	16.1	**168.7**
2006	2.9	0.6	156.0	1.7	3.4	13.7	**178.3**
2007	2.7	0.6	161.9	1.6	3.4	10.8	**181.0**
2008	2.8	0.7	167.2	2.5	3.5	10.8	**187.5**
2009	2.8	0.7	167.2	1.8	3.5	11.0	**187.0**
2010	2.7	0.7	171.7	1.8	3.5	10.9	**191.3**
2011	2.9	0.7	166.6	2.2	3.8	10.1	**186.3**

Table 3.2.4.9 continuation

Years	Electricity and Heat Production	Manufacturing Industries and Construction	Transport	Commercial sector	Residential sector	Agriculture	Total
2012	2.9	0.8	185.2	2.8	3.5	10.2	**205.4**
2013	2.5	1.7	187.2	2.5	3.3	0	**197.2**
2014	2.6	1.8	196.2	1.5	3.7	0	**205.8**
2015	2.7	1.7	206.6	1.1	3.3	0	**215.4**
2016	2.7	2.0	197.9	2.7	3.2	0	**208.5**
2017	2.6	2.0	223.1	1.7	3.4	0	**232.8**
2018	3.2	1.6	250.2	3.0	6.9	0	**264.9**
2019	3.4	1.4	238.4	2.9	5.0	0.2	**251.2**
2020	3.2	1.2	280.8	2.0	5.1	0.3	**292.5**
2021	3.8	1.3	309.4	1.5	5.9	0.2	**322.2**
$\Delta_{(1990–2021)}$	**-13.60%**	**30%**	**13.60%**	**-64.30%**	**-25.30%**	**-99.60%**	**-4.30%**
%, 2021	**1.2**	**0.4**	**96**	**0.5**	**1.8**	**0.1**	**100.0**

For the period 1990-2021, there was a 4.3% decrease in NMVOC emissions from fuel combustion in the category Activities related to Fuel Combustion as a whole, including in subcategories:

– Electricity and Heat Production by 13,6%;
– Commercial sector by 64,3%;
– Residential sector by 25,3%;
– Agriculture by 99,6%.

At the same time, the Manufacturing Industries and Construction subcategory shows a 30% increase in NMVOC emissions. The largest contributor to total NMVOC emissions from fuel combustion is the Transport category.

Table 3.2.4.10 show the change in SO_2 emissions from fuel combustion for the period 1990-2021. In 2021, SO_2 emissions from fuel combustion amounted to 0.272 Gg.

Table 3.2.4.10 SO_2 emissions from Fuel Combustion Activities by category, ton gas

Years	Electricity and Heat Production	Manufacturing Industries and Construction	Transport	Commercial sector	Residential sector	Agriculture	Total
1990	302.4	27.6	34.6	54.8	44.7	39.4	**503.5**
1991	255.3	23.5	32.3	52.1	44.2	36.1	**443.5**
1992	191.2	17.6	25.2	41.7	33.6	35.2	**344.5**
1993	172.9	12.1	21.4	16.9	20.8	28.2	**272.3**
1994	160.6	8.9	20.1	18.8	15.3	24.9	**248.6**
1995	188.4	7.0	18.3	15.6	3.1	25.1	**257.5**
1996	199.0	6.1	16.2	22.7	1.7	24.6	**270.3**
1997	194.4	6.2	14.3	14.5	1.5	25.8	**256.7**
1998	161.9	6.6	15.9	14.5	1.2	19.8	**219.9**
1999	172.3	3.6	6.3	12.1	1.1	9.8	**205.2**
2000	185.3	3.8	6.1	18.3	0.9	8.3	**222.7**
2001	145.5	2.7	6.1	17.8	1	9.4	**182.5**
2002	157.4	3.1	5.8	15.5	0.9	8.2	**190.9**
2003	150.7	2.3	6.1	9.1	1.1	6.6	**175.9**
2004	144.7	1.9	5.9	9.1	1.0	6.2	**168.8**
2005	104.3	2.7	6.8	9.7	2.6	6.3	**132.4**
2006	110.9	4.4	9.1	9.1	5.3	5.3	**144.1**
2007	79.5	4.0	8.6	7.0	5.1	4.2	**108.4**
2008	78.8	4.0	8.7	8.8	6.8	4.2	**111.3**
2009	77.1	3.7	8.1	7.3	5.1	4.3	**105.6**
2010	56.8	2.8	6.9	9.7	6.1	4.2	**86.5**
2011	57.1	2.5	6.8	8.4	12	3.9	**90.7**

Table 3.2.4.10 continuation

Years	Electricity and Heat Production	Manufacturing Industries and Construction	Transport	Commercial sector	Residential sector	Agriculture	Total
2012	71.1	2.8	6.9	10.6	11.8	4.0	**107.2**
2013	73.1	4.1	11.7	31.8	17.8	0	**138.5**
2014	71.7	4.1	10.8	15.6	17.8	0	**120.0**
2015	57.5	2.8	13.0	10.2	14.5	0	**98.0**
2016	58.8	2.5	11.1	23.3	15.8	0	**111.5**
2017	59.2	3.1	11.2	13	16.5	0	**103.0**
2018	150.8	8.5	11.6	22.2	42.2	0	**233.8**
2019	137.6	25.3	11.3	24.3	27.1	0	**224.0**
2020	153.8	20.9	12.4	15.4	24.4	0	**226.0**
2021	199.4	18.6	11.2	13.1	31.3	0	**272.0**
$\Delta_{(1990–2021)}$	**-34.10%**	**-32.60%**	**-67.60%**	**-76.10%**	**-30%**	**-100%**	**-46%**
$\%_{2021}$	**73.2**	**6.7**	**4**	**4.7**	**11.4**	**0.0**	**100.0**

There is a decrease in SO_2 emissions from fuel combustion in all subcategories of the category Activities related to Fuel Combustion in general (by 46%) for the period 1990-2021, including:

- Electricity and Heat Production 34,1%;
- Manufacturing Industries and Construction by 32,6%;
- Transport by 67,6%;
- Commercial sector by 76,1%;
- Residential sector by 30%;
- Agriculture by 100%.

The largest contributor to SO_2 emissions is the Electricity and Heat Production category. The decrease in SO_2 emissions in the energy sector is due to a gradual increase in the share of natural gas in the structure of fuel used and the government policy to reduce pollutant emissions from stationary sources.

Methodology

The Tier 1 methodology of the 2006 IPCC 2006 Tier 1 Guidelines was used to estimate GHG emissions in Category 1.A. Energy Industries using default factors.

The previous inventory used partly national factors for the net calorific value of fuels. According to recommendations of international experts during the voluntary assessment of the Uzbekistan inventory (2021), the use of national fuel properties implies the use of national carbon content values as well. It was decided to use default values until relevant national data were available.

The estimates of greenhouse gas emissions from each type of fuel used for energy production was calculated using Equation 2.1 of the 2006 IPCC Guidelines, Vol. 2, Chapter 2, p. 2.11:

$$Emission_{GHG,\ fuel} = Fuel\ Consumption_{fuel} \bullet EF_{GHG,\ fuel}$$

where:

Emissions $_{GHG, fuel}$ – *emissions* of a given GHG by fuel type, kg GHG;

Fuel consumption $_{fuel}$ – amount of fuel burned, TJ;

$EF_{GHG, fuel}$ – emission factor of a given GHG by fuel type, kg/gas/TJ.

Equation 2.2 of the 2006 IPCC Guidelines, Vol. 2, Chapter 2, page 2.11 was used to calculate total GHG emissions for all fuel types used:

$$Emissions_{GHG} = \sum_{fuels} Emissioms_{GHG,\ fuel}$$

Activity data

Amount of fuel consumption in category 1.A Activities related to Fuel Combustion for 2018-2021 were provided by the Statistics Agency of the Republic of Uzbekistan in the structure of the fuel balance.

These data (million cubic meters of natural gas, thousand tons for other types of fuel) are of limited dissemination and are therefore not provided in this report.

Emission factors

IPCC default emission factors for relevant fuel types (except for natural gas, domestic heating oil and gas from underground coal gasification) were used in the calculations (Table 3.2.4.11).

Table 3.2.4.11 Basic Fuel Data used to calculate CO_2 emissions from fuel combustion

Fuel	Calorific value, tJ/t thousand tons	Carbon emission factor, t C/TJ	Fuel	Calorific value, tJ/t thousand tons	Carbon emission factor, t C/TJ
Solid			Aviation gasoline	44.3	19.1
Subbituminous (brown) coal	18.9	26.2	Aviation kerosene	44.1	19.5
Bituminous coal	25.8	25.8	Other kerosene	43.8	19.6
Coal briquettes	20.7	26.6	Diesel fuel	43.0	20.2
Metallurgical coke	28.2	29.2	Heating oil	40.4	21.1
Gaseous			Domestic heating oil	42.496	20.2
Underground gasification gas (mln. m^3)	3.647	26.2	Liquefied petroleum gas	47.3	17.2
Natural and associated gas (mln m^3)	33.997	15.3	Petroleum bitumen	40.2	22.0
Compressed natural gas (mln m^3)	33.997	15.3	Petroleum oil	40.2	20.0
Refinery gas	43.961	18.2	Petroleum coke	32.5	26.6
Liquid			Other oil products	40.2	20.0
Crude oil and gas condensate	42.3	20	Biomass (wood/wood waste)	15.6	30.5
Motor gasoline	44.3	18.9			

Tier 1 default CH_4 and N_2O emission factors for various source categories are given in Table 3.2.4.12.

Table 3.2.4.12 Basic Fuel Data used to calculate CH_4 and N_2O emissions from fuel combustion

Fuel	kg CH_4/TJ	kg N_2O/TJ	Fuel	kg CH_4/TJ	kg N_2O/TJ
Solid			Aviation gasoline	3	0.6
Uzbek brown coal	1	1.5	Aviation kerosene	3	0.6
Uzbek coal	1	1.5	Other kerosene	3	0.6
Uzbek coal briquettes	1	1.5	Diesel fuel	3	0.6
Metallurgical coke	1	0.1	Heating oil	3	0.6
Gaseous			Domestic heating oil	3	0.6
Underground gasification gas (mln. m^3)	1	0.1	Liquefied petroleum gas	1	0.1
Natural and associated gas (mln m^3)	1	0.1	Petroleum bitumen	3	0.6
Compressed natural gas (mln m^3)	1	0.1	Petroleum oil	3	0.6
Refinery gas	1	0.1	Petroleum coke	3	0.6
Liquid			Other oil products	3	0.6
Crude oil and gas condensate	3	0.6	Biomass (wood/wood waste)	30	4.0
Motor gasoline	3	0.6			

Uncertainties and time series consistency

The activity data uncertainty is assumed to be ±5% (as for countries with a less developed system of national statistics), except for biomass data (IPCC Guidelines 2006, Chapter 2, Vol. 2, Table 2.15, p. 2.44).

The biomass data uncertainty is assumed to be about 60%, since data on biomass as a fuel is not so reliable.

Default emission factor uncertainties were calculated based on data for all types of fuel from Tables 1.2 and 1.3 of Vol.2, Introduction chapter of the 2006 IPCC Guidelines and are about ±5% for CO_2, ±75% for CH_4, ±100% for N_2O.

Combined uncertainty for fossil fuels in category 1.A.1 "Energy industries" was about ±7.1% for CO_2, ±75.2% for CH_4 and ±316% for N_2O.

The same calculation method and similar data sets were used for all years.

Quality assurance/Quality control

Tier 1 QA/QC procedures were applied to Category 1.A.1 Energy Industries.

The QA/QC procedures were performed in accordance with the general QA/QC principles and the QA/QC plan. Verification of the following was conducted:

- emission source documentation,
- data for mechanical errors,
- correctness of the formulas and units of measurement used for the entire time series,
- consistency of the emission factors used,
- all references to information sources for source data in the Software.

Planned improvements in the category

In the next inventory, it is planned to collect separate data to estimate emissions for subcategories of category 1.A.1 Energy industries:

- 1.A.1.a Main Activity, Production of Electricity and Heat,
- 1.A.1.b Petroleum Refining,
- 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries.

It is planned to develop national emission factors for all types of fuel, in particular, establishing the carbon content of fuels to transit to the use of Tier 2 methodology.

Transport (category 1.A.3)

Category description

This report provides more detailed information on GHG emissions in the Transport category. GHG emissions were estimated by main modes of transportation (aviation, road, rail, water and pipeline) (Table 3.2.4.13 and Figure 3.2.4.5).

Table 3.2.4.13 GHG emissions in the Transport category, Gg CO_2-eq.

Years	Domestic Aviation	Road Transportation	Railways	Water-born navigation	Pipeline Transport	Total
1990	1041.31	10472.56	2002.73	12.88	4598.34	**18127.81**
1995	340.25	5497.42	501.57	6.44	2393.58	**8739.26**
2000	400.50	5895.94	373.51	0	5139.99	**11809.94**
2005	246.22	5504.39	501.57	0	3864.05	**10116.23**
2010	185.47	7267.75	494.46	0	5375.91	**13323.58**
2015	62.34	11540.52	373.34	0	1769.91	**13746.11**
2016	72.58	10852.63	375.35	0	1331.25	**12631.80**
2017	58.66	11770.26	356.28	0	1796.61	**13981.81**
2018	73.11	13072.98	319.18	0	1195.09	**14660.36**
2019	61.34	12969.71	293.41	0	1171.94	**14496.39**
2020	48.55	14315.78	190.53	0	1019.32	**15574.18**
2021	43.88	15536.89	251.79	0	1200.95	**17033.51**
$\Delta_{(1990-2021)}$	**-96%**	**+48%**	**-87%**	**-100%**	**-74%**	**-6%**
$\%_{2021}$	**0.3 %**	**91.2%**	**1.5 %**	**0.00%**	**7.0%**	**100.00%**

According to the data in the table, road (91.2%) and pipeline (7.05%) modes of transport are the largest contributors to GHG emissions in the Transport category in 2021.

For the period 1990-2021, there was a 6% decrease in total GHG emissions in the Transport category. According to Table 3.2.5.12 and Figure 3.2.5.2, there was a decrease in GHG emissions for all modes of transport except for Road Transportation:

- Domestic Aviation by 96%;
- Railways by 87%;
- Pipeline Transport by 74%;

– Water-born Navigation by 1997, emissions dropped to zero due to the lack of separate statistical data on river navigation.

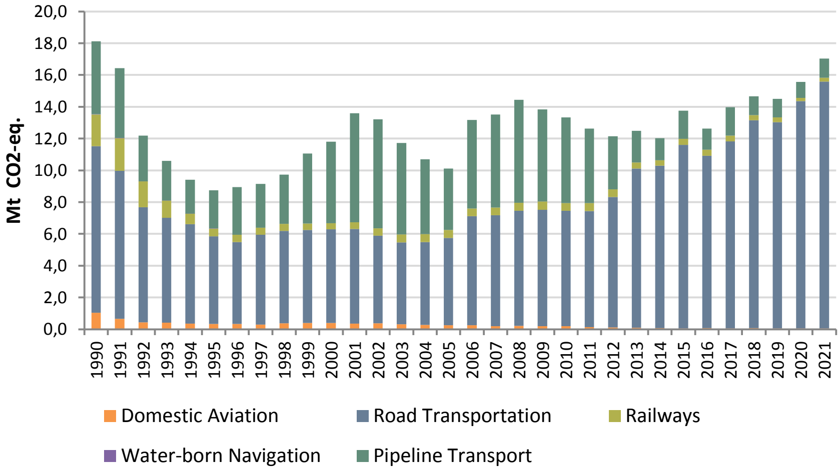

Figure 3.2.4.5 GHG trends from various modes of transport

The reason for reduced emissions from aviation and rail transport is the targeted implementation of the following measures, leading to reduced fuel consumption:

– maintaining the transport fleet in technically sound condition;
– renewal of the transport fleet;
– systematic transition of railway transport to electric traction;
– decrease in the number of domestic air flights relative to the 1990 level.

The decrease in GHG emissions during pipeline maintenance is due to a decrease in natural gas transportation volumes, fuel and energy saving measures, introduction of automation systems, replacement and reconstruction of obsolete technical equipment.

The 48% increase in emissions from road transport over the study period is due to a significant increase in the transport fleet. Measures on technical renewal of motor vehicles, conversion of a significant number of vehicles to gas fuel (mainly trucks and public transport) contribute to curbing the growth of emissions.

Methodology

Greenhouse gas emissions (carbon dioxide, methane and nitrous oxide) from category 1.A.3 Transport were estimated using Tier 1 methodology in accordance with the 2006 IPCC methodologies for national civil aviation (1.A.3.a), road transport (1.A.3.b), rail transport (1.A.3.c), water transport not involved in international transport (1.A.3.d), and other modes of transport (pipeline transport) (1.A.3.e).

Activity data

The volumes of final fuel consumption for the main types of transport (aviation, road, rail, pipelines) for 2018-2021, provided by the Statistics Agency, included in the structure of the fuel balance, were used as activity data. The balance includes the following types of fuel used in transport: motor gasoline, diesel fuel, compressed natural gas, propane-butane mixture.

Currently, the collection of detailed data on fuel consumption in the Road Transport subcategory has begun, which enables further refinement of emission estimates.

Data on fuel consumption by the main modes of transport included in the country’s fuel balance (million cubic meters of natural gas, thousand tons for other types of fuel) are of limited dissemination, therefore they are not provided in this report.

Emission factors

The IPCC default emission factors for the relevant fuel types given in Tables 3.2.18 and 3.2.19 were used in the calculations.

Uncertainties and time series consistency

The *activity data uncertainty* is assumed to be ±5% (IPCC Guidelines 2006, Chapter 2, Vol. 2, Table 2.15, p.2.44).

Default emission factor uncertainties are calculated based on data for all types of fuel in Tables 1.2 and 1.3, Vol.2, Introduction chapter of the 2006 IPCC Guidelines and are about ±5% for CO_2, ±75% for CH_4, and ±100% for N_2O.

Combined uncertainty for fossil fuels in category 1.A.3 “Transport” was about ±7.1% for CO_2, ±75.2% for CH_4 and ±316% for N_2O.

The same calculation method and similar data sets were used for all years.

Quality assurance/Quality control

Tier 1 QA/QC procedures were applied to category 1.A.3 Transport:

- information on the selection of activity data and emission factors is documented;
- for category 1.A.3 Transport, the correctness of the formulas and units of measurement used for the entire time series was verified;
- homogeneity of the data entered and methods used for the entire time series was verified.

Planned improvements

The following improvements are planned in the Transport category:

- Detailed activity data in the Road Transport subcategory;
- Detailed and refined activity data in the Civil Aviation category;
- Collection of detailed data on fuel consumption in the Water transport subcategory.

It is planned to develop national emission factors for all fuel types, in particular, establishing the carbon content of fuels to transit to a Tier 2 methodology.

3.2.5 Comparison of national estimates of CO_2 emissions from activities related to fuel combustion with data from the International Energy Agency

To assess the accuracy of the estimates of carbon dioxide emissions from activities related to fuel combustion obtained during the current inventory, they were compared with similar data from the International Energy Agency (IEA).

Results of the comparison are given in Table 3.2.5.1.

Table 3.2.5.1 Comparison of the current inventory results with IEA data on CO_2 emissions from Fuel Combustion Activities, Mt

Years	Uzbekistan		IEA	Difference	
	Reference	Sectoral		Reference	Sectoral
1990	112.7	108.2	118.9	5.5%	9%
1995	102.8	97.9	95.0	7.6%	3%
2000	121.1	106.1	120.5	0.5%	12%
2005	112.9	96.8	112.7	0.2%	14%
2010	115.0	94.8	120.4	4.7%	21%
2015	100.6	88.2	94.3	6.3%	7%
2016	100.6	90.7	100.4	0.2%	10%
2017	102.7	88.6	105.0	2.2%	16%
2018	110.0	99.2	108.5	1.4%	9%
2019	113.3	96.5	112.7	0.5%	15%
2020	114.9	98.7	-	-	-
2021	123.8	112.3	-	-	-

A comparative analysis of estimates of sectoral CO_2 emissions from fuel combustion activities showed that the obtained national estimates of CO_2 emissions from fossil fuel combustion are 3-21% less than IEA data for different years. The reasons for the differences in estimates of total CO_2 emissions from fuel combustion are likely due to differences in the values of the emission factors used, as well as differences in activity data sets.

A comparative analysis of estimates obtained by the reference method showed better convergence with the IEA data, especially for the period 2016-2019.

3.3 Fugitive fuel emissions (1.B category)

Category overview

Uzbekistan has significant fossil fuel energy reserves, of which around 70% is natural gas. About 60% of the country's territory has potential oil and gas resources. Uzbekistan currently ranks 8th in the world in natural gas production. The country produces about 55 billion m^3 of natural gas annually.

In 2019, the country implemented a large-scale restructuring of the oil and gas system to reduce unnecessary intermediate links in the management system. Uzbekneftegaz JSC is part of the Ministry of Energy of the Republic of Uzbekistan. It includes oil and gas producing and processing organizations that have been transformed into structural subdivisions of Uzbekneftegaz JSC in the following areas: Hydrocarbon production, Oil and Gas processing, Transportation and storage of Oil Products, Oil and Gas exploration and Services. Uztransgaz JSC was separated from Uzbekneftegaz JSC and designated as a single operator for the purchase of natural gas from producing organizations for further transportation, including export and import, as well as sales to consumers. Khududgaztaminot JSC was established on the basis of territorial gas supply branches of Uztransgaz JSC to operate gas distribution networks and supply natural and liquefied gas to the population and social facilities.

Uzbekistan's Oil and Gas industry has its own refining base. Oil and gas condensate are refined mainly at three refineries: Fergana Oil Refinery, Bukhara Oil Refinery and Chinaz Oil Refinery. The main function of the refineries is to process oil into gasoline, aviation kerosene, residual fuel oil, diesel fuel, lubricating oils, lubricants, bitumen, petroleum coke, and raw materials for petrochemicals. Oil products received at refineries are delivered to consumers through a network of tank farms.

Five plants: Mubarek GPP, Shurtan Oil and gas production department (OGPD) and Shurtan GCC, Ustyurt GCC and Kandym GCC process natural gas, dehydrating and purifying it from acidic components to produce commercial gas, gas condensate, liquefied gas and sulphur and polymer raw materials.

The Mubarek GPP is one of the world's largest gas processing plants and is designed to process 30 billion m^3 of Gas annually. The plant produces several types of products: commercial gas, gas condensate, liquefied gas and industrial sulphur.

The production capacity of the Shurtan OGPD is about 20 billion m^3 of gas. It also specializes in the production of commercial gas, gas condensate, liquefied gas, propane-butane mixture and industrial sulphur.

The Shurtan Gas Chemical Complex processes sour natural gas and produces polyethylene, commercial gas, liquefied gas, stable gas condensate, industrial sulphur and polyethylene products.

The Ustyurt Gas Chemical Complex processes natural gas and unstable gas condensate to produce commercial gas, high-density polyethylene, polypropylene, pyrolysis distillate, pyrolysis oil and tar products.

Natural gas is exported to Kazakhstan, Kyrgyzstan, Tajikistan and China. Uzbekistan has a developed gas infrastructure, including main gas pipelines, low and medium pressure networks, special underground gas storage facilities (UGSF): Khadjaabad, Sokh and Gazli. The length of main gas networks is over 13 thousand kilometers and they are serviced by 24 compressor stations. In total, the system operates 248 gas compressor units.

Uztransgaz Joint Stock Company performs transportation and transit of natural gas to consumers through the main gas pipeline system. As of 2017, Uztransgaz JSC services more than 13 thousand kilometers of main gas pipelines and includes 23 compressor units. In total, the system operates 237 gas compressor units. Gas transportation goes through main gas pipeline departments and underground gas storage stations in the northern, southern and eastern directions, which ensure natural gas supply to consumers of the Republic of Uzbekistan, for export and transit.

Due to limited production volumes, oil is used in Uzbekistan to supply the national refineries. The maximum production volume was about 7 million tons. But domestic oil is not enough against the growing needs of the economy and population, hence oil has to be imported.

Uzbekistan’s oil and gas industry is the largest source of GHGs - it accounts for about 1/3 of all emissions in the country. The largest volumes of GHGs, amounting to 99%, are generated during gas transportation and distribution. This is due to the fact that in order to maintain the gas transportation process in the operating mode, mandatory technological operations are required that involve purging (venting) of the gas transportation system., Leakages through sealing elements of fittings and pipe microfissures are also possible in the gas transportation system, mainly due to corrosion of pipelines and use of obsolete equipment, in particular, shut-off valves.

This inventory-taking covers GHG emissions *from enterprises that are part of Uzbekneftegaz JSC alone*. GHG emissions from the activities of joint ventures with foreign companies - Kandym GPC (Lukoil Uzbekistan Operating Company, Bukhara region), JV Uz-Kor Gas Chemical LLC (consortium of Korean companies Kor-Uz Gas Chemical Investment Ltd., Republic of Karakalpakstan) - have not been estimated.

Uzbekistan has proven coal reserves of 1.9 billion tons, and about 70% of all coal reserves are lignite or brown coal. Coal is mined at three deposits: Angren (Tashkent region, lignite), where about 80% of all coal is produced, Shargun and Baysun (Surkhandarya region, hard coal). All the coal produced is consumed domestically. The main consumer of coal fuel is the power sector, which accounts for about 90% of total coal consumption and 100% of gas from underground coal gasification. About 4 million tons of coal is produced annually. Institutionally, JSC Uzbekugol JSC and Shargunugol JSC are part of Uzbekistan Temir Yollari JSC [12].

Fugitive methane emissions from coal mining are insignificant, as the main volume of coal is produced by surface method.

"Fugitive Fuel Emissions" 1.B category include estimates of CH_4, CO_2, N_2O, NMVOCs, SO_2 emissions from natural gas production, processing, transportation and oil production, as well as CH_4 emissions from coal mining. Emissions were estimated in the following subcategories:

- 1.B.1.a Coal Mining and Processing;
- 1.B.2.a Oil;
- 1.B.2.b Natural gas.

3.3.1 Trends in fugitive GHG emissions in the "Fugitive fuels emissions" category

Table 3.3.1.1 represents changes in fugitive emissions for selected GHGs in the "Fugitive Fuel Emissions" category, which includes the "Coal Mining and Processing," "Oil," and "Natural Gas" subcategories for the period 1990-2021.

Table 3.3.1.1 GHG emissions in the "Fugitive fuel emissions" category, Gg CO_2-eq.

Years	CH_4	CO_2	N_2O	Total	Years	CH_4	CO_2	N_2O	Total
1990	16808.26	890.26	1.33	**17699.84**	2007	28379.06	1316.96	2.39	**29698.41**
1991	17261.67	917.99	1.35	**18181.01**	2008	29157.80	1336.46	2.40	**30496.66**
1992	18022.90	931.57	1.48	**18955.95**	2009	27999.23	1286.86	2.30	**29288.39**
1993	20419.77	995.46	1.70	**21416.93**	2010	26828.88	1225.16	2.07	**28056.12**
1994	22042.58	1102.62	2.13	**23147.34**	2011	25734.95	1187.11	1.95	**26924.02**
1995	24710.14	1300.61	2.84	**26013.60**	2012	25223.20	1212.15	1.97	**26437.32**
1996	25024.96	1305.44	2.86	**26333.26**	2013	23083.52	3543.02	1.98	**26628.52**
1997	25663.91	1317.37	2.95	**26984.23**	2014	21891.08	1130.24	1.62	**23022.95**
1998	26859.04	1346.46	3.04	**28208.53**	2015	21997.47	1107.55	1.67	**23106.69**
1999	27336.64	1354.55	3.06	**28694.25**	2016	22283.34	1063.74	1.63	**23348.72**
2000	27359.59	1350.91	2.91	**28713.42**	2017	22628.50	1055.93	1.67	**23686.11**
2001	27432.17	1374.79	2.84	**28809.81**	2018	24265.17	1019.81	1.69	**25286.67**
2002	28183.36	1384.88	2.87	**29571.11**	2019	23980.98	964.62	1.69	**24947.29**
2003	27707.08	1384.59	2.85	**29094.52**	2020	20394.33	869.00	1.50	**21264.84**
2004	27907.29	1362.48	2.73	**29272.49**	2021	22110.72	880.93	1.56	**22993.21**
2005	26908.66	1300.85	2.41	**28211.92**	**Δ $_{(1990-2021)}$**	**+31.55%**	**-1.00%**	**+17.29%**	**+29.91%**
2006	28002.18	1344.81	2.47	**29349.46**	**%. $_{2021}$**	**96.17%**	**3.82%**	**0.01%**	**100.00%**

The major contributor to the Fugitive fuel emissions category in 2021 was methane (96.2%), with carbon dioxide accounting for 3.8% and nitrous oxide accounting for thousandths of a percent.

Table 3.3.1.2 presents the changes in fugitive GHG emissions by major subcategories for the period 1990-2021.

12 Decree of the President of the Republic of Uzbekistan PP-3380 dated 8.11.2017 "On organizational measures for transfer of Uzbekugol JSC and Shargunkumir JSC under the structure of Uzbekistan Temir Yullari and financial rehabilitation of coal industry enterprises".

Table 3.3.1.2 Fugitive GHG emissions by subcategory, Gg CO_2-eq.

Year	Coal mining	Oil	Natural gas	Total	Year	Coal mining	Oil	Natural gas	Total
1990	370.02	2818.69	14511.14	**17699.84**	2007	139.30	5207.71	24351.40	**29698.41**
1991	334.06	2839.46	15007.50	**18181.01**	2008	145.53	5127.14	25224.00	**30496.66**
1992	292.32	3300.77	15362.86	**18955.95**	2009	151.79	4843.30	24293.30	**29288.39**
1993	274.25	4008.80	17133.88	**21416.93**	2010	109.24	4043.81	23903.06	**28056.12**
1994	216.22	5526.37	17404.74	**23147.34**	2011	96.96	3742.87	23084.19	**26924.02**
1995	204.79	7597.77	18211.03	**26013.60**	2012	86.33	3823.62	22527.37	**26437.32**
1996	203.60	7632.82	18496.83	**26333.26**	2013	95.52	3171.69	23361.31	**26628.52**
1997	178.66	7902.28	18903.29	**26984.23**	2014	130.22	2871.08	20021.65	**23022.95**
1998	208.04	8115.30	19885.20	**28208.53**	2015	116.79	3119.60	19870.30	**23106.69**
1999	193.63	8156.23	20344.39	**28694.25**	2016	135.67	2980.72	20232.33	**23348.72**
2000	180.45	7546.31	20986.65	**28713.42**	2017	127.66	3172.42	20386.03	**23686.11**
2001	188.32	7222.85	21398.64	**28809.81**	2018	149.11	3131.28	22006.29	**25286.67**
2002	158.63	7244.06	22168.42	**29571.11**	2019	165.94	3261.51	21519.85	**24947.29**
2003	132.03	7179.62	21782.87	**29094.52**	2020	174.80	3013.54	18076.49	**21264.84**
2004	164.26	6626.49	22481.75	**29272.49**	2021	198.57	3106.67	19687.97	**22993.21**
2005	98.81	5456.49	22656.61	**28211.92**	$\Delta_{(1990-2021)}$	**-46.3%**	**+10.2%**	**+35.7%**	**+29.9%**
2006	154.81	5541.03	23653.63	**29349.46**	**%. $_{2021}$**	**0.9%**	**13.5%**	**85.6%**	**100.0%**

The dynamics of fugitive GHG emissions is mainly determined by the dynamics of methane emissions from gas systems, which account for 85.6%. By 2021, total Fugitive fuel emissions increased by 29.9%, including:

– Oil - by 10.2%;
– Natural gas - by 35.7%.

Fugitive emissions from coal mining decreased by 46.3% by 2021 due to a reduction in coal production compared to 1990 levels.

Growth of fugitive emissions for 1990-2021 is due to an increase in natural gas and oil production over the period under review. After 2008, there was a gradual decrease in fugitive emissions from oil and gas systems, which is associated with a decrease in oil production, a reduction in natural gas transportation, as well as measures taken to reduce leaks in the oil and gas industry (Figure 3.3.1.1).

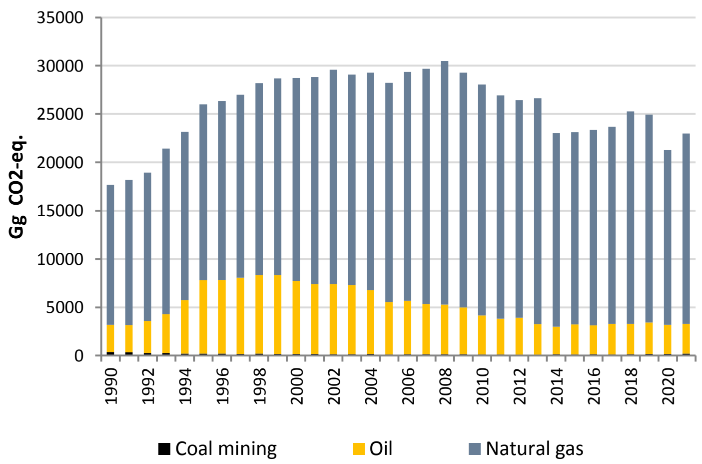

Figure 3.3.1.1 Trends in fugitive GHG emissions in the category "Fugitive Emissions from Fuels"

Emissions of gases with an indirect greenhouse effect (NMVOCs and SO_2 in the category "Fugitive emissions from fuel" are estimated only for the categories "Oil" and "Natural gas". Emissions of gases with an indirect greenhouse effect in the category "Coal" were not assessed. Changes in emissions of NMVOCs and SO_2 are presented in table 3.3.3 and figure 3.3.3.

Table 3.3.4 Emissions of gases with an indirect greenhouse effect from Oil and Natural Gas, Gg

Years	NMVOCs	SO_2	Years	NMVOCs	SO_2
1990	159.55	133.93	2007	291.34	41.91
1991	161.23	125.76	2008	289.43	53.72
1992	182.72	105.56	2009	275.38	57.99
1993	217.49	91.71	2010	237.72	68.62
1994	288.64	83.31	2011	221.79	81.08
1995	389.14	72.87	2012	224.12	85.12
1996	391.33	59.20	2013	193.55	89.27
1997	405.13	63.22	2014	173.86	88.57
1998	417.08	63.56	2015	185.35	93.52
1999	419.63	62.21	2016	179.74	93.50
2000	392.2	59.57	2017	188.81	104.03
2001	377.84	57.37	2018	190.39	103.71
2002	380.63	49.47	2019	195.42	103.42
2003	377.36	42.57	2020	176.49	102.42
2004	353.32	38.70	2021	183.47	103.42
2005	299.33	35.17	Δ (2021-1990	**+15.0%**	**-22.8%**
2006	305.13	37.02			

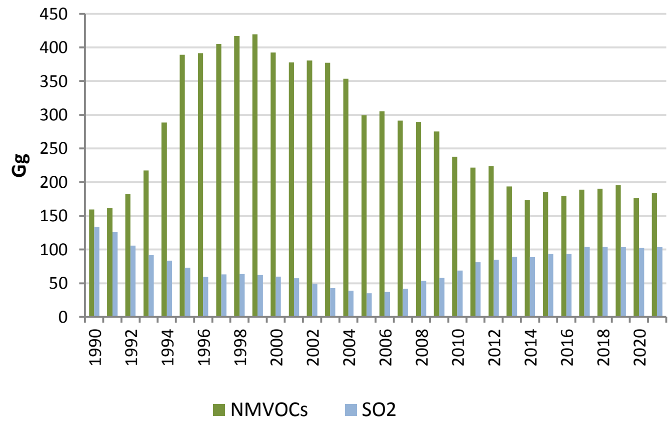

Figure 3.3.3 Trends in indirect greenhouse gases from Oil and Gas

In 2021, NMVOCs emissions amounted to 183.47 Gg, SO_2 emissions - 103.42 Gg. Over the period 1990-2021, NMVOCs emissions increased by 15%, and SO_2 emissions decreased by 22.8%. Changes in the dynamics of emissions for these gases correspond to the dynamics of production, processing and transportation of natural gas, as well as the oil refining and transportation.

3.3.2 Comparison of emission estimates obtained in the current inventory with estimates of the International Energy Agency for the category Fugitive Emissions from Fuel

The results obtained from estimating emissions in the current inventory were compared with estimates of the International Energy Agency (www.iea.org) and showed good agreement with them. This is explained by the use of almost the same set of input data and default IPCC average coefficients. The results are shown in Table 3.3.2.1 and Figure 3.3.2.1

Table 3.3.2.1 Comparison of the results of the current inventory with IEA data on Fugitive fuel emissions, Mt CO_2-eq.

Years	Uzbekistan	IEA	Difference	Year	Uzbekistan	IEA	Difference
1990	17.7	18.0	1.7%	2016	23.3	22.4	4.0%
1995	26.0	23.3	11.6%	2017	23.7	22.3	6.3%
2000	28.7	26.8	7.1%	2018	25.3	25.5	0.8%
2005	28.2	30.7	5.2%	2019	24.9	25.5	2.4%
2010	28.1	29.2	3.8%	2020	21.3	-	-
2015	23,1	22.0	5.0%				

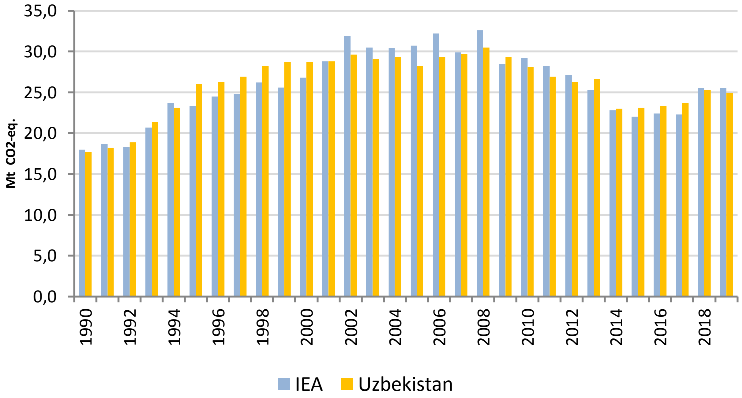

Figure 3.3.2.1 Comparative assessment of emissions by the IEA and Uzbekistan in the category "Fugitive emissions from fuel"

3.3.3 Coal Mining and Handling (1.B.1.a category)

Description of category

Subbituminous coal in Uzbekistan is mined in open-pits at the Angren deposit (Tashkent region), and bituminous coal is mined at the Shargun and Baysun deposits (Surkhandarya region).

The main consumer of coal fuel is the Energy sector, which accounts for over 85% of total coal consumption. The demand for solid fuel is also generated by industrial enterprises, social and municipal spheres, and the population.

Fugitive methane emissions were estimated in this category by type of coal mining:

- 1.B.1.a.i – underground mines;
- 1.B.1.a.ii – surface mines.

Methane emissions from coal mining in 2021 totaled 198.57 Gg.

Methane emissions from Coal Mining and Handling category for the period 1990-2021 are presented in Table 3.3.3.1 and Figure3.3.3.1.

Table 3.3.3.1 Methane emissions from Coal Mining, Gg CO_2-eq.

Years	Underground			Surface			Total
	Mining	Later stages	Sum	Mining	Later stages	Sum	
1990	214.67	29.81	244.48	115.88	9.66	125.53	**370.02**
1991	191.75	26.63	218.39	106.77	8.90	115.67	**334.05**
1992	178.49	24.79	203.28	82.19	6.85	89.04	**292.32**
1993	179.39	24.92	204.31	64.56	5.38	69.94	**274.25**
1994	124.22	17.25	141.47	69.00	5.75	74.75	**216.22**
1995	129.64	18.01	147.65	52.74	4.39	57.14	**204.79**
1996	132.96	18.47	151.43	48.16	4.01	52.17	**203.60**
1997	107.33	14.91	122.24	52.08	4.34	56.42	**178.66**
1998	134.77	18.72	153.49	50.35	4.20	54.55	**208.03**
1999	121.20	16.83	138.04	51.31	4.28	55.59	**193.63**
2000	119.99	16.67	136.66	40.42	3.37	43.79	**180.45**
2001	121.20	16.83	138.04	46.41	3.87	50.28	**188.31**
2002	92.86	12.90	105.76	48.80	4.07	52.87	**158.63**
2003	84.72	11.77	96.49	32.80	2.73	35.54	**132.02**
2004	98.89	13.73	112.63	47.66	3.97	51.63	**164.26**
2005	31.36	4.35	35.71	58.25	4.85	63.10	**98.81**
2006	85.75	11.91	97.66	52.75	4.40	57.15	**154.81**
2007	68.62	9.53	78.15	56.44	4.70	61.15	**139.30**
2008	68.02	9.45	77.46	62.83	5.24	68.06	**145.53**
2009	73.14	10.16	83.30	63.22	5.27	68.48	**151.79**
2010	33.86	4.70	38.56	65.24	5.44	70.67	**109.24**

Table 3.3.3.1 continuation

Years	Underground			Surface			Total
	Mining	Later stages	Sum	Mining	Later stages	Sum	
2011	18.03	2.50	20.53	70.55	5.88	76.43	**96.96**
2012	8.05	1.12	9.17	71.22	5.93	77.16	**86.33**
2013	6.06	0.84	6.90	81.81	6.82	88.62	**95.52**
2014	32.32	4.49	36.81	86.22	7.18	93.41	**130.22**
2015	38.29	5.32	43.61	67.56	5.63	73.19	**116.79**
2016	48.24	6.70	54.94	74.52	6.21	80.73	**135.67**
2017	37.23	5.17	42.41	78.69	6.56	85.25	**127.66**
2018	54.57	7.58	62.15	80.27	6.69	86.96	**149.11**
2019	72.93	10.13	83.06	76.50	6.37	82.88	**165.94**
2020	79.51	11.04	90.55	77.77	6.48	84.26	**174.80**
2021	82.94	11.52	94.46	96.10	8.01	104.11	**198.57**
Δ (1990-2021)			**-61.4%**			**-17.2%**	**-46.4%**

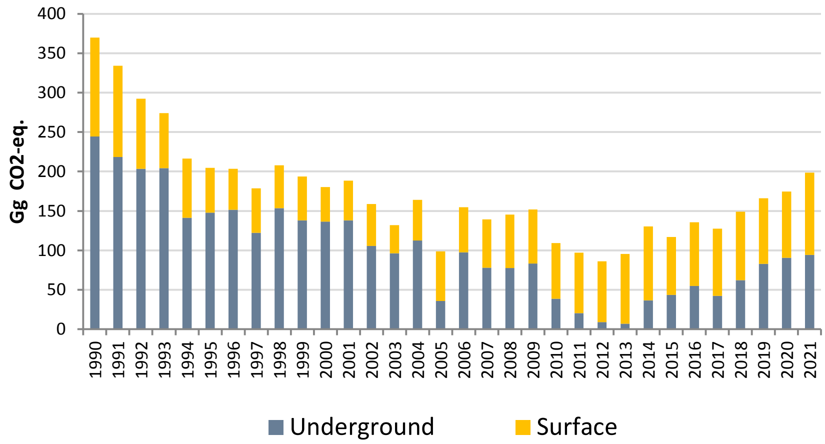

Figure 3.3.3.1 Trends in methane emissions from coal mining

For the period 1990-2021 there is a general decrease in methane emissions from coal mining and processing by 46.4%, including from underground mining - by 61.4%; when open - by 17.2%. The minimum emissions were observed in 2012, the maximum in 1990. The trajectory of methane emissions is proportional to the dynamics of bituminous and subbituminous coal production.

Methodology

CH_4 emissions from coal mining were estimated in accordance with the IPCC methodology 2006, Tier 1. The resulting methane emission was determined as the product of coal mining (processing) and the corresponding emission factors.

Calculation of methane emissions from coal mining (underground mines and surface mines) was carried out according to equation 4.1.3 (IPCC Guidelines, 2006, Vol. 2, p. 4.13) using default IPCC coefficients.

Calculation of methane emissions after coal mining was carried out according to equation 4.1.4 (IPCC Guidelines, 2006, Vol. 2, p. 4.14) using default IPCC coefficients.

Emissions from other sources of the coal industry are not included in this inventory due to the lack of necessary activity data. It is expected to further include in the inventory categories 1.B.1.a.i.3 "Abandoned underground mines", 1.B.1.a.i.4 "Faring of diverted methane or conversion of methane to CO_2" and 1.B.1.b "Uncontrolled combustion and burning coal dumps".

Activity data

Data on coal mining for both surface and underground for 2018-2021 are provided by the Agency for Statistics under the President of the Republic of Uzbekistan. Dynamics of hard (bituminous) and brown (sub-bituminous) coal production for 1990-2021 presented in Figure 3.3.3.2. Hard coal is mined in Uzbekistan using the open pit method, and brown coal is mined using the open pit method.

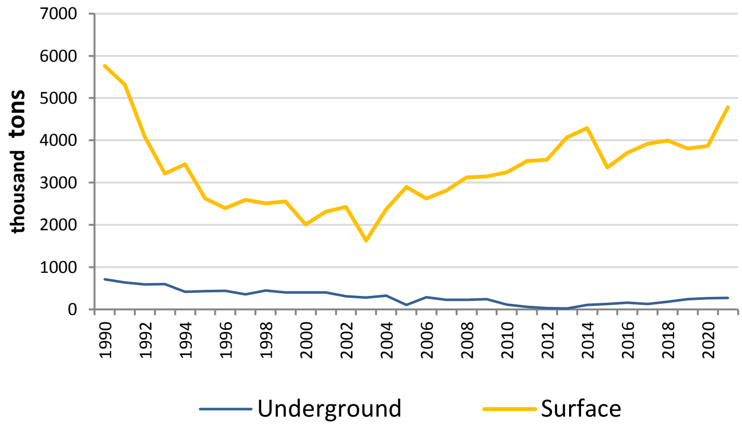

Figure 3.3.3.2 Coal production for 1990-2021

The largest contribution to coal production in the country comes from brown coal mining. After 1990, there was a significant reduction in brown coal production associated with the economic crisis after the collapse of the USSR. From the beginning of the 200s, a gradual increase in coal production began.

In recent years, the main factor in the development of the coal industry has been the feasibility of replacing energy resources such as natural gas and petroleum products used in the production of electricity on the domestic market.

Emission factors

In accordance with good practice recommendations the calculations used average *default* emission factors (Table3.3.3.2) in accordance with section 4.1.3.2 T.2 of the IPCC Guidelines, 2006, pp. 4.13 – 4.14.
A default conversion factor of 0.67 Gg CH_4/million m^3 was used to convert the CH_4 volume to a weight category.

Table 3.3.3.2 Methane emission factors from coal mining, m^3/ton

Activity	Method	
	Underground	Surface
Production	18.0	1.2
Subsequent activities	2.5	0.1

Uncertainties and sequence of time series

The uncertainty of CH_4 emissions from coal mining in 1.B.1.a.i “Underground coal mining” and 1.B.1.a.ii “Surface mines” categories is estimated in accordance with IPCC Guidelines, 2006.

Activity data uncertainty was ±2% by default (for default mining) and ±5% for downstream processing stages.

Uncertainty of coal mining emission factors was ± 200% (default).

Uncertainty of emission factors for coal processing was ± 300% (default).

Combined uncertainty in coal mining was ±200%.

Combined uncertainty in coal processing was ±300%.

The same method and similar data sets were used for all years.

Quality Assessment / Quality Control

QA/QC procedures were performed in accordance with general QA/QC principles and the QA/QC plan. The verification of the following has been conducted:

- emission source documentation,
- data for mechanical errors,
- all links to information sources for baseline data in the Software.

Recalculations by category

Recalculations in the category “Coal mining and processing” relative to the estimates presented in the First Biennial Report were not carried out.

Planned improvements by category

As part of the next inventory, it is planned to clarify the coal mining technology, the depth of coal seams and, based on these data, clarify the emission coefficients. It is also planned to assess methane emissions from closed coal mines and emissions from flaring of diverted methane. For open-pit coal mining: estimate associated gas emissions after the mining phase and emissions from uncontrolled burning and combustion of coal deposits.

3.3.4 Oil (1.B.2.a category)

Description of category

Proven oil reserves in the country amount to only about 530 million tons, gas condensate - 480 million tons, and these volumes are distributed among over 200 oil, oil and gas and oil and gas condensate fields.

Oil fields have been explored in the Karakalpak Autonomous Republic and six administrative regions: Kashkadarya, Bukhara, Surkhandarya, Namangan, Andijan and Fergana. The main volume of reserves is concentrated in the Kashkadarya region, primarily within the country's largest Kokdumalak field. The development of the border Kokdumalak field (over 50% of the reserves are concentrated on the territory of Turkmenistan) is carried out in accordance with the intergovernmental Agreement between Uzbekistan and Turkmenistan, signed in March 1997. The main volume of oil production is provided through the development of fields in southwestern Uzbekistan (Kokdumalak, Shurtan, South Tandircha, etc.). In addition, there are more than 500 small oil production facilities in the country with an average flow rate of 1-2 tons of oil per day. In the structure of extracted petroleum feedstock, there is a tendency to increase the share of gas condensate.

Since 2003, Uzbekistan has been importing oil from Southern Kazakhstan, Turkmenistan, Russia, Iran to ensure the operation of production facilities for oil refining (Bukhara, Fergana, Alty-Aryk refineries, as well as small refineries in the cities of Chinaz and Jarkurgan). Raw materials enter the country in railway tanks.

In the category Oil – 1.B.2.a, an assessment of emissions of methane, CO_2, N_2O and non-volatile substances was carried out by subcategories:

– 1.B.2.a.iii 2 Oil production,
– 1.B.2.a.iii 3 Oil transportation.

The calculation was performed using the IPCC 2006 methodology, Tier 1.

Due to the fact that the Concept for the development of the oil and gas industry of the Republic of Uzbekistan until 2030 assumes an increase in the production of hydrocarbon, in the future it is planned to conduct assessments of GHG emissions also in the category “Oil exploration”.

GHG emissions from “Oil” category in 2021 totaled 3,106.67 Gg CO_2-eq.

GHG emissions from “Oil” category for the period 1990-2021 are presented in Table 3.3.4.1 and Figure3.3.3.4.1.

Table 3.3.4.1 GHG emissions from “Oil” category, Gg CO_2-eq.

Years	CH_4	CO_2	N_2O	Total	NMVOCs, Gg	Years	CH_4	CO_2	N_2O	Total	NMVOCs, Gg
1990	2644.36	173.55	0.77	**2818.69**	131.98	2007	4885.12	321.15	1.43	**5207.71**	240.76
1991	2663.83	174.85	0.78	**2839.45**	132.85	2008	4809.55	316.18	1.41	**5127.13**	237.09
1992	3096.49	203.37	0.91	**3300.77**	153.71	2009	4543.3	298.67	1.33	**4843.30**	223.99
1993	3760.66	247.03	1.10	**4008.8**	186.45	2010	3793.33	249.37	1.11	**4043.81**	187.00
1994	5184.20	340.65	1.52	**5526.37**	256.42	2011	3511.05	230.79	1.03	**3742.87**	173.19
1995	7127.14	468.54	2.09	**7597.774**	351.30	2012	3586.77	235.8	1.05	**3823.62**	176.79
1996	7160.02	470.70	2.10	**7632.82**	352.92	2013	2975.23	195.59	0.87	**3171.69**	146.65
1997	7412.79	487.31	2.17	**7902.28**	365.40	2014	2693.23	177.06	0.79	**2871.08**	132.72
1998	7612.60	500.47	2.23	**8115.30**	375.16	2015	2926.35	192.39	0.86	**3119.59**	144.21
1999	7650.99	503.00	2.24	**8156.23**	377.00	2016	2796.09	183.82	0.82	**2980.72**	137.82
2000	7078.85	465.39	2.08	**7546.31**	348.78	2017	2975.91	195.64	0.87	**3172.42**	146.67
2001	6775.42	445.44	1.99	**7222.85**	333.82	2018	2937.32	193.09	0.86	**3131.28**	144.82
2002	6795.33	446.74	1.99	**7244.06**	334.87	2019	3059.49	201.12	0.90	**3261.51**	150.89
2003	6734.92	442.73	1.97	**7179.62**	332.12	2020	2826.89	185.82	0.83	**3013.54**	139.45
2004	6216.03	408.64	1.82	**6626.49**	306.43	2021	2914.23	191.58	0.85	**3106.67**	143.63
2005	5118.48	336.51	1.50	**5456.49**	252.21	Δ (1990–2021)	**+10.2%**	**+10.4%**	**+10.4%**	**+10.2%**	**+8.8%**
2006	5197.79	341.71	1.52	**5541.03**	256.16	**%. 2021**	**93.8%**	**6.2%**	**0.0%**	**100.0%**	**-**

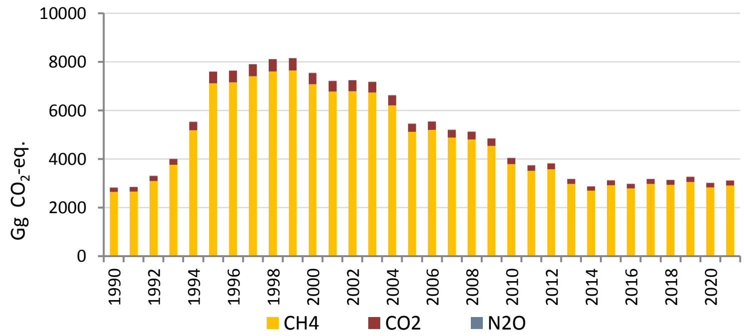

Figure 3.3.4.1 Trends in GHG emissions from "Oil" category, Gg CO_2-eq.

For the period 1990-2021 the growth of GHG emissions in the "Oil" category was 10.2%, the growth of non-vegetable substances emissions was 8.8%. Methane emissions in 2021 accounted for 93.8%, CO_2 for 6.2%, and N_2O for less than 1%. The most significant increase in GHG emissions was observed in the period 1995-2004, which is associated with an increase in oil production from small fields during this period, then GHG emissions gradually decreased due to the depletion of reserves.

Table 3.3.4.2 and Figure 3.3.4.2 show GHG emissions by assessed subcategories included in the "Oil" category.

Table 3.3.4.2 GHG emissions by subcategories of the "Oil" category

Years	Oil production	Oil transportation	Total	Years	Oil production	Oil transportation	Total
1990	2813.77	4.92	**2818.69**	2007	5207.37	0.34	**5207.71**
1991	2834.80	4.66	**2839.45**	2008	5126.67	0.47	**5127.13**
1992	3297.41	3.36	**3300.77**	2009	4842.79	0.51	**4843.30**
1993	4005.36	3.43	**4008.80**	2010	4043.41	0.40	**4043.81**
1994	5523.39	2.98	**5526.37**	2011	3742.21	0.66	**3742.87**
1995	7597.17	0.60	**7597.77**	2012	3823.32	0.30	**3823.62**
1996	7632.22	0.60	**7632.82**	2013	3171.44	0.25	**3171.69**
1997	7901.58	0.67	**7902.28**	2014	2870.95	0.13	**2871.08**
1998	8114.86	0.44	**8115.30**	2015	3119.45	0.15	**3119.60**
1999	8155.92	0.31	**8156.23**	2016	2980.49	0.23	**2980.72**
2000	7546.10	0.21	**7546.31**	2017	3172.19	0.22	**3172.42**
2001	7222.67	0.18	**7222.85**	2018	3130.93	0.35	**3131.28**
2002	7243.70	0.36	**7244.06**	2019	3261.00	0.51	**3261.51**
2003	7178.61	1.01	**7179.62**	2020	3013.00	0.55	**3013.54**
2004	6625.87	0.62	**6626.49**	2021	3106.45	0.21	**3106.67**
2005	5456.30	0.19	**5456.49**	Δ (1990–2021)	**+10.4%**	**-95.6%**	**+10.2%**
2006	5540.72	0.31	**5541.03**	**%. 2021**	**99.99%**	**0.01%**	**100.00%**

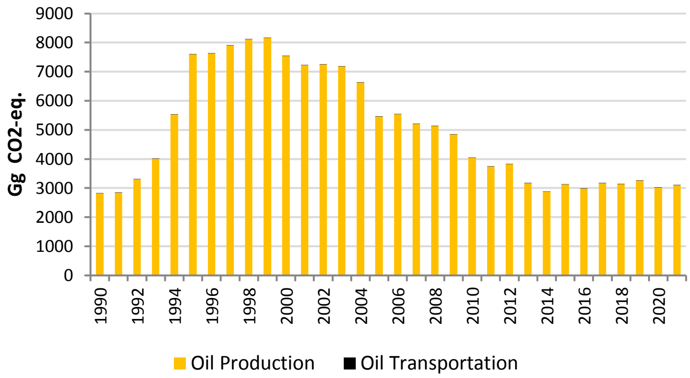

Figure 3.3.4.2 Trends in GHG emissions by subcategory of the "Oil" category

The share of GHG emissions from oil production accounts for 99.9% of emissions, the contribution of the subcategory "Oil transportation" is 0.01%. For the period 1990-2021 in the subcategory "Oil production" there is an increase in emissions, which amounted to 10.4%.

GHG emissions from oil transportation decreased over the same period by 96%, this is explained by a significant decrease in oil imports compared to the early 90s, which is associated with changes in interstate economic relations after the collapse of the USSR.

Recalculations for the “Oil” category

In the “Oil” category, recalculations were made relative to the previously received data from the First Biennial Report. The need for recalculation was caused by clarification of data on activities in the subcategory “Oil production” and correction of identified errors in calculations when converting thousand tons of oil into cubic meters. The results of the recalculation are given in table 3.3.4.3.

Table 3.3.4.3 Recalculation of methane emissions by category “Oil” for the period 1990-2017, Gg CO_2-eq.

Years	FNC	FBUR	Difference	Years	FNC	FBUR	Difference
1990	2818.69	1906.18	912.51	2004	6626.49	4477.72	2148.78
1991	2839.45	1920.12	919.33	2005	5456.49	3687.01	1769.48
1992	3300.77	2231.43	1069.35	2006	5541.03	3686.79	1854.24
1993	4008.78	2709.85	1298.94	2007	5207.71	3488.78	1718.93
1994	5526.37	3735.13	1791.24	2008	5127.13	3328.35	1798.78
1995	7597.77	5134.00	2463.77	2009	4843.30	2986.50	1856.79
1996	7632.82	5157.68	2475.14	2010	4043.81	2732.12	1311.69
1997	7902.28	5339.78	2562.49	2011	3742.87	2529.27	1213.60
1998	8115.30	5483.64	2631.66	2012	3823.62	2258.20	1565.42
1999	8156.23	5511.26	2644.97	2013	3171.69	2143.19	1028.50
2000	7546.31	5099.38	2446.94	2014	2871.08	1940.02	931.05
2001	7222.85	4880.19	2342.66	2015	3119.60	1845.99	1273.60
2002	7244.06	4894.72	2349.34	2016	2980.72	1769.82	1210.90
2003	7179.62	4851.39	2328.23	2017	3172.42	1872.12	1300.30

The updated estimates of GHG emissions in the Oil category are 1.5-1.7 times higher than those estimated in the First Biennial Report.

3.3.4.1 Oil production (category 1.B.2.a.iii.2)

Category description

In category 1.B.2.a. iii. 2 Oil production, emissions of CH_4, CO_2 N_2O, and NMVOCs are assessed.

GHG and NMVOCs emissions from oil production for the period 1990-2021. are presented in table 3.3.4.1.1 In 2021, GHG emissions from oil production amounted to 3,106.45 Gg CO_2-eq.

Table 3.3.4.1.1 GHG and NMVOCs emissions from Oil production, Gg CO_2-eq.

Years	CH_4	CO_2	N_2O	Total	NMVOCs, Gg	Years	CH_4	CO_2	N_2O	Total	NMVOCs, Gg
1990	2639.46	173.53	0.77	**2813.77**	130.02	2007	4884.78	321.15	1.43	**5207.37**	240.63
1991	2659.19	174.83	0.78	**2834.80**	130.99	2008	4809.08	316.18	1.41	**5126.67**	236.90
1992	3093.14	203.36	0.91	**3297.41**	152.37	2009	4542.77	298.67	1.33	**4842.79**	223.78
1993	3757.24	247.02	1.10	**4005.36**	185.08	2010	3792.93	249.37	1.11	**4043.41**	186.84
1994	5181.23	340.64	1.52	**5523.39**	255.23	2011	3510.39	230.79	1.03	**3742.21**	172.92
1995	7126.54	468.54	2.09	**7597.17**	351.06	2012	3586.47	235.80	1.05	**3823.32**	176.67
1996	7159.42	470.7	2.10	**7632.22**	352.68	2013	2974.98	195.59	0.87	**3171.44**	146.55
1997	7412.09	487.31	2.17	**7901.58**	365.13	2014	2693.10	177.06	0.79	**2870.95**	132.66
1998	7612.16	500.47	2.23	**8114.86**	374.98	2015	2926.21	192.38	0.86	**3119.45**	144.15
2000	7078.63	465.39	2.08	**7546.10**	348.70	2017	2975.68	195.64	0.87	**3172.19**	146.58
2001	6775.24	445.44	1.99	**7222.67**	333.75	2018	2936.98	193.09	0.86	**3130.93**	144.68
2002	6794.97	446.74	1.99	**7243.70**	334.73	2019	3058.99	201.11	0.90	**3261.00**	150.69
2003	6733.91	442.72	1.98	**7178.61**	331.72	2020	2826.34	185.82	0.83	**3012.99**	139.23
2004	6215.41	408.64	1.82	**6625.87**	306.18	2021	2914.01	191.58	0.85	**3106.45**	143.55
2005	5118.29	336.50	1.50	**5456.30**	252.13	**Δ (1990-2021)**	**+10.4%**	**+10.4%**	**+10.4%**	**+10.4%**	**+10.4 %**
2006	5197.48	341.71	1.52	**5540.72**	256.03	**%. 2021**	**93.80%**	**6.20%**	**0.03%**	**100.00%**	-

Over the period 1990-2021, there was an increase in GHG emissions from oil production by 10.4%. There was an increase in GHG emissions from oil production by 10.4%. The contribution of methane to the total GHG emissions from oil production in 2021 was 93.8%, carbon dioxide - 6.2%, nitrous oxide - hundredths of a percent.

In accordance with the methodology of the 2006 IPCC Guidelines, emissions of NMVOCs were also assessed in the "Oil Production" category. Their growth for the period 1990-2021 also amounted to 10.4%.

Table 3.3.4.1.2 and Figure 3.3.4.1.1 present the distribution of GHG emissions from oil production by individual subcategories in accordance with the methodology of the 2006 IPCC Guidelines.

Table 3.3.4.1.2 GHG emissions from Oil Production by subcategory, Gg CO_2-eq.

Years	Fugitive	Flaring	Removal	Total	Years	Fugitive	Flaring	Removal	Total
1990	2571.22	169.09	73.46	**2813.77**	2007	4758.49	312.93	135.94	**5207.37**
1991	2590.43	170.36	74.01	**2834.80**	2008	4684.74	308.08	133.84	**5126.67**
1992	3013.17	198.16	86.08	**3297.41**	2009	4425.33	291.02	126.43	**4842.79**
1993	3660.10	240.70	104.56	**4005.36**	2010	3694.87	242.99	105.56	**4043.41**
1994	5047.27	331.93	144.19	**5523.39**	2011	3419.63	224.89	97.69	**3742.21**
1995	6942.29	456.55	198.33	**7597.17**	2012	3493.74	229.76	99.81	**3823.32**
1996	6974.32	458.66	199.25	**7632.22**	2013	2898.06	190.59	82.79	**3171.44**
1997	7220.46	474.84	206.28	**7901.58**	2014	2623.47	172.53	74.95	**2870.95**
1998	7415.36	487.70	211.85	**8114.86**	2015	2850.55	187.46	81.44	**3119.45**
1999	7452.87	490.13	212.92	**8155.92**	2016	2723.57	179.11	77.81	**2980.49**
2000	6895.62	453.48	197.00	**7546.10**	2017	2898.75	190.63	82.81	**3172.19**
2001	6600.07	434.04	188.56	**7222.67**	2018	2861.04	188.15	81.74	**3130.93**
2002	6619.29	435.31	189.10	**7243.70**	2019	2979.90	195.97	85.13	**3261.00**
2003	6559.81	431.40	187.41	**7178.61**	2020	2753.27	181.06	78.67	**3013.00**
2004	6054.72	398.18	172.98	**6625.87**	2021	2838.67	186.68	81.10	**3106.45**
2005	4985.96	327.89	142.44	**5456.30**	$\Delta_{(1990-2021)}$	**+10.4%**	**+10.4%**	**+10.4%**	**+10.4%**
2006	5063.10	332.97	144.65	**5540.72**	**%. 2021**	**91.4%**	**6.0%**	**2.6%**	**100.0%**

The largest contribution to GHG emissions from oil production is made by the subcategory "Fugitive emissions" - 91.4%, "Flaring" accounts for 6.0%, and "Removal" - 2.6%.

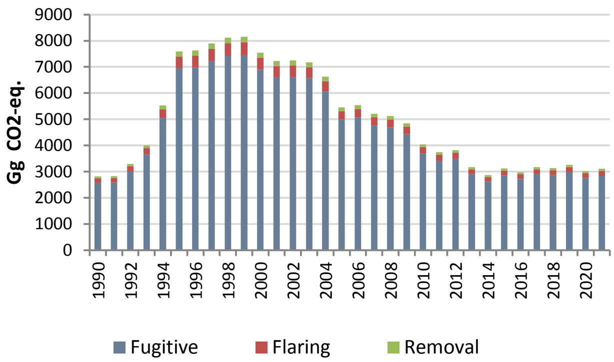

Figure 3.3.4.1.1 Trends in GHG emissions from "Oil Production"

The most significant increase in emissions in the "Oil Production" category was observed in the period 1995-2004, which is associated with the development of a large number of small fields, then, due to the depletion of reserves, there was a gradual decrease in emissions associated with a decrease in production volumes. Overall, compared to the 1990 level, GHG emissions from oil production increased by 10.4%.

Methodology

The assessment of GHG and NMVOC emissions from oil production was carried out in accordance with the "Guidelines for National Greenhouse Gas Inventories, IPCC, 2006" – Tier 1.

The resulting volume of emissions was calculated as the product of the corresponding default emission factors (Table3.3.11) by the volume of oil involved in the process using Equation 4.2.1 for each segment of the oil industry and Equation 4.2.2 for the oil industry as a whole (page 4.45, Vol.2 IPCC Guidelines 2006).

In converting thousand tons of oil into units of volume, the average density of oil for Uzbekistan = 0.884 t/m^3 (data obtained in 2019 from Uzbekneftegaz JSC) and the average density of gas condensate = 0.760 t/m^3 were used. Since the ratio of oil and gas condensate production volumes varies from year to year, but on average is close to 1:1, the densities of these products were averaged for calculations. The average oil density is assumed to be 0.822 t/m^3.

Activity data

Total production of oil and gas condensate for 2018-2021 (thousand tons) provided by the Statistics Agency and Uzbekneftegaz JSC.

Figure 3.3.4.1.2 shows oil production in the country for the period 1990-2021.

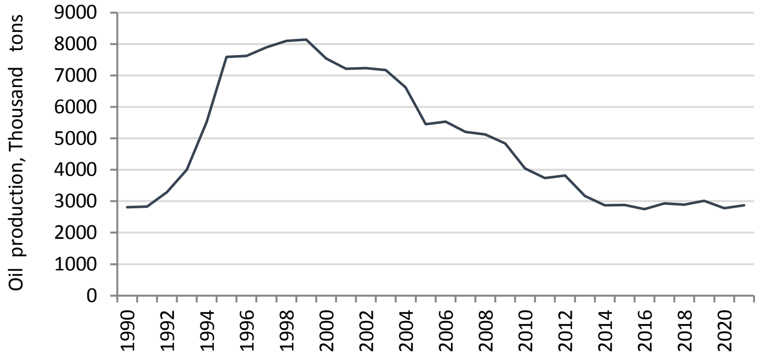

Figure 3.3.4.1.2 Total oil and gas condensate production for the period 1990-2021

The most significant growth rates in oil production were observed in the period 1990-1994, which is associated with the development of a large number of small fields, then after 2000 there was a decrease in oil production due to depletion of reserves. Over the past seven years, there has been a stabilization of the level of oil production, mainly due to the production of gas condensate.

Emission factors

To estimate GHG and NMVOC emissions in the “Oil production” category calculations, the average default factors of the 2006 IPCC Guidelines were used (Table 4.2.5, V.2, p. 4.62). The emission factors used in the calculations are summarized in Table 3.3.4.1.3.

Table 3.3.4.1.3 Emission factors for “Oil production” category

Gas	Subcategory		EF	Uncertainty, %
CH_4	Oil production	Fugitive	$3,0*10^{-2}$ Gg CH_4/ thousand cubic meters of oil produced	-12,5 to + 800
		Flaring	$2,95*10^{-5}$ Gg CH_4/ thousand cubic meters of oil produced	±75
		Removal	$8,55*10^{-4}$ Gg CH_4/ thousand cubic meters of oil produced	±75
CO_2	Oil production	Fugitive	$2,15*10^{-3}$ Gg CO_2/ thousand cubic meters of oil produced	-12,5 to + 800
		Flaring	$4,85*10^{-2}$ Gg CO_2/ thousand cubic meters of oil produced	±75
		Removal	$1,13*10^{-4}$ Gg CO_2/ thousand cubic meters of oil produced	±75
NMVOCs	Oil production	Fugitive	$3,75*10^{-2}$ Gg NMVOCs / thousand cubic meters of oil produced	-100 to + 800
		Flaring	$2,5*10^{-5}$ Gg NMVOCs / thousand cubic meters of oil produced	±75
		Removal	$5,1*10^{-4}$ Gg NMVOCs / thousand cubic meters of oil produced	±75
N_2O	Oil production	Fugitive	NA	-
		Flaring	$7,6*10^{-7}$ Gg N_2O/ thousand cubic meters of oil produced	-10 to + 1000
		Removal	NA	-

Uncertainties and sequence of time series

The uncertainty of activity data does not exceed ±2%, since statistical data was used. The uncertainties in the emission factors for direct and indirect GHG emissions from oil systems are summarized in Table 3.3.11.
The same method and similar data sets were used for all years.

Quality assessment / Quality control by category

QA/QC procedures were performed in accordance with the general QA/QC principles and the QA/QC plan. The following was verified:

- emission source documentation,
- data on mechanical errors,
- all information source links for baseline data in the Software.

Recalculations by category

Table 3.3.4.1.4 shows the differences in GHG emissions estimates obtained for the "Oil Production" category relative to the estimates of the First Biennial Update Report (FBUR).

Table 3.3.4.1.4 GHG emissions recalculation by "Oil production" category for the period 1990-2017, Gg CO_2-eq.

Years	FNC	FBUR	Difference	Years	FNC	FBUR	Difference
1990	2813.77	1853.95	959.82	2004	6625.87	4512.59	2113.28
1991	2834.80	1930.65	904.15	2005	5456.30	3716.05	1740.25
1992	3297.41	2245.73	1051.68	2006	5540.72	3773.54	1767.18
1993	4005.36	2727.88	1277.48	2007	5207.37	3546.51	1660.86
1994	5523.39	3761.74	1761.65	2008	5126.67	3491.55	1635.12
1995	7597.17	5174.10	2423.07	2009	4842.79	3298.21	1544.58
1996	7632.22	5197.97	2434.25	2010	4043.41	5139.32	-1095.91
1997	7901.58	5381.42	2520.16	2011	3742.21	4919.05	-1176.84
1998	8114.86	5526.68	2588.18	2012	3823.32	4933.37	-1110.05
1999	8155.92	5554.64	2601.28	2013	3171.44	4889.04	-1717.60
2000	7546.10	5139.32	2406.78	2014	2870.95	4512.59	-1641.64
2001	7222.67	4919.05	2303.62	2015	3119.45	3716.05	-596.60
2002	7243.70	4933.37	2310.33	2016	2980.49	3773.54	-793.05
2003	7178.61	4889.04	2289.57	2017	3172.19	2212.28	959.91

The difference in the calculations of FBUR and FNC is due to the clarification of the initial data on oil production for 2015-2017, as well as due to the correction of errors in the calculations when converting thousand tons to thousand m^3 throughout the entire time series, taking into account the significant increase in the share of gas condensate in total production oil. In general, the recalculation led to an increase in the estimated GHG emissions for this category relative to the emission data previously presented in the FBUR.

Planned improvements by category

In the future, it is planned to carry out calculations for the "Oil Production" category separately for oil and gas condensate. This requires collecting and detailing production data series from 1990 to 2013.

3.3.4.2 Oil transportation (category 1.B.2.a.iii.3)

Category description

In category 1.B.2.a. iii. 3 "Oil transportation" emissions of CH_4, CO_2 and NMVOCs are assessed. This category is included in the cadastre for the first time.

GHG and NMVOCs emissions from Oil transportation for the period 1990-2021 are presented in Table 3.3.4.2.1 and Figure 3.3.4.2.1, in 2021 the total GHG emissions by category amounted to 0.214 Gg CO_2-eq.

Table 3.3.4.2.1 GHG and NMVOCs emissions from "Oil transportation", Gg CO_2-eq.

Years	CH_4	CO_2	Total	NMVOCs,Gg	Years	CH_4	CO_2	Total	NMVOCs,Gg
1990	4.90	0.02	**4.92**	1.96	2007	0.33	0.00	**0.34**	0.13
1991	4.64	0.02	**4.66**	1.86	2008	0.47	0.00	**0.47**	0.19
1992	3.35	0.01	**3.36**	1.34	2009	0.51	0.00	**0.51**	0.20
1993	3.42	0.01	**3.43**	1.37	2010	0.40	0.00	**0.40**	0.16
1994	2.97	0.01	**2.98**	1.19	2011	0.66	0.00	**0.66**	0.26
1995	0.60	0.00	**0.60**	0.24	2012	0.30	0.00	**0.30**	0.12
1996	0.60	0.00	**0.60**	0.24	2013	0.25	0.00	**0.25**	0.10
1997	0.69	0.00	**0.69**	0.28	2014	0.13	0.00	**0.13**	0.05

Table 3.3.4.2.1 continuation

Years	CH_4	CO_2	Total	NMVOCs,Gg	Years	CH_4	CO_2	Total	NMVOCs,Gg
1998	0.44	0.00	**0.44**	0.17	2015	0.14	0.00	**0.15**	0.06
1999	0.31	0.00	**0.31**	0.12	2016	0.23	0.00	**0.23**	0.09
2000	0.21	0.00	**0.21**	0.08	2017	0.22	0.00	**0.22**	0.10
2001	0.18	0.00	**0.18**	0.07	2018	0.35	0.00	**0.35**	0.14
2002	0.36	0.00	**0.36**	0.14	2019	0.51	0.00	**0.51**	0.20
2003	1.01	0.00	**1.01**	0.40	2020	0.55	0.00	**0.55**	0.22
2004	0.62	0.00	**0.62**	0.25	2021	0.21	0.00	**0.21**	0.08
2005	0.19	0.00	**0.19**	0.08	Δ (1990-2021)	**23-fold decrease**	**23-fold decrease**	**23-fold decrease**	**23-fold decrease**
2006	0.31	0.00	**0.31**	0.12	%.2021	**99.50%**	**0.50%**	**100.00%**	-

Over the period 1990-2021, there was a 23-fold decrease in GHG and VOC emissions from oil transportation (Figure 3.3.10). The contribution of methane to the total GHG emissions from oil transportation in 2021 was 99.5%, carbon dioxide – 0.5%.

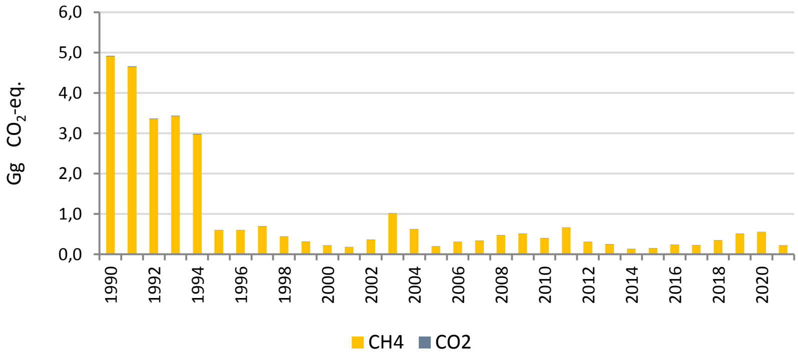

Figure 3.3.4.2.1 Trends in GHG emissions from "Oil transportation"

The highest level of emissions from oil transportation was observed in 1990-1994, then emissions sharply decreased. The high level of emissions in the early 90s is explained by large volumes of oil imports from the CIS countries to oil refineries in Uzbekistan. The sharp decrease in emissions after 1994 is explained by the transition to the supply of oil for refining, mainly for its own needs. There have been no oil imports from the country over the past ten years.

Methodology

The assessment of GHG and NMVOCs emissions from Oil transportation was carried out in accordance with the "Guidelines for National Greenhouse Gas Inventories, IPCC, 2006", Tier 1.
Emissions of methane, carbon dioxide and NMVOCs were calculated as the product of the corresponding default emission factors and the volume of petroleum involved, using Equation 4.2.1 for each segment of the oil industry and Equation 4.2.2 to obtain total emissions estimates (page 4.45, Vol.2 IPCC Guidelines 2006).
To obtain the amount of transported oil used in the calculations, the amount of import and export of oil (gas condensate) were added up.
When converting thousand tons of oil into units of volume, the average density of oil for Uzbekistan = 0.884 t/m3 (data obtained in 2019 from Uzbekneftegaz JSC) and the average density of gas condensate = 0.760 t/m3 were used. Since the ratio of oil and gas condensate production volumes varies from year to year, but on average is close to 1:1, the densities of these products were averaged for calculations. The average density value = 0.822 t/m3 was used when recalculating the entire time series from thousand tons of oil (gas condensate) to thousand cubic meters.

Activity data

The volumes of export and import of oil and gas condensate (in total) for 2018-2021, expressed in thousand tons, are presented by the Statistics Agency under the President of the Republic of Uzbekistan. The data is confidential and is therefore not included in this report.

Emission factors

To estimate GHG and NMVOC emissions in calculations for the “Oil Transportation” category, the average default coefficients of the 2006 IPCC Guidelines for the transportation of oil by rail tank cars were used (Table 4.2.5, Vol. 2, p. 4.65). The emission factors used in the calculations are given in Table 3.3.15.

Table 3.3.4.2.2 Emission factors for calculating GHG emissions from “Oil transportation”

Gas	Subcategory	EF	Uncertainty, %
CH_4	Removal	$2,5*10^{-5}$ Gg CH_4/ thousand cubic meters of oil transported by railway tanks	-50 to + 200
CO_2	Removal	$2,3*10^{-6}$ Gg CO_2/ thousand cubic meters of oil transported by railway tanks	-50 to + 200
NMVOCs	Removal	$2,5*10^{-4}$ Gg NMVOCs / thousand cubic meters of oil transported by railway tanks	-50 to + 200

Uncertainties and time series consistency

The uncertainty of activity data does not exceed ±2%, since government statistics were used.
Uncertainties in the emission factors of methane, carbon dioxide and NMVOCs from Oil transportation are given in Table 3.3.15.
Combined uncertainty is ±200%.
The same method and similar data sets were used for all years.

Quality control/quality assessment

QA/QC procedures were performed in accordance with general QA/QC principles and the QA/QC plan. Checked verification:
- documentation of emission sources,
- data on mechanical errors,
- all links to sources of information for source data in the IPCC Software.

Recalculations by category

Recalculations relative to the First Biennial Report for the category “Oil Transportation” were not carried out.

Planned improvements by category

In the future, it is planned to take into account in calculations for the “Oil Transportation” category transportation through the existing pipeline in the Andijan region. This requires collecting data for the entire time series.

3.3.5 Natural gas (1.B.2.b category)

Description of category

Emissions in the following subcategories were estimated:

1.B.2.b. iii. 2 - Gas production;

1.B.2.b. iii.3 - Gas processing

1.B.2.b. iii. 4 – Transportation and storage;

1.B.2.b. iii. 5 - Distribution.

The category estimates fugitive emissions of CH_4, CO_2, N_2O, NMVOCs in accordance with the methodology of the 2006 IPCC Guidelines, as well as SO_2 from sulphur production during gas purification from sulphur compounds. GHG emissions from flaring are accounted for in the “Gas production” and “Gas processing” subcategories. The “Gas transportation” category estimates fugitive emissions during technological purging of the gas transmission system and possible leakages of sealing elements of equipment fittings and pipelines.
Emissions of methane, carbon dioxide, nitrous oxide and other gases are estimated using average default emission factors at the individual plant level.

In 2021, GHG emissions in the Natural Gas category amounted to 19,687.97 Gg CO_2-eq.Table 3.3.5.1 presents the contribution of each GHG to total emissions under the “Natural gas” category.

Table 3.3.5.1 GHG emissions by "Natural Gas" category, Gg CO_2-eq.

Years	CH_4	CO_2	N_2O	Total	Years	CH_4	CO_2	N_2O	Total
1990	13793.88	716.70	0.55	**14 511.14**	2007	23354.64	995.81	0.96	**24 351.40**
1991	14263.78	743.14	0.57	**15 007.50**	2008	24202.73	1020.28	0.99	**25224.00**
1992	14634.09	728.19	0.57	**15 362.86**	2009	23304.15	988.19	0.97	**24 293.30**
1993	16384.86	748.43	0.60	**17 133.88**	2010	22926.31	975.79	0.96	**23 903.07**
1994	16642.16	761.97	0.61	**17 404.74**	2011	22126.95	956.32	0.92	**23 084.19**
1995	17378.21	832.07	0.75	**18 211.03**	2012	21550.11	976.35	0.92	**22 527.37**
1996	17661.34	834.73	0.76	**18 496.83**	2013	20355.68	988.34	0.88	**21 344.91**
1997	18072.46	830.05	0.77	**18 903.29**	2014	19067.64	953.18	0.83	**20 021.65**
1998	19038.40	845.99	0.80	**19 885.20**	2015	18954.33	915.16	0.81	**19 870.30**
1999	19492.02	851.55	0.81	**20 344.39**	2016	19351.59	879.93	0.81	**20 232.33**
2000	20100.29	885.52	0.83	**20 986.65**	2017	19524.93	860.30	0.80	**20 386.03**
2001	20468.44	929.35	0.85	**21 398.64**	2018	21178.74	826.72	0.83	**22 006.29**
2002	21229.40	938.14	0.88	**22 168.42**	2019	20755.55	763.51	0.79	**21 519.85**
2003	20840.14	941.86	0.88	**21 782.87**	2020	17392.637	683.18	0.67	**18 076.49**
2004	21527.01	953.84	0.90	**22 481.75**	2021	18997.921	689.35	0.70	**19 687.97**
2005	21691.36	964.34	0.91	**22 656.61**	**$\Delta_{(1990\text{-}2021)}$**	**+37.7%**	**-3.80%**	**+27.0%**	**+35.7%**
2006	22649.59	1 003.10	0.94	**23 653.63**	**%. $_{2021}$**	**96.50%**	**3.50%**	**0.00%**	**100.00%**

Table 3.3.5.1 shows that fugitive methane emissions account for 96.5% of the total emissions in the "Natural gas" category. The contribution of carbon dioxide is 3.8%. The proportion of nitrous oxide is tenths of a percent.

Table 3.3.5.2 presents indirect greenhouse gas emissions by "Natural gas" category. NMVOCs emissions occur at all stages of natural gas production, processing and transportation. The table shows the total values.

Sulphur dioxide emissions are estimated at the gas treatment stage using a national emission factor.

Table 3.3.5.2 NMVOC and SO_2 emissions by "Natural gas" category, Gg gas

Years	NMVOCs	SO_2	Years	NMVOCs	SO_2
1990	27.56	133.93	2007	50.58	41.50
1991	28.38	125.76	2008	52.34	53.35
1992	29.01	105.56	2009	51.40	57.59
1993	31.03	91.71	2010	50.72	68.22
1994	32.22	83.31	2011	48.60	80.71
1995	37.84	72.87	2012	47.32	84.70
1996	38.41	59.20	2013	46.90	88.85
1997	39.73	63.22	2014	41.14	88.15
1998	41.93	63.56	2015	41.15	93.10
1999	42.62	62.11	2016	41.92	93.08
2000	43.41	59.02	2017	42.13	103.61
2001	44.01	57.09	2018	45.57	103.29
2002	45.76	49.37	2019	44.53	103.00
2003	45.24	42.54	2020	37.04	102.00
2004	46.89	38.57	2021	39.84	103.00
2005	47.12	34.75	$\Delta_{(1990\text{-}2021)}$	**+44.6%**	**-23.1%**
2006	48,98	36,62			

Table 3.3.5.3 and Figure 3.3.5.1 summarize GHG emissions by estimated subcategories in the "Natural gas" category.

Table 3.3.5.3 GHG emissions by subcategories of the “Natural gas” category, Gg CO_2-eq.

Years	Production	Processing	Transportation	Storage	Distribution	Total	Years	Production	Processing	Transportation	Storage	Distribution	Total
1990	12494.32	1001.45	630.48	6.85	378.04	**14 511.14**	2007	20108.14	1668.34	1495.40	8.91	1070.61	**24 351.40**
1991	12837.94	1039.86	647.37	5.99	476.34	**15 007.50**	2008	20944.65	1700.19	1503.69	6.67	1068.79	**25 224.00**
1992	13120.25	1013.96	647.80	6.59	574.25	**15 362.86**	2009	20521.33	1661.99	1041.10	11.56	1057.31	**24 293.30**
1993	13804.42	1037.64	1477.47	8.05	806.31	**17 133.88**	2010	20217.87	1645.49	970.49	11.63	1057.58	**23 903.06**
1994	14462.22	1050.79	1060.51	11.82	819.4	**17 404.74**	2011	19323.73	1607.59	950.93	11.43	1190.51	**23 084.19**
1995	14905.16	1393.04	1042.65	7.27	862.91	**18 211.03**	2012	18860.88	1632.49	942.61	7.00	1084.4	**22 527.37**
1996	15015.81	1408.45	1101.85	7.18	963.54	**18 496.83**	2013	17872.02	1621.67	918.65	5.07	927.49	**21 344.91**
1997	15707.95	1396.92	863.91	7.34	927.17	**18 903.29**	2014	16601.78	1547.21	893.65	7.12	971.90	**20 021.65**
1998	16794.58	1405.95	738.78	14.08	931.8	**19 885.19**	2015	16736.65	1481.38	775.04	7.87	869.36	**19 870.30**
1999	17037.05	1417.80	880.99	11.71	996.84	**20 344.39**	2016	17205.94	1415.70	728.32	7.88	874.49	**20 232.33**
2000	17288.40	1472.72	1214.32	8.65	1002.56	**20 986.65**	2017	17362.27	1379.26	750.48	6.58	887.45	**20 386.03**
2001	17598.91	1532.16	1261.49	8.01	998.07	**21 398.64**	2018	18877.74	1327.35	828.26	4.57	968.37	**22 006.29**
2002	18295.95	1558.27	1279.26	11.76	1023.18	**22 168.42**	2019	18609.8	1215.32	871.62	3.67	819.43	**21 519.85**
2003	17797.54	1586.62	1339.99	8.03	1050.70	**21 782.87**	2020	15255.27	1095.66	794.44	6.99	924.13	**18 076.49**
2004	18522.78	1608.18	1364.76	6.78	979.24	**22 481.75**	2021	16491.74	1094.57	906.99	5.89	1188.79	**19 687.97**
2005	18613.51	1621.99	1367.97	7.86	1045.28	**22 656.61**	$\Delta_{(1990-2021)}$	**+32.0%**	**+9.3%**	**+43.9%**	**-14.0%**	**+214.5%**	**+35.7%**
2006	19403.12	1676.71	1482.20	11.51	1080.09	**23 653.63**	**%.** $_{2021}$	**83.80%**	**5.60%**	**4.60%**	**0.03%**	**6.00%**	**100.00%**

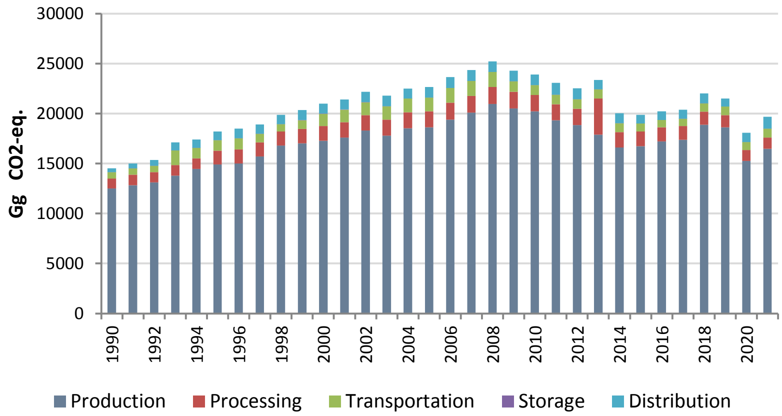

Figure 3.3.5.1 Trends in GHG emissions from “Natural Gas” category by subcategory

The above data shows that methane emissions from gas systems increased by 35,7% during 1990-2021, which is due to a increase in fugitive emissions from:

- Production by 32,0%;
- Processing by 9,3%;
- Transportation by 43,9%;
- Distribution by 214.5%.

GHG emissions from natural gas storage decreased by 14% due to a decrease in storage volumes.

The decrease in GHG emissions from gas production in recent years is explained by the gradual depletion of gas fields. Increase in emissions from transportation in 1993, 2006-2008 explained by the increase in volumes of transported gas, including transit. The reduction in emissions during processing and transportation after 2010 is associated with the transition to new technologies, including advanced processing of natural gas, and the elimination of leakages on main pipelines(including during the implementation of CDM projects)..

Methodology

Estimation of GHG emissions from Gas systems for the subcategories “Gas Production”, “Gas Processing”, “Transportation and Distribution”, “Other Leakage” was carried out in accordance with the “Guidelines for National Greenhouse Gas Inventories, IPCC, 2006”, using Equations 4.2.1 and 4.2.2.

The default average coefficients were used in the calculations (Table 4.2.5, pp. 4.59 – 4.67, Vol. 2, Chapter 4 "Fugitive emissions") –Tier 1.

Estimation of SO_2 emissions during the purification of sour gas from sulfur compounds is not provided for in the 2006 IPCC Guidelines. The calculation proposed for estimating SO_2 was carried out using the national emission factor.

Activity data

The amounts of production and processing of natural gas in thousand cubic meters were received from Uzbekneftegaz JSC and the Statistics Agency, the amounts of transportation and storage of natural gas – from Uztransgaz JSC, the amounts of distribution to consumers - from Uzgaztaminot JSC. To a large extent, activity data is confidential.

The dynamics of natural gas production in recent years has tended to decline slightly due to the gradual depletion of reserves. This is also related to the dynamics of natural gas processing. A significant increase in natural gas transportation volumes is associated with the volumes of transit gas pumping from 1993 to 2010 in accordance with prevailing market conditions at that time.

Emission factors

National methane emission factors were recalculated and refined to estimate the methane emissions from natural gas production /preparation, processing (gas purification from sulfur compounds), and transportation.

To estimate methane emissions from natural gas consumption in the Commercial and Residential sectors, venting and flaring from oil and gas production, default average emission factors for developing countries were used in the calculations (Table 4.2.5, T.2, pp. 4.59-4.67) [2].

Emissions of all greenhouse gases and NMVOCs are estimated using the Tier 1 methodology using default emission coefficients, since during the Voluntary Inventory Assessment in 2022 and the inventory assessment as part of the preparation of the First Biennial Update Report, international experts made the observation that the use of national coefficients leads to overestimates of emissions for this category and the values of national coefficients used in previous inventories are outside the default IPCC recommended ranges. It was recommended that separate studies be carried out to establish national coefficients in the Natural Gas category. This proposal is currently included in the Near-Term Inventory Improvement Plan (NIIP). Until new national emission factors were established in this category, it was recommended to use average default emission factors.

To estimate methane emissions from production, processing, and transportation of natural gas, average default emission factors from Table 4.2.5 of the 2006 IPCC Guidelines, Vol. 2, pp. 4.59-4.67 were used.

To estimate SO_2 emissions from gas sulfur production, the national emission factor was used, the value of which was 0.00268 t SO_2/t sulfur produced.

Table 3.3.5.4 presents the emission factors used in the calculations.

Table 3.3.5.4 Emission factors for the "Natural Gas" category

Subcategory		EF	Units	Uncertainty,%
		CH_4		
1.B.2.b.iii.2 Production	Fugitive - All	0.0122	Gg/ million m^3 of produced gas	-40+250
1.B.2.b.ii Production	Flaring	$8.8*10^{-7}$	Gg/ million m^3 of produced gas	±75
1.B.2.b.iii.3 Processing (neutral gas plants)	Fugitive	$7.9*10^{-4}$	Gg/ million m^3 of raw gas supply	-40+250
1.B.2.b.ii Processing (neutral gas plants)	Flaring	$8.8*10^{-7}$	Gg/ million m^3 of raw gas supply	±75
1.B.2.b.iii.3 Processing (Sour gas plants)	Fugitive	$1.58*10^{-4}$	Gg/ million m^3 of raw gas supply	-40+250
1.B.2.b.ii Processing (Sour gas plants)	Flaring	$2.85*10^{-6}$	Gg/ million m^3 of raw gas supply	±75
1.B.2.b.iii.4 Transportation	Fugitive	$0.61*10^{-3}$	Gg/ million m^3 of commercial gas	-40+250
1.B.2.b.i Transportation	Removal	$3.92*10^{-6}$	Gg/ million m^3 of commercial gas	-40+250
1.B.2.b.iii.4 Storage	All	$4.15*10^{-5}$	Gg/ million m^3 of commercial gas	-20+500
1.B.2.b.iii.5 Distribution	All	$1.80*10^{-3}$	Gg/ million m^3 of municipal gas sales	-20+500

Table 3.3.5.4 continuation

Subcategory		EF	Units	Uncertainty,%
		CO_2		
1.B.2.b.iii.2 Production	Fugitive - All	$9.70*10^{-5}$	Gg/ million m^3 of produced gas	-40+250
1.B.2.b.ii Production	Flaring	$1.40*10^{-3}$	Gg/ million m^3 of produced gas	±75
1.B.2.b.iii.3 Processing (neutral gas plants)	Fugitive	$2.5*10^{-4}$	Gg/ million m^3 of raw gas supply	-40+250
1.B.2.b.ii Processing (neutral gas plants)	Flaring	$2.15*10^{-3}$	Gg/ million m^3 of raw gas supply	±75
1.B.2.b.iii.3 Processing (Sour gas plants)	Fugitive	$1.29*10^{-5}$	Gg/ million m^3 of raw gas supply	-40+250
1.B.2.b.ii Processing (Sour gas plants)	Flaring	$4.25*10^{-3}$	Gg/ million m^3 of raw gas supply	±75
1.B.2.b.ii Processing (Sour gas plants)	Raw CO_2 Removal	$1.06*10^{-1}$	Gg/ million m^3 of raw gas supply	-10+1000
1.B.2.b.iii.4 Transportation	Fugitive	$1.44*10^{-8}$	Gg/ million m^3 of commercial gas	-40+250
1.B.2.b.i Transportation	Removal	$5.20*10^{-6}$	Gg/ million m^3 of commercial gas	-40+250
1.B.2.b.iii.4 Storage	All	$1.85*10^{-7}$	Gg/ million m^3 of commercial gas	-20+500
1.B.2.b.iii.5 Distribution	All	$9.55*10^{-5}$	Gg/ million m^3 of municipal gas sales	-20+500
		N_2O		
1.B.2.b.iii.2 Production	Fugitive - All	NA	Gg/ million m^3 of produced gas	-
1.B.2.b.ii Production	Flaring	$2.5*10^{-8}$	Gg/ million m^3 of produced gas	-10+1000
1.B.2.b.iii.3 Processing (neutral gas plants)	Fugitive	NA	Gg/ million m^3 of raw gas supply	-
1.B.2.b.ii Processing (neutral gas plants)	Flaring	$2.95*10^{-8}$	Gg/ million m^3 of raw gas supply	-10+1000
1.B.2.b.iii.3 Processing (Sour gas plants)	Fugitive	NA	Gg/ million m^3 of raw gas supply	-
1.B.2.b.ii Processing (Sour gas plants)	Flaring	$6.4*10^{-8}$	Gg/ million m^3 of raw gas supply	-10+1000
1.B.2.b.iii.4 Transportation	Fugitive	NA	Gg/ million m^3 of commercial gas	-
1.B.2.b.i Transportation	Removal	NA	Gg/ million m^3 of commercial gas	-
1.B.2.b.iii.4 Storage	All	ND	Gg/ million m^3 of commercial gas	-
1.B.2.b.iii.5 Distribution	All	ND	Gg/ million m^3 of municipal gas sales	-
		NMVOCs		
1.B.2.b.iii.2 Production	Fugitive - All	$6.45*10^{-4}$	Gg/ million m^3 of produced gas	-40+250
1.B.2.b.ii Production	Flaring	$7.35*10^{-7}$	Gg/ million m^3 of produced gas	±75
1.B.2.b.iii.3 Processing (neutral gas plants)	Fugitive	$3.65*10^{-4}$	Gg/ million m^3 of raw gas supply	-40+250
1.B.2.b.ii Processing (neutral gas plants)	Flaring	$1.13*10^{-8}$	Gg/ million m^3 of raw gas supply	±75
1.B.2.b.iii.3 Processing (Sour gas plants)	Fugitive	$1.14*10^{-4}$	Gg/ million m^3 of raw gas supply	-40+250
1.B.2.b.ii Processing (Sour gas plants)	Flaring	$2.25*10^{-6}$	Gg/ million m^3 of raw gas supply	±75
1.B.2.b.iii.4 Transportation	Fugitive	$1.15*10^{-7}$	Gg/ million m^3 of commercial gas	-40+250
1.B.2.b.i Transportation	Removal	$7.80*10^{-6}$	Gg/ million m^3 of commercial gas	-40+250
1.B.2.b.iii.4 Storage	All	$5.95*10^{-7}$	Gg/ million m^3 of commercial gas	-20+500
1.B.2.b.iii.5 Distribution	All	$2.60*10^{-5}$	Gg/ million m^3 of municipal gas sales	-20+500
		SO_2 (national)		
Sulphur production from gas purification		$2.68*10^{-3}$	SO_2/t sulfur produced	±15,9

Uncertainties and sequence of time series

The uncertainty of greenhouse gas emissions from Gas systems was estimated in accordance with the "Guidelines for National Greenhouse Gas Inventories, IPCC, 2006". The uncertainty of activity data is assumed to be 2% (according to expert estimates of Uzbekneftegaz JSC), the uncertainty of the emission factors used in the calculations is presented in the Table 3.3.5.4.

The same method and similar data sets were used for all years.

Quality assessment / Quality control by category

QA/QC procedures were performed in accordance with the general QA/QC principles and the QA/QC plan. The following was verified:

- documentation of Activity Data,
- documentation of national emission factors,

- data on mechanical errors,
- all information source links for baseline data in the Software.

Recalculations by category

In this inventory, estimates of fugitive emissions for the category “Natural Gas” have been revised, relative to the estimates obtained in the First Biennial Update Report for the period 1990-2017, based on the recommendations of a group of international experts who conducted a Voluntary in-depth assessment of the inventory of Uzbekistan in 2022.

Inventory in this category as part of the First Biennial Update Report was carried out using national coefficients, the values of which were an order of magnitude or more higher than the maximum values of the corresponding default coefficients and did not coincide with estimates obtained by independent international organizations. In addition, activity data for individual years was clarified. Also included in the new assessment were emissions from the subcategory “Natural Gas Storage”, which were not previously taken into account.

As a result of recalculations for the Natural Gas category, the estimate of total emissions has decreased significantly and is in good agreement with the estimate of the International Energy Agency (table 3.3.2.1).

Table 3.3.5.5 Recalculation of GHG emissions in the "Natural Gas" category for the period 1990-2017, Gg CO_2-eq.

Years	FBUR	FNC	Difference	Years	FBUR	FNC	Difference
1990	43764.16	14511.14	29253.02	2004	73914.24	22481.75	51432.50
1991	45916.42	15007.50	30908.92	2005	75435.56	22656.61	52778.94
1992	46279.10	15362.86	30916.26	2006	79773.17	23653.63	56119.54
1993	73931.41	17133.88	56797.52	2007	80870.49	24351.40	56519.09
1994	61755.80	17404.74	44351.06	2008	81740.67	24293.30	57447.37
1995	64593.67	18211.03	46382.63	2009	66647.12	24293.30	42353.82
1996	67356.46	18496.83	48859.62	2010	63783.31	23903.07	39880.24
1997	59683.63	18903.29	40780.34	2011	61425.94	23084.19	38341.75
1998	56282.01	19885.19	36396.81	2012	60940.08	22527.37	38412.71
1999	61346.98	20344.39	41002.60	2013	57684.54	23361.31	34323.23
2000	72575.71	20986.65	51589.06	2014	56127.16	20021.65	36105.51
2001	72557.85	21398.64	51159.20	2015	50749.37	19870.30	30879.07
2002	73380.02	22168.42	51211.60	2016	47922.82	20232.33	27690.49
2003	74898.73	21782.87	53115.86	2017	47370.58	20386.03	26984.55

The results of GHG emissions assessment in the Natural Gas category, calculated in the First Biennial Update Report (FBUR) using national coefficients, are more than twice as high as the estimates of the Fourth National Communication (FNC) and significantly affect the assessment of emissions, both for the Energy sector and for the assessment of total emissions.

Planned improvements by category

The next inventory intends to develop national emission factors to estimate fugitive carbon dioxide emissions for all subcategories of the Natural Gas category

4. “INDUSTRIAL PROCESSES AND PRODUCT USE” SECTOR

4.1 Sector overview

Uzbekistan's industry is based on the manufacturing sector, which occupies 83.2% of industry. Between 2017 and 2022, the share of industry in the GDP structure increased from 21.1% to 26.7%. This was facilitated by a steady growth in industrial production, which amounted to 141.3% over the period.

Uzbekistan has a well-developed mining and oil refining industry, non-ferrous and ferrous metallurgy, gold mining and processing. There are 70.6 thousand industrial enterprises in the Republic, of which 11.4 thousand (16.2% of the total number of operating enterprises) are located in Tashkent city, 8.0 thousand (11.3%) in Fergana region, 7.2 thousand (10.2%) in Tashkent region, 6.3 thousand (8.9%) in Samarkand region and 6.0 thousand (8.5%) in Andijan region.

According to the Ministry of Investment, Industry and Trade, in 2021 the structure of the manufacturing industry of the Republic of Uzbekistan included the following sectors (%):

- Production of food, beverages and tobacco products – 16.2%;
- Production of textiles and clothing – 17.4%;
- Production of coke and refined oil products – 3.0%;
- Chemical industry – 7.4%;
- Production of rubber and plastic products – 2.2%;
- Production of mineral products – 5.5%;
- Ferrous and non-ferrous metallurgy – 25.6%;
- Production of metal products – 2.9%;
- Production of electronic products – 1.4%;
- Production of electrical equipment – 3.0%;
- Automotive industry – 8.5%;
- Other – 6.9%.

In the structure of the manufacturing industry, the share of high-tech industries in 2021 amounted to 1.3%, medium-high-tech - 23.4%, medium-low-tech - 36.7% and low-tech - 38.6%.

The largest industrial enterprises in the country are:

- Almalyk Mining and Metallurgical Complex - the only copper producer in Uzbekistan, and one of the largest producers of non-ferrous metals in the Central Asian region. The Complex includes two mining enterprises, two enrichment plants and two metallurgical plants with their own infrastructure.
- The Navoi Mining and Metallurgical Complex comprises five metallurgical plants in Navoi, Zarafshan, Uchkuduk and Zarmitan, and also includes the Marjanbulak gold extraction plant.
- Uzbek Plant of Refractory and High Temperature Metals (UzPRHTM), which processes tungsten ores and molybdenum, located in Chirchik.
- Uzbek Metallurgical Complex OJSC, located in Bekabad. It accounts for 90% of ferrous metallurgy production in the republic.
- Maksam-Chirchik JSC, located in Chirchik. It is one of the largest enterprises in the chemical industry of Uzbekistan. It produces more than 40 types of products, such as ammonium nitrate, carbamide, ammoniacal water, liquid ammonia, nitric acid, and various catalysts.
- Ferghanaazot JSC, Ferghana, a modern highly automated enterprise of chemical industry. It produces ammonium nitrate, carbamide, ammonia, sodium chlorate, magnesium chlorate defoliant, etc.
- Navoiazot JSC, Navoi, specializes in the production of ammonium nitrate, liquid nitrogen fertilizers, acetic acid, etc.

The Industrial Processes and Product Use (IPPU) sector examines greenhouse gas emissions associated with industrial processes, the use of greenhouse gases in products, and the non-energy use of fossil fuel carbon.

In the industry of Uzbekistan, greenhouse gases - CO_2, CH_4, N_2O, as well as indirect greenhouse gases - CO, SO_2, NOx, NH_3, NMVOCs are released during the chemical and physical transformation of materials.

The sector estimates GHG emissions from seven categories:

- 2.A Mineral Industry;
- 2.B Chemical Industry;
- 2.C Metal Industry;
- 2.D Non-energy Products from Fuel and Solvent Use (Use of lubricants);
- 2.F Product Uses as Substitutes for Ozone Depleting Substances (Air conditioning and refrigeration);
- 2.H Other (Food Industry).

The section presents the main industrial sources of GHG emissions available in Uzbekistan, for which statistical data are available.

There is no production of HFCs, PFCs and SF_6 in Uzbekistan. Statistical data on consumption of PFCs and SF_6 are also not available, which did not enable estimating emissions from consumption of these GHGs. Activity data are currently being collected to estimate GHG emissions for sources not yet covered by the inventory.

The current inventory estimates for the first time GHG emissions in categories:

- 2.A.3 Glass Production,
- 2.A.4.a Ceramics Production,
- 2.B.5 Calcium Carbide Production,
- 2.C.2 Ferroalloys Production,
- 2.C.5 Lead Production
- 2.C.6 Zinc Production.

The largest contribution to sectoral emissions is made by the Mineral Industry category, which accounted for 74% of GHG emissions in 2021, the Chemical industry accounted for 17%, the Metallurgical industry category – for 5%, the Lubricants category – for 1%, and the Product Uses as Substitutes for Ozone Depleting Substances – for 3% of GHG emissions (Figure 4.1).

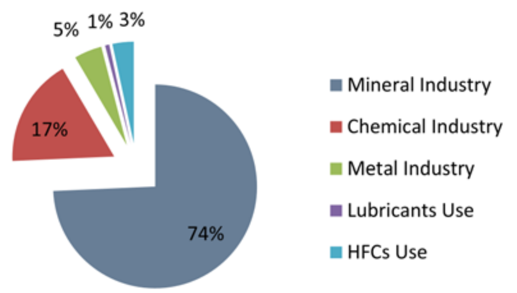

Figure 4.1 Contribution of individual categories to IPPU sector emissions

The largest sources of GHG emissions in the sector (2021) are the production of:

- Glass (CO_2) 16,420 Gg,
- Cement (CO_2) 4,482.5 Gg,
- Ammonia (CO_2) 2,975.5 Gg,
- Nitric Acid (N_2O) 2037.9 Gg CO2-eq,
- Steel (CO_2) 1,113.0 Gg.

Together, these categories account for 92.5% of GHG emissions from the IPPU sector.

4.2 Emissions in the IPPU sector by individual gases

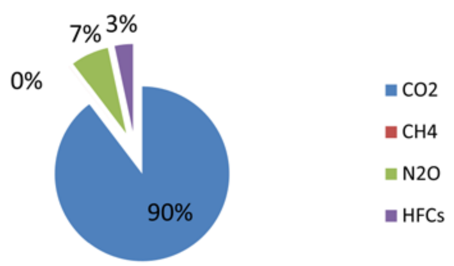

Figure 4.2. Contribution of individual GHGs to total emissions in the IPPU sector

In 2021, in the IPPU sector, CO_2 emissions account for 90%, N_2O – for 7%, HFCs – for 3%, methane – for 0.04%. In 2021, total GHG emissions from the IPPU sector amounted to 29,214.9 Gg CO_2-eq (Figure 4.2).

The sources of CO_2 emissions are production of cement, glass, ceramics, lime, ammonia, calcium carbide, methanol, acrylonitrile, steel, ferroalloys, lead, zinc, and consumption of lubricants.

The only source of N_2O emissions in the sector is nitric acid production.The sources of methane emissions are the production of calcium carbide, acrylonitrile, methanol, and ferroalloys.

An estimated source of hydrofluorocarbon emissions is refrigeration equipment.

Emissions of gases with indirect greenhouse effect are also calculated in the IPPU sector. The sources of CO emissions in the sector are ammonia production and steel production. The sources of NO_x emissions are nitric acid and steel production, SO_2 - cement and sulfuric acid production, NMVOCs - production of alcoholic beverages, food products, ammonia, acrylonitrile and formaldehyde. In 2021, CO emissions from the sector amounted to 12.65 Gg; NOx to 1.23 Gg; SO_2 to 6.23 Gg; NMVOCs - 49.51 Gg.

The contribution of GHG emissions from the IPPU sector to total emissions in 2021 amounted to 14%. In 1990, the sector's contribution to total emissions was 8%.

4.2.1 GHG emission trends

Table 4.2.1.1 and Figure 4.2.1.1 show the dynamics of GHG emissions in the "Industrial Processes and Product Use"(IPPU) sector for the period 1990-2021.

Table 4.2.1.1 GHG emissions in the "Industrial Processes and Product Use" sector, Gg CO_2-eq.

Years	CO_2	CH_4	N_2O	HFCs	Total
1990	10835.03	0.07	2385.89	-	**13220.99**
1991	10543.58	0.09	2416.97	-	**12960.65**
1992	9579.31	0.11	2336.30	-	**11915.71**
1993	8567.68	0.08	2019.62	-	**10587.39**
1994	7126.49	0.05	1550.17	-	**8676.71**
1995	6318.95	0.03	1623.90	-	**7942.88**
1996	6579.61	0.04	1734.53	-	**8314.19**
1997	7463.54	0.03	1512.74	-	**8976.32**
1998	8463.58	0.05	1585.61	-	**10049.25**
1999	7489.12	0.08	1379.61	-	**8868.81**
2000	7465.94	0.21	1404.95	1.08	**8872.18**
2001	11387.81	0.22	1444.51	1.99	**12834.53**
2002	9562.55	0.22	1383.36	1.98	**10948.11**
2003	10649.42	0.36	1446.60	3.22	**12099.60**
2004	13049.34	0.32	1563.65	9.21	**14622.53**
2005	13347.54	0.32	1646.17	9.88	**15003.92**
2006	14266.26	0.36	1701.49	14.55	**15982.66**
2007	15086.56	0.36	1918.95	14.18	**17020.05**
2008	16076.67	0.37	1999.12	17.44	**18093.61**
2009	15723.78	0.32	1016.56	18.10	**16758.77**
2010	18072.38	0.41	860.95	19.15	**18952.88**
2011	16007.47	0.52	812.56	29.01	**16849.56**
2012	16542.49	0.49	843.14	41.03	**17427.16**
2013	13692.39	0.37	1765.67	47.81	**15506.24**
2014	12636.69	1.42	1966.28	56.58	**14660.96**
2015	13671.74	0.79	1973.73	85.70	**15731.96**
2016	13972.38	0.74	1884.69	171.46	**16029.27**
2017	14500.81	0.72	1689.64	269.73	**16460.91**
2018	16697.05	0.58	1720.55	439.40	**18857.59**
2019	18347.55	0.89	1972.82	734.52	**21055.78**
2020	18980.11	0.90	1673.26	909.55	**21563.81**
2021	26185.86	2.36	2037.97	988.81	**29215.00**
Δ $_{(1990-2021)}$	**+141.7%**	**32.5-fold increase**	**-14.6%**	**919-fold increase**	**+121%**
%. $_{2021}$	**90.0%**	**0.04%**	**7.0%**	**3.0%**	**100.0%**

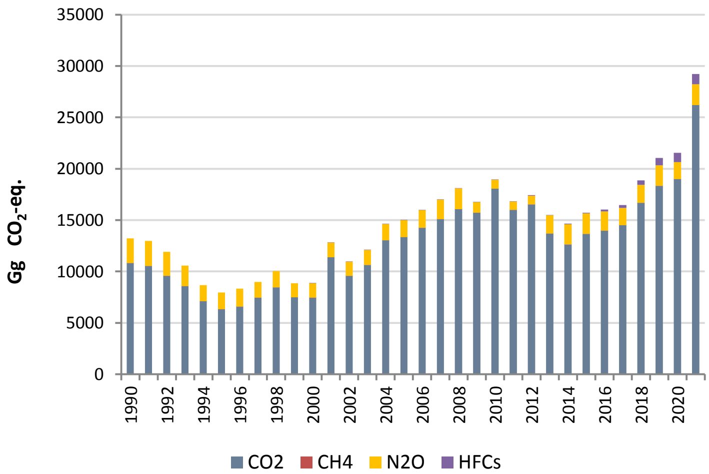

Figure 4.2.1.1 GHG trends in the "Industrial Processes and Product Use" sector

Over the period 1990-2021, the IPPU sector has seen an increase in total GHG emissions, especially significant in 2021, which is mainly due to an increase in production in the Production of mineral materials category. Compared to 1990, GHG emissions in the sector increased by 121%.
Table 4.2.1.2 and Figure 4.2.1.2 present indirect GHG emissions in the IPPU sector for the period 1990-2021.

Table 4.2.1.2 Indirect GHG emissions in the “Industrial Processes and Product Use” sector, Gg

Years	CO	NOx	SO_2	NMVOCs
1990	13.75	1.42	5.28	28.67
1991	13.71	1.44	5.18	27.93
1992	12.59	1.39	3.86	25.00
1993	10.62	1.20	3.50	24.42
1994	7.78	0.92	3.09	19.56
1995	8.71	0.96	2.45	20.24
1996	9.13	1.03	2.38	21.21
1997	9.06	0.91	2.22	22.41
1998	8.44	0.95	2.21	23.36
1999	7.62	0.84	2.26	24.68
2000	7.79	0.85	2.15	23.41
2001	6.42	0.88	2.01	21.92
2002	7.15	0.84	2.37	23.35
2003	7.85	0.88	2.36	23.71
2004	8.12	0.94	2.63	23.93
2005	8.42	0.99	2.58	22.98
2006	9.02	1.03	2.88	23.24
2007	9.66	1.15	3.23	28.05
2008	10.12	1.19	3.32	32.48
2009	10.00	1.17	3.52	33.13
2010	10.62	1.19	3.73	35.41
2011	10.20	1.19	3.65	37.95
2012	10.71	1.19	3.85	39.95
2013	9.09	1.08	4.24	28.17
2014	9.98	1.19	4.26	30.18
2015	9.59	1.19	4.65	34.53
2016	10.18	1.13	4.72	35.72
2017	9.30	1.02	4.74	36.91
2018	9.16	1.05	4.88	29.90
2019	10.80	1.18	5.37	33.03
2020	9.94	1.02	5.80	29.38
2021	12.65	1.23	6.23	35.75
$\Delta_{(1990-2021)}$	**-8.1%**	**-13.4%**	**+17.9%**	**1.25 -fold increase**

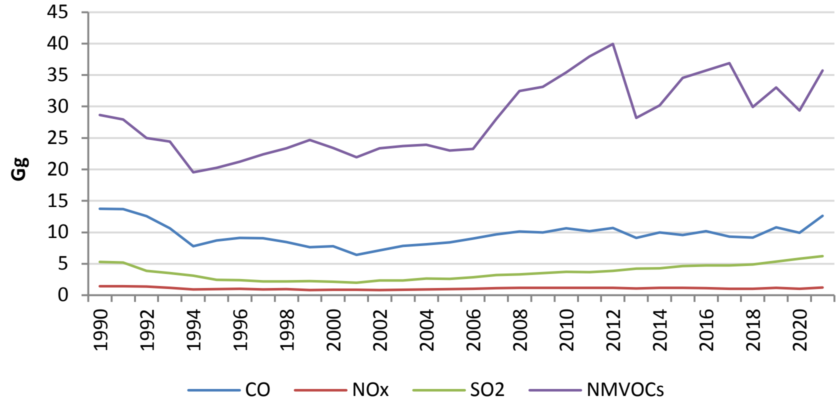

Figure 4.2.1.2 Trends in indirect GHG emissions in the IPPU sector

The majority of indirect GHG emissions come from NMVOCs. Over the period 1990-2021, the following changes in indirect GHG emissions occurred: a reduction in CO emissions by 8.1%, NOx by 13.4% and an increase in SO_2 emissions by 18% and NMVOCs by 1.67 times. Trends in emissions of precursor gases depend on the dynamics of product production.

4.2.2 Emission trends by categories of the sector

Table 4.2.2.1 and Figure 4.2.2.1 present the trends of GHG emissions by main categories of the sector for the period 1990-2021.

Table 4.2.2.1 GHG emissions by category in the "Industrial Processes and Product Use" sector, Gg CO_2-eq.

Years	Mineral Industry	Chemical industry	Metal industry	Lubricant use	HFCs Use	Total
1990	5893.73	6390.23	733.68	203.35	-	**13220.99**
1991	5590.79	6393.54	773.56	202.76	-	**12960.65**
1992	5014.06	5925.22	806.68	169.75	-	**11915.71**
1993	4718.91	4997.28	726.78	144.41	-	**10587.39**
1994	4194.56	3752.98	593.02	136.16	-	**8676.71**
1995	3329.55	4056.25	469.86	87.23	-	**7942.89**
1996	3382.44	4269.45	575.66	86.64	-	**8314.19**
1997	4431.57	3957.29	484.30	103.15	-	**8976.32**
1998	5655.59	3831.97	467.97	93.72	-	**10049.25**
1999	4986.79	3376.28	423.81	81.93	-	**8868.81**
2000	4766.64	3456.34	565.02	83.11	1.08	**8872.18**
2001	9035.92	3099.72	610.85	86.05	1.99	**12834.53**
2002	6975.80	3272.13	625.69	72.50	1.98	**10948.11**
2003	7820.63	3505.21	623.78	146.76	3.22	**12099.60**
2004	10086.90	3714.15	741.53	70.73	9.21	**14622.53**
2005	10267.46	3887.61	703.99	134.98	9.88	**15003.92**
2006	10999.32	4110.40	749.56	108.83	14.56	**15982.66**
2007	11558.31	4531.76	819.31	96.49	14.18	**17020.05**
2008	12440.87	4744.43	831.04	59.83	17.44	**18093.61**
2009	12211.22	3666.66	808.49	54.29	18.11	**16758.77**
2010	14285.58	3731.51	863.12	53.52	19.15	**18952.88**
2011	12317.31	3562.21	885.04	55.99	29.01	**16849.56**
2012	12662.52	3747.17	899.82	76.62	41.03	**17427.16**
2013	10337.04	4117.75	925.84	77.80	47.81	**15506.24**
2014	8901.86	4551.62	1071.34	79.57	56.58	**14660.96**
2015	10237.22	4443.99	884.30	80.75	85.70	**15731.96**
2016	10389.55	4561.43	824.22	82.62	171.46	**16029.27**
2017	10933.08	4129.18	1044.53	84.39	269.73	**16460.91**
2018	13103.49	4128.26	1103.82	82.62	439.40	**18857.59**
2019	14148.31	4920.86	1160.74	91.35	734.52	**21055.78**
2020	14959.91	4383.70	1207.50	103.16	909.55	**21563.81**
2021	21708.06	5039.15	1286.95	192.03	988.80	**29215.00**
Δ (1990-2021)	**3.68-fold increase**	**-21.14%**	**+75.4%**	**-5.7%**	**919-fold increase**	**+120.9%**
%, 2021	**74.30%**	**17.24%**	**4.40%**	**0.66%**	**3.40 %**	**100.00%**

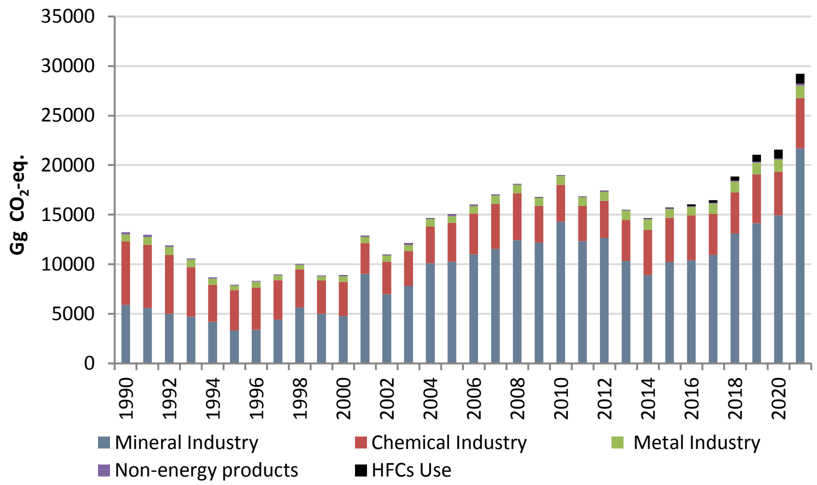

Figure 4.2.2.1 Trends in GHG emissions by category of the "Industrial Processes and Product Use" sector

The largest contribution to emissions from the IPPU sector comes from the Mineral Industry (74.3%) and Chemical Industry (17.2%) categories.

Over the period 1990-2021, total emissions for the sector increased by 121%, most significantly in 2021 due to growth in the construction materials industry, especially sheet glass and cement.

The GHG emission reduction in the Chemical Industry category is due to modernization of ammonia and nitric acid production.

The increase in emissions from the use of HFCs is associated with a significant increase in the consumption of CFCs in the economic and social sectors.

4.2.3 Recalculations for the "Industrial Processes and Product Use" sector

In the current inventory, the entire time series for the IPPU sector has been recalculated relative to the inventory data for 1990-2017 in connection with the introduction of new categories into the inventory (2.A.3 "Glass production", 2.A.4.a "Ceramic production", 2.B.5 "Calcium carbide production", 2.C.2 "Ferroalloy production" ", 2.C.5 "Lead production", 2.C.6 "Zinc production") and clarification of national emission factors. The results of the recalculation are presented in Table 4.2.3.1.

Table 4.2.3.1 Recalculation of GHG emissions for the "Industrial Processes and Product Use" sector for the period 1990-2017, Gg CO_2-eq.

Years	FNC	FBUR	Difference	Years	FNC	FBUR	Difference
1990	13220.99	8800.41	4420.58	2004	14622.53	6861.61	7760.92
1991	12960.65	8818.70	4141.95	2005	15003.92	7083.19	7920.73
1992	11915.71	8506.41	3409.30	2006	15982.66	7402.99	8579.67
1993	10587.39	7557.20	3030.19	2007	17020.05	7987.95	9032.10
1994	8676.71	6192.19	2484.52	2008	18093.61	8375.67	9717.94
1995	7942.89	5919.68	2023.21	2009	16758.77	8168.07	8590.70
1996	8314.19	6161.25	2152.94	2010	18952.88	8434.23	10518.65
1997	8976.32	5981.12	2995.20	2011	16849.56	8228.41	8621.15
1998	10049.25	5964.92	4084.33	2012	17427.16	8169.35	9257.81
1999	8868.81	5538.52	3330.29	2013	15506.24	8179.67	7326.57
2000	8872.18	5887.83	2984.35	2014	14660.96	8554.05	6106.91
2001	12834.53	5741.05	7093.48	2015	15731.96	8416.70	7315.26
2002	10948.11	5823.77	5124.34	2016	16029.27	8603.17	7426.10
2003	12099.60	6205.52	5894.08	2017	16460.91	8468.12	7992.79

The results of GHG emissions for the sector IPPU, calculated in the Fourth National Communication (FNC), are 1.3 – 2 times higher than in the First Biennial Update Report (FBUR). This significant difference in estimates is mainly due to the introduction of new categories into the current inventory. The greatest impact on emissions assessed in the FNS was exerted by the category "Glass production", which accounts for more than half of sectoral GHG emissions.

4.3 Mineral Industry (2.A category)

4.3.1 Description of the category

The following categories of CO_2 emissions have been estimated in the Production of mineral materials category:

- 2.A.1 Cement Production,
- 2.A.2 Lime Production,
- 2.A.3 Glass Production,
- 2.A.4.a Ceramics Production.

The sector also estimated emissions of the following precursor gases: CO, NOx, SO_2 and NMVOC.

The main source of GHG emissions in the Production of mineral materials category is the production of sheet glass and glass containers (58% of the sectoral GHG emissions). This source of CO_2 emissions is estimated in the current inventory for the first time. JSC Quartz (Kuvasay city, Fergana region) is the largest enterprise in the Central Asian region producing colored, tinted and tempered sheet glass, glass jars and bottles. Its products fully satisfy the needs of the domestic market and are exported to many countries such as Kazakhstan, Turkmenistan, Tajikistan, Kyrgyzstan and Afghanistan. One of the rapidly developing glass enterprises in the country is ASL OYNA JSC, located in Tashkent. Today the company produces more than 100 million pieces of glass containers per year. The share of exports is about 30% in the total volume of sales. The plant is equipped with modern equipment and produces mainly colorless, semi-white and colored glass containers for bottling alcoholic beverages. Another enterprise located in Tashkent is FE CAMPALIA LLC, producing products for pharmaceutical and food industry, household needs, which fully comply with international standards and are competitive in the world market. Three glass furnaces with a total capacity of about 300 tons of glass melt per day are installed at the enterprise.

Over the past few years, a number of enterprises producing glass containers have also been put into operation in the regions. Among them are Karakalpak Glass Container LLC and JV Khorazm Shisha Idishlari LLC. The production volumes of glass and glass containers are constantly growing, which is due to the ever-increasing demand for the products both within the country and in the region as a whole. Production growth is facilitated by the raw material base available in the country - large deposits of quartz sand, feldspars, dolomite and limestone, production of soda ash and sodium sulfate.

The second largest CO2 emitter in the category is the production of cement clinker, which is produced at six enterprises: Kyzylkumcement JSC, Akhangarancement JSC, Kuvasaycement JSC, Bekabadcement JSC, Okhangaron Rangli Cement JSC, Angren BMP JSC .

From 1990 to 2021, CO_2 emissions from clinker production in the country increased by 73% due to the increase in production and amounted to 2021 4,482.58 Gg. Clinker is produced from local mineral raw materials - limestone, loess, kaolin clay, iron supplements.

On a much smaller scale, carbon dioxide emissions occur in the production of ceramics, lime and the use of soda in industry.

The Ceramics production category includes CO_2 emissions from the production of bricks, roofing tiles, glazed ceramic pipes, refractory and expanded clay products, floor and wall tiles, tableware (ceramic, porcelain), ceramic sanitary ware, and technical ceramics.

Bricks and stones are made by semi-dry pressing or plastic molding from clayey and siliceous (trepel, diatomite) sedimentary rocks and industrial waste (coal mining and coal enrichment of ash). There are more than 350 enterprises producing bricks of various brands in the country. The production of ceramic tiles, sanitary ware and tableware is also well developed. The production of ceramic products is constantly increasing. This category is assessed for the first time in the current inventory.

Lime is produced at 22 enterprises of the country by decarbonization of limestone at a temperature of 750 - 900 ° C [13], mainly on the basis of limestone of Kutarma deposit located in the Jizzak region.

In the “Other uses of soda ash” category, the use of soda ash in certain industries (chemical, petrochemical, light, pulp and paper, non-ferrous and ferrous metallurgy, food and meat and dairy industries, synthetic detergents, etc.) is estimated according to statistical data on soda ash produced, its import, export and its sales volumes in the country as a whole.

In 2021, total GHG emissions in the Mineral Products category amounted to 2,329.610 Gg CO_2.

Table 4.3.1 present CO_2 emissions from the production and use of mineral materials for the period 1990-2021.

13 Official website of “Uzsanoatkurilish materiallari” JSC - www.uzsm.uz

Table 4.3.1 CO_2 emissions from the Mineral Industry subcategories, Gg CO_2

Years	Cement Production	Lime Production	Glass Production	Ceramics Production	Total
1990	2584.89	335.92	2573.96	398.94	**5893.73**
1991	2556.71	325.20	2298.60	410.28	**5590.79**
1992	2496.33	288.75	1807.38	421.61	**5014.06**
1993	2372.19	295.65	1618.13	432.94	**4718.91**
1994	2103.02	227.10	1420.15	444.29	**4194.55**
1995	1545.82	142.50	1185.58	455.65	**3329.55**
1996	1434.47	170.47	1310.48	467.01	**3382.44**
1997	1503.27	138.45	2311.48	478.38	**4431.57**
1998	1593.06	90.07	3482.72	489.74	**5655.59**
1999	1498.84	72.37	2914.48	501.10	**4986.79**
2000	1482.78	76.80	2694.58	512.47	**4766.63**
2001	1683.01	80.55	6748.54	523.83	**9035.92**
2002	1694.27	67.20	4679.14	535.19	**6975.80**
2003	1793.79	47.70	5421.58	557.56	**7820.63**
2004	2134.00	70.12	7302.85	579.92	**10086.90**
2005	2268.48	65.10	7320.58	613.29	**10267.45**
2006	2349.61	100.72	7880.32	668.66	**10999.32**
2007	2556.00	142.72	8135.56	724.02	**11558.31**
2008	2828.89	82.72	8771.87	757.38	**12440.87**
2009	2907.27	92.17	8432.03	779.75	**12211.22**
2010	2926.38	167.70	10356.80	834.70	**14285.57**
2011	2794.14	214.95	8675.03	633.19	**12317.31**
2012	2793.22	133.72	9169.00	566.58	**12662.52**
2013	2970.87	191.68	6592.93	581.55	**10337.04**
2014	3105.71	243.37	5018.31	534.47	**8901.85**
2015	3103.36	223.08	6353.86	556.92	**10237.21**
2016	3167.47	229.52	6362.96	629.59	**10389.55**
2017	3613.41	239.30	6418.18	662.19	**10933.08**
2018	3814.60	277.16	8227.65	784.08	**13103.49**
2019	4010.77	255.23	9299.98	582.32	**14148.31**
2020	3848.26	227.54	10395.26	488.84	**14959.91**
2021	4482.58	252.89	16420.05	552.54	**21708.06**
$\Delta_{(1990-2021)}$	**+73.41%**	**-24.72%**	**6.4-fold increase**	**+38.67%**	**3.7-fold increase**
$\%_{,\ 2021}$	**20.65%**	**1.16%**	**75.64%**	**2.55%**	**100.00%**

Trends in CO_2 emissions in the "Mineral Industry" category are shown in Figure 4.3.1

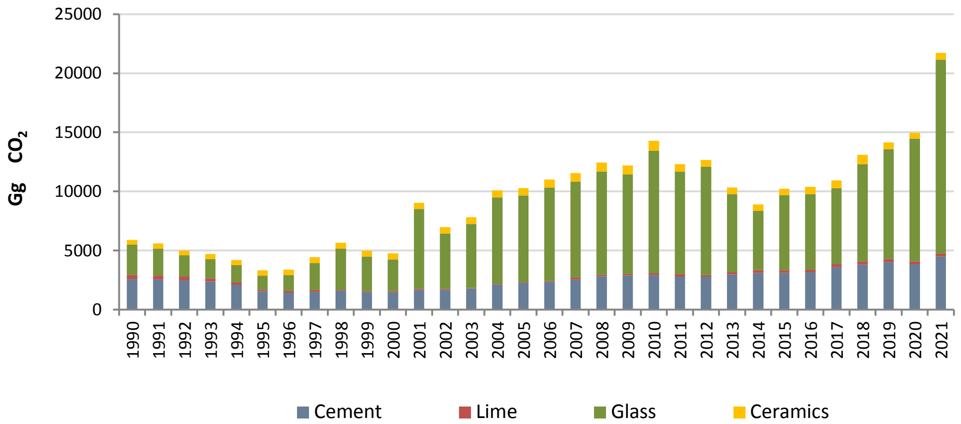

Figure 4.3.1 Trends in CO_2 emissions from Mineral Industry

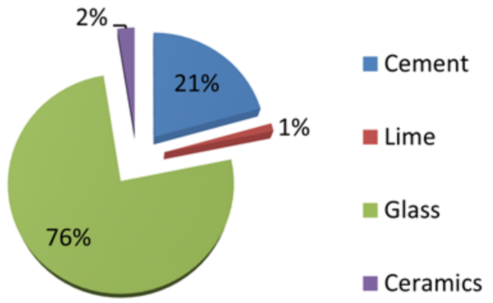

Figure 4.3.2 Share of CO_2 emissions of individual subcategories in the Mineral Industry category, 2021

In 2021, the majority of emissions in the Production of mineral materials category (76%) came from emissions from glass production and cement production (21%) – Figure 4.3.2.

Over the period 1990-2021, the total CO_2 emissions in the Production of mineral materials category increased by 3.7 times, with an increase in CO_2 emissions in all subcategories, except for the Production of lime subcategory (Table 4.3.1). The growth of emissions in the category is proportional to the growth of production.

4.3.2 Cement Production (2.A.1 category)

In cement production, CO_2 emissions occur during the production of the intermediate product, clinker. In this process, the limestone is heated to high temperatures, which causes emissions as the limestone's main component, calcium carbonate, breaks down and is converted into lime and carbon dioxide. Limestone contains minor amounts of magnesium carbonate ($MgCO_3$), which is also calcined during processing and results in CO_2 emissions. Cement production also produces SO_2 emissions.

Cement production is one of the key categories in the Industrial processes and product use sector, and influences the overall emission trend for the sector. Cement production, in turn, is determined and depends on the pace of housing construction in the country, as well as export volumes.

Table 4.3.2.1 summarizes the emissions in category 2.A.1 Cement Production for the period 1990-2021. CO_2 emissions in 2021 amounted to 4,482.58 Gg.

Table 4.3.2.1 CO_2 and SO_2 emissions from Cement Production, Gg

Years	CO_2 emissions from Cement Production	SO_2 emissions from Cement Production	Years	CO_2 emissions from Cement Production	SO_2 emissions from Cement Production
1990	2584.89	1.92	2007	2556.00	1.81
1991	2556.71	1.86	2008	2828.89	1.99
1992	2496.33	1.78	2009	2907.27	2.06
1993	2372.19	1.58	2010	2926.38	2.04
1994	2103.02	1.43	2011	2794.14	2.01
1995	1545.82	1.03	2012	2793.22	2.05
1996	1434.47	0.98	2013	2970.87	2.12
1997	1503.27	0.99	2014	3105.71	2.29
1998	1593.06	1.01	2015	3103.36	2.54
1999	1498.84	1.00	2016	3167.47	2.59
2000	1482.78	0.98	2017	3613.41	2.74
2001	1683.01	1.12	2018	3814.60	2.72
2002	1694.27	1.18	2019	4010.77	3.16
2003	1793.79	1.22	2020	3848.26	3.58
2004	2134.00	1.44	2021	4482.58	3.91
2005	2268.48	1.52	$\Delta_{(1990-2021)}$	**+73.4%**	**2.04-fold increase**
2006	2349,61	1,68			

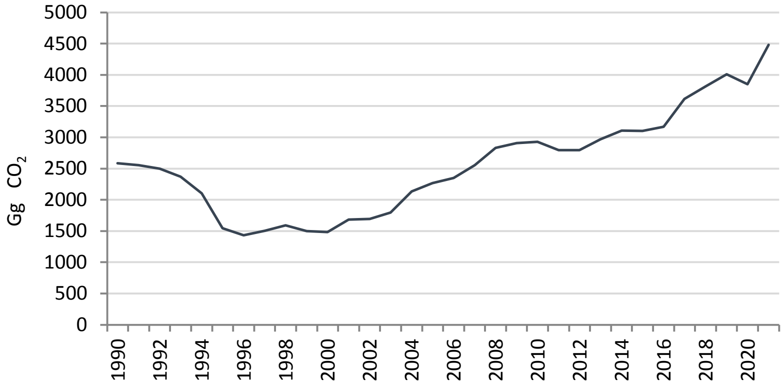

Figure 4.3.2.1 CO_2 emissions from Cement Production

The decrease in emissions in this category in the first half of the 1990s is related to the decrease in production in general. Since 2003, there has been a significant increase in CO_2 emissions due to the growth of cement production (Figure 4.3.2.1).

The growth of sulphur dioxide emissions in cement production in 1990-2021 is determined by the dynamics of production growth.

Methodology

CO_2 emissions were calculated using the Tier 2 methodology using the national emission factor in accordance with Equation 2.2, (Vol. 3, Part 1, Chapter 2.2.1 of the 2006 IPCC Guidelines) [14] based on clinker production data.

SO_2 emissions from cement production were estimated using the Tier 1 methodology in accordance with the 1996 IPCC Guidelines [15], using a default factor.

Activity data

To estimate CO_2 emissions from clinker production and SO_2 emissions from cement production, data from the Uzsanoatqurilishmateriallari Association and the Statistics Agency of the Republic of Uzbekistan were used.

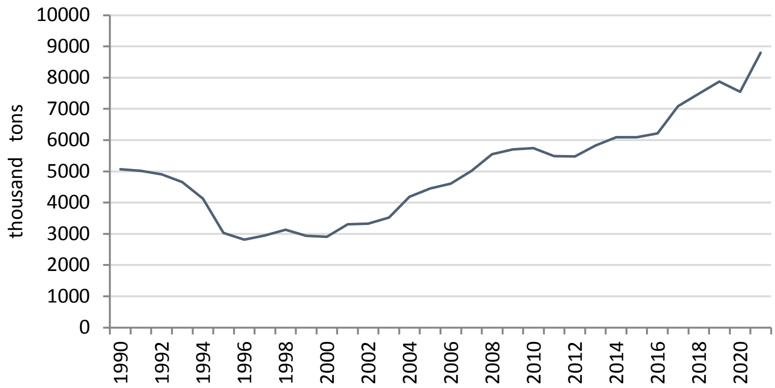

Figure 4.3.2.2 Dynamics of cement clinker production, thousand tons

Emission factors

The Cement production category uses a revised national emission factor of **0.5096 tCO_2/t** clinker (as in the First Biennial Report), which is calculated from national data on the weighted average CaO content (%) in clinker at four major cement plants. The coefficient was calculated in accordance with Equation 2.4, Chapter 2, Vol.3 of the 2006 IPCC Guidelines. The emission factor calculations include a 2% correction for cement dust emissions =1.02, taken in accordance with good practice, due to insufficient data on emissions of this substance at the plant level.

In the same category, an emission factor of **0.3 tSO_2/t product** (default, IPCC,1996), was used to estimate SO_2 emissions from cement production, as in the previous inventory.

14 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Vol. 3

15 Revised IPCC Guidelines for National Greenhouse Gas Inventories, 1996, Greenhouse Gas Inventory Workbook, Part 2

Uncertainties and time series consistency

The uncertainty of activity data for cement clinker production was ±1%, since government statistics were used. Emission factor uncertainty was ±2% by default.

Quality assurance/quality control

QA/QC procedures were performed in accordance with the general QA/QC principles [4] and the QA/QC plan. The following were verified:

- emission source documentation,
- data on mechanical errors,
- homogeneity of the source data and methods used for the entire time series.

Planned improvements in the category

As part of the next inventory, detailed activity data is expected.

4.3.3 Lime Production (2.A.2 category)

CO_2 emissions from lime production result from the calcination of calcium and magnesium carbonates at high temperatures.

There are more than 22 lime production enterprises in the country. A large share of lime is produced at enterprises that are members of the Uzsanoatqurilishmateriallari Association. There are no data on the production of non-commercial lime.

Table 4.3.3.1 presents CO_2 emissions by 2.A.2 Lime production category. In 2021, emissions amounted to 252.90 Gg CO_2.

Between 1990 and 2021, there was a 24.7% decrease in CO_2 emissions from lime production, due to a decrease in production compared to the early 1990s.

Table 4.3.3.1 CO_2 emissions from Lime Production, Gg CO_2

Years	CO_2	Years	CO_2	Years	CO_2
1990	335.93	2001	80.55	2012	133.73
1991	325.20	2002	67.20	2013	191.69
1992	288.75	2003	47.70	2014	243.37
1993	295.65	2004	70.13	2015	223.08
1994	227.10	2005	65.10	2016	229.52
1995	142.50	2006	100.73	2017	239.30
1996	170.48	2007	142.73	2018	277.16
1997	138.45	2008	82.73	2019	255.24
1998	90.08	2009	92.18	2020	227.54
1999	72.38	2010	167.70	2021	252.90
2000	76.80	2011	214.95	$\Delta_{(1990-2021)}$	**-24.7%**

Methodology

CO_2 emissions were calculated using the Tier 1 methodology using production data with IPCC default emission factors.

Activity data

State statistics data on production of quicklime and hydraulic lime were used in the calculations. Production of hydrated lime has not been taken into account. Separate statistics on hydraulic lime production have been kept since 2018. Its production accounts for approximately 1/12th of all lime produced, which is an insignificant share. Therefore, for the period 1990-2017, emissions were calculated assuming that all lime produced was quicklime.

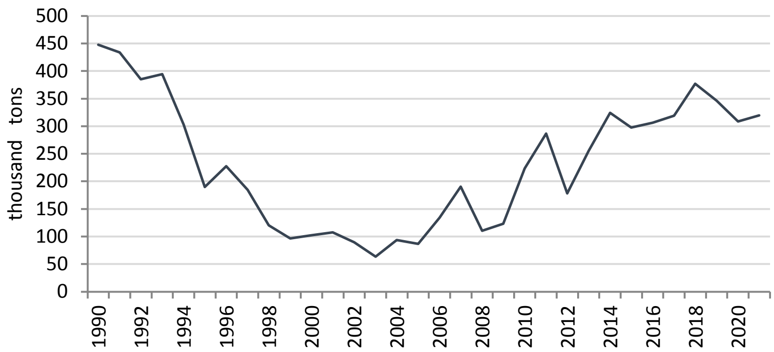

Figure 4.3.3.1 Dynamics of lime production, thousand tons

Figure 4.3.3.1 shows the dynamics of lime production for 1990-2021. The decline in lime production in the early 2000s is explained by the decline in housing construction, and subsequent growth reflects upward trends.

Emission factors

The Lime production category uses default emission factors of **0.75 t CO_2/t product** for quicklime **and 0.59 t CO_2/t product** for hydraulic lime (Table 2.4, p. 2.25, Vol. 3, Part 1 [16]). The time series up to 2018 were calculated using an emission factor of **0.75 t CO_2/t product**.

Uncertainties and time series consistency

The uncertainty in the lime production activity data was ±2% since government statistics were used.

Emission factor uncertainty was ±2% (by default) [16].

Quality assurance/quality control

QA/QC procedures were performed in accordance with the general QA/QC principles and the QA/QC plan. Verification of the following was checked:

- emission source documentation,
- data on mechanical errors,
- homogeneity of the source data and methods used for the entire time series.

Planned improvements in the category

As part of the next inventory, it is expected to refine the activity data to include non-commodity lime production.

4.3.4 Glass Production (2.A.3 category)

CO_2 emissions in the production of glass and glass products occur during the melting of glass raw materials, which include limestone, dolomite and soda ash. Limestone and dolomite are mined as carbonate minerals for the glass industry. Soda ash is supplied to glass production from the Kungrad Soda Plant. Raw materials such as barium carbonate, bone ash, potassium and strontium carbonates, etc. emit less CO_2.
This category is included in the inventory for the first time. In the Third National Communication, CO_2 emissions from glass production were not estimated as the methodologies were used [17].
Table 4.3.4.1 summarizes the emissions in 2.A.3 Glass Production category for the period 1990-2021. CO_2 emissions in 2021 for the Glass Production category amounted to 16,420.05 Gg.

Table 4.3.4.1 CO_2 emissions from Glass Production, Gg

Years	CO_2 emissions from sheet glass production	CO_2 emissions from container glass (jar) production	CO_2 emissions from container glass (bottle) production	Total CO_2 emissions from Glass Production
1990	2569.98	1.62	2.37	**2573.96**
1991	2294.19	1.76	2.66	**2298.60**
1992	1802.64	1.85	2.89	**1807.38**
1993	1612.98	2.03	3.12	**1618.13**
1994	1414.62	2.12	3.41	**1420.15**
1995	1179.72	2.22	3.64	**1185.58**
1996	1304.13	2.31	4.04	**1310.48**
1997	2304.63	2.40	4.45	**2311.48**
1998	3475.65	2.45	4.62	**3482.72**
1999	2906.67	2.49	5.31	**2914.48**
2000	2685.69	2.54	6.35	**2694.58**
2001	6739.02	2.59	6.93	**6748.54**
2002	4668.42	2.63	8.08	**4679.14**
2003	5409.66	2.68	9.24	**5421.58**
2004	7289.73	2.73	10.39	**7302.85**
2005	7306.26	2.77	11.55	**7320.58**
2006	7864.80	2.82	12.70	**7880.32**
2007	8118.84	2.86	13.86	**8135.56**
2008	8753.94	2.91	15.01	**8771.87**
2009	8412.90	2.96	16.17	**8432.03**

16 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Vol. 3
17 Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Greenhouse Gas Inventory Workbook, Part 2.

Table 4.3.4.1 continuation

Years	CO_2 emissions from sheet glass production	CO_2 emissions from container glass (jar) production	CO_2 emissions from container glass (bottle) production	Total CO_2 emissions from Glass Production
2010	10336.47	3.00	17.32	**10356.80**
2011	8653.02	3.05	18.96	**8675.03**
2012	9145.44	3.09	20.46	**9169.00**
2013	6570.24	3.14	19.55	**6592.93**
2014	4995.54	3.19	19.58	**5018.31**
2015	6330.12	3.23	20.51	**6353.86**
2016	6336.21	3.33	23.43	**6362.96**
2017	6392.76	3.50	21.92	**6418.18**
2018	8201.32	3.94	22.40	**8227.65**
2019	9274.81	2.29	22.88	**9299.98**
2020	10359.61	3.22	32.43	**10395.26**
2021	16386.54	2.64	30.88	**16420.05**
$\Delta_{(1990-2021)}$	**6.37-fold increase**	**1.63-fold increase**	**13.04-fold increase**	**6.38-fold increase**

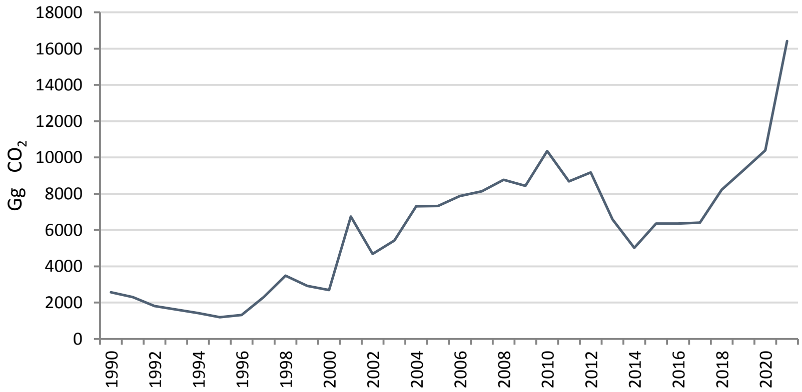

Figure 4.3.4.1 CO_2 emissions from Glass Production

The dynamics of CO_2 emissions from glass production (sheet and container glass) is determined by the dynamics of sheet glass production (shown in Figure 4.3.4.1). The contribution of CO_2 emissions from container glass production is insignificant, is therefore not shown on the graph.

Methodology

This category is key. Efforts have been made to estimate CO_2 emissions from different types of glass products manufactured: sheet glass and container glass (cans and bottles). CO_2 emissions were calculated using the Tier 1 methodology in accordance with Equation 2.10, (Vol. 3, Part 1, Chapter 2.4.1.1 of the 2006 IPCC Guidelines) using default emission factors and cullet proportions (averages of the proposed range) for different glass types (Table 2.6) [18].

Activity data

To estimate CO_2 emissions from glass production, data from the Statistical Agency of the Republic of Uzbekistan and the Association of Enterprises "Uzsanoatqurilishmateriallari" were used. Statistical data on the production of sheet glass have the dimension of thousand square meters. Therefore, to carry out calculations of CO_2 emissions in accordance with the IPCC methodology, they were recalculated in tons, based on direct weighing data provided by the experts of the Association of enterprises "Uzsanoatqurilishmateriallari". The recalculation was made for 2 mm thick sheet glass, 1 square meter of which weighs 5 kg. Statistical data on the production of canning jars is presented in standard jars and standard bottles. To convert standard jars into tons, it was assumed that they have a capacity of 0.5 liters and weigh 0.4 kg; to convert standard bottles into tons, it was assumed that they have a capacity of 0.75 liters and weigh 0.5 kg.

The obtained actual statistical data on container glass production were available for the period 2013-2021, so the time series on its production for the period 1990-2012 were restored according to the trend. Statistics for sheet

18 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Volume 3.

glass production are available for the entire period 1990-2021. Container glass accounts for less than 1% of the total glass production. The overall dynamics of glass production is determined by the production of sheet glass, it is shown in Figure 4.3.4.2.

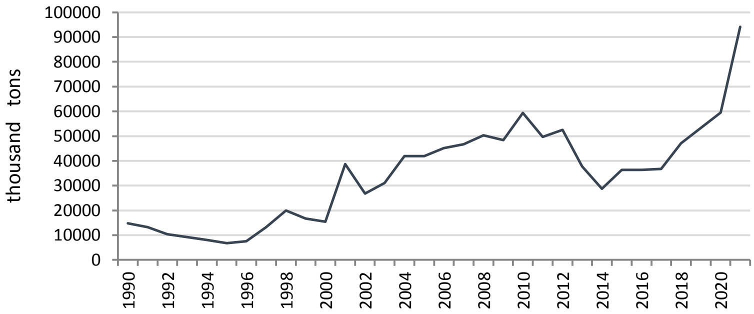

Figure 4.3.4.2 Dynamics of glass production

The decrease in glass production from 2012 to 2018 is due to the reconstruction and modernization of sheet glass production at Quartz JSC, which is the largest manufacturer in the country. In addition, the production of sheet glass and glass products mainly depends on the concluded contracts for the supply of products. This explains the uneven dynamics of glass production. Since 2018, there has been a significant increase in glass production due to the commissioning of new enterprises.

Emission factors

In the Glass production category, a default emission factor of **0.21 t CO_2/t sheet and container glass** was used. The share of glass waste was assumed to be the average of the default range (17% for sheet glass and 45% for container glass) (Table 2.6, p.2.34, Vol. 3, Part 1 of the 2006 IPCC Guidelines), [19].

Uncertainties and time series consistency

The uncertainty in glass production activity data was ±5%, as recommended by the IPCC, since statistics were used in thousand square meters rather than in tons.

Default emission factor uncertainty was ±60%.

Combined uncertainty was ±60.2%.

Quality assurance/quality control

QA/QC procedures were performed in accordance with the general QA/QC principles [10] and the QA/QC plan. Verification on the following was conducted:

- homogeneity of the source data and methods used for the entire time series,
- correctness of the formulas and units of measurement used for the entire time series,
- correctness of the use of default emission factors,
- documentation of emission sources,
- data for mechanical errors.

Planned improvements in the category

As part of the next inventory, it is expected to refine the activity data and detail them over the entire time series. To refine the Tier 2 emission estimates, additional information on glass production technologies at the facilities as well as the raw materials used is required.

4.3.5 Other processes using carbonates (2.A.4 category)

The category includes the following subcategories:

- 2.A.4.a Ceramics Production,
- 2.A.4.b Other Uses of Soda Ash,
- 2.A.4.c Non-metallurgical Production of Magnesium.

19 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Volume 3

4.3.5.1 Ceramics Production (2.A.4.a category)

In the Ceramics Production category, CO_2 emissions from the production of ceramic bricks, ceramic floor/wall/facade tiles and porcelain tiles, ceramic and porcelain tableware, ceramic tiles and ceramic sanitary ware have been estimated.

In the Ceramics production, CO_2 emissions occur from calcination of clay carbonates and from additives (use of limestone as a flux) in kilns at high temperatures.

This category is included in the inventory for the first time.

Table 4.3.5.1.1 and Figure 4.3.5.1.1 summarize the emissions in 2.A.4.a Ceramics production category for the period 1990-2021. CO_2 emissions in 2021 amounted to 552.536 Gg.

Table 4.3.5.1.1 CO_2 emissions from Ceramics Production, Gg

Years	Bricks	Roof tiles	Tiles	Plumbing products	Tableware	Other	Total CO_2 emissions from Ceramics Production
1990	396.00	0.01	1.98	0.02	0.44	0.49	**398.94**
1991	407.00	0.02	2.20	0.02	0.49	0.55	**410.28**
1992	418.00	0.02	2.42	0.02	0.55	0.60	**421.61**
1993	429.00	0.02	2.64	0.017	0.60	0.66	**432.94**
1994	440.00	0.03	2.86	0.02	0.66	0.71	**444.29**
1995	451.00	0.07	3.08	0.02	0.72	0.77	**455.65**
1996	462.00	0.10	3.30	0.02	0.77	0.82	**467.01**
1997	473.00	0.13	3.52	0.02	0.82	0.88	**478.38**
1998	484.00	0.16	3.74	0.02	0.88	0.93	**489.74**
1999	495.00	0.20	3.96	0.02	0.93	0.99	**501.10**
2000	506.00	0.23	4.18	0.02	0.99	1.04	**512.47**
2001	517.00	0.26	4.40	0.02	1.04	1.10	**523.83**
2002	528.00	0.30	4.62	0.02	1.10	1.15	**535.19**
2003	550.00	0.33	4.84	0.03	1.15	1.21	**557.56**
2004	572.00	0.36	5.06	0.03	1.21	1.26	**579.92**
2005	605.00	0.40	5.28	0.03	1.26	1.32	**613.29**
2006	660.00	0.43	5.50	0.03	1.32	1.37	**668.66**
2007	715.00	0.46	5.72	0.03	1.37	1.43	**724.02**
2008	748.00	0.49	5.94	0.03	1.43	1.48	**757.38**
2009	770.00	0.53	6.16	0.03	1.48	1.54	**779.75**
2010	824.58	0.56	6.38	0.04	1.54	1.59	**834.70**
2011	622.71	0.59	6.60	0.04	1.59	1.65	**633.19**
2012	555.76	0.63	6.79	0.05	1.65	1.70	**566.58**
2013	565.15	0.66	12.23	0.05	1.70	1.76	**581.55**
2014	515.82	0.69	13.75	0.63	1.76	1.81	**534.47**
2015	538.10	0.71	14.28	0.14	1.81	1.87	**556.92**
2016	605.23	0.75	19.54	0.28	1.87	1.92	**629.59**
2017	637.85	0.77	19.36	0.25	1.98	1.98	**662.19**
2018	733.84	0.83	44.32	0.50	2.07	2.52	**784.08**
2019	536.85	0.69	41.18	0.42	2.16	1.02	**582.32**
2020	445.02	0.53	40.76	0.65	1.12	0.76	**488.84**
2021	485.44	1.23	55.12	1.72	8.12	0.90	**552.54**
$\Delta_{(1990-2021)}$	**+22.5%**	**112.2-fold increase**	**27.8-fold increase**	**101-fold increase**	**18.4-fold increase**	**1.8-fold increase**	**+27.8%**

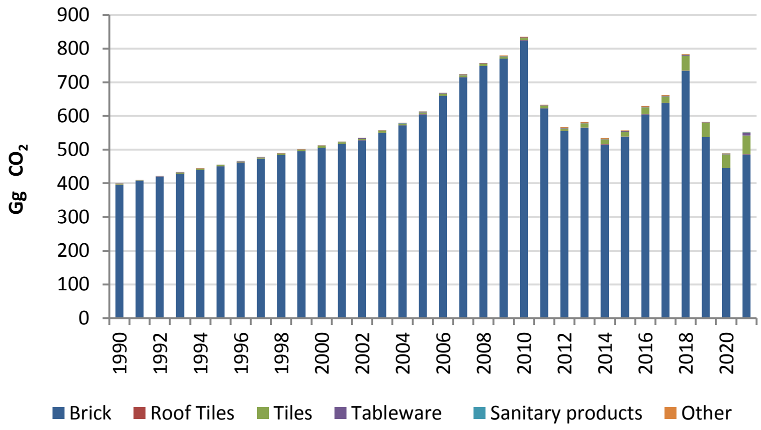

Figure 4.3.5.1.1 CO_2 emissions from Ceramics Production

CO_2 emissions from Ceramics Production are mainly related to the production of building bricks. The contribution of CO_2 emissions from brick production to total category emissions is about 85%. In the last five years, the contribution to the category of CO_2 emissions from the production of ceramic tiles has been increasing due to the expansion of its production in the country.

Methodology

This category is not key. Efforts have been made to estimate CO_2 emissions from various types of ceramic products: building bricks, roof tiles, tiles, sanitary products, tableware for various purposes (dining and laboratory), other products (ceramic pipes, blocks, etc.).

CO_2 emissions from ceramic production were calculated using the Tier 1 methodology in accordance with Equation 2.14 (Vol. 3, Part 1, Chapter 2.5.1.1 of the 2006 IPCC Guidelines) using default emission factors from Table 2.1 [20]. The carbonate content in the clay was assumed to be 10%, and the amount of clay used to produce ceramics was calculated by multiplying the weight of the product by the default loss factor of 1.1.

Activity data

To estimate CO_2 emissions from ceramics production, data from the Statistical Agency of the Republic of Uzbekistan for the period 2010-2021 were used. For the period 1990-2008 time series were restored based on existing trends using linear extrapolation.

Statistical data on the production of bricks, sanitary ware, and tableware have a dimension of thousand pieces, and data on the production of roof tiles and tiles have a dimension of thousand square meters, therefore, for the calculation of CO_2 emissions in accordance with the IPCC methodology, they were converted into tons (Table 4.3.5.1.2).

Table 4.3.5.1.2 Average weight of ceramic products

Product	Average weight, kg
Standard ceramic brick, pcs.	3.7
Ceramic sanitary product, pcs.	20
Porcelain tiles, sq. m.	19
Ceramic tiles, sq. m.	13
Facade tiles, sq. m.	25
Ceramic roof tiles, sq. m.	50
Standard tableware, pcs.	0.2

Data on the average weight of ceramic products were obtained from the websites of building materials suppliers and National Inventory Reports of CIS countries (National Greenhouse Gas Inventory Reports of the Russian Federation, Republic of Belarus, 2020).

The overall dynamics of ceramics production is mainly determined by the production of building bricks, it is shown in Figure 4.3.5.1.2.

20 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Vol. 3

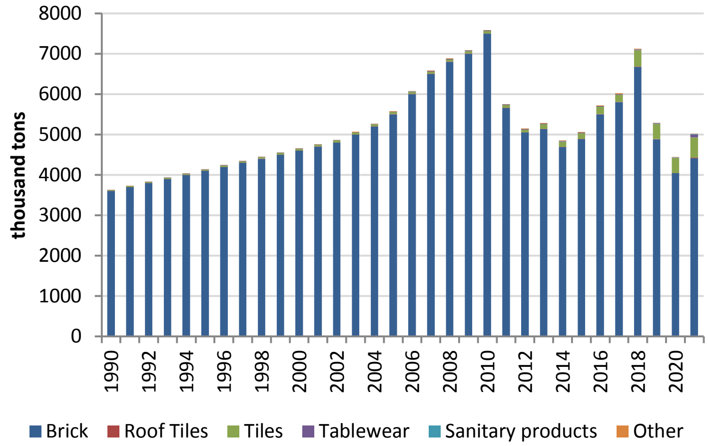

Figure 4.3.5.1.2 Dynamics of ceramic products production

Activity data for the period 1990-2008 are obtained by trend recovery. The uneven dynamics of brick production mainly depends on the concluded contracts for the supply of products. Since 2018, there has been a slight decline in the rate of brick production. The reason for the decline in brick production is the increased use of silicate blocks, reinforced concrete panels and slabs for housing construction.

Emission factors

In the Ceramics production category, default emission factors were used to calculate CO_2 emissions using Equation 2.14:

CO_2 emissions (Gg) = M (weight of finished products, thousand tons) *1.1*0.1,

where the proportion of carbonates in clay for the production of ceramics is taken as 0.1 (p.2.38, Vol. 3, Part 1 [21]).

The default loss factor for converting the weight of ceramic products into the amount of clay used to produce ceramics = 1.1.

Uncertainties and time series consistency

Since the activity statistics are incomplete and presented in units that differ from the requirements of the IPCC methodology, an expert assumption has been made that their uncertainty was ±10 %.

The default uncertainty of the emission factor was ±5%.

Combined uncertainty was ±11.2%.

Quality assurance/quality control

QA/QC procedures were performed in accordance with the general QA/QC principles [21] and the QA/QC plan. Verification on the following was conducted:

- homogeneity of the source data and methods used for the entire time series,
- correctness of the formulas and units of measurement used for the entire time series,
- correctness of the use of default emission factors,
- documentation of emission sources,
- data for mechanical errors.

Planned improvements in the category

As part of the next inventory, it is expected to refine the activity data and detail it over the entire time series.

4.3.5.2 Other Uses of Soda Ash (2.A.4.b category)

Soda ash is of great importance to the national economy. It is widely used in many industries: glass, chemical, pulp and paper, non-ferrous and ferrous metallurgy, food, petrochemical and oil refining and other industries, and is also used for household needs.

In the previous inventory for the period 1990-2017, emissions from total industrial soda consumption were estimated, the contribution of which to sectoral emissions was insignificant. However, in the previous inventory,

21 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Vol. 3

2.A.3 Glass production category was not estimated, which is key both for the IPPU sector and the inventory as a whole.

This inventory assumes that the glass industry is a major consumer of soda ash, and emissions from soda use are largely already accounted for in the Glass production category.

Additional data collection is required to make estimates on other industrial soda use, as data currently available on industrial soda consumption are inconsistent.

In the future, it is planned to estimate CO_2 emissions in this category in the context of individual industries.

4.3.5.3 Non-metallurgical Production of Magnesia (2.A.4.c category)

There is no magnesia production in Uzbekistan.

4.3.6 Recalculations for 2.A "Mineral Industry" category

The entire time series for the category "Mineral Industry" obtained in this inventory has been recalculated relative to the inventory of the First Biennial Update Report (FBUR) for the period 1990-2017 due to the inclusion of the new "Glass Production" and "Ceramics Production" categories. Also, the "Other Use of Soda Ash" category, the contribution of which was insignificant, was temporarily excluded from the calculation. The results of the recalculation are presented in Table 4.3.6.1.

Table 4.3.6.1 Recalculation of CO_2 emissions for the Mineral Industry category for the period 1990-2017, Gg CO_2

Years	FNC	FBUR	Difference	Years	FNC	FBUR	Difference
1990	5893.73	2925.43	2968.30	2004	10086.90	2208.73	7878.17
1991	5590.79	2886.52	2704.27	2005	10267.46	2338.19	7929.26
1992	5014.06	2789.69	2224.38	2006	10999.32	2454.95	8544.37
1993	4718.91	2672.45	2046.47	2007	11558.31	2717.55	8840.76
1994	4194.55	2334.73	1859.83	2008	12440.87	2934.75	9506.12
1995	3329.55	1692.93	1636.62	2009	12211.22	3023.09	9188.12
1996	3382.44	1609.61	1772.83	2010	14285.58	3120.01	11165.56
1997	4431.57	1646.33	2785.25	2011	12317.31	3039.81	9277.50
1998	5655.59	1687.64	3967.95	2012	12662.52	3029.70	9632.82
1999	4986.79	1575.87	3410.92	2013	10337.04	3196.00	7141.04
2000	4766.63	1564.19	3202.44	2014	8901.85	3378.48	5523.37
2001	9035.92	1768.16	7267.76	2015	10237.22	3358.01	6879.20
2002	6975.80	1766.08	5209.72	2016	10389.55	3439.20	6950.34
2003	7820.63	1846.10	5974.53	2017	10933.08	3455.54	7477.54

The results of CO_2 emissions calculated in this inventory for the "Mineral Industry" category are 1.7 - 4.5 times higher than the previously obtained estimates. The inclusion of a new Glass production subcategory had the greatest impact on the obtained significantly higher estimates of CO_2 emissions in the category, since its contribution to the emissions of the "Mineral Industry" category is 76%.

4.4 Chemical Industry (2.B category)

4.4.1 Description of the category

In the Chemical Industry category, greenhouse gas emissions for the following subcategories have been estimated:

- 2.B.1 Ammonia Production (CO_2),
- 2.B.2 Nitric Acid Production (N_2O),
- 2.B.5 Calcium Carbide Production (CO_2, CH_4),
- 2.B.8.a Methanol Production (CO_2, CH_4),
- 2.B.8.e Acrylonitrile Production (CO_2, CH_4).

Caprolactam, glyoxal, titanium dioxide, vinyl chloride, ethylene oxide, F-gases are not produced in the Republic of Uzbekistan.

Chemical industry enterprises in Uzbekistan are united into the Uzkimyosanoat Joint Stock Company [22]. They produce mineral fertilizers, organic and inorganic substances, artificial fibers, polymer materials, chemical reagents

22 Official website of Uzkimyosanoat JSC - www.uzkimyosanoat.uz

for the energy, gold mining, chemical industries, and chemical plant protection products. The raw materials for this industry are natural gas, oil, coal, sulphur, ozokerite, table salt, various non-ferrous metallurgy wastes, raw cotton processing products, etc.

Ammonia and weak nitric acid are produced at three enterprises of the Uzkimyosanoat JSC: Maksam Chirchik JSC, Navoiazot JSC and Ferghanaazot JSC.

Soda ash is produced at the Kungrad soda plant, the only plant in Central Asia using the Solvay method (the production process does not emit carbon dioxide). The plant was put into operation in 2006 and produces products based on local raw materials - sodium chloride and limestone. The plant is supplied with ammonia from the enterprises of Uzkimyosanoat JSC (Maksam-Chirchik JSC and Navoiazot JSC). The largest consumers of soda ash in Uzbekistan are Quartz JSC, CAMPALIA LLC, Asl oyna JSC, NMMC, etc. Soda ash is exported to Kazakhstan, Kyrgyzstan, the Russian Federation, Tajikistan, Afghanistan, Iran, etc.

The producers of sulfuric acid in Uzbekistan are Almalyk and Navoi mining and metallurgical complexes, as well as Ammophos-Maksam plant (Almalyk). The products produced are used for production needs of the enterprises, as well as for the republican consumers and for export.

In 2021, total greenhouse gas emissions in the Chemical Industry category amounted to 5,039.15 Gg CO_2-eq.

Emission trends by gas

In the Chemical industry category, the main GHGs are carbon dioxide (59.5%) and nitrous oxide (40.4%), together accounting for 99.9% of total emissions.

In 2021, greenhouse gas emissions by category were as follows:

CO_2 – 2,999.15 Gg. The source of emissions is ammonia production.

N_2O – 2,037.97 Gg CO_2-eq. The source of emissions is nitric acid production.

CH_4 - 2.02 Gg CO_2-eq. The sources of methane emissions are calcium carbide, methanol, acrylonitrile, formaldehyde production.

Emissions of indirect greenhouse gases: CO, NOx, SO_2 and NMVOCs are also estimated in the Chemical industry category. The most significant are CO and NMVOC emissions. In 2021, CO emissions amounted to 12.65 Gg, NMVOC emissions - 8.90 Gg, NOx emissions - 1.19 Gg, and SO_2 emissions - 2.26 Gg. For all precursor gases, except for NMVOC, there is a decreasing trend in emissions.

The source of CO emissions in the Chemical industry category is ammonia production; of nitrogen oxides - nitric acid production; of NMVOCs - ammonia, acrylonitrile, formaldehyde production; of sulphur dioxide - sulphuric acid, ammonia production.

Table 4.4.1.1 shows GHG and precursor gas emissions in the Chemical Industry category for the period 1990 - 2021.

Over the period 1990-2021, total GHG emissions in the Chemical processes category decreased by 21%, including a decrease in CO_2 by 25.1% and N_2O by 14.6%. CH_4 emissions account for 0.04% of the total sectoral emissions and tend to increase significantly. Methane emissions increased 30 times compared to the 1990 level. Figure 4.4.1.1 shows the dynamics of precursor gas emissions in the Chemical Industry category.

Table 4.4.1.1 GHG emissions for the Chemical Industry category

Years	CO_2,	CH_4	N_2O,	Total GHG	CO	NOx	SO_2	NMVOCs
	Gg CO_2-eq.				Gg			
1990	4004.27	0.07	2385.89	**6390.23**	13.75	1.39	3.34	8.20
1991	3976.47	0.09	2416.97	**6393.54**	13.71	1.41	3.30	8.18
1992	3588.82	0.11	2336.30	**5925.22**	12.59	1.36	2.05	7.51
1993	2977.58	0.08	2019.62	**4997.28**	10.62	1.17	1.88	6.34
1994	2202.76	0.05	1550.17	**3752.98**	7.78	0.90	1.64	4.64
1995	2432.32	0.03	1623.90	**4056.25**	8.70	0.95	1.41	5.19
1996	2534.87	0.04	1734.53	**4269.45**	9.12	1.01	1.37	5.44
1997	2444.52	0.03	1512.74	**3957.29**	9.06	0.89	1.21	5.40
1998	2246.30	0.05	1585.61	**3831.96**	8.44	0.94	1.19	5.03
1999	1996.59	0.08	1379.61	**3376.28**	7.62	0.82	1.24	4.54

Table 4.4.1.1 continuation

Years	CO_2,	CH_4	N_2O,	Total GHG	CO	NOx	SO_2	NMVOCs
	Gg CO_2-eq.				Gg			
2000	2051.17	0.21	1404.95	**3456.34**	7.79	0.83	1.15	4.65
2001	1654.98	0.22	1444.51	**3099.72**	6.42	0.86	0.87	3.84
2002	1888.55	0.22	1383.36	**3272.13**	7.15	0.82	1.17	4.27
2003	2058.24	0.36	1446.60	**3505.20**	7.84	0.86	1.12	4.86
2004	2150.18	0.32	1563.65	**3714.15**	8.12	0.92	1.16	5.15
2005	2241.11	0.32	1646.17	**3887.60**	8.41	0.96	1.04	5.37
2006	2408.55	0.36	1701.49	**4110.39**	9.01	1.01	1.17	5.78
2007	2612.45	0.36	1918.95	**4531.76**	9.66	1.12	1.39	6.19
2008	2744.94	0.37	1999.12	**4744.43**	10.12	1.16	1.29	6.43
2009	2649.78	0.32	1016.56	**3666.66**	10.00	1.14	1.43	6.36
2010	2870.16	0.41	860.95	**3731.51**	10.62	1.16	1.66	6.73
2011	2749.13	0.52	812.56	**3562.21**	10.20	1.16	1.60	6.49
2012	2903.53	0.49	843.14	**3747.17**	10.71	1.16	1.77	6.78
2013	2351.72	0.36	1765.67	**4117.75**	9.09	1.05	2.09	5.82
2014	2583.93	1.41	1966.28	**4551.62**	9.98	1.16	1.93	6.00
2015	2469.48	0.78	1973.73	**4443.99**	9.59	1.15	2.08	6.26
2016	2676.07	0.67	1884.69	**4561.43**	10.18	1.10	2.10	7.47
2017	2438.89	0.65	1689.64	**4129.18**	9.30	0.99	1.96	7.12
2018	2407.20	0.50	1720.55	**4128.26**	9.16	1.01	2.11	6.98
2019	2947.42	0.62	1972.82	**4920.86**	10.80	1.14	2.16	7.97
2020	2709.93	0.51	1673.26	**4383.70**	9.94	0.98	2.18	7.41
2021	2999.15	2.02	2037.97	**5039.15**	12.65	1.19	2.26	8.90
$\Delta_{(1990-2021)}$	**-25.1%**	**30-fold increase**	**-14.6%**	**-21.1%**	**-8.0%**	**-14.6%**	**-32.2%**	**+8.6%**
%, 2021	**59.52%**	**0.04%**	**40.44%**	**100%**				

According to calculated data, for the last 10 years emissions of all estimated gases remained practically at the same level, except for sulphur dioxide, for which there has been some increase in emissions mainly due to the growth of sulphuric acid production (Figure 4.4.1.2)

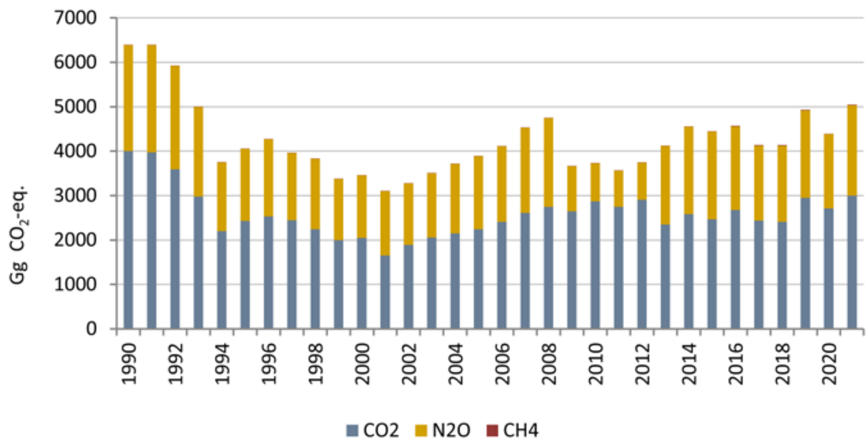

Figure 4.4.1.1 GHG emission trends for the Chemical industry category

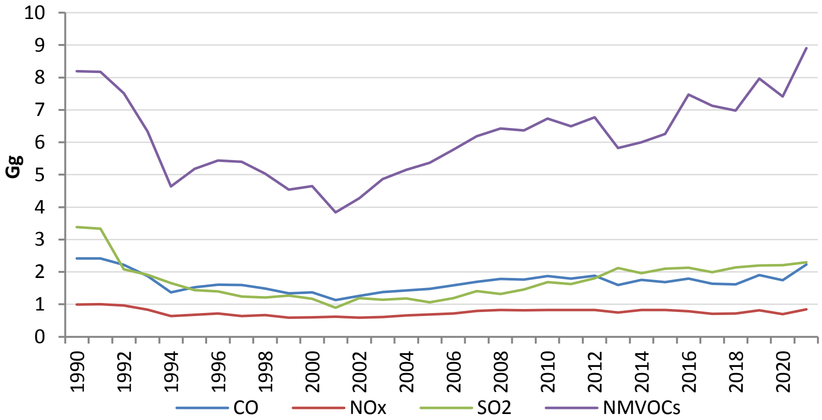

Figure 4.4.1.2 Indirect greenhouse gas emission trends for the Chemical Industry category

Emission trends by subcategory

Table 4.4.1.2 shows GHG emissions from selected Chemical Industry categories for the period 1990-2021.

Table 4.4.1.2 GHG emissions from the Chemical Industry category by subcategory, Gg CO_2-eq.

Years	Ammonia Production	Nitric Acid Production	Calcium Carbide Production	Methanol Production	Acrylonitrile Production	Total GHG, Gg CO_2-eq.
1990	3989.31	2385.89	-	-	15.03	**6390.23**
1991	3955.91	2416.97	-	-	20.65	**6393.54**
1992	3564.88	2336.30	-	-	24.05	**5925.22**
1993	2959.23	2019.62	-	-	18.43	**4997.28**
1994	2192.23	1550.17	-	-	10.58	**3752.98**
1995	2424.77	1623.90	-	-	7.58	**4056.25**
1996	2525.02	1734.53	-	-	9.89	**4269.45**
1997	2437.47	1512.74	-	-	7.08	**3957.29**
1998	2234.45	1585.61	-	-	11.90	**3831.96**
1999	1984.12	1379.61	-	0.37	12.17	**3376.28**
2000	2033.06	1404.95	-	1.75	16.57	**3456.34**
2001	1638.22	1444.51	-	1.89	15.09	**3099.72**
2002	1870.92	1383.36	-	1.89	15.96	**3272.13**
2003	2039.13	1446.60	-	3.64	15.83	**3505.20**
2004	2136.51	1563.65	-	3.49	10.50	**3714.15**
2005	2229.63	1646.17	-	3.63	8.17	**3887.60**
2006	2391.23	1701.49	-	3.73	13.96	**4110.39**
2007	2591.89	1918.95	-	3.59	17.32	**4531.76**
2008	2725.08	1999.12	-	3.80	16.43	**4744.43**
2009	2632.72	1016.56	-	3.29	14.09	**3666.66**
2010	2850.05	860.94	-	4.25	16.27	**3731.51**
2011	2727.95	812.56	-	5.67	16.03	**3562.21**
2012	2888.92	843.14	-	5.66	9.44	**3747.20**
2013	2341.72	1765.67	0.01	4.18	6.15	**4117.75**
2014	2574.35	1966.28	5.07	4.38	1.54	**4551.62**
2015	2463.37	1973.73	2.32	3.74	0.83	**4443.99**
2016	2669.70	1884.69	2.06	2.91	2.06	**4561.43**
2017	2431.63	1689.64	1.20	4.94	1.76	**4129.18**
2018	2399.61	1720.55	0.82	3.94	3.33	**4128.26**
2019	2938.85	1972.82	0.83	5.53	2.83	**4920.86**
2020	2705.94	1673.26	1.19	3.31	0.00	**4383.70**
2021	2975.54	2037.97	0.88	23.20	1.56	**5039.15**
Δ $_{(1990-2021)}$	**-25.4%**	**-14.6%**	**58.5-fold increase since 2013.**	**62.5-fold increase since 1999**	**9.6-fold decrease**	**-21.1%**
%, $_{2021}$	**59.05%**	**40.44%**	**0.02%**	**0.46%**	**0.03%**	**100%**

The largest contribution to GHG emissions from the Chemical industry comes from the Ammonia production (59%) and Nitric acid production (40.4%) categories. For the period from 1990 to 2021, the Chemical industry category shows a 21% downward trend in GHG emissions relative to 1990. The decrease in GHG emissions in the category is associated with the decrease in the production of chemical industry products relative to the 1990 level.

4.4.2 Ammonia Production (2.B.1 category)

Ammonia is produced in Uzbekistan at three major enterprises: Navoiazot JSC, Maksam-Chirchik JSC and Ferghanaazot JSC, mainly as an intermediate product for the production of mineral fertilizers. Maksam-Chirchik JSC and Ferghanaazot JSC also produce urea. Navoiazot JSC started urea production in 2020. The raw material for ammonia production at all enterprises is natural gas.

The ammonia synthesis technology consists of the following stages: purification of natural gas from sulphur compounds, steam methane reforming, steam-air conversion of residual methane, two-stage conversion of carbon monoxide with water steam, monoethanolamine purification of converted gas from carbon dioxide, methanation of residual carbon oxides, ammonia synthesis, its condensation and removal from the cycle to storage.

In 2021, CO_2 emissions from ammonia production (including urea production) amounted to 2,975.54 Gg. Table 4.4.2.1 shows CO_2 and other gas emissions for the period 1990-2021 for the Ammonia production category.

Table 4.4.2.1 CO_2 and indirect greenhouse gas emissions from the Ammonia Production category

Years	Gg CO_2				Gg		
	Navoiazot JSC	Maksam-Chirchik JSC	Ferghanaazot JSC	Total	CO	NMVOCs	SO_2
1990	788.92	1806.57	1393.82	**3989.31**	13.75	8.18	0.05
1991	825.11	1755.25	1375.55	**3955.91**	13.71	8.16	0.05
1992	841.80	1650.43	1072.65	**3564.88**	12.59	7.49	0.05
1993	664.02	1344.42	950.78	**2959.23**	10.62	6.32	0.04
1994	544.04	969.61	678.57	**2192.23**	7.78	4.63	0.03
1995	584.27	1143.95	696.55	**2424.77**	8.71	5.18	0.03
1996	616.24	1257.23	651.54	**2525.02**	9.12	5.43	0.04
1997	676.32	1138.67	622.48	**2437.47**	9.06	5.39	0.03
1998	744.65	1038.23	451.57	**2234.46**	8.44	5.02	0.03
1999	722.17	960.72	301.24	**1984.12**	7.62	4.53	0.03
2000	749.40	801.00	482.67	**2033.06**	7.79	4.63	0.03
2001	776.80	600.03	261.39	**1638.22**	6.42	3.82	0.02
2002	750.63	830.82	289.47	**1870.92**	7.15	4.25	0.03
2003	753.26	860.83	425.04	**2039.13**	7.84	4.67	0.03
2004	760.11	843.16	533.24	**2136.51**	8.12	4.83	0.03
2005	712.51	906.35	610.78	**2229.64**	8.41	5.01	0.03
2006	779.47	961.70	650.06	**2391.23**	9.01	5.36	0.03
2007	807.29	1091.29	693.32	**2591.89**	9.66	5.75	0.04
2008	818.32	1157.75	749.01	**2725.08**	10.12	6.02	0.04
2009	830.42	1186.98	615.32	**2632.72**	10.00	5.95	0.04
2010	803.50	1216.01	830.54	**2850.05**	10.62	6.32	0.04
2011	818.33	1067.16	842.46	**2727.95**	10.20	6.07	0.04
2012	827.94	1234.04	826.94	**2888.92**	10.71	6.37	0.04
2013	826.01	975.30	540.42	**2341.73**	9.09	5.41	0.04
2014	853.83	865.03	855.49	**2574.35**	9.98	5.94	0.04
2015	815.84	726.63	920.90	**2463.37**	9.59	5.70	0.04
2016	751.03	913.29	1005.37	**2669.70**	10.18	6.06	0.04
2017	672.47	903.33	855.83	**2431.63**	9.30	5.53	0.04
2018	719.48	925.74	754.39	**2399.61**	9.16	5.45	0.04
2019	747.50	1157.61	1033.74	**2938.85**	10.80	6.43	0.04
2020	583.31	1295.15	827.49	**2705.94**	9.94	5.91	0.04
2021	904.04	1254.52	816.98	**2975.54**	12.65	7.53	0.05

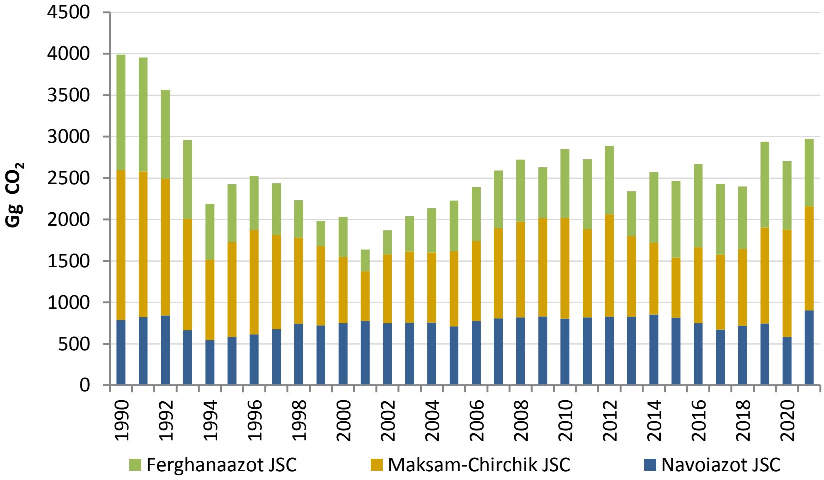

Figure 4.4.2.1 CO_2 emissions from the Ammonia Production category

Figure 4.4.2.1 shows CO_2 emissions in the Ammonia Production category for 1990-2021.
In general, CO_2 emissions from ammonia production have been stable over the last 10 years, but there is an upward trend in 2018-2021 due to the increase in ammonia production. CO_2 emissions from ammonia production in 2021 are lower than 1990 emissions. The decline in ammonia production after 1992 was explained by the economic crisis after the collapse of the USSR. The reduction in ammonia production at Ferghanaazot JSC in the early 2000s was due to large-scale reconstruction and renovation of production facilities.

Methodology

This category is key. CO_2 emissions from ammonia production were estimated for individual plants using national emission factors.
CO_2 emissions were calculated at the individual plant level using Equation 3.1 pp. 3.12 Vol.3, Part 1 [23], assuming that all plants use only natural gas as fuel.
When calculating GHG emissions according to Equation 3.1, national data were used for the conversion factor of natural units into energy units - **34.001 million m^3/TJ;** carbon content factor for natural gas - **15 kg/GJ** (default); carbon oxidation factor equal to **1** (default). The amount of CO_2 used for urea production is calculated using the default factor (**0.733 t CO_2 /t urea**).
The calculations of final emissions have taken into account CO_2 consumption during urea production at Maksam-Chirchik JSC and Ferghanaazot JSC, at Navoiazot JSC - only from 2021.
The assessment of CO_2 emissions from urea use in agriculture is considered in the AFOLU Sector.
In addition to CO_2 emissions, NMVOCs, CO and SO_2 emissions were estimated for the Ammonia production category in accordance with the 1996 IPCC Guidelines [24].

Activity data

To estimate CO_2 emissions from ammonia production, data from technical reports of Navoiazot JSC, Maksam-Chirchik JSC and Ferghanaazot JSC provided by Uzkimyosanoat JSC were used. With the help of experts of Uzkimyosanoat JSC, historical data on ammonia production at Ferghanaazot JSC in 1990-1992, as well as data for the period 2005-2017 for Navoiazot JSC were specified.

Emission factors

The FNC refined the average annual emission factors for each company. They made up:

– for Navoiazot JSC - **1.756** kg CO_2/ton of ammonia;
– for Maksam-Chirchik JSC - **2.695** kg CO_2/ton of ammonia;
– for Ferghanaazot JSC – **2.845** kg CO_2/ton of ammonia.

Due to changes in the values of CO_2 emission factors from ammonia production, all time series were recalculated.
To estimate emissions of other gases - NMVOCs, CO and SO_2, *default emission factors* were used, equal to, respectively, **4.7 kg NMVOC/t ammonia, 7.9 kg CO/t ammonia, and 0.03 kg SO_2/t ammonia.**

23 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Vol. 3
24 Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Greenhouse Gas Inventory Workbook, Part 2

Uncertainties and time series consistency

Activity data uncertainty was ±2% (default assumption, [25]).
Emission factor uncertainties were:

- for Maxam-Chirchik ±13,7%,
- for Maxam-Chirchik ±3,0%,
- for Ferghanaazot ±20,9%.

Quality assurance/quality control

QA/QC procedures were performed in accordance with the general QA/QC principles [14] and the QA/QC plan. Verification on the following was conducted:

- homogeneity of the source data and methods used for the entire time series,
- correctness of the formulas and units of measurement used for the entire time series,
- correctness of the use of default emission factors,
- documentation of emission sources,
- data for mechanical errors.

Recalculations for the Ammonia production category

Due to the refinement of activity data at Navoiazot JSC for 2005-2017, as well as at Ferghanaazot JSC for 1990-1992, as well as the refinement of national emission factors, the time series for the Ammonia production category were recalculated for the period 1990-2017. The results of recalculation are shown in Table 4.4.2.2.

Table 4.4.2.2 Results of CO_2 emission recalculation for the Ammonia Production category, Gg

Years	FNC	FBUR	Difference	Years	FNC	FBUR	Difference
1990	3989.31	3983.83	5.48	2004	2136.51	2140.70	-4.19
1991	3955.91	3967.96	-12.05	2005	2229.64	2234.51	-4.87
1992	3564.88	3576.96	-12.08	2006	2391.23	2396.63	-5.40
1993	2959.23	2969.03	-9.80	2007	2591.89	2598.55	-6.66
1994	2192.23	2198.94	-6.71	2008	2725.08	2732.47	-7.39
1995	2424.77	2433.47	-8.70	2009	2632.72	2640.95	-8.23
1996	2525.02	2535.49	-10.47	2010	2850.05	2857.98	-7.93
1997	2437.47	2445.96	-8.49	2011	2727.95	2733.63	-5.68
1998	2234.46	2241.98	-7.52	2012	2888.92	2896.60	-7.68
1999	1984.12	1991.37	-7.25	2013	2341.73	2348.32	-6.59
2000	2033.06	2037.09	-4.03	2014	2574.35	2577.97	-3.62
2001	1638.22	1640.35	-2.13	2015	2463.37	2465.11	-1.74
2002	1870.92	1875.91	-4.99	2016	2669.70	2673.77	-4.07
2003	2039.13	2043.94	-4.81	2017	2431.63	2434.66	-3.03

The largest difference in emission estimates was obtained for 1991 and 1992 and amounted to about 12 Gg of CO_2, which is associated with refined activity data at Ferghanaazot JSC.

Planned improvements for the category

No improvements are planned in this category.

4.4.3 Nitric Acid Production (2.B.2 category)

Nitric acid is produced in Uzbekistan at three large enterprises: Navoiazot JSC, Maksam-Chirchik JSC and Ferghanaazot JSC, mainly as an intermediate product for the production of mineral fertilizers. The enterprises are part of Uzkimyosanoat JSC.
The production of weak nitric acid causes emissions of nitrous oxide as a by-product of the catalytic oxidation of ammonia at high temperatures. NOx emissions also occur during nitric acid production. The method of nitric acid production at each of the plants is combined. The plants have units operating at both elevated and atmospheric pressures.
In 2021, CO_2 emissions from Nitric Acid Production amounted to 2,037.97 Gg. Table 4.4.3.1 presents N_2O and NOx emissions for the period 1990-2021 in the Nitric Acid Production category.

25 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Vol. 3

Table 4.4.3.1 Emissions of N_2O and other gases for the Nitric Acid Production category

Years	N_2O, Gg CO_2-eq.				NOx, Gg
	Navoiazot JSC	Maksam-Chirchik JSC	Ferganaazot JSC	Total	
1990	1132.59	661.93	591.37	**2385.89**	1.39
1991	1172.05	637.53	607.39	**2416.97**	1.41
1992	1159.22	586.00	591.08	**2336.30**	1.36
1993	888.52	530.44	600.66	**2019.62**	1.17
1994	734.70	357.50	457.98	**1550.17**	0.90
1995	788.39	422.29	413.21	**1623.90**	0.95
1996	825.21	477.85	431.48	**1734.53**	1.01
1997	887.13	451.19	174.42	**1512.74**	0.89
1998	988.94	442.31	154.36	**1585.61**	0.94
1999	987.40	391.14	1.06	**1379.61**	0.82
2000	1014.88	390.07	-	**1404.95**	0.83
2001	995.21	449.30	-	**1444.51**	0.86
2002	969.83	413.53	-	**1383.36**	0.82
2003	959.51	435.56	51.53	**1446.60**	0.86
2004	911.68	412.58	239.39	**1563.65**	0.92
2005	908.33	407.72	330.12	**1646.17**	0.96
2006	951.00	515.28	235.20	**1701.49**	1.01
2007	1005.81	528.66	384.47	**1918.95**	1.12
2008	996.33	514.57	488.22	**1999.12**	1.16
2009	584.43	62.93	369.20	**1016.56**	1.14
2010	544.83	91.36	224.76	**860.95**	1.16
2011	558.75	91.38	162.42	**812.56**	1.16
2012	520.76	148.52	173.86	**843.14**	1.16
2013	790.76	620.23	354.67	**1765.67**	1.05
2014	880.44	612.29	473.55	**1966.28**	1.16
2015	923.53	559.00	491.22	**1973.73**	1.15
2016	786.02	525.11	573.56	**1884.69**	1.10
2017	705.27	509.47	474.90	**1689.64**	0.99
2018	697.04	554.61	468.91	**1720.55**	1.01
2019	762.24	532.52	678.05	**1972.82**	1.14
2020	533.03	577.96	562.27	**1673.26**	0.98
2021	889.09	588.50	560.38	**2037.97**	1.19
$\Delta_{(1990-2021)}$				**-14.6%**	**-14.4%**

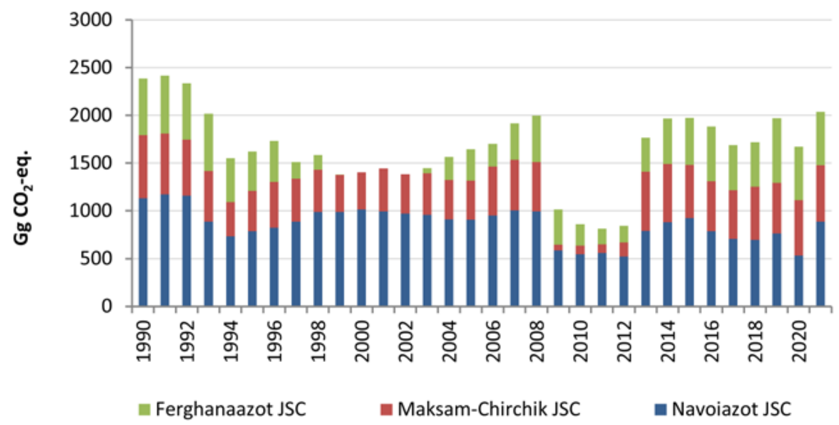

Figure 4.4.3.1 N_2O emissions from the Nitric Acid Production category

Figure 4.4.3.1 shows the dynamics of nitrous oxide emissions from three nitric acid production facilities. The decline in nitric acid production after 1992 was explained by the economic crisis after the collapse of the USSR. The sharp decrease in nitrous oxide emissions in 2009-2012 was due to the implementation of CDM projects at these facilities. After the completion of the CDM projects, platinum catalysts were removed from production under the terms of the partnership agreement, the weak nitric acid production process continued under the previous conditions and nitrous oxide emissions returned to the previous values. Since 2014, there have been no sharp changes in nitrous oxide emissions and nitric acid production levels have remained stable. In general, over the period 1990-2021, N_2O emissions decreased by 14.6%.

Methodology

This category is key. N_2O emissions from nitric acid production were estimated using the Tier 2 methodology for individual enterprises using national emission factors according to Equation 3.5 p. 3.22, Vol.3, Part 1 of the 2006 IPCC Guidelines [26].

In addition to N_2O emissions, NOx emissions were estimated for the Nitric acid production category in accordance with the 1996 IPCC Guidelines [27].

Activity data

To estimate N_2O emissions from nitric acid production, data from technical reports of Navoiazot JSC, Maksam-Chirchik JSC and Ferghanaazot JSC provided by Uzkimyosanoat JSC were used. With the help of experts of Uzkimyosanoat JSC, historical data on nitric acid production at Ferghanaazot JSC were clarified. It follows from the history of the enterprise that in the period 1999-2003 the plant did not produce nitric acid due to modernization and construction of new lines. At Navoiazot JSC in 2020, one of the nitric acid production workshops was decommissioned, so the total annual production decreased in that year. The time series from 1990 to 2017 was recalculated due to the refinement of activity data.

Emission factors

The FNC clarified the average annual N_2O emission factors for each enterprise. They made up:

- for Maksam-Chirchik JSC – **424** kg N_2O/t HNO_3 (3.171 was used in the FBR),
- for Ferghanaazot JSC – **5.024** kg N_2O/t HNO_3 (3.570 was used in the FBR),
- for Navoiazot JSC – **4.677** kg N_2O/t HNO_3 (4.312 was used in the FBR).

These coefficient values were used in N_2O emission calculations, except for CDM project years. In CDM project years, annual values of emission factors were used in N_2O emission calculations.

Due to changes in the values of N_2O emission factors from nitric acid production, all time series were recalculated.

A default emission factor from [27] equal to 0.79 kg NOx /t of nitric acid was used to estimate NOx emissions. The calculation results are presented in Table 4.18.

Uncertainties and time series consistency

Activity data uncertainty was ±2% (default assumption).
Uncertainty in national emission factors was as follows:

- for Maxam-Chirchik - ±13,7%,
- for Navoiazot - ±3,0%,
- for Ferghanaazot - ±20,9%.

Quality assurance/quality control

QA/QC procedures were performed in accordance with the general QA/QC principles and the QA/QC plan. Verification on the following was conducted:

- homogeneity of the source data and methods used for the entire time series,
- correctness of the formulas and units of measurement used for the entire time series,
- correctness of the use of emission factors,
- documentation of emission sources,
- data for mechanical errors.

Recalculations for the category

Due to the refinement of activity data as well as the refinement of national emission factors, the time series for the Nitric acid production category have been recalculated for the period 1990-2017. The results of the recalculation are presented in Table 4.4.3.2.

26 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Vol. 3
27 Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Greenhouse Gas Inventory Workbook, Part 2

Table 4.4.3.2 Results of N_2O emission recalculation for the Nitric Acid Production category, Gg CO_2-eq.

Years	FNC	FBUR	Difference	Years	FNC	FBUR	Difference
1990	2385.89	1634.86	751.03	2004	1563.65	1393.16	170.49
1991	2416.97	2101.42	315.55	2005	1646.17	1452.98	193.19
1992	2336.30	2034.30	301.99	2006	1701.49	1512.98	188.51
1993	2019.62	1735.82	283.80	2007	1818.95	1686.96	231.99
1994	1550.17	1339.40	210.78	2008	1999.12	1742.87	256.25
1995	1623.90	1411.54	212.36	2009	1016.56	1717.48	-700.91
1996	1734.53	1506.43	228.10	2010	860.95	1737.39	-876.44
1997	1512.74	1353.65	159.10	2011	812.56	1731.29	-918.73
1998	1585.61	1429.02	156.58	2012	843.14	1719.16	-876.02
1999	1379.61	1271.77	107.83	2013	1765.67	1534.80	230.86
2000	1404.95	1296.44	108.52	2014	1966.28	1702.04	264.24
2001	1444.51	1326.74	117.78	2015	1973.73	1712.17	261.57
2002	1383.36	1272.72	110.63	2016	1884.69	1613.12	271.57
2003	1446.60	1319.21	127.39	2017	1689.64	1449.82	239.82

The largest difference in emission estimates was obtained for 1990 and 2009-2012, which is due to refined activity data at Ferghanaazot JSC in 1990 and the recalculation of nitrous oxide emissions during the implementation of CDM projects.

Planned improvements in the category

In this category, it is planned to estimate N_2O emissions taking into account the technologies used for nitric acid production (at normal and elevated pressure) according to Equation 3.6 [28].

4.4.4 Calcium carbide Production (2.B.5 category)

The Calcium carbide production category is included in the inventory for the first time.
Calcium carbide has been produced at the CARBIDE IMPEX PLUS plant (Zarafshan city, Navoi region) since 2013. Calcium carbide ($CaC_{2)}$ is produced by heating calcium carbonate (limestone) followed by reduction of CaO with carbon (e.g., carbon from petroleum coke). During the CaC_2 production, CO_2 emissions occur from the limestone, as well as from the lime reduction process and the use of carbide. The calcium carbide production process is also accompanied by methane emissions.
Table 4.4.4.1 presents GHG emissions from calcium carbide production. During the period from 2013 to 2021, there has been a significant increase in GHG emissions from calcium carbide production, which was due to the growth of production capacity. In 2021, GHG emissions in this category amounted to 0.877 Gg CO_2-eq.

Table 4.4.4.1 GHG emissions from Calcium Carbide Production category, Gg CO_2-eq.

	2013	2014	2015	2016	2017	2018	2019	2020	2021	$\Delta_{(1990-2021)}$
CO_2	0.012	4.015	1.833	1.634	0.953	0.651	0.659	0.941	0.694	**57.8-fold increase**
CH_4	0.003	1.058	0.483	0.431	0.251	0.172	0.174	0.248	0.183	**61-fold increase**
Total	**0.015**	**5.073**	**2.316**	**2.064**	**1.205**	**0.823**	**0.833**	**1.190**	**0.877**	**58.4-fold increase**

Methodology

CO_2 and CH_4 emissions from calcium carbide production were estimated using Tier 1 methodology with default emission factors.
Emissions were calculated using Equation 3.11 pg. 3.46 Vol.3, Part 1 of the 2006 IPCC Guidelines.

Activity data

Data on calcium carbide production are provided by the Statistical Agency of the Republic of Uzbekistan.

Emission factors

In accordance with the Tier 1 methodology, CO_2 emissions were calculated using production data and an average default factor from **1.1 t CO_2/t carbide** (T. 3, Table 3.8, p. 3.48).
H_4 emissions were also calculated using production data and the average default factor from **11.6 kg CH_4 /t carbide** (0.0116 t CH_4 /t carbide) (Vol. 3, p. 3.47).

28 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Vol. 3

Uncertainties and time series consistency

Activity data uncertainty was ±2% (default assumption, [21]).
Emission factor uncertainty was ±10% (default)
Combined uncertainty was ±10.2%

Quality assurance/quality control

QA/QC procedures were performed in accordance with the general QA/QC principles and the QA/QC plan. Verification on the following was conducted:

- homogeneity of the source data and methods used for the entire time series,
- correctness of the formulas and units of measurement used for the entire time series,
- correctness of the use of emission factors,
- documentation of emission sources,
- data for mechanical errors.

Planned improvements in the category

In this category, it is planned to refine the activity data and obtain additional information on calcium carbide production technology.
It is also planned to estimate emissions from calcium carbide consumption in the next inventory.

4.4.5 Production of Soda ash (2.B.7 category)

Soda ash has been produced in the Republic of Uzbekistan using the Solvay method since 2006 at the Kungrad soda plant. The production process is a closed cycle and is practically not accompanied by CO_2 emissions (Chapter 3.8.3, p. 3.62 Vol.3, Part 1, [21], therefore this category is not included in the inventory.

4.4.6 Methanol Production (2.B.8.a category)

Methanol has been produced at Navoiazot JSC since 1999. Methanol production is accompanied by CO_2 and CH_4 emissions. GHG emissions from methanol production are presented in Table 4.4.6.1 and Figure 4.4.6.1. During the period from 1999 to 2021, GHG emissions in this category increased 62.5 times due to the growth of production capacity. In 2021, GHG emissions from Methanol Production amounted to 23.20 Gg CO_2-eq.

Table 4.4.6.1 GHG emissions from the Methanol Production category

Years	CO_2	CH_4	Total	Years	CO_2	CH_4	Total
	Gg CO_2-eq.				Gg CO_2-eq.		
1999	0.34	0.03	**0.37**	2011	5.22	0.45	**5.67**
2000	1.61	0.14	**1.75**	2012	5.21	0.45	**5.66**
2001	1.74	0.15	**1.89**	2013	3.85	0.33	**4.18**
2002	1.74	0.15	**1.89**	2014	4.03	0.35	**4.38**
2003	3.35	0.29	**3.64**	2015	3.44	0.29	**3.74**
2004	3.22	0.28	**3.49**	2016	2.68	0.23	**2.91**
2005	3.34	0.29	**3.63**	2017	4.55	0.39	**4.94**
2006	3.43	0.29	**3.73**	2018	3.63	0.31	**3.94**
2007	3.31	0.28	**3.59**	2019	5.09	0.44	**5.53**
2008	3.50	0.30	**3.80**	2020	3.05	0.26	**3.31**
2009	3.03	0.26	**3.29**	2021	21.36	1.83	**23.20**
2010	3.91	0.34	**4.25**	$\Delta_{(1990-2021)}$	**62.6-fold increase**	**63.2-fold increase**	**62.5-fold increase**

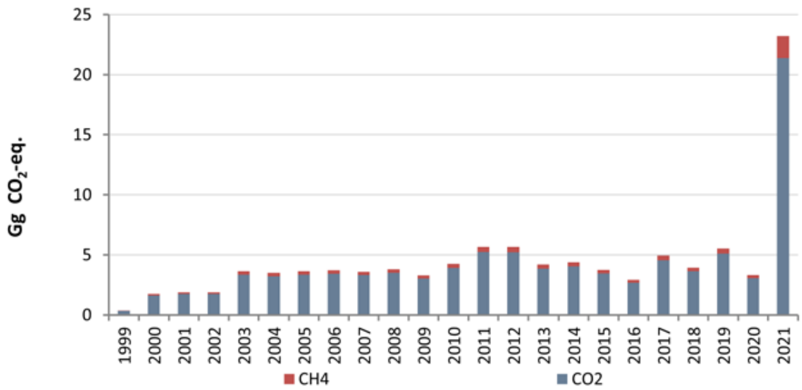

Figure 4.4.6.1 GHG emissions from Methanol Production

Methodology

CO_2 and CH_4 emissions from methanol production were estimated using Tier 1 methodology with default emission factors.
Emissions were calculated using Equation 3.15 p. 3.73 Vol.3, Part 1 of the 2006 IPCC Guidelines [29].

Activity data

Data on methanol production were provided by the Statistics Agency of the Republic of Uzbekistan. A significant increase in methanol production in 2021 is explained by the commissioning of new capacities (expected production capacity up to 295.4 thousand tons/year) as part of the investment project of Navoiazot JSC.

Emission factors

The 2006 IPCC Guidelines recommend using a factor of **0.67 t CO_2/t** methanol produced for the default process to calculate CO_2 emissions (conventional steam reforming without a primary reformer), Table 3.12, "CO_2 emission factors from methanol production ", pp. 3.82, Vol.3, Part 1, Chapter 3.9.2.2.
A default factor of **2.3 kg CH_4/ton of methanol** was used to calculate methane emissions from methanol production (p.3.83, Vol.3, Ch.1, Chapter 3.9.2.2.)

Uncertainties and time series consistency

Activity data uncertainty was 2% (default assumption).
Emission factor uncertainty was ±30% (default, Table 3.27).

Combined uncertainty was ±30.1%.

Quality assurance/quality control

QA/QC procedures were performed in accordance with the general QA/QC principles and the QA/QC plan. Verification on the following was conducted:

- homogeneity of the source data and methods used for the entire time series,
- correctness of the formulas and units of measurement used for the entire time series,
- correctness of the use of emission factors,
- documentation of emission sources,
- data for mechanical errors.

Planned improvements in the category

In this category, it is planned to refine data on methanol production technology.

4.4.7 Ethylene (polyethylene) Production (2.B.8.b category)

Uz-Kor Gas Chemical (Ustyurt Gas Chemical Complex, UGCC), which produces HDPE under license from LOTTE Chemical (Korea) and Shurtan Gas Chemical Complex (SGCC) are engaged in production of high-density polyethylene in Uzbekistan. Uz-Kor Gas Chemical was commissioned in 2016 and has production capacities of 400,000 tons of ethylene per year, 387,000 tons of high-density polyethylene (HDPE) per year, 83,000 tons of

29 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Vol. 3.

propylene per year and 83,000 tons of polypropylene (PP) per year. Shurtan GCC has production capacities of 125 thousand tons of HDPE and LLDPE per year.

Additional data are currently being collected to estimate GHG emissions from ethylene production, an intermediate product. It is planned to estimate GHG emissions from this category in the next inventory.

4.4.8 Acrylonitrile Production (2.B.8.e category)

Acrylonitrile is produced at Navoiazot JSC. Acrylonitrile (AAN) production is accompanied by CO_2 and CH_4 emissions. Acrylonitrile is produced by cyanhydrogenation of acetylene on a liquid-phase copper acid catalyst, i.e. by interaction of acetylene and hydrocyanic acid in the presence of a catalyst – an aqueous solution of copper monochloride containing ammonium chloride.

Raw materials for the production of acrylonitrile: acetylene, hydrocyanic acid, hydrochloric acid, copper, chlorine.

The production of acrylonitrile consists of 2 technological lines, including the following stages: acrylonitrile synthesis, absorption, rectification of raw AAN, vacuum rectification of raw AAN, except for the stage of fine purification of AAN, which is performed by one technological line.

The obtained commercial product is used to produce nitron fiber, ammonium rhodanide, polyacrylamide, flocculants and so on.

GHG emissions from acrylonitrile production are presented in Table 4.4.8.1. In 2021, GHG emissions amounted to 1.561 Gg CO_2-eq.

Table 4.4.8.1 GHG emissions from Acrylonitrile Production

Years	CO_2	CH_4	Total	NMVOCs	Years	CO_2	CH_4	Total	NMVOCs
	CO_2-eq.			Gg		CO_2-eq.			Gg
1990	14.96	0.07	**15.03**	0.01	2007	17.24	0.08	**17.32**	0.02
1991	20.56	0.09	**20.65**	0.02	2008	16.35	0.07	**16.43**	0.02
1992	23.94	0.11	**24.05**	0.02	2009	14.03	0.06	**14.09**	0.02
1993	18.35	0.08	**18.43**	0.02	2010	16.20	0.07	**16.27**	0.02
1994	10.53	0.05	**10.58**	0.01	2011	15.96	0.07	**16.03**	0.02
1995	7.55	0.03	**7.58**	0.01	2012	9.40	0.04	**9.44**	0.01
1996	9.85	0.04	**9.89**	0.01	2013	6.13	0.03	**6.15**	0.01
1997	7.05	0.03	**7.08**	0.01	2014	1.53	0.01	**1.54**	0.00
1998	11.85	0.05	**11.90**	0.01	2015	0.83	0.00	**0.83**	0.00
1999	12.12	0.05	**12.17**	0.01	2016	2.05	0.01	**2.06**	0.00
2000	16.50	0.07	**16.57**	0.02	2017	1.75	0.01	**1.76**	0.00
2001	15.02	0.07	**15.09**	0.02	2018	3.31	0.01	**3.33**	0.00
2002	15.89	0.07	**15.96**	0.02	2019	2.82	0.01	**2.83**	0.00
2003	15.76	0.07	**15.83**	0.02	2020	0	0	**0**	0
2004	10.45	0.05	**10.50**	0.01	2021	1.55	0.01	**1.56**	0.00
2005	8.13	0.04	**8.17**	0.01	$\Delta_{(1990-2021)}$	**9.6-fold decrease**	**9.6-fold decrease**	**9.6-fold decrease**	**9.6-fold decrease**
2006	13.89	0.06	**13.96**	0.01					

Methodology

CO_2 and CH_4 emissions from acrylonitrile production were estimated according to the Tier 1 methodology using production data and default emission factors (according to Equation 3.15, page 3.73 Vol.3, Part 1 of the 2006 IPCC Guidelines) [30]. NMVOC emissions are estimated using the methodology of the 1996 IPCC Guidelines [31].

Activity data

Data on methanol production were provided by the Statistics Agency and Uzkimyosanoat JSC based on technical reports of Navoiazot JSC.

According to Navoiazot JSC, the reasons for the decrease in acrylonitrile production were:

- unloaded operation of the shop due to the maximum residuals of nitron fiber in warehouses, the lack of its processing and sale;
- insufficient supply of metallic copper used to prepare the catalyst solution.

30 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Vol. 3
31Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Greenhouse Gas Inventory Workbook, Part 2

Emission factors

A default factor of **1 t CO_2/t acrylonitrile** was used to calculate default CO_2 emissions from acrylonitrile production (Table 3.22, "CO_2 emission factors for acrylonitrile production," pg. 3.89, Vol.3, Part 1, Chap. 3.9.2.2.)[32].
A default factor of **0.18 kg CH_4/ton of acrylonitrile** was used to calculate methane emissions from acrylonitrile production (p.3.89, Vol. 3, Part 1, Chap. 3.9.2.2.2.)[32]
A default factor =**1 ton of NMVOC/ thousand tons of acrylonitrile** was used to calculate NMVOC emissions [33].

Uncertainties and time series consistency

Uncertainty of activity statistics was ±2% (default assumption, [32]).
Uncertainty of CO_2 emission factor was ±60% (default, Table 3.27)
Uncertainty of CH_4 emission factor was ±10% (default, Table 3.27)
Combined uncertainty of CO was ± emissions was ±60.03%, CH_4 emissions was ±10.2%.

Quality assurance/quality control

QA/QC procedures were performed in accordance with the general QA/QC principles [32] and the QA/QC plan. Verification on the following was conducted:

- homogeneity of the source data and methods used for the entire time series,
- correctness of the formulas and units of measurement used for the entire time series,
- correctness of the use of emission factors,
- documentation of emission sources,
- data for mechanical errors.

Planned improvements in the category

No improvements are planned in this category.

4.4.9 Carbon Black Production (2.B.8.f category)

Data on carbon black production in Uzbekistan are currently being collected. It is planned to estimate emissions from the category in the next inventory. It is assumed that the volume of carbon black production is small, and it is mainly imported from other countries.

4.4.10 Sulfuric Acid Production

The production of sulfuric acid is accompanied by SO_2 emissions. There are several sulfuric acid production enterprises in the country. The main production is located in Almalyk as part of the Almalyk Mining and Metallurgical Complex, as well as at Maksam-Chirchik JSC. SO_2 emissions were calculated based on statistical data on the total production of sulfuric acid (Figure 4.4.10.1) using the national default emission factor calculated based on long-term data from Maksam-Chirchik JSC, equal to **1.356 kg SO_2/t sulfuric acid**. The resulting SO_2 emission estimates are presented in Table 4.4.10.1. In 2021, SO_2 emissions from sulfuric acid production amounted to 2.22 Gg, compared to 1990 they decreased by 32.3%, which is due to the decline in production levels in the early 1990s, as shown in Figure 4.4.10.1. But in recent years, there has been a gradual increase in sulfuric acid production.

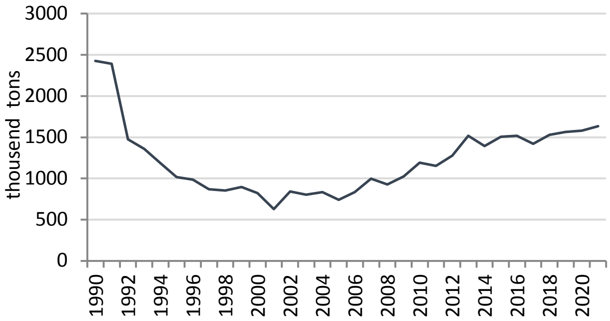

Figure 4.4.10.1 Dynamics of Sulfuric Acid Production

32 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Vol. 3
33Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Greenhouse Gas Inventory Workbook, Part 2

Table 4.4.10.1 SO_2 emissions from Sulfuric Acid Production, Gg

Years	SO_2	Year	SO_2	Year	SO_2
1990	3.29	2001	0.85	2012	1.73
1991	3.24	2002	1.14	2013	2.06
1992	2.00	2003	1.09	2014	1.89
1993	1.84	2004	1.13	2015	2.04
1994	1.61	2005	1.00	2016	2.06
1995	1.38	2006	1.13	207	1.92
1996	1.34	2007	1.35	2018	2.07
1997	1.18	2008	1.25	2019	2.12
1998	1.16	2009	1.39	2020	2.14
1999	1.22	2010	1.62	2021	2.22
2000	1.12	2011	1.56	$\Delta_{(1990–2021)}$	**-32.3%**

4.4.11 NMVOCs Emissions from Formaldehyde Production

NMVOC Emissions from Formaldehyde Production were estimated in the Chemical Industry category. Formaldehyde has been produced at Navoiazot JSC since 2000. Production dynamics is shown in Figure 4.4.11.1.

NMVOCs emissions were calculated according to the methodology of the 1996 IPCC Guidelines using a default emission factor of **5 kg NMVOC/ton of formaldehyde** [34]. NMVOCs emissions from formaldehyde production are presented in Table 4.4.11.1. A 12-fold increase in NMVOCs emissions is associated with an increase in formaldehyde production. In 2021, NMVOCs emissions from formaldehyde production amounted to 0.036 Gg.

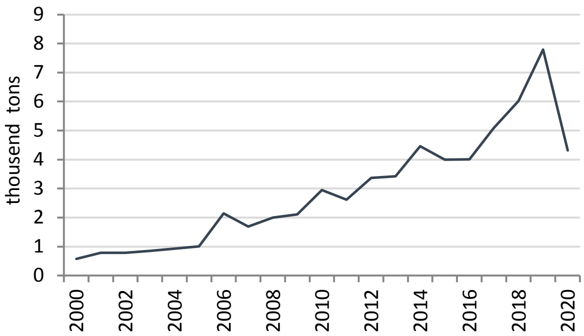

Figure 4.4.11.1 Dynamics of Formaldehyde Production

Table 4.4.11.1 NMVOCs emissions from Formaldehyde Production

Years	NMVOCs, Gg	Years	NMVOCs, Gg
2000	0.003	2012	0.017
2001	0.004	2013	0.017
2002	0.004	2014	0.022
2003	0.004	2015	0.020
2004	0.050	2016	0.020
2005	0.005	2017	0.025
2006	0.011	2018	0.030
2007	0.008	2019	0.039
2008	0.010	2020	0.022
2009	0.011	2021	0.036
2010	0.015	$\Delta_{(1990–2021)}$	**12-fold increase**
2011	0.013		

4.4.12 Recalculations for the "Chemical Industry" category

The entire time series for the Chemical Industry category obtained in this inventory was recalculated relative to the inventory for the period 1990-2017. The First Biennial Update Report (FBUR) due to the refinement of activity data and emission factors for key categories: Ammonia Production and Nitric Acid Production and the inclusion of a new Calcium Carbide Production category. The results of the recalculation are presented in Table 4.4.12.1.

Table 4.4.12.1 Recalculation of GHG emissions for the Chemical Industry category for the period 1990-2017, Gg CO_2-eq.

Years	FNC	FBUR	Difference	Years	FNC	FBUR	Difference
1990	6390.23	5010.38	1379.85	2004	3714.15	3833.91	-119.76
1991	6393.54	5030.00	1363.53	2005	3887.60	3965.01	-77.41
1992	5925.22	4817.85	1107.37	2006	4110.39	4119.94	-9.54
1993	4997.28	4092.82	904.46	2007	4531.76	4375.02	156.73
1994	3752.98	3208.39	544.59	2008	4744.43	4532.67	211.76
1995	4056.25	3750.57	305.67	2009	3666.66	4264.13	-597.47
1996	4269.45	3971.11	298.33	2010	3731.51	4378.46	-646.95
1997	3957.29	3829.99	127.29	2011	3562.21	4218.61	-656.40

34 Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Greenhouse Gas Inventories Workbook, Part 2.

Table 4.4.12.1 continuation

Years	FNC	FBUR	Difference	Years	FNC	FBUR	Difference
1998	3831.96	3715.68	116.28	2012	3747.17	4122.23	-375.07
1999	3376.28	3456.98	-80.71	2013	4117.75	3932.56	185.18
2000	3456.34	3674.50	-218.17	2014	4551.62	4120.39	431.23
2001	3099.72	3274.07	-174.36	2015	4443.99	4008.29	435.70
2002	3272.13	3357.59	-85.46	2016	4561.43	3941.09	620.34
2003	3505.20	3662.09	-156.88	2017	4129.18	3617.65	511.53

Recalculations in the category had a different impact on the time series. This is mostly due to the refinement of activity data for the Nitric acid production category.

4.5 Metal Industry (2.C category)

4.5.1 Description of the category

The following categories are estimated in 2.C Metal Industry category:

- 2.C.1 Iron and Steel Production (CO_2),
- 2.C.2 Ferroalloys Production (CO_2, CH_4),
- 2.C.5 Lead Production (CO_2),
- 2.C.6 Zinc Production (CO_2).

There is no production of cast iron and magnesium in the country. Primary aluminum is not produced; there are small secondary aluminum production facilities that use aluminum ingots imported from other countries as raw materials. Therefore, calculations have not been made for 2.C.3 Aluminum proauction, and 2.C.4 Magnesium producaion categories.

The metal industry provides a tenth of the country's industrial output. A significant part of ferrous metals (about 90%) is produced by Uzbek Metallurgical Complex JSC, located in Bekabad city, Tashkent region. Steel at the plant is smelted in arc furnaces. [35]

All production of copper, zinc and lead, 90% of silver production and 20% of gold production is concentrated at the Almalyk Mining and Metallurgical Complex. Having two mining enterprises, two enrichment plants and two metallurgical enterprises in its structure, the Complex is engaged in the development of copper-molybdenum and lead-zinc deposits.

The Uzbek Refractory and Heat Resistant Metals Complex in Chirchik specializes in the processing molybdenum and tungsten. A significant part of gold smelting is concentrated at the Navoi Mining and Metallurgical Complex, one of the top ten largest uranium and gold producers in the world.

The source of raw materials for the production of ferrous metals (steel) at Uzbek Iron and Steel Works JSC is scrap, part of which is imported to supply production capacity. The only studied iron ore deposit in Uzbekistan is Tebinbulak (Karakalpakstan). Its development requires large investments, and this project is still under development.

In general, currently, there are more than 50 economic entities with their own foundries, with a total number of 63 furnaces and a casting production volume of more than 1.2 million tons in the ferrous metallurgy of Uzbekistan. About 94% of the total casting volume is directed to the production of rolled metal products used mainly in the construction industry.

Emission trends by gas

In 2.C Metal Industry category, emissions of CO_2, CH_4 and indirect greenhouse gases: CO, NOx, SO_2 and NMVOCs are estimated.

Table 4.5.1.1 and Figure 4.5.1.1 present emissions of GHGs and other gases from metal production for the period 1990-2021.

35 Official website of Uzbek Metallurgical Complex JSC- www.uzbeksteel.uz

Table 4.5.1.1 Emissions of GHGs and other gases in the Metal Industry category

Years	CO_2	CH_4	Total	CO	NOx	SO_2	NMVOCs
	Gg CO_2-eq.			Gg			
1990	733.68	-	**733.68**	0.001	0.025	0.028	0.019
1991	773.56	-	**773.56**	0.001	0.026	0.030	0.020
1992	806.68	-	**806.68**	0.001	0.028	0.031	0.021
1993	726.78	-	**726.78**	0.001	0.024	0.027	0.018
1994	593.02	-	**593.02**	0.000	0.019	0.022	0.015
1995	469.86	-	**469.86**	0.000	0.015	0.017	0.011
1996	575.66	-	**575.66**	0.000	0.014	0.021	0.014
1997	484.30	-	**484.30**	0.000	0.014	0.017	0.011
1998	467.97	-	**467.97**	0.000	0.017	0.016	0.011
1999	423.81	-	**423.81**	0.000	0.018	0.016	0.011
2000	565.02	-	**565.02**	0.000	0.019	0.019	0.012
2001	610.85	-	**610.85**	0.000	0.024	0.020	0.013
2002	625.69	-	**625.69**	0.000	0.024	0.021	0.014
2003	623.78	-	**623.78**	0.000	0.025	0.022	0.015
2004	741.53	-	**741.53**	0.001	0.026	0.027	0.018
2005	703.99	-	**703.99**	0.001	0.027	0.027	0.018
2006	749.56	-	**749.56**	0.001	0.029	0.028	0.019
2007	819.31	-	**819.31**	0.001	0.029	0.030	0.020
2008	831.04	-	**831.04**	0.001	0.030	0.031	0.021
2009	808.49	-	**808.49**	0.001	0.031	0.033	0.022
2010	863.12	-	**863.12**	0.001	0.033	0.033	0.022
2011	885.04	-	**885.04**	0.001	0.033	0.034	0.022
2012	899.82	-	**899.82**	0.001	0.034	0.034	0.023
2013	925.83	0.01	**925.84**	0.001	0.036	0.036	0.024
2014	1071.33	0.00	**1071.34**	0.001	0.041	0.041	0.027
2015	884.30	0.01	**884.30**	0.001	0.033	0.033	0.022
2016	824.14	0.07	**824.21**	0.001	0.030	0.030	0.020
2017	1044.45	0.08	**1044.53**	0.001	0.039	0.039	0.026
2018	1103.73	0.08	**1103.81**	0.001	0.041	0.041	0.028
2019	1160.47	0.26	**1160.73**	0.001	0.044	0.044	0.029
2020	1207.11	0.39	**1207.50**	0.001	0.045	0.045	0.030
2021	1286.62	0.34	**1286.95**	0.001	0.047	0.047	0.032
Δ (1990-2021)	**+75.36%**	**56-fold increase**	**+75.41%**	-	**+88.00%**	**+67.85%**	**+68.42%**
%, 2021	**99.97%**	**0.03%**	**100%**				

The growth of GHG emissions from metal production for the period 1990-2021 amounted to 75.4%. The dynamics of GHG emissions in the Metal Industry category is determined by the dynamics of CO_2 emissions from steel production (Figure 4.22). Methane emissions for the period 2013-2021 increased by 56 times, which is associated with the growth of production in the Ferroalloy production, Lead Production and Zinc Production categories.

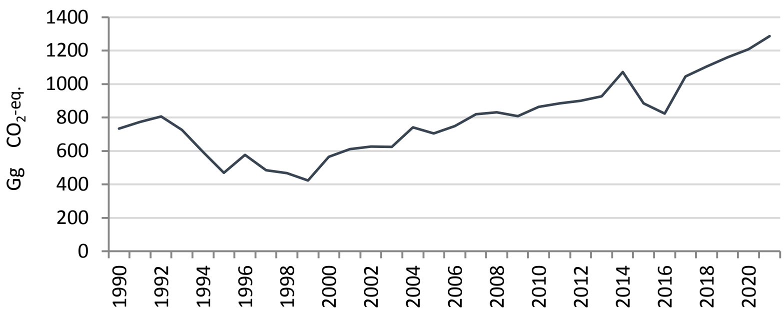

Figure 4.5.1.1 GHG emissions in the Metal Industry category

In 2021, GHG emissions in the Metal Industry category amounted to 1,286.95 Gg CO_2-eq. The CO_2 contribution to total emissions in the category is 99.97%, respectively, the contribution of methane is 0.03%.
Emissions of other gases (CO, NOx, SO_2 and NMVOCs), except for CO, tend to increase (Figure 4.5.1.2). Emissions of other gases are estimated only for the Iron and Steel Production subcategory.

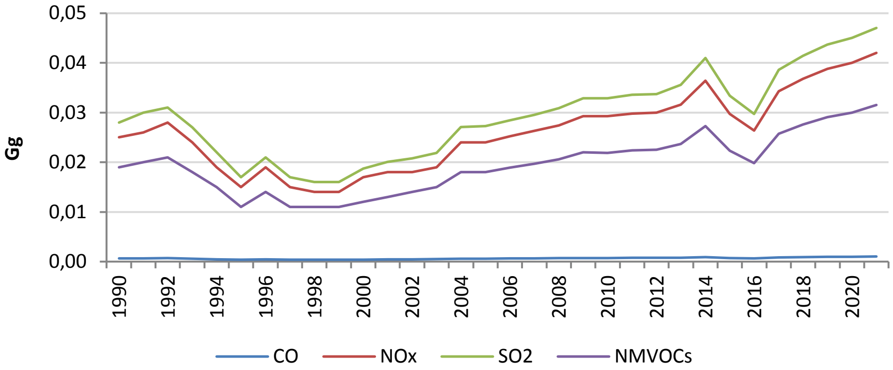

Figure 4.5.1.2 Emissions of other gases in the Metal Industry category

Emissions of other gases are insignificant and follow the dynamics of carbon dioxide emissions during steel production. For the period 1990-2021, there was an increase in emissions of other gases by 67-88%. In 2016, there was a slight decrease in steel production, which is likely due to the iron scrap supply volume.

Emission trends by subcategory

Table 4.5.1.2 presents GHG emissions from individual subcategories of the Metal Industry category for the period 1990-2021.

Table 4.5.1.2 GHG emissions from Metal Industry category by subcategory, Gg CO_2-eq.

Years	Steel Production	Ferroalloys Production	Lead Production	Zinc Production	Total	Years	Steel Production	Ferroalloys Production	Lead Production	Zinc Production	Total
1990	661.44	-	-	72.24	**733.68**	2007	695.78	-	-	123.53	**819.31**
1991	699.60	-	-	73.96	**773.56**	2008	726.84	-	-	104.19	**831.04**
1992	729.28	-	-	77.40	**806.68**	2009	775.60	-	-	32.89	**808.49**
1993	647.66	-	-	79.12	**726.78**	2010	775.28	-	-	87.837	**863.12**
1994	513.04	-	-	79.98	**593.02**	2011	790.76	-	-	94.28	**885.04**
1995	389.02	-	-	80.84	**469.86**	2012	794.89	-	-	104.93	**899.82**
1996	493.96	-	-	81.70	**575.66**	2013	838.46	0.27	0.01	87.10	**925.84**
1997	401.74	-	-	82.56	**484.30**	2014	964.81	0.19	0.00	106.34	**1071.34**
1998	378.53	-	-	89.44	**467.97**	2015	787.05	0.29	0.00	96.97	**884.30**
1999	377.15	-	-	46.67	**423.81**	2016	699.71	3.22	0.00	121.29	**824.22**
2000	440.32	-	-	124.7	**565.02**	2017	908.31	3.37	0.18	132.68	**1044.53**
2001	473.08	-	-	137.77	**610.85**	2018	975.20	3.76	3.67	121.19	**1103.82**
2002	490.04	-	-	135.66	**625.69**	2019	1028.20	11.77	4.07	116.69	**1160.74**
2003	514.74	-	-	109.05	**623.78**	2020	1060.00	17.14	4.81	125.55	**1207.50**
2004	638.33	-	-	103.20	**741.53**	2021	1113.00	14.91	4.21	154.83	**1286.95**
2005	643.74	-	-	60.26	**703.99**	Δ (1990-2021)	**+68.27%**	**55.6-fold increase**	**324-fold increase**	**+114.33%**	**+75.41%**
2006	668.12	-	-	81.44	**749.56**	%, 2021	**86.48%**	**1.16%**	**0.33%**	**12.03%**	**100%**

The largest contribution to GHG emissions from the Metal Industry is made by the Steel production subcategory (86.5%). For the period from 1990 to 2021, the Metal Industry category shows an upward trend in GHG emissions relative to 1990 by 75.4%. The largest increase in GHG emissions occurred in the new Ferroalloy production and Lead production categories, the production of which started in 2013, but their contribution to the total emissions in the Metal Industry category is insignificant.

4.5.2 Iron and Steel Production (2.C.1 category)

Steel is produced at Uzbek Metallurgical Complex JSC (Uzmetkombinat) mainly from recycled scrap in electric arc furnaces and oxygen converters, as well as at several smaller plants. The products of foundries of machine-building plants account for an insignificant part (0.1%) of the total steel production. These products are primarily intended for internal plant use, and their quantities have a limited impact on the overall production of ferrous metals in the country. The most significant factors for the present and future development of ferrous metallurgy in the country are the available resources of scrap metal and the steelmaking slags produced by Uzmetkombinat JSC.
In 2021, CO_2 emissions from steel production amounted to 1,113.0 Gg. Emissions of CO_2 and other gases for the category for 1990-2021 are presented in Table 4.5.2.1

Table 4.5.2.1 Emissions of CO_2 and other gases in the Iron and Steel Production category, Gg

Years	CO_2	CO	NOx	SO_2	NMVOCs
1990	**661.44**	0.001	0.025	0.028	0.019
1991	**699.60**	0.001	0.026	0.030	0.020
1992	**729.28**	0.001	0.028	0.031	0.021
1993	**647.66**	0.001	0.024	0.027	0.018
1994	**513.04**	0.000	0.019	0.022	0.015
1995	**389.02**	0.000	0.015	0.017	0.011
1996	**493.96**	0.000	0.014	0.021	0.014
1997	**401.74**	0.000	0.014	0.017	0.011
1998	**378.53**	0.000	0.017	0.016	0.011
1999	**377.15**	0.000	0.018	0.016	0.011
2000	**440.32**	0.000	0.019	0.019	0.012
2001	**473.08**	0.000	0.024	0.020	0.013
2002	**490.04**	0.000	0.024	0.021	0.014
2003	**514.74**	0.000	0.025	0.022	0.015
2004	**638.33**	0.001	0.026	0.027	0.018
2005	**643.74**	0.001	0.027	0.027	0.018
2006	**668.12**	0.001	0.029	0.028	0.019
2007	**695.78**	0.001	0.029	0.030	0.020
2008	**726.84**	0.001	0.030	0.031	0.021
2009	**775.60**	0.001	0.031	0.033	0.022
2010	**775.28**	0.001	0.033	0.033	0.022
2011	**790.76**	0.001	0.033	0.034	0.022
2012	**794.89**	0.001	0.034	0.034	0.023
2013	**838.46**	0.001	0.036	0.036	0.024
2014	**964.81**	0.001	0.041	0.041	0.027
2015	**787.05**	0.001	0.033	0.033	0.022
2016	**699.71**	0.001	0.030	0.030	0.020
2017	**908.31**	0.001	0.039	0.039	0.026
2018	**975.20**	0.001	0.041	0.041	0.028
2019	**1028.20**	0.001	0.044	0.044	0.029
2020	**1060.00**	0.001	0.045	0.045	0.030
2021	**1113.00**	0.001	0.047	0.047	0.032
$\Delta_{(1990-2021)}$	**+68.3%**	**0.0%**	**+88.0%**	**+67.8%**	**+68.4%**

Methodology

Direct and indirect greenhouse gas emissions in the "2.C.1 Iron and Steel Production" category were estimated based on the 2006 IPCC Guidelines [36]. While this category is of key importance, the Tier 1 methodology was

36 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Vol. 3

utilized to estimate CO_2 emissions from steel production due to ongoing data collection efforts concerning steel production technology and activity data refinement. The calculation of CO_2 emissions followed Equation 4.4 on page 4.22 of the guidelines [29], using statistics related to steel production and the average emission factor for mixed-method steel production from Table 4.7 (page 4.27). This approach was adopted since detailed data on the quantity of steel produced using different technologies are currently unavailable.

There are almost no methane emissions from steel production from scrap iron (p. 4.25) [29].

Emissions of other gases have been calculated by the methodology of the 1996 IPCC Guidelines 1996 [37].

Activity data

Data from the Statistics Agency of the Republic of Uzbekistan were used to estimate direct and indirect greenhouse gas emissions from steel production. In the early 1990s, there was a significant decrease in steel production due to the economic crisis. Then there was a systematic increase in steel production. In 2016, a slight decline in production was due to insufficient supply of scrap iron to the enterprise. The dynamics of steel production is shown in Figure 4.5.2.1.

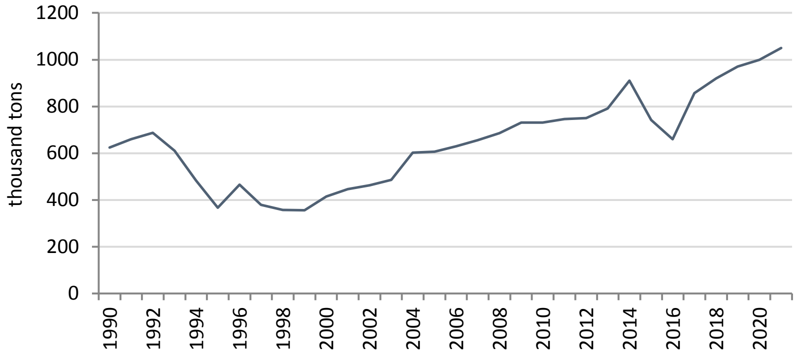

Figure 4.5.2.1 Steel production 1990-2021

Emission factors

The following IPCC default factors [38] were used in the calculations of emissions from steel production:

- For CO_2 – **1.06 t CO_2/t product**.

The following IPCC default factors were used in the calculations of indirect GHG emissions from steel production:

- For CO – **1.0 g CO/t product**.
- For NOx – **40 g NOx/t of product**.
- For NMVOCs – **30 g NMVOCs/t of product**.
- For SO_2 – **45 g SO2/t product**.

Uncertainties and time series consistency

The uncertainty of the activity data was ±2%, as statistical data were used for the calculations.
The uncertainty of the CO_2 emission factor from steel production is assumed to be ±25% by default (Section 4.2.3 Chapter 4, Vol.3, Part 1, p. 4.32) [38].
The combined uncertainty was ±25.1%

Quality assurance/quality control

QA/QC procedures were performed in accordance with general QA/QC principles and the QA/QC plan. Verification on the following was conducted:

- documentation of emission sources,
- data for mechanical errors,
- all source references for source data in the Software.

Recalculations in the category

There have been no recalculations of emissions relative to the 1990-2017 Inventory.

37 Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Greenhouse Gas Inventory Workbook, Part 2
38 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Vol. 3

Planned improvements in the category

As part of the future inventory, it is planned to refine data on the activities and technology of steel production at Uzbek Metallurgical Complex JSC and switch to Tier 2 emission estimation methodology.

4.5.3 Ferroalloys Production (2.C.2 category)

2.C.2 Ferroalloys Production category is included in the GHG inventory for the first time due to the appearance of statistical data on the production of these products in the country.
Ferrosilicon and ferromanganese are produced at the Uzbek Metallurgical Complex. Ferromanganese is also produced at five small private sector production enterprises in Andijan, Tashkent, and Fergana regions.
In the Ferroalloy production category, CO2 and CH4 emissions are estimated. For the period from 2013 to 2021, there is an increase in GHG emissions from ferroalloy production by 55.6 times. In 2021, emissions in the category amounted to 14.91 Gg CO_2-eq. (Table 4.5.3.1).

Table 4.5.3.1 GHG emissions from the Ferroalloys Production category, Gg CO_2-eq.

GHG	2013	2014	2015	2016	2017	2018	2019	2020	2021	$\Delta_{(1990-2021)}$
CO_2	0.262	0.182	0.284	3.149	3.291	3.673	11.504	16.757	14.569	**56-fold increase**
CH_4	0.006	0.004	0.007	0.073	0.076	0.085	0.266	0.387	0.336	**56-fold increase**
Total	**0.268**	**0.186**	**0.291**	**3.222**	**3.367**	**3.758**	**11.769**	**17.143**	**14.905**	**56-fold increase**

Methodology

CO_2 and CH_4 emissions in 2.C.2 Ferroalloys Production category were estimated in accordance with the2006 IPCC Guidelines [39]. The Tier 1 methodology was used to estimate CO_2 and CH_4 emissions from ferrosilicon and ferromanganese production. Statistical data on total ferroalloy production and default emission factors were used in the calculations.
CO_2 emissions were calculated according to Equation 4.15, p. 4.36, Vol.3, Part 1 [39], CH4 emissions were calculated according to Equation 4.18, p. 4.40, p. 4.40. 4.40.
Since there are no separate statistical data on ferrosilicon and ferromanganese production, the calculations assume that they are produced in equal quantities and there was no production of ferroalloys until 2013.

Activity data

To estimate greenhouse gas emissions from the production of total ferroalloys, data from the Statistics Agency of the Republic of Uzbekistan were used (Figure 4.5.3.1). State statistics have data on ferroalloy production only from 2013. To study the situation up to 2013, as well as to obtain separate data on ferrosilicon and ferromanganese production, additional data collection is required, which is planned for the future.

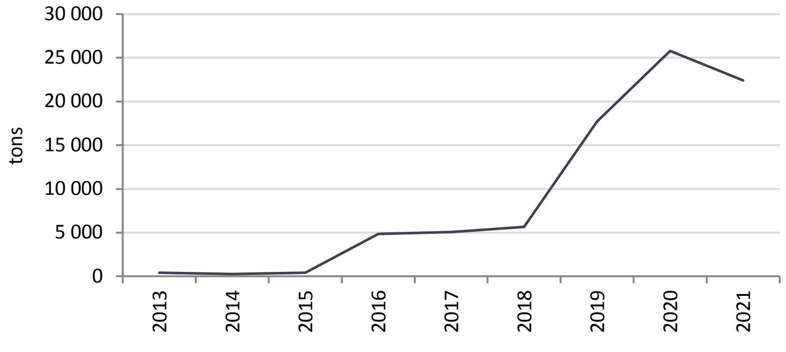

Figure 4.5.3.1 Ferroalloys Production in 2013-2021

Emission factors

In the calculations of GHG emissions from ferroalloys production, the following average default factors from 2006 IPCC Guidelines [39] were used: **3.6 t CO_2 /t of ferrosilicon and 1.3 t CO_2 /t of ferromanganese** (Vol. 3, Table 4.5, p. 4.40) to estimate CO_2 emissions; and **1.0 kg CH_4/t ferrosilicon (for FeSi 65) and 1.2 kg CH_4/t ferromanganese** (Vol. 3, Table 4.7, page 4.42) to estimate CH_4 emissions.

39 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Vol. 3.

Uncertainties and time series consistency

Uncertainty of activity data was ±100% (according to expert estimates).
Uncertainty of emission factors was ±50% (default maximum) [39], since the production technology is unknown.
Combined uncertainty was ±111.8%.

Quality assurance/quality control

QA/QC procedures were performed in accordance with general QA/QC principles and the QA/QC plan. Verification on the following was conducted:

- documentation of emission sources,
- data for mechanical errors,
- all source references for source data in the Software.

Recalculations in the category

There have been no recalculations of emissions, as this category is included in the inventory for the first time.

Planned improvements in the category

As part of the future inventory, it is planned to collect complete information on ferroalloys production in Uzbekistan and refine activity data on separate ferrosilicon and ferromanganese production.

4.5.4 Lead Production (2.C.5 category)

Lead is produced at the zinc plant, which is part of the Almalyk Mining and Metallurgical Complex (AMMC), as a by-product of zinc production. The plant processes its own raw materials and imported concentrates on a tolling terms. The lead smelter was built in 2017-2019. It operates on the basis of the Handiza deposit.
There is no data on lead production technology.
2.C.5 Lead production category is included in the inventory for the first time.
In the Lead production category, CO_2 emissions have been estimated. In 2021, emissions for the category amounted to 4.21 Gg CO_2. Emissions for the category from 2013 to 2021 increased by 324 times (Table 4.5.4.1).

Table 4.5.4.1 CO_2 emissions from the Lead production category, Gg

	2013	2014	2015	2016	2017	2018	2019	2020	2021	$\Delta_{(1990-2021)}$
CO_2	0.013	0	0	0	0.175	3.688	4.073	4.807	4.213	**324-fold increase**

Methodology

CO_2 emissions in 2.C.5 Lead production category were estimated in accordance with the2006 IPCC Guidelines [40]. The Tier 1 methodology was used to estimate CO_2 emissions.
CO_2 emissions were calculated according to Equation 4.32, pp. 4.80, Vol. 3, Part 1 [40]. The calculations used lead production statistics and a default emission factor, since data on lead production technology are not yet available.

Activity data

To estimate greenhouse gas emissions from lead production, data from the Statistics Agency of the Republic of Uzbekistan were used. State statistics contain data on lead production only from 2013. The state statistics has data on lead production only from 2013. To study the situation on lead production up to 2013 and the technology used, additional data collection is required, which is planned for the future.
The unevenness of the time series until 2018 is explained by the fact that lead production was organized on the basis of imported raw materials on tolling terms. The increase in lead production starting from 2018 is explained by the commissioning of a new lead smelter as part of the AMMC, which is mostly focused on processing local raw materials from the Handiza deposit (Figure 4.5.4.1).

40 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Vol. 3.

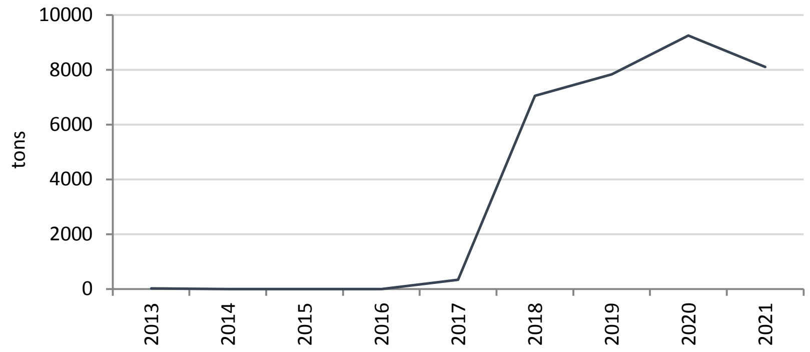

Figure 4.5.4.1 Lead Production in 2013-2021

Emission factors

In calculations of CO_2 emissions from lead production, the average default factor from the 2006 IPCC Guidelines [41] was used, which is equal to **0.52 t CO_2 /t lead** (Vol.3, table 4.21, p. 4.81).

Uncertainties and time series consistency

Uncertainty of activity data was ±10% (default).

Uncertainty of the emission factor was ±50% [41].

Combined uncertainty was ±51%.

Quality assurance/quality control

QA/QC procedures were performed in accordance with general QA/QC principles and the QA/QC plan. Verification on the following was conducted:

- documentation of emission sources,
- data for mechanical errors,
- all source references for source data in the Software.

Recalculations in the category

There have been no recalculations of emissions, as this category is included in the inventory for the first time.

Planned improvements in the category

To improve the accuracy of estimating CO_2 emissions from Lead Production, it is planned to collect information on product technology as part of a future inventory.

4.5.5 Zinc Production (2.C.6 category)

Zinc is produced at the zinc plant, which is part of AMMC. It was put into operation in September 1970. The plant has been processing its own raw materials and imported zinc concentrates on tolling terms since 1992. In 1998, the plant operated only under tolling contracts due to the development of local deposits Kurgashinkan and Altyntapkan. In September 2010, the Handiza deposit was put into operation. Since then, the plant has been processing its own and imported zinc concentrate.

No data on zinc production technology is available. Information is being collected.

2.C.6 Zinc Production category is included in the inventory for the first time.

Table 4.5.5.1CO_2 emissions from the Zinc Production category, Gg

Years	CO_2	Years	CO_2	Years	CO_2
1990	72.24	2001	137.77	2012	104.93
1991	73.96	2002	135.66	2013	87.10
1992	77.40	2003	109.05	2014	106.34
1993	79.12	2004	103.20	2015	96.96
1994	79.98	2005	60.26	2016	121.29
1995	80.84	2006	81.44	2017	132.67
1996	81.70	2007	123.53	2018	121.19
1997	82.56	2008	104.20	2019	116.69
1998	89.44	2009	32.89	2020	125.54
1999	46.66	2010	87.84	2021	154.83
2000	124.70	2011	94.28	$\Delta_{(1990-2021)}$	**+214.3%**

41 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Vol. 3.

In the Zinc Production category, CO_2 emissions have been estimated. In 2021, emissions for the category amounted to 154.83 Gg of CO_2. Over the period 1990-2021, emissions growth amounted to +214% (Table 4.5.5.1).

Methodology

CO_2 emissions in 2.C.6 Zinc Production category were estimated in accordance with the 2006 IPCC Guidelines based on raw zinc production data. The Tier 1 methodology was used to estimate CO_2 emissions. CO_2 emissions were calculated using Equation 4.33, pp. 4.87, Vol. 3, Part 1. Statistical data on zinc production and a default emission factor were used in the calculations, since no data on zinc production technology were available.

Activity data

To estimate greenhouse gas emissions from zinc production, data on zinc production volumes provided upon request by the Agency for Statistics of the Republic of Uzbekistan for the period 1998-2021 were used. Data for 1990-1997 were restored according to the trend.

The unevenness of the time series until 2010 is explained by the fact that zinc production was organized on the basis of imported raw materials on tolling terms. The increase in zinc production since 2010 is due to the commissioning of the Handiza deposit. The dynamics of zinc production are presented in Figure 4.5.5.1.

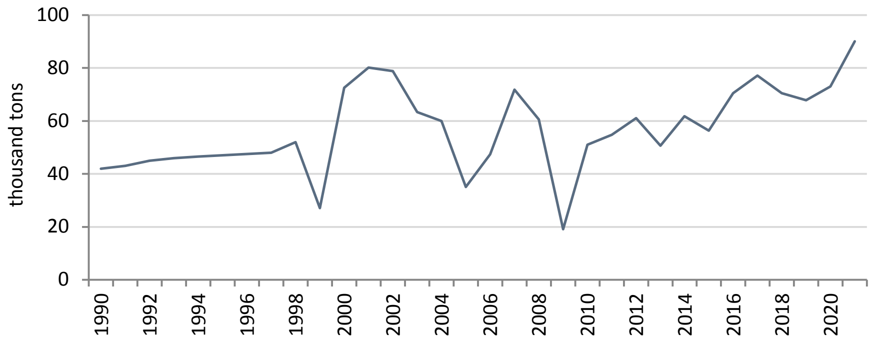

Figure 4.5.5.1 Zinc Production in 1990-2021

Emission factors

The default factor from the 2006 IPCC Guidelines [42] equal to **1.72 t CO_2/t zinc** was used in the calculations of CO_2 emissions from zinc production (Vol. 3, Table 4.24, p. 4.88).

Uncertainties and time series consistency

To estimate the uncertainty for this category, the data from Table 4.25, page 4.90 Vol. 3 of the 2006 IPCC Guidelines were used.

Uncertainty of activity data was ±10%.

Emission factor uncertainty was ±50%.

Combined uncertainty was ±51%.

Quality assurance/quality control

QA/QC procedures were performed in accordance with general QA/QC principles and the QA/QC plan. Verification on the following was conducted:

- documentation of emission sources,
- data for mechanical errors,
- all source references for source data in the Software.

Recalculations in the category

There have been no recalculations of emissions, as this category is included in the inventory for the first time.

Planned improvements in the category

To improve the accuracy of estimating CO_2 emissions from Zinc Production, it is planned to collect information on product technology as part of a future inventory.

42 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Vol. 3.

4.6 Non-energy Products from Fuel and Solvent Use (2.D category)

4.6.1 Description of the category

Only 2.D.1 Non-energy Products from Fuel and Solvent Use category has been estimated in 2.D Use of Lubricants category.
The necessary data are being collected to estimate 2.D.2 Paraffin Wax Use and 2.D.3 Solvent Use categories. It is planned to include them in the next inventory.
CO_2 emissions from the use of lubricants in 2021 amounted to 192.0 Gg.

Emission trends by gas

Table 4.6.1.1 and Figure 4.6.1.1 show CO_2 emissions from the Use of Lubricants category for the period 1990-2021.

Table 4.6.1.1 CO_2 emissions from the Use of Lubricants category, Gg

Years	CO_2	Years	CO_2	Years	CO_2
1990	203.35	2001	86.05	2012	76.62
1991	202.76	2002	72.5	2013	77.8
1992	169.75	2003	146.76	2014	79.57
1993	144.41	2004	70.73	2015	80.75
1994	136.16	2005	134.98	2016	82.62
1995	87.23	2006	108.83	2017	84.39
1996	86.64	2007	96.49	2018	82.62
1997	103.15	2008	59.83	2019	91.35
1998	93.72	2009	54.29	2020	103.16
1999	81.93	2010	53.52	2021	192.03
2000	83.11	2011	55.99	$\Delta_{(1990-2021)}$	**-5.6%**

The reduction in CO_2 emissions from the use of lubricants for the period 1990-2021 amounted to 5.6%.

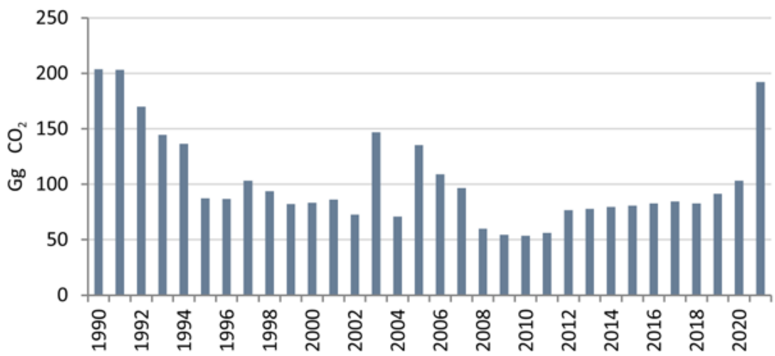

Figure 4.6.1.1 Trends in CO_2 emissions from the Use of Lubricants category

Methodology

CO_2 emissions in 2.D.1 Lubricant Use category were estimated in accordance with the 2006 IPCC Guidelines [43]. The Tier 1 methodology and Equation 5.2 p. 5.8 Vol.3, Part 2 were used to estimate CO_2 emissions [43]. The default value of carbon content of lubricants equal to **20 kg C/GJ** was used in the calculations (Table 1.3, Vol.2, Ch.1).

Activity data

To estimate greenhouse gas emissions from the use of lubricants, data from the Statistics Agency of the Republic of Uzbekistan on production, exports and imports of lubricants, including oils for gears and gearboxes, were used.

Emission factors

IPCC default factors [43] and national factors were used in calculations of emissions from the use of lubricants.
- The net calorific value for lubricating oils is **40.151 TJ/thousand tons** (national factor);
- Carbon content in lubricants = **20.0 t C/TJ** (default);
- ODU factor = **0.2** (default).

Uncertainties and time series consistency

Activity data uncertainty was ±5% (default), as statistical data was used for calculations.
The uncertainty of CO_2 emission factors from the use of lubricants is assumed to be ±50% by default [43].
The overall emissions uncertainty was ±50.25%.
The same method and similar data sets were used for all years.

43 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Vol. 3.

Quality assurance/quality control

QA/QC procedures were performed in accordance with general QA/QC principles and the QA/QC plan. Verification on the following was conducted:

- documentation of emission sources,
- data for mechanical errors,
- all source references for source data in the Software.

Recalculations in the category

There have been no recalculations in this category.

Planned improvements in the category

As part of the future inventory, it is expected to refine and detail the activity data.

4.7 Product Uses as Substitutes for Ozone Depleting Substances (2.F category)

4.7.1 Description of the category

There is no HFCs production in the country, storage and destruction data are also not available.

In 2.F Product Uses as Substitutes for Ozone Depleting Substances category, hydrofluorocarbons (HFCs) emissions are estimated only for 2.F.1 Refrigeration and Air Conditioning category without disaggregation into stationary and mobile air conditioning due to lack of data. The category is key.

The country produces refrigeration equipment, as well as imports and exports it. It also has its own production of HFC-fueled vehicles. However, emissions from these sub-applications have not yet been accounted for in this inventory, but it is planned to be done in the future. Research and restoration of historical data series is needed.

There is insufficient baseline data to estimate 2.F.2 Foam Blowing Agents, 2.F.3 Fire Protection, 2.F.4 Aerosols, and 2.F.5 Solvents categories. Information is currently being collected for their further estimation.

Refrigerant blends used in the country are purchased abroad. In 2021, the estimated hydrofluorocarbons emissions amounted to 988.8 Gg CO_2-eq.

HFCs emission trends from Refrigeration and Air Conditioning category for the period 2000-2021 are presented in Table 4.7.1.1 and Figure 4.7.1.1.

Table 4.7.1.1 HFCs emissions from Refrigeration and Air Conditioning category, Gg CO_2-eq.

Years	HFC-32	HFC-125	HFC-134a	HFC-143a	Total HFCs
2000	0.005	0.158	0.766	0.148	**1.076**
2001	0.009	0.291	1.417	0.273	**1.990**
2002	0.009	0.290	1.408	0.272	**1.979**
2003	0.015	0.477	2.289	0.439	**3.220**
2004	0.041	1.372	6.555	1.245	**9.212**
2005	0.044	1.470	7.035	1.333	**9.882**
2006	0.122	2.677	9.598	2.158	**14.555**
2007	0.127	2.680	9.242	2.127	**14.176**
2008	0.164	2.739	12.574	1.965	**17.443**
2009	0.192	3.041	12.748	2.124	**18.105**
2010	0.197	3.119	13.657	2.177	**19.150**
2011	0.282	5.295	19.419	4.012	**29.008**
2012	0.258	8.665	24.310	7.798	**41.031**
2013	0.435	11.384	26.235	9.757	**47.811**
2014	0.509	14.588	28.684	12.798	**56.579**
2015	2.080	29.209	34.640	19.767	**85.697**
2016	7.614	71.049	58.552	34.245	**171.458**
2017	15.274	119.033	92.306	43.117	**269.730**
2018	28.932	198.716	158.739	53.015	**439.401**
2019	57.566	371.979	224.352	80.626	**734.523**
2020	72.808	467.237	270.979	98.525	**909.549**
2021	79.331	511.831	287.500	110.141	**988.803**
$\Delta_{(1990-2021)}$	**15860-fold increase**	**3240-fold increase**	**375-fold increase**	**743-fold increase**	**915-fold increase**

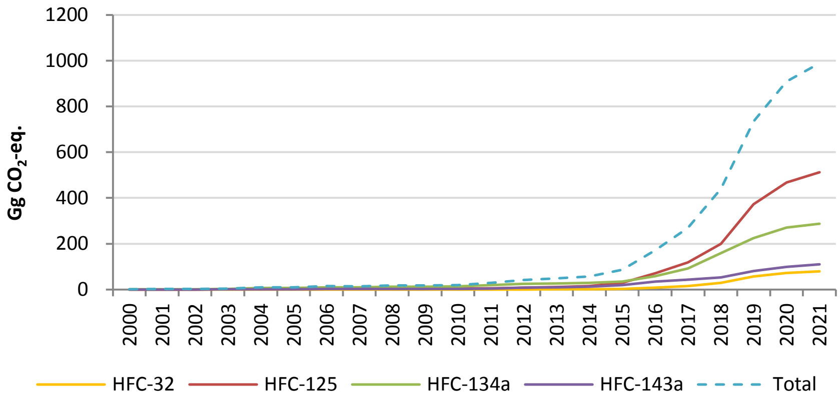

Figure 4.7.1.1 Trend in HFCs emissions from Refrigeration and Air Conditioning category

HFC emissions were estimated to have increased 915-fold between 2000 and 2021.

Methodology

HFC emissions in the category were estimated in accordance with the 2006 IPCC Guidelines [44], Tier 1a/b.
The estimation of HFC emissions was based on the following assumptions:

1. The composition of the HFC blends for each year is the same.
2. The proportion of each HFC in the blend remains the same for each year.
3. Maintenance of equipment containing refrigerant begins no earlier than 3 years after its installation.
4. Emissions from HFC banks (refrigeration equipment) average 15% annually (default).
5. The average service life of equipment is 15 years (by default).

There are no data on the growth rates of new equipment sales.

The shares of individual HFCs in the composition of imported refrigerant blends are presented in Table 4.7.1.2.

Based on these assumptions, the amount of individual HFCs for each year was calculated. The Excel spreadsheets presented in Chapter 7.5.2 Vol.3, Part 2 of the 2006 IPCC Guidelines [40] were used to estimate HFC emissions [44].

Table 4.7.1.2 Composition of blends of imported refrigerants*

Refrigerant name	Composition	Component shares
R-134a	HFC-134a	1.00
R-404a	HFC-143a	0.44
	HFC-125	0.52
	HFC-134a	0.04
R-407c	HFC-32	0.23
	HFC-125	0.25
	HFC-134a	0.52
R-410a	HFC-32	0.50
	HFC-125	0.50
R-507a	HFC-125	0.50
	HFC-143a	0.50

Emissions for each HFC from imported blends were calculated according to the following equations:

HFC bank = HFC Emissions $_{\textit{(thousand tons)}}$ ***in the current year + Previous year bank*** $_{\textit{(thousand tons)}}$ ***– Previous year HFC emissions*** $_{\textit{(thousand tons)}}$

Current year HFC emissions = Current year bank $_{\textit{(thousand tons)}}$ **** 0.15***

The results were multiplied by the respective GWPs for each of the HFCs and then summed to total emissions.

Activity data

To estimate HFC emissions, data on the import of refrigerant blends into the country from the State Customs Committee of the Republic of Uzbekistan, obtained from experts from the Ozone Office under the Ministry of Ecology, Environmental Protection and Climate Change of the Republic of Uzbekistan, were used. Data before 2000 are not available.

Analysis of data on import of refrigerant blends into the country showed that the following blends are imported into the country: R-134a, R-404a, R-407c, R-410a and R-507a. Since there were no statistical data on import of refrigerant blends for 2001, it was assumed that their quantity coincides with the quantity of these mixtures imported in 2000. The quantities of HFC blends imported into the country for 2000-2021 are presented in Table 4.7.1.3.

44 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Vol. 3

Table 4.7.1.3 Imports of hydrofluorocarbon blends for the period 2000-2021, tons

Years	HFC blend					Years	HFC blend				
	R-134a	R-404a	R-407c	R-410a	R-507a		R-134a	R-404a	R-407c	R-410a	R-507a
2000	3.442	0.490	0.199	0	0	2011	33.568	7.326	4.907	0	0
2001	3.442	0.490	0.199	0	0	2012	35.377	14.875	0.786	0	0
2002	0.916	0.131	0.053	0	0	2013	24.736	10.301	1.587	3.535	0.268
2003	1.203	0.700	0.285	0	0	2014	27.971	15.268	2.276	1.695	0
2004	20.743	2.954	1.203	0	0	2015	42.130	28.839	8.734	28.539	1.135
2005	6.581	0.937	0.382	0	0	2016	130.400	52.160	6.180	112.617	6.127
2006	14.837	3.474	3.645	0	0	2017	193.672	46.973	5.300	171.445	0.450
2007	4.482	0.992	1.018	0	0	2018	365.570	44.945	13.26	308.934	9.265
2008	20.725	0.533	2.407	0	0	2019	405.031	97.275	15.328	20.479	20.479
2009	8.378	1.536	2.239	0	0	2020	799.941	88.233	5.818	11.821	11.821
2010	12.35	1.261	1.447	0	0	2021	261.668	84.053	2.864	4.763	4.763

Emission factors

The GWPs of the IPCC 4th Assessment Report, based on greenhouse gas impacts over a 100-year period [45] were used to calculate potential HFC emissions in CO_2 equivalent:

- HFC-32 – 675;
- HFC-125 – 3500;
- HFC-134a – 1430;
- HFC-143a – 4470.

Uncertainties and time series consistency

The uncertainty of HFC emissions is assumed to be quite high, since many assumptions were used in the calculations.
The uncertainty of activity data can be on the order of ±10%,
Uncertainty in emission factors and other parameters was ± 50%.
The combined uncertainty of HFC emissions from cooling systems was ±51%.

Quality assurance/quality control

QA/QC procedures were performed in accordance with general QA/QC principles and the QA/QC plan. Verification on the following was conducted:

- documentation of emission sources,
- data for mechanical errors,
- all source references for source data in the Software.

Recalculations in the category

No category recalculations were made relative to the 1990-2017 inventory data, since the same calculation methodologies, input data sets, and emission factors were used.

Planned improvements in the category

As part of the next inventory, it is planned to refine activity data to include the exports and imports of refrigeration equipment, and to detail HFC utilization data for stationary and mobile installations.

4.8 Other (2.H category)

4.8.1 Description of the category

The category estimates NMVOCs emissions from food and beverage production.
The Yog'moytamakisanoat (Oil and tobacco industry) and Oziq-ovqatsanoat (Food Industry) associations have been established in the fats and oil and food industry of Uzbekistan.
The Yog'moytamakisanoat Association is responsible for the production of fat and oil products and tobacco products. The association includes 19 fat and oil enterprises, the largest of which are Kokand and Ferghana fat and oil complexes, and 4 joint ventures. Production is based on processing of local agricultural raw materials: technical

45 Fourth Assessment Report of the Intergovernmental Panel on Climate Change, IPCC, 2007.

cotton seeds, stone and seed raw materials, soybeans, etc. The main products are refined oil, laundry and toilet soap, margarine products, glycerin, cotton meal.

The Oziq-ovqatsanoat association is engaged in the production of confectionery, tea, beer, soft drinks and other food products, ensuring the saturation of the consumer market of the country with food products. The association includes 24 manufacturing enterprises.

In the meat and dairy industry, the O’zgo’shtsutsanoat association was established, which includes associations and enterprises for the procurement of meat and dairy products and fattening of animals. The association includes 22 meat processing enterprises and more than 150 cattle fattening farms.

Uzdonmakhsulot Joint Stock Company is engaged in **production of bread products**. The company includes 283 structural business units. Of these, 118 are open-type joint stock companies, 34 are state-owned enterprises, 12 are subsidiaries, 63 are collective, 49 are private, 3 are joint ventures with foreign capital, and 4 are limited liability companies.

Baking industry includes 183 enterprises, production capacity is about 3 thousand tons per day.

The **feed industry** has a capacity to produce more than 3 million tons of feed for all types of farm animals, birds and fish.

Fruit and vegetable industry. Uzbekistan produces a wide range of fruits and vegetables and grapes. Currently, the country’s fruit and vegetable complex operates in the form of the “O'zmevasabzavotuzumsanoatholding” Republican company and “Mevasabzavot” regional associations. The company includes 27 specialized companies for harvesting, storage, processing and sale of fruits and vegetables and grapes, 40 processing, 89 agricultural and 15 joint ventures.

The food and beverages industry is the main emitter of NMVOCs in the IPPU sector. Total NMVOCs emissions from food and beverage production in 2021 amounted to 28.16 Gg of gas, of which by subcategory:

- Production of Alcoholic beverages –7.2 Gg NMVOCs;
- Food production –20.96 Gg NMVOCs.

Table 4.8.1.1 and Figure 4.8.1.1 show the dynamics of NMVOCs emissions from Food and Beverage Industry category over the period 1990-2021.

Table 4.8.1.1 NMVOCs emissions from Food and Beverage Industry category , Gg

Years	Subcategory			Years	Subcategory		
	Alcoholic beverages	Food products	Total		Alcoholic beverages	Food products	Total
1990	9.80	10.70	**20.50**	2007	13.98	8.28	**22.26**
1991	9.60	10.10	**19.70**	2008	15.28	11.13	**26.41**
1992	9.00	8.50	**17.50**	2009	16.42	10.71	**27.13**
1993	8.00	10.1	**18.10**	2010	17.69	11.35	**29.04**
1994	7.60	7.30	**14.90**	2011	18.65	13.18	**31.83**
1995	7.10	7.98	**15.08**	2012	20.36	13.17	**33.53**
1996	7.60	8.17	**15.77**	2013	8.80	13.92	**22.72**
1997	8.50	8.52	**17.02**	2014	9.12	15.07	**24.19**
1998	9.50	8.86	**18.36**	2015	9.13	19.65	**28.78**
1999	10.90	9.24	**20.14**	2016	9.38	20.24	**29.62**
2000	10.86	7.88	**18.74**	2017	9.52	21.81	**31.33**
2001	10.07	7.98	**18.05**	2018	9.42	14.98	**24.4**
2002	9.34	9.70	**19.04**	2019	8.51	18.03	**26.54**
2003	9.89	9.12	**19.01**	2020	7.72	15.69	**23.41**
2004	10.50	8.56	**19.06**	2021	7.20	20.96	**28.16**
2005	10.29	7.65	**17.94**	$\Delta_{(1990–2021)}$	**-26.5%**	**+195.9%**	**+137.4%**
2006	10.47	7.36	**17.83**	**%.** $_{2021}$	**25.6%**	**74.4%**	**100.0%**

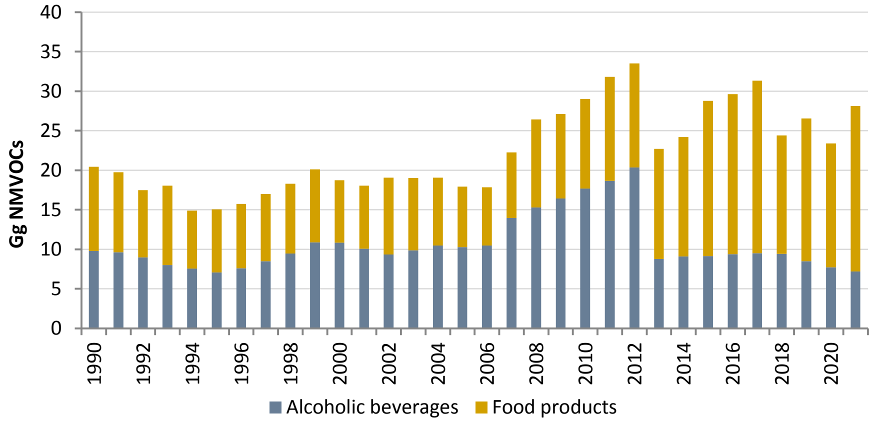

Figure 4.8.1.1 NMVOCs emissions from Food and Beverage Industry category

For the period 1990 and 2021, there is an overall 137.4% increase in NMVOCs emissions in the "Other" category due to increased production, with a 25.6% emission decrease in the production of alcoholic beverages and a 196% emission increase in food production.

Methodology

NMVOCs emissions in the "Other" category were estimated in accordance with the1996 IPCC Guidelines [46], and Tier 1 methodology was used for calculations.

NMVOCs emissions were calculated using the following equation:

$$E_{NMVOC} = \frac{A \bullet EF}{10^6}$$

where:

E_{NMVOC} – NMVOC emissions, Gg;

A – quantity of food products (tons), or alcoholic beverages (hectoliters) produced;

EF – kg of NMVOC/t of food products produced or kg of NMVOC/hectoliter of beverages produced;

10^6 – 106 – factor for conversion to Gg.

Activity data

To estimate the NMVOC emissions from the production of food products and alcoholic beverages, data from the Statistics Agency of the Republic of Uzbekistan was used. The dynamics of the production of alcoholic beverages and food products are presented in Figures 4.8.1.2 and 4.8.1.3.

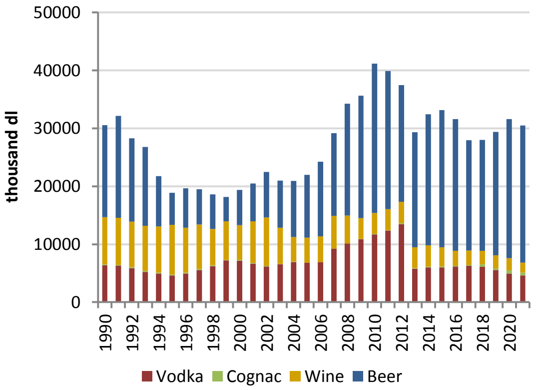

Figure 4.8.1.2 Alcoholic beverage production

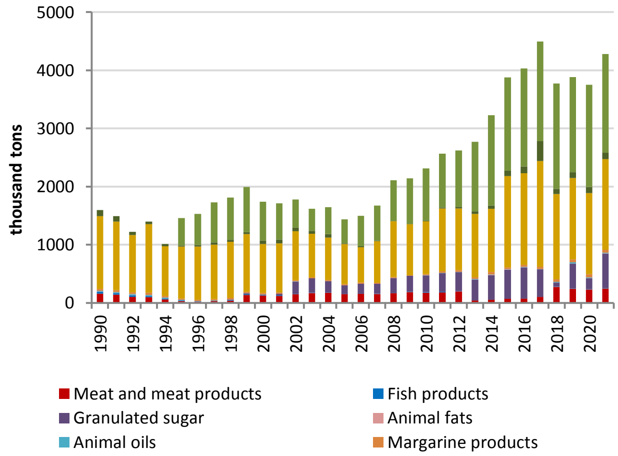

Figure 4.8.1.3 Production of Food products

46 Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Greenhouse Gas Inventory Workbook, Part 2.

Emission factors

The following IPCC 1996 default factors Table 2.26, p.2.42 were used in calculations of NMVOCs emissions associated with food production:

– Meat, fish and poultry - 0**.3 kg NMVOC/t product**;
– Sugar - **10.0 kg NMVOC/t product**;
– Margarine and edible fats - **10.0 kg NMVOC/t product**;
– Cakes, biscuits, etc. - **1.0 kg NMVOC/t product**;
– Bread - **8.0 kg NMVOC/t product**;
– Combined feed– **1.0 kg NMVOC/t product**.

The following IPCC 1996 default factors.**Ошибка! Закладка не определена.** Table 2-25, p.2.41, were used in calculations of NMVOC emissions associated with the production of alcoholic beverages:

– Wine - **0.08 kg of NMVOC/hectoliter of beverage**;
– Beer - **0.035 kg NMVOC/hectoliter of beverage**;
– Vodka and liqueur drinks - **15 kg NMVOC/hectoliter of beverage**;
– Cognac - **3.5 kg NMVOC/hectoliter of beverage**.

Uncertainties and time series consistency

Emission uncertainty was not assessed. The same calculation method and similar data sets were used for all years.

Quality assurance/quality control

QA/QC procedures were performed in accordance with general QA/QC principles and the QA/QC plan. Verification on the following was conducted:

- documentation of emission sources,
- data for mechanical errors,
- all source references for source data in the Software.

Recalculations in the category

No category recalculations were conducted relative to previous assessments.

Planned improvements in the category

No improvements are planned in this category.

5. “AGRICULTURE, FORESTRY AND OTHER LAND USE (AFOLU)” SECTOR

5.1 “Agriculture” Sector

5.1.1 Sector overview

Agriculture plays a significant role in Uzbekistan's economy, contributing 26.9% of GDP (2021) and supports the development of the country's industrial base, including food and non-food processing industries [1]. Agriculture is one of the largest income sources for the rural population, accounting for about 50% of the total population. Agricultural production involves 44% of the country's labor force. Between 2010 and 2021, the share of agriculture (including forestry and fishery) in employment remained stable at about 27% each year, which indicates the sector’s crucial role in the labor market.

Given favorable agro-climatic conditions, modernization currently underway is increasing agricultural productivity while making it more sustainable. The implementation of crop diversification policies implies possible environmental benefits in the form of reduced consumption of water, fertilizers and pesticides and, consequently, a halt in the degradation of soil quality.

Crop and livestock production accounted for 96.8%; forestry - 2.4%, fishery – 0.8% of total agricultural output in 2021. Samarkand, Andijan and Tashkent regions occupy leading positions in terms of total agricultural output.

Analysis by farm category showed that 65.9% of the total agricultural output falls on dekhkan (private subsidiary) farms, 29.2% - on farms, 4.9% - on other enterprises engaged in agricultural activities.

There is a steady increase in livestock population in the country. Andijan, Tashkent, Jizzakh and Bukhara regions have the highest growth rates of livestock production. The growth of livestock population and the saturation of the domestic consumer market with livestock products are facilitated by consistent implementation of measures to further increase the potential of the livestock sector, as well as systemic government support. As of January 1, 2022, the total number of cattle reached 13,555.8 thousand heads. Compared to the previous year, the increase was 3.1%.

Between 2010 and 2021, the number of poultry more than doubled and the number of cattle increased by 45%; the number of horses, goats and sheep also increased. Grazing is still the predominant in feeding animals, although forage crops are also among the crop products that the government seeks to stimulate. Agriculture is based on irrigation. Arable land accounts for 4.4 million hectares of land (about 10% of the total area of the country) [47].

Uzbekistan is consistently reforming its agriculture to ensure the country's food security. In a short period of time, Uzbekistan has carried out cardinal reforms that have enabled to diversify agriculture almost completely and provide the population with basic food crops and export them.

The Government of the Republic of Uzbekistan approved the “Agriculture Development Strategy until 2030” in October 2019, which has already contributed to the launch of numerous major reforms.

The main directions of the strategy are as follows:

- preserve and improve the soil fertility with the introduction of the practice of efficient fertilizer use depending on soil and climatic conditions through the purchase of mobile soil analysis laboratories;
- improve the cadastral system of accounting of agricultural lands;
- improve the water management system;
- improve the forest management system;
- introduce the modern methods of forest resource assessment and monitoring, etc.

The expected results of the Agriculture Development Strategy include:

- develop 1.1 million hectares of agricultural land, increase the efficiency of use of 535.6 thousand hectares of rainfed, pasture and other lands;

including to achieve such targets as:

- reduce the proportion of the food-insecure populations to zero;
- reduce agricultural greenhouse gas emissions by 50% of the 2016 level;
- expand the area with forest cover by 30% of the 2016 level (3.2 million hectares).

In recent years, a significant increase in the yield of cotton (by 23.5%) and grapes (by 14.1%) has been achieved. At the same time, there has been a decline in yields for a number of major crops due to the increasing frequency of dry years and emerging climatic anomalies [48].

As part of the Agriculture Development Strategy, systemic measures have been implemented to create sustainable food production systems. The area under perennial crops such as orchards and vineyards has been increased by utilizing land released from cotton. In addition, traditional orchards with low yields are gradually being replaced by intensive orchards with much higher yields.

47 Analytical statistics review “Agriculture, forestry and fisheries” for January-December 2021 www.stat.uz

48 Second Voluntary National Review on the Implementation of the National Sustainable Development Goals and Targets of Uzbekistan until 2030, Ministry of Economy and Finance, 2023.

In 2020-2021, Uzbekistan began to actively provide support for the introduction of water-saving technologies in cotton and horticulture. The size of areas irrigated with water-saving technologies increased dramatically from 1.7% in 2018 to 19.6% in 2021.

The agricultural sector is the second largest source of GHG emissions in Uzbekistan. The Livestock category accounts for the bulk (74%) of the sector's GHG emissions in 2021, with Nitrous oxide emissions from managed soils being the second largest source of GHG emissions (25.7%).

The Agriculture, Forestry and Other Land Use (AFOLU) sector provides information on the assessment of methane, carbon dioxide and nitrous oxide emissions. It estimates the following categories:

- 3.A Livestock:
    - 3.A.1 Enteric fermentation;
    - 3.A.2 Manure management.
- 3.C Aggregate sources and Non-CO_2 Emissions on Land:
    - 3.C.1.b Biomass Burning in Croplands;
    - 3.C.4 Direct N_2O Emissions from Managed Soils;
    - 3.C.5 Indirect N_2O Emissions from Managed Soils;
    - 3.C.6 Indirect N_2O Emissions from Manure Management;
    - 3.C.7 Rice Cultivation.

In the Agriculture sector, CH_4, CO_2 and N_2O emissions were estimated.

In 2021, GHG emissions in the Agriculture sector amounted to 16% of total emissions. The sector's contribution to total emissions increased by 8% compared to 1990 due to an increase in methane emissions in the Enteric fermentation category, driven by a significant increase in the number of cattle and nitrous oxide emissions from cultivated soils.

Emissions trends by gas and category

GHG emissions trends in the Agriculture sector for the period 1990-2021 are given in Table 5.1.1.1 and Figure 5.1.1.1.

Table 5.1.1.1 GHG emissions in the Agriculture sector, Gg CO_2-eq.

Years	CH_4	N_2O	Total	Years	CH_4	N_2O	Total
1990	8052.49	3775.15	**11827.65**	2007	12376.32	5989.04	**18365.35**
1991	8878.95	4416.87	**13295.81**	2008	13268.56	6481.54	**19750.10**
1992	9536.79	4584.65	**14121.45**	2009	14172.99	6930.30	**21103.29**
1993	9795.76	4531.50	**14327.26**	2010	15134.33	7373.81	**22508.14**
1994	9909.09	4503.23	**14412.31**	2011	15932.98	7837.51	**23770.48**
1995	9702.04	4394.83	**14096.87**	2012	16864.59	8217.12	**25081.71**
1996	9361.60	4077.40	**13439.00**	2013	17170.52	8476.43	**25646.95**
1997	9327.21	4623.47	**13950.68**	2014	17517.80	8677.72	**26195.52**
1998	9335.55	4638.87	**13974.42**	2015	18211.20	8996.81	**27208.00**
1999	9454.25	4658.34	**14112.59**	2016	18976.15	9388.58	**28364.74**
2000	9487.78	4687.19	**14174.98**	2017	19812.01	9805.59	**29617.60**
2001	9380.92	4673.19	**14054.21**	2018	20386.84	10138.22	**30525.05**
2002	9552.36	4728.76	**14281.22**	2019	21065.23	10189.83	**31255.06**
2003	10087.56	4914.54	**15002.11**	2020	21490.56	10339.54	**31830.10**
2004	10606.87	5092.33	**15699.19**	2021	21780.54	10474.63	**32255.17**
2005	11130.85	5414.56	**16545.41**	$\Delta_{(1990-2021)}$	**+270.0%**	**+277.0%**	**+273.0%**
2006	11691.25	5659.93	**17351.17**	**%, 2021**	**68.0%**	**32.0%**	**100.0%**

Note: The difference with the estimated data by sector category in tenths (Table 5.2) for some years is due to rounding of the value.

Between 1990 and 2021, total GHG emissions in the Agriculture sector, as well as methane and nitrous oxide emissions, increased by 2.7 times.

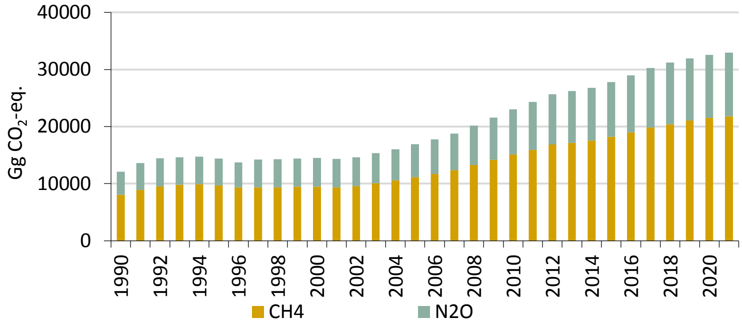

Figure 5.1.1.1 GHG emission trends in the Agriculture sector

Table 5.1.1.2 and Figure 5.1.1.2 present GHG emissions by estimated category in the Agriculture sector for the period 1990-2021.

Table 5.1.1.2 GHG emissions by category in the Agriculture sector, Gg CO_2-eq.

Years	Enteric Fermentation	Manure Management	Biomass Burning	N_2O Emissions from Managed Soils	Rice Cultivation	Total
1990	7005.53	1372.69	30.00	3071.82	347.61	**11827.65**
1991	7725.45	1504.13	29.50	3658.82	377.92	**13295.81**
1992	8270.89	1592.08	36.00	3791.52	430.96	**14121.45**
1993	8509.15	1619.85	38.60	3731.78	427.88	**14327.26**
1994	8640.62	1636.51	38.50	3701.01	395.67	**14412.31**
1995	8443.79	1591.81	44.30	3624.14	392.83	**14096.87**
1996	8085.04	1519.48	46.40	3349.55	438.53	**13439.00**
1997	8030.22	1507.62	48.70	3901.93	462.21	**13950.68**
1998	8140.76	1527.26	46.90	3908.10	351.39	**13974.42**
1999	8216.15	1541.70	46.50	3919.43	388.81	**14112.59**
2000	8317.49	1560.52	45.40	3939.48	312.09	**14174.98**
2001	8415.76	1578.90	50.70	3915.18	93.58	**14054.11**
2002	8519.27	1597.09	50.70	3961.59	152.47	**14281.12**
2003	8885.86	1665.68	50.50	4113.60	286.47	**15002.11**
2004	9478.24	1755.95	52.40	4236.06	156.54	**15699.19**
2005	10026.5	1875.15	-	4519.49	124.27	**16545.41**
2006	10518.45	1976.68	-	4712.40	143.64	**17351.17**
2007	11177.29	2099.93	-	4974.47	113.66	**18365.35**
2008	12036.93	2249.21	-	5383.82	80.13	**19750.10**
2009	12844.45	2401.30	-	5754.39	103.15	**21103.29**
2010	13667.86	2557.74	-	6118.79	163.75	**22508.14**
2011	14509.46	2714.04	-	6492.30	54.70	**23770.48**
2012	15274.38	2848.50	-	6779.16	179.68	**25081.71**
2013	15638.64	2910.81	-	6992.20	105.30	**25646.95**
2014	15959.35	2969.71	-	7153.40	113.06	**26195.52**
2015	16566.14	3078.84	-	7397.29	165.73	**27208.00**
2016	17289.69	3206.92	-	7698.13	170.00	**28364.74**
2017	18090.31	3348.45	-	8010.07	168.77	**29617.60**
2018	18697.84	3460.87	-	8266.56	99.79	**30525.05**
2019	19252.96	3581.38	-	8266.99	153.73	**31255.06**
2020	19665.13	36672.29	-	8380.39	112.30	**31830.10**
2021	19931.98	3721.54	-	8485.89	115.76	**32255.17**
$\Delta_{(1990-2021)}$	**+184.5%**	**+171.0%**	**-100.0%**	**+176.2%**	**-66.7%**	**+172.7%**
%. 2021	**60.50%**	**13.50%**	**0.00%**	**25.70%**	**0.40%**	**100.00%**

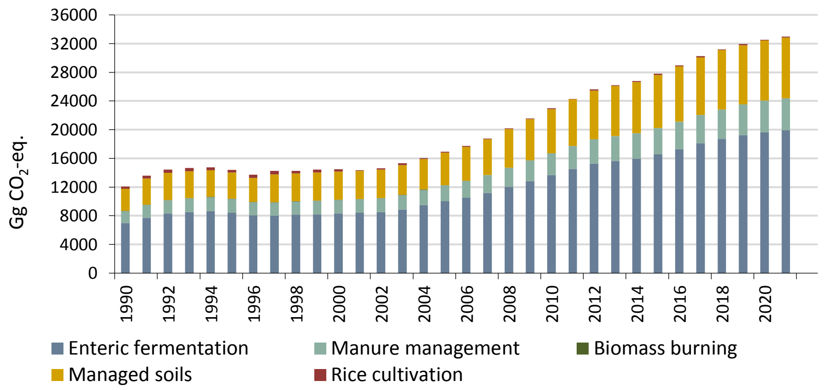

Figure 5.1.1.2 GHG emission trends by category in the Agriculture sector

The following changes are observed over the period 1990-2021:
Increase in GHG emissions in the categories is as follows:

- Enteric fermentation - by 184.5%;
- Manure management - by 171%;
- Agricultural soils - by 176.2%.

Emission reductions in the categories are as follows:

- Rice cultivation by 67%;
- Burning of agricultural residues by 100% since 2005;

Recalculation of emissions for the Agriculture sector

In the current inventory, the entire time series for the Agriculture sector has been recalculated relative to the 1990-2017 inventory data due to refinement of activity data and *default emission factors*. The results of the recalculation are given in Table 5.1.1.3.

Table 5.1.1.3 Results of emission recalculation for the Agriculture sector relative to the FBUR estimates

Years	FNC	FBUR	Difference	Years	FNC	FBUR	Difference
1990	11827.65	15139.18	3311.53	2004	15699.19	18060.21	2361.02
1991	13295.81	16509.74	3213.93	2005	16545.41	19378.64	2833.23
1992	14121.45	16643.26	2521.81	2006	17351.17	19986.16	2634.99
1993	14327.26	17360.85	3033.59	2007	18365.35	20995.05	2629.70
1994	14412.31	16952.49	2540.18	2008	19750.10	22495.02	2744.92
1995	14096.97	16483.22	2386.25	2009	21103.29	24016.09	2912.80
1996	13438.90	15972.55	2533.65	2010	22508.14	25685.09	3176.95
1997	13950.68	16050.65	2099.97	2011	23770.48	26895.89	3125.41
1998	13974.42	16144.29	2169.87	2012	25081.71	28077.94	2996.23
1999	14112.59	15976.36	1863.77	2013	25646.95	29207.88	3560.93
2000	14174.98	16024.15	1849.17	2014	26195.52	30340.20	4144.68
2001	14054.21	16306.82	2252.61	2015	27208.00	32003.95	4795.95
2002	14281.22	16545.32	2264.10	2016	2864.74	32876.32	30011.58
2003	15002.11	17277.62	2275.51	2017	2917.60	33652.28	30734.68

The recalculation resulted in a decrease of GHG emissions in the Agriculture sector by 11-13 % for different years of the time series. The recalculation of emissions in the Livestock and Nitrous oxide emissions from managed soils categories influenced the reduction of GHG emissions in the Agriculture sector.

5.1.2 Livestock (3.A category)

Description of source category

Natural-climatic and feeding conditions of the Republic of Uzbekistan have their specific features. Based on this, there are four zones of livestock breeding:

I Irrigated farming – mainly dairy cattle breeding.

II Rainfed farming – meat and dairy cattle breeding.
III Foothill zone – meat cattle breeding, meat and wool and meat and fat sheep breeding, wool and down goat breeding, as well as horse breeding.
IV Desert and semi-desert – Karakul sheep and camel breeding.

The livestock population is mainly concentrated in private households.
In order to improve the efficiency of livestock breeding, much attention is paid to the breed qualities of animals. Cattle is mainly represented by black-and-white, red, brown, Kazakh white-headed and Bushuev breeds. There are 24 breeding plants and 238 breeding farms in the country to improve breeding and increase productive qualities of cattle.
Due to the lack of natural and cultivated pastures in the country, there has been a tendency of stalled cattle breeding. Almost all year round, animals are kept in barnyards depending on age groups. Depending on weather conditions, the way of keeping animals is combined. In the housing it is tethered, and at sites it is loose.
The basis of feeding of cattle – rough and succulent feed, hay, haylage and silage. The animals are provided with the concentrated feed to a less extent.
The main food source for sheep, goats, horses and camels is pastures [49].
3.A Livestock category includes the following categories:

- 3.A.1 Enteric Fermentation;
- 3.A.2 Manure Management.

Recalculations for the Livestock category

In the current inventory, the entire time series for the Livestock category has been recalculated relative to the 1990-2017 inventory data due to the refinement of *national emission factors*. The results of the recalculation are given in Table 5.1.2.1.

Table 5.1.2.1 Recalculation of GHG emissions for the Livestock category for the period 1990-2017, Gg CO_2-eq.

Years	FNC	FBUR	Difference	Years	FNC	FBUR	Difference
1990	8378.22	8508.06	129.84	2004	11254.19	11538.44	284.25
1991	9229.58	9391.72	162.14	2005	11901.65	12198.25	296.60
1992	9862.97	10054.63	191.66	2006	12495.13	12812.46	317.33
1993	10129.00	10342.06	213.06	2007	13277.22	13608.40	331.18
1994	10277.13	10505.44	228.32	2008	14286.15	14623.91	337.77
1995	10035.60	10274.57	238.98	2009	15245.75	15602.20	356.44
1996	9604.51	9849.52	245.00	2010	16225.60	16601.54	375.94
1997	9537.84	9787.42	249.58	2011	17223.49	17611.80	388.31
1998	9668.02	9919.34	251.32	2012	18122.88	18508.67	385.79
1999	9757.85	10008.84	250.99	2013	18549.45	19314.67	765.22
2000	9878.00	10131.81	253.80	2014	18929.06	20030.63	1101.57
2001	9994.66	10251.72	257.06	2015	19644.98	20882.52	1237.54
2002	10116.36	10375.64	259.28	2016	20496.61	21822.98	1326.37
2003	10551.54	10819.93	268.39	2017	21438.76	22540.13	1101.37

The results of GHG emissions for the Livestock category calculated in the Fourth National Communication are lower than in the First Biennial Update Report by 1.5-6%. This difference in estimates is mainly due to the refinement of default emission factors, as well as the refinement of information on distribution of manure across different manure management systems.

5.1.2.1 Enteric fermentation (3.A.1 category)

3A1 Enteric Fermentation category considers emissions from the following types of livestock: dairy cattle, other cattle, sheep, goats, camels, horses, mules and asses and swine.
In 2021, the contribution of methane emissions from enteric fermentation of livestock to the total emissions for the Agriculture sector amounted to 61.8%.

Emission trends

Table 5.1.2.1.1 and Figure 5.1.2.1.1 show methane emissions from enteric fermentation of livestock for the period 1990-2021.

49 Uzbekistan. Third Environmental Performance Review. - UNECE, 2020 - 514 p.

Table 5.1.2.1.1 CH_4 emissions from Enteric Fermentation, Gg CO_2-eq.

Years	Dairy Cattle	Other Cattle	Sheep	Goats	Camels	Horses	Mules and Asses	Swine	Total
1990	2669.59	3090.19	1027.78	98.18	25.93	45.59	30.05	18.24	**7005.53**
1991	3032.01	3358.74	1099.894	108.80	26.62	48.98	33.29	17.12	**7725.45**
1992	3307.34	3554.43	1159.99	117.39	26.51	52.88	37.58	14.78	**8270.89**
1993	3442.00	3637.51	1174.46	120.51	26.34	57.67	38.84	11.84	**8509.15**
1994	3533.04	3689.74	1156.97	121.17	26.28	62.69	41.13	9.61	**8640.62**
1995	3525.27	3562.31	1093.99	117.36	26.11	66.33	45.45	6.98	**8443.79**
1996	3446.96	3398.92	986.70	110.26	24.55	66.92	47.01	3.71	**8085.04**
1997	3443.07	3397.75	936.53	114.46	21.79	66.65	47.94	2.04	**8030.22**
1998	3485.77	3436.93	955.03	125.26	20.01	66.89	48.94	1.93	**8140.76**
1999	3507.65	3470.25	964.22	133.34	19.15	66.80	52.69	2.05	**8216.15**
2000	3548.22	3514.31	971.69	140.53	18.17	66.31	56.15	2.11	**8317.49**
2001	3587.72	3562.78	976.16	146.04	17.54	65.48	57.96	2.09	**8415.76**
2002	3625.69	3606.49	986.13	154.91	17.54	64.82	61.74	1.96	**8519.27**
2003	3774.30	3763.82	1028.37	169.29	17.94	65.45	64.63	2.07	**8885.86**
2004	4011.28	4030.72	1087.36	194.42	18.57	67.28	66.40	2.21	**9478.24**
2005	4213.04	4282.17	1152.82	217.92	19.03	69.66	69.69	2.17	**10026.50**
2006	4425.40	4589.67	1101.54	235.64	19.15	72.11	72.69	2.25	**10518.45**
2007	4656.89	4932.12	1164.16	253.26	19.55	74.41	74.54	2.37	**11177.29**
2008	4919.65	5306.42	1367.78	267.16	19.84	77.42	76.25	2.43	**12036.93**
2009	5232.89	5683.59	1463.11	284.13	20.01	80.19	78.10	2.43	**12844.45**
2010	5561.53	6058.07	1553.98	306.87	20.49	82.83	81.63	2.47	**13667.86**
2011	5822.83	6521.78	1636.73	333.89	21.03	86.12	84.61	2.47	**14509.46**
2012	5957.72	7032.73	1722.96	359.40	21.63	89.41	88.13	2.40	**15274.38**
2013	6000.88	7292.40	1770.19	370.91	21.99	90.99	88.91	2.38	**15638.64**
2014	6066.15	7516.01	1794.86	383.04	21.60	92.48	82.87	2.35	**15959.36**
2015	6179.99	7929.96	1859.63	400.16	21.27	95.00	77.89	2.26	**16566.14**
2016	6296.57	8447.49	1928.20	419.16	21.50	96.82	77.77	2.20	**17289.69**
2017	6397.99	9066.24	1975.67	450.38	20.81	98.62	78.45	2.17	**18090.31**
2018	6522.27	9457.93	2048.00	473.18	20.16	101.70	72.60	2.01	**18697.84**
2019	6833.91	9589.53	2161.59	477.24	21.34	106.44	61.23	1.68	**19252.96**
2020	7083.24	9678.65	2248.28	469.68	22.49	110.15	51.21	1.42	**19665.13**
2021	7162.09	9817.76	2314.19	458.67	23.08	112.66	42.21	1.34	**19931.98**
$\Delta_{(1990-2021)}$	**2.68-fold increase**	**3.18-fold increase**	**2.25-fold increase**	**4.68-fold increase**	**-3,8%**	**2.46-fold increase**	**1.4-fold increase**	**14-fold decrease**	**2.84-fold increase**
%, 2021	**35.93%**	**49.26%**	**11.61%**	**2.30%**	**0.12%**	**0.57%**	**0.21%**	**0.007%**	**100%**

Over the period 1990-2021, there was a 2.84-fold increase in emissions from enteric fermentation of livestock. The changes in emissions are due to the increase in livestock population, mainly cattle and dairy cattle.

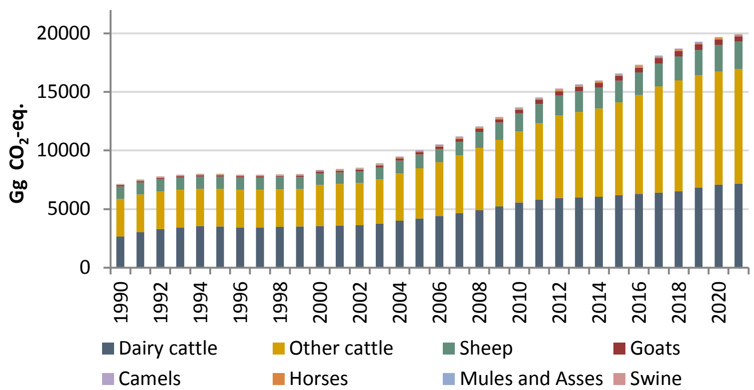

Figure 5.1.2.1.1 Methane emission trend from Enteric Fermentation of Livestock

Methodology

CH_4 emissions from enteric fermentation were estimated in accordance with [1] for the following livestock types: cattle (including dairy), sheep, goats, horses, mules and asses, camels at the countrywide level. A Tier 1 approach was used. There were no changes in methodology relative to the previous inventory (2017).

The category is key category. However, for using the Tier 2 method, there is insufficient information to derive national emission factors.

Equations 10.19 and 10.20 were used to calculate methane emissions from enteric fermentation (pp. 10.31-10.32, Vol.4, Part 2, Chapter 10 of the 2006 IPCC Guidelines).

Activity data

The number of livestock and poultry in farms of all categories in Uzbekistan is accounted once a year and is calculated as of January 1 of the year following the reporting year. The relevant data were provided by the Statistics Agency of the Republic of Uzbekistan. The calculations used annual average number of livestock of each type for two climatic zones. The temperate climate zone includes the whole territory of Uzbekistan, except for Surkhandarya region, and the subtropical climate zone includes only the territory of Surkhandarya region. The previous inventory used livestock data as of the first January of each reporting year. As a result of recalculation of activity data and their refinement for individual years, the estimate of emissions in this category changed downward. Tables 5.1.2.1.2-5.1.2.1.3 and Figure 5.1.2.1.2 show the dynamics of livestock of all categories included in the inventory.

Table 5.1.2.1.2 Average annual livestock and poultry population in Surkhandarya region, thousand heads

Years	Dairy Cattle	Other Cattle	Sheep	Goats	Camels	Horses	Mules and Asses	Swine	Poultry
1990	171.30	213.90	810.30	75.40	0.10	8.30	12.00	58.30	2166.00
1991	177.65	216.90	833.25	79.65	0.10	8.25	11.95	45.30	2155.55
1992	188.20	222.85	871.00	86.15	0.10	8.40	12.25	25.20	2112.80
1993	198.15	237.85	886.55	89.70	0.05	9.35	13.35	16.50	187.00
1994	206.35	247.20	881.95	90.50	0	10.55	14.10	14.25	1655.75
1995	204.25	218.10	848.80	88.85	0.05	11.45	14.20	10.20	1174.60
1996	202.00	204.95	829.00	88.95	0.05	12.00	14.05	4.45	716.85
1997	206.30	221.25	844.15	94.60	0.00	12.30	12.55	1.40	767.30
1998	209.70	225.95	846.55	106.05	0	12.55	12.90	0.80	798.95
1999	211.25	229.85	850.65	117.65	0	12.85	14.15	0.90	862.65
2000	213.25	231.70	854.80	123.60	0	13.05	13.70	1.15	934.60
2001	217.00	233.65	818.30	166.95	0	13.00	13.00	1.45	959.00
2002	220.50	237.40	777.95	223.75	0	12.65	12.70	1.35	1007.45
2003	224.75	249.25	799.85	253.75	0	12.25	13.50	1.15	1047.35
2004	232.25	265.75	820.05	295.95	0	12.35	12.80	1.20	1066.60
2005	239.50	280.50	842.95	350.20	0	12.90	12.55	1.25	1123.00
2006	245.35	294.80	717.00	396.45	0	13.50	13.25	1.05	1215.85
2007	253.10	305.90	796.30	415.55	0	13.85	13.55	0.95	1311.45
2008	265.35	331.80	1072.25	419.55	0	14.15	14.20	1.00	1500.25
2009	278.65	357.95	1138.85	424.95	0	14.30	14.30	0.85	1737.50
2010	293.70	374.85	1193.30	454.35	0.005	14.63	14.33	0.64	1906.70
2011	309.20	402.90	1238.00	496.80	0.005	14.99	14.42	0.53	2165.65
2012	315.85	439.45	1281.55	526.45	0	14.96	14.49	0.44	2512.85
2013	316.70	459.10	1305.80	541.60	0	14.91	14.51	0.38	2673.20
2014	318.45	466.35	1262.65	624.15	0	14.84	14.61	0.36	2773.10
2015	321.70	477.25	1293.70	658.85	0	14.80	14.81	0.33	2979.45
2016	325.40	501.70	1383.25	618.25	0	14.84	14.93	0.29	3218.80
2017	327.65	543.65	1419.50	637.40	0	14.88	14.95	0.24	3668.75
2018	329.95	589.35	1470.65	691.25	0.013	14.78	14.76	0.19	4042.85
2019	355.25	598.85	1613.00	662.50	0.026	14.40	12.94	0.16	4454.20
2020	378.60	589.50	1750.70	588.45	0.030	14.26	11.32	0.13	4851.10
2021	382.15	601.75	1806.35	584.80	0.030	14.56	10.25	0.098	4898.80

Table 5.1.2.1.3 Average annual livestock and poultry population in Uzbekistan except for Surkhandarya region, thousand heads

Years	Dairy Cattle	Other Cattle	Sheep	Goats	Camels	Horses	Mules and Asses	Swine	Poultry
1990	1579.25	2416.05	7411.90	710.00	22.45	93.00	108.20	671.15	34516.60
1991	1810.55	2641.60	7965.90	790.75	23.05	100.60	121.20	639.50	33457.25
1992	1980.55	2802.20	8408.90	852.95	22.95	109.10	138.05	565.90	28577.60
1993	2058.90	2857.90	8509.10	874.35	22.85	118.80	142.00	457.10	22461.80
1994	2110.40	2893.00	8373.80	878.85	22.85	128.75	150.40	370.25	19396.65
1995	2107.40	2813.65	7903.10	850.05	22.65	135.95	167.60	268.95	15321.90
1996	2058.30	2687.75	7064.60	793.15	21.30	136.70	174.00	144.05	12304.25
1997	2051.45	2670.45	6648.05	821.10	18.95	135.80	179.20	80.10	11706.90
1998	2076.05	2699.10	6793.70	896.00	17.40	136.10	182.85	76.55	12308.10
1999	2088.85	2723.55	6863.10	949.10	16.65	135.60	196.60	81.00	13365.45
2000	2113.45	2759.20	6918.75	1000.65	15.80	134.30	210.90	83.25	13581.05
2001	2135.60	2798.50	6991.00	1001.35	15.25	132.50	218.85	82.25	13710.35
2002	2157.00	2831.95	7111.05	1015.55	15.25	131.40	234.25	77.15	14084.35
2003	2250.20	2954.00	7427.10	1100.55	15.60	133.20	245.00	81.50	15467.95
2004	2398.10	3164.65	7878.85	1259.40	16.15	137.15	252.80	87.10	17188.10
2005	2523.15	3363.90	8379.60	1393.15	16.55	141.90	266.20	85.55	18564.05
2006	2656.55	3611.30	8095.35	1488.70	16.65	146.75	277.50	88.95	21148.70
2007	2800.60	3891.65	8516.95	1610.55	17.00	151.50	284.60	93.70	23842.35
2008	2960.65	4184.30	9869.95	1717.70	17.25	157.90	290.80	96.00	26311.90
2009	3152.75	4479.15	10566.05	1848.10	17.40	163.90	298.10	96.30	29541.70
2010	3353.20	4780.95	11238.50	2000.60	17.82	169.44	312.21	98.06	33486.45
2011	3509.05	5147.55	11855.80	2174.35	18.28	176.38	324.03	98.33	38110.20
2012	3590.85	5545.85	12502.15	2348.75	18.81	183.73	338.00	95.57	42639.25
2013	3618.30	5747.20	12855.70	2425.70	19.12	187.29	341.11	94.80	44812.60
2014	3659.35	5930.25	13096.25	2440.15	18.79	190.68	316.87	93.56	47151.40
2015	3730.75	6271.65	13583.30	2542.40	18.49	196.32	296.75	89.89	51340.30
2016	3803.50	6687.65	14042.35	2735.00	18.69	200.31	296.16	87.50	55593.95
2017	3867.75	7172.30	14385.85	2965.60	18.10	204.26	298.83	86.43	60524.70
2018	3946.95	7459.95	14913.35	3094.15	17.51	211.22	275.64	80.19	66911.05
2019	4126.00	7562.45	15679.75	3155.45	18.53	222.13	231.99	66.89	76168.25
2020	4266.15	7647.65	16235.55	3169.00	19.53	230.51	193.52	56.70	82266.15
2021	4314.30	7753.79	16707.15	3084.55	20.04	235.79	158.58	53.52	83825.90

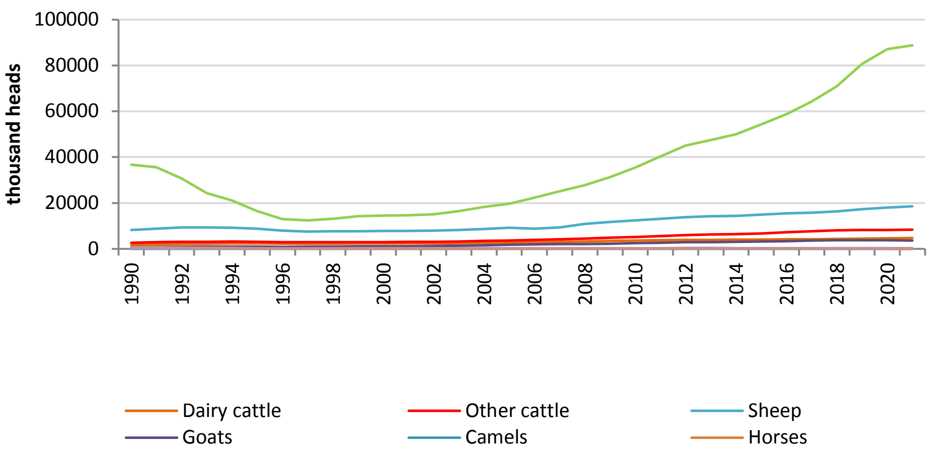

Figure 5.1.2.1.2 Dynamics of growth in the average annual livestock population

The increase in methane emissions from enteric fermentation is proportional to the increase in the livestock population. Poultry and sheep growth rates are most significant.

Emission factors

Default factors of methane emission from enteric fermentation were used for each animal type in accordance with [3], (Tables 10.10 and 10.11, Asia, developing countries).

- Dairy cattle – 61;
- Other cattle – 47;
- Swine – 1;
- Sheep – 5;
- Goats – 5;
- Camels – 46;
- Horses – 18;
- Mules and Asses – 10.

Uncertainties and time series consistency

Uncertainty of methane emissions in the Enteric Fermentation category was estimated according to [1].
Uncertainty of the statistical information on livestock population is in the range of 5%. Uncertainty of IPCC default emission factors is ±30-50%.
Combined uncertainty of methane emissions in the Enteric Fermentation category was ±50.3%.

The same method and ~~similar~~ data sets were used for all years.

Quality assurance/Quality control

QA/QC procedures were performed in accordance with the general QA/QC principles and the QA/QC Plan. The following were verified:

- emission sources documentation,
- mechanical errors in data,
- all source references for data sources in the IPCC Software.

Recalculations for the category

In the current inventory, the entire time series for the Enteric Fermentation category has been recalculated relative to the 1990-2017 inventory data due to refinement of livestock population data. The results of the recalculation are given in Table 5.1.2.1.4.

Table 5.1.2.1.4 Recalculation of GHG emissions by Enteric Fermentation category for the period 1990-2017, Gg CO_2-eq.

Years	FNC	FBUR	Difference	Years	FNC	FBUR	Difference
1991	7005.53	7311.88	306.35	2004	9478.24	9938.55	460.31
1991	7725.45	8073.38	347.93	2005	10026.50	10509.96	483.46
1992	8270.89	8650.42	379.53	2006	10518.45	11026.28	507.83
1993	8509.15	8904.13	394.98	2007	11177.29	11711.69	534.40
1994	8640.62	9046.05	405.43	2008	12036.93	12601.48	564.55
1995	8443.79	8848.33	404.54	2009	12844.45	13444.95	600.49
1996	8085.04	8480.59	395.55	2010	13667.86	14306.07	638.21
1997	8030.22	8425.32	395.11	2011	14509.46	15177.65	668.19
1998	8140.76	8540.77	400.01	2012	15274.38	15956.20	681.82
1999	8216.15	8618.66	402.52	2013	15638.64	16655.28	1016.64
2000	8317.49	8724.66	407.17	2014	15959.35	17275.20	1315.85
2001	8415.76	8827.46	411.70	2015	16566.14	18012.25	1446.11
2002	8519.27	8935.33	416.06	2016	17289.69	18824.50	1534.81
2003	8885.86	9318.97	433.12	2017	18090.31	19446.30	1355.99

The recalculation of emissions in the Enteric Fermentation category resulted in a 4.4-8.9% decrease in the 1990-2021 inventory emissions estimates relative to the previous First Biennial Update Report estimates. The change in the emission estimate in this category was due to the refinement and recalculation of activity data (livestock population).

Planned improvements in the category

It is planned to move towards the use of the Tier 2 methodology for emission estimates in the Enteric Fermentation category in the future, which will require the development of national emission factors and refinement of activity data.

5.1.2.2 Manure Management (3.A.2 category)

Category description

In 3.A.2 Manure Management category, methane and nitrous oxide emissions were estimated. GHG emissions in this category were estimated for two climatic zones: temperate and subtropical. The subtropical climatic zone includes the territory of Surkhandarya region (average annual temperature is 16.14°C), while the temperate dry climatic zone includes the rest of the Republic of Uzbekistan (average annual temperature is 13.47°C).

Methane emissions were estimated for the following categories of livestock: dairy cattle, other cattle, swine, sheep, goats, camels, horses, mules and asses and poultry (total).

Direct and indirect nitrous oxide emissions have been estimated from all available animal waste management systems (AWMS), including: anaerobic storage, liquid systems, dairy farming and field application, solid and paddock storage at farms, pastures, and fenced pastures.

CO_2 emissions from manure burning were reported under the CO_2 emissions from biomass category in the Energy sector.

Table 5.1.2.2.1 and Figure 5.1.2.2.1 show total methane and nitrous oxide emissions for the Manure management category. In 2021, GHG emissions from manure management amounted to 3721.55 Gg CO_2-eq. (11.5% of emissions in the Agriculture sector).

Table 5.1.2.2.1 GHG emissions from Manure Management, Gg CO_2-eq.

Years	CH_4	N_2O	Total	Years	CH_4	N_2O	Total
1990	676.45	696.24	**1372.69**	2007	1085.36	1014.56	**2099.92**
1991	753.08	751.05	**1504.13**	2008	1151.49	1097.72	**2249.21**
1992	807.45	784.63	**1592.08**	2009	1225.39	1175.91	**2401.30**
1993	829.23	790.62	**1619.85**	2010	1302.72	1255.02	**2557.74**
1994	843.39	793.12	**1636.51**	2011	1368.83	1345.21	**2714.04**
1995	831.52	760.29	**1591.81**	2012	1410.54	1437.96	**2848.50**
1996	802.63	716.84	**1519.47**	2013	1426.58	1484.23	**2910.81**
1997	797.58	710.04	**1507.62**	2014	1445.38	1524.32	**2969.70**
1998	807.59	719.67	**1527.26**	2015	1479.32	1599.52	**3078.84**
1999	813.80	727.91	**1541.71**	2016	1516.46	1690.45	**3206.91**
2000	823.51	737.01	**1560.52**	2017	1552.93	1795.52	**3348.45**
2001	832.78	746.12	**1578.90**	2018	1589.21	1871.66	**3460.87**
2002	841.82	755.27	**1597.09**	2019	1658.55	1922.84	**3581.39**
2003	876.64	789.04	**1665.68**	2020	1713.14	1959.15	**3672.29**
2004	932.09	843.86	**1775.95**	2021	1732.80	1988.75	**3721.55**
2005	980.08	895.06	**1875.14**	$\Delta_{(1990-2021)}$	**+156.2%**	**+185.6%**	**+171.1%**
2006	1029.16	947.52	**1976.68**	$\%_{2021}$	**46.6%**	**53.4%**	**100.0%**

Over the period 1990-2021, the total GHG emissions in this category increased by 171%, while there was an increase in CH_4 emissions by 156.2%; in N_2O emissions by 185.6 %. Methane accounts for 46.6 % of the total category emissions, nitrous oxide – 53.4 %, respectively.

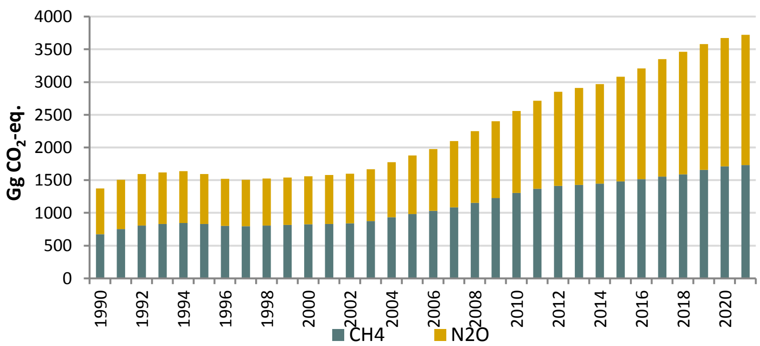

Figure 5.1.2.2.1 GHG trends from Manure Management

The increase in GHG emissions in the category is due to an increase in the livestock population, including an increase in the number of cattle.

5.1.2.2.1 Methane emissions from Manure Management

Table 5.1.2.2.1.1 shows trends in methane emissions from manure management systems from different livestock species for the period 1990-2021. In 2021, methane emissions from this category amounted to 1732.804 Gg CO_2-eq.

Table 5.1.2.2.1.1 Methane emissions from Manure Management, Gg CO_2-eq.

Years	Dairy cattle	Other cattle	Sheep	Goats	Camels	Horses	Mules and Asses	Swine	Poultry	Total
1990	533.73	65.75	21.57	2.27	0.72	2.87	1.89	37.93	9.71	**676.45**
1991	605.34	71.46	23.04	2.51	0.74	3.08	2.09	35.37	9.44	**753.08**
1992	660.03	75.63	24.29	2.71	0.74	3.32	2.35	30.18	8.20	**807.45**
1993	687.02	77.39	24.60	2.79	0.73	3.62	2.43	24.09	6.55	**829.23**
1994	705.34	78.51	24.24	2.80	0.73	3.94	2.57	19.58	5.68	**843.39**
1995	703.71	75.79	22.94	2.71	0.73	4.17	2.83	14.21	4.42	**831.52**
1996	688.19	72.32	20.77	2.56	0.68	4.22	2.93	7.54	3.43	**802.63**
1997	687.64	72.29	19.79	2.66	0.61	4.20	2.97	4.11	3.31	**797.58**
1998	696.21	73.13	20.16	2.91	0.56	4.22	3.03	3.89	3.48	**807.59**
1999	700.59	73.83	20.35	3.11	0.53	4.22	3.27	4.12	3.77	**813.79**
2000	700.59	73.83	20.35	3.28	0.53	4.19	3.47	4.25	3.86	**814.36**
2001	716.63	75.80	20.55	3.46	0.49	4.14	3.57	4.22	3.91	**832.78**
2002	724.27	76.73	20.69	3.74	0.49	4.10	3.80	3.96	4.02	**841.82**
2003	753.72	80.08	21.57	4.10	0.50	4.13	3.98	4.16	4.39	**876.64**
2004	800.72	85.76	22.77	4.72	0.52	4.24	4.08	4.44	4.83	**932.09**
2005	800.37	85.78	22.77	5.32	0.52	4.40	4.27	4.37	5.20	**933.00**
2006	882.84	97.65	22.93	5.78	0.53	4.55	4.46	4.53	5.89	**1029.16**
2007	928.76	104.94	24.28	6.19	0.54	4.70	4.57	4.76	6.62	**1085.36**
2008	981.07	112.90	28.70	6.51	0.55	4.88	4.68	4.87	7.33	**1151.49**
2009	1043.35	120.93	30.69	6.89	0.56	5.05	4.79	4.88	8.25	**1225.39**
2010	1108.75	128.89	32.57	7.43	0.57	5.22	5.00	4.95	9.32	**1302.72**
2011	1160.93	138.76	34.28	8.09	0.58	5.41	5.18	4.96	10.61	**1368.83**
2012	1187.80	149.63	36.06	8.70	0.60	5.62	5.40	4.81	11.92	**1410.54**
2013	1196.33	155.16	37.04	8.97	0.61	5.71	5.44	4.77	12.54	**1426.58**
2014	1209.26	159.91	37.48	9.36	0.60	5.80	5.08	4.70	13.17	**1445.38**
2015	1231.82	168.72	38.81	9.79	0.59	5.96	4.78	4.52	14.32	**1479.32**
2016	1254.94	179.73	40.29	10.15	0.60	6.07	4.78	4.40	15.51	**1516.46**
2017	1275.00	192.90	41.29	10.86	0.58	6.18	4.82	4.34	16.97	**1552.93**
2018	1299.57	201.23	42.80	11.45	0.56	6.36	4.49	4.02	18.75	**1589.23**
2019	1362.14	204.03	45.25	11.49	0.59	6.64	3.71	3.36	21.27	**1658.55**
2020	1412.35	205.93	47.15	11.22	0.63	6.87	3.16	2.84	22.99	**1713.14**
2021	1428.04	208.89	48.54	10.97	0.64	7.02	2.61	2.68	23.41	**1732.80**
$\Delta_{(1990-2021)}$	**2.68-fold increase**	**3.18-fold increase**	**2.25 fold increase**	**4.83-fold increase**	**decrease 1.12 times**	**2.44-fold increase**	**1.38-fold increase**	**14.13-fold increase**	**2.41-fold increase**	**2.56-fold increase**
%,$_{2021}$	**82%**	**12%**	**3%**	**1%**	**0%**	**0%**	**0%**	**0%**	**1%**	**100%**

The largest contributors to methane emissions from manure management systems are dairy cattle and other cattle. Methane emissions from manure management systems increased 2.56 times in 1990-2021.

Methodology

Livestock data were used to calculate methane emissions from manure and poultry manure management systems. The main factors affecting methane emissions are the amount of manure produced and the fraction of manure that undergoes anaerobic decomposition. In cases where manure is processed in solid form or left on pasture, decomposition occurs under more aerobic conditions and less methane is produced.

To estimate CH_4 emissions from manure management, the Tier 1 approach of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* was used [3]. Calculations were made for the following livestock categories: cattle, including dairy cattle, sheep, goats, horses, camels, mules and asses, swine and poultry.

CH_4 emissions were estimated separately for Surkhandarya region and the rest of Uzbekistan, as they are located in different climatic zones. Default methane emission factors were used for each climatic zone. The total methane emissions were obtained as the amount of calculated emissions for both climatic zones.

Equation 10.22 (page 10.42, Vol.4, Part 2, Ch. 10) [3] was used to calculate methane emissions from manure management.

Activity data

Initial statistical data on livestock population as of January 1 of each year in all categories of farms were provided by the Statistics Agency of the Republic of Uzbekistan (Tables 5.6 - 5.7). Average annual data were used in calculations.

Emission factors

Default methane emission factors from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Tables 10.14 and 10.15, Asia, Developing Countries) were adopted for each category of animal. These factors are given in Table 5.1.2.2.1.2.

Table 5.1.2.2.1.2 Default emission factors for calculating methane emissions from Manure Management, kg CH_4/head/year

Category of animal	Surkhandarya region	Rest of Uzbekistan
Dairy cattle	14	12
Other cattle	1	1
Swine	3	2
Sheep	0.15	0.1
Goats	0.17	0.11
Camels	1.92	1.28
Horses	1.64	1.09
Mules and Asses	0.90	0.60
Poultry	0.02	0.01

Uncertainties and time series consistency

Uncertainty of CH_4 emissions for 3.A.2 Manure Management category were estimated according to [1].

In estimating the uncertainty of CH_4 emissions from manure management, the uncertainty of the statistical information on livestock population is estimated to be ±5%, and the uncertainty of the default CH_4 emission factors is ±30%. Combined uncertainty of methane emission estimates for the category was ±30.4%.

5.1.2.2.2 Nitrous oxide emissions from Manure Management

The category considers **direct and indirect** nitrous oxide **emissions** from manure management systems. Indirect nitrous oxide emissions from the “Pasture and paddock” system were classified as Nitrous oxide Emissions from Managed Soils.

Table 5.1.2.2.2.1 shows trends in direct and indirect nitrous oxide emissions from manure management systems for the period 1990-2021. In 2021, direct nitrous oxide emissions from this category amounted to 1988.74 Gg CO_2-eq., and indirect emissions – 713.41 Gg CO_2-eq.

Table 5.1.2.2.2.1 Direct and indirect nitrous oxide emissions from Manure Management, Gg CO_2-eq.

Years	Direct	Indirect	Total	Years	Direct	Indirect	Total
1990	696.24	263.73	**959.97**	2007	1014.56	411.24	**1425.80**
1991	751.05	291.15	**1042.20**	2008	1097.72	440.15	**1537.87**
1992	784.63	309.62	**1094.25**	2009	1175.92	469.95	**1645.87**
1993	790.62	315.88	**1106.50**	2010	1255.02	500.64	**1755.66**
1994	793.12	319.75	**1112.87**	2011	1345.21	529.84	**1875.05**
1995	760.29	312.30	**1072.59**	2012	1437.96	552.70	**1990.66**
1996	716.84	299.49	**1016.33**	2013	1484.23	562.92	**2047.15**
1997	710.04	297.40	**1007.44**	2014	1524.32	573.05	**2097.37**
1998	719.67	301.28	**1020.95**	2015	1599.52	592.13	**2191.65**

Table 5.1.2.2.2.1 continuation

Years	Direct	Indirect	Total	Years	Direct	Indirect	Total
1999	727.91	304.26	**1032.17**	2016	1690.45	613.58	**2304.03**
2000	737.01	307.83	**1044.84**	2017	1795.52	636.23	**2431.75**
2001	746.12	311.41	**1057.53**	2018	1871.66	656.49	**2528.15**
2002	755.27	314.99	**1070.26**	2019	1922.84	683.61	**2606.45**
2003	789.04	328.40	**1117.44**	2020	1959.15	704.17	**2663.32**
2004	843.86	349.85	**1193.71**	2021	1988.74	713.41	**2702.15**
2005	895.06	369.22	**1264.28**	$\Delta_{(1990-2021)}$	**+185.7%**	**+170.5%**	**181.48%**
2006	947.52	387.70	**1335.22**				

Over the period 1990-2021, nitrous oxide emissions from Manure Management increased by 181.5%, including direct emissions by 185.7% and indirect emissions by 170.5%. The increase in nitrous oxide emissions was due to the increase in livestock population.

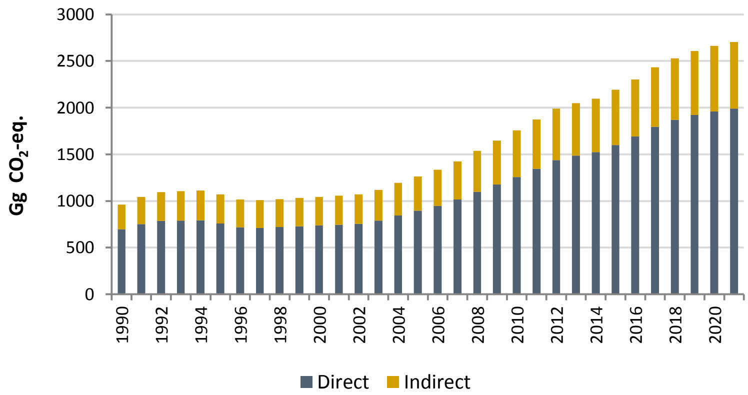

Figure 5.1.2.2.2.1 Nitrous oxide emissions from Manure Management category

Table 5.1.2.2.2.2 shows direct nitrous oxide emissions from Manure Management by category of animal.

Table 5.1.2.2.2.2 Direct nitrous oxide emissions from Manure Management, Gg CO_2-eq.

Years	Dairy Cattle	Other Cattle	Sheep	Goats	Camels	Horses	Mules and Asses	Swine	Poultry	Total
1990	93.52	448.55	78.27	2.76	0.19	0.95	0.61	22.34	49.05	**696.24**
1991	106.21	487.53	83.76	3.06	0.20	1.02	0.68	20.97	47.62	**751.05**
1992	115.86	515.93	88.34	3.30	0.20	1.10	0.77	18.10	41.04	**784.63**
1993	120.58	527.99	89.44	3.39	0.19	1.20	0.79	14.51	32.54	**790.62**
1994	123.77	535.57	88.11	3.40	0.19	1.30	0.84	11.78	28.15	**793.12**
1995	123.49	517.08	83.31	3.30	0.19	1.38	0.93	8.55	22.06	**760.29**
1996	120.75	493.36	75.14	3.10	0.18	1.39	0.96	4.55	17.41	**716.84**
1997	120.61	493.19	71.32	3.22	0.16	1.39	0.98	2.50	16.68	**710.04**
1998	122.11	498.88	72.73	3.52	0.15	1.39	1.00	2.37	17.53	**719.67**
1999	122.88	503.71	73.43	3.75	0.14	1.39	1.08	2.51	19.02	**727.91**
2000	124.30	510.11	74.00	3.95	0.13	1.38	1.15	2.58	19.41	**737.01**
2001	125.68	517.15	74.34	4.10	0.13	1.36	1.19	2.56	19.62	**746.12**
2002	127.01	523.49	75.10	4.35	0.13	1.35	1.26	2.40	20.18	**755.27**
2003	132.22	546.33	78.31	4.76	0.13	1.36	1.32	2.53	22.08	**789.04**
2004	140.52	585.07	82.81	5.46	0.14	1.40	1.36	2.71	24.41	**843.86**
2005	147.59	621.57	87.79	6.12	0.14	1.45	1.43	2.66	26.32	**895.06**
2006	155.03	666.20	83.89	6.62	0.14	1.50	1.49	2.76	29.90	**947.52**
2007	163.14	715.91	88.65	7.12	0.15	1.55	1.52	2.90	33.63	**1014.56**
2008	172.34	770.24	104.16	7.51	0.15	1.61	1.56	2.97	37.19	**1097.72**
2009	183.31	824.99	111.42	7.98	0.15	1.67	1.60	2.98	41.82	**1175.92**
2010	194.83	879.34	118.34	8.62	0.15	1.72	1.67	3.02	47.32	**1255.02**

Table 5.1.2.2.2 continuation

Years	Dairy cattle	Other cattle	Sheep	Goats	Camels	Horses	Mules and Asses	Swine	Poultry	Total
2011	203.98	946.65	124.64	9.38	0.16	1.79	1.73	3.03	53.85	**1345.21**
2012	208.71	1020.82	131.21	10.10	0.16	1.86	1.80	2.94	60.37	**1437.96**
2013	210.22	1058.51	134.81	10.42	0.16	1.89	1.82	2.92	63.49	**1484.23**
2014	212.50	1090.96	136.68	10.76	0.16	1.92	1.69	2.88	66.75	**1524.32**
2015	216.49	1151.05	141.62	11.24	0.16	1.98	1.59	2.76	72.63	**1599.52**
2016	220.58	1226.17	146.84	11.78	0.16	2.01	1.59	2.69	78.64	**1690.45**
2017	224.13	1315.98	150.45	12.66	0.15	2.05	1.60	2.66	85.83	**1795.52**
2018	228.48	1372.84	155.96	13.30	0.15	2.12	1.48	2.46	94.87	**1871.66**
2019	239.40	1391.94	164.61	13.41	0.16	2.21	1.25	2.05	107.80	**1922.84**
2020	248.13	1404.88	171.21	13.20	0.17	2.29	1.05	1.74	116.49	**1959.15**
2021	250.90	1425.07	176.23	12.89	0.17	2.34	0.86	1.64	118.63	**1988.74**
Δ (1990-2021)	**2.68-fold increase**	**3.18-fold increase**	**2.25-fold increase**	**4.67-fold increase**	**1.12-fold increase**	**2.47-fold increase**	**1.4-fold increase**	**13.6-fold decrease**	**2.42-fold increase**	**2.86-fold increase**
%, 2021	**12.62%**	**71.66%**	**8.86%**	**0.65%**	**0.01%**	**0.12%**	**0.04%**	**0.08%**	**5.97%**	**100.00%**

Nitrous oxide emissions from Manure Management increased by 2.86 times between 1990 and 2021. The largest contributors to emissions in this category are animals such as dairy cattle, other cattle, sheep and poultry.

Methodology

The Tier 1 methodology of the 2006 IPCC Guidelines was used to estimate direct N_2O emissions in the Manure Management category, taking into account the division of the country into two climatic zones (to ensure comparability of methane and nitrous oxide emission estimates for this category).

The total amount of nitrogen (N) excreted for each category of animal and each type of manure management system was multiplied by the appropriate emission factor for each type of management system. Total nitrous oxide emissions were summed from all available animal waste management systems (AWMS), including: anaerobic storage, liquid systems, dairy farming and field application, solid and paddock storage at farms, pastures and fenced pastures. Conversion from nitrogen (N) to nitrous oxide (N_2O) was then performed.

Calculations were made using Equation 10.25, Direct N_2O Emissions from Manure management (Chapter 10.5.1 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Part 2).

Indirect N_2O emissions from nitrogen volatilization in the form of ammonia and nitrogen oxides (NOx) were estimated using Equation 10.27 of the same Chapter of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Emission factors for estimating nitrous oxide from manure management

The fraction of Manure Management System Usage (%) (Table 5.1.2.2.3) is taken by default from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Volume 4, Part 2, Tables 10A-4, 10A-5, 10A-7, pp. 10.88, 10.91, Asia Region (for dairy cattle, cattle and swine). For the rest of categories of animal, due to the lack of data in the 2006 Guidelines, default data from the 1996 Guidelines (Table 4-7, p.4.13) have been used.

Table 5.1.2.2.3 Fraction of (Manure Management System Usage, MS%)

Category of animal	Lagoons (anaerobic storage)	Liquid storage	Solid storage	Drylot	Pasture / Range / Paddock	Daily spread	Digester	Burned for fuel	Other
Dairy cattle	4%	38%	0%	0%	20%	29%	2%	7%	0%
Other cattle	0%	0%	0%	46%	50%	2%	0%	2%	0%
Swine	0%	40%	0%	54%	0%	0%	0%	7%	0%
Sheep	0%	0%	0%	0%	83%		0%	0%	17%
Poultry[1]	1%	2%	0%	0%	44%	0%	0%	1%	52%
Other animals[2]	0%	0%	0%	0%	95%	0%	0%	0%	5%

Note: 1 - includes chickens, ducks and turkeys
2 - other animals include goats, horses, mules and asses and camels

Emission factor for direct N_2O emissions for each AWMS - (EF_3) was adopted **by default** from Table 10.21, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Part 2, p.10.72.

Table 5.1.2.2.4 Nitrogen excretion rates from manure for each animal type (Nex)

Category of animal	kg N/head/year
Dairy cattle	60.04
Other cattle	39.59
Sheep	11.96
Goats	15.00
Camels	36.43
Horses	39.96
Swine	5.11
Mules and Asses	21.83
Poultry	0.54

Nitrogen excretion rates for each category of animal (Nex) - kg N/head/year - were calculated based on default values for nitrogen excretion rates (kg N/1000 kg animal weight * day) from Table 10.19 (IPCC 2006, Vol.4, Part 2) and average animal weight default values from Tables 10.A-4, 10.A.5, 10A.7, 10.A.9 (p.10.88, 10.89, 10.91, 10.93) for the Asia region. The resulting values of N excretion rates by category of animal are given in Table 5.15:

Uncertainties and time series consistency

Uncertainty of direct N_2O emissions in 3.A.2 Manure Management category were estimated according to [1].

In estimating the uncertainty of N_2O emissions from Manure Management, the uncertainty of activity data, according to expert estimates from the Ministry of Agriculture, was ±50%. Uncertainty associated with the distribution of manure across manure management systems is the largest contributor to activity data uncertainty. Uncertainty of the default direct N_2O emission factors is ±100%.

Combined uncertainty in N_2O emissions for the Manure Management category was ±111.8%.

The same method and data sets were used for all years.

Quality assurance/Quality control

QA/QC procedures were performed in accordance with the general QA/QC principles and the QA/QC plan. The following were verified:

- emission sources documentation,
- mechanical errors in data,
- all source references for data sources in the IPCC Software.

Recalculations for the category

Recalculations of nitrous oxide emissions (direct and indirect) relative to the First Biennial Update Report estimates were performed due to the refinement of the emission factors values for each manure management system. The results are given in Table 5.1.2.2.5.

Table 5.1.2.2.5 Recalculation of N_2O emissions for the "N_2O emissions from Manure Management" category for the period 1990-2017, Gg CO_2-eq.

Years	FBUR	FNC	Difference	Years	FBUR	FNC	Difference
1990	1196.18	959.86	236.32	2004	1599.89	1193.79	406.10
1991	1318.34	1042.11	276.23	2005	1688.29	1264.41	423.87
1992	1404.21	1094.26	309.96	2006	1786.18	1335.64	450.55
1993	1437.93	1106.47	331.45	2007	1896.71	1425.93	470.78
1994	1459.40	1112.73	346.66	2008	2022.43	1537.98	484.45
1995	1426.25	1072.50	353.75	2009	2157.25	1645.85	511.40
1996	1368.93	1016.48	352.45	2010	2295.48	1755.52	539.96
1997	1362.10	1007.54	354.56	2011	2434.15	1875.02	559.14
1998	1378.57	1020.95	357.62	2012	2552.47	1990.64	561.83
1999	1390.17	1032.27	357.90	2013	2659.39	2047.26	612.13
2000	1407.15	1044.79	362.36	2014	2755.42	2097.32	658.10
2001	1424.27	1057.60	366.66	2015	2870.27	2191.79	678.48
2002	1440.32	1070.12	370.20	2016	2998.47	2304.14	694.34
2003	1500.95	1117.50	383.45	2017	3093.82	2431.68	662.14

Planned improvements in the category

The next inventory is expected to use national data on manure distribution across manure management systems, and to refine national data on average animal weights. This requires special research.

5.1.3 Aggregate Sources and Non-CO_2 Emissions Sources on Land (3.C category)

The following subcategories are considered in 3.C Aggregate Sources and Non-CO_2 Emissions Sources on Land category:

- 3.C.1 Emissions from Biomass Burning;
- 3.C.4 Direct N_2O Emissions from Managed Soils;
- 3.C.5 Indirect N_2O Emissions from Managed Soils;
- 3.C.6 Indirect N_2O Emissions from Manure Management;
- 3.C.7 Rice Cultivation.

5.1.3.1 Emissions from Biomass Burning (3.C.1 category)

Category description

Category 3.C.1 Emissions from Biomass Burning, considers emissions from cereal crop residues burning in 3.C.1.b Biomass Burning in Croplands subcategory. There is no practice of biomass burning in other land categories in the country.

Calculations were made for the period 1990-2004. In 2005, the Decree of the President of the Republic of Uzbekistan "On organizational measures for the harvesting of cereal crops" was adopted to prohibit cereal crop residues burning (No. PP-76 dated May 16, 2005). In this regard, calculations for this category for the period 2005-2021 were not made, as there are no statistical data on the areas where crop residues burning was carried out.

Currently, the following practice is used: after harvesting, the cereal crop fields are cleaned of straw residues, plowed and prepared for re-sowing.

Emission trends

Table 5.1.3.1.1 and Figure 5.1.3.1.1 show GHG emissions from crop residues burning in fields for the period 1990-2005.

Table 5.1.3.1.1 GHG emissions from crop residues burning in fields, Gg-CO_2-eq.

Years	CH_4	N_2O	Total	Years	CH_4	N_2O	Total
1990	22.9	7.1	**29.9**	1998	35.8	11.1	**46.9**
1991	22.5	7.0	**29.5**	1999	35.5	11.0	**46.5**
1992	27.5	8.5	**36.0**	2000	34.7	10.7	**45.4**
1993	29.5	9.1	**38.6**	2001	38.8	12	**50.7**
1994	29.4	9.1	**38.5**	2002	38.8	12	**50.7**
1995	33.9	10.5	**44.3**	2003	38.6	11.9	**50.5**
1996	35.4	10.9	**46.4**	2004	40.0	12.4	**52.4**
1997	37.2	11.5	**48.7**	2005	-	-	**-**

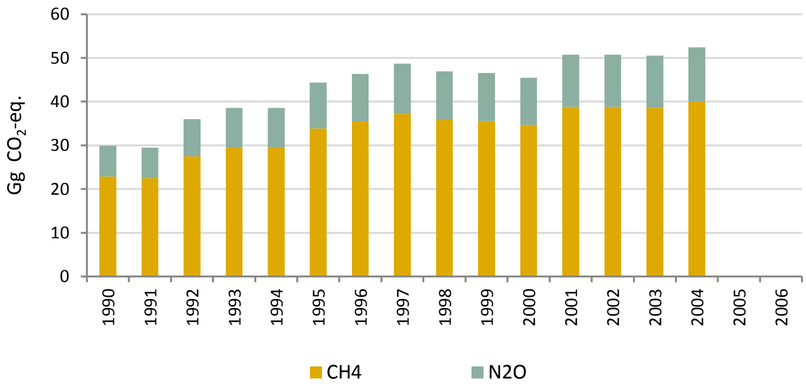

Figure 5.1.3.1.1 Trends in direct GHGs from crop residues burning

Change in emissions of methane, nitrous oxide and total emissions for the period 1990-2021: reduction by 100%, due to the prohibition crop residues burning in fields after 2004.
Indirect GHG emissions from crop residues burning for the period 1990-2004 are given in Table 5.1.3.1.2.
Change in CO and NOx emissions for the period 1990-2021 was the reduction by 100%, due to the prohibition of crop residue burning in fields after 2004.

Table 5.1.3.1.2 Indirect GHG emissions from crop residues burning, Gg gas

Years	CO	NOx	Years	CO	NOx
1990	31.18	0.85	1998	48.86	1.33
1991	30.71	0.83	1999	48.44	1.32
1992	37.48	1.02	2000	47.31	1.29
1993	40.17	1.09	2001	52.83	1.44
1994	40.12	1.09	2002	52.83	1.44
1995	46.17	1.25	2003	52.59	1.43
1996	48.27	1.31	2004	54.56	1.48
1997	50.,66	1.38	2005	-	-

Methodology

Emissions of direct and indirect greenhouse gases from crop residues burning in fields, except for CO_2, were estimated in accordance with [50]. Tier 1 methodology and default emission factors were used. Emissions of CH_4, N_2O, CO and NOx were calculated using Equation 2.27 of the 2006 IPCC Guidelines, Vol.4, Part 1, Ch.2, p.2.51.

Activity data

Data on harvested areas of cereal crops (excluding areas under rice) for 1990-2004 were provided by the Statistics Agency of the Republic of Uzbekistan, the yearbook "Gross harvest of agricultural crops in initially recorded weight and weight after refinement of XXXX year (on all lands)".
Due to the lack of statistical data on the area of cereal crop residues burned, it is assumed that 10% of the total harvested area is burned (IPCC Good Practice Guidance, 2000).

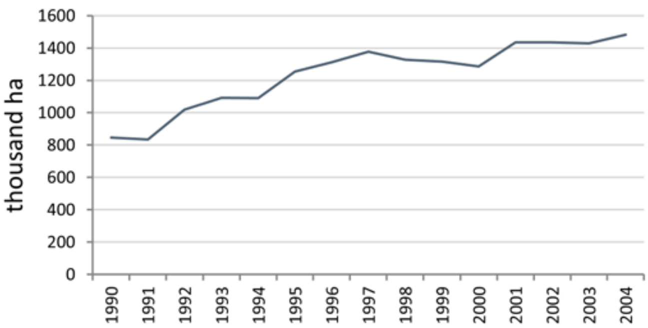

Figure 5.1.3.1.2 Change in harvested area of cereal crops for the period 1990-2004

Emission factors

In calculations of CH_4, N_2O, CO and NOx emissions from cereal crop residues burning, the following default emission factors were used according to [3], Vol.4, Part 1, Chapter 2:

M_b - mass of fuel available for combustion, t/ha =**4** (Table 2.4, p.2.55 for wheat residues)

C_f – combustion factor (dimensionless), Table 2.6, default=**1**

G_{EF} – emission factor (g/kg dry matter burnt), Table 2.5, default for agricultural residues:
- for CO = 92;
- for CH_4 = 2.7;
- for N_2O = 0.07;
- for NOx = 2.5.

Uncertainties and time series consistency

Uncertainty of activity data is ±5%.
G_{EF} uncertainty is determined by default in accordance with Table 2.5 (Vol. 4, Part 1, p. 2.56):
for CH_4 2.7 ±0%; for N_2O 0.07 ±0%; for CO 92 ±91%; for NOx 2.5 ±40%.
Combined emission uncertainty for the category for each gas was: for CO 91.1%; for CH_4 5.0%; for N_2O 5.0%; for NOx 40.3%.
The same method and data sets were used for all years.

Quality assurance/Quality control

QA/QC procedures were performed in accordance with the general QA/QC principles and the QA/QC Plan. The following were verified:

- emission sources documentation,
- mechanical errors in data,

50 2006 IPCC Guidelines

- all source references for data sources in the IPCC Software.

Recalculations for the category

Emissions in the “Biomass burning in croplands” category have not been recalculated relative to the latest estimates made in the First Biennial Update Report.

Planned improvements in the category

No improvements are planned in this category as part of a future inventory.

5.1.3.2 Liming (3.C.2 category)

Liming is usually used for acidic soils. There are no acidic soils in Uzbekistan. In addition, there is no information on limestone and dolomite application to soils in Uzbekistan.
Based on the information obtained, we can conclude that soil liming is not practiced in Uzbekistan and this category will be designated as "NO" in the reporting tables.

5.1.3.3 Urea Application (3.C.3 category)

Annual statistical information on the application of certain types of fertilizers to soils, including urea, is not collected in Uzbekistan. In accordance with the IPCC recommendations, additional data collection and studies are planned to estimate CO_2 emissions for this category to obtain an approximate estimate of the annual amount of urea applied to soil.
The urea application category will be designated as "NO" in the reporting tables.

5.1.3.4 N_2O Emissions from Managed Soils (3.C.4, 3.C.5, 3.C.6 categories)

Category description

Nitrous oxide is formed in soils continuously, naturally.
For most agricultural lands, with changes in the content of available carbon in the soil, which is regulated by soil treatment methods and land use, as well as with additional organic nitrogen inputs to the soil, nitrification and denitrification rates increase, thereby increasing the intensity of nitrous oxide formation and nitrous oxide fluxes to the atmosphere.
In Uzbekistan, mineral fertilizers are widely used in agriculture. This is a basic condition for agricultural production on irrigated lands in Uzbekistan due to problems caused by the use of inefficient irrigation methods, which leads to leaching of nutrients (mainly nitrogen and phosphorus) from the soil; thus, soil fertility will be very low without fertilizers. Ammonium nitrate, containing 34% pure nitrogen, is the most common nitrogen fertilizer [51]. Application of mineral fertilizers in Uzbekistan averages 233 kg/ha, which is much higher than the world average (141 kg/ha).
Organic fertilizers are also widely used in the country. Manure accounts for a significant share of applied organic fertilizers, and it provides a significant contribution to maintaining soil fertility in irrigated lands. Organic fertilizers are applied before autumn sowing (20-30 tons per 0.5 ha), and in addition to the sowing period they are also mixed for application with mineral fertilizers.
Direct nitrous oxide emissions from managed soils consist of emissions caused by: (1) the use of synthetic nitrogen fertilizers; (2) use of organic fertilizers (manure); (3) nitrogen inputs from urine and dung left on pastures and paddocks by ruminants; and (4) nitrogen from crop residues.
Indirect nitrous oxide emissions consist of emissions caused by: (1) atmospheric deposition of nitrogen and (2) leaching and runoff of nitrogen from managed soils.
N_2O emissions from managed soils and pastures in 2021 amounted to:

- Direct emissions – 5797.45 Gg CO_2-eq;
- Indirect emissions – 2688.44 Gg CO_2-eq;
- Total emissions – 8485.89 Gg CO_2-eq.

The N_2O emissions from managed soils category is a key inventory category.

Emission trends

Table 5.1.3.4.1 and Figure 5.1.3.4.1 show direct and indirect N_2O emissions from managed soils for the period 1990-2021.
Between 1990 and 2021, there was a 2.76-fold increase in total N_2O emissions, including:

– direct emissions by 2.46 times;
– indirect emissions by 3.75 times.

The increase in nitrous oxide emissions from agricultural soils tends to increase significantly. The increase in nitrous oxide emissions is mainly influenced by an increase in the amount of synthetic and organic fertilizers applied to fields and an increase in the number of livestock grazing on pastures.

51 Uzbekistan. Third Environmental Performance Review. – UNECE, 2020 - 514 p.

Table 5.1.3.4.1 N_2O Emissions from Managed Soils, Gg CO_2-eq.

Years	Direct emissions				Indirect emissions		Total
	Synthetic fertilizers	Organic fertilizers	Livestock grazing	Crop residues	Atmospheric deposition	Leaching / runoff	
1990	455.83	704.03	1188.00	7.38	349.09	367.49	**3071.82**
1991	429.89	771.03	1296.13	7.22	561.85	592.70	**3658.82**
1992	395.56	814.78	1371.96	7.29	590.45	611.48	**3791.52**
1993	309.16	827.07	1397.35	7.10	592.87	598.22	**3731.78**
1994	290.24	834.27	1382.17	7.12	594.03	593.18	**3701.01**
1995	290.10	810.07	1357.28	7.76	580.38	578.54	**3624.14**
1996	212.84	772.24	1278.81	7.60	545.66	532.39	**3349.55**
1997	656.40	765.90	1261.18	8.06	584.80	625.58	**3901.93**
1998	622.91	776.51	1284.10	8.48	589.53	626.57	**3908.10**
1999	602.92	784.36	1301.24	9.00	593.35	628.56	**3919.43**
2000	588.73	793.85	1319.13	8.03	598.78	630.96	**3939.48**
2001	542.51	802.99	1334.75	8.26	600.47	626.20	**3915.18**
2002	542.32	812.43	1354.57	10.24	607.57	634.45	**3961.59**
2003	546.49	847.97	1416.74	10.99	632.51	658.90	**4113.60**
2004	466.04	904.51	1515.11	10.66	663.48	676.26	**4236.06**
2005	519.33	955.64	1610.42	6.64	705.06	722.42	**4519.49**
2006	540.45	1005.21	1670.12	10.98	736.64	749.01	**4712.40**
2007	546.72	1068.61	1778.68	11.25	780.01	789.20	**4974.47**
2008	581.56	1148.59	1945.09	11.17	842.13	855.29	**5383.82**
2009	623.05	1227.61	2077.89	12.07	899.39	914.37	**5754.39**
2010	653.96	1309.01	2214.19	12.18	957.18	972.27	**6118.79**
2011	685.34	1390.17	2359.76	11.85	1015.55	1029.64	**6492.30**
2012	666.51	1460.47	2504.17	13.05	1063.34	1071.62	**6779.16**
2013	715.45	1493.24	2575.60	12.39	1091.82	1103.71	**6992.20**
2014	741.30	1524.04	2632.24	12.77	1115.01	1128.05	**7153.40**
2015	741.86	1581.47	2743.05	12.88	1154.29	1163.73	**7397.29**
2016	754.36	1647.99	2874.63	12.71	1201.45	1206.99	**7698.13**
2017	756.19	1720.74	3020.90	10.96	1251.93	1249.35	**8010.07**
2018	756.94	1781.66	3137.29	9.68	1293.20	1287.78	**8266.56**
2019	563.82	1850.42	3233.80	11.45	1316.18	1291.32	**8266.99**
2020	513.43	1901.78	3299.39	11.37	1341.81	1312.61	**8380.39**
2021	512.40	1928.74	3345.14	11.17	1359.21	1329.23	**8485.89**
$\Delta_{(1990-2021)}$	**+12%**	**+174%**	**+182%**	**+51%**	**3.89-fold increase**	**3.52-fold increase**	**2.76-fold increase**

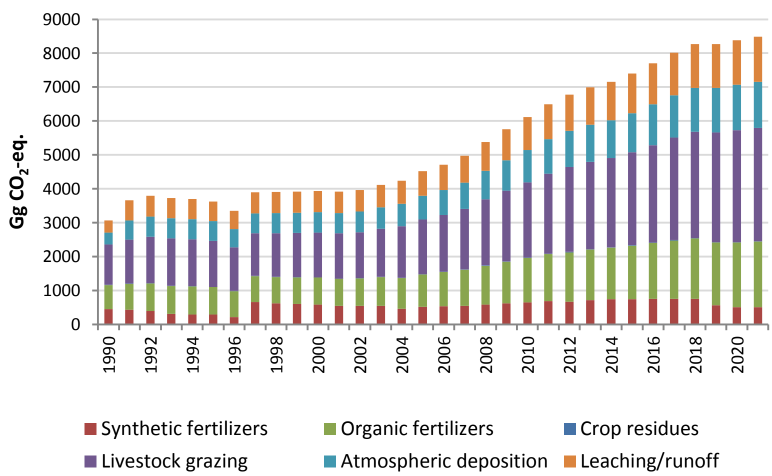

Figure 5.1.3.4.1 Trends in N_2O Emissions from Managed Soils by category

Methodology

N_2O emissions from managed soils were estimated in accordance with the 2006 IPCC Guidelines.

Direct N_2O emissions (kg N_2O-N/year) were calculated using Tier 1 methodology, according to Equation 11.1 page 11.7 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol.4, Part 2 [3] without taking into account N_2O emissions from cultivated organic soils (since such soils are absent on the territory of Uzbekistan). The equation includes the following parameters:

- F_{SN} – annual amount of synthetic nitrogen fertilizer applied to soils, kg N/year;

- F_{ON} – annual amount of organic nitrogen fertilizer applied to soils, except for that left by ruminants, kg N/year. Calculated for manure only, as data on the use of compost and sewage sludge as organic fertilizers are not available (F_{ON} = F_{AW} according to Equation 11.4);

- F_{CR} – annual nitrogen input from crop residues, calculated using Equations 11.6 and 11.7, page 11.16;

- F_{PRP} – annual amount of nitrogen left on pastures, grazing and paddocks by ruminants (in urine and dung), calculated using Equation 11.5, page 11.15.

The emission factors included in Equation 11.1 were taken by default from Table 11.1 (page 11.12, Chapter 11, Vol. 4, Part 2, 2006 IPCC Guidelines).

Conversion factor of N_2O-N emissions to N_2O emissions = 44/28.

Organic soils are not found on the territory of Uzbekistan. Therefore, nitrous oxide emissions from managed organic soils were not considered.

Data on the annual amount of nitrogen synthetic fertilizers converted to nitrogen were taken from the *fao.stat* database for 1990-2018 and supplemented with national data for 2019-2021 (Table 5.1.3.4.2).

Organic fertilizer nitrogen included manure nitrogen applied to managed soils from manure management systems. The nitrogen fraction of manure used for construction and for livestock feeding was assumed to be zero, due to the lack of such practice in the country.

Calculation of nitrous oxide emissions from keeping farm animals on pastures and in fenced pastures is based on data on the total mass of nitrogen produced by animals per year.

Table 5.1.3.4.2 Amount of nitrogen fertilizers applied to soils, converted to nitrogen, thousand tons

Years	thous.tons	Years	thous.tons	Years	thous.tons
1990	97.34	2001	115.85	2012	142.33
1991	91.80	2002	115.81	2013	152.78
1992	84.47	2003	116.70	2014	158.30
1993	66.02	2004	99.52	2015	158.42
1994	61.98	2005	110.90	2016	161.09
1995	61.95	2006	115.41	2017	161.48
1996	45.45	2007	116.75	2018	161.64
1997	140.17	2008	124.19	2019	120.40
1998	133.02	2009	133.05	2020	109.64
1999	128.75	2010	139.65	2021	109.42
2000	125.72	2011	146.35		

Gross harvest data for major annual crops were used to calculate nitrogen content in crop residues. The factors used to estimate nitrous oxide emissions from crop production were taken by default from Table 11.2 of the 2006 IPCC Guidelines and are given in Table 5.1.3.4.3.

Table 5.1.3.4.3 Default factors for estimating nitrogen added to soils from crop residues

Crop	Dry matter fraction of harvested product (DRY)	Slope	Intercept	Above-ground residue dry matter (AG_{DM})	Nitrogen content of above-ground residues (N_{AG})	Nitrogen content of below-ground residues (N_{BG})
Beans & pulses	0.91	1.13	0.85	2186.42	0.08	0.008
Grains	0.88	1.09	0.88	60079.75	0.006	0.009
Cotton	0.9	-	-	-	0.01	0.009
Kenaf	0.9	1	-	0	0.01	0.01
Sugar beet	0.9	1	-	0	0.01	0.01
Tobacco	0.9	1	-	49.89	0.01	0.01
Sunflower	0.9	1	-	245.98	0.009	0.009
Crown flax	0.9	1	-	0	0.01	0.01
Soybeans	0.91	0.93	1.35	53.29	0.008	0.008
Sesame	0.9	1		54.11	0.01	0.01
Safflower	0.9	1		132.31	0.01	0.01

Table 5.1.3.4.3 continuation

Crop	Dry matter fraction of harvested product (DRY)	Slope	Intercept	Above-ground residue dry matter (AG_{DM})	Nitrogen content of above-ground residues (N_{AG})	Nitrogen content of below-ground residues (N_{BG})
Peanut	0.94	1.07	1.54	258.89	0.016	0.01
Potato	0.22	0.1	1.06	615.67	0.019	0.014
Parent plants and seed plants	0.22	1	-	0.68	0.01	0.01
Melons	0.22	1	-	4468.18	0.01	0.01
Forage root crops	0.22	1	-	397.21	0.01	0.01
Melons for feed	0.22	1		0	0.01	0.01
Corn for livestock feed	0.87	1.03	0.61	24873.28	0.006	0.007
Annual herbs	0.22	1		1870.20	0.01	0.01
Perennial grasses	0.9	0.3	0.03	2297.9	0.015	0.012

Note: *For cotton, melons, parent plants and forage root crops, total aboveground residue to harvested area ratio (RAG) coefficients from reports of other countries (Kazakhstan, USA and Belarus) were used, due to the lack of default factors in Table 11.2, page 11.20.*

Indirect N_2O emissions due to atmospheric deposition of nitrogen volatilized from managed soils were calculated according to Equation 11.9, page 11.24. Equation 11.10 was used to calculate N_2O emissions due to nitrogen leaching/runoff from managed soils.

Emission, volatilization and leaching factors for estimating indirect N_2O emissions from soils were taken by default from Table 11.3.

Conversion of the obtained values of kg N/year to kg N_2O-N/year was performed by multiplying the obtained values by the conversion factor = 44/28.

Total N_2O emissions (kg N_2O-N/year) for the "N_2O emissions from managed soils" category were calculated as the sum of direct and indirect emissions.

Activity data

All necessary activity data for the 2018-2021 N_2O emissions from managed soils category calculations have been obtained from the Statistics Agency of the Republic of Uzbekistan. These include:

- Amount of synthetic nitrogen fertilizers applied to soils converted to nitrogen, thousand tons (Table 5.20);
- Livestock population, thousand heads (Tables 5.6-5.7);
- Land area (thousand hectares) under crops and their yield (thousand cwts) (on all lands).

Emission factors

Default emission factors recommended by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories for Tier 1 were used in the calculations.

Default emission factors values were used to estimate direct N_2O emissions in accordance with Table 11.1. Ch.11, Vol.4 (shown in Table 5.1.3.4.4).

Table 5.1.3.4.4 Default emission factors for estimating direct N_2O emissions from managed soils

Emission factor	Default value	Uncertainty range
EF1 for N additions from mineral fertilizers, organic fertilizers and crop residues and for N mineralized from mineral soil resulting from soil carbon loss, kg N_2O–N/kg N	0.01	0.003 – 0.03
$EF1_{FR}$ for flooded rice fields, kg N_2O–N / kg N	0.003	0.000 – 0.006
$EF3_{PRP, CPP}$ for cattle (dairy and non-dairy), poultry and swine, kg N_2O–N / kg N	0.02	0.007 – 0.06
$EF3_{PRP, SO}$ for sheep and "other animals", kg N_2O–N / kg N	0.01	0.003 – 0.03

Default emission factor values from Table 11.3 of Chapter 11, Vol.4 were used to estimate indirect N_2O emissions from managed soils (given in Table 5.1.3.4.5).

Table 5.1.3.4.5 Default emission factors for estimating indirect N_2O emissions from managed soils

Emission factor	Default value	Uncertainty range
EF4 [N volatilization and re-deposition], kg N_2O-N/(kg NH_3-N + NO_X-N volatilized)	0.010	0.002 – 0.05
EF5 [leaching/runoff], kg N_2O–N /(kg N leaching/runoff)	0.0075	0.0005 – 0.025
FracGASF [volatilization from synthetic fertilizer], (kg NH_3–N + NOx–N)/(kg N applied)	0.10	0.03 – 0.3
FracGASM [volatilization from all organic N fertilizers applied, and dung and urine deposited by grazing animals], (kg NH_3–N + NOx–N)/(kg N applied or deposited)	0.20	0.05 – 0.5
FracLEACH-(H) [N losses by leaching/runoff for regions where precipitation is greater than the soil water-holding capacity or under irrigation], kg N/(kg N in additions or deposition by grazing animals)	0.30	0.1 – 0.8

Uncertainties and time series consistency

Uncertainties of N_2O emissions for "N_2O emissions from managed soils" categories were estimated in accordance with Chapter 11, Vol.4 of the 2006 IPCC Guidelines.
Statistical data with uncertainty not exceeding ±5% were used as activity data.
Default factors with uncertainty greater than ±200% were used as emission factors (Tables 5.16 and 5.17).
The same method and data sets were used for all years.

Quality assurance/Quality control

QA/QC procedures were performed in accordance with general QA/QC principles and the QA/QC Plan. The following were verified:

- emission sources documentation,
- mechanical errors in data,
- all source references for data sources in the IPCC Software.

Recalculations for the category

The recalculation of emissions relative to the First Biennial Update Report (FBUR) estimates was made due to a refinement of the activity data on synthetic nitrogen fertilizers application to agricultural soils. The FBUR overestimates were obtained as the calculations used data on the amount of nitrogen fertilizer applied without conversion to nitrogen. The results of the recalculation are given in Table 5.1.3.4.6.

Table 5.1.3.4.6 Results of emission recalculation for the "N_2O Emissions from Managed Soils" category

Years	FNC	FBUR	Difference	Years	FNC	FBUR	Difference
1990	3071.82	6254.55	3182.73	2004	4236.06	6313.30	2077.24
1991	3658.82	6711.63	3052.81	2005	4519.49	7056.12	2536.63
1992	3791.52	6121.24	2329.72	2006	4712.4	7030.07	2317.67
1993	3731.78	6552.48	2820.70	2007	4974.47	7273.00	2298.53
1994	3701.01	6012.93	2311.92	2008	5383.82	7790.98	2407.16
1995	3624.14	5769.90	2145.76	2009	5754.39	8310.74	2556.35
1996	3349.55	5637.09	2287.54	2010	6118.79	8919.80	2801.01
1997	3901.93	5751.86	1849.93	2011	6492.30	9229.39	2737.09
1998	3908.10	5825.88	1917.78	2012	6779.16	9389.60	2610.44
1999	3919.43	5531.31	1611.88	2013	6992.20	9787.91	2795.71
2000	3939.48	5533.58	1594.10	2014	7153.40	10196.53	3043.13
2001	3915.18	5910.86	1995.68	2015	7397.29	10955.71	3558.42
2002	3961.59	5966.53	2004.94	2016	7698.13	10883.34	3185.21
2003	4113.60	6120.80	2007.20	2017	8010.07	10943.38	2933.31

Planned improvements in the category

Since the category is key, it is intended to refine the values of the emission factors in the future, taking into account country specificities and activity data.

5.1.3.5 Rice Cultivation(3.C.7 category)

Category description

In Uzbekistan, rice fields occupy an insignificant part of arable land; their maximum area reached 195.2 thousand hectares in 1997. In recent decades, there has been a steady trend to reduce the areas under rice crops. The reduction in the area planted is due to water shortages. The minimum area under rice crops was in 2011 – 23.1 thousand hectares. The traditional rice growing areas are Khorezm region and Karakalpakstan, which cover 82% of the area. In most other regions, the area under rice crops ranges from 0.2 to 7.0 thousand hectares.
In flooding of rice fields, in the absence of oxygen, anaerobic decomposition of organic matter in the soil occurs and methane is formed, which is emitted into the air through water mass. Methane fluxes from rice production depend on soil type and structure, application of organic and mineral fertilizers, irrigation regime and other factors.
In the national practice, rice is cultivated under the so-called "shortened flooding" conditions with the application of synthetic nitrogen fertilizers. Rice planting usually starts in late April – early May. Seeds are sown in large leveled paddy fields by grain seeders or manually. Initially, a water layer is created in the field after crop sowing.

During the period of plant germination, water is discharged for 1-2 days. Standing water layer is created in the field only after the mass sprouting phase with the appearance of the second or third leaf. As the leaves emerge, the water layer is increased. When the rice ripens, water is discharged from the paddy fields and rice is ready for harvesting.

The length of the vegetation period averages 125-140 days depending on the varieties sown, the amount of effective temperature and other factors. There are rice varieties, "Nukus-21", "Uzbek-5", which mature in 105-115 days. The average rice yield is 25 cwt/ha [50].

In 2021, 48.876 thousand hectares were occupied by rice crops [48], emissions from rice cultivation amounted to 115.8 Gg CO_2-eq.

Emission trends

CH_4 emissions from rice cultivation for the period 1990-2021 are given in Table 5.1.3.5.1 and Figure 5.1.3.5.1.

Table 5.1.3.5.1 CH_4 emissions from Rice Cultivation, Gg CO_2-eq.

Years	CH_4	Years	CH_4	Years	CH_4
1990	347.61	2001	93.58	2012	179.68
1991	377.92	2002	152.47	2013	105.3
1992	430.96	2003	286.47	2014	113.06
1993	427.88	2004	156.54	2015	165.73
1994	395.67	2005	124.27	2016	170.00
1995	392.83	2006	143.64	2017	168.77
1996	438.53	2007	113.66	2018	99.79
1997	462.21	2008	80.13	2019	153.73
1998	351.39	2009	103.15	2020	112.30
1999	388.81	2010	163.75	2021	115.76
2000	312.09	2011	54.70	$\Delta_{(1990-2021)}$	**-66.70%**

For the period 1990-2021, there has been a 67% decrease in methane emissions, which is due to a significant reduction in the area planted.

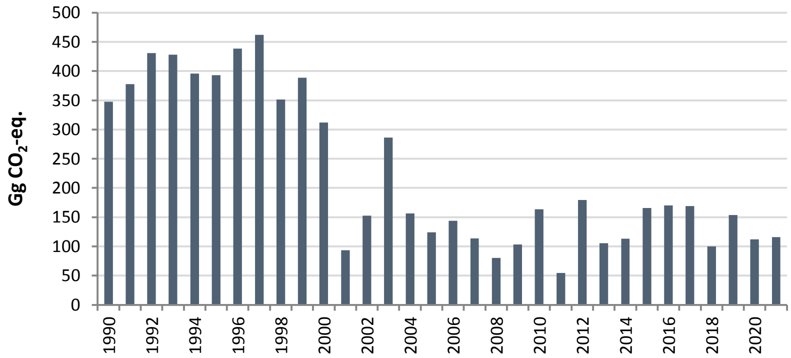

Figure 5.1.3.5.1 Trends of CH_4 emissions from Rice Cultivation

Methodology

CH_4 emissions from rice cultivation were estimated in accordance with the 2006 IPCC Guidelines, using a Tier 1 methodology. Data were not stratified by variety, region, climate zone, or cultivation method. Under Uzbek conditions, rice is grown per year. Early maturing rice varieties are grown for 115 days, while later maturing ones – up to 145-150 days (120 days on average).

In estimating methane emissions from rice cultivation, the following were taken into account:

- water regime,
- application of organic and synthetic fertilizers.

Methane emission factors for the calculation were taken by default.

All land under rice cultivation refer to the irrigation water regime of intermittent flooding with more than one aeration number.

Calculations were performed using Equation 5.1 page 5.54 (Section 5.5 Methane emissions from rice cultivation Vol.4, Part 1)

Activity data

For calculations, national statistical data on areas under rice were used (Statistical Yearbook "Results of the final accounting of sown areas of agricultural crops for the 2021 harvest (on all lands)".
Dynamics of changes in the sown areas under rice crops are given in Figure 5.1.3.5.2.

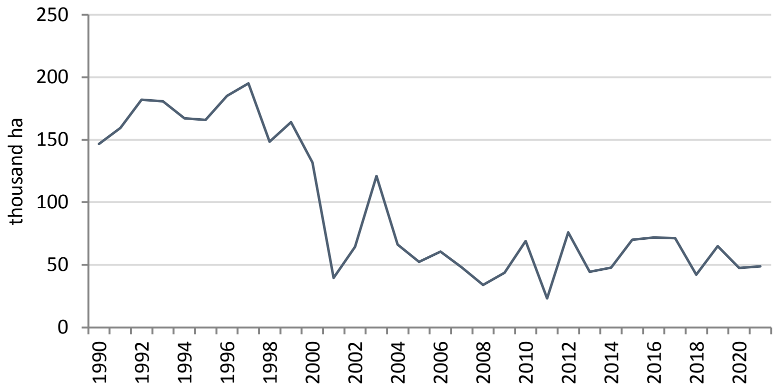

Figure 5.1.3.5.2 Rice crop area dynamics

The dynamics of methane emissions from rice cultivation is directly related to the change in area planted.

Emission factors

Given ***fertilizers are applied*** in rice fields, the flooding type is ***intermittent***, ***with multiple aeration***, the relevant default factors from [3] were used.

To derive the adjusted daily methane emission factor EF from Equation 5.2 page 5.56 (Section 5.5, Methane emissions from rice cultivation, Vol.4, Part 1), the following default factors were used:

EFc – baseline emission factor for continuously flooded fields without organic amendments = **1.3** (Table 5.11);

SFw – scaling factor to account to account for differences in water regime during the cultivation period (Table 5.12) = **0.52** (irrigated, periodically flooded, repeated aeration, detailed option);

SFp – scaling factor to account for differences in water regime in the pre-season before the cultivation period (Table 5.13) = **0.68** (without flooding more than 180 days before sowing, detailed option);

SFo – scaling factor to account for type and amount of organic amendment applied (Equation 5.3 and Table 5.14) = **1.717**.

The resulting EF value was **0.789**.

Uncertainties and time series consistency

Uncertainty of rice harvested area data is about ±5%.

The estimated total error of methane emissions estimate from rice fields is about ±30%, including ±20% due to uncertainty of the emission factor.

Combined uncertainty of methane emission estimates by category was ±30.41%.

The same method and data sets were used for all years.

Quality assurance/Quality control

QA/QC procedures were performed in accordance with the general QA/QC principles and the QA/QC plan. The following were verified:

- emission sources documentation,
- mechanical errors in data,
- all source references for data sources in the IPCC Software.

Recalculations for the category

There were no recalculations relative to the First Biennial Update Report estimates.

Planned improvements in the category

Further research may include:

– refinement of factors for methane emission calculations;
– more detailed consideration of irrigation regime, farming practices, soil characteristics;
– refinement of information on the duration of the growing season for new rice varieties.

5.2 "Forestry and Other Land Use" Sector

5.2.1 Sector overview

The land resources of Uzbekistan amount to 448.92 km^2. Structurally, the land fund of the country is divided into eight major categories. Table 5.26 presents the land categories and the area occupied by them according to the Cadastral Agency of the Republic of Uzbekistan for 2020. Between 1990 and 2021, the total area of the country decreased from 45,585.0 thousand hectares to 44,892.4 thousand hectares. Changes in the total area of the country are due to the clarification of demarcation lines with neighboring countries.

Table 5.2.1.1 Distribution of the land fund of the Republic of Uzbekistan by land use purpose

Land use purpose	1990	2005	2010	2017	2020
Agricultural land	33167.8	22446.1	21453.2	20174.0	20761.6
Settlements (cities, towns and rural settlements)	197.2	237.6	220.4	220.8	223.4
Industry, transport, communications, defense and other purposes	1821.2	1937.9	1995.8	905.3	867.4
Environmental, health and recreational purposes	13.9	72.5	75.9	704.3	731.7
Historical and cultural significance	-	0.2	1.1	14.1	14.6
Forest Fund	2507.5	8536.5	9462.3	11191.9	12020.8
Water Fund	618.8	825.4	821.1	833.6	835.2
Reserve land	7258.6	10354.1	10380.5	10848.4	9437.7
Total:	**45585.0**	**44410.3**	**44410.3**	**44892.4**	**44892.4**

As can be seen from Table 5.2.1.1, agricultural land accounts for 46.25%, followed by forest fund lands (26.78%), reserve lands (21.02%), and land in other categories for 5.95%.

In the national classification, **agricultural land** includes arable land, hayfields, pastures, land under perennial crops, land of household plots, land under development and fallow lands. These lands are distributed taking into account natural and climatic factors. There are more than 4.0 mln ha of arable land, including about 3.3 mln ha of irrigated land, 380.8 thousand ha of perennial crops, 1.2 mln ha of pastures. In the period from 1990 to 2021, the area of agricultural land decreased by 37.4%.

Reserve land is all land not allocated to legal entities and individuals for the purposes of ownership, use, lease, as well as those not accounted for in other land categories. The reserve land is mainly provided for the purposes of ownership, use and lease in agriculture. The most significant areas of reserve land are located in the Republic of Karakalpakstan (5854 thousand ha) and Navoi region (3306.4 thousand ha), the least amount of such lands is located in Syrdarya (0.1 thousand ha) and Bukhara (0.1 thousand ha) regions.

Forest fund include land covered with forest, and not covered with forest, but allocated for forestry needs. The forest fund lands have a special environmental significance. The total area of such lands in 2020 was 12020.8 thousand hectares. The largest areas of forest land are in the Republic of Karakalpakstan (6614.4 thousand ha), Navoi (2903.6 thousand ha) and Tashkent (588.9 thousand ha) regions, and the smallest areas are in Andijan (8.5 thousand ha) and Syrdarya (11.1 thousand ha) regions.

Water fund lands are divided into subtypes for domestic, industrial and agricultural purposes. This category of lands includes water basins, rivers, lakes, reservoirs, hydraulic engineering and other water structures, in addition, lands of adjacent banks of rivers, water basins and other water bodies allocated in in the established manner to meet the needs of the water sector located in the regions, enterprises, institutions and organizations. Most of the water fund lands are located in Jizzakh (312.1 thousand ha), Navoi (154.4 thousand ha) regions and the Republic of Karakalpakstan (81.1 thousand ha), and least in Andijan (19 thousand ha), Tashkent (17.7 thousand ha) regions and Tashkent city (1.1 thousand ha).

Among the **lands of settlements**, the largest areas fall in the Tashkent region (38.0 thousand ha) and the Republic of Karakalpakstan (36.6 thousand ha), and the least in the Khorezm (6.3 thousand ha) and Bukhara regions (7.6 thousand ha).

Lands for industry, transport, communication and defense use. This land group includes lands allocated for permanent use to industrial enterprises, intended for the construction of structures, railways, inland waterway, land, air and pipeline transport, communication lines, as well as for the placement of relevant communication facilities, radio, television and information transmission, as well as the armed forces. In 2020, most of the considered lands were available in Karakalpakstan – 178.2 thousand hectares, Surkhandarya – 109.4 thousand hectares and Bukhara – 86.2, and the least in Andijan – 20.4 thousand hectares, Khorezm – 18.5 thousand hectares and Syrdarya regions – 11.2 thousand hectares.

Lands for environmental, health and recreational purposes are intended to meet the environmental requirements of land functioning as the most important component of the natural complex and the social needs of society. Most of them are in the Republic of Karakalpakstan (628.7 thousand hectares), Jizzakh region (70.4 thousand hectares), Khorezm region (21.7 thousand hectares) and Navoi region (8.4 thousand hectares), in other regions, the area of such land ranges from 0.1 to 0.7 thousand hectares.

The group of **lands for historical and cultural purposes** includes historical and cultural reserves, memorial gardens, lands allocated for permanent use for archaeological, historical and cultural monuments, relevant institutions and organizations. The largest area of such lands in 2020 was in Karakalpakstan - 2.8 thousand ha, Kashkadarya region – 2.6 thousand ha, Namangan region – 2.4 thousand ha, and the smallest in Andijan and Khorezm regions – 0.1 thousand ha each [52].

Dynamics of changes in the areas of national land use categories included in the inventory for the period 1990-2021 according to the Cadastral Agency of the Republic of Uzbekistan are given in Figure 5.2.1.1.

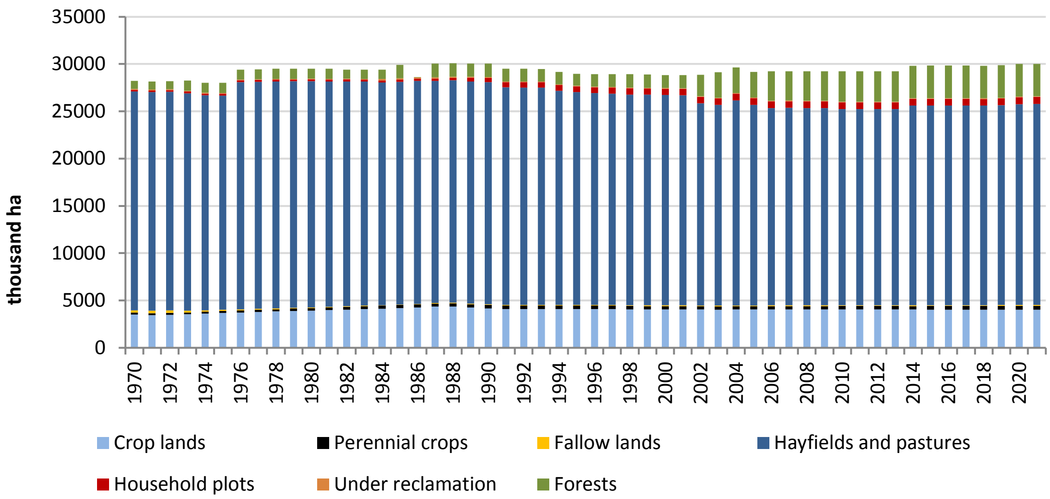

Figure 5.2.1.1 Dynamics of changes in the areas of national land use categories included in the inventory

As follows from the above data, there are no significant changes in the areas of the considered land use categories, with the exception of forest areas, which have increased significantly, especially in the period after 2000, mainly due to the reduction of pasture areas.

IPCC land use categories and land categories of the Republic of Uzbekistan was compared to conduct a GHG inventory in accordance with the methodology of the 2006 IPCC Guidelines [3], (Table 5.2.1.2).

Table 5.2.1.2 Correspondence between land use categories of the Republic of Uzbekistan and the IPCC

Land use category according to IPCC 2006	Land use category of the Republic of Uzbekistan	Description of the category according to the Land Code of the Republic of Uzbekistan
3.B.1 Forest land	Forest land covered with forest	Forest fund land includes *lands covered with forest,* as well as lands not covered with forest, but allocated for forestry needs. In calculating in this category, only areas covered with forest were taken into account.
3.B.2 Cropland	Agricultural land	Agricultural land includes arable land, hayfields, pastures, lands under perennial crops, household plots, lands under reclamation and fallow lands. In the calculations, pastures and hayfields are excluded from this category. They have been transferred to IPCC category 4C.
4.B.3 Grassland	Agricultural land	Agricultural land includes arable land, hayfields, pastures, lands under perennial crops, personal plots, lands under reclamation and fallow lands. In the calculations, arable lands, lands under perennial crops, lands of personal plots, lands under reclamation and fallow lands are excluded from this category. They are transferred to IPCC category 4B.

52 Nigmadjanov U.Kh. Presentation on the topic “Country’s land fund and its categories.” – TIIAME, 2020.

Table 5.2.1.2 continuation

Land use category according to IPCC 2006	Land use category of the Republic of Uzbekistan	Description of the category according to the Land Code of the Republic of Uzbekistan
3.B.4 Wetlands	Water fund lands	Water fund lands include lands occupied by water bodies (rivers, lakes, reservoirs, etc.), hydraulic structures and other water management structures, as well as buffer strips along the banks of reservoirs and other water bodies. Not considered in the current inventory.
3.B.5 Settlements	Lands of settlements	Settlements include lands located within the boundaries of cities, towns, rural settlements and adjacent suburban areas, constituting a single social, natural and economic territory with the city. Not considered in the current inventory.
3.B.6 Other land	Lands for industry, transport, communications, defense, etc. Lands for environmental, health and recreational purposes Lands of historical and cultural significance Reserve lands	GHGs are not considered in the inventory

In the Forestry and Other Land Use sector, emissions/removals are estimated according to the IPCC Tier 1 methodology in the following categories:

- Forest Land Remaining Forest Land (biomass and soil carbon stock change);
- Cropland Remaining Cropland (biomass and soil carbon stock change);
- Grassland Remaining Grassland (soil carbon stock change).

Emissions/removals from other sector categories, namely wetlands and settlements, have not been estimated in the current inventory. These are assumed to be small.
The obtained estimates of CO_2 emissions/removals for the Forestry and Other Land Use sector for 1990-2021 are given in Table 5.2.1.3 and Figure 5.2.1.2.

Table 5.2.1.3 Emissions/removals in the Forestry and Other Land Use sector, Gg CO_2

Years	Forest land	Cropland	Grassland	Total	Years	Forest land	Cropland	Grassland	Total
1990	-4894.00	-9149.81	-1339.24	**-15383.05**	2007	-5541.31	-1638.91	10737.65	**3557.43**
1991	-4991.29	-9547.97	589.01	**-13950.25**	2008	-5946.30	-1292.30	10999.96	**3761.36**
1992	-5052.29	-9835.16	590.00	**-14297.45**	2009	-6258.91	-1801.16	11242.75	**3182.68**
1993	-4080.70	-10000.65	110.22	**-13971.13**	2010	-6606.53	-2153.83	11200.42	**2440.06**
1994	-4172.70	-9230.62	331.13	**-13072.19**	2011	-6959.39	-1519.59	9223.64	**744.66**
1995	-4225.40	-8033.99	569.99	**-11689.40**	2012	-7289.32	-1804.61	9174.37	**80.44**
1996	-4470.60	-8260.86	6767.71	**-5963.75**	2013	-7593.52	-1556.73	9584.19	**433.94**
1997	-4565.62	-7832.33	6755.45	**-5642.50**	2014	-7237.94	-1733.23	6245.08	**-2726.09**
1998	-4545.70	-5969.69	7091.96	**-3423.43**	2015	-6838.46	-2102.86	5664.86	**-3276.46**
1999	-4836.12	-7326.73	6940.47	**-5222.38**	2016	-6476.76	-1907.22	5227.15	**-3156.83**
2000	-5125.03	-5347.30	6811.07	**-3661.26**	2017	-6035.75	-1667.92	5024.19	**-2679.48**
2001	-5199.25	-4492.24	6576.73	**-3114.76**	2018	-5664.70	-1532.80	4828.84	**-2368.66**
2002	-6092.39	-3661.77	9833.16	**79.00**	2019	-6740.29	-2120.64	4739.35	**-4121.58**
2003	-6199.88	-5360.50	10180.05	**-1380.33**	2020	-6686.71	-2350.24	4150.51	**-4886.44**
2004	-6511.29	-2950.46	7633.96	**-1827.79**	2021	-6745.69	-3568.38	3963.37	**-6350.70**
2005	-4795.85	-1913.46	9658.08	**2948.77**	$\Delta_{(1990-2021)}$	**1.38-fold removal increase**	**2.6-fold removal decrease**	**6.7-fold emission increase**	**2.4-fold removal decrease**
2006	-5156.90	-2737.30	11153.29	**3259.09**					

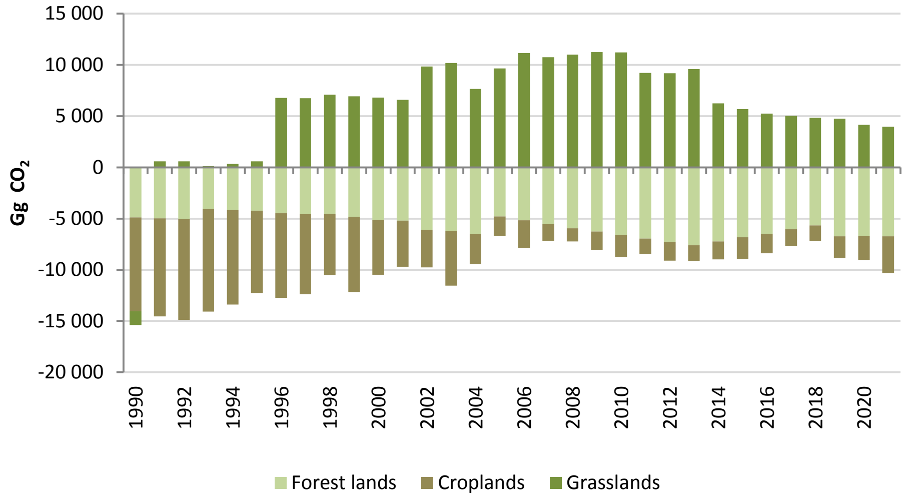

Figure 5.2.1.2 Emissions/removals in the Forestry and Other Land Use sector

The main CO_2 sinks in the sector are the "Forest Land" and "Cropland" categories, the main source of emissions is the "Grassland Remaining Grassland" category (Figure 5.13).

In general, there was a 2.4-fold removal decrease in the FOLU sector for the period 1990-2021. This is due to the gradual decrease in the area of land occupied by pastures since 1980s.

The removal increase in the sector is related to gradual growth of forest land areas, mainly as a result of a targeted state policy on planting forest plantations on desert lands in the Aral Sea region and adjacent territories of Navoi and Bukhara regions.

5.2.2 Recalculations for the FOLU sector

Recalculation of emissions relative to the First Biennial Update Report (FBUR) estimates was conducted due to the refinement of activity data and default parameters. The most significant changes occurred in the Forest Land category as a result of the refinement of the national biomass increment values, as well as the completeness of accounting for carbon losses due to fuelwood removals and disturbances from wildfires. The results of the recalculation are given in Table 5.2.2.1.

Table 5.2.2.1 Results of emissions/removals recalculation in the Forestry and Other Land Use sector, Gg CO_2

Year	FBUR	FNC	Year	FBUR	FNC	Year	FBUR	FNC
1990	-14064.20	-15383.05	2000	-6382.36	-3661.26	2010	-12949.59	2440.06
1991	-12517.93	-13950.25	2001	-306.69	-3114.76	2011	-13341.33	744.66
1992	-12823.04	-14297.45	2002	9053.40	79.00	2012	-12881.33	80.44
1993	-13469.46	-13971.13	2003	12924.04	-1380.33	2013	-11326.13	433.94
1994	-15463.03	-13072.19	2004	6612.63	-1827.79	2014	-13029.81	-2726.09
1995	-17031.47	-11689.40	2005	3282.09	2948.77	2015	-12175.22	-3276.46
1996	-14083.90	-5963.75	2006	-2503.50	3259.09	2016	-10538.66	-3156.83
1997	-16669.78	-5642.50	2007	-8133.06	3557.43	2017	-8632.24	-2679.48
1998	-17386.04	-3423.43	2008	-13882.80	3761.36			
1999	-13622.22	-5222.38	2009	-13340.94	3182.68			

5.2.3 Forest Land Remaining Forest Land (3.B.1.a category)

Category description

This category estimates CO_2 removals in two carbon pools: Biomass and Soils. Relative to the previous inventory (FBUR), the estimates have been updated due to refinements of activity data on forest land areas, and as a result of refinements of the national factor on average net annual increment (Iv) for all forest species groups. In addition, carbon losses from wildfires and associated emissions of CO_2 and other gases have been estimated for the first time.

To date, due to the lack of statistical data on the conversion of lands from other land use categories to the "Forest lands" category, carbon stock changes in lands converted from other categories have not been estimated.

In recent years, the Government has paid special attention to forest management. In particular, work was carried out to create forests on the dried Aral Sea bed, expand the area of protective forest plantations, increase windbreaks on agricultural lands, and create improved monitoring systems [53].

In accordance with the Law of the Republic of Uzbekistan No. O'RQ-475 "On Forests" dated April 16, 2018, all forests of the Republic of Uzbekistan form a single state forest fund, which consists of:

- forests of national importance, i.e. forests managed by state forestry authorities;
- forests used by other agencies and legal entities.

In 2017, a major reorganization was conducted in the structure of forestry in Uzbekistan. Forestry of the Republic, previously administratively under the Main Department of Forestry under the Ministry of Agriculture and Water Resources of the Republic of Uzbekistan, acquired a new status in accordance with the Decree of the President of the Republic of Uzbekistan No. PD-5041 "On the establishment of the State Committee of the Republic of Uzbekistan on Forestry" dated May 11, 2017 and the Decree No. PR-2966 "On the organization of the activities of the State Committee of the Republic of Uzbekistan on Forestry" dated May 11, 2017. In 2022, the Committee was transformed into the Forestry Agency (FA) [54].

The Agency and its territorial subdivisions are public administration bodies in the field of conservation, protection, breeding, reproduction, restoration, increasing productivity and use of forests.

Activities in the forestry complex are carried out by following 119 specialized organizations and enterprises throughout the country, which are under the authority of the Agency:

- 8 republican organizations;
- Forestry Agency of the Republic of Karakalpakstan and 10 regional forestry departments;
- 4 national natural parks;
- 66 state forestry enterprises;
- 13 state forestry enterprises for the cultivation of medicinal plants;
- 10 state forestry and hunting enterprises;
- 4 research and experimental stations;
- 3 research organizations.

The total area of the State Forest Fund managed by the FA as of January 1, 2021 is 12 million ha (25% of the total area of the country). The area of the State Forest Fund (SFF) is formed by:

- **forest land** – land for afforestation. In turn, forest land are divided into the following categories: forested areas (forests of natural and artificial origin, forest nurseries) and unforested areas (woodlands, forests destroyed due to natural disasters, planned clearcuts, wastelands). All unforested lands are intended for afforestation or reforestation. The area of the SFF is constantly changing towards increase.
- **non-forest land** – land occupied by other categories of land use: arable land, hayfields, pastures, water, orchards and vineyards, roads, settlements, etc.

Areas covered with forest are distributed unevenly across the territory of the Republic of Uzbekistan. The bulk of forested lands are in Navoi region – 37% and Karakalpakstan – 35%. Bukhara region accounts for 12%; Tashkent, Jizzakh, Kashkadarya, Surkhandarya and Khorezm regions account for 1 to 5% of forested land. In Andijan, Namangan, Samarkand, Syrdarya and Fergana regions, the areas covered with forest are so insignificant that they amount to less than 1%.

The forest cover of the Republic of Uzbekistan was about 7.3% as of January 1, 2021. The low forest cover rate is due to natural climatic conditions, which determine the low survival rate and high loss rate of forest species, as well as high anthropogenic pressure.

The productivity of Uzbekistan's forests is low due to the general aridity of the country's territory. Wood stock per 1 ha of mature and overmature plantations averages 6 m^3, coniferous – 29 m^3, hardwood – only 6 m^3, including saxaul – about 3 m^3.

Forests in Uzbekistan differ significantly in their natural composition; therefore, they are divided into the following groups according to natural zones:

53 Decree of the President of the Republic of Uzbekistan No. PD-5853 dated 23.10.2019 "On Approval of the Agricultural Development Strategy of the Republic of Uzbekistan for 2020-2030"

54 Decree of the President of the Republic of Uzbekistan No. PD-269 dated 21.12.2022 "On measures to implement administrative reforms of New Uzbekistan"

- Mountain forests;
- Valley-floodplain/tugai forests;
- Desert forests.

Mountain forests occupy about 14% of the total forested area. They are located mainly in Jizzakh, Surkhandarya, Kashkadarya, Navoi, Samarkand and Tashkent regions. In the middle mountain belt, the forest-forming species are wild fruit (apricot, cherry plum, apple, pear, hawthorn, almond, pistachio, walnut), broad-leaved forests (maple, ash, etc.). The high-mountain belt is represented by juniper formations (Zarafshan juniper, semispherical and Turkestan juniper).

Desert forests make up a large part of the Forest Fund of the country (84%) and are represented by sparse stands of white and black saxaul, tree-like kandyms, sand acacia, cherkez, salt cedar and large saltwort. There are about 110 tree and shrub species in the sand-desert zone. Almost all desert plants have rough branches and narrow small leaves or thorns, the wood is dense, and the root system is long.

The forest fund of the valley-floodplain (tugai) zone of the country accounts for about 2% of the total area of forested lands. The largest areas of natural tugai forests are concentrated along the banks of the plain part of the rivers, in particular in the delta of the Amudarya River, along the banks of the Syrdarya and Zarafshan rivers. The forest-forming species in the lowland tugai are turanga, oleaster, willow and salt cedar. Valley forests also include artificially created forest plantations and plantings of various functional purposes made of poplar, ash, maple, plane tree (chinar), elm and other fast-growing deciduous and coniferous species, as well as fruit trees.

Significant damage to the forest fund is caused by overgrazing and lack of pasture rotation, illegal cutting of trees and shrubs, as well as pests and diseases.

Uzbekistan's forests are natural carbon dioxide sinks. Emissions and sinks for the Forest Land Remaining Forest Land category were calculated using the methodology of the 2006 IPCC Guidelines for the Biomass and Soils carbon pools. Carbon stock changes in this category were estimated for forest land that has been forest land for at least 20 years. Due to the lack of historical data on land converted to forest land, carbon stock changes on such lands have not been estimated.

Based on the results of the GHG inventory, we can conclude that among the forested areas of the SFF, the desert forests of the Navoi region, Karakalpakstan, and to a slightly lesser extent the Bukhara region have the highest sink capacity. In other words, the main sink occurs in desert forests – saxaul and shrub communities, due to the huge occupied areas, although they do not have high productivity.

Emission trends

Biomass and soils CO_2 removals in the Forest Land Remaining Forest Land category covering the period 1990-2021 are given in Table 5.30 and Figure 5.14. The resulting forest biomass carbon removals already taking into account carbon losses in the form of CO_2 due to forest fires (Table 5.2.3.1)

Table 5.2.3.1 CO_2 removals in the Forest Land Remaining Forest Land category, Gg

Years	Biomass	Soils	Total	Years	Biomass	Soils	Total
1990	-1691.46	-3202.54	**-4894.00**	2007	-2615.67	-2923.74	**-5541.31**
1991	-1718.00	-3273.28	**-4991.29**	2008	-2745.83	-3200.47	**-5946.30**
1992	-1744.55	-3307.74	**-5052.29**	2009	-2849.03	-3426.71	**-6258.91**
1993	-1771.09	-2309.61	**-4080.70**	2010	-2952.23	-3652.95	**-6606.53**
1994	-1955.20	-2386.71	**-4172.70**	2011	-3055.44	-3879.19	**-6959.39**
1995	-2139.32	-2424.50	**-4225.40**	2012	-3158.64	-4105.44	**-7289.32**
1996	-2323.43	-2654.80	**-4470.60**	2013	-3261.84	-4331.68	**-7593.52**
1997	-2507.55	-2734.93	**-4565.62**	2014	-3171.95	-4035.81	**-7237.94**
1998	-2691.66	-2697.13	**-4545.70**	2015	-3082.05	-3739.94	**-6838.46**
1999	-2572.33	-2938.26	**-4836.12**	2016	-2992.16	-3444.07	**-6476.76**
2000	-2453.01	-3177.87	**-5125.03**	2017	-2902.27	-3148.20	**-6035.75**
2001	-2333.68	-3202.81	**-5199.25**	2018	-2812.37	-2852.33	**-5664.70**
2002	-2214.36	-4046.65	**-6092.39**	2019	-3112.16	-3628.13	**-6740.29**
2003	-2095.04	-4104.84	**-6199.88**	2020	-3137.30	-3549.41	**-6686.71**
2004	-2225.19	-4291.47	**-6511.29**	2021	-3260.77	-3484.92	**-6745.69**
2005	-2355,35	-2451,22	**-4795,85**	$\Delta_{(1990-2018)}$	**-93%**	**-9%**	**-38%**
2006	-2485,51	-2687,48	**-5156,90**	**%, 2021**	**48%**	**52%**	**100%**

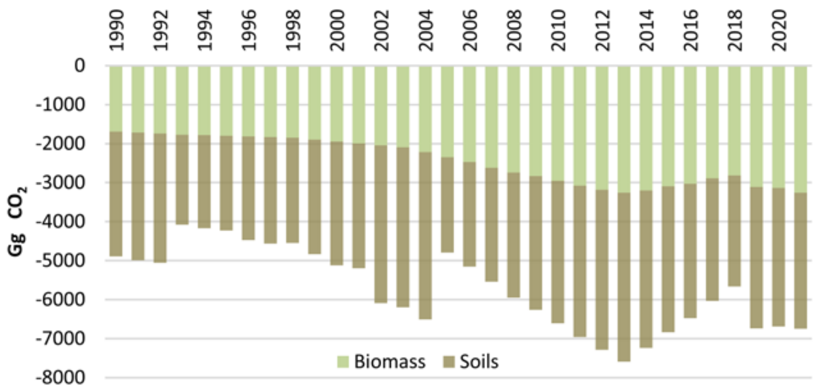

Figure 5.2.3.1 Trends in CO_2 removals in the Forest Land category

The increase in CO_2 removals is due to the increase in forested areas, mainly occupied by desert forests, and the inclusion of the "Soils" carbon pool in the estimates.

Table 5.2.3.2 CO_2 and non-CO_2 emissions from Forest fires, 2008-2021, tons of gas

Years	CO_2	CO	CH_4	N_2O	NOx
2008	1 463.22	99.79	4.38	0.24	2.8
2009	12 065.49	822.82	36.14	2	23.07
2010	2 694.06	183.72	8.07	0.45	5.15
2011	3 023.05	206.16	9.06	0.5	5.78
2012	339.86	23.18	1.02	0.06	0.65
2013	11 224.22	765.45	33.62	1.86	21.46
2014	2 250.44	153.47	6.74	0.37	4.3
2015	6 330.36	431.71	18.96	1.05	12.1
2016	121.16	8.26	0.36	0.02	0.23
2017	750.56	51.19	2.25	0.12	1.44
2018	1 674.47	114.19	5.02	0.28	3.2
2019	559.19	38.13	1.68	0.09	1.07
2020	55 919.16	3 813.48	167.51	9.27	106.92
2021	4 811.22	328.11	14.41	0.8	9.2

The increase in Forest Fund areas was due to the refinement of activity data and methodological approaches to forestry inventory, as well as due to a significant increase in the SFF at the expense of other land categories (mainly pastures) after 2003. This is also due to the implementation of planned regular afforestation activities in the Southern Aral Sea region, Karakalpakstan, Navoi and Bukhara regions within the framework of the State programs on environmental protection, as well as programs for the creation of forest areas on the dried Aral Sea bed [55 , 56].
The results of estimates of CO_2 and other gases emissions from forest fires are given in Table 5.2.3.2.

Methodology

The methodology for estimating changes in forest biomass carbon and calculating CO_2 removals in the Forest Land Remaining Forest Land category were conducted in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories using the biomass Gain-Loss Method (Equation 2.7) with both national and default factors. Average annual above-ground biomass growth (G_W) was calculated using national values for average net annual increment (Iv) for all forest species groups and basic wood density (D) – Equations 2.9-2.10 (Vol. 4, Part 1, Ch.2, p.2.16).
Woody biomass carbon losses due to removals and disturbances are estimated using Equations 2.11-2.14 of the same chapter of the Guidelines.
Conversion of stored carbon to CO_2-eq. units was performed by multiplying by the conversion factor (-44/12).
Emissions of CO_2 and non-CO_2 gases from disturbances (fires) were estimated using national statistics on areas affected by fires according to Tier 1 methodology. Equation 2.27 of the same chapter of the Guidelines was used.

55 Forestry Development Program for 2020-2024.
56 Program of measures to eliminate the consequences of the drying of the Aral Sea and prevent disaster of ecosystems in the Aral Sea region www.aral.uz

Additional tables developed in MS Excel based on the IPCC Guidelines worksheets (Vol. 4, Part 2, Annex 1: Worksheets) were used in the calculations.
Since Tier 1 methodology was used, in carbon stock changes in dead organic matter were not estimated.
In addition to the default data, some national factors were used in the calculations.
Since several tree species – juniper, saxaul, poplar, salt cedar, cherkez, other shrubs – are characterized by significant increment, and most other species have increment within the rounding range, forest species were grouped into the following natural zones:

I. Mountain forests:
   1) Juniper tree;
   2) Other tree species growing mainly in the mountains: maple, apricot, almond, walnut, pistachio, apple;
II. Valley-floodplain forests:
   1) Poplar (turanga);
   2) Other tree species growing mainly in river valleys and floodplains: ash, elm, Robinia pseudoacacia, willow, mulberry, ailanthus, sophora, catalpa;
III. Desert forests:
   1) Saxaul
IV. Shrubs

To determine annual changes in carbon stocks and associated CO_2 removals during the period between forest area inventories, time series of activity data (forest areas by major species groups) were completed using the interpolation method.
Methodology for estimating forest soils carbon changes. The estimate for the “Soils” carbon pool was conducted using a Tier 1 methodology to ensure consistent representation of carbon pools in the FOLU sector (although it is not required under the Tier 1 methodology). Estimates were made using data on forest land areas covered by forest in year t, as well as data on similar areas in year (t -20), (ha). For desert forests, relevant default reference soil organic carbon stocks in sandy soils located in a warm temperate, dry climate region were used, for other forest types, reference soil organic carbon stocks for mineral soils with high activity clay (HAC) from Table 2.3 (Vol. 4, Part. 1, Chapter 2, p.2.37) were used. Equation 2.25 (Vol. 4, Part 1, Ch. 2, p.2.35) for mineral soils was used to calculate carbon stock changes in forest land. The input, management and disturbance regime factors are equal to 1 (using the Tier 1 approach) – In accordance with Section 4.2.3.2, 2006 IPCC Guidelines (Vol. 4, Part 1).
Conversion of stored carbon to CO_2-eq. units was performed by multiplying by the conversion factor (-44/12).

Activity data

In estimating **forest biomass** carbon changes, Approach 1: “Total land-use area, lack of data on land use change” was used to represent areas in this category, as national statistics lack information on land conversions.
In Uzbekistan, the state Forest Fund accounting is conducted once every five years. For the period 1990-2018, it was conducted in 1988, 1993, 1998, 2003, 2008, 2013 and in 2018. Interpolation methods were used to fill gaps in the source data for the intervening years. For the period 2019-2021, annual data on forest areas provided by FA were used.
The forest areas in Table 5.2.3.3 are given in accordance with the materials of the State Forest Fund Accounting.

Table 5.2.3.3 Forest area by dominant species, 2017-2021, thousand hectares

Forest type	Species groups	Area, thousand hectares				
		2017	2018	2019	2020	2021
Mountain forests	Juniper tree	141.9	106.1	115.5	116.5	117.7
	Other tree species growing in mountains	46.2	46.9	51.0	51.5	52.0
Floodplain forests	Poplar (turanga)	50.8	35.5	38.6	39.0	39.,4
	Other tree species growing in valleys and floodplains	11.6	12.4	13.5	13.6	13.8
Desert forests	Saxaul	2238.9	2246.0	2443.4	2465.6	2490.6
	Shrubs	464.3	496.0	539.6	544.5	550.1
Total		2953.7	2942.9	3201.5	3230.7	3263.6

National data provided by FA were used as data on the amount of wood harvested and total fuelwood consumption.

To estimate the biomass carbon losses from removed commercial wood (roundwood), the **assumption** that only poplar wood is used as roundwood.
Biomass carbon losses from removed fuelwood were estimated using the expert **assumption** for the entire series that poplar and saxaul are used as fuelwood in a ratio of 1:11 (Table 5.2.3.4). The reduction in the volume of fuelwood harvesting is associated with increased gasification in rural areas and increased use of coal.

Table 5.2.3.4 Wood use data, 2017-2021, thousand m^3

Wood use	Species group	Quantity, thousand m^3				
		2017	2018	2019	2020	2021
Quantity of roundwood harvested	Poplar	13.23	12.00	8.38	0.17	0.05
Total fuelwood consumption	Poplar	1.44	1.64	1.26	0.16	0.12
	Saxaul	14.36	16.36	12.56	1.58	1.16

To estimate **forest soils** carbon stock changes, data on areas of forest land covered by forests obtained from a combination of data series for the period 1970-2021 from the Cadastral Agency and the Forestry Agency, using an interpolation method to fill in missing years, are used. The baseline data are given in Table 5.2.3.5.

Table 5.2.3.5 Data on Forest land areas, thousand hectares

Years	Area, thous. ha	Years	Area, thous. ha	Years	Area, thous. ha	Years	Area, thous. ha
1970	832.10	1983	977.40	1996	1331.60	2009	3129.10
1971	836.10	1984	995.30	1997	1341.70	2010	3213.70
1972	847.30	1985	1415.40	1998	1409.60	2011	3220.00
1973	1063.40	1986	1423.50	1999	1420.00	2012	3219.90
1974	1065.10	1987	1431.50	2000	1373.10	2013	3219.90
1975	1074.60	1988	1402.40	2001	1374.30	2014	3427.50
1976	1045.90	1989	1409.00	2002	2259.80	2015	3433.70
1977	1047.00	1990	1410.00	2003	2703.30	2016	3433.60
1978	1071.50	1991	1333.90	2004	2693.80	2017	3442.70
1979	1060.70	1992	1333.70	2005	2697.00	2018	3442.50
1980	1050.20	1993	1327.50	2006	3104.40	2019	3433.90
1981	1082.30	1994	1330.30	2007	3105.80	2020	3434.50
1982	951.90	1995	1254.70	2008	3129.10	2021	3435.70

Annual biomass carbon losses due to disturbances were estimated using statistics on forest land area affected by fires that are available since 2008. For the earlier period, it is assumed that no disturbances occurred (Table 5.2.3.6). The **assumption** is made that fires occur predominantly in deciduous forests. Poplar was assumed as the dominant species group.

Emission factors

Table 5.2.3.6 Data on Forest areas affected by fires in 2017-2021, ha

Years	Area, ha	Year	Area, ha
2008	1 463.22	2015	6 330.36
2009	12 065.49	2016	121.16
2010	2 694.06	2017	24.16
2011	3 023.05	2018	53.9 0
2012	339.86	2019	18 .00
2013	11 224.22	2020	1800.00
2014	2 250.44	2021	154.87

Forest biomass carbon stocks changes were estimated using both national and default factors. Average annual above-ground biomass growth (G_W) was calculated using national values for average net annual increment (Iv) estimated by national FA experts for all forest species groups and basic wood density (D) from national studies [57]. Other factors are used by default from the 2006 IPCC Guidelines (Vol. 4, Chapter 4) from relevant tables – for temperate forests (Table 5.2.3.7). These factors are included in Equations 2.9-2.10 (Vol. 4, Part 1, Ch.2, p.2.16).

57 D. M. Fuzailov. Wood of Uzbekistan. (Scientific and technical basis of use). – Tashkent, Fan Publishing House, 1983. – 135 p.

Average annual above-ground biomass growth is calculated using Tier 2 Equation 2.10. National data on average net annual increment (Iv) and biomass conversion and expansion factor ($BCEF_I$) values are used – Table 5.36.
Carbon stock changes in **mineral soils** were estimated using default factors characterizing reference soil carbon stocks (Table 2.3, p.2.37). The input (F_{ND}), management (F_{MG}) and disturbance regime (F_1) factors are equal to 1 (if Tier 1 approach is used) – in accordance with the 2006 IPCC Guidelines (Vol. 4, Part 1, Section 4.2.3.2). There are no organic soils on the territory of the country.

Uncertainties and time series consistency

Uncertainty of estimates of **forest biomass** carbon stock changes and associated carbon dioxide removals is mainly due to the uncertainty of activity data (by species composition, area occupied) obtained from forest inventories. According to expert estimates, it is about 15-25%.

Uncertainty of the emission factors used is given in Table 5.36.

Combined uncertainty in the estimates of carbon dioxide removals in biomass pool by category is about ±104%.

Uncertainty in estimates of **forest soils** carbon stock changes and associated carbon dioxide removals is mainly due to uncertainty in activity data (area of forest land covered by forest). According to expert estimates, it is 15-25%.

Uncertainty of the reference soil organic carbon stocks is ±90% (according to Table 2.3, p.2.37 of the 2006 IPCC Guidelines).

Combined uncertainty in the estimates of carbon dioxide removals in soils pool by category is about ±93%.

The same method and data sets were used for all years.

Quality assurance/Quality control

QA/QC procedures were performed in accordance with the general QA/QC principles and the QA/QC plan. The following were verified:

- emission sources documentation,
- mechanical errors in data,
- values of emission factors and other calculated parameters used.

Recalculations for the category

Due to the transition to the 2006 IPCC Guidelines methodology and the use of new default factors, a recalculation was made for this category for the period 1990-2017.
The result obtained in this way differs significantly from the previously calculated values in accordance with the IPCC 1996 and IPCC 2003 methodologies. Comparative data for estimates of CO_2 removals by forest land are given in Table 5.2.3.7.

Table 5.2.3.8 Removals comparison in the "Forest Land Remaining Forest Land" category relative to FBUR estimates, Gg CO_2

Years	FNC	FBUR	Difference	Years	FNC	FBUR	Difference
1990	-4894.00	-3517.74	-1376.26	2004	-6511.29	1730.29	-8241.59
1991	-4991.29	-3491.39	-1499.91	2005	-4795.85	-4664.45	-131.35
1992	-5052.29	-3465.04	-1587.26	2006	-5156.90	-11059.2	5902.30
1993	-4080.70	-3438.69	-642.01	2007	-5541.31	-17453.95	11912.65
1994	-4172.70	-6428.41	2255.71	2008	-5946.30	-23848.7	17902.4
1995	-4225.40	-9418.12	5192.72	2009	-6258.91	-22998.28	16739.38
1996	-4470.60	-12407.83	7937.23	2010	-6606.53	-22147.86	15541.36
1997	-4565.62	-15397.54	10831.94	2011	-6959.39	-21297.44	14338.04
1998	-4545.70	-18387.25	13841.55	2012	-7289.32	-20447.02	13157.72
1999	-4836.12	-13084.79	8248.69	2013	-7593.52	-19596.6	12003.10
2000	-5125.03	-7782.33	2657.33	2014	-7237.94	-17749.38	10511.48
2001	-5199.25	-2479.87	-2719.43	2015	-6838.46	-15902.16	9063.66
2002	-6092.39	2822.58	-8914.98	2016	-6476.76	-14054.94	7578.14
2003	-6199.88	8125.04	-14324.94	2017	-6035.75	-12207.72	6171.92

Table 5.2.3.7 Conversion factors for biomass increment and losses in Forest Land used in calculations

Forest categories	Average net annual increment	Biomass conversion and expansion factor for conversion gross annual increment in volume (including bark) to above-ground biomass growth	Ratio of below-ground biomass to above-ground biomass	Carbon fraction of dry matter in above-ground forest biomass	Biomass conversion and expansion factor for conversion of removals in merchantable volume to total biomass (including bark) removals	Basic wood density	Average above-ground biomass of land areas affected by disturbances	Fraction of biomass lost in disturbance
	m^3/ (ha*yr)	tonnes biomass/m^3 wood volume	tonnes of roots, dry matter/ton of branches, dry matter	tonnes C/ton dry matter	tonnes of biomass harvested / m^3 of removals	tonnes dry matter/m^3	tonnes dry matter/ha	dimensionles s (fraction)
	National data	Table 4.5	Table 4.4	0.5 by default	Table 4.5	National data	Table 4.7	share
	Iv	$BCEF_I$	R	CF	$BCEF_R$	D	B_W	fd
I. Mountain forests: 1.Juniper tree	0.205 ± 1%	1.00 ± NA	0.40 ± 65%	0.5 ± 4%	3.33 ± NA	0.440 ± 2%	100 ± 80%	1.0 ± NA
2. Other mountain forests	0.215 ± 2%	1.50 ± NA	0.46 ± 90%	0.5 ± 4%	3.33 ± NA	0.545 ± 2%	20 ± NA	1.0 ± NA
II. Valley-tugai forests: 1. Poplar	1.972 ± 20%	1.50 ± NA	0.46 ± 90%	0.5 ± 4%	3.33 ± NA	0.395 ± 2%	20 ± NA	1.0 ± NA
2. Other valley forests	0.975 ± 45%	1.50 ± NA	0.46 ± 90%	0.5 ± 4%	3.33 ± NA	0.710 ± 1%	20 ± NA	1.0 ± NA
III. Desert forests: Saxaul	0.195 ± 1%	1.50 ± NA	0.46 ± 90%	0.5 ± 4%	3.33 ± NA	0.867 ± 1%	20 ± NA	1.0 ± NA
IV. Shrubs	0.387 ± 6%	1.50 ± NA	0.46 ± 90%	0.5 ± 4%	3.33 ± NA	0.510 ± 1%	20 ± NA	1.0 ± NA

As follows from Table 5.37, the estimates of removals/emissions in “Forest Land Remaining Forest Land” category obtained in FNC are approximately two times less than FBUR estimates. This is due to changes in methodological approaches as well as application of revised national factors for calculations.

Planned improvements in the category

It is planned to establish permanent closer contact with the forest cadaster department of Forestry Agency in order to receive explanations from them on changes in the species composition on forested lands, changes in the land areas under certain forest species, as well as in the distribution of lands by age categories and wood biomass stocks of the respective species.
It is planned to refine the values of national factors used in the calculations, as well as to detail the activity data, including the amount of harvested roundwood and fuelwood.

5.2.4 Cropland Remaining Cropland (3.B.2.a category)

Category description

Agriculture is concentrated in the plains and foothills of the Republic of Uzbekistan, which determines the nature of development of soil formation processes and difference in the quality of agricultural lands. The total irrigated area is more than 4.3 million hectares. Irrigated arable land occupies 81.4% of the irrigated area. According to expert estimates, more than 60% of all irrigated agricultural land in Uzbekistan (3,702,400 ha in 2018) are classified as saline and about half of them are moderately or strongly saline [58].
The leading economic crops in the irrigated zone are winter wheat and cotton, which occupy about 70% of the area. Potatoes, forage crops, vegetables, melons and other crops are grown on the remaining lands. Perennial tree plantations are represented by various garden species – apple, pear, cherry, plum, peach, apricot, grapes, pomegranate, persimmon, fig, nuts. High dependence on irrigation together with natural predisposition to desertification create preconditions for land degradation. Rainfed agriculture is concentrated in the foothill plains, foothills and low mountains of Tien Shan and Pamir-Alai on the area of 753.6 thousand ha (18.6% of the total arable land area). Most of rainfed lands are located in the zone of unsupplied and semi-supplied natural moisture. This circumstance causes low productivity and unstable yield of rainfed crops.
The soil types found throughout the country are very diverse. In the desert zone, gray-brown, takyr soils, desert, sandy, solonchaks and hydromorphic soils of the desert zone are common. Soils of high-altitude zones – light, typical and dark gray soils, carbonate, mountain brown, brown forest, light brown, meadow-steppe soils, as well as hydromorphic soils of high-altitude zones.
Most of the cultivated soils in Uzbekistan belong to the group of soils with highly active alumina minerals (mineral soils with high activity clay (HAC) according to the IPCC classification).
Category 3.B.2.a "Cropland" includes arable and tillable land, as well as perennial crops. In 2021, the total area of cropland (according to the IPCC classification) was 5339.1 thousand ha.
From 1990 to 2021, the area of cropland increased by 26.1%. The structure of land subcategories included in "Cropland" has also changed (Figure 5.2.4.1), with the share of cropland decreasing by 4% and the share of household plots increasing by 5%.

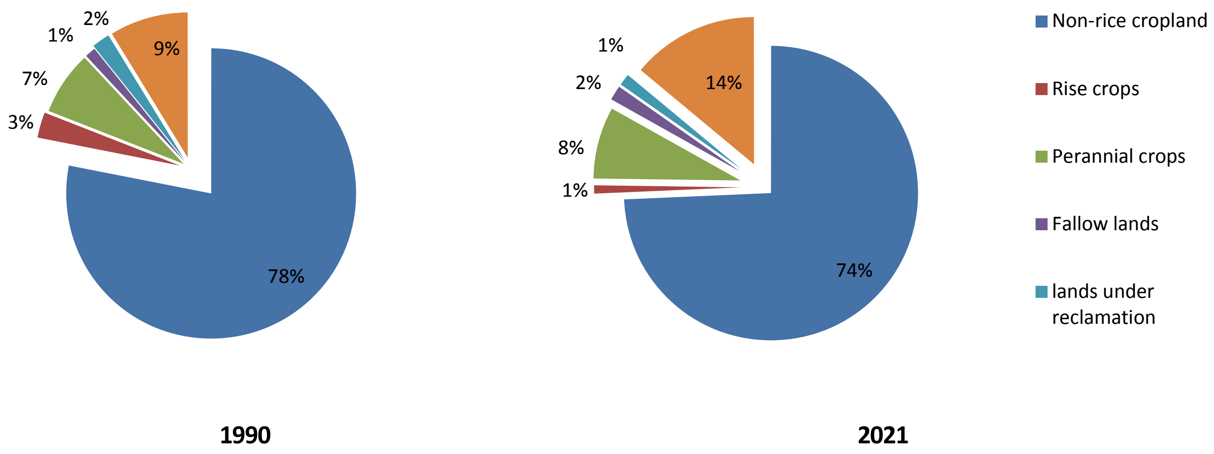

Figure 5.2.4.1 Change in the structure of land subcategories in the “Cropland” category from 1990 to 2021

58 Uzbekistan. Third Environmental Performance Review. - UNECE, 2020 - 514 p.

The Cropland Remaining Cropland category considers emissions/removals due to the carbon stock changes in mineral cropland caused by changes in area and land use practices.
There are no soils classified as organic soils according to the 2006 IPCC Guidelines classification in Uzbekistan.
The “Land Converted to Cropland” category was not considered due to the lack of necessary statistical data.
Since the Tier 1 methodology was used to estimate the carbon stock changes, only two pools were considered in the category:
- Carbon pool in above-ground biomass of woody perennials,
- Carbon pool in soils.
Other pools (below-ground biomass, dead organic matter) were not considered in this inventory.
Changes in woody biomass carbon stocks in cropland were estimated for woody perennials as a whole, without subdivision into individual species, based on annual data on areas under perennial crops using IPCC default factors.
The following land-use systems were considered in estimating the change in soil carbon stocks in cropland soils:

- arable land,
- woody perennials (orchards, fruit tree nurseries, mulberry trees, vineyards, etc.),
- fallow lands,
- lands under reclamation,
- household lands and lands of horticultural and vegetable associations.

Carbon dioxide removals (from above-ground biomass and soils) in this category in 2021 totaled 3568.38 Gg CO_2.

Emission trends

Table 5.2.4.1 and Figure 5.2.4.2 show CO_2 emissions/removals for the Cropland Remaining Cropland category for the period 1990-2021, including estimates of biomass and soil carbon stock changes in accordance with Equation 2.3 (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 4, Part 1, Chapter 2, p. 2.7)

Table 5.2.4.1 CO_2 emissions/removals in “Cropland Remaining Cropland” category, Gg

Years	Soils	Biomass	Total	Years	Soils	Biomass	Total
1990	-6325.45	-2824.36	**-9149.81**	2007	996.80	-2635.71	**-1638.91**
1991	-6635.83	-2912.14	**-9547.97**	2008	1356.50	-2648.80	**-1292.30**
1992	-6909.16	-2926.00	**-9835.16**	2009	876.90	-2678.06	**-1801.16**
1993	-7066.18	-2934.47	**-10000.65**	2010	548.10	-2701.93	**-2153.83**
1994	-6654.20	-2576.42	**-9230.62**	2011	1227.00	-2746.59	**-1519.59**
1995	-6328.44	-1705.55	**-8033.99**	2012	954.30	-2758.91	**-1804.61**
1996	-6427.49	-1833.37	**-8260.86**	2013	1276.10	-2832.83	**-1556.73**
1997	-6152.19	-1680.14	**-7832.33**	2014	1130.40	-2863.63	**-1733.23**
1998	-5425.30	-544.39	**-5969.69**	2015	829.30	-2932.16	**-2102.86**
1999	-5256.20	-2070.53	**-7326.73**	2016	1061.90	-2969.12	**-1907.22**
2000	-4062.17	-1285.13	**-5347.30**	2017	1347.40	-3015.32	**-1667.92**
2001	-2847.52	-1644.72	**-4492.24**	2018	1531.80	-3064.60	**-1532.80**
2002	-2503.69	-1158.08	**-3661.77**	2019	1076.40	-3197.04	**-2120.64**
2003	-2765.60	-2594.90	**-5360.50**	2020	846.80	-3197.04	**-2350.24**
2004	-341.70	-2608.76	**-2950.46**	2021	-323.60	-3244.78	**-3568.38**
2005	-20.80	-1892.66	**-1913.46**	$\Delta_{(1990-2021)}$	**19.5-fold decrease in removals**	**1.15-fold increase in removals**	**2.6-fold decrease in removals**
2006	-127.00	-2610.30	**-2737.30**				

During the period 1990-2021, there was a 2.6-fold decrease in CO_2 removals in the Cropland Remaining Cropland category due to a reduction in the total area of cropland. The main influence on the reduction of removals in the category is the decrease of carbon content in the “Soils” pool.

In the “Soils” pool, from 2007 to 2020, CO_2 emissions, rather than removals, were observed. The transition from CO_2 removals to emissions is associated with a slight reduction in the area of cropland, including rice crops, reclaimed land and fallow lands. However, there have been no noticeable changes in cropland management practices since the early 1990s. Some internationally recognized land improvement practices are being implemented only at pilot sites in some regions of the country.

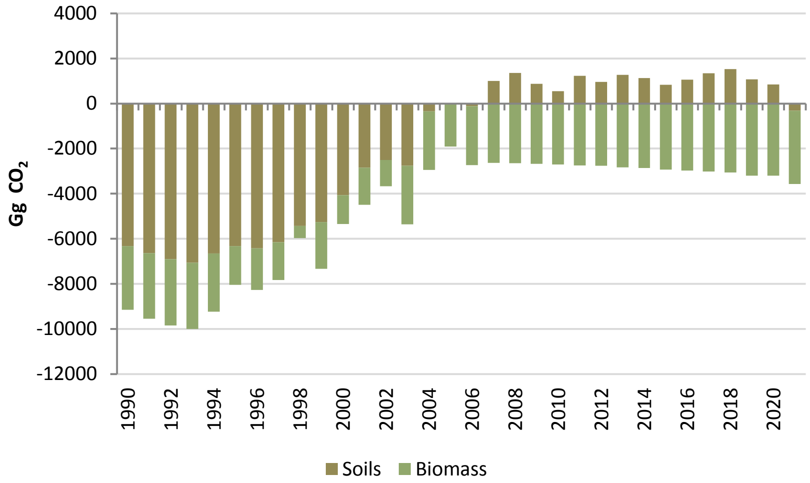

Figure 5.2.4.2 Trend in CO_2 removals in the Cropland category

Methodology

Carbon stock changes in the **biomass of perennial crops** on cropland were estimated in accordance with the Tier 1 methodology of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories based on data on annual areas under perennial crops (ha), as well as data on changes in these areas compared to the previous year (ha). At the same time, decrease in carbon stocks due to biomass loss was estimated in the case of a reduction in the area under perennial crops. Carbon storage (t C/year) was calculated from the areas under perennial crops in each inventory year.

Calculations of the annual carbon stock change ***in biomass*** on cropland were carried out according to Equation 2.7 (IPCC Guidelines 2006, Vol. 4, Part 1, Chapter 2, p. 2.13) using default factors (Table 5.1 of the same Guidelines, Vol. 4, Part 1, Chapter 5, page 5.10 for the Temperate zone).

Carbon stock changes ***in soils*** in croplands were estimated in accordance with the Tier 1 methodology of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories [3] based on data on areas under crops (including rice, perennial crops, fallow lands, land under reclamation, household plots (ha) in year t, as well as data on similar areas in year (t -20), (ha).

Carbon stock changes in soils in croplands were calculated using Equation 2.25 (2006 IPCC Guidelines, Vol. 4, Part 1, Chapter 2, p. 2.35 for mineral soils) with default factors.

Reference soil organic carbon stocks were selected from Table 2.3 of the same Guidelines (Vol. 4, Part 1, Chapter 5, p. 2.37) for mineral soils with high activity clay (HAC) located in a warm temperate, dry climatic region; stock change factors for different management activities on croplands – from Table 5.5, pp. 5.20-5.21 ibid.

Conversion of stored carbon to CO_2-eq. units was done by multiplying by a conversion factor (-44/12).

Activity data

"Biomass" carbon pool. Data on areas under perennial crops were provided by the Statistics Agency of the Republic of Uzbekistan (Table 5.2.4.2).

Table 5.2.4.2 Areas under perennial crops on Cropland and estimation of their biomass carbon stock

Years	Woody perennials, thousand hectares	Reduction of area, thousand hectares	Annual carbon loss, thousand tons of C/year	Annual change in carbon stock, thousand tons of C/year	CO_2 removals, CO_2, Gg
1989	351.6	-	-	-	-
1990	366.8	0	0	770.28	-2824.36
1991	378.2	0	0	794.22	-2912.14
1992	380.0	0	0	798	-2926.00
1993	381.1	0	0	800.31	-2934.47
1994	379.6	1.5	94.5	702.66	-2576.42
1995	374.5	5.1	321.3	465.15	-1705.55
1996	370.1	4.4	277.2	500.01	-1833.37
1997	365.2	4.9	308.7	458.22	-1680.14
1998	355.7	9.5	598.5	148.47	-544.39
1999	352.9	2.8	176.4	564.69	-2070.53
2000	346.9	6.0	378.0	350.49	-1285.13

Table 5.2.4.2 continuation

Years	Woody perennials, thousand hectares	Reduction of area, thousand hectares	Annual carbon loss, thousand tons of C/year	Annual change in carbon stock, thousand tons of C/year	CO_2 removals, CO_2, Gg
2001	342.6	4.3	270.9	448.56	-1644.72
2002	336.4	6.2	390.6	315.84	-1158.08
2003	337.0	0	0	707.7	-2594.90
2004	338.8	0	0	711.48	-2608.76
2005	335.8	3	189.0	516.18	-1892.66
2006	339.0	0	0	711.9	-2610.30
2007	342.3	0	0	718.83	-2635.71
2008	344.0	0	0	722.4	-2648.80
2009	347.8	0	0	730.38	-2678.06
2010	350.9	0	0	736.89	-2701.93
2011	356.7	0	0	749.07	-2746.59
2012	358.3	0	0	752.43	-2758.91
2013	367.9	0	0	772.59	-2832.83
2014	371.9	0	0	780.99	-2863.63
2015	380.8	0	0	799.68	-2932.16
2016	385.6	0	0	809.76	-2969.12
2017	391.6	0	0	822.36	-3015.32
2018	398.0	0	0	835.8	-3064.60
2019	415.2	0	0	871.92	-3197.04
2020	415.2	0	0	871.92	-3197.04
2021	421.4	0	0	884.94	-3244.78

"Soil" carbon pool. Data on areas of cropland are provided by the Statistics Agency of the Republic of Uzbekistan (Table 5.2.4.3).

Table 5.2.4.3 Areas under perennial crops on Cropland, thousand ha

Years	Cropland excluding land under rice crops	Rice crops	Perennial crops	Fallow lands	Land under reclamation	Household plots
1970	3457.9	63.3	184.1	251.8	99.4	177.9
1975	3624.9	64.9	204.0	137.1	91.1	191.0
1980	3832.3	104.1	269.9	70.3	87.8	201.5
1985	4053.6	149.9	325.7	46.8	149.4	225.5
1990	4029.7	146.8	366.8	62.1	103.7	451.3
1995	3926.9	165.9	374.5	69.2	75.3	601.5
2000	3926.9	131.8	346.9	82.8	82.8	649.2
2005	4004.7	52.5	335.8	83.6	78.6	698.8
2010	4001.8	69.2	350.9	80.5	73.0	698.5
2013	4010.8	44.5	367.9	80.4	72.7	699.6
2014	3995.9	47.7	371.9	80.3	72.6	700.4
2015	3970.8	70.0	380.8	80.0	72.3	701.3
2016	3963.5	71.8	385.6	79.9	72.1	702.6
2017	3955.1	71.3	391.6	80.8	71.9	703.9
2018	3977.7	42.1	398.0	80.7	71.9	704.7
2019	3958.0	64.9	415.2	83.6	68.9	733.2
2020	3975.5	47.4	415.2	83.6	68.9	739.5
2021	3967.2	48.9	421.4	83.6	68.9	746.1

Emission factors

Default emission factors from Table 5.1 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Vol. 4, Part 1, Chapter 5, p.5.10), were used in calculations of carbon accumulation by ***biomass of perennial crops*** on cropland:

Climate region – temperate zone;

Biomass accumulation rate (G) – 2.1 t C/ha/year;

Biomass carbon loss (L) – 63 t C/ha.

Default reference values from Table 2.3 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Vol. 4, Part 1, Chapter 2, p.2.37) were used in estimates of carbon stock changes in ***soils*** on cropland:

Climate region – warm temperate, dry;

Soil type – HAC mineral soils (soils with high activity clay);

Reference soil organic C stock (SOC_{REF}) = 38 t C/ha for 0-30 cm layer.

Reference soil organic C stock (SOC_{REF}) = 88 t C/ha for the 0-30 cm layer (for rice fields).

Relative stock change factors for different management activities on cropland were selected from Table 5.5, pp. 5.20-5.21 ibid., according to expert estimates.

The factors used in the calculations are given in Table 5.2.4.4.

Table 5.2.4.4 Relative stock change factors (over 20 years) for different management activities on cropland

Subcategory	F_{LU}	F_{MG}	F_1
Cropland under annual crops (without rice)	0.8±9%	1±NA	1±NA
Cropland under rice*	1.1±50%	1±NA	1±NA
Perennial crops	1±50%	1±NA	1±NA
Fallow lands	0.93±11%	1± NA	0.95±13%
Lands under reclamation	0.93±11%	1±NA	1.04±13%
Household plots	0.8±9%	1±NA	1±NA

In this inventory, the data on F_{MG} factor value have been specified. In the previous inventory under the FBUR other values of F_{MG} factor were used: for cropland under rice – 1.1; for perennial crops – 1.02; for fallow land – 1.1; for land under reclamation – 1.02. The difference in the obtained estimates of emissions/removals with the inventory for 1990-2017 is associated with the change of F_{MG} factor values.

Uncertainties and time series consistency

The following were taken into account in the uncertainty assessment:

− uncertainty in area inventory statistics (10% - IPCC default);

− uncertainty associated with land management practices (IPCC default from Table 5.5. Uncertainties for each factor are given in the Table 5.41 – F_{LU}, F_{MG}, F_I);

− uncertainty in biomass carbon stock change factors – IPCC default (for factor G – biomass accumulation rate: ±75%; for factor L – biomass carbon loss ±75%).

Combined uncertainty: for the "Soils" carbon pool ±51%; for the "Biomass" carbon pool ±75.7%.
The same method and ~~similar~~ data sets were used for all years.
Conversion of stored carbon to CO_2-eq. units was done by multiplying by a conversion factor (-44/12).

Quality assurance/Quality control

QA/QC procedures were performed in accordance with the general QA/QC principles and the QA/QC plan. The following were verified:

- emission sources documentation,
- mechanical errors in data,
- values of emission factors and other calculated parameters used.

Recalculations for the category

In the Fourth National Communication, in connection with the refinement of the F_{MG} default factors in the “Soils” carbon pool, a recalculation has been made for the Cropland Remaining Cropland category relative to the First Biennial Update Report estimates for the period 1990-2017.

The result thus obtained differs from the previously calculated values by a maximum of about ±15% for individual years. The minimum differences in the estimates are about ±0.4%. The comparative data are given in Table 5.2.4.5.

Table 5.2.4.5 Comparison of removals in the “Cropland Remaining Cropland” category obtained from FNC relative to FBUR, Gg CO_2

Years	FNC	FBUR	Difference	Years	FNC	FBUR	Difference
1990	-9149.81	-9207.30	57.49	2004	-2950.46	-2751.70	-198.76
1991	-9547.97	-9615.50	67.53	2005	-1913.46	-1711.60	-201.86
1992	-9835.16	-9948.00	112.84	2006	-2737.3	-2597.60	-139.70
1993	-10000.65	-10141.00	140.35	2007	-1638.91	-1416.70	-222.21
1994	-9230.62	-9365.70	135.08	2008	-1292.3	-1034.10	-258.20
1995	-8033.99	-8183.40	149.41	2009	-1801.16	-1585.50	-215.66
1996	-8260.86	-8443.80	182.94	2010	-2153.83	-2002.10	-151.73
1997	-7832.33	-8027.60	195.27	2011	-1519.59	-1267.50	-252.09
1998	-5969.69	-6090.80	121.11	2012	-1804.61	-1608.70	-195.91
1999	-7326.73	-7477.90	151.17	2013	-1556.73	-1313.70	-243.03
2000	-5347.30	-5411.10	63.80	2014	-1733.23	-1525.50	-207.73
2001	-4492.24	-4403.50	-88.74	2015	-2102.86	-1938.00	-164.86
2002	-3661.77	-3602.40	-59.37	2016	-1907.22	-1710.90	-196.32
2003	-5360.50	-5381.10	20.60	2017	-1667.92	-1448.70	-219.22

Planned improvements in the category

The next inventory is expected to refine and detail the activity data.

5.2.5 Grassland Remaining Grassland (3.B.3.a category)

Category description

Grassland in Uzbekistan covers 21.1 million ha, or half of the total territory, of which 14.4 million ha are deserts, 5.7 million ha are foothills, and 1.1 million ha are mountainous and high-mountainous areas. Pastures are mainly located in the Republic of Karakalpakstan, Bukhara, Navoi, Jizzak and Kashkadarya regions. Approximately 19.4 million ha of pastures are flooded. 16.4 million hectares (77.3%) of pastures are subject to digression. Digression is most pronounced in Karakalpakstan, Navoi, Bukhara and Surkhandarya regions.

In Kyzylkums, the main area is occupied by unproductive and degraded pastures. Depending on the weather conditions of individual years, the species composition of vegetation developing on desert pastures ranges from 9 to 55 species, and yield from 2 to 9 cwt/ha. The average pasture yield is 2.4 – 2.7 cwt/ha. Desert pastures form the basis of the forage base of sheep breeding, providing year-round maintenance.

According to the analysis prepared during the drafting of the Law "On Pastures" adopted in 2019, 78% of pastures are classified as degraded, which primarily means soil degradation. The condition of the remaining pastures is also unsatisfactory, their productivity has been halved, as evidenced by a decrease in the yield of forage crops by an average of 2% per hectare. The causes of pasture degradation are overgrazing, impact of technogenic factors and climate change.

Soil types of desert pastures are gray-brown, takyr soils, desert, sandy, solonchaks and hydromorphic soils. Soils of mountain and high mountain pastures are light, typical and dark gray, carbonate, mountain brown, brown forest, light brown, meadow-steppe, and hydromorphic soils [58].

Category 3.B.3.a, Grassland Remaining Grassland, estimates carbon stock changes in soils on grassland over a 20-year period. Other carbon pools were not considered because Tier 1 methodology was used for the calculations. Research is required to estimate carbon stock changes in the Biomass pool.

The following land-use systems were considered in estimating carbon stock change in grassland soils:

- Pastures,
- Hayfields.

According to the Cadastral Agency of the Republic of Uzbekistan, the total area of pastures in 2021 was 21,152 thousand hectares, and the area of hayfields – 101.1 thousand hectares. Over the period from 1990 to 2021, the area of pastures decreased by 9.5%, hayfields – by 10.3% mainly due to their conversion to forest land (Figure 5.2.1.1).

Carbon dioxide removals from Grassland Remaining Grassland in 2021 amounted to 3963.37 Gg CO_2.

Emission trends

Table 5.2.5.1 presents CO_2 emissions/removals for the “Grassland Remaining Grassland” category for the period 1990-2021, based on estimates of soil carbon stock changes.

Table 5.2.5.1 CO_2 emissions/removals for the "Grassland Remaining Grassland" category, Gg

Years	Soils	Years	Soils	Years	Soils
1990	-1339.24	2001	6576.73	2012	9174.37
1991	589.01	2002	9833.16	2013	9584.19
1992	590.00	2003	10180.05	2014	6245.08
1993	110.22	2004	7633.96	2015	5664.86
1994	331.13	2005	9658.08	2016	5227.15
1995	569.99	2006	11153.29	2017	5024.19
1996	6767.71	2007	10737.65	2018	4828.84
1997	6755.45	2008	10999.96	2019	4739.35
1998	7091.96	2009	11242.75	2020	4150.51
1999	6940.47	2010	11200.42	2021	3963.37
2000	6811.07	2011	9223.64	$\Delta_{(1991-2021)}$	**6.73-fold increase in emissions**

During the period 1990-2021, CO_2 removals in category were observed only in 1990. In subsequent years, only emissions were observed. From 1991 to 2021, CO_2 emissions from grassland soils increased by 6.7 times. Maximum CO_2 emissions were observed in 2004-2009. Over the last 8 years, a decrease in emissions by 2 times has been observed. Changes in CO_2 emissions in the "Grassland Remaining Grassland " category are due to a reduction of grassland areas. According to expert data, there have been no changes in land management practices on grassland since the early 1990s. Some internationally recognized practices of pasture improvement are implemented only at pilot sites in some regions of the country.

Methodology

Carbon stock change in soils on grassland were estimated according to the Tier 1 methodology of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories based on data on areas of pastures (desert and other) and hayfields (ha) per year t, as well as data on similar areas in year (t -20), (ha). Since there were no accurate data on the areas of pastures of different classes (deserts, foothills and mountains), it was **assumed** that *desert pastures* accounted for about 78% of the total pasture area and *foothill and mountain pastures* 22%, respectively [[59]]. This made it possible to divide pastures by soil types.

It is also **assumed** that desert pastures are characterized by sandy soils, and for other pastures and hayfields – mineral soils with high activity clay (HAC).

Carbon stock changes in soils on grassland were calculated using Equation 2.25 (2006 IPCC Guidelines, Vol.4, Part 1, Chapter 2, p. 2.35 for mineral soils) with default factors from Table 6.2, p. 6.19 ibid.

Reference soil organic carbon stocks were selected from Table 2.3 of the same Guidelines (Vol.4, Part 1, Chapter 5, p. 2.37) for mineral soils with high activity clay (HAC) and for sandy soils located in a warm temperate, dry climate region.

Conversion of stored carbon to CO_2-eq. units was performed by multiplying by the conversion factor (-44/12).

Activity data

Data on areas of pastures and hayfields from 1970 to 2021 were provided by the Cadastral Agency of the Republic of Uzbekistan (Table 5.2.5.2, Figure 5.2.5.1).

Table 5.2.5.2 Areas of pastures and hayfields for 1990-2021, thousand hectares

Years	Hayfields	Pastures	Years	Hayfields	Pastures
1990	112.7	23362.3	2006	101.7	20751.4
1991	111.0	22878.8	2007	106.6	20765.5
1992	109.3	22869.6	2008	106.7	20739.6
1993	109.4	22855.6	2009	106.6	20670.0
1994	109.6	22532.2	2010	106.6	20649.5

[59] N. Bobokulov, T. Mukimov. Problems of pastures management and solutions (presentation). - Research Institute of Karakul Sheep Breeding and Ecology of Deserts. - Samarkand, 2015

Table 5.2.5.2 continuation

Years	Hayfields	Pastures	Years	Hayfields	Pastures
1995	109.4	22393.3	2011	106.5	20643.9
1996	107.5	22286.1	2012	106.5	20643.8
1997	107.0	22228.4	2013	106.4	20530.5
1998	112.0	22159.0	2014	106.5	21019.1
1999	112.1	22151.3	2015	105.1	21023.3
2000	112.3	22134.1	2016	105.1	21019.3
2001	111.2	22098.5	2017	105.1	21010.1
2002	101.3	21265.7	2018	104.9	20997.6
2003	101.3	21115.8	2019	102.2	21015.8
2004	101.6	21595.5	2020	102.2	21142.1
2005	101.7	21105.7	2021	101.1	21152.0

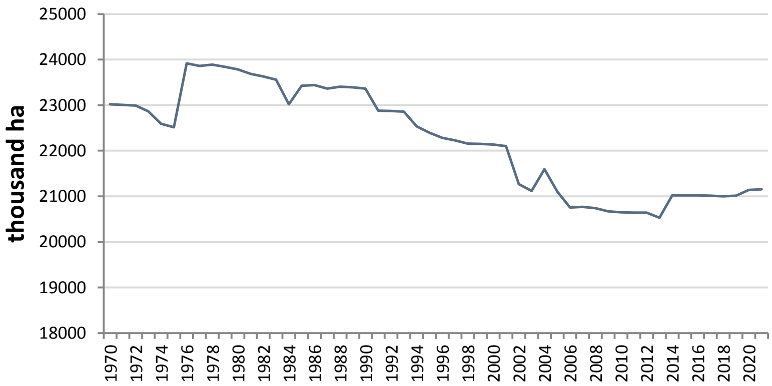

Figure 5.2.5.1 Dynamics of Grassland areas from 1970 to 2021

From the data presented, it follows that pasture areas have gradually reduced since 1978 and have been transferred to other land use categories, mainly to forest land in desert areas.

Emission factors

Default emission factors from Table 2.3 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Vol.4, Part 1, Chapter 5, p.2.37) were used in the estimates of carbon stock changes in ***soils*** on grassland:
Climate region – warm temperate, dry;
Soil type – HAC mineral soils (soils with high activity clay) – used for soils of mountainous and foothill pastures and hayfields. For them, the reference soil organic carbon stock (SOC_{REF}) = 38 t C/ha for 0-30 cm layer.
Soil type – sandy soils – Is used for soils of desert pastures. For them, the reference soil organic C stock (SOC_{REF}) = 19 t C/ha for the 0-30 cm layer.
Relative stock change factors for different management activities on grassland were selected from Table 6.2, p. 6.19 ibid (Table 5.2.5.3).

Table 5.2.5.3 Relative stock change factors (over 20 years) for different management activities on grassland

Subcategory	F_{LU}	F_{MG}	F_1
Hayfields	1±NA	1±NA	not applicable
Desert pastures	1±NA	0.95±13%	not applicable
Foothill and mountain pastures	1±NA	1±NA	not applicable

The land use factor $\mathbf{F_{LU}}$ is assumed to be 1 for all permanent pastures.
The management factor F_{MG} for hayfields and mountain pastures is assumed to be 1 for non-degraded and sustainably managed pastures but without significant improvements in use; for desert pastures it is assumed to be 0.95 for moderately degraded pastures (since there is no detailed information on pasture degradation).
The input factor $\mathbf{F_1}$ is not applicable to the conditions of Uzbekistan.

Uncertainties and time series consistency

Uncertainty of activity data (areas of pastures and hayfields) is about ±2%. Uncertainty of default emission factors – see Table 5.45.

The same method and data sets were used for all years.

Quality assurance/Quality control

QA/QC procedures were performed in accordance with the general QA/QC principles and the QA/QC plan. The following were verified:

- emission sources documentation,
- mechanical errors in data,
- values of emission factors and other calculated parameters used.

Recalculations for the category

No recalculations were made in the Fourth National Communication for the "Grassland Remaining Grassland" category relative to the First Biennial Update Report estimates for the period 1990-2017.

Planned improvements in the category

The next inventory is expected to refine and detail activity data, including data on the areas of pastures of various classes (deserts, mountains and foothills), as well as the degree of degradation for the period from 1970 to the present.

5.2.6 Wetlands (3.B.4 category)

Wetlands include lands covered or saturated with water throughout the year or part of the year, including reservoirs as managed features. Natural rivers and lakes as part of wetlands are classified as unmanaged land.

Uzbekistan has artificial reservoirs as managed lands as part of wetlands. They are intended for irrigation of agricultural lands and water supply, power generation, municipal needs and fisheries, and as collectors for emergency water discharge. Data are currently being collected to make further estimates of CO_2 emissions/removals in the Wetland category.

"NE" keys in the general reporting tables have been used in presenting this GHG emissions inventory for the Wetland category.

5.2.7 Settlements (3.B.5category)

Settlements represent all developed land, including transport infrastructure and settlements of any size, if they are not allocated to other land categories, by national definition.

Currently, data is being collected on settlement areas for further estimates of CO_2 emissions/removals in the Settlements category.

"NE" keys in the general reporting tables have been used in presenting this GHG emissions inventory for the Settlements category.

5.2.8 Other Lands (3.B.6 category)

Other lands include land with soil devoid of vegetation, rocks, ice and all other lands not included in any of the above categories. Other lands refer to unmanaged land.

"NE" keys in the general reporting tables have been used in presenting this GHG emissions inventory for the "Other lands" category.

6. “WASTE” SECTOR

6.1 Sector overview

“Waste” sector covers CH_4 and N_2O greenhouse gas emissions in the following categories:

4.A – Solid Waste Disposal (municipal and industrial);

4.D.1 –Domestic wastewater Treatment and Discharge;

4.D.2 – Industrial Wastewater Treatment and Discharge.

In this inventory, emissions from industrial solid waste were estimated for the first time in the Waste Sector. Recalculations were made in 4.D “Wastewater Treatment and Discharge” category. The increased completeness of source coverage in the “Waste” sector, as well as the recalculations performed relative to the previous inventory estimates for 1990-2017, resulted in an increase in GHG emissions in the sector and a higher contribution of the “Waste” sector to total emissions.

4.C"Waste incineration" category was not covered with the inventory, and the necessary activity data are currently being collected.

In 2021, GHG emissions in the Waste sector amounted to 9,145.93 Gg CO_2-eq. The contribution of the Waste sector to the total emission in 2021 was 4.4%, according to previous estimates - 1.7%.

Emission trends

Table 6.1.1 and Figure 6.1.1 and show the dynamics of methane and nitrous oxide emissions in the "Waste" sector for the period 1990-2021. For the period 1990-2021, sectoral GHG emissions increased by 207%, including:

- CH_4 emissions - by 206%;
- N_2O emission - by 216%.

Table 6.1.1 GHG emissions in the “Waste” sector, Gg CO_2-eq.

Years	CH_4	N_2O	Total	Years	CH_4	N_2O	Total
1990	4013.77	402.34	**4416.11**	2007	5778.40	480.04	**6258.44**
1991	4126.63	411.01	**4537.64**	2008	5919.18	492.47	**6411.64**
1992	4243.88	420.76	**4664.64**	2009	6060.39	532.15	**6592.54**
1993	4357.38	430.43	**4787.81**	2010	6244.94	578.65	**6823.58**
1994	4451.77	438.96	**4890.74**	2011	6427.68	631.69	**7059.37**
1995	4550.55	446.97	**4997.52**	2012	6586.59	660.19	**7246.78**
1996	4655.83	455.60	**5111.43**	2013	6728.06	687.23	**7415.29**
1997	4760.97	427.51	**5188.47**	2014	6907.04	713.64	**7620.68**
1998	4855.02	434.44	**5289.47**	2015	7089.14	738.91	**7828.06**
1999	4949.69	439.15	**5388.84**	2016	7284.16	754.17	**8038.33**
2000	5050.95	377.41	**5428.36**	2017	7472.74	769.31	**8242.05**
2001	5148.77	395.97	**5544.73**	2018	7594.18	791.64	**8385.82**
2002	5292.96	411.11	**5704.07**	2019	7797.94	822.71	**8620.65**
2003	5377.67	428.16	**5805.82**	2020	8015.18	843.38	**8858.56**
2004	5462.79	445.50	**5908.29**	2021	8277.25	868.68	**9145.93**
2005	5547.98	458.77	**6006.76**	$\Delta_{(1990-2021)}$	**+206%**	**+216%**	**+207%**
2006	5659.62	467.01	**6126.63**	**% $_{2021}$**	**90.5%**	**9.5%**	**100.0%**

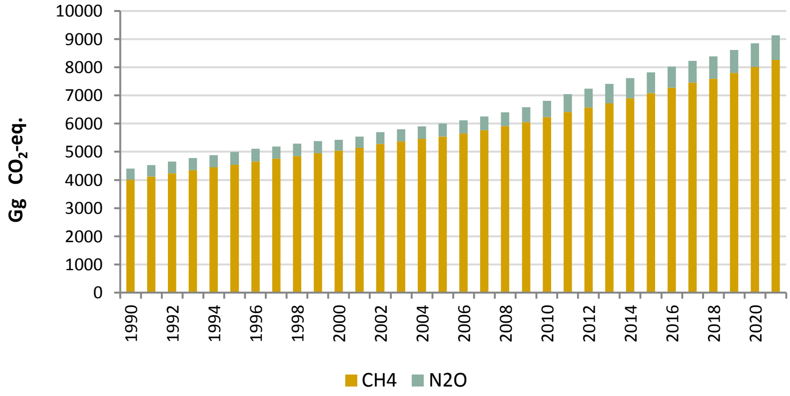

Figure 6.1.1 GHG emissions trend in the “Waste” sector, Gg CO_2-eq.

The main contribution to emissions in the "Waste" sector is made methane, which accounts for 90.5% of the total emissions in the sector; 9.5% is nitrous oxide. Sources of methane emissions in the sector are solid waste landfills, as well as municipal and wastewater. The source of nitrous oxide emissions is municipal wastewater.

Table 6.1.2 and Figure 6.1.2 show the trend of greenhouse gases in the "Waste" sector by main categories.

The "Solid Waste Disposal" category accounts for 51% of sectoral emissions. The contribution to sectoral emissions of the "Domestic Wastewater Treatment and Discharge" category is 47.5%, and the "Industrial Wastewater Treatment and Discharge" category is 1.5%.

Table 6.1.2 GHG emissions in the “Waste” sector by category, Gg CO_2-eq.

Years	Solid Waste Disposal	Industrial Wastewater	Domestic Wastewater	Total	Years	Solid Waste Disposal	Industrial Wastewater	Domestic Wastewater	Total
1990	1761.85	113.88	2540.38	**4416.11**	2007	2890.65	86.92	3280.87	**6258.44**
1991	1835.89	106.62	2595.13	**4537.64**	2008	2973.19	99.84	3338.62	**6411.65**
1992	1909.27	98.68	2656.69	**4664.64**	2009	3062.66	103.14	3426.73	**6592.53**
1993	1974.83	95.23	2717.75	**4787.81**	2010	3158.49	108.99	3556.11	**6823.59**
1994	2039.41	79.7	2771.63	**4890.74**	2011	3261.79	116.38	3681.2	**7059.37**
1995	2101.13	74.22	2822.17	**4997.52**	2012	3372.6	119.3	3754.88	**7246.78**
1996	2162.72	72.05	2876.67	**5111.44**	2013	3489.15	99.49	3826.66	**7415.3**
1997	2223.97	69.85	2894.65	**5188.47**	2014	3612.16	111.48	3897.04	**7620.68**
1998	2286.9	60.95	2941.62	**5289.47**	2015	3741.48	121.31	3965.27	**7828.06**
1999	2350.67	64.67	2973.49	**5388.83**	2016	3878.13	129.33	4030.88	**8038.34**
2000	2414.74	66.55	2947.07	**5428.36**	2017	4020.09	127.4	4094.56	**8242.05**
2001	2479.15	67.22	2998.36	**5544.73**	2018	4164.49	56.28	4165.05	**8385.82**
2002	2544.02	114.5	3045.55	**5704.07**	2019	4317.55	53.38	4249.72	**8620.65**
2003	2609.2	103.19	3093.43	**5805.82**	2020	4488.52	78.12	4291.92	**8858.56**
2004	2674.84	91.75	3141.7	**5908.29**	2021	4667.01	138.77	4340.15	**9145.93**
2005	2743.46	76.77	3186.53	**6006.76**	$\Delta_{(1990-2021)}$	**+265%**	**+22%**	**+171%**	**+207%**
2006	2814.87	83.51	3228.25	**6126.63**	$\%_{2021}$	**51.0%**	**1.5%**	**47.5%**	**100.0%**

For the period 1990-2021, the following increase in emissions by category is observed:

- Solid Waste Disposal - by 265%;
- Industrial Wastewater Treatment and Discharge - by 22%;
- DomesticWastewater Treatment and Discharge - by 171%.

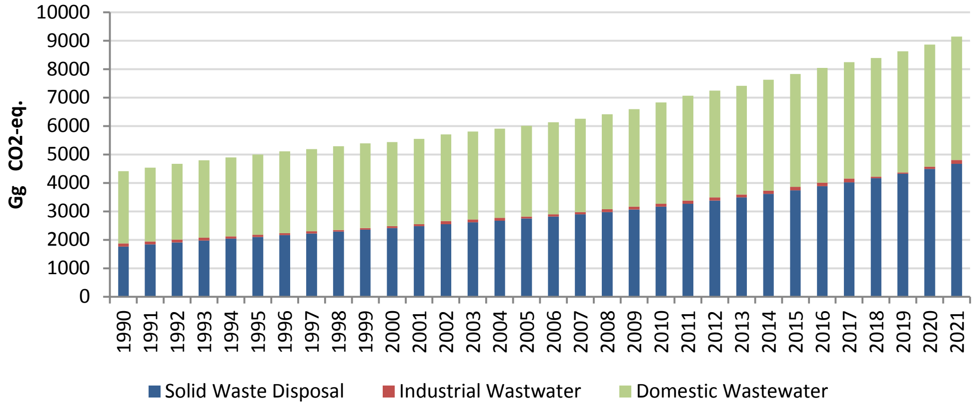

Figure 6.1.2 GHG trend in the "Waste" sector by category

There is a gradual increase in the contribution of the "Solid Waste Disposal" category to sectoral GHG emissions. The increase in emissions in the "Solid Waste Disposal" and "Domestic Wastewater Treatment and Discharge" categories is mainly due to population growth and industrial development.

6.2 Solid Waste Disposal (4.A category)

Category description

Anaerobic decomposition of organic matter in landfills occurs by methanogenic bacteria and results in methane emissions. The amount of methane emitted depends on various physical factors and methods of waste collection and disposal.

There are 2.8 thousand waste collection points and 221 landfills on the territory of the country.

The existing practice of MSW management has so far been aimed exclusively at its collection and transportation to landfills, where MSW is placed mainly without disposal. For these purposes there are 221 landfills in the country, which are managed by organizations of various forms of ownership. The total area of all operating landfills is 1,533.79 hectares, the area of one landfill varies from 0.5 hectares to 60.0 hectares.

The volume of disposed waste according to expert estimates is about 18.54 million tons (2019). The number of MSW landfills is not evenly distributed by location in certain areas.

Characteristics of solid waste landfills. In addition to municipal waste landfills, Uzbekistan has 75 industrial waste landfills, including:

- 14 toxic chemical waste landfills (special landfills -122.32 ha, waste volume - 67.93 thousand tons);
- 21 sludge storage sites (total occupied area - 985,06 ha, waste volume - 251,5 million tons);
- 15 ash and slag disposal sites (occupied area - 7,751.03 ha, waste volume - 2,160.0 million tons);
- 16 industrial waste disposal sites (area - 205.39 ha, waste - 38.2 million tons);
- 4 construction waste landfills (area - 79.91 ha, waste - 2.40 million tons);
- 5 radioactive and hazardous waste disposal sites (total area - 396.36 ha, waste from gold and uranium production - 489.6 million m^3, soil, reinforced concrete and used scrap metal - 27.63 tons).

Currently, according to experts' estimates, all landfills in the country are classified as ***unmanaged landfills*** according to the IPCC classification, as none of the landfills are built according to the requirements of regulatory documents (i.e. impermeable bottom, leachate collection, LFG collection, etc.). Most of the MSW landfills are not equipped with scales for weighing machines, so it is difficult to quantify the mass of waste entering the landfills.

At the same time, the number of landfills deeper than 5 m is about 35%,

The number of unmanaged shallow landfills is 65%.

In 2022, construction of a new landfill that meets modern requirements in was started Tashkent region.

Today, the country has a mechanism for the collection and removal of mainly mixed MSW. The procurement of secondary material resources is carried out through receiving (procurement) points and is mostly unregulated (spontaneous). At the same time, the procurement process covers only highly liquid types of secondary raw materials (paper, plastic products, scrap metal, etc.), as a result of which quite large volumes of other secondary material resources remain unused in recycling and are disposed of. According to expert estimates, the volume of MSW processing as of 2021 is estimated at about 15% on average across the country. It is planned to increase the level of waste recycling to 65% by 2030.

As part of the UNDP/UNEP/Uzhydromet joint project "Green Climate Fund (GCF) Readiness Program in Uzbekistan" (2017-2019), the morphological composition was studied and the actual average MSW generation rate was experimentally determined (for five regions of the country), which amounted to 0.411 kg/day or 150 kg/year.

Coverage of the population with municipal solid waste collection and transportation services. Generally, population of large cities has access to MSW collection and disposal services, while small towns and rural areas (especially remote rural settlements) are characterized by the problem of lack or insufficient level of provision of these services.

In 2018, MSW collection and disposal services covered more than 15.7 million people, or 48% of the total population. It is planned to reach 100% coverage of the population with MSW collection and disposal services by 2030. In Uzbekistan, the Ministry of Ecology, Environmental Protection and Climate Change coordinates municipal solid waste management activities, including the organization of an efficient system of collection, transportation, utilization, recycling and disposal of municipal waste in close cooperation with local authorities and citizens' self-government bodies. It has a Department for waste management coordination and organization.

Industrial waste is not taken to solid municipal waste landfills, there are special landfills for it. The sources of the generation of industrial waste are the faclities of energy, mining and metallurgical, chemical and construction industries. The annual volume of industrial waste generation is about 100 million tons, including toxic waste. The largest amount of industrial waste is generated by mining and processing enterprises located in Navoi, Tashkent and Fergana regions. The bulk of industrial waste is stored in storage tanks and a small part is used as secondary raw materials [60].

Statistical data on waste is given in the context of hazard and toxicity classes. There are no data on waste by industry sector.

In accordance with IPCC requirements, the current inventory used the 2006 IPCC First Order Attenuation methodology, Tier 2 to estimate methane emissions from municipal solid waste landfills instead of the previously used method based on urban population statistics (IPCC Guidelines, 1996). CH_4 emissions from solid waste landfills in 2021 amounted to 4,667.01 Gg CO_2-eq., including: 2,238 Gg CO_2-eq. from municipal waste landfills and 2,429 Gg CO_2-eq. from industrial dumps.

Emission trends

The Solid Waste Disposal category accounts for 51% of emissions in the "Waste" sector.

Table 6.2.1 and Figure 6.2.1 show methane emissions from municipal and industrial solid waste landfills for the period 1990-2021.

Table 6.2.1 CH_4 emissions from Solid Waste Disposal, Gg CO_2-eq.

Years	Municipal	Industrial	Total	Years	Municipal	Industrial	Total
1990	1100.78	661.07	**1761.85**	2007	1759.24	1131.41	**2890.65**
1991	1136.59	699.30	**1835.89**	2008	1791.55	1181.63	**2973.19**
1992	1173.95	735.32	**1909.27**	2009	1823.74	1238.93	**3062.66**
1993	1213.10	761.73	**1974.83**	2010	1855.81	1302.67	**3158.49**
1994	1253.99	785.42	**2039.41**	2011	1889.04	1372.75	**3261.79**
1995	1296.34	804.78	**2101.13**	2012	1923.15	1449.46	**3372.60**
1996	1340.03	822.69	**2162.72**	2013	1956.52	1532.63	**3489.15**
1997	1383.28	840.69	**2223.97**	2014	1989.19	1622.97	**3612.16**
1998	1426.06	860.84	**2286.90**	2015	2021.22	1720.25	**3741.48**
1999	1468.04	882.64	**2350.67**	2016	2052.60	1825.53	**3878.13**
2000	1508.63	906.11	**2414.74**	2017	2083.20	1936.89	**4020.09**
2001	1548.16	930.99	**2479.15**	2018	2112.86	2051.63	**4164.49**
2002	1586.49	957.54	**2544.02**	2019	2144.48	2173.08	**4317.55**
2003	1623.56	985.65	**2609.20**	2020	2186.68	2301.85	**4488.52**
2004	1659.29	1015.55	**2674.84**	2021	2237.99	2429.02	**4667.01**
2005	1693.66	1049.80	**2743.46**	$\Delta_{(1990-2021)}$	**2.0 fold**	**3.7 fold**	**2.6 fold**
2006	1726.66	1088.21	**2814.87**	$\%_{2021}$	**48.0%**	**52.0%**	**100.0%**

60 National Report on the state of the environment and the use of natural resources in the Republic of Uzbekistan (2008-2011). – Tashkent, "Chinor ENK", 2013. – 254 p.

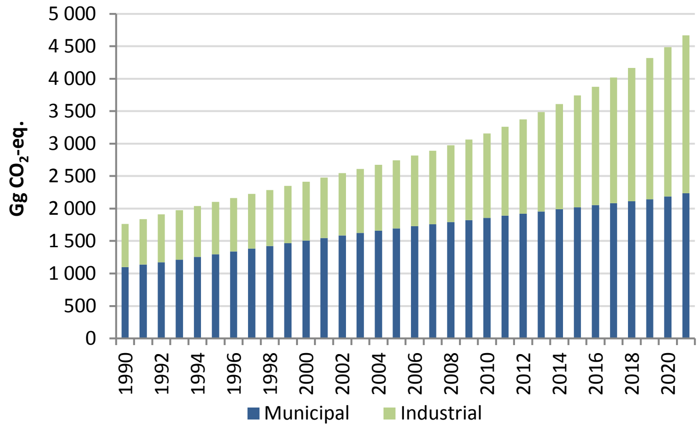

Figure 6.2.1 Trend of CH_4 emissions from Solid Waste Disposal

Methane emissions in the “Solid Waste Disposal" category for the period 1990-2021 increased by 2.6 times. At the same time, methane emissions from municipal solid waste increased by 2 times, and from industrial waste by 3.7 times.

The increase in methane emissions over the entire period under review from municipal waste is due to a growth of the population covered by centralized waste collection, as well as an increase in the waste generation rate per capita.

The increase in methane emissions from industrial waste is associated with increased GDP growth rates, as well as increased production in the mining and processing industries.

Methodology

CH_4 emissions from ***municipal solid waste (MSW) landfills*** were estimated in accordance with the IPCC Guidelines, 2006, using the First Order Decay (FOD), Tier 2 methodology. The calculations used national data on the morphological composition of MSW, taking into account the characteristics of landfills. The FOD model is based on *Equations 3.4 and 3.5* of the IPCC Guidelines, 2006, Vol. 5, Chapter 3.

The main input data required to calculate CH_4 emissions from landfill disposal sites were information on annual waste disposal volumes, their morphological composition and DOC content in various types of waste.

Data on the morphological composition of waste for 2017 and subsequent years were taken from research results conducted in 2017-2018 as part of the UNDP/UNEP/Uzhydromet joint project "Green Climate Fund (GCF) Readiness Program in Uzbekistan". For the period 1950-1970s, literature data were used [61]. For the period 1980-1990s, information from SanPin of the Republic of Uzbekistan No. 0068-96 was used [62]. Intermediate indicators for 1996-2016 were calculated using the interpolation method. The obtained data on morphological composition of municipal solid waste are given in Table 6.2.2.

Table 6.2.2 Morphological composition of municipal solid waste

Years	Fractions, %						
	Paper	Food waste	Waste generated in gardens and parks	Wood waste and straw	Textile	Disposable diapers	Plastic and more
1950-1995	18.9	38.4	12.9	4.9	3.9	0	21.0
1996	18.2	37.9	12.9	4.7	3.9	0.2	22.2
1997	17.5	37.4	12.9	4.6	3.8	0.4	23.4
1998	16.8	36.9	12.9	4.4	3.8	0.6	24.6
1999	16.0	36.4	12.9	4.3	3.8	0.8	25.8
2000	15.3	35.9	12.9	4.1	3.8	1.0	27.0
2001	14.6	35.4	12.9	4.0	3.7	1.2	28.2
2002	13.9	34.9	12.9	3.8	3.7	1.4	29.4
2003	13.2	34.4	12.9	3.6	3.7	1.6	30.6
2004	12.5	33.9	12.9	3.5	3.7	1.8	31.8
2005	11.8	33.4	12.9	3.3	3.6	2.0	33.0
2006	11.1	33.0	12.9	3.2	3.6	2.2	34.2

61 Sanitation and cleaning of populated places. Handbook ed. A.N. Mirny, Moscow, Stroyizdat, 1990 (p. 6)

62 Sanitary Rules for the collection, storage, transportation, neutralization and disposal of municipal solid waste (MSW) in the cities of the Republic of Uzbekistan. SanPin RUz No. 0068-96, Tashkent 1996. - 20 p.

Table 6.2.2 continuation

Years	Fractions, %						
	Paper	Food waste	Waste generated in gardens and parks	Wood waste and straw	Textile	Disposable diapers	Plastic and more
2007	10.3	32.5	12.9	3.0	3.6	2.3	35.4
2008	9.6	32.0	12.9	2.8	3.5	2.5	36.6
2009	8.9	31.5	12.9	2.7	3.5	2.7	37.8
2010	8.2	31.0	12.9	2.5	3.5	2.9	39.0
2011	7.5	30.5	12.9	2.4	3.5	3.1	40.2
2012	6.8	30.0	12.9	2.2	3.4	3.3	41.4
2013	6.1	29.5	12.9	2.1	3.4	3.5	42.6
2014	5.3	29.0	12.9	1.9	3.4	3.7	43.8
2015	4.6	28.5	12.9	1.7	3.4	3.9	45.0
2016	3.9	28.0	12.9	1.6	3.3	4.1	46.2
2017	3.2	27.5	12.9	1.42	3.3	4.3	47.4
2018	3.2	27.5	12.9	1.42	3.3	4.3	47.4
2019	3.2	27.5	12.9	1.42	3.3	4.3	47.4
2020	3.2	27.5	12.9	1.42	3.3	4.3	47.4
2021	3.2	27.5	12.9	1.42	3.3	4.3	47.4

With regard to dried sewage sludge (activated sludge from water treatment systems), there is expert information that it is not disposed of in MWS landfills, but is stored separately. Data on combined sludge amounts are currently not available and this type of waste has not been taken into account in the calculations.

Accepted assumptions used in the calculations. It is assumed that all MSW landfills in Uzbekistan are categorized as unmanaged. Unmanaged landfills are divided into deep (more than 5 m) and shallow (less than 5 m). Changes in the shares of deep and shallow landfills over time, according to expert estimates, are given in Table 6.2.3.

Table 6.2.3 Types of landfills, share in total number

Types of landfills	1950.	2005.	2017
Unmanaged – deep (>=5 m waste)	0,10	0,21	0,35
Unmanaged – shallow (< 5 m waste)	0,90	0,79	0,65

It was assumed that in 1950, the share of deep landfills in total number was 10%, gradually increasing to 21% in 2005 and then to 35% in 2017. This value is then assumed to remain unchanged until new data are available.

The share of waste disposed of in landfills is assumed to be 90% of MSW generated, with the amount of waste generated obtained by multiplying the total population by the waste generation rate (Table 6.6). For the period 1950-1995, the waste recovery rate was assumed to be 5%, increasing to 15% by 2017 and remaining unchanged until updated data are available. Linear interpolation methods were used to fill in intermediate data.

Due to the lack of information on LFG utilization, the methane recovery rate is assumed to be zero.

CH_4 emissions ***from industrial waste landfills*** were estimated in accordance with the IPCC Guidelines, 2006, using the First Order Decay (FOD), Tier 1 methodology (electronic annex to Vol.5 of the IPCC Guidelines) using GDP data.

Due to the lack of actual evidence, *it was assumed* that the share of industrial waste containing degradable carbon (DOC) = 0.015, as opposed to the default value of 0.15. The assumption was based on the average composition of industrial waste, which is dominated by mineral components of inorganic origin [63]. It is assumed that carbon degradable with the formation of methane is contained in the waste from food, textile, and paper industries.

Activity data

Municipal solid waste. Due to the lack of reliable and complete statistical data on the volumes of municipal solid waste disposed of in landfills, data of the Statistics Agency on the average annual population of Uzbekistan for the period 1990-2021 were used for methane emission calculations. Population data for 1960-1989 were obtained from the World Bank database. Data for 1950-1959 were obtained by linear interpolation of available data.

Available data for individual years were used to account for the number of the population covered by solid waste collection services. The number of the population covered by centralized MSW collection services in 2018 was 48%

63 National Report on the state of the environment and use of natural resources in the Republic of Uzbekistan (2008-2011). – Tashkent, "Chinor ENK", 2013. – 254 p.

and increased to 57% by 2021. It was assumed that before 2018, population coverage was also 48% (including only the urban population). To estimate the country's population for the period 1960-1989 were used World Bank data for Uzbekistan, for the period 1990-2021 – national statistical data, and for the period 1950-1960 - extrapolated World Bank data.

The resulting data series on the population covered by waste collection services is given in Table 6.2.4.

Table 6.2.4 Estimated amount of municipal solid waste generation for 1990-2021, thousand tons

Years	Population, million people		Estimated volume of solid waste, thousand tons	Years	Population, million people		Estimated volume of solid waste, thousand tons
	Total	Covered by services			Total	Covered by services	
1990	20.510	9.845	6153.000	2006	26.488	12.714	98946.229
1991	20.952	10.057	6379.523	2007	26.868	12.897	10107.927
1992	21.449	10.296	6627.001	2008	27.303	13.105	10393.970
1993	21.942	10.532	6877.682	2009	27.767	13.328	10695.082
1994	22.377	10.741	7114.343	2010	28.562	13.710	11129.331
1995	22.785	10.937	7346.198	2011	29.339	14.083	11563.613
1996	23.225	11.148	7592.172	2012	29.775	14.292	11868.931
1997	23.667	11.360	7842.754	2013	30.243	14.517	12191.058
1998	24.051	11.544	8077.819	2014	30.758	14.764	12536.537
1999	24.312	11.670	8274.463	2015	31.299	15.024	12897.347
2000	24.650	11.832	8500.000	2016	31.848	15.287	13266.339
2001	24.964	11.983	8720.183	2017	32.389	15.547	13636.886
2002	25.272	12.131	8941.059	2018	32.956	15.819	14023.346
2003	25.568	12.273	9160.397	2019	33.580	17.126	14439.400
2004	25.864	12.415	9382.389	2020	34.232	18.485	14719.760
2005	26.167	12.560	9609.605	2021	34.915	19.902	15013.450

The value of the waste generation coefficient (kg/person/year) for the period 1950-1990 was obtained on the basis of literature data and is equal to 300 kg/person/year; for 2019-2022 the coefficient value was 430 kg/person/year (according to data on the actual generation of solid waste given in the Solid Waste Management Strategy (2019)). Intermediate coefficient values for the period 1990-2018 calculated used the interpolation method. For 2019-2022 the coefficients have the same values. This coefficient was assumed to be the same for the entire territory of the country.

It was also assumed that the population not covered by waste collection services takes it to spontaneous shallow landfills that do not produce methane.

Industrial waste. There is no information on solid waste disposal from individual industries. There are data for the period 2010-2017 on the total amount of industrial waste generated in the amount of about 100 million tons/year.

Industrial waste landfills are concentrated mainly in the Navoi region in the central part of the country, as well as in the vicinity of the Tashkent, Almalyk and Chirchik cities. According to the Ministry of Ecology, Environmental Protection and Climate Change, the total volume of industrial waste is dominated by mineral waste from mining and processing industry, ash and slag from TPPs, and construction waste. At the same time, the bulk of wood from construction waste is reused and is not subject to disposal in landfills.

Due to the lack of annual data on industrial waste generation until 2010, in accordance with the recommendations of the IPCC, the dynamics of the country's GDP growth in billion US dollars was used:

- since 1960 according to the World Bank data;
- for the period 1950-1959 was calculated by extrapolation method;
- for 1990-2021 according to statistical data.

The industrial waste generation rate (thousand tons/GDP/year) was calculated according to the data of the Ministry of Ecology, Environmental Protection and Climate Change on industrial waste generation for 2010-2017, which averaged 1.2 thousand tons/GDP/year.

Assumptions:

– Share of degradable organic carbon to form methane (DOC) is equal to 0.015 (instead of the default 0.15). This is its content in waste from food, textile, and paper industries. The bulk of industrial waste does not contain organic biodegradable carbon;

– share of industrial waste recycling is 50% for the entire time series.

The calculated volumes of ***industrial waste*** generation are given in Table 6.2.5.

Table 6.2.5. Estimated amount of industrial waste generation for 1990-2021, thousand tons

Years	GDP, million US dollars (2015)	Waste generation rate, kg/USD(2015)/year	Estimated volume of waste, thousand tons	Years	GDP, million US dollars (2015)	Waste generation rate, kg/USD(2015)/year	Estimated volume of waste, thousand tons
1990	32110	1.2	38532.0	2006	43870	1.2	52644.0
1991	31952	1.2	38342.4	2007	48026	1.2	57631.2
1992	28373	1.2	34047.6	2008	52363	1.2	62835.6
1993	27721	1.2	33265.2	2009	56578	1.2	67893.6
1994	26279	1.2	31534.8	2010	60877	1.2	73052.4
1995	26043	1.2	31251.6	2011	65458	1.2	78549.6
1996	26485	1.2	31782.0	2012	70107	1.2	84128.4
1997	27863	1.2	33435.6	2013	75222	1.2	90266.4
1998	29061	1.2	34873.2	2014	80393	1.2	96471.6
1999	30310	1.2	36372.0	2015	86196	1.2	103435.2
2000	31473	1.2	37767.6	2016	91310	1.2	109572.0
2001	32783	1.2	39339.6	2017	95323	1.2	114387.6
2002	34086	1.2	40903.2	2018	100928	1.2	121113.6
2003	35528	1.2	42633.6	2019	106965	1.2	128358.0
2004	38175	1.2	45810.0	2020	109099	1.2	130918.8
2005	40828	1.2	48993.6	2021	117176	1.2	140611.2

Emission factors and other parameters used in calculations

Emission factors and other parameters used to estimate methane emissions from municipal solid waste. To calculate the total amount of municipal solid waste, national values of the **generation rate** (kg/person-year) were used.

The value of this rate for the period 1950-1990 is based on literature data =300 kg/person/year.

For the last 2019-2021, the generation rate was 430 kg/person/year; it is calculated based on the data on the actual MSW generation f given in the "Strategy for Solid Waste Management for the period up to 2030" [64] and population statistics.

Intermediate values for the period 1990-2017 were calculated by interpolation method.

Methane conversion factor (MCF) by landfill type, degradable organic carbon (DOC), degradable organic carbon fraction (DOCf), and some other parameters were assumed by default due to the lack of national data.

The default values used for MSW were taken from the 2006 IPCC Guidelines (Table 6.2.6).

Table 6.2.6 Default factors used in calculations of methane emissions from MSW landfills

Fractions	DOC	Reaction rate constant k (climate: dry temperate)
Food waste	0,15	0,06
Waste generated in gardens and parks	0,2	0,05
Paper	0,4	0,04
Wood waste and straw	0,43	0,02
Textile	0,24	0,04
Disposable diapers	0,24	0,05
DOCf	0,5	
Delay time	6 months	
Volume fraction of methane in landfill gas (F)	0,5	
Conversion factor (CH_4/C)	1,33	
Oxidation factor (OX)	0	
Amount of methane recovered per year (R)	0	

64 Resolution of the President of the Republic of Uzbekistan № PR-4291 dated 17.04.2019 "On Approval of the Strategy on Solid Waste Management in the Republic of Uzbekistan for the period 2019-2028"

The factors and parameters used to estimate methane emissions from industrial waste were taken from the IPCC Guidelines, 2006 (Table 6.2.7).

Table 6.2.7 Factors used in methane emissions calculations from Industrial Waste

Factor	Value	Note
Waste generation rate, kg/USD(2015)/year	1,2	National [65]
Recycling share, %	50	default
DOC, share	0,015	National [66]

Uncertainties and consistency of time series

The uncertainty in emission estimates from waste disposal in landfills consists of uncertainties in the estimation parameters. Statistical data (population and GDP) have a fairly high accuracy, so their uncertainty is assumed to be equal to ±5%.

The estimated value of the combined uncertainty associated with the default parameters used in the calculation of the FOD model is ±51.2%. It consists of the following values [67] - Table 6.2.8.

Table 6.2.8 Uncertainties associated with the default parameters used in the FOD method

Parameter	Range of uncertainty
Share of MSW placed in landfills (MSW_F)	±30%
Degradable organic carbon (DOC)	±20%
Fraction of degradable organic carbon actually degraded (DOC_f)	±20%
Methane Correction Factor (MCF): for unmanaged deep landfills 0.8 for unmanaged shallow landfills 0.4	 ±20% ±30%
Fraction of methane in landfill gas (F)=0.5	±5%

Methodological approach 1 was chosen to assess uncertainty.

The combined uncertainty of methane emissions estimates from the Solid waste disposal category is 51.5%.

The time series of dynamics of methane emissions from municipal and industrial solid waste landfills is homogeneous and consistent.

Gaps in the source initial data (population, GDP) were filled using extrapolation methods. Changes in the morphological composition of municipal waste over time were accounted for using interpolation methods.

Quality assurance/Quality control

In preparing this inventory, all data used have undergone quality control checks consistent with the use of the Tier 2 methodology. This included verification of initial activity data, emission factor values, waste morphological composition data and waste generation rate per capita. The obtained estimates were compared with inventories of other countries. Reliability of the obtained estimates of methane emissions by category was verified by independent national experts.
QA/QC procedures were performed in accordance with the general QA/QC principles and the QA/QC plan.

Recalculations for category

Methane emissions for 4.A category were recalculated relative to previous estimates of the First Biennial Update Report (FBUR, 2021) for the period 1990-2017. The reasons for the recalculation were:
- methane emissions estimates from industrial waste, performed for the first time to improve the completeness of emission sources covered with the inventory;
- changes in the methodology for estimating methane emissions from MSW landfills in accordance with the requirements of the IPCC Waste Model FOD Software;
- refinements to the activity data regarding population and waste morphological composition.
The FBR estimated methane emissions from municipal waste and urban population only.

65 www.uznature.uz, www.stat.uz Industrial waste generation and GDP statistics (2010-2017).
66 Expert estimates
67 Estimated uncertainties associated with activity data and default parameters used in the FOD method for CH4 emissions from solid waste landfills - IPCC, 2006, Vol. 5, Chapter 3, Table 3.5.

The results obtained are given in Table 6.2.9.

Table 6.2.9 Results of recalculations of methane emissions for 4.A "Solid Waste Disposal" category relative to the First Biennial Update Report estimates, Gg CO_2-eq.

Years	FNC	FBUR	Difference	Years	FNC	FBUR	Difference
1990	1761.85	1582.08	179.77	2004	2674.84	2135.08	539.76
1991	1835.89	1637.68	198.21	2005	2743.46	2117.15	626.31
1992	1909.27	1692.30	216.97	2006	2814.87	2098.38	716.49
1993	1974.83	1746.25	228.58	2007	2890.65	2087.48	803.17
1994	2039.41	1798.92	240.49	2008	2973.19	2075.70	897.49
1995	2101.13	1850.38	250.75	2009	3062.66	2100.28	962.38
1996	2162.72	1900.68	262.04	2010	3158.49	2121.80	1036.69
1997	2223.97	1947.30	276.67	2011	3261.79	2141.55	1120.24
1998	2286.90	1990.50	296.40	2012	3372.60	2157.45	1215.15

The methane emission estimates obtained in the Fourth National Communication for the "Solid Waste Disposal" category are 1.1-2.0 times higher than those obtained in the previous inventory.

Planned improvements in the category

In the future, as part of the preparation of the Fifth National Communication, to refine the methane emission estimates in 5.A "Solid waste disposal" category, it is planned to:

- refine data on industrial waste generation volumes and patterns by industry sector when the relevant data become available;
- conduct research and collect the necessary historical data for a refined estimate of methane emissions from municipal waste landfills, taking into account the actual coverage of the population with waste collection services;
- conduct research on the morphological composition of waste in rural areas;
- strengthen further cooperation with the Ministry of Ecology, Environmental Protection and Climate Change and the Statistics Agency to improve the quality of source data.

6.3 Biological Treatment of Solid Waste (4.B category)

Composting and other methods of biological treatment of MSW are not widely practiced in Uzbekistan. This is mainly due to the lack of introduction of separate MSW collection.

For further estimations, more detailed information on the use of composting in the country needs to be collected.

In presenting this GHG emissions inventory for the "Biological treatment of solid waste" category in the general reporting tables, "NE" keys were used.

6.4 Incineration and Open Burning of Waste (4.C category)

There is no practice of solid waste incineration in the country. There are no records and reports on the amount of MSW incinerated for the period 1990-2020 in the country. Accounting of the number of the population burning MSW is also not available. However, there is no doubt that such solid waste management practices exist in rural areas. Further research and data collection in the "Open waste burning" category is needed to estimate emissions in the category.

In presenting this GHG emissions inventory for the "Incineration and open burning of Waste" category in the general reporting tables, the 'NE' keys were used.

6.5 Wastewater Treatment and Discharge (4.D category)

In 4.D "Wastewater Treatment and Discharge" category, CH_4 emissions from municipal and industrial wastewater treatment and indirect N_2O emissions from human activity from wastewater disposal are estimated.

Methane generation in wastewater occurs only under anaerobic conditions, and the main factor determining potential methane generation is the amount of organic material in the wastewater stream and physical parameters (temperature).

- For domestic and commercial wastewater and sludge waste, the amount of methane generation is quantified by the biochemical oxygen demand (BOD) of the wastewater, i.e., the amount of oxygen consumed by the organic material in the wastewater during the degradation period.
- For industrial waters, the chemical oxygen demand (COD) indicator is used to show the total amount of carbon available for oxidation, both biodegradable and resistant to degradation.

In Uzbekistan, industrial wastewater is only partially treated and then mixed with municipal wastewater in a common treatment system, thus ending up in surface water. The country has developed food, oil refining, and textile industries, and the volumes of effluent wastewater from these industries were analyzed. Methane generation occurs mainly at the stage of their processing. The insignificant amount of methane emissions from industrial wastewater is partly due to incomplete accounting of industrial activities, including the lack of developed standards for wastewater generation per unit of production.

Where there is centralized sewerage, municipal wastewater is completely discharged to treatment facilities. According to the Institute of Forecasting and Macroeconomic Research in Uzbekistan, about 84% of households do not have access to centralized sewerage and use pit latrines as toilets. The use of septic tanks is not yet a common practice.

This inventory estimated GHG emissions from domestic wastewater covering the entire population of the country, while the 1990-2017 inventory estimated emissions from only the sewered portion of the country's population. This recalculation resulted in significantly higher GHG emission estimates in the “Wastewater treatment and discharge” category. Also, in the "Industrial Wastewater Treatment and Discharge" subcategory, recalculations were performed using a refined emission factor, which also resulted in higher emission values in the "Wastewater treatment and discharge" category, relative to the FBUR data.

According to the updated estimates in 2021, methane emissions from wastewater treatment and discharge amounted to 3,610.34 Gg CO_2-eq., nitrous oxide - 868.68 Gg CO_2-eq.Total GHG emissions in the "Wastewater treatment and discharge" category amounted to 4,479.02 Gg CO_2-eq (Table 6.5.1 and Figure 6.5.1).

Table 6.5.1 GHG emissions in the “Wastewater Treatment and Discharge” category

Years	CH_4	N_2O	Total	Years	CH_4	N_2O	Total
1990	2248.87	402.34	**2651.21**	2007	2887.35	480.04	**3367.40**
1991	2287.52	411.01	**2698.53**	2008	2945.98	492.47	**3438.44**
1992	2332.23	420.76	**2752.99**	2009	2997.73	532.15	**3529.88**
1993	2380.07	430.43	**2810.50**	2010	3086.43	578.65	**3665.08**
1994	2409.94	438.96	**2848.91**	2011	3165.88	631.69	**3797.58**
1995	2447.02	446.97	**2893.99**	2012	3213.99	660.19	**3874.18**
1996	2491.89	455.60	**2947.49**	2013	3238.88	687.23	**3926.11**
1997	2536.09	427.51	**2963.60**	2014	3294.80	713.64	**4008.44**
1998	2566.72	434.44	**3001.17**	2015	3347.76	738.91	**4086.67**
1999	2597.34	439.15	**3036.49**	2016	3406.16	754.17	**4160.33**
2000	2634.31	377.41	**3011.72**	2017	3452.75	769.31	**4222.06**
2001	2668.17	395.97	**3064.14**	2018	3429.81	791.64	**4221.45**
2002	2747.54	411.11	**3158.65**	2019	3480.33	822.71	**4303.04**
2003	2766.95	428.16	**3195.11**	2020	3526.59	843.38	**4369.97**
2004	2786.88	445.50	**3232.38**	2021	3610.34	868.68	**4479.02**
2005	2803.43	458.77	**3262.20**	$\Delta_{(1990-2021)}$	**+160.5%**	**+215.9%**	**+168.9%**
2006	2844.44	467.01	**3311.45**	$\%_{2021}$	**80.6%**	**19.4%**	**100.0%**

The largest contributor to emissions in the "Wastewater Treatment and Discharge" category is methane emissions - 80.6% (in 2021). Increase in methane emissions for 1990-2021 amounted to 160%. The major contributor to methane emissions is the "Domestic wastewater Treatment and Discharge" category. The increase in methane emissions is mainly related to the growth of the country's population, as well as to the increase in food and textile industry production.

Indirect nitrous oxide emissions account for 19.5% of GHG emissions in the "Wastewater treatment and discharge" category for 2021. These emissions occur in the “Domestic wastewater Treatment and Discharge” category. For the period 1990-2021, the increase in nitrous oxide emissions was 215.9%. The increase in nitrous oxide emissions in this category is due to the country's population growth as well as an increase in total protein consumption.

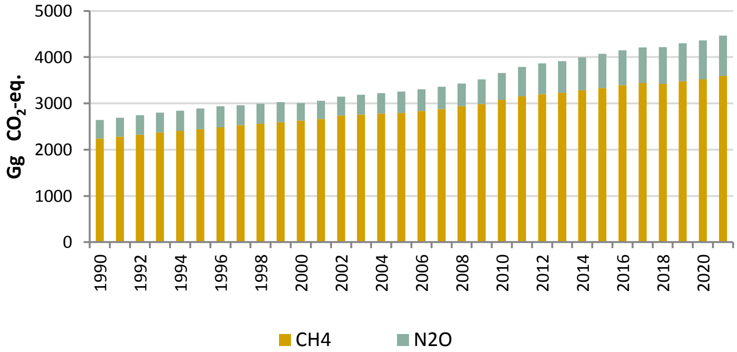

Figure 6.5.1 Trends in GHG emissions in the "Wastewater Treatment and Discharge" category

Table 6.5.2 and Figure 6.5.2 show emission trends by individual categories of “Wastewater Treatment and Discharge”. In 2021, GHG emissions were as follows:

- from domestic wastewater – 4,340.15 Gg CO_2-eq.,

- from industrial wastewater - 138.87 Gg CO_2-eq.

Total for the "Wastewater Treatment and Discharge" category is 4,479.02 Gg CO_2-eq.

Table 6.5.2 GHG emissions in the “Wastewater Treatment and Discharge” category by subcategory

Years	Domestic	Industrial	Total	Years	Domestic	Industrial	Total
1990	2540.38	110.82	**2651.20**	2007	3280.87	86.52	**3367.39**
1991	2595.13	103.40	**2698.53**	2008	3338.62	99.82	**3438.44**
1992	2656.69	96.30	**2752.99**	2009	3426.73	103.15	**3529.88**
1993	2717.75	92.75	**2810.50**	2010	3556.11	108.97	**3665.08**
1994	2771.63	77.27	**2848.90**	2011	3681.20	116.37	**3797.57**
1995	2822.17	71.82	**2893.99**	2012	3754.88	119.3	**3874.18**
1996	2876.67	70.82	**2947.49**	2013	3826.66	99.45	**3926.11**
1997	2894.65	68.95	**2963.60**	2014	3897.04	111.40	**4008.44**
1998	2941.62	59.55	**3001.17**	2015	3965.27	121.40	**4086.67**
1999	2973.49	63.00	**3036.49**	2016	4030.88	129.45	**4160.33**
2000	2947.07	64.65	**3011.72**	2017	4094.56	127.50	**4222.06**
2001	2998.36	65.77	**3064.13**	2018	4165.05	56.40	**4221.45**
2002	3045.55	113.10	**3158.65**	2019	4249.72	53.32	**4303.04**
2003	3093.43	101.67	**3195.10**	2020	4291.92	78.05	**4369.97**
2004	3141.7	90.67	**3232.37**	2021	4340.15	138.87	**4479.02**
2005	3186.53	75.67	**3262.20**	$\Delta_{(1990-2021)}$	**+170.8%**	**+25.3%**	**+168.9%**
2006	3228.25	83.20	**3311.45**	$\%_{2021}$	**96.9%**	**3.1%**	**100.0%**

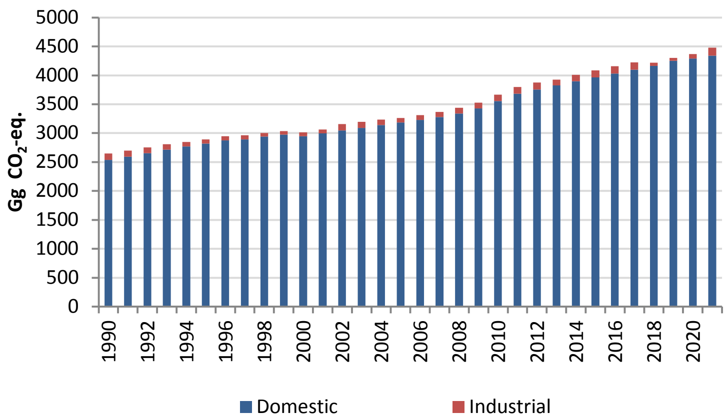

Figure 6.5.2 Trends in GHG emissions in the “Wastewater Treatment and Discharge” category by subcategory

The largest contributor to GHG emissions in the "Wastewater Treatment and Discharge" category is the "Domestic Wastewater Treatment and Discharge" category. According to the results of 2021, it accounts for 96.9% of total emissions, while GHG emissions from industrial wastewater account for only 3.1%.

For the period 1990-2021, the increase in GHG emissions in the "Domestic wastewater Treatment and Discharge" category amounted to 170.8%; in the "Industrial wastewater Treatment and Discharge" category - 25.3%.

Recalculations for the “Wastewater Treatment and Discharge” category

GHG emissions in the 4.D “Wastewater Treatment and Discharge” category were recalculated relative to previous estimates of the First Biennial Update Report (FBUR, 2021) for the period 1990-2017. The reasons for the recalculation were:

- refinements in the activity data regarding the population included in the calculations;
- refinements in emission factors for the "Domestic wastewater" and "Industrial wastewater" categories.

The results obtained are given in Table 6.5.3.

Table 6.5.3 Results of recalculations of methane emissions for the 4.D "Wastewater Treatment and Discharge" category relative to the First Biennial Update Report estimates, Gg CO_2-eq.

Years	FNC	FBUR	Difference	Years	FNC	FBUR	Difference
1990	2540.38	276.34	2264.04	2004	3141.70	282.56	2859.14
1991	2595.13	273.36	2321.77	2005	3186.53	272.58	2913.95
1992	2656.69	271.07	2385.62	2006	3228.25	284.41	2943.84
1993	2717.75	272.86	2444.89	2007	3280.87	287.52	2993.35
1994	2771.63	267.42	2504.21	2008	3338.62	296.54	3042.08
1995	2822.17	261.75	2560.42	2009	3426.73	313.98	3112.75
1996	2876.67	264.65	2612.02	2010	3556.11	323.11	3233.00
1997	2894.65	258.71	2635.94	2011	3681.20	337.26	3343.94
1998	2941.62	256.48	2685.14	2012	3754.88	341.27	3413.61
1999	2973.49	249.06	2724.43	2013	3826.66	381.11	3445.55
2000	2947.07	251.58	2695.49	2014	3897.04	439.22	3457.82
2001	2998.36	256.76	2741.60	2015	3965.27	497.91	3467.36
2002	3045.55	282.76	2762.79	2016	4030.88	544.98	3485.90
2003	3093.43	290.03	2803.40	2017	4094.56	589.28	3505.28

The estimates of GHG emissions for the “Wastewater Treatment and Discharge” category obtained in the Fourth National Communication (FNC) are significantly higher than those obtained in the previous inventory.
As a result of the recalculations, the category's contribution to the “Waste” sector increased from 19% (FBUR) to 49%.

6.5.1 Domestic Wastewater Treatment and Discharge (4.D.1 category)

Category description

The category estimated CH_4 emissions from domestic wastewater and indirect N_2O emissions from human activity. The category’s contribution to the “Waste” sector emissions in 2021 amounted to 47.5%.

Emission trends

Table 6.5.1.1 and Figure 6.5.1.1 show the change in greenhouse gas emissions from domestic wastewater for the period 1990-2021. The increase in methane and nitrous oxide emissions in this category is associated with an increase in population and an increase in overall protein consumption.

Table 6.5.1.1 GHG emissions from Domestic Wastewater Treatment and Discharge, Gg CO_2-eq.

Years	CH_4	N_2O	Total	Years	CH_4	N_2O	Total
1990	2138.04	402.34	**2540.38**	2007	2800.83	480.04	**3280.87**
1991	2184.12	411.01	**2595.13**	2008	2846.15	492.47	**3338.62**
1992	2235.93	420.76	**2656.69**	2009	2894.58	532.15	**3426.73**
1993	2287.32	430.43	**2717.75**	2010	2977.46	578.65	**3556.11**
1994	2332.67	438.96	**2771.63**	2011	3049.51	631.69	**3681.20**
1995	2375.20	446.97	**2822.17**	2012	3094.69	660.19	**3754.88**
1996	2421.07	455.60	**2876.67**	2013	3139.43	687.23	**3826.66**
1997	2467.14	427.51	**2894.65**	2014	3183.40	713.64	**3897.04**
1998	2507.17	434.44	**2941.62**	2015	3226.36	738.91	**3965.27**
1999	2534.34	439.15	**2973.49**	2016	3276.71	754.17	**4030.88**
2000	2569.66	377.41	**2947.07**	2017	3325.25	769.31	**4094.56**
2001	2602.39	395.97	**2998.36**	2018	3373.41	791.64	**4165.05**
2002	2634.44	411.11	**3045.55**	2019	3427.01	822.71	**4249.72**
2003	2665.27	428.16	**3093.43**	2020	3448.54	843.38	**4291.92**
2004	2696.20	445.5	**3141.70**	2021	3471.47	868.68	**4340.15**
2005	2727.75	458.77	**3186.53**	$\Delta_{(1990-2021)}$	**+162.0%**	**+216.0%**	**+171.0%**
2006	2761.24	467.01	**3228.25**	$\%_{2021}$	**80.0%**	**20.0%**	**100.0%**

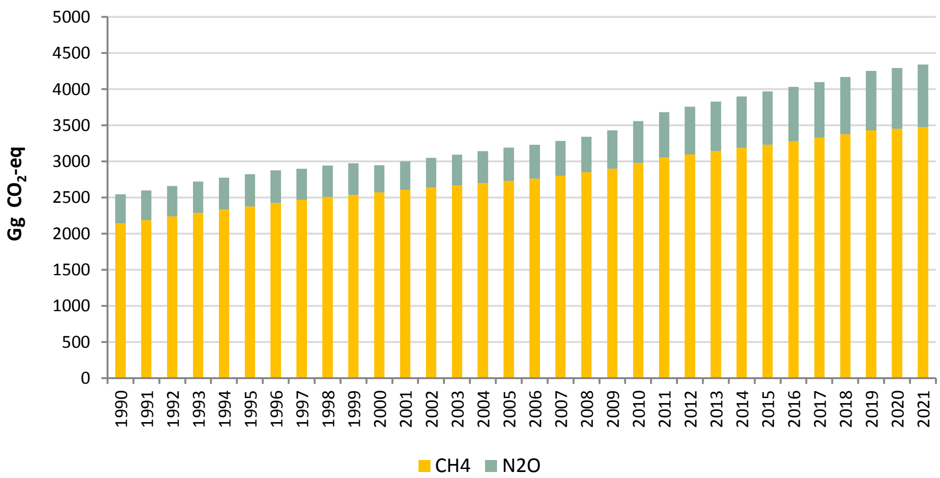

Figure 6.5.1.1 GHG emissions from Domestic Wastewater Treatment and Discharge

For the period 1990-2021, the increase in GHG emissions in the “Domestic Wastewater Treatment and Discharge” category amounted to 171%, and in particular:

- for CH_4 by 162%;
- for N_2O by 216%.

Methodology

In this inventory, methane emissions and indirect N_2O emissions from human wastewater were determined for the entire population of the country.

Estimates of methane emissions. CH_4 emissions from domestic wastewater, as well as N_2O emissions from human activity were estimated in accordance with the 2006 IPCC Guidelines. Tier 1 methodology and default factors were used.

Total methane emissions from domestic wastewater were calculated using Equation 6.1 of the IPCC Guidelines, 2006, Vol. 5, Chapter 6. It was assumed that the amount of organic component extracted as sludge in the accounting year S=0 (BOD kg/year). Also, due to the lack of practice of methane recovery from wastewater in the country, the amount of recovered methane in the reference year was assumed to be R=0 (kg/year).

Methane emissions from domestic wastewater were calculated for the following population groups, in thousand people:

- population covered by sewerage services;
- population using pit latrines;
- population using septic sistems.

The share of the population per each group was calculated based on available statistical data on population coverage with sewerage services (2012 - 12%, 2017 - 15.6%, 2019 - 17%). For the period 2020-2021, the coverage of the population with sewerage services was calculated based on the target indicators of the Ministry of Housing and Communal Services by 2025 (35%).

It was **assumed** that the rest of the population uses pit latrines, with 1% of the population in this group using septic systems. Wastewater from septic tanks and pit latrines is discharged into the municipal sewerage system for further treatment.

The population was not divided by income level due to lack of necessary data.

Table 6.5.1.2 shows the population breakdown used to estimate GHG emissions in this category.

Table 6.5.1.2 Population groups of the Republic of Uzbekistan included in the calculation for the "Domestic Wastewater Treatment and Discharge" category (estimated data), thousand people

Years	Population, thousand people			
	Total	covered by sewerage services	using septic sistems	using pit latrines
1990	20510.00	2461.20	180.49	17868.31
1991	20952.00	2514.24	184.38	18253.38
1992	21449.00	2573.88	188.75	18686.37
1993	21942.00	2633.04	193.09	19115.87
1994	22377.00	2685.24	196.92	19494.84
1995	22785.00	2734.20	200.51	19850.29
1996	23225.00	2787.00	204.38	20233.62
1997	23667.00	2840.04	208.27	20618.69
1998	24051.00	2886.12	211.65	20953.23
1999	24311.65	2917.40	213.94	21180.31
2000	24650.40	2958.05	216.92	21475.43
2001	24964.45	2995.73	219.69	21749.03
2002	25271.85	3032.62	222.39	22016.84
2003	25567.65	3068.12	225.00	22274.54
2004	25864.35	3103.72	227.61	22533.02
2005	26167.00	3140.04	230.27	22796.69
2006	26488.25	3178.59	233.10	23076.56
2007	26868.00	3224.16	236.44	23407.40
2008	27302.80	3276.34	240.26	23786.20
2009	27767.40	3332.09	244.35	24190.96
2010	28562.40	3427.49	251.35	24883.56
2011	29339.40	3725.01	256.14	25358.25
2012	29774.50	3781.19	259.93	25733.38

Table 6.5.1.2 continuation

Years	Population, thousand people			
	Total	covered by sewerage services	using septic sistems	using pit latrines
2013	30243.20	3931.62	263.12	26048.47
2014	30757.70	4213.81	265.44	26278.46
2015	31298.90	4586.10	267.13	26445.67
2016	31847.90	4809.03	270.39	26768.48
2017	32388.60	5052.62	273.36	27062.62
2018	32956.10	5371.84	275.84	27308.41
2019	33580.35	5708.66	278.72	27592.97
2020	34232.05	6846.41	273.86	27111.78
2021	34915.10	8030.47	268.85	26615.78

Calculation of indirect nitrous oxide emissions. To estimate indirect nitrous oxides from treated wastewater discharges into the aquatic environment, the Tier 1 methodology of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5, Chapter 6.3 was used. The calculation was based on total population data (Table 6.5.1.2), since it was assumed that waste from pit latrines is also discharged to the general sewerage system.

Indirect nitrous oxide emissions from the wastewater discharge were calculated according to Equation 6.7. using a default emission factor.

Total nitrogen in the treated wastewater discharge was calculated according to Equation 6.8 using default factors and data taken from the *fao.stat* database on annual per capita protein consumption (Table 6.5.1.3).

Activity data

To calculate CH_4 emissions from domestic and commercial wastewater, as well as N_2O emissions from human activity, statistics on the country's population provided by the Statistics Agency were used (Table 6.5.1.2).

Emission factors and other parameters used in calculations

The following factors and multipliers were used to *calculate CH_4 emissions*, according to:

Maximum methane generation capacity Bo = 0.6 kg CH_4/kg BOD, default.

Methane correction factor (MCF) for each treatment pathway **T** - according to Table 6.3, Chapter 6:

- Septic treatment tanks - 0.5
- Pit latrines – 0.5
- Sewage systems (centralized aerobic overloaded) - 0.3

The total mass of organically degradable materials in municipal wastewater (**TOW**) is calculated according to Equation 6.3. The **BOD** value is assumed to be 40 g/person/day for the Asia region (Table 6.4). The correction factor **(I)** in Equation 6.3 is assumed to be 1.00 for each population group.

The following factors and multipliers were used to *calculate N_2O emissions*, according to:

BOD_5 - degradable organic matter - 14.6 kg/person/year, Table 6.4, p. 6.15, "Asia, Middle East, Latin America" row.

The share of wastewater attributable to this treatment system is 1.0 (Data from the Ministry of Ecology, Environmental Protection and Climate Change).

MCF - methane conversion factor - assumed 0.9, Table 6.3, page. 6.14, line "Anaerobic digesters", average value.

The maximum value of methane generation is 0.6 kg CH_4/kg BOD, table. 6.2, page 6.13

Annual protein consumption per capita in Uzbekistan in 1990-2019 was obtained from the FAO database [68]. The values of total protein consumption for the period 2020-2021 were calculated according to the available trend (Table 6.17). Nitrous oxide emissions were estimated using Equation 6.7 .

F_{NPR} – nitrogen fraction in protein - 0.16 kg N/kg protein, Equation 6.8, p.6.27.

68 www.fao.org/faostat/ru/#country

EF_6 - emission factor - 0.005 average default (kg N_2O-N per kg nitrogen from wastewater), page 6.27, Section 6.3.1.2

Table 6.5.1.3 Protein consumption per capita in the Republic of Uzbekistan (according to FAO data)

Period, years	Protein consumption		Period, years	Protein consumption	
	g/capita/day	kg/capita/year		g/capita/day	kg/capita/year
1990 – 1993	82.0	29.93	2010	84.7	30.91
1994 – 1996	82.0	29.93	2011	90.0	32.85
1997 – 1998	75.5	27.56	2012	92.7	33.83
2000	64.0	23.36	2013	95.0	34.67
2001	66.3	24.20	2014	97.0	35.40
2002	68.0	24.82	2015	98.7	36.02
2003	70.0	25.55	2016	99.0	36.13
2004	72.0	26.28	2017	99.3	36.24
2005	73.3	26.75	2018	100.4	36.65
2006	73.7	26.90	2019	102.4	37.38
2007	74.7	27.26	2020	103.0	37.59
2008	75.4	27.52	2021	104.0	37.96
2009	80.1	29.24			

Uncertainties and time series consistency

The uncertainty of methane and nitrous oxide emissions in 4.D.1 “Domestic Wastewater” category was estimated in accordance with the 2006 IPCC Guidelines. To estimate methane emissions, the uncertainty was calculated in accordance with Table 6.7, Chap. 6, Vol.5, page 6.18 of the IPCC Guidelines):

Activity data uncertainty (population) was ±5%;

Uncertainty of emission factors:

Bo - ±30%;

MCF: for pit latrines - ±50%; for poorly managed wastewater treatment plants - ±30%.

Degree of application of T treatment systems - ±30% (expert estimates);

Estimated BOD value (g/person/day) - ±30%.

The combined uncertainty was ±75%.

To estimate N_2O emissions from Domestic Wastewater, uncertainties were calculated according to Table 6.11, Chap. 6, Vol.5, p. 6.29.

Activity data uncertainty (population) was ±5%;

Uncertainty in protein intake data was ±10%.

Emission factor uncertainty:

EF_{CTOK} - ±10% (default);

F_{NPR} ±10% (default);

$F_{IND\text{-}COM}$ ±17% (default).

The combined uncertainty of the obtained emission estimates for indirect nitrous oxide emissions by category was ±27%.

The same method and similar data sets were used for all years.

Quality assurance/Quality control

QA/QC procedures were performed in accordance with the general QA/QC principles and the QA/QC plan. Verification of the following was performed:

- emission source documentation;
- data on mechanical errors;
- all links to sources of information for source data in the Software.

Recalculations for the category

Recalculation for the "Domestic Wastewater Treatment and Discharge" category as part of the preparation for the current inventory was performed for the entire time series due to the use of a different population dataset and assumptions made. In the previous inventory, GHG emissions were estimated only from the population with access to sewage services.

The results of the recalculation are given in Table 6.5.1.4.

Table 6.5.1.4 Recalculation of GHG emissions for the “Domestic Wastewater Treatment and Discharge” category for the period 1990-2021, Gg CO_2-eq.

Years	FNC	FBUR	Difference	Years	FNC	FBUR	Difference
1990	2540.38	205.57	2334.82	2004	3141.7	220.93	2920.78
1991	2595.13	209.01	2386.12	2005	3186.53	224.5	2962.03
1992	2656.69	211.1	2445.59	2006	3228.25	235.98	2992.27
1993	2717.75	214.11	2503.65	2007	3280.87	236.32	3044.56
1994	2771.63	215.04	2556.6	2008	3338.62	238.14	3100.48
1995	2822.17	217.02	2605.15	2009	3426.73	251.63	3175.1
1996	2876.67	223.57	2653.1	2010	3556.11	257.23	3298.87
1997	2894.65	219.21	2675.44	2011	3681.2	265.78	3415.43
1998	2941.62	221.55	2720.07	2012	3754.88	268.59	3486.29
1999	2973.49	209.26	2764.23	2013	3826.66	310.61	3516.04
2000	2947.07	212.1	2734.97	2014	3897.04	358.72	3538.32
2001	2998.36	212.98	2785.38	2015	3965.27	405.13	3560.14
2002	3045.55	212.66	2832.89	2016	4030.88	446.3	3584.57
2003	3093.43	217.18	2876.25	2017	4094.56	493.83	3600.73

Compared to the results of the First Biennial Update Report (FBUR), the emissions estimates of the Fourth National Communication (FNC) for the "Domestic Wastewater Treatment and Discharge" category resulted in a significant increase in the value of GHG emissions (about 10 fold).

Planned improvements in the category

The next GHG inventory will include detailed activity data.

6.5.2 Industrial Wastewater Treatment and Discharge (4.D.2 category)

Description of the source category

The main industrial sources of methane generation in wastewater in Uzbekistan are food, textile and oil refining industries.
CH_4 emissions from industrial wastewater in 2021 amounted to 138.87 Gg CO_2-eq.

Emission trends

Table 6.5.2.1 and Figure 6.5.2.1 show methane emissions from Industrial Wastewater Treatment and Discharge for the period 1990-2021. Over this period, the category experienced a 25.3% increase in methane emissions.

Table 6.5.2.1 CH_4 emissions from “Industrial Wastewater Treatment and Discharge”, Gg CO_2-eq.

Years	CH_4	Years	CH_4
1990	113.88	2007	86.92
1991	106.62	2008	99.84
1992	98.68	2009	103.14
1993	95.23	2010	108.99
1994	79.70	2011	116.38
1995	74.22	2012	119.30
1996	72.05	2013	99.49
1997	69.85	2014	111.48
1998	60.95	2015	121.31

Table 6.5.2.1 continuation

Years	CH_4	Years	CH_4
1999	64.67	2016	129.33
2000	66.55	2017	127.40
2001	67.22	2018	56.28
2002	114.5	2019	53.38
2003	103.19	2020	78.12
2004	91.75	2021	138.77
2005	76.77	$\Delta_{(1990-2021)}$	**+22.0%**

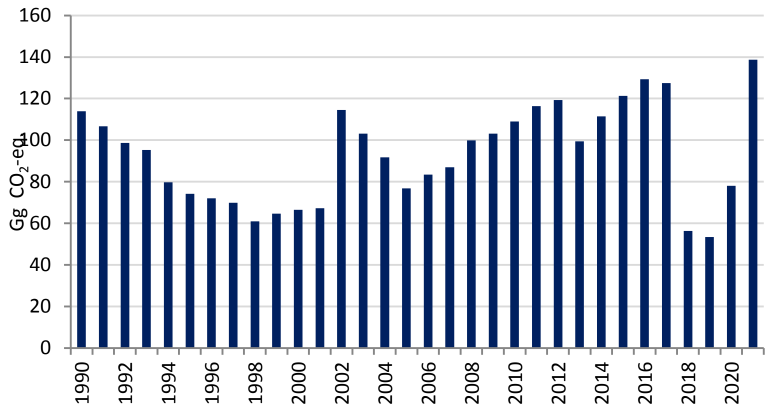

Figure 6.5.2.1 Dynamics of CH_4 emissions from “Industrial Wastewater Treatment and Discharge”

The dynamics of methane emissions from Industrial Wastewater Treatment and Discharge is determined by the dynamics of industrial production volumes that were included in the calculations. Decline in industrial production in 2019-2020 is probably due to the impact of the COVID pandemic. A significant increase in methane emissions in 2021 is associated with increased production of food and textile products.

Methodology

CH_4 emissions from Industrial Wastewater Treatment and Discharge were estimated in accordance with IPCC Guidelines 2006, Tier 1. Methane emissions from industrial wastewater were calculated using Equation 6.4, page 6.21, Vol.5. The amount of organic matter in sludge waste $\mathbf{S_i}$ and the amount of recovered methane $\mathbf{R_i}$ were assumed to be zero due to lack of data.

Activity data

To calculate CH_4 emissions from Industrial Wastewater Treatment and Discharge, data from the Statistics Agency for 2018-2021 on the production of selected industrial products were used, Table 6.5.2.2.

Table 6.5.2.2 Production of selected industrial products in 2017-2021

Production	Unit dimensions	2017	2018	2019	2020	2021
Nitrogen fertilizers	thousand tons	547.1	357.3	326.8	296.1	299.3
Canned food, total	million standard tins	558.4	575.0	595.0	610.0	630.0
Beer	thousand dL	19009.3	19119.0	21275.9	23988.9	23708.7
Grape wine	thousand dL	2494.5	2288.7	2156.6	2043.8	1584.6
Cognac	thousand dL	181.8	194.9	163.4	431.9	453.4
Vodka and liquor products	thousand dL	6003.1	6029.2	5426.3	4837.0	4512.3
Semi-finished meat products	thousand tons	1.8	1.7	1.6	1.9	1.9
Sausages	thousand tons	292.3	292.0	393.2	381.3	351.8
Whole milk products	thousand tons	579.9	486.9	504.3	487.4	568.6
Sugar	thousand tons	473.3	688.0	427.5	188.8	595.7
Compound feed	thousand tons	1748.5	1112.6	1006.0	1079.1	1080.9
Animal oils	thousand tons	6.2	0.7	1.1	1.2	1.1

Table 6.5.2.2 continuation

Production	Unit dimensions	2017	2018	2019	2020	2021
Animal fats	thousand tons	2.2	1.9	3.3	3.5	3.3
Margarine	thousand tons	36.1	38.6	51.3	50.0	45.0
Vegetable oil	thousand tons	236.3	209.8	189.8	181.9	113.3
Soft drinks	thousand gave	59410.5	84881.8	105957.1	137762.7	172101.1
Paper	thousand tons	9.9	17.1	20.6	15.7	17.9
Cotton fabrics	thousand m^2	288054.9	113039.0	95683.0	129114.0	149879.0
Silk fabrics	thousand m^2	8645.5	5867.2	4095.6	7825.5	12347.6
paints and varnishes	thousand tons	66.3	78.2	81.5	77.5	76.9
Oil refining	thousand tons	2721.1	3170.0	3663.0	3490.0	3133.0

Emission factors

The amount of organic matter TOW_i was calculated using the standards for wastewater generation and COD concentration available in the current regulatory document [69].

The factors used in estimation of CH_4 emissions from industrial wastewater are given in Table 6.5.2.3

Table 6.5.2.3 Factors used in estimation of CH_4 emissions from Industrial Wastewater Treatment and Discharge

Product	Wastewater generation standards	COD concentrations, kg O/m^3
Nitrogen fertilizers	480 m^3/ t	0,035
Canned food, total	5,67 m^3/1000 standard tins	0,233
Beer	76,4 m^3/1000 dL	1,5
Grape wine	28,15 m^3/1000 dL	13,0
Cognac	164,56 m^3/1000 dL	17,0
Vodka and liquor products	259 m^3/1000 dL	0,6
Meat products	19,3 m^3/t	1,0
Whole milk products	5,2 m^3/t	1,4
Sugar	16,2 m^3/t	4,5
Compound feed	0,38 m^3/t	0,6
Animal oils and fats	1,74 m^3/t	0,25
Margarine	3,14 m^3/t	15,0
Vegetable oil	1,31 m^3/t	1,5
Soft drinks	38,05 m^3/1000 dL	1,0
Paper	43,75 m^3/t	0,12
Petrochemicals/oil refining	0,215 m^3/t	0,6
Cotton fabrics	42,6 m^3/1000 m^2	0,675 (0,35-1,0)
Silk fabrics	76,5 m^3/1000 m^2	0,8 (0,6-1,0)
Paints and varnishes	58,0 m^3/t	0,02

Methane conversion factor (MCF) is 0.3, default, Table 6.8, p. 6.22, row "Aerobic wastewater treatment plants, overloaded".
Maximum methane generation (B_0) is 0.25 kg CH_4/kg BOD].
Methane emission factor from industrial wastewater EF_i is 0.075 kg CH_4/kg BOD.

Uncertainties and time series consistency

The uncertainty of activity data is about ±25% by default, in accordance with table. 6.10. Vol.5, IPCC Guidelines, 2006.
Uncertainty of CH_4 emission factors from Industrial Wastewater by default is also in accordance with Table 6.10.:
- B_0 ±30%;
- MCF±50% (expert estimate);
- standards for wastewater generation, COD concentration ±10%.

The combined uncertainty of the category emission estimate was ±65%.

69 Reference book "Consolidated water supply and sanitation standards for different industries". - COMECON, VNII WATERGEO SCC USSR Moscow, 1982

The same method and similar data sets were used for all years.

Quality assurance/ Quality control

QA/QC procedures were performed in accordance with the general QA/QC principles and the QA/QC plan. Verification of the following was performed:

- documentation of emission sources,
- data on mechanical errors,
- all links to sources of information for source data in the Software.

Recalculations for the category

Recalculation of methane emissions in 4.D.2 “Industrial Wastewater Treatment and Discharge” category for the period 1990-2017 was conducted due to the refinement of the methane emission factor value of 0.075 instead of the 0.068 kg CH_4/kg COD factor used in the inventory, as well as activity data.

The results of recalculation are given in Table 6.5.2.4.

Table 6.5.2.4 Recalculation of methane emissions in the “Industrial Wastewater Treatment and Discharge” category, Gg CO_2-eq.

Years	FNC	FBUR	Difference	Years	FNC	FBUR	Difference
1990	110.82	70.77	40.05	2004	90.67	61.63	29.05
1991	103.40	64.35	39.05	2005	75.67	48.08	27.60
1992	96.30	59.97	36.33	2006	83.20	48.43	34.78
1993	92.75	58.75	34.00	2007	86.52	51.20	35.32
1994	77.27	52.38	24.90	2008	99.82	58.40	41.42
1995	71.82	44.73	27.10	2009	103.15	62.35	40.80
1996	70.82	41.08	29.75	2010	108.97	65.88	43.10
1997	68.95	39.50	29.45	2011	116.37	71.48	44.90
1998	59.55	34.93	24.63	2012	119.30	72.68	46.63
1999	63.00	39.80	23.20	2013	99.45	70.50	28.95
2000	64.65	39.48	25.18	2014	111.40	80.50	30.90
2001	65.77	43.78	22.00	2015	121.40	92.78	28.63
2002	113.10	70.10	43.00	2016	129.45	98.68	30.78
2003	101.67	72.85	28.82	2017	127.50	95.45	32.05

The new estimates of methane emissions from this category are higher than the First Biennial Update Report by 22- 46.6 Gg CO_2-eq.

Planned improvements in the category

As part of future inventories, it is planned to assess methane emissions from a wider range of industries, as well as clarify the types of industrial wastewater treatment systems used.

ANNEX 1.SUMMARY REPORTS ON GHG EMISSIONS IN THE REPUBLIC OF UZBEKISTAN FOR 1990, 2010, 2021

Sector «Energy», Gg, 1990

Categories	CO_2	CH_4	N_2O	NOx	CO	NMVOCs	SO_2
1 - Energy	109101.10	694.30	1.72	409.62	1895.80	496.15	134.40
1.A - Fuel Combustion Activities	108214.27	21.97	1.71	409.62	1895.80	336.60	0.50
1.A.1 - Energy Industries	57223.40	1.15	0.29	151.00	9.20	4.40	0.30
1.A.1.a - Main Activity Electricity and Heat Production	57223.40	1.15	0.29	151.00	9.20	4.40	0.30
1.A.1.a.i - Electricity Generation	57223.40	1.15	0.29				
1.A.1.a.ii - Combined Heat and Power Generation (CHP)							
1.A.1.a.iii - Heat Plants							
1.A.1.b - Petroleum Refining							
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries	0.00	0.00					
1.A.1.c.i - Manufacture of Solid Fuels	NE	NE					
1.A.1.c.ii - Other Energy Industries							
1.A.2 - Manufacturing Industries and Construction	7273.32	0.24	0.03	29.40	5.70	1.00	0.03
1.A.2.a - Iron and Steel							
1.A.2.b - Non-Ferrous Metals							
1.A.2.c - Chemicals							
1.A.2.d - Pulp, Paper and Print							
1.A.2.e - Food Processing, Beverages and Tobacco							
1.A.2.f - Non-Metallic Minerals							
1.A.2.g - Transport Equipment							
1.A.2.h - Machinery							
1.A.2.i - Mining (excluding fuels) and Quarrying							
1.A.2.j - Wood and wood products							
1.A.2.k - Construction	1705.22	0.07	0.01				
1.A.2.l - Textile and Leather							
1.A.2.m - Non-specified Industry	5568.10	0.17	0.02				
1.A.3 - Transport	17665.97	4.15	1.20	58.12	1567.60	272.40	0.03
1.A.3.a - Civil Aviation	1032.53	0.01	0.03				
1.A.3.a.i - International Aviation (International Bunkers) (1)							
1.A.3.a.ii - Domestic Aviation	1032.53	0.01	0.03				
1.A.3.b - Road Transportation	10228.48	4.04	0.48				
1.A.3.b.i - Cars	10228.48	4.04	0.48				
1.A.3.b.i.1 - Passenger cars with 3-way catalysts							
1.A.3.b.i.2 - Passenger cars without 3-way catalysts							
1.A.3.b.ii - Light-duty trucks							
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts							
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts							
1.A.3.b.iii - Heavy-duty trucks and buses							
1.A.3.b.iv - Motorcycles							
1.A.3.b.v - Evaporative emissions from vehicles							
1.A.3.b.vi - Urea-based catalysts	NE						
1.A.3.c - Railways	1793.89	0.10	0.69				
1.A.3.d - Water-borne Navigation	12.75	0.00	0.00				
1.A.3.d.i - International water-borne navigation (International bunkers) (1)							
1.A.3.d.ii - Domestic Water-borne Navigation	12.75	0.00	0.00				
1.A.3.e - Other Transportation	4598.34	0.00	0.00				
1.A.3.e.i - Pipeline Transport	4598.34	0.00	0.00				
1.A.3.e.ii - Off-road							
1.A.4 - Other Sectors	26051.57	16.44	0.19	71.10	313.30	58.80	0.14
1.A.4.a - Commercial/Institutional	7257.56	0.76	0.05	7.3	41.1	4.2	0.06
1.A.4.b - Residential	13047.70	13.60	0.09	12.1	78.6	7.9	0.05
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	5746.31	2.08	0.05	51.7	193.6	46.7	0.04
1.A.4.c.i - Stationary	1723.41	1.53	0.01				
1.A.4.c.ii - Off-road Vehicles and Other Machinery	4022.91	0.55	0.03				
1.A.4.c.iii - Fishing (mobile combustion)							

Categories	CO_2	CH_4	N_2O	NOx	CO	NMVOCs	SO_2
1.A.5 - Non-Specified							
1.A.5.a - Stationary							
1.A.5.b - Mobile							
1.A.5.b.i - Mobile (aviation component)							
1.A.5.b.ii - Mobile (water-borne component)							
1.A.5.b.iii - Mobile (Other)							
1.A.5.c - Multilateral Operations (1)(2)							
1.B - Fugitive emissions from fuels	886.83	672.33	0.00	0.00	0.00	159.55	133.93
1.B.1 - Solid Fuels	0.00	14.80	0.00	0.00	0.00	0.00	0.00
1.B.1.a - Coal mining and handling	0.00	14.80					
1.B.1.a.i - Underground mines	0.00	9.78					
1.B.1.a.i.1 - Mining		8.59					
1.B.1.a.i.2 - Post-mining seam gas emissions		1.19					
1.B.1.a.i.3 - Abandoned underground mines	NE						
1.B.1.a.i.4 - Flaring of drained methane or conversion of methane to CO2	NE	NE					
1.B.1.a.ii - Surface mines							
1.B.1.a.ii.1 - Mining							
1.B.1.a.ii.2 - Post-mining seam gas emissions		NE					
1.B.1.a.ii.3 - Abandoned surface mines	NE	NE					
1.B.1.b - Uncontrolled combustion and burning coal dumps							
1.B.1.c - Fuel transformation	NE	NE	NE				
1.B.1.c.i - Charcoal and Biochar production							
1.B.1.c.ii - Coke production							
1.B.1.c.iv - Gasification transformation	NE	NE	NE				
1.B.2 - Oil and Natural Gas	886.83	657.53	0.00			159.55	133.93
1.B.2.a - Oil	173.55	105.77	0.00			131.98	
1.B.2.a.i - Venting	0.40	3.12					
1.B.2.a.ii - Flaring	165.80	0.10	0.00				
1.B.2.a.iii - All Other	7.35	102.55					
1.B.2.a.iii.1 - Exploration							
1.B.2.a.iii.2 - Production and Upgrading	7.35	102.55					
1.B.2.a.iii.3 - Transport							
1.B.2.a.iii.4 - Refining							
1.B.2.a.iii.5 - Distribution of oil products							
1.B.2.a.iii.6 - Other							
1.B.2.b - Natural Gas	713.28	551.76	0.00			27.56	133.93
1.B.2.b.i - Venting	588.17	0.16					
1.B.2.b.ii - Flaring	116.14	0.07	0.00				
1.B.2.b.iii - All Other	8.97	551.52					
1.B.2.b.iii.1 - Exploration							
1.B.2.b.iii.2 - Production	3.95	497.28					
1.B.2.b.iii.3 - Processing	4.21	13.96					
1.B.2.b.iii.4 - Transmission and Storage	0.00	25.19					
1.B.2.b.iii.5 - Distribution	0.80	15.09					
1.B.2.b.iii.6 - Other							
1.B.3 - Other emissions from Energy Production	NO	NO	NO				
1.C - Carbon dioxide Transport and Storage	NO						
1.C.1 - Transport of CO2	NO						
1.C.1.a - Pipelines	NO						
1.C.1.b - Ships	NO						
1.C.1.c - Other (please specify)	NO						
1.C.2 - Injection and Storage	NO						
1.C.2.a - Injection	NO						
1.C.2.b - Storage	NO						
1.C.3 - Other							

Categories	CO_2	CH_4	N_2O	NOx	CO	NMVOCs	SO_2
Memo Items (3)							
International Bunkers	2064.02	0.01	0.06	11.90	4.00	2.00	2.00
1.A.3.a.i - International Aviation (International Bunkers) (1)	2064.02	0.01	0.06	11.90	4.00	2.00	2.00
1.A.3.d.i - International water-borne navigation (International bunkers) (1)							
1.A.5.c - Multilateral Operations (1)(2)							
Information Items							
CO2 from Biomass Combustion	990.57						
CO2 from Biomass Combustion Captured							

Sector «Energy», Gg, 2010

Categories	CO_2	CH_4	N_2O	NOx	CO	NMVOCs	SO_2
1 - Energy	96008.11	1083.59	0.74	249.60	1032.00	429.02	68.71
1.A - Fuel Combustion Activities	94788.76	10.44	0.73	249.60	1032.00	191.30	0.09
1.A.1 - Energy Industries	32990.11	0.61	0.12	83.70	5.40	2.70	0.06
1.A.1.a - Main Activity Electricity and Heat Production	32990.11	0.61	0.12	83.70	5.40	2.70	0.06
1.A.1.a.i - Electricity Generation	32990.11	0.61	0.12				
1.A.1.a.ii - Combined Heat and Power Generation (CHP)							
1.A.1.a.iii - Heat Plants							
1.A.1.b - Petroleum Refining							
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries	0	0					
1.A.1.c.i - Manufacture of Solid Fuels	NE	NE					
1.A.1.c.ii - Other Energy Industries							
1.A.2 - Manufacturing Industries and Construction	4871.77	0.10	0.01	21.50	4.20	0.70	0.00
1.A.2.a - Iron and Steel							
1.A.2.b - Non-Ferrous Metals							
1.A.2.c - Chemicals							
1.A.2.d - Pulp, Paper and Print							
1.A.2.e - Food Processing, Beverages and Tobacco							
1.A.2.f - Non-Metallic Minerals							
1.A.2.g - Transport Equipment							
1.A.2.h - Machinery							
1.A.2.i - Mining (excluding fuels) and Quarrying							
1.A.2.j - Wood and wood products							
1.A.2.k - Construction	414.30	0.02	0.00				
1.A.2.l - Textile and Leather							
1.A.2.m - Non-specified Industry	4457.47	0.08	0.01				
1.A.3 - Transport	13073.18	4.22	0.49	91.50	937.70	171.70	0.01
1.A.3.a - Civil Aviation	183.90	0.00	0.01				
1.A.3.a.i - International Aviation (International Bunkers) (1)							
1.A.3.a.ii - Domestic Aviation	183.90	0.00	0.01				
1.A.3.b - Road Transportation	7070.46	4.20	0.31				
1.A.3.b.i - Cars	7070.46	4.20	0.31				
1.A.3.b.i.1 - Passenger cars with 3-way catalysts							
1.A.3.b.i.2 - Passenger cars without 3-way catalysts							
1.A.3.b.ii - Light-duty trucks							
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts							
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts							
1.A.3.b.iii - Heavy-duty trucks and buses							
1.A.3.b.iv - Motorcycles							
1.A.3.b.v - Evaporative emissions from vehicles							
1.A.3.b.vi - Urea-based catalysts	NE						
1.A.3.c - Railways	442.90	0.02	0.17				
1.A.3.d - Water-borne Navigation	0	0	0				
1.A.3.d.i - International water-borne navigation (International bunkers) (1)							
1.A.3.d.ii - Domestic Water-borne Navigation	0	0	0				
1.A.3.e - Other Transportation	5375.91	0	0				
1.A.3.e.i - Pipeline Transport	5375.91	0	0				
1.A.3.e.ii - Off-road							

Categories	CO_2	CH_4	N_2O	NOx	CO	NMVOCs	SO_2
1.A.4 - Other Sectors	43853.70	5.50	0.11	52.90	84.80	16.20	0.02
1.A.4.a - Commercial/Institutional	10186.37	0.95	0.03	9.70	14.80	1.80	0.01
1.A.4.b - Residential	32254.06	4.36	0.07	28.60	32.90	3.50	0.006
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	1413.28	0.19	0.01	14.60	37.10	10.50	0.00
1.A.4.c.i - Stationary	278.50	0.03	0.00				
1.A.4.c.ii - Off-road Vehicles and Other Machinery	1134.78	0.15	0.01				
1.A.4.c.iii - Fishing (mobile combustion)							
1.A.5 - Non-Specified							
1.A.5.a - Stationary							
1.A.5.b - Mobile							
1.A.5.b.i - Mobile (aviation component)							
1.A.5.b.ii - Mobile (water-borne component)							
1.A.5.b.iii - Mobile (Other)							
1.A.5.c - Multilateral Operations (1)(2)							
1.B - Fugitive emissions from fuels	1219.35	1073.16	0.01	0.00	0.00	237.72	68.62
1.B.1 - Solid Fuels	0	4.37	0	0.00	0.00	0.00	0.00
1.B.1.a - Coal mining and handling	0	4.37					
1.B.1.a.i - Underground mines	0	1.54					
1.B.1.a.i.1 - Mining		1.35					
1.B.1.a.i.2 - Post-mining seam gas emissions		0.19					
1.B.1.a.i.3 - Abandoned underground mines	NE						
1.B.1.a.i.4 - Flaring of drained methane or conversion of methane to CO2	NE	NE					
1.B.1.a.ii - Surface mines	0	2.83					
1.B.1.a.ii.1 - Mining		2.61					
1.B.1.a.ii.2 - Post-mining seam gas emissions		0.22					
1.B.1.a.ii.3 - Abandoned surface mines	NE	NE					
1.B.1.b - Uncontrolled combustion and burning coal dumps							
1.B.1.c - Fuel transformation	NE	NE	NE				
1.B.1.c.i - Charcoal and Biochar production							
1.B.1.c.ii - Coke production							
1.B.1.c.iv - Gasification transformation	NE	NE	NE				
1.B.2 - Oil and Natural Gas	1219.35	1068.79	0.01			237.72	68.62
1.B.2.a - Oil	249.37	151.73	0.00			187.00	
1.B.2.a.i - Venting	0.56	4.22					
1.B.2.a.ii - Flaring	238.25	0.14	0.00				
1.B.2.a.iii - All Other	10.56	147.37					
1.B.2.a.iii.1 - Exploration							
1.B.2.a.iii.2 - Production and Upgrading	10.56	147.37					
1.B.2.a.iii.3 - Transport							
1.B.2.a.iii.4 - Refining							
1.B.2.a.iii.5 - Distribution of oil products							
1.B.2.a.iii.6 - Other							
1.B.2.b - Natural Gas	969.98	917.05	0.00			50.72	68.62
1.B.2.b.i - Venting	748.32	0.25					
1.B.2.b.ii - Flaring	203.48	0.13	0.00				
1.B.2.b.iii - All Other	18.18	916.67					
1.B.2.b.iii.1 - Exploration							
1.B.2.b.iii.2 - Production	6.40	804.69					
1.B.2.b.iii.3 - Processing	9.54	30.98					
1.B.2.b.iii.4 - Transmission and Storage	0.00	38.79					
1.B.2.b.iii.5 - Distribution	2.24	42.21					
1.B.2.b.iii.6 - Other							
1.B.3 - Other emissions from Energy Production	NO	NO	NO				
1.C - Carbon dioxide Transport and Storage	NO						
1.C.1 - Transport of CO2	NO						
1.C.1.a - Pipelines	NO						
1.C.1.b - Ships	NO						
1.C.1.c - Other (please specify)	NO						
1.C.2 - Injection and Storage	NO						

Categories	CO_2	CH_4	N_2O	NOx	CO	NMVOCs	SO_2
1.C.2.a - Injection	NO						
1.C.2.b - Storage	NO						
1.C.3 - Other							
Memo Items (3)							
International Bunkers	913.87	0.01	0.03	4.10	1.40	0.70	0.60
1.A.3.a.i - International Aviation (International Bunkers) (1)	913.87	0.01	0.03				
1.A.3.d.i - International water-borne navigation (International bunkers) (1)							
1.A.5.c - Multilateral Operations (1)(2)							
Information Items							
CO2 from Biomass Combustion	29.20						
CO2 from Biomass Combustion Captured							

Sector «Energy», Gg, 2021

Categories	CO_2	CH_4	N_2O	NOx	CO	NMVOCs	SO_2
1 - Energy	113218.98	909.83	1.18	397.20	1347.2	505.57	103.69
1.A - Fuel Combustion Activities	112340.99	25.40	1.18	397.20	1347.2	322.10	0.27
1.A.1 - Energy Industries	47607.13	0.80	0.23	131.50	15.22	3.80	0.20
1.A.1.a - Main Activity Electricity and Heat Production	47607.13	0.80	0.23	131.50	15.22	3.80	0.20
1.A.1.a.i - Electricity Generation	47607.13	0.80	0.23				
1.A.1.a.ii - Combined Heat and Power Generation (CHP)							
1.A.1.a.iii - Heat Plants							
1.A.1.b - Petroleum Refining							
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries	0	0					
1.A.1.c.i - Manufacture of Solid Fuels	0	0					
1.A.1.c.ii - Other Energy Industries							
1.A.2 - Manufacturing Industries and Construction	12731.28	0.32	0.04	34.50	7.79	1.30	0.00
1.A.2.a - Iron and Steel							
1.A.2.b - Non-Ferrous Metals							
1.A.2.c - Chemicals							
1.A.2.d - Pulp, Paper and Print							
1.A.2.e - Food Processing, Beverages and Tobacco							
1.A.2.f - Non-Metallic Minerals							
1.A.2.g - Transport Equipment							
1.A.2.h - Machinery							
1.A.2.i - Mining (excluding fuels) and Quarrying							
1.A.2.j - Wood and wood products							
1.A.2.k - Construction	49.52	0.00	0.00				
1.A.2.l - Textile and Leather							
1.A.2.m - Non-specified Industry	12681.76	0.32	0.04				
1.A.3 - Transport	16416.07	15.19	0.80	197.90	1248.30	309.40	0.00
1.A.3.a - Civil Aviation	43.51	0.00	0.00				
1.A.3.a.i - International Aviation (International Bunkers) (1)							
1.A.3.a.ii - Domestic Aviation	43.51	0.00	0.00				
1.A.3.b - Road Transportation	14944.74	15.18	0.71				
1.A.3.b.i - Cars	14944.74	15.18	0.71				
1.A.3.b.i.1 - Passenger cars with 3-way catalysts							
1.A.3.b.i.2 - Passenger cars without 3-way catalysts							
1.A.3.b.ii - Light-duty trucks							
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts							
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts							
1.A.3.b.iii - Heavy-duty trucks and buses							
1.A.3.b.iv - Motorcycles							
1.A.3.b.v - Evaporative emissions from vehicles							
1.A.3.b.vi - Urea-based catalysts	0						
1.A.3.c - Railways	226.87	0.01	0.08				
1.A.3.d - Water-borne Navigation	0	0	0				
1.A.3.d.i - International water-borne navigation (International							

Categories	CO_2	CH_4	N_2O	NOx	CO	NMVOCs	SO_2
bunkers) (1)							
1.A.3.d.ii - Domestic Water-borne Navigation	0	0	0				
1.A.3.e - Other Transportation	1200.95	0	0				
1.A.3.e.i - Pipeline Transport	1200.95	0	0				
1.A.3.e.ii - Off-road							
1.A.4 - Other Sectors	35586.51	9.09	0.11	33.30	75.70	7.60	0.00
1.A.4.a - Commercial/Institutional	8576.46	0.81	0.03	8.10	14.30	1.50	0.00
1.A.4.b - Residential	26184.43	7.98	0.08	24.40	59.20	5.90	0.00
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	825.62	0.30	0.00	0.80	2.20	0.20	0.00
1.A.4.c.i - Stationary	823.94	0.30	0.00				
1.A.4.c.ii - Off-road Vehicles and Other Machinery	1.68	0.00	0.00				
1.A.4.c.iii - Fishing (mobile combustion)							
1.A.5 - Non-Specified							
1.A.5.a - Stationary							
1.A.5.b - Mobile							
1.A.5.b.i - Mobile (aviation component)							
1.A.5.b.ii - Mobile (water-borne component)							
1.A.5.b.iii - Mobile (Other)							
1.A.5.c - Multilateral Operations (1)(2)							
1.B - Fugitive emissions from fuels	877.98	884.43	0.01	0.00	0.00	183.47	103.42
1.B.1 - Solid Fuels	0	7.94	0	0.00	0.00	0.00	0.00
1.B.1.a - Coal mining and handling	0	7.94					
1.B.1.a.i - Underground mines	0	3.78					
1.B.1.a.i.1 - Mining		3.32					
1.B.1.a.i.2 - Post-mining seam gas emissions		0.46					
1.B.1.a.i.3 - Abandoned underground mines	0						
1.B.1.a.i.4 - Flaring of drained methane or conversion of methane to CO2	0	0					
1.B.1.a.ii - Surface mines	0	4.16					
1.B.1.a.ii.1 - Mining		3.84					
1.B.1.a.ii.2 - Post-mining seam gas emissions		0.32					
1.B.1.a.ii.3 - Abandoned surface mines	0	0					
1.B.1.b - Uncontrolled combustion and burning coal dumps							
1.B.1.c - Fuel transformation	0	0	0				
1.B.1.c.i - Charcoal and Biochar production							
1.B.1.c.ii - Coke production							
1.B.1.c.iv - Gasification transformation	0	0	0				
1.B.2 - Oil and Natural Gas	877.98	876.49	0.01			183.47	103.42
1.B.2.a - Oil	191.58	116.57	0.00			143.63	
1.B.2.a.i - Venting	0.43	3.24					
1.B.2.a.ii - Flaring	183.04	0.11	0.00				
1.B.2.a.iii - All Other	8.11	113.22					
1.B.2.a.iii.1 - Exploration							
1.B.2.a.iii.2 - Production and Upgrading	8.11	113.22					
1.B.2.a.iii.3 - Transport							
1.B.2.a.iii.4 - Refining							
1.B.2.a.iii.5 - Distribution of oil products							
1.B.2.a.iii.6 - Other							
1.B.2.b - Natural Gas	686.40	759.92	0.00			39.84	103.42
1.B.2.b.i - Venting	525.15	0.23					
1.B.2.b.ii - Flaring	147.49	0.09	0.00				
1.B.2.b.iii - All Other	13.76	759.59					
1.B.2.b.iii.1 - Exploration							
1.B.2.b.iii.2 - Production	5.22	656.38					
1.B.2.b.iii.3 - Processing	6.02	19.60					
1.B.2.b.iii.4 - Transmission and Storage	0.00	36.15					
1.B.2.b.iii.5 - Distribution	2.52	47.45					
1.B.2.b.iii.6 - Other							
1.B.3 - Other emissions from Energy Production	0	0	0				
1.C - Carbon dioxide Transport and Storage	0						

Categories	CO_2	CH_4	N_2O	NOx	CO	NMVOCs	SO_2
1.C.1 - Transport of CO2	0						
1.C.1.a - Pipelines	0						
1.C.1.b - Ships	0						
1.C.1.c - Other (please specify)	0						
1.C.2 - Injection and Storage	0						
1.C.2.a - Injection	0						
1.C.2.b - Storage	0						
1.C.3 - Other							
Memo Items (3)							
International Bunkers	319.10	0.00	0.01	1.30	0.50	0.20	0.20
1.A.3.a.i - International Aviation (International Bunkers) (1)	319.10	0.00	0.01				
1.A.3.d.i - International water-borne navigation (International bunkers) (1)							
1.A.5.c - Multilateral Operations (1)(2)							
Information Items							
CO2 from Biomass Combustion	19.37						
CO2 from Biomass Combustion Captured							

Sector «Industrial Processes and Product Use», 1990

Categories	(Gg)			CO2 Equivalents(Gg)						(Gg)			
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	Other halogenated gases with CO_2-eq. conversion factors (1)	Other halogenated gases without CO_2-eq. conversion factors (2)	NOx	CO	NMVOCs	SO_2
2 - Industrial Processes and Product Use	10835.03	0.003	8.01	0	0	0	0	0	0	1.42	13.75	28.715	8.63
2.A - Mineral Industry	5893.73	0	0	0	0	0	0	0	0	0	0	0	1.92
2.A.1 - Cement production	2584.90									0	0	0	1.92
2.A.2 - Lime production	335.92									0	0	0	0
2.A.3 - Glass Production	2573.97									0	0	0	0
2.A.4 - Other Process Uses of Carbonates	398.94	0	0	0	0	0	0	0	0	0	0	0	0
2.A.4.a - Ceramics	398.94									0	0	0	0
2.A.4.b - Other Uses of Soda Ash	NE									0	0	0	0
2.A.4.c - Non Metallurgical Magnesia Production	NO									0	0	0	0
2.A.4.d - Other (please specify) (3)	NO									0	0	0	0
2.A.5 - Other (please specify) (3)										0	0	0	0
2.B - Chemical Industry	4004.27	0.003	8.01	0	0	0	0	0	0	1.39	13.75	8.18	3.39
2.B.1 - Ammonia Production	3989.31										13.75	8.18	3.34
2.B.2 - Nitric Acid Production			8.01							1.39	0	0	0.05
2.B.3 - Adipic Acid Production			NO							0	0	0	0
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production			NO							0	0	0	0
2.B.5 - Carbide Production	NO	NO								0	0	0	0
2.B.6 - Titanium Dioxide Production	NO									0	0	0	0
2.B.7 - Soda Ash Production	NA									0	0	0	0
2.B.8 - Petrochemical and Carbon Black Production	14.96	0.003	0	0	0	0	0	0	0	0	0	0.015	0
2.B.8.a - Methanol	NO	NO								0	0	0	0
2.B.8.b - Ethylene	NE	NE								0	0	0	0
2.B.8.c - Ethylene Dichloride and Vinyl Chloride Monomer	NO	NO								0	0	0	0
2.B.8.d - Ethylene Oxide	NO	NO								0	0	0	0
2.B.8.e - Acrylonitrile	14.96	0.003								0	0	0.015	0
2.B.8.f - Carbon Black	NE	NE								0	0	0	0
2.B.9 - Fluorochemical Production	0	0	0	NO	0	0	0	0	0	0	0	0	0
2.B.9.a - By-product emissions (4)				NO						0	0	0	0
2.B.9.b - Fugitive Emissions (4)										0	0	0	0
2.B.10 - Other (Sulphuric Acid) (3)										0	0	0	3.29
2.B.10 - Other (Formaldehyd) (3)										0	0	NO	0
2.C - Metal Industry	733.68	0	0	0	NO	NO	0	0	0	0.02	0.001	0.02	0.03

Categories	(Gg)			CO2 Equivalents(Gg)						(Gg)			
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	Other halogenated gases with CO_2-eq. conversion factors (1)	Other halogenated gases without CO_2-eq. conversion factors (2)	NOx	CO	NMVOCs	SO_2
2.C.1 - Iron and Steel Production	661.44	NA								0.02	0.001	0.02	0.03
2.C.2 - Ferroalloys Production	NO	NO								0	0	0	0
2.C.3 - Aluminium production	NO				NO					0	0	0	0
2.C.4 - Magnesium production (5)	NO					NO				0	0	0	0
2.C.5 - Lead Production	NO									0	0	0	0
2.C.6 - Zinc Production	72.24									0	0	0	0
2.C.7 - Other (please specify) (3)										0	0	0	0
2.D - Non-Energy Products from Fuels and Solvent Use (6)	203.35	0	0	0	0	0	0	0	0	0	0	0	0
2.D.1 - Lubricant Use	203.35									0	0	0	0
2.D.2 - Paraffin Wax Use	NE									0	0	0	0
2.D.3 - Solvent Use (7)										0	0	0	0
2.D.4 - Other (please specify) (3), (8)										0	0	0	0
2.E - Electronics Industry	0	0	0	NE	NE	NE	NE	0	NO	0	0	0	0
2.E.1 - Integrated Circuit or Semiconductor (9)				NE	NE	NE	NE		NO	0	0	0	0
2.E.2 - TFT Flat Panel Display (9)				NE	NE	NE	NE		NO	0	0	0	0
2.E.3 - Photovoltaics (9)				NE	NE	NE	NE		NO	0	0	0	0
2.E.4 - Heat Transfer Fluid (10)					NE					0	0	0	0
2.E.5 - Other (please specify) (3)										0	0	0	0
2.F - Product Uses as Substitutes for Ozone Depleting Substances	0	0	0	NO	0	0	0	0	NO	0	0	0	0
2.F.1 - Refrigeration and Air Conditioning	0	0	0	NO	0	0	0	0	NO	0	0	0	0
2.F.1.a - Refrigeration and Stationary Air Conditioning				NO	NO				NO	0	0	0	0
2.F.1.b - Mobile Air Conditioning				NO	NO				NO	0	0	0	0
2.F.2 - Foam Blowing Agents				NE	NE				NO	0	0	0	0
2.F.3 - Fire Protection				NE						0	0	0	0
2.F.4 - Aerosols										0	0	0	0
2.F.5 - Solvents				NE	NE					0	0	0	0
2.F.6 - Other Applications (please specify) (3)										0	0	0	0
2.G - Other Product Manufacture and Use	0	0	0	0	NE	NE	0	0	0	0	0	0	0
2.G.1 - Electrical Equipment	0	0	0	0	NE	NE	0	0	0	0	0	0	0
2.G.1.a - Manufacture of Electrical Equipment					NE	NE				0	0	0	0
2.G.1.b - Use of Electrical Equipment					NE	NE				0	0	0	0
2.G.1.c - Disposal of Electrical Equipment					NE	NE				0	0	0	0
2.G.2 - SF6 and PFCs from Other Product Uses	0	0	0	0	NE	NE	0	0	0	0	0	0	0
2.G.2.a - Military Applications					NE	NE				0	0	0	0

Categories	(Gg)			CO2 Equivalents(Gg)						(Gg)			
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	Other halogenated gases with CO_2-eq. conversion factors (1)	Other halogenated gases without CO_2-eq. conversion factors (2)	NOx	CO	NMVOCs	SO_2
2.G.2.b - Accelerators					NE	NE				0	0	0	0
2.G.2.c - Other (please specify) (3)					NE	NE				0	0	0	0
2.G.3 - N2O from Product Uses	0	0	NE	0	0	0	0	0	0	0	0	0	0
2.G.3.a - Medical Applications			NE							0	0	0	0
2.G.3.b - Propellant for pressure and aerosol products			NE							0	0	0	0
2.G.3.c - Other (Please specify) (3)			NE							0	0	0	0
2.G.4 - Other (Please specify) (3)										0	0	0	0
2.H - Other	NE	0	0	0	0	0	0	0	0	0	0	20.5	0
2.H.1 - Pulp and Paper Industry										0	0	0	0
2.H.2 - Food and Beverages Industry	NE									0	0	20.5	0
2.H.3 - Other (please specify) (3)										0	0	0	0

Sector «Industrial Processes and Product Use», 2010

Categories	(Gg)			CO2 Equivalents(Gg)						(Gg)			
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	Other halogenated gases with CO_2-eq. conversion factors (1)	Other halogenated gases without CO_2-eq. conversion factors (2)	NOx	CO	NMVOCs	SO_2
2 - Industrial Processes and Product Use	18072.378	0.016	2.89	19.15	0	0	0	0	0	1.19	10.62	35.44	3.74
2.A - Mineral Industry	14285.58	0	0	0	0	0	0	0	0	0	0	0	2.04
2.A.1 - Cement production	2926.38									0	0	0	2.04
2.A.2 - Lime production	167.70									0	0	0	0
2.A.3 - Glass Production	10356.80									0	0	0	0
2.A.4 - Other Process Uses of Carbonates	834.7	0	0	0	0	0	0	0	0	0	0	0	0
2.A.4.a - Ceramics	834.70									0	0	0	0
2.A.4.b - Other Uses of Soda Ash	NE									0	0	0	0
2.A.4.c - Non Metallurgical Magnesia Production	NO									0	0	0	0
2.A.4.d - Other (please specify) (3)	NO									0	0	0	0
2.A.5 - Other (please specify) (3)										0	0	0	0
2.B - Chemical Industry	2870.16	0.016	2.89	0	0	0	0	0	0	1.16	10.62	6.34	1.66
2.B.1 - Ammonia Production	2850.05									0	10.62	6.34	0.04
2.B.2 - Nitric Acid Production			2.89							1.16	0	0	0
2.B.3 - Adipic Acid Production			NO							0	0	0	0
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production			NO							0	0	0	0
2.B.5 - Carbide Production	NO	NO								0	0	0	0

Categories	(Gg)			CO2 Equivalents(Gg)						(Gg)			
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	Other halogenated gases with CO_2-eq. conversion factors (1)	Other halogenated gases without CO_2-eq. conversion factors (2)	NOx	CO	NMVOCs	SO_2
2.B.6 - Titanium Dioxide Production	NO									0	0	0	0
2.B.7 - Soda Ash Production	NA									0	0	0	0
2.B.8 - Petrochemical and Carbon Black Production	20.108	0.016	0	0	0	0	0	0	0	0	0	0.016	0
2.B.8.a - Methanol	3.91	0.013								0	0	0	0
2.B.8.b - Ethylene	NE	NE								0	0	0	0
2.B.8.c - Ethylene Dichloride and Vinyl Chloride Monomer	NO	NO								0	0	0	0
2.B.8.d - Ethylene Oxide	NO	NO								0	0	0	0
2.B.8.e - Acrylonitrile	16.198	0.003								0	0	0.016	0
2.B.8.f - Carbon Black	NE	NE								0	0	0	0
2.B.9 - Fluorochemical Production	0	0	0	NO	0	0	0	0	0	0	0	0	0
2.B.9.a - By-product emissions (4)				NO						0	0	0	0
2.B.9.b - Fugitive Emissions (4)										0	0	0	0
2.B.10 - Other (Sulphuric Acid) (3)										0	0	0	1.62
2.B.10 - Other (Formaldehyd) (3)										0	0	0.02	0
2.C - Metal Industry	863.12	0	0	0	NO	NO	0	0	0	0.03	0.001	0.02	0.03
2.C.1 - Iron and Steel Production	775.28	NA								0.03	0.001	0.02	0.03
2.C.2 - Ferroalloys Production	NO	NO								0	0	0	0
2.C.3 - Aluminium production	NO				NO					0	0	0	0
2.C.4 - Magnesium production (5)	NO					NO				0	0	0	0
2.C.5 - Lead Production	NO									0	0	0	0
2.C.6 - Zinc Production	87.84									0	0	0	0
2.C.7 - Other (please specify) (3)										0	0	0	0
2.D - Non-Energy Products from Fuels and Solvent Use (6)	53.52	0	0	0	0	0	0	0	0	0	0	0	0
2.D.1 - Lubricant Use	53.52									0	0	0	0
2.D.2 - Paraffin Wax Use	NE									0	0	0	0
2.D.3 - Solvent Use (7)										0	0	0	0
2.D.4 - Other (please specify) (3), (8)										0	0	0	0
2.E - Electronics Industry	0	0	0	NE	NE	NE	NE	0	NO	0	0	0	0
2.E.1 - Integrated Circuit or Semiconductor (9)				NE	NE	NE	NE		NO	0	0	0	0
2.E.2 - TFT Flat Panel Display (9)				NE	NE	NE	NE		NO	0	0	0	0
2.E.3 - Photovoltaics (9)				NE	NE	NE	NE		NO	0	0	0	0
2.E.4 - Heat Transfer Fluid (10)					NE					0	0	0	0
2.E.5 - Other (please specify) (3)										0	0	0	0
2.F - Product Uses as Substitutes for Ozone Depleting Substances	0	0	0	19.15	0	0	0	0	NO	0	0	0	0

Categories	(Gg)			CO2 Equivalents(Gg)					(Gg)				
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	Other halogenated gases with CO_2-eq. conversion factors (1)	Other halogenated gases without CO_2-eq. conversion factors (2)	NOx	CO	NMVOCs	SO_2
2.F.1 - Refrigeration and Air Conditioning	0	0	0	19.15	0	0	0	0	NO	0	0	0	0
2.F.1.a - Refrigeration and Stationary Air Conditioning				19.15	NE				NO	0	0	0	0
2.F.1.b - Mobile Air Conditioning				NE	NE				NO	0	0	0	0
2.F.2 - Foam Blowing Agents				NE	NE				NO	0	0	0	0
2.F.3 - Fire Protection				NE						0	0	0	0
2.F.4 - Aerosols										0	0	0	0
2.F.5 - Solvents				NE	NE					0	0	0	0
2.F.6 - Other Applications (please specify) (3)										0	0	0	0
2.G - Other Product Manufacture and Use	0	0	0	0	NE	NE	0	0	0	0	0	0	0
2.G.1 - Electrical Equipment	0	0	0	0	NE	NE	0	0	0	0	0	0	0
2.G.1.a - Manufacture of Electrical Equipment					NE	NE				0	0	0	0
2.G.1.b - Use of Electrical Equipment					NE	NE				0	0	0	0
2.G.1.c - Disposal of Electrical Equipment					NE	NE				0	0	0	0
2.G.2 - SF6 and PFCs from Other Product Uses	0	0	0	0	NE	NE	0	0	0	0	0	0	0
2.G.2.a - Military Applications					NE	NE				0	0	0	0
2.G.2.b - Accelerators					NE	NE				0	0	0	0
2.G.2.c - Other (please specify) (3)					NE	NE				0	0	0	0
2.G.3 - N2O from Product Uses	0	0	NE	0	0	0	0	0	0	0	0	0	0
2.G.3.a - Medical Applications			NE							0	0	0	0
2.G.3.b - Propellant for pressure and aerosol products			NE							0	0	0	0
2.G.3.c - Other (Please specify) (3)			NE							0	0	0	0
2.G.4 - Other (Please specify) (3)										0	0	0	0
2.H - Other	NE	0	0	0	0	0	0	0	0	0	0	29.04	0
2.H.1 - Pulp and Paper Industry										0	0	0	0
2.H.2 - Food and Beverages Industry	NE									0	0	29.04	0
2.H.3 - Other (please specify) (3)										0	0	0	0

Sector «Industrial Processes and Product Use», 2021

Categories	(Gg)			CO2 Equivalents(Gg)						(Gg)			
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	Other halogenated gases with CO_2-eq. conversion factors (1)	Other halogenated gases without CO_2-eq. conversion factors (2)	NOx	CO	NMVOCs	SO_2
2 - Industrial Processes and Product Use	26185.86	0.0936	6.84	988.8	0	0	0	0	0	1.23	12.65	35.75	6.23
2.A - Mineral Industry	21708.07	0	0	0	0	0	0	0	0	0	0	0	3.91
2.A.1 - Cement production	4482.58									0	0	0	3.91
2.A.2 - Lime production	252.90									0	0	0	0
2.A.3 - Glass Production	16420.05									0	0	0	0
2.A.4 - Other Process Uses of Carbonates	552.54	0	0	0	0	0	0	0	0	0	0	0	0
2.A.4.a - Ceramics	552.54									0	0	0	0
2.A.4.b - Other Uses of Soda Ash	NE									0	0	0	0
2.A.4.c - Non Metallurgical Magnesia Production	NO									0	0	0	0
2.A.4.d - Other (please specify) (3)	NO									0	0	0	0
2.A.5 - Other (please specify) (3)										0	0	0	0
2.B - Chemical Industry	2999.15	0.0806	6.84	0	0	0	0	0	0	1.19	12.65	7.57	2.27
2.B.1 - Ammonia Production	2975.54										12.65	7.53	0.05
2.B.2 - Nitric Acid Production			6.84							1.19	0	0	0
2.B.3 - Adipic Acid Production			NO							0	0	0	0
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production			NO							0	0	0	0
2.B.5 - Carbide Production	0.69	0.0073								0	0	0	0
2.B.6 - Titanium Dioxide Production	NO									0	0	0	0
2.B.7 - Soda Ash Production	NA									0	0	0	0
2.B.8 - Petrochemical and Carbon Black Production	22.92	0.0733	0	0	0	0	0	0	0	0	0	0.002	0
2.B.8.a - Methanol	21.37	0.073								0	0	0	0
2.B.8.b - Ethylene	NE	NE								0	0	0	0
2.B.8.c - Ethylene Dichloride and Vinyl Chloride Monomer	NO	NO								0	0	0	0
2.B.8.d - Ethylene Oxide	NO	NO								0	0	0	0
2.B.8.e - Acrylonitrile	1.55	0.0003								0	0	0.002	0
2.B.8.f - Carbon Black	NE	NE								0	0	0	0
2.B.9 - Fluorochemical Production	0	0	0	NO	0	0	0	0	0	0	0	0	0
2.B.9.a - By-product emissions (4)				NO						0	0	0	0
2.B.9.b - Fugitive Emissions (4)										0	0	0	0
2.B.10 - Other (Sulphuric Acid) (3)										0	0	0	2.22
2.B.10 - Other (Formaldehyd) (3)										0	0	0.036	0

Categories	(Gg)			CO2 Equivalents(Gg)						(Gg)			
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	Other halogenated gases with CO_2-eq. conversion factors (1)	Other halogenated gases without CO_2-eq. conversion factors (2)	NOx	CO	NMVOCs	SO_2
2.C - Metal Industry	1286.61	0.013	0	0	NO	NO	0	0	0	0.042	0.001	0.032	0.05
2.C.1 - Iron and Steel Production	1113.00	NA								0.042	0.001	0.032	0.05
2.C.2 - Ferroalloys Production	14.57	0.013								0	0	0	0
2.C.3 - Aluminium production	NO				NO					0	0	0	0
2.C.4 - Magnesium production (5)	NO					NO				0	0	0	0
2.C.5 - Lead Production	4.21									0	0	0	0
2.C.6 - Zinc Production	154.83									0	0	0	0
2.C.7 - Other (please specify) (3)										0	0	0	0
2.D - Non-Energy Products from Fuels and Solvent Use (6)	192.03	0	0	0	0	0	0	0	0	0	0	0	0
2.D.1 - Lubricant Use	192.03									0	0	0	0
2.D.2 - Paraffin Wax Use	NE									0	0	0	0
2.D.3 - Solvent Use (7)										0	0	0	0
2.D.4 - Other (please specify) (3), (8)										0	0	0	0
2.E - Electronics Industry	0	0	0	NE	NE	NE	NE	0	NO	0	0	0	0
2.E.1 - Integrated Circuit or Semiconductor (9)				NE	NE	NE	NE		NO	0	0	0	0
2.E.2 - TFT Flat Panel Display (9)				NE	NE	NE	NE		NO	0	0	0	0
2.E.3 - Photovoltaics (9)				NE	NE	NE	NE		NO	0	0	0	0
2.E.4 - Heat Transfer Fluid (10)					NE					0	0	0	0
2.E.5 - Other (please specify) (3)										0	0	0	0
2.F - Product Uses as Substitutes for Ozone Depleting Substances	0	0	0	988.8	NE	0	0	0	NO	0	0	0	0
2.F.1 - Refrigeration and Air Conditioning	0	0	0	988.8	NE	0	0	0	NO	0	0	0	0
2.F.1.a - Refrigeration and Stationary Air Conditioning				988.8	NE				NO	0	0	0	0
2.F.1.b - Mobile Air Conditioning				NE	NE				NO	0	0	0	0
2.F.2 - Foam Blowing Agents				NE	NE				NO	0	0	0	0
2.F.3 - Fire Protection				NE						0	0	0	0
2.F.4 - Aerosols										0	0	0	0
2.F.5 - Solvents				NE	NE					0	0	0	0
2.F.6 - Other Applications (please specify) (3)										0	0	0	0
2.G - Other Product Manufacture and Use	0	0	0	0	NE	NE	0	0	0	0	0	0	0
2.G.1 - Electrical Equipment	0	0	0	0	NE	NE	0	0	0	0	0	0	0
2.G.1.a - Manufacture of Electrical Equipment					NE	NE				0	0	0	0
2.G.1.b - Use of Electrical Equipment					NE	NE				0	0	0	0
2.G.1.c - Disposal of Electrical Equipment					NE	NE				0	0	0	0
2.G.2 - SF6 and PFCs from Other Product Uses	0	0	0	0	NE	NE	0	0	0	0	0	0	0

Categories	(Gg)			CO2 Equivalents(Gg)						(Gg)			
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	Other halogenated gases with CO_2-eq. conversion factors (1)	Other halogenated gases without CO_2-eq. conversion factors (2)	NOx	CO	NMVOCs	SO_2
2.G.2.a - Military Applications					NE	NE				0	0	0	0
2.G.2.b - Accelerators					NE	NE				0	0	0	0
2.G.2.c - Other (please specify) (3)					NE	NE				0	0	0	0
2.G.3 - N2O from Product Uses	0	0	NE	0	0	0	0	0	0	0	0	0	0
2.G.3.a - Medical Applications			NE							0	0	0	0
2.G.3.b - Propellant for pressure and aerosol products			NE							0	0	0	0
2.G.3.c - Other (Please specify) (3)			NE							0	0	0	0
2.G.4 - Other (Please specify) (3)										0	0	0	0
2.H - Other	NE	0	0	0	0	0	0	0	0	0	0	28.16	0
2.H.1 - Pulp and Paper Industry										0	0	0	0
2.H.2 - Food and Beverages Industry	NE									0	0	28.16	0
2.H.3 - Other (please specify) (3)										0	0	0	0

Sector«Agriculture, Forestry and Other Land Use», Gg, 1990

Categories	Net CO_2 emissions / removals	Emissions				
		CH_4	N_2O	NOx	CO	NMVOCs
3 - Agriculture, Forestry, and Other Land Use	-15383.05	322.10	13.56	0.85	31.18	0
3.A - Livestock	0	307.28	2.34	0	0	0
3.A.1 - Enteric Fermentation	0	280.22	0	0	0	0
3.A.1.a - Cattle	0		0	0	0	0
3.A.1.a.i - Dairy Cows		106.78		0	0	0
3.A.1.a.ii - Other Cattle		123.61		0	0	0
3.A.1.b - Buffalo		0		0	0	0
3.A.1.c - Sheep		41.11		0	0	0
3.A.1.d - Goats		3.93		0	0	0
3.A.1.e - Camels		1.04		0	0	0
3.A.1.f - Horses		1.82		0	0	0
3.A.1.g - Mules and Asses		1.2		0	0	0
3.A.1.h - Swine		0.73		0	0	0
3.A.1.j - Other (please specify)		0		0	0	0
3.A.2 - Manure Management (1)	0	27.06	2.34	0	0	0
3.A.2.a - Cattle	0			0	0	0
3.A.2.a.i - Dairy cows		21.35	0.31	0	0	0
3.A.2.a.ii - Other cattle		2.63	1.51	0	0	0
3.A.2.b - Buffalo		0	0.00	0	0	0
3.A.2.c - Sheep		0.86	0.26	0	0	0
3.A.2.d - Goats		0.09	0.01	0	0	0
3.A.2.e - Camels		0.03	0.00	0	0	0
3.A.2.f - Horses		0.11	0.00	0	0	0
3.A.2.g - Mules and Asses		0.08	0.00	0	0	0
3.A.2.h - Swine		1.52	0.07	0	0	0
3.A.2.i - Poultry		0.39	0.16	0	0	0
3.A.2.j - Other (please specify)		0	0	0	0	0
3.B - Land	-15383.05	0	0	0	0	0
3.B.1 - Forest land	0	0	0	0	0	0
3.B.1.a - Forest land Remaining Forest land	-4894.00			0	0	0
3.B.1.b - Land Converted to Forest land	0	0	0	0	0	0
3.B.1.b.i - Cropland converted to Forest Land	NE			0	0	0
3.B.1.b.ii - Grassland converted to Forest Land	NE			0	0	0
3.B.1.b.iii - Wetlands converted to Forest Land	NE			0	0	0
3.B.1.b.iv - Settlements converted to Forest Land	NE			0	0	0
3.B.1.b.v - Other Land converted to Forest Land	NE			0	0	0
3.B.2 - Cropland	0	0	0	0	0	0
3.B.2.a - Cropland Remaining Cropland	-9149.81			0	0	0
3.B.2.b - Land Converted to Cropland	0	0	0	0	0	0
3.B.2.b.i - Forest Land converted to Cropland	NE			0	0	0
3.B.2.b.ii - Grassland converted to Cropland	NE			0	0	0
3.B.2.b.iii - Wetlands converted to Cropland	NE			0	0	0
3.B.2.b.iv - Settlements converted to Cropland	NE			0	0	0
3.B.2.b.v - Other Land converted to Cropland	NE			0	0	0
3.B.3 - Grassland	0	0	0	0	0	0
3.B.3.a - Grassland Remaining Grassland	-1339.24			0	0	0
3.B.3.b - Land Converted to Grassland	0	0	0	0	0	0
3.B.3.b.i - Forest Land converted to Grassland	NE			0	0	0
3.B.3.b.ii - Cropland converted to Grassland	NE			0	0	0
3.B.3.b.iii - Wetlands converted to Grassland	NE			0	0	0
3.B.3.b.iv - Settlements converted to Grassland	NE			0	0	0
3.B.3.b.v - Other Land converted to Grassland	NE			0	0	0
3.B.4 - Wetlands	0	0	0	0	0	0
3.B.4.a - Wetlands Remaining Wetlands	0	0	0	0	0	0
3.B.4.a.i - Peat Extraction remaining Peat Extraction	NE			0	0	0
3.B.4.a.ii - Flooded Land remaining Flooded Land				0	0	0
3.B.4.a.iii - Other Wetlands Remaining Other Wetlands	NE			0	0	0

Categories	Net CO_2 emissions / removals	Emissions				
		CH_4	N_2O	NOx	CO	NMVOCs
3.B.4.b - Land Converted to Wetlands	0	0	0	0	0	0
3.B.4.b.i - Land converted for Peat Extraction	NE			0	0	0
3.B.4.b.ii - Land converted to Flooded Land	NE			0	0	0
3.B.4.b.iii - Land converted to Other Wetlands	NE			0	0	0
3.B.5 - Settlements	0	0	0	0	0	0
3.B.5.a - Settlements Remaining Settlements	NE			0	0	0
3.B.5.b - Land Converted to Settlements	0	0	0	0	0	0
3.B.5.b.i - Forest Land converted to Settlements	NE			0	0	0
3.B.5.b.ii - Cropland converted to Settlements	NE			0	0	0
3.B.5.b.iii - Grassland converted to Settlements	NE			0	0	0
3.B.5.b.iv - Wetlands converted to Settlements	NE			0	0	0
3.B.5.b.v - Other Land converted to Settlements	NE			0	0	0
3.B.6 - Other Land	0	0	0	0	0	0
3.B.6.a - Other land Remaining Other land				0	0	0
3.B.6.b - Land Converted to Other land	0	0	0	0	0	0
3.B.6.b.i - Forest Land converted to Other Land	NE			0	0	0
3.B.6.b.ii - Cropland converted to Other Land	NE			0	0	0
3.B.6.b.iii - Grassland converted to Other Land	NE			0	0	0
3.B.6.b.iv - Wetlands converted to Other Land	NE			0	0	0
3.B.6.b.v - Settlements converted to Other Land	NE			0	0	0
3.C - Aggregate sources and non-CO2 emissions sources on land (2)	0	14.82	11.22	0.85	31.18	0
3.C.1 - Burning	0	0	0	0	0	0
3.C.1.a - Burning in Forest Land	NE	NE	NE	0	0	0
3.C.1.b - Burning in Cropland	IE	0.92	0.02	0.85	31.18	0
3.C.1.c - Burning in Grassland	NE	NE	NE	0	0	0
3.C.1.d - Burning in All Other Lands	NE	NE	NE	0	0	0
3.C.2 - Liming	NO			0	0	0
3.C.3 - Urea application	NE			0	0	0
3.C.4 - Direct N2O Emissions from managed soils (3)			7.90	0	0	0
3.C.5 - Indirect N2O Emissions from managed soils			2.41	0	0	0
3.C.6 - Indirect N2O Emissions from manure management			0.89	0	0	0
3.C.7 - Rice cultivation		13.9		0	0	0
3.C.8 - CH4 from Drained Organic Soils		0		0	0	0
3.C.9 - CH4 from Drainage Ditches on Organic Soils		0		0	0	0
3.C.10 - CH4 from Rewetting of Organic Soils		0		0	0	0
3.C.11 - CH4 Emissions from Rewetting of Mangroves and Tidal Marshes		0		0	0	0
3.C.12 - N2O Emissions from Aquaculture			0	0	0	0
3.C.13 - CH4 Emissions from Rewetted and Created Wetlands on Inland Wetland Mineral Soils		0		0	0	0
3.C.14 - Other (please specify)				0	0	0
3.D - Other	0	0	0	0	0	0
3.D.1 - Harvested Wood Products	NE			0	0	0
3.D.2 - Other (please specify)				0	0	0

Sector«Agriculture, Forestry and Other Land Use», Gg, 2010

Categories	Net CO_2 emissions / removals	Emissions				
		CH_4	N_2O	NOx	CO	NMVOCs
3 - Agriculture, Forestry, and Other Land Use	2440.06	605.37	26.42	5.78	183.72	0
3.A - Livestock	0	598.82	4.21	0	0	0
3.A.1 - Enteric Fermentation	0	546.71	0	0	0	0
3.A.1.a - Cattle	0	679.19	0	0	0	0
3.A.1.a.i - Dairy Cows		222.46		0	0	0
3.A.1.a.ii - Other Cattle		242.32		0	0	0
3.A.1.b - Buffalo		0		0	0	0
3.A.1.c - Sheep		62.16		0	0	0
3.A.1.d - Goats		12.27		0	0	0
3.A.1.e - Camels		0.82		0	0	0
3.A.1.f - Horses		3.31		0	0	0
3.A.1.g - Mules and Asses		3.27		0	0	0
3.A.1.h - Swine		0.1		0	0	0
3.A.1.j - Other (please specify)		0		0	0	0
3.A.2 - Manure Management (1)	0	52.11	4.21	0	0	0
3.A.2.a - Cattle	0			0	0	0
3.A.2.a.i - Dairy cows		44.35	0.65	0	0	0
3.A.2.a.ii - Other cattle		5.16	2.95	0	0	0
3.A.2.b - Buffalo		0	0.00	0	0	0
3.A.2.c - Sheep		1.30	0.40	0	0	0
3.A.2.d - Goats		0.30	0.03	0	0	0
3.A.2.e - Camels		0.02	0.00	0	0	0
3.A.2.f - Horses		0.21	0.01	0	0	0
3.A.2.g - Mules and Asses		0.20	0.01	0	0	0
3.A.2.h - Swine		0.20	0.01	0	0	0
3.A.2.i - Poultry		0.37	0.16	0	0	0
3.A.2.j - Other (please specify)		0	0	0	0	0
3.B - Land	2440.06	0	0	5.78	183.72	0
3.B.1 - Forest land	-6606.53	0	0	0	0	0
3.B.1.a - Forest land Remaining Forest land	-6606.53			5.78	183.72	0
3.B.1.b - Land Converted to Forest land	0	0	0	0	0	0
3.B.1.b.i - Cropland converted to Forest Land	NE			0	0	0
3.B.1.b.ii - Grassland converted to Forest Land	NE			0	0	0
3.B.1.b.iii - Wetlands converted to Forest Land	NE			0	0	0
3.B.1.b.iv - Settlements converted to Forest Land	NE			0	0	0
3.B.1.b.v - Other Land converted to Forest Land	NE			0	0	0
3.B.2 - Cropland	-2153.83	0	0	0	0	0
3.B.2.a - Cropland Remaining Cropland	-2153.83			0	0	0
3.B.2.b - Land Converted to Cropland	0	0	0	0	0	0
3.B.2.b.i - Forest Land converted to Cropland	NE			0	0	0
3.B.2.b.ii - Grassland converted to Cropland	NE			0	0	0
3.B.2.b.iii - Wetlands converted to Cropland	NE			0	0	0
3.B.2.b.iv - Settlements converted to Cropland	NE			0	0	0
3.B.2.b.v - Other Land converted to Cropland	NE			0	0	0
3.B.3 - Grassland	11200.42	0	0	0	0	0
3.B.3.a - Grassland Remaining Grassland	11200.42			0	0	0
3.B.3.b - Land Converted to Grassland	0	0	0	0	0	0
3.B.3.b.i - Forest Land converted to Grassland	NE			0	0	0
3.B.3.b.ii - Cropland converted to Grassland	NE			0	0	0
3.B.3.b.iii - Wetlands converted to Grassland	NE			0	0	0
3.B.3.b.iv - Settlements converted to Grassland	NE			0	0	0
3.B.3.b.v - Other Land converted to Grassland	NE			0	0	0
3.B.4 - Wetlands	0	0	0	0	0	0
3.B.4.a - Wetlands Remaining Wetlands	0	0	0	0	0	0
3.B.4.a.i - Peat Extraction remaining Peat Extraction	NE			0	0	0
3.B.4.a.ii - Flooded Land remaining Flooded Land				0	0	0
3.B.4.a.iii - Other Wetlands Remaining Other Wetlands	NE			0	0	0

Categories	Net CO_2 emissions / removals	Emissions				
		CH_4	N_2O	NOx	CO	NMVOCs
3.B.4.b - Land Converted to Wetlands	0	0	0	0	0	0
3.B.4.b.i - Land converted for Peat Extraction	NE			0	0	0
3.B.4.b.ii - Land converted to Flooded Land	NE			0	0	0
3.B.4.b.iii - Land converted to Other Wetlands	NE			0	0	0
3.B.5 - Settlements	0	0	0	0	0	0
3.B.5.a - Settlements Remaining Settlements	NE			0	0	0
3.B.5.b - Land Converted to Settlements	0	0	0	0	0	0
3.B.5.b.i - Forest Land converted to Settlements	NE			0	0	0
3.B.5.b.ii - Cropland converted to Settlements	NE			0	0	0
3.B.5.b.iii - Grassland converted to Settlements	NE			0	0	0
3.B.5.b.iv - Wetlands converted to Settlements	NE			0	0	0
3.B.5.b.v - Other Land converted to Settlements	NE			0	0	0
3.B.6 - Other Land	0	0	0	0	0	0
3.B.6.a - Other land Remaining Other land				0	0	0
3.B.6.b - Land Converted to Other land	0	0	0	0	0	0
3.B.6.b.i - Forest Land converted to Other Land	NE			0	0	0
3.B.6.b.ii - Cropland converted to Other Land	NE			0	0	0
3.B.6.b.iii - Grassland converted to Other Land	NE			0	0	0
3.B.6.b.iv - Wetlands converted to Other Land	NE			0	0	0
3.B.6.b.v - Settlements converted to Other Land	NE			0	0	0
3.C - Aggregate sources and non-CO2 emissions sources on land (2)	0	6.55	22.21	0	0	0
3.C.1 - Burning	0	0	0	0	0	0
3.C.1.a - Burning in Forest Land	0	0	0	0	0	0
3.C.1.b - Burning in Cropland	NO	NO	NO	0	0	
3.C.1.c - Burning in Grassland	NE	NE	NE	0	0	0
3.C.1.d - Burning in All Other Lands	NE	NE	NE	0	0	0
3.C.2 - Liming	NO			0	0	0
3.C.3 - Urea application	NE			0	0	0
3.C.4 - Direct N2O Emissions from managed soils (3)			14.06	0	0	0
3.C.5 - Indirect N2O Emissions from managed soils			6.48	0	0	0
3.C.6 - Indirect N2O Emissions from manure management			1.68	0	0	0
3.C.7 - Rice cultivation		6.55		0	0	0
3.C.8 - CH4 from Drained Organic Soils		0		0	0	0
3.C.9 - CH4 from Drainage Ditches on Organic Soils		0		0	0	0
3.C.10 - CH4 from Rewetting of Organic Soils		0		0	0	0
3.C.11 - CH4 Emissions from Rewetting of Mangroves and Tidal Marshes		0		0	0	0
3.C.12 - N2O Emissions from Aquaculture			0	0	0	0
3.C.13 - CH4 Emissions from Rewetted and Created Wetlands on Inland Wetland Mineral Soils		0		0	0	0
3.C.14 - Other (please specify)				0	0	0
3.D - Other	0	0	0	0	0	0
3.D.1 - Harvested Wood Products	NE			0	0	0
3.D.2 - Other (please specify)				0	0	0

Sector«Agriculture, Forestry and Other Land Use», Gg, 2021

Categories	Net CO_2 emissions / removals	Emissions				
		CH_4	N_2O	NOx	CO	NMVOCs
3 - Agriculture, Forestry, and Other Land Use	-6350.70	871.22	37.54	106.92	328.11	0
3.A - Livestock	0	866.59	6.67	0	0	0
3.A.1 - Enteric Fermentation	0	797.28	0	0	0	0
3.A.1.a - Cattle	0	679.19	0	0	0	0
3.A.1.a.i - Dairy Cows		286.48		0	0	0
3.A.1.a.ii - Other Cattle		392.71		0	0	0
3.A.1.b - Buffalo		0		0	0	0
3.A.1.c - Sheep		92.57		0	0	0
3.A.1.d - Goats		18.35		0	0	0
3.A.1.e - Camels		0.92		0	0	0
3.A.1.f - Horses		4.51		0	0	0
3.A.1.g - Mules and Asses		1.69		0	0	0
3.A.1.h - Swine		0.05		0	0	0
3.A.1.j - Other (please specify)		0		0	0	0
3.A.2 - Manure Management (1)	0	69.31	6.67	0	0	0
3.A.2.a - Cattle	0	65.48	5.62	0	0	0
3.A.2.a.i - Dairy cows		57.12	0.84	0	0	0
3.A.2.a.ii - Other cattle		8.36	4.78	0	0	0
3.A.2.b - Buffalo		0	0.00	0	0	0
3.A.2.c - Sheep		1.94	0.59	0	0	0
3.A.2.d - Goats		0.44	0.04	0	0	0
3.A.2.e - Camels		0.03	0.00	0	0	0
3.A.2.f - Horses		0.28	0.01	0	0	0
3.A.2.g - Mules and Asses		0.10	0.00	0	0	0
3.A.2.h - Swine		0.11	0.01	0	0	0
3.A.2.i - Poultry		0.94	0.40	0	0	0
3.A.2.j - Other (please specify)		0	0	0	0	0
3.B - Land	-6350.70	0	0	106.92	328.11	0
3.B.1 - Forest land	-6745.69	0	0	0	0	0
3.B.1.a - Forest land Remaining Forest land	-6745.69			106.92	328.11	0
3.B.1.b - Land Converted to Forest land	0	0	0	0	0	0
3.B.1.b.i - Cropland converted to Forest Land	NE			0	0	0
3.B.1.b.ii - Grassland converted to Forest Land	NE			0	0	0
3.B.1.b.iii - Wetlands converted to Forest Land	NE			0	0	0
3.B.1.b.iv - Settlements converted to Forest Land	NE			0	0	0
3.B.1.b.v - Other Land converted to Forest Land	NE			0	0	0
3.B.2 - Cropland	-3568.38	0	0	0	0	0
3.B.2.a - Cropland Remaining Cropland	-3568.38			0	0	0
3.B.2.b - Land Converted to Cropland	0	0	0	0	0	0
3.B.2.b.i - Forest Land converted to Cropland	NE			0	0	0
3.B.2.b.ii - Grassland converted to Cropland	NE			0	0	0
3.B.2.b.iii - Wetlands converted to Cropland	NE			0	0	0
3.B.2.b.iv - Settlements converted to Cropland	NE			0	0	0
3.B.2.b.v - Other Land converted to Cropland	NE			0	0	0
3.B.3 - Grassland	3963.30	0	0	0	0	0
3.B.3.a - Grassland Remaining Grassland	3963.30			0	0	0
3.B.3.b - Land Converted to Grassland	0	0	0	0	0	0
3.B.3.b.i - Forest Land converted to Grassland	NE			0	0	0
3.B.3.b.ii - Cropland converted to Grassland	NE			0	0	0
3.B.3.b.iii - Wetlands converted to Grassland	NE			0	0	0
3.B.3.b.iv - Settlements converted to Grassland	NE			0	0	0
3.B.3.b.v - Other Land converted to Grassland	NE			0	0	0
3.B.4 - Wetlands	0	0	0	0	0	0
3.B.4.a - Wetlands Remaining Wetlands	0	0	0	0	0	0
3.B.4.a.i - Peat Extraction remaining Peat Extraction	NE			0	0	0
3.B.4.a.ii - Flooded Land remaining Flooded Land				0	0	0
3.B.4.a.iii - Other Wetlands Remaining Other Wetlands	NE			0	0	0

Categories	Net CO_2 emissions / removals	Emissions				
		CH_4	N_2O	NOx	CO	NMVOCs
3.B.4.b - Land Converted to Wetlands	0	0	0	0	0	0
3.B.4.b.i - Land converted for Peat Extraction	NE			0	0	0
3.B.4.b.ii - Land converted to Flooded Land	NE			0	0	0
3.B.4.b.iii - Land converted to Other Wetlands	NE			0	0	0
3.B.5 - Settlements	0	0	0	0	0	0
3.B.5.a - Settlements Remaining Settlements	NE			0	0	0
3.B.5.b - Land Converted to Settlements	0	0	0	0	0	0
3.B.5.b.i - Forest Land converted to Settlements	NE			0	0	0
3.B.5.b.ii - Cropland converted to Settlements	NE			0	0	0
3.B.5.b.iii - Grassland converted to Settlements	NE			0	0	0
3.B.5.b.iv - Wetlands converted to Settlements	NE			0	0	0
3.B.5.b.v - Other Land converted to Settlements	NE			0	0	0
3.B.6 - Other Land	0	0	0	0	0	0
3.B.6.a - Other land Remaining Other land				0	0	0
3.B.6.b - Land Converted to Other land	0	0	0	0	0	0
3.B.6.b.i - Forest Land converted to Other Land	NE			0	0	0
3.B.6.b.ii - Cropland converted to Other Land	NE			0	0	0
3.B.6.b.iii - Grassland converted to Other Land	NE			0	0	0
3.B.6.b.iv - Wetlands converted to Other Land	NE			0	0	0
3.B.6.b.v - Settlements converted to Other Land	NE			0	0	0
3.C - Aggregate sources and non-CO2 emissions sources on land (2)	0	4.63	30.87	0	0	0
3.C.1 - Burning	0	0	0	0	0	0
3.C.1.a - Burning in Forest Land	0	0	0	0	0	0
3.C.1.b - Burning in Cropland	NO	NO	NO	0	0	
3.C.1.c - Burning in Grassland	NE	NE	NE	0	0	0
3.C.1.d - Burning in All Other Lands	NE	NE	NE	0	0	0
3.C.2 - Liming	NO			0	0	0
3.C.3 - Urea application	NE			0	0	0
3.C.4 - Direct N2O Emissions from managed soils (3)			19.45	0	0	0
3.C.5 - Indirect N2O Emissions from managed soils			9.02	0	0	0
3.C.6 - Indirect N2O Emissions from manure management			2.39	0	0	0
3.C.7 - Rice cultivation		4.63		0	0	0
3.C.8 - CH4 from Drained Organic Soils		0		0	0	0
3.C.9 - CH4 from Drainage Ditches on Organic Soils		0		0	0	0
3.C.10 - CH4 from Rewetting of Organic Soils		0		0	0	0
3.C.11 - CH4 Emissions from Rewetting of Mangroves and Tidal Marshes		0		0	0	0
3.C.12 - N2O Emissions from Aquaculture			0	0	0	0
3.C.13 - CH4 Emissions from Rewetted and Created Wetlands on Inland Wetland Mineral Soils		0		0	0	0
3.C.14 - Other (please specify)				0	0	0
3.D - Other	0	0	0	0	0	0
3.D.1 - Harvested Wood Products	NE			0	0	0
3.D.2 - Other (please specify)				0	0	0

Sector«Waste», Gg, 1990

Categories	CO_2	CH_4	N_2O	NOx	CO	NMVOCs	SO_2
4 - Waste	NE	160.54	1.35	0	0	0	0
4.A - Solid Waste Disposal	NE	70.47	0	0	0	0	0
4.A.1 - Managed Waste Disposal Sites		NO		0	0	0	0
4.A.2 - Unmanaged Waste Disposal Sites				0	0	0	0
4.A.3 - Uncategorised Waste Disposal Sites		70.47		0	0	0	0
4.B - Biological Treatment of Solid Waste		NE	NE	0	0	0	0
4.C - Incineration and Open Burning of Waste	NO , NE	NO , NE	NO , NE	0	0	0	0
4.C.1 - Waste Incineration	NO	NO	NO	0	0	0	0
4.C.2 - Open Burning of Waste	NE	NE	NE	0	0	0	0
4.D - Wastewater Treatment and Discharge	0	90.07	1.35	0	0	0	0
4.D.1 - Domestic Wastewater Treatment and Discharge		85.52	1.35	0	0	0	0
4.D.2 - Industrial Wastewater Treatment and Discharge		4.55	0	0	0	0	0
4.E - Other (please specify)				0	0	0	0

Sector«Waste», Gg, 2010

Categories	CO_2	CH_4	N_2O	NOx	CO	NMVOCs	SO_2
4 - Waste	NE	249.80	1.94	0	0	0	0
4.A - Solid Waste Disposal	NE	126.34	0	0	0	0	0
4.A.1 - Managed Waste Disposal Sites		NO		0	0	0	0
4.A.2 - Unmanaged Waste Disposal Sites				0	0	0	0
4.A.3 - Uncategorised Waste Disposal Sites		126.34		0	0	0	0
4.B - Biological Treatment of Solid Waste		NE	NE	0	0	0	0
4.C - Incineration and Open Burning of Waste	NO , NE	NO , NE	NO , NE	0	0	0	0
4.C.1 - Waste Incineration	NO	NO	NO	0	0	0	0
4.C.2 - Open Burning of Waste	NE	NE	NE	0	0	0	0
4.D - Wastewater Treatment and Discharge	0	123.46	1.94	0	0	0	0
4.D.1 - Domestic Wastewater Treatment and Discharge		119.1	1.94	0	0	0	0
4.D.2 - Industrial Wastewater Treatment and Discharge		4.36	0	0	0	0	0
4.E - Other (please specify)				0	0	0	0

Sector«Waste», Gg, 2021

Categories	CO_2	CH_4	N_2O	NOx	CO	NMVOCs	SO_2
4 - Waste	NE	331.09	2.91	0	0	0	0
4.A - Solid Waste Disposal	NE	186.68	0	0	0	0	0
4.A.1 - Managed Waste Disposal Sites		NO		0	0	0	0
4.A.2 - Unmanaged Waste Disposal Sites				0	0	0	0
4.A.3 - Uncategorised Waste Disposal Sites		186.68		0	0	0	0
4.B - Biological Treatment of Solid Waste		NE	NE	0	0	0	0
4.C - Incineration and Open Burning of Waste	NO, NE	NO, NE	NO, NE	0	0	0	0
4.C.1 - Waste Incineration	NO	NO	NO	0	0	0	0
4.C.2 - Open Burning of Waste	NE	NE	NE	0	0	0	0
4.D - Wastewater Treatment and Discharge	0	144.41	2.91	0	0	0	0
4.D.1 - Domestic Wastewater Treatment and Discharge		138.85	2.91	0	0	0	0
4.D.2 - Industrial Wastewater Treatment and Discharge		5.55	0	0	0	0	0
4.E - Other (please specify)				0	0	0	0

Summary Report on GHG Emissions in the Republic of Uzbekistan, 1990

Categories	Emissions, (Gg)			Emissions, CO_2 Equivalents (Gg)						Emissions (Gg)			
	Net CO_2 (1)(2)	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	Other halogenated gases with CO_2-eq. conversion factors (3)	Other halogenated gases without CO_2-eq. conversion factors (4)	NOx	CO	NMVOCs	SO_2
Total National Emissions and Removals	104353.08	1176.95	24.63	0.00	0.00	0.00	0.00	0.00	0.00	413.28	1940.73	524.89	142.98
1 - Energy	109101.10	694.30	1.72	0.00	0.00	0.00	0.00	0.00	0.00	409.62	1895.80	496.15	134.40
1.A - Fuel Combustion Activities	108214.27	21.97	1.71							409.62	1895.80	336.60	0.50
1.B - Fugitive emissions from fuels	886.83	672.33	0.00							0	0	159.55	133.93
1.C - Carbon dioxide Transport and Storage	NO									0	0	0	0
2 - Industrial Processes and Product Use	10835.03	0.00	8.01	0.00	0.00	0.00	0.00	0.00	0.00	2.81	13.75	28.74	8.58
2.A - Mineral Industry	5893.73	0	0							0	0	0	1.92
2.B - Chemical Industry	4004.27	0.00	8.01	0	NO	NO	0	0	0	2.78	13.75	8.22	6.63
2.C - Metal Industry	733.68	0	0	0	0	0	0	0	0	0.03	0.00	0.02	0.03
2.D - Non-Energy Products from Fuels and Solvent Use	203.35	0	0							0	0	0	0
2.E - Electronics Industry	0	0	0	NE	NE	NE	NE	0	NO	0	0	0	0
2.F - Product Uses as Substitutes for Ozone Depleting Substances	0	0	0	NO	0	0	0	0	NO	0	0	0	0
2.G - Other Product Manufacture and Use	0	0	0	0	NE	NE	0	0	0	0	0	0	0
2.H - Other (Food and Beverages Industry)	NE	0	0	0	0	0	0	0	0	0	0	20.5	0
3 - Agriculture, Forestry, and Other Land Use	-15583.05	322.10	13.56	0	0	0	0	0	0	0.85	31.18	0	0
3.A - Livestock		307.28	2.34							0	0	0	0
3.B - Land	-15583.05									0	0	0	0
3.C - Aggregate sources and non-CO2 emissions sources on land	0	14.82	11.22							0.85	31.18	0	0
3.D - Other	0	0	0							0	0	0	0
4 - Waste	0	160.55	1.35	0	0	0	0	0	0	0	0	0	0
4.A - Solid Waste Disposal		70.47								0	0	0	0
4.B - Biological Treatment of Solid Waste		NE	NE							0	0	0	0
4.C - Incineration and Open Burning of Waste	NO, NE	NO, NE	NO, NE							0	0	0	0
4.D - Wastewater Treatment and Discharge		90.08	1.35							0	0	0	0
4.E - Other (please specify)	0	0	0							0	0	0	0
5 - Other	0	0	0	0	0	0	0	0	0	0	0	0	0
5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3			0							0	0	0	0
5.B - Other (please specify)	0	0	0	0	0	0	0	0	0	0	0	0	0
Memo Items (5)													
International Bunkers	2064.02	0.01	0.06	0	0	0	0	0	0	11.90	4.00	2.00	2.00
1.A.3.a.i - International Aviation (International Bunkers) (1)	2064.02	0.01	0.06							11.90	4.00	2.00	2.00
1.A.3.d.i - International water-borne navigation (International bunkers) (1)	0	0	0							0	0	0	0
1.A.5.c - Multilateral Operations (1)(2)	0	0	0	0	0	0	0	0	0	0	0	0	0

Summary Report on GHG Emissions in the Republic of Uzbekistan, 2010

Categories	Emissions, (Gg)			Emissions, CO_2 Equivalents (Gg)						Emissions (Gg)			
	Net CO_2 (1)(2)	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	Other halogenated gases with CO_2-eq. conversion factors (3)	Other halogenated gases without CO_2-eq. conversion factors (4)	NOx	CO	NMVOCs	SO_2
Total National Emissions and Removals	116520.55	1938.78	31.99	19.15	0.00	0.00	0.00	0.00	0.00	256.57	1226.34	464.46	72.45
1 - Energy	96008.11	1083.59	0.74	0.00	0.00	0.00	0.00	0.00	0.00	249.60	1032.00	429.02	68.71
1.A - Fuel Combustion Activities	94788.76	10.44	0.73							249.60	1032.00	191.30	0.09
1.B - Fugitive emissions from fuels	1219.35	1073.16	0.01							0.00	0.00	237.72	68.62
1.C - Carbon dioxide Transport and Storage	NO									0	0	0	0
2 - Industrial Processes and Product Use	18072.38	0.02	2.89	19.15	0	0	0	0	0	1.19	10.62	35.44	3.74
2.A - Mineral Industry	14285.58	0	0							0	0	0	2.04
2.B - Chemical Industry	2870.16	0.02	2.89	0	0	0	0	0	0	1.16	10.62	6.34	1.66
2.C - Metal Industry	863.12	0	0	0	NO	NO	0	0	0	0.03	0.00	0.02	0.03
2.D - Non-Energy Products from Fuels and Solvent Use	53.52	0	0							0	0	0	0
2.E - Electronics Industry	0	0	0	NE	NE	NE	NE	0	NO	0	0	0	0
2.F - Product Uses as Substitutes for Ozone Depleting Substances	0	0	0	19.15	0	0	0	0	NO	0	0	0	0
2.G - Other Product Manufacture and Use	0	0	0	0	NE	NE	0	0	0	0	0	0	0
2.H - Other (Food and Beverages Industry)	NE	0	0	0	0	0	0	0	0	0	0	29.04	0
3 - Agriculture, Forestry, and Other Land Use	2440.06	605.37	26.42	0	0	0	0	0	0	5.78	183.72	0	0
3.A - Livestock		598.82	4.21							0	0	0	0
3.B - Land	2440.06									5.78	183.72	0	0
3.C - Aggregate sources and non-CO2 emissions sources on land	0	6.55	22.21							0	0	0	0
3.D - Other	0	0	0							0	0	0	0
4 - Waste	0	249.80	1.94	0	0	0	0	0	0	0	0	0	0
4.A - Solid Waste Disposal		126.34								0	0	0	0
4.B - Biological Treatment of Solid Waste		NE	NE							0	0	0	0
4.C - Incineration and Open Burning of Waste	NO, NE	NO, NE	NO, NE							0	0	0	0
4.D - Wastewater Treatment and Discharge		123.46	1.94							0	0	0	0
4.E - Other (please specify)	0	0	0							0	0	0	0
5 - Other	0	0	0	0	0	0	0	0	0	0	0	0	0
5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3			0							0	0	0	0
5.B - Other (please specify)	0	0	0	0	0	0	0	0	0	0	0	0	0
Memo Items (5)													
International Bunkers	913.87	0.01	0.03	0	0	0	0	0	0	4.10	1.40	0.70	0.60
1.A.3.a.i - International Aviation (International Bunkers) (1)	913.87	0.01	0.03							4.10	1.40	0.70	0.60
1.A.3.d.i - International water-borne navigation (International bunkers) (1)	0	0	0							0	0	0	0
1.A.5.c - Multilateral Operations (1)(2)	0	0	0	0	0	0	0	0	0	0	0	0	0

Summary Report on GHG Emissions in the Republic of Uzbekistan, 2021

Categories	Emissions, (Gg)			Emissions, CO_2 Equivalents (Gg)						Emissions (Gg)			
	Net CO_2 (1)(2)	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	Other halogenated gases with CO_2-eq. conversion factors (3)	Other halogenated gases without CO_2-eq. conversion factors (4)	NOx	CO	NMVOCs	SO_2
Total National Emissions and Removals	133054.14	2112.24	48.48	988.80	0.00	0.00	0.00	0.00	0.00	505.35	1687.96	541.33	109.92
1 - Energy	113218.98	909.83	1.18	0.00	0.00	0.00	0.00	0.00	0.00	397.20	1347.2	505.57	103.69
1.A - Fuel Combustion Activities	112340.99	25.40	1.18							397.20	1347.2	322.10	0.27
1.B - Fugitive emissions from fuels	877.98	884.43	0.01							0	0	183.47	103.42
1.C - Carbon dioxide Transport and Storage	NO									0	0	0	0
2 - Industrial Processes and Product Use	26185.86	0.09	6.84	988.80	0	0	0	0	0	1.234	12.65	35.76	6.23
2.A - Mineral Industry	21708.07	0	0							0	0	0	3.91
2.B - Chemical Industry	2999.15	0.08	6.84	0	0	0	0	0	0	1.19	12.65	7.57	2.27
2.C - Metal Industry	1286.61	0.01	0	0	NO	NO	0	0	0	0.04	0.001	0.03	0.05
2.D - Non-Energy Products from Fuels and Solvent Use	192.03	0	0							0	0	0	0
2.E - Electronics Industry	0	0	0	NE	NE	NE	NE	0	NO	0	0	0	0
2.F - Product Uses as Substitutes for Ozone Depleting Substances	0	0	0	988.80	NE	0	0	0	NO	0	0	0	0
2.G - Other Product Manufacture and Use	0	0	0	0	NE	NE	0	0	0	0	0	0	0
2.H - Other (Food and Beverages Industry)	NE	0	0	0	0	0	0	0	0	0	0	28.16	0
3 - Agriculture, Forestry, and Other Land Use	-6350.70	871.22	37.54	0	0	0	0	0	0	106.92	328.11	0	0
3.A - Livestock		866.59	6.67							0	0	0	0
3.B - Land	-6350.70									106.92	328.11	0	0
3.C - Aggregate sources and non-CO2 emissions sources on land	0	4.63	30.87							0	0	0	0
3.D - Other	0	0	0							0	0	0	0
4 - Waste	0	331.09	2.92	0	0	0	0	0	0	0	0	0	0
4.A - Solid Waste Disposal		186.68								0	0	0	0
4.B - Biological Treatment of Solid Waste		NE	NE							0	0	0	0
4.C - Incineration and Open Burning of Waste	NO, NE	NO, NE	NO, NE							0	0	0	0
4.D - Wastewater Treatment and Discharge		144.41	2.92							0	0	0	0
4.E - Other (please specify)	0	0	0							0	0	0	0
5 - Other	0	0	0	0	0	0	0	0	0	0	0	0	0
5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3			0							0	0	0	0
5.B - Other (please specify)	0	0	0	0	0	0	0	0	0	0	0	0	0
Memo Items (5)													
International Bunkers	319.10	0.00	0.01	0	0	0	0	0	0	0	0	0	0
1.A.3.a.i - International Aviation (International Bunkers) (1)	319.10	0.00	0.01							1.30	0.50	0.20	0.29
1.A.3.d.i - International water-borne navigation (International bunkers) (1)	0	0	0							0	0	0	0
1.A.5.c - Multilateral Operations (1)(2)	0	0	0	0	0	0	0	0	0	0	0	0	0

ANNEX 2. KEY CATEGORIES ANALYSIS

Key Categories Analysis without FOLU by level, 1990

IPCC Category code	IPCC Category	Greenhouse gas	1990, Ex,t (Gg CO2 Eq)	|Ex,t| (Gg CO2 Eq)	Lx,t	Cumulative Total
1.A.1	Energy Industries - Gaseous Fuels	CO2	38208,29	38208,29	24,42%	24,42%
1.B.2.b	Natural Gas	CH4	13793,88	13793,88	8,82%	33,24%
1.A.4	Other Sectors - Gaseous Fuels	CO2	11651,28	11651,28	7,45%	40,69%
1.A.3.b	Road Transportation - Liquid Fuels	CO2	10140,75	10140,75	6,48%	47,17%
1.A.1	Energy Industries - Liquid Fuels	CO2	9471,78	9471,78	6,05%	53,23%
1.A.1	Energy Industries - Solid Fuels	CO2	9347,83	9347,83	5,98%	59,20%
1.A.4	Other Sectors - Liquid Fuels	CO2	7739,48	7739,48	4,95%	64,15%
3.A.1	Enteric Fermentation	CH4	7005,53	7005,53	4,48%	68,63%
1.A.4	Other Sectors - Solid Fuels	CO2	6660,82	6660,82	4,26%	72,88%
1.A.3.e	Pipeline Transportation - Gaseous Fuels	CO2	4598,34	4598,34	2,94%	75,82%
1.A.2	Manufacturing Industries and Construction - Gaseous Fuels	CO2	4337,05	4337,05	2,77%	78,60%
2.B.1	Ammonia Production	CO2	2990,69	2990,69	1,91%	80,51%
2.A.3	Glass Production	CO2	2801,30	2801,30	1,79%	82,30%
1.B.2.a	Oil	CH4	2644,36	2644,36	1,69%	83,99%
2.A.1	Cement production	CO2	2584,90	2584,90	1,65%	85,64%
4.D	Wastewater Treatment and Discharge	CH4	2251,93	2251,93	1,44%	87,08%
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO2	2234,53	2234,53	1,43%	88,51%
1.A.3.c	Railways - Liquid Fuels	CO2	1793,89	1793,89	1,15%	89,66%
4.A	Solid Waste Disposal	CH4	1761,85	1761,85	1,13%	90,78%
2.B.2	Nitric Acid Production	N2O	1702,03	1702,03	1,09%	91,87%
3.C.4	Direct N2O Emissions from managed soils	N2O	1167,24	1167,24	0,75%	92,62%
1.A.3.a	Civil Aviation - Liquid Fuels	CO2	1032,53	1032,53	0,66%	93,28%
1.B.2.b	Natural Gas	CO2	713,28	713,28	0,46%	93,73%
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO2	701,75	701,75	0,45%	94,18%
3.A.2	Manure Management	N2O	696,24	696,24	0,45%	94,63%
3.A.2	Manure Management	CH4	676,45	676,45	0,43%	95,06%
	Total Emissions of Key Sources, Gg CO_2 Eq			**148707,97**		**95,06%**

Key Categories Analysis with FOLU by level, 1990

IPCC Category code	IPCC Category	Greenhouse gas	1990, Ex,t (Gg CO2 Eq)	|Ex,t| (Gg CO2 Eq)	Lx,t	Cumulative Total
1.A.1	Energy Industries - Gaseous Fuels	CO2	38208,29	38208,29	22,24%	22,24%
1.B.2.b	Natural Gas	CH4	13793,88	13793,88	8,03%	30,27%
1.A.4	Other Sectors - Gaseous Fuels	CO2	11651,28	11651,28	6,78%	37,05%
1.A.3.b	Road Transportation - Liquid Fuels	CO2	10140,75	10140,75	5,90%	42,95%
1.A.1	Energy Industries - Liquid Fuels	CO2	9471,78	9471,78	5,51%	48,46%
1.A.1	Energy Industries - Solid Fuels	CO2	9347,83	9347,83	5,44%	53,90%
3.B.2.a	Cropland Remaining Cropland	CO2	-9149,81	9149,81	5,33%	59,23%
1.A.4	Other Sectors - Liquid Fuels	CO2	7739,48	7739,48	4,50%	63,73%
3.A.1	Enteric Fermentation	CH4	7005,53	7005,53	4,08%	67,81%
1.A.4	Other Sectors - Solid Fuels	CO2	6660,82	6660,82	3,88%	71,68%
3.B.1.a	Forest land Remaining Forest land	CO2	-4894,00	4894,00	2,85%	74,53%
1.A.3.e	Pipeline Transportation - Gaseous Fuels	CO2	4598,34	4598,34	2,68%	77,21%
1.A.2	Manufacturing Industries and Construction - Gaseous Fuels	CO2	4337,05	4337,05	2,52%	79,73%
2.B.1	Ammonia Production	CO2	2990,69	2990,69	1,74%	81,47%
2.A.3	Glass Production	CO2	2801,30	2801,30	1,63%	83,10%
1.B.2.a	Oil	CH4	2644,36	2644,36	1,54%	84,64%
2.A.1	Cement production	CO2	2584,90	2584,90	1,50%	86,15%
4.D	Wastewater Treatment and Discharge	CH4	2251,93	2251,93	1,31%	87,46%
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO2	2234,53	2234,53	1,30%	88,76%
1.A.3.c	Railways - Liquid Fuels	CO2	1793,89	1793,89	1,04%	89,80%
4.A	Solid Waste Disposal	CH4	1761,85	1761,85	1,03%	90,83%
2.B.2	Nitric Acid Production	N2O	1702,03	1702,03	0,99%	91,82%
3.B.3.a	Grassland Remaining Grassland	CO2	-1339,24	1339,24	0,78%	92,60%
3.C.4	Direct N2O Emissions from managed soils	N2O	1167,24	1167,24	0,68%	93,28%
1.A.3.a	Civil Aviation - Liquid Fuels	CO2	1032,53	1032,53	0,60%	93,88%
1.B.2.b	Natural Gas	CO2	713,28	713,28	0,42%	94,29%
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO2	701,75	701,75	0,41%	94,70%
3.A.2	Manure Management	N2O	696,24	696,24	0,41%	95,11%
	Total Emissions of Key Sources, Gg CO_2 Eq			**163414,6**		**95,11%**

Key Categories Analysis without FOLU by level, 2021

IPCC Category code	IPCC Category	Greenhouse gas	2021 Ex,t (Gg CO2 Eq)	|Ex,t| (Gg CO2 Eq)	Lx,t	Cumulative Total
1.A.1	Energy Industries - Gaseous Fuels	CO2	36002,24	36002,24	17,95%	17,95%
1.A.4	Other Sectors - Gaseous Fuels	CO2	31355,08	31355,08	15,63%	33,58%
3.A.1	Enteric Fermentation	CH4	19931,98	19931,98	9,94%	43,52%
1.B.2.b	Natural Gas	CH4	18997,92	18997,92	9,47%	52,99%
2.A.3	Glass Production	CO2	16420,05	16420,05	8,19%	61,17%
1.A.2	Manufacturing Industries and Construction - Gaseous Fuels	CO2	11441,86	11441,86	5,70%	66,88%
1.A.1	Energy Industries - Solid Fuels	CO2	10007,11	10007,11	4,99%	71,87%
4.D	Wastewater Treatment and Discharge	CH4	8277,25	8277,25	4,13%	75,99%
1.A.3.b	Road Transportation - Gaseous Fuels	CO2	7480,54	7480,54	3,73%	79,72%
1.A.3.b	Road Transportation - Liquid Fuels	CO2	7464,20	7464,20	3,72%	83,44%
3.C.4	Direct N2O Emissions from managed soils	N2O	5797,45	5797,45	2,89%	86,34%
4.A	Solid Waste Disposal	CH4	4667,01	4667,01	2,33%	88,66%
2.A.1	Cement production	CO2	4482,58	4482,58	2,23%	90,90%
2.B.1	Ammonia Production	CO2	2975,54	2975,54	1,48%	92,38%
1.B.2.a	Oil	CH4	2914,23	2914,23	1,45%	93,83%
1.A.4	Other Sectors - Solid Fuels	CO2	2235,43	2235,43	1,11%	94,95%
2.B.2	Nitric Acid Production	N2O	2037,97	2037,97	1,02%	95,96%
	Total Emissions of Key Sources, Gg CO_2 Eq			**192488,44**		**95,96%**

Key Categories Analysis with FOLU by level, 2021

IPCC Category code	IPCC Category	Greenhouse gas	2021, Ex,t (Gg CO2 Eq)	|Ex,t| (Gg CO2 Eq)	Lx,t	Cumulative Total
1.A.1	Energy Industries - Gaseous Fuels	CO2	36002,24	36002,24	16,76%	16,76%
1.A.4.	Other Sectors - Gaseous Fuels	CO2	31355,08	31355,08	14,59%	31,35%
3.A.1	Enteric Fermentation	CH4	19931,98	19931,98	9,28%	40,63%
1.B.2.b	Natural Gas	CH4	18997,92	18997,92	8,84%	49,47%
2.A.3	Glass Production	CO2	16420,05	16420,05	7,64%	57,11%
1.A.2	Manufacturing Industries and Construction - Gaseous Fuels	CO2	11441,86	11441,86	5,33%	62,43%
1.A.1	Energy Industries - Solid Fuels	CO2	10007,11	10007,11	4,66%	67,09%
4.D	Wastewater Treatment and Discharge	CH4	8277,25	8277,25	3,85%	70,94%
1.A.3.b	Road Transportation - Gaseous Fuels	CO2	7480,54	7480,54	3,48%	74,43%
1.A.3.b	Road Transportation - Liquid Fuels	CO2	7464,20	7464,20	3,47%	77,90%
3.B.1.a	Forest land Remaining Forest land	CO2	-6745,69	6745,69	3,14%	81,04%
3.C.4	Direct N2O Emissions from managed soils	N2O	5797,45	5797,45	2,70%	83,74%
4.A	Solid Waste Disposal	CH4	4667,01	4667,01	2,17%	85,91%
2.A.1	Cement production	CO2	4482,58	4482,58	2,09%	88,00%
3.B.3.a	Grassland Remaining Grassland	CO2	3963,37	3963,37	1,84%	89,84%
3.B.2.a	Cropland Remaining Cropland	CO2	-3568,38	3568,38	1,66%	91,50%
2.B.1	Ammonia Production	CO2	2975,54	2975,54	1,38%	92,89%
1.B.2.a	Oil	CH4	2914,23	2914,23	1,36%	94,24%
1.A.4	Other Sectors - Solid Fuels	CO2	2235,43	2235,43	1,04%	95,28%
	Total Emissions of Key Sources, Gg CO_2 Eq			**204727,91**		**95,28%**

Key Categories Analysis without FOLU by trend, 1990 -2021

IPCC Category code	IPCC Category	Greenhouse gas	1990 Year Estimate Ex_0 (Gg CO_2 Eq)	2021 Year Estimate Ext (Gg CO_2 Eq)	Trend Assessment (Txt)	% Contribution to Trend	Cumulative Total
1.A.4	Other Sectors - Gaseous Fuels	CO2	11651.28	31355.08	0.102	12.67	12.67
1.A.1	Energy Industries - Gaseous Fuels	CO2	38208.29	36002.24	0.093	11.56	24.23
2.A.3	Glass Production	CO2	2573.96	16420.05	0.083	10.34	34.57
1.A.1	Energy Industries - Liquid Fuels	CO2	9471.78	1504.80	0.070	8.76	43.33
3.A.1	Enteric Fermentation	CH4	7005.53	19931.98	0.068	8.48	51.81
1.A.4	Other Sectors - Liquid Fuels	CO2	7739.48	1996.00	0.053	6.55	58.36
1.A.3.b	Road Transportation - Gaseous Fuels	CO2	87.73	7480.54	0.047	5.85	64.21
1.A.4	Other Sectors - Solid Fuels	CO2	6660.82	2235.43	0.042	5.23	69.44
1.A.3.b	Road Transportation - Liquid Fuels	CO2	10140.75	7464.20	0.038	4.73	74.17
1.A.2	Manufacturing Industries and Construction - Gaseous Fuels	CO2	4337.05	11441.86	0.036	4.53	78.70
1.A.3.e	Other Transportation - Gaseous Fuels	CO2	4598.34	1200.95	0.031	3.88	82.58
3.C.4	Direct N2O Emissions from managed soils	N2O	1167.24	5797.45	0.027	3.38	85.96
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO2	2234.53	244.58	0.017	2.15	88.12
2.B.1	Ammonia Production	CO2	3989.31	2687.96	0.017	2.06	90.18
1.A.1	Energy Industries - Solid Fuels	CO2	9347.83	10007.11	0.015	1.87	92.05
4.A	Solid Waste Disposal	CH4	1761.85	4667.01	0.015	1.86	93.91
1.A.3.c	Railways - Liquid Fuels	CO2	1793.89	213.79	0.014	1.72	95.62
	Total				**0.769**		**95.62%**

Key Categories Analysis with FOLU by trend, 1990 -2021

IPCC Category code	IPCC Category	Greenhouse gas	1990 Year Estimate	2021 Year Estimate Ext (Gg CO2 Eq)	Trend Assessment (Txt)	% Contribution to Trend	Cumulative Total
1.A.1	Energy Industries - Gaseous Fuels	CO2	38208.29	36002.24	0.130	16.25	16.25
1.A.4.	Other Sectors - Gaseous Fuels	CO2	11651.28	31355.08	0.105	13.10	29.35
2.A.3	Glass Production	CO2	2573.96	16420.05	0.090	11.31	40.66
3.A.1	Enteric Fermentation	CH4	7005.53	19931.98	0.071	8.84	49.49
1.A.3.b	Road Transportation - Gaseous Fuels	CO2	87.73	7480.54	0.052	6.52	56.01
1.A.4	Other Sectors - Solid Fuels	CO2	6660.82	2235.43	0.051	6.41	62.43
1.A.3.b	Road Transportation - Liquid Fuels	CO2	10140.75	7464.20	0.049	6.17	68.59
1.A.2	Manufacturing Industries and Construction - Gaseous Fuels	CO2	4337.05	11441.86	0.037	4.67	73.27
4.D	Wastewater Treatment and Discharge	CH4	2138.04	8277.25	0.037	4.64	77.91
3.B.3.a	Grassland Remaining Grassland	CO2	-1339.24	3963.37	0.034	4.20	82.11
3.C.4	Direct N2O Emissions from managed soils	N2O	1167.24	5797.45	0.029	3.67	85.77
3.B.1.a	Forest land Remaining Forest land	CO2	-4894.00	-6745.69	0.028	3.47	89.25
1.A.1	Energy Industries - Solid Fuels	CO2	9347.83	10007.11	0.023	2.91	92.16
2.B.1	Ammonia Production	CO2	3989.31	2975.54	0.019	2.39	94.55
4.A	Solid Waste Disposal	CH4	1761.85	4667.01	0.015	1.92	96.46
					0.772		**96.46%**

ANNEX 3. UNSERTAINTY ANALYSIS

Overall Inventory Uncertainty without FOLU, 2021

2006 IPCC Categories	Gas	Base Year emissions or removals (Gg CO2 equivalent)	Year T emissions or removals (Gg CO2 equivalent)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in Year T	Type A Sensitivity (%)	Type B Sensitivity (%)	Uncertainty in trend in national emissions introduced by emission factor uncertainty (%)	Uncertainty in trend in national emissions introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
1.A - Fuel Combustion Activities												
1.A.1.a.i - Electricity Generation - Liquid Fuels	CO2	9471.782	1504.803	5	5	7.07	0.003	0.0704	0.0096	0.3521	0.3521	0.2480
1.A.1.a.i - Electricity Generation - Liquid Fuels	CH4	9.210	1.425	5	75	75.17	0.000	0.0001	0.0000	0.0052	0.0003	0.0000
1.A.1.a.i - Electricity Generation - Liquid Fuels	N2O	21.957	3.278	5	100	100.12	0.000	0.0002	0.0000	0.0165	0.0008	0.0003
1.A.1.a.i - Electricity Generation - Solid Fuels	CO2	9347.827	10007.106	5	5	7.07	0.117	0.0151	0.0640	0.0753	0.0753	0.0113
1.A.1.a.i - Electricity Generation - Solid Fuels	CH4	2.433	2.600	5	75	75.17	0.000	0.0000	0.0000	0.0003	0.0000	0.0000
1.A.1.a.i - Electricity Generation - Solid Fuels	N2O	43.509	46.786	5	100	100.12	0.001	0.0001	0.0003	0.0069	0.0003	0.0000
1.A.1.a.i - Electricity Generation - Gaseous Fuels	CO2	38208.292	36002.241	5	5	7.07	1.513	0.0927	0.2301	0.4636	0.4636	0.4298
1.A.1.a.i - Electricity Generation - Gaseous Fuels	CH4	16.965	16.050	5	75	75.17	0.000	0.0000	0.0001	0.0031	0.0002	0.0000
1.A.1.a.i - Electricity Generation - Gaseous Fuels	N2O	20.222	19.072	5	100	100.12	0.000	0.0000	0.0001	0.0049	0.0002	0.0000
1.A.1.a.i - Electricity Generation - Other Fossil Fuels	CO2	195.498	92.984	5	5	7.07	0.000	0.0011	0.0006	0.0053	0.0053	0.0001
1.A.1.a.i - Electricity Generation - Other Fossil Fuels	CH4	0.051	0.025	5	75	75.17	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.1.a.i - Electricity Generation - Other Fossil Fuels	N2O	0.061	0.000	5	100	100.12	0.000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.2.k - Construction - Liquid Fuels	CO2	1656.182	6.834	5	5	7.07	0.000	0.0140	0.0000	0.0698	0.0698	0.0097
1.A.2.k - Construction - Liquid Fuels	CH4	1.705	0.008	5	75	75.17	0.000	0.0000	0.0000	0.0011	0.0001	0.0000
1.A.2.k - Construction - Liquid Fuels	N2O	3.930	0.000	5	100	100.12	0.000	0.0000	0.0000	0.0033	0.0002	0.0000
1.A.2.k - Construction - Solid Fuels	CO2	49.040	42.683	5	5	7.07	0.000	0.0001	0.0003	0.0007	0.0007	0.0000
1.A.2.k - Construction - Solid Fuels	CH4	0.128	0.100	5	75	75.17	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.2.k - Construction - Solid Fuels	N2O	0.228	0.209	5	100	100.12	0.000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.2.k - Construction - Gaseous Fuels	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.2.k - Construction - Gaseous Fuels	CH4	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.2.k - Construction - Gaseous Fuels	N2O	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000

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1.A.4.a - Commercial/Institutional - Liquid Fuels	CO2	2063.067	809.260	5	5	7.07	0.001	0.0123	0.0052	0.0614	0.0614	0.0075
1.A.4.a - Commercial/Institutional - Liquid Fuels	CH4	6.716	2.800	5	75	75.17	0.000	0.0000	0.0000	0.0029	0.0002	0.0000
1.A.4.a - Commercial/Institutional - Liquid Fuels	N2O	4.733	2.086	5	100	100.12	0.000	0.0000	0.0000	0.0027	0.0001	0.0000
1.A.4.a - Commercial/Institutional - Solid Fuels	CO2	2142.926	346.925	5	5	7.07	0.000	0.0159	0.0022	0.0795	0.0795	0.0126
1.A.4.a - Commercial/Institutional - Solid Fuels	CH4	5.581	0.900	5	75	75.17	0.000	0.0000	0.0000	0.0031	0.0002	0.0000
1.A.4.a - Commercial/Institutional - Solid Fuels	N2O	9.978	1.490	5	100	100.12	0.000	0.0001	0.0000	0.0075	0.0004	0.0001
1.A.4.a - Commercial/Institutional - Gaseous Fuels	CO2	3051.571	7420.276	5	5	7.07	0.064	0.0216	0.0474	0.1081	0.1081	0.0234
1.A.4.a - Commercial/Institutional - Gaseous Fuels	CH4	6.799	16.525	5	75	75.17	0.000	0.0000	0.0001	0.0036	0.0002	0.0000
1.A.4.a - Commercial/Institutional - Gaseous Fuels	N2O	1.621	3.874	5	100	100.12	0.000	0.0000	0.0000	0.0011	0.0001	0.0000
1.A.4.b - Residential - Liquid Fuels	CO2	884.265	1170.118	5	5	7.07	0.002	0.0000	0.0075	0.0000	0.0000	0.0000
1.A.4.b - Residential - Liquid Fuels	CH4	3.437	4.625	5	75	75.17	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.4.b - Residential - Liquid Fuels	N2O	2.458	3.278	5	100	100.12	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.4.b - Residential - Solid Fuels	CO2	4074.860	1816.083	5	5	7.07	0.004	0.0228	0.0116	0.1142	0.1142	0.0261
1.A.4.b - Residential - Solid Fuels	CH4	318.447	143.200	5	75	75.17	0.003	0.0018	0.0009	0.1333	0.0089	0.0178
1.A.4.b - Residential - Solid Fuels	N2O	18.979	8.642	5	100	100.12	0.000	0.0001	0.0001	0.0105	0.0005	0.0001
1.A.4.b - Residential - Gaseous Fuels	CO2	8088.570	23198.231	5	5	7.07	0.628	0.0799	0.1483	0.3993	0.3993	0.3188
1.A.4.b - Residential - Gaseous Fuels	CH4	18.023	51.675	5	75	75.17	0.000	0.0002	0.0003	0.0133	0.0009	0.0002
1.A.4.b - Residential - Gaseous Fuels	N2O	4.297	12.218	5	100	100.12	0.000	0.0000	0.0001	0.0042	0.0002	0.0000
1.A.4.c.i - Stationary - Liquid Fuels	CO2	769.240	14.941	5	5	7.07	0.000	0.0064	0.0001	0.0320	0.0320	0.0021
1.A.4.c.i - Stationary - Liquid Fuels	CH4	2.596	0.025	5	75	75.17	0.000	0.0000	0.0000	0.0016	0.0001	0.0000
1.A.4.c.i - Stationary - Liquid Fuels	N2O	1.845	0.000	5	100	100.12	0.000	0.0000	0.0000	0.0016	0.0001	0.0000
1.A.4.c.i - Stationary - Solid Fuels	CO2	443.031	72.426	5	5	7.07	0.000	0.0033	0.0005	0.0164	0.0164	0.0005
1.A.4.c.i - Stationary - Solid Fuels	CH4	34.567	5.725	5	75	75.17	0.000	0.0003	0.0000	0.0192	0.0013	0.0004
1.A.4.c.i - Stationary - Solid Fuels	N2O	2.060	0.298	5	100	100.12	0.000	0.0000	0.0000	0.0016	0.0001	0.0000

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1.A.4.c.i - Stationary - Gaseous Fuels	CO2	511.138	736.573	5	5	7.07	0.001	0.0004	0.0047	0.0019	0.0019	0.0000
1.A.4.c.i - Stationary - Gaseous Fuels	CH4	1.139	1.650	5	75	75.17	0.000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.4.c.i - Stationary - Gaseous Fuels	N2O	0.272	0.298	5	100	100.12	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.1.c.i - Manufacture of Solid Fuels	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.1.c.i - Manufacture of Solid Fuels	CH4	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.1.c.i - Manufacture of Solid Fuels	N2O	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.2.m - Non-specified Industry - Liquid Fuels	CO2	578.347	237.741	5	5	7.07	0.000	0.0034	0.0015	0.0169	0.0169	0.0006
1.A.2.m - Non-specified Industry - Liquid Fuels	CH4	0.509	0.225	5	75	75.17	0.000	0.0000	0.0000	0.0002	0.0000	0.0000
1.A.2.m - Non-specified Industry - Liquid Fuels	N2O	0.330	0.596	5	100	100.12	0.000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.2.m - Non-specified Industry - Solid Fuels	CO2	652.709	1002.153	5	5	7.07	0.001	0.0009	0.0064	0.0044	0.0044	0.0000
1.A.2.m - Non-specified Industry - Solid Fuels	CH4	1.710	2.625	5	75	75.17	0.000	0.0000	0.0000	0.0002	0.0000	0.0000
1.A.2.m - Non-specified Industry - Solid Fuels	N2O	3.057	4.768	5	100	100.12	0.000	0.0000	0.0000	0.0005	0.0000	0.0000
1.A.2.m - Non-specified Industry - Gaseous Fuels	CO2	4337.045	11441.864	5	5	7.07	0.153	0.0365	0.0731	0.1823	0.1823	0.0665
1.A.2.m - Non-specified Industry - Gaseous Fuels	CH4	1.933	5.100	5	75	75.17	0.000	0.0000	0.0000	0.0012	0.0001	0.0000
1.A.2.m - Non-specified Industry - Gaseous Fuels	N2O	2.304	6.258	5	100	100.12	0.000	0.0000	0.0000	0.0021	0.0001	0.0000
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	CO2	1032.526	43.513	75	5	75.17	0.000	0.0085	0.0003	0.0423	0.6339	0.4036
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	CH4	0.180	0.000	75	75	106.07	0.000	0.0000	0.0000	0.0001	0.0001	0.0000
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	N2O	8.606	0.298	75	100	125.00	0.000	0.0001	0.0000	0.0071	0.0053	0.0001
1.A.3.e.i - Pipeline Transport - Gaseous Fuels	CO2	4598.336	1200.946	5	5	7.07	0.002	0.0312	0.0077	0.1560	0.1560	0.0487
1.A.3.e.i - Pipeline Transport - Gaseous Fuels	CH4	0.000	0.000	5	75	75.17	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.e.i - Pipeline Transport - Gaseous Fuels	N2O	0.000	0.000	5	100	100.12	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.b.i - Cars - Liquid Fuels	CO2	10140.747	7464.199	5	5	7.07	0.065	0.0380	0.0477	0.1900	0.1900	0.0722
1.A.3.b.i - Cars - Liquid Fuels	CH4	97.372	72.750	5	75	75.17	0.001	0.0004	0.0005	0.0269	0.0018	0.0007
1.A.3.b.i - Cars - Liquid Fuels	N2O	141.712	93.572	5	100	100.12	0.002	0.0006	0.0006	0.0600	0.0030	0.0036

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1.A.3.b.i - Cars - Gaseous Fuels	CO2	87.733	7480.544	5	5	7.07	0.065	0.0471	0.0478	0.2354	0.2354	0.1108
1.A.3.b.i - Cars - Gaseous Fuels	CH4	3.597	306.675	5	75	75.17	0.012	0.0019	0.0020	0.1447	0.0096	0.0210
1.A.3.b.i - Cars - Gaseous Fuels	N2O	1.398	119.200	5	100	100.12	0.003	0.0008	0.0008	0.0750	0.0038	0.0056
1.A.3.b.vi - Urea-based catalysts	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.c - Railways - Liquid Fuels	CO2	1793.887	213.793	5	5	7.07	0.000	0.0138	0.0014	0.0690	0.0690	0.0095
1.A.3.c - Railways - Liquid Fuels	CH4	2.512	0.300	5	75	75.17	0.000	0.0000	0.0000	0.0014	0.0001	0.0000
1.A.3.c - Railways - Liquid Fuels	N2O	206.328	24.436	5	100	100.12	0.000	0.0016	0.0002	0.1588	0.0079	0.0253
1.A.3.c - Railways - Solid Fuels	CO2	0.000	13.077	5	5	7.07	0.000	0.0001	0.0001	0.0004	0.0004	0.0000
1.A.3.c - Railways - Solid Fuels	CH4	0.000	0.000	5	75	75.17	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.c - Railways - Solid Fuels	N2O	0.000	0.000	5	100	100.12	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.d.ii - Domestic Water-borne Navigation - Liquid Fuels	CO2	12.745	0.000	5	5	7.07	0.000	0.0001	0.0000	0.0005	0.0005	0.0000
1.A.3.d.ii - Domestic Water-borne Navigation - Liquid Fuels	CH4	0.753	0.000	5	75	75.17	0.000	0.0000	0.0000	0.0005	0.0000	0.0000
1.A.3.d.ii - Domestic Water-borne Navigation - Liquid Fuels	N2O	30.549	0.000	5	100	100.12	0.000	0.0003	0.0000	0.0258	0.0013	0.0007
1.A.4.c.ii - Off-road Vehicles and Other Machinery - Liquid Fuels	CO2	4022.905	1.678	5	5	7.07	0.000	0.0340	0.0000	0.1700	0.1700	0.0578
1.A.4.c.ii - Off-road Vehicles and Other Machinery - Liquid Fuels	CH4	13.669	0.000	5	75	75.17	0.000	0.0001	0.0000	0.0087	0.0006	0.0001
1.A.4.c.ii - Off-road Vehicles and Other Machinery - Liquid Fuels	N2O	9.776	0.000	5	100	100.12	0.000	0.0001	0.0000	0.0083	0.0004	0.0001
1.B.1 - Fugitive Emissions from Fuels - Solid Fuels												
1.B.1.a.i.1 - Mining	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.1.a.i.1 - Mining	CH4	214.668	82.943	2	200	200.01	0.006	0.0013	0.0005	0.2570	0.0026	0.0661
1.B.1.a.i.2 - Post-mining seam gas emissions	CO2	0	0	2	200	200.01	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.1.a.i.2 - Post-mining seam gas emissions	CH4	29.815	11.5198125	2	200	200.01	0.000	0.0002	0.0001	0.0357	0.0004	0.0013
1.B.1.a.i.3 - Abandoned underground mines	CH4	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000

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1.B.1.a.i.3 - Abandoned underground mines	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.1.a.i.4 - Flaring of drained methane or conversion of methane to CO2	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.1.a.i.4 - Flaring of drained methane or conversion of methane to CO2	CH4	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.1.a.ii.1 - Mining	CO2	0	0	0	200	200.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.1.a.ii.1 - Mining	CH4	115.877	96.102	2	200	200.01	0.009	0.0004	0.0006	0.0731	0.0007	0.0053
1.B.1.a.ii.2 - Post-mining seam gas emissions	CO2	0.000	0.000	2	200	200.01	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.1.a.ii.2 - Post-mining seam gas emissions	CH4	9.656	8.009	2	300	300.01	0.000	0.0000	0.0001	0.0091	0.0001	0.0001
1.B.2 - Fugitive Emissions from Fuels - Oil and Natural Gas												
1.B.2.a.i - Venting	CO2	0.404	0.427	2	800	800.00	0.000	0.0000	0.0000	0.0006	0.0000	0.0000
1.B.2.a.i - Venting	CH4	77.974	80.885	2	800	800.00	0.098	0.0001	0.0005	0.1138	0.0003	0.0130
1.B.2.a.i - Venting	N2O	0.000	0.000	2	800	800.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.a.ii - Flaring	CO2	165.797	183.043	30	75	80.78	0.005	0.0002	0.0012	0.0174	0.0070	0.0004
1.B.2.a.ii - Flaring	CH4	2.521	2.783	30	75	80.78	0.000	0.0000	0.0000	0.0003	0.0001	0.0000
1.B.2.a.ii - Flaring	N2O	0.774	0.855	30	75	80.78	0.000	0.0000	0.0000	0.0001	0.0000	0.0000
1.B.2.a.iii.1 - Exploration	CO2	0.000	0.000	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.a.iii.1 - Exploration	CH4	0.000	0.000	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.a.iii.1 - Exploration	N2O	0.000	0.000	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.a.iii.2 - Production and Upgrading	CO2	7.350	8.114	2	800	800.00	0.001	0.0000	0.0001	0.0082	0.0000	0.0001
1.B.2.a.iii.2 - Production and Upgrading	CH4	2563.868	2830.560	2	800	800.00	119.744	0.0036	0.0181	2.8680	0.0072	8.2257
1.B.2.a.iii.3 - Transport	CO2	0.02	0	2	200	200.01	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.a.iii.3 - Transport	CH4	4.9	0	2	200	200.01	0.000	0.0000	0.0000	0.0083	0.0001	0.0001
1.B.2.a.iii.3 - Transport	N2O	0	0	2	200	200.01	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b.i - Venting	CO2	588.173	525.154	0	250	250.00	0.403	0.0016	0.0034	0.4041	0.0000	0.1633

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1.B.2.b.i - Venting	CH4	4.024	5.789	0	250	250.00	0.000	0.0000	0.0000	0.0007	0.0000	0.0000
1.B.2.b.i - Venting	N2O	0.000	0.000	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b.ii - Flaring	CO2	116.137	147.489	2	75	75.03	0.003	0.0000	0.0009	0.0029	0.0001	0.0000
1.B.2.b.ii - Flaring	CH4	1.870	2.369	2	75	75.03	0.000	0.0000	0.0000	0.0001	0.0000	0.0000
1.B.2.b.ii - Flaring	N2O	0.555	0.704	2	1000	1000.00	0.000	0.0000	0.0000	0.0002	0.0000	0.0000
1.B.2.b.iii.2 - Production	CO2	3.954	5.219	2	250	250.01	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b.iii.2 - Production	CH4	12432.105	16409.610	2	250	250.01	393.035	0.0002	0.1049	0.0569	0.0005	0.0032
1.B.2.b.iii.2 - Production	N2O	0.000	0.000	2	0	2.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b.iii.3 - Processing	CO2	4.212	6.020	2	250	250.01	0.000	0.0000	0.0000	0.0007	0.0000	0.0000
1.B.2.b.iii.3 - Processing	CH4	348.980	490.051	2	250	250.01	0.351	0.0002	0.0031	0.0454	0.0004	0.0021
1.B.2.b.iii.3 - Processing	N2O	0.000	0.000	2	0	2.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b.iii.4 - Transmission and Storage	CO2	0.001	0.001	2	500	500.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b.iii.4 - Transmission and Storage	CH4	629.667	903.835	2	500	500.00	4.769	0.0005	0.0058	0.2266	0.0009	0.0514
1.B.2.b.iii.4 - Transmission and Storage	N2O	0.000	0.000	2	0	2.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b.iii.5 - Distribution	CO2	0.801	2.518	2	500	500.00	0.000	0.0000	0.0000	0.0047	0.0000	0.0000
1.B.2.b.iii.5 - Distribution	CH4	377.235	1186.268	2	500	500.00	8.216	0.0044	0.0076	2.1965	0.0088	4.8249
2.A - Mineral Industry												
2.A.1 - Cement production	CO2	2584.895	4482.578	1.0	2.0	2.24	0.002	0.0068	0.0287	0.0136	0.0068	0.0002
2.A.2 - Lime production	CO2	335.925	252.895	2.0	2.0	2.83	0.000	0.0012	0.0016	0.0024	0.0024	0.0000
2.A.3 - Glass Production	CO2	2573.965	16420.050	5	60	60.21	22.824	0.0832	0.1050	4.9910	0.4159	25.0832
2.A.4.a - Ceramics	CO2	398.943	552.536	10	5	11.18	0.001	0.0002	0.0035	0.0008	0.0016	0.0000
2.A.4.b - Other Uses of Soda Ash	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
2.A.4.c - Non Metallurgical Magnesia Production	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
2.A.4.d - Other (please specify)	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000

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2.A.5 - Other (please specify)	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B - Chemical Industry												
2.B.1 - Ammonia Production	CO2	3989.310	2975.540	2	20.9	21.00	0.091	0.0147	0.0190	0.3074	0.0294	0.0954
2.B.2 - Nitric Acid Production	N2O	2385.889	2037.969	2	20.9	21.00	0.043	0.0071	0.0130	0.1494	0.0143	0.0225
2.B.5 - Carbide Production	CO2	0.000	0.694	2	10	10.20	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.5 - Carbide Production	CH4	0.000	0.183	2	10	10.20	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.8.a - Methanol	CO2	0.000	21.365	2.0	30.0	30.07	0.000	0.0001	0.0001	0.0041	0.0003	0.0000
2.B.8.a - Methanol	CH4	0.000	1.834	2.0	30.0	30.07	0.000	0.0000	0.0000	0.0004	0.0000	0.0000
2.B.8.e - Acrylonitrile	CO2	14.960	1.554	2.0	60.0	60.03	0.000	0.0001	0.0000	0.0070	0.0002	0.0000
2.B.8.e - Acrylonitrile	CH4	0.067	0.007	2.0	10.0	10.20	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.8.f - Carbon Black	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.8.f - Carbon Black	CH4	0	0	10	0	10.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
2.C - Metal Industry												
2.C.1 - Iron and Steel Production	CO2	661.440	1113.0	2.0	25.0	25.08	0.018	0.0015	0.0071	0.0380	0.0030	0.0015
2.C.2 - Ferroalloys Production	CO2	0	14.569	100	50	111.80	0.000	0.0001	0.0001	0.0047	0.0093	0.0001
2.C.2 - Ferroalloys Production	CH4	0	0.336	100	50	111.80	0.000	0.0000	0.0000	0.0001	0.0002	0.0000
2.C.5 - Lead Production	CO2	0	4.213	10	50	50.99	0.000	0.0000	0.0000	0.0013	0.0003	0.0000
2.C.6 - Zinc Production	CO2	72.24	154.834	10	50	50.99	0.001	0.0004	0.0010	0.0189	0.0038	0.0004
2.D - Non-Energy Products from Fuels and Solvent Use												
2.D.1 - Lubricant Use	CO2	203.350	192.03	5	50	50.25	0.002	0.0005	0.0012	0.0246	0.0025	0.0006
2.F - Product Uses as Substitutes for Ozone Depleting Substances												
2.F.1.a - Refrigeration and Stationary Air Conditioning	HFCs	0	988.803	10	50	50.99	0.059	0.0063	0.0063	0.3160	0.0632	0.1039
3.A - Livestock												

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3.A.1.a.i - Dairy Cows	CH4	2669.589	7162.086	5	50	50.25	3.025	0.0232	0.0458	1.1602	0.1160	1.3596
3.A.1.a.ii - Other Cattle	CH4	3090.191	9817.757	5	50	50.25	5.683	0.0366	0.0628	1.8311	0.1831	3.3863
3.A.1.b - Buffalo	CH4	0.000	0.000	5	50	50.25	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.A.1.c - Sheep	CH4	1027.775	2314.188	5	50	50.25	0.316	0.0061	0.0148	0.3051	0.0305	0.0940
3.A.1.d - Goats	CH4	98.175	458.669	5	50	50.25	0.012	0.0021	0.0029	0.1051	0.0105	0.0112
3.A.1.e - Camels	CH4	25.933	23.079	5	50	50.25	0.000	0.0001	0.0001	0.0036	0.0004	0.0000
3.A.1.f - Horses	CH4	45.585	112.657	5	50	50.25	0.001	0.0003	0.0007	0.0167	0.0017	0.0003
3.A.1.g - Mules and Asses	CH4	30.050	42.208	5	50	50.25	0.000	0.0000	0.0003	0.0008	0.0001	0.0000
3.A.1.h - Swine	CH4	18.236	1.341	5	50	50.25	0.000	0.0001	0.0000	0.0073	0.0007	0.0001
3.A.1.j - Other (please specify)	CH4	0.000	0.000	5	50	50.25	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.A.2.a.i - Dairy cows	CH4	533.730	1428.043	50	100	111.80	0.595	0.0046	0.0091	0.4615	0.2308	0.2663
3.A.2.a.i - Dairy cows	N2O	93.519	250.896	50	100	111.80	0.018	0.0008	0.0016	0.0813	0.0407	0.0083
3.A.2.a.ii - Other cattle	CH4	65.749	208.888	50	100	111.80	0.013	0.0008	0.0013	0.0779	0.0390	0.0076
3.A.2.a.ii - Other cattle	N2O	448.548	1425.068	50	100	111.80	0.593	0.0053	0.0091	0.5317	0.2658	0.3533
3.A.2.b - Buffalo	CH4	0.000	0.000	50	100	111.80	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.A.2.b - Buffalo	N2O	0.000	0.000	50	100	111.80	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.A.2.c - Sheep	CH4	21.568	48.542	50	100	111.80	0.001	0.0001	0.0003	0.0128	0.0064	0.0002
3.A.2.c - Sheep	N2O	78.268	176.232	50	100	111.80	0.009	0.0005	0.0011	0.0465	0.0232	0.0027
3.A.2.d - Goats	CH4	2.273	10.968	50	100	111.80	0.000	0.0001	0.0001	0.0051	0.0025	0.0000
3.A.2.d - Goats	N2O	2.759	12.889	50	100	111.80	0.000	0.0001	0.0001	0.0059	0.0030	0.0000
3.A.2.e - Camels	CH4	0.723	0.643	50	100	111.80	0.000	0.0000	0.0000	0.0002	0.0001	0.0000
3.A.2.e - Camels	N2O	0.192	0.171	50	100	111.80	0.000	0.0000	0.0000	0.0001	0.0000	0.0000
3.A.2.f - Horses	CH4	2.875	7.022	50	100	111.80	0.000	0.0000	0.0000	0.0021	0.0010	0.0000
3.A.2.f - Horses	N2O	0.948	2.342	50	100	111.80	0.000	0.0000	0.0000	0.0007	0.0003	0.0000

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3.A.2.g - Mules and Asses	CH4	1.893	2.609	50	100	111.80	0.000	0.0000	0.0000	0.0001	0.0000	0.0000
3.A.2.g - Mules and Asses	N2O	0.614	0.863	50	100	111.80	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.A.2.h - Swine	CH4	37.930	2.683	50	100	111.80	0.000	0.0003	0.0000	0.0304	0.0152	0.0012
3.A.2.h - Swine	N2O	22.343	1.642	50	100	111.80	0.000	0.0002	0.0000	0.0178	0.0089	0.0004
3.A.2.i - Poultry	CH4	9.712	23.406	50	100	111.80	0.000	0.0001	0.0001	0.0067	0.0034	0.0001
3.A.2.i - Poultry	N2O	49.049	118.634	50	100	111.80	0.004	0.0003	0.0008	0.0344	0.0172	0.0015
3.C - Aggregate sources and non-CO2 emissions sources on land												
3.C.1.a - Burning in Forest Land	CO2	0	0	5	41	41.30	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.C.1.a - Burning in Forest Land	CH4	0	0	5	59	59.21	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.C.1.a - Burning in Forest Land	N2O	0	0	5	54	54.23	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.C.1.b - Burning in Cropland	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.C.1.b - Burning in Cropland	CH4	22.9	0	5	2.7	5.68	0.000	0.0002	0.0000	0.0005	0.0010	0.0000
3.C.1.b - Burning in Cropland	N2O	7.1	0	5	0.07	5.00	0.000	0.0001	0.0000	0.0000	0.0003	0.0000
3.C.1.c - Burning in Grassland	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.C.1.c - Burning in Grassland	CH4	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.C.1.c - Burning in Grassland	N2O	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.C.2 - Liming	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.C.3 - Urea application	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.C.4 - Direct N2O Emissions from managed soils	N2O	1167.236	5797.449	5	200	200.06	31.415	0.0272	0.0371	5.4374	0.1359	29.5843
3.C.5 - Indirect N2O Emissions from managed soils	N2O	452.890	2687.960	5	200	200.06	6.753	0.0134	0.0172	2.6705	0.0668	7.1359
3.C.6 - Indirect N2O Emissions from manure management	N2O	263.687	713.537	5	30	30.41	0.011	0.0023	0.0046	0.0699	0.0117	0.0050
3.C.7 - Rice cultivation	CH4	347.606	115.757	5	30	30.41	0.000	0.0022	0.0007	0.0660	0.0110	0.0045
4.A - Solid Waste Disposal												
4.A.1 - Managed Waste Disposal Sites	CH4	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000

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4.A.2 - Unmanaged Waste Disposal Sites	CH4	1761.85	4667.01	5	51.2	51.44	1.346	0.0149	0.0298	0.7646	0.0747	0.5902
4.A.3 - Uncategorised Waste Disposal Sites	CH4	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
4.D - Wastewater Treatment and Discharge												
4.D.1 - Domestic Wastewater Treatment and Discharge	CH4	2138.040	3471.470	5	72.11	72.28	1.470	0.0041	0.0222	0.2965	0.0206	0.0883
4.D.1 - Domestic Wastewater Treatment and Discharge	N2O	402.340	868.680	5	72.11	72.28	0.092	0.0022	0.0056	0.1551	0.0108	0.0242
4.D.2 - Industrial Wastewater Treatment and Discharge	CH4	113.880	138.770	25	59.16	64.23	0.002	0.0001	0.0009	0.0045	0.0019	0.0000
4.D.2 - Industrial Wastewater Treatment and Discharge	N2O	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
4.E - Other (please specify)												
5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3												
5.B - Other (please specify)												
Total		156 437.84	206 936.31				603.64					83.46
							Uncertainty in total inventory: 24.57					Trend uncertainty: 9.14

Overall Inventory Uncertainty with FOLU, 2021

2006 IPCC Categories	Gas	Base Year emissions or removals (Gg CO2 equivalent)	Year T emissions or removals (Gg CO2 equivalent)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in Year T	Type A Sensitivity (%)	Type B Sensitivity (%)	Uncertainty in trend in national emissions introduced by emission factor uncertainty (%)	Uncertainty in trend in national emissions introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
1.A - Fuel Combustion Activities												
1.A.1.a.i - Electricity Generation - Liquid Fuels	CO2	9471.782	1504.803	5	5	7.07	0.003	0.0848	0.0107	0.4238	0.4238	0.3593
1.A.1.a.i - Electricity Generation - Liquid Fuels	CH4	9.210	1.425	5	75	75.17	0.000	0.0001	0.0000	0.0062	0.0004	0.0000
1.A.1.a.i - Electricity Generation - Liquid Fuels	N2O	21.957	3.278	5	100	100.12	0.000	0.0002	0.0000	0.0198	0.0010	0.0004
1.A.1.a.i - Electricity Generation - Solid Fuels	CO2	9347.827	10007.106	5	5	7.07	0.124	0.0233	0.0709	0.1164	0.1164	0.0271
1.A.1.a.i - Electricity Generation - Solid Fuels	CH4	2.433	2.600	5	75	75.17	0.000	0.0000	0.0000	0.0005	0.0000	0.0000
1.A.1.a.i - Electricity Generation - Solid Fuels	N2O	43.509	46.786	5	100	100.12	0.001	0.0001	0.0003	0.0107	0.0005	0.0001
1.A.1.a.i - Electricity Generation - Gaseous Fuels	CO2	38208.292	36002.241	5	5	7.07	1.611	0.1296	0.2552	0.6480	0.6480	0.8399
1.A.1.a.i - Electricity Generation - Gaseous Fuels	CH4	16.965	16.050	5	75	75.17	0.000	0.0001	0.0001	0.0043	0.0003	0.0000
1.A.1.a.i - Electricity Generation - Gaseous Fuels	N2O	20.222	19.072	5	100	100.12	0.000	0.0001	0.0001	0.0069	0.0003	0.0000
1.A.1.a.i - Electricity Generation - Other Fossil Fuels	CO2	195.498	92.984	5	5	7.07	0.000	0.0013	0.0007	0.0066	0.0066	0.0001
1.A.1.a.i - Electricity Generation - Other Fossil Fuels	CH4	0.051	0.025	5	75	75.17	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.1.a.i - Electricity Generation - Other Fossil Fuels	N2O	0.061	0.000	5	100	100.12	0.000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.2.k - Construction - Liquid Fuels	CO2	1656.182	6.834	5	5	7.07	0.000	0.0166	0.0000	0.0832	0.0832	0.0139
1.A.2.k - Construction - Liquid Fuels	CH4	1.705	0.008	5	75	75.17	0.000	0.0000	0.0000	0.0013	0.0001	0.0000
1.A.2.k - Construction - Liquid Fuels	N2O	3.930	0.000	5	100	100.12	0.000	0.0000	0.0000	0.0040	0.0002	0.0000
1.A.2.k - Construction - Solid Fuels	CO2	49.040	42.683	5	5	7.07	0.000	0.0002	0.0003	0.0010	0.0010	0.0000
1.A.2.k - Construction - Solid Fuels	CH4	0.128	0.100	5	75	75.17	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.2.k - Construction - Solid Fuels	N2O	0.228	0.209	5	100	100.12	0.000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.2.k - Construction - Gaseous Fuels	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.2.k - Construction - Gaseous Fuels	CH4	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.2.k - Construction - Gaseous Fuels	N2O	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.4.a - Commercial/Institutional - Liquid Fuels	CO2	2063.067	809.260	5	5	7.07	0.001	0.0151	0.0057	0.0753	0.0753	0.0113

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1.A.4.a - Commercial/Institutional - Liquid Fuels	CH4	6.716	2.800	5	75	75.17	0.000	0.0000	0.0000	0.0036	0.0002	0.0000
1.A.4.a - Commercial/Institutional - Liquid Fuels	N2O	4.733	2.086	5	100	100.12	0.000	0.0000	0.0000	0.0033	0.0002	0.0000
1.A.4.a - Commercial/Institutional - Solid Fuels	CO2	2142.926	346.925	5	5	7.07	0.000	0.0191	0.0025	0.0957	0.0957	0.0183
1.A.4.a - Commercial/Institutional - Solid Fuels	CH4	5.581	0.900	5	75	75.17	0.000	0.0000	0.0000	0.0037	0.0002	0.0000
1.A.4.a - Commercial/Institutional - Solid Fuels	N2O	9.978	1.490	5	100	100.12	0.000	0.0001	0.0000	0.0090	0.0005	0.0001
1.A.4.a - Commercial/Institutional - Gaseous Fuels	CO2	3051.571	7420.276	5	5	7.07	0.068	0.0218	0.0526	0.1092	0.1092	0.0238
1.A.4.a - Commercial/Institutional - Gaseous Fuels	CH4	6.799	16.525	5	75	75.17	0.000	0.0000	0.0001	0.0036	0.0002	0.0000
1.A.4.a - Commercial/Institutional - Gaseous Fuels	N2O	1.621	3.874	5	100	100.12	0.000	0.0000	0.0000	0.0011	0.0001	0.0000
1.A.4.b - Residential - Liquid Fuels	CO2	884.265	1170.118	5	5	7.07	0.002	0.0006	0.0083	0.0031	0.0031	0.0000
1.A.4.b - Residential - Liquid Fuels	CH4	3.437	4.625	5	75	75.17	0.000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.4.b - Residential - Liquid Fuels	N2O	2.458	3.278	5	100	100.12	0.000	0.0000	0.0000	0.0002	0.0000	0.0000
1.A.4.b - Residential - Solid Fuels	CO2	4074.860	1816.083	5	5	7.07	0.004	0.0282	0.0129	0.1410	0.1410	0.0398
1.A.4.b - Residential - Solid Fuels	CH4	318.447	143.200	5	75	75.17	0.003	0.0022	0.0010	0.1646	0.0110	0.0272
1.A.4.b - Residential - Solid Fuels	N2O	18.979	8.642	5	100	100.12	0.000	0.0001	0.0001	0.0130	0.0007	0.0002
1.A.4.b - Residential - Gaseous Fuels	CO2	8088.570	23198.231	5	5	7.07	0.669	0.0829	0.1645	0.4144	0.4144	0.3434
1.A.4.b - Residential - Gaseous Fuels	CH4	18.023	51.675	5	75	75.17	0.000	0.0002	0.0004	0.0138	0.0009	0.0002
1.A.4.b - Residential - Gaseous Fuels	N2O	4.297	12.218	5	100	100.12	0.000	0.0000	0.0001	0.0043	0.0002	0.0000
1.A.4.c.i - Stationary - Liquid Fuels	CO2	769.240	14.941	5	5	7.07	0.000	0.0076	0.0001	0.0382	0.0382	0.0029
1.A.4.c.i - Stationary - Liquid Fuels	CH4	2.596	0.025	5	75	75.17	0.000	0.0000	0.0000	0.0019	0.0001	0.0000
1.A.4.c.i - Stationary - Liquid Fuels	N2O	1.845	0.000	5	100	100.12	0.000	0.0000	0.0000	0.0019	0.0001	0.0000
1.A.4.c.i - Stationary - Solid Fuels	CO2	443.031	72.426	5	5	7.07	0.000	0.0040	0.0005	0.0198	0.0198	0.0008
1.A.4.c.i - Stationary - Solid Fuels	CH4	34.567	5.725	5	75	75.17	0.000	0.0003	0.0000	0.0231	0.0015	0.0005
1.A.4.c.i - Stationary - Solid Fuels	N2O	2.060	0.298	5	100	100.12	0.000	0.0000	0.0000	0.0019	0.0001	0.0000
1.A.4.c.i - Stationary - Gaseous Fuels	CO2	511.138	736.573	5	5	7.07	0.001	0.0001	0.0052	0.0003	0.0003	0.0000

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1.A.4.c.i - Stationary - Gaseous Fuels	CH4	1.139	1.650	5	75	75.17	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.4.c.i - Stationary - Gaseous Fuels	N2O	0.272	0.298	5	100	100.12	0.000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.1.c.i - Manufacture of Solid Fuels	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.1.c.i - Manufacture of Solid Fuels	CH4	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.1.c.i - Manufacture of Solid Fuels	N2O	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.2.m - Non-specified Industry - Liquid Fuels	CO2	578.347	237.741	5	5	7.07	0.000	0.0041	0.0017	0.0207	0.0207	0.0009
1.A.2.m - Non-specified Industry - Liquid Fuels	CH4	0.509	0.225	5	75	75.17	0.000	0.0000	0.0000	0.0003	0.0000	0.0000
1.A.2.m - Non-specified Industry - Liquid Fuels	N2O	0.330	0.596	5	100	100.12	0.000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.2.m - Non-specified Industry - Solid Fuels	CO2	652.709	1002.153	5	5	7.07	0.001	0.0005	0.0071	0.0026	0.0026	0.0000
1.A.2.m - Non-specified Industry - Solid Fuels	CH4	1.710	2.625	5	75	75.17	0.000	0.0000	0.0000	0.0001	0.0000	0.0000
1.A.2.m - Non-specified Industry - Solid Fuels	N2O	3.057	4.768	5	100	100.12	0.000	0.0000	0.0000	0.0003	0.0000	0.0000
1.A.2.m - Non-specified Industry - Gaseous Fuels	CO2	4337.045	11441.864	5	5	7.07	0.163	0.0374	0.0811	0.1869	0.1869	0.0699
1.A.2.m - Non-specified Industry - Gaseous Fuels	CH4	1.933	5.100	5	75	75.17	0.000	0.0000	0.0000	0.0013	0.0001	0.0000
1.A.2.m - Non-specified Industry - Gaseous Fuels	N2O	2.304	6.258	5	100	100.12	0.000	0.0000	0.0000	0.0021	0.0001	0.0000
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	CO2	1032.526	43.513	75	5	75.17	0.000	0.0101	0.0003	0.0505	0.7575	0.5764
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	CH4	0.180	0.000	75	75	106.07	0.000	0.0000	0.0000	0.0001	0.0001	0.0000
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	N2O	8.606	0.298	75	100	125.00	0.000	0.0001	0.0000	0.0085	0.0063	0.0001
1.A.3.e.i - Pipeline Transport - Gaseous Fuels	CO2	4598.336	1200.946	5	5	7.07	0.002	0.0378	0.0085	0.1892	0.1892	0.0716
1.A.3.e.i - Pipeline Transport - Gaseous Fuels	CH4	0.000	0.000	5	75	75.17	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.e.i - Pipeline Transport - Gaseous Fuels	N2O	0.000	0.000	5	100	100.12	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.b.i - Cars - Liquid Fuels	CO2	10140.747	7464.199	5	5	7.07	0.069	0.0493	0.0529	0.2464	0.2464	0.1214
1.A.3.b.i - Cars - Liquid Fuels	CH4	97.372	72.750	5	75	75.17	0.001	0.0005	0.0005	0.0349	0.0023	0.0012
1.A.3.b.i - Cars - Liquid Fuels	N2O	141.712	93.572	5	100	100.12	0.002	0.0008	0.0007	0.0765	0.0038	0.0059
1.A.3.b.i - Cars - Gaseous Fuels	CO2	87.733	7480.544	5	5	7.07	0.070	0.0521	0.0530	0.2607	0.2607	0.1360

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1.A.3.b.i - Cars - Gaseous Fuels	CH4	3.597	306.675	5	75	75.17	0.013	0.0021	0.0022	0.1603	0.0107	0.0258
1.A.3.b.i - Cars - Gaseous Fuels	N2O	1.398	119.200	5	100	100.12	0.004	0.0008	0.0008	0.0831	0.0042	0.0069
1.A.3.b.vi - Urea-based catalysts	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.c - Railways - Liquid Fuels	CO2	1793.887	213.793	5	5	7.07	0.000	0.0166	0.0015	0.0828	0.0828	0.0137
1.A.3.c - Railways - Liquid Fuels	CH4	2.512	0.300	5	75	75.17	0.000	0.0000	0.0000	0.0017	0.0001	0.0000
1.A.3.c - Railways - Liquid Fuels	N2O	206.328	24.436	5	100	100.12	0.000	0.0019	0.0002	0.1907	0.0095	0.0365
1.A.3.c - Railways - Solid Fuels	CO2	0.000	13.077	5	5	7.07	0.000	0.0001	0.0001	0.0005	0.0005	0.0000
1.A.3.c - Railways - Solid Fuels	CH4	0.000	0.000	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.c - Railways - Solid Fuels	N2O	0.000	0.000	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.A.3.d.ii - Domestic Water-borne Navigation - Liquid Fuels	CO2	12.745	0.000	5	5	7.07	0.000	0.0001	0.0000	0.0006	0.0006	0.0000
1.A.3.d.ii - Domestic Water-borne Navigation - Liquid Fuels	CH4	0.753	0.000	5	75	75.17	0.000	0.0000	0.0000	0.0006	0.0000	0.0000
1.A.3.d.ii - Domestic Water-borne Navigation - Liquid Fuels	N2O	30.549	0.000	5	100	100.12	0.000	0.0003	0.0000	0.0308	0.0015	0.0010
1.A.4.c.ii - Off-road Vehicles and Other Machinery - Liquid Fuels	CO2	4022.905	1.678	5	5	7.07	0.000	0.0405	0.0000	0.2027	0.2027	0.0821
1.A.4.c.ii - Off-road Vehicles and Other Machinery - Liquid Fuels	CH4	13.669	0.000	5	75	75.17	0.000	0.0001	0.0000	0.0103	0.0007	0.0001
1.A.4.c.ii - Off-road Vehicles and Other Machinery - Liquid Fuels	N2O	9.776	0.000	5	100	100.12	0.000	0.0001	0.0000	0.0099	0.0005	0.0001
1.B.1 - Fugitive Emissions from Fuels - Solid Fuels												
1.B.1.a.i.1 - Mining	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.1.a.i.1 - Mining	CH4	214.668	82.943	2	200	200.01	0.007	0.0016	0.0006	0.3152	0.0032	0.0994
1.B.1.a.i.2 - Post-mining seam gas emissions	CO2	0	0	2	200	200.01	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.1.a.i.2 - Post-mining seam gas emissions	CH4	29.815	11.5198125	2	200	200.01	0.000	0.0002	0.0001	0.0438	0.0004	0.0019
1.B.1.a.i.3 - Abandoned underground mines	CH4	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.1.a.i.3 - Abandoned underground mines	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000

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1.B.1.a.i.4 - Flaring of drained methane or conversion of methane to CO2	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.1.a.i.4 - Flaring of drained methane or conversion of methane to CO2	CH4	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.1.a.ii.1 - Mining	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.1.a.ii.1 - Mining	CH4	115.877	96.102	2	200	200.01	0.009	0.0005	0.0007	0.0974	0.0010	0.0095
1.B.1.a.ii.2 - Post-mining seam gas emissions	CO2	0.000	0.000	2	200	200.01	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.1.a.ii.2 - Post-mining seam gas emissions	CH4	9.656	8.009	2	300	300.01	0.000	0.0000	0.0001	0.0122	0.0001	0.0001
1.B.2 - Fugitive Emissions from Fuels - Oil and Natural Gas												
1.B.2.a.i - Venting	CO2	0.404	0.427	2	800	800.00	0.000	0.0000	0.0000	0.0008	0.0000	0.0000
1.B.2.a.i - Venting	CH4	77.974	80.885	2	800	800.00	0.104	0.0002	0.0006	0.1701	0.0004	0.0289
1.B.2.a.i - Venting	N2O	0.000	0.000	2	800	800.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.a.ii - Flaring	CO2	165.797	183.043	30	75	80.78	0.005	0.0004	0.0013	0.0280	0.0112	0.0009
1.B.2.a.ii - Flaring	CH4	2.521	2.783	30	75	80.78	0.000	0.0000	0.0000	0.0004	0.0002	0.0000
1.B.2.a.ii - Flaring	N2O	0.774	0.855	30	75	80.78	0.000	0.0000	0.0000	0.0001	0.0001	0.0000
1.B.2.a.iii.1 - Exploration	CO2	0.000	0.000	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.a.iii.1 - Exploration	CH4	0.000	0.000	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.a.iii.1 - Exploration	N2O	0.000	0.000	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.a.iii.2 - Production and Upgrading	CO2	7.350	8.114	2	800	800.00	0.001	0.0000	0.0001	0.0133	0.0000	0.0002
1.B.2.a.iii.2 - Production and Upgrading	CH4	2563.868	2830.560	2	800	800.00	127.446	0.0058	0.0201	4.6235	0.0116	21.3772
1.B.2.a.iii.3 - Transport	CO2	0.02	0	2	200	200.01	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.a.iii.3 - Transport	CH4	4.9	0	2	200	200.01	0.000	0.0000	0.0000	0.0099	0.0001	0.0001
1.B.2.a.iii.3 - Transport	N2O	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b.i - Venting	CO2	588.173	525.154	0	250	250.00	0.428	0.0022	0.0037	0.5516	0.0000	0.3043
1.B.2.b.i - Venting	CH4	4.024	5.789	0	250	250.00	0.000	0.0000	0.0000	0.0001	0.0000	0.0000

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1.B.2.b.i - Venting	N2O	0.000	0.000	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b.ii - Flaring	CO2	116.137	147.489	2	75	75.03	0.003	0.0001	0.0010	0.0094	0.0003	0.0001
1.B.2.b.ii - Flaring	CH4	1.870	2.369	2	75	75.03	0.000	0.0000	0.0000	0.0002	0.0000	0.0000
1.B.2.b.ii - Flaring	N2O	0.555	0.704	2	1000	1000.00	0.000	0.0000	0.0000	0.0006	0.0000	0.0000
1.B.2.b.iii.2 - Production	CO2	3.954	5.219	2	250	250.01	0.000	0.0000	0.0000	0.0007	0.0000	0.0000
1.B.2.b.iii.2 - Production	CH4	12432.105	16409.610	2	250	250.01	418.316	0.0090	0.1163	2.2478	0.0180	5.0527
1.B.2.b.iii.2 - Production	N2O	0.000	0.000	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b.iii.3 - Processing	CO2	4.212	6.020	2	250	250.01	0.000	0.0000	0.0000	0.0001	0.0000	0.0000
1.B.2.b.iii.3 - Processing	CH4	348.980	490.051	2	250	250.01	0.373	0.0000	0.0035	0.0110	0.0001	0.0001
1.B.2.b.iii.3 - Processing	N2O	0.000	0.000	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b.iii.4 - Transmission and Storage	CO2	0.001	0.001	2	500	500.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b.iii.4 - Transmission and Storage	CH4	629.667	903.835	2	500	500.00	5.076	0.0001	0.0064	0.0299	0.0001	0.0009
1.B.2.b.iii.4 - Transmission and Storage	N2O	0.000	0.000	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
1.B.2.b.iii.5 - Distribution	CO2	0.801	2.518	2	500	500.00	0.000	0.0000	0.0000	0.0049	0.0000	0.0000
1.B.2.b.iii.5 - Distribution	CH4	377.235	1186.268	2	500	500.00	8.744	0.0046	0.0084	2.3034	0.0092	5.3057
2.A - Mineral Industry												
2.A.1 - Cement production	CO2	2584.895	4482.578	1.0	2.0	2.24	0.002	0.0057	0.0318	0.0114	0.0057	0.0002
2.A.2 - Lime production	CO2	335.925	252.895	2.0	2.0	2.83	0.000	0.0016	0.0018	0.0032	0.0032	0.0000
2.A.3 - Glass Production	CO2	2573.965	16420.050	5	60	60.21	24.292	0.0904	0.1164	5.4266	0.4522	29.6524
2.A.4.a - Ceramics	CO2	398.943	552.536	10	5	11.18	0.001	0.0001	0.0039	0.0005	0.0010	0.0000
2.A.4.b - Other Uses of Soda Ash	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
2.A.4.c - Non Metallurgical Magnesia Production	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
2.A.4.d - Other (please specify)	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
2.A.5 - Other (please specify)	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000

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2.B - Chemical Industry												
2.B.1 - Ammonia Production	CO2	3989.310	2975.540	2	20.9	21.00	0.097	0.0191	0.0211	0.3996	0.0382	0.1611
2.B.2 - Nitric Acid Production	N2O	2385.889	2037.969	2	20.9	21.00	0.046	0.0096	0.0144	0.2007	0.0192	0.0407
2.B.5 - Carbide Production	CO2	0.000	0.694	2	10	10.20	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.5 - Carbide Production	CH4	0.000	0.183	2	10	10.20	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.8.a - Methanol	CO2	0.000	21.365	2.0	30.0	30.07	0.000	0.0002	0.0002	0.0045	0.0003	0.0000
2.B.8.a - Methanol	CH4	0.000	1.834	2.0	30.0	30.07	0.000	0.0000	0.0000	0.0004	0.0000	0.0000
2.B.8.e - Acrylonitrile	CO2	14.960	1.554	2.0	60.0	60.03	0.000	0.0001	0.0000	0.0084	0.0003	0.0001
2.B.8.e - Acrylonitrile	CH4	0.067	0.007	2.0	10.0	10.20	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.8.f - Carbon Black	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
2.B.8.f - Carbon Black	CH4	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
2.C - Metal Industry												
2.C.1 - Iron and Steel Production	CO2	661.440	1113.0	2.0	25.0	25.08	0.019	0.0012	0.0079	0.0306	0.0024	0.0009
2.C.2 - Ferroalloys Production	CO2	0	14.569	100	50	111.80	0.000	0.0001	0.0001	0.0052	0.0103	0.0001
2.C.2 - Ferroalloys Production	CH4	0	0.336	100	50	111.80	0.000	0.0000	0.0000	0.0001	0.0002	0.0000
2.C.5 - Lead Production	CO2	0	4.213	10	50	50.99	0.000	0.0000	0.0000	0.0015	0.0003	0.0000
2.C.6 - Zinc Production	CO2	72.24	154.834	10	50	50.99	0.002	0.0004	0.0011	0.0185	0.0037	0.0004
2.D - Non-Energy Products from Fuels and Solvent Use												
2.D.1 - Lubricant Use	CO2	203.350	192.03	5	50	50.25	0.002	0.0007	0.0014	0.0344	0.0034	0.0012
2.F - Product Uses as Substitutes for Ozone Depleting Substances												
2.F.1.a - Refrigeration and Stationary Air Conditioning	HFCs	0	988.803	10	50	50.99	0.059	0.0063	0.0063	0.3160	0.0632	0.1039
3.A - Livestock												
3.A.1.a.i - Dairy Cows	CH4	2669.589	7162.086	5	50	50.25	3.219	0.0239	0.0508	1.1929	0.1193	1.4372

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3.A.1.a.ii - Other Cattle	CH4	3090.191	9817.757	5	50	50.25	6.049	0.0384	0.0696	1.9220	0.1922	3.7311
3.A.1.b - Buffalo	CH4	0.000	0.000	5	50	50.25	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.A.1.c - Sheep	CH4	1027.775	2314.188	5	50	50.25	0.336	0.0060	0.0164	0.3022	0.0302	0.0922
3.A.1.d - Goats	CH4	98.175	458.669	5	50	50.25	0.013	0.0023	0.0033	0.1131	0.0113	0.0129
3.A.1.e - Camels	CH4	25.933	23.079	5	50	50.25	0.000	0.0001	0.0002	0.0049	0.0005	0.0000
3.A.1.f - Horses	CH4	45.585	112.657	5	50	50.25	0.001	0.0003	0.0008	0.0170	0.0017	0.0003
3.A.1.g - Mules and Asses	CH4	30.050	42.208	5	50	50.25	0.000	0.0000	0.0003	0.0002	0.0000	0.0000
3.A.1.h - Swine	CH4	18.236	1.341	5	50	50.25	0.000	0.0002	0.0000	0.0087	0.0009	0.0001
3.A.1.j - Other (please specify)	CH4	0.000	0.000	5	50	50.25	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.A.2.a.i - Dairy cows	CH4	533.730	1428.043	50	100	111.80	0.634	0.0047	0.0101	0.4743	0.2372	0.2812
3.A.2.a.i - Dairy cows	N2O	93.519	250.896	50	100	111.80	0.020	0.0008	0.0018	0.0836	0.0418	0.0087
3.A.2.a.ii - Other cattle	CH4	65.749	208.888	50	100	111.80	0.014	0.0008	0.0015	0.0818	0.0409	0.0084
3.A.2.a.ii - Other cattle	N2O	448.548	1425.068	50	100	111.80	0.631	0.0056	0.0101	0.5581	0.2790	0.3893
3.A.2.b - Buffalo	CH4	0.000	0.000	50	100	111.80	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.A.2.b - Buffalo	N2O	0.000	0.000	50	100	111.80	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.A.2.c - Sheep	CH4	21.568	48.542	50	100	111.80	0.001	0.0001	0.0003	0.0127	0.0063	0.0002
3.A.2.c - Sheep	N2O	78.268	176.232	50	100	111.80	0.010	0.0005	0.0012	0.0460	0.0230	0.0026
3.A.2.d - Goats	CH4	2.273	10.968	50	100	111.80	0.000	0.0001	0.0001	0.0055	0.0027	0.0000
3.A.2.d - Goats	N2O	2.759	12.889	50	100	111.80	0.000	0.0001	0.0001	0.0064	0.0032	0.0001
3.A.2.e - Camels	CH4	0.723	0.643	50	100	111.80	0.000	0.0000	0.0000	0.0003	0.0001	0.0000
3.A.2.e - Camels	N2O	0.192	0.171	50	100	111.80	0.000	0.0000	0.0000	0.0001	0.0000	0.0000
3.A.2.f - Horses	CH4	2.875	7.022	50	100	111.80	0.000	0.0000	0.0000	0.0021	0.0010	0.0000
3.A.2.f - Horses	N2O	0.948	2.342	50	100	111.80	0.000	0.0000	0.0000	0.0007	0.0004	0.0000
3.A.2.g - Mules and Asses	CH4	1.893	2.609	50	100	111.80	0.000	0.0000	0.0000	0.0001	0.0000	0.0000

2006 IPCC Categories	Gas	Base Year emissions or removals (Gg CO2 equivalent)	Year T emissions or removals (Gg CO2 equivalent)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in Year T	Type A Sensitivity (%)	Type B Sensitivity (%)	Uncertainty in trend in national emissions introduced by emission factor uncertainty (%)	Uncertainty in trend in national emissions introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
3.A.2.g - Mules and Asses	N2O	0.614	0.863	50	100	111.80	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.A.2.h - Swine	CH4	37.930	2.683	50	100	111.80	0.000	0.0004	0.0000	0.0363	0.0182	0.0017
3.A.2.h - Swine	N2O	22.343	1.642	50	100	111.80	0.000	0.0002	0.0000	0.0214	0.0107	0.0006
3.A.2.i - Poultry	CH4	9.712	23.406	50	100	111.80	0.000	0.0001	0.0002	0.0068	0.0034	0.0001
3.A.2.i - Poultry	N2O	49.049	118.634	50	100	111.80	0.004	0.0003	0.0008	0.0347	0.0173	0.0015
3.B - Land												
3.B.1.a - Forest land Remaining Forest land	CO2	-4894	-6745.69	25	100.95	104.00	12.233	0.0015	0.0478	0.1530	0.0379	0.0249
3.B.2.a - Cropland Remaining Cropland	CO2	-9149.81	-3568.38	10	75	75.66	1.812	0.0670	0.0253	5.0242	0.6699	25.6912
3.B.3.a - Grassland Remaining Grassland	CO2	-1339.24	3963.37	2	13	13.15	0.068	0.0416	0.0281	0.5408	0.0832	0.2994
3.C - Aggregate sources and non-CO2 emissions sources on land												
3.C.1.a - Burning in Forest Land	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.C.1.a - Burning in Forest Land	CH4	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.C.1.a - Burning in Forest Land	N2O	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.C.1.b - Burning in Cropland	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.C.1.b - Burning in Cropland	CH4	22.9	0	5	2.7	5.68	0.000	0.0002	0.0000	0.0006	0.0012	0.0000
3.C.1.b - Burning in Cropland	N2O	7.1	0	5	0.07	5.00	0.000	0.0001	0.0000	0.0000	0.0004	0.0000
3.C.1.c - Burning in Grassland	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.C.1.c - Burning in Grassland	CH4	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.C.1.c - Burning in Grassland	N2O	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.C.2 - Liming	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.C.3 - Urea application	CO2	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
3.C.4 - Direct N2O Emissions from managed soils	N2O	1167.236	5797.449	5	200	200.06	33.435	0.0293	0.0411	5.8662	0.1467	34.4334
3.C.5 - Indirect N2O Emissions from managed soils	N2O	452.890	2687.960	5	200	200.06	7.187	0.0145	0.0191	2.8980	0.0724	8.4035
3.C.6 - Indirect N2O Emissions from manure management	N2O	263.687	713.537	5	30	30.41	0.012	0.0024	0.0051	0.0720	0.0120	0.0053

2006 IPCC Categories	Gas	Base Year emissions or removals (Gg CO2 equivalent)	Year T emissions or removals (Gg CO2 equivalent)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in Year T	Type A Sensitivity (%)	Type B Sensitivity (%)	Uncertainty in trend in national emissions introduced by emission factor uncertainty (%)	Uncertainty in trend in national emissions introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
3.C.7 - Rice cultivation	CH4	347.606	115.757	5	30	30.41	0.000	0.0027	0.0008	0.0805	0.0134	0.0067
4.A - Solid Waste Disposal												
4.A.1 - Managed Waste Disposal Sites	CH4	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
4.A.2 - Unmanaged Waste Disposal Sites	CH4	1761.85	4667.01	5	51.2	51.44	1.433	0.0153	0.0331	0.7845	0.0766	0.6213
4.A.3 - Uncategorised Waste Disposal Sites	CH4	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
4.D - Wastewater Treatment and Discharge												
4.D.1 - Domestic Wastewater Treatment and Discharge	CH4	2138.040	3471.470	5	72.11	72.28	1.565	0.0031	0.0246	0.2203	0.0153	0.0488
4.D.1 - Domestic Wastewater Treatment and Discharge	N2O	402.340	868.680	5	72.11	72.28	0.098	0.0021	0.0062	0.1516	0.0105	0.0231
4.D.2 - Industrial Wastewater Treatment and Discharge	CH4	113.880	138.770	25	59.16	64.23	0.002	0.0002	0.0010	0.0097	0.0041	0.0001
4.D.2 - Industrial Wastewater Treatment and Discharge	N2O	0	0	0	0	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000
4.E - Other (please specify)												
5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3												
5.B - Other (please specify)												
Total		141 054.789	200 585.606				656.62					140.53
							Uncertainty in total inventory: 25.62					Trend uncertainty: 11.85

ANNEX 4. INFORMATION ON THE METHODOLOGIES USED,ACTIVITY DATA AND EMISSION FACTORS

Category	CO_2			CH4			N_2O		
	Methodological tier	EF	AD	Methodological tier	EF	AD	Methodological tier	EF	AD
1. ENERGY									
FUEL COMBUSTION ACTIVITIES:									
ENERGY INDUSTRY	T1	D	STATISTICS AGENCY, MINISTRY OF ENERGY	T1	D	STATISTICS AGENCY, MINISTRY OF ENERGY	T1	D	STATISTICS AGENCY, MINISTRY OF ENERGY
MANUFACTURING INDUSTRIES AND CONSTRUCTION	T1	D	STATISTICS AGENCY, MINISTRY OF ENERGY	T1	D	STATISTICS AGENCY, MINISTRY OF ENERGY	T1	D	STATISTICS AGENCY, MINISTRY OF ENERGY
TRANSPORTATION	T1	D	STATISTICS AGENCY, MINISTRY OF TRANSPORTATION, MINISTRY OF ECOLOGY, ENVIRONMENTAL PROTECTION AND CLIMATE CHANGE	T1	D	STATISTICS AGENCY, MINISTRY OF TRANSPORTATION, MINISTRY OF ECOLOGY, ENVIRONMENTAL PROTECTION AND CLIMATE CHANGE	T1	D	STATISTICS AGENCY, MINISTRY OF TRANSPORTATION, MINISTRY OF ECOLOGY, ENVIRONMENTAL PROTECTION AND CLIMATE CHANGE
COMMERCIAL SECTOR	T1	D	STATISTICS AGENCY	T1	D	STATISTICS AGENCY	T1	D	STATISTICS AGENCY
RESIDENTIAL SECTOR	T1	D	STATISTICS AGENCY	T1	D	STATISTICS AGENCY	T1	D	STATISTICS AGENCY
AGRICULTURE	T1	D	STATISTICS AGENCY	T1	D	STATISTICS AGENCY	T1	D	STATISTICS AGENCY
FUGITIVE FUEL EMISSIONS:									
COAL	-	-	-	T1	D	STATISTICS AGENCY, MINISTRY OF ENERGY, UZBEKCOAL JSC, UZBEKISTON TEMIR YULLARI JSC	-	-	-
OIL	T1	D	STATISTICS AGENCY, MINISTRY OF ENERGY, UZBEKNEFTEGAZ JSC	T1	D	STATISTICS AGENCY, MINISTRY OF ENERGY, UZBEKNEFTEGAZ JSC	T1	D	STATISTICS AGENCY, MINISTRY OF ENERGY, UZBEKNEFTEGAZ JSC
NATURAL GAS	T1	D	STATISTICS AGENCY, MINISTRY OF ENERGY, UZBEKNEFTEGAZ JSC, UZTRANSGAZ JSC, KHUDUDGAZTAMINOT JSC	T1	D	STATISTICS AGENCY, MINISTRY OF ENERGY, UZBEKNEFTEGAZ JSC, UZTRANSGAZ JSC, KHUDUDGAZTAMINOT JSC	T1	D	STATISTICS AGENCY, MINISTRY OF ENERGY, UZBEKNEFTEGAZ JSC, UZTRANSGAZ JSC, KHUDUDGAZTAMINOT JSC
2. INDUSTRIAL PROCESSES AND PRODUCT USE									
MINERAL INDUSTRY	T1, T2	CS	STATISTICS AGENCY, ASSOCIATION "UZPROMSTROYMATERIALI"	-	-	-	-	-	-
CHEMICAL INDUSTRY	T2	CS	STATISTICS AGENCY, UZKIMYOSANOAT JSC	T1	D	STATISTICS AGENCY, UZKIMYOSANOAT JSC	T2	CS	STATISTICS AGENCY, UZKIMYOSANOAT JSC
METAL INDUSTRY	T1	D	STATISTICS AGENCY	T1	D	STATISTICS AGENCY	-		-
LUBRICANT USE	T1	D	STATISTICS AGENCY	-	-	-	-		-
3. AGRICULTURE									
ENTERIC FERMENTATION	-	-	-	T1	D	STATISTICS AGENCY, MINISTRY OF AGRICULTURE	-		-
MANURE MANAGEMENT	-	-	-	T1	D	STATISTICS AGENCY,	T1	D	STATISTICS AGENCY,

Category	CO_2			CH4			N_2O		
	Methodological tier	EF	AD	Methodological tier	EF	AD	Methodological tier	EF	AD
						MINISTRY OF AGRICULTURE			MINISTRY OF AGRICULTURE
BURNING IN CROPLAND	T1	D	STATISTICS AGENCY, MINISTRY OF AGRICULTURE	T1	D	STATISTICS AGENCY, MINISTRY OF AGRICULTURE	-	-	-
N2O EMISSIONS FROM MANAGED SOILS	-	-	-	-	-	-	T1	D	STATISTICS AGENCY, MINISTRY OF AGRICULTURE
RICE CULTIVATION	-	-	-	T1	D	STATISTICS AGENCY, MINISTRY OF AGRICULTURE	-	-	-
4. FOREST LAND AND OTHER LAND USE									
FOREST LAND	T1	D	FORESTRY AGENCY, RESEARCH INSTITUTE OF FORESTRY, CADASTRAL AGENCY	-	-	-	-	-	-
GRASSLAND	T1	D	STATISTICS AGENCY, CADASTRAL AGENCY	-	-	-	-	-	-
CROPLAND	T1	D	STATISTICS AGENCY, CADASTRAL AGENCY	-	-	-	-	-	-
5. WASTE									
SOLID WASTE DISPOSAL	-	-	-	T2	CS	MINISTRY OF ECOLOGY, ENVIRONMENTAL PROTECTION AND CLIMATE CHANGE, "ECO MONS VITA" COMPANY, STATISTICS AGENCY	-	-	-
INDUSTRIAL WASTEWATER TREATMENT AND DISCHARGE	-	-	-	T1	D	STATISTICS AGENCY	-	-	-
DOMESTIC WASTEWATER TREATMENT AND DISCHARGE	-	-	-	T1	D	STATISTICS AGENCY, "ECO MONS VITA" COMPANY	T1	D	STATISTICS AGENCY, "ECO MONS VITA" COMPANY

T1 – IPCC Tier 1; T2 - IPCC Tier 2; D – IPCC default; CS – Country Specific