National Inventory Report 2023 of Montenegro

submission under the
United Nations Framework Convention on Climate Change (UNFCCC)

version 31.07.2023

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1.1.1 Global Warming

According to the Fifth assessment report of the IPCC (AR5) and stated in the IPCC special report *Global Warming of 1.5 °C* (SR1.5)[1] human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate.

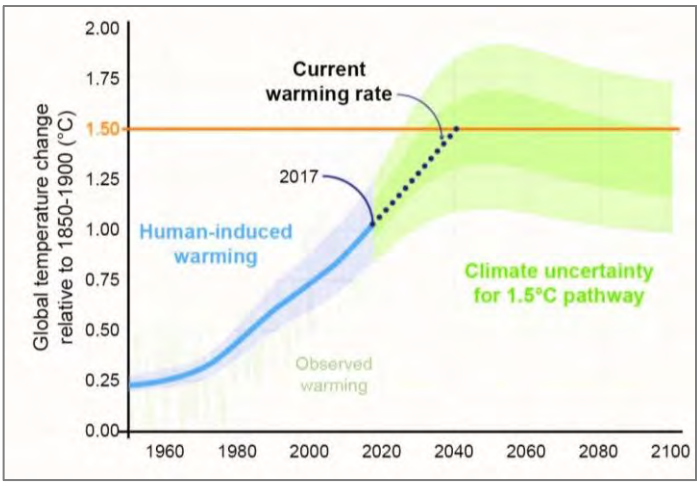


Figure 1 Human-induced warming reached approximately 1°C above pre-industrial levels in 2018.

Source: IPCC (2018): IPCC special report *Global Warming of 1.5 °C* (SR1.5).

As summarized in IPCC special report *Global Warming of 1.5 °C* (SR1.5) the increase of the average surface temperature of the earth will lead to

- differences in regional climate characteristics with
    - changes in climate and weather extremes, temperature extremes on land,
    - risks from droughts and precipitation deficits,
    - global mean sea level rise;
- impacts on biodiversity and ecosystems including species loss and extinction;
- increase in ocean temperature with associated increase in ocean acidity and decreases in ocean oxygen levels;
- climate-related risks to health, livelihoods, food security, water supply, human security, and economic growth;
- needs for adaptation which also includes limited adaptive capacity for some human and natural systems.

[1] Available (25 May 2019) on https://www.ipcc.ch/sr15/

According to Sixth assessment report of the IPCC (AR6) global warming, reaching 1.5°C in the near-term (2021–2040), would cause unavoidable increases in multiple climate hazards and present multiple risks to ecosystems and humans (very high confidence). The level of risk will depend on concurrent nearterm trends in vulnerability, exposure, level of socioeconomic development and adaptation (high confidence). Near-term actions that limit global warming to close to 1.5°C would substantially reduce projected losses and damages related to climate change in human systems and ecosystems, compared to higher warming levels, but cannot eliminate them all (very high confidence)

As presented in the 3rd NC, submitted in 2020, Montenegro is particularly exposed and vulnerable to climate hazards, such as droughts, floods, forest fires, and heatwaves. Climate projections show that these climate extremes will increase in frequency and magnitude in the future. A summary of the vulnerability analysis and proposed adaptation measures by sector for Montenegro includes:[2]

- The **water sector** shows a reduction in the water balance in all river basins in Montenegro. The decrease in rainfall and snowfall will drastically affect surface water availability. By the end of the 21st century a reduction in average annual flow of 27% is expected.
- The **forestry sector** is affected by climate change not only in the current developmental processes and growth, but often results in cumulative effects that can last for the lifetime of the tree. The greatest risk is to forests located in the coastal and central regions, where high air temperatures during the summer period and the typical vegetation create the necessary preconditions for forest fires to start.
- The **agricultural sector** is highly vulnerable to climate change due to its dependence on specific temperature conditions and water availability, and it is also exposed to climate hazards such as droughts or floods. A large part of the agricultural areas in Montenegro are located in lowlands, which makes them particularly prone to regular floods.
- The **fishing sector** is highly affected by an increase in the temperature of sea water which favours the distribution, spread, abundance, and impact of invasive species.
- Good **public health** depends on safe drinking water, sufficient food, secure shelter, and good social conditions, which may all be affected by a changing climate – and are particularly important in the context of economies in transition, such as Montenegro's. It is important to consider that climate change could affect the capacity of health services to deal with emergencies.

1.1.2 Convention, Kyoto Protocol and Paris Agreement

Montenegro became a Party to the UN Framework Convention on Climate Change (UNFCCC) as Non-Annex I Party in October 2006, accede the Kyoto Protocol also on 27 June 2007 and ratified the Paris Agreement on 20 December 2017. In the following paragraphs the key massages of the convention and Kyoto Protocol and Paris agreement are presented as on the website of UNFCCC.

[2] available (15 January 2021) on https://www4.unfccc.int/sites/SubmissionsStaging/NationalReports/Documents/8596012_Montenegro-NC3-1-TNC%20-%20MNE.pdf

- The **UN Framework Convention on Climate Change** (UNFCCC) is a "Rio Convention", one of three adopted at the "Rio Earth Summit" in 1992. Its sister Rio Conventions are the UN Convention on Biological Diversity and the Convention to Combat Desertification. Preventing "dangerous" human interference with the climate system is the ultimate aim of the UNFCCC.[3]
- The **Kyoto Protocol** (KP) is an international agreement linked to the United Nations Framework Convention on Climate Change, which commits its Parties by setting internationally binding emission reduction targets. Recognizing that developed countries are principally responsible for the current high levels of GHG emissions in the atmosphere as a result of more than 150 years of industrial activity, the Protocol places a heavier burden on developed nations under the principle of "common but differentiated responsibilities.[4]
- The **Paris Agreement** (PA) builds upon the Convention and for the first time brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. As such, it charts a new course in the global climate effort:[5]
  - The Paris Agreement is a legally binding international treaty on climate change.
  - Its goal is to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels.
  - To achieve this long-term temperature goal, countries aim to reach global peaking of greenhouse gas emissions as soon as possible to achieve a climate neutral world by mid-century.

  Article 13 is related to transparency.

In the following tables are presented the Convention, Kyoto Protocol and Paris Agreement with the dates of entry into force and the current status as well as the Montenegrin submissions – reports and data sets –.

Table 1 Status of signature and ratification by Montenegro of the UNFCCC, Kyoto Protocol and Paris Agreement

	Entry into force	Status (07/2020)	Montenegro	
			Signature	Ratification
United Nations Framework Convention on Climate Change (UNFCCC)	21 March 1994	197 Parties		23 October 2006 d [3]
Kyoto Protocol *to the UNFCCC* (First commitment period 2008-2012)	16 February 2005	192 Parties	-	4 June 2007 a [4]
Doha Amendment[6] *to the Kyoto Protocol* (Second commitment period 2013-2020)		130 Parties		26 December 2018 A [7]
Copenhagen Accord[8]			agreeing to the Accord[9]	
Paris Agreement *to the UNFCCC*	4 November 2016	189 Parties	22 April 2016	20 December 2017

Remark: Ratification, Acceptance(A), Accession(a), Approval(AA), Succession(d)

[3] Link to and Text of the United Nations Framework Convention on Climate Change; available (8 January 2020) on https://unfccc.int/process/the-convention/what-is-the-convention/status-of-ratification-of-the-convention

[4] Link to and Text of the Kyoto Protocol; available (15 January 2021) on https://unfccc.int/process/the-kyoto-protocol/status-of-ratification

[5] Link to and Text of the Paris Agreement; available (15 January 2021) on https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.

[6] Link and Text of the Doha amendment; available (15 January 2021) on https://unfccc.int/files/kyoto_protocol/application/pdf/kp_doha_amendment_english.pdf

[7] https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-c&chapter=27&clang=_en

[8] Link to and text of the Copenhagen Accord: FCCC/CP/2009/11/Add.1, 2/CP.15; available (15 January 2021) on https://unfccc.int/resource/docs/2009/cop15/eng/11a01.pdf

[9] Available (15 January 2021) on https://unfccc.int/process/conferences/pastconferences/copenhagen-climate-change-conference-december-2009/statements-and-resources/information-provided-by-parties-to-the-convention-relating-to-the-copenhagen-accord
https://unfccc.int/files/meetings/cop_15/copenhagen_accord/application/pdf/montenegrocphaccord.pdf

Table 2 Status of Montenegro's submission of the National Communication (NC), Biennial Update Report (BUR) and Nationally Determined Contribution (NDC)

UNFCCC Reporting obligation	National Communication (NC)	Biennial Update Report (BUR)	Biennial transparency report (BTR)	National Inventory Report (NIR)	GHG inventory (tables) as part of NC and BUR *Time series based on*		
					1996 revised IPCC GL & IPCC GPG	2006 IPCC Guidelines	2019 Refinements to the 2006 IPCC GL
NC1 = INC	12 Oct 2010[10]				2005 UNFCCC software		
NC2	28 May 2015[11]				1990-2013 UNFCCC software		
NC3	12 Oct 2020[12]					1990-2017 IPCC software	
NC4	Planned for end of 2024						
1st BUR		13 Jan 2016[13]				1990 – 2013 IPCC software	
2nd BUR		3 May 2019[14]		NIR 2021[15]		1990 – 2015 IPCC software	
3rd BUR		7 Feb 2022[16]		NIR 2022[17]		1990 – 2020 Excel-based calculation tool	
				NIR 2023[18]		1990 – 2021 Excel-based calculation tool	
1st BTR			Planned for end of 2024				

UNFCCC Reporting obligation	Nationally Determined Contribution (INDC) / Nationally Determined Contribution (NDC)
INDC	September 2015[19]
NDC	21 December 2017[20]
Updated NDC	15 June 2021[21]

[10] Available (08 January 2020) on https://unfccc.int/documents/125549; https://unfccc.int/sites/default/files/resource/INC_Montenegro_Eng.pdf

[11] Available (08 January 2020) on https://unfccc.int/documents/125550; https://unfccc.int/sites/default/files/resource/mnenc2_eng.pdf

[12] Available (16 March 2021) on https://unfccc.int/sites/default/files/resource/TNC%20-%20MNE_0.pdf

[13] Available (08 January 2020) on https://unfccc.int/documents/180668; https://unfccc.int/sites/default/files/resource/MONBUR1.pdf

[14] Available (08 January 2020) on https://unfccc.int/documents/195274; https://unfccc.int/sites/default/files/resource/SECOND%20BIENNIAL%20UPDATE%20REPORT%20ON%20CLIMATE%20CHANGE_Montenegro.pdf

[15] Not published

[16] Available (16 March 2023) on https://unfccc.int/documents/453020

[17] Available (16 March 2023) on https://unfccc.int/documents/461972

[18] Not published

[19] Available (08 January 2020) on https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Montenegro%20First/INDCSubmission_%20Montenegro.pdf

[20] Available (28 March 2023) on https://unfccc.int/documents/497737

[21] Available (28 June 2021) on https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Montenegro%20First/Updated%20NDC%20for%20Montenegro.pdf

The Convention divides countries into three main groups according to differing commitments:

Annex I Parties — The industrialized countries that were members of the OECD (Organization for Economic Co-operation and Development) in 1992 and listed in Annex I to the Convention. They include the 24 original OECD members, the European Union, and 14 countries with economies in transition (EIT).

Annex II Parties — Consist of the OECD members of Annex I, but not the EIT Parties.

Non-Annex I Parties — Refers to countries that have ratified or acceded to the United Nations Framework Convention on Climate Change that are not included in Annex I of the Convention.

1.2 A description of national circumstances and institutional arrangements

As a Party to the Convention and according to the Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention, section III[22], non-Annex I Parties

Para 6. shall, in accordance with Article 4, paragraph 1 (a), and Article 12, paragraph 1(a) of the Convention, communicate to the Conference of the Parties a national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases (GHGs) not controlled by the Montreal Protocol, to the extent its capacities permit, following the provisions in these guidelines.

Para 7. shall estimate national GHG inventories for the year 1994 for the initial national communication (INC) or alternatively may provide data for the year 1990. For the second national communication (SNC), non-Annex I Parties shall estimate national GHG inventories for the year 2000. The least developed country Parties could estimate their national GHG inventories for years at their discretion.

Therefore, Montenegro is required to produce regularly a National Greenhouse Gas Inventory; see here table above.

A National Inventory Report (NIR) containing detailed and complete information on the inventory, in order to ensure the transparency of the inventory, the two relevant Guidelines provide the following guidance:

(1) Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention, section B, non-Annex I Parties,

Para 13 are encouraged to describe procedures and arrangements undertaken to collect and archive data for the preparation of national GHG inventories, as well as efforts to make this a continuous process, including information on the role of the institutions involved.

Para 21 are encouraged to provide information on methodologies used in the estimation of anthropogenic emissions by sources and removals by sinks of GHG not controlled by the Montreal Protocol, including a brief explanation of the sources of emission factors and activity data. If non-Annex I Parties estimate anthropogenic emissions and removals from country specific sources and/or sinks which are not part of the IPCC Guidelines, they should explicitly describe the source and/or sink categories, methodologies, emission factors and activity data used in their estimation of emissions, as appropriate. Parties are encouraged to identify areas where data may be further improved in future communications through capacity-building.

[22] Available (30 January 2019) on FCCC/CP/2002/7/Add.2, section III., paragraph 6.

(2) UNFCCC biennial update reporting guidelines for Parties not included in Annex I to the Convention

Para 9 The inventory section of the biennial update report should consist of a national inventory report as a summary or as an update of the information contained in chapter III (National greenhouse gas inventories) of the annex to decision 17/CP.8, including table 1, on "National greenhouse gas inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol and greenhouse gas precursors", and table 2, on "National greenhouse gas inventory of anthropogenic emissions of HFCs, PFCs and SF6".

Therefore, Montenegro prepared a standalone report 'Montenegrin National Inventory Report (NIR) 2023', covering the period 1990 to 2021.

1.2.1 National entity or national focal point

In the following figure the MRV framework for the GHG inventory of Montenegro is illustrated. In the following (sub-)chapters below a description of the various roles and responsibilities is provided.

According to the Law on air protection (Official Gazette of Montenegro 25/10 and 43/15) the Montenegrin Environmental Protection Agency (EPA) is the Single National Entity (SNE) responsible for the preparation of emission inventories. EPA has the overall responsibility and submits the inventory report to

- the United Nations Framework Convention on Climate Change (UNFCCC), and
- the UNECE[23] Convention on Long-range Transboundary Air Pollution (CLRTAP).

The institutional arrangements for the inventory system currently used in Montenegro are presented in following figure.

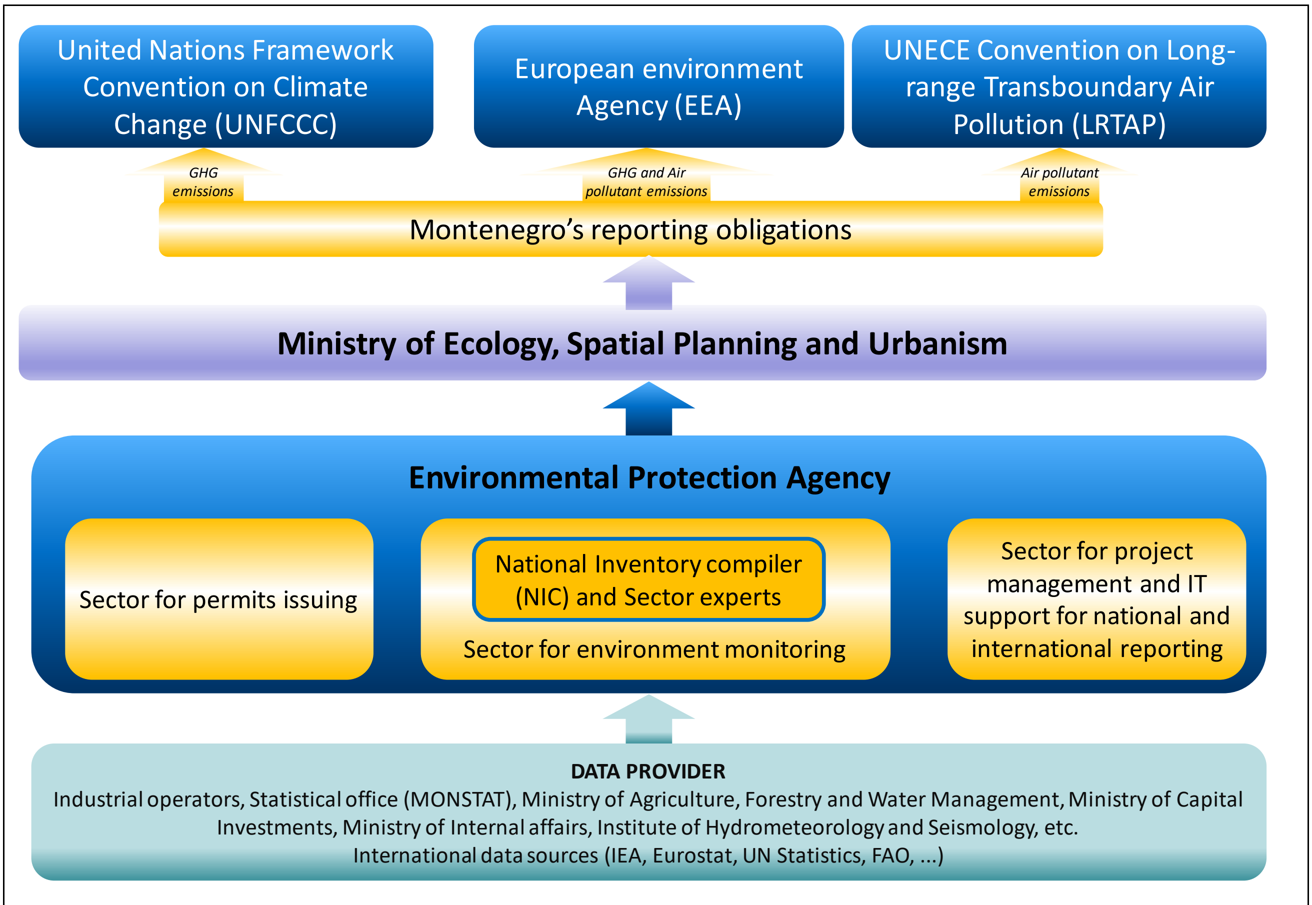


Figure 2 National System

[23] United Nations, Economic Commission for Europe (UNECE)

Within the EPA, experts from different departments are contributing, whereby experts from the Sector for nature protection, monitoring, analysis and reporting are compiling and reporting the inventory. Data needed for the preparation of the inventory are provided by either

- Industrial operators,
- Statistical office (MONSTAT),
- Ministry of Capital Investments
- Ministry of Agriculture, Forestry and Water management,
- Ministry of Internal affairs,
- Institute of hydrometeorology and seismology.

EPA has signed memorandum of understanding on mutual cooperation on data with MONSTAT.

The other ministries/institutions mentioned above are delivering the data on voluntary basis and upon our requirements. The plant operators are reporting the data due to their obligation under European Pollutant Release and Transfer Register (PRTR) and national sub legislation under the Law on air protection.

In the following figure the *draft* MRV framework for the GHG and Air pollution emission inventory of Montenegro is illustrated. In the following (sub-)chapters below a description of the various roles and responsibilities are provided.

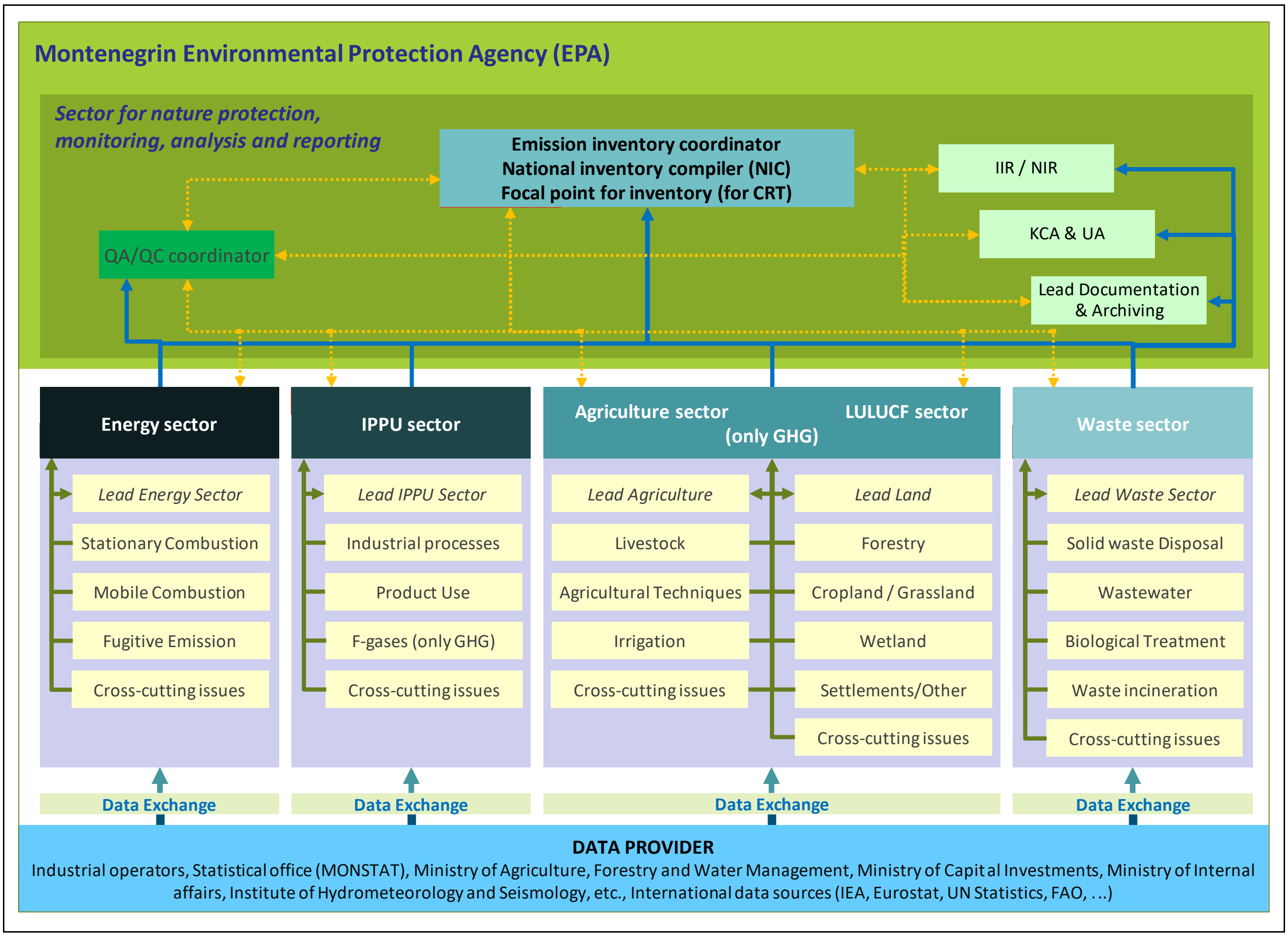


Figure 3 National system - detailed

Emissions shall be estimated by *sector experts* for

(a) all sectors of the Air pollutants inventory according to the 2006 IPCC guidelines and the EMEP/EEA Air pollutant Emission Inventory Guidebook 2019

- IPCC/NFR sector 1 Energy
- IPCC/NFR sector 2 Industrial Processes and Product Use (IPPU)
- IPCC/NFR sector 3 Agriculture
- IPCC sector 4 Land Use, Land use Change and Forestry (LULUCF)
- IPCC/NFR sector 5 Waste
- IPCC/NFR sector 6 Other

The IPCC sector AFOLU – Agriculture, Forestry and Other Land Use - is divided into two 'sectors' but with close linkage.

(b) all seven gases of the GHG inventory according to the 2006 IPCC guidelines

- carbon dioxide (CO_2)
- methane (CH_4),
- nitrous oxide (N_2O),
- hydrofluorocarbons (HFCs),
- perfluorocarbons (PFCs),
- sulphur hexafluoride (SF_6), and
- nitrogen trifluoride (NF_3).

(c) Emissions carbon monoxide (CO), nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOCs), and sulphur oxides (SOx) are estimated in the air pollutants inventory according to the EMEP/EEA Air pollutant Emission Inventory Guidebook 2019 and are submitted under UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP).

Table 3 Overview on reporting obligation

Greenhouse gases (GHG) and Air pollutants emission inventory	GHG							Air pollutants																					
				F-gases				Main pollutants				Particulate matter (PM)				Persistent organic pollutants (POPs)				Heavy Metals (HMs)									
								Precursors												Priority HMs			Additional HMs						
	CO_2	N_2O	CH_4	SF_6	HFC	PFC	NF_3	SO_x	NOx	NMVOC	CO	NH_3	TSP	PM_{10}	$PM_{2.5}$	BC	PCDD/ PCDF	HCB	PAH	PCB	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
IPCC / NFR Sectors																													
1. Energy																													
2. Industrial processes and product use (IPPU)																													
AFOLU 3. Agriculture																													
4. LULUCF																													
5. Waste																													
6. Other																													
Reporting obligation																													
UNFCCC - Greenhouse gas (GHG) inventory under the Convention, the Kyoto protocol and under the Paris Agreement																													
Data – CRF/CRT or Non-Annex I Tables																													
National Inventory report (NIR)/document (NID)																													
EU Greenhouse gas Monitoring Mechanism Regulation (MMR) and EU Governance Regulation of the Energy Union and Climate Action*																													
Data – CRF/CRT																													
National Inventory report (NIR)/document (NID)																													
UNECE / LRTAP - Air pollution emissions inventory																													
Data - NFR tables																													
Informative Inventory Report (IIR)																													
EU National Emission Ceilings Directive*																													
Data - NFR tables																													
Informative Inventory Report (IIR)																													
POPs under the Stockholm Convention																													
National reports																													
Voluntary obligation																													
Climate and Clean Air Coalition**																													
Short-lived climate pollutants (SLCPs)***																													
Batumi Action for Cleaner Air (BACA) */****																													
Batumi Action for Cleaner Air (BACA)																													

Remark: polycyclic aromatic hydrocarbons (PAHs) reported as {benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene,Total 1-4}

* currently not relevant to Montenegro

** https://www.ccacoalition.org/en

*** https://www.ccacoalition.org/en/partners/herceg-novi-montenegro

**** https://unece.org/baca

Remark

- According to Decision 17/CP.8 - Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention Non-Annex I Parties are encouraged to provide information relating to HFCs, PFCs, SF6.
- According to Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement: para 48. Each Party shall report seven gases (CO_2, CH_4, N_2O, HFCs, PFCs, SF6 and NF3); those developing country Parties that need flexibility in the light of their capacities with respect to this provision have the flexibility to instead report at least three gases (CO_2, CH_4 and N_2O) as well as any of the additional four gases (HFCs, PFCs, SF6 and NF3) that are included in the Party's NDC under Article 4 of the Paris Agreement, are covered by an activity under Article 6 of the Paris Agreement, or have been previously reported. (https://unfccc.int/sites/default/files/resource/cp24_auv_transparency.pdf)

1.2.2 Inventory preparation process

The greenhouse gas inventory of Montenegro for the period 1990 to 2021 was compiled according to the recommendations for inventories set out in the

- Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention. Decision 17/CP.8 (FCCC/CP/2002/7/Add.2)[24];

  Non-Annex I Parties are required to submit their first National Communication (NC) within three years of entering the Convention, and every four years thereafter. The NCs shall be prepared in accordance with the guidelines contained in decision 17/CP.8.

  III. NATIONAL GREENHOUSE GAS INVENTORY

  6. Each non-Annex I Party shall, in accordance with Article 4, paragraph 1 (a), and Article 12, paragraph 1(a) of the Convention, communicate to the Conference of the Parties a national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases (GHGs) not controlled by the Montreal Protocol, to the extent its capacities permit, following the provisions in these guidelines.
  7. Non-Annex I Parties shall estimate national GHG inventories for the year 1994 for the initial national communication or alternatively may provide data for the year 1990. For the second national communication, non-Annex I Parties shall estimate national GHG inventories for the year 2000. The least developed country Parties could estimate their national GHG inventories for years at their discretion.

- UNFCCC biennial update reporting guidelines for Parties not included in Annex I to the Convention (Decision 2/CP.17, FCCC/CP/2011/9/Add.1, Annex III[25])

  Non-Annex I Parties, consistent with their capabilities and the level of support provided for reporting, should submit their first Biennial Update Report (BUR) by December 2014, and every two years thereafter. The least developed country Parties and small island developing States may submit BURs at their own discretion. The BURs shall be prepared in accordance with the guidelines contained in.

  III. National greenhouse gas inventory

  3. Non-Annex I Parties should submit updates of national GHG inventories according to paragraphs 8–24 in the "Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention" (hereinafter referred to as the UNFCCC guidelines for the preparation of national communications from non-Annex I Parties) as contained in the annex to decision 17/CP.8. The scope of the updates on national GHG inventories should be consistent with capacities, time constraints, data availabilities and the level of support provided by developed countries Parties for biennial update reporting.

The current National GHG Inventory and National Inventory Report (NIR) of Montenegro for the period 1990 – 2021 has been prepared also in the light of the 'Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement'[26] which will be in place from 2024 onwards:

- Application of 2006 IPCC Guidelines for National Greenhouse Gas Inventories;
- Preparation of the NIR according to the principles listed in section B. Guiding principles para 3:

[24] Available (8 January 2020) on FCCC/CP/2002/7/Add.2 https://unfccc.int/sites/default/files/17_cp.8.pdf

[25] Available (8 January 2020) on FCCC/CP/2011/9/Add.1, Annex III. https://unfccc.int/sites/default/files/resource/docs/2011/cop17/eng/09a01.pdf

[26] Available (8 January 2020) on FCCC/PA/CMA/2018/3/Add.2 (18/CMA.1) https://unfccc.int/sites/default/files/resource/CMA2018_03a02E.pdf

(a) Building on and enhancing the transparency arrangements under the Convention, recognizing the special circumstances of the least developed countries (LDCs) and small island developing States (SIDS), and implementing the transparency framework in a facilitative, non-intrusive, non-punitive manner, respecting national sovereignty and avoiding placing undue burden on Parties;

(b) The importance of facilitating improved reporting and transparency over time;

(c) Providing flexibility to those developing country Parties that need it in the light of their capacities;

(d) Promoting transparency, accuracy, completeness, consistency and comparability;

(e) Avoiding duplication of work and undue burden on Parties and the secretariat;

(f) Ensuring that Parties maintain at least the frequency and quality of reporting in accordance with their respective obligations under the Convention;

(g) Ensuring that double counting is avoided;

(h) Ensuring environmental integrity.

In the following Figure the current reporting and review obligations and the reporting and review obligations under the Paris Agreement (current status of negotiations) are presented. A biennial reporting and review of the greenhouse gas inventory and National Inventory Report (NIR) will be status.

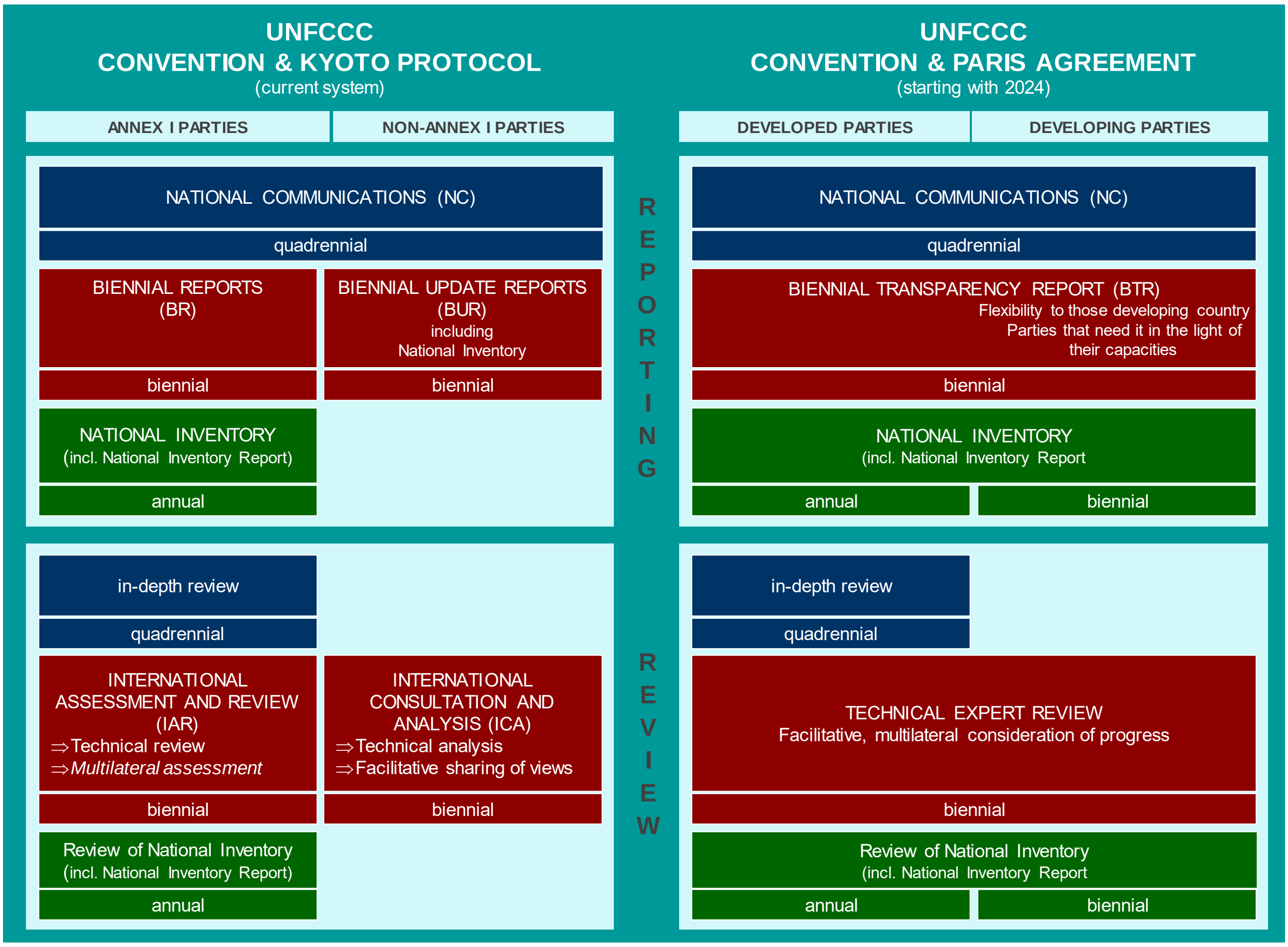


Figure 4 Comparison of the current reporting and review obligations and the reporting and review obligations under the Paris Agreement.

Source: Köther, Traute (2019): Comparison of the current reporting obligations and the reporting obligations under the Paris Agreement. Based on After WRI (2017): Designing the Enhanced Transparency Framework, Part 2: Review under the Paris Agreement.

1.2.3 Archiving of information

1.2.3.1 Documentation

For each category the documentation of the methodology and actual emission calculation is provided in the calculation tool (e.g. 1A1a_ElectricityTool_MNE.xlsx).

	A	B	C	D	E	F	G
1		umweltbundesamt ENVIRONMENT AGENCY AUSTRIA		This calculation tool was created and updated by the Umweltbundesamt (Environmental Agency Austria) within the framework of the Twinning light MN 17 IPA EN 01 20 TWL. It has been adapted for the needs of the Montenegrin Inventory and is based on the latest IPCC and EMEP/EEA guidebooks and should be used in conjunction with them.			
2		Integrated inventory for Greenhouse gas (GHG) and Air pollutant emissions		Feedback and questions can be sent to **trainingcenter@umweltbundesamt.at**			
3		editor	Traute Köther, Umweltbundesamt (Envionmental Agency Austria)				
4		version	28.03.2022				
5		file name:	**1A1a_ElectricityTool_MNE.xlsx**	*older versions always with date; e.g. 1A1ai_InventoryTool_2019-07-25.xlsx*			
6		status	**in progress**	*drop down*			
7		timeseries	1990-2021				
8		IPCC-Sources:	1.A1.a - Energy Industries - Public electricity	Please select year for Trend calculation (last year)	Please select the source		
9		file linked to:	JQ_COAL_Lignite.xlsx JQ_Liquid_Oil.xlsx JQ_Renewable.xlsx JQ_Gaseous_LNG.xlsx	Trend	Source		
10		folder of linked files:	###_MNE\06_Inventory\2023_submission\01_Energy\EnergyBalance	2021	1.A.1.a.i		
11		description/content:	Integrated inventory Tools for estimation of (1) Greenhouse gas (GHG) emissions based on 2006 IPCC Guidelines 2019 Refinements to the 2006 IPCC Guidelines and (2) Air pollutant emissions based on EMEP/EEA Air pollutant emissions guidebook 2019		Energy Industries - Main Activity Electricity and Heat Production - Electricity Generation		
13		**Sheet name**	**Content**	**Content description**	**Susanne2018**	**IPCC**	**Other remarks**
14					Password		
15		ChangeLog	Information regarding updating / modification / changes	*Information*	*unprotected worksheet*		
16		1A1ai_IncentoryCylce	ToDo list linked to InventoryCycle.xlsx	*Information*	*unprotected worksheet*	1.A.1.a.i	
17		1A1ai_QC Checklist	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6 linked to QC_TIER-1-2_Checklist.xlsx	*Information*	*unprotected worksheet*	1.A.1.a.i	
18		1A1ai_ChoiceMethology	Choice of Methology	*Information*	*unprotected worksheet*	1.A.1.a.i	
19		1A1ai_Completness & KeyCategory	Completness evaluation & KeyCategory linked to CompletnessEvaluation_KeyCategory.xlsx	*Information*	*unprotected worksheet*	1.A.1.a.i	
20		1A1ai_PlannedImprovements	Information related to Planned Improvements for transfer to NIR sectoral chapter for transfer to NIR chapter Recalculation & Planned improvements for transfer to IIR sectoral chapter for transfer to IIR chapter Recalculation & Planned improvements linked to PlannedImprovements.xlsx	*Information*	*unprotected worksheet*	1.A.1.a.i	
21		1A1ai_Recalculation	Information related to Recalculation for transfer to NIR sectoral chapter for transfer to NIR chapter Recalculation & Planned improvements for transfer to IIR sectoral chapter for transfer to IIR chapter Recalculation & Planned improvements linked to Reclaculation.xlsx	Recalculation	*unprotected worksheet*	1.A.1.a.i	
22		1A1ai_Uncertainty	Information related to Uncertainty for transfer to NIR sectoral chapter for transfer to NIR chapter Uncertainty for transfer to IIR sectoral chapter for transfer to IIR chapter Uncertainty linked to Uncertainty.xlsx	*Information*	*unprotected worksheet*	1.A.1.a.i	
23		1A1ai_NIR_tables_&_gr	Tables & graphs für NIR	*result*	*unprotected worksheet but occasional*	1.A.1.a.i	
24		1A1ai_IIR_tables_&_gra	Tables & graphs für IIR	*result*	*unprotected worksheet but occasional*	1.A.1.a.i	
25		1A1ai_CRT	**GHG** emissions (automatised) for CRT reporting for transfer to **CRT - Common ReportingTables**	*(intermediate)* ***result***	*protected worksheet*	1.A.1.a.i	CRT - Common Reporting Tables
26		1A1ai_NFR	**Air Pollutants** emissions (automatised) for NFR for transfer to **NFR - Tables**	*(intermediate)* ***result***	*protected worksheet*	1.A.1.a.i	Nomenclature Format for Reporting (NFR) tables
27		**1A1ai_AD_Liquid**	**Calculation of emissions by liquid fuel and GHG / Pollutants**	***Input data***	*unprotected worksheet but occasional protected cells*	1.A.1.a.i	
28		**1A1ai_AD_Solid**	**Calculation of emissions by solid fuel and GHG / Pollutants**	***Input data***	*unprotected worksheet but occasional protected cells*	1.A.1.a.i	
29		**1A1ai_AD_Gas**	**Calculation of emissions by gaseous fuel and GHG / Pollutants**	***Input data***	*unprotected worksheet but occasional protected cells*	1.A.1.a.i	
30		**1A1ai_AD_Other-Fossil**	**Calculation of emissions by other fossil fuel and GHG / Pollutants**	***Input data***	*unprotected worksheet but occasional protected cells*	1.A.1.a.i	
31		**1A1ai_AD_Peat**	**Calculation of emissions by peat (fuel) and GHG / Pollutants**	***Input data***	*unprotected worksheet but occasional protected cells*	1.A.1.a.i	
32		**1A1ai_AD_Biomass**	**Calculation of emissions by biomass (fuel) and GHG / Pollutants**	***Input data***	*unprotected worksheet but occasional protected cells*	1.A.1.a.i	
33		EF IPCC	Emission factors of 2006 IPCC GL for sector 1 A	*Emission factors*	*protected worksheet*	1.A	
34		EF EMEP-EEA 1A1	Emission factors of 2019 EMEP/EEA GB for sector 1.A.1	*Emission factors*	*protected worksheet*	1.A.1	
35		NCV_Default_2006_IPCC	TABLE 1.2 DEFAULT NET CALORIFIC VALUES (NCVs) AND LOWER AND UPPER LIMITS OF THE 95% CONFIDENCE INTERVALS	*Parameter*	*protected worksheet*	1.A	
36		Metric GWP	Global warming potential	*Information*	*unprotected worksheet*		
37		ExcelSupport	Excel support regarding used formulars	*Information*	*unprotected worksheet*		
38		Matrix_EBxCRF	Correspondance of activities of Energy Balance (IEA/EUROSTAT Questionnaire) and CRF sub categories	*Information*	*unprotected worksheet*		
39		DropDown&Definition	List for DropDown and Definitions of sectors and fuels	*Information*	*protected worksheet*		

Figure 5 Documentation of the methodology and actual emission calculation

1.2.3.2 Expert judgements

The documentation of expert judgements in line with the IPCC 2006 Guidelines should include:

- Name of the expert and institution/department,
- Date,
- Basis of judgement (references to relevant studies etc.),
- Underlying assumptions

1.2.3.3 Archiving

Archiving should takes place on a central server within the folder 'GHG inventory' and relevant subfolders. The proposed structure of the 'GHG inventory' is provided in the next Figure. Relevant literature has to be archived and references to be stated in the internal documentation as well as in the NIR.

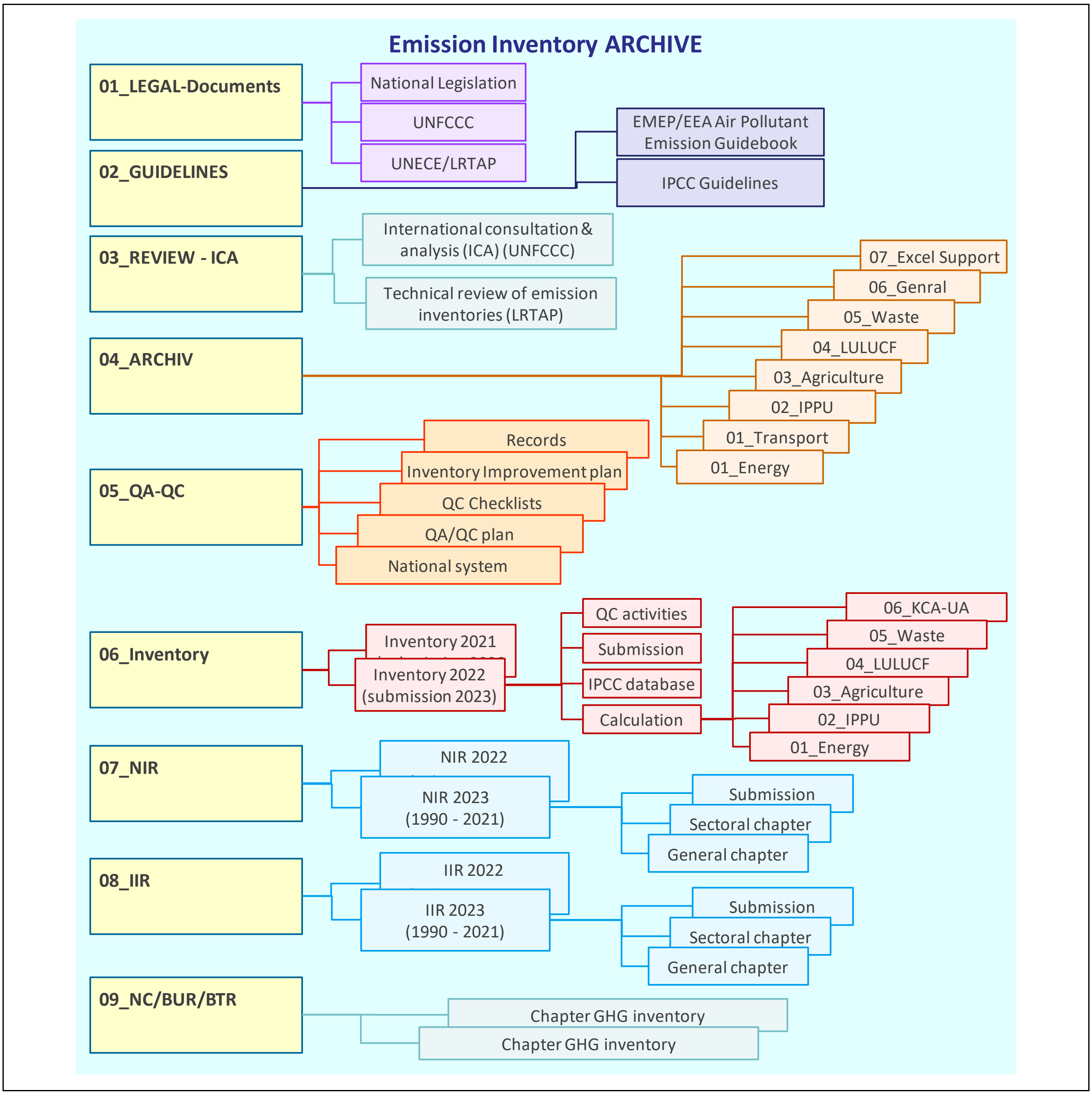


Figure 6 Emission Inventory Archive

1.2.4 Processes for official consideration and approval of inventory

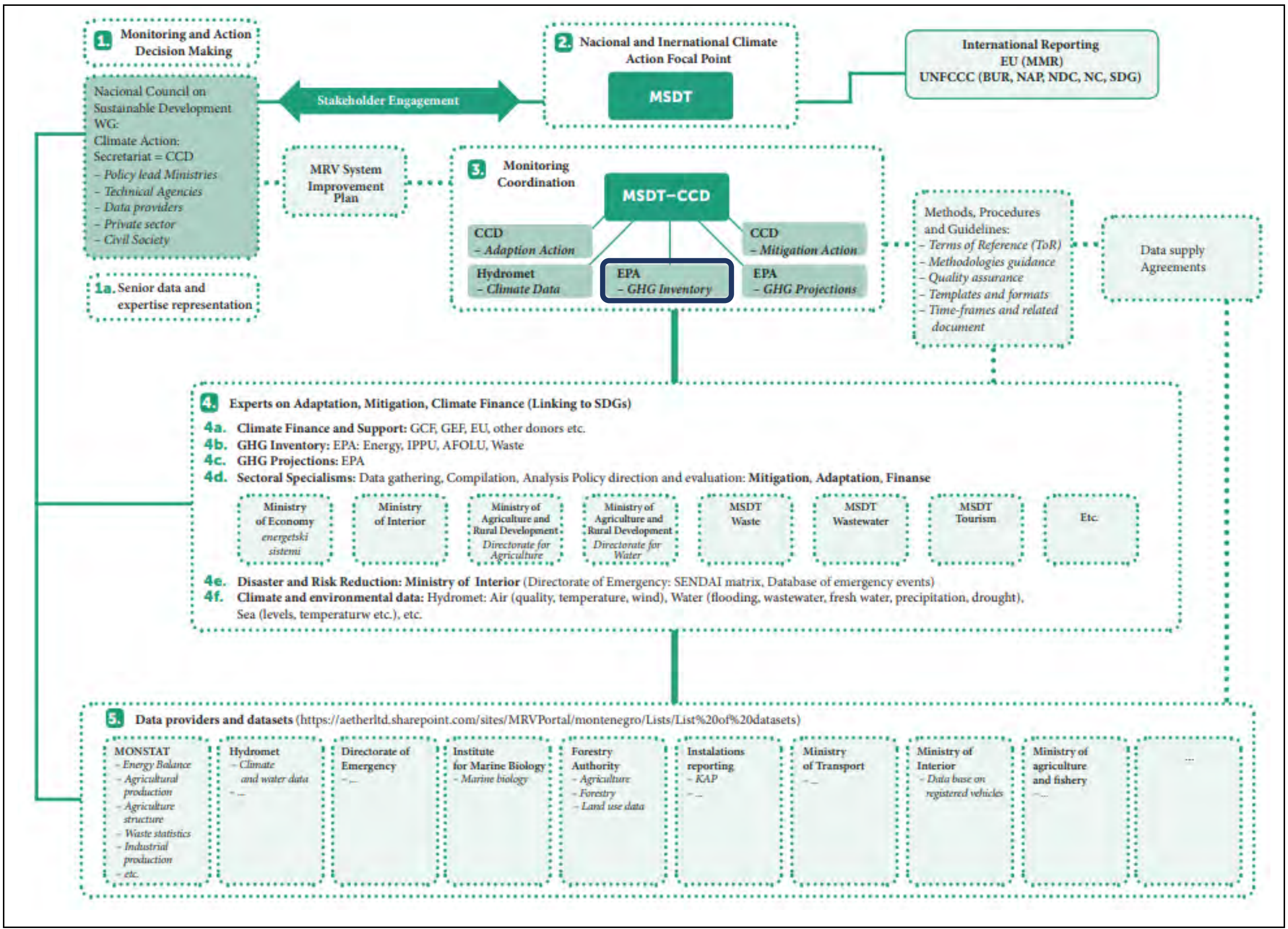


Figure 7 National MRV system

Source: Ministry of Tourism and Sustainable Development (2020): Third National Communication (NC) of Montenegro. [27]

1.3 Brief general description of methodologies and data sources used

The main sources for activity data are national statistics from MONSTAT and international statistics like Eurostat, UNSD and FAO. In order to fill gaps expert judgement based on discussion with relevant national experts is applied.

The main sources for emission factors of GHG are the 2006 IPCC Guidelines and 2019 Refinements to the 2006 IPCC Guidelines. For the emission factors of air pollutants, the EMEP/EEA air pollutant emission inventory guidebook 2019 is used.

For key categories, the most accurate methods for the preparation of the greenhouse gas inventory should be used. Due to lack of data and resources, it was not possible to estimate for all emissions according to the sectoral decision trees. Where the methodological choice is not in line with the sectoral decision tree, actions are defined and listed in the inventory improvement plan.

The following table briefly presents the activity data (AD) sources, the types of emission factors (EF) used, and the methods applied for estimating GHG emissions reported in this NIR. Detailed information on applied methodology, used activity data (AD) and emission factors (EF) are presented in the relevant

[27] Available (16 March 2021) on https://unfccc.int/sites/default/files/resource/TNC%20-%20MNE_0.pdf

sectoral chapters.

The preparation of the inventory starts always with identification of the key categories of the previous inventory followed by the selection of the appropriate identify the appropriate method for estimation for each category according to the **decision tree** of each source presented in Volume 2 – 5 of the 2006 IPCC guidelines. In the following Figure the general Decision Tree to choose a **Good Practice method** is presented.

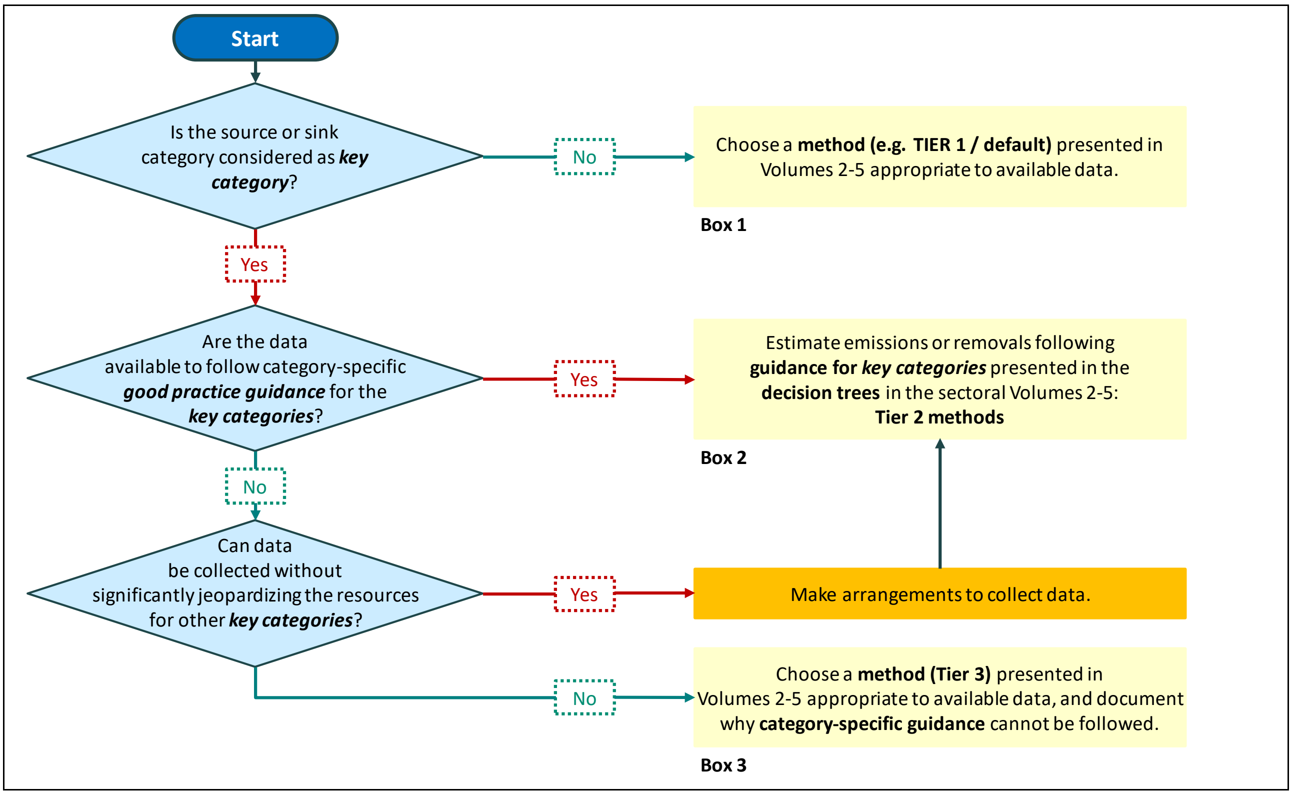


Figure 8 Decision Tree to choose a Good Practice method

Source: 2006 IPCC guidelines, Vol. 1: General Guidance and Reporting, Chap. 1: Introduction to the 2006 Guidelines, sub-chap. 4.1.2 Purpose of the key category analysis, Figure 4.1, p. 4.6.

In the following table, an overview is provided for

- Notation keys (in general)
- Notation keys to specify the method applied
- Notation keys to specify the emission factor used
- Notation keys to specify the activity data used

Table 4 Notation keys used to specify the method applied, emission factor used report and activity data used

Notation keys to specify completness		Notation keys to specify the method applied			
NA	Not applicable	**D**	IPCC default	**CS**	Country Specific
NO	Not occurring	**T1**	IPCC Tier 1	**CR**	CORINAIR
NE	Not estimated	**T1a, T1b, T1c**	IPCC Tier 1a, Tier 1b and Tier 1c, respectively	**RA**	Reference Approach
IE	Included elsewhere	**T2**	IPCC Tier 2	**OTH**	Other
C	Confidential	**T3**	IPCC Tier 3	**M**	Model

Notation keys to specify the emission factor used		Notation keys to specify the activity data used			
D	IPCC default	**Q**	Specific Questionnaire	**PS**	Plant specific
CS	Country specific	**Monstat**	Statistical Office of Montenegro	**EJ**	Expert Judgement
PS	Plant specific	**UNSD**	United Nations Statistics Division (UNSD)		
OTH	Other	**FAO**	FAO Statistics Division (FAOSTAT)		
M	Model				

Table 5 Summary report for methods and emission factors used and source of activity data in IPCC sector 1 Energy

IPCC sector	CO2			CH4			N2O		
1 Energy	Method aplied	Emission factor (EF)	Activity data	Method aplied	Emission factor (EF)	Activity data	Method aplied	Emission factor (EF)	Activity data
1.A Fuel combustion									
1.A.1 Energy industries									
1.A.1.a Public electricity and heat production	T1/T2	D/CS	MONSTAT	T1	D	MONSTAT	T1	D	MEM/UNSD
1.A.1.b Petroleum refining	NA	NA	NO	NA	NA	NO	NA	NA	NO
1.A.1.c Manufacture solid fuels Other energy industries	NA	NA	NA	NA	NA	NE	NA	NA	NA
1.A.2 Manufacturing industries Construction									
1.A.2.a Iron and steel	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
1.A.2.b Non-ferrous metals	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
1.A.2.c Chemicals	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
1.A.2.d Pulp paper and print	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
1.A.2.e Food processing beverages and tobacco	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
1.A.2.f Non-metallic minerals	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
1.A.2.g Manufacturing machinery	NA	NA	NO	NA	NA	NO	NA	NA	NO
1.A.2.h Manufacturing transport equipment	NA	NA	NO	NA	NA	NO	NA	NA	NO
1.A.2.i Mining excluding fuels and quarrying	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT

IPCC sector	CO2			CH4			N2O		
1 Energy	Method aplied	Emission factor (EF)	Activity data	Method aplied	Emission factor (EF)	Activity data	Method aplied	Emission factor (EF)	Activity data
1.A.2.j Wood and wood products	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
1.A.2.k Construction	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
1.A.2.l Textile and leather	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
1.A.2.g.vii Off-road vehicles Other machinery	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
1.A.2.m Other	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
1.A.3 Transport									
1.A.3.a Domestic aviation	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
1.A.3.b Road transportation	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
1.A.3.c Railways	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
1.A.3.d Domestic Navigation	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
1.A.3.e Other transportation	NA	NA	NO	NA	NA	NO	NA	NA	NO
1.A.4 Other sectors									
1.A.4.a Commercial institutional	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
1.A.4.b Residential	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
1.A.4.c Agriculture forestry fishing	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
1.A.5 Other	NE	NA	NE	NE	NA	NA	NE	NA	NE
1.B Fugitive emissions from fuels									
1.B.1 Solid Fuels									
1.B.1.a Coal mining and handling	T1	D	MONSTAT	T1	D	MONSTAT	NA	NA	NA
1.B.1.b Fuel transformation									
1.B.1.b.i Charcoal and biochar production	NE	NA	NA	NE	NA	NA	NE	NA	NA
1.B.1.c Other	NA	NA	NO	NA	NA	NO	NA	NA	NO
1.B.2 Oil and gas									
1.B.2.a Oil									
1.B.2.a.i Exploration	NA	NA	NO	NA	NA	NO	NA	NA	NO
1.B.2.a.ii Production and upgrading	NA	NA	NO	NA	NA	NO	NA	NA	NO
1.B.2.a.iii Transport	NA	NA	NO	NA	NA	NO	NA	NA	NO
1.B.2.a.iv Refining storage	NA	NA	NO	NA	NA	NO	NA	NA	NO
1.B.2.a.v Distribution of oil products	T1	D	MONSTAT	T1	D	MONSTAT	NA	NA	NO
1.B.2.a.vi Other	NA	NA	NO	NA	NA	NO	NA	NA	NO
Natural gas									
1.B.2.b Natural gas	NA	NA	NO	NA	NA	NO	NA	NA	NO
1.C CO2 Transport and storage									
1.D Memo items									
1.D.1 International bunkers - Aviation	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
1.D.1 International bunkers - Navigation	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
1.D.2 Multilateral operations	NA	NA	NO	NA	NA	NO	NA	NA	NO

IPCC sector	CO2			CH4			N2O		
1 Energy	Method aplied	Emission factor (EF)	Activity data	Method aplied	Emission factor (EF)	Activity data	Method aplied	Emission factor (EF)	Activity data
1.D.3 CO2 emissions from biomass	T1	D	MONSTAT	NA	NA	NA	NA	NA	NA
CO2 captured	NA	NA	NO	NA	NA	NO	NA	NA	NO
Waste incineration with energy recovery included	NA	NA	NO	NA	NA	NO	NA	NA	NO

Table 6 Summary report for methods and emission factors used and source of activity data in IPCC sector 2 IPPU

IPCC sector	CO2			CH4			N2O		
2 **Industrial processes and product Use (IPPU)**	Method aplied	Emission factor (EF)	Activity data	Method aplied	Emission factor (EF)	Activity data	Method aplied	Emission factor (EF)	Activity data
2.A Mineral industry									
2.A.1 Cement production	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.A.2 Lime production	T1	D	MONSTAT	NA	NA	NA	NA	NA	NA
2.A.3 Glass production	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.A.4 Other process uses of carbonates	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.A.4.d Other	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.B Chemical industry	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.C Metal industry									
2.C.1 Iron and steel production	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.C.2 Ferroalloys production	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.C.3 Aluminium production	T1	D	MONSTAT	NA	NA	NA	NA	NA	NA
2.C.4 Magnesium production	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.C.5 Lead production	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.C.6 Zinc production	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.C.7 Other	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.D Non-energy products Solvent use									
2.D.1 Lubricant use	T1	D	MONSTAT	NA	NA	NA	NA	NA	NA
2.D.2 Paraffin wax use	T1	D	MONSTAT	NA	NA	NA	NA	NA	NA
2.D.3 Other	T1	D	MONSTAT	NA	NA	NA	NA	NA	NA
2.E Electronics industry	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.F. Product uses as substitutes for ODS	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.G Other product manufacture and use									
2.G.1. Electrical equipment	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.G.2. SF6 and PFCs from other product use	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.G.3 N2O from product uses	NA	NA	NO	NA	NA	NO	NA	NA	NE
2.G.4 Other	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.H Other	NA	NA	NO	NA	NA	NO	NA	NA	NO

Table 7 Summary report for methods and emission factors used and source of activity data in sector 2 IPPU – F-gases

IPCC sector	HFCs			PFCs			SF6		
2 Industrial processes and product Use (IPPU)	Method aplied	Emission factor (EF)	Activity data	Method aplied	Emission factor (EF)	Activity data	Method aplied	Emission factor (EF)	Activity data
2.A Mineral industry	NA	NA	NA	NO	NA	NA	NA	NA	NA
2.B Chemical industry	NA	NA	NA	NO	NA	NA	NA	NA	NA
2.C Metal industry	NA	NA	NO	T2	CS	PS	NA	NA	NA
2.D Non-energy products Solvent use	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.E Electronics industry									
2.E.1 Integrated circuit or semiconductor	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.E.2 TFT flat panel display	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.E.3 Photovoltaics	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.E.4 Heat transfer fluid	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.E.5 Other	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.F. Product uses as substitutes for ODS									
2.F.1. Refrigeration and air-conditioning									
2.F.1.a. Commercial refrigeration	NE	NA	EPA	NA	NA	NO	NA	NA	NO
2.F.1.b. Domestic refrigeration	T1	D	EPA	NA	NA	NO	NA	NA	NO
2.F.1.c. Industrial refrigeration	NE	NA	EPA	NA	NA	NO	NA	NA	NO
2.F.1.d. Transport refrigeration	NE	NA	EPA	NA	NA	NO	NA	NA	NO
2.F.1.e. Mobile air-conditioning	T1	D	EPA	NA	NA	NO	NA	NA	NO
2.F.1.f. Stationary air-conditioning	T1	D	EPA	NA	NA	NO	NA	NA	NO
2.F.2. Foam blowing agents	T1	D	EPA	NA	NA	NO	NA	NA	NO
2.F.3. Fire protection	T1	D	EPA	NA	NA	NO	NA	NA	NO
2.F.4. Aerosols	NA	NA	NE	NA	NA	NE	NA	NA	NE
2.F.5. Solvents	NA	NA	NE	NA	NA	NE	NA	NA	NE
2.F.6. Other applications	NA	NA	NE	NA	NA	NE	NA	NA	NE
2.G Other product manufacture and use									
2.G.1. Electrical equipment	T1	D	PS	T1	D	PS	T1	D	PS
2.G.2. SF6 and PFCs from other product use	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.G.3 N2O from product uses	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.G.4 Other	NA	NA	NO	NA	NA	NO	NA	NA	NO
2.H Other	NA	NA	NO	NA	NA	NO	NA	NA	NO

Table 8 Summary report for methods and emission factors used and source of activity data in IPCC sector 3 Agriculture

IPCC sector	CO2			CH4			N2O		
3 Agriculture	Method aplied	Emission factor (EF)	Activity data	Method aplied	Emission factor (EF)	Activity data	Method aplied	Emission factor (EF)	Activity data
3.A Enteric fermentation									
3.A.1 Cattle									
Option A:	NA	NA	NA	NA	NA	NA	NA	NA	NA
Option B (country-specific)									
3.A.1.a Other									
3.A.1.a.i Mature dairy cattle	NA	NA	NA	T2	D	MONSTAT	NA	NA	NA
3.A.1.a.ii Other mature cattle	NA	NA	NA	T2	D	MONSTAT	NA	NA	NA
3.A.1.a.iii Growing cattle	NA	NA	NA	T2	D	MONSTAT	NA	NA	NA
3.A.1.a.iv Other	NA	NA	NA	NA	NA	NO	NA	NA	NA
3.A.2 Sheep	NA	NA	NA	T2	D	MONSTAT	NA	NA	NA
3.A.3 Swine	NA	NA	NA	T2	D	MONSTAT	NA	NA	NA
3.A.4 Other livestock									
3.A.4.a Buffalo	NA	NA	NA	NA	NA	NO	NA	NA	NA
3.A.4.b Camels	NA	NA	NA	NA	NA	NO	NA	NA	NA
3.A.4.c Deer	NA	NA	NA	NA	NA	NO	NA	NA	NA
3.A.4.d Goats	NA	NA	NA	T2	D	MONSTAT	NA	NA	NA
3.A.4.e Horses	NA	NA	NA	T2	D	MONSTAT	NA	NA	NA
3.A.4.f Mules and asses	NA	NA	NA	T2	D	MONSTAT	NA	NA	NA
3.A.4.g Poultry	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.A.4.h Other									
3.A.4.h.i Rabbit	NA	NA	NA	NA	NA	NO	NA	NA	NA
3.A.4.h.ii Reindeer	NA	NA	NA	NA	NA	NO	NA	NA	NA
3.A.4.h.iii Ostrich	NA	NA	NA	NA	NA	NO	NA	NA	NA
3.A.4.h.iv Fur-bearing animals	NA	NA	NA	NA	NA	NO	NA	NA	NA
3.A.4.h.v Other	NA	NA	NA	NA	NA	NO	NA	NA	NA
3.B Manure management									
3.B.1 Cattle									
Option A	NA	NA	NA	T2	D	MONSTAT	T2	NA	MONSTAT
Option B (country-specific)									
3.B.1.a Other	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B.2 Sheep	NA	NA	NA	T2	D	MONSTAT	T2	D	MONSTAT
3.B.3 Swine	NA	NA	NA	T2	D	MONSTAT	T2	D	MONSTAT
3.B.4 Other livestock									
3.B.4.a Buffalo	NA	NA	NO	NA	NA	NO	NA	NA	NO
3.B.4.b Camels	NA	NA	NO	NA	NA	NO	NA	NA	NO
3.B.4.c Deer	NA	NA	NO	NA	NA	NO	NA	NA	NO
3.B.4.d Goats	NA	NA	NA	T2	D	MONSTAT	T2	D	MONSTAT
3.B.4.e Horses	NA	NA	NA	T2	D	MONSTAT	T2	D	MONSTAT
3.B.4.f Mules and Asses	NA	NA	NA	T2	D	MONSTAT	T2	D	MONSTAT
3.B.4.g Poultry	NA	NA	NA	T2	D	MONSTAT	T2	D	MONSTAT
3.B.4.h Other	NA	NA	NA	NA	NA	NO	NA	NA	NO

IPCC sector	CO2			CH4			N2O		
3 Agriculture	**Method aplied**	**Emission factor (EF)**	**Activity data**	**Method aplied**	**Emission factor (EF)**	**Activity data**	**Method aplied**	**Emission factor (EF)**	**Activity data**
3.C Rice cultivation	NA	NA		NO	NA		NA	NA	
3.D Agricultural soils									
3.D.1 Direct N2O emissions from managed soils									
3.D.1.a Inorganic N fertilizers	NA	NA	NA	NA	NA	NA	T1	D	MONSTAT
3.D.1.b Organic N fertilizers									
3.D.1.b.i Animal manure applied to soils	NA	NA	NA	NA	NA	NA	T2	D	MONSTAT
3.D.1.b.ii Sewage sludge applied to soils	NA	NA	NA	NA	NA	NA	NA	NA	NE
3.D.1.b.iii Other organic fertilizers applied to soils	NA	NA	NA	NA	NA	NA	NA	NA	NE
3.D.1.c Urine and dung deposited by grazing animals	NA	NA	NA	NA	NA	NA	T2	D	MONSTAT
3.D.1.d Crop residues	NA	NA	NA	NA	NA	NA	T1	D	MONSTAT
3.D.1.e Mineralization immobilization loss-gain	NA	NA	NA	NA	NA	NA	NA	NA	NE
3.D.1.f Cultivation of organic soils histosols	NA	NA	NA	NA	NA	NA	NA	NA	NE
3.D.1.g Other	NA	NA	NA	NA	NA	NA	NA	NA	NO
3.D.2 Indirect N2O Emissions from managed soils	NA	NA	NA	NA	NA	NA	T1	D	MONSTAT
3.E Prescribed burning of savannahs	NA	NA	NO	NA	NA	NO	NA	NA	NO
3.F Field burning of agricultural residues	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
3.G Liming	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
3.H Urea application	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
3.I Other carbon-containing fertilizers	NA	NA	NO	NA	NA	NO	NA	NA	NO
3.J Other	NA	NA	NO	NA	NA	NO	NA	NA	NO

Table 9 Summary report for methods and emission factors used and source of activity data in IPCC sector 5 Waste

IPCC sector	CO2			CH4			N2O		
5 Waste	**Method aplied**	**Emission factor (EF)**	**Activity data**	**Method aplied**	**Emission factor (EF)**	**Activity data**	**Method aplied**	**Emission factor (EF)**	**Activity data**
5.A Solid waste disposal									
5.A.1 Managed waste disposal sites									
5.A.1.a Anaerobic	NA	NA	NA	T1	D	MONSTAT	NA	NA	NA
5.A.1.b Semi-aerobic	NA	NA	NA	NA	NA	NO	NA	NA	NA
5.A.1.c Active-aeration	NA	NA	NA	NA	NA	NO	NA	NA	NA
5.A.2 Unmanaged waste disposal sites	NA	NA	NA	T1	D	MONSTAT	NA	NA	NA
5.A.3 Uncategorized waste disposal sites	NA	NA	NA	NA	NA	NO	NA	NA	NA

IPCC sector	CO2			CH4			N2O		
5 Waste	Method aplied	Emission factor (EF)	Activity data	Method aplied	Emission factor (EF)	Activity data	Method aplied	Emission factor (EF)	Activity data
5.B Biological treatment of solid waste									
5.B.1 Composting	NA	NA	NA	NA	NA	NE	NA	NA	NA
5.B.2 Anaerobic digestion at biogas facilities	NA	NA	NA	NA	NA	NO	NA	NA	NA
5.C Incineration and open burning of waste									
5.C.1 Waste incineration	NA	NA	NO	NA	NA	NO	NA	NA	NO
5.C.2 Open burning of waste	NA	NA	NE	NA	NA	NE	NA	NA	NE
5.D Wastewater treatment and discharge									
5.D.1 Domestic wastewater	NA	NA	NA	T1	D	MONSTAT	T1	D	MONSTAT
5.D.2 Industrial wastewater	NA	NA	NA	NO	NA	IE	NA	NA	NE
5.D.3 Other	NA	NA	NA	NO	NA	NO	NA	NA	NO
5.E Other	NA	NA	NA	NO	NA	NO	NA	NA	NO

1.4 Brief description of key categories

The identification of key categories (KCA) is prepared in accordance with 2006 IPCC Guidelines[28]. It stipulates that a key category is one that is prioritized within the National System because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level of emissions or removals, the trend in emissions or removals, or both.

Key categories according to the following equation are those that, when summed together in descending order of magnitude, add up to 95% of the sum of all Lx,t or any category meeting the 95% threshold in any year of the Level Assessment (LA) or in the Trend Assessment (TA) is considered a *key category*.

The identification of key categories consists in general of six steps. However, for the current submission a KCA no qualitative considerations were included.

- Identifying categories
- Level Assessment excluding LULUCF (Approach 1)
- Trend Assessment excluding LULUCF (Approach 1)
- Level Assessment including LULUCF (Approach 1)
- Trend Assessment including LULUCF (Approach 1)
- Qualitative considerations

1.4.1 Level of disaggregation and identification of key categories

Following *good practice* in determining the appropriate level of disaggregation of categories to identify key categories:

• The analysis is performed at the level of IPCC categories/subcategories at which the IPCC methods	✓
• Each greenhouse gas emitted from each category is considered separately.	✓
• An analysis should be performed for emissions and removals separately within a given category.	Not applicable for this submission

1.4.2 Level Assessment

The 2006 IPCC Guidelines Tier 1 approach has been applied: contribution of each source or sink category to the total national inventory.

Equation 4.1: Level Assessment (2006 IPCC GL, Vol. 1, Chap. 4.3.1)

$$\boldsymbol{Key\ category\ level\ assessment} = \frac{|\boldsymbol{source\ or\ sink\ category\ estimate}|}{|\boldsymbol{total\ contribution}|} \Rightarrow \boldsymbol{L_{x,t}} = \frac{|\boldsymbol{E_{x,t}}|}{\sum|\boldsymbol{E_{y,t}}|}$$

Where:

$L_{x,t}$ = level assessment for source or sink x in latest inventory year (year t)

$|E_{x,t}|$ = absolute value of emission or removal estimate of source or sink category x in year t

$\sum|E_{y,t}|$ = total contribution, which is the sum of the absolute values of emissions and removals in year t calculated using the aggregation level chosen by the country for key category analysis. Because both emissions and removals are entered with positive sign, the total contribution/level can be larger than a country's total emissions less removals

[28] IPCC. (2006). *Methodological Choice and Identification of Key Categories. Volume 1 - General Guidance and Reporting, Chapter 4.*

1.4.3 Trend Assessment

The 2006 IPCC Guidelines Tier 1 approach has been applied:

- The trend assessment identifies categories whose trend is different from the trend of the total inventory, regardless whether category trend is increasing or decreasing, or is a sink or source.
- Categories whose trend diverges most from the total trend should be identified as **key**, when this difference is weighted by the level of emissions or removals of the category in the base year.

Equation 4.2: Trend assessment (2006 IPCC GL, Vol. 1, Chap. 4.3.1)

$$\boldsymbol{Key\ category\ Trend\ assessment} = \quad \boldsymbol{T_{x,0}} = \frac{|\boldsymbol{E_{x,0}}|}{\sum_y |\boldsymbol{E_{y,0}}|} \times \left| \left[\frac{(\boldsymbol{E_{x,t}} - \boldsymbol{E_{x,0}})}{|\boldsymbol{E_{x,0}}|} \right] - \frac{(\sum_y \boldsymbol{E_{y,t}} - \sum_y \boldsymbol{E_{y,0}})}{\sum_y |\boldsymbol{E_{y,0}}|} \right|$$

Category Significance | **Category Trend** | **Overall Trend**

Where:

$T_{x,0}$ = trend assessment of source or sink category x in year t as compared to the base year (year 0)

$|Ex,0|$ = absolute value of emission or removal estimate of source or sink category x in year 0

$E_{x,t}$ and $E_{x,0}$ = real values of estimates of source or sink category x in years t and 0, respectively

$\sum_y E_{y,t}$, and $\sum_y E_{y,0}$ = total inventory estimates in years *t* and 0, respectively

1.4.4 Results of the Key Categories Analysis (KCA) with LULUCF

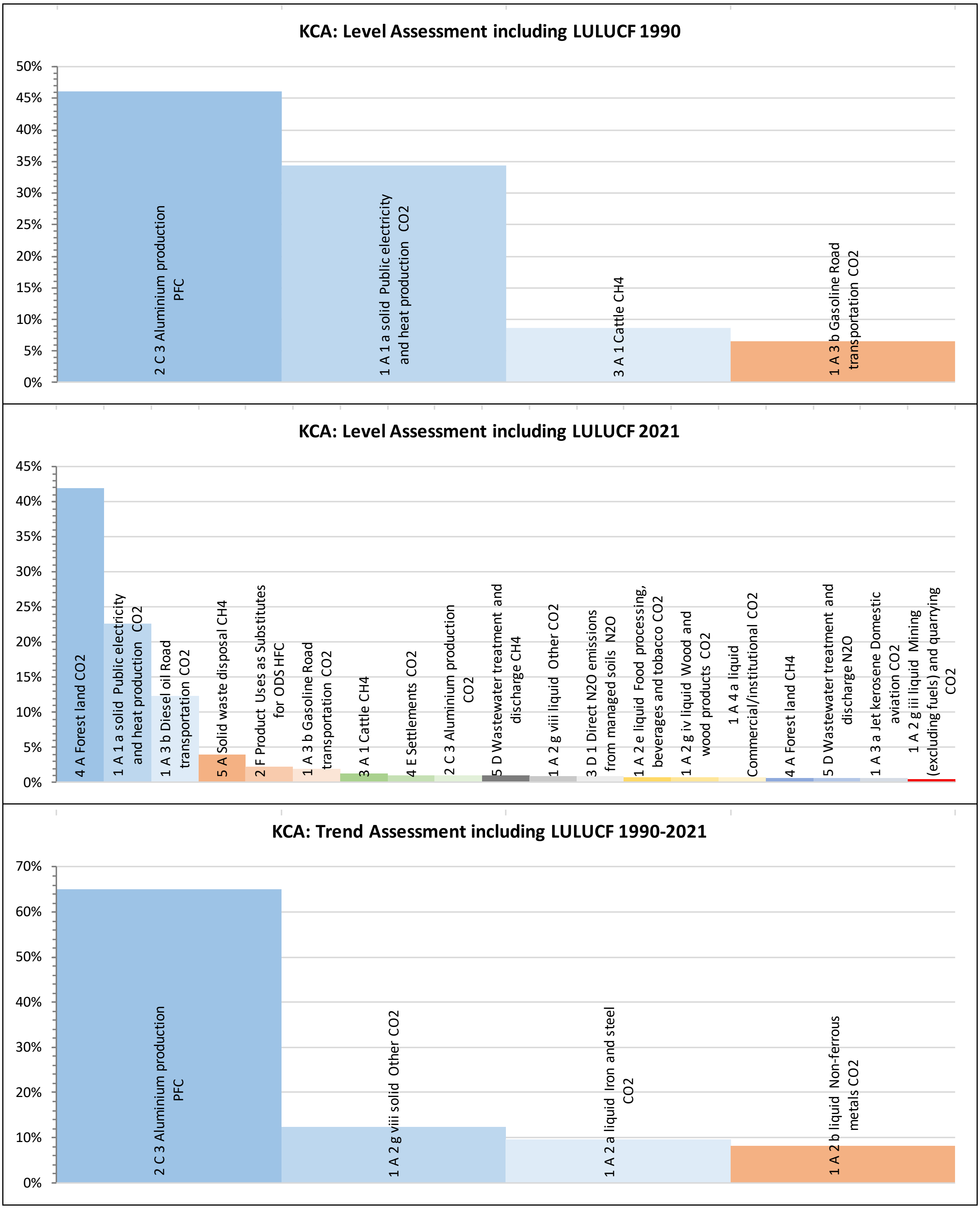


Figure 9 Key Categories including LULUCF.

Table 10 Level Assessment: Key categories including LULUCF 1990

Level Assessment - 1990		GHG	Year 1990 Estimate Ex,t	Absolute Value of Year 1990 Estimate Ex,t	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
IPCC Code	IPCC Category		Gg CO_2-equivalent			
2 C 3	Aluminium production	PFC	1 491	1 491	46.2%	46.2%
1 A 1 a solid	Public electricity and heat production	CO2	1 109	1 109	34.3%	80.5%
3 A 1	Cattle	CH4	280	280	8.7%	89.2%
1 A 3 b Gasoline	Road transportation	CO2	213	213	6.6%	95.8%

Table 11 Level Assessment: Key categories including LULUCF 2021

Level Assessment - 2021		GHG	Year 2021 Estimate Ex,t	Absolute Value of Year 2021 Estimate Ex,t	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
IPCC Code	IPCC Category		Gg CO_2-equivalent			
4 A	Forest land	CO2	-2 569	2 569	41.9%	41.9%
1 A 1 a solid	Public electricity and heat production	CO2	1 384	1 384	22.6%	64.4%
1 A 3 b Diesel oil	Road transportation	CO2	754	754	12.3%	76.7%
5 A	Solid waste disposal	CH4	247	247	4.0%	80.7%
2 F	Product Uses as Substitutes for ODS	HFC	139	139	2.3%	83.0%
1 A 3 b Gasoline	Road transportation	CO2	118	118	1.9%	84.9%
3 A 1	Cattle	CH4	82	82	1.3%	86.3%
4 E	Settlements	CO2	59	59	1.0%	87.2%
2 C 3	Aluminium production	CO2	59	59	1.0%	88.2%
5 D	Wastewater treatment and discharge	CH4	58	58	0.9%	89.1%
1 A 2 g viii liquid	Other	CO2	57	57	0.9%	90.0%
3 D 1	Direct N2O emissions from managed soils	N2O	52	52	0.8%	90.9%
1 A 2 e liquid	Food processing, beverages and tobacco	CO2	47	47	0.8%	91.6%
1 A 2 g iv liquid	Wood and wood products	CO2	47	47	0.8%	92.4%
1 A 4 a liquid	Commercial/institutional	CO2	41	41	0.7%	93.1%
4 A	Forest land	CH4	40	40	0.6%	93.7%
5 D	Wastewater treatment and discharge	N2O	35	35	0.6%	94.3%
1 A 3 a Jet kerosene	Domestic aviation	CO2	33	33	0.5%	94.8%
1 A 2 g iii liquid	Mining (excluding fuels) and quarrying	CO2	32	32	0.5%	95.3%

Table 12 Trend Assessment: Key categories including LULUCF 2021

Trend Assessment		GHG	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2021) Estimate $E_{x,t}$	Trend Assessment $L_{x,t}$	% Contribution to the trend	Cumulative Total of $L_{x,t}$
IPCC Code	IPCC Category		Gg CO_2-equivalent		$L_{x,t}$		
2 C 3	Aluminium production	PFC	1 491	20	35.21	65.0%	65.0%
1 A 2 g viii solid	Other	CO2	16	1	6.66	12.3%	77.3%
1 A 2 a liquid	Iron and steel	CO2	84	1	5.18	9.6%	86.9%
1 A 2 b liquid	Non-ferrous metals	CO2	113	0	4.43	8.2%	95.1%
2 C 3	Aluminium production	PFC	1 491	20	35.21	65.0%	65.0%
1.A.4.c	Agriculture/Forestry/Fishing /Fish Farms	CO2	16	1	6.66	12.3%	77.3%

Table 13 Overview of Key categories including LULUCF

IPCC Category Code	IPCC Category	GHG	Level Assessment 1990	Level Assesment 2021	Trend Assessment 1990-2021	Base Year (1990) Estimate Ex,0	Latest Year (2021) Estimate Ex,t
1 A 1 a solid	Public electricity and heat production	CO2	2	2		1 109	1 384
1 A 2 a liquid	Iron and steel	CO2			3	84	1
1 A 2 b liquid	Non-ferrous metals	CO2			4	113	0
1 A 2 e liquid	Food processing, beverages and tobacco	CO2		13		3	47
1 A 2 g iii liquid	Mining (excluding fuels) and quarrying	CO2		19		0	32
1 A 2 g iv liquid	Wood and wood products	CO2		14		0	47
1 A 2 g viii liquid	Other	CO2		11		18	57
1 A 2 g viii solid	Other	CO2			2	16	1
1 A 3 a Jet kerosene	Domestic aviation	CO2		18		10	33
1 A 3 b Diesel oil	Road transportation	CO2		3		120	754
1 A 3 b Gasoline	Road transportation	CO2	4	6		213	118
1 A 4 a liquid	Commercial/institutional	CO2		15		28	41
2 C 3	Aluminium production	PFC	1		1	1 491	20
2 C 3	Aluminium production	CO2		9		169	59
2 F	Product Uses as Substitutes	HFC		5		0	139

IPCC Category Code	IPCC Category	GHG	Level Assessment 1990	Level Assesment 2021	Trend Assessment 1990-2021	Base Year (1990) Estimate Ex,0	Latest Year (2021) Estimate Ex,t
	for ODS						
3 A 1	Cattle	CH4	3	7		280	82
3 D 1	Direct N2O emissions from managed soils	N2O		12		119	52
4 A	Forest land	CO2		1		-1 272	-2 569
4 A	Forest land	CH4		16		2	40
4 E	Settlements	CO2		8		19	59
5 A	Solid waste disposal	CH4		4		154	247
5 D	Wastewater treatment and discharge	CH4		10		51	58

1.4.5 Results of the Key Categories Analysis (KCA) without LULUCF

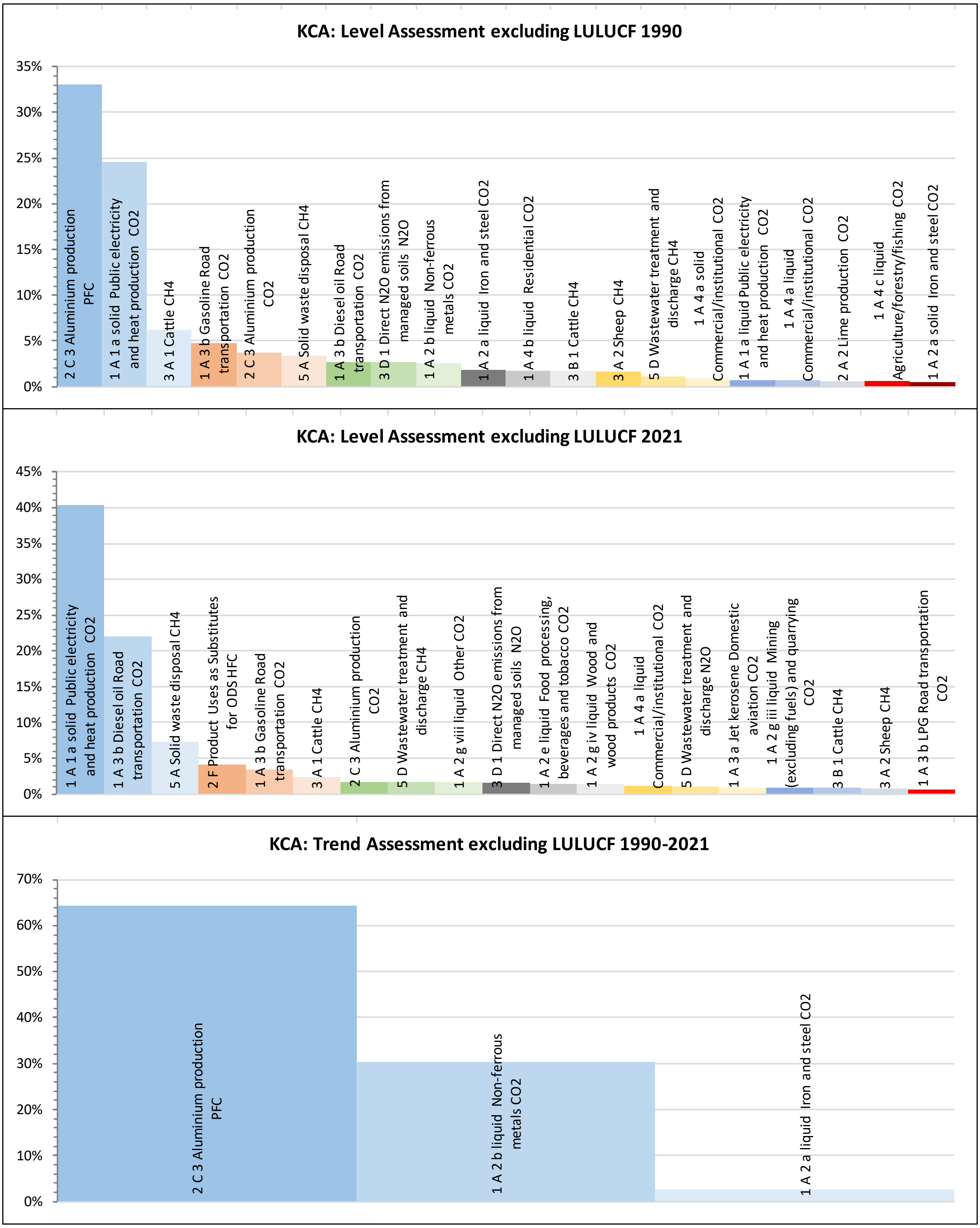


Figure 10 Key Categories without LULUCF

Table 14 Level Assessment: Key categories without LULUCF 1990

Level Assessment - 1990		GHG	Year 1990 Estimate Ex,t	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
IPCC Code	IPCC Category		Gg CO_2-equivalent		
2 C 3	Aluminium production	PFC	1 491	33.1%	33.1%
1 A 1 a solid	Public electricity and heat production	CO2	1 109	24.6%	57.6%
3 A 1	Cattle	CH4	280	6.2%	63.8%
1 A 3 b Gasoline	Road transportation	CO2	213	4.7%	68.6%
2 C 3	Aluminium production	CO2	169	3.7%	72.3%
5 A	Solid waste disposal	CH4	154	3.4%	75.7%
1 A 3 b Diesel oil	Road transportation	CO2	120	2.7%	78.4%
3 D 1	Direct N2O emissions from managed soils	N2O	119	2.6%	81.0%
1 A 2 b liquid	Non-ferrous metals	CO2	113	2.5%	83.5%
1 A 2 a liquid	Iron and steel	CO2	84	1.9%	85.4%
1 A 4 b liquid	Residential	CO2	78	1.7%	87.1%
3 B 1	Cattle	CH4	78	1.7%	88.8%
3 A 2	Sheep	CH4	74	1.6%	90.5%
5 D	Wastewater treatment and discharge	CH4	51	1.1%	91.6%
1 A 4 a solid	Commercial/institutional	CO2	38	0.8%	92.4%
1 A 1 a liquid	Public electricity and heat production	CO2	29	0.6%	93.1%
1 A 4 a liquid	Commercial/institutional	CO2	28	0.6%	93.7%
2 A 2	Lime production	CO2	25	0.6%	94.3%
1 A 4 c liquid	Agriculture/forestry/fishing	CO2	25	0.5%	94.8%
1 A 2 a solid	Iron and steel	CO2	23	0.5%	95.3%

Table 15 Level Assessment: Key categories without LULUCF 2021

Level Assessment - 2021		GHG	Year 2021 Estimate Ex,t	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
IPCC Code	IPCC Category		Gg CO_2-equivalent		
1 A 1 a solid	Public electricity and heat production	CO2	1 384	40.4%	40.4%
1 A 3 b Diesel oil	Road transportation	CO2	754	22.0%	62.4%
5 A	Solid waste disposal	CH4	247	7.2%	69.6%
2 F	Product Uses as Substitutes for ODS	HFC	139	4.1%	73.7%
1 A 3 b Gasoline	Road transportation	CO2	118	3.4%	77.1%
3 A 1	Cattle	CH4	82	2.4%	79.5%
2 C 3	Aluminium production	CO2	59	1.7%	81.2%
5 D	Wastewater treatment and discharge	CH4	58	1.7%	82.9%
1 A 2 g viii liquid	Other	CO2	57	1.7%	84.6%
3 D 1	Direct N2O emissions from managed soils	N2O	52	1.5%	86.1%
1 A 2 e liquid	Food processing, beverages and tobacco	CO2	47	1.4%	87.5%
1 A 2 g iv liquid	Wood and wood products	CO2	47	1.4%	88.8%
1 A 4 a liquid	Commercial/institutional	CO2	41	1.2%	90.0%
5 D	Wastewater treatment and discharge	N2O	35	1.0%	91.0%
1 A 3 a Jet kerosene	Domestic aviation	CO2	33	1.0%	92.0%
1 A 2 g iii liquid	Mining (excluding fuels) and quarrying	CO2	32	0.9%	92.9%
3 B 1	Cattle	CH4	30	0.9%	93.8%
3 A 2	Sheep	CH4	24	0.7%	94.5%
1 A 3 b LPG	Road transportation	CO2	23	0.7%	95.1%

Table 16 Trend Assessment: Key categories without LULUCF 1990-2021

Trend Assessment		GHG	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2021) Estimate $E_{x,t}$	Trend Assessment $L_{x,t}$	% Contribution to the trend	Cumulative Total of $L_{x,t}$
IPCC Code	IPCC Category		Gg CO_2-equivalent		$L_{x,t}$		
2 C 3	Aluminium production	PFC	1 491	20	23.79	64.3%	64.3%
1 A 2 b liquid	Non-ferrous metals	CO2	113	0	11.24	30.4%	94.7%
1 A 2 a liquid	Iron and steel	CO2	84	1	0.99	2.7%	97.3%

Table 17 Overview of Key categories including LULUCF

IPCC Category Code	IPCC Category	GHG	Level Assessment 1990	Level Assessment 2021	Trend Assessment 1990-2021	Base Year (1990) Estimate Ex,0	Latest Year (2021) Estimate Ex,t
1 A 1 a liquid	Public electricity and heat production	CO2	16			29	0
1 A 1 a solid	Public electricity and heat production	CO2	2	1		1 109	1 384
1 A 2 a liquid	Iron and steel	CO2	10		3	84	1
1 A 2 a solid	Iron and steel	CO2	20			23	14
1 A 2 b liquid	Non-ferrous metals	CO2	9		2	113	0
1 A 2 e liquid	Food processing, beverages and tobacco	CO2		11		3	47
1 A 2 g iii liquid	Mining (excluding fuels) and quarrying	CO2		16		0	32
1 A 2 g iv liquid	Wood and wood products	CO2		12		0	47
1 A 2 g viii liquid	Other	CO2		9		18	57
1 A 3 a Jet kerosene	Domestic aviation	CO2		15		10	33
1 A 3 b Diesel oil	Road transportation	CO2	7	2		120	754
1 A 3 b Gasoline	Road transportation	CO2	4	5		213	118
1 A 3 b LPG	Road transportation	CO2		19		0	23
1 A 4 a liquid	Commercial/institutional	CO2	17	13		28	41
1 A 4 a solid	Commercial/institutional	CO2	15			38	7
1 A 4 b liquid	Residential	CO2	11			78	5
1 A 4 c liquid	Agriculture/forestry/fishing	CO2	19			25	9

IPCC Category Code	IPCC Category	GHG	Level Assessment 1990	Level Assesment 2021	Trend Assessment 1990-2021	Base Year (1990) Estimate Ex,0	Latest Year (2021) Estimate Ex,t
2 A 2	Lime production	CO2	18			25	0
2 C 3	Aluminium production	PFC	1		1	1 491	20
2 C 3	Aluminium production	CO2	5	7		169	59
2 F	Product Uses as Substitutes for ODS	HFC		4		0	139
3 A 1	Cattle	CH4	3	6		280	82
3 A 2	Sheep	CH4	13	18		74	24
3 B 1	Cattle	CH4	12	17		78	30
3 D 1	Direct N2O emissions from managed soils	N2O	8	10		119	52
5 A	Solid waste disposal	CH4	6	3		154	247
5 D	Wastewater treatment and discharge	CH4	14	8		51	58
5 D	Wastewater treatment and discharge	N2O		14		10	35

1.5 Brief general description of QA/QC plan and implementation

The 2006 IPCC Guidelines set out the major elements of a QA/QC system to be implemented by inventory compilers

(1) inventory agency (EPA) responsible for coordinating QA/QC activities and definition of roles and responsibilities,
(2) a QA/QC plan,
(3) general QC procedures (Tier 1) and source category-specific QC procedures (Tier 2)
(4) QA and review procedures, and verification activities,
(5) QA/QC system interaction with uncertainty analysis (see chapter on uncertainties),
(6) reporting, documentation and archiving.

The first steps to carry out **quality assurance (QA) and quality control (QC) procedures** have already been undertaken but need further improvement. The current status and planned improvements are described in the following sub-sections.

1.5.1 QA/QC plan

As described in the 2006 IPCC Guidelines, Chapter 6.5, a **QA/QC plan** is a **fundamental element of a QA/QC and verification system**. The QA/QC plan

- outlines the QA/QC and verification activities;
- include a scheduled time frame for the QA/QC activities;
- is an internal document to organize and implement QA/QC and verification activities that ensure the inventory is fit for purpose and allow for improvement.
    - QC activities
    - procedures for country specific methodologies
    - internal/external audits (QM specific)
    - inventory improvement plan
    - documentation and archiving
    - treatment of confidential data

1.5.1.1 Quality objectives

A **key component** of a QA/QC plan is the list of data **quality objectives**, against which an inventory can be measured in a review. However, a *good practice* approach is a pragmatic means of building inventories that are TACCC – and maintaining them in a manner that improves inventory quality over time. This means that the *good practice* approach reflects the national circumstances regarding financial and technical resources and capacities.

However, the GHG inventory - estimation of GHG emissions and removals including reporting elements - is subject to continuous improvement.

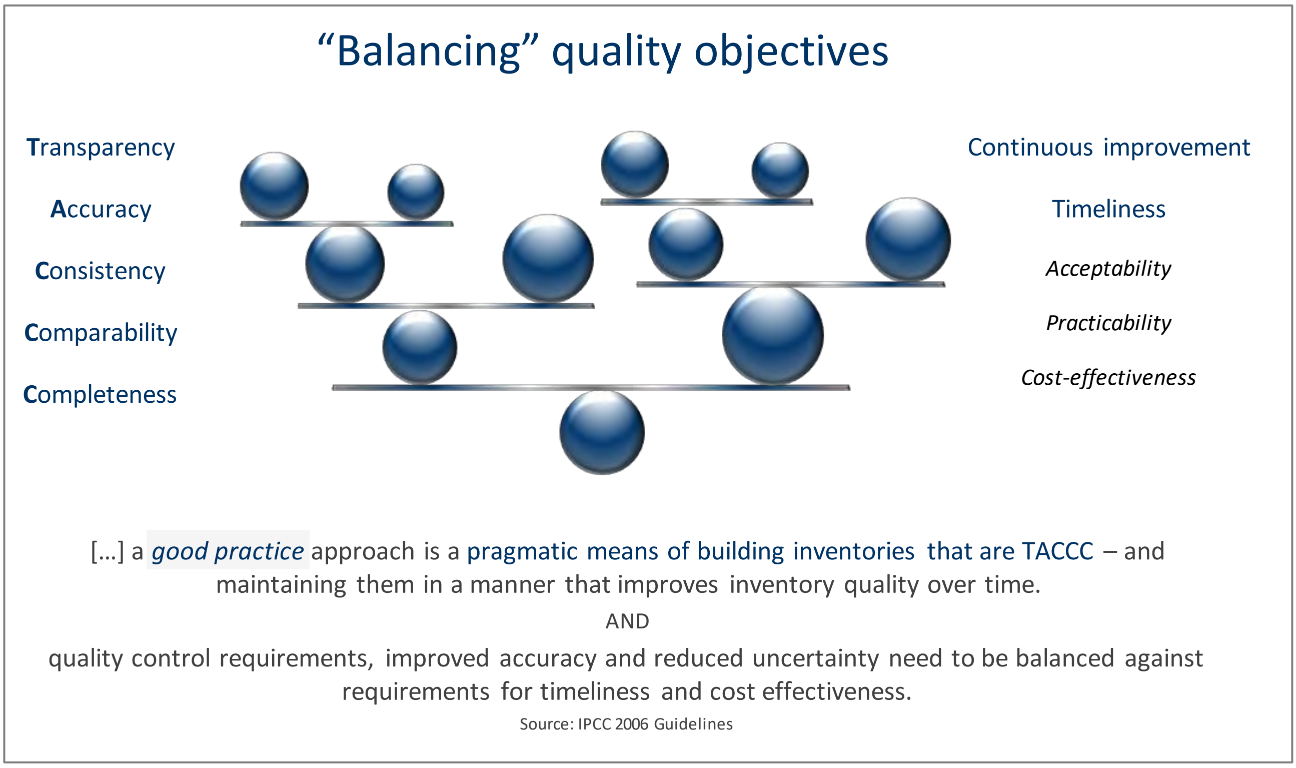


Figure 11 Balancing quality objectives

1.5.1.2 Inventory improvement plan

The planning of the GHG inventory preparation of each inventory cycle start with thoroughly analysis of the **QA/QC plan** and **Inventory improvement plan** in order to prioritize the tasks and available resources.

- QA/QC plan: bases on findings of internal and external audits; it also includes a training plan for sector experts;
- Inventory improvement plan: bases on findings of the International Consultation and Analysis (ICA), (peer-) reviews, audits of the GHG inventory.

The QA/QC plan and the improvement of the GHG inventory follows a Plan-Do-Check-Act-Cycle (PDCA-cycle)[29], which is an accepted model for pursuing a continual improvement of a process, product or service according to international standards and is in line with in the General Guidance and Reporting of the 2006 IPCC Guidelines.

[29] https://asq.org/quality-resources/pdca-cycle

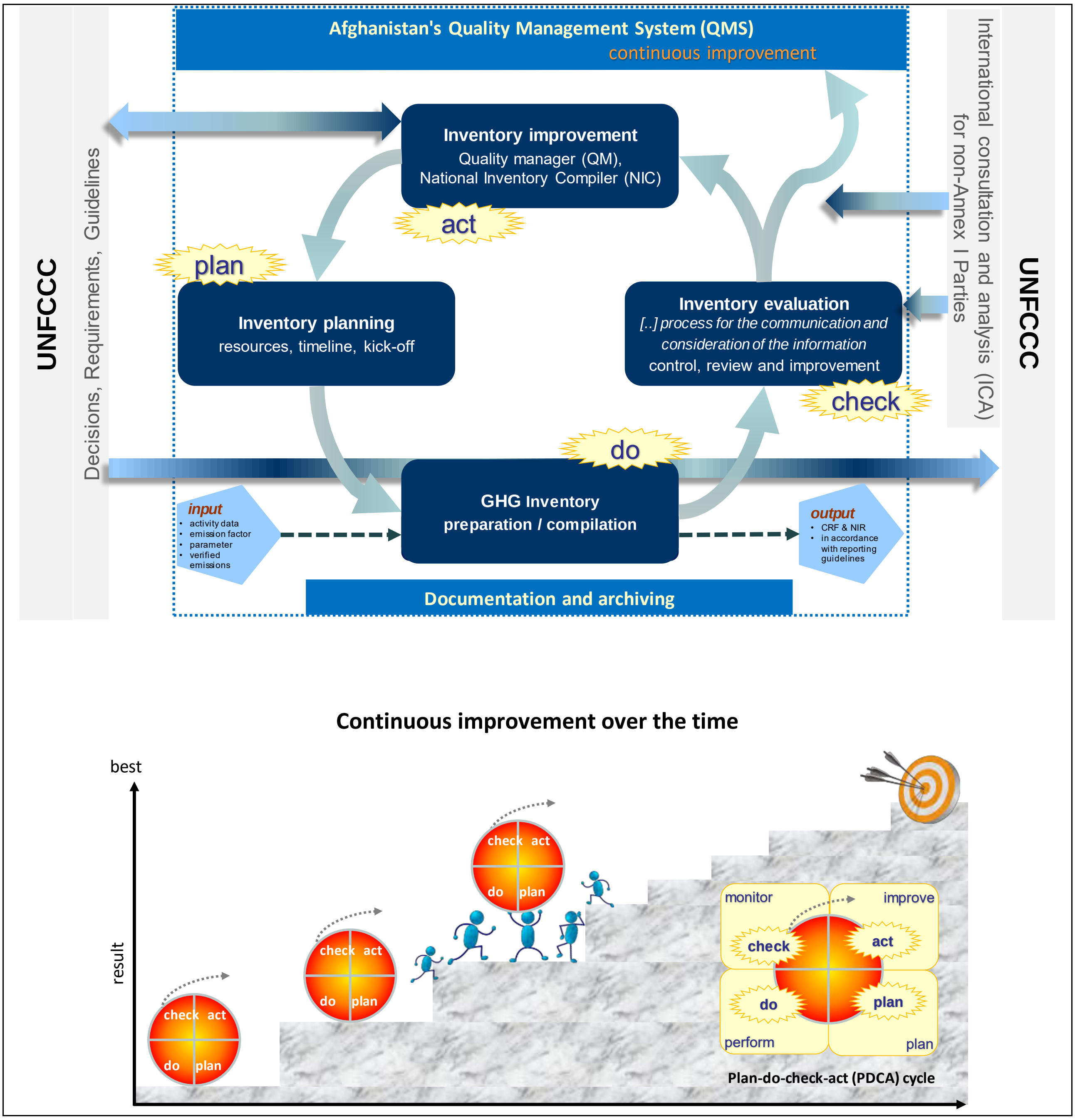


Figure 12 **Continuous improvement**

The results from internal/external audits, expert peer reviews and UNFCCC international consultation and analysis (ICA) are merged in the inventory improvement plan and Quality improvement plan. These plans lists the relevant sector, recommendations for improvement (reference and citation), priorities, responsibilities, deadlines and confirmation of implementation.

The following table presents the template of the inventory improvement plan which is prepared for each sector, QA/QC plan and Institutional arrangements.

Table 18 Template of the inventory improvement plan

Area covered (example IPCC 2 IPPU, or QMS or INVENTORY general)

Name of sector expert / responsible person for the relevant activity (e.g.quality manger)!

No	IPCC category	Source	Citation	Issue	Urgency	Ressources	Timeline	responsible person (s)	Finished	Check NIC	Improvement made
1											
2											

Source: Review / Technical analysis: Desk Review (DR) / Centralized Review (CR) / In Country Review (ICR), year, paragraph and/or page: e.g. "UNFCCC CR 2001, §34 Facilitative Sharing of Views (FSV) workshop under International Consultation and Analysis (ICA), round 1,2,..., year, paragraph and/or page; e.g. FSVR.1 ICA 2016, year, § 10
Archive: email, mail, (oral) complaints documented expl. with protocol "Pxxx"
Inventory team / Personal: "Name, date"
Audit protocol: "Audit_No"

!!! Each finding, which is not identified by responsible inventory person, have to be available in writen form!!!

Citation: Original quote of the (review) reports!

Issue: summary (in non-technical /informal language) of PROBLEM and MEASURE

Urgency:
1 - urgent / high e.g. finding were several times topic or recommendation; SHALL requirements
2 - important / medium new topic, might be urgent topic in the future, Key Category (KCA) related, SHOULD requirement
3 - low for non-urgent topics, Non-Key Category related; ENCOURAGEMENT --> does not need a schedule

Ressources: Estimates of time frame for NEPA and UNFCCC focal point!
NEPA: more financial resouces are needed for research
UNFCCC Focal point: more resouces are neededs is needed
GHG inventory 20XX: can be solved within the 'normal' framework of inventory preparation (ususal planning run)

Timeline:
- GHG inventory 20XX if related to numbers
- NIR 20XX if related to transparency
!! In case of delay: crossing out of date (Format Cells box, under Effects, click Strikethrough) and adding new time line. Add comment with reason of delay!!!

Responsible person (s): name of responsible experts/persons (and name of institutions)

Check NIC:
- GHG inventory 20XX if related to numbers
- NIR 20XX if related to transparency
!!!Remarks or links (e.g. NIR 2019, page 213) as a comment!!!

Improvement made: Text for NIR!

1.5.1.3 Inventory development cycle and guidance

The biennial and/or annual preparation of the GHG inventory follows in general the **inventory development cycle** presented in the following figure and described in Chapter 1 *Introduction to the 2006 Guidelines* of Volume 1: General Guidance and Reporting (GGR).

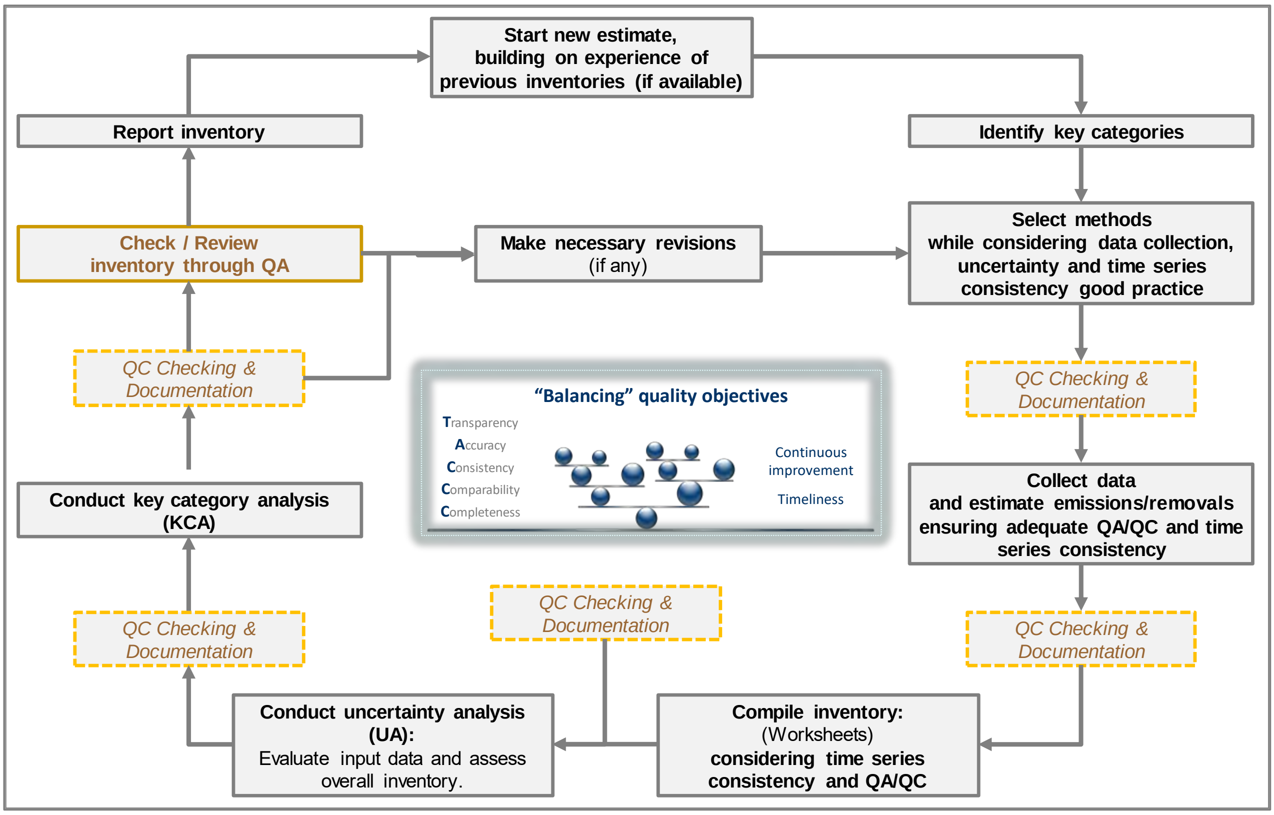


Figure 13 Inventory development cycle

Source: 2006 IPCC guidelines, Vol. 1: General Guidance and Reporting, Chap. 1: Introduction to the 2006 Guidelines, sub-chap. 1.5 Compiling an inventory, Figure 1.1, p. 1.9.

The preparation of the inventory starts always with identification of the key categories of the previous inventory followed by the selection of the appropriate identify the appropriate method for estimation for each category according to the **decision tree** of each source presented in Volume 2 – 5 of the 2006 IPCC guidelines.

The collection of activity data and relevant parameters and the estimation of emission by sources and removals by sinks should be follow the selection of the appropriate methods. As stated in the 2006 IPCC Guidelines the data collection activities should consider time series consistency and establish and maintain good verification, documentation and checking procedures (QA/QC) to minimize errors and inconsistencies in the inventory estimates.[30] Information and data on uncertainties should if possible be collected at the same time. The relevant QC Checking and documentation is done according to the QC TIER 1 & 2 Checklist which is presented in Chapter 1.5.2 (Table 20- Table 32).

The following table presents relevant inventory tasks which are based on each other. It is also indicated which documents (chapter and/or sheet) are required for the respective work steps. The relevant responsible experts involved in each step are also identified.

[30] 2006 IPCC guidelines, Vol. 1: General Guidance and Reporting, Chap. 1: Introduction to the 2006 Guidelines, 1.5 Compiling an inventory, p. 1.9.

Table 19 National Inventory preparation schedule / guidance

	When	Task	Where / What	BUR & NC coordinator	Focal point GHG inventory	National Inventory Compiler (NIC)	QA/QC coordinator	NIR coordinator	Documentation & Archiving Lead	KCA & UA coordinator	Sector experts	Data provider	QA experts	tbd
1.		Start new estimate, building on experience of previous inventories												
2.		Meeting of BUR & NC coordinator, Focal point GHG inventory, National Inventory Compiler (NIC) and QA/QC Coordinator: • Analyzing the QA/QC plan & Inventory improvement plan • Prioritizing the recommended improvements (including a timeline and responsibilities) • planning relevant resources.	Protocol (template) Inventory improvement plan.xlsx QA-QC improvement plan.xlsx											
3.		Kick-off meeting – GHG inventory team (News, deadlines, changes, etc.)	Protocol (template) Inventory improvement plan.xlsx QA-QC improvement plan.xlsx											
4.		Conducting Capacity trainings and/or refreshing general issues, sector-specific topics, QC activities	Training plan Inventory improvement plan											
5.		Identify key categories	NIR 2019 chapter 1.5.docx ME_KCA_2019.xlsx											
6.		Select methods while considering data collection, uncertainty and time series consistency good practice	2006 IPCC GL, Volume 2 – 5 NIR – sectoral chapters											
7.		QC Checking & Documentation, updating Inventory improvement plan	ME_Inventory improvement plan.xlsx QC checks according to part 1 of QC TIER 1 & 2 Checklist											
8.		Kick-off meeting – with data provider (with all / in groups)	Protocol (template)											
9.		Collection of activity data and relevant parameters ensuring adequate • QC Checking (completeness, transparency, accuracy) • time series consistency • documentation (if discrepancies, delay, etc.)	Data collection using data collection files (template) (source-specific) from data provider											
10.			Archiving response (letter, Email, etc.) in folder 04_Archive											
11.		Preparation/Updating of calculation sheets • adding new year • modification if higher TIER methodology will be applied • updating NIR tables templates • updating graphs	source-specific calculation sheets, e.g. 1A1a_InventoryTool_ME.xlsx											

	When	Task	Where / What	BUR & NC coordinator	Focal point GHG inventory	National Inventory Compiler (NIC)	QA/QC coordinator	NIR coordinator	Documentation & Archiving Lead	KCA & UA coordinator	Sector experts	Data provider	QA experts	tbd
12.		Estimate emissions/removals ensuring adequate QA/QC and time series consistency	Inserting activity data or linking data collection files with calculation files											
13.		QC Checking & Documentation, updating Inventory improvement plan	• Documentation in column Update of each “source-specific” calculation file, sheet AD • QC checks according to part 1,2,3 and 6 of QC TIER 1 & 2 Checklist											
14.		Preparation/Updating of Inventory file • adding new year • adding new calculation file, if needed • updating NIR tables templates • updating graphs	CTR-CommonReportingTables_ME.xlsx											
15.		Compile inventory considering time series consistency and QA/QC: update links of all calculation sheets	CTR-CommonReportingTables_ME.xlsx QC checks according to part 2b of *QC TIER 1 & 2 Checklist*											
16.		Sharing results with inventory team and QC check of Inventory file by sector experts and if needed revision of Inventory file	QC checks according to part 1, 2 and 3 of *QC TIER 1 & 2 Checklist*											
17.		Make necessary revisions (if any)												
18.		Conduct uncertainty analysis (UA): Evaluation of input data: AD and EF.	“source-specific” calculation files, sheet uncertainties											
19.		Conduct uncertainty analysis (UA): assessment of overall inventory uncertainty.	ME_Uncertainties_Table6.1.xlsx QC checks according to part 4 and 5 of *QC TIER 1 & 2 Checklist*											
20.		QC Checking & Documentation, updating Inventory improvement plan	QC checks according to part 7 of *QC TIER 1 & 2 Checklist*											
21.		Sharing results with inventory team and QC check of UA file by sector experts and NIR coordinator												
22.		Make necessary revisions (if any)												
23.		Conduct key category analysis (KCA) • Update formula for new inventory year • Update link with CTR-CommonReportingTables_MNE.xlsx	ME-KCA-2019.xlsx CTR-CommonReportingTables_ME.xlsx											
24.		QC Checking & Documentation, updating Inventory improvement plan	QC checks according to part 1 of *QC TIER 1 & 2 Checklist*											

	When	Task	Where / What	BUR & NC coordinator	Focal point GHG inventory	National Inventory Compiler (NIC)	QA/QC coordinator	NIR coordinator	Documentation & Archiving Lead	KCA & UA coordinator	Sector experts	Data provider	QA experts	tbd
25.		Sharing results with inventory team and QC check of KCA file by sector experts and NIR coordinator	ME-KCA-2019.xlsx											
26.		Make necessary revisions of emission estimation if higher TIER methodology has to be applied according to decision tree of relevant source (if any)												
27.		Repeat step 14. to – 25. in case of revision												
28.		• Add new in IPCC software • Update of timeseries entry files for IPCC software • Update database (sector)												
29.		QC Checking & Documentation, updating Inventory improvement plan	QC checks according to part 2 and 3 of *QC TIER 1 & 2 Checklist*											
30.		Compile inventory with IPCC software as QC activity												
31.		QC Checking & Documentation, updating Inventory improvement plan	QC checks according to part 2 and 3 of *QC TIER 1 & 2 Checklist*											
32.		Update NIR sectoral chapter												
33.		QC Checking & Documentation, Cross-checking with Inventory improvement plan	QC checks according to part 2 and 3 of *QC TIER 1 & 2 Checklist*											
34.		Update NIR chapter 1 Introduction												
35.		QC Checking & Documentation, Cross-checking with Inventory improvement plan	QC checks according to part 2 and 3 of *QC TIER 1 & 2 Checklist*											
36.		Update NIR chapter 1.6 KCA												
37.		QC Checking & Documentation, Cross-checking with Inventory improvement plan	QC checks according to part 2 and 3 of *QC TIER 1 & 2 Checklist*											
38.		Update NIR chapter 1.7 Uncertainties												
39.		QC Checking & Documentation, Cross-checking with Inventory improvement plan	QC checks according to part 2 and 3 of *QC TIER 4 & 5 Checklist*											

	When	Task	Where / What	BUR & NC coordinator	Focal point GHG inventory	National Inventory Compiler (NIC)	QA/QC coordinator	NIR coordinator	Documentation & Archiving Lead	KCA & UA coordinator	Sector experts	Data provider	QA experts	tbd
40.		Finalization of Inventory Improvement Plan and QA-QC improvement plan Finalization of NIR Chapter 9 Recalculation and Improvement	Inventory improvement plan.xlsx QA-QC improvement plan.xlsx											
41.		Update NIR chapter 1.6 QA/QC												
42.		QC Checking & Documentation, Cross-checking with Inventory improvement plan	QC checks according to part 2, 3, and 7 of *QC TIER 1 & 2 Checklist*											
43.		Update NIR chapter 2 Trend												
44.		QC Checking & Documentation, Cross-checking with Inventory improvement plan	QC checks according to part 2 of *QC TIER 1 & 2 Checklist*											
45.		Treatment of confidentiality issues	Checklist - Confidential data											
46.		Update NIR chapter # References												
47.		QC Checking & Documentation, Cross-checking with Inventory improvement plan	QC checks according to part 7 of *QC TIER 1 & 2 Checklist*											
48.		Check / Review inventory and NIR through QA	QA checks using the *QC TIER 1 & 2 Checklist*											
49.		Make necessary revisions of emission estimation and /or NIR based on findings and recommendations of QA (if any)												
50.		Repeat step 14. to – 47. in case of revision												
51.		Finalize National GHG Inventory and National Inventory Report (NIR) for approval												
52.		Reporting of National Inventory and National Inventory Report (NIR)												
53.		Collection of QC documents, QA documents, Inventory Improvement Plan												
54.		Archiving calculations files, Inventory files, KCA & UA file, NIR, QC documents, QA documents, Inventory Improvement Plan	05_QA-QC\04_InventoryImprovementList 06_Inventory\2018\Submission 07_NIR\2018_NIR\02_Submission_UNFCCC											

1.5.2 Quality control (QC) procedures

As stated in the 2006 IPCCC Guidelines, Chapter 6.6, and presented in the following figure,

- general QC procedures include generic quality checks related to calculations, data processing, completeness, and documentation that are applicable to all inventory source and sink categories.
- category-specific QC complements general inventory QC procedures and is directed at specific types of data used in the methods for individual source or sink categories. These procedures require knowledge of the specific category, the types of data available and the parameters associated with emissions or removals, and are performed in addition to the general QC checks

does NOT require	requires
knowledge of the emission source category	
⇩ general	⇩ source specific
QC procedures sector experts (1st party) performed throughout preparation of inventory	
TIER 1	**TIER 2**
data validation, calculation sheet (check of formal aspects)	**preparation of NIR, comparison with IPCC Guidelines** (check of applicability, comparisons)
QA procedures **quality manager** (2nd or 3rd party; staff not directly involved, preferably independent) performed at different levels or after inventory work has finished	
TIER 1 basic, before submission	
	expert peer review **internal audit / expert peer review** evaluate if TIER2 QC is effectively performed (check if methodologies are applicable)
TIER 2 extensive	
(quality management) system audit evaluate if TIER 2 QC is effectively performed	**expert peer review** **International Consultation and Analysis (ICA)** • A technical analysis of BUR by a team of experts (TTE) • A facilitative sharing of views in the form of workshop under the SBI evaluate if TIER 2 QC is effectively performed (check if methodologies are applicable)

Figure 14 General overview of QA/QC procedures

QC procedures are performed as defined in the QC TIER 1 & 2 Checklist which is prepared according to IPCC 2006 Guidelines,

- Table 6.1 General inventory QC procedures
- A1. General QC checklist
- A2. Category-specific QC checklist

For each step of the inventory cycle relevant QC checks are prepared. Furthermore, the checks are divided in content checks and formal checks. As well checks could be done for activity data, emission factor, and emission factor separately. In case of higher Tier method, not only AD and EF are used but also other parameters. In case of reported AD and Emissions (e.g. Emission trading data (ETS) data or data from NAMA projects) the checks only of IEF are important.

As the estimation of the GHG emissions and removal and the preparation of the reporting elements NIR and NAI tables are done at different stages of the inventory preparation cycle, the QC TIER 1 & 2 Checklist provides guidance on how and where the checks have to be done. Finally, each source has its own QC TIER 1 & 2 Checklist which can be individually refined.

1	Choosing Good Practice method
2	Activity data / Emission factors / Emissions– check regarding content
2a	Trend checks
2b	Check time series consistency (Recalculations due to methodological changes & refinements / Adding new categories / Tracking increases & decreases due to technological change etc.)
2c	Check completeness
2d	Direct emission measurement: Checks on procedures to measure emissions
3	Activity data / Emission factors / Emissions – Formal check - There shall be no transcription errors in the calculation and each data has a clear reference ?
3a	Check that assumptions and criteria for the selection of activity data are documented
3b	Check for transcription errors in data input and reference: There shall be no transcription errors in the activity data and each data has a clear reference (e.g. UNSD 2016)?
3c	Calculations correct / Check that parameters and units are correctly recorded and that appropriate conversion factors are used.
3d	Check for consistency in data between categories.
4	Uncertainties – Check regarding content
4a	Check that uncertainties in emissions and removals are estimated and calculated correctly
5	Uncertainties – Formal check - There shall be no transcription errors in the calculation and each data has a clear reference ?
6	Check the integrity of database files
7	Review of internal documentation/calculation sheet and archiving.

Table 20 QC TIER 1 & 2 Checklist according to IPCC 2006 Guidelines - Chapter 6

1	**QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6**			
2	**Submission**		**Source / Sink Category**	
3	**Title of calculation sheets/internal_documentation/NIR/CTR (e.g. AFG-2019_v2.1.xls):**			
4	**Insert of data path/folder**			
5	**Source/sink category estimates prepared by (name)**			
6	**Summary of general QC checks and corrective action**			
7	**Summary of results of checks and corrective actions taken**			
8	**Suggested checks to be performed in the future**			
9	**Any residual problems after corrective actions have been taken**			
10	**Other**			
11	**Date**		**Signature**	

13	**EXPLANATION & INSTRUCTION** *QC checks should be not seen as an additional task; QC should help you to document your QC checks which you are doing anyway*	**Abbreviation**			
14	**Why checks for each gas?** The estimations for the different GHG might be different!	TTE	Team of experts	NIR	National Inventory report
15	**What kind of remarks have to be documented and why?** Any comments, additional information, and/or corrective measures etc. should be documented; at the end of the inventory year, an analysis of the remarks will be done by the QM in order to undertake measures to prevent such findings (if possible :-).	ICA	International consultation and analysis	FSV	facilitative sharing of views
16	**What is the reason for dating the checks?** The inventory preparation process is a long and 'discontinuously' process; therefore the checklist serves also as a log / chronicle.	QA	Quality Assurance	sectoral chap	sectoral chapter
17	**What should be mentioned under Reference?** Here the exact location of the findings should be referenced!	QC	Quality Control	CTR	common reporting tables
18	**Why have checks to be done for activity data, emission factor, and emission factor separately?** In case of higher Tier method, not only AD and EF are used but also other parameters. In case of reported AD and Emissions (e.g. ETS data) the checks only of IEF are important.	ERT	Expert Review Team	NAI	Non Annex I Party

19	**AD**	**Activity data**	**internal docu**	**internal documentation**	**Y = Yes**	**NA = not applicable**	**NR = Not relevant**	**If not answered with YES, please provide all information regarding comments, corrective measures, etc.**
20	**EF**	**Emission factor**	**calc sheet**	**calculation sheet**	**N = No**	**NC = not checked**	**NO = Not occurent**	
21	**EMI**	**Emission**	**KCA**	**key category analysis**		**C = Confidential**	**IE = Included elsewhere**	

Table 21 QC TIER 1 & 2 Checklist – (1) Choosing Good Practice method

QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6	Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included	CO2	CH4	N2O	HFC	PFC	SF6	NF3	SO2	NOx	NMVOC	NH3	CO	Remarks Comments, Corrective measures	Check done Date	Finding Y/ N/ NR	Correction Date	Person	References
1 Choosing Good Practice method																			
Is a more detailed higher tier method selected for *key categories* according to the latest key category analysis (KCA)? If not, is a comprehensive and plausible explanation provided? *Any key categories where the good practice method cannot be used should have priority for future improvements.*	*calc sheets*																		
	NIR - sectoral chap																		
	NIR – chap 1.4																		
Is the methodological choice <u>in line</u> with the sectoral 'Decision Tree to choose a Good Practice method'? Is the methodological choice clearly documented?	*In line with Decision Tree*																		
	calc sheets / background documentation																		
	NIR - sectoral chap																		
Is the methodological choice in line with the Inventory Improvement plan? If not, are explanations and new schedule provided?	*calc sheets / background documentation*																		
	NIR - sectoral chap																		
Is the methodological choice applicable to the entire time series (starting from the base year)? If not, is an explanation and appropriate recalculation provided?	*time series consistent*																		
	calc sheets / background documentation																		
	NIR - sectoral chap																		
	NIR – chap 11																		

Table 22 QC TIER 1 & 2 Checklist - (2a) Check regarding content: Activity data / Emission factors / Emissions

	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6		Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included	CO2	CH4	N2O	HFC	PFC	SF6	NF3	SO2	NOx	NMVOC	NH3	CO	Remarks Comments, Corrective measures	Check done: Date	Check done: Finding Y/ N/ NR	Correction: Date	Correction: Person	References
38	2 Activity data / Emission factors / Emissions– check regarding content																				
39	**2a Trend checks**																				
40	Are the activity data applicable according to the sectoral 'Decision Tree' and sector-specific *good practice guidance* ?	*calc sheets / background documentation*																			
41		*NIR - sectoral chap*																			
42		*NIR – chap 1.4*																			
43		*NAI table - CTR*																			
44	Confirm consistency and plausibility of the trend of **activity data / emission factor / emissions**! If there are significant outlier (dips or jumps) from expected trends, has a re-check of the data been done? Are plausible explanations for any unexplained or unusual trends provided (documented)?	*documented*	*calc sheets*																		
45		*re-checked*	*calc sheets / background documentation*																		
46		*documented*																			
47		*documented*	*NIR - sectoral chap*																		
48		*documented*	*NIR - Chap 2*																		

Table 23 QC TIER 1 & 2 Checklist - (2a) Check regarding content: Activity data / Emission factors / Emissions

	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6		Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included	CO2	CH4	N2O	HFC	PFC	SF6	NF3	SO2	NOx	NMVOC	NH3	CO	Remarks Comments, Corrective measures	Check done Date	Finding Y/ N/ NR	Correction Date	Person	References
1	**2a Trend checks**																				
49	Are the **activity data (AD) and other parameters** plausible in comparison to / consistent with other references? (e.g. national statistics *versus* international statistics *versus* data from association *versus* plant specific data *versus* literature) Are the **emission factors (EF) and other parameters** plausible in comparison to / consistent with other references? (e.g. default, national values *versus* international values (Cross country) *versus* values from associations *versus* plant specific data *versus* literature) Are the **emissions (EMI)** plausible in comparison to / consistent with other references? (e.g. national estimates *versus* international estimates *versus* estimates from associations *versus* plant specific estimates *versus* literature)	*Compared with*																			
50		AD- Official data	*calc sheets / background documentation*																		
51		AD- Other data																			
52		EF- Official data																			
53		EF- Other data																			
54		EMI- Official data																			
55		EMI- Other data																			
56		AD- Official data	*NIR - sectoral chap*																		
57		AD- Other data																			
58		EF- Official data																			
59		EF- Other data																			
60		EMI- Official data																			
61		EMI- Other data																			
62	Is information about representativeness of emission factors, national circumstances and analogous emissions data provided?		*calc sheets / background documentation*																		
63			*NIR - sectoral chap*																		
64	Are the values of implied emission/removal factors across time series checked and are explanations for unexplained outliers provided?	Check	*calc sheets*																		
65		explanation																			
66			*NIR - sectoral chap*																		
67	Is a sufficient methodology for filling in time series (overlap, interpolation, trend extrapolation, etc.) for activity , emission factor that are not available annually applied?		*calc sheets / background documentation*																		
68			*NIR - sectoral chap*																		

Table 24 QC TIER 1 & 2 Checklist - (2b) Check time series consistency

	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6	Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included		CO2	CH4	N2O	HFC	PFC	SF6	NF3	SO2	NOx	NMVOC	NH3	CO	Remarks Comments, Corrective measures	Check done Date	Check done Finding Y/ N/ NR	Correction Date	Correction Person	References
69	**2b Check time series consistency** (Recalculations due to methodological changes & refinements / Adding new categories / Tracking increases & decreases due to technological change etc.)																				
70	For each category: Are plausible explanations on changes in activity data/ emission factors/ emissions resulting in recalculations provided (documentation)? If there is a change in AD/EF/EMI is the temporal consistency in time series ensured? Are plausible explanations on changes resulting in recalculations provided? If no consistency can be ensured, is an explanation provided?		*No change*																		
71		AD - Changes documented	*calc sheets / background documentation*																		
72		AD -Consistency ensured																			
73		AD - Explain for inconsistency																			
74		EF - Changes documented																			
75		EF -Consistency ensured																			
76		EF - Explain for inconsistency																			
77		EMI - Changes documented																			
78		EMI -Consistency ensured																			
79		EMI - Explain for inconsistency																			
80		AD - Changes documented	*NIR - sectoral chap*																		
81		AD -Consistency ensured																			
82		AD - Explain for inconsistency																			
83		EF - Changes documented																			
84		EF -Consistency ensured																			
85		EF - Explain for inconsistency																			
86		EMI - Changes documented																			
87		EMI -Consistency ensured																			
88		EMI - Explain for inconsistency																			
89		Changes documented	*NIR - Chap 11*																		

Table 25 QC TIER 1 & 2 Checklist – (2c) Check completeness

	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6	Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included	CO2	CH4	N2O	HFC	PFC	SF6	NF3	SO2	NOx	NMVOC	NH3	CO	Remarks Comments, Corrective measures	Check done Date	Check done Finding Y/ N/ NR	Correction Date	Correction Person	References
103	**2c Check completeness**																			
104	Confirm that activity data / emission factors / emnissions are reported for all categories and for all years from the appropriate base year to the period of the current inventory!	*AD - calc sheets / background documentation*																		
105		*AD - NIR - sectoral chap*																		
106		*EF - calc sheets / background documentation*																		
107		*EF - NIR - sectoral chap*																		
108		*EMI - calc sheets / background documentation*																		
109		*EMI - NIR - sectoral chap*																		
110	For subcategories, confirm that the entire category is being covered.	*calc sheets / background documentation*																		
111		*NIR - sectoral chap*																		
112	Is a clear definition of 'Other' type categories (Non-specified) provided?	*calc sheets / background documentation*																		
113		*NIR - sectoral chap*																		
114		NAI table - CTR																		
115	Are there known data gaps that result in incomplete estimates (notation key NE)? Are these data gaps documented, including a qualitative evaluation of the importance of the estimate in relation to total emissions (e.g., subcategories classified as 'NE')?	*No data gaps*																		
116		*calc sheets / background documentation*																		
117		*NIR - sectoral chap*																		
118		*NIR – chap 1.8 & Annex*																		
119		*NAI table - CTR*																		
120	Are all information provided in respect to the notation key IE (allocation as per IPCC Guidelines)?	*calc sheets / background documentation*																		
121		*NIR - sectoral*																		
122		*NIR – chap 1.8 & Annex 5*																		
123		*NAI table - CTR*																		
124	Are the notation key NA and NO correctly used?	*calc sheets / background documentation*																		
125		*NIR - sectoral chap*																		
126		*NAI table - CTR*																		

Table 26 QC TIER 1 & 2 Checklist – (2d) Direct emission measurement: Checks on procedures to measure emissions

	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6	Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included	CO2	CH4	N2O	HFC	PFC	SF6	NF3	SO2	NOx	NMVOC	NH3	CO	Remarks Comments, Corrective measures	Check done Date	Check done Finding Y/ N/ NR	Correction Date	Correction Person	References
127	**2c Check completeness**																			
127	Are there confidential data used (notation key C)? ® **see section Checklist Confidential data !!!**																			
128	Have uncertainties for activity data been estimated and documented? ® **see section Uncertainty below!!!**																			
129	Do the activity / emission factors data relying on a legal reporting commitment (Stockholm convention, questionnaire of UN statistic devision (UNSD), International Energy Agency (IEA) questionnaire, etc.)?	*calc sheets / background documentation*																		
130		*NIR - sectoral chap*																		
131		*NIR - chap 1.4*																		
132	For site-specific activity data, are any national or international standards applicable to the measurement of the data? If so, have they been employed and documented?	*calc sheets / background documentation*																		
133		*NIR - sectoral chap*																		
134	**2d Direct emission measurement: Checks on procedures to measure emissions**																			
135	Which variables rely on direct emission measurements?	*calc sheets / background documentation*																		
136		*NIR - sectoral chap*																		
137	Are procedures used to measure emissions, including sampling procedures, equipment calibration and maintenance? Are these procedures documented?	*calc sheets / background documentation*																		
138		*NIR - sectoral chap*																		
139	Have standard procedures been used, where they exist (such as IPCC methods or ISO standards)?	*calc sheets / background documentation*																		
140		*NIR - sectoral chap*																		

Table 27 QC TIER 1 & 2 Checklist – (3a) Formal check: Activity data / Emission factors / Emissions

	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6	Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included	CO2	CH4	N2O	HFC	PFC	SF6	NF3	SO2	NOx	NMVOC	NH3	CO	Remarks Comments, Corrective measures	Check done Date	Check done Finding Y/ N/ NR	Correction Date	Correction Person	References
141	**3 Activity data / Emission factors / Emissions – Formal check** - There shall be no transcription errors in the calculation and each data has a clear reference ?																			
142	Is the collection of activity data, emission factor, emissions transparent (described)?	*calc sheets / background documentation*																		
143		*NIR*																		
144	**3a Check that assumptions and criteria for the selection of activity data are documented**																			
145	Are assumptions and criteria for the selection of activity data, emission factor, emissions (e.g. PS) and other relevant parameters documented?	*calc sheets / background documentation*																		
146		*NIR*																		
147	Cross-check descriptions of activity data, emission factor, emissions and other input data with information on categories and ensure that these are properly recorded and archived.	*calc sheets / background documentation*																		
148		*NIR*																		
149		*Archive*																		

Table 28 QC TIER 1 & 2 Checklist – (3b) Check for transcription errors in data input and reference

	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6	Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included	CO2	CH4	N2O	HFC	PFC	SF6	NF3	SO2	NOx	NMVOC	NH3	CO	Remarks Comments, Corrective measures	Check done: Date	Check done: Finding Y/ N/ NR	Correction: Date	Correction: Person	References
150	**3b Check for transcription errors in data input and reference:** *There shall be no transcription errors in the activity data and each data has a clear reference (e.g. UNSD 2016)?*																			
151	Are the activity data, emission factors, emissions and other input data correctly entered and transcribed? Samples in case of big data sets! Electronic data should be used where possible to minimize transcription errors!	*AD -From original source (data provider) to calculations sheet*																		
152		*AD - From calculation sheet to NAI table / CTR*																		
153		*AD - From calc sheets to NIR*																		
154		*AD - From calc sheets to uncertainty file*																		
155		*EF- From original source (data provider) to calculations sheet*																		
156		*EF - From calculation sheet to NAI table / CTR*																		
157		*EF - From calc sheets to NIR*																		
158		*EF - From calc sheets to uncertainty file*																		
159		*EMI - From original source (data provider) to calculations sheet*																		
160		*EMI - From calculation sheet to NAI table / CTR*																		
161		*EMI - From calc sheets to NIR*																		
162		*EMI - From calc sheets to uncertainty file*																		
163		*From calc sheets to 'KCA' file*																		
164	Confirm that bibliographical data references for every activity data, emission factors and other input data (primary data) are properly cited ! Confirm that bibliographical data references for every primary data - Emissions (e.g. EU ETS) are properly cited.	*From original source (data provider)*																		
165		*to calc sheets / background documentation*																		
166		*calc sheets / background documentation*																		
167		*to Model (e.g. energy/transport)*																		
168		*to NIR*																		
169	Do the citations in spreadsheets and NIR conform to acceptable style guidelines (UNFCCC reporting GL)?	*calc sheets / background documentation*																		
170		*Structure of NIR, proposed by the guidelines? (annotated NIR/Annex II: Recommended structure for the Informative Inventory Report)*																		
171	Randomly cross-check a sample of input data from each source category (either measurements or parameters used in calculations) for transcription errors																			
172																				
173	Randomly cross-check bibliographical citations for transcription errors																			
174																				
175	Randomly check that the originals of citations (including Contact Persons) contain the material & content referenced																			
176																				

Table 29 QC TIER 1 & 2 Checklist – (3c) Check calculations & Check for consistency in data between categories.

	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6	Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included		CO2	CH4	N2O	HFC	PFC	SF6	NF3	SO2	NOx	NMVOC	NH3	CO	Remarks, Comments, Corrective measures	Check done Date	Check done Finding Y/ N/ NR	Correction Date	Correction Person	References
177	**3c Calculations correct / Check that parameters and units are correctly recorded and that appropriate conversion factors are used.**																				
178	Are all calculation steps (intermediate results) regarding activity data, emission factor and emissions included (instead of presenting results only? Is the data transmission of intermediate result correct?	provided	*calc sheets / background documentation*																		
179		correct																			
180		provided	*NIR - sectoral chap*																		
181		correct																			
182	Are parameters presented/used appropriately in the spreadsheets and transferred accurately to the NIR & CTR?	appropriately used	*calc sheets / background documentation*																		
183		referenced																			
184		labelled																			
185		carried / go through	*NIR - sectoral chap*																		
186		transferred																			
187	Are conversion factors presented/used appropriately in the spreadsheets and transferred accurately to the NIR & CTR?	appropriately used	*calc sheets / background documentation*																		
188		referenced																			
189		carried / go through	*NIR - sectoral chap*																		
190		transferred																			
191	Are the temporal and spatial adjustments factors (conservative factors) are used correctly and documented ?	correct	*calc sheets / background documentation*																		
192		documented																			
193		correct	*NIR - sectoral chap*																		
194		documented																			
195	Are the units properly labelled and correctly carried through from beginning to end of calculations? Are the units transferred accurately to the NIR & CTR?	correct	*calc sheets / background documentation*																		
196		labelled																			
197		carried / go through																			
198		transferred	*NIR - sectoral chap*																		
199			*NAI table / CTR*																		
200	**3d Check for consistency in data between categories.**																				
201	Are parameters (e.g., activity data, constants) identified that are common to multiple categories? Confirm that there is consistency in the values used for these parameters in the emission/removal calculations?	*calc sheets & NIR of sector #*																			
202		*calc sheets & NIR of sector #*																			
203		*calc sheets & NIR of sector #*																			
204		*calc sheets & NIR of sector #*																			
205		*calc sheets & NIR of sector #*																			

Table 30 QC TIER 1 & 2 Checklist – (4) Uncertainties – Check regarding content

	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6		Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included	CO2	CH4	N2O	HFC	PFC	SF6	NF3	SO2	NOx	NMVOC	NH3	CO	Remarks Comments, Corrective measures	Check done Date	Check done Finding Y/ N/ NR	Correction Date	Correction Person	References
206	**4 Uncertainties – Check regarding content**																				
207	**4a Check that uncertainties in emissions and removals are estimated and calculated correctly**																				
208	Is the uncertainty estimation of activity data plausible?	*Default*																			
209		*Expert judgement*																			
210																					
211	Are the qualifications of individuals providing expert judgement for uncertainty estimates appropriate?																				
212																					
213																					
214	Is the uncertainty estimation of emission factors plausible?	*Default*																			
215		*Expert judgement*																			
216																					
217	Are the qualifications of individuals providing expert judgement for uncertainty estimates appropriate?																				
218																					

Table 31 QC TIER 1 & 2 Checklist – (5) Uncertainties – Formal check

	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6	Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included		CO_2	CH_4	N_2O	HFC	PFC	SF_6	NF_3	SO_2	NO_x	NMVOC	NH_3	CO	Remarks Comments, Corrective measures	Check done Date	Check done Finding Y/ N/ NR	Correction Date	Correction Person	References
219	**5 Uncertainties – Formal check** *There shall be no transcription errors in the calculation and each data has a clear reference ?*																				
220	Is the designation of uncertainties understandable?	*Sector calc sheets*																			
221		*NIR - sectoral chap*																			
222		*internal 'Uncertainty' calculation file*																			
223	Are the uncertainties estimates complete?	*Calc sheets / background documentation*																			
224		*NIR - sectoral chap*																			
225		*internal 'Uncertainty' calculation file*																			
226		*Table 6.1 GPG Uncertainty Analysis*																			
227	Are the Emissions and the Uncertainties of activity data and emission factor correctly entered and transcribed? *Electronic data should be used where possible to minimize transcription errors!*	*Sector calc sheets*																			
228		*NIR - sectoral chap*																			
229		*internal 'Uncertainty' calculation file*																			
230		*Table 6.1 GPG Uncertainty Analysis*																			
231	Confirm that bibliographical data references for each uncertainty of AD & EF are properly cited	*Calc sheets / background documentation*																			
232		*NIR - sectoral chap*																			
233		*internal 'Uncertainty' calculation file*																			
234	Are assumptions and criteria for the selection of uncertainty of activity data (AD) and emission factor (EF) concerning expert judgement documented?	qualifications	*Sector calc sheets*																		
235		assumptions																			
236		expert judgements																			
237		qualifications	*internal 'Uncertainty' calculation file*																		
238		assumptions																			
239		expert judgements																			
240		qualifications	*NIR - sectoral chap*																		
241		assumptions																			
242		expert judgements																			
243	The archiving of primary data and records has to be ensured! Are the originals of new citations (e-mails, mails, literature sources, statistics, etc.) in the archive?		*properly labelled*																		
244			*stored*																		
245			*stored*																		
246	Randomly cross-check bibliographical citations for transcription errors																				
247	Randomly cross-check: originals of citations (including Contact Reports) contain the material & content referenced																				

Table 32 QC TIER 1 & 2 Checklist – (6) Check the integrity of database files & (7) Review of internal documentation/calculation sheet and archiving.

QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6		Y = Yes N = No NC = not checked NA = not applicable NR = nor relevant NO = not occurent IE = Included	CO2	CH4	N2O	HFC	PFC	SF6	NF3	SO2	NOx	NMVOC	NH3	CO	Remarks Comments, Corrective measures	Check done Date	Finding Y/ N/ NR	Correction Date	Person	References
6 Check the integrity of database files																				
Are the data relationships and processing steps correct (e.g., equations) in the spreadsheets? Confirm the correctness of calculations (formulas)!		*calc sheets*																		
Are data path and data coherence understandable?		*calc sheets*																		
Are input data and calculated data (e.g. intra/extrapolated data) clearly differentiated in the spreadsheets?		*calc sheets*																		
Is a representative sample of calculations checked by hand or electronically (only for models and complex calculations)?		*calc sheets*																		
Is it ensued that data fields are properly labelled and have the correct design specifications?		*calc sheets*																		
Are the calculations cross-checked (tested) with “quick” calculations?		*calc sheets*																		
Is it ensured that adequate documentation of database and model structure and operation are archived.		*calc sheets*																		
7 Review of internal documentation/calculation sheet and archiving.																				
Is a detailed internal documentation to support the estimates and enable reproduction of the emission, removal and uncertainty estimates available?																				
Is the archiving of primary data – acticity data, other parameters and records - ensured?	properly labelled																			
	stored																			
Are the originals of new citations (e-mails, mails, literature sources, statistics, etc.) in the archive and stored to facilitate detailed review?	properly labelled																			
	stored																			
Is the archive closed and retained in secure place following completion of the inventory?																				
Is the integrity of any data archiving arrangements of outside organisations involved in inventory preparation ensured?																				

1.5.3 QA and review procedures, and verification activities

As stated in the 2006 IPCCC Guidelines, Chapter 6.8, and presented in Figure 14, Quality assurance (QA) comprises activities outside the actual inventory compilation. Good practice for QA procedures includes reviews and audits to

- assess the quality of the inventory,
- determine the conformity of the procedures taken and to identify areas where improvements could be made.

QA procedures may be taken at different levels (internal/external), and they are used in addition to the general and category-specific QC procedures

Through internal/external audit and expert peer review an evaluation if TIER2 QC is effectively performed:

- GHG inventory preparation and the GHG inventory is in line with 2006 IPCC Guidelines;
- data collection, calculation, referencing and archiving is handled according to the QA/QC plan;
- enough resources for the preparation of the GHG inventory and related reporting elements (NAI/CTR) table and National Inventory Report (NIR)) are guaranteed by relevant national institutions;
- relevant activity data (e.g. energy balance, livestock data) are available and if the reliability of external data is ensured;
- QA/QC plan needs improvement;
- recommendations of UNFCCC international consultation and analysis (ICA) and previous internal/external audits and expert peer reviews have been considered and implemented;
- tailor-made / suitable trainings for the sector experts, National Inventory Compiler and other experts involved in the inventory preparation are provided.

The QC TIER 1 & 2 Checklist which is presented in Chapter 1.5.2 (Table 20- Table 32) is also used for the QA procedures.

1.5.4 Treatment of confidentiality issues

Information or data is declared as confidential when it could directly or indirectly identify an individual person, business or organization. Following the Statistics Law Article, confidential data should not be published. To ensure completeness confidential data may be used to estimation of GHG emissions and removal, but these emissions can be reported at a higher aggregated level so that confidentiality is no longer an issue.

The checklist *Confidential data*, which is presented in the next Table, should be used in order to ensure, that confidential data used in the inventory is not published.

In the current GHG Inventory no confidential data are used.

Table 33 Checklist - Confidential data

	CHECKLIST CONFIDENTIAL DATA according to IPCC 2006 Guidelines - Chapter 6				
1	Submission:		Source / Sink Category:		
2	DATA USE				
3	Title of calculation sheets / internal_documentation / NIR / CTR				
4	Insert of data path/folder				
5	Source/sink category estimates prepared by (name):				
6	Source of confidential data				
7	Description of confidential data				
8	RELEASE OF RESULTS		YES	NO	Comment
9	Data in calculations sheets (Background calculation) visible / marked as confidential data				
10	Data in NAI table / CTR visible directly or indirectly or marked as confidential data (example in „Recalculations“)				
11	Data in NIR not reproducible				
12	RESULTS	confidentiality ensured, publication of results allowed			
13		confidentiality not ensured, publication of results not allowed			
14		Remarks			
15		If confidentiality not ensured, publication of results not allowed			
16		required action / measurements (e.g. higher aggregation)			
17	DATA USED / Acknowledgement of confidential data				
18	Date		Signature (sector expert)		
19	Date		Signature (National Inventory Compiler (NIC))		

1.6 General uncertainty assessment, including data pertaining to the overall uncertainty of inventory totals

A general uncertainty assessment is not performed for this inventory cycle. However, for all sources uncertainties for activity data and emission factors used are provided in the sectoral chapters. The provided information on uncertainties are mainly based on default uncertainties provided in the 2006 IPCC Guidelines.

1.7 General assessment of the completeness

1.7.1 Information on completeness

Notation keys - NA, NO, NE, IE, C - used are in accordance with the 2006 IPCC Guidelines[31] and MPG[32]:

NO	**not occurring**	for categories or processes, including recovery, under a particular source or sink category that do not occur within a Party;
NE	**not estimated**	for activity data and/or emissions by sources and removals by sinks of GHGs that have not been estimated but for which a corresponding activity may occur within a Party;
NA	**not applicable**	for activities under a given source/sink category that do occur within the Party but do not result in emissions or removals of a specific gas;
IE	**included elsewhere**	for emissions by sources and removals by sinks of GHGs estimated but included elsewhere in the inventory instead of under the expected source/sink category;
C	**confidential**	for emissions by sources and removals by sinks of GHGs where the reporting would involve the disclosure of confidential information.

The sources and sinks not considered in the inventory but included in the IPCC 2006 Guidelines are clearly indicated, the reasons for such exclusion are explained (see relevant sectoral chapters).

Gases	Both direct GHGs as well as precursor gases are covered by the GHG inventory of Montenegro.
Geographic coverage	The geographic coverage is complete. There is no part of the Montenegro's territory not covered by the inventory.
Sources and sinks	All sources and sinks included in the IPCC 2006 Guidelines are addressed. No additional sources and sinks specific to Montenegro have been identified. Currently the source and sink categories, listed in the following table, could not be estimated due to lack of data and resources

Table 34 List of sources and sinks that have been not estimated (NE)

IPCC Code	IPCC description	CO_2	N_2O	CH_4	HFC/PFC	SF_6	NF_3
1	**Energy**						
1.A	Fuel Combustion Activities						
1.A.1	Energy Industries						
1.A.1.c.i	Manufacture of Solid Fuels	NE	NE	NE	NA	NA	NA
1.A.3	Transport						
1.A.3.b.v	Evaporative emissions from vehicles	NE	NE	NE	NA	NA	NA
1.A.3.b.vi	Urea-based catalysts	NE	NE	NE	NA	NA	NA
1.A.5	Non-Specified	NE	NE	NE	NA	NA	NA

[31] 2006 IPCC Guidelines, Volume 1: General Guidance and Reporting, Chapter 8: Reporting Guidance and Tables, TABLE 8, page 8.7.

[32] Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement, Para 31, https://unfccc.int/sites/default/files/resource/CMA2018_03a02E.pdf

IPCC Code	IPCC description	CO_2	N_2O	CH_4	HFC/PFC	SF_6	NF_3
2	**Industrial processes**						
2.F	Product Uses as Substitutes for Ozone Depleting Substances						
2.F.4	Aerosols	NA	NA	NA	NE	NA	NA
2.F.5	Solvents	NA	NA	NA	NE	NA	NA
2.F.6	Other Applications	NA	NA	NA	NE	NA	NA
2.G	Other Product Manufacture and Use						
2.G.2	SF_6 and PFCs from Other Product Uses	NE	NE	NE	NE	NE	NA
2.G.2.b	Accelerators	NE	NE	NE	NE	NE	NA
2.G.3	N_2O from Product Uses						
2.G.3.a	Medical Applications	NE	NE	NE	NA	NA	NA
2.G.3.b	Propellant for pressure and aerosol products	NE	NE	NE	NA	NA	NA
3	**Agriculture**						
3.D.a	Direct N_2O emissions from managed soils						
3.D.a.2.b	Sewage sludge applied to soils	NA	NE	NA	NA	NA	NA
3.D.a.2.c	Other organic fertilizers applied to soils	NA	NE	NA	NA	NA	NA
3.D.a.5	Mineralization/immobilization associated with loss/ gain of soil organic matter	NA	NE	NA	NA	NA	NA
3.D.a.6	Cultivation of organic soils (i.e. histosols)	NA	NE	NA	NA	NA	NA
3.D.b	Indirect N_2O Emissions from managed soils						
3.D.b.1	Atmospheric deposition	NA	NE	NA	NA	NA	NA
3.D.b.2	Nitrogen leaching and run-off	NA	NE	NA	NA	NA	NA
4	**Land use, Land-use change and Forestry**						
4.B	Cropland						
4.B.2	Land converted to cropland						
4.B.2.3	Carbon stock change in soils (Land converted to cropland)	NE	NA	NA	NA	NA	NA
4.B.2.5	Carbon stock change in soils (Other land converted to cropland)	NE	NA	NA	NA	NA	NA
4.D	Wetlands						
4.D.1	Wetlands remaining wetlands	NE/NO	NA	NA	NA	NA	NA
4.E	Settlements						
4.E.1	Settlements remaining settlements	NE	NA	NA	NA	NA	NA
4.F	Other Land						
4.F.1	Other land remaining other land	NE	NA	NA	NA	NA	NA
4.F.2.1	Carbon stock change in soil (Forest land converted to other land)	NE	NA	NA	NA	NA	NA
4(V) 4 B 1	Biomass burning: controlled: residues of perennial cropland	NE	NE	NE	NA	NA	NA

IPCC Code	IPCC description	CO_2	N_2O	CH_4	HFC/PFC	SF_6	NF_3
5	**Waste**						
5.B	Biological Treatment of Solid Waste	NA	NE	NE	NA	NA	NA
5.C	Incineration and Open Burning of Waste						
5.C.1	Waste Incineration	NE	NE	NE	NA	NA	NA
5.C.2	Open Burning of Waste	NE	NE	NE	NA	NA	NA
5.D	Wastewater Treatment and Discharge						
5.D.2	Industrial Wastewater Treatment and Discharge	NA	NE	NE	NA	NA	NA
	Memo Items						
	International Bunkers						
1.A.3.a.i	Multilateral Operations	NE	NE	NE	NE	NE	NE

1.7.2 Description of insignificant categories

No insignificant categories have been identified.

1.7.3 Total aggregate emissions considered insignificant

No insignificant total aggregate emissions have been identified.

1.8 Metrics

The aggregated greenhouse gases (GHG in CO_2 equivalents) are prepared using the global warming potentials (GWP) provided by the IPCC Fourth Assessment Report (AR4)[33] based on the effects of GHGs over a 100-year time horizon.

Table 35 Global warming potentials (GWP) provided by the IPCC Fourth Assessment Report (AR4).

Gas name	Chemical formula / Abbreviation	Global Warming Potential (Time Horizon) based on the effects of GHGs over a 100-year time horizon
Carbon dioxide	CO_2	1
Methane	CH_4	25
Nitrous oxide	N_2O	298
Sulphur hexafluoride	SF_6	23 800
Hydrofluorocarbons	HFC	hydrofluorocarbons (HFCs) consist of different substances, therefore GWPs have to be calculated individually depending on the substances
HFC-32		675
HFC-134a		1 430
HFC-143a		4 470
HFC-125		3 500
HFC-227ea		3 220
Perfluorocarbons	PFC	perfluorocarbons (PFCs) consist of different substances, therefore GWPs have to be calculated individually depending on the substances
CF4		7 390
C2F6		12 200
Nitrogen trifluoride	NFH_3	17 200

1.9 Summary of any flexibility applied

No flexibilities within the meaning of para 3(c) of the Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement have been applied.

[33] IPCC. (2007). *Climate Change 2007 - The Physical Science Basis Contribution of Working Group I to the Fourth Assessment Report of the IPCC. (Table TS.2)*. Available (12 May 2019) at: https://www.ipcc.ch/site/assets/uploads/2018/05/ar4_wg1_full_report-1.pdf

2 Trends in greenhouse gas emissions and removals

2.1 Description of emission and removal trends for aggregated GHG emissions and removals

In 2021 Montenegro's total greenhouse gas (GHG) emissions (without LULUCF) amounted to 3 427.05 kt CO_2 equivalents (CO_2eq). Compared to 1990 GHG emissions decreased by -24.5%, compared to 2005 GHG emissions increased by 11.0%, compared to 2021 GHG emissions increased by 0.1%.

In 2005 total GHG emissions (without LULUCF) amounted to 3 849.16 kt CO_2eq and in 1990 total GHG emissions (without LULUCF) amounted to 4 540.68 kt CO_2eq.

In 2021 Montenegro's total greenhouse gas (GHG) emissions (with LULUCF) amounted to 972.74 kt CO_2 equivalents (CO_2eq). Compared to 1990 GHG emissions decreased by -70.2%, compared to 2005 GHG emissions increased by -39.5%, compared to 2020 GHG emissions increased by -5.5%.

In 2005 total GHG emissions (with LULUCF) amounted to 1 607.53 kt CO_2eq and in 1990 total GHG emissions (with LULUCF) amounted to 3 259.33kt CO_2eq.

The general trend is marked by significant dips and jumps due to the

- break-up of Yugoslavia (1992);
- overall economic downturn in the country;
- break-up of the union with Serbia (2006);
- world economic crisis (2009)
- break-down (1995) and reconstruction of the power plant (2009/2010);
- temporary shut-down of alumina plant (2009) and shutdown of one electrolysis line (2016);
- forest and wild fires (2000, 2003, 2011, 2017);
- agricultural activities;
- growing population;
- increasing road transport;
- worldwide COVID pandemic and the lockdown.

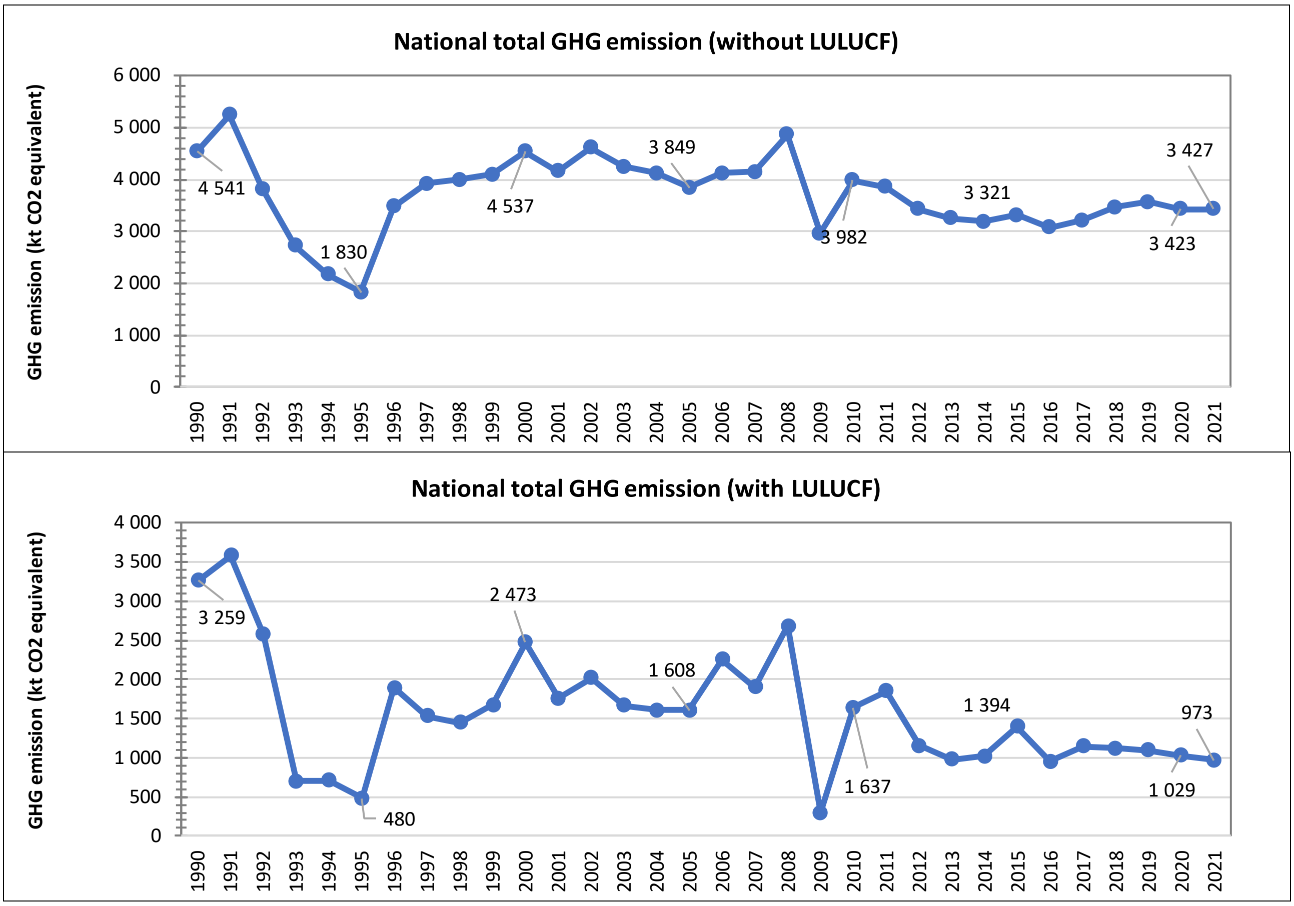


Figure 15 Trend of national total GHG emissions (without and with LULUCF): 1990 – 2021

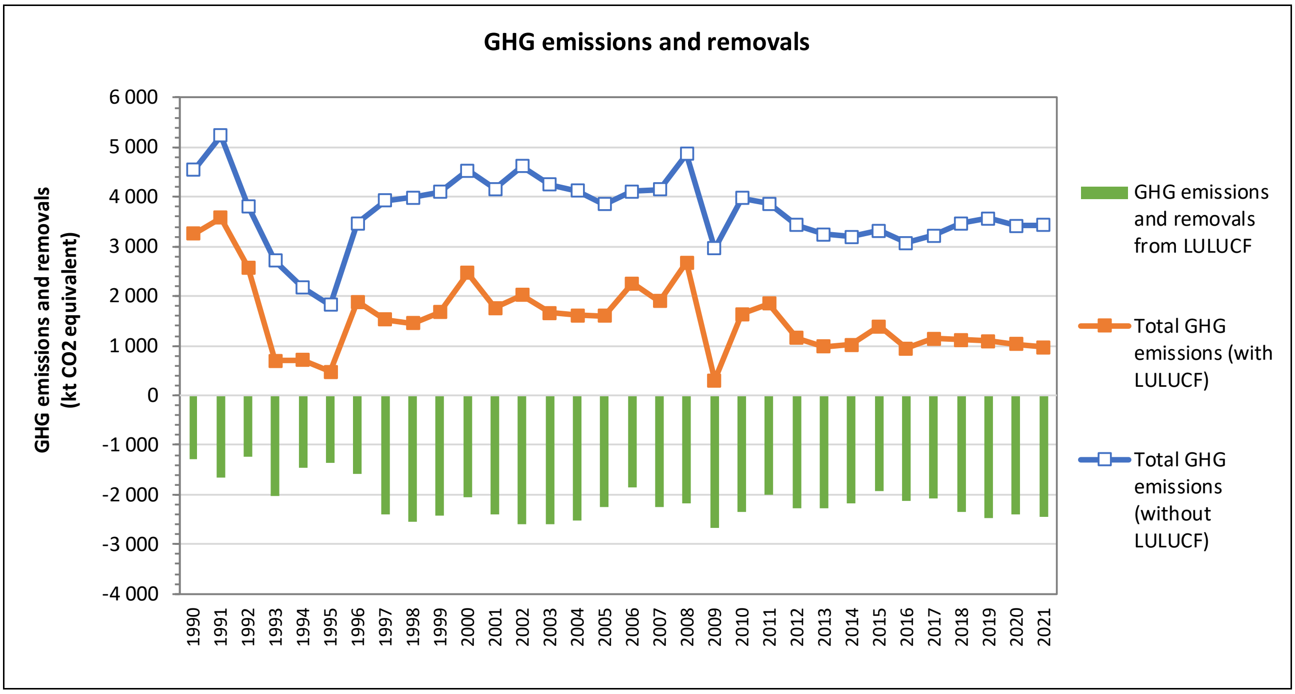


Figure 16 Trend of national total GHG emissions and net emissions/removal from LULUCF

Table 36 National total GHG emissions (with and without LULUCF) and net emissions/removal from LULUCF

GHG emissions	Total GHG emissions without LULUCF	Total GHG emissions with LULUCF	GHG emissions and removals from LULUCF
	kt CO_2 equivalent	kt CO_2 equivalent	kt CO_2 equivalent
1990	4 540.68	3 259.33	-1 281.34
1991	5 240.63	3 582.43	-1 658.20
1992	3 819.62	2 576.08	-1 243.54
1993	2 720.87	700.73	-2 020.14
1994	2 171.19	708.17	-1 463.02
1995	1 829.90	480.17	-1 349.73
1996	3 475.40	1 890.13	-1 585.28
1997	3 925.61	1 530.24	-2 395.37
1998	3 992.45	1 451.15	-2 541.30
1999	4 102.40	1 674.30	-2 428.10
2000	4 536.97	2 473.23	-2 063.74
2001	4 164.93	1 762.51	-2 402.42
2002	4 617.37	2 021.90	-2 595.48
2003	4 250.90	1 666.08	-2 584.82
2004	4 120.67	1 609.86	-2 510.81
2005	3 849.16	1 607.53	-2 241.63
2006	4 117.49	2 251.80	-1 865.70
2007	4 145.74	1 904.75	-2 240.99
2008	4 870.32	2 682.14	-2 188.18
2009	2 963.27	299.61	-2 663.66
2010	3 981.92	1 637.24	-2 344.67
2011	3 861.49	1 850.31	-2 011.18
2012	3 429.31	1 152.71	-2 276.61
2013	3 252.56	978.49	-2 274.07
2014	3 193.91	1 019.84	-2 174.07
2015	3 321.38	1 394.36	-1 927.02
2016	3 074.23	949.71	-2 124.53
2017	3 218.21	1 146.60	-2 071.61
2018	3 466.13	1 116.43	-2 349.70
2019	3 564.92	1 095.16	-2 469.76
2020	3 423.37	1 028.92	-2 394.44
2021	3 427.05	972.74	-2 454.32
Trend			
1990 - 2021	*-24.5%*	*-70.2%*	*91.5%*
2005 - 2021	*-11.0%*	*-39.5%*	*9.5%*
2020 - 2021	*0.1%*	*-5.5%*	*2.5%*

In 2021, the most important GHG (without LULUCF) in Montenegro is CO_2 with a share of 78.2%. The CO_2 emissions primarily result from combustion activities, here mainly in the coal-fired power plant, but also from road transport. CH_4 emissions, which mainly arises from livestock farming and waste disposal, contributes 13.7% to total national GHG emissions; N_2O emissions, with agricultural soils and other sector (households) as the main source, contributes 3.3% in 2021. The remaining 4.7% are emissions of fluorinated compounds, which are mostly emitted from the use of HFC as substitutes for ODS in refrigeration equipment.

Also in 2005, the most important GHG (without LULUCF) in Montenegro was CO_2 with a share of 58.1%. CH_4 emissions contributed 15.2% to total national GHG emissions; N_2O emissions contributes 3.5% in 2005. The remaining 23.2% are emissions of fluorinated compounds.

In 1990, the most important GHG (without LULUCF) in Montenegro was CO_2 with a share of 48.6%. The CO_2 emissions primarily result from combustion activities, here mainly in the coal-fired power plant. CH_4 emissions contributed 15.2% to total national GHG emissions; N_2O emissions, with agricultural soils and other sector (households) as the main source, contributes 3.3% in 1990. The remaining 32.9% are emissions of fluorinated compounds, which are mostly emitted from the use of PFC in aluminium production.

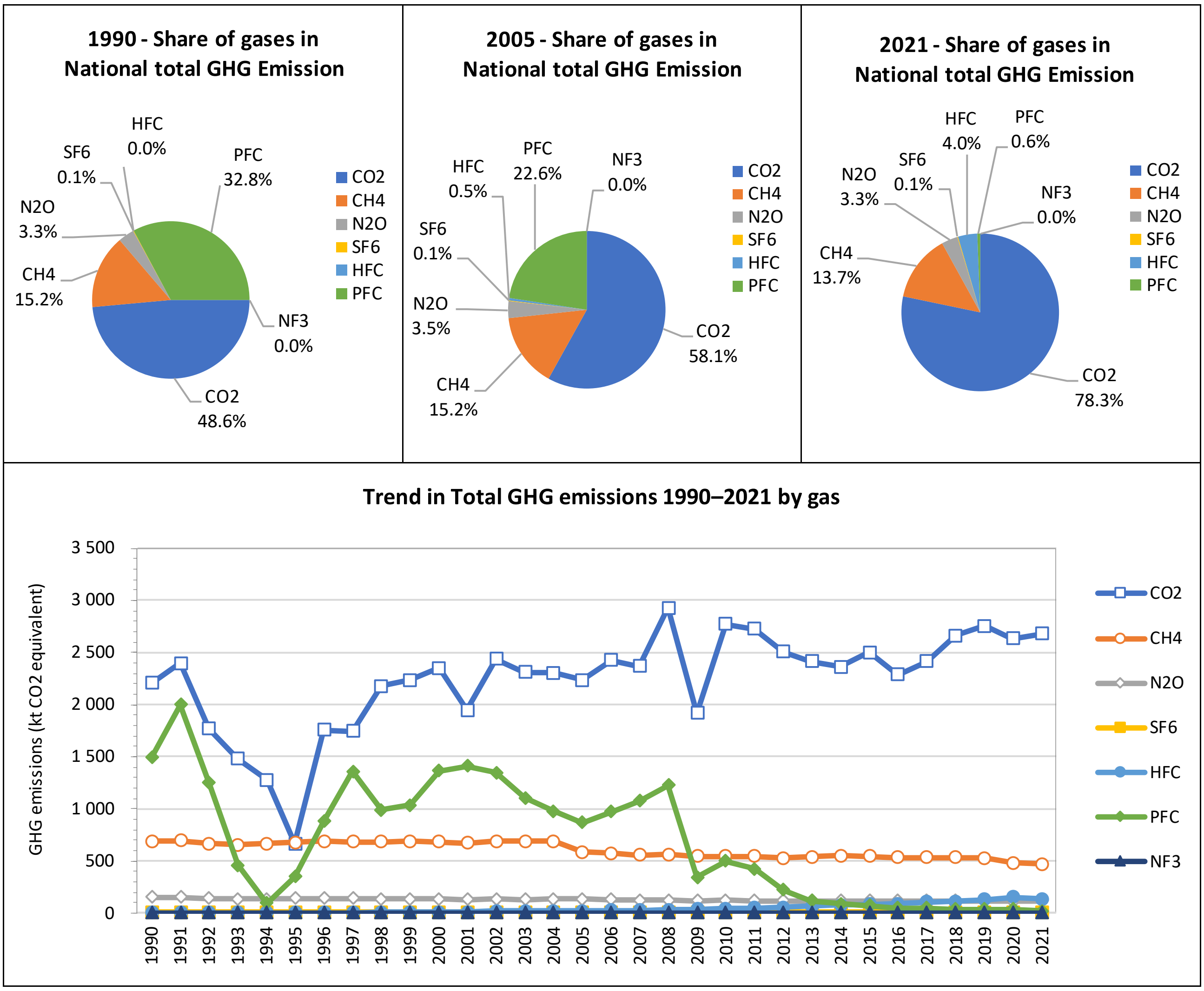


Figure 17 Trend and share of National total GHG emissions (without LULUCF) by greenhouse gas

Table 37 National total GHG Emissions by gases without LULUCF: 1990 - 2021

GHG emissions without LULUCF	TOTAL GHG (excluding CO_2 biomass)	CO_2 (excluding biomass)	CH_4	N_2O	SF_6	HFC	PFC	NF_3	MEMO ITEM CO_2 from biomass
	kt CO_2 eq	kt	kt CO_2 equivalent (CO_2 eq)						kt
1990	**4 540.68**	2 204.74	689.78	150.49	5.04	NA	1 490.64	NO	0.80
1991	**5 240.63**	2 394.00	693.45	150.42	5.04	0.01	1 997.72	NO	0.68
1992	**3 819.62**	1 764.08	666.71	138.83	5.04	0.12	1 244.84	NO	0.74
1993	**2 720.87**	1 475.79	653.18	132.02	5.04	0.34	454.50	NO	0.82
1994	**2 171.19**	1 276.62	663.86	133.50	5.04	0.89	91.29	NO	0.56
1995	**1 829.90**	663.05	678.30	136.96	5.04	1.50	345.05	NO	0.64
1996	**3 475.40**	1 757.50	687.36	142.37	5.04	2.27	880.87	NO	0.61
1997	**3 925.61**	1 744.23	679.27	137.73	5.04	3.16	1 356.19	NO	0.55
1998	**3 992.45**	2 178.38	679.44	135.83	5.04	4.16	989.61	NO	0.50
1999	**4 102.40**	2 236.19	686.23	134.66	5.04	5.24	1 035.04	NO	0.52
2000	**4 536.97**	2 349.44	680.19	134.28	5.04	6.32	1 361.71	NO	0.54
2001	**4 164.93**	1 945.13	670.76	129.08	5.04	7.40	1 407.51	NO	0.46
2002	**4 617.37**	2 433.72	687.87	131.82	5.04	16.20	1 342.74	NO	0.66
2003	**4 250.90**	2 311.14	688.93	127.91	5.04	17.24	1 100.65	NO	0.68
2004	**4 120.67**	2 304.22	685.06	133.88	5.04	18.28	974.19	NO	0.70
2005	**3 849.16**	2 235.50	585.95	133.68	5.04	19.62	869.31	NO	0.67
2006	**4 117.49**	2 422.23	570.24	129.19	5.04	22.23	968.42	NE	0.69
2007	**4 145.74**	2 364.18	553.51	124.58	5.04	25.83	1 072.31	NE	0.72
2008	**4 870.32**	2 926.25	559.15	124.07	5.04	30.25	1 225.15	NE	0.71
2009	**2 963.27**	1 918.95	546.36	117.21	5.04	35.25	339.87	NE	0.75
2010	**3 981.92**	2 771.18	545.94	120.97	5.04	40.83	497.18	NE	0.75
2011	**3 861.49**	2 723.68	546.44	115.52	5.04	46.76	423.06	NE	4.12
2012	**3 429.31**	2 502.76	529.13	114.47	5.04	53.48	223.21	NE	4.13
2013	**3 252.56**	2 413.41	538.23	115.48	5.04	63.46	115.39	NE	4.09
2014	**3 193.91**	2 361.38	548.42	116.83	5.04	73.70	86.61	NE	4.07
2015	**3 321.38**	2 500.11	542.91	117.62	5.04	81.66	71.93	NE	4.13
2016	**3 074.23**	2 283.13	533.01	117.36	5.04	87.79	45.58	NE	4.13
2017	**3 218.21**	2 410.24	534.03	117.11	5.04	103.56	45.13	NE	4.17
2018	**3 466.13**	2 661.29	530.30	117.14	5.04	111.49	37.32	NE	4.13
2019	**3 564.92**	2 752.78	523.57	116.61	5.04	129.70	34.03	NE	4.15
2020	**3 423.37**	2 630.23	482.89	112.27	5.04	152.72	35.49	NE	4.16
2021	**3427.05**	2 679.73	469.25	114.05	5.04	135.60	20.18	NE	5.02
Trend									
1990 - 2021	***-24.5%***	*21.5%*	*-32.0%*	*-24.2%*	*0%*	*NA*	*-99%*	*NA*	*527.6%*
2005 - 2021	***-11.0%***	*19.9%*	*-19.9%*	*-14.7%*	*0%*	*591%*	*-98%*	*NA*	*648.4%*
2020 - 2021	***0.1%***	*1.9%*	*-2.8%*	*1.6%*	*0%*	*-11%*	*-43%*	*NA*	*20.8%*

Remark: MEMO ITEM: CO_2 (biomass): CO_2 from Biomass Combustion for Energy Production

Table 38 National total GHG Emissions by gases without LULUCF: 1990 - 2021

GHG emissions without LULUCF	TOTAL GHG (excluding CO_2 biomass)	CO_2 (excluding biomass)	CH_4	N_2O	SF_6	HFC	PFC	NF_3	MEMO ITEM CO_2 from biomass
	kt CO_2 eq	kt	kt CO_2 equivalent (CO_2 eq)						kt
1990	**3 259.33**	**919.28**	691.45	152.93	5.04	NA	1 490.64	NO	0.80
1991	**3 582.43**	**733.14**	694.25	152.29	5.04	0.01	1 997.72	NO	0.68
1992	**2 576.08**	**514.12**	669.77	142.19	5.04	0.12	1 244.84	NO	0.74
1993	**700.73**	**-550.39**	656.01	135.23	5.04	0.34	454.50	NO	0.82
1994	**708.17**	**-189.92**	665.17	135.71	5.04	0.89	91.29	NO	0.56
1995	**480.17**	**-692.87**	681.22	140.23	5.04	1.50	345.05	NO	0.64
1996	**1 890.13**	**165.50**	690.60	145.85	5.04	2.27	880.87	NO	0.61
1997	**1 530.24**	**-653.95**	680.15	139.66	5.04	3.16	1 356.19	NO	0.55
1998	**1 451.15**	**-370.32**	683.09	139.58	5.04	4.16	989.61	NO	0.50
1999	**1 674.30**	**-193.73**	686.53	136.19	5.04	5.24	1 035.04	NO	0.52
2000	**2 473.23**	**255.39**	697.64	147.13	5.04	6.32	1 361.71	NO	0.54
2001	**1 762.51**	**-460.46**	671.87	131.15	5.04	7.40	1 407.51	NO	0.46
2002	**2 021.90**	**-164.64**	688.80	133.77	5.04	16.20	1 342.74	NO	0.66
2003	**1 666.08**	**-290.45**	698.22	135.38	5.04	17.24	1 100.65	NO	0.68
2004	**1 609.86**	**-213.24**	688.26	137.34	5.04	18.28	974.19	NO	0.70
2005	**1 607.53**	**-7.86**	586.19	135.18	5.04	19.62	869.31	NO	0.67
2006	**2 251.80**	**554.38**	570.73	130.85	5.04	22.23	968.42	NE	0.69
2007	**1 904.75**	**51.09**	596.11	154.09	5.04	25.83	1 072.31	NE	0.72
2008	**2 682.14**	**722.57**	567.59	131.12	5.04	30.25	1 225.15	NE	0.71
2009	**299.61**	**-746.61**	546.56	118.91	5.04	35.25	339.87	NE	0.75
2010	**1 637.24**	**422.19**	547.55	123.67	5.04	40.83	497.18	NE	0.75
2011	**1 850.31**	**521.58**	660.46	192.41	5.04	46.76	423.06	NE	4.12
2012	**1 152.71**	**202.99**	542.02	124.75	5.04	53.48	223.21	NE	4.13
2013	**978.49**	**136.78**	538.63	117.63	5.04	63.46	115.39	NE	4.09
2014	**1 019.84**	**185.07**	548.56	118.93	5.04	73.70	86.61	NE	4.07
2015	**1 394.36**	**558.91**	550.17	124.53	5.04	81.66	71.93	NE	4.13
2016	**949.71**	**152.14**	535.57	121.28	5.04	87.79	45.58	NE	4.13
2017	**1 146.60**	**254.38**	583.39	151.99	5.04	103.56	45.13	NE	4.17
2018	**1 116.43**	**295.96**	538.25	124.83	5.04	111.49	37.32	NE	4.13
2019	**1 095.16**	**275.95**	526.29	120.97	5.04	129.70	34.03	NE	4.15
2020	**1 028.92**	**215.19**	493.69	122.07	5.04	152.72	35.49	NE	4.16
2021	**972.74**	**156.61**	509.04	143.07	5.04	135.60	20.18	NE	5.02
Trend									
1990 - 2021	***-70.2%***	*-141.8%*	*-26.4%*	*-6.5%*	*0%*	*NA*	*-99%*	*NA*	*527.6%*
2005 - 2021	***-39.5%***	*221.1%*	*-13.2%*	*5.8%*	*0%*	*591%*	*-98%*	*NA*	*648.4%*
2020 - 2021	***-5.5%***	*-31.5%*	*3.1%*	*17.2%*	*0%*	*-11%*	*-43%*	*NA*	*20.8%*

Remark: MEMO ITEM: CO_2 (biomass): CO_2 from Biomass Combustion for Energy Production

2.2 Description of emission and removal trends by sector

2.2.1 Total GHG emissions without emissions and removals from sector LULUCF

The dominant sector regarding GHG emissions in Montenegro is Energy, causing 75.8% of total national GHG emissions in 2021, followed by the sectors Industrial Processes and Other Product Use (7.8%), Agriculture (6.5%), and Waste (10.0%).

In 2005, the IPCC sector Energy accounted for 53.4%of the national total GHG emissions. The IPCC sector Industrial Processes and Product Use (IPPU) accounted for 28.6% of the national total GHG emissions. The remaining GHG emissions are split between agriculture (9.9%) and waste (8.2%).

In 1990, the IPCC sector Energy accounted for 46.9% of the national total GHG emissions. The IPCC sector Industrial Processes and Product Use (IPPU) accounted for 35.9% of the national total GHG emissions. The remaining GHG emissions are split between agriculture (12.7%) and waste (4.5%).

The change in contribution of the IPCC sectors in national total GHG emissions is due to the

- increasing energy consumption here especially the combustion of lignite but also liquid fuels;
- increasing road transport;
- temporary shut-down of alumina plant (2009) and shutdown of one electrolysis line (2016);
- extensive agricultural activities;
- growing population which implies increasing waste generation.

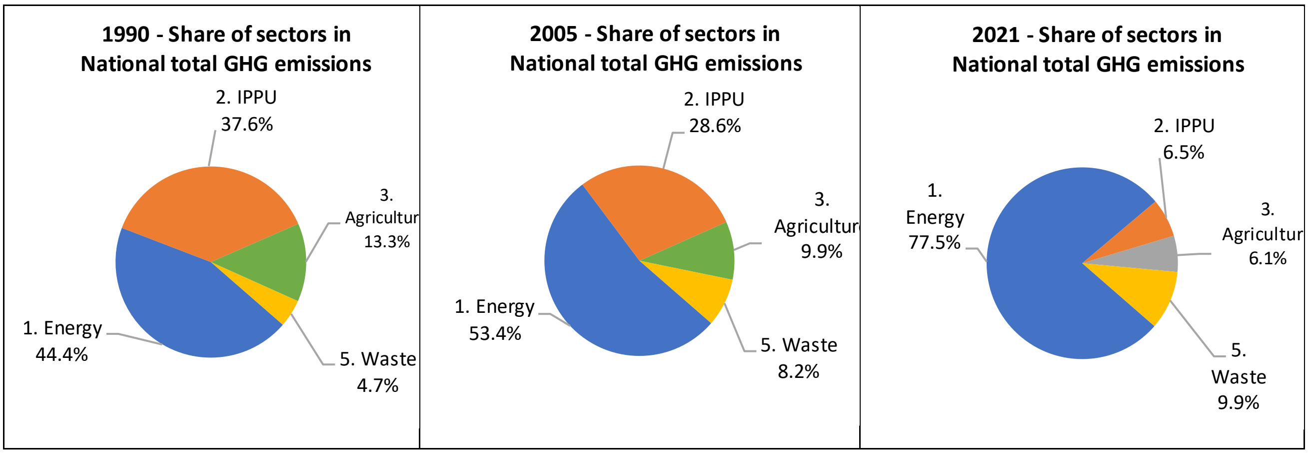


Figure 18 Share of IPCC sector in National GHG emissions (without LULUCF) for the period 1990 – 2021

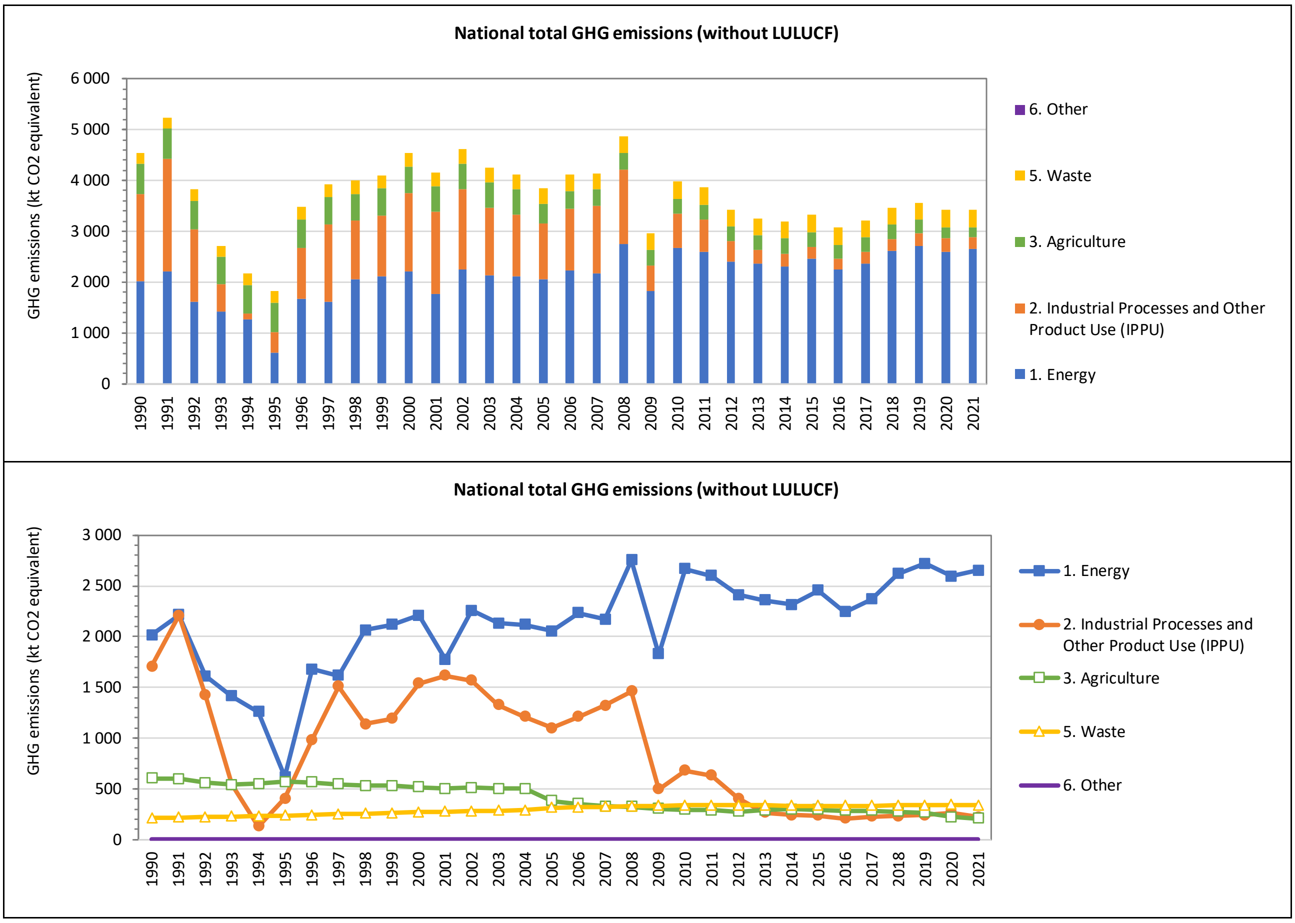


Figure 19 **Trend of National GHG emissions (without LULUCF) by IPCC sector from 1990 – 2021**

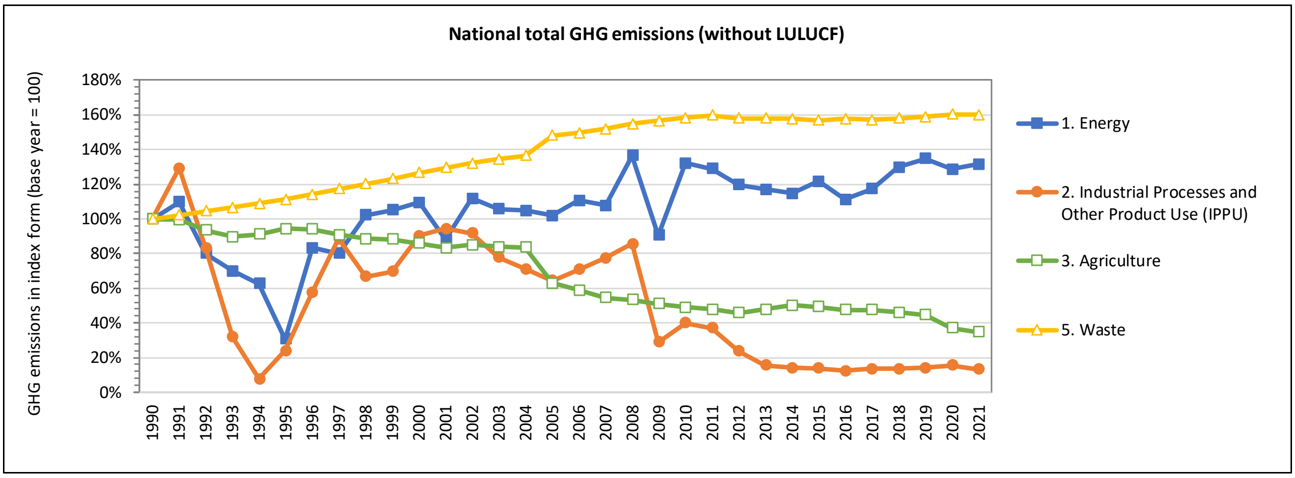


Figure 20 **Trend of National GHG emissions with LULUCF in index form (base year = 100) by IPCC sector with LULUCF for the period 1990 – 2021**

Table 39 National GHG Emissions (without LULUCF) by IPCC sector from 1990 - 2021

GHG emissions without LULUCF		1	2	3	5	6
	TOTAL GHG (without LULUCF)	Energy	Industrial Processes and Other Product Use (IPPU)	Agriculture	Waste	Other
	kt $_{CO2\ equivalent}$					
1990	**4 540.68**	2 017.55	1 708.51	601.90	212.72	NO
1991	**5 240.63**	2 215.30	2 208.60	599.19	217.54	NO
1992	**3 819.62**	1 613.03	1 422.63	561.91	222.04	NO
1993	**2 720.87**	1 412.91	541.07	540.24	226.65	NO
1994	**2 171.19**	1 261.50	129.01	549.32	231.36	NO
1995	**1 829.90**	617.82	407.51	567.80	236.77	NO
1996	**3 475.40**	1 680.60	986.15	565.85	242.80	NO
1997	**3 925.61**	1 617.14	1 511.99	547.08	249.40	NO
1998	**3 992.45**	2 063.03	1 140.79	532.93	255.70	NO
1999	**4 102.40**	2 119.51	1 189.99	530.74	262.16	NO
2000	**4 536.97**	2 210.74	1 540.25	516.79	269.20	NO
2001	**4 164.93**	1 774.14	1 613.78	501.61	275.40	NO
2002	**4 617.37**	2 257.63	1 567.61	511.00	281.14	NO
2003	**4 250.90**	2 131.94	1 328.43	504.47	286.06	NO
2004	**4 120.67**	2 115.10	1 213.16	502.25	290.15	NO
2005	**3 849.16**	2 054.20	1 100.54	379.41	315.01	NO
2006	**4 117.49**	2 233.97	1 210.95	354.44	318.14	NO
2007	**4 145.74**	2 171.26	1 322.70	328.65	323.12	NO
2008	**4 870.32**	2 755.54	1 463.79	321.64	329.36	NO
2009	**2 963.27**	1 828.60	495.03	306.25	333.39	NO
2010	**3 981.92**	2 668.56	681.62	295.17	336.57	NO
2011	**3 861.49**	2 599.11	634.32	288.01	340.06	NO
2012	**3 429.31**	2 412.48	404.66	276.26	335.91	NO
2013	**3 252.56**	2 360.81	267.29	288.11	336.35	NO
2014	**3 193.91**	2 314.97	242.16	301.28	335.50	NO
2015	**3 321.38**	2 454.72	236.98	295.91	333.76	NO
2016	**3 074.23**	2 244.45	208.13	286.23	335.44	NO
2017	**3 218.21**	2 368.12	229.31	286.76	334.03	NO
2018	**3 466.13**	2 620.69	231.23	277.92	336.30	NO
2019	**3 564.92**	2 719.14	239.75	268.14	337.88	NO
2020	**3 423.37**	2 593.98	266.19	222.12	341.08	NO
2021	**3 427.05**	2 654.94	223.19	208.40	340.52	NO
Trend						
1990 - 2021	*-24.5%*	*31.6%*	*-86.9%*	*-65.4%*	*60.1%*	*NA*
2005 - 2021	*-11.0%*	*29.2%*	*-79.7%*	*-45.1%*	*8.1%*	*NA*
2020 - 2021	*0.1%*	*2.4%*	*-16.2%*	*-6.2%*	*-0.2%*	*NA*

Table 40 National CO_2 Emissions (without LULUCF) by IPCC sector from 1990 - 2021

CO_2 emissions without LULUCF	TOTAL CO_2 (without LULUCF)	1 Energy	2 Industrial Processes and Other Product Use (IPPU)	3 Agriculture	5 Waste	6 Other
	kt					
1990	**2 204.74**	1 991.47	212.78	0.49	NE	NO
1991	**2 394.00**	2 187.73	205.79	0.49	NE	NO
1992	**1 764.08**	1 590.99	172.60	0.48	NE	NO
1993	**1 475.79**	1 394.15	81.16	0.48	NE	NO
1994	**1 276.62**	1 244.36	31.77	0.49	NE	NO
1995	**663.05**	606.67	55.90	0.48	NE	NO
1996	**1 757.50**	1 659.06	97.95	0.48	NE	NO
1997	**1 744.23**	1 596.17	147.58	0.48	NE	NO
1998	**2 178.38**	2 035.95	141.95	0.47	NE	NO
1999	**2 236.19**	2 091.07	144.65	0.47	NE	NO
2000	**2 349.44**	2 181.81	167.16	0.47	NE	NO
2001	**1 945.13**	1 750.87	193.80	0.46	NE	NO
2002	**2 433.72**	2 229.64	203.62	0.46	NE	NO
2003	**2 311.14**	2 105.19	205.49	0.45	NE	NO
2004	**2 304.22**	2 088.16	215.62	0.44	NE	NO
2005	**2 235.50**	2 028.58	206.49	0.43	NE	NO
2006	**2 422.23**	2 206.74	215.08	0.42	NE	NO
2007	**2 364.18**	2 144.56	219.20	0.42	NE	NO
2008	**2 926.25**	2 722.95	202.88	0.42	NE	NO
2009	**1 918.95**	1 804.28	114.25	0.42	NE	NO
2010	**2 771.18**	2 633.00	137.77	0.41	NE	NO
2011	**2 723.68**	2 564.83	158.45	0.40	NE	NO
2012	**2 502.76**	2 380.74	121.70	0.32	NE	NO
2013	**2 413.41**	2 331.19	81.84	0.38	NE	NO
2014	**2 361.38**	2 286.13	74.88	0.38	NE	NO
2015	**2 500.11**	2 423.50	76.23	0.38	NE	NO
2016	**2 283.13**	2 215.37	67.39	0.38	NE	NO
2017	**2 410.24**	2 337.40	72.47	0.37	NE	NO
2018	**2 661.29**	2 587.10	73.82	0.37	NE	NO
2019	**2 752.78**	2 684.61	67.80	0.37	NE	NO
2020	**2 630.23**	2 561.66	68.20	0.37	NE	NO
2021	**2 679.73**	2 620.18	59.18	0.37	NE	NO
Trend						
1990 - 2021	***21.5%***	*31.6%*	*-72.2%*	*-24.3%*	*NA*	*NA*
2005 - 2021	***19.9%***	*29.2%*	*-71.3%*	*-14.4%*	*NA*	*NA*
2020 - 2021	***1.9%***	*2.3%*	*-13.2%*	*0.0%*	*NA*	*NA*

Table 41 National CH_4 Emissions (without LULUCF) by IPCC sector from 1990 - 2021

CH_4 emissions without LULUCF	TOTAL CH_4 (without LULUCF)	1 Energy	2 Industrial Processes and Other Product Use (IPPU)	3 Agriculture	5 Waste	6 Other
	kt					
1990	**27.59**	0.60	0.0021	18.79	8.19	NO
1991	**27.74**	0.62	0.0020	18.74	8.38	NO
1992	**26.67**	0.53	0.0014	17.58	8.55	NO
1993	**26.13**	0.45	0.0012	16.94	8.73	NO
1994	**26.55**	0.40	0.0011	17.23	8.91	NO
1995	**27.13**	0.27	0.0009	17.73	9.13	NO
1996	**27.49**	0.48	0.0010	17.65	9.36	NO
1997	**27.17**	0.47	0.0013	17.08	9.62	NO
1998	**27.18**	0.59	0.0014	16.72	9.87	NO
1999	**27.45**	0.59	0.0009	16.74	10.12	NO
2000	**27.21**	0.59	0.0008	16.22	10.39	NO
2001	**26.83**	0.47	0.0011	15.73	10.63	NO
2002	**27.51**	0.61	0.0008	16.06	10.84	NO
2003	**27.56**	0.58	0.0006	15.95	11.03	NO
2004	**27.40**	0.55	0.0015	15.67	11.18	NO
2005	**23.44**	0.47	0.0010	11.67	11.29	NO
2006	**22.81**	0.54	0.0016	10.88	11.39	NO
2007	**22.14**	0.46	0.0017	10.13	11.55	NO
2008	**22.37**	0.60	0.0020	9.98	11.78	NO
2009	**21.85**	0.40	0.0010	9.53	11.93	NO
2010	**21.84**	0.66	0.0005	9.11	12.07	NO
2011	**21.86**	0.64	0.0006	9.01	12.21	NO
2012	**21.17**	0.58	0.0003	8.53	12.05	NO
2013	**21.53**	0.56	0.0002	8.92	12.05	NO
2014	**21.94**	0.57	0.0001	9.35	12.02	NO
2015	**21.72**	0.61	0.0004	9.18	11.93	NO
2016	**21.32**	0.51	0.0005	8.83	11.97	NO
2017	**21.36**	0.54	0.0005	8.91	11.92	NO
2018	**21.21**	0.58	0.0005	8.63	12.01	NO
2019	**20.94**	0.58	0.0002	8.29	12.07	NO
2020	**19.32**	0.57	0.0003	6.54	12.20	NO
2021	**18.77**	0.57	<0.0001	6.01	12.19	NO
Trend						
1990 - 2021	*-32.0%*	*-5.3%*	*-98.5%*	*-68.0%*	*48.7%*	*NA*
2005 - 2021	*-19.9%*	*20.0%*	*-97.0%*	*-48.5%*	*7.9%*	*NA*
2020 - 2021	*-2.8%*	*-0.5%*	*-91.1%*	*-8.1%*	*-0.1%*	*NA*

Table 42 National N_2O Emissions (without LULUCF) by IPCC sector from 1990 - 2021

N_2O emissions without LULUCF	TOTAL N_2O (without LULUCF)	1 Energy	2 Industrial Processes and Other Product Use (IPPU)	3 Agriculture	5 Waste	6 Other
	kt					
1990	**0.505**	0.037	NE	0.441	0.026	NO
1991	**0.505**	0.041	NE	0.437	0.027	NO
1992	**0.466**	0.029	NE	0.409	0.028	NO
1993	**0.443**	0.025	NE	0.390	0.028	NO
1994	**0.448**	0.024	NE	0.396	0.028	NO
1995	**0.460**	0.015	NE	0.416	0.029	NO
1996	**0.478**	0.032	NE	0.417	0.029	NO
1997	**0.462**	0.031	NE	0.401	0.030	NO
1998	**0.456**	0.041	NE	0.384	0.030	NO
1999	**0.452**	0.046	NE	0.375	0.031	NO
2000	**0.451**	0.048	NE	0.371	0.031	NO
2001	**0.433**	0.039	NE	0.362	0.033	NO
2002	**0.442**	0.042	NE	0.366	0.034	NO
2003	**0.429**	0.041	NE	0.353	0.035	NO
2004	**0.449**	0.044	NE	0.370	0.036	NO
2005	**0.449**	0.046	NE	0.293	0.110	NO
2006	**0.434**	0.046	NE	0.275	0.112	NO
2007	**0.418**	0.051	NE	0.252	0.115	NO
2008	**0.416**	0.059	NE	0.240	0.117	NO
2009	**0.393**	0.048	NE	0.227	0.118	NO
2010	**0.406**	0.064	NE	0.225	0.117	NO
2011	**0.388**	0.061	NE	0.209	0.117	NO
2012	**0.384**	0.057	NE	0.210	0.116	NO
2013	**0.388**	0.053	NE	0.217	0.117	NO
2014	**0.392**	0.049	NE	0.226	0.118	NO
2015	**0.395**	0.053	NE	0.222	0.119	NO
2016	**0.394**	0.054	NE	0.218	0.121	NO
2017	**0.393**	0.058	NE	0.214	0.121	NO
2018	**0.393**	0.064	NE	0.208	0.121	NO
2019	**0.391**	0.067	NE	0.203	0.121	NO
2020	**0.377**	0.060	NE	0.195	0.121	NO
2021	**0.383**	0.069	NE	0.193	0.120	NO
Trend						
1990 - 2021	***-24.2%***	*85.7%*	*NA*	*-56.2%*	*355.0%*	*NA*
2005 - 2021	***-14.7%***	*49.1%*	*NA*	*-33.9%*	*9.7%*	*NA*
2020 - 2021	***1.6%***	*13.9%*	*NA*	*-0.9%*	*-0.5%*	*NA*

Table 43 National SF_6, HFC and PFC Emissions (without LULUCF) by IPCC sector from 1990 - 2021

F-gas emissions	TOTAL F-gases	TOTAL SF6	TOTAL HFC	TOTAL PFC
	kt CO2 equivalent	kt CO2 equivalent	kt CO2 equivalent	kt CO2 equivalent
1990	1 419.95	5.04	NA	1 490.64
1991	1 363.97	5.04	0.01	1 997.72
1992	1 122.92	5.04	0.12	1 244.84
1993	997.50	5.04	0.34	454.50
1994	893.97	5.04	0.89	91.29
1995	995.68	5.04	1.50	345.05
1996	1 103.18	5.04	2.27	880.87
1997	1 260.44	5.04	3.16	1 356.19
1998	380.16	5.04	4.16	989.61
1999	543.04	5.04	5.24	1 035.04
2000	474.85	5.04	6.32	1 361.71
2001	281.72	5.04	7.40	1 407.51
2002	183.89	5.04	16.20	1 342.74
2003	165.34	5.04	17.24	1 100.65
2004	158.63	5.04	18.28	974.19
2005	138.41	5.04	19.62	869.31
2006	153.73	5.04	22.23	968.42
2007	153.84	5.04	25.83	1 072.31
2008	168.77	5.04	30.25	1 225.15
2009	193.25	5.04	35.25	339.87
2010	160.82	5.04	40.83	497.18
2011	1 419.95	5.04	46.76	423.06
2012	1 363.97	5.04	53.48	223.21
2013	1 122.92	5.04	63.46	115.39
2014	997.50	5.04	73.70	86.61
2015	893.97	5.04	81.66	71.93
2016	995.68	5.04	87.79	45.58
2017	1 103.18	5.04	103.56	45.13
2018	1 260.44	5.04	111.49	37.32
2019	380.16	5.04	129.70	34.03
2020	543.04	5.04	152.72	35.49
2021	474.85	5.04	135.60	20.18
Trend				
1990 - 2021	-89.2%	*0%*	*NA*	*-98.6%*
2005 - 2021	-82.0%	*0%*	*591.2%*	*-97.7%*
2020 - 2021	-16.8%	*0%*	*-11.2%*	*-43.1%*

2.2.2 Total GHG emissions with emissions and removals from sector LULUCF

In 2021 Montenegro's total greenhouse gas (GHG) emissions (with LULUCF) amounted to 972.74 kt CO_2 equivalents (CO_2eq). Compared to 1990 GHG emissions decreased by -70.2%, compared to 2005 GHG emissions increased by -39.5%, compared to 2020 GHG emissions increased by -5.5%.

In 2005 total GHG emissions (with LULUCF) amounted to 1 607.53 kt CO_2eq and in 1990 total GHG emissions (with LULUCF) amounted to 3 259.33kt CO_2eq.

The IPCC sector Land use, Land use Change and Forestry (LULUCF) is an important sector in Montenegro due to its significant removals. In 2021, the net emissions and removals of the IPCC sector LULUCF are with -2 454.32 kt CO_2 equivalent almost equal to the emissions of the IPCC sector Energy (2 655.19 kt CO2 equivalent). In 2005, the emissions and removals of the IPCC sector LULUCF are with -2 241.63 kt CO_2 equivalent almost equal to the emissions of the IPCC sector Energy (2 054.22 kt CO2 equivalent). In 1990, the emissions and removals of the IPCC sector LULUCF are with -1 281.34 kt CO_2 equivalent.

The net removal and the related land use has been rather stable, with only a small proportion of the total territory undergoing land use change. Nevertheless, considerable dynamics in Forest land remaining Forest land have resulted the long-term trend as well as significant inter-annual variability. These fluctuations are primarily due to changes in total drain due to timber harvest and biomass losses due to forest fires.

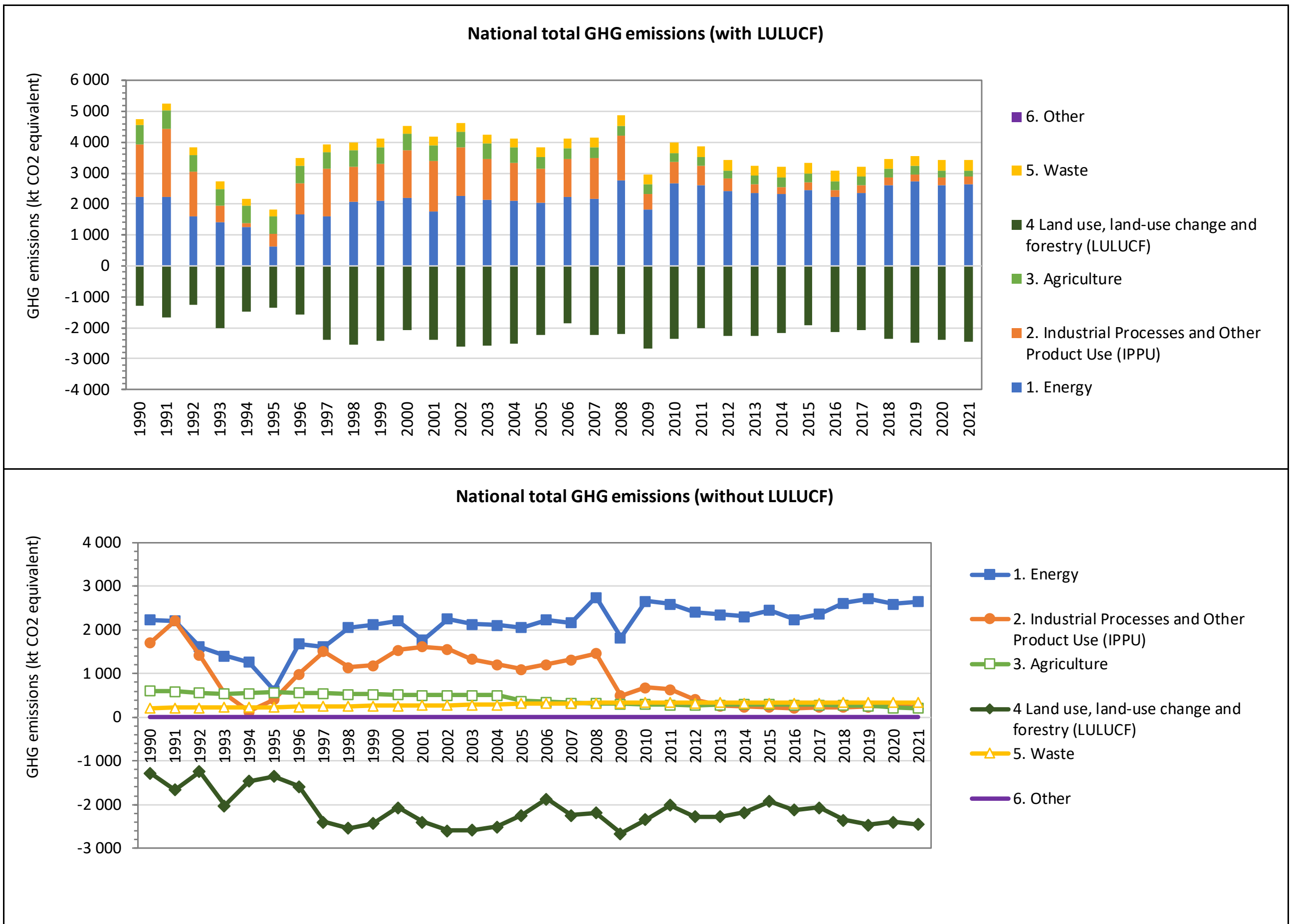


Figure 21 **Trend of National GHG emissions without LULUCF by IPCC sector from 1990 – 2021**

Table 44 National GHG Emissions (with LULUCF) by IPCC sector from 1990 - 2021

GHG emissions (with LULUCF)	TOTAL GHG (with LULUCF)	1 Energy	2 Industrial Processes and Other Product Use (IPPU)	3 Agriculture	4 Land Use, Land Use Change and Forestry (LULUCF)	5 Waste	6 Other
	kt $_{CO2\ equivalent}$						
1990	**3 259.33**	2 017.55	1 708.51	601.90	-1 281.34	212.72	NO
1991	**3 582.43**	2 215.30	2 208.60	599.19	-1 658.20	217.54	NO
1992	**2 576.08**	1 613.03	1 422.63	561.91	-1 243.54	222.04	NO
1993	**700.73**	1 412.91	541.07	540.24	-2 020.14	226.65	NO
1994	**708.17**	1 261.50	129.01	549.32	-1 463.02	231.36	NO
1995	**480.17**	617.82	407.51	567.80	-1 349.73	236.77	NO
1996	**1 890.13**	1 680.60	986.15	565.85	-1 585.28	242.80	NO
1997	**1 530.24**	1 617.14	1 511.99	547.08	-2 395.37	249.40	NO
1998	**1 451.15**	2 063.03	1 140.79	532.93	-2 541.30	255.70	NO
1999	**1 674.30**	2 119.51	1 189.99	530.74	-2 428.10	262.16	NO
2000	**2 473.23**	2 210.74	1 540.25	516.79	-2 063.74	269.20	NO
2001	**1 762.51**	1 774.14	1 613.78	501.61	-2 402.42	275.40	NO
2002	**2 021.90**	2 257.63	1 567.61	511.00	-2 595.48	281.14	NO
2003	**1 666.08**	2 131.94	1 328.43	504.47	-2 584.82	286.06	NO
2004	**1 609.86**	2 115.10	1 213.16	502.25	-2 510.81	290.15	NO
2005	**1 607.53**	2 054.20	1 100.54	379.41	-2 241.63	315.01	NO
2006	**2 251.80**	2 233.97	1 210.95	354.44	-1 865.70	318.14	NO
2007	**1 904.75**	2 171.26	1 322.70	328.65	-2 240.99	323.12	NO
2008	**2 682.14**	2 755.54	1 463.79	321.64	-2 188.18	329.36	NO
2009	**299.61**	1 828.60	495.03	306.25	-2 663.66	333.39	NO
2010	**1 637.24**	2 668.56	681.62	295.17	-2 344.67	336.57	NO
2011	**1 850.31**	2 599.11	634.32	288.01	-2 011.18	340.06	NO
2012	**1 152.71**	2 412.48	404.66	276.26	-2 276.61	335.91	NO
2013	**978.49**	2 360.81	267.29	288.11	-2 274.07	336.35	NO
2014	**1 019.84**	2 314.97	242.16	301.28	-2 174.07	335.50	NO
2015	**1 394.36**	2 454.72	236.98	295.91	-1 927.02	333.76	NO
2016	**949.71**	2 244.45	208.13	286.23	-2 124.53	335.44	NO
2017	**1 146.60**	2 368.12	229.31	286.76	-2 071.61	334.03	NO
2018	**1 116.43**	2 620.69	231.23	277.92	-2 349.70	336.30	NO
2019	**1 095.16**	2 719.14	239.75	268.14	-2 469.76	337.88	NO
2020	**1 028.92**	2 593.98	266.19	222.12	-2 394.44	341.08	NO
2021	**972.74**	2 654.94	223.19	208.40	-2 454.32	340.52	NO
Trend							
1990 - 2021	***-70.2%***	*31.6%*	*-86.9%*	*-65.4%*	*91.5%*	*60.1%*	NA
2005 - 2021	***-39.5%***	*29.2%*	*-79.7%*	*-45.1%*	*9.5%*	*8.1%*	NA
2020 - 2021	***-5.5%***	*2.4%*	*-16.2%*	*-6.2%*	*2.5%*	*-0.2%*	NA

Table 45 National CO_2 Emissions (with LULUCF) by IPCC sector from 1990 - 2021

CO_2 emissions (with LULUCF)	TOTAL CO_2 (with LULUCF)	1 Energy	2 Industrial Processes and Other Product Use (IPPU)	3 Agriculture	4 Land Use, Land Use Change and Forestry (LULUCF)	5 Waste	6 Other
	kt						
1990	919.28	1 991.47	212.78	0.49	-1 285.46	NE	NO
1991	733.14	2 187.73	205.79	0.49	-1 660.86	NE	NO
1992	514.12	1 590.99	172.60	0.48	-1 249.96	NE	NO
1993	-550.39	1 394.15	81.16	0.48	-2 026.18	NE	NO
1994	-189.92	1 244.36	31.77	0.49	-1 466.54	NE	NO
1995	-692.87	606.67	55.90	0.48	-1 355.92	NE	NO
1996	165.50	1 659.06	97.95	0.48	-1 591.99	NE	NO
1997	-653.95	1 596.17	147.58	0.48	-2 398.18	NE	NO
1998	-370.32	2 035.95	141.95	0.47	-2 548.70	NE	NO
1999	-193.73	2 091.07	144.65	0.47	-2 429.93	NE	NO
2000	255.39	2 181.81	167.16	0.47	-2 094.05	NE	NO
2001	-460.46	1 750.87	193.80	0.46	-2 405.60	NE	NO
2002	-164.64	2 229.64	203.62	0.46	-2 598.36	NE	NO
2003	-290.45	2 105.19	205.49	0.45	-2 601.59	NE	NO
2004	-213.24	2 088.16	215.62	0.44	-2 517.46	NE	NO
2005	-7.86	2 028.58	206.49	0.43	-2 243.37	NE	NO
2006	554.38	2 206.74	215.08	0.42	-1 867.85	NE	NO
2007	51.09	2 144.56	219.20	0.42	-2 313.09	NE	NO
2008	722.57	2 722.95	202.88	0.42	-2 203.67	NE	NO
2009	-746.61	1 804.28	114.25	0.42	-2 665.56	NE	NO
2010	422.19	2 633.00	137.77	0.41	-2 348.99	NE	NO
2011	521.58	2 564.83	158.45	0.40	-2 202.10	NE	NO
2012	202.99	2 380.74	121.70	0.32	-2 299.77	NE	NO
2013	136.78	2 331.19	81.84	0.38	-2 276.62	NE	NO
2014	185.07	2 286.13	74.88	0.38	-2 176.31	NE	NO
2015	558.91	2 423.50	76.23	0.38	-1 941.20	NE	NO
2016	152.14	2 215.37	67.39	0.38	-2 131.00	NE	NO
2017	254.38	2 337.40	72.47	0.37	-2 155.85	NE	NO
2018	295.96	2 587.10	73.82	0.37	-2 365.33	NE	NO
2019	275.95	2 684.61	67.80	0.37	-2 476.84	NE	NO
2020	215.19	2 561.66	68.20	0.37	-2 415.04	NE	NO
2021	156.61	2 620.18	59.18	0.37	-2 523.12	NE	NO
Trend							
1990 - 2021	*-141.8%*	*31.6%*	*-72.2%*	*-24.3%*	*96.3%*	*NA*	*NA*
2005 - 2021	*221.1%*	*29.2%*	*-71.3%*	*-14.4%*	*12.5%*	*NA*	*NA*
2020 - 2021	*-31.5%*	*2.3%*	*-13.2%*	*0.0%*	*4.5%*	*NA*	*NA*

Table 46 National CH_4 Emissions (with LULUCF) by IPCC sector from 1990 - 2021

CH4 emissions (with LULUCF)	TOTAL CH4 (with LULUCF)	1 Energy	2 Industrial Processes and Other Product Use (IPPU)	3 Agriculture	4 Land Use, Land Use Change and Forestry (LULUCF)	5 Waste	6 Other
	kt						
1990	27.66	0.60	0.0021	18.79	0.07	8.19	NO
1991	27.77	0.62	0.0020	18.74	0.03	8.38	NO
1992	26.79	0.53	0.0014	17.58	0.12	8.55	NO
1993	26.24	0.45	0.0012	16.94	0.11	8.73	NO
1994	26.61	0.40	0.0011	17.23	0.05	8.91	NO
1995	27.25	0.27	0.0009	17.73	0.12	9.13	NO
1996	27.62	0.48	0.0010	17.65	0.13	9.36	NO
1997	27.21	0.47	0.0013	17.08	0.04	9.62	NO
1998	27.32	0.59	0.0014	16.72	0.15	9.87	NO
1999	27.46	0.59	0.0009	16.74	0.01	10.12	NO
2000	27.91	0.59	0.0008	16.22	0.70	10.39	NO
2001	26.87	0.47	0.0011	15.73	0.04	10.63	NO
2002	27.55	0.61	0.0008	16.06	0.04	10.84	NO
2003	27.93	0.58	0.0006	15.95	0.37	11.03	NO
2004	27.53	0.55	0.0015	15.67	0.13	11.18	NO
2005	23.45	0.47	0.0010	11.67	0.01	11.29	NO
2006	22.83	0.54	0.0016	10.88	0.02	11.39	NO
2007	23.84	0.46	0.0017	10.13	1.70	11.55	NO
2008	22.70	0.60	0.0020	9.98	0.34	11.78	NO
2009	21.86	0.40	0.0010	9.53	0.01	11.93	NO
2010	21.90	0.66	0.0005	9.11	0.06	12.07	NO
2011	26.42	0.64	0.0006	9.01	4.56	12.21	NO
2012	21.68	0.58	0.0003	8.53	0.52	12.05	NO
2013	21.55	0.56	0.0002	8.92	0.02	12.05	NO
2014	21.94	0.57	0.0001	9.35	0.01	12.02	NO
2015	22.01	0.61	0.0004	9.18	0.29	11.93	NO
2016	21.42	0.51	0.0005	8.83	0.10	11.97	NO
2017	23.34	0.54	0.0005	8.91	1.97	11.92	NO
2018	21.53	0.58	0.0005	8.63	0.32	12.01	NO
2019	21.05	0.58	0.0002	8.29	0.11	12.07	NO
2020	19.75	0.57	0.0003	6.54	0.43	12.20	NO
2021	20.36	0.57	<0.0001	6.01	1.59	12.19	NO
Trend							
1990 - 2021	*-43.7%*	*-93.7%*	*-98.5%*	*-68.0%*	*2275.3%*	*48.7%*	*NA*
2005 - 2021	*-13.1%*	*21.9%*	*-97.0%*	*-48.5%*	*16503.9%*	*7.9%*	*NA*
2020 - 2021	*3.1%*	*0.4%*	*-91.1%*	*-8.1%*	*268.3%*	*-0.1%*	*NA*

Table 47 National N_2O Emissions (with LULUCF) by IPCC sector from 1990 - 2021

N_2O emissions (with LULUCF)	TOTAL CH4 (with LULUCF)	1 Energy	2 Industrial Processes and Other Product Use (IPPU)	3 Agriculture	4 Land Use, Land Use Change and Forestry (LULUCF)	5 Waste	6 Other
	kt						
1990	0.51	0.04	NE	0.44	0.01	0.03	NO
1991	0.51	0.04	NE	0.44	0.01	0.03	NO
1992	0.48	0.03	NE	0.41	0.01	0.03	NO
1993	0.45	0.03	NE	0.39	0.01	0.03	NO
1994	0.46	0.02	NE	0.40	0.01	0.03	NO
1995	0.47	0.01	NE	0.42	0.01	0.03	NO
1996	0.49	0.03	NE	0.42	0.01	0.03	NO
1997	0.47	0.03	NE	0.40	0.01	0.03	NO
1998	0.47	0.04	NE	0.38	0.01	0.03	NO
1999	0.46	0.05	NE	0.38	0.01	0.03	NO
2000	0.49	0.05	NE	0.37	0.04	0.03	NO
2001	0.44	0.04	NE	0.36	0.01	0.03	NO
2002	0.45	0.04	NE	0.37	0.01	0.03	NO
2003	0.45	0.04	NE	0.35	0.03	0.03	NO
2004	0.46	0.04	NE	0.37	0.01	0.04	NO
2005	0.45	0.05	NE	0.29	0.01	0.11	NO
2006	0.44	0.05	NE	0.27	0.01	0.11	NO
2007	0.52	0.05	NE	0.25	0.10	0.12	NO
2008	0.44	0.06	NE	0.24	0.02	0.12	NO
2009	0.40	0.05	NE	0.23	0.01	0.12	NO
2010	0.41	0.06	NE	0.22	0.01	0.12	NO
2011	0.65	0.06	NE	0.21	0.26	0.12	NO
2012	0.42	0.06	NE	0.21	0.03	0.12	NO
2013	0.39	0.05	NE	0.22	0.01	0.12	NO
2014	0.40	0.05	NE	0.23	0.01	0.12	NO
2015	0.42	0.05	NE	0.22	0.02	0.12	NO
2016	0.41	0.05	NE	0.22	0.01	0.12	NO
2017	0.51	0.06	NE	0.21	0.12	0.12	NO
2018	0.42	0.06	NE	0.21	0.03	0.12	NO
2019	0.41	0.07	NE	0.20	0.01	0.12	NO
2020	0.41	0.06	NE	0.20	0.03	0.12	NO
2021	0.48	0.07	NE	0.19	0.10	0.12	NO
Trend							
1990 - 2021	*-6.5%*	*85.7%*	*NA*	*-56.2%*	*1086.0%*	*355.0%*	*NA*
2005 - 2021	*5.8%*	*49.1%*	*NA*	*-33.9%*	*1834.5%*	*9.7%*	*NA*
2020 - 2021	*17.2%*	*13.9%*	*NA*	*-0.9%*	*196.3%*	*-0.5%*	*NA*

2.2.3 Description of emission trends: IPCC sector 1 Energy

In 2021, greenhouse gas emissions from IPCC sector 1 *Energy* amounted to 2 654.94 kt CO_2 equivalents which corresponds to 75.8% of the total national emissions (without LULUCF). 99.55% of the emissions from this sector originate from fuel combustion (1.A) while fugitive emissions from fuels (1.B) contribute with about 0.45%. the main sub-categories within 1.A fuel combustion are 1.A.1. Energy industries and 1.A.3. Transport (here road transport)

The **overall trend** in GHG emissions from the sector *Energy* shows increasing emissions with a increase of 31.6% from 1990 to 2021, 29.2% from 1990 to 2021, and 2.4% from 1990 to 2021.

Fugitive emissions decreased by -8.4% since 1990 due to slightly decreasing mining and post-mining activities.

Fluctuation of emissions in IPCC sector 1 Energy are due to stopped/shut-down electricity and industrial production and/or limited public life during the time of

- break-up of Yugoslavia (1992);
- overall economic downturn in the country;
- break-up of the union with Serbia (2006);
- world economic crisis (2009)
- break-down (1995) and reconstruction of the power plant (2009/2010);
- shut-down of alumina plant (2009) and shutdown of one electrolysis line (2016);
- forest and wild fires (2000, 2003, 2011, 2017);
- agricultural activities;
- growing population;
- increasing road transport;
- worldwide COVID pandemic and the lockdown.

The IPCC category 1.C. Carbon capture and storage (CCS) does not exist in Montenegro.

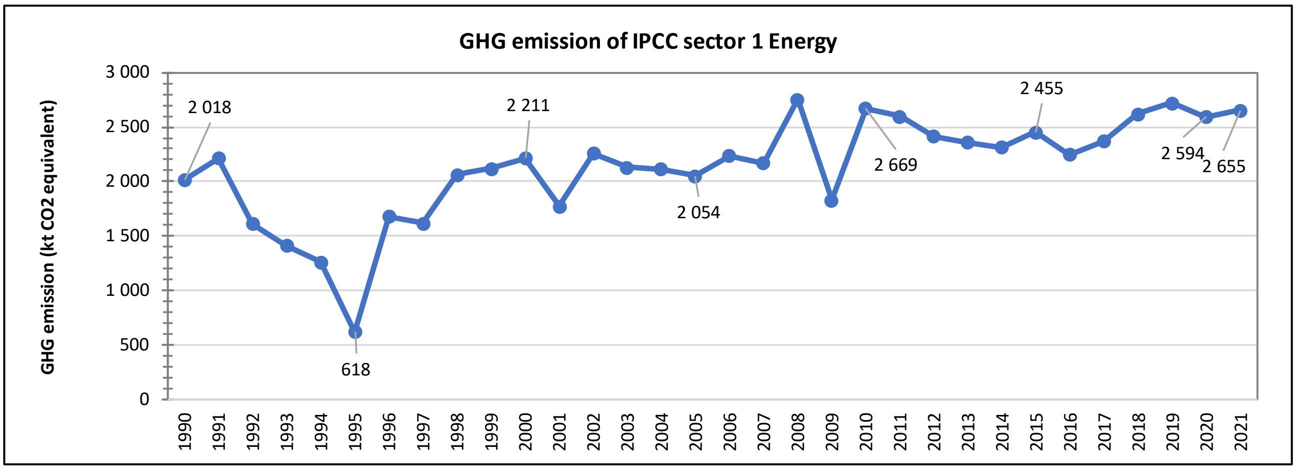


Figure 22 Trend of GHG emissions from IPCC sector 1 Energy: 1990 – 2021

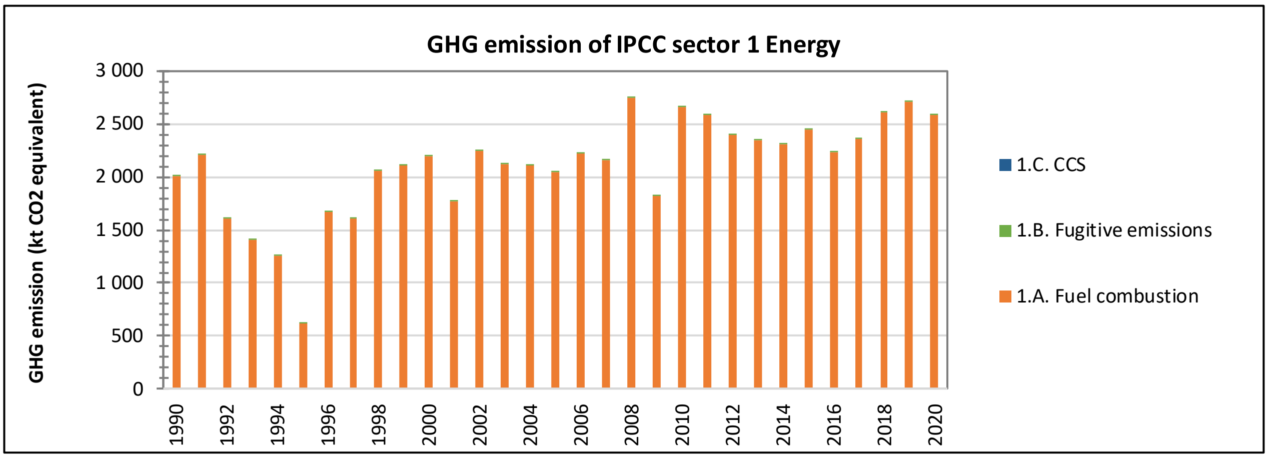


Figure 23 Trend of GHG emissions of IPCC category 1.A Fuel combustion and 1.B Fugitive emissions for the period 1990 – 2021

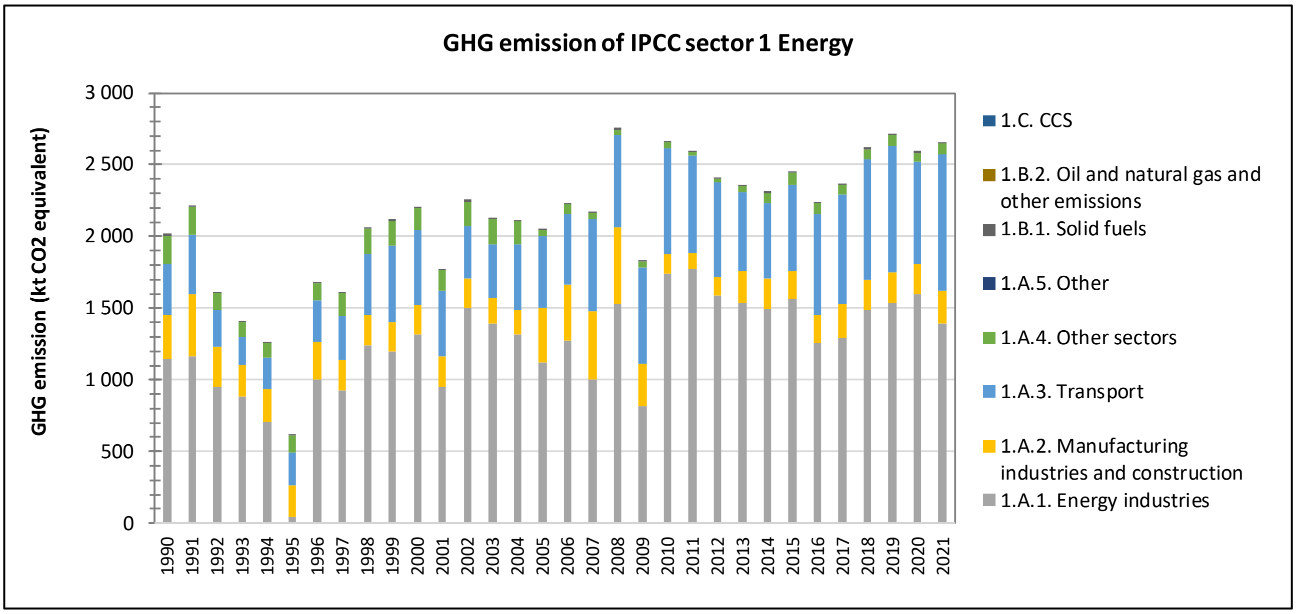


Figure 24 Trend of GHG emissions of IPCC sector 1 Energy by category for the period 1990 – 2021

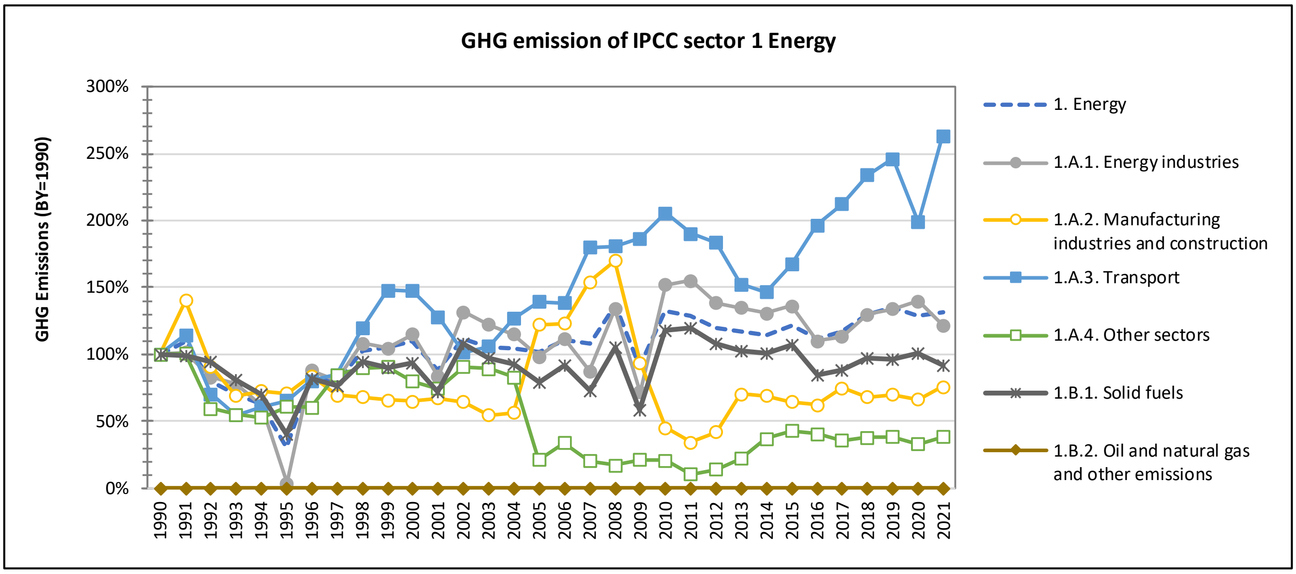


Figure 25 Trend of emissions from IPCC sector 1 Energy in index form (base year = 100) by category for the period 1990 – 2021

Table 48 GHG Emissions from IPCC sub-category 1 Energy by sub-categories for the period 1990-2021

GHG emissions	1 Energy	1.A Fuel Combustion Activities	1.A.1 Energy Industries	1.A.2 Manufacturing Industries and Construction	1.A.3 Transport	1.A.4 Other Sectors	1.A.5 Non-Specified	1.B Fugitive emissions from fuels
	kt CO_2 equivalent							
1990	**2 017.55**	2 006.00	1 142.70	310.88	358.42	194.00	NE	11.55
1991	**2 215.30**	2 203.81	1 161.08	436.63	410.73	195.37	NE	11.49
1992	**1 613.03**	1 602.14	950.15	283.02	253.06	115.91	NE	10.89
1993	**1 412.91**	1 403.50	886.60	214.64	195.76	106.50	NE	9.41
1994	**1 261.50**	1 253.43	707.79	225.26	218.09	102.29	NE	8.07
1995	**617.82**	613.13	41.12	219.95	234.09	117.97	NE	4.68
1996	**1 680.60**	1 671.13	1 004.67	261.10	288.36	117.00	NE	9.47
1997	**1 617.14**	1 608.35	923.37	215.86	304.16	164.96	NE	8.79
1998	**2 063.03**	2 052.11	1 238.01	211.16	428.68	174.26	NE	10.92
1999	**2 119.51**	2 109.08	1 197.52	204.62	531.09	175.85	NE	10.43
2000	**2 210.74**	2 199.90	1 314.34	202.39	528.34	154.84	NE	10.84
2001	**1 774.14**	1 765.84	952.97	208.77	459.27	144.83	NE	8.30
2002	**2 257.63**	2 245.12	1 504.34	200.63	364.31	175.84	NE	12.51
2003	**2 131.94**	2 120.66	1 396.87	169.98	380.66	173.16	NE	11.28
2004	**2 115.10**	2 104.50	1 314.63	175.29	453.57	161.00	NE	10.61
2005	**2 054.20**	2 045.15	1 125.21	379.50	499.21	41.23	NE	9.06
2006	**2 233.97**	2 223.48	1 277.54	383.32	497.12	65.49	NE	10.49
2007	**2 171.26**	2 162.97	999.04	478.95	645.62	39.36	NE	8.29
2008	**2 755.54**	2 743.44	1 532.67	528.54	649.00	33.22	NE	12.10
2009	**1 828.60**	1 821.94	819.61	291.51	669.56	41.27	NE	6.66
2010	**2 668.56**	2 655.06	1 736.41	140.68	737.62	40.35	NE	13.51
2011	**2 599.11**	2 585.38	1 775.66	106.56	682.71	20.45	NE	13.73
2012	**2 412.48**	2 400.07	1 584.07	130.55	658.64	26.81	NE	12.40
2013	**2 360.81**	2 349.01	1 540.15	219.00	546.95	42.91	NE	11.80
2014	**2 314.97**	2 303.44	1 492.49	214.63	524.88	71.43	NE	11.53
2015	**2 454.72**	2 442.41	1 558.84	200.50	599.47	83.59	NE	12.31
2016	**2 244.45**	2 234.73	1 256.84	193.96	704.82	79.10	NE	9.72
2017	**2 368.12**	2 357.96	1 293.39	233.41	761.76	69.40	NE	10.16
2018	**2 620.69**	2 609.56	1 486.22	211.20	838.52	73.62	NE	11.12
2019	**2 719.14**	2 708.10	1 533.10	217.15	883.29	74.57	NE	11.04
2020	**2 593.98**	2 582.45	1 599.77	205.70	713.46	63.53	NE	11.53
2021	**2 654.94**	2 644.35	1 390.53	235.46	943.65	74.71	NE	10.59
Trend								
1990 - 2021	*31.6%*	*31.8%*	*21.7%*	*-24.3%*	*163.3%*	*-61.5%*	*NA*	*-8.4%*
2005 - 2021	*29.2%*	*29.3%*	*23.6%*	*-38.0%*	*89.0%*	*81.2%*	*NA*	*16.9%*
2020 - 2021	*2.4%*	*2.4%*	*-13.1%*	*14.5%*	*32.3%*	*17.6%*	*NA*	*-8.2%*

Table 49 CO_2 Emissions from IPCC sub-category 1 Energy by sub-categories for the period 1990-2021

CO_2 emissions	1 Energy	1.A Fuel Combustion Activities	1.A.1 Energy Industries	1.A.2 Manufacturing Industries and Construction	1.A.3 Transport	1.A.4 Other Sectors	1.A.5 Non-Specified	1.B Fugitive emissions from fuels
	kt							
1990	**1 991.47**	1 990.95	1 137.43	309.77	350.37	193.38	NE	0.52
1991	**2 187.73**	2 187.22	1 155.72	435.11	401.63	194.76	NE	0.51
1992	**1 590.99**	1 590.49	945.75	282.01	247.21	115.52	NE	0.50
1993	**1 394.15**	1 393.72	882.49	213.87	191.23	106.13	NE	0.42
1994	**1 244.36**	1 243.99	704.51	224.45	213.08	101.95	NE	0.37
1995	**606.67**	606.42	40.93	219.16	228.76	117.57	NE	0.25
1996	**1 659.06**	1 658.65	1 000.01	260.12	281.89	116.62	NE	0.41
1997	**1 596.17**	1 595.79	919.10	214.99	297.26	164.44	NE	0.38
1998	**2 035.95**	2 035.48	1 232.28	210.32	419.16	173.72	NE	0.47
1999	**2 091.07**	2 090.62	1 191.97	203.79	519.55	175.31	NE	0.44
2000	**2 181.81**	2 181.35	1 308.26	201.60	517.15	154.33	NE	0.46
2001	**1 750.87**	1 750.52	948.55	207.99	449.61	144.37	NE	0.35
2002	**2 229.64**	2 229.11	1 497.35	199.85	356.63	175.27	NE	0.53
2003	**2 105.19**	2 104.71	1 390.39	169.30	372.43	172.60	NE	0.48
2004	**2 088.16**	2 087.71	1 308.52	174.62	444.09	160.48	NE	0.45
2005	**2 028.58**	2 028.20	1 119.97	378.21	488.94	41.07	NE	0.38
2006	**2 206.74**	2 206.29	1 271.60	382.06	487.36	65.28	NE	0.45
2007	**2 144.56**	2 144.21	994.39	477.40	633.21	39.20	NE	0.35
2008	**2 722.95**	2 722.44	1 525.54	526.85	636.96	33.09	NE	0.51
2009	**1 804.28**	1 804.00	815.79	290.60	656.48	41.12	NE	0.28
2010	**2 633.00**	2 632.43	1 728.33	140.29	723.61	40.20	NE	0.57
2011	**2 564.83**	2 564.25	1 767.40	106.28	670.37	20.20	NE	0.58
2012	**2 380.74**	2 380.21	1 576.71	130.14	646.82	26.54	NE	0.53
2013	**2 331.19**	2 330.69	1 532.99	218.30	536.81	42.59	NE	0.50
2014	**2 286.13**	2 285.64	1 485.55	213.90	515.16	71.03	NE	0.49
2015	**2 423.50**	2 422.97	1 551.59	199.78	588.45	83.15	NE	0.52
2016	**2 215.37**	2 214.96	1 251.00	193.26	692.03	78.68	NE	0.41
2017	**2 337.40**	2 336.97	1 287.37	232.59	748.01	69.00	NE	0.43
2018	**2 587.10**	2 586.63	1 479.31	210.49	823.62	73.21	NE	0.47
2019	**2 684.61**	2 684.14	1 525.97	216.41	867.61	74.16	NE	0.47
2020	**2 561.66**	2 561.17	1 592.32	205.01	700.68	63.15	NE	0.49
2021	**2 620.18**	2 619.73	1 384.06	234.64	926.76	74.27	NE	0.46
Trend								
1990 - 2021	***31.6%***	*31.6%*	*21.7%*	*-24.3%*	*164.5%*	*-61.6%*	*NA*	*-11.8%*
2005 - 2021	***29.2%***	*29.2%*	*23.6%*	*-38.0%*	*89.5%*	*80.8%*	*NA*	*19.4%*
2020 - 2021	***2.3%***	*2.3%*	*-13.1%*	*14.4%*	*32.3%*	*17.6%*	*NA*	*-7.0%*

Table 50 CH_4 Emissions from IPCC sub-category 1 Energy by sub-categories for the period 1990-2021

CH_4 emissions	1 Energy	1.A Fuel Combustion Activities	1.A.1 Energy Industries	1.A.2 Manufacturing Industries and Construction	1.A.3 Transport	1.A.4 Other Sectors	1.A.5 Non-Specified	1.B Fugitive emissions from fuels
	kt CO2 equivalent							
1990	**0.601**	0.160	0.012	0.014	0.109	0.025	NE	0.441
1991	**0.615**	0.176	0.012	0.019	0.121	0.024	NE	0.439
1992	**0.533**	0.118	0.010	0.013	0.080	0.016	NE	0.416
1993	**0.452**	0.092	0.009	0.010	0.059	0.015	NE	0.359
1994	**0.404**	0.096	0.007	0.010	0.065	0.014	NE	0.308
1995	**0.272**	0.095	0.000	0.010	0.068	0.016	NE	0.178
1996	**0.483**	0.121	0.010	0.013	0.083	0.015	NE	0.362
1997	**0.470**	0.134	0.010	0.012	0.092	0.021	NE	0.336
1998	**0.589**	0.171	0.013	0.011	0.126	0.022	NE	0.418
1999	**0.592**	0.193	0.012	0.011	0.148	0.022	NE	0.399
2000	**0.589**	0.174	0.014	0.010	0.129	0.020	NE	0.415
2001	**0.467**	0.149	0.010	0.010	0.110	0.019	NE	0.318
2002	**0.613**	0.134	0.015	0.010	0.086	0.023	NE	0.479
2003	**0.579**	0.146	0.014	0.009	0.101	0.022	NE	0.432
2004	**0.554**	0.148	0.013	0.009	0.105	0.021	NE	0.406
2005	**0.474**	0.127	0.011	0.016	0.094	0.006	NE	0.347
2006	**0.536**	0.134	0.013	0.016	0.097	0.009	NE	0.402
2007	**0.456**	0.139	0.010	0.019	0.104	0.006	NE	0.317
2008	**0.604**	0.140	0.015	0.021	0.099	0.005	NE	0.464
2009	**0.398**	0.143	0.008	0.011	0.118	0.006	NE	0.255
2010	**0.658**	0.141	0.017	0.005	0.112	0.006	NE	0.517
2011	**0.644**	0.118	0.017	0.004	0.087	0.010	NE	0.526
2012	**0.585**	0.110	0.016	0.005	0.078	0.011	NE	0.475
2013	**0.557**	0.105	0.015	0.009	0.068	0.013	NE	0.452
2014	**0.571**	0.129	0.015	0.009	0.089	0.016	NE	0.442
2015	**0.611**	0.140	0.015	0.009	0.097	0.018	NE	0.472
2016	**0.514**	0.142	0.012	0.009	0.104	0.017	NE	0.372
2017	**0.536**	0.147	0.013	0.010	0.108	0.016	NE	0.389
2018	**0.576**	0.150	0.015	0.009	0.110	0.016	NE	0.426
2019	**0.578**	0.156	0.015	0.009	0.115	0.016	NE	0.423
2020	**0.572**	0.130	0.016	0.008	0.091	0.015	NE	0.442
2021	**0.569**	0.164	0.014	0.010	0.122	0.018	NE	0.405
Trend								
1990 - 2021	***-5.3%***	*2.6%*	*13.4%*	*-27.7%*	*12.2%*	*-27.4%*	*NA*	*-8.2%*
2005 - 2021	***20.0%***	*28.7%*	*23.6%*	*-37.4%*	*30.3%*	*188.2%*	*NA*	*16.8%*
2020 - 2021	***-0.5%***	*25.7%*	*-13.1%*	*20.6%*	*34.1%*	*18.2%*	*NA*	*-8.2%*

Table 51 N_2O Emissions from IPCC sub-category 1 Energy by sub-categories for the period 1990-2021

N_2O emissions	1 Energy	1.A Fuel Combustion Activities	1.A.1 Energy Industries	1.A.2 Manufacturing Industries and Construction	1.A.3 Transport	1.A.4 Other Sectors	1.A.5 Non-Specified	1.B Fugitive emissions from fuels
	kt CO2 equivalent							
1990	**0.037**	0.037	0.017	0.003	0.018	<0.001	NE	NO
1991	**0.041**	0.041	0.017	0.004	0.020	<0.001	NE	NO
1992	**0.029**	0.029	0.014	0.002	0.013	<0.001	NE	NO
1993	**0.025**	0.025	0.013	0.002	0.010	<0.001	NE	NO
1994	**0.024**	0.024	0.010	0.002	0.011	<0.001	NE	NO
1995	**0.015**	0.015	0.001	0.002	0.012	<0.001	NE	NO
1996	**0.032**	0.032	0.015	0.002	0.015	<0.001	NE	NO
1997	**0.031**	0.031	0.014	0.002	0.015	<0.001	NE	NO
1998	**0.041**	0.041	0.018	0.002	0.021	<0.001	NE	NO
1999	**0.046**	0.046	0.018	0.002	0.026	<0.001	NE	NO
2000	**0.048**	0.048	0.019	0.002	0.027	<0.001	NE	NO
2001	**0.039**	0.039	0.014	0.002	0.023	<0.001	NE	NO
2002	**0.042**	0.042	0.022	0.002	0.019	<0.001	NE	NO
2003	**0.041**	0.041	0.021	0.002	0.019	<0.001	NE	NO
2004	**0.044**	0.044	0.019	0.002	0.023	<0.001	NE	NO
2005	**0.046**	0.046	0.017	0.003	0.027	<0.001	NE	NO
2006	**0.046**	0.046	0.019	0.003	0.025	<0.001	NE	NO
2007	**0.051**	0.051	0.015	0.004	0.033	<0.001	NE	NO
2008	**0.059**	0.059	0.023	0.004	0.032	<0.001	NE	NO
2009	**0.048**	0.048	0.012	0.002	0.034	<0.001	NE	NO
2010	**0.064**	0.064	0.026	0.001	0.038	<0.001	NE	NO
2011	**0.061**	0.061	0.026	0.001	0.034	<0.001	NE	NO
2012	**0.057**	0.057	0.023	0.001	0.033	<0.001	NE	NO
2013	**0.053**	0.053	0.023	0.002	0.028	<0.001	NE	NO
2014	**0.049**	0.049	0.022	0.002	0.025	<0.001	NE	NO
2015	**0.053**	0.053	0.023	0.002	0.029	<0.001	NE	NO
2016	**0.054**	0.054	0.019	0.002	0.034	<0.001	NE	NO
2017	**0.058**	0.058	0.019	0.002	0.037	<0.001	NE	NO
2018	**0.064**	0.064	0.022	0.002	0.041	<0.001	NE	NO
2019	**0.067**	0.067	0.023	0.002	0.043	<0.001	NE	NO
2020	**0.060**	0.060	0.024	0.002	0.035	<0.001	NE	NO
2021	**0.069**	0.069	0.021	0.002	0.046	<0.001	NE	NO
Trend								
1990 - 2021	*85.7%*	*85.7%*	*23.2%*	*-24.7%*	*159.7%*	*-24.7%*	*NA*	*NA*
2005 - 2021	*49.1%*	*49.1%*	*23.6%*	*-35.9%*	*74.6%*	*-35.9%*	*NA*	*NA*
2020 - 2021	*13.9%*	*13.9%*	*-13.1%*	*18.9%*	*31.8%*	*18.9%*	*NA*	*NA*

2.2.4 Description of emission trends: sector Industrial Processes and Other Product Use (IPPU)

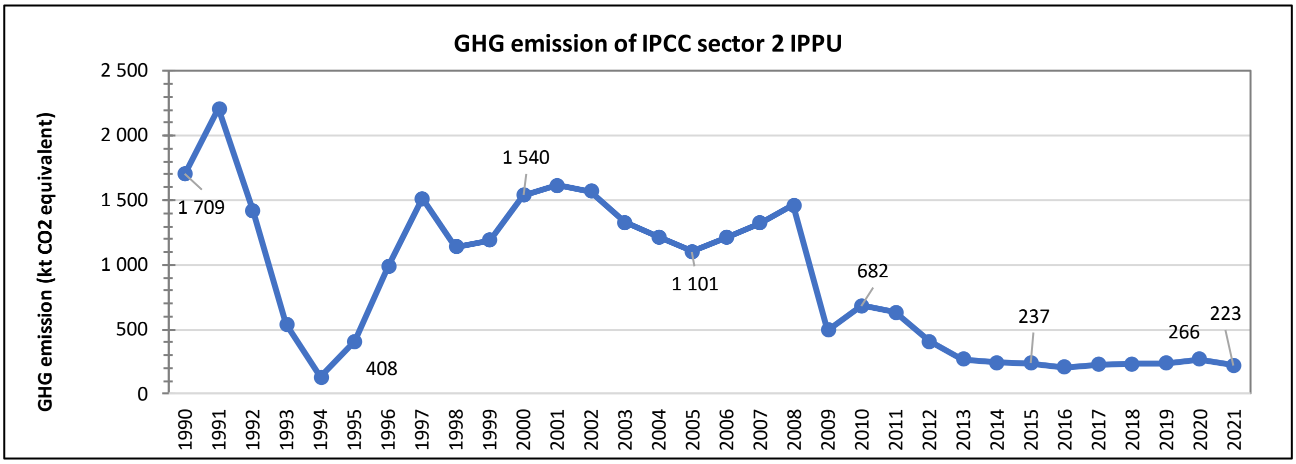


Figure 26 Trend of GHG emissions from IPCC sector 2 IPPU: 1990 – 2021

In 2021 greenhouse gas emissions from sector *Industrial Processes and Other Product Use* amounted to 223.19 kt CO_2 equivalent, which correspond to 7.8% of total national emissions.

The most important sub-categories of this sector are 2.C *Metal industry* (mainly metal/aluminium production and 2.F Consumption of HFC/PFC and SF6, generating 37.5% and 61.0% of total sectoral emissions, respectively. An important greenhouse gas of this sector is CO_2 with a contribution of 26.5% to total sectoral emissions, however emission from the use of HFCs contribute with 60.8% to this sector. Emission from the use of PFCs contribute with 9% and emissions from the use of SF6 contribute with 2.3 to this sector. N_2O does not occur from sector IPPU.

In 2005 greenhouse gas emissions from sector *Industrial Processes and Other Product Use* amounted to 1 100.54 kt CO_2 equivalent, which correspond to 37.6% of total national emissions.

The overall trend in GHG emissions from *Industrial Processes and Other Product Use* is an decrease of -79.7% from 2005 to 2021 due to reduced aluminium production, in the same time increased emissions of HFC.

In 1990 greenhouse gas emissions from sector *Industrial Processes and Other Product Use* amounted to 1 708.51 kt CO_2 equivalent, which correspond to 28.6% of total national emissions.

The most important sub-category of this sector is 2.C *Metal industry* (aluminium production). Important greenhouse gases of this sector are CO_2 with a contribution of 12.5% and PFCs with a contribution of 87.2% to this sector.

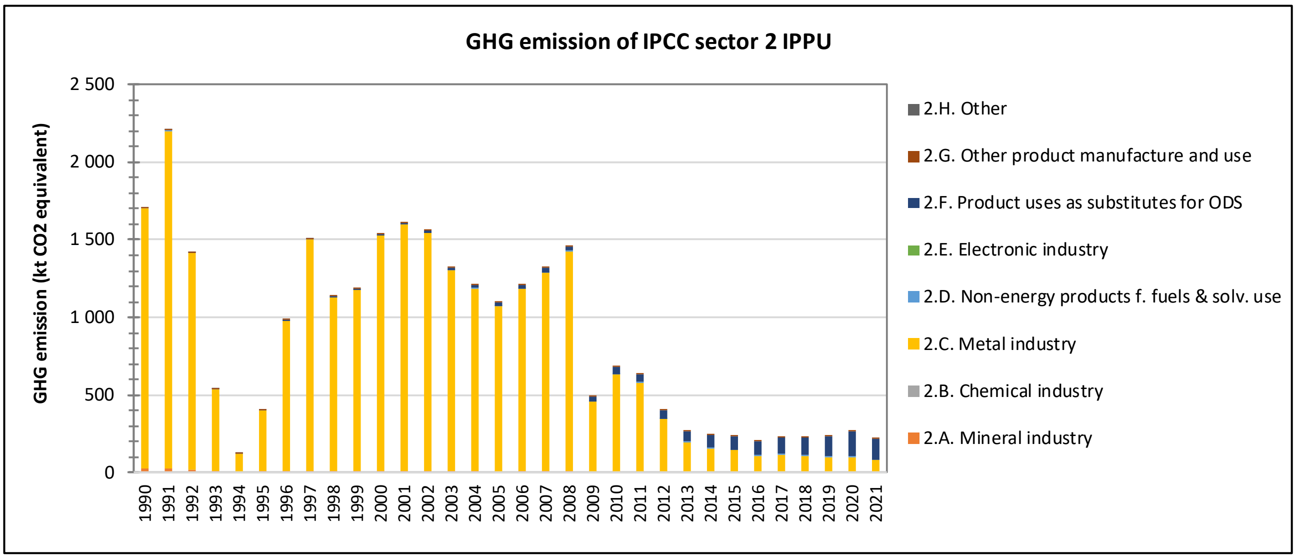


Figure 27 Trend of GHG emissions of IPCC sector 2 IPPU by category for the period 1990 – 2021

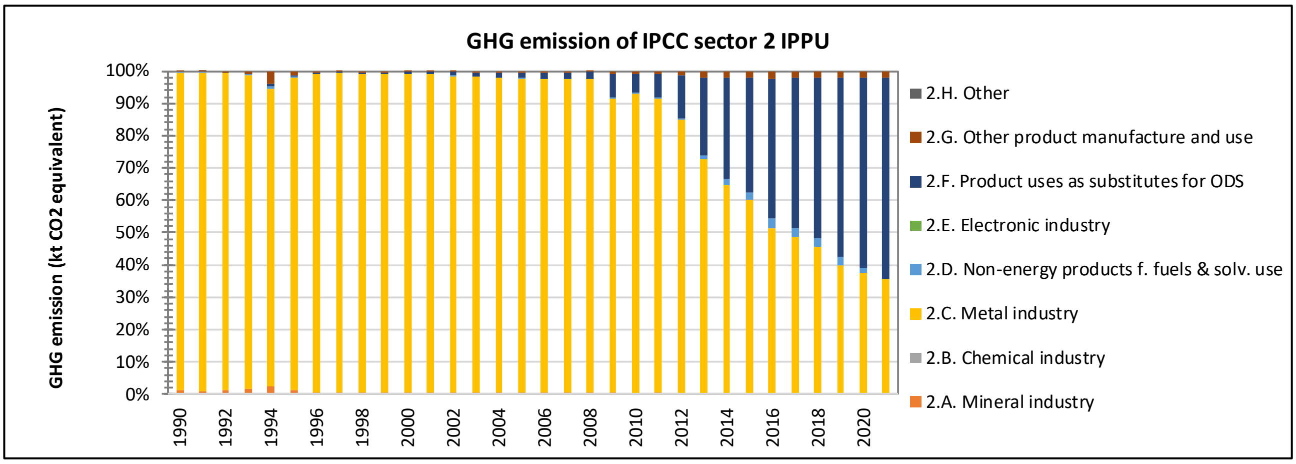


Figure 28 Trend and share GHG emissions of IPCC sector 2 IPPU by category for the period 1990 – 2021

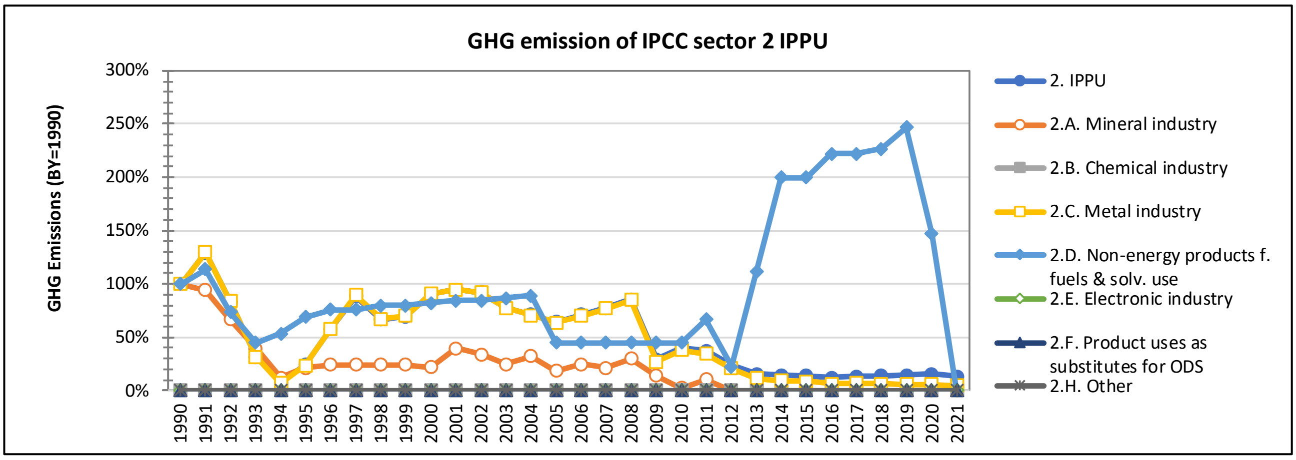


Figure 29 Trend of emissions from IPCC sector 2 IPPU in index form (base year = 100) by category

Table 52 GHG Emissions from IPCC sub-category 2 IPPU by sub-categories for the period 1990-2021

GHG emissions	2 Industrial Processes and Other Product Use (IPPU)	2.A Mineral industry	2.B Chemical industry	2.C Metal industry	2.D Non-energy products from fuels and solvent use	2.E Electronic industry	2.F Product uses as substitutes for ODS	2.G Other product manufacture and use	2.H Other
	kt CO_2 equivalent								
1990	**1 708.51**	24.85	NO	1 675.97	2.65	NA	NA	5.04	NO
1991	**2 208.60**	23.34	NO	2 177.20	3.01	NA	0.01	5.04	NO
1992	**1 422.63**	16.57	NO	1 398.96	1.95	NA	0.12	5.04	NO
1993	**541.07**	9.79	NO	524.72	1.18	NA	0.34	5.04	NO
1994	**129.01**	3.01	NO	118.66	1.42	NA	0.89	5.04	NO
1995	**407.51**	5.27	NO	393.88	1.83	NA	1.50	5.04	NO
1996	**986.15**	6.02	NO	970.82	2.01	NA	2.27	5.04	NO
1997	**1 511.99**	6.02	NO	1 495.77	2.01	NA	3.16	5.04	NO
1998	**1 140.79**	6.02	NO	1 123.45	2.12	NA	4.16	5.04	NO
1999	**1 189.99**	6.02	NO	1 171.57	2.12	NA	5.24	5.04	NO
2000	**1 540.25**	5.36	NO	1 521.35	2.18	NA	6.32	5.04	NO
2001	**1 613.78**	9.78	NO	1 589.32	2.24	NA	7.40	5.04	NO
2002	**1 567.61**	8.38	NO	1 535.75	2.24	NA	16.20	5.04	NO
2003	**1 328.43**	6.13	NO	1 297.72	2.30	NA	17.24	5.04	NO
2004	**1 213.16**	7.98	NO	1 179.57	2.36	NA	18.28	5.04	NO
2005	**1 100.54**	4.52	NO	1 070.17	1.18	NA	19.68	5.04	NO
2006	**1 210.95**	6.11	NO	1 176.34	1.18	NA	22.38	5.04	NO
2007	**1 322.70**	5.34	NO	1 285.12	1.18	NA	26.11	5.04	NO
2008	**1 463.79**	7.41	NO	1 419.58	1.18	NA	30.68	5.04	NO
2009	**495.03**	3.39	NO	449.67	1.18	NA	35.85	5.04	NO
2010	**681.62**	0.63	NO	633.23	1.18	NA	41.62	5.04	NO
2011	**634.32**	2.60	NO	577.24	1.77	NA	47.76	5.04	NO
2012	**404.66**	NO	NO	344.41	0.59	NA	54.72	5.04	NO
2013	**267.29**	NO	NO	194.37	2.95	NA	65.02	5.04	NO
2014	**242.16**	NO	NO	156.26	5.31	NA	75.63	5.04	NO
2015	**236.98**	NO	NO	142.95	5.31	NA	83.77	5.04	NO
2016	**208.13**	NO	NO	107.16	5.90	NA	90.11	5.04	NO
2017	**229.31**	NO	NO	111.79	5.90	NA	106.67	5.04	NO
2018	**231.23**	NO	NO	105.21	6.01	NA	115.04	5.04	NO
2019	**239.75**	NO	NO	95.36	6.54	NA	132.88	5.04	NO
2020	**266.19**	NO	NO	99.88	3.89	NA	157.45	5.04	NO
2021	**223.19**	NO	NO	79.43	0.00	NA	138.80	5.04	NO
Trend									
1990 - 2021	*-86.9%*	*NA*	*NA*	*-95.3%*	*-99.9%*	*NA*	*NA*	*0.0%*	*NA*
2005 - 2021	*-79.7%*	*NA*	*NA*	*-92.6%*	*-99.9%*	*NA*	*605.4%*	*0.0%*	*NA*
2020 - 2021	*-16.2%*	*NA*	*NA*	*-20.5%*	*-100.0%*	*NA*	*-11.8%*	*0.0%*	*NA*

Table 53 CO_2 Emissions from IPCC sub-category 2 IPPU by sub-categories for the period 1990-2021

CO_2 emissions	2 Industrial Processes and Other Product Use (IPPU)	2.A Mineral industry	2.B Chemical industry	2.C Metal industry	2.D Non-energy products from fuels and solvent use	2.E Electronic industry	2.F Product uses as substitutes for ODS	2.G Other product manufacture and use	2.H Other
	kt								
1990	**212.78**	24.85	NO	185.28	2.65	NA	NA	NA	NO
1991	**205.79**	23.34	NO	179.43	3.01	NA	NA	NA	NO
1992	**172.60**	16.57	NO	154.08	1.95	NA	NA	NA	NO
1993	**81.16**	9.79	NO	70.19	1.18	NA	NA	NA	NO
1994	**31.77**	3.01	NO	27.34	1.42	NA	NA	NA	NO
1995	**55.90**	5.27	NO	48.80	1.83	NA	NA	NA	NO
1996	**97.95**	6.02	NO	89.92	2.01	NA	NA	NA	NO
1997	**147.58**	6.02	NO	139.55	2.01	NA	NA	NA	NO
1998	**141.95**	6.02	NO	133.81	2.12	NA	NA	NA	NO
1999	**144.65**	6.02	NO	136.51	2.12	NA	NA	NA	NO
2000	**167.16**	5.36	NO	159.62	2.18	NA	NA	NA	NO
2001	**193.80**	9.78	NO	181.78	2.24	NA	NA	NA	NO
2002	**203.62**	8.38	NO	193.00	2.24	NA	NA	NA	NO
2003	**205.49**	6.13	NO	197.06	2.30	NA	NA	NA	NO
2004	**215.62**	7.98	NO	205.29	2.36	NA	NA	NA	NO
2005	**206.49**	4.52	NO	200.79	1.18	NA	NA	NA	NO
2006	**215.08**	6.11	NO	207.78	1.18	NA	NA	NA	NO
2007	**219.20**	5.34	NO	212.68	1.18	NA	NA	NA	NO
2008	**202.88**	7.41	NO	194.29	1.18	NA	NA	NA	NO
2009	**114.25**	3.39	NO	109.68	1.18	NA	NA	NA	NO
2010	**137.77**	0.63	NO	135.96	1.18	NA	NA	NA	NO
2011	**158.45**	2.60	NO	154.08	1.77	NA	NA	NA	NO
2012	**121.70**	NO	NO	121.11	0.59	NA	NA	NA	NO
2013	**81.84**	NO	NO	78.90	2.95	NA	NA	NA	NO
2014	**74.88**	NO	NO	69.57	5.31	NA	NA	NA	NO
2015	**76.23**	NO	NO	70.93	5.31	NA	NA	NA	NO
2016	**67.39**	NO	NO	61.49	5.90	NA	NA	NA	NO
2017	**72.47**	NO	NO	66.57	5.90	NA	NA	NA	NO
2018	**73.82**	NO	NO	67.81	6.01	NA	NA	NA	NO
2019	**67.80**	NO	NO	61.25	6.54	NA	NA	NA	NO
2020	**68.20**	NO	NO	64.31	3.89	NA	NA	NA	NO
2021	**59.18**	NO	NO	59.18	0.00	NA	NA	NA	NO
Trend									
1990 - 2021	*-72.2%*	*NA*	*NA*	*-68.1%*	*-99.9%*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*-71.3%*	*NA*	*NA*	*-70.5%*	*-99.9%*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*-13.2%*	*NA*	*NA*	*-8.0%*	*-100.0%*	*NA*	*NA*	*NA*	*NA*

Table 54 CH_4 Emissions from IPCC sub-category 2 IPPU by sub-categories for the period 1990-2021

CH_4 emissions	2 Industrial Processes and Other Product Use (IPPU)	2.A Mineral industry	2.B Chemical industry	2.C Metal industry	2.D Non-energy products from fuels and solvent use	2.E Electronic industry	2.F Product uses as substitutes for ODS	2.G Other product manufacture and use	2.H Other
	kt								
1990	0.0021	NO	NO	0.0021	NA	NA	NA	NE	NO
1991	0.0020	NO	NO	0.0020	NA	NA	NA	NE	NO
1992	0.0014	NO	NO	0.0014	NA	NA	NA	NE	NO
1993	0.0012	NO	NO	0.0012	NA	NA	NA	NE	NO
1994	0.0011	NO	NO	0.0011	NA	NA	NA	NE	NO
1995	0.0009	NO	NO	0.0009	NA	NA	NA	NE	NO
1996	0.0010	NO	NO	0.0010	NA	NA	NA	NE	NO
1997	0.0013	NO	NO	0.0013	NA	NA	NA	NE	NO
1998	0.0014	NO	NO	0.0014	NA	NA	NA	NE	NO
1999	0.0009	NO	NO	0.0009	NA	NA	NA	NE	NO
2000	0.0008	NO	NO	0.0008	NA	NA	NA	NE	NO
2001	0.0011	NO	NO	0.0011	NA	NA	NA	NE	NO
2002	0.0008	NO	NO	0.0008	NA	NA	NA	NE	NO
2003	0.0006	NO	NO	0.0006	NA	NA	NA	NE	NO
2004	0.0015	NO	NO	0.0015	NA	NA	NA	NE	NO
2005	0.0010	NO	NO	0.0010	NA	NA	NA	NE	NO
2006	0.0016	NO	NO	0.0016	NA	NA	NA	NE	NO
2007	0.0017	NO	NO	0.0017	NA	NA	NA	NE	NO
2008	0.0020	NO	NO	0.0020	NA	NA	NA	NE	NO
2009	0.0010	NO	NO	0.0010	NA	NA	NA	NE	NO
2010	0.0005	NO	NO	0.0005	NA	NA	NA	NE	NO
2011	0.0006	NO	NO	0.0006	NA	NA	NA	NE	NO
2012	0.0003	NO	NO	0.0003	NA	NA	NA	NE	NO
2013	0.0002	NO	NO	0.0002	NA	NA	NA	NE	NO
2014	0.0001	NO	NO	0.0001	NA	NA	NA	NE	NO
2015	0.0004	NO	NO	0.0004	NA	NA	NA	NE	NO
2016	0.0005	NO	NO	0.0005	NA	NA	NA	NE	NO
2017	0.0005	NO	NO	0.0005	NA	NA	NA	NE	NO
2018	0.0005	NO	NO	0.0005	NA	NA	NA	NE	NO
2019	0.0002	NO	NO	0.0002	NA	NA	NA	NE	NO
2020	0.0003	NO	NO	0.0003	NA	NA	NA	NE	NO
2021	<0.0001	NO	NO	<0.0001	NA	NA	NA	NE	NO
Trend									
1990 - 2021	*-98.5%*	*NA*	*NA*	*-98.5%*	*-98.5%*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*-97.0%*	*NA*	*NA*	*-97.0%*	*-97.0%*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*-91.1%*	*NA*	*NA*	*-91.1%*	*-91.1%*	*NA*	*NA*	*NA*	*NA*

Table 55 Emissions of HFCs, PFCs and SF6 from IPCC sub-category 2 IPPU by sub-categories

GHG emissions	2 Industrial Processes and Other Product Use (IPPU)	2.A Mineral industry	2.B Chemical industry	2.C Metal industry	2.D Non-energy products from fuels and solvent use	2.E Electronic industry	2.F Product uses as substitutes for ODS	2.G Other product manufacture and use	2.H Other
	GHG			PFCs			HFCs	SF6	
	kt CO_2 equivalent								
1990	**1 495.67**	NA	NO	1 490.64	NA	NO	NA	5.04	NA
1991	**2 002.76**	NA	NO	1 997.72	NA	NO	0.01	5.04	NA
1992	**1 250.00**	NA	NO	1 244.84	NA	NO	0.12	5.04	NA
1993	**459.88**	NA	NO	454.50	NA	NO	0.34	5.04	NA
1994	**97.21**	NA	NO	91.29	NA	NO	0.89	5.04	NA
1995	**351.59**	NA	NO	345.05	NA	NO	1.50	5.04	NA
1996	**888.17**	NA	NO	880.87	NA	NO	2.27	5.04	NA
1997	**1 364.38**	NA	NO	1 356.19	NA	NO	3.16	5.04	NA
1998	**998.80**	NA	NO	989.61	NA	NO	4.16	5.04	NA
1999	**1 045.31**	NA	NO	1 035.04	NA	NO	5.24	5.04	NA
2000	**1 373.06**	NA	NO	1 361.71	NA	NO	6.32	5.04	NA
2001	**1 419.95**	NA	NO	1 407.51	NA	NO	7.40	5.04	NA
2002	**1 363.97**	NA	NO	1 342.74	NA	NO	16.20	5.04	NA
2003	**1 122.92**	NA	NO	1 100.65	NA	NO	17.24	5.04	NA
2004	**997.50**	NA	NO	974.19	NA	NO	18.28	5.04	NA
2005	**893.97**	NA	NO	869.31	NA	NO	19.62	5.04	NA
2006	**995.68**	NA	NO	968.42	NA	NO	22.23	5.04	NA
2007	**1 103.18**	NA	NO	1 072.31	NA	NO	25.83	5.04	NA
2008	**1 260.44**	NA	NO	1 225.15	NA	NO	30.25	5.04	NA
2009	**380.16**	NA	NO	339.87	NA	NO	35.25	5.04	NA
2010	**543.04**	NA	NO	497.18	NA	NO	40.83	5.04	NA
2011	**474.85**	NA	NO	423.06	NA	NO	46.76	5.04	NA
2012	**281.72**	NA	NO	223.21	NA	NO	53.48	5.04	NA
2013	**183.89**	NA	NO	115.39	NA	NO	63.46	5.04	NA
2014	**165.34**	NA	NO	86.61	NA	NO	73.70	5.04	NA
2015	**158.63**	NA	NO	71.93	NA	NO	81.66	5.04	NA
2016	**138.41**	NA	NO	45.58	NA	NO	87.79	5.04	NA
2017	**153.73**	NA	NO	45.13	NA	NO	103.56	5.04	NA
2018	**153.84**	NA	NO	37.32	NA	NO	111.49	5.04	NA
2019	**168.77**	NA	NO	34.03	NA	NO	129.70	5.04	NA
2020	**193.25**	NA	NO	35.49	NA	NO	152.72	5.04	NA
2021	**160.82**	NA	NO	20.18	NA	NO	135.60	5.04	NA
Trend									
1990 - 2021	***-89.2%***	*NA*	*NA*	-98.6%	*NA*	*NA*	NA	*0.0%*	*NA*
2005 - 2021	***-82.0%***	*NA*	*NA*	-97.7%	*NA*	*NA*	591.2%	*0.0%*	*NA*

GHG emissions	2 Industrial Processes and Other Product Use (IPPU)	2.A Mineral industry	2.B Chemical industry	2.C Metal industry	2.D Non-energy products from fuels and solvent use	2.E Electronic industry	2.F Product uses as substitutes for ODS	2.G Other product manufacture and use	2.H Other
	GHG			PFCs			HFCs	SF6	
	kt CO_2 equivalent								
2020 - 2021	***-16.8%***	*NA*	*NA*	-43.1%	*NA*	*NA*	-11.2%	*0.0%*	*NA*

2.2.5 Description of emission trends: sector 3 Agriculture

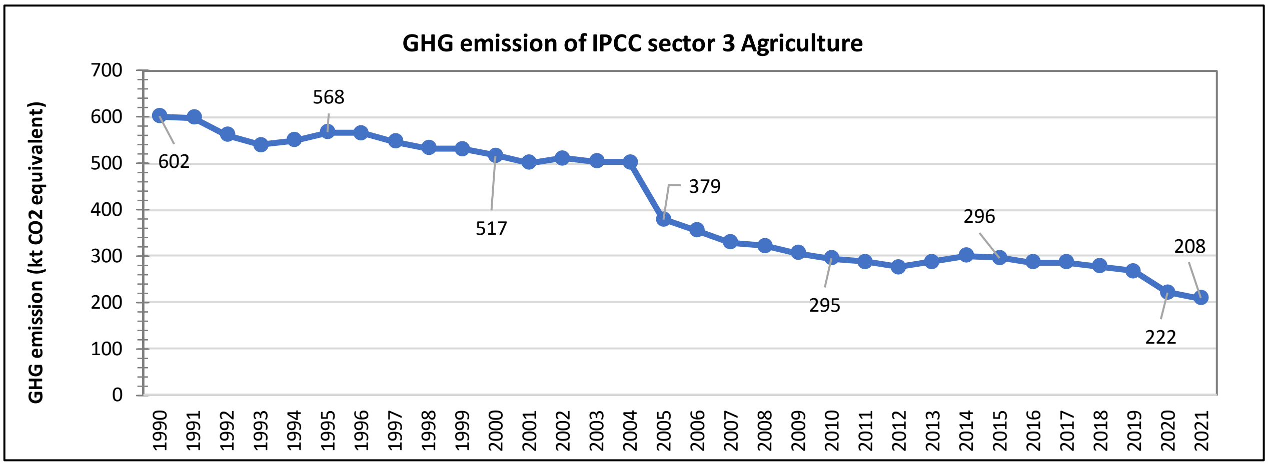


Figure 30 Trend of GHG emission of IPCC sector 3 Agriculture for the period 1990 – 2021

In **2021**, greenhouse gas emissions from IPCC sector 3 *Agriculture* amounted to 208.40 kt CO2 equivalent, which correspond to 6.5% of total national emissions.

In **2005**, greenhouse gas emissions from IPCC sector 3 *Agriculture* amounted to 379.41 kt CO2 equivalent, which correspond to 9.9% of total national emissions.

In **1990**, greenhouse gas emissions from IPCC sector 3 *Agriculture* amounted to 601.90kt CO2 equivalent, which correspond to 13.3% of total national emissions.

The most important sub-categories of this sector are *3.A Enteric fermentation* and *3.B Manure Management*. IPCC sector 3 *Agriculture* is the largest source of national N_2O and CH_4 emissions.

The overall trend in GHG emissions from *Agriculture* shows a decrease of -65.4% from 1990 to 2021 and -45.1% from 2005 to 2021. The main drivers for this trend are decreasing livestock.

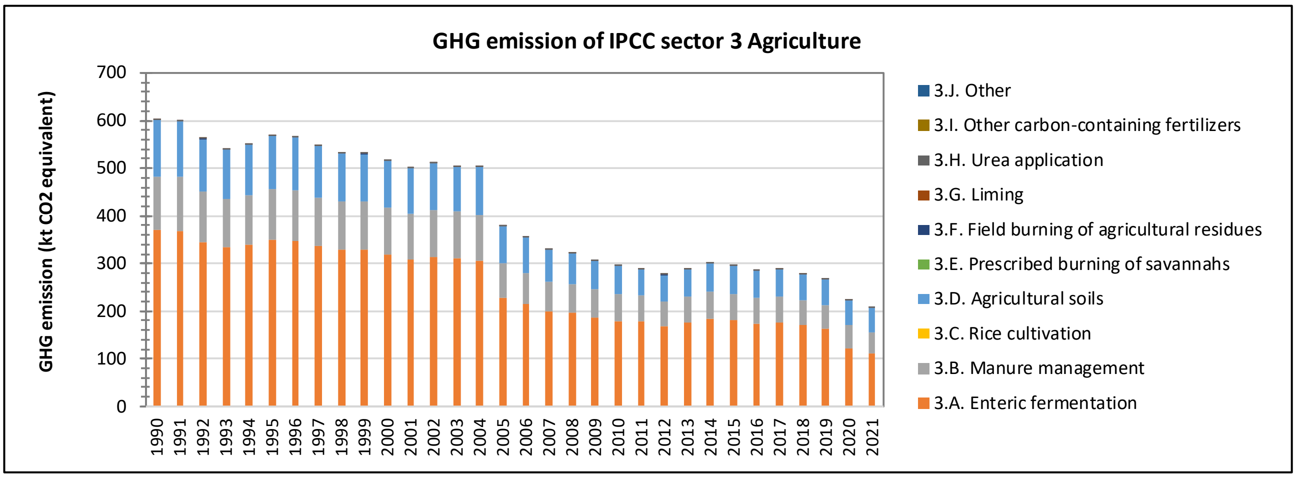


Figure 31 Trend of GHG emission of IPCC sector 3 Agriculture by category for the period 1990 – 2021

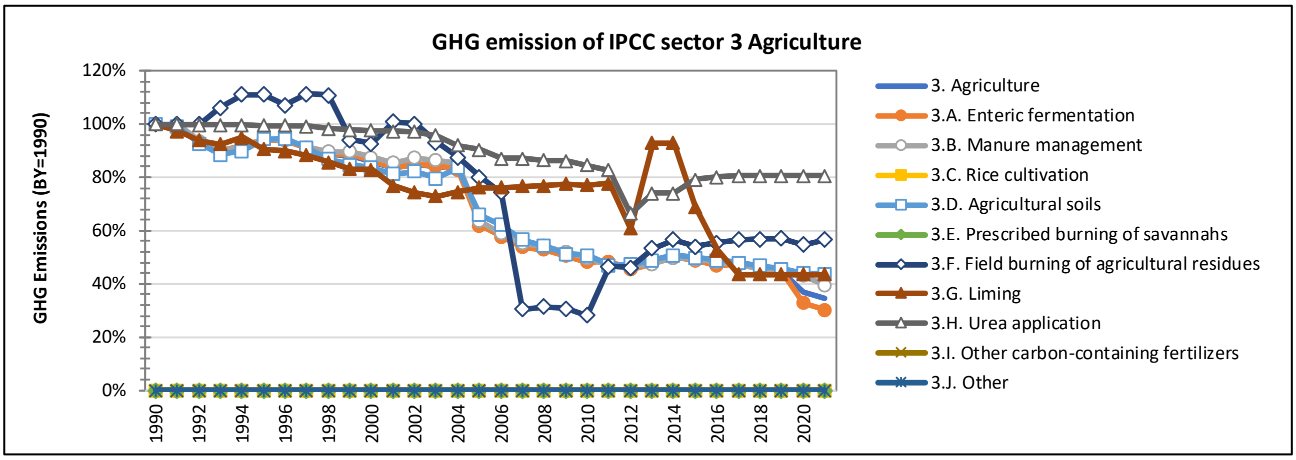


Figure 32 Trend of emissions from IPCC sector 3 Agriculture in index form (base year = 100) by category for the period 1990 – 2021

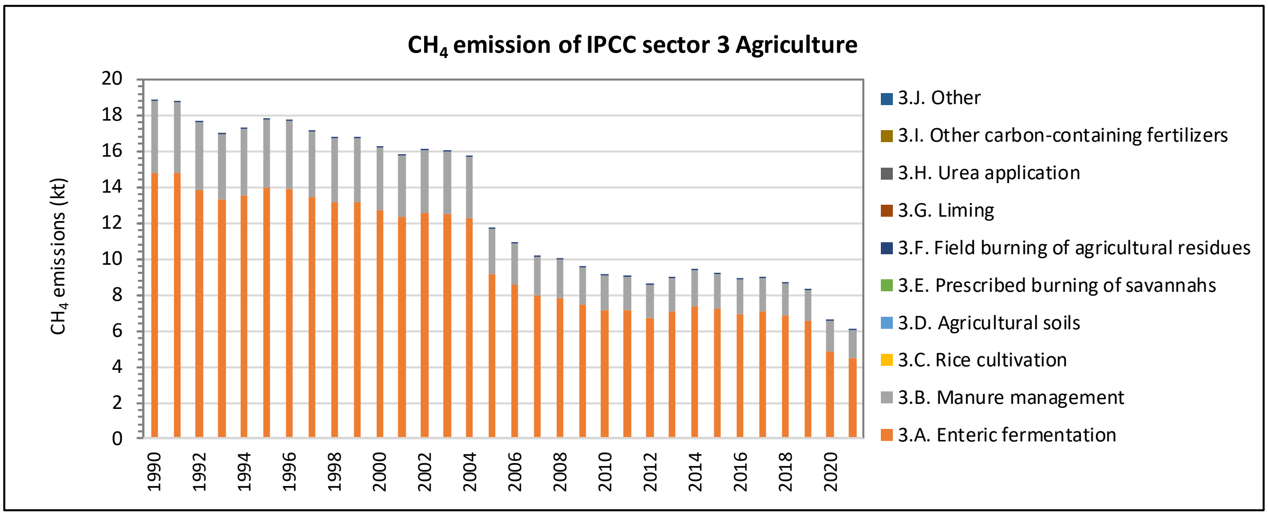


Figure 33 Trend of CH_4 emission of IPCC sector 3 Agriculture by category for the period 1990 – 2021

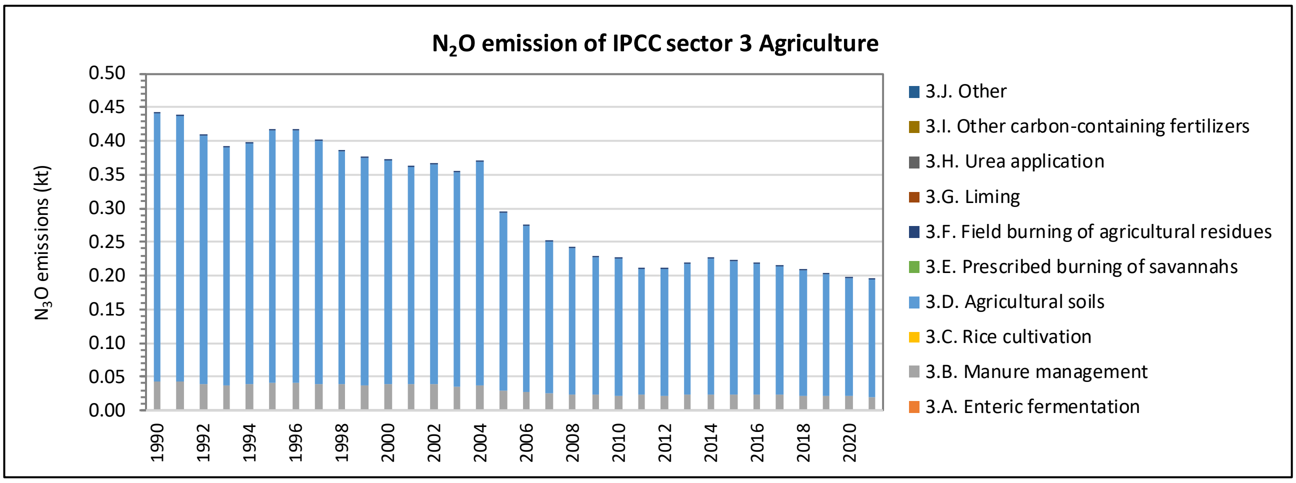


Figure 34 Trend of N_2O emission of IPCC sector 3 Agriculture by category for the period 1990 – 2021

Table 56 GHG Emissions from IPCC sub-category 3 Agriculture by sub-categories for the period 1990-2021

GHG emissions	3 Agriculture	3.A Enteric Fermentation	3.B Manure Management	3.C Rice Cultivation	3.D Agricultural soils	3.E Prescribed burning of savannas	3.F Field burning of agricultural residues	3. Liming	3.H Urea application	3.I Other carbon-containing fertilizers	3.J Other
	kt $_{CO_2\ equivalent}$										
1990	**601.90**	370.03	112.53	NO	118.80	NO	0.05	0.06	0.43	NO	NO
1991	**599.19**	369.00	112.02	NO	117.64	NO	0.05	0.06	0.42	NO	NO
1992	**561.91**	345.94	105.33	NO	110.10	NO	0.05	0.06	0.42	NO	NO
1993	**540.24**	333.40	101.30	NO	105.00	NO	0.05	0.06	0.42	NO	NO
1994	**549.32**	339.08	103.06	NO	106.65	NO	0.05	0.06	0.42	NO	NO
1995	**567.80**	348.96	106.20	NO	112.11	NO	0.05	0.06	0.42	NO	NO
1996	**565.85**	347.17	105.86	NO	112.28	NO	0.05	0.06	0.42	NO	NO
1997	**547.08**	335.68	102.69	NO	108.17	NO	0.06	0.06	0.42	NO	NO
1998	**532.93**	328.42	100.86	NO	103.12	NO	0.05	0.06	0.42	NO	NO
1999	**530.74**	328.58	100.90	NO	100.74	NO	0.05	0.05	0.42	NO	NO
2000	**516.79**	318.62	98.45	NO	99.20	NO	0.05	0.05	0.42	NO	NO
2001	**501.61**	308.49	96.10	NO	96.49	NO	0.05	0.05	0.41	NO	NO
2002	**511.00**	314.67	98.20	NO	97.62	NO	0.05	0.05	0.41	NO	NO
2003	**504.47**	312.20	97.13	NO	94.64	NO	0.05	0.05	0.41	NO	NO
2004	**502.25**	306.48	96.12	NO	99.16	NO	0.04	0.05	0.39	NO	NO
2005	**379.41**	229.13	71.48	NO	78.31	NO	0.04	0.05	0.38	NO	NO
2006	**354.44**	213.79	66.30	NO	73.89	NO	0.04	0.05	0.37	NO	NO
2007	**328.65**	199.07	61.96	NO	67.20	NO	0.02	0.05	0.37	NO	NO
2008	**321.64**	195.77	61.04	NO	64.40	NO	0.02	0.05	0.37	NO	NO
2009	**306.25**	186.60	58.40	NO	60.82	NO	0.02	0.05	0.37	NO	NO
2010	**295.17**	178.36	56.05	NO	60.33	NO	0.01	0.05	0.36	NO	NO
2011	**288.01**	179.10	52.73	NO	55.76	NO	0.02	0.05	0.35	NO	NO
2012	**276.26**	167.71	51.98	NO	56.24	NO	0.02	0.04	0.28	NO	NO
2013	**288.11**	176.26	53.36	NO	58.08	NO	0.03	0.06	0.31	NO	NO
2014	**301.28**	184.76	55.95	NO	60.16	NO	0.03	0.06	0.31	NO	NO
2015	**295.91**	180.91	55.53	NO	59.06	NO	0.03	0.04	0.34	NO	NO
2016	**286.23**	173.38	54.33	NO	58.12	NO	0.03	0.03	0.34	NO	NO
2017	**286.76**	176.41	53.12	NO	56.83	NO	0.03	0.03	0.34	NO	NO
2018	**277.92**	170.60	51.42	NO	55.50	NO	0.03	0.03	0.34	NO	NO
2019	**268.14**	163.50	50.09	NO	54.15	NO	0.03	0.03	0.34	NO	NO

GHG emissions	3 Agriculture	3.A Enteric Fermentation	3.B Manure Management	3.C Rice Cultivation	3.D Agricultural soils	3.E Prescribed burning of savannas	3.F Field burning of agricultural residues	3. Liming	3.H Urea application	3.I Other carbon-containing fertilizers	3.J Other
	kt $_{CO_2\ equivalent}$										
2020	**222.12**	121.32	48.30	NO	52.11	NO	0.03	0.03	0.34	NO	NO
2021	**208.40**	111.59	44.54	NO	51.87	NO	0.03	0.03	0.34	NO	NO
Trend											
1990 - 2021	*-65.4%*	*-69.8%*	*-60.4%*	*NA*	*-56.3%*	*NA*	*-43.5%*	*-56.4%*	*-19.4%*	*NA*	*NA*
2005 - 2021	*-45.1%*	*-51.3%*	*-37.7%*	*NA*	*-33.8%*	*NA*	*-29.4%*	*-42.7%*	*-10.8%*	*NA*	*NA*
2020 - 2021	*-6.2%*	*-8.0%*	*-7.8%*	*NA*	*-0.5%*	*NA*	*3.6%*	*0.0%*	*0.0%*	*NA*	*NA*

Table 57 CO_2 Emissions from IPCC sub-category 3 Agriculture by sub-categories for the period 1990-2021

CO_2 emissions	3 Agriculture	3.A Enteric Fermentation	3.B Manure Management	3.C Rice Cultivation	3.D Agricultural soils	3.E Prescribed burning of savannas	3.F Field burning of agricultural residues	3. Liming	3.H Urea application	3.I Other carbon-containing fertilizers	3.J Other
	kt										
1990	**0.490**	NA	NA	NA	NA	NA	NA	0.065	0.425	NO	NO
1991	**0.488**	NA	NA	NA	NA	NA	NA	0.063	0.425	NO	NO
1992	**0.485**	NA	NA	NA	NA	NA	NA	0.061	0.424	NO	NO
1993	**0.484**	NA	NA	NA	NA	NA	NA	0.060	0.424	NO	NO
1994	**0.485**	NA	NA	NA	NA	NA	NA	0.062	0.424	NO	NO
1995	**0.482**	NA	NA	NA	NA	NA	NA	0.059	0.423	NO	NO
1996	**0.481**	NA	NA	NA	NA	NA	NA	0.058	0.423	NO	NO
1997	**0.479**	NA	NA	NA	NA	NA	NA	0.057	0.422	NO	NO
1998	**0.473**	NA	NA	NA	NA	NA	NA	0.055	0.418	NO	NO
1999	**0.470**	NA	NA	NA	NA	NA	NA	0.054	0.416	NO	NO
2000	**0.469**	NA	NA	NA	NA	NA	NA	0.054	0.415	NO	NO
2001	**0.464**	NA	NA	NA	NA	NA	NA	0.050	0.414	NO	NO
2002	**0.461**	NA	NA	NA	NA	NA	NA	0.048	0.413	NO	NO
2003	**0.454**	NA	NA	NA	NA	NA	NA	0.047	0.407	NO	NO
2004	**0.440**	NA	NA	NA	NA	NA	NA	0.048	0.392	NO	NO
2005	**0.434**	NA	NA	NA	NA	NA	NA	0.049	0.384	NO	NO
2006	**0.420**	NA	NA	NA	NA	NA	NA	0.049	0.370	NO	NO
2007	**0.420**	NA	NA	NA	NA	NA	NA	0.050	0.370	NO	NO
2008	**0.417**	NA	NA	NA	NA	NA	NA	0.050	0.367	NO	NO

CO_2 emissions	3 Agriculture	3.A Enteric Fermentation	3.B Manure Management	3.C Rice Cultivation	3.D Agricultural soils	3.E Prescribed burning of savannas	3.F Field burning of agricultural residues	3. Liming	3.H Urea application	3.I Other carbon-containing fertilizers	3.J Other
	kt										
2009	**0.417**	NA	NA	NA	NA	NA	NA	0.050	0.367	NO	NO
2010	**0.409**	NA	NA	NA	NA	NA	NA	0.050	0.359	NO	NO
2011	**0.402**	NA	NA	NA	NA	NA	NA	0.050	0.352	NO	NO
2012	**0.322**	NA	NA	NA	NA	NA	NA	0.039	0.282	NO	NO
2013	**0.375**	NA	NA	NA	NA	NA	NA	0.060	0.315	NO	NO
2014	**0.375**	NA	NA	NA	NA	NA	NA	0.060	0.315	NO	NO
2015	**0.382**	NA	NA	NA	NA	NA	NA	0.045	0.337	NO	NO
2016	**0.375**	NA	NA	NA	NA	NA	NA	0.034	0.341	NO	NO
2017	**0.371**	NA	NA	NA	NA	NA	NA	0.028	0.343	NO	NO
2018	**0.371**	NA	NA	NA	NA	NA	NA	0.028	0.343	NO	NO
2019	**0.371**	NA	NA	NA	NA	NA	NA	0.028	0.343	NO	NO
2020	**0.371**	NA	NA	NA	NA	NA	NA	0.028	0.343	NO	NO
2021	**0.371**	NA	NA	NA	NA	NA	NA	0.028	0.343	NO	NO
Trend											
1990 - 2021	*-24.3%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*-56.4%*	*-19.4%*	*NA*	*NA*
2005 - 2021	*-14.4%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*-42.7%*	*-10.8%*	*NA*	*NA*
2020 - 2021	*0.0%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*0.0%*	*0.0%*	*NA*	*NA*

Table 58 CH_4 Emissions from IPCC sub-category 3 Agriculture by sub-categories for the period 1990-2021

CH4 emissions	3 Agriculture	3.A Enteric Fermentation	3.B Manure Management	3.C Rice Cultivation	3.D Agricultural soils	3.E Prescribed burning of savannas	3.F Field burning of agricultural residues	3. Liming	3.H Urea application	3.I Other carbon-containing fertilizers	3.J Other
	kt										
1990	**18.79**	14.80	3.99	NO	NA	NO	0.0015	NA	NA	NO	NO
1991	**18.74**	14.76	3.98	NO	NA	NO	0.0015	NA	NA	NO	NO
1992	**17.58**	13.84	3.74	NO	NA	NO	0.0015	NA	NA	NO	NO
1993	**16.94**	13.34	3.60	NO	NA	NO	0.0016	NA	NA	NO	NO
1994	**17.23**	13.56	3.67	NO	NA	NO	0.0017	NA	NA	NO	NO
1995	**17.73**	13.96	3.77	NO	NA	NO	0.0017	NA	NA	NO	NO
1996	**17.65**	13.89	3.76	NO	NA	NO	0.0016	NA	NA	NO	NO
1997	**17.08**	13.43	3.65	NO	NA	NO	0.0017	NA	NA	NO	NO
1998	**16.72**	13.14	3.58	NO	NA	NO	0.0017	NA	NA	NO	NO
1999	**16.74**	13.14	3.59	NO	NA	NO	0.0014	NA	NA	NO	NO

CH4 emissions	3 Agriculture	3.A Enteric Fermentation	3.B Manure Management	3.C Rice Cultivation	3.D Agricultural soils	3.E Prescribed burning of savannas	3.F Field burning of agricultural residues	3. Liming	3.H Urea application	3.I Other carbon-containing fertilizers	3.J Other
	kt										
2000	**16.22**	12.74	3.48	NO	NA	NO	0.0014	NA	NA	NO	NO
2001	**15.73**	12.34	3.39	NO	NA	NO	0.0015	NA	NA	NO	NO
2002	**16.06**	12.59	3.47	NO	NA	NO	0.0015	NA	NA	NO	NO
2003	**15.95**	12.49	3.46	NO	NA	NO	0.0014	NA	NA	NO	NO
2004	**15.67**	12.26	3.41	NO	NA	NO	0.0013	NA	NA	NO	NO
2005	**11.67**	9.17	2.50	NO	NA	NO	0.0012	NA	NA	NO	NO
2006	**10.88**	8.55	2.33	NO	NA	NO	0.0011	NA	NA	NO	NO
2007	**10.13**	7.96	2.17	NO	NA	NO	0.0005	NA	NA	NO	NO
2008	**9.98**	7.83	2.15	NO	NA	NO	0.0005	NA	NA	NO	NO
2009	**9.53**	7.46	2.06	NO	NA	NO	0.0005	NA	NA	NO	NO
2010	**9.11**	7.13	1.98	NO	NA	NO	0.0004	NA	NA	NO	NO
2011	**9.01**	7.16	1.84	NO	NA	NO	0.0007	NA	NA	NO	NO
2012	**8.53**	6.71	1.82	NO	NA	NO	0.0007	NA	NA	NO	NO
2013	**8.92**	7.05	1.87	NO	NA	NO	0.0008	NA	NA	NO	NO
2014	**9.35**	7.39	1.96	NO	NA	NO	0.0009	NA	NA	NO	NO
2015	**9.18**	7.24	1.94	NO	NA	NO	0.0008	NA	NA	NO	NO
2016	**8.83**	6.94	1.90	NO	NA	NO	0.0008	NA	NA	NO	NO
2017	**8.91**	7.06	1.85	NO	NA	NO	0.0009	NA	NA	NO	NO
2018	**8.63**	6.82	1.80	NO	NA	NO	0.0009	NA	NA	NO	NO
2019	**8.29**	6.54	1.75	NO	NA	NO	0.0009	NA	NA	NO	NO
2020	**6.54**	4.85	1.69	NO	NA	NO	0.0008	NA	NA	NO	NO
2021	**6.01**	4.46	1.55	NO	NA	NO	0.0009	NA	NA	NO	NO
Trend											
1990 - 2021	*-68.0%*	*-69.8%*	*-61.2%*	*NA*	*NA*	*NA*	*-43.5%*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*-48.5%*	*-51.3%*	*-38.1%*	*NA*	*NA*	*NA*	*-29.4%*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*-8.1%*	*-8.0%*	*-8.2%*	*NA*	*NA*	*NA*	*3.6%*	*NA*	*NA*	*NA*	*NA*

Table 59 N_2O Emissions from IPCC sub-category 3 Agriculture by sub-categories for the period 1990-2021

N_2O emissions	3 Agriculture	3.A Enteric Fermentation	3.B Manure Management	3.C Rice Cultivation	3.D Agricultural soils	3.E Prescribed burning of savannas	3.F Field burning of agricultural residues	3. Liming	3.H Urea application	3.I Other carbon-containing fertilizers	3.J Other
	kt										
1990	**0.441**	NA	0.043	NA	0.399	NO	0.00004	NA	NA	NO	NO
1991	**0.437**	NA	0.042	NA	0.395	NO	0.00004	NA	NA	NO	NO
1992	**0.409**	NA	0.040	NA	0.369	NO	0.00004	NA	NA	NO	NO
1993	**0.390**	NA	0.038	NA	0.352	NO	0.00004	NA	NA	NO	NO
1994	**0.396**	NA	0.038	NA	0.358	NO	0.00004	NA	NA	NO	NO
1995	**0.416**	NA	0.040	NA	0.376	NO	0.00004	NA	NA	NO	NO
1996	**0.417**	NA	0.040	NA	0.377	NO	0.00004	NA	NA	NO	NO
1997	**0.401**	NA	0.038	NA	0.363	NO	0.00004	NA	NA	NO	NO
1998	**0.384**	NA	0.038	NA	0.346	NO	0.00004	NA	NA	NO	NO
1999	**0.375**	NA	0.037	NA	0.338	NO	0.00004	NA	NA	NO	NO
2000	**0.371**	NA	0.039	NA	0.333	NO	0.00004	NA	NA	NO	NO
2001	**0.362**	NA	0.038	NA	0.324	NO	0.00004	NA	NA	NO	NO
2002	**0.366**	NA	0.039	NA	0.328	NO	0.00004	NA	NA	NO	NO
2003	**0.353**	NA	0.036	NA	0.318	NO	0.00004	NA	NA	NO	NO
2004	**0.370**	NA	0.037	NA	0.333	NO	0.00003	NA	NA	NO	NO
2005	**0.293**	NA	0.030	NA	0.263	NO	0.00003	NA	NA	NO	NO
2006	**0.275**	NA	0.027	NA	0.248	NO	0.00003	NA	NA	NO	NO
2007	**0.252**	NA	0.026	NA	0.225	NO	0.00001	NA	NA	NO	NO
2008	**0.240**	NA	0.024	NA	0.216	NO	0.00001	NA	NA	NO	NO
2009	**0.227**	NA	0.023	NA	0.204	NO	0.00001	NA	NA	NO	NO
2010	**0.225**	NA	0.022	NA	0.202	NO	0.00001	NA	NA	NO	NO
2011	**0.209**	NA	0.022	NA	0.187	NO	0.00002	NA	NA	NO	NO
2012	**0.210**	NA	0.022	NA	0.189	NO	0.00002	NA	NA	NO	NO
2013	**0.217**	NA	0.022	NA	0.195	NO	0.00002	NA	NA	NO	NO
2014	**0.226**	NA	0.024	NA	0.202	NO	0.00002	NA	NA	NO	NO
2015	**0.222**	NA	0.024	NA	0.198	NO	0.00002	NA	NA	NO	NO
2016	**0.218**	NA	0.023	NA	0.195	NO	0.00002	NA	NA	NO	NO
2017	**0.214**	NA	0.023	NA	0.191	NO	0.00002	NA	NA	NO	NO
2018	**0.208**	NA	0.021	NA	0.186	NO	0.00002	NA	NA	NO	NO
2019	**0.203**	NA	0.021	NA	0.182	NO	0.00002	NA	NA	NO	NO
2020	**0.195**	NA	0.020	NA	0.175	NO	0.00002	NA	NA	NO	NO
2021	**0.193**	NA	0.019	NA	0.174	NO	0.00002	NA	NA	NO	NO
Trend											
1990 - 2021	*-56.2%*	*NA*	*-54.6%*	*NA*	*-56.3%*	*NA*	*-43.5%*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*-33.9%*	*NA*	*-35.0%*	*NA*	*-33.8%*	*NA*	*-29.4%*	*NA*	*NA*	*NA*	*NA*

N_2O emissions	3 Agriculture	3.A Enteric Fermentation	3.B Manure Management	3.C Rice Cultivation	3.D Agricultural soils	3.E Prescribed burning of savannas	3.F Field burning of agricultural residues	3. Liming	3.H Urea application	3.I Other carbon-containing fertilizers	3.J Other
	kt										
2020 - 2021	*-0.9%*	*NA*	*-5.1%*	*NA*	*-0.5%*	*NA*	*3.6%*	*NA*	*NA*	*NA*	*NA*

2.2.6 Description of emission trends: sector Land use, Land use change and Forestry (LULUCF)

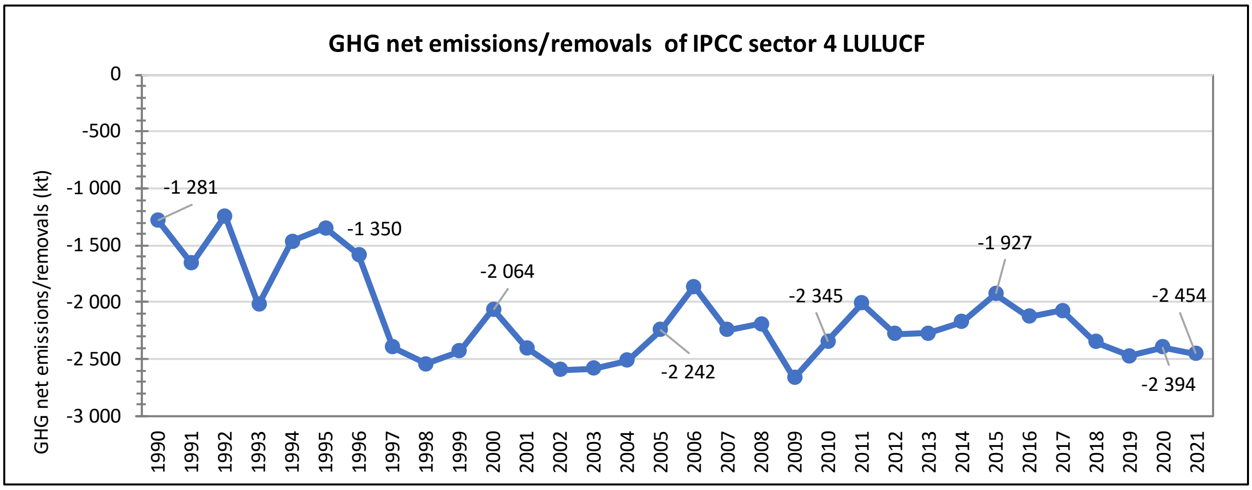


Figure 35 Trend of GHG net removals of IPCC sector 4 LULUCF for the period 1990 – 2021

In 2**021,** net removals from sector *LULUCF* amounted to -2 454.32 kt CO_2 equivalent, which is an increased by 91.5% compared to 1990.

In 2**005,** net removals from sector *LULUCF* amounted to -2 241.63 kt CO_2 equivalent. In the period 2005-2021, GHG net removals increased by 9.5%,

In **1990,** net removals from sector *LULUCF* amounted to -1 281.34 kt CO_2 equivalent.

With regard to the overall trend of net removals from *LULUCF*, the removals increased by 88.2% over the observed period. The main driver for this trend is the net removals from Forest land, which dwarf the net emission/removals of the other subcategories of the sector. The next most significant subcategories are Harvested Wood Products and Settlements. Generally, land use has been rather stable in Montenegro, with only a small proportion of the total territory undergoing land use change. Nevertheless, significant dynamics in Forest land remaining forest land have driven the aforementioned substantial long-term trend as well as considerable inter-annual variability. Principally, this variation has been driven by year-to-year changes in total drain due to timber harvest and biomass losses due to forest fires.

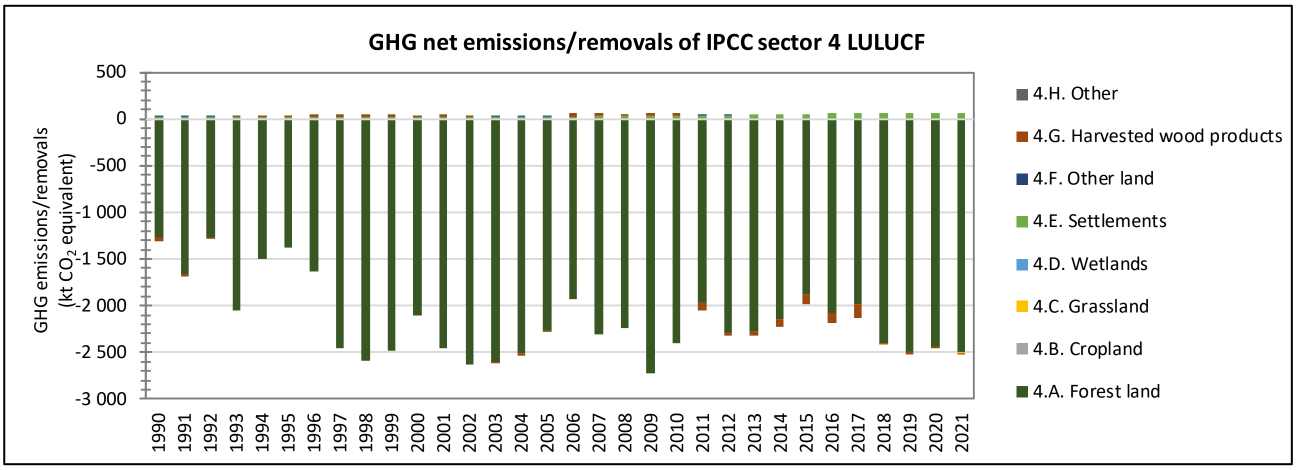


Figure 36 Net emissions/ removals in IPCC sector LULUCF from 1990 – 2021

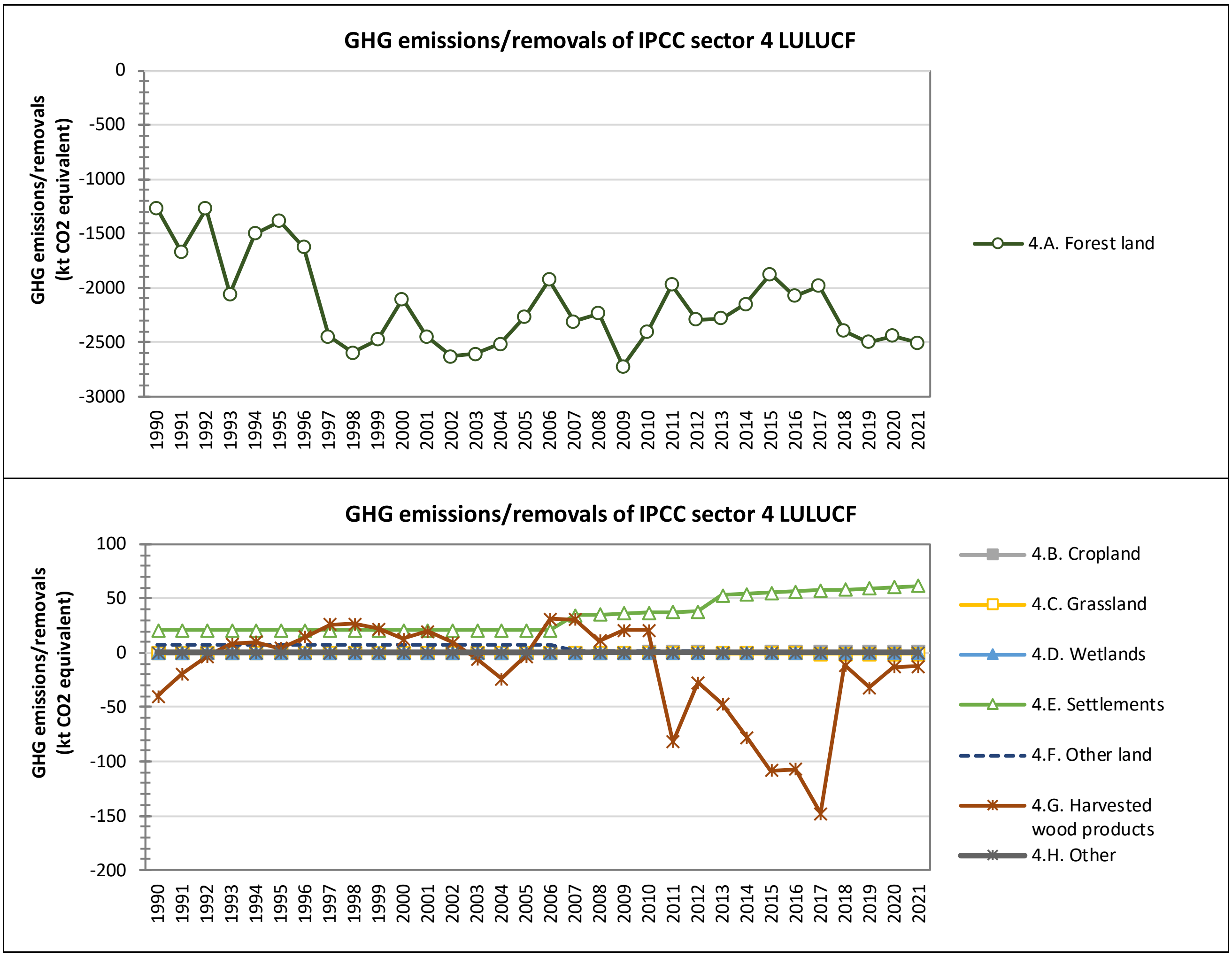


Figure 37 Trend of emissions and removals from IPCC sector 4 LULUCF by greenhouse gas for the period 1990 – 2021

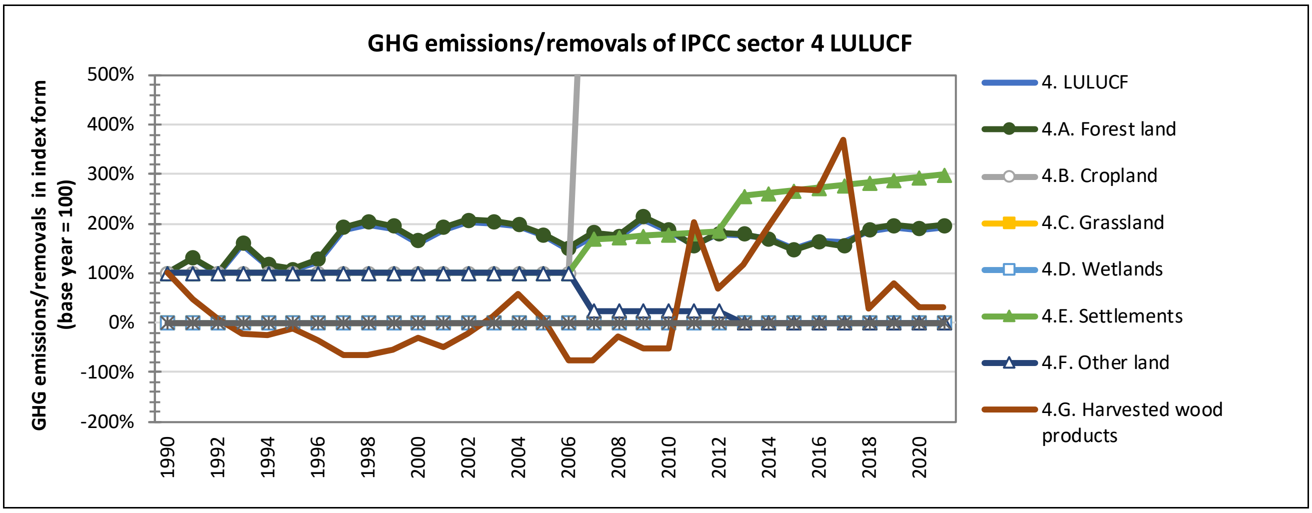


Figure 38 **Trend of emissions from IPCC sector 4 LULUCF in index form (base year = 100) by category for the period 1990 – 2021**

Table 60 GHG Emissions from IPCC sub-category 4 LULUCF by subcategories for the period 1990 - 2021

GHG emissions	4 TOTAL LULUCF	4.A Total Forest land	4.B Cropland	4.C Grassland	4.D Wetlands	4.E Settlements	4.F Other land	4.G Harvested Wood Products
	kt CO2 equivalent							
1990	**-1 281.34**	-1 269.70	0.03	NO	NO	20.67	7.87	-40.22
1991	**-1 658.20**	-1 667.20	0.03	NO	NO	20.67	7.87	-19.57
1992	**-1 243.54**	-1 268.88	0.03	NO	NO	20.67	7.87	-3.24
1993	**-2 020.14**	-2 057.24	0.03	NO	NO	20.67	7.87	8.52
1994	**-1 463.02**	-1 501.75	0.03	NO	NO	20.67	7.87	10.15
1995	**-1 349.73**	-1 382.78	0.03	NO	NO	20.67	7.87	4.47
1996	**-1 585.28**	-1 628.67	0.03	NO	NO	20.67	7.87	14.82
1997	**-2 395.37**	-2 450.23	0.03	NO	NO	20.67	7.87	26.28
1998	**-2 541.30**	-2 596.72	0.03	NO	NO	20.67	7.87	26.84
1999	**-2 428.10**	-2 478.75	0.03	NO	NO	20.67	7.87	22.08
2000	**-2 063.74**	-2 104.92	0.03	NO	NO	20.67	7.87	12.60
2001	**-2 402.42**	-2 450.96	0.03	NO	NO	20.67	7.87	19.97
2002	**-2 595.48**	-2 633.33	0.03	NO	NO	20.67	7.87	9.28
2003	**-2 584.82**	-2 607.87	0.03	NO	NO	20.67	7.87	-5.53
2004	**-2 510.81**	-2 515.56	0.03	NO	NO	20.67	7.87	-23.82
2005	**-2 241.63**	-2 267.07	0.03	NO	NO	20.67	7.87	-3.13
2006	**-1 865.70**	-1 925.35	0.03	NO	NO	20.67	7.87	31.07
2007	**-2 240.99**	-2 308.99	0.38	0.43	NO	34.83	1.92	30.44
2008	**-2 188.18**	-2 237.47	0.44	0.41	NO	35.50	1.92	11.02
2009	**-2 663.66**	-2 723.65	0.50	0.39	NO	36.16	1.92	21.02
2010	**-2 344.67**	-2 405.02	0.56	0.37	NO	36.83	1.92	20.67
2011	**-2 011.18**	-1 969.63	0.61	0.35	NO	37.50	1.92	-81.94
2012	**-2 276.61**	-2 290.50	0.67	0.33	NO	38.17	1.92	-27.20
2013	**-2 274.07**	-2 280.08	0.47	-0.36	NO	52.95	NO	-47.05
2014	**-2 174.07**	-2 150.20	0.49	-0.45	NO	54.06	NO	-77.97
2015	**-1 927.02**	-1 873.88	0.51	-0.54	NO	55.17	NO	-108.28
2016	**-2 124.53**	-2 073.28	0.54	-0.63	NO	56.28	NO	-107.44
2017	**-2 071.61**	-1 980.68	0.56	-0.73	NO	57.39	NO	-148.16
2018	**-2 349.70**	-2 396.96	0.58	-0.82	NO	58.51	NO	-11.00
2019	**-2 469.76**	-2 497.04	0.60	-0.91	NO	59.62	NO	-32.04
2020	**-2 394.44**	-2 441.89	0.63	-1.00	NO	60.73	NO	-12.90
2021	**-2 454.32**	-2 503.01	0.65	-1.10	NO	61.84	NO	-12.69
Trend								
1990 – 2021	*91.5%*	*97.1%*	*1952.7%*	*NA*	*NA*	*199.1%*	*NA*	*-68.4%*
2005 – 2021	*9.5%*	*10.4%*	*1952.7%*	*NA*	*NA*	*199.1%*	*NA*	*305.8%*
2020 - 2021	*2.5%*	*2.5%*	*3.6%*	*9.2%*	*NA*	*1.8%*	*NA*	*-1.6%*

Table 61 CO_2 Emissions from IPCC sub-category 4 LULUCF by subcategories for the period 1990 - 2021

CO_2 emissions	4 TOTAL LULUCF	4.A Total Forest land	4.B Cropland	4.C Grassland	4.D Wetlands	4.E Settlements	4.F Other land	4.G Harvested Wood Products
	kt							
1990	**-1 285.46**	-1 272.48	-0.01	NO	NO	19.37	7.87	-40.22
1991	**-1 660.86**	-1 668.52	-0.01	NO	NO	19.37	7.87	-19.57
1992	**-1 249.96**	-1 273.95	-0.01	NO	NO	19.37	7.87	-3.24
1993	**-2 026.18**	-2 061.94	-0.01	NO	NO	19.37	7.87	8.52
1994	**-1 466.54**	-1 503.93	-0.01	NO	NO	19.37	7.87	10.15
1995	**-1 355.92**	-1 387.63	-0.01	NO	NO	19.37	7.87	4.47
1996	**-1 591.99**	-1 634.04	-0.01	NO	NO	19.37	7.87	14.82
1997	**-2 398.18**	-2 451.70	-0.01	NO	NO	19.37	7.87	26.28
1998	**-2 548.70**	-2 602.77	-0.01	NO	NO	19.37	7.87	26.84
1999	**-2 429.93**	-2 479.23	-0.01	NO	NO	19.37	7.87	22.08
2000	**-2 094.05**	-2 133.88	-0.01	NO	NO	19.37	7.87	12.60
2001	**-2 405.60**	-2 452.80	-0.01	NO	NO	19.37	7.87	19.97
2002	**-2 598.36**	-2 634.87	-0.01	NO	NO	19.37	7.87	9.28
2003	**-2 601.59**	-2 623.29	-0.01	NO	NO	19.37	7.87	-5.53
2004	**-2 517.46**	-2 520.87	-0.01	NO	NO	19.37	7.87	-23.82
2005	**-2 243.37**	-2 267.47	-0.01	NO	NO	19.37	7.87	-3.13
2006	**-1 867.85**	-1 926.16	-0.01	NO	NO	19.37	7.87	31.07
2007	**-2 313.09**	-2 379.68	0.33	0.43	NO	33.46	1.92	30.44
2008	**-2 203.67**	-2 251.48	0.38	0.41	NO	34.06	1.92	11.02
2009	**-2 665.56**	-2 723.99	0.44	0.39	NO	34.66	1.92	21.02
2010	**-2 348.99**	-2 407.70	0.49	0.37	NO	35.26	1.92	20.67
2011	**-2 202.10**	-2 158.83	0.54	0.35	NO	35.87	1.92	-81.94
2012	**-2 299.77**	-2 311.89	0.59	0.33	NO	36.47	1.92	-27.20
2013	**-2 276.62**	-2 280.74	0.38	-0.36	NO	51.14	NO	-47.05
2014	**-2 176.31**	-2 150.44	0.41	-0.45	NO	52.14	NO	-77.97
2015	**-1 941.20**	-1 885.95	0.43	-0.54	NO	53.15	NO	-108.28
2016	**-2 131.00**	-2 077.52	0.45	-0.63	NO	54.15	NO	-107.44
2017	**-2 155.85**	-2 062.58	0.47	-0.73	NO	55.15	NO	-148.16
2018	**-2 365.33**	-2 410.15	0.49	-0.82	NO	56.15	NO	-11.00
2019	**-2 476.84**	-2 501.55	0.51	-0.91	NO	57.15	NO	-32.04
2020	**-2 415.04**	-2 459.82	0.53	-1.00	NO	58.15	NO	-12.90
2021	**-2 523.12**	-2 569.04	0.56	-1.10	NO	59.15	NO	-12.69

Table 62 CH_4 Emissions from IPCC sub-category 4 LULUCF by subcategories for the period 1990 - 2021

CH_4 emissions	4 TOTAL LULUCF	4.A Total Forest land	4.B Cropland	4.C Grassland	4.D Wetlands	4.E Settlements	4.F Other land	4.G Harvested Wood Products
	kt							
1990	**0.067**	0.067	NO	NO	NO	NO	NO	NA
1991	**0.032**	0.032	NO	NO	NO	NO	NO	NA
1992	**0.122**	0.122	NO	NO	NO	NO	NO	NA
1993	**0.113**	0.113	NO	NO	NO	NO	NO	NA
1994	**0.052**	0.052	NO	NO	NO	NO	NO	NA
1995	**0.117**	0.117	NO	NO	NO	NO	NO	NA
1996	**0.130**	0.130	NO	NO	NO	NO	NO	NA
1997	**0.035**	0.035	NO	NO	NO	NO	NO	NA
1998	**0.146**	0.146	NO	NO	NO	NO	NO	NA
1999	**0.012**	0.012	NO	NO	NO	NO	NO	NA
2000	**0.698**	0.698	NO	NO	NO	NO	NO	NA
2001	**0.044**	0.044	NO	NO	NO	NO	NO	NA
2002	**0.037**	0.037	NO	NO	NO	NO	NO	NA
2003	**0.372**	0.372	NO	NO	NO	NO	NO	NA
2004	**0.128**	0.128	NO	NO	NO	NO	NO	NA
2005	**0.010**	0.010	NO	NO	NO	NO	NO	NA
2006	**0.020**	0.020	NO	NO	NO	NO	NO	NA
2007	**1.704**	1.704	NO	NO	NO	NO	NO	NA
2008	**0.338**	0.338	NO	NO	NO	NO	NO	NA
2009	**0.008**	0.008	NO	NO	NO	NO	NO	NA
2010	**0.065**	0.065	NO	NO	NO	NO	NO	NA
2011	**4.561**	4.561	NO	NO	NO	NO	NO	NA
2012	**0.515**	0.515	NO	NO	NO	NO	NO	NA
2013	**0.016**	0.016	NO	NO	NO	NO	NO	NA
2014	**0.006**	0.006	NO	NO	NO	NO	NO	NA
2015	**0.291**	0.291	NO	NO	NO	NO	NO	NA
2016	**0.102**	0.102	NO	NO	NO	NO	NO	NA
2017	**1.974**	1.974	NO	NO	NO	NO	NO	NA
2018	**0.318**	0.318	NO	NO	NO	NO	NO	NA
2019	**0.109**	0.109	NO	NO	NO	NO	NO	NA
2020	**0.432**	0.432	NO	NO	NO	NO	NO	NA
2021	**1.592**	1.592	NO	NO	NO	NO	NO	NA
Trend								
1990 – 2021	*2275.3%*	*2275.3%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 – 2021	*16503.9%*	*16503.9%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*268.3%*	*268.3%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

Table 63 N_2O Emissions from IPCC sub-category 4 LULUCF by subcategories for the period 1990 - 2021

N_2O emissions	4 TOTAL LULUCF	4.A Total Forest land	4.B Cropland	4.C Grassland	4.D Wetlands	4.E Settlements	4.F Other land	4.G Harvested Wood Products
	kt CO2 equivalent							
1990	**0.441**	NA	0.043	NA	0.399	NO	0.000	**0.441**
1991	**0.437**	NA	0.042	NA	0.395	NO	0.000	**0.437**
1992	**0.409**	NA	0.040	NA	0.369	NO	0.000	**0.409**
1993	**0.390**	NA	0.038	NA	0.352	NO	0.000	**0.390**
1994	**0.396**	NA	0.038	NA	0.358	NO	0.000	**0.396**
1995	**0.416**	NA	0.040	NA	0.376	NO	0.000	**0.416**
1996	**0.417**	NA	0.040	NA	0.377	NO	0.000	**0.417**
1997	**0.401**	NA	0.038	NA	0.363	NO	0.000	**0.401**
1998	**0.384**	NA	0.038	NA	0.346	NO	0.000	**0.384**
1999	**0.375**	NA	0.037	NA	0.338	NO	0.000	**0.375**
2000	**0.371**	NA	0.039	NA	0.333	NO	0.000	**0.371**
2001	**0.362**	NA	0.038	NA	0.324	NO	0.000	**0.362**
2002	**0.366**	NA	0.039	NA	0.328	NO	0.000	**0.366**
2003	**0.353**	NA	0.036	NA	0.318	NO	0.000	**0.353**
2004	**0.370**	NA	0.037	NA	0.333	NO	0.000	**0.370**
2005	**0.293**	NA	0.030	NA	0.263	NO	0.000	**0.293**
2006	**0.275**	NA	0.027	NA	0.248	NO	0.000	**0.275**
2007	**0.252**	NA	0.026	NA	0.225	NO	0.000	**0.252**
2008	**0.240**	NA	0.024	NA	0.216	NO	0.000	**0.240**
2009	**0.227**	NA	0.023	NA	0.204	NO	0.000	**0.227**
2010	**0.225**	NA	0.022	NA	0.202	NO	0.000	**0.225**
2011	**0.209**	NA	0.022	NA	0.187	NO	0.000	**0.209**
2012	**0.210**	NA	0.022	NA	0.189	NO	0.000	**0.210**
2013	**0.217**	NA	0.022	NA	0.195	NO	0.000	**0.217**
2014	**0.226**	NA	0.024	NA	0.202	NO	0.000	**0.226**
2015	**0.222**	NA	0.024	NA	0.198	NO	0.000	**0.222**
2016	**0.218**	NA	0.023	NA	0.195	NO	0.000	**0.218**
2017	**0.214**	NA	0.023	NA	0.191	NO	0.000	**0.214**
2018	**0.208**	NA	0.021	NA	0.186	NO	0.000	**0.208**
2019	**0.203**	NA	0.021	NA	0.182	NO	0.000	**0.203**
2020	**0.195**	NA	0.020	NA	0.175	NO	0.000	**0.195**
2021	**0.193**	NA	0.019	NA	0.174	NO	0.000	**0.193**
Trend								
1990 – 2021	*-56.2%*	*NA*	*-54.6%*	*NA*	*-56.3%*	*NA*	*-43.5%*	*-56.2%*
2005 – 2021	*-33.9%*	*NA*	*-35.0%*	*NA*	*-33.8%*	*NA*	*-29.4%*	*-33.9%*
2020 - 2021	*-0.9%*	*NA*	*-5.1%*	*NA*	*-0.5%*	*NA*	*3.6%*	*-0.9%*

2.2.7 Description of emission trends: sector 5 Waste

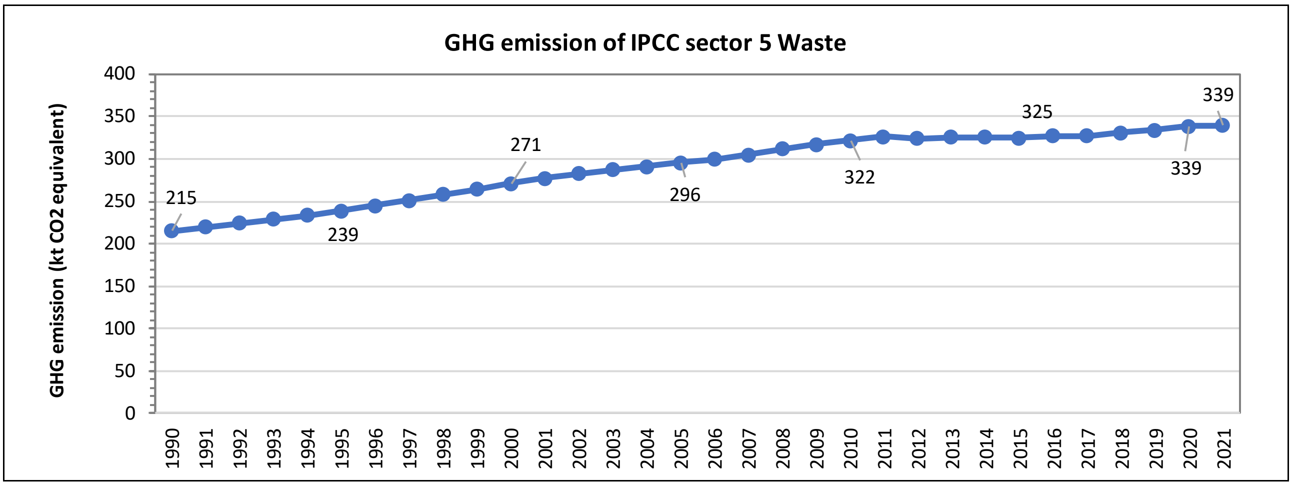


Figure 39 Trend of GHG emission of IPCC sector 5 Waste for the period 1990 – 2021

In **2021**, GHG emissions from IPCC sector 5 *Waste* amounted to 339.34 kt CO_2 equivalent, which correspond to 9.9% of total national emissions. In the period 1990 to 2021 GHG emissions from the IPCC sector 5 *Waste* increased by 57.7% from 215.12 kt CO_2 eq in 1990 due to increasing landfilling activities (IPCC category 5.A *Solid waste disposal*) as a result of increasing population and growing waste generation rates. Also, the reduction of illegal disposal (sites) or open burning results in increasing landfilling. In the same period GHG emissions from the IPCC category 5.D *Wastewater treatment and discharge* increased slightly due to increasing number of population connected to sewage systems and waste water treatment plants (WWTPs) and due to growing population and higher protein consumption per capita.

The most important categories of *Waste* is *solid waste disposal* followed by *wastewater treatment and discharge*. The most important greenhouse gas is CH_4.

Emissions from the categories 5.B *Biological Treatment of Solid Waste* and 5.C *Incineration and Open Burning of Waste* were not estimated due to lack of data.

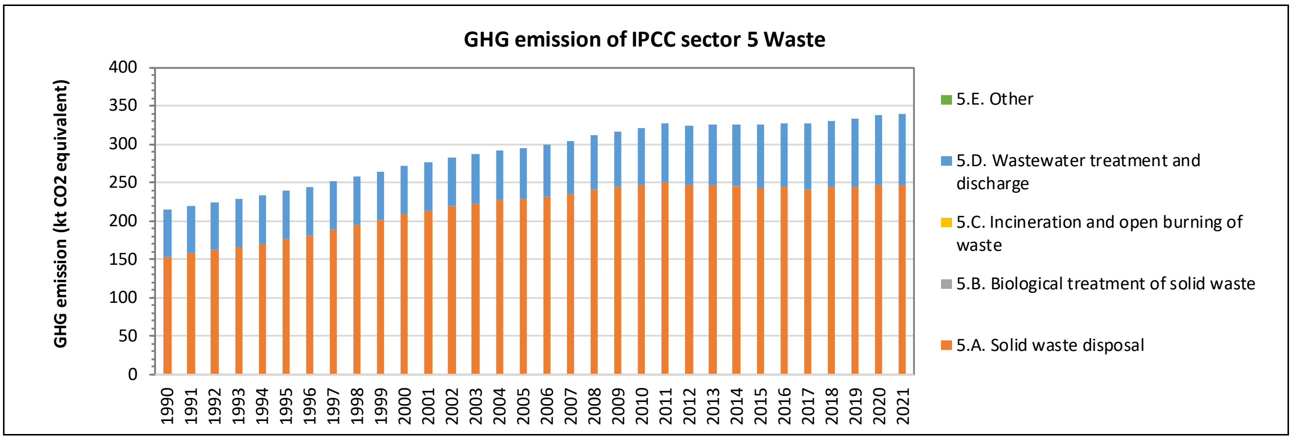


Figure 40 Trend of GHG emission of IPCC sector 5 Waste by category for the period 1990 – 2021

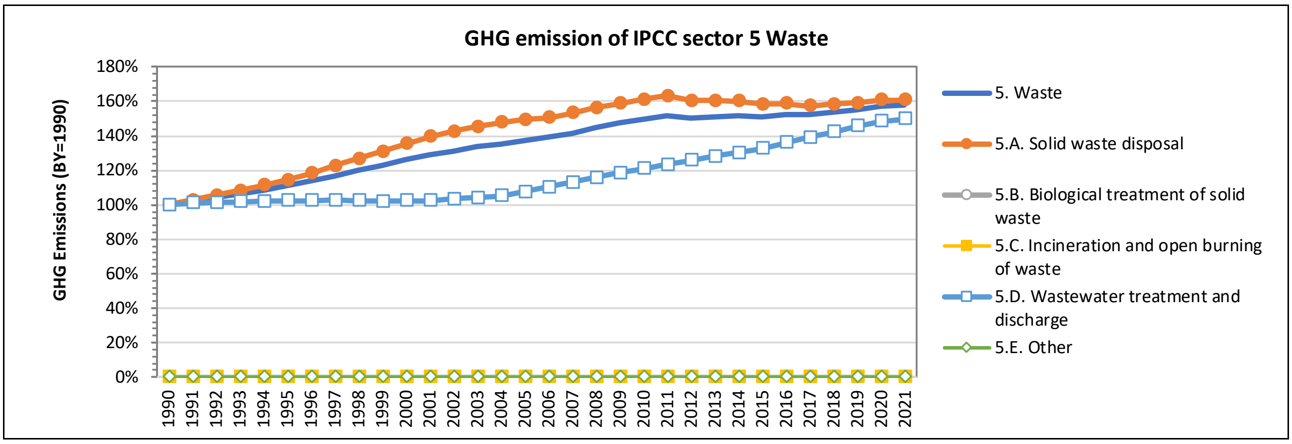


Figure 41 GHG emissions from IPCC sector 5 waste by category in index form (base year = 100)

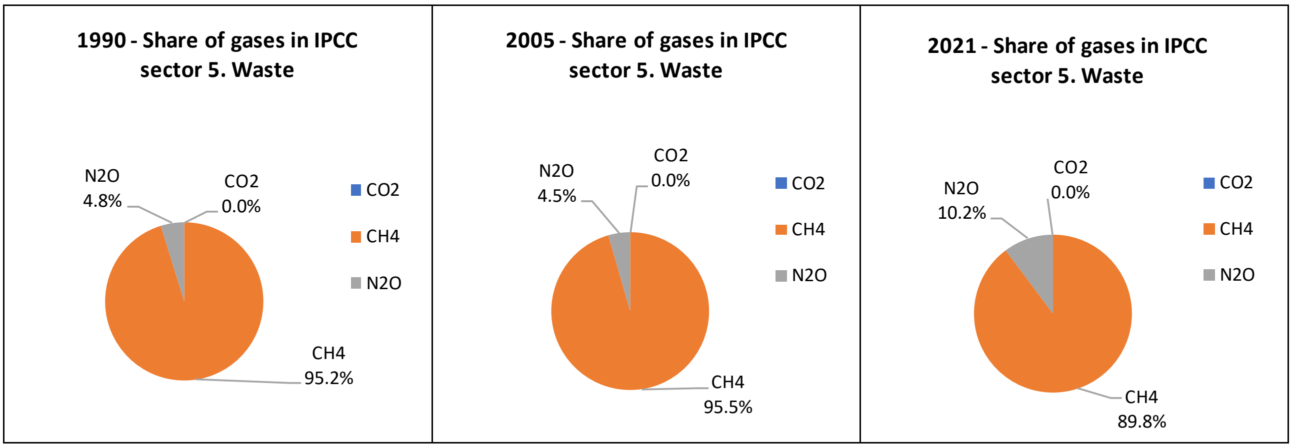


Figure 42 Share of gases in from IPCC sector 5 waste

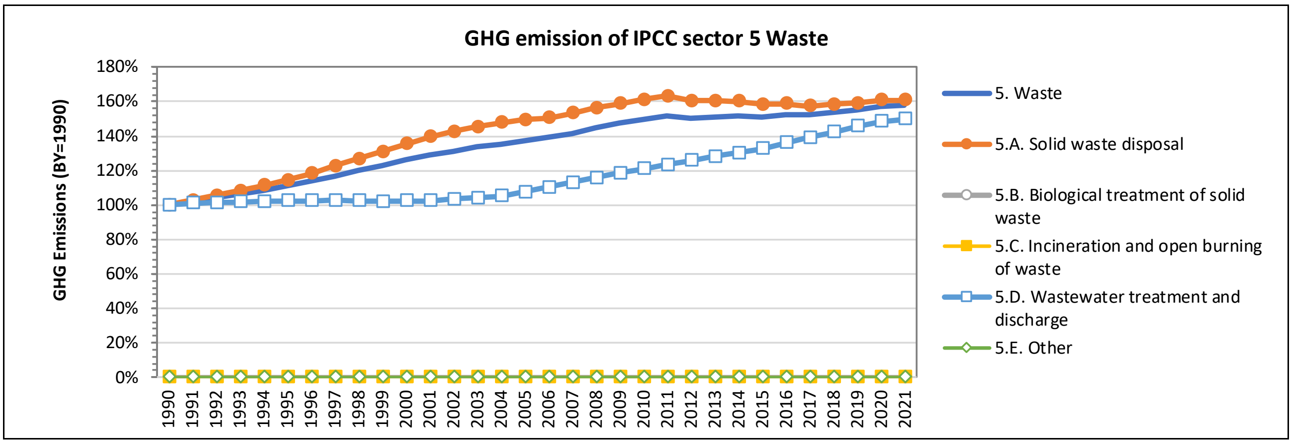


Figure 43 GHG emissions from IPCC sector 5 waste by gas in index form (base year = 100) by category

Table 64 Emissions from IPCC sector 5 Waste by gas

GHG emissions	TOTAL GHG	CO_2	CH_4	N_2O
	kt CO_2 equivalent	kt	kt	kt
1990	215.12	NE	8.19	0.034
1991	219.88	NE	8.38	0.035
1992	224.35	NE	8.55	0.035
1993	228.92	NE	8.73	0.036
1994	233.56	NE	8.91	0.036
1995	238.94	NE	9.13	0.036
1996	244.90	NE	9.36	0.036
1997	251.46	NE	9.62	0.037
1998	257.73	NE	9.87	0.037
1999	264.12	NE	10.12	0.037
2000	271.13	NE	10.39	0.038
2001	277.15	NE	10.63	0.038
2002	282.73	NE	10.84	0.039
2003	287.45	NE	11.03	0.039
2004	291.38	NE	11.18	0.040
2005	295.52	NE	11.29	0.044
2006	299.24	NE	11.39	0.049
2007	304.69	NE	11.55	0.053
2008	311.68	NE	11.78	0.058
2009	316.90	NE	11.93	0.063
2010	321.72	NE	12.07	0.067
2011	326.54	NE	12.21	0.072
2012	324.05	NE	12.05	0.076
2013	325.49	NE	12.05	0.081
2014	325.99	NE	12.02	0.086
2015	325.05	NE	11.93	0.090
2016	327.52	NE	11.97	0.095
2017	327.45	NE	11.92	0.099
2018	331.08	NE	12.01	0.104
2019	334.01	NE	12.07	0.108
2020	338.55	NE	12.20	0.112
2021	339.34	NE	12.19	0.116
Trend				
1990 - 2021	*57.7%*	*NA*	*48.7%*	*237.5%*
2005 - 2021	*14.8%*	*NA*	*7.9%*	*162.7%*
2020 - 2021	*0.2%*	*NA*	*-0.1%*	*3.5%*

Table 65 Total GHG Emissions from IPCC sector Waste for the period 1990 - 2021

GHG emissions	5 TOTAL Waste	5.A Solid Waste Disposal	5.B Biological Treatment of Solid Waste	5.C Incineration and Open Burning of Waste	5.D Wastewater Treatment and Discharge
	kt $_{CO_2}$ equivalent	kt $_{CO_2}$ equivalent	kt $_{CO_2}$ equivalent	kt $_{CO_2}$ equivalent	kt $_{CO_2}$ equivalent
1990	**215.12**	153.58	NE	NE	61.54
1991	**219.88**	157.71	NE	NE	62.17
1992	**224.35**	161.98	NE	NE	62.37
1993	**228.92**	166.35	NE	NE	62.57
1994	**233.56**	170.82	NE	NE	62.74
1995	**238.94**	176.00	NE	NE	62.94
1996	**244.90**	181.80	NE	NE	63.10
1997	**251.46**	188.17	NE	NE	63.29
1998	**257.73**	194.69	NE	NE	63.04
1999	**264.12**	201.36	NE	NE	62.75
2000	**271.13**	208.18	NE	NE	62.95
2001	**277.15**	214.08	NE	NE	63.07
2002	**282.73**	219.09	NE	NE	63.64
2003	**287.45**	223.32	NE	NE	64.13
2004	**291.38**	226.77	NE	NE	64.61
2005	**295.52**	229.39	NE	NE	66.13
2006	**299.24**	231.39	NE	NE	67.85
2007	**304.69**	235.18	NE	NE	69.51
2008	**311.68**	240.43	NE	NE	71.25
2009	**316.90**	244.03	NE	NE	72.87
2010	**321.72**	247.35	NE	NE	74.38
2011	**326.54**	250.70	NE	NE	75.84
2012	**324.05**	246.73	NE	NE	77.32
2013	**325.49**	246.69	NE	NE	78.81
2014	**325.99**	245.73	NE	NE	80.25
2015	**325.05**	243.41	NE	NE	81.64
2016	**327.52**	243.86	NE	NE	83.66
2017	**327.45**	241.80	NE	NE	85.66
2018	**331.08**	243.44	NE	NE	87.63
2019	**334.01**	244.42	NE	NE	89.59
2020	**338.55**	247.13	NE	NE	91.42
2021	**339.34**	247.03	NE	NE	92.31
Trend					
1990 - 2021	57.7%	*60.9%*	*NA*	*NA*	*50.0%*
2005 - 2021	14.8%	*7.7%*	*NA*	*NA*	*39.6%*
2020 - 2021	0.2%	*<0.1%*	*NA*	*NA*	*1.0%*

Table 66 CH_4 Emissions from IPCC sector 5 Waste for the period 1990 - 2021

CH_4 emissions	5 TOTAL Waste	5.A Solid Waste Disposal	5.B Biological Treatment of Solid Waste	5.C Incineration and Open Burning of Waste	5.D Wastewater Treatment and Discharge
	kt $_{CO_2 \text{ equivalent}}$	kt $_{CO_2 \text{ equivalent}}$	kt $_{CO_2 \text{ equivalent}}$	kt $_{CO_2 \text{ equivalent}}$	kt $_{CO_2 \text{ equivalent}}$
1990	**8.19**	6.14	NE	NE	2.05
1991	**8.38**	6.31	NE	NE	2.07
1992	**8.55**	6.48	NE	NE	2.07
1993	**8.73**	6.65	NE	NE	2.08
1994	**8.91**	6.83	NE	NE	2.08
1995	**9.13**	7.04	NE	NE	2.09
1996	**9.36**	7.27	NE	NE	2.09
1997	**9.62**	7.53	NE	NE	2.09
1998	**9.87**	7.79	NE	NE	2.08
1999	**10.12**	8.05	NE	NE	2.07
2000	**10.39**	8.33	NE	NE	2.07
2001	**10.63**	8.56	NE	NE	2.07
2002	**10.84**	8.76	NE	NE	2.08
2003	**11.03**	8.93	NE	NE	2.10
2004	**11.18**	9.07	NE	NE	2.11
2005	**11.29**	9.18	NE	NE	2.12
2006	**11.39**	9.26	NE	NE	2.13
2007	**11.55**	9.41	NE	NE	2.14
2008	**11.78**	9.62	NE	NE	2.16
2009	**11.93**	9.76	NE	NE	2.17
2010	**12.07**	9.89	NE	NE	2.17
2011	**12.21**	10.03	NE	NE	2.18
2012	**12.05**	9.87	NE	NE	2.18
2013	**12.05**	9.87	NE	NE	2.19
2014	**12.02**	9.83	NE	NE	2.19
2015	**11.93**	9.74	NE	NE	2.19
2016	**11.97**	9.75	NE	NE	2.22
2017	**11.92**	9.67	NE	NE	2.24
2018	**12.01**	9.74	NE	NE	2.27
2019	**12.07**	9.78	NE	NE	2.29
2020	**12.20**	9.89	NE	NE	2.32
2021	**12.19**	9.88	NE	NE	2.31
Trend					
1990 - 2021	***48.7%***	*60.9%*	*NA*	*NA*	*12.4%*
2005 - 2021	***7.9%***	*7.7%*	*NA*	*NA*	*8.9%*
2020 - 2021	***-0.1%***	*0.0%*	*NA*	*NA*	*-0.5%*

Table 67 Total N_2O Emissions from IPCC sector Waste for the period 1990 - 2021

N_2O emissions	5 TOTAL Waste	5.A Solid Waste Disposal	5.B Biological Treatment of Solid Waste	5.C Incineration and Open Burning of Waste	5.D Wastewater Treatment and Discharge
	kt	kt	kt	kt	kt
1990	**0.034**	NA	NE	NE	0.034
1991	**0.035**	NA	NE	NE	0.035
1992	**0.035**	NA	NE	NE	0.035
1993	**0.036**	NA	NE	NE	0.036
1994	**0.036**	NA	NE	NE	0.036
1995	**0.036**	NA	NE	NE	0.036
1996	**0.036**	NA	NE	NE	0.036
1997	**0.037**	NA	NE	NE	0.037
1998	**0.037**	NA	NE	NE	0.037
1999	**0.037**	NA	NE	NE	0.037
2000	**0.038**	NA	NE	NE	0.038
2001	**0.038**	NA	NE	NE	0.038
2002	**0.039**	NA	NE	NE	0.039
2003	**0.039**	NA	NE	NE	0.039
2004	**0.040**	NA	NE	NE	0.040
2005	**0.044**	NA	NE	NE	0.044
2006	**0.049**	NA	NE	NE	0.049
2007	**0.053**	NA	NE	NE	0.053
2008	**0.058**	NA	NE	NE	0.058
2009	**0.063**	NA	NE	NE	0.063
2010	**0.067**	NA	NE	NE	0.067
2011	**0.072**	NA	NE	NE	0.072
2012	**0.076**	NA	NE	NE	0.076
2013	**0.081**	NA	NE	NE	0.081
2014	**0.086**	NA	NE	NE	0.086
2015	**0.090**	NA	NE	NE	0.090
2016	**0.095**	NA	NE	NE	0.095
2017	**0.099**	NA	NE	NE	0.099
2018	**0.104**	NA	NE	NE	0.104
2019	**0.108**	NA	NE	NE	0.108
2020	**0.112**	NA	NE	NE	0.112
2021	**0.116**	NA	NE	NE	0.116
Trend					
1990 - 2021	*237.5%*	*NA*	*NA*	*NA*	*237.5%*
2005 - 2021	*162.7%*	*NA*	*NA*	*NA*	*162.7%*
2020 - 2021	*3.5%*	*NA*	*NA*	*NA*	*3.5%*

2.3 Emission Trends for Indirect Greenhouse Gases and SO_2

Montenegro reports emission estimates for NO_x, CO, NMVOC and SO_2 under the United Nations Economic Commission for Europe (UNECE) Convention on Long-range Transboundary Air Pollution (LRTAP). https://unece.org/convention-and-its-achievements

This chapter summarizes the trends for these gases.

A detailed description of the methodology used to estimate these emissions is provided in the *Informative Inventory Report (IIR) 2023 of Montenegro, Submission under the UNECE/CLRTAP Convention*, published in spring 2023.

https://www.ceip.at/status-of-reporting-and-review-results/2023-submission

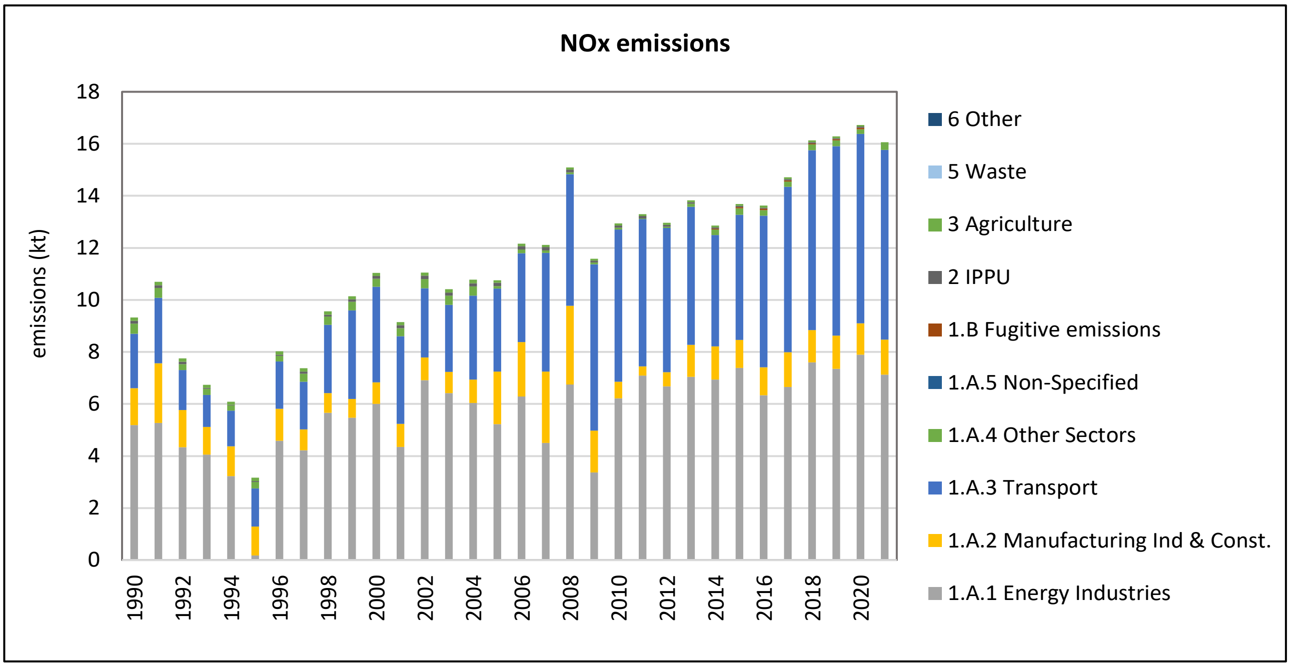


Figure 44 Nitrogen oxides (NOx) Emissions for the period 1990 - 2021

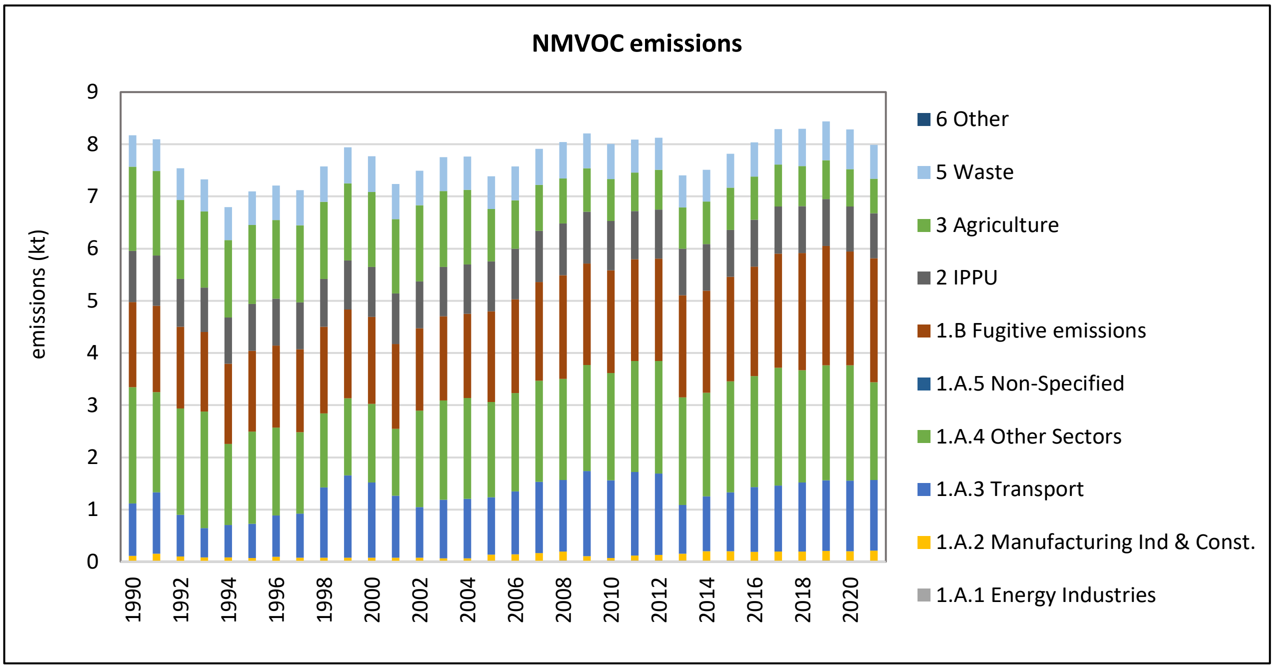


Figure 45 Non-Methane Volatile Organic Compounds (NMVOC) Emissions for the period 1990 – 2021

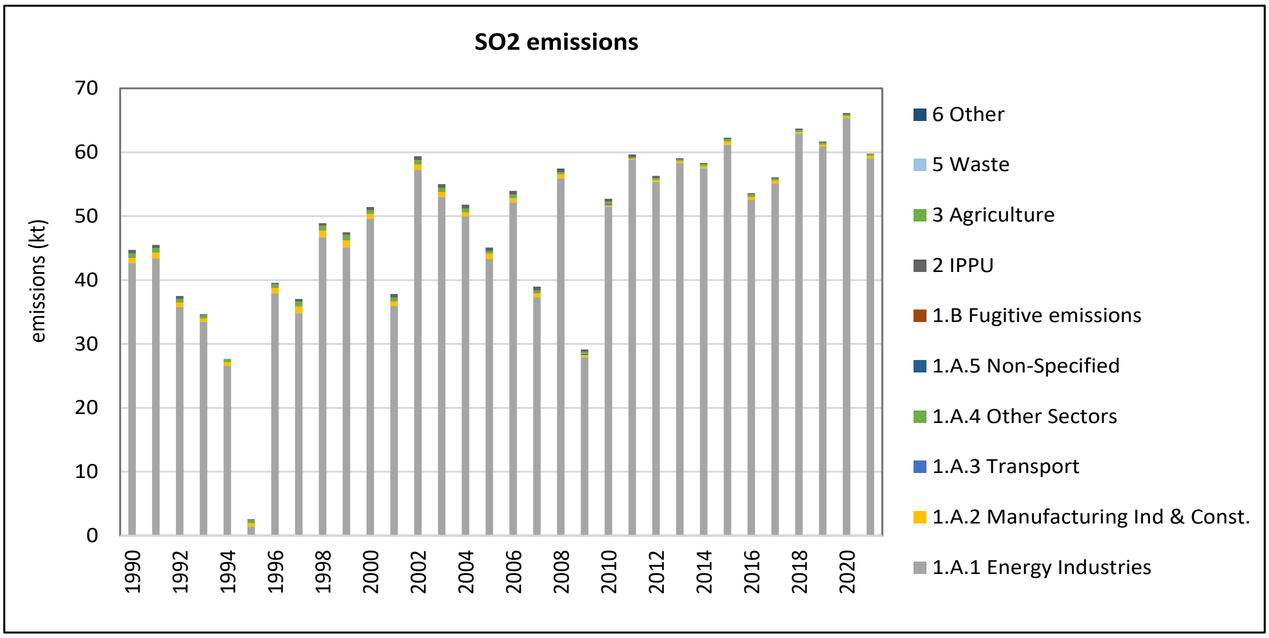


Figure 46 Sulphur dioxide (SO2) Emissions for the period 1990 - 2021

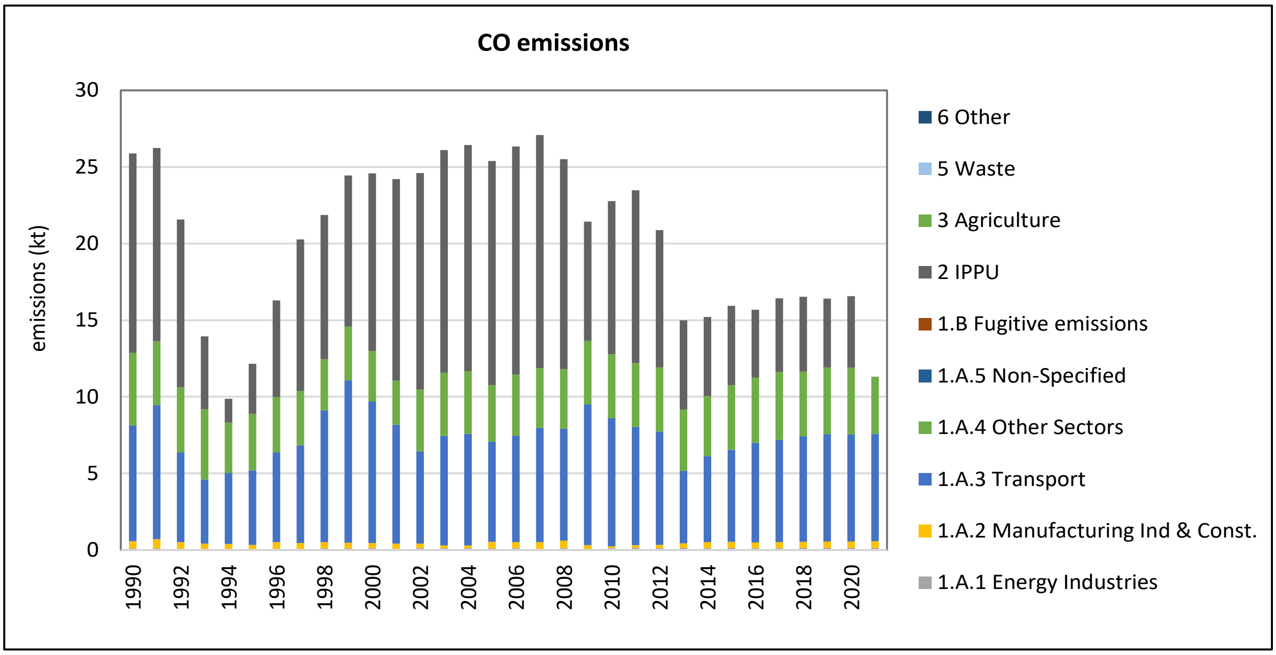


Figure 47 Carbon monoxide (CO) Emissions for the period 1990 - 2021

Table 68 Nitrogen oxides (NOx) Emissions for the period 1990 - 2021

Nitrogen oxides (NOx)		1	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5	1.B	2	3	3.B	3.D	3F	3I	5	6
kt	Total	Energy	Fuel Combustion	Energy Industries	Manufacturing Industries & Const.	Transport	Other Sectors	Non-Specified	Fugitive emissions	IPPU	Agriculture	Manure Management	Emission from soil	Field burning	Agriculture other	Waste	Other
1990	9.331	9.087	9.087	5.184	1.429	2.089	0.386	NO	NO	0.110	0.134	0.124	0.010	NA	NA	NE	NA
1991	10.700	10.460	10.460	5.268	2.291	2.520	0.381	NO	NO	0.107	0.133	0.123	0.010	NA	NA	NE	NA
1992	7.749	7.531	7.531	4.339	1.434	1.529	0.228	NO	NO	0.094	0.124	0.114	0.010	NA	NA	NE	NA
1993	6.740	6.581	6.581	4.051	1.069	1.224	0.237	NO	NO	0.043	0.116	0.108	0.008	NA	NA	NE	NA
1994	6.085	5.951	5.951	3.226	1.150	1.364	0.211	NO	NO	0.016	0.119	0.110	0.009	NA	NA	NE	NA
1995	3.165	3.007	3.007	0.174	1.111	1.475	0.248	NO	NO	0.031	0.127	0.110	0.017	NA	NA	NE	NA
1996	8.030	7.844	7.844	4.591	1.220	1.819	0.214	NO	NO	0.056	0.130	0.109	0.021	NA	NA	NE	NA
1997	7.374	7.159	7.159	4.219	0.803	1.834	0.303	NO	NO	0.085	0.130	0.106	0.024	NA	NA	NE	NA
1998	9.563	9.357	9.357	5.660	0.756	2.622	0.319	NO	NO	0.081	0.126	0.105	0.020	NA	NA	NE	NA
1999	10.139	9.932	9.932	5.471	0.718	3.408	0.335	NO	NO	0.085	0.122	0.104	0.018	NA	NA	NE	NA
2000	11.038	10.819	10.819	6.006	0.823	3.678	0.313	NO	NO	0.100	0.118	0.099	0.019	NA	NA	NE	NA
2001	9.153	8.915	8.915	4.354	0.881	3.375	0.306	NO	NO	0.113	0.125	0.098	0.027	NA	NA	NE	NA
2002	11.054	10.808	10.808	6.920	0.867	2.664	0.358	NO	NO	0.121	0.125	0.100	0.025	NA	NA	NE	NA
2003	10.409	10.162	10.162	6.416	0.819	2.578	0.349	NO	NO	0.125	0.122	0.100	0.022	NA	NA	NE	NA
2004	10.780	10.517	10.517	6.041	0.895	3.230	0.351	NO	NO	0.125	0.137	0.097	0.040	NA	NA	NE	NA
2005	10.761	10.534	10.534	5.224	2.021	3.191	0.098	NO	NO	0.125	0.102	0.066	0.036	NA	NA	NE	NA
2006	12.159	11.940	11.940	6.292	2.091	3.416	0.140	NO	NO	0.126	0.093	0.061	0.032	NA	NA	NE	NA
2007	12.118	11.907	11.907	4.502	2.743	4.569	0.094	NO	NO	0.129	0.083	0.057	0.026	NA	NA	NE	NA
2008	15.095	14.900	14.900	6.747	3.031	5.051	0.071	NO	NO	0.116	0.080	0.055	0.025	NA	NA	NE	NA
2009	11.583	11.442	11.442	3.366	1.605	6.394	0.077	NO	NO	0.068	0.074	0.053	0.020	NA	NA	NE	NA
2010	12.942	12.777	12.777	6.214	0.638	5.849	0.075	NO	NO	0.087	0.078	0.052	0.025	NA	NA	NE	NA

Nitrogen oxides (NOx)		1	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5	1.B	2	3	3.B	3.D	3F	3I	5	6
kt	**Total**	Energy	Fuel Combustion	Energy Industries	Manufacturing Industries & Const.	Transport	Other Sectors	Non-Specified	Fugitive emissions	IPPU	Agriculture	Manure Management	Emission from soil	Field burning	Agriculture other	Waste	Other
2011	13.297	13.127	13.127	7.094	0.352	5.660	0.022	NO	NO	0.098	0.072	0.050	0.022	NA	NA	NE	NA
2012	12.963	12.808	12.808	6.678	0.540	5.540	0.048	NO	NO	0.079	0.077	0.053	0.024	NA	NA	NE	NA
2013	13.831	13.701	13.701	7.040	1.239	5.301	0.122	NO	NO	0.053	0.077	0.051	0.026	NA	NA	NE	NA
2014	12.859	12.737	12.700	6.942	1.272	4.280	0.206	NO	0.037	0.047	0.075	0.051	0.025	NA	NA	NE	NA
2015	13.687	13.565	13.521	7.387	1.071	4.815	0.249	NO	0.044	0.047	0.074	0.050	0.024	NA	NA	NE	NA
2016	13.627	13.507	13.452	6.341	1.069	5.832	0.211	NO	0.054	0.041	0.080	0.055	0.025	NA	NA	NE	NA
2017	14.709	14.595	14.549	6.653	1.334	6.358	0.203	NO	0.046	0.044	0.070	0.051	0.019	NA	NA	NE	NA
2018	16.134	16.020	15.977	7.595	1.241	6.924	0.217	NO	0.042	0.045	0.070	0.047	0.023	NA	NA	NE	NA
2019	16.289	16.181	16.130	7.350	1.281	7.282	0.217	NO	0.051	0.040	0.067	0.044	0.023	NA	NA	NE	NA
2020	16.726	16.617	16.564	7.892	1.211	7.282	0.179	NO	0.053	0.043	0.066	0.043	0.023	NA	NA	NE	NA
2021	16.057	15.981	15.981	7.123	1.358	7.282	0.219	NO	NO	0.000	0.076	0.040	0.035	NA	NA	NE	NA
Trend																	
1990 - 2021	72.1%	75.9%	75.9%	37.4%	-13.2%	231.5%	-43.8%	NA	NA	-59.4%	-47.7%	-62.3%	128.5%	NA	NA	NA	NA
2005 - 2021	49.2%	51.7%	51.7%	36.4%	-38.6%	117.0%	122.0%	NA	NA	-64.3%	-31.6%	-29.3%	-35.6%	NA	NA	NA	NA
2020 - 2021	-4.0%	-3.8%	-3.5%	-9.7%	-7.0%	8.9%	6.8%	NA	-8.2%	1.8%	-0.4%	-8.3%	20.3%	NA	NA	NA	NA
Share in National Total																	
1990		97.4%	97.4%	55.6%	15.3%	22.4%	4.1%	NO	NO	1.2%	1.4%	1.3%	0.1%	NA	NA	NE	NA
2005		97.9%	97.9%	48.5%	18.8%	29.7%	0.9%	NO	NO	1.2%	1.0%	0.6%	0.3%	NA	NA	NE	NA
2021		99.5%	99.5%	44.4%	8.5%	45.3%	1.4%	NO	NO	0.0%	0.5%	0.3%	0.2%	NA	NA	NE	NA

Table 69 Non-Methane Volatile Organic Compounds (NMVOC) Emissions for the period 1990 – 2021

NMVOC		1	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5	1.B	2	3	3.B	3.D	3F	3I	5	6
kt	Total	Energy	Fuel Combustion	Energy Industries	Manufacturing Industries & Const.	Transport	Other Sectors	Non-Specified	Fugitive emissions	IPPU	Agriculture	Manure Management	Emission from soil	Field burning	Agriculture other	Waste	Other
1990	8.173	4.974	3.345	0.016	0.095	1.008	2.225	NO	1.629	0.980	1.62	1.618	NA	NA	NA	0.60	NA
1991	8.094	4.904	3.252	0.016	0.138	1.177	1.920	NO	1.652	0.966	1.62	1.616	NA	NA	NA	0.61	NA
1992	7.543	4.504	2.936	0.013	0.089	0.795	2.039	NO	1.568	0.914	1.51	1.514	NA	NA	NA	0.61	NA
1993	7.325	4.401	2.877	0.012	0.068	0.562	2.234	NO	1.524	0.855	1.45	1.454	NA	NA	NA	0.61	NA
1994	6.794	3.797	2.260	0.010	0.071	0.623	1.556	NO	1.537	0.886	1.48	1.482	NA	NA	NA	0.63	NA
1995	7.097	4.040	2.496	0.001	0.069	0.657	1.768	NO	1.544	0.900	1.51	1.512	NA	NA	NA	0.65	NA
1996	7.207	4.143	2.570	0.014	0.081	0.789	1.686	NO	1.573	0.896	1.507	1.507	NA	NA	NA	0.66	NA
1997	7.119	4.072	2.480	0.013	0.061	0.851	1.555	NO	1.592	0.901	1.476	1.476	NA	NA	NA	0.67	NA
1998	7.578	4.505	2.845	0.017	0.062	1.347	1.419	NO	1.660	0.913	1.480	1.480	NA	NA	NA	0.68	NA
1999	7.942	4.837	3.132	0.017	0.058	1.580	1.477	NO	1.704	0.937	1.479	1.479	NA	NA	NA	0.69	NA
2000	7.769	4.695	3.027	0.018	0.058	1.440	1.511	NO	1.667	0.954	1.440	1.440	NA	NA	NA	0.68	NA
2001	7.237	4.173	2.547	0.013	0.062	1.193	1.280	NO	1.626	0.967	1.424	1.424	NA	NA	NA	0.67	NA
2002	7.492	4.472	2.894	0.021	0.057	0.971	1.846	NO	1.578	0.901	1.457	1.457	NA	NA	NA	0.66	NA
2003	7.753	4.703	3.093	0.019	0.045	1.125	1.904	NO	1.610	0.947	1.452	1.452	NA	NA	NA	0.65	NA
2004	7.766	4.750	3.138	0.018	0.047	1.141	1.932	NO	1.612	0.948	1.430	1.430	NA	NA	NA	0.64	NA
2005	7.388	4.800	3.062	0.016	0.120	1.100	1.826	NO	1.738	0.956	1.005	1.005	NA	NA	NA	0.63	NA
2006	7.574	5.028	3.231	0.018	0.123	1.204	1.886	NO	1.797	0.973	0.927	0.927	NA	NA	NA	0.65	NA
2007	7.913	5.360	3.471	0.014	0.154	1.361	1.942	NO	1.890	0.982	0.877	0.877	NA	NA	NA	0.69	NA
2008	8.044	5.489	3.504	0.021	0.172	1.371	1.940	NO	1.984	0.995	0.864	0.864	NA	NA	NA	0.70	NA
2009	8.206	5.716	3.773	0.011	0.097	1.627	2.037	NO	1.943	0.994	0.828	0.828	NA	NA	NA	0.67	NA
2010	8.005	5.583	3.614	0.024	0.048	1.487	2.055	NO	1.969	0.945	0.806	0.806	NA	NA	NA	0.67	NA

NMVOC		1	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5	1.B	2	3	3.B	3.D	3F	3I	5	6
kt	Total	Energy	Fuel Combustion	Energy Industries	Manufacturing Industries & Const.	Transport	Other Sectors	Non-Specified	Fugitive emissions	IPPU	Agriculture	Manure Management	Emission from soil	Field burning	Agriculture other	Waste	Other
2011	8.092	5.796	3.849	0.024	0.096	1.597	2.131	NO	1.948	0.923	0.736	0.736	NA	NA	NA	0.64	NA
2012	8.127	5.806	3.848	0.022	0.107	1.563	2.156	NO	1.958	0.943	0.762	0.762	NA	NA	NA	0.61	NA
2013	7.407	5.107	3.148	0.021	0.135	0.934	2.058	NO	1.958	0.893	0.790	0.790	NA	NA	NA	0.62	NA
2014	7.514	5.195	3.236	0.021	0.179	1.052	1.985	NO	1.959	0.893	0.813	0.813	NA	NA	NA	0.61	NA
2015	7.816	5.463	3.458	0.022	0.178	1.131	2.128	NO	2.005	0.894	0.814	0.814	NA	NA	NA	0.65	NA
2016	8.039	5.657	3.555	0.017	0.175	1.236	2.127	NO	2.102	0.894	0.827	0.827	NA	NA	NA	0.66	NA
2017	8.290	5.906	3.717	0.018	0.175	1.268	2.255	NO	2.189	0.902	0.803	0.803	NA	NA	NA	0.68	NA
2018	8.296	5.916	3.669	0.021	0.172	1.326	2.151	NO	2.246	0.898	0.767	0.767	NA	NA	NA	0.72	NA
2019	8.440	6.053	3.764	0.021	0.184	1.355	2.204	NO	2.290	0.899	0.743	0.743	NA	NA	NA	0.74	NA
2020	8.283	5.948	3.767	0.022	0.180	1.355	2.210	NO	2.181	0.861	0.716	0.716	NA	NA	NA	0.76	NA
2021	7.991	5.815	3.442	0.019	0.193	1.355	1.875	NO	2.373	0.865	0.662	0.662	NA	NA	NA	0.65	NA
Trend																	
1990 - 2021	-2.2%	16.9%	2.9%	18.3%	80.4%	31.6%	-3.4%	NA	37.9%	-8.4%	-52.6%	-52.6%	NA	NA	NA	19.0%	NA
2005 - 2021	8.2%	21.1%	12.4%	23.6%	43.5%	20.5%	17.8%	NA	29.3%	-6.1%	-23.7%	-23.7%	NA	NA	NA	14.2%	NA
2020 - 2021	-3.5%	-2.2%	-8.6%	-13.1%	-1.8%	4.5%	-4.6%	NA	2.6%	-0.5%	-4.4%	-4.4%	NA	NA	NA	5.3%	NA
Share in National Total																	
1990		60.9%	40.9%	0.2%	1.2%	12.3%	27.2%	NO	19.9%	12.0%	19.8%	19.8%	NA	NA	NA	7.4%	NA
2005		65.0%	41.4%	0.2%	1.6%	14.9%	24.7%	NO	23.5%	12.9%	13.6%	13.6%	NA	NA	NA	8.5%	NA
2021		72.8%	43.1%	0.2%	2.4%	17.0%	23.5%	NO	29.7%	10.8%	8.3%	8.3%	NA	NA	NA	8.1%	NA

Table 70 Sulphur dioxide (SO2) Emissions for the period 1990 - 2021

Sulphur dioxide (SOx)		1	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5	1.B	2	3	5	6
kt	Total	Energy	Fuel Combustion	Energy Industries	Manufacturing Industries & Const.	Transport	Other Sectors	Non-Specified	Fugitive emissions	IPPU	Agriculture	Waste	Other
1990	44.709	44.170	44.170	42.666	0.836	0.003	0.665	NO	NO	0.540	NA	NA	NA
1991	45.514	44.991	44.991	43.368	0.938	0.003	0.681	NO	NO	0.523	NA	NA	NA
1992	37.484	37.030	37.030	35.815	0.688	0.000	0.526	NO	NO	0.454	NA	NA	NA
1993	34.673	34.475	34.475	33.443	0.568	0.000	0.464	NO	NO	0.197	NA	NA	NA
1994	27.676	27.612	27.612	26.621	0.567	0.000	0.423	NO	NO	0.064	NA	NA	NA
1995	2.569	2.433	2.433	1.411	0.579	0.000	0.443	NO	NO	0.136	NA	NA	NA
1996	39.591	39.329	39.329	37.901	0.884	0.000	0.544	NO	NO	0.262	NA	NA	NA
1997	37.032	36.621	36.621	34.813	1.083	0.000	0.726	NO	NO	0.411	NA	NA	NA
1998	48.902	48.510	48.510	46.713	1.042	0.001	0.755	NO	NO	0.391	NA	NA	NA
1999	47.481	47.071	47.071	45.143	1.083	0.003	0.842	NO	NO	0.410	NA	NA	NA
2000	51.418	50.935	50.935	49.554	0.837	0.003	0.541	NO	NO	0.483	NA	NA	NA
2001	37.834	37.287	37.287	35.925	0.758	0.052	0.552	NO	NO	0.547	NA	NA	NA
2002	59.380	58.793	58.793	57.241	0.853	0.024	0.674	NO	NO	0.587	NA	NA	NA
2003	55.025	54.421	54.421	53.049	0.706	0.023	0.643	NO	NO	0.605	NA	NA	NA
2004	51.798	51.185	51.185	49.962	0.620	0.025	0.579	NO	NO	0.613	NA	NA	NA
2005	45.094	44.486	44.486	43.275	0.842	0.056	0.313	NO	NO	0.608	NA	NA	NA
2006	53.983	53.365	53.365	52.121	0.698	0.052	0.494	NO	NO	0.619	NA	NA	NA
2007	38.991	38.359	38.359	37.291	0.671	0.095	0.302	NO	NO	0.632	NA	NA	NA
2008	57.461	56.892	56.892	55.894	0.696	0.008	0.295	NO	NO	0.569	NA	NA	NA
2009	29.150	28.827	28.827	27.885	0.381	0.174	0.387	NO	NO	0.323	NA	NA	NA
2010	52.697	52.282	52.282	51.479	0.207	0.215	0.380	NO	NO	0.416	NA	NA	NA
2011	59.679	59.210	59.210	58.764	0.251	0.009	0.186	NO	NO	0.470	NA	NA	NA
2012	56.294	55.921	55.921	55.324	0.391	0.011	0.195	NO	NO	0.373	NA	NA	NA

Sulphur dioxide (SOx)		1	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5	1.B	2	3	5	6
kt	Total	Energy	Fuel Combustion	Energy Industries	Manufacturing Industries & Const.	Transport	Other Sectors	Non-Specified	Fugitive emissions	IPPU	Agriculture	Waste	Other
2013	59.061	58.818	58.818	58.319	0.296	0.011	0.192	NO	NO	0.243	NA	NA	NA
2014	58.336	58.121	58.121	57.509	0.332	0.008	0.271	NO	NO	0.215	NA	NA	NA
2015	62.263	62.048	62.048	61.192	0.537	0.009	0.311	NO	NO	0.215	NA	NA	NA
2016	53.583	53.399	53.399	52.532	0.519	0.010	0.340	NO	NO	0.184	NA	NA	NA
2017	56.097	55.897	55.897	55.118	0.495	0.011	0.273	NO	NO	0.199	NA	NA	NA
2018	63.686	63.482	63.482	62.920	0.281	0.012	0.269	NO	NO	0.203	NA	NA	NA
2019	61.700	61.513	61.513	60.885	0.328	0.020	0.281	NO	NO	0.187	NA	NA	NA
2020	66.128	65.933	65.933	65.377	0.287	0.020	0.250	NO	NO	0.194	NA	NA	NA
2021	59.731	59.731	59.731	59.007	0.454	0.020	0.250	NO	NO	0.000	NA	NA	NA
Trend													
1990 - 2021	33.6%	35.2%	35.2%	38.3%	-66.3%	272.5%	-59.6%	NA	NA	-62.3%	NA	NA	NA
2005 - 2021	32.5%	34.3%	34.3%	36.4%	-66.6%	-78.8%	-14.2%	NA	NA	-66.6%	NA	NA	NA
2020 - 2021	-9.7%	-9.4%	-9.4%	-9.7%	-43.2%	2.7%	-1.5%	NA	NA	1.9%	NA	NA	NA
Share in National Total													
1990		98.8%	98.8%	95.4%	1.9%	0.0%	1.5%	NO	NO	1.2%	NA	NA	NA
2005		98.7%	98.7%	96.0%	1.9%	0.1%	0.7%	NO	NO	1.3%	NA	NA	NA
2021		100.0%	100.0%	98.8%	0.8%	0.0%	0.4%	NO	NO	0.0%	NA	NA	NA

Table 71 Carbon monoxide (CO) Emissions for the period 1990 - 2021

Carbon monoxide (CO)		1	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5	1.B	2	3	5	6
kt	Total	Energy	Fuel Combustion	Energy Industries	Manufacturing Industries & Const.	Transport	Other Sectors	Non-Specified	Fugitive emissions	IPPU	Agriculture	Waste	Other
1990	25.874	12.871	12.871	0.101	0.481	7.561	4.729	NO	NO	13.003	NA	NE	NA
1991	26.243	13.630	13.630	0.102	0.609	8.746	4.173	NO	NO	12.613	NA	NE	NA
1992	21.567	10.624	10.624	0.082	0.423	5.849	4.270	NO	NO	10.942	NA	NE	NA
1993	13.943	9.174	9.174	0.077	0.335	4.187	4.576	NO	NO	4.769	NA	NE	NA
1994	9.879	8.309	8.309	0.061	0.337	4.636	3.276	NO	NO	1.570	NA	NE	NA
1995	12.159	8.880	8.880	0.004	0.331	4.859	3.686	NO	NO	3.279	NA	NE	NA
1996	16.301	9.997	9.997	0.087	0.426	5.854	3.630	NO	NO	6.304	NA	NE	NA
1997	20.271	10.374	10.374	0.080	0.380	6.368	3.546	NO	NO	9.897	NA	NE	NA
1998	21.872	12.445	12.445	0.108	0.399	8.621	3.317	NO	NO	9.427	NA	NE	NA
1999	24.437	14.577	14.577	0.104	0.377	10.589	3.506	NO	NO	9.860	NA	NE	NA
2000	24.588	12.981	12.981	0.114	0.334	9.243	3.290	NO	NO	11.607	NA	NE	NA
2001	24.207	11.046	11.046	0.083	0.335	7.759	2.870	NO	NO	13.161	NA	NE	NA
2002	24.596	10.478	10.478	0.129	0.289	6.024	4.035	NO	NO	14.119	NA	NE	NA
2003	26.094	11.568	11.568	0.120	0.182	7.150	4.115	NO	NO	14.526	NA	NE	NA
2004	26.435	11.684	11.684	0.113	0.176	7.288	4.107	NO	NO	14.751	NA	NE	NA
2005	25.383	10.763	10.763	0.096	0.438	6.539	3.690	NO	NO	14.619	NA	NE	NA
2006	26.329	11.439	11.439	0.116	0.394	6.965	3.964	NO	NO	14.890	NA	NE	NA
2007	27.077	11.874	11.874	0.083	0.440	7.456	3.895	NO	NO	15.203	NA	NE	NA
2008	25.504	11.800	11.800	0.124	0.481	7.309	3.886	NO	NO	13.704	NA	NE	NA
2009	21.438	13.656	13.656	0.062	0.262	9.179	4.153	NO	NO	7.781	NA	NE	NA
2010	22.776	12.786	12.786	0.115	0.113	8.378	4.181	NO	NO	9.989	NA	NE	NA
2011	23.481	12.188	12.188	0.131	0.187	7.723	4.147	NO	NO	11.293	NA	NE	NA
2012	20.887	11.917	11.917	0.123	0.216	7.378	4.200	NO	NO	8.971	NA	NE	NA

Carbon monoxide (CO)		1	1.A	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5	1.B	2	3	5	6
kt	Total	Energy	Fuel Combustion	Energy Industries	Manufacturing Industries & Const.	Transport	Other Sectors	Non-Specified	Fugitive emissions	IPPU	Agriculture	Waste	Other
2013	14.999	9.167	9.167	0.130	0.305	4.726	4.006	NO	NO	5.832	NA	NE	NA
2014	15.209	10.053	10.053	0.128	0.380	5.611	3.934	NO	NO	5.156	NA	NE	NA
2015	15.928	10.766	10.766	0.136	0.390	6.006	4.233	NO	NO	5.162	NA	NE	NA
2016	15.673	11.255	11.255	0.117	0.387	6.488	4.263	NO	NO	4.418	NA	NE	NA
2017	16.429	11.631	11.631	0.123	0.396	6.673	4.440	NO	NO	4.798	NA	NE	NA
2018	16.534	11.643	11.643	0.140	0.387	6.876	4.240	NO	NO	4.891	NA	NE	NA
2019	16.400	11.910	11.910	0.136	0.415	7.009	4.351	NO	NO	4.490	NA	NE	NA
2020	16.567	11.891	11.891	0.146	0.400	7.009	4.336	NO	NO	4.676	NA	NE	NA
2021	11.289	11.284	11.284	0.131	0.436	7.009	3.708	NO	NO	0.005	NA	NE	NA
Trend													
1990 - 2021	-56.4%	-12.3%	-12.3%	30.7%	-19.6%	-9.0%	-10.3%	NA	NA	-62.4%	NA	NA	NA
2005 - 2021	-55.5%	4.8%	4.8%	36.4%	-11.7%	5.2%	14.9%	NA	NA	-66.5%	NA	NA	NA
2020 - 2021	-31.9%	-5.1%	-5.1%	-9.7%	-2.2%	3.1%	-4.5%	NA	NA	1.9%	NA	NA	NA
Share in National Total													
1990		49.7%	49.7%	0.4%	1.9%	29.2%	18.3%	NO	NO	50.3%	NA	NE	NA
2005		42.4%	42.4%	0.4%	1.7%	25.8%	14.5%	NO	NO	57.6%	NA	NE	NA
2021		100.0%	100.0%	1.2%	3.9%	62.1%	32.8%	NO	NO	0.0%	NA	NE	NA

3 Energy (IPCC sector 1)

3.1 Overview of the sector

In the Energy Sector, emissions originating from, fuel combustion activities in road traffic, in the energy and manufacturing industry and in the commercial, agricultural and residential sector (Category 1.A) as well as fugitive emissions from fuels (Category 1.B) are considered.

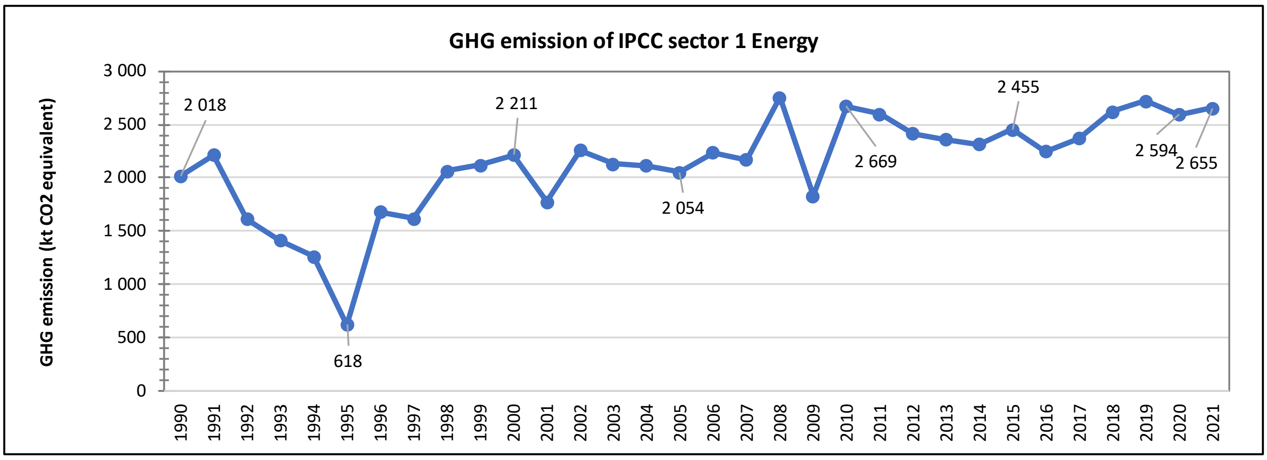


Figure 48 Trend of GHG emissions from IPCC sector 1 Energy: 1990 – 2021

In 2021, greenhouse gas emissions from IPCC sector 1 *Energy* amounted to 2 654.94 kt CO_2 equivalents which corresponds to 75.8% of the total national emissions (without LULUCF). 99.55% of the emissions from this sector originate from fuel combustion (1.A) while fugitive emissions from fuels (1.B) contribute with about 0.45%. the main sub-categories within 1.A fuel combustion are 1.A.1. Energy industries and 1.A.3. Transport (here road transport)

The **overall trend** in GHG emissions from the sector *Energy* shows increasing emissions with a increase of 31.6% from 1990 to 2021, 29.2% from 1990 to 2021, and 2.4% from 1990 to 2021.

Fugitive emissions decreased by -8.4% since 1990 due to slightly decreasing mining and post-mining activities.

Fluctuation of emissions in IPCC sector 1 Energy are due to stopped/shut-down electricity and industrial production and/or limited public life during the time of

- break-up of Yugoslavia (1992);
- overall economic downturn in the country;
- break-up of the union with Serbia (2006);
- world economic crisis (2009)
- break-down (1995) and reconstruction of the power plant (2009/2010);
- shut-down of alumina plant (2009) and shutdown of one electrolysis line (2016);
- forest and wild fires (2000, 2003, 2011, 2017);
- agricultural activities;
- growing population;
- increasing road transport;
- worldwide COVID pandemic and the lockdown.

The IPCC category 1.C. Carbon capture and storage (CCS) does not exist in Montenegro.

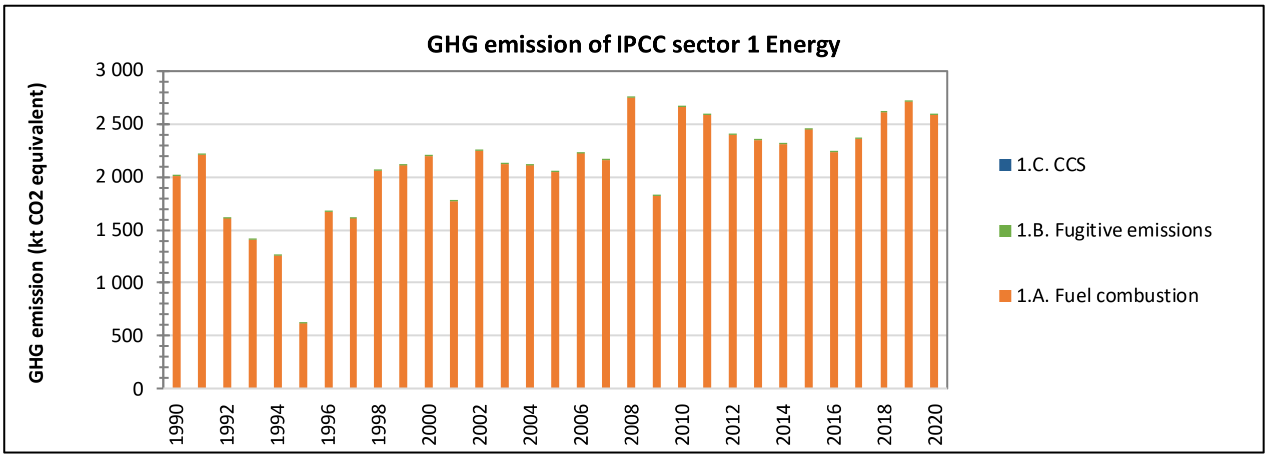


Figure 49 Trend of GHG emissions of IPCC category 1.A Fuel combustion and 1.B Fugitive emissions for the period 1990 – 2021

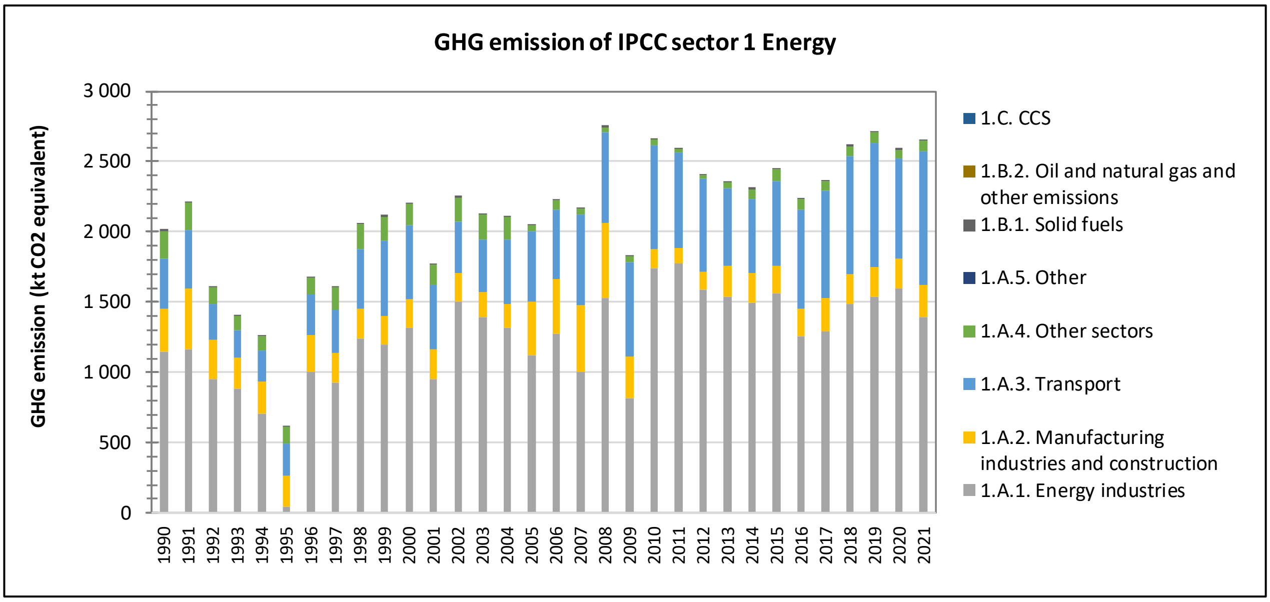


Figure 50 Trend of GHG emissions of IPCC sector 1 Energy by category for the period 1990 – 2021

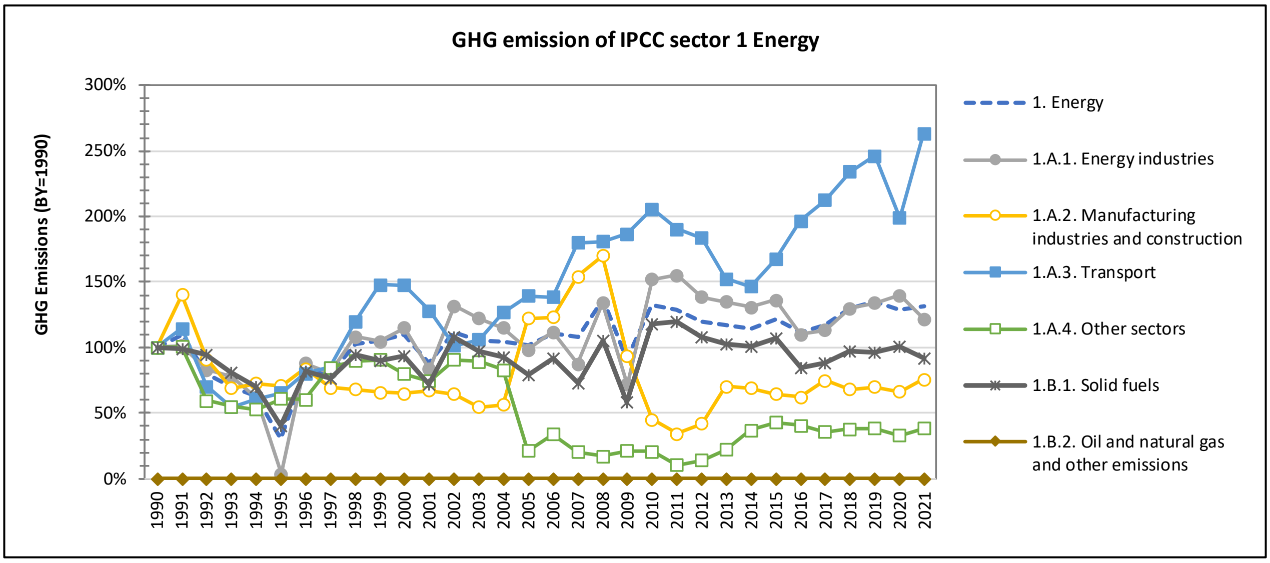


Figure 51 Trend of emissions from IPCC sector 1 Energy in index form (base year = 100) by category for the period 1990 – 2021

Table 72 GHG Emissions from IPCC sub-category 1 Energy by sub-categories for the period 1990-2021

GHG emissions	1 Energy	1.A Fuel Combustion Activities	1.A.1 Energy Industries	1.A.2 Manufacturing Industries and Construction	1.A.3 Transport	1.A.4 Other Sectors	1.A.5 Non-Specified	1.B Fugitive emissions from fuels
	kt CO_2 equivalent							
1990	**2 017.55**	2 006.00	1 142.70	310.88	358.42	194.00	NE	11.55
1991	**2 215.30**	2 203.81	1 161.08	436.63	410.73	195.37	NE	11.49
1992	**1 613.03**	1 602.14	950.15	283.02	253.06	115.91	NE	10.89
1993	**1 412.91**	1 403.50	886.60	214.64	195.76	106.50	NE	9.41
1994	**1 261.50**	1 253.43	707.79	225.26	218.09	102.29	NE	8.07
1995	**617.82**	613.13	41.12	219.95	234.09	117.97	NE	4.68
1996	**1 680.60**	1 671.13	1 004.67	261.10	288.36	117.00	NE	9.47
1997	**1 617.14**	1 608.35	923.37	215.86	304.16	164.96	NE	8.79
1998	**2 063.03**	2 052.11	1 238.01	211.16	428.68	174.26	NE	10.92
1999	**2 119.51**	2 109.08	1 197.52	204.62	531.09	175.85	NE	10.43
2000	**2 210.74**	2 199.90	1 314.34	202.39	528.34	154.84	NE	10.84
2001	**1 774.14**	1 765.84	952.97	208.77	459.27	144.83	NE	8.30
2002	**2 257.63**	2 245.12	1 504.34	200.63	364.31	175.84	NE	12.51
2003	**2 131.94**	2 120.66	1 396.87	169.98	380.66	173.16	NE	11.28
2004	**2 115.10**	2 104.50	1 314.63	175.29	453.57	161.00	NE	10.61
2005	**2 054.20**	2 045.15	1 125.21	379.50	499.21	41.23	NE	9.06
2006	**2 233.97**	2 223.48	1 277.54	383.32	497.12	65.49	NE	10.49
2007	**2 171.26**	2 162.97	999.04	478.95	645.62	39.36	NE	8.29
2008	**2 755.54**	2 743.44	1 532.67	528.54	649.00	33.22	NE	12.10
2009	**1 828.60**	1 821.94	819.61	291.51	669.56	41.27	NE	6.66
2010	**2 668.56**	2 655.06	1 736.41	140.68	737.62	40.35	NE	13.51
2011	**2 599.11**	2 585.38	1 775.66	106.56	682.71	20.45	NE	13.73
2012	**2 412.48**	2 400.07	1 584.07	130.55	658.64	26.81	NE	12.40
2013	**2 360.81**	2 349.01	1 540.15	219.00	546.95	42.91	NE	11.80
2014	**2 314.97**	2 303.44	1 492.49	214.63	524.88	71.43	NE	11.53
2015	**2 454.72**	2 442.41	1 558.84	200.50	599.47	83.59	NE	12.31
2016	**2 244.45**	2 234.73	1 256.84	193.96	704.82	79.10	NE	9.72
2017	**2 368.12**	2 357.96	1 293.39	233.41	761.76	69.40	NE	10.16
2018	**2 620.69**	2 609.56	1 486.22	211.20	838.52	73.62	NE	11.12
2019	**2 719.14**	2 708.10	1 533.10	217.15	883.29	74.57	NE	11.04
2020	**2 593.98**	2 582.45	1 599.77	205.70	713.46	63.53	NE	11.53
2021	**2 654.94**	2 644.35	1 390.53	235.46	943.65	74.71	NE	10.59
Trend								
1990 - 2021	*31.6%*	*31.8%*	*21.7%*	*-24.3%*	*163.3%*	*-61.5%*	*NA*	*-8.4%*
2005 - 2021	*29.2%*	*29.3%*	*23.6%*	*-38.0%*	*89.0%*	*81.2%*	*NA*	*16.9%*
2020 - 2021	*2.4%*	*2.4%*	*-13.1%*	*14.5%*	*32.3%*	*17.6%*	*NA*	*-8.2%*

Table 73 CO_2 Emissions from IPCC sub-category 1 Energy by sub-categories for the period 1990-2021

CO_2 emissions	1 Energy	1.A Fuel Combustion Activities	1.A.1 Energy Industries	1.A.2 Manufacturing Industries and Construction	1.A.3 Transport	1.A.4 Other Sectors	1.A.5 Non-Specified	1.B Fugitive emissions from fuels
	kt							
1990	**1 991.47**	1 990.95	1 137.43	309.77	350.37	193.38	NE	0.52
1991	**2 187.73**	2 187.22	1 155.72	435.11	401.63	194.76	NE	0.51
1992	**1 590.99**	1 590.49	945.75	282.01	247.21	115.52	NE	0.50
1993	**1 394.15**	1 393.72	882.49	213.87	191.23	106.13	NE	0.42
1994	**1 244.36**	1 243.99	704.51	224.45	213.08	101.95	NE	0.37
1995	**606.67**	606.42	40.93	219.16	228.76	117.57	NE	0.25
1996	**1 659.06**	1 658.65	1 000.01	260.12	281.89	116.62	NE	0.41
1997	**1 596.17**	1 595.79	919.10	214.99	297.26	164.44	NE	0.38
1998	**2 035.95**	2 035.48	1 232.28	210.32	419.16	173.72	NE	0.47
1999	**2 091.07**	2 090.62	1 191.97	203.79	519.55	175.31	NE	0.44
2000	**2 181.81**	2 181.35	1 308.26	201.60	517.15	154.33	NE	0.46
2001	**1 750.87**	1 750.52	948.55	207.99	449.61	144.37	NE	0.35
2002	**2 229.64**	2 229.11	1 497.35	199.85	356.63	175.27	NE	0.53
2003	**2 105.19**	2 104.71	1 390.39	169.30	372.43	172.60	NE	0.48
2004	**2 088.16**	2 087.71	1 308.52	174.62	444.09	160.48	NE	0.45
2005	**2 028.58**	2 028.20	1 119.97	378.21	488.94	41.07	NE	0.38
2006	**2 206.74**	2 206.29	1 271.60	382.06	487.36	65.28	NE	0.45
2007	**2 144.56**	2 144.21	994.39	477.40	633.21	39.20	NE	0.35
2008	**2 722.95**	2 722.44	1 525.54	526.85	636.96	33.09	NE	0.51
2009	**1 804.28**	1 804.00	815.79	290.60	656.48	41.12	NE	0.28
2010	**2 633.00**	2 632.43	1 728.33	140.29	723.61	40.20	NE	0.57
2011	**2 564.83**	2 564.25	1 767.40	106.28	670.37	20.20	NE	0.58
2012	**2 380.74**	2 380.21	1 576.71	130.14	646.82	26.54	NE	0.53
2013	**2 331.19**	2 330.69	1 532.99	218.30	536.81	42.59	NE	0.50
2014	**2 286.13**	2 285.64	1 485.55	213.90	515.16	71.03	NE	0.49
2015	**2 423.50**	2 422.97	1 551.59	199.78	588.45	83.15	NE	0.52
2016	**2 215.37**	2 214.96	1 251.00	193.26	692.03	78.68	NE	0.41
2017	**2 337.40**	2 336.97	1 287.37	232.59	748.01	69.00	NE	0.43
2018	**2 587.10**	2 586.63	1 479.31	210.49	823.62	73.21	NE	0.47
2019	**2 684.61**	2 684.14	1 525.97	216.41	867.61	74.16	NE	0.47
2020	**2 561.66**	2 561.17	1 592.32	205.01	700.68	63.15	NE	0.49
2021	**2 620.18**	2 619.73	1 384.06	234.64	926.76	74.27	NE	0.46
Trend								
1990 - 2021	***31.6%***	*31.6%*	*21.7%*	*-24.3%*	*164.5%*	*-61.6%*	*NA*	*-11.8%*
2005 - 2021	***29.2%***	*29.2%*	*23.6%*	*-38.0%*	*89.5%*	*80.8%*	*NA*	*19.4%*
2020 - 2021	***2.3%***	*2.3%*	*-13.1%*	*14.4%*	*32.3%*	*17.6%*	*NA*	*-7.0%*

Table 74 CH_4 Emissions from IPCC sub-category 1 Energy by sub-categories for the period 1990-2021

CH_4 emissions	1 Energy	1.A Fuel Combustion Activities	1.A.1 Energy Industries	1.A.2 Manufacturing Industries and Construction	1.A.3 Transport	1.A.4 Other Sectors	1.A.5 Non-Specified	1.B Fugitive emissions from fuels
	kt CO2 equivalent							
1990	**0.601**	0.160	0.012	0.014	0.109	0.025	NE	0.441
1991	**0.615**	0.176	0.012	0.019	0.121	0.024	NE	0.439
1992	**0.533**	0.118	0.010	0.013	0.080	0.016	NE	0.416
1993	**0.452**	0.092	0.009	0.010	0.059	0.015	NE	0.359
1994	**0.404**	0.096	0.007	0.010	0.065	0.014	NE	0.308
1995	**0.272**	0.095	0.000	0.010	0.068	0.016	NE	0.178
1996	**0.483**	0.121	0.010	0.013	0.083	0.015	NE	0.362
1997	**0.470**	0.134	0.010	0.012	0.092	0.021	NE	0.336
1998	**0.589**	0.171	0.013	0.011	0.126	0.022	NE	0.418
1999	**0.592**	0.193	0.012	0.011	0.148	0.022	NE	0.399
2000	**0.589**	0.174	0.014	0.010	0.129	0.020	NE	0.415
2001	**0.467**	0.149	0.010	0.010	0.110	0.019	NE	0.318
2002	**0.613**	0.134	0.015	0.010	0.086	0.023	NE	0.479
2003	**0.579**	0.146	0.014	0.009	0.101	0.022	NE	0.432
2004	**0.554**	0.148	0.013	0.009	0.105	0.021	NE	0.406
2005	**0.474**	0.127	0.011	0.016	0.094	0.006	NE	0.347
2006	**0.536**	0.134	0.013	0.016	0.097	0.009	NE	0.402
2007	**0.456**	0.139	0.010	0.019	0.104	0.006	NE	0.317
2008	**0.604**	0.140	0.015	0.021	0.099	0.005	NE	0.464
2009	**0.398**	0.143	0.008	0.011	0.118	0.006	NE	0.255
2010	**0.658**	0.141	0.017	0.005	0.112	0.006	NE	0.517
2011	**0.644**	0.118	0.017	0.004	0.087	0.010	NE	0.526
2012	**0.585**	0.110	0.016	0.005	0.078	0.011	NE	0.475
2013	**0.557**	0.105	0.015	0.009	0.068	0.013	NE	0.452
2014	**0.571**	0.129	0.015	0.009	0.089	0.016	NE	0.442
2015	**0.611**	0.140	0.015	0.009	0.097	0.018	NE	0.472
2016	**0.514**	0.142	0.012	0.009	0.104	0.017	NE	0.372
2017	**0.536**	0.147	0.013	0.010	0.108	0.016	NE	0.389
2018	**0.576**	0.150	0.015	0.009	0.110	0.016	NE	0.426
2019	**0.578**	0.156	0.015	0.009	0.115	0.016	NE	0.423
2020	**0.572**	0.130	0.016	0.008	0.091	0.015	NE	0.442
2021	**0.569**	0.164	0.014	0.010	0.122	0.018	NE	0.405
Trend								
1990 - 2021	***-5.3%***	*2.6%*	*13.4%*	*-27.7%*	*12.2%*	*-27.4%*	*NA*	*-8.2%*
2005 - 2021	***20.0%***	*28.7%*	*23.6%*	*-37.4%*	*30.3%*	*188.2%*	*NA*	*16.8%*
2020 - 2021	***-0.5%***	*25.7%*	*-13.1%*	*20.6%*	*34.1%*	*18.2%*	*NA*	*-8.2%*

Table 75 N_2O Emissions from IPCC sub-category 1 Energy by sub-categories for the period 1990-2021

N_2O emissions	1 Energy	1.A Fuel Combustion Activities	1.A.1 Energy Industries	1.A.2 Manufacturing Industries and Construction	1.A.3 Transport	1.A.4 Other Sectors	1.A.5 Non-Specified	1.B Fugitive emissions from fuels
	kt CO2 equivalent							
1990	**0.037**	0.037	0.017	0.003	0.018	<0.001	NE	NO
1991	**0.041**	0.041	0.017	0.004	0.020	<0.001	NE	NO
1992	**0.029**	0.029	0.014	0.002	0.013	<0.001	NE	NO
1993	**0.025**	0.025	0.013	0.002	0.010	<0.001	NE	NO
1994	**0.024**	0.024	0.010	0.002	0.011	<0.001	NE	NO
1995	**0.015**	0.015	0.001	0.002	0.012	<0.001	NE	NO
1996	**0.032**	0.032	0.015	0.002	0.015	<0.001	NE	NO
1997	**0.031**	0.031	0.014	0.002	0.015	<0.001	NE	NO
1998	**0.041**	0.041	0.018	0.002	0.021	<0.001	NE	NO
1999	**0.046**	0.046	0.018	0.002	0.026	<0.001	NE	NO
2000	**0.048**	0.048	0.019	0.002	0.027	<0.001	NE	NO
2001	**0.039**	0.039	0.014	0.002	0.023	<0.001	NE	NO
2002	**0.042**	0.042	0.022	0.002	0.019	<0.001	NE	NO
2003	**0.041**	0.041	0.021	0.002	0.019	<0.001	NE	NO
2004	**0.044**	0.044	0.019	0.002	0.023	<0.001	NE	NO
2005	**0.046**	0.046	0.017	0.003	0.027	<0.001	NE	NO
2006	**0.046**	0.046	0.019	0.003	0.025	<0.001	NE	NO
2007	**0.051**	0.051	0.015	0.004	0.033	<0.001	NE	NO
2008	**0.059**	0.059	0.023	0.004	0.032	<0.001	NE	NO
2009	**0.048**	0.048	0.012	0.002	0.034	<0.001	NE	NO
2010	**0.064**	0.064	0.026	0.001	0.038	<0.001	NE	NO
2011	**0.061**	0.061	0.026	0.001	0.034	<0.001	NE	NO
2012	**0.057**	0.057	0.023	0.001	0.033	<0.001	NE	NO
2013	**0.053**	0.053	0.023	0.002	0.028	<0.001	NE	NO
2014	**0.049**	0.049	0.022	0.002	0.025	<0.001	NE	NO
2015	**0.053**	0.053	0.023	0.002	0.029	<0.001	NE	NO
2016	**0.054**	0.054	0.019	0.002	0.034	<0.001	NE	NO
2017	**0.058**	0.058	0.019	0.002	0.037	<0.001	NE	NO
2018	**0.064**	0.064	0.022	0.002	0.041	<0.001	NE	NO
2019	**0.067**	0.067	0.023	0.002	0.043	<0.001	NE	NO
2020	**0.060**	0.060	0.024	0.002	0.035	<0.001	NE	NO
2021	**0.069**	0.069	0.021	0.002	0.046	<0.001	NE	NO
Trend								
1990 - 2021	*85.7%*	*85.7%*	*23.2%*	*-24.7%*	*159.7%*	*-24.7%*	*NA*	*NA*
2005 - 2021	*49.1%*	*49.1%*	*23.6%*	*-35.9%*	*74.6%*	*-35.9%*	*NA*	*NA*
2020 - 2021	*13.9%*	*13.9%*	*-13.1%*	*18.9%*	*31.8%*	*18.9%*	*NA*	*NA*

3.2 Fuel combustion

3.2.1 Comparison of the Sectoral Approach (SA) with the Reference Approach

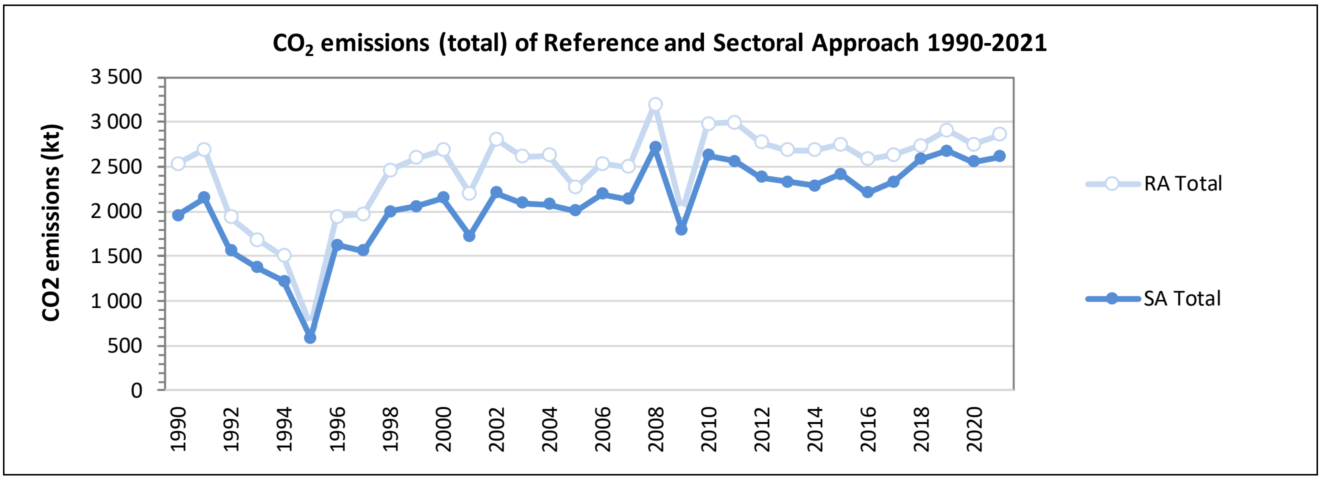


Figure 52 CO_2 emissions (Total) of the Reference and Sectoral Approach 1990 to 2021.

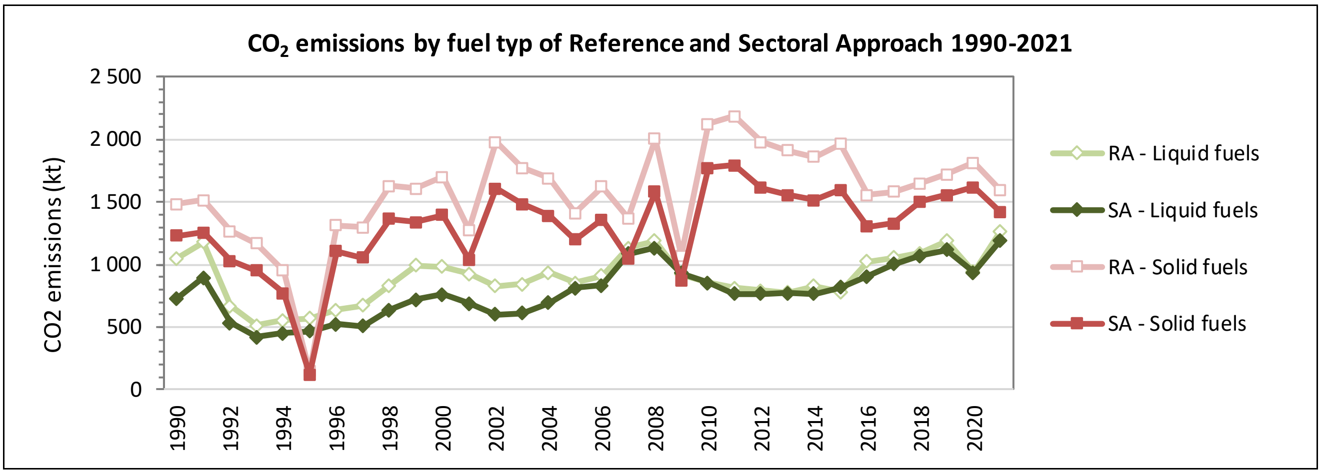


Figure 53 CO_2 emissions (detailed) of the Reference and Sectoral Approach 1990 to 2021.

Explanation of differences

- Use of country specific NCV (CS NCV) for solid fuels – Lignite.
- Use of country specific emissions factor.
- Non-energy use consumption of fuels like bitumen and luibricants

The following table provides the results of the CO_2 emissions of the reference and sectoral approaches.

Table 76 CO_2 emissions of the Reference and Sectoral Approach 1990 to 2020

	Reference Approach					Sectoral Approach 1.A Fuel Combustion				
	Total fossil fuels	Liquid fossil fuels	Solid fossil fuels	Gaseous fossil fuels	Other fossil fuels	Total fossil fuels	Liquid fossil fuels	Solid fossil fuels	Gaseous fossil fuels	Other fossil fuels
	kt					kt				
1990	**2 535**	1 052	1 483	NO	NO	**1 957**	728	1 229	NO	NO
1991	**2 696**	1 179	1 517	NO	NO	**2 152**	896	1 255	NO	NO
1992	**1 935**	669	1 266	NO	NO	**1 564**	533	1 030	NO	NO
1993	**1 682**	513	1 169	NO	NO	**1 371**	419	952	NO	NO
1994	**1 502**	552	950	NO	NO	**1 223**	449	773	NO	NO
1995	**717**	571	146	NO	NO	**585**	465	119	NO	NO
1996	**1 946**	635	1 311	NO	NO	**1 628**	523	1 104	NO	NO
1997	**1 969**	672	1 296	NO	NO	**1 564**	509	1 055	NO	NO
1998	**2 462**	833	1 629	NO	NO	**2 001**	634	1 366	NO	NO
1999	**2 601**	993	1 607	NO	NO	**2 058**	720	1 338	NO	NO
2000	**2 685**	984	1 701	NO	NO	**2 155**	759	1 395	NO	NO
2001	**2 200**	923	1 277	NO	NO	**1 725**	686	1 039	NO	NO
2002	**2 809**	830	1 979	NO	NO	**2 209**	598	1 610	NO	NO
2003	**2 615**	845	1 771	NO	NO	**2 095**	611	1 484	NO	NO
2004	**2 628**	935	1 693	NO	NO	**2 080**	691	1 389	NO	NO
2005	**2 266**	854	1 412	NO	NO	**2 009**	811	1 197	NO	NO
2006	**2 533**	912	1 621	NO	NO	**2 193**	834	1 358	NO	NO
2007	**2 501**	1 132	1 368	NO	NO	**2 136**	1 085	1 050	NO	NO
2008	**3 194**	1 189	2 005	NO	NO	**2 714**	1 132	1 581	NO	NO
2009	**1 990**	919	1 071	NO	NO	**1 799**	929	870	NO	NO
2010	**2 982**	856	2 126	NO	NO	**2 631**	855	1 775	NO	NO
2011	**2 999**	814	2 185	NO	NO	**2 563**	765	1 794	NO	NO
2012	**2 770**	790	1 980	NO	NO	**2 379**	764	1 611	NO	NO
2013	**2 688**	777	1 911	NO	NO	**2 329**	769	1 555	NO	NO
2014	**2 688**	825	1 863	NO	NO	**2 286**	765	1 516	NO	NO
2015	**2 748**	782	1 966	NO	NO	**2 420**	816	1 600	NO	NO
2016	**2 582**	1 026	1 556	NO	NO	**2 212**	904	1 304	NO	NO
2017	**2 637**	1 056	1 581	NO	NO	**2 334**	1 002	1 328	NO	NO
2018	**2 739**	1 090	1 649	NO	NO	**2 584**	1 073	1 507	NO	NO
2019	**2 912**	1 191	1 721	NO	NO	**2 681**	1 119	1 558	NO	NO
2020	**2 754**	939	1 815	NO	NO	**2 558**	935	1 619	NO	NO
2021	**2 860**	1 263	1 597	NO	NO	**2 616**	1 190	1 421	NO	NO

The following tables provide the differences of CO_2 emissions in percent between reference and sectoral approaches.

Table 77 Differences of CO_2 emissions of the Reference and Sectoral Approaches by type of fuel in percent

	Total	Liquid	Solid	Gaseous	Peat	Other fossil fuels
1990	-30.8%	-17.1%	NA	NA	NA	-22.8%
1991	-24.0%	-17.3%	NA	NA	NA	-20.2%
1992	-20.4%	-18.6%	NA	NA	NA	-19.2%
1993	-18.3%	-18.6%	NA	NA	NA	-18.5%
1994	-18.7%	-18.6%	NA	NA	NA	-18.6%
1995	-18.5%	-18.6%	NA	NA	NA	-18.4%
1996	-17.6%	-15.8%	NA	NA	NA	-16.3%
1997	-24.3%	-18.6%	NA	NA	NA	-20.6%
1998	-23.9%	-16.1%	NA	NA	NA	-18.7%
1999	-27.5%	-16.8%	NA	NA	NA	-20.9%
2000	-22.8%	-18.0%	NA	NA	NA	-19.7%
2001	-25.7%	-18.6%	NA	NA	NA	-21.6%
2002	-28.0%	-18.6%	NA	NA	NA	-21.4%
2003	-27.7%	-16.2%	NA	NA	NA	-19.9%
2004	-26.1%	-18.0%	NA	NA	NA	-20.9%
2005	-5.1%	-15.2%	NA	NA	NA	-11.4%
2006	-8.5%	-16.2%	NA	NA	NA	-13.4%
2007	-4.2%	-23.3%	NA	NA	NA	-14.6%
2008	-4.8%	-21.1%	NA	NA	NA	-15.0%
2009	1.1%	-18.8%	NA	NA	NA	-9.6%
2010	-0.1%	-16.5%	NA	NA	NA	-11.8%
2011	-6.1%	-17.9%	NA	NA	NA	-14.5%
2012	-3.3%	-18.6%	NA	NA	NA	-14.1%
2013	-0.9%	-18.6%	NA	NA	NA	-13.4%
2014	-7.2%	-18.6%	NA	NA	NA	-15.0%
2015	4.3%	-18.6%	NA	NA	NA	-11.9%
2016	-11.9%	-16.2%	NA	NA	NA	-14.3%
2017	-5.1%	-16.0%	NA	NA	NA	-11.5%
2018	-1.6%	-8.6%	NA	NA	NA	-5.7%
2019	-6.0%	-9.5%	NA	NA	NA	-7.9%
2020	-0.4%	-10.8%	NA	NA	NA	-7.1%
2021	-5.8%	-11.0%	NA	NA	NA	-8.5%

3.2.1.1 Methodology

The default methodology is applied according to 2006 IPCC Guidelines[34]. The Reference Approach methodology breaks the calculation of carbon dioxide emissions from fuel combustion into 5 steps:

Step 1: Estimate apparent fuel consumption in original units

Step 2: Convert to a common energy unit

Step 3: Multiply by carbon content to compute the total carbon

Step 4: Compute the excluded carbon

Step 5a: Correct for carbon unoxidised

Step 5b: Convert to CO_2 emissions

These steps are expressed in the following equation.

Equation 6.1: CO_2 Emissions from fuel combustion using the Reference approach (2006 IPCC GL, Vol. 2, Chap. 6.3)

$$CO_2 Emissions = \sum_{all\ fuels}\left[\left(\left(\textbf{Apparent Consumption}_{fuel} \times \textbf{ConversionFactor}_{fuel} \times \textbf{Carbon Content}_{fuel}\right) \times 10^{-3} - \textbf{Excluded Carbon}_{fuel}\right) \times \textbf{Fraction of carbon oxidised}_{fuel} \times \frac{44}{12}\right]$$

Where:

Emissions $_{CO2}$	= CO_2 emissions (Gg CO_2)
Apparent Consumption	= production + imports – exports – international bunkers - stock change
Conversion Factor (ConVer)	= conversion factor for the fuel to energy units (TJ) on a net calorific value basis
Carbon content (CC)	= carbon content (tonne C/TJ) *Note that tonne C/TJ is identical to kg C/GJ*
Excluded Carbon	= carbon in feedstocks and non-energy use excluded from fuel combustion emissions (Gg C)
Fraction of carbon oxidised (COF)	= fraction of carbon oxidised. *Usually the value is 1, reflecting complete oxidation. Lower values are used only to account for carbon retained indefinitely in ash or soot*
44/12	= molecular weight ratio of CO_2 to C

[34] 2006 IPCC Guidelines, Volume 2: Energy, Chapter 6: Reference Approach, sub-chapter 6.3 ALGORITHM , page 6.5

3.2.1.2 Activity data

3.2.1.2.1 Apparent consumption of fuels

***Step 1**: Estimate apparent fuel consumption in original units*

According to 2006 IPCC Guidelines the supply of fuels is calculated based on data for each fuel and inventory year:

- ⇨ the amounts of primary fuels **produced**[35] (production of secondary fuels and fuel products is not included);
- ⇨ the amounts of primary and secondary fuels **imported**;
- ⇨ the amounts of primary and secondary fuels **exported**;
- ⇨ the amounts of primary and secondary fuels **used in international bunkers**;
- ⇨ the net **increases or decreases** in **stocks** of primary and secondary fuels.

The production of secondary fuels should be ignored in the calculations because the carbon in these fuels is already included in the supply of primary fuels from which they were derived.

The **apparent consumption of a primary fuel** is calculated as follows:

Equation 6.2: Apparent consumption of primary fuel (2006 IPCC GL, Vol. 2, Chap. 6.3)

$$\text{Apparent Consumption}_{fuel} = \text{Production}_{fuel} + \text{Imports}_{fuel} - \text{Exports}_{fuel} - \text{International Bunkers}_{fuel} - \text{Stock Change}_{fuel}$$

The **apparent consumption of a secondary fuel** is calculated as follows:

Equation 6.3: Apparent consumption of secondary fuel (2006 IPCC GL, Vol. 2, Chap. 6.3)

$$\text{Apparent Consumption}_{fuel} = \text{Imports}_{fuel} - \text{Exports}_{fuel} - \text{International Bunkers}_{fuel} - \text{Stock Change}_{fuel}$$

The activity data are taken from the national energy balance but not the IEA Joint Questionaire (JQ) as this was not available.

3.2.1.2.2 Conversion to energy units

***Step 2**: Convert to a common energy unit*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic meters. To convert these data to energy units, in this case terajoules, requires calorific values. For estimation of emissions that arise from combustion of fossil fuels, the default net caloric values (NCV) have been used according to 2006 IPCC Guidelines and presented in the following table.

[35] Production of coal includes the quantities extracted or produced calculated after any operation for removal of inert matter.

3.2.2 Excluded carbon

***Step 4**: Compute the excluded carbon*

The amount of carbon which does not lead to fuel combustion emissions has to be excluded, as the because the aim is to provide an estimate of fuel combustion emissions (Source category 1A).

Carbon excluded from fuel combustion is either emitted in another sector of the inventory (for example as an industrial process emission) or is stored in a product manufactured from the fuel. In the 1996 Guidelines, carbon in the apparent consumption that does not lead to fuel combustion emissions has been referred to as “stored carbon” but, as the above definition makes clear, stored carbon is only part of the carbon to be excluded from “total carbon” in the 2006 IPCC Guidelines. The main flows of carbon concerned in the calculation of excluded carbon are those used as feedstock, reductant or as non-energy products. Table 6.1 sets out the main products in each group. If countries have other fossil fuel carbon products which should be excluded they should be taken into consideration and documented.

Table 78 Fuel used as feedstock, reductant and/or non-energy products in Montenegro

	Fuel	Fuel used as feedstock, reductant and/or non-energy products in Montenegro
Feedstock	Naphtha	
	LPG (butane/propane)	
	Gas/diesel oil and Kerosene	
	Natural gas	
	Ethane	
Reductant	Coke oven coke (metallurgical coke) and petroleum coke	
	Coal and coal tar/pitch	
	Natural gas	
Non-energy products	Bitumen	X
	Lubricants	X
	Paraffin waxes	X
	White spirit	

3.2.2.1 Emission factor

3.2.2.1.1 Carbon content

Step 3: Multiply by carbon content to compute the total carbon

For estimation of emissions that arise from combustion of fossil fuels, the default carbon content has been used according to 2006 IPCC Guidelines and presented in the following table.

3.2.2.1.2 Fraction of carbon oxidized

Step 5a: Correct for carbon unoxidised

For estimation of emissions that arise from combustion of fossil fuels, the default fraction of carbon oxidated has been used according to 2006 IPCC Guidelines and presented in the following table.

A small part of the fuel carbon entering the combustion process escapes oxidation. This fraction is usually small (99 to 100 % of the carbon is oxidized) and it is assumed that 100% is oxidated.

Table 79 Default net calorific values (NCVs), default values of carbon content (CC), default fraction of carbon oxidized and indication which fuel was used in Montenegro

		Default Net Calorific Values (NCVs)	Default values of Carbon Content (CC)	Default Fraction of carbon oxidized	Fuel used in Montenegro
		TJ/Gg	kg/GJ	%	
LIQUID (Crude oil and petroleum products)					
Gasoline	Motor Gasoline	44.3	18.9	1	X
Jet Kerosene		44.1	19.5	1	X
Gas/Diesel Oil		43.0	20.2	1	X
Residual Fuel Oil		40.4	21.1	1	X
Liquefied Petroleum Gases		47.3	17.2	1	X
Bitumen		40.2	22	1	x
Lubricants		40.2	20	1	x
Other Oil	Paraffin Waxes	40.2	20	1	
	White Spirit and SBP	40.2	20	1	
	Other Petroleum Products	40.2	20	1	x
SOLID (Coal and coal products)					
Lignite		11.9	27.6	1	x
GAS (Natural Gas)					
OTHER FOSSIL FUELS					
PEAT					
BIOMASS					
Source *Footnote (above) in this tables are referred to footnotes provided in tables in 2006 IPCC Guidelines.*		*TABLE 1.2* [36]	*TABLE 1.3* [37]	*TABLE 1.4* [38]	

[36] 2006 IPCC Guidelines, Volume 2: Energy, Chapter 1: Introduction, sub-chapter 1.4.1.3 ACTIVITY DATA SOURCES, page 1.17

[37] 2006 IPCC Guidelines, Volume 2: Energy, Chapter 1: Introduction, sub-chapter 1.4.2.1 CO2 EMISSION FACTORS, page 1.20

[38] 2006 IPCC Guidelines, Volume 2: Energy, Chapter 1: Introduction, sub-chapter 1.4.2.1 CO2 EMISSION FACTORS, page 1.23

3.2.3 International bunker fuels

International bunkers are relevant for

- International aviation: international airports Podgorica and Tivat;
- International navigation on Adriatic Sea (Mediterranean Sea) and Lake Skadar

3.2.3.1 International Aviation (International bunkers)

As described in the 2006 IPCC Guidelines, the IPCC category *International Aviation (International bunkers)* includes emissions from flights that depart in one country and arrive in a different country. Also, International navigations include take-offs and landings for these flight stages. It is *good practice*, that emissions from domestic navigation are reported separately from international navigation and it it is *good practice* to apply the definition presented in the following table.

Table 80 Criteria for defining international or domestic *Aviation*

Criteria for defining international or domestic navigation (applies to individual legs of journeys with more than one take-off and landing)		
Journey type between two airports	**Domestic**	**International**
• Departs and arrives in same country	Yes	No
• Departs from one country and arrives in another	No	Yes
Source: 2006 IPCC Guidelines, Volume 2, Chapter 3: Mobile Combustion, 3.6.1.3 Choice of activity data, TABLE 3.6.		

Montenegro has two airports, both for national and international flights. The number of passengers carried by international aviation but also the international freight transport increased. The drop in 2020 is due to worldwide pandemic.

GHG emissions from combustion of fuel in *international aviation* amounted to

- 10.55 kt CO_2 equivalent in the year 1990,
- 15.13 kt CO_2 equivalent in the year 2005.
- 32.95kt CO_2 equivalent in the year 2021.

GHG emissions from *international aviation* increased by 212.4% in the period 1990 – 2021, which is mainly caused by increasing activities in passenger and freight transport.

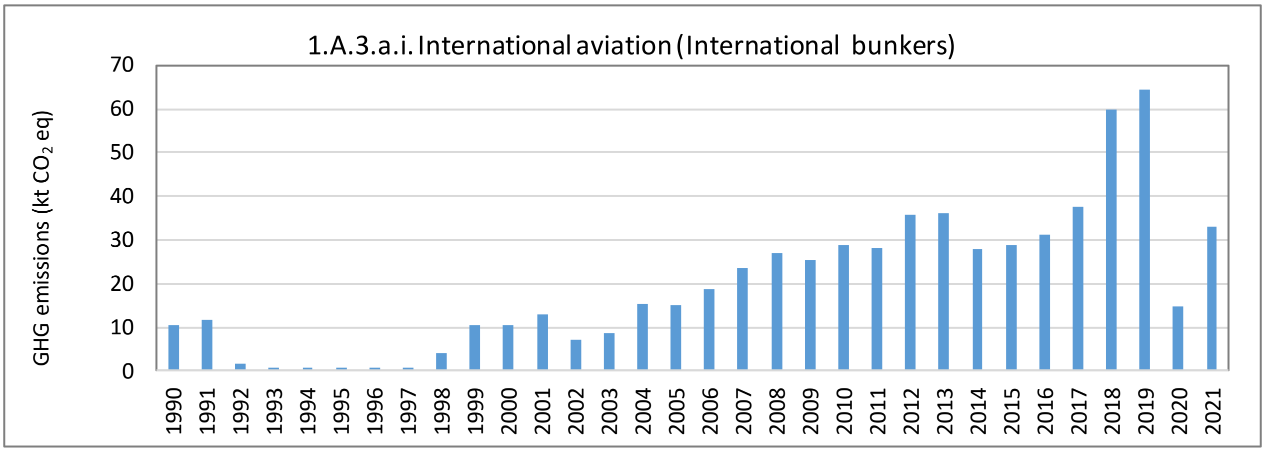


Figure 54 GHG emissions from International Bunkers: International aviation

Table 81 Activity data and Emissions from International Bunkers - International aviation

International aviation	Emission				Activity data		
	GHG	CO_2	N_2O	CH_4	Jet Kerosene	Aviation fuel	Biomass
	kt CO_2 equivalent	kt	kt	kt	[TJ]	[TJ]	
1990	10.55	10.42	0.0004	0.0004	145.33	NO	NO
1991	11.62	11.48	0.0004	0.0004	160.14	NO	NO
1992	1.62	1.60	0.0001	0.0001	22.36	NO	NO
1993	0.81	0.80	0.0000	0.0000	11.18	NO	NO
1994	0.81	0.80	0.0000	0.0000	11.18	NO	NO
1995	0.81	0.80	0.0000	0.0000	11.18	NO	NO
1996	0.81	0.80	0.0000	0.0000	11.18	NO	NO
1997	0.81	0.80	0.0000	0.0000	11.18	NO	NO
1998	4.06	4.01	0.0002	0.0002	55.90	NO	NO
1999	10.55	10.42	0.0004	0.0004	145.33	NO	NO
2000	10.55	10.42	0.0004	0.0004	145.33	NO	NO
2001	12.98	12.82	0.0005	0.0005	178.87	NO	NO
2002	7.14	7.05	0.0003	0.0003	98.39	NO	NO
2003	8.57	8.47	0.0003	0.0003	118.09	NO	NO
2004	15.45	15.26	0.0006	0.0006	212.92	NO	NO
2005	15.13	14.94	0.0006	0.0006	208.39	NO	NO
2006	18.82	18.58	0.0007	0.0007	259.24	NO	NO
2007	23.56	23.27	0.0009	0.0009	324.55	NO	NO
2008	27.05	26.72	0.0010	0.0010	372.75	NO	NO
2009	25.45	25.14	0.0010	0.0010	350.67	NO	NO
2010	28.80	28.45	0.0011	0.0011	396.80	NO	NO
2011	28.08	27.73	0.0011	0.0011	386.86	NO	NO
2012	35.85	35.41	0.0014	0.0014	493.88	NO	NO
2013	36.11	35.67	0.0014	0.0014	497.51	NO	NO
2014	27.77	27.43	0.0011	0.0011	382.65	NO	NO
2015	28.90	28.54	0.0011	0.0011	398.14	NO	NO
2016	31.30	30.92	0.0012	0.0012	431.25	NO	NO
2017	37.77	37.31	0.0014	0.0014	520.40	NO	NO
2018	59.80	59.06	0.0023	0.0023	823.88	NO	NO
2019	64.43	63.64	0.0024	0.0024	887.67	NO	NO
2020	14.73	14.55	0.0006	0.0006	202.95	NO	NO
2021	32.95	32.55	0.0013	0.0013	454.03	NO	NO
Trend							
1990 - 2020	*212.4%*	*212.4%*	*212.4%*	*212.4%*	*NA*	*NA*	*NA*
2005 - 2020	*117.9%*	*117.9%*	*117.9%*	*117.9%*	*NA*	*NA*	*NA*
2019 - 2020	*123.7%*	*123.7%*	*123.7%*	*123.7%*	*NA*	*NA*	*NA*

3.2.3.1.1 Methodological issues

3.2.3.1.1.1 Choice of methods – TIER 1

For estimating the CO_2, CH_4 and N_2O emissions the 2006 IPCC Guidelines Tier 1 approach[39] has been applied:

Equation 3.6.1: Aviation equation (2006 IPCC GL, Vol. 3, Chap. 3.6.1.1)

$$\boldsymbol{Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}}$$

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG} = \sum_{fuel} emissions_{\mathrm{GHG,\,fuel}}}$$

Where:

Emissions $_{GHG,\ fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG,\ fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ)
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, e.g., jet kerosene, aviation gasoline

3.2.3.1.1.2 Choice of activity data

The following fuels are used in international aviation:

Liquid fuels:
- Jet Kerosene

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 – 2021 were taken from MONSTAT. Activity data are provided in the tables above.

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic meters. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC category *Domestic aviation* are provided.

Table 82 Net calorific values (NCVs) and Conversion factors applied for conversion to energy units in IPCC category IPCC category 1.A.3.a.i *International aviation.*

Fuel type	Fuel	Unit	Net calorific value (NCV) 2006 IPCC default NCV
liquid	Jet Kerosene	TJ / Gg	44.1
			2006 IPCC Guidelines, Vol. 2, Chap. 1 (1.4.1.3), Table 1.2
Note:			
D Default	CS Country specific	PS Plant specific	

[39] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 3: Mobile Combustion - 3.6.1.1 Methodological issues - Choice of method

3.2.3.1.1.3 Choice of emission factors

Default emission factors for CO_2, CH_4 and N_2O for Jet Kerosene were taken from EMEP/EEA GB 2019 and are presented in the following table.

Table 83 Fuel consumption factor for LTO and cruise for IPCC category 1.A.3.a.i *International aviation.*

Fuel type	Fuel	Fuels consumption for LTO (kg/LTO)		Fuels consumption for cruise (kg/LTO)
		EF	type	EF
liquid	Jet Kerosene - LTO	825	D	-
liquid	Jet Kerosene - Cruise	-	D	Difference (Fuel_consumed - Fuel for LTO`s)
Source	EMEP/EEA GB 2019, Chapter Aviation 1.A.3.a, Page 18 Table 3–3 Emission factors and fuel use for the Tier 1 methodology using jet kerosene as fuel."			

Table 84 GHG Emission factors TIER 1 for IPCC category 1.A.3.a.i *International aviation.*

Fuel type	Fuel	CO_2 (t/LTO)		CH_4 (t/LTO)		N_2O (t/LTO)	
		EF	type	EF	type	EF	type
liquid	Jet Kerosene	2.6	D	0.0001	D	0.0001	D
Source	EMEP/EEA GB 2019, Chapter Aviation 1.A.3.a Table 3–3 Emission factors and fuel use for the Tier 1 methodology using jet kerosene as fuel.						
Note:							
D	Default	CS	Country specific	PS	Plant specific	IEF	Implied emission factor

3.2.3.1.2 Uncertainty assessment and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category IPCC category 1.A.3.a.ii *Domestic aviation* are presented in the following table.

Table 85 Uncertainty for IPCC category 1.A.3.a.i *International aviation.*

Uncertainty	Jet Kerosene			Reference
	CO_2	CH_4	N_2O	
Activity data (AD)	10%	10%	10%	2006 IPCC GL, Vol. 2, Chap. 3.6.1.7
Emission factor (EF)	5%	82%	133%	
Combined Uncertainty (U)	11%	83%	133%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period.

3.2.3.1.3 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- consistent use of energy balance data (preparation of a time series),
- documented sources,
- use of units and conversion factors,
- strictly defined interfaces between spreadsheets/calculation modules,
- unique structure of sheets which do the same,
- record keeping, use of write protection,
- unique use of formulas, special cases are documented/highlighted,
- quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from different sources:
- national statistic published by MONSTAT and information from 'Airports of Montenegro'[40]
- international energy statistics of UN statistics[41] and
- Eurostat[42]

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.3.1.4 Category-specific recalculations including explanatory information and justifications for recalculations

The following table presents the main revisions and recalculations done since the last two submission to the UNFCCC and relevant to IPCC category IPCC category 1.A.3.a.i *International aviation.*

Table 86 Recalculations done since NC in IPCC category 1.A.3.a.i *International aviation*

Source category	Revisions of data	Type of revision	Type of improvement
1.3.1.a.ii	Application of 2006 IPCC Guidelines methodology and estimation of GHG emissions	EMI	Comparability Completeness

3.2.3.1.5 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

[40] https://montenegroairports.com/en/airports-of-montenegro/business-information/statistical-data/

[41] United Nations - Department of Economic and Social Affairs - Statistics Division Statistics - Energy Statistics https://unstats.un.org/unsd/energystats/

[42] Data and statistics - https://ec.europa.eu/eurostat/web/main/data/database

Table 87 Planned improvements for IPCC category 1.A.3.a.i *International aviation*

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.3.a.i 1.A.3.a.ii	Energy balance (1990-2021) for all aviation related fuels • improvement of time series completeness and consistency • for all aviation related fuels o Jet kerosene o aviation gasoline • Investigation regarding fuel consumption of aviation gasoline used by small planes and helicopters.	AD	Accuracy Completeness Comparability Transparency Consistency	high
1.A.3.a.i 1.A.3.a.ii	Collection of data on aircraft movement • international aviation by air craft and destination • domestic aviation by air craft and destination	AD	Accuracy Completeness Comparability Transparency	medium
1.A.3.a.i 1.A.3.a.ii	Application of Tier 3 methodology using data on aircraft movement • Estimate fuel consumption for LTO and cruise for o *International aviation* o domestic aviation • Estimate emissions from LTO and cruise phases for o *International aviation* o domestic *aviation*	M EF	Accuracy Completeness Comparability Transparency Consistency	medium
1.A.3.a.i 1.A.3.a.ii	Investigation regarding fuel consumption from domestic and international military aviation.	AD	Completeness	Medium

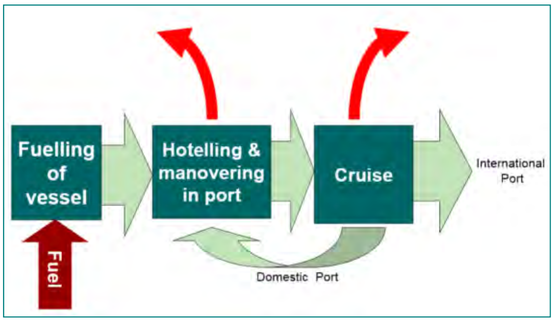
3.2.3.2 International navigation (International bunkers)

As described in the 2006 IPCC Guidelines, the IPCC category *International Water-borne Navigation (International bunkers)* includes emissions from fuels used by vessels of all flags that are engaged in international water-borne navigation. The international navigation may take place at sea, on inland lakes and waterways and in coastal waters. This category includes emissions from journeys that depart in one country and arrive in a different country. The category exclude consumption by fishing vessels (see here Other Sector - Fishing). It is *good practice*, that emissions from domestic navigation are reported separately from international navigation and it is *good practice* to apply the definition presented in the following table.

Table 88 Criteria for defining international or domestic water-borne navigation

Criteria for defining international or domestic water-borne navigation (applies to each segment of a voyage calling at more than two ports)		
Journey type between two ports	**Domestic**	**International**
• Departs and arrives in same country	Yes	No
• Departs from one country and arrives in another	No	Yes

Source: 2006 IPCC Guidelines, Volume 2, Chapter 3: Mobile Combustion, 3.5.1.3 Choice of activity data, TABLE 3.5.4.[43]



Source: EMEP/EEA air pollutant emission inventory guidebook 2019, Chapter 1.A.3.d Navigation (shipping) 2019, Figure 2 – 1 Flow diagram for the contribution from navigation to mobile sources combustion emissions [44]

Montenegro stretches for 294 km along the coastline including 5 commercial ports, mainly used in the touristic sector:

- Port of Bar
- Port of Tivat
- Port of Bijela
- Port of Kotor
- Port of Risan
-

GHG emissions from international shipping are not well reported due to allocation of the fuel in the Energy balance. The emissions of fuels used in International navigation is included in Road transport.

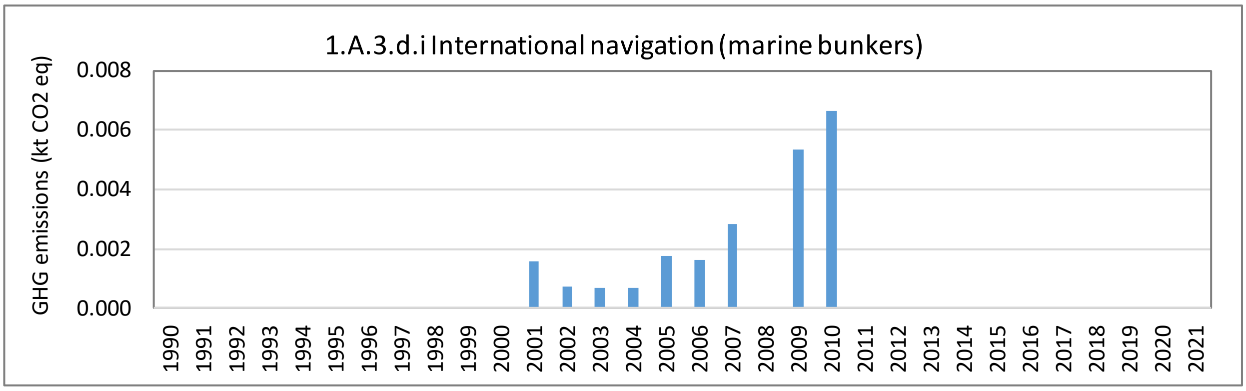


Figure 55 GHG emissions from International Bunkers - International Navigation

[43] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf

[44] Source: EMEP/EEA air pollutant emission inventory guidebook 2016, Part B: sectoral guidance chapters, 1. Energy , 1.A Combustion, Chapter 1.A.3.d Navigation (shipping) 2016 https://www.eea.europa.eu/publications/emep-eea-guidebook-2016/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-d-navigation/view

Table 89 Activity data and Emissions from International Bunkers - International Navigation

International Navigation	Emission				Activity data		
	GHG	CO_2	N_2O	CH_4	Total Fuel consumption	Residual fuel oil	Gas/diesel oil
	Kt CO_2 equivalent	Gg	Gg	Gg	[TJ]	[TJ]	[TJ]
1990	IE	IE	IE	IE	IE	NO	IE
1991	IE	IE	IE	IE	IE	NO	IE
1992	IE	IE	IE	IE	IE	NO	IE
1993	IE	IE	IE	IE	IE	NO	IE
1994	IE	IE	IE	IE	IE	NO	IE
1995	IE	IE	IE	IE	IE	NO	IE
1996	IE	IE	IE	IE	IE	NO	IE
1997	IE	IE	IE	IE	IE	NO	IE
1998	IE	IE	IE	IE	IE	NO	IE
1999	IE	IE	IE	IE	IE	NO	IE
2000	IE	IE	IE	IE	IE	NO	IE
2001	0.0016	0.0015	0.00000004	0.0000006	0.0016	NO	0.0016
2002	0.0007	0.0007	0.00000002	0.0000003	0.0007	NO	0.0007
2003	0.0007	0.0007	0.00000002	0.0000003	0.0007	NO	0.0007
2004	0.0007	0.0007	0.00000002	0.0000003	0.0007	NO	0.0007
2005	0.0018	0.0017	0.00000005	0.0000007	0.0018	NO	0.0018
2006	0.0016	0.0016	0.00000004	0.0000006	0.0016	NO	0.0016
2007	0.0028	0.0028	0.00000007	0.0000011	0.0028	NO	0.0028
2008	IE	IE	IE	IE	IE	NO	IE
2009	0.0053	0.0052	0.00000014	0.0000021	0.0053	NO	0.0053
2010	0.0066	0.0065	0.00000018	0.0000026	0.0066	NO	0.0066
2011	IE	IE	IE	IE	IE	NO	IE
2012	IE	IE	IE	IE	IE	NO	IE
2013	IE	IE	IE	IE	IE	NO	IE
2014	IE	IE	IE	IE	IE	NO	IE
2015	IE	IE	IE	IE	IE	NO	IE
2016	IE	IE	IE	IE	IE	NO	IE
2017	IE	IE	IE	IE	IE	NO	IE
2018	IE	IE	IE	IE	IE	NO	IE
2019	IE	IE	IE	IE	IE	NO	IE
2020	IE	IE	IE	IE	IE	NO	IE
	IE	IE	IE	IE	IE	NO	IE
Trend							
1990 - 2020	NA	NA	NA	NA	NA	NA	NA
2005 - 2020	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2019 - 2020	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

3.2.3.2.1 Methodological issues

3.2.3.2.1.1 Choice of methods

For estimating the CO_2, CH_4 and N_2O emissions the 2006 IPCC Guidelines Tier 1 approach[45] has been applied:

Equation 3.5.1: Water-borne navigation equation (2006 IPCC GL, Vol. 3, Chap. 3.5.1.1)

$$\boldsymbol{Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}}$$

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG} = \sum_{fuel} emissions_{\mathbf{GHG,\,fuel}}}$$

Where:

Emissions $_{GHG,\ fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG,\ fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ)
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, e.g., Residual fuel oil, Gas/diesel oil

3.2.3.2.1.2 Choice of activity data

The following fuels are used in international navigation:

Liquid fuels:
- Gas/Diesel Oil

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 – 2021 were taken from MONSTAT. Activity data are provided in the tables above.

In energy statistics production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g., in tonnes or cubic metres. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are based on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC category *International Bunkers - International Navigation* are provided.

Table 90 Net calorific values (NCVs) and Conversion factors applied for conversion to energy units in IPCC category *International Bunkers - International Navigation*

Fuel type	Fuel	Unit	Net calorific value (NCV) 2006 IPCC default NCV*
liquid	Gas/diesel oil	TJ / Gg	43.0
Sources	Default Net Calorific values (NCVs)	2006 IPCC Guidelines, Vol. 2, Chap. 1 (1.4.1.3), Table 1.2	
Note:			
D Default	CS Country specific	PS Plant specific	

[45] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 3: Mobile Combustion - 3.5.1.1 Methodological issues - Choice of method

3.2.3.2.1.3 Choice of emission factors

Default emission factors for CO_2, CH_4 and N_2O for Natural gas were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 91 GHG Emission factor TIER 1 for IPCC category International Bunkers - International Navigation

Fuel type	Fuel	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)	
		EF	type	EF	type	EF	type
liquid	Gas/diesel oil	74,100	D	7	D	2	D
Source	2006 IPCC Guidelines Vol. 2, Chap. 3 (3.5.1.2) Table 3.5.2 CO_2 EF and Table 3.5.3 NON-CO_2 EF						
Note:							
D Default	CS Country specific		PS Plant specific		IEF Implied emission factor		

3.2.3.2.2 Uncertainty assessment and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category *International Bunkers - International Navigation* are presented in the following table.

Table 92 Uncertainty for IPCC category International Bunkers - International Navigation.

Uncertainty	Gas/Diesel Oil			Reference
	CO_2	CH_4	N_2O	
Activity data (AD)	15%	15%	15%	2006 IPCC GL, Vol. 2, Chap. 3.5.1.7
Emission factor (EF)	1.5%	+/-50%	-40% to 140%	
Combined Uncertainty (U)	15%	72%	135%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period.

3.2.3.2.3 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- consistent use of energy balance data (preparation of a time series),
- documented sources,
- use of units and conversion factors,
- strictly defined interfaces between spreadsheets/calculation modules,
- unique structure of sheets which do the same,
- record keeping, use of write protection,
- unique use of formulas, special cases are documented/highlighted,
- quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from different sources:
- national statistic published by MONSTAT and
- international energy statistics of UN statistics[46] and International Energy Agency (IEA)[47]

⇒ time series consistency - plausibility checks of dips and jumps.

[46] United Nations - Department of Economic and Social Affairs - Statistics Division Statistics - Energy Statistics https://unstats.un.org/unsd/energystats/

[47] Data and statistics - Data tools - Data tables Energy data by category, indicator, country or region https://www.iea.org/data-and-statistics/data-browser?country=WORLD&fuel=Energy%20supply&indicator=TESbySource

3.2.3.2.4 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC category *International Bunkers - International Navigation*.

Table 93 Recalculations done in IPCC category International Bunkers - International Navigation

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
1.A.3.d.i	No recalculations were performed	EF	Comparability

3.2.3.2.5 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 94 Planned improvements for IPCC category International Bunkers - International Navigation

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.3.d.i 1.A.3.d.ii	Revision of the energy balance (1990-2020) • improvement of time series completeness and consistency (consumption and production, NCV, carbon content) o for all navigation related fuels: motor gasoline, gas/diesel oil, fuel oil	AD	Accuracy Comparability Transparency Consistency	high
1.A.3.d.i 1.A.3.d. ii	Application of *good practice* approach to separate the activity data (fuel consumption) consistent with the definition of Table 3.6 of the 2006 IPCC Guidelines, Vol. 2, Chapter 3: Mobile Combustion, 3.5.1.3 Choice of activity data.	AD	Accuracy Comparability Transparency Consistency	high
1.A.3.d.i 1.A.3.d.ii	Data on fuel consumption by fuel type and engine type • Surveys of shipping companies (including ferry and freight) • Surveys of individual port and marine authorities	AD	Accuracy Completeness Comparability Transparency Consistency	medium
1.A.3.d.i 1.A.3.d.ii	Ship movement data and standard passenger and freight ferry schedules Fishery boot movements	AD	Transparency	medium
1.A.3.d.i 1.A.3.d.ii	Application of Tier 2 methodology • Estimate fuel consumption for hotelling & movements and cruise for navigation. • Estimate emissions from for hotelling & movements and cruise for navigation.	M EF	Accuracy Completeness Comparability Transparency Consistency	medium
1.A.3.d.ii	Investigation regarding fuel consumption from military navigation.	AD	Completeness	medium

3.2.4 Feedstocks and non-energy use of fuels

Feedstocks and non-energy use of fuels, also final non-energy consumption, includes quantities of primary or derived fossil fuels that were not combusted but were used for their chemical properties.

There are several fuels used as feedstock, for e.g. in transport sector. However, this needs to be completed once the Energy balance is improved.

3.2.4.1 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 95 Planned improvements for IPCC category feedstock

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A	Preparation of a consistent timeseries of activity data - National Energy balance - for the period 1990 – 2020 for all fuels with focus on Non-energy use	AD	Accuracy Comparability Transparency Consistency	high
1.A	Identification of fuel used as feedstock, reductant and/or non-energy products	AD	Accuracy Comparability Transparency Consistency Completeness	high

3.2.5 Energy Industries (IPCC category 1.A.1)

Energy industries are defined as consisting of economic units whose principal activity is primary energy production, transformation of energy or distribution[48]. This section describes GHG emissions resulting from fuel combustion activities (fuel extraction or energy-producing industries) in energy industries, which, originate from

• public electricity and heat production plants (IPCC category 1.A.1.a)	Occurring
• petroleum refining (IPCC category 1.A.1.b)	Not occurring
• manufacturing of solid fuels (IPCC category 1.A.1.c) e.g. charcoal production	Not estimated

An overview of the emissions from fuel combustion in IPCC category 1.A.1 Energy Industries is provided in the following figures and tables:

- annual GHG, CO2, CH4 and N2O emissions
- Trend of the periods 1990 – 2020, 2005 – 2021, 2020 – 2021.

The main fuel used for electricity and heat production was lignite which come from the Pljevija basin. Fluctuation of emissions are due to stopped/shut-down industrial production and limited public life during the time of

- breakup of Yugoslavia,
- shut-down and reduced production at the power plant of the KAP (2009),
- overall economic downturn in the country;
- break-up of the union with Serbia;
- world-wide economic crisis;
- temporary shutdown (1995) and reconstruction of the power plant (2009).

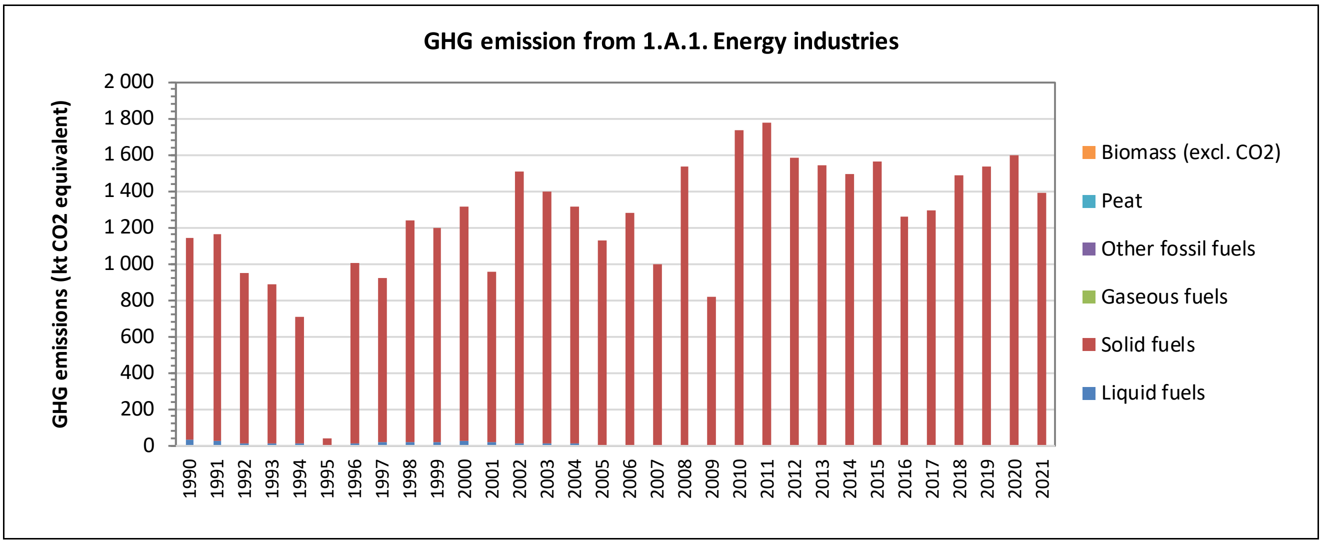


Figure 56 Emissions from IPCC sub-category 1.A.1 Energy Industries

48 For more information see https://unstats.un.org/unsd/energy/ires/IRES-web.pdf

Table 96 Emissions from IPCC sub-category 1.A.1 Energy Industries

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	kt CO2 equivalent	Gg	Gg	Gg	Gg
1990	1 142.70	1 137.43	0.012	0.017	NO
1991	1 161.08	1 155.72	0.012	0.017	NO
1992	950.15	945.75	0.010	0.014	NO
1993	886.60	882.49	0.009	0.013	NO
1994	707.79	704.51	0.007	0.010	NO
1995	41.12	40.93	0.000	0.001	NO
1996	1 004.67	1 000.01	0.010	0.015	NO
1997	923.37	919.10	0.010	0.014	NO
1998	1 238.01	1 232.28	0.013	0.018	NO
1999	1 197.52	1 191.97	0.012	0.018	NO
2000	1 314.34	1 308.26	0.014	0.019	NO
2001	952.97	948.55	0.010	0.014	NO
2002	1 504.34	1 497.35	0.015	0.022	NO
2003	1 396.87	1 390.39	0.014	0.021	NO
2004	1 314.63	1 308.52	0.013	0.019	NO
2005	1 125.21	1 119.97	0.011	0.017	NO
2006	1 277.54	1 271.60	0.013	0.019	NO
2007	999.04	994.39	0.010	0.015	NO
2008	1 532.67	1 525.54	0.015	0.023	NO
2009	819.61	815.79	0.008	0.012	NO
2010	1 736.41	1 728.33	0.017	0.026	NO
2011	1 775.66	1 767.40	0.017	0.026	NO
2012	1 584.07	1 576.71	0.016	0.023	NO
2013	1 540.15	1 532.99	0.015	0.023	NO
2014	1 492.49	1 485.55	0.015	0.022	NO
2015	1 558.84	1 551.59	0.015	0.023	NO
2016	1 256.84	1 251.00	0.012	0.019	NO
2017	1 293.39	1 287.37	0.013	0.019	NO
2018	1 486.22	1 479.31	0.015	0.022	NO
2019	1 533.10	1 525.97	0.015	0.023	NO
2020	1 599.77	1 592.32	0.016	0.024	NO
2021	1 390.53	1 384.06	0.014	0.021	NO
Trend					
1990 - 2021	*21.7%*	*21.7%*	*13.4%*	*13.4%*	*NA*
2005 - 2021	*23.6%*	*23.6%*	*23.6%*	*23.6%*	*NA*
2020 - 2021	*-13.1%*	*-13.1%*	*-13.1%*	*-13.1%*	*NA*

3.2.5.1 Main Activity Electricity and Heat Production (IPCC category 1.A.1.a)

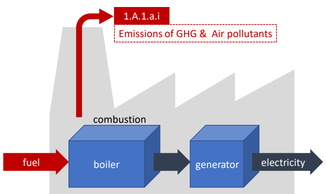
GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.1.a.i	*✓	✓	NO	NO	NO	NO	*✓	✓	NO	NO	NO	NO	*✓	✓	NO	NO	NO	NO
1.A.1.a.ii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.1.a.iii	**✓	*** ✓	NO	NO	NO	NO	**✓	*** ✓	NO	NO	NO	NO	**✓	*** ✓	NO	NO	NO	NO
Key Category	LA 1990 LA 2021		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF																		
* Until 2012 **until 2004 ***until 2011																		

This section describes GHG emissions resulting from fuel combustion activities in energy industries which, originate from public electricity and heat production plants can be distinguished: Main activity producer and auto-producer. According to 2006 IPCC Guidelines main activity producers are defined as those undertakings whose primary activity is to supply the public.

Type of producer	Electricity plant	Heat plant	Remark
Main activity producer	• units that produce electricity or heat as their principal activity;		They may be in public or private ownership. Emissions from own on-site use of fuel are also included.
Auto-producer	• units that produce electricity but for which the production is not their principal activity;	• units that produce heat for sale but for which the production is not their principal activity;	

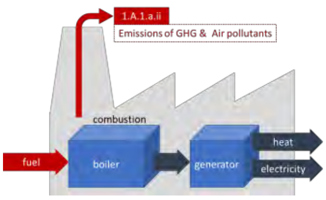
The following sub-categories are defined in the 2006 IPCC Guidelines:

1.A.1.a.i Electricity Generation



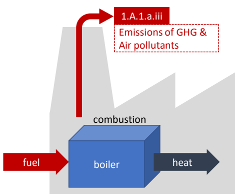
Comprises emissions from <u>all</u> fuel use for electricity generation from main activity producers except those from combined heat and power plants.

1.A.1.a.ii Combined Heat and Power Generation (CHP)



Emissions from production of both heat and electrical power from main activity producers for sale to the public, at a single CHP facility.

1.A.1.a.iii Heat Plants



Production of heat from main activity producers for sale by pipe network.

The majority of electricity in Montenegro is produced at the Pljevlja coal-fired Thermal Power Plant, the Perucica, and the Piva Hydro Plants.

3.2.5.2 Electricity Generation (IPCC category 1.A.1.a.i)

3.2.5.2.1 Category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.1.a.i	*✓	✓	NO	NO	NO	NO	*✓	✓	NO	NO	NO	NO	*✓	✓	NO	NO	NO	NO
Key Category	LA 1990 LA 2021		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF																		
* Until 2012																		

An overview of the GHG emission from fuel combustion in Sub-category 1.A.1.a.i Electricity Generation is provided in the following figures and tables:

- annual GHG emissions;
- Trend of the periods 1990 – 2021, 2005 – 2021, 2020 – 2021;

The main fuel used for electricity and heat production was lignite which come from the Pljevija basin. Fluctuation of emissions are due to stopped/shut-down industrial production and limited public life during the time of

- breakup of Yugoslavia,
- shut-down and reduced production at the power plant of the KAP (2009),
- overall economic downturn in the country;
- break-up of the union with Serbia;
- world-wide economic crisis;
- temporary shutdown (1995) and reconstruction of the power plant (2009).

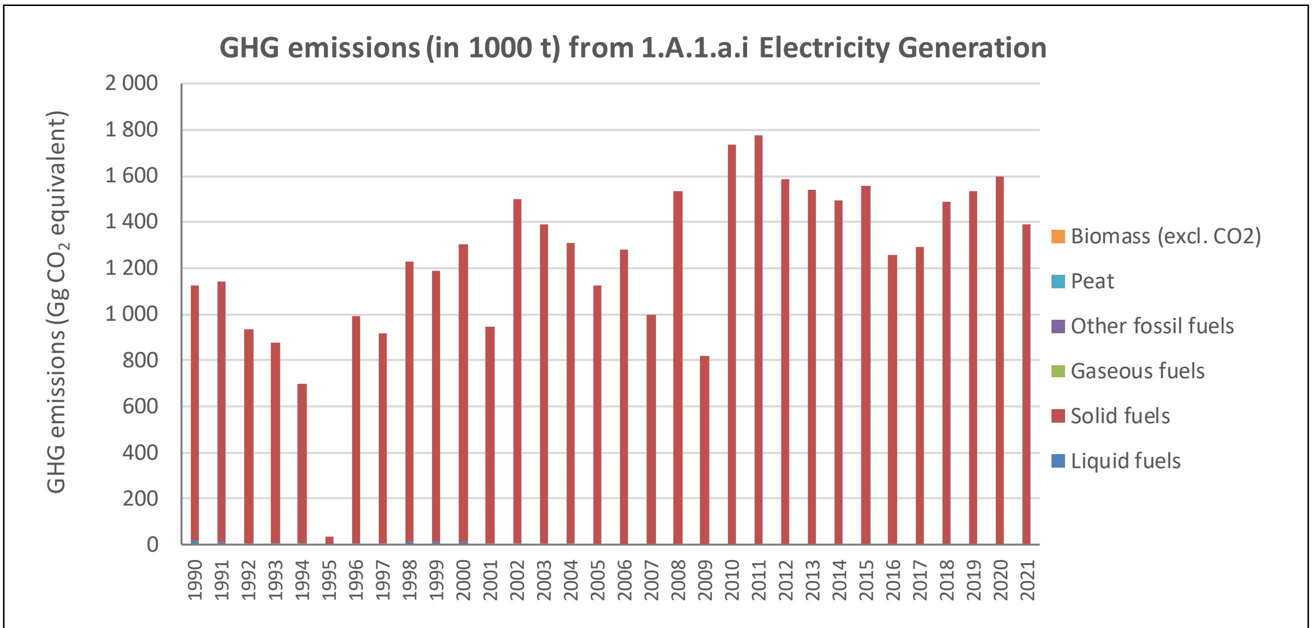


Figure 57 Emissions from IPCC sub-category 1.A.1.a.i Electricity Generation for the period 1990-2021

Table 97 Emissions from IPCC sub-category 1.A.1.a.i Electricity Generation for the period 1990-2021

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	kt CO2 equivalent	kt CO2 equivalent	kt CO2 equivalent	kt CO2 equivalent	kt CO2 equivalent
1990	1 121.81	1 116.61	4.91	0.29	NO
1991	1 138.94	1 133.66	4.99	0.29	NO
1992	936.75	932.40	4.11	0.24	NO
1993	874.13	870.07	3.84	0.22	NO
1994	695.01	691.78	3.05	0.17	NO
1995	33.64	33.49	0.15	0.01	NO
1996	990.64	986.04	4.35	0.25	NO
1997	914.01	909.77	4.01	0.23	NO
1998	1 226.47	1 220.78	5.38	0.31	NO
1999	1 185.66	1 180.16	5.20	0.30	NO
2000	1 301.55	1 295.51	5.71	0.33	NO
2001	943.29	938.92	4.14	0.24	NO
2002	1 497.48	1 490.52	6.59	0.37	NO
2003	1 388.14	1 381.69	6.10	0.35	NO
2004	1 306.83	1 300.76	5.75	0.32	NO
2005	1 125.21	1 119.97	4.96	0.28	NO
2006	1 277.54	1 271.60	5.63	0.31	NO
2007	999.04	994.39	4.40	0.25	NO
2008	1 532.67	1 525.54	6.75	0.38	NO
2009	819.61	815.79	3.61	0.20	NO
2010	1 736.41	1 728.33	7.65	0.43	NO
2011	1 775.66	1 767.40	7.82	0.44	NO
2012	1 584.07	1 576.71	6.98	0.39	NO
2013	1 540.15	1 532.99	6.78	0.38	NO
2014	1 492.49	1 485.55	6.57	0.37	NO
2015	1 558.84	1 551.59	6.87	0.38	NO
2016	1 256.84	1 251.00	5.54	0.31	NO
2017	1 293.39	1 287.37	5.70	0.32	NO
2018	1 486.22	1 479.31	6.55	0.37	NO
2019	1 533.10	1 525.97	6.75	0.38	NO
2020	1 599.77	1 592.32	7.05	0.39	NO
2021	1 390.53	1 384.06	6.13	0.34	NO
Trend					
1990 - 2021	24.0%	24.0%	24.7%	19.5%	*NA*
2005 - 2021	23.6%	23.6%	23.6%	23.6%	*NA*
2020-- 2021	-13.1%	-13.1%	-13.1%	-13.1%	*NA*

3.2.5.2.2 Methodological issues

3.2.5.2.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[49] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}$$

Where:

Emissions $_{GHG,\ fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG,\ fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ) For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, solid fuels, gaseous fuels, other fossil fuel, biomass, peat

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG} = \sum_{fuel} emissions_{\mathrm{GHG,\,fuel}}$$

3.2.5.2.2.2 Choice of activity data

The following fuels are used for electricity production:

Liquid fuels:
- Residual fuel oil

Solid fuels:
- Lignite
- Sub-Bituminous Coal

An overview of Pljevlja coal-fired Thermal Power Plant which is a condensation power plant, the capacity and the type of engine is provided in the following table.

Table 98 Thermal Power plants, capacity and output

Name	Year Built	Unit	Unit configuration	Capacity		Type of Engine	Type of fuel
				Installed	Operating		
			(MW)				
Pljevlja coal-fired Thermal Power Plant (condensation power plant)	1982	1	210	180	180	Steam boiler	Coal
After reconstruction	2009	1	225	191	191	Steam boiler	Coal

Source: Termoelektrana Pljevlja, Pljevlja

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 - 2021 are **plant specific data** and were taken from Statistical Office of Montenegro (MONSTAT).

[49] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method

The total fuel consumption decreased by 20.8% in the period 1990 – 2021. From 2005 to 2021 the total fuel consumption increased by 23.6%. From 2020 to 2021 the total fuel consumption decreased by -13.1%. The fluctuation of the fuel consumption are mainly due to increased electricity consumption for heating coupled with non-availability of hydropower in winter and during droughts and other way around. And finally ehe fluctuation in energy consumption is a result of the political and economic situation after the break-up of the Socialist Federal Republic of Yugoslavia, overall economic downturn in the country, break-up of the union with Serbia and world-wide economic crisis. Furthermore, Pljevlja Thermal Power Plant was shut down and under construction (1995) and modernized (2009).

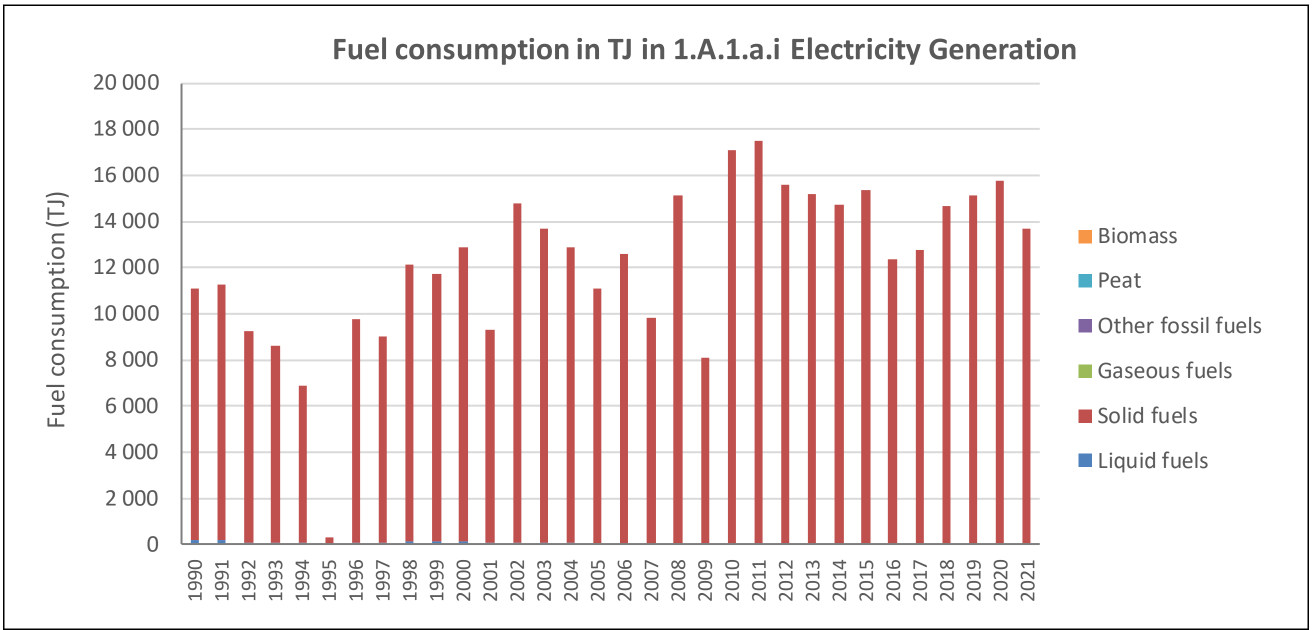


Figure 58 Activity data for IPCC sub-category 1.A.1.a.i Electricity Generation for the period 1990-2021

Table 99 Activity data for IPCC sub-category 1.A.1.a.i Electricity Generation for the period 1990-2021

Activity data 1.A.1.a.i	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	11 098.72	184.87	10 913.85	NO	NO	NO	NO
1991	11 265.68	176.84	11 088.84	NO	NO	NO	NO
1992	9 249.52	76.36	9 173.16	NO	NO	NO	NO
1993	8 629.60	64.30	8 565.30	NO	NO	NO	NO
1994	6 862.46	56.27	6 806.19	NO	NO	NO	NO
1995	331.56	NO	331.56	NO	NO	NO	NO
1996	9 779.68	72.34	9 707.34	NO	NO	NO	NO
1997	9 030.16	96.46	8 933.70	NO	NO	NO	NO
1998	12 116.01	124.59	11 991.42	NO	NO	NO	NO
1999	11 714.79	128.61	11 586.18	NO	NO	NO	NO
2000	12 859.68	140.67	12 719.01	NO	NO	NO	NO
2001	9 319.69	100.48	9 219.21	NO	NO	NO	NO
2002	14 769.83	52.25	14 717.58	NO	NO	NO	NO
2003	13 695.10	64.30	13 630.80	NO	NO	NO	NO
2004	12 890.99	52.25	12 838.74	NO	NO	NO	NO
2005	11 088.84	NO	11 088.84	NO	NO	NO	NO
2006	12 590.07	NO	12 590.07	NO	NO	NO	NO
2007	9 845.49	NO	9 845.49	NO	NO	NO	NO
2008	15 104.40	NO	15 104.40	NO	NO	NO	NO
2009	8 077.17	NO	8 077.17	NO	NO	NO	NO
2010	17 112.18	NO	17 112.18	NO	NO	NO	NO
2011	17 499.00	NO	17 499.00	NO	NO	NO	NO
2012	15 610.95	NO	15 610.95	NO	NO	NO	NO
2013	15 178.08	NO	15 178.08	NO	NO	NO	NO
2014	14 708.37	NO	14 708.37	NO	NO	NO	NO
2015	15 362.28	NO	15 362.28	NO	NO	NO	NO
2016	12 386.10	NO	12 386.10	NO	NO	NO	NO
2017	12 746.25	NO	12 746.25	NO	NO	NO	NO
2018	14 646.63	NO	14 646.63	NO	NO	NO	NO
2019	15 108.57	NO	15 108.57	NO	NO	NO	NO
2020	15 765.59	NO	15 765.59	NO	NO	NO	NO
2021	13 703.54	NO	13 703.54	NO	NO	NO	NO
Trend							
1990 - 2021	23.5%	NA	23.5%	*NA*	*NA*	*NA*	*NA*
2005 - 2021	23.6%	NA	23.6%	*NA*	*NA*	*NA*	*NA*
2020 - 2021	-13.1%	NA	-13.1%	*NA*	*NA*	*NA*	*NA*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic meters. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC sub-category 1.A.1.a.i Electricity Generation.

Table 100 Net calorific values (NCVs) applied for conversion to energy units in IPCC sub-category 1.A.1.a.i Electricity Generation

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg)		Source
		NCV	type	
Lignite	solid	10.026	PS	Pljevlja coal-fired Thermal Power Plant (annual average)
Sub-Bituminous Coal	solid	16.75	PS	
Residual fuel oil	liquid	41.20	PS	
Note: D Default CS Country specific PS Plant specific				

3.2.5.2.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 101 GHG Emission factor TIER 1 for IPCC sub-category 1.A.1.a.i Electricity Generation

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source
		EF	type	EF	type	EF	type	2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)
Lignite	solid	101 000	D	1	D	1.5	D	**Table 2.2** Default emission factors for stationary combustion in the energy industries (page 2.16)
Sub-Bituminous Coal	solid	96 000	D	3	D	0.6	D	
Residual Fuel Oil / Total fuel oil	liquid	77 400	D	3	D	0.6	D	
Note: D Default CS Country specific PS Plant specific IEF Implied emission factor								

3.2.5.2.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 1.A.1.a.i Electricity Generation are presented in the following table.

Table 102 Uncertainty for IPCC sub-category 1.A.1.a.i Electricity Generation.

Uncertainty	Solid fuels						Reference
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	2006 IPCC GL, Vol. 2, Chap. 2 (2.4.2)
Activity data (AD)	2%	2%	2%				Table 2.15 and Table 3.1
Emission factor (EF)	1%						Table 2.13
		187%					Table 2.12
			224%				Table 2.14
Combined Uncertainty (U)	2%	187%	224%				$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period. Activity data are considered to be consistent as national and international data were always compared.

3.2.5.2.4 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
  - consistent use of energy balance data (energy statistic questionnaires),
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic and international energy statistics of UN

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.5.2.5 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last two submission to the UNFCCC and relevant to IPCC sub-category *1.A.1.a.i Electricity Generation*.

Table 103 Recalculations done since NC & BUR in IPCC sub-category 1.A.1.a.i Electricity Generation

source category	Revisions of data	Type of revision	Type of improvement
1.A.1.a	Revision of NCV	AD	Accuracy

3.2.5.2.6 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 104 Planned improvements for IPCC sub-category 1.A.1.a.i Electricity Generation

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.1.a.ii	Survey for use of fuels in Heat Plants and CHP	AD	Completeness	medium
1.A.1.a	Carbon content (%) of lignite, gas/diesel oil, residual fuel oil, etc. for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{CO2}$** [t/TJ] = (C [%] • 44 • Ox)/(NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	medium
1.A.1.a	Information about fitted/non-fitted equipment for flue gas cleaning, improvement in combustion	EF non-GHG	Accuracy Transparency	medium

3.2.5.3 Combined Heat and Power Generation (CHP) (IPCC category 1.A.1.a.ii)

GHG emissions/ removals	CO₂						CH₄						N₂O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.1.a.ii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF																		

The IPCC subcategory 1.A.1.a.ii *Combined Heat and Power Generation* does not exist in Montenegro.

3.2.5.4 Heat plants (IPCC category 1.A.1.a.iii)

3.2.5.4.1 Category description

GHG emissions/ removals	CO₂						CH₄						N₂O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.1.a.iii	**✓	*** ✓	NO	NO	NO	NO	**✓	*** ✓	NO	NO	NO	NO	**✓	*** ✓	NO	NO	NO	NO
Key Category	LA 1990 LA 2021		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF																		
**until 2004 ***until 2011																		

An overview of the GHG emission from fuel combustion in Sub-category 1.A.1.a.iii Heat Plants is provided in the following figures and tables:

- annual GHG emissions;
- Trend of the periods 1990 – 2004.

The main fuel used for heat production was lignite which come from the Pljevija basin.

From 2005 onwards, the emissions from heat plants are included in IPCC category 1.A.1.a.iii Electricity production due to allocation of fuels in the Energy balance. However, the contribution of emissions from heat plants are minor.

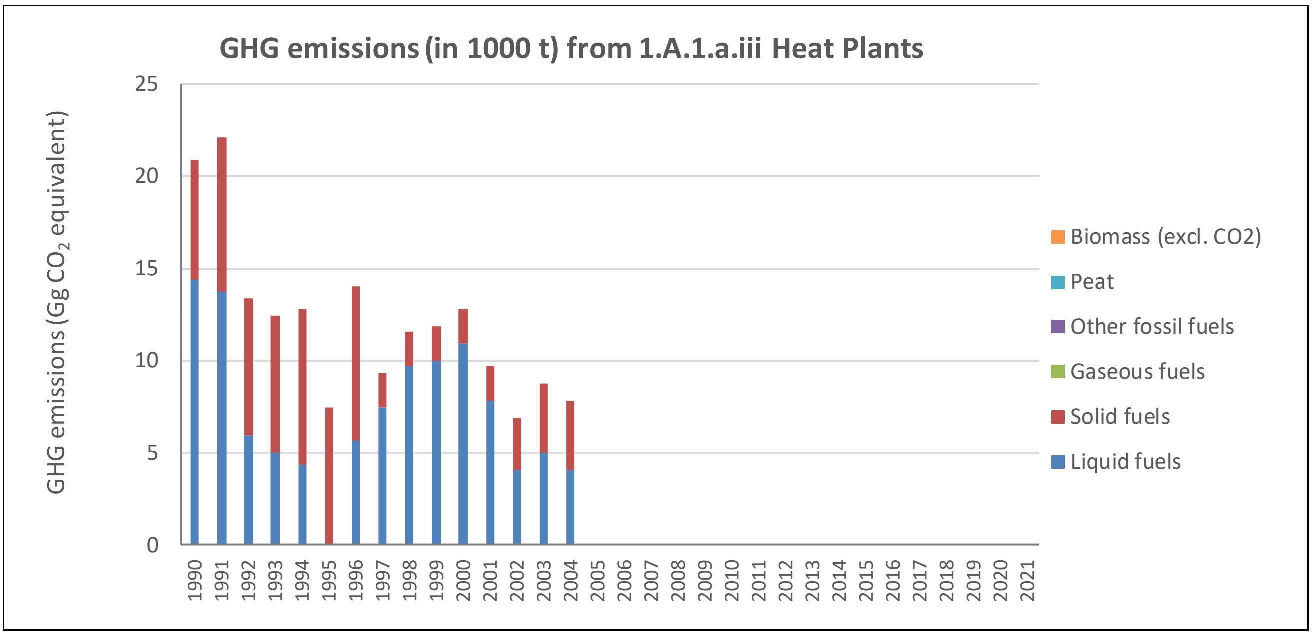


Figure 59 Emissions from IPCC sub-category 1.A.1.a.iii Heat Plants for the period 1990-2021

Table 105 Emissions from IPCC sub-category 1.A.1.a.iii Heat Plants for the period 1990-2021

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	kt CO2 equivalent	kt CO2 equivalent	kt CO2 equivalent	kt CO2 equivalent	kt CO2 equivalent
1990	20.90	20.82	0.06	0.02	NO
1991	22.14	22.06	0.07	0.02	NO
1992	13.41	13.35	0.05	0.01	NO
1993	12.47	12.42	0.04	0.01	NO
1994	12.78	12.73	0.05	0.01	NO
1995	7.48	7.44	0.03	0.00	NO
1996	14.03	13.97	0.05	0.01	NO
1997	9.36	9.33	0.03	0.01	NO
1998	11.54	11.50	0.03	0.01	NO
1999	11.86	11.81	0.03	0.01	NO
2000	12.79	12.75	0.03	0.01	NO
2001	9.67	9.64	0.03	0.01	NO
2002	6.86	6.83	0.02	0.00	NO
2003	8.73	8.70	0.03	0.01	NO
2004	7.80	7.76	0.03	0.00	NO
2005	IE	IE	IE	IE	NO
2006	IE	IE	IE	IE	NO
2007	IE	IE	IE	IE	NO
2008	IE	IE	IE	IE	NO
2009	IE	IE	IE	IE	NO
2010	IE	IE	IE	IE	NO
2011	IE	IE	IE	IE	NO

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	kt CO2 equivalent	kt CO2 equivalent	kt CO2 equivalent	kt CO2 equivalent	kt CO2 equivalent
2012	IE	IE	IE	IE	NO
2013	IE	IE	IE	IE	NO
2014	IE	IE	IE	IE	NO
2015	IE	IE	IE	IE	NO
2016	IE	IE	IE	IE	NO
2017	IE	IE	IE	IE	NO
2018	IE	IE	IE	IE	NO
2019	IE	IE	IE	IE	NO
2020	IE	IE	IE	IE	NO
2021	IE	IE	IE	IE	NO
Trend					
1990 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*
2020-- 2021	*NA*	*NA*	*NA*	*NA*	*NA*

3.2.5.4.2 Methodological issues

3.2.5.4.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[50] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}}$$

Where:

Emissions $_{GHG,\ fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG,\ fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ) For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, solid fuels, gaseous fuels, other fossil fuel, biomass, peat

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG} = \sum_{fuel} emissions_{GHG,\,fuel}}$$

[50] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method

3.2.5.4.2.2 Choice of activity data

The following fuels are used for electricity production:

Liquid fuels:
- Residual fuel oil

Solid fuels:
- Lignite

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 - 2004 are **plant specific data** and were taken from Statistical Office of Montenegro (MONSTAT).

The total fuel consumption decreased by 64.3% in the period 1990 – 2004.

From 2005 onwards, the fuels used in heat plants were included in IPCC category 1.A.1.a.iii Electricity production due to allocation of fuels in the Energy balance.

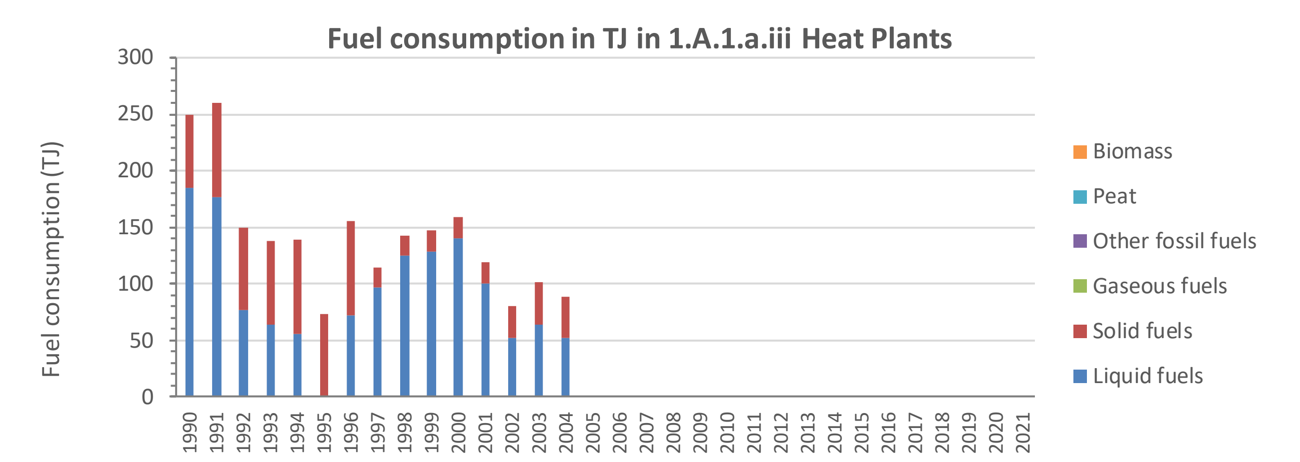


Figure 60 Activity data for IPCC sub-category 1.A.1.a.iii Heat Plants for the period 1990-2021

Table 106 Activity data for IPCC sub-category 1.A.1.a.iii Heat Plants for the period 1990-2021

Activity data 1.A.1.a.iii	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	249.34	184.87	64.47	NO	NO	NO	NO
1991	259.73	176.84	82.89	NO	NO	NO	NO
1992	150.04	76.36	73.68	NO	NO	NO	NO
1993	137.98	64.30	73.68	NO	NO	NO	NO
1994	139.16	56.27	82.89	NO	NO	NO	NO
1995	73.68	NO	73.68	NO	NO	NO	NO
1996	155.23	72.34	82.89	NO	NO	NO	NO
1997	114.88	96.46	18.42	NO	NO	NO	NO
1998	143.01	124.59	18.42	NO	NO	NO	NO
1999	147.03	128.61	18.42	NO	NO	NO	NO
2000	159.09	140.67	18.42	NO	NO	NO	NO
2001	118.90	100.48	18.42	NO	NO	NO	NO
2002	79.88	52.25	27.63	NO	NO	NO	NO
2003	101.14	64.30	36.84	NO	NO	NO	NO
2004	89.09	52.25	36.84	NO	NO	NO	NO
2005	IE	IE	IE	NO	NO	NO	NO

Activity data 1.A.1.a.iii	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
2006	IE	IE	IE	NO	NO	NO	NO
2007	IE	IE	IE	NO	NO	NO	NO
2008	IE	IE	IE	NO	NO	NO	NO
2009	IE	IE	IE	NO	NO	NO	NO
2010	IE	IE	IE	NO	NO	NO	NO
2011	IE	IE	IE	NO	NO	NO	NO
2012	IE	IE	IE	NO	NO	NO	NO
2013	IE	IE	IE	NO	NO	NO	NO
2014	IE	IE	IE	NO	NO	NO	NO
2015	IE	IE	IE	NO	NO	NO	NO
2016	IE	IE	IE	NO	NO	NO	NO
2017	IE	IE	IE	NO	NO	NO	NO
2018	IE	IE	IE	NO	NO	NO	NO
2019	IE	IE	IE	NO	NO	NO	NO
2020	IE	IE	IE	NO	NO	NO	NO
2021	IE	IE	IE	NO	NO	NO	NO
Trend							
1990 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic meters. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC sub-category 1.A.1.a.iii Heat Plants.

Table 107 Net calorific values (NCVs) applied for conversion to energy units in IPCC sub-category 1.A.1.a.iii Heat Plants

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg)		Source
		NCV	type	
Lignite	solid	10.026	PS	Pljevlja coal-fired Thermal Power Plant (annual average)
Residual fuel oil	liquid	41.20	PS	
Note:				
D Default	CS Country specific	PS Plant specific		

3.2.5.4.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 108 GHG Emission factor TIER 1 for IPCC sub-category 1.A.1.a.iii Heat Plants

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source
		EF	type	EF	type	EF	type	2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)
Lignite	solid	101 000	D	1	D	1.5	D	**Table 2.2** Default emission factors for stationary combustion in the energy industries (page 2.16)
Residual Fuel Oil / Total fuel oil	liquid	77 400	D	3	D	0.6	D	

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

3.2.5.4.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 1.A.1.a.iii Heat Plants are presented in the following table.

Table 109 Uncertainty for IPCC sub-category 1.A.1.a.iii Heat Plants.

Uncertainty	Solid fuels			Liquid fuels			Reference
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	2006 IPCC GL, Vol. 2, Chap. 2 (2.4.2)
Activity data (AD)	2%	2%	2%	2%	2%	2%	Table 2.15 and Table 3.1
Emission factor (EF)	1%			2%			Table 2.13
		187%			224%		Table 2.12
			224%			224%	Table 2.14
Combined Uncertainty (U)	2%	187%	224%	3%	224%	224%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period. Activity data are considered to be consistent as national and international data were always compared.

3.2.5.4.4 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- o consistent use of energy balance data (energy statistic questionnaires),
- o documented sources,
- o use of units,
- o strictly defined interfaces between spreadsheets/calculation modules,
- o unique structure of sheets which do the same,
- o record keeping, use of write protection,
- o unique use of formulas, special cases are documented/highlighted,
- o quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic and international energy statistics of UN

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ time series consistency - plausibility checks of dips and jumps;

3.2.5.4.5 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last two submission to the UNFCCC and relevant to IPCC sub-category *1.A.1.a.iii Heat Plants*.

Table 110 Recalculations done since NC & BUR in IPCC sub-category 1.A.1.a.iii Heat Plants

source category	Revisions of data	Type of revision	Type of improvement
1.A.1.a.iii	Revision of NCV	AD	Accuracy

3.2.5.4.6 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 111 Planned improvements for IPCC sub-category 1.A.1.a.iii Heat Plants

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.1.a.ii 1.A.1.a.iii	Survey for use of fuels in Heat Plants and CHP	AD	Completeness	medium
1.A.1.a	Carbon content (%) of lignite, gas/diesel oil, residual fuel oil, etc. for preparing country specific emission factor (CS EF) $\Rightarrow$ **CS EF$_{CO2}$** [t/TJ] = (C [%] • 44 • Ox)/(NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	medium
1.A.1.a	Information about fitted/non-fitted equipment for flue gas cleaning, improvement in combustion	EF non-GHG	Accuracy Transparency	medium

3.2.5.5 Petroleum Refining (IPCC category 1.A.1.b)

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.1.b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF																		

The IPCC subcategory 1.A.1.b *Petroleum refining* does not exist in Montenegro.

3.2.5.6 Manufacture of Solid Fuels and Other Energy Industries (IPCC category 1.A.1.c)

The IPCC category 1.A.1.c *Manufacture of Solid Fuels and Other Energy Industries* is divided in two sub-categories:

1.A.1.c.i *Manufacture of Solid Fuels*
1.A.1.c.ii *Other Energy Industries*

3.2.5.6.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	Biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.1.c.i	NO	NO	NO	NO	NO	NE	NO	NO	NO	NO	NO	NE	NO	NO	NO	NO	NO	NE
1.A.1.c.ii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF																		

The emissions from charcoal production were not estimated as the activity data were not consistent as different sources provided various activity data.

3.2.5.6.2 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 112 Planned improvements for IPCC sub-category 1.A.1.c.i Manufacture of Solid Fuels

source	Planned improvement	Type of improvement		Priority
1.A.1.c.i	Cross-check of national and international data sources on charcoal production	AD	Consistency Transparency	high
1.A.1.c.i	Analysis of charcoal production (1) Raw materials for carbonization. • Fuelwood & wood fuel: type of wood and wood waste • Agricultural residues • bark waste (2) charcoal making technologies (3) efficiencies of various types of kiln			high
1.A.1.c.i	Country specific Net Caloric Value (NCV) for fuels of national production: charcoal ⇒ conversion from mass unit to energy unit (unit EF is kg /TJ)	AD EF	Accuracy Transparency	medium
1.A.1.c.i	Estimation of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)		Completness	high
1.A.1.c.i	Carbon content (%) of charcoal for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{CO2}$** [t/TJ] = (C [%] • 44 • Ox)/(NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	medium

3.2.6 Manufacturing Industries and Construction (IPCC category 1.A.2)

This section describes GHG emissions resulting from fuel combustion activities in manufacturing industries and construction, which originate from the following sources:

IPCC/NFR code	Description	Occurrent		Not occurrent (NO)
		Estimated	Not estimated (NE)	
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	Manufacturing of transport equipment	✓		
1.A.2.h	Manufacturing of machinery			✓
1.A.2.i	Mining (excluding fuels) and Quarrying	✓		
1.A.2.j	Wood and wood products	✓		
1.A.2.k	Construction	✓		
1.A.2.l	Textile and Leather	✓		
1.A.2.m	Other	✓		

A '✓' indicates: emissions from this sub-category have been estimated.
Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential

An overview of the emissions from fuel combustion in IPCC category 1.A.2 *Manufacturing Industries and Construction* is provided in the following figures and tables:

- annual GHG, CO2, CH4 and N2O emissions
- Trend of the periods 1990 – 2020, 2005 – 2021, 2020 – 2021
- by sub-category.

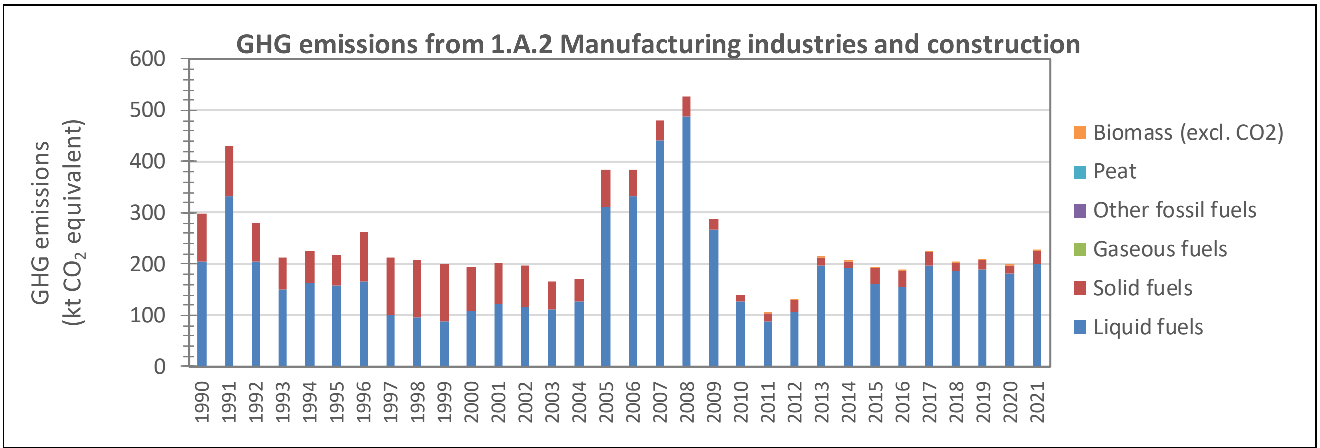


Figure 61 Emissions from IPCC sub-category 1.A.2 Manufacturing Industries and Construction

The main fuels used in 1.A.2 were liquid fuel, such as Gas/diesel oil and fuel oil. The fuel was used mainly in 1.A.2.b Non-ferrous metals. In 2009, the production of alumina stopped accordingly three boilers were shut-down.

For the period 1990-2009, the energy balance does not provide detailed data per sub-category. In the last decade, share of emissions changed due to energy balance refinements and change in the fuels mix used. Important sources of emissions were 1.A.2.e Food processing, beverages and tobacco, 1.A.2.i Mining (excluding fuels) and quarrying and 1.A.2.j Wood and wood products. The share of emissions from the sub-category 1.A.2.a Iron and steel became smaller due to fuels mix ((change from fuel oil to natural gas liquids) and use of electricity.

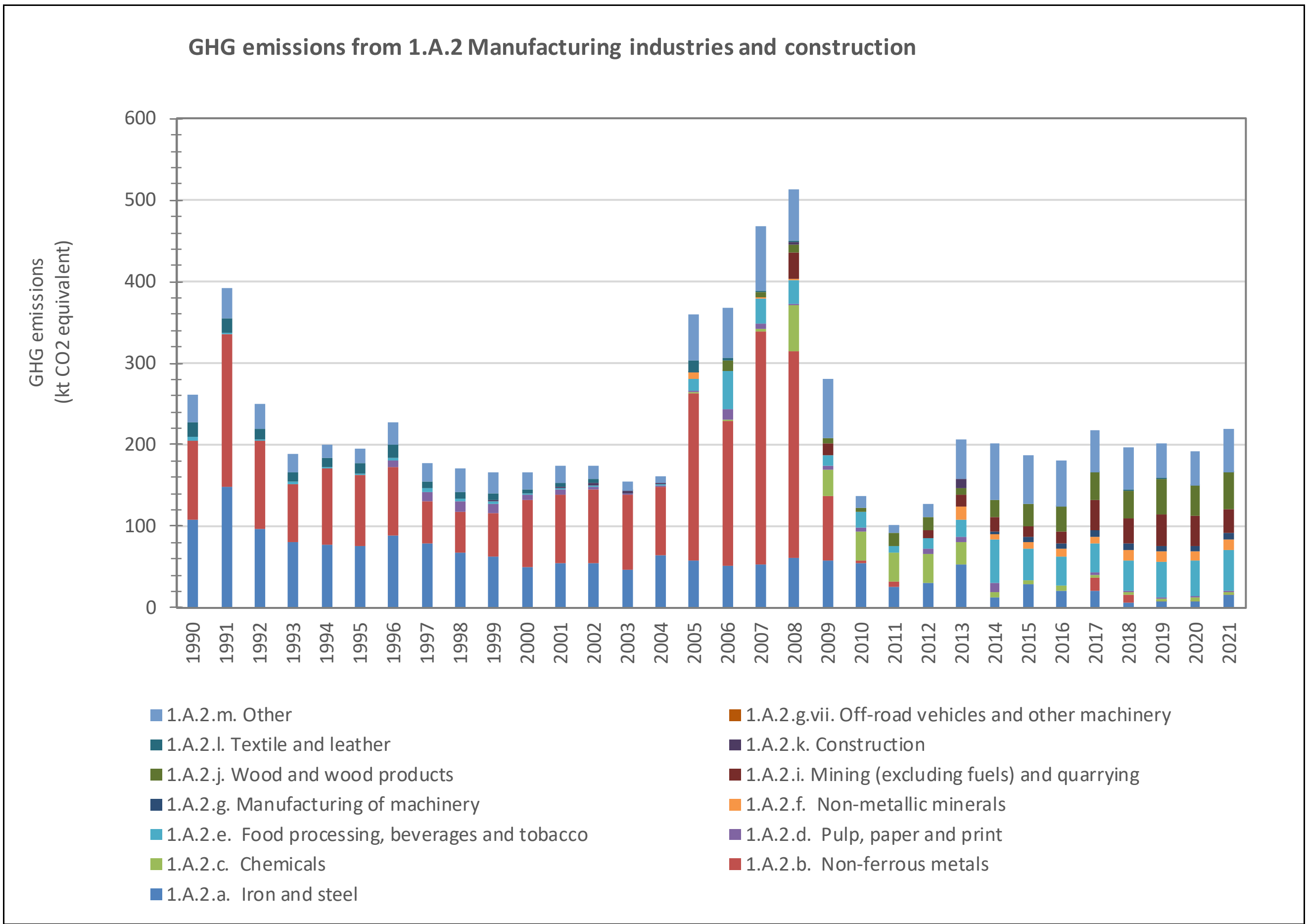


Figure 62 Emissions from IPCC sub-category 1.A.2 Manufacturing Industries and Construction by subcategory

Table 113 Emissions from IPCC sub-category 1.A.2 Manufacturing Industries and Construction

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	kt CO_2 equivalent	kt	kt	kt	kt
1990	295.00	293.948	0.0024	0.0135	IE
1991	427.10	425.611	0.0034	0.0187	IE
1992	276.67	275.682	0.0023	0.0124	IE
1993	211.47	210.708	0.0017	0.0097	IE
1994	222.08	221.290	0.0018	0.0100	IE
1995	216.78	215.999	0.0018	0.0099	IE
1996	257.92	256.958	0.0022	0.0125	IE
1997	209.51	208.664	0.0019	0.0113	IE
1998	204.81	203.992	0.0018	0.0110	IE
1999	198.27	197.460	0.0018	0.0109	IE
2000	192.86	192.110	0.0017	0.0099	IE
2001	199.24	198.495	0.0017	0.0098	IE
2002	194.28	193.521	0.0017	0.0100	IE
2003	163.63	162.975	0.0015	0.0085	IE
2004	168.94	168.290	0.0015	0.0084	IE
2005	379.09	377.798	0.0030	0.0163	IE
2006	381.06	379.800	0.0029	0.0158	IE
2007	477.10	475.559	0.0036	0.0191	IE
2008	521.98	520.285	0.0039	0.0209	IE
2009	285.77	284.859	0.0021	0.0113	IE
2010	138.83	138.442	0.0009	0.0051	IE
2011	101.89	101.624	0.0006	0.0038	0.0234
2012	127.66	127.252	0.0009	0.0054	0.0250
2013	210.78	210.082	0.0016	0.0086	0.0234
2014	202.19	201.472	0.0017	0.0089	0.0419
2015	189.70	188.997	0.0016	0.0090	0.0444
2016	184.17	183.470	0.0016	0.0088	0.0439
2017	221.25	220.432	0.0019	0.0102	0.0389
2018	199.37	198.668	0.0016	0.0086	0.0390
2019	205.05	204.313	0.0017	0.0090	0.0428
2020	194.83	194.148	0.0016	0.0084	0.0423
2021	222.91	222.099	0.0019	0.0101	0.0448
Trend					
1990 - 2021	*-24.4%*	*-24.4%*	*-21.5%*	*-25.1%*	*NA*
2005 - 2021	*-41.2%*	*-41.2%*	*-36.7%*	*-38.1%*	*NA*
2020 - 2021	*14.4%*	*14.4%*	*18.6%*	*20.3%*	*5.8%*

3.2.6.1 Iron and Steel (IPCC category 1.A.2.a)

The IPCC category 1.A.2.a *Iron and Steel* includes GHG emissions resulting from fuel combustion activities in

Activities	Occurring in Montenegro
▪ Manufacture of basic iron and steel (ISIC Class 2410)	✓
▪ Casting of iron and steel (ISIC Class 2431)	✓

3.2.6.1.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.a	✓	✓	✓*	NO	NO	NO **	✓	✓	✓*	NO	NO	NO **	✓	✓	✓*	NO	NO	NO **
Key Category	LA1990 TA 1990-2021		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF																		
* Until 2016: IE **until 2013: IE																		

An overview of the emissions from fuel combustion in IPCC sub-category *1.A.2.a Iron and Steel* is provided in the following figures and tables:

- annual GHG emissions
- Trend of the periods 1990 – 2020, 2005 – 2021, 2020 – 2021.

The main fuels used in 1.A.2.a were liquid fuel, such as Gas/diesel oil and fuel oil.

The emissions from the sub-category 1.A.2.a Iron and steel decreased due to fuels mix (change from fuel oil to natural gas liquids) and use of electricity. Also, the level of production decreased.

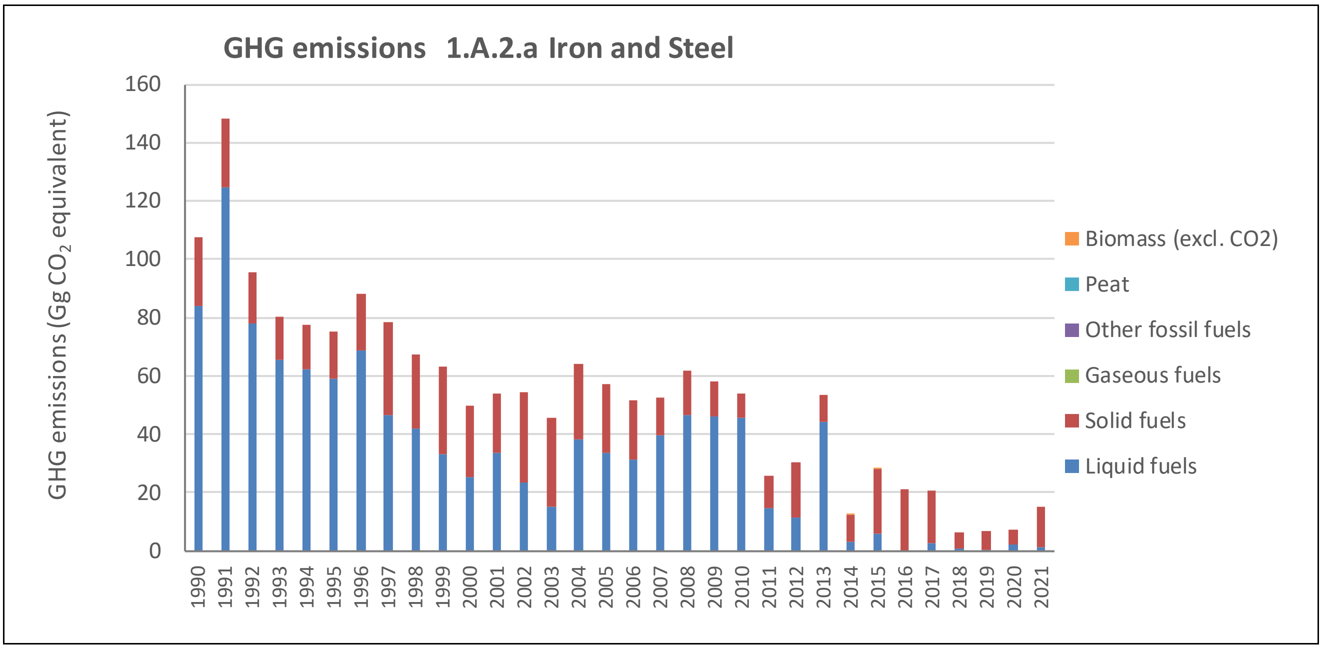


Figure 63 Emissions from IPCC sub-category 1.A.2.a Iron and Steel

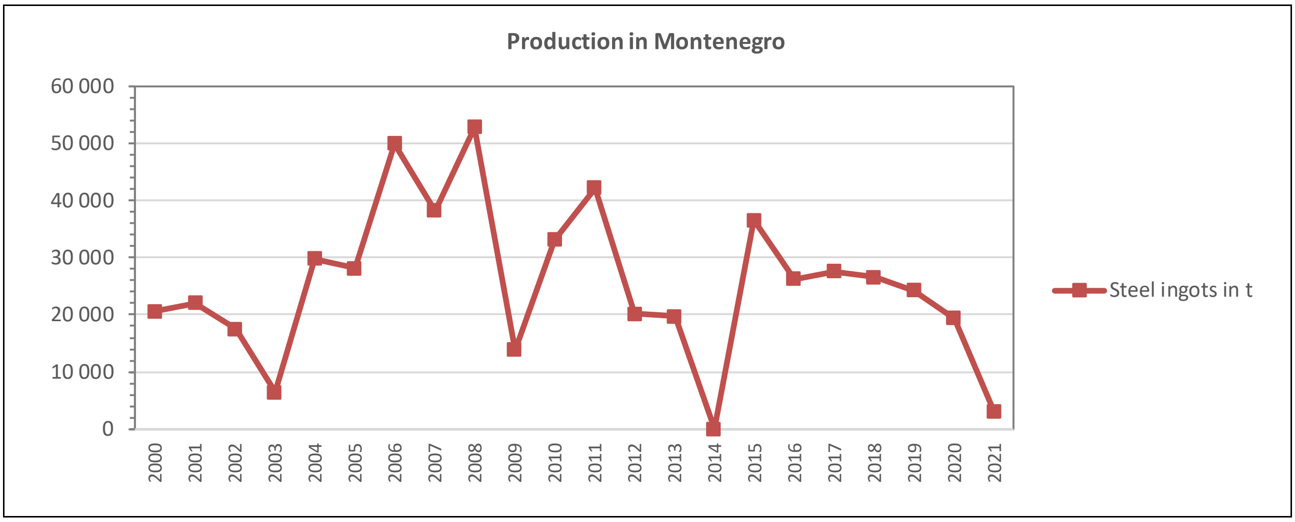


Figure 64 Main products in category 1.A.2.a Iron and Steel in the period 2000-2021; Source: MONSTAT)

Table 114 Emissions from IPCC sub-category 1.A.2.a Main Activity Iron and Steel

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	kt CO2 equivalent	kt	kt CO2 equivalent	kt CO2 equivalent	kt
1990	107.68	107.24	0.30	0.14	NO
1991	148.26	147.69	0.39	0.18	NO
1992	95.82	95.44	0.26	0.12	NO
1993	80.53	80.21	0.22	0.10	NO
1994	77.40	77.10	0.21	0.10	NO
1995	75.22	74.92	0.21	0.10	NO
1996	88.33	87.97	0.24	0.11	NO
1997	78.48	78.12	0.24	0.12	NO
1998	67.25	66.94	0.20	0.10	NO
1999	63.19	62.88	0.20	0.10	NO
2000	49.77	49.52	0.16	0.08	NO
2001	54.14	53.89	0.16	0.08	NO
2002	54.45	54.17	0.19	0.10	NO
2003	45.89	45.63	0.17	0.09	NO
2004	64.30	64.00	0.20	0.10	NO
2005	57.26	56.99	0.18	0.09	NO
2006	51.81	51.57	0.16	0.08	NO
2007	52.71	52.50	0.14	0.07	NO
2008	61.65	61.39	0.17	0.08	NO
2009	58.21	58.02	0.12	0.06	NO
2010	53.97	53.82	0.10	0.05	NO
2011	25.87	25.76	0.07	0.04	NO
2012	30.24	30.09	0.10	0.05	NO
2013	53.70	53.49	0.14	0.07	NO
2014	12.49	12.41	0.05	0.03	0.13
2015	28.23	28.07	0.11	0.06	0.13
2016	21.22	21.07	0.09	0.05	NO
2017	20.71	20.58	0.08	0.05	NO
2018	6.20	6.17	0.02	0.01	NO
2019	6.99	6.95	0.03	0.02	NO
2020	7.49	7.45	0.02	0.01	NO
2021	15.08	14.99	0.06	0.03	NO
Trend					
1990 - 2021	*-87.9%*	*-86.0%*	*-79.4%*	*-75.2%*	*NA*
2005 - 2021	*-76.6%*	*-73.7%*	*-65.3%*	*-61.3%*	*NA*
2020 - 2021	*71.5%*	*101.3%*	*157.6%*	*152.4%*	*NA*

3.2.6.1.2 Methodological issues

3.2.6.1.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[51] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}$$

Where:

Emissions $_{GHG,\,fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG,\,fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ) For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, solid fuels, gaseous fuels, other fossil fuel, biomass, peat

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG} = \sum_{fuel} emissions_{GHG,\,fuel}$$

3.2.6.1.2.2 Choice of activity data

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 - 2021 were taken from Statistical Office of Montenegro (MONSTAT).

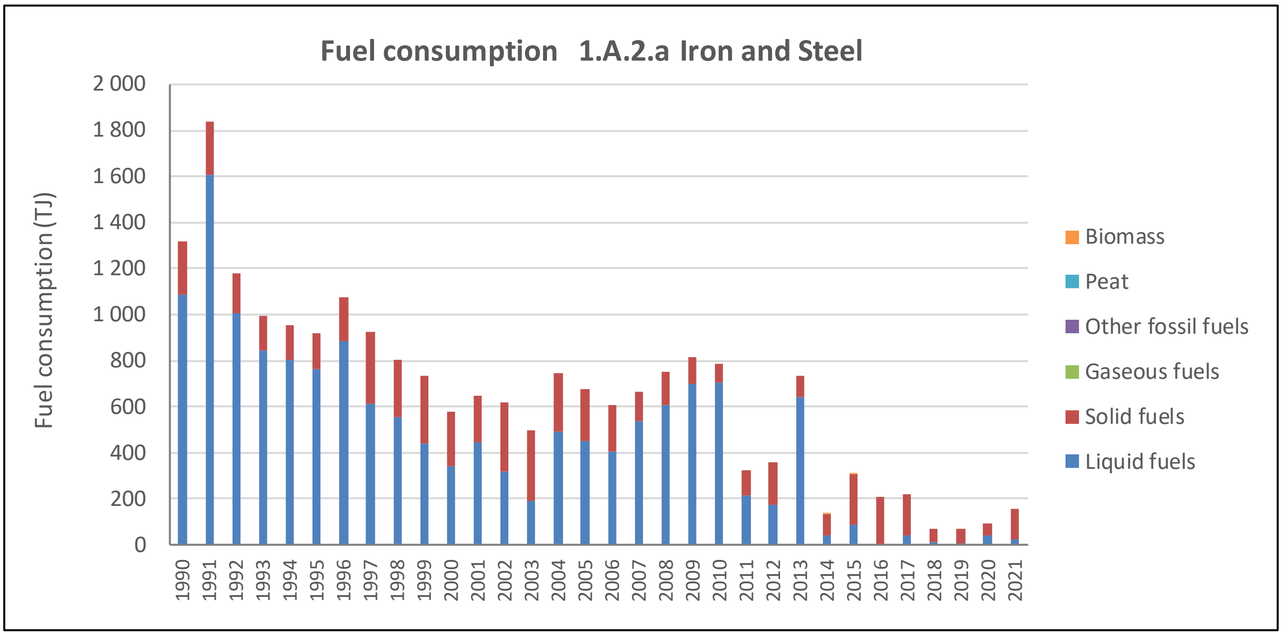


Figure 65 Activity data for sub-category 1.A.2.a Iron and Steel

[51] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method

Table 115 Activity data for sub-category 1.A.2.a Iron and Steel

Activity data 1.A.2.a	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	1 315.38	1 085.13	230.25	NO	NO	NO	NO
1991	1 837.88	1 607.60	230.28	NO	NO	NO	NO
1992	1 179.74	1 004.75	174.99	NO	NO	NO	NO
1993	991.35	843.99	147.36	NO	NO	NO	NO
1994	951.16	803.80	147.36	NO	NO	NO	NO
1995	920.18	763.61	156.57	NO	NO	NO	NO
1996	1 077.59	884.18	193.41	NO	NO	NO	NO
1997	926.71	613.57	313.14	NO	NO	NO	NO
1998	801.95	553.28	248.67	NO	NO	NO	NO
1999	735.47	440.75	294.72	NO	NO	NO	NO
2000	579.74	340.28	239.46	NO	NO	NO	NO
2001	647.39	444.77	202.62	NO	NO	NO	NO
2002	620.09	316.16	303.93	NO	NO	NO	NO
2003	496.84	192.91	303.93	NO	NO	NO	NO
2004	748.20	490.32	257.88	NO	NO	NO	NO
2005	679.04	448.79	230.25	NO	NO	NO	NO
2006	604.52	401.90	202.62	NO	NO	NO	NO
2007	664.81	535.87	128.94	NO	NO	NO	NO
2008	752.73	605.37	147.36	NO	NO	NO	NO
2009	816.37	696.64	119.73	NO	NO	NO	NO
2010	786.23	703.34	82.89	NO	NO	NO	NO
2011	324.87	214.35	110.52	NO	NO	NO	NO
2012	358.36	174.16	184.20	NO	NO	NO	NO
2013	733.55	641.45	92.10	NO	NO	NO	NO
2014	133.29	40.19	92.10	NO	NO	NO	1.00
2015	309.12	87.08	221.04	NO	NO	NO	1.00
2016	208.65	IE	208.65	NO	NO	NO	NO
2017	219.11	40.32	178.79	NO	NO	NO	NO
2018	67.35	14.21	53.13	NO	NO	NO	NO
2019	70.90	4.82	66.08	NO	NO	NO	NO
2020	92.58	42.28	50.31	NO	NO	NO	NO
2021	158.80	23.45	135.35	NO	NO	NO	NO
Trend							
1990 - 2021	*-87.9%*	*-97.8%*	*-41.2%*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*-76.6%*	*-94.8%*	*-41.2%*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*71.5%*	*-44.5%*	*169.1%*	*NA*	*NA*	*NA*	*NA*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic meters. To convert these data to energy units, in

this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC/NFR sub-category 1.A.2.a Iron and Steel.

Table 116 Net calorific values (NCVs) applied for conversion to energy units in sub-category 1.A.2.a Iron and Steel

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg)		Source
		NCV	type	
Lignite	solid	9.21	CS	Statistical Office of Montenegro (MONSTAT)
Residual fuel oil	liquid	41.20	CS	
Liquefied Petroleum Gases (LPG)	liquid	46.89	CS	
Natural Gas	gaseous	46.00	CS	
Wood pellets	biomass	16.85	CS	
Note:				
D Default	CS	Country specific	PS	Plant specific

3.2.6.1.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 117 GHG Emission factor TIER 1 for IPCC sub-category 1.A.2 Manufacturing Industries and Construction

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source 2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)
		EF	type	EF	type	EF	type	
Gas/Diesel Oil	liquid	74 100	D	3	D	0.6	D	**Table 2.3** Default emission factors for stationary combustion in manufacturing industries and construction (page 2.18)
Residual Fuel Oil / Total fuel oil	liquid	77 400	D	3	D	0.6	D	
Lignite	solid	101 000	D	10	D	1.5	D	
LPG	gaseous	63 100	D	1	D	0.1	D	
Natural gas	gaseous	56 100	D	1	D	0.1	D	
Wood pellets	biomass	112 000	D	30	D	4	D	
Note:								
D Default	CS	Country specific	PS	Plant specific		IEF	Implied emission factor	

3.2.6.1.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 1.A.1.a Main Activity Electricity and Heat Production are presented in the following table.

Table 118 Uncertainty for IPCC sub-category 1.A.2 Manufacturing Industries and Construction.

Uncertainty	Liquid fuels			Reference
	CO_2	CH_4	N_2O	2006 IPCC GL, Vol. 2, Chap. 2 (2.4.2)
Activity data (AD)	2%	2%	2%	Table 2.15 and Table 3.1
Emission factor (EF)	2%			Table 2.13
		100%		Table 2.12
			20%	Table 2.14
Combined Uncertainty (U)	2%	100%	20%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period. Activity data are considered to be consistent as national and international data were always compared.

3.2.6.1.4 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- consistent use of energy balance data (energy statistic questionnaires),
- documented sources,
- use of units,
- strictly defined interfaces between spreadsheets/calculation modules,
- unique structure of sheets which do the same,
- record keeping, use of write protection,
- unique use of formulas, special cases are documented/highlighted,
- quick-control checks for data consistency through all steps of calculation.
- cross-checked from two sources: national statistic, Eurostat and international energy statistics of UN
- cross checks with other relevant sectors are performed to avoid double counting or omissions;
- time series consistency - plausibility checks of dips and jumps.

3.2.6.1.5 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last two submission and relevant to sub-category 1.A.2.a Iron and Steel .

Table 119 Recalculations done in sub-category 1.A.2.a Iron and Steel

source category	Revisions of data	Type of revision	Type of improvement
1.A.2.a	Revision of NCV		

3.2.6.1.6 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 120 Planned improvements for sub-category 1.A.2.a Iron and Steel

source category	Planned improvement	Type of improvement		Priority
1.A.2.a	Carbon content (%) of lignite, gas/diesel oil, residual fuel oil, etc. for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{CO2}$** [t/TJ] = (C [%] • 44 • Ox)/(NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	Medium
1.A.2.a	Information about fitted/non-fitted equipment for flue gas cleaning, improvement in combustion	EF	Accuracy Transparency	Medium
1.A.2.a	Improvement of time series consistency and split of fuels: the energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire time series. Emissions are allocated in IPCC/NFR subcategory 1.A.2.m Other.	AD	Accuracy Transparency	High
1.A.2.a	Cross-check of national and international data sources (Eurostat and UNSD)	AD	Consistency Transparency	Medium

3.2.6.2 Non-Ferrous Metals (IPCC category 1.A.2.b)

The IPCC category 1.A.2.b *Non-Ferrous Metals* includes GHG emissions resulting from fuel combustion activities in

Activities	Occurring in Montenegro
▪ Manufacture of basic precious and other non-ferrous metals (ISIC Class 2420)	✓
▪ Casting of non-ferrous metals (ISIC Class 2432)	✓

3.2.6.2.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.b	✓	✓	✓	NO	NO	IE*	✓	✓	✓	NO	NO	IE*	✓	✓	✓	NO	NO	IE*
Key category	LA 1990; TA						-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF																		
* data provided only in the period 2014-2016																		

Use of notation key

IE 1.A.2.b (liquid, solid, biomass) The energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire timeseries. Emissions are currently allocated in IPCC subcategory 1.A.2.m *Other*.

An overview of the emissions from fuel combustion in IPCC sub-category *1.A.2.b Non-Ferrous Metals* is provided in the following figures and tables:

- annual emissions of GHGs;
- Trend of the periods 1990 – 2020, 2005 – 2021, 2020 – 2021.

The main fuels used in 1.A.2.b were liquid fuel, such as gas/diesel oil and fuel oil. In 2009, the production of alumina stopped accordingly three boilers were shut-down.

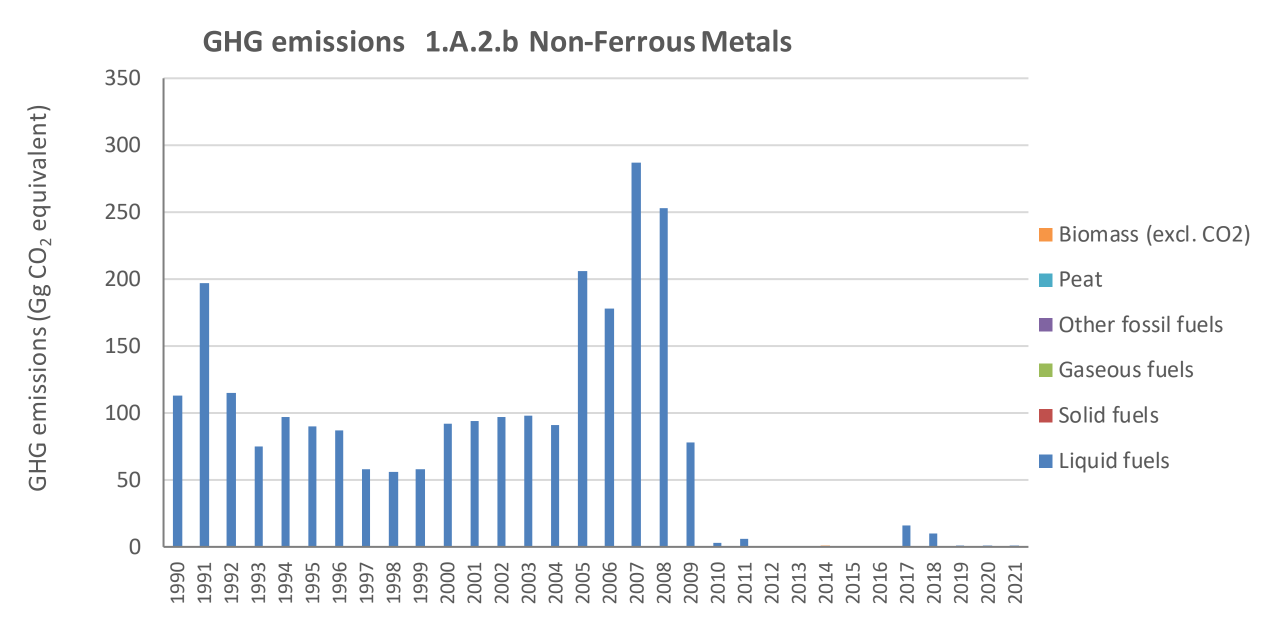


Figure 66 Emissions from IPCC sub-category 1.A.2.b Non-Ferrous Metals

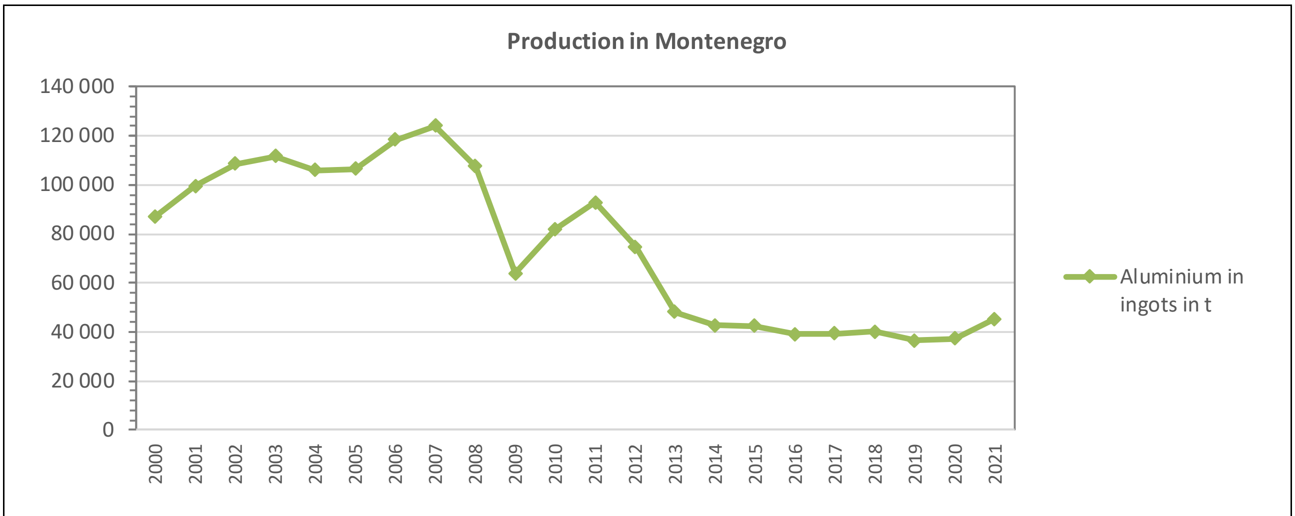


Figure 67 Main products in category 1.A.2.a Non-Ferrous Metals in the period 2000-2021; Source: MONSTAT)

Table 121 Emissions from IPCC sub-category 1.A.2.b Non-Ferrous Metals

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	kt CO2 equivalent	kt	kt CO2 equivalent	kt CO2 equivalent	kt
1990	113.25	112.88	0.262	0.110	NO
1991	196.78	196.14	0.454	0.190	NO
1992	115.58	115.20	0.267	0.112	NO
1993	74.96	74.71	0.173	0.073	NO
1994	96.80	96.49	0.223	0.094	NO
1995	90.56	90.26	0.209	0.088	NO
1996	87.44	87.15	0.202	0.085	NO
1997	58.16	57.97	0.135	0.056	NO
1998	56.29	56.10	0.130	0.055	NO
1999	58.47	58.28	0.135	0.057	NO
2000	91.92	91.62	0.213	0.089	NO
2001	94.10	93.79	0.218	0.091	NO
2002	96.86	96.54	0.224	0.094	NO
2003	98.42	98.10	0.227	0.095	NO
2004	90.62	90.32	0.209	0.088	NO
2005	205.98	205.31	0.474	0.199	NO
2006	177.89	177.31	0.410	0.172	NO
2007	286.83	285.93	0.628	0.267	NO
2008	252.85	252.02	0.583	0.244	NO
2009	78.02	77.77	0.180	0.075	NO
2010	3.12	3.11	0.007	0.003	NO
2011	6.24	6.22	0.014	0.006	NO
2012	IE	IE	IE	IE	NO
2013	IE	IE	IE	IE	NO
2014	<0.001	IE	IE	<0.001	0.0001
2015	IE	IE	IE	IE	NO
2016	IE	IE	IE	IE	NO
2017	16.54	16.48	0.040	0.017	NO
2018	10.00	9.96	0.024	0.010	NO
2019	0.63	0.63	0.002	0.001	NO
2020	0.63	0.63	0.002	0.001	NO
2021	0.01	0.01	<0.001	<0.001	NO
Trend					
1990 - 2021	*-99.9%*	*-99.9%*	*-99.9%*	*-99.9%*	*NA*
2005 - 2021	*-99.9%*	*-99.9%*	*-99.9%*	*-99.9%*	*NA*
2020 - 2021	*-98.3%*	*-98.3%*	*-98.0%*	*-98.0%*	*NA*

3.2.6.2.2 Methodological issues

3.2.6.2.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[52] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}}$$

Where:

Emissions $_{GHG,\ fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG,\ fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ) For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, solid fuels, gaseous fuels, other fossil fuel, biomass, peat

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG} = \sum_{fuel} emissions_{GHG,\,fuel}}$$

3.2.6.2.2.2 Choice of activity data

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 - 2021 were taken from Statistical Office of Montenegro (MONSTAT).

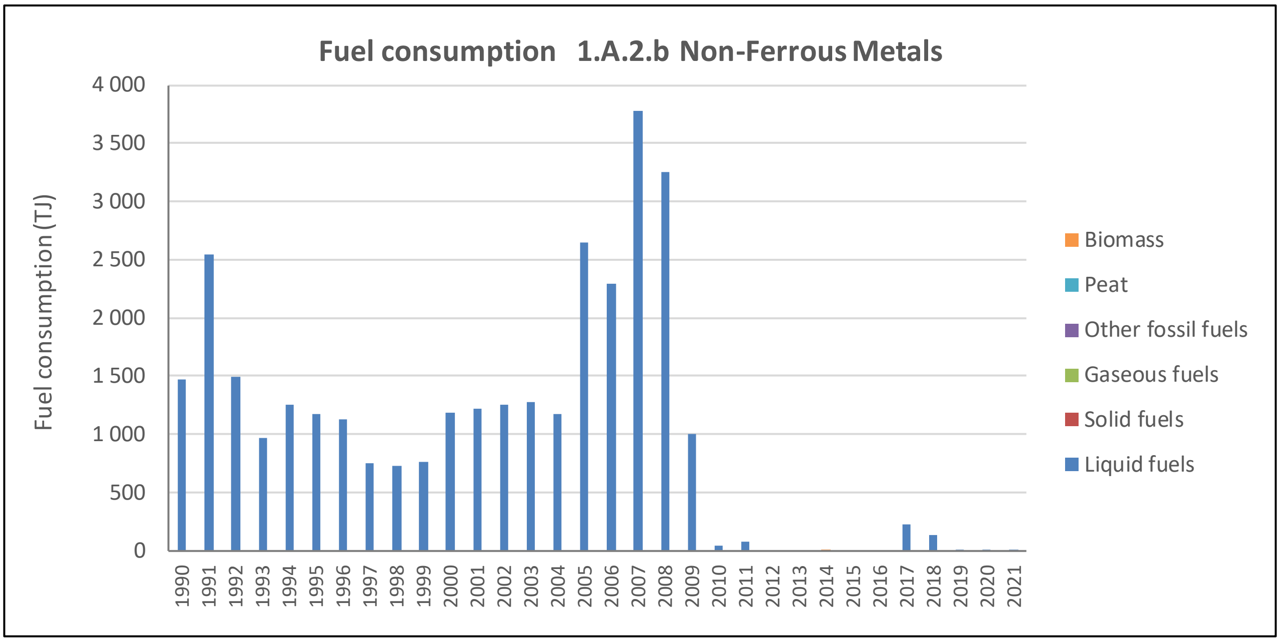


Figure 68 Activity data for IPCC sub-category 1.A.2.b Non-Ferrous

[52] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method

Table 122 Activity data for sub-category 1.A.2.b Non-Ferrous Metals

Activity data 1.A.1.b	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	1 467.48	1 467.48	NO	NO	NO	NO	NO
1991	2 539.53	2 539.53	NO	NO	NO	NO	NO
1992	1 492.07	1 492.07	NO	NO	NO	NO	NO
1993	967.08	967.08	NO	NO	NO	NO	NO
1994	1 248.41	1 248.41	NO	NO	NO	NO	NO
1995	1 168.03	1 168.03	NO	NO	NO	NO	NO
1996	1 127.84	1 127.84	NO	NO	NO	NO	NO
1997	752.57	752.57	NO	NO	NO	NO	NO
1998	728.46	728.46	NO	NO	NO	NO	NO
1999	756.59	756.59	NO	NO	NO	NO	NO
2000	1 189.15	1 189.15	NO	NO	NO	NO	NO
2001	1 217.28	1 217.28	NO	NO	NO	NO	NO
2002	1 250.93	1 250.93	NO	NO	NO	NO	NO
2003	1 271.03	1 271.03	NO	NO	NO	NO	NO
2004	1 170.55	1 170.55	NO	NO	NO	NO	NO
2005	2 652.54	2 652.54	NO	NO	NO	NO	NO
2006	2 290.83	2 290.83	NO	NO	NO	NO	NO
2007	3 784.57	3 784.57	NO	NO	NO	NO	NO
2008	3 257.91	3 257.91	NO	NO	NO	NO	NO
2009	1 004.75	1 004.75	NO	NO	NO	NO	NO
2010	40.19	40.19	NO	NO	NO	NO	NO
2011	80.38	80.38	NO	NO	NO	NO	NO
2012	IE	IE	NO	NO	NO	NO	NO
2013	IE	IE	NO	NO	NO	NO	NO
2014	1.00	IE	NO	NO	NO	NO	1.00
2015	IE	IE	NO	NO	NO	NO	NO
2016	IE	IE	NO	NO	NO	NO	NO
2017	222.44	222.44	NO	NO	NO	NO	NO
2018	134.44	134.44	NO	NO	NO	NO	NO
2019	8.49	8.49	NO	NO	NO	NO	NO
2020	8.49	8.49	NO	NO	NO	NO	NO
2021	0.17	0.17	NO	NO	NO	NO	NO
Trend							
1990 - 2021	*-99.9%*	*-99.9%*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*-99.9%*	*-99.9%*	*NA*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*-98.0%*	*-98.0%*	*NA*	*NA*	*NA*	*NA*	*NA*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic meters. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC/NFR sub-category 1.A.2.b Non-Ferrous Metals.

Table 123 Net calorific values (NCVs) applied for conversion to energy units in sub-category 1.A.2.b Non-Ferrous Metals

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg) or *(TJ/m3)		Source
		NCV	type	
Gas/Diesel Oil	liquid	42.71	CS	Statistical Office of Montenegro (MONSTAT)
Residual fuel oil	liquid	41.20	CS	
Petroleum Coke	liquid	40.19	CS	
Natural Gas	gaseous	46.00	CS	
Wood / Fuelwood	biomass	9.18*	CS	
Wood pellets	biomass	16.85	CS	
Note: D Default CS Country specific PS Plant specific				

3.2.6.2.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 124 GHG Emission factor TIER 1 for IPCC sub-category 1.A.2 Manufacturing Industries and Construction

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source
		EF	type	EF	type	EF	type	2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)
Gas/Diesel Oil	liquid	74 100	D	3	D	0.6	D	**Table 2.3** Default emission factors for stationary combustion in manufacturing industries and construction (page 2.18)
Residual Fuel Oil / Total fuel oil	liquid	77 400	D	3	D	0.6	D	
Lignite	solid	101 000	D	10	D	1.5	D	
LPG	gaseous	63 100	D	1	D	0.1	D	
Natural gas	gaseous	56 100	D	1	D	0.1	D	
Wood pellets	biomass	112 000	D	30	D	4	D	
Note: D Default CS Country specific PS Plant specific IEF Implied emission factor								

3.2.6.2.3 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- consistent use of energy balance data (energy statistic questionnaires),
- documented sources,
- use of units,
- strictly defined interfaces between spreadsheets/calculation modules,
- unique structure of sheets which do the same,

- o record keeping, use of write protection,
- o unique use of formulas, special cases are documented/highlighted,
- o quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic, Eurostat and international energy statistics of UN

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.6.2.4 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last two submission and relevant to sub-category 1.A.2.b Non-Ferrous Metals.

Table 125 Recalculations done in sub-category 1.A.2.b Non-Ferrous Metals

source category	Revisions of data	Type of revision	Type of improvement
1.A.2.b	Revision of NCV		

3.2.6.2.5 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 126 Planned improvements for sub-category 1.A.2.b Non-Ferrous Metals

source category	Planned improvement	Type of improvement		Priority
1.A.2.b	Carbon content (%) of lignite, gas/diesel oil, residual fuel oil, etc. for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{CO2}$** [t/TJ] = (C [%] • 44 • Ox)/(NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	Medium
1.A.2.b	Information about fitted/non-fitted equipment for flue gas cleaning, improvement in combustion	EF	Accuracy Transparency	Medium
1.A.2.b	Improvement of time series consistency and split of fuels: the energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire time series. Emissions are allocated in IPCC/NFR subcategory 1.A.2.m Other.	AD	Accuracy Transparency	High
1.A.2.b	Cross-check of national and international data sources (Eurostat and UNSD)	AD	Consistency Transparency	Medium

3.2.6.3 Chemical industry (IPCC category 1.A.2.c)

The IPCC category 1.A.2.c *Chemical industry* includes GHG emissions resulting from fuel combustion activities in

Activities	Occurring in MNE
▪ Manufacture of chemicals and chemical products (ISIC division 20)	✓
▪ Manufacture of pharmaceuticals, medicinal chemical & botanical products (ISIC Class 21)	✓

3.2.6.3.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.c	✓	✓*	NO	NO	NO	✓	✓	✓*	NO	NO	NO	✓	✓	✓*	NO	NO	NO	✓
Key category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF																		
* data provided only from 2005 onwards, all other years IE																		

<u>Use of notation key</u>

IE	1.A.2.c (liquid, solid)	The energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire timeseries. Emissions are currently allocated in IPCC subcategory 1.A.2.m *Other*.

An overview of the emissions from fuel combustion in IPCC sub-category *1.A.2.c Chemical industry* is provided in the following figures and tables:

- annual emissions of GHGs;
- Trend of the periods 1990 – 2021, 2005 – 2021, 2020 – 2021.

The main fuels used in 1.A.2.c were liquid fuel, such as gas/diesel oil and fuel oil.

For the period 1990-2009, the emissions from this sub-category are included in 1.A.2.m Other.

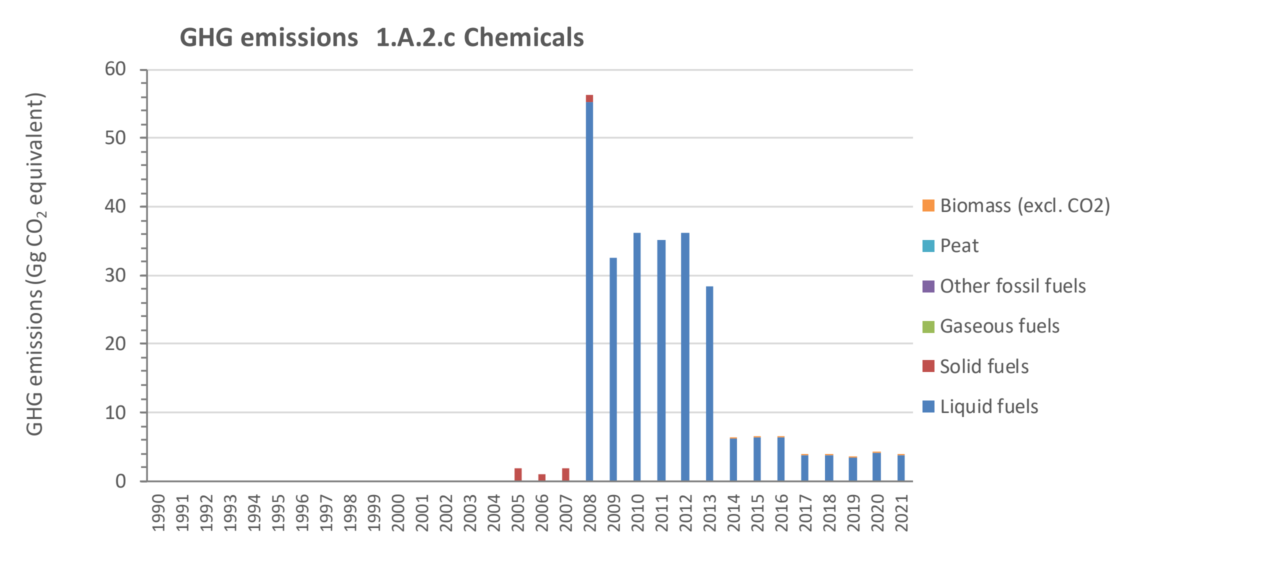


Figure 69 Emissions from IPCC sub-category 1.A.2.c Chemical industry

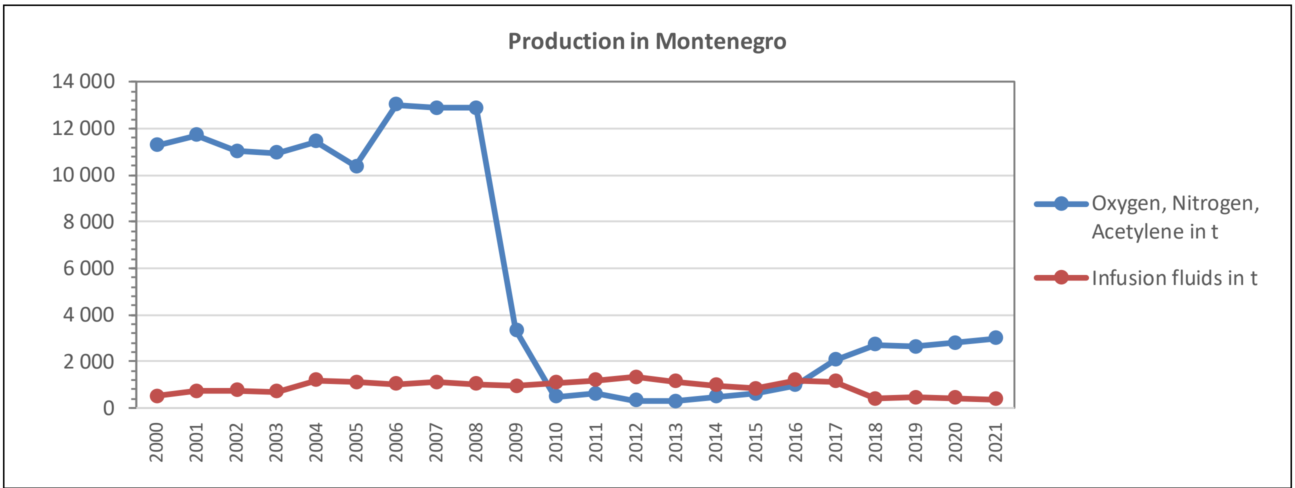


Figure 70 Main products in category 1.A.2.j Chemical industry in the period 2000-2021; Source: MONSTAT

Table 127 Emissions from IPCC sub-category 1.A.2.c Chemical industry

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	kt CO2 equivalent	kt	kt CO2 equivalent	kt CO2 equivalent	kt
1990	IE	IE	IE	IE	NO
1991	IE	IE	IE	IE	NO
1992	IE	IE	IE	IE	NO
1993	IE	IE	IE	IE	NO
1994	IE	IE	IE	IE	NO
1995	IE	IE	IE	IE	NO
1996	IE	IE	IE	IE	NO
1997	IE	IE	IE	IE	NO
1998	IE	IE	IE	IE	NO
1999	IE	IE	IE	IE	NO
2000	IE	IE	IE	IE	NO
2001	IE	IE	IE	IE	NO
2002	IE	IE	IE	IE	NO
2003	IE	IE	IE	IE	NO
2004	IE	IE	IE	IE	NO
2005	1.873	1.860	0.008	0.005	NO
2006	0.937	0.930	0.004	0.002	NO
2007	1.873	1.860	0.008	0.005	NO
2008	56.232	56.171	0.033	0.027	NO
2009	32.570	32.523	0.029	0.018	NO
2010	36.176	36.110	0.043	0.023	NO
2011	35.206	35.157	0.030	0.019	NO
2012	36.233	36.168	0.042	0.023	NO
2013	28.356	28.260	0.068	0.029	NO
2014	6.244	6.218	0.015	0.006	0.004
2015	6.308	6.276	0.015	0.006	0.012
2016	6.307	6.276	0.015	0.006	0.011
2017	3.769	3.748	0.009	0.004	0.008
2018	3.768	3.748	0.009	0.004	0.007
2019	3.449	3.432	0.008	0.003	0.006
2020	4.080	4.059	0.010	0.004	0.007
2021	3.767	3.748	0.009	0.004	0.006
Trend					
1990 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*101.1%*	*101.5%*	*7.9%*	*-18.2%*	*NA*
2020 - 2021	*-7.7%*	*-7.7%*	*-7.5%*	*-7.6%*	*-15.9%*

3.2.6.3.2 Methodological issues

3.2.6.3.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[53] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}$$

Where:

Emissions $_{GHG, fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG, fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ) For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, solid fuels, gaseous fuels, other fossil fuel, biomass, peat

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG} = \sum_{fuel} emissions_{GHG,\,fuel}$$

3.2.6.3.2.2 Choice of activity data

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 - 2021 were taken from Statistical Office of Montenegro (MONSTAT).

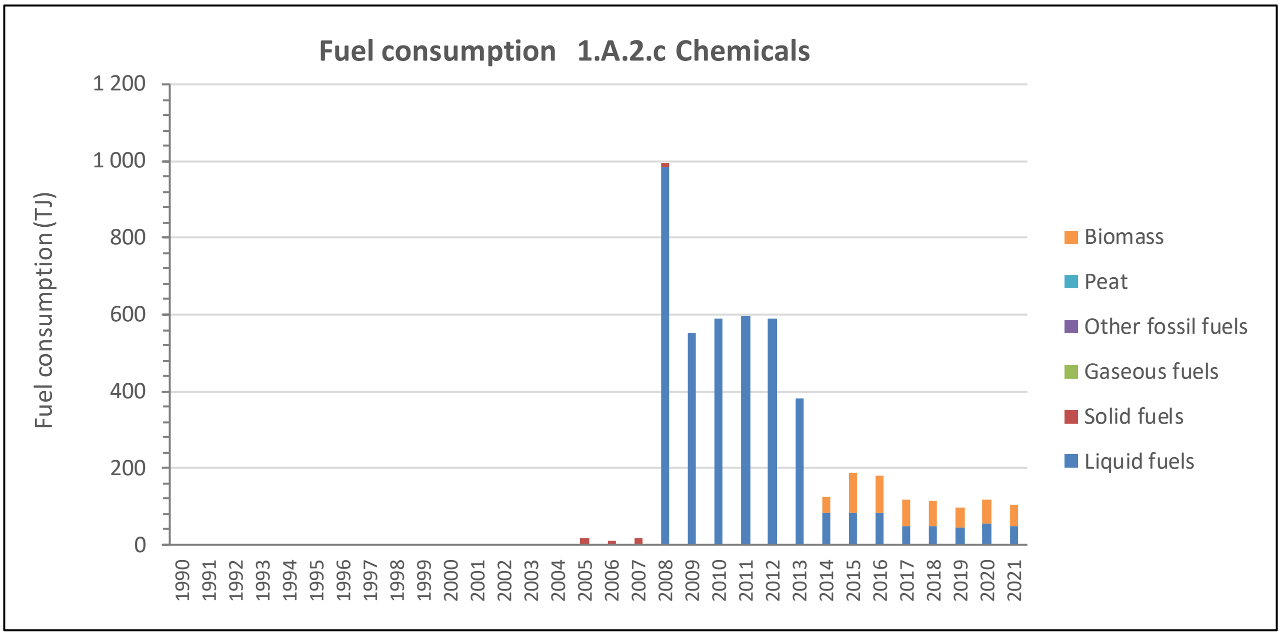


Figure 71 Activity data for IPCC sub-category 1.A.2.c Chemical industry

<u>Use of notation key</u>

IE	1.A.2.c liquid, solid	The energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire timeseries. Emissions are currently allocated in IPCC subcategory 1.A.2.m *Other*.

[53] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method

Table 128 Activity data for IPCC sub-category 1.A.2.c Chemical industry

Activity data 1.A.1.c	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	IE	IE	IE	NO	NO	NO	NO
1991	IE	IE	IE	NO	NO	NO	NO
1992	IE	IE	IE	NO	NO	NO	NO
1993	IE	IE	IE	NO	NO	NO	NO
1994	IE	IE	IE	NO	NO	NO	NO
1995	IE	IE	IE	NO	NO	NO	NO
1996	IE	IE	IE	NO	NO	NO	NO
1997	IE	IE	IE	NO	NO	NO	NO
1998	IE	IE	IE	NO	NO	NO	NO
1999	IE	IE	IE	NO	NO	NO	NO
2000	IE	IE	IE	NO	NO	NO	NO
2001	IE	IE	IE	NO	NO	NO	NO
2002	IE	IE	IE	NO	NO	NO	NO
2003	IE	IE	IE	NO	NO	NO	NO
2004	IE	IE	IE	NO	NO	NO	NO
2005	18.42	IE	18.42	NO	NO	NO	NO
2006	9.21	IE	9.21	NO	NO	NO	NO
2007	18.42	IE	18.42	NO	NO	NO	NO
2008	993.90	984.69	9.21	NO	NO	NO	NO
2009	552.81	552.81	NO	NO	NO	NO	NO
2010	589.83	589.83	NO	NO	NO	NO	NO
2011	596.17	596.17	NO	NO	NO	NO	NO
2012	588.82	588.82	NO	NO	NO	NO	NO
2013	381.37	381.37	NO	NO	NO	NO	NO
2014	123.91	83.91	NO	NO	NO	NO	40.00
2015	186.90	82.90	NO	NO	NO	NO	104.00
2016	178.90	82.90	NO	NO	NO	NO	96.00
2017	116.69	49.69	NO	NO	NO	NO	67.00
2018	115.69	49.69	NO	NO	NO	NO	66.00
2019	95.42	45.42	NO	NO	NO	NO	50.00
2020	116.71	53.71	NO	NO	NO	NO	63.00
2021	102.69	49.69	NO	NO	NO	NO	53.00
Trend							
1990 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*457.5%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*-12.0%*	*-7.5%*	*NA*	*NA*	*NA*	*NA*	*-15.9%*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tons or cubic meters. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC sub-category 1.A.2.c Chemical industry.

Table 129 Net calorific values (NCVs) applied for conversion to energy units in sub-category 1.A.2.c Chemicals

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg) or *(TJ/m3)		Source
		NCV	type	
Gas/Diesel Oil	liquid	42.71	CS	Statistical Office of Montenegro (MONSTAT)
Residual fuel oil	liquid	41.20	CS	
Liquefied Petroleum Gases (LPG)	liquid	46.89	CS	
Sub-Bituminous Coal	solid	16.75	CS	
Wood / Fuelwood	biomass	9.18*	CS	
Note: D Default CS Country specific PS Plant specific				

3.2.6.3.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 130 GHG Emission factor TIER 1 for IPCC sub-category 1.A.2 Main Activity Manufacturing Industries and Construction

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source
		EF	type	EF	type	EF	type	**2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)**
Residual Fuel Oil	liquid	77 400	D	3	D	0.6	D	**Table 2.3** Default emission factors for stationary combustion in manu-facturing industries and construction (page 2.18)
Lignite	solid	101 000	D	10	D	1.5	D	
Wood pellets	biomass	112 000	D	30	D	4	D	
Note: D Default CS Country specific PS Plant specific IEF Implied emission factor								

3.2.6.3.3 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ consistent use of energy balance data (energy statistic questionnaires),
- o documented sources,
- o use of units,
- o strictly defined interfaces between spreadsheets/calculation modules,
- o unique structure of sheets which do the same,
- o record keeping, use of write protection,
- o unique use of formulas, special cases are documented/highlighted,
- o quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic, Eurostat and international energy statistics of UN

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.6.3.4 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission and relevant to sub-category 1.A.2.c Chemicals.

Table 131 Recalculations done in sub-category 1.A.2.c Chemicals

source category	Revisions of data	Type of revision	Type of improvement
1.A.2.c	Revision of NCV		

3.2.6.3.5 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 132 Planned improvements for sub-category 1.A.2.c Chemicals

source category	Planned improvement	Type of improvement		Priority
1.A.2.c	Carbon content (%) of lignite, gas/diesel oil, residual fuel oil, etc. for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{CO2}$** [t/TJ] = (C [%] • 44 • Ox)/(NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	Medium
1.A.2.c	Information about fitted/non-fitted equipment for flue gas cleaning, improvement in combustion	EF	Accuracy Transparency	Medium
1.A.2.c	Improvement of time series consistency and split of fuels: the energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire time series. Emissions are allocated in IPCC/NFR subcategory 1.A.2.m Other.	AD	Accuracy Transparency	High
1.A.2.c	Cross-check of national and international data sources (Eurostat and UNSD)	AD	Consistency Transparency	Medium

3.2.6.4 Pulp, Paper and Print (IPCC category 1.A.2.d)

The IPCC category 1.A.2.d *Pulp, Paper and Printing* includes GHG emissions resulting from fuel combustion activities in

Activities	Occurring in MNE
▪ Manufacture of paper and paper products (ISIC Division 17)	✓
o ISIC Group 1701 Manufacture of pulp, paper and paperboard	
o ISIC Group 1702 Manufacture of corrugated paper and paperboard and of containers of paper and paperboard	
o ISIC Group 1709 Manufacture of other articles of paper and paperboard	
▪ Printing and reproduction of recorded media (ISIC Division 18)	✓
o ISIC Group 181 Printing and service activities related to printing	
o ISIC Group 182 Reproduction of recorded media	

3.2.6.4.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.d	✓*	✓*	NO	NO	NO	NO	✓*	✓*	NO	NO	NO	NO	✓*	✓*	NO	NO	NO	NO
Key category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF																		
* data provided only from 1995 onwards, all other years IE																		

Use of notation key

IE	1.A.2.d (liquid, solid)	The energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire timeseries. Emissions are currently allocated in IPCC subcategory 1.A.2.m *Other*.

An overview of the emissions from fuel combustion in IPCC sub-category *1.A.2.d Pulp, Paper and Print* is provided in the following figures and tables:

- annual emissions of GHGs;
- Trend of the periods 1990 – 2020, 2005 – 2021, 2020 – 2021.

GHG emissions decreased significantly to change in fuel mix. Whereas until 2005 the main fuel used was lignite which come from the Pljevija basin, the fuel mix changed to liquid fuel, such as gas/diesel oil and fuel oil.

For the period 1990-1995, 2011 and 2015-2016 the emissions from this sub-category are included in 1.A.2.m Other.

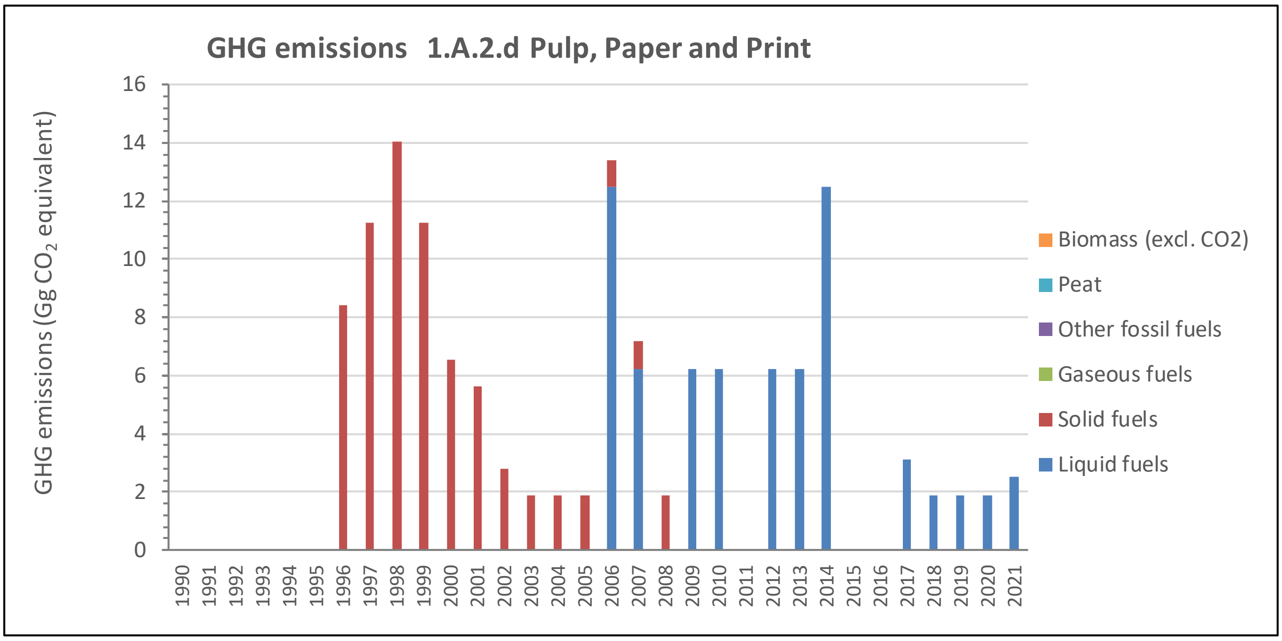


Figure 72 GHG emissions from IPCC sub-category 1.A.2.d Pulp, Paper and Printing

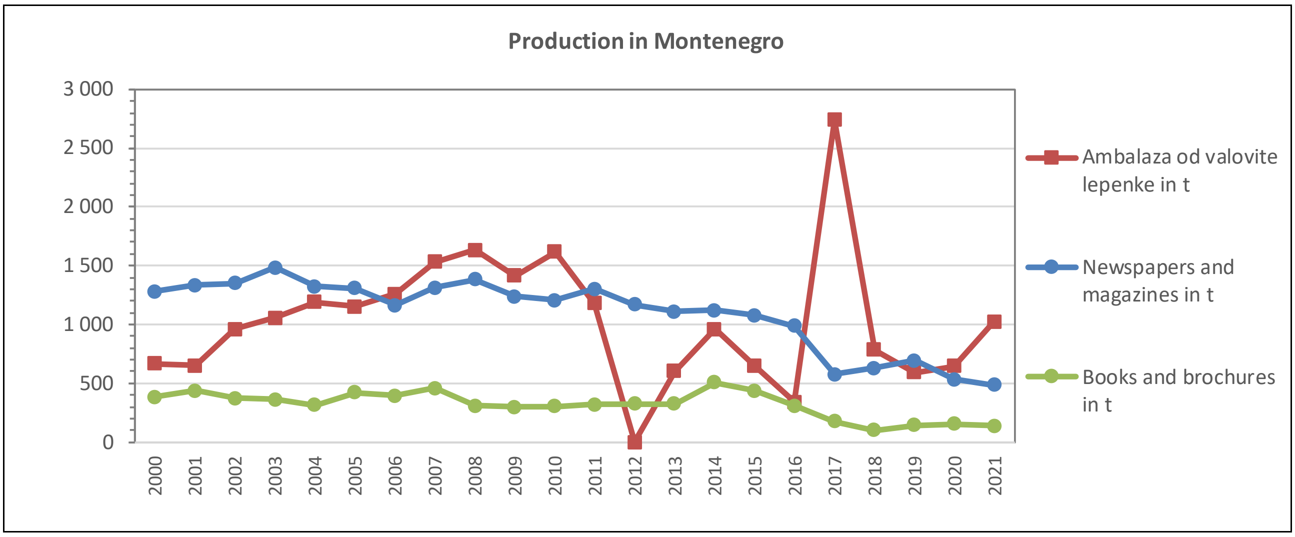


Figure 73 Main products in category 1.A.2.d Pulp, Paper and Print in the period 2000-2021; Source: MONSTAT

Table 133 GHG Emissions from IPCC sub-category 1.A.2.d Pulp, Paper and Print

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	kt CO2 equivalent	kt	kt CO2 equivalent	kt CO2 equivalent	kt
1990	IE	IE	IE	IE	NO
1991	IE	IE	IE	IE	NO
1992	IE	IE	IE	IE	NO
1993	IE	IE	IE	IE	NO
1994	IE	IE	IE	IE	NO
1995	IE	IE	IE	IE	NO
1996	8.43	8.37	0.037	0.021	NO
1997	11.24	11.16	0.049	0.028	NO
1998	14.05	13.95	0.062	0.035	NO
1999	11.24	11.16	0.049	0.028	NO
2000	6.56	6.51	0.029	0.016	NO
2001	5.62	5.58	0.025	0.014	NO
2002	2.81	2.79	0.012	0.007	NO
2003	1.87	1.86	0.008	0.005	NO
2004	1.87	1.86	0.008	0.005	NO
2005	1.87	1.86	0.008	0.005	NO
2006	13.41	13.37	0.034	0.015	NO
2007	7.18	7.15	0.019	0.009	NO
2008	1.87	1.86	0.008	0.005	NO
2009	6.24	6.22	0.015	0.006	NO
2010	6.24	6.22	0.015	0.006	NO
2011	NO	NO	NO	NO	NO
2012	6.24	6.22	0.015	0.006	NO
2013	6.24	6.22	0.015	0.006	NO
2014	12.48	12.44	0.030	0.013	NO
2015	NO	NO	NO	NO	NO
2016	NO	NO	NO	NO	NO
2017	3.12	3.11	0.008	0.003	NO
2018	1.87	1.87	0.005	0.002	NO
2019	1.87	1.87	0.005	0.002	NO
2020	1.87	1.87	0.005	0.002	NO
2021	2.50	2.49	0.006	0.003	NO
Trend					
1990 - 2021	NA	NA	NA	NA	NA
2005 - 2021	33.2%	33.7%	-27.1%	-45.3%	NA
2020 - 2021	33.3%	33.3%	33.3%	33.3%	NA

3.2.6.4.2 Methodological issues

3.2.6.4.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[54] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}$$

Where:

Emissions $_{GHG,\,fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG,\,fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ) For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, solid fuels, gaseous fuels, other fossil fuel, biomass, peat

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG} = \sum_{fuel} emissions_{GHG,\,fuel}$$

3.2.6.4.2.2 Choice of activity data

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 - 2021 were taken from Statistical Office of Montenegro (MONSTAT).

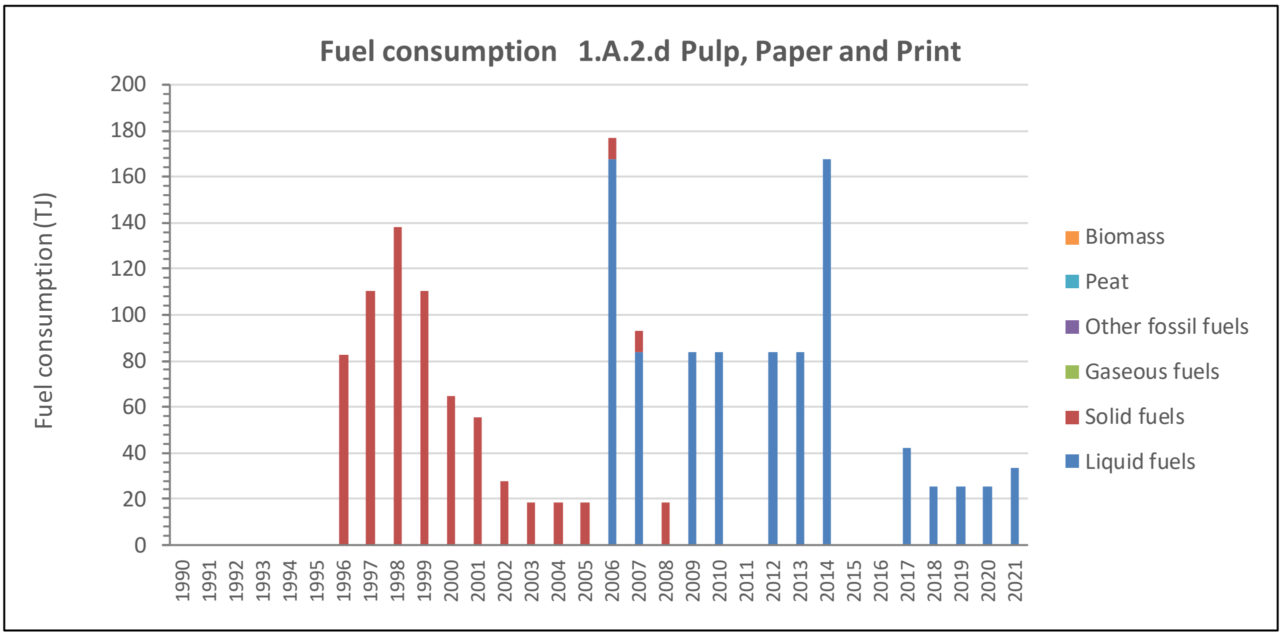


Figure 74 Activity data for sub-category 1.A.2.d Pulp, Paper and Print

<u>Use of notation key</u>

IE	1.A.2.d liquid, solid	The energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire timeseries. Emissions are currently allocated in IPCC subcategory 1.A.2.m *Other*.

[54] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method

Table 134 Activity data for sub-category 1.A.2.d Pulp, Paper and Print

Activity data 1.A.1.d	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	IE	IE	IE	NO	NO	NO	NO
1991	IE	IE	IE	NO	NO	NO	NO
1992	IE	IE	IE	NO	NO	NO	NO
1993	IE	IE	IE	NO	NO	NO	NO
1994	IE	IE	IE	NO	NO	NO	NO
1995	IE	IE	IE	NO	NO	NO	NO
1996	82.89	IE	82.89	NO	NO	NO	NO
1997	110.52	IE	110.52	NO	NO	NO	NO
1998	138.15	IE	138.15	NO	NO	NO	NO
1999	110.52	IE	110.52	NO	NO	NO	NO
2000	64.47	IE	64.47	NO	NO	NO	NO
2001	55.26	IE	55.26	NO	NO	NO	NO
2002	27.63	IE	27.63	NO	NO	NO	NO
2003	18.42	IE	18.42	NO	NO	NO	NO
2004	18.42	IE	18.42	NO	NO	NO	NO
2005	18.42	IE	18.42	NO	NO	NO	NO
2006	177.03	167.82	9.21	NO	NO	NO	NO
2007	93.12	83.91	9.21	NO	NO	NO	NO
2008	18.42	NO	18.42	NO	NO	NO	NO
2009	83.91	83.91	NO	NO	NO	NO	NO
2010	83.91	83.91	NO	NO	NO	NO	NO
2011	IE	IE	NO	NO	NO	NO	NO
2012	83.91	83.91	NO	NO	NO	NO	NO
2013	83.91	83.91	NO	NO	NO	NO	NO
2014	167.82	167.82	NO	NO	NO	NO	NO
2015	IE	IE	NO	NO	NO	NO	NO
2016	IE	IE	NO	NO	NO	NO	NO
2017	41.96	41.96	NO	NO	NO	NO	NO
2018	25.17	25.17	NO	NO	NO	NO	NO
2019	25.17	25.17	NO	NO	NO	NO	NO
2020	25.17	25.17	NO	NO	NO	NO	NO
2021	33.56	33.56	NO	NO	NO	NO	NO
Trend							
1990 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*82.2%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*33.3%*	*33.3%*	*NA*	*NA*	*NA*	*NA*	*NA*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tons or cubic meters. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC sub-category 1.A.2.d Pulp, Paper and Print.

Table 135 Net calorific values (NCVs) applied for conversion to energy units in sub-category 1.A.2.d Pulp, Paper and Print

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg)		Source
		NCV	type	
Gas/Diesel Oil	liquid	42.71	CS	Statistical Office of Montenegro (MONSTAT)
Residual fuel oil	liquid	41.20	CS	
Liquefied Petroleum Gases (LPG)	liquid	46.89	CS	
Sub-Bituminous Coal	solid	16.75	CS	
Lignite	solid	9.21	CS	

Note:
D Default CS Country specific PS Plant specific

3.2.6.4.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 136 GHG Emission factor TIER 1 for IPCC sub-category 1.A.2 Manufacturing Industries and Construction

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source
		EF	type	EF	type	EF	type	2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)
Residual Fuel Oil	liquid	77 400	D	3	D	0.6	D	**Table 2.3** Default emission factors for stationary combustion in manufacturing industries and construction (page 2.18)
Lignite	solid	101 000	D	10	D	1.5	D	
Wood pellets	biomass	112 000	D	30	D	4	D	

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

3.2.6.4.3 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ consistent use of energy balance data (energy statistic questionnaires),
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic, Eurostat and international energy statistics of UN

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.6.4.4 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission and relevant to sub-category 1.A.2.d Pulp, Paper and Print.

Table 137 Recalculations done in sub-category 1.A.2.d Pulp, Paper and Print

source category	Revisions of data	Type of revision	Type of improvement
1.A.2.d	Revision of NCV		

3.2.6.4.5 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 138 Planned improvements for sub-category 1.A.2.d Pulp, Paper and Print

source category	Planned improvement	Type of improvement		Priority
1.A.2.d	Carbon content (%) of lignite, gas/diesel oil, residual fuel oil, etc. for preparing country specific emission factor (CS EF) $\Rightarrow$ **CS EF_{CO_2}** [t/TJ] = (C [%] • 44 • Ox)/(NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	Medium
1.A.2.d	Information about fitted/non-fitted equipment for flue gas cleaning, improvement in combustion	EF	Accuracy Transparency	Medium
1.A.2.d	Improvement of time series consistency and split of fuels: the energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire time series. Emissions are allocated in IPCC/NFR subcategory 1.A.2.m Other.	AD	Accuracy Transparency	High
1.A.2.d	Cross-check of national and international data sources (Eurostat and UNSD)	AD	Consistency Transparency	Medium

3.2.6.5 Food Processing, Beverages and Tobacco (IPCC category 1.A.2.e)

The IPCC category 1.A.2.d *Pulp, Paper and Printing* includes GHG emissions resulting from fuel combustion activities in

Activities	Occurring in Montenegro
▪ ISIC Divisions 10 Manufacture of food products	✓
o Processing and preserving of meat, fish, crustaceans and molluscs, fruit and vegetables	
o Manufacture of vegetable and animal oils and fats, dairy products, grain mill products, starches and starch products and of other food products	
▪ ISIC Divisions 11 Manufacture of beverages	
o Distilling, rectifying and blending	✓
o Manufacture of wines, malt liquors and malt, soft drinks; production of mineral waters and	

other bottled waters	
▪ ISIC Divisions 12 Manufacture of tobacco products.	NO

3.2.6.5.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.e	✓*	✓**	NO	NO	NO	✓	✓*	✓**	NO	NO	NO	✓	✓*	✓**	NO	NO	NO	✓
Key Category	LA 2020						-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF																		
* data provided only for 1990, 1995 and after 2004, all other years IE; ** data provided for all years except f2009 and 2010, for which IE is used																		

Use of notation key

IE 1.A.2.e (liquid) The energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire timeseries. Emissions are currently allocated in IPCC subcategory 1.A.2.m *Other*.

An overview of the emissions from fuel combustion in IPCC sub-category *1.A.2.e Food Processing, Beverages and Tobacco* is provided in the following figures and tables:

- annual emissions of GHGs;
- Trend of the periods 1990 – 2020, 2005 – 2021, 2020 – 2021.

The main fuels used in 1.A.2.e were liquid fuel, such as gas/diesel oil and fuel oil.

In the last decade the GHG emissions increased significantly to change in fuel mix but also due to increased processing of food and beverages. Whereas until 2005 the main fuel used was lignite which come from the Pljevija basin, the fuel mix changed to liquid fuel, such as gas/diesel oil and fuel oil.

For 1990-2005, , the emissions from liquid fuels combusted in IPCC category 1.A.2.e Food Processing, Beverages and Tobacco is included in IPCC subcategory 1.A.2.m Other.

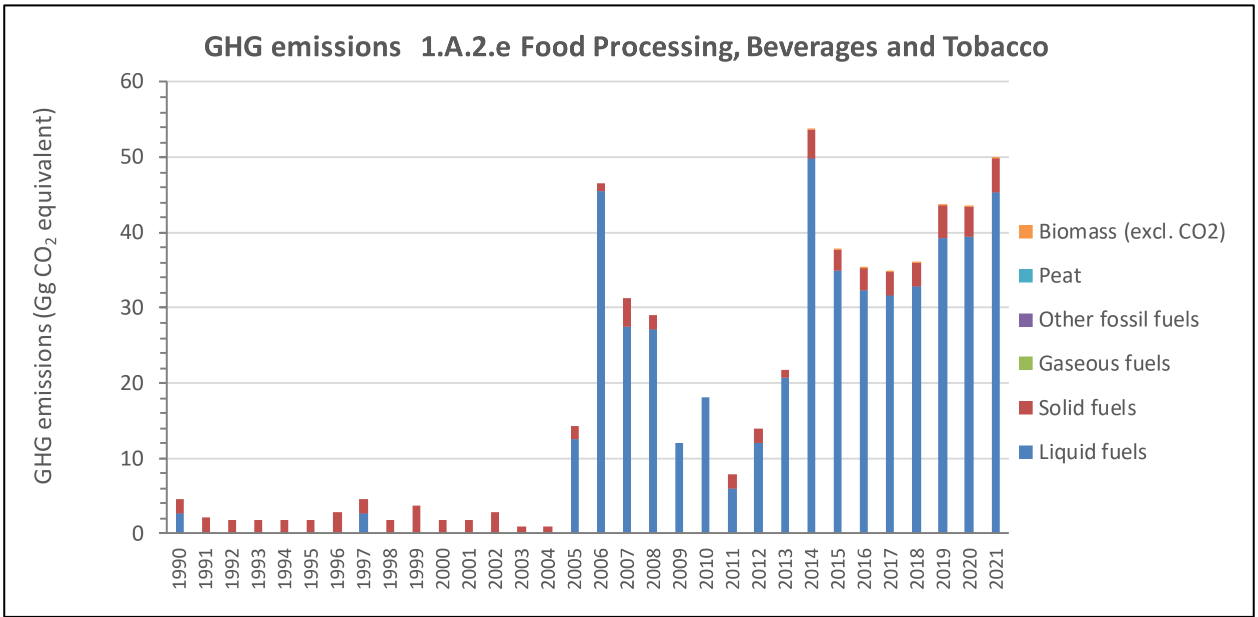


Figure 75: GHG Emissions from sub-category 1.A.2.e Food Processing, Beverages and Tobacco

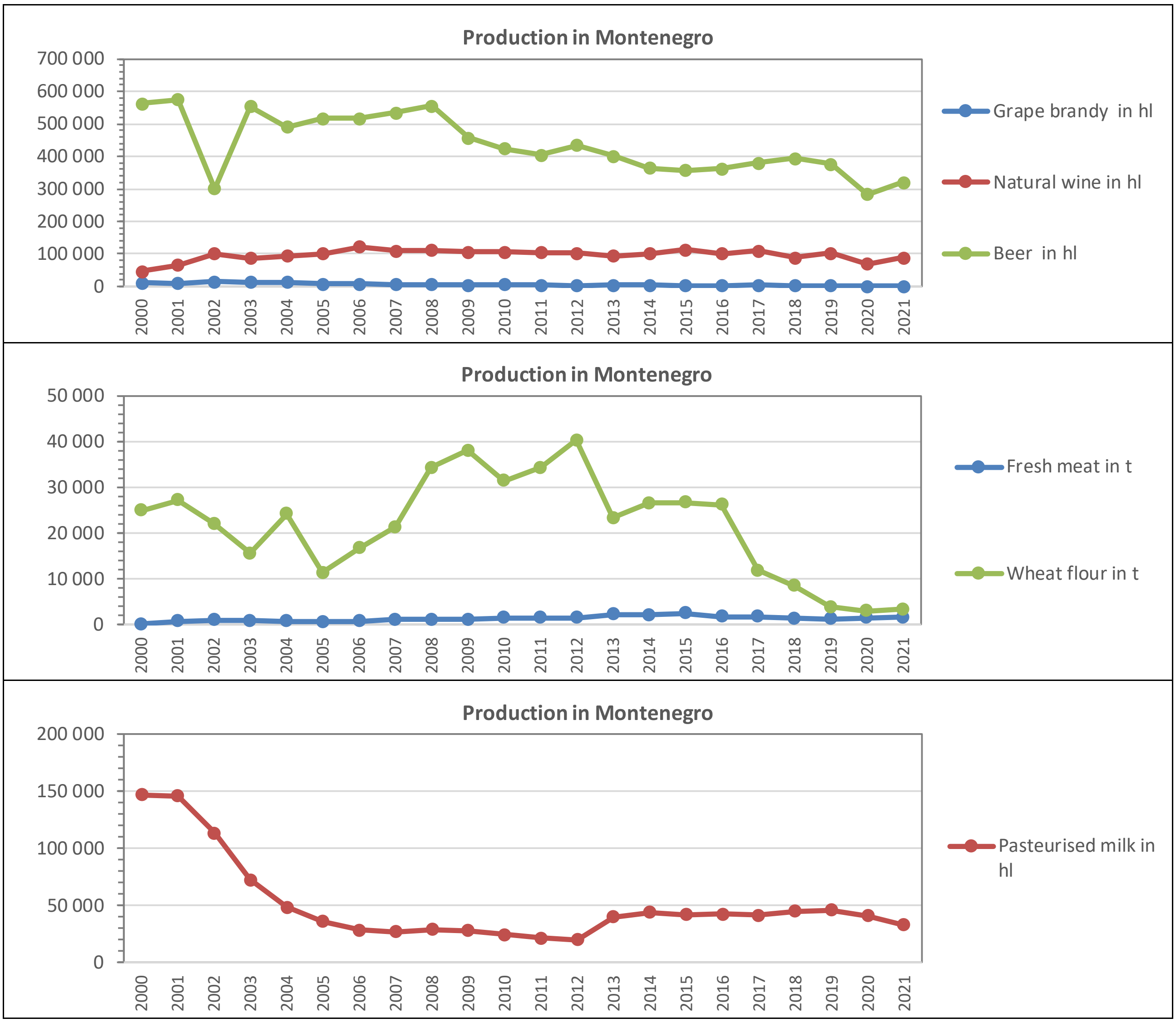


Figure 76 Main products in category 1.A.2.d Food Processing, Beverages and Tobacco in the period 2000-2021; Source: MONSTAT

Table 139 GHG Emissions from IPCC sub-category 1.A.2.e Food Processing, Beverages and Tobacco

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	kt CO2 equivalent	kt	kt CO2 equivalent	kt CO2 equivalent	kt
1990	4.51	4.49	0.010	0.006	NO
1991	2.23	2.22	0.010	0.005	NO
1992	1.87	1.86	0.008	0.005	NO
1993	1.87	1.86	0.008	0.005	NO
1994	1.87	1.86	0.008	0.005	NO
1995	1.87	1.86	0.008	0.005	NO
1996	2.81	2.79	0.012	0.007	NO
1997	4.51	4.49	0.010	0.006	NO
1998	1.87	1.86	0.008	0.005	NO
1999	3.75	3.72	0.016	0.009	NO
2000	1.87	1.86	0.008	0.005	NO
2001	1.87	1.86	0.008	0.005	NO
2002	2.81	2.79	0.012	0.007	NO
2003	0.94	0.93	0.004	0.002	NO
2004	0.94	0.93	0.004	0.002	NO
2005	14.36	14.30	0.037	0.017	NO
2006	46.50	46.34	0.116	0.049	NO
2007	31.21	31.09	0.083	0.037	NO
2008	28.97	28.87	0.069	0.031	NO
2009	12.07	12.03	0.030	0.013	NO
2010	18.10	18.04	0.045	0.019	NO
2011	7.91	7.87	0.023	0.011	NO
2012	13.94	13.89	0.038	0.017	NO
2013	21.67	21.60	0.051	0.022	NO
2014	53.70	53.48	0.126	0.057	0.032
2015	37.81	37.66	0.084	0.039	0.027
2016	35.26	35.11	0.083	0.038	0.028
2017	34.74	34.59	0.081	0.037	0.027
2018	36.09	35.94	0.084	0.039	0.028
2019	43.59	43.41	0.103	0.048	0.033
2020	43.50	43.32	0.099	0.046	0.032
2021	49.85	49.65	0.117	0.054	0.035
Trend					
1990 - 2021	*1006.3%*	*1005.5%*	*1113.1%*	*830.6%*	*NA*
2005 - 2021	*247.2%*	*247.1%*	*216.0%*	*222.7%*	*NA*
2020 - 2021	*14.6%*	*14.6%*	*17.6%*	*16.0%*	*9.8%*

3.2.6.5.2 Methodological issues

3.2.6.5.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[55] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}$$

Where:

Emissions $_{GHG, fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG, fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ) For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, solid fuels, gaseous fuels, other fossil fuel, biomass, peat

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG} = \sum_{fuel} emissions_{GHG,\,fuel}$$

3.2.6.5.2.2 Choice of activity data

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 - 2021 were taken from Statistical Office of Montenegro (MONSTAT).

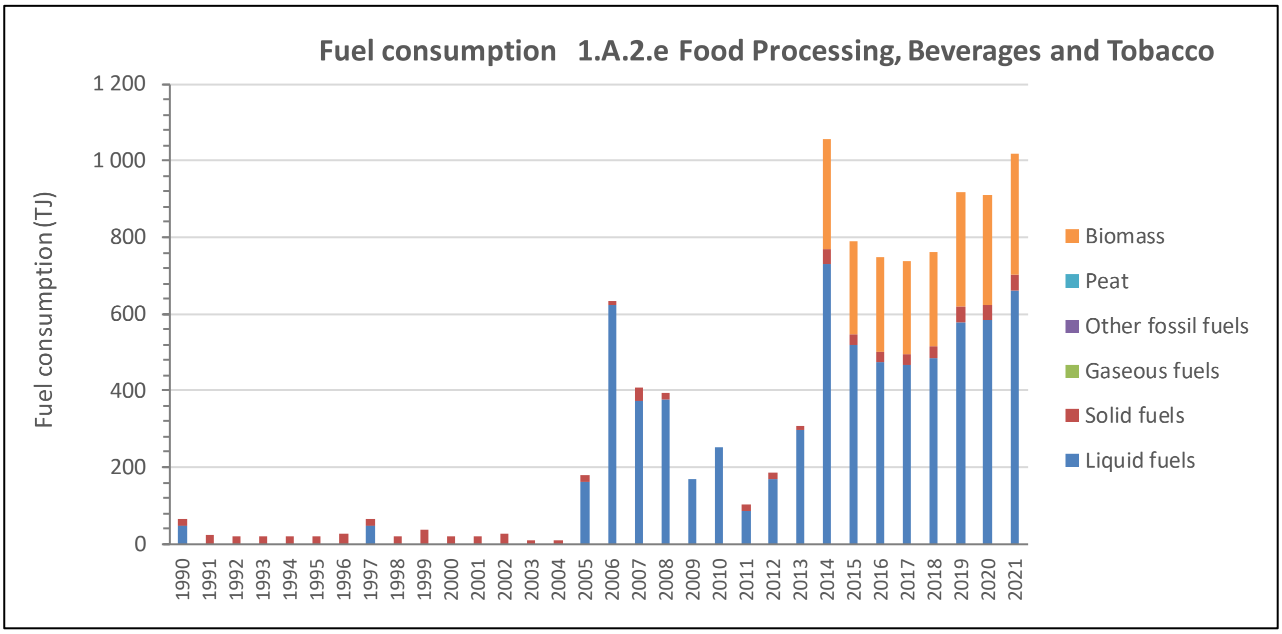


Figure 77 Activity data for sub-category 1.A.2.e Food Processing, Beverages and Tobacco

<u>Use of notation key</u>

IE	1.A.2.e (liquid)	The energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire timeseries. Emissions are currently allocated in IPCC subcategory 1.A.2.m *Other*.

[55] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method

Table 140 Activity data for sub-category 1.A.2.e Food Processing, Beverages and Tobacco

Activity data 1.A.1.e	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	65.31	46.89	18.42	NO	NO	NO	NO
1991	21.93	IE	21.93	NO	NO	NO	NO
1992	18.42	IE	18.42	NO	NO	NO	NO
1993	18.42	IE	18.42	NO	NO	NO	NO
1994	18.42	IE	18.42	NO	NO	NO	NO
1995	18.42	IE	18.42	NO	NO	NO	NO
1996	27.63	IE	27.63	NO	NO	NO	NO
1997	65.31	46.89	18.42	NO	NO	NO	NO
1998	18.42	IE	18.42	NO	NO	NO	NO
1999	36.84	IE	36.84	NO	NO	NO	NO
2000	18.42	IE	18.42	NO	NO	NO	NO
2001	18.42	IE	18.42	NO	NO	NO	NO
2002	27.63	IE	27.63	NO	NO	NO	NO
2003	9.21	IE	9.21	NO	NO	NO	NO
2004	9.21	IE	9.21	NO	NO	NO	NO
2005	179.18	160.76	18.42	NO	NO	NO	NO
2006	633.24	624.03	9.21	NO	NO	NO	NO
2007	409.14	372.30	36.84	NO	NO	NO	NO
2008	395.40	376.98	18.42	NO	NO	NO	NO
2009	167.82	167.82	IE	NO	NO	NO	NO
2010	251.73	251.73	IE	NO	NO	NO	NO
2011	102.33	83.91	18.42	NO	NO	NO	NO
2012	186.24	167.82	18.42	NO	NO	NO	NO
2013	307.83	298.62	9.21	NO	NO	NO	NO
2014	1 057.40	731.56	36.84	NO	NO	NO	289.00
2015	790.15	519.52	27.63	NO	NO	NO	243.00
2016	748.08	472.63	28.45	NO	NO	NO	247.00
2017	736.23	465.80	30.43	NO	NO	NO	240.00
2018	762.41	483.15	32.26	NO	NO	NO	247.00
2019	916.90	577.57	42.33	NO	NO	NO	297.00
2020	911.33	584.08	40.24	NO	NO	NO	287.00
2021	1 019.51	660.40	44.11	NO	NO	NO	315.00
Trend							
1990 - 2021	*1461.0%*	*1308.4%*	*139.5%*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*469.0%*	*310.8%*	*139.5%*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*11.9%*	*13.1%*	*9.6%*	*NA*	*NA*	*NA*	*9.8%*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic meters. To convert these data to energy units, in

this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in sub-category 1.A.2.e Food Processing, Beverages and Tobacco.

Table 141 Net calorific values (NCVs) applied for conversion to energy units in sub-category 1.A.2. e Food Processing, Beverages and Tobacco

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg) or *(TJ/m3)		Source
		NCV	type	
Gas/Diesel Oil	liquid	42.71	CS	Statistical Office of Montenegro (MONSTAT)
Residual fuel oil	liquid	41.20	CS	
Liquefied Petroleum Gases (LPG)	liquid	46.89	CS	
Petroleum Coke	liquid	40.19	CS	
Sub-Bituminous Coal	solid	16.75	CS	
Lignite	solid	9.21	CS	
Charcoal	biomass	29.30	CS	
Wood / Fuelwood	biomass	9.18*	CS	
Wood pellets	biomass	16.85	CS	
Note: D Default CS Country specific PS Plant specific				

3.2.6.5.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 142 GHG Emission factor TIER 1 for IPCC sub-category 1.A.2 Manufacturing Industries and Construction

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source
		EF	type	EF	type	EF	type	2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)
Gas/Diesel Oil	liquid	74 100	D	3	D	0.6	D	**Table 2.3** Default emission factors for stationary combustion in manufacturing industries and construction (page 2.18)
Residual Fuel Oil / Total fuel oil	liquid	77 400	D	3	D	0.6	D	
Lignite	solid	101 000	D	10	D	1.5	D	
LPG	gaseous	63 100	D	1	D	0.1	D	
Natural gas	gaseous	56 100	D	1	D	0.1	D	
Wood pellets	biomass	112 000	D	30	D	4	D	
Note: D Default CS Country specific PS Plant specific IEF Implied emission factor								

3.2.6.5.3 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- consistent use of energy balance data (energy statistic questionnaires),
- documented sources,
- use of units,
- strictly defined interfaces between spreadsheets/calculation modules,

- o unique structure of sheets which do the same,
- o record keeping, use of write protection,
- o unique use of formulas, special cases are documented/highlighted,
- o quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic, Eurostat and international energy statistics of UN

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.6.5.4 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission and relevant to sub-category 1.A.2.e Food Processing, Beverages and Tobacco.

Table 143 Recalculations done in sub-category 1.A.2.e Food Processing, Beverages and Tobacco

source category	Revisions of data	Type of revision	Type of improvement
1.A.2.e	Revision of NCV		

3.2.6.5.5 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 144 Planned improvements for sub-category 1.A.2.e Food Processing, Beverages and Tobacco

source category	Planned improvement	Type of improvement		Priority
1.A.2.e	Carbon content (%) of lignite, gas/diesel oil, residual fuel oil, etc. for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{CO2}$** [t/TJ] = (C [%] • 44 • Ox)/(NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	Medium
1.A.2.e	Information about fitted/non-fitted equipment for flue gas cleaning, improvement in combustion	EF	Accuracy Transparency	Medium
1.A.2.e	Improvement of time series consistency and split of fuels: the energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire time series. Emissions are allocated in IPCC/NFR subcategory 1.A.2.m Other.	AD	Accuracy Transparency	High
1.A.2.e	Cross-check of national and international data sources (Eurostat and UNSD)	AD	Consistency Transparency	Medium

3.2.6.6 Non-Metallic Minerals (IPCC category 1.A.2.f)

The IPCC category 1.A.2.f *Non-metallic minerals* includes GHG emissions resulting from fuel combustion activities in

Activities	Occurring in Montenegro
▪ ISIC Divisions 23 Manufacture of other non-metallic mineral products	
o Manufacture of glass and glass products	-
o Manufacture of non-metallic mineral products n.e.c.	
▪ Manufacture of refractory products. Manufacture of clay building materials	✓
▪ Manufacture of other porcelain and ceramic products	-
▪ Manufacture of • cement, • lime, limestone • plaster	 - ✓ -
▪ Manufacture of articles of concrete, cement and plaster	✓
▪ Cutting, shaping and finishing of stone	✓
▪ Manufacture of other non-metallic mineral products n.e.c.	✓

3.2.6.6.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.f	✓*	✓*	NO	NO	NO	✓	✓*	✓*	NO	NO	NO	✓	✓*	✓*	NO	NO	NO	✓
Key category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

A '✓' indicates: emissions from this sub-category have been estimated.
Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF

* data provided only in the period 2004 – 2008 and after 2012, all other years IE

<u>Use of notation key</u>

IE	1.A.2.e (liquid, solid)	The energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire timeseries. Emissions are currently allocated in IPCC subcategory 1.A.2.m *Other*.

An overview of the emissions from fuel combustion in IPCC sub-category *1.A.2.e Food Processing, Beverages and Tobacco* is provided in the following figures and tables:

- annual emissions of GHGs;
- Trend of the periods 1990 – 2020, 2005 – 2021, 2020 – 2021.

The main fuels used in 1.A.2.e were liquid fuel, such as gas/diesel oil and fuel oil.

In the last decade the GHG emissions increased due to increased processing of food and beverages. Whereas until 2005 the main fuel used was lignite which come from the Pljevija basin, the fuel mix changed to liquid fuel, such as gas/diesel oil and fuel oil.

The lime production stopped in 2008, thus no big amounts of lignite was needed anymore.

For 1990-2005 and 2009-2012, the emissions from solid and liquid fuels combusted in IPCC category 1.A.2.f Non-Metallic Minerals is included in IPCC subcategory 1.A.2.m Other.

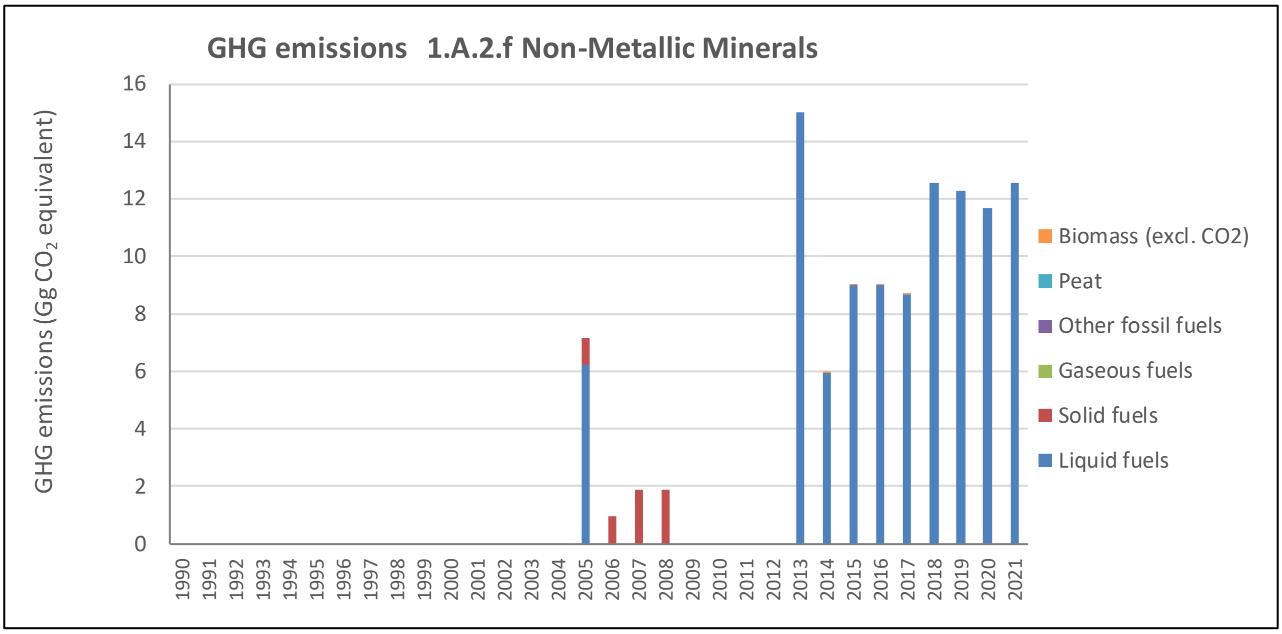


Figure 78: GHG Emissions from sub-category 1.A.2.f Non-Metallic Minerals

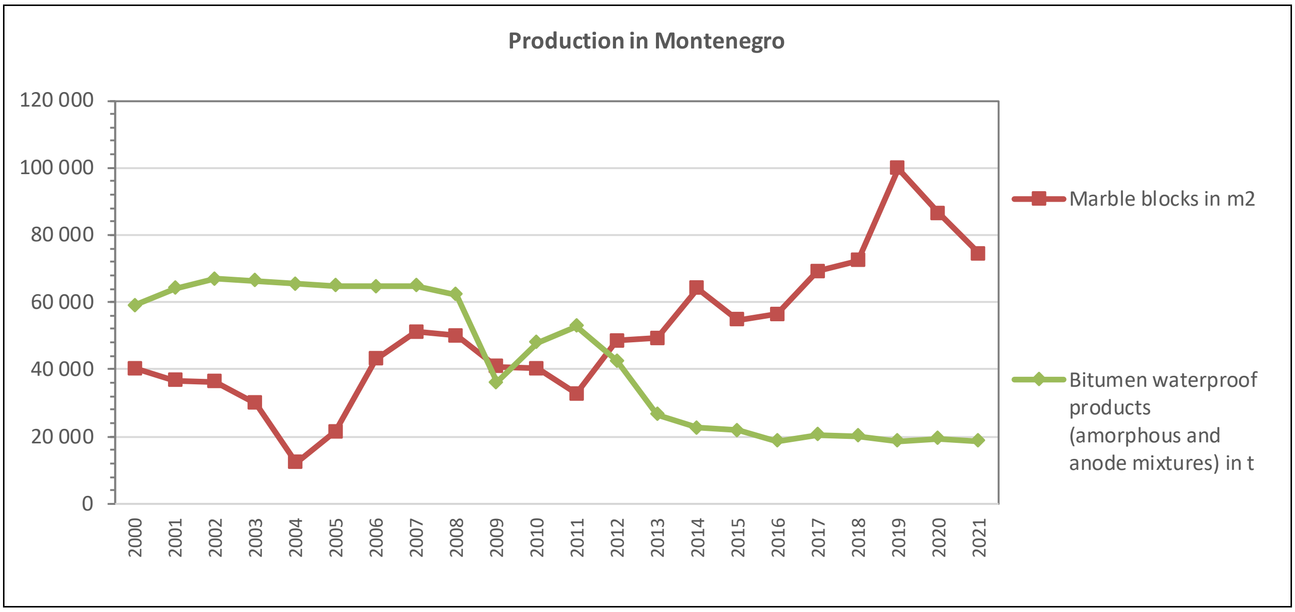


Figure 79 Main products in category 1.A.2.f Non-Metallic Minerals in the period 2000-2021; Source: MONSTAT

Table 145 Emissions from IPCC sub-category 1.A.2.f Non-Metallic Minerals

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	kt CO2 equivalent	kt	kt CO2 equivalent	kt CO2 equivalent	kt
1990	IE	IE	IE	IE	NO
1991	IE	IE	IE	IE	NO
1992	IE	IE	IE	IE	NO
1993	IE	IE	IE	IE	NO
1994	IE	IE	IE	IE	NO
1995	IE	IE	IE	IE	NO
1996	IE	IE	IE	IE	NO
1997	IE	IE	IE	IE	NO
1998	IE	IE	IE	IE	NO
1999	IE	IE	IE	IE	NO
2000	IE	IE	IE	IE	NO
2001	IE	IE	IE	IE	NO
2002	IE	IE	IE	IE	NO
2003	IE	IE	IE	IE	NO
2004	IE	IE	IE	IE	NO
2005	7.18	7.15	0.018	0.008	NO
2006	0.94	0.93	0.004	0.002	NO
2007	1.87	1.86	0.008	0.005	NO
2008	1.87	1.86	0.008	0.005	NO
2009	IE	IE	IE	IE	NO
2010	IE	IE	IE	IE	NO
2011	IE	IE	IE	IE	NO
2012	IE	IE	IE	IE	NO
2013	15.00	14.95	0.038	0.016	NO
2014	5.94	5.92	0.015	0.006	0.0008
2015	9.01	8.97	0.023	0.010	0.0009
2016	9.01	8.97	0.023	0.010	0.0009
2017	8.68	8.65	0.022	0.009	0.0001
2018	12.57	12.52	0.032	0.013	NO
2019	12.27	12.23	0.031	0.013	NO
2020	11.67	11.63	0.030	0.012	NO
2021	12.57	12.52	0.032	0.013	
Trend					
1990 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*75.1%*	*75.1%*	*72.0%*	*60.1%*	*NA*
2020 - 2021	*7.7%*	*7.7%*	*7.7%*	*7.7%*	*NA*

3.2.6.6.2 Methodological issues

3.2.6.6.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[56] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}}$$

Where:

Emissions $_{GHG,\ fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG,\ fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ) For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, solid fuels, gaseous fuels, other fossil fuel, biomass, peat

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG} = \sum_{fuel} emissions_{GHG,\,fuel}}$$

3.2.6.6.2.2 Choice of activity data

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 - 2021 were taken from Statistical Office of Montenegro (MONSTAT).

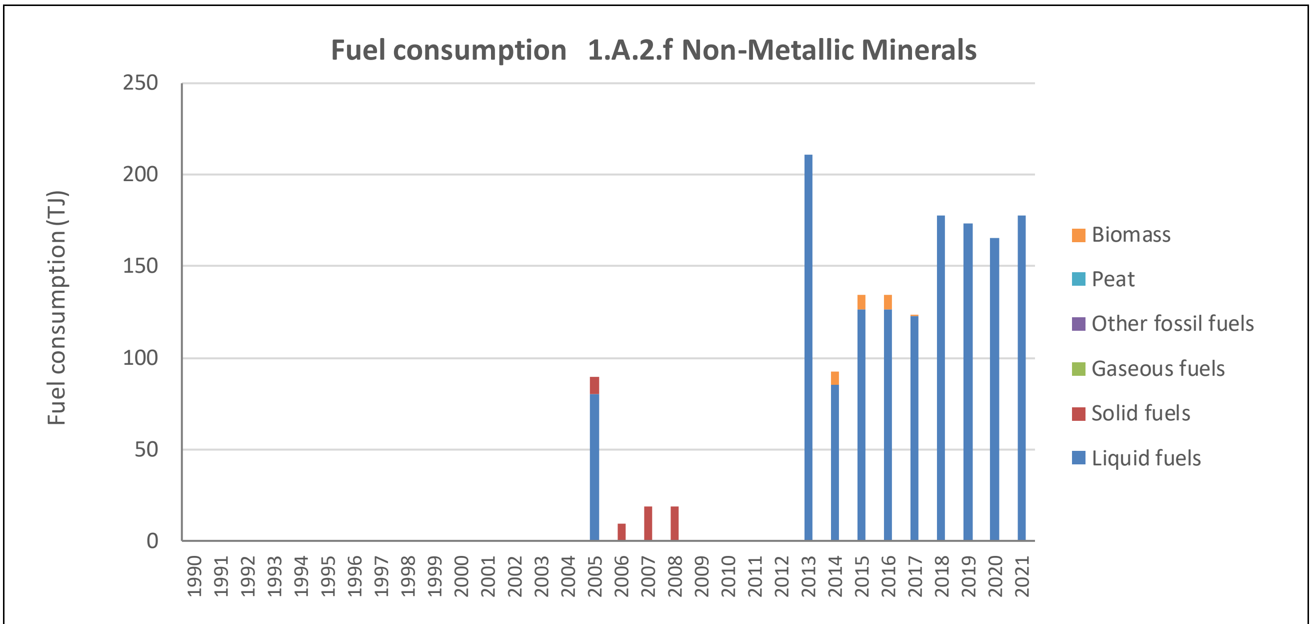


Figure 80 Activity data for sub-category 1.A.2.f Non-Metallic Minerals

Use of notation key

IE	1.A.2.e (liquid, solid)	The energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire timeseries. Emissions are currently allocated in IPCC subcategory 1.A.2.m *Other*.

[56] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method

Table 146 Activity data for sub-category 1.A.2.f Non-Metallic Minerals

Activity data 1.A.1.f	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	IE	IE	IE	NO	NO	NO	NO
1991	IE	IE	IE	NO	NO	NO	NO
1992	IE	IE	IE	NO	NO	NO	NO
1993	IE	IE	IE	NO	NO	NO	NO
1994	IE	IE	IE	NO	NO	NO	NO
1995	IE	IE	IE	NO	NO	NO	NO
1996	IE	IE	IE	NO	NO	NO	NO
1997	IE	IE	IE	NO	NO	NO	NO
1998	IE	IE	IE	NO	NO	NO	NO
1999	IE	IE	IE	NO	NO	NO	NO
2000	IE	IE	IE	NO	NO	NO	NO
2001	IE	IE	IE	NO	NO	NO	NO
2002	IE	IE	IE	NO	NO	NO	NO
2003	IE	IE	IE	NO	NO	NO	NO
2004	IE	IE	IE	NO	NO	NO	NO
2005	89.59	80.38	9.21	NO	NO	NO	NO
2006	9.21	IE	9.21	NO	NO	NO	NO
2007	18.42	IE	18.42	NO	NO	NO	NO
2008	18.42	IE	18.42	NO	NO	NO	NO
2009	IE	IE	NO	NO	NO	NO	NO
2010	IE	IE	NO	NO	NO	NO	NO
2011	IE	IE	NO	NO	NO	NO	NO
2012	IE	IE	NO	NO	NO	NO	NO
2013	211.03	211.03	NO	NO	NO	NO	NO
2014	92.42	85.42	NO	NO	NO	NO	7.00
2015	134.62	126.62	NO	NO	NO	NO	8.00
2016	134.62	126.62	NO	NO	NO	NO	8.00
2017	123.80	122.80	NO	NO	NO	NO	1.00
2018	177.87	177.87	NO	NO	NO	NO	NO
2019	173.60	173.60	NO	NO	NO	NO	NO
2020	165.21	165.21	NO	NO	NO	NO	NO
2021	177.87	177.87	NO	NO	NO	NO	NO
Trend							
1990 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*98.5%*	*121.3%*	*NA*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*7.7%*	*7.7%*	*NA*	*NA*	*NA*	*NA*	*NA*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic meters. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in sub-category 1.A.2.f Non-Metallic Minerals.

Table 147 Net calorific values (NCVs) applied for conversion to energy units in sub-category 1.A.2.f Non-Metallic Minerals

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg) or *(TJ/m3)		Source
		NCV	type	
Gas/Diesel Oil	liquid	42.71	CS	Statistical Office of Montenegro (MONSTAT)
Residual fuel oil	liquid	41.20	CS	
Liquefied Petroleum Gases (LPG)	liquid	46.89	CS	
Petroleum Coke	liquid	40.19	CS	
Sub-Bituminous Coal	solid	16.75	CS	
Lignite	solid	9.21	CS	
Charcoal	biomass	29.30	CS	
Wood / Fuelwood	biomass	9.18*	CS	
Wood pellets	biomass	16.85	CS	

Note:
D Default CS Country specific PS Plant specific

3.2.6.6.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 148 GHG Emission factor TIER 1 for IPCC sub-category 1.A.2.f Non-Metallic Minerals

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source: 2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)
		EF	type	EF	type	EF	type	
Gas/Diesel Oil	liquid	74 100	D	3	D	0.6	D	**Table 2.3** Default emission factors for stationary combustion in manufacturing industries and construction (page 2.18)
Residual Fuel Oil / Total fuel oil	liquid	77 400	D	3	D	0.6	D	
Lignite	solid	101 000	D	10	D	1.5	D	
LPG	gaseous	63 100	D	1	D	0.1	D	
Natural gas	gaseous	56 100	D	1	D	0.1	D	
Wood pellets	biomass	112 000	D	30	D	4	D	

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

3.2.6.6.3 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- consistent use of energy balance data (energy statistic questionnaires),
- documented sources,
- use of units,
- strictly defined interfaces between spreadsheets/calculation modules,
- unique structure of sheets which do the same,

  - o record keeping, use of write protection,
  - o unique use of formulas, special cases are documented/highlighted,
  - o quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic, Eurostat and international energy statistics of UN

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.6.6.4 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission and relevant to sub-category 1.A.2.f Non-Metallic Minerals.

Table 149 Recalculations done in sub-category 1.A.2.f Non-Metallic Minerals

source category	Revisions of data	Type of revision	Type of improvement
1.A.2.e	Revision of NCV		

3.2.6.6.5 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 150 Planned improvements for IPCC sub-category 1.A.2.f Non-Metallic Minerals

source category	Planned improvement	Type of improvement		Priority
1.A.2.e	Carbon content (%) of lignite, gas/diesel oil, residual fuel oil, etc. for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{CO2}$** [t/TJ] = (C [%] • 44 • Ox)/(NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	Medium
1.A.2.e	Information about fitted/non-fitted equipment for flue gas cleaning, improvement in combustion	EF	Accuracy Transparency	Medium
1.A.2.e	Improvement of time series consistency and split of fuels: the energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire time series. Emissions are allocated in IPCC/NFR subcategory 1.A.2.m Other.	AD	Accuracy Transparency	High
1.A.2.e	Cross-check of national and international data sources (Eurostat and UNSD)	AD	Consistency Transparency	Medium

3.2.6.7 Manufacturing of transport equipment (IPCC category 1.A.2.g)

The IPCC category 1.A.2.g *Manufacturing of transport equipment* includes GHG emissions resulting from fuel combustion activities in

Activities	Occurring in Montenegro

▪ ISIC Division 29 Manufacture of motor vehicles, trailers and semi-trailers.	-
▪ ISIC Division 30 Manufacture of other transport equipment	-

3.2.6.7.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.g	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF																		

The IPCC category 1.A.2.g Manufacturing of transport equipment does not exist in Montenegro.

3.2.6.7.2 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 151 Planned improvements for IPCC sub-category 1.A.2.g Manufacturing of transport equipment

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.2.g	Analysis of Manufacturing of transport equipment • annual quantities of product produced • annual consumption of fuel by type • annual electricity consumption	AD	Accuracy Transparency Completeness	high

3.2.6.8 Manufacturing of machinery (IPCC category 1.A.2.h)

The IPCC category 1.A.2.h *Manufacturing of machinery* includes GHG emissions resulting from fuel combustion activities in

Activities	Occurring in Montenegro
▪ ISIC Division 25 Manufacture of fabricated metal products, except machinery and equipment	
o Manufacture of structural metal products, tanks, reservoirs and steam generators	-
o Manufacture of weapons and ammunition	✓
o Manufacture of other fabricated metal products; metalworking service activities	✓
▪ ISIC Division 26 Manufacture of computer, electronic and optical products	
o Manufacture of electronic components and boards	-
o Manufacture of computers and peripheral equipment	-
o Manufacture of communication equipment	-
o Manufacture of consumer electronics	-
o Manufacture of measuring, testing, navigating and control equipment; watches and clocks	-

o Manufacture of irradiation, electromedical and electrotherapeutic equipment	-
o Manufacture of optical instruments and photographic equipment	-
o Manufacture of magnetic and optical media	-
▪ ISIC Division 27 Manufacture of electrical equipment	
o Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus	-
o Manufacture of batteries and accumulators	-
o Manufacture of wiring and wiring devices	-
o Manufacture of electric lighting equipment	-
o Manufacture of domestic appliances	✓
o Manufacture of other electrical equipment	-
▪ ISIC Division 28 Manufacture of machinery and equipment n.e.c.	
o Manufacture of general-purpose machinery	✓
o Manufacture of special-purpose machinery	✓

3.2.6.8.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.h	✓	✓	NO	NO	NO	✓	✓	✓	NO	NO	NO	✓	✓	✓	NO	NO	NO	✓
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF																		

An overview of the emissions from fuel combustion in IPCC sub-category *1.A.2.e Manufacturing of machinery* is provided in the following figures and tables:

- annual emissions of GHGs;
- Trend of the periods 1990 – 2020, 2005 – 2021, 2020 – 2021.

The main fuels used in 1.A.2.e were

- liquid fuels, such as gas/diesel oil and fuel oil,
- solid fuels, here lignite which come from the Pljevija basin,
- biomass.

GHG emissions fluctuating due to the various activities as listed above.

For the period 1990-2013 the emissions from this sub-category are included in 1.A.2.m Other.

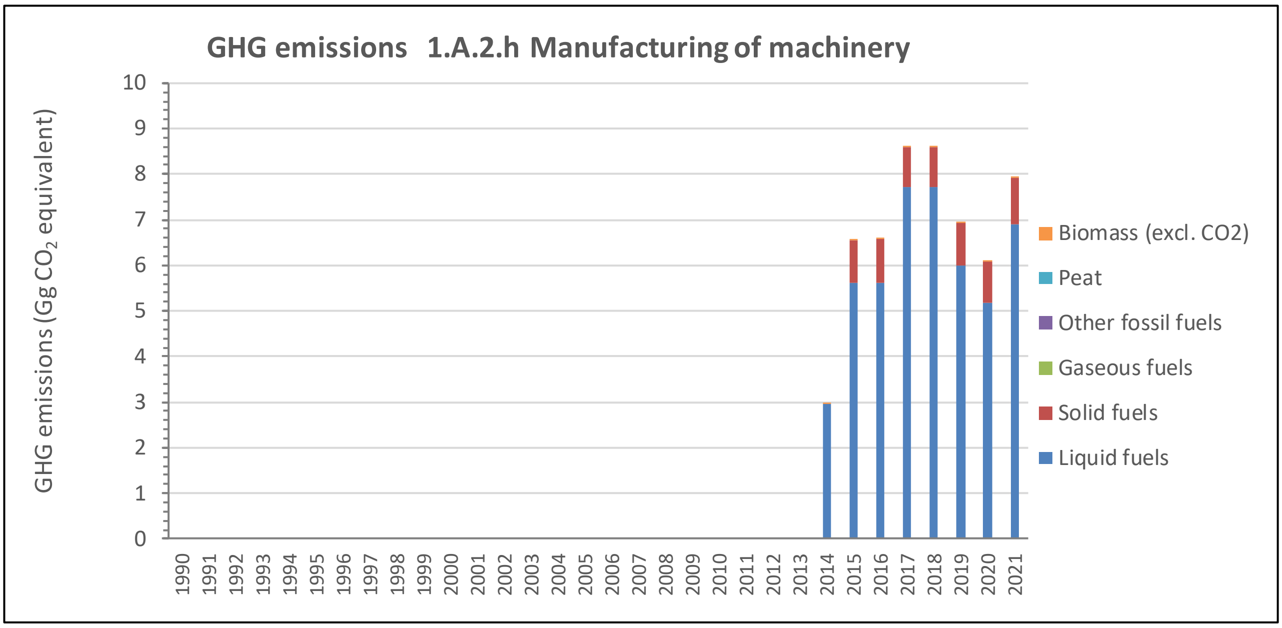


Figure 81: GHG Emissions from sub-category 1.A.2.h Manufacturing of machinery

Table 152 Emissions from IPCC sub-category 1.A.2. h Manufacturing of machinery

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	kt CO2 equivalent	kt	kt CO2 equivalent	kt CO2 equivalent	kt
1990	IE	IE	IE	IE	NO
1991	IE	IE	IE	IE	NO
1992	IE	IE	IE	IE	NO
1993	IE	IE	IE	IE	NO
1994	IE	IE	IE	IE	NO
1995	IE	IE	IE	IE	NO
1996	IE	IE	IE	IE	NO
1997	IE	IE	IE	IE	NO
1998	IE	IE	IE	IE	NO
1999	IE	IE	IE	IE	NO
2000	IE	IE	IE	IE	NO
2001	IE	IE	IE	IE	NO
2002	IE	IE	IE	IE	NO
2003	IE	IE	IE	IE	NO
2004	IE	IE	IE	IE	NO
2005	IE	IE	IE	IE	NO
2006	IE	IE	IE	IE	NO
2007	IE	IE	IE	IE	NO
2008	IE	IE	IE	IE	NO
2009	IE	IE	IE	IE	NO

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	kt CO2 equivalent	kt	kt CO2 equivalent	kt CO2 equivalent	kt
2010	IE	IE	IE	IE	NO
2011	IE	IE	IE	IE	NO
2012	IE	IE	IE	IE	NO
2013	IE	IE	IE	IE	NO
2014	2.973	2.960	0.0076	0.0032	0.0021
2015	6.543	6.521	0.0132	0.0067	0.0024
2016	6.570	6.548	0.0133	0.0068	0.0021
2017	8.593	8.564	0.0181	0.0087	0.0021
2018	8.591	8.562	0.0181	0.0087	0.0021
2019	6.943	6.919	0.0151	0.0074	0.0020
2020	6.095	6.073	0.0140	0.0068	0.0015
2021	7.918	7.890	0.0177	0.0085	0.0016
Trend					
1990 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*29.9%*	*29.9%*	*26.8%*	*25.8%*	*7.7%*

3.2.6.8.2 Methodological issues

3.2.6.8.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[57] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}}$$

Where:

Emissions $_{GHG,\ fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG,\ fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ) For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, solid fuels, gaseous fuels, other fossil fuel, biomass, peat

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG} = \sum_{fuel} emissions_{GHG,\,fuel}}$$

3.2.6.8.2.2 Choice of activity data

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 - 2021 were taken from Statistical Office of Montenegro (MONSTAT).

[57] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method

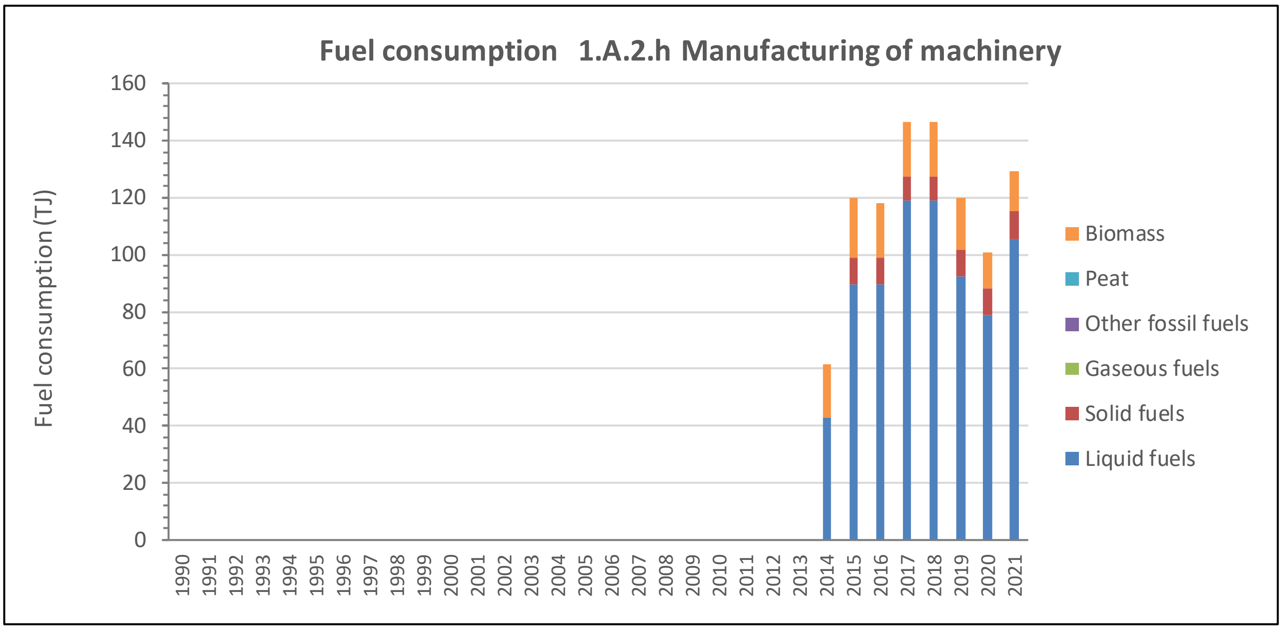


Figure 82 Activity data for sub-category 1.A.2.h Manufacturing of machinery

Table 153 Activity data for sub-category 1.A.2.h Manufacturing of machinery

Activity data 1.A.1.e	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	IE	IE	IE	NO	NO	NO	NO
1991	IE	IE	IE	NO	NO	NO	NO
1992	IE	IE	IE	NO	NO	NO	NO
1993	IE	IE	IE	NO	NO	NO	NO
1994	IE	IE	IE	NO	NO	NO	NO
1995	IE	IE	IE	NO	NO	NO	NO
1996	IE	IE	IE	NO	NO	NO	NO
1997	IE	IE	IE	NO	NO	NO	NO
1998	IE	IE	IE	NO	NO	NO	NO
1999	IE	IE	IE	NO	NO	NO	NO
2000	IE	IE	IE	NO	NO	NO	NO
2001	IE	IE	IE	NO	NO	NO	NO
2002	IE	IE	IE	NO	NO	NO	NO
2003	IE	IE	IE	NO	NO	NO	NO
2004	IE	IE	IE	NO	NO	NO	NO
2005	IE	IE	IE	NO	NO	NO	NO
2006	IE	IE	IE	NO	NO	NO	NO
2007	IE	IE	IE	NO	NO	NO	NO
2008	IE	IE	IE	NO	NO	NO	NO
2009	IE	IE	IE	NO	NO	NO	NO
2010	IE	IE	IE	NO	NO	NO	NO
2011	IE	IE	IE	NO	NO	NO	NO
2012	IE	IE	IE	NO	NO	NO	NO
2013	IE	IE	IE	NO	NO	NO	NO

Activity data 1.A.1.e	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
2014	61.71	42.71	IE	NO	NO	NO	19.00
2015	119.81	89.60	9.21	NO	NO	NO	21.00
2016	118.08	89.60	9.48	NO	NO	NO	19.00
2017	146.45	118.89	8.56	NO	NO	NO	19.00
2018	146.43	118.89	8.54	NO	NO	NO	19.00
2019	119.87	92.58	9.29	NO	NO	NO	18.00
2020	100.99	78.93	9.05	NO	NO	NO	13.00
2021	129.27	105.24	10.03	NO	NO	NO	14.00
Trend							
1990 - 2021	NA	NA	NA	NA	NA	NA	NA
2005 - 2021	NA	NA	NA	NA	NA	NA	NA
2020 - 2021	28.0%	33.3%	10.7%	NA	NA	NA	7.7%

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic meters. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in sub-category 1.A.2.f Non-Metallic Minerals.

Table 154 Net calorific values (NCVs) applied for conversion to energy units in sub-category 1.A.2.h Manufacturing of Machinery

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg) or *(TJ/m3)		Source
		NCV	type	
Gas/Diesel Oil	liquid	42.71	CS	Statistical Office of Montenegro (MONSTAT)
Residual fuel oil	liquid	41.20	CS	
Liquefied Petroleum Gases (LPG)	liquid	46.89	CS	
Petroleum Coke	liquid	40.19	CS	
Sub-Bituminous Coal	solid	16.75	CS	
Lignite	solid	9.21	CS	
Charcoal	biomass	29.30	CS	
Wood / Fuelwood	biomass	9.18*	CS	
Wood pellets	biomass	16.85	CS	
Note:				
D Default	CS Country specific	PS Plant specific		

3.2.6.8.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 155 GHG Emission factor TIER 1 for IPCC sub-category 1.A.2 Manufacturing Industries and Construction

Fuel	Fuel type	CO_2 (kg/TJ)	CH_4 (kg/TJ)	N_2O (kg/TJ)	Source
					2006 IPCC Guidelines

		EF	type	EF	type	EF	type	Vol. 2, Chap. 2 (2.3.2.1)
Gas/Diesel Oil	liquid	74 100	D	3	D	0.6	D	**Table 2.3** Default emission factors for stationary combustion in manufacturing industries and construction (page 2.18)
Residual Fuel Oil / Total fuel oil	liquid	77 400	D	3	D	0.6	D	
Lignite	solid	101 000	D	10	D	1.5	D	
LPG	gaseous	63 100	D	1	D	0.1	D	
Natural gas	gaseous	56 100	D	1	D	0.1	D	
Wood pellets	biomass	112 000	D	30	D	4	D	
Note: D Default CS Country specific PS Plant specific IEF Implied emission factor								

3.2.6.8.3 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
  - consistent use of energy balance data (energy statistic questionnaires),
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic, Eurostat and international energy statistics of UN

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.6.8.4 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission and relevant to sub-category 1.A.2.f Non-Metallic Minerals.

Table 156 Recalculations done in sub-category 1.A.2.f Non-Metallic Minerals

source category	Revisions of data	Type of revision	Type of improvement
1.A.2.e	Revision of NCV		

3.2.6.8.5 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 157 Planned improvements for IPCC sub-category 1.A.2.f Non-Metallic Minerals

source category	Planned improvement	Type of improvement	Priority

source category	Planned improvement	Type of improvement		Priority
1.A.2.e	Carbon content (%) of lignite, gas/diesel oil, residual fuel oil, etc. for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{CO2}$** [t/TJ] = (C [%] • 44 • Ox)/(NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	Medium
1.A.2.e	Information about fitted/non-fitted equipment for flue gas cleaning, improvement in combustion	EF	Accuracy Transparency	Medium
1.A.2.e	Improvement of time series consistency and split of fuels: the energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire time series. Emissions are allocated in IPCC/NFR subcategory 1.A.2.m Other.	AD	Accuracy Transparency	High
1.A.2.e	Cross-check of national and international data sources (Eurostat and UNSD)	AD	Consistency Transparency	Medium

3.2.6.9 Mining (excluding fuels) and Quarrying (IPCC category 1.A.2.i)

The IPCC category 1.A.2.i *Mining (excluding fuels) and Quarrying* includes GHG emissions resulting from fuel combustion activities in

Activities	Occurring in Montenegro
▪ ISIC Division 07 Mining of metal ores (iron ores and non-ferrous metal ores),	-
▪ ISIC Division 08 Other mining and quarrying	
o Quarrying of stone, sand and clay	✓
o Mining and quarrying n.e.c.:	
▪ Mining of chemical and fertilizer minerals (Extraction of peat, salt)	✓
▪ Other mining and quarrying n.e.c..	✓
▪ ISIC Division 09 Mining support service activities	
o Support activities for petroleum and natural gas extraction	-
o Support activities for other mining and quarrying	✓

3.2.6.9.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.i	√*	NO	NO	NO	NO	NO	√*	NO	NO	NO	NO	NO	√*	NO	NO	NO	NO	NO
Key Category	LA 2021																	

A '✓' indicates: emissions from this sub-category have been estimated.
Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF

* for 2010 and 2011

Use of notation key

IE 1.A.2.i (liquid) The energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire timeseries. Emissions are currently allocated in IPCC subcategory 1.A.2.m *Other*.

An overview of the emissions from fuel combustion in IPCC sub-category *1.A.2.i Mining (excluding fuels) and Quarrying* is provided in the following figures and tables:

- annual emissions of GHGs;
- Trend of the periods 1990 – 2020, 2005 – 2021, 2020 – 2021.

The main fuels used in 1.A.2.i were liquid fuel, such as gas/diesel oil and fuel oil.

In the last decade, the GHG emissions increased due to increased red bauxite exploration and export.

For 1990-2007 and 2010-2011, the emissions from liquid fuels combusted in IPCC category 1.A.2.i Mining (excluding fuels) and Quarrying are included in IPCC subcategory 1.A.2.m Other.

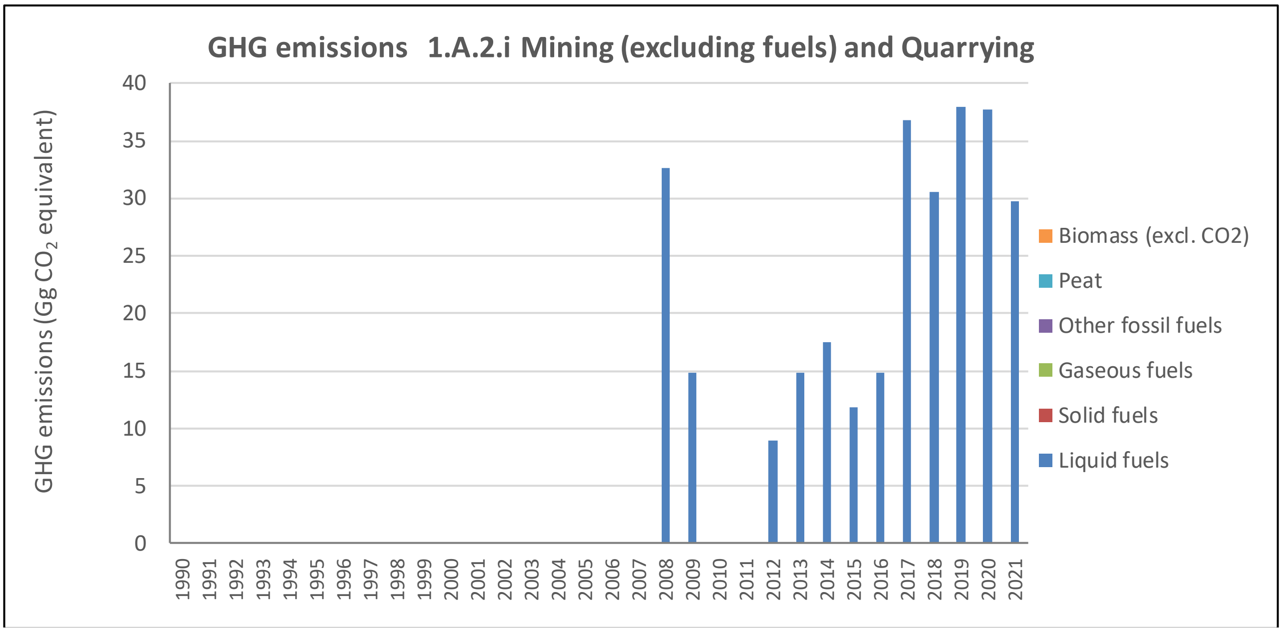


Figure 83 GHG Emissions from IPCC sub-category 1.A.2.i Mining and quarrying product: red bauxite, salt, marble, stucco, stone mortar, sand and gravel

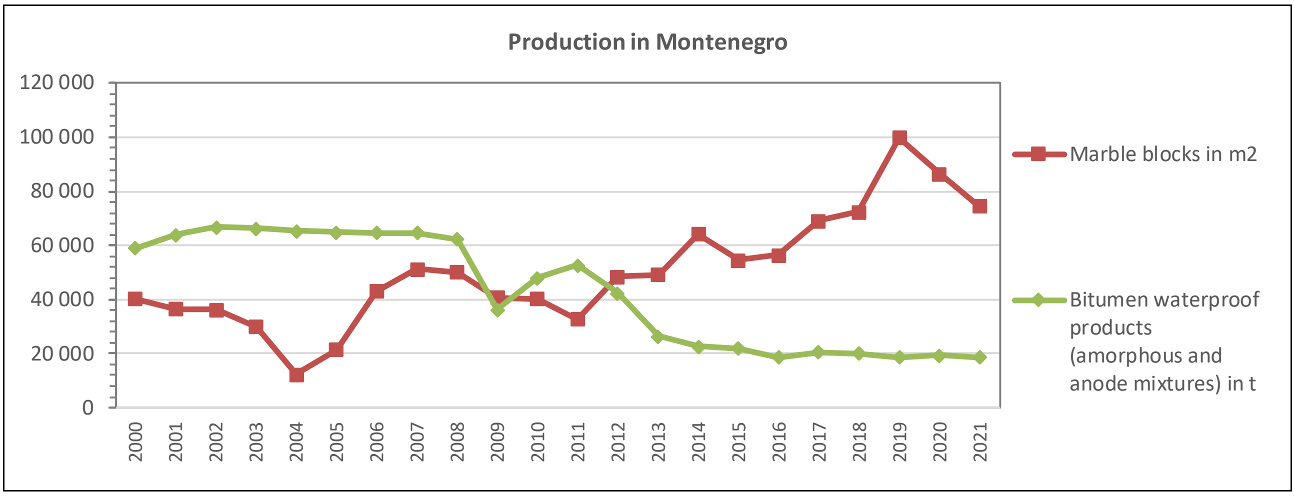


Figure 84 Main products in category 1.A.2.j Mining (excluding fuels) and Quarrying in the period 2000-2021; Source: MONSTAT

Table 158 GHG Emissions from IPCC sub-category 1.A.2.i Mining and quarrying products

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	kt CO2 equivalent	kt	kt CO2 equivalent	kt CO2 equivalent	kt
1990	IE	IE	IE	IE	NO
1991	IE	IE	IE	IE	NO
1992	IE	IE	IE	IE	NO
1993	IE	IE	IE	IE	NO
1994	IE	IE	IE	IE	NO
1995	IE	IE	IE	IE	NO
1996	IE	IE	IE	IE	NO
1997	IE	IE	IE	IE	NO
1998	IE	IE	IE	IE	NO
1999	IE	IE	IE	IE	NO
2000	IE	IE	IE	IE	NO
2001	IE	IE	IE	IE	NO
2002	IE	IE	IE	IE	NO
2003	IE	IE	IE	IE	NO
2004	IE	IE	IE	IE	NO
2005	IE	IE	IE	IE	NO
2006	IE	IE	IE	IE	NO
2007	IE	IE	IE	IE	NO
2008	32.68	32.56	0.084	0.035	NO
2009	14.85	14.80	0.038	0.016	NO
2010	IE	IE	IE	IE	NO
2011	IE	IE	IE	IE	NO
2012	8.91	8.88	0.023	0.010	NO
2013	14.85	14.80	0.038	0.016	NO
2014	17.49	17.43	0.040	0.017	NO
2015	11.88	11.84	0.031	0.013	NO
2016	14.85	14.80	0.038	0.016	NO
2017	36.84	36.70	0.095	0.040	NO
2018	30.60	30.49	0.079	0.033	NO
2019	38.02	37.89	0.098	0.041	NO
2020	37.73	37.59	0.097	0.041	NO
2021	29.71	29.60	0.076	0.032	NO
Trend					
1990 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*-21.3%*	*-21.3%*	*-21.3%*	*-21.3%*	*NA*

3.2.6.9.2 Methodological issues

3.2.6.9.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[58] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}$$

Where: Emissions $_{GHG,\,fuel}$ = emissions of a given GHG by type of fuel (kg GHG)

Fuel consumption $_{fuel}$ = amount of fuel combusted (TJ)

Emission factor $_{GHG,\,fuel}$ = default emission factor of a given GHG by type of fuel (kg gas/TJ) For CO_2, it includes the carbon oxidation factor, assumed to be 1.

GHG = CO_2, CH_4, N_2O

Fuel = liquid fuels, solid fuels, gaseous fuels, other fossil fuel, biomass, peat

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG} = \sum_{fuel} emissions_{GHG,\,fuel}$$

3.2.6.9.2.2 Choice of activity data

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 - 2021 were taken from Statistical Office of Montenegro (MONSTAT).

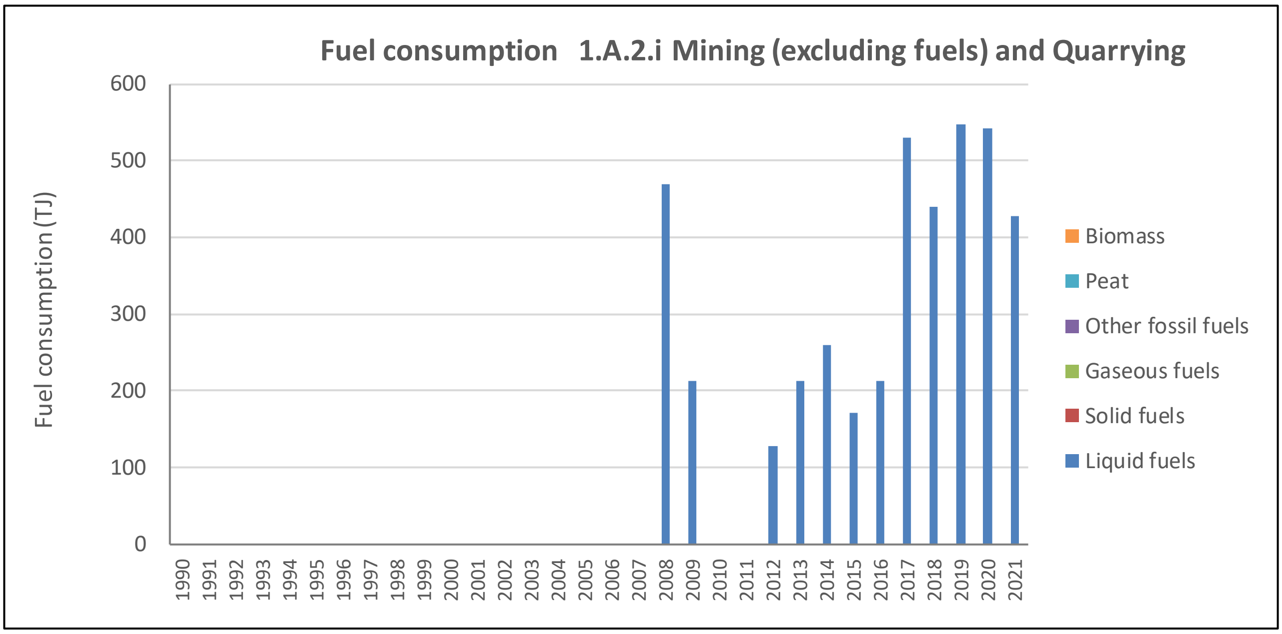


Figure 85: Activity data for sub-category 1.A.2.i Mining (excluding fuels) and Quarrying

<u>Use of notation key</u>

IE 1.A.2.i (liquid) The energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire timeseries. Emissions are currently allocated in IPCC subcategory 1.A.2.m *Other*.

[58] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method

Table 159: Activity data for sub-category 1.A.2.i Mining (excluding fuels) and Quarrying

Activity data 1.A.2.i	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	IE	IE	NO	NO	NO	NO	NO
1991	IE	IE	NO	NO	NO	NO	NO
1992	IE	IE	NO	NO	NO	NO	NO
1993	IE	IE	NO	NO	NO	NO	NO
1994	IE	IE	NO	NO	NO	NO	NO
1995	IE	IE	NO	NO	NO	NO	NO
1996	IE	IE	NO	NO	NO	NO	NO
1997	IE	IE	NO	NO	NO	NO	NO
1998	IE	IE	NO	NO	NO	NO	NO
1999	IE	IE	NO	NO	NO	NO	NO
2000	IE	IE	NO	NO	NO	NO	NO
2001	IE	IE	NO	NO	NO	NO	NO
2002	IE	IE	NO	NO	NO	NO	NO
2003	IE	IE	NO	NO	NO	NO	NO
2004	IE	IE	NO	NO	NO	NO	NO
2005	IE	IE	NO	NO	NO	NO	NO
2006	IE	IE	NO	NO	NO	NO	NO
2007	IE	IE	NO	NO	NO	NO	NO
2008	469.81	469.81	NO	NO	NO	NO	NO
2009	213.55	213.55	NO	NO	NO	NO	NO
2010	IE	IE	NO	NO	NO	NO	NO
2011	IE	IE	NO	NO	NO	NO	NO
2012	128.13	128.13	NO	NO	NO	NO	NO
2013	213.55	213.55	NO	NO	NO	NO	NO
2014	260.44	260.44	NO	NO	NO	NO	NO
2015	170.84	170.84	NO	NO	NO	NO	NO
2016	213.55	213.55	NO	NO	NO	NO	NO
2017	529.60	529.60	NO	NO	NO	NO	NO
2018	439.91	439.91	NO	NO	NO	NO	NO
2019	546.69	546.69	NO	NO	NO	NO	NO
2020	542.42	542.42	NO	NO	NO	NO	NO
2021	427.10	427.10	NO	NO	NO	NO	NO
Trend							
1990 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*-21.3%*	*-21.3%*	*NA*	*NA*	*NA*	*NA*	*NA*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic meters. To convert these data to energy units, in

this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in sub-category 1.A.2.i Mining (excluding fuels) and Quarrying.

Table 160 Net calorific values (NCVs) applied for conversion to energy units in sub-category 1.A.2.i Mining (excluding fuels) and Quarrying

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg) or *(TJ/m3)		Source
		NCV	type	
Gas/Diesel Oil	liquid	42.71	CS	Statistical Office of Montenegro (MONSTAT)
Residual fuel oil	liquid	41.20	CS	
Liquefied Petroleum Gases (LPG)	liquid	46.89	CS	
Petroleum Coke	liquid	40.19	CS	
Sub-Bituminous Coal	solid	16.75	CS	
Lignite	solid	9.21	CS	
Charcoal	biomass	29.30	CS	
Wood / Fuelwood	biomass	9.18*	CS	
Wood pellets	biomass	16.85	CS	

Note:
D Default CS Country specific PS Plant specific

3.2.6.9.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 161 GHG Emission factor TIER 1 for IPCC sub-category 1.A.2 Manufacturing Industries and Construction

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source
		EF	type	EF	type	EF	type	2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)
Gas/Diesel Oil	liquid	74 100	D	3	D	0.6	D	**Table 2.3** Default emission factors for stationary combustion in manufacturing industries and construction (page 2.18)
Residual Fuel Oil / Total fuel oil	liquid	77 400	D	3	D	0.6	D	
Lignite	solid	101 000	D	10	D	1.5	D	
LPG	gaseous	63 100	D	1	D	0.1	D	
Natural gas	gaseous	56 100	D	1	D	0.1	D	
Wood pellets	biomass	112 000	D	30	D	4	D	

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

3.2.6.9.3 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- consistent use of energy balance data (energy statistic questionnaires),
- documented sources,
- use of units,
- strictly defined interfaces between spreadsheets/calculation modules,

  - o unique structure of sheets which do the same,
  - o record keeping, use of write protection,
  - o unique use of formulas, special cases are documented/highlighted,
  - o quick-control checks for data consistency through all steps of calculation.
- ⇒ cross-checked from two sources: national statistic, Eurostat and international energy statistics of UN
- ⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;
- ⇒ time series consistency - plausibility checks of dips and jumps.

3.2.6.9.4 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission and relevant to sub-category 1.A.2.i Mining (excluding fuels) and Quarrying.

Table 162 Recalculations done in sub-category 1.A.2.i Mining (excluding fuels) and Quarrying

source category	Revisions of data	Type of revision	Type of improvement
1.A.2.i	Revision of NCV	AD	Consistency

3.2.6.9.5 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 163 Planned improvements for IPCC sub-category 1.A.2.i Mining (excluding fuels) and Quarrying

source category	Planned improvement	Type of improvement		Priority
1.A.2.i	Carbon content (%) of lignite, gas/diesel oil, residual fuel oil, etc. for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{CO2}$** [t/TJ] = (C [%] • 44 • Ox)/(NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	Medium
1.A.2.i	Improvement of time series consistency and split of fuels: the energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire time series. Emissions are allocated in IPCC/NFR subcategory 1.A.2.m Other.	AD	Accuracy Transparency	High
1.A.2.i	Cross-check of national and international data sources (Eurostat and UNSD)	AD	Consistency Transparency	Medium

3.2.6.10 Wood and wood products (IPCC category 1.A.2.j)

The IPCC category 1.A.2.j *Wood and wood products* includes GHG emissions resulting from fuel combustion activities in

Activities	Occurring in Montenegro

▪ ISIC Division 16 Manufacture of wood and of products of wood and cork (except furniture), and manufacture of articles of straw and plaiting materials	
▪ Sawmilling and planing of wood	✓
▪ Manufacture of products of wood, cork, straw and plaiting materials	✓
o Manufacture of veneer sheets and wood-based panels	
▪ Manufacture of builders' carpentry and joinery	✓
▪ Manufacture of wooden containers	✓
▪ Manufacture of other products of wood; manufacture of articles of cork, straw and plaiting materials Quarrying	✓

3.2.6.10.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.j	√*	√*	NO	NO	NO	√**	√*	√*	NO	NO	NO	√**	√*	√*	NO	NO	NO	√**
Key category	LA 2021	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF																		
* data provided only from 2006 onwards; ** data provided only from 2011 onwards																		

Use of notation key

IE	1.A.2.j (liquid, solid, biomass)	The energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire timeseries. Emissions are currently allocated in IPCC subcategory 1.A.2.m *Other*.

An overview of the emissions from fuel combustion in IPCC sub-category *1.A.2.j Wood and wood products* is provided in the following figures and tables:

- annual emissions of GHGs;
- Trend of the periods 1990 – 2020, 2005 – 2021, 2020 – 2021.

The main fuels used in 1.A.2.j were liquid fuel, such as gas/diesel oil and fuel oil.

In the last decade, the GHG emissions increased due to increased wood and wood products such as Spruce and fir lumber, beech lumber, balcony doors and other doors.

For 1990-2005, the emissions from liquid fuels combusted in IPCC category 1.A.2.j are included in IPCC subcategory 1.A.2.m Other.

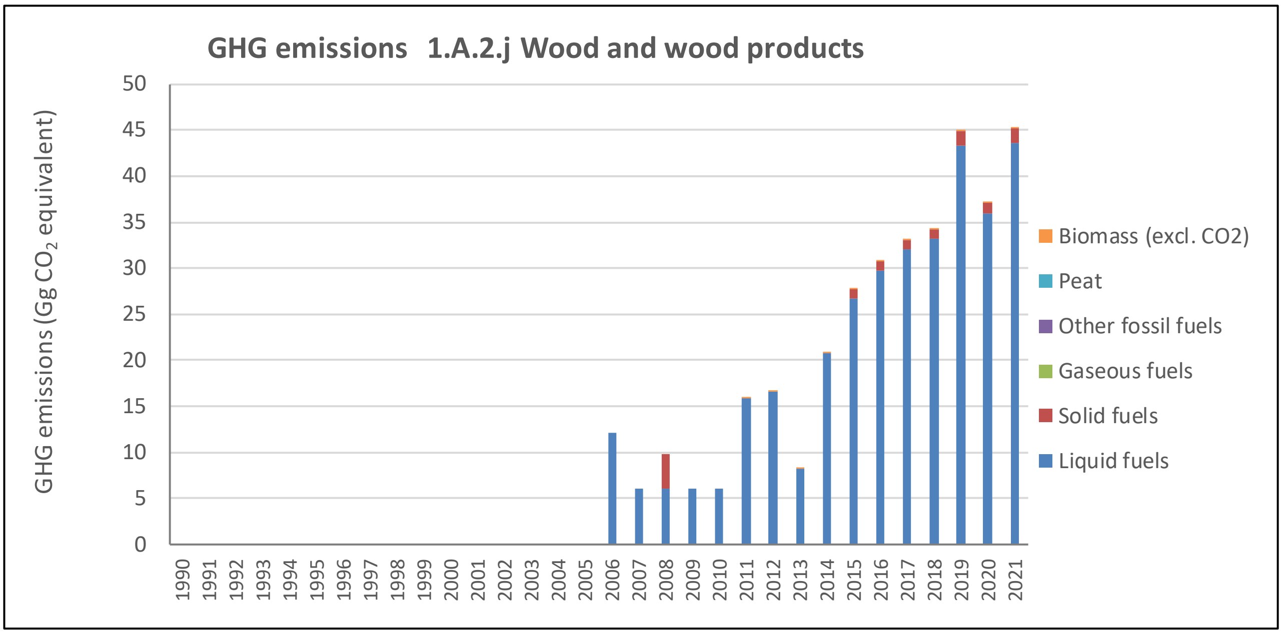


Figure 86 GHG emissions from sub-category 1.A.2.j Wood and wood products

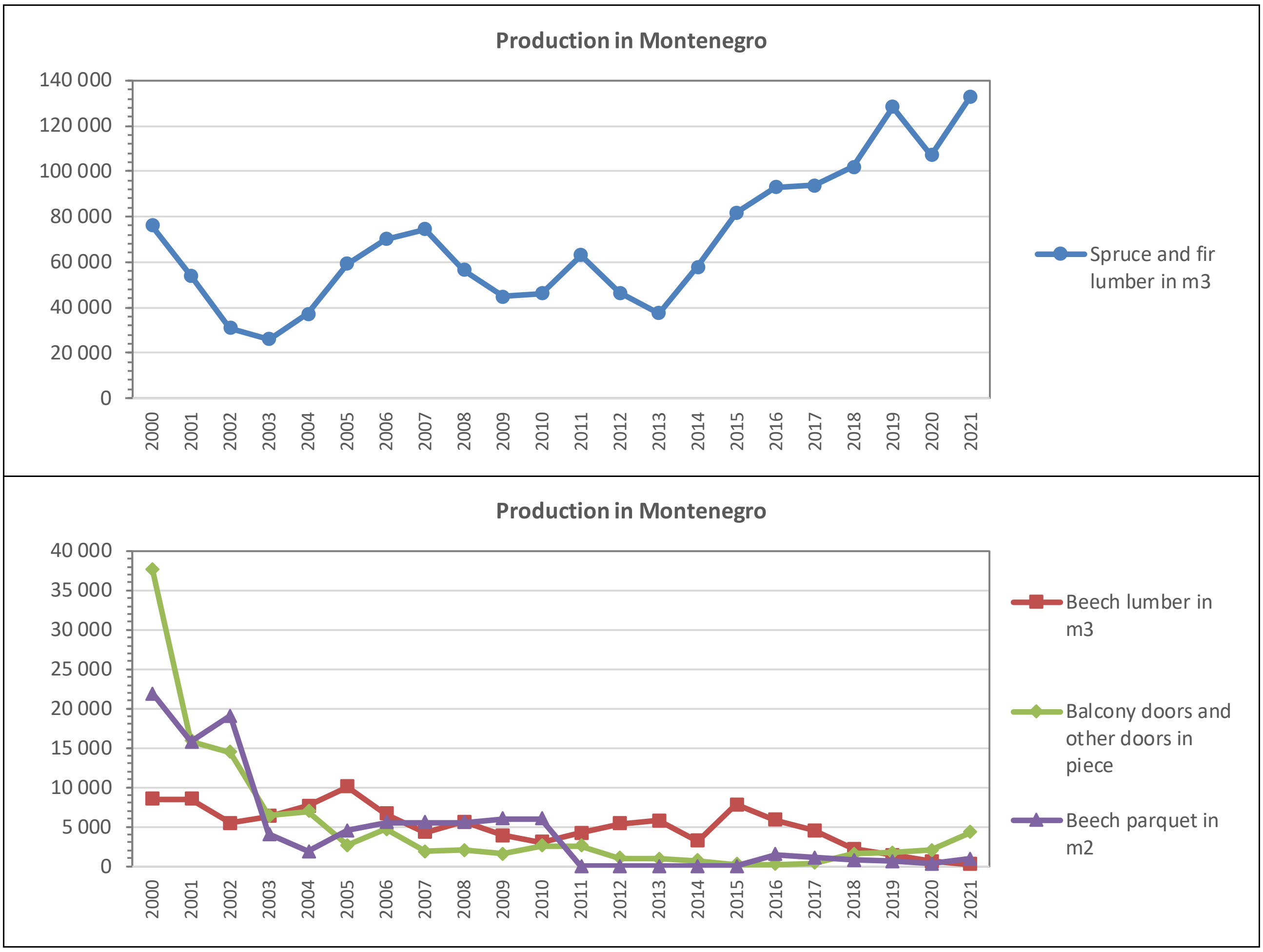


Figure 87 Main products in category 1.A.2.j Wood and wood products in the period 2000-2021; Source: MONSTAT

Table 164 Emissions from IPCC sub-category 1.A.2.j Wood and wood products

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	kt CO2 equivalent	kt	kt CO2 equivalent	kt CO2 equivalent	kt
1990	IE	IE	IE	IE	IE
1991	IE	IE	IE	IE	IE
1992	IE	IE	IE	IE	IE
1993	IE	IE	IE	IE	IE
1994	IE	IE	IE	IE	IE
1995	IE	IE	IE	IE	IE
1996	IE	IE	IE	IE	IE
1997	IE	IE	IE	IE	IE
1998	IE	IE	IE	IE	IE
1999	IE	IE	IE	IE	IE
2000	IE	IE	IE	IE	IE
2001	IE	IE	IE	IE	IE
2002	IE	IE	IE	IE	IE
2003	IE	IE	IE	IE	IE
2004	IE	IE	IE	IE	IE
2005	IE	IE	IE	IE	IE
2006	12.07	12.03	0.030	0.013	IE
2007	6.03	6.01	0.015	0.006	IE
2008	9.78	9.73	0.031	0.016	IE
2009	6.03	6.01	0.015	0.006	IE
2010	6.03	6.01	0.015	0.006	IE
2011	15.82	15.78	0.008	0.007	0.024
2012	16.59	16.53	0.021	0.011	0.025
2013	8.26	8.22	0.010	0.006	0.024
2014	20.80	20.72	0.053	0.022	0.001
2015	27.67	27.57	0.073	0.031	0.001
2016	30.67	30.56	0.081	0.034	0.001
2017	33.05	32.93	0.087	0.037	0.001
2018	34.24	34.11	0.090	0.038	0.001
2019	44.84	44.67	0.118	0.050	0.001
2020	37.17	37.03	0.098	0.042	0.001
2021	45.20	45.03	0.119	0.051	0.001
Trend					
1990 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*21.6%*	*21.6%*	*21.7%*	*21.7%*	*25.0%*

3.2.6.10.2 Methodological issues

3.2.6.10.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[59] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}$$

Where:

Emissions $_{GHG,\ fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG,\ fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ) For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, solid fuels, gaseous fuels, other fossil fuel, biomass, peat

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG} = \sum_{fuel} emissions_{\mathrm{GHG,\,fuel}}$$

3.2.6.10.2.2 Choice of activity data

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 - 2021 were taken from Statistical Office of Montenegro (MONSTAT).

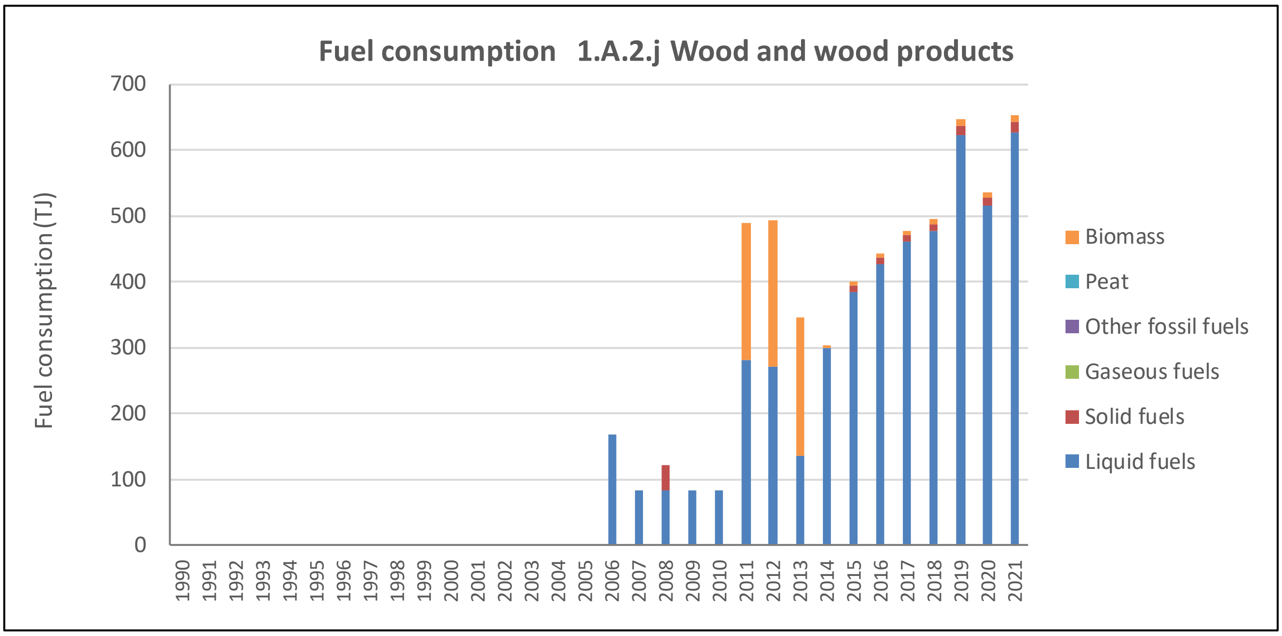


Figure 88: Activity data for sub-category 1.A.2.j *Wood and wood products*

<u>Use of notation key</u>

IE	1.A.2.j (liquid, solid, biomass)	The energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire timeseries. Emissions are currently allocated in IPCC subcategory 1.A.2.m *Other*.

[59] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method

Table 165: Activity data for sub-category 1.A.2.j *Wood and wood products*

Activity data 1.A.2.j	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	IE	IE	IE	NO	NO	NO	NO
1991	IE	IE	IE	NO	NO	NO	NO
1992	IE	IE	IE	NO	NO	NO	NO
1993	IE	IE	IE	NO	NO	NO	NO
1994	IE	IE	IE	NO	NO	NO	NO
1995	IE	IE	IE	NO	NO	NO	NO
1996	IE	IE	IE	NO	NO	NO	NO
1997	IE	IE	IE	NO	NO	NO	NO
1998	IE	IE	IE	NO	NO	NO	NO
1999	IE	IE	IE	NO	NO	NO	NO
2000	IE	IE	IE	NO	NO	NO	NO
2001	IE	IE	IE	NO	NO	NO	NO
2002	IE	IE	IE	NO	NO	NO	NO
2003	IE	IE	IE	NO	NO	NO	NO
2004	IE	IE	IE	NO	NO	NO	NO
2005	IE	IE	IE	NO	NO	NO	NO
2006	167.82	167.82	IE	NO	NO	NO	NO
2007	83.91	83.91	IE	NO	NO	NO	NO
2008	120.75	83.91	36.84	NO	NO	NO	NO
2009	83.91	83.91	IE	NO	NO	NO	NO
2010	83.91	83.91	IE	NO	NO	NO	NO
2011	490.34	281.34	IE	NO	NO	NO	209.00
2012	494.47	271.47	IE	NO	NO	NO	223.00
2013	345.49	136.49	IE	NO	NO	NO	209.00
2014	303.97	298.97	IE	NO	NO	NO	5.00
2015	399.60	384.39	9.21	NO	NO	NO	6.00
2016	443.58	427.10	9.48	NO	NO	NO	7.00
2017	477.78	461.27	9.51	NO	NO	NO	7.00
2018	495.84	478.35	9.49	NO	NO	NO	8.00
2019	648.02	623.57	14.46	NO	NO	NO	10.00
2020	536.86	516.79	12.07	NO	NO	NO	8.00
2021	652.88	627.84	15.04	NO	NO	NO	10.00
Trend							
1990 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*21.6%*	*21.5%*	*24.6%*	*NA*	*NA*	*NA*	*25.0%*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic meters. To convert these data to energy units, in

this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in sub-category 1.A.2.j Wood and wood products.

Table 166 Net calorific values (NCVs) applied for conversion to energy units in sub-category 1.A.2.j Wood and wood products

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg) or *(TJ/m3)		Source
		NCV	type	
Gas/Diesel Oil	liquid	42.71	CS	Statistical Office of Montenegro (MONSTAT)
Residual fuel oil	liquid	41.20	CS	
Liquefied Petroleum Gases (LPG)	liquid	46.89	CS	
Petroleum Coke	liquid	40.19	CS	
Sub-Bituminous Coal	solid	16.75	CS	
Lignite	solid	9.21	CS	
Charcoal	biomass	29.30	CS	
Wood / Fuelwood	biomass	9.18*	CS	
Wood pellets	biomass	16.85	CS	

Note:
D Default CS Country specific PS Plant specific

3.2.6.10.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 167 GHG Emission factor TIER 1 for IPCC sub-category 1.A.2 Manufacturing Industries and Construction

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source
		EF	type	EF	type	EF	type	2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)
Gas/Diesel Oil	liquid	74 100	D	3	D	0.6	D	**Table 2.3** Default emission factors for stationary combustion in manufacturing industries and construction (page 2.18)
Residual Fuel Oil / Total fuel oil	liquid	77 400	D	3	D	0.6	D	
Lignite	solid	101 000	D	10	D	1.5	D	
LPG	gaseous	63 100	D	1	D	0.1	D	
Natural gas	gaseous	56 100	D	1	D	0.1	D	
Wood pellets	biomass	112 000	D	30	D	4	D	

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

3.2.6.10.3 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- consistent use of energy balance data (energy statistic questionnaires),
- documented sources,
- use of units,
- strictly defined interfaces between spreadsheets/calculation modules,

- unique structure of sheets which do the same,
- record keeping, use of write protection,
- unique use of formulas, special cases are documented/highlighted,
- quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic, Eurostat and international energy statistics of UN

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.6.10.4 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission and relevant to sub-category 1.A.2.j Wood and wood products.

Table 168 Recalculations done in sub-category 1.A.2.j Wood and wood products

source category	Revisions of data	Type of revision	Type of improvement
1.A.2.j	Revision of NCV		

3.2.6.10.5 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 169 Planned improvements for IPCC sub-category 1.A.2.j Wood and wood products

source category	Planned improvement	Type of improvement		Priority
1.A.2.j	Carbon content (%) of lignite, gas/diesel oil, residual fuel oil, etc. for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{CO2}$** [t/TJ] = (C [%] • 44 • Ox)/(NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	Medium
1.A.2.j	Information about fitted/non-fitted equipment for flue gas cleaning, improvement in combustion	EF	Accuracy Transparency	Medium
1.A.2.j	Improvement of time series consistency and split of fuels: the energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire time series. Emissions are allocated in IPCC/NFR subcategory 1.A.2.m Other.	AD	Accuracy Transparency	High
1.A.2.j	Cross-check of national and international data sources (Eurostat and UNSD)	AD	Consistency Transparency	Medium

3.2.6.11 Construction (IPCC category 1.A.2.k)

The IPCC category 1.A.2.k *Construction* includes GHG emissions resulting from fuel combustion activities in

Activities	Occurring in Montenegro
▪ ISIC Division 41 Construction of buildings	✓
▪ Division 42 Civil engineering	
o Construction of roads and railways	✓
o Construction of utility projects	✓
o Construction of other civil engineering projects	✓
▪ Division 43 Specialized construction activities	
o Demolition and site preparation	✓
o Electrical, plumbing and heat and air-conditioning installation and other construction installation activities	✓
o Building completion and finishing	✓
o Other specialized construction activities Manufacture	✓

3.2.6.11.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.k	√*	√*	NO	NO	NO	NO	√*	√*	NO	NO	NO	NO	√*	√*	NO	NO	NO	NO
Key category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF																		
* data provided only from 2006 onwards; ** data provided only from 2011 onwards																		

Use of notation key

IE	1.A.2.j (liquid, solid, biomass)	The energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire timeseries. Emissions are currently allocated in IPCC subcategory 1.A.2.m *Other*.

An overview of the emissions from fuel combustion in IPCC sub-category *1.A.2.j Wood and wood products* is provided in the following figures and tables:

- annual emissions of GHGs;
- Trend of the periods 1990 – 2020, 2005 – 2021, 2020 – 2021.

For 1999, 2001-2005, 2008 and 2013, emissions from liquid fuels combusted in IPCC category 1.A.2.k are provided; for all other years, emissions from IPCC category 1.A.2.k are included in IPCC subcategory 1.A.2.m Other.

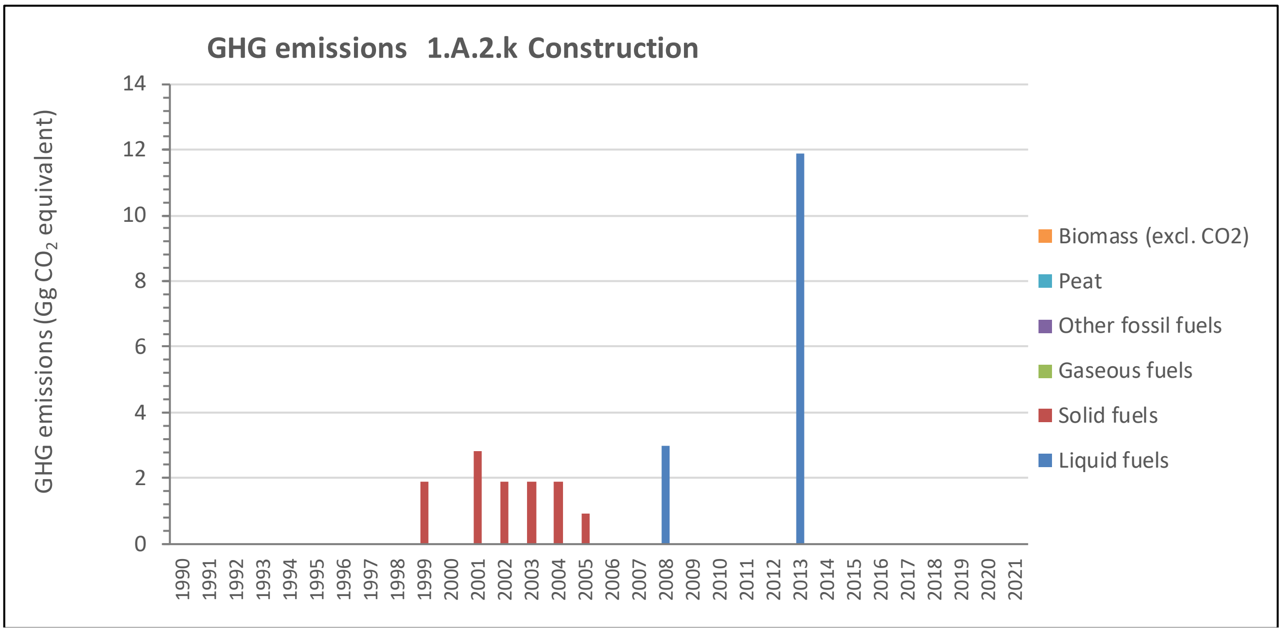


Figure 89 GHG emissions from sub-category 1.A.2.k Construction

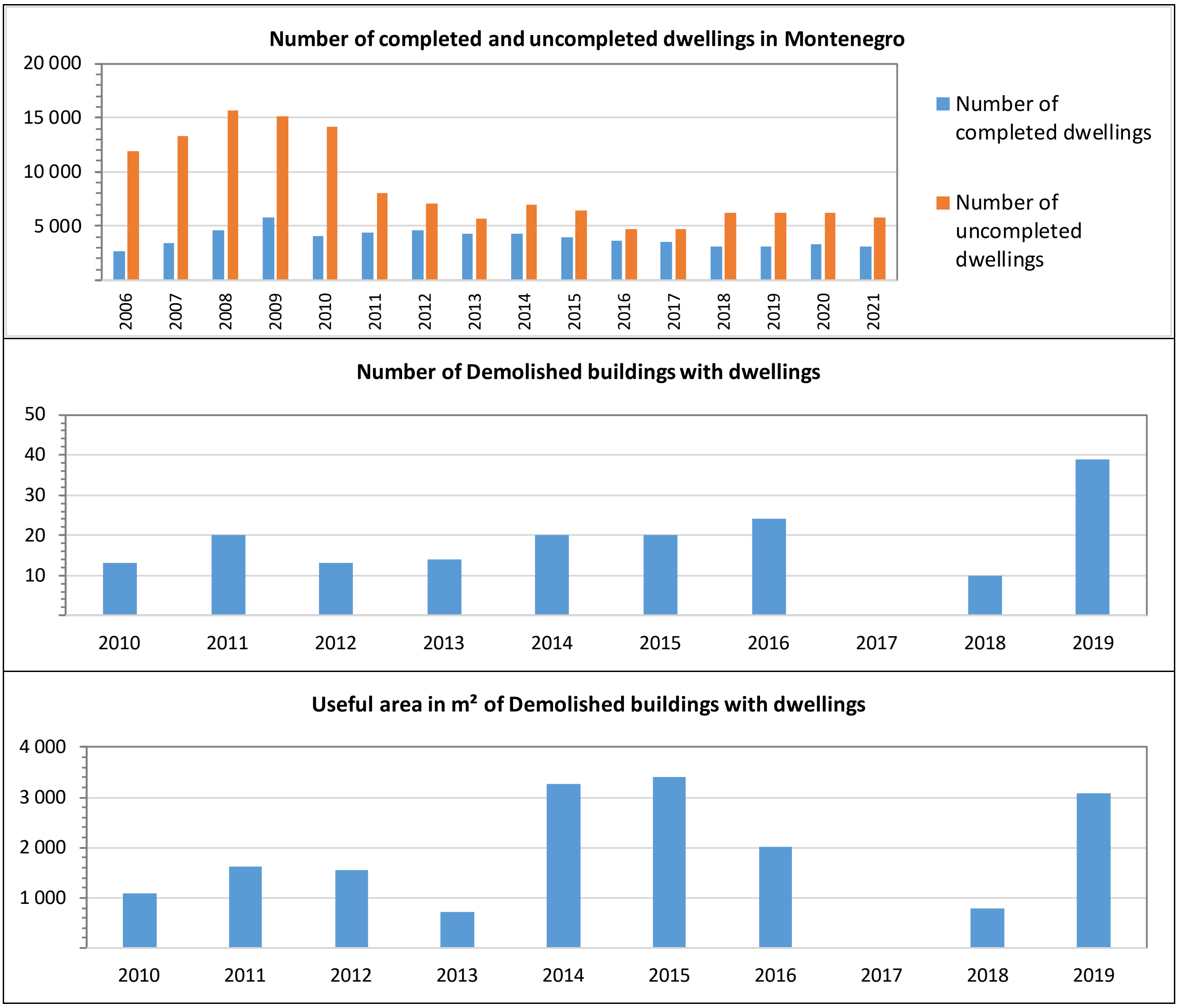


Figure 90 Number and floor area of completed and uncompleted dwellings and demolishing in category 1.A.2.k Constructioin in the period 2006-2021; Source: MONSTAT

Table 170 Emissions from IPCC sub-category 1.A.2.k Construction

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	kt CO2 equivalent	kt	kt CO2 equivalent	kt CO2 equivalent	kt
1990	IE	IE	IE	IE	NO
1991	IE	IE	IE	IE	NO
1992	IE	IE	IE	IE	NO
1993	IE	IE	IE	IE	NO
1994	IE	IE	IE	IE	NO
1995	IE	IE	IE	IE	NO
1996	IE	IE	IE	IE	NO
1997	IE	IE	IE	IE	NO
1998	IE	IE	IE	IE	NO
1999	1.87	1.86	0.008	0.005	NO
2000	IE	IE	IE	IE	NO
2001	2.81	2.79	0.012	0.007	NO
2002	1.87	1.86	0.008	0.005	NO
2003	1.87	1.86	0.008	0.005	NO
2004	1.87	1.86	0.008	0.005	NO
2005	0.94	0.93	0.004	0.002	NO
2006	IE	IE	IE	IE	NO
2007	IE	IE	IE	IE	NO
2008	2.97	2.96	0.008	0.003	NO
2009	IE	IE	IE	IE	NO
2010	IE	IE	IE	IE	NO
2011	IE	IE	IE	IE	NO
2012	IE	IE	IE	IE	NO
2013	11.88	11.84	0.031	0.013	NO
2014	IE	IE	IE	IE	NO
2015	IE	IE	IE	IE	NO
2016	IE	IE	IE	IE	NO
2017	IE	IE	IE	IE	NO
2018	IE	IE	IE	IE	NO
2019	IE	IE	IE	IE	NO
2020	IE	IE	IE	IE	NO
2021	IE	IE	IE	IE	NO
Trend					
1990 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*

3.2.6.11.2 Methodological issues

3.2.6.11.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[60] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}$$

Where:

Emissions $_{GHG, fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG, fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ) For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, solid fuels, gaseous fuels, other fossil fuel, biomass, peat

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG} = \sum_{fuel} emissions_{GHG,\,fuel}$$

3.2.6.11.2.2 Choice of activity data

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 - 2021 were taken from Statistical Office of Montenegro (MONSTAT).

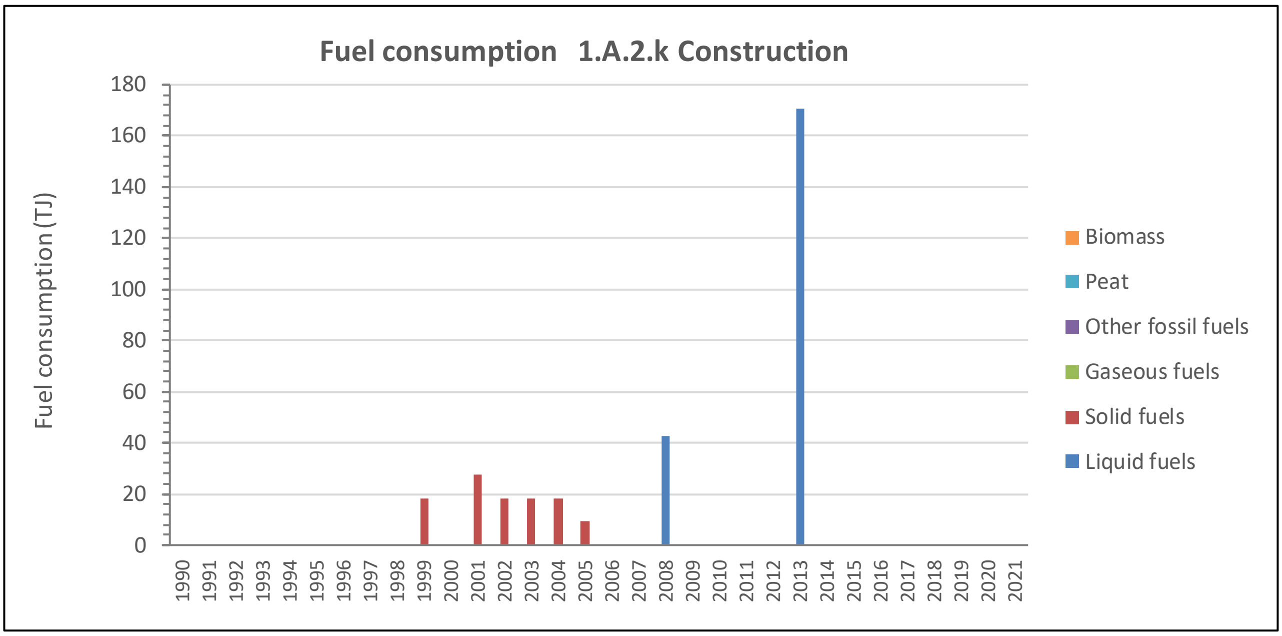


Figure 91 Activity data for sub-category 1.A.2.k *Construction* 1990 – 2021

<u>Use of notation key</u>

IE	1.A.2.j (liquid, solid)	The energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire timeseries. Emissions are currently allocated in IPCC subcategory 1.A.2.m *Other*.

[60] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method

Table 171 Activity data for sub-category 1.A.2.k *Construction* 1990 - 2021

Activity data 1.A.2.k	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	IE	IE	IE	NO	NO	NO	NO
1991	IE	IE	IE	NO	NO	NO	NO
1992	IE	IE	IE	NO	NO	NO	NO
1993	IE	IE	IE	NO	NO	NO	NO
1994	IE	IE	IE	NO	NO	NO	NO
1995	IE	IE	IE	NO	NO	NO	NO
1996	IE	IE	IE	NO	NO	NO	NO
1997	IE	IE	IE	NO	NO	NO	NO
1998	IE	IE	IE	NO	NO	NO	NO
1999	18.42	IE	18.42	NO	NO	NO	NO
2000	IE	IE	IE	NO	NO	NO	NO
2001	27.63	IE	27.63	NO	NO	NO	NO
2002	18.42	IE	18.42	NO	NO	NO	NO
2003	18.42	IE	18.42	NO	NO	NO	NO
2004	18.42	IE	18.42	NO	NO	NO	NO
2005	9.21	IE	9.21	NO	NO	NO	NO
2006	IE	IE	IE	NO	NO	NO	NO
2007	IE	IE	IE	NO	NO	NO	NO
2008	42.71	42.71	IE	NO	NO	NO	NO
2009	IE	IE	IE	NO	NO	NO	NO
2010	IE	IE	IE	NO	NO	NO	NO
2011	IE	IE	IE	NO	NO	NO	NO
2012	IE	IE	IE	NO	NO	NO	NO
2013	170.84	170.84	IE	NO	NO	NO	NO
2014	IE	IE	IE	NO	NO	NO	NO
2015	IE	IE	IE	NO	NO	NO	NO
2016	IE	IE	IE	NO	NO	NO	NO
2017	IE	IE	IE	NO	NO	NO	NO
2018	IE	IE	IE	NO	NO	NO	NO
2019	IE	IE	IE	NO	NO	NO	NO
2020	IE	IE	IE	NO	NO	NO	NO
2021	IE	IE	IE	NO	NO	NO	NO
Trend							
1990 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic meters. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in sub-category 1.A.2.k Construction.

Table 172 Net calorific values (NCVs) applied for conversion to energy units in sub-category 1.A.2.k Construction

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg) or *(TJ/m3) NCV	type	Source
Gas/Diesel Oil	liquid	42.71	CS	Statistical Office of Montenegro (MONSTAT)
Residual fuel oil	liquid	41.20	CS	
Liquefied Petroleum Gases (LPG)	liquid	46.89	CS	
Petroleum Coke	liquid	40.19	CS	
Sub-Bituminous Coal	solid	16.75	CS	
Lignite	solid	9.21	CS	
Charcoal	biomass	29.30	CS	
Wood / Fuelwood	biomass	9.18*	CS	
Wood pellets	biomass	16.85	CS	

Note:
D Default CS Country specific PS Plant specific

3.2.6.11.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 173 GHG Emission factor TIER 1 for IPCC sub-category 1.A.2.k *Construction*

Fuel	Fuel type	CO_2 (kg/TJ) EF	type	CH_4 (kg/TJ) EF	type	N_2O (kg/TJ) EF	type	Source: 2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)
Gas/Diesel Oil	liquid	74 100	D	3	D	0.6	D	**Table 2.3** Default emission factors for stationary combustion in manufacturing industries and construction (page 2.18)
Residual Fuel Oil / Total fuel oil	liquid	77 400	D	3	D	0.6	D	
Lignite	solid	101 000	D	10	D	1.5	D	
LPG	gaseous	63 100	D	1	D	0.1	D	
Natural gas	gaseous	56 100	D	1	D	0.1	D	
Wood pellets	biomass	112 000	D	30	D	4	D	

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

3.2.6.11.3 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- o consistent use of energy balance data (energy statistic questionnaires),
- o documented sources,

- use of units,
- strictly defined interfaces between spreadsheets/calculation modules,
- unique structure of sheets which do the same,
- record keeping, use of write protection,
- unique use of formulas, special cases are documented/highlighted,
- quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic, Eurostat and international energy statistics of UN

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.6.11.4 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission and relevant to sub-category 1.A.2.k *Construction*.

Table 174 Recalculations done in sub-category 1.A.2.k Construction

source category	Revisions of data	Type of revision	Type of improvement
1.A.2.j	Revision of NCV		

3.2.6.11.5 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 175 Planned improvements for IPCC sub-category 1.A.2.k Construction

source category	Planned improvement	Type of improvement		Priority
1.A.2.k	Carbon content (%) of lignite, gas/diesel oil, residual fuel oil, etc. for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{CO2}$** [t/TJ] = (C [%] • 44 • Ox)/(NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	Medium
1.A.2.k	Information about fitted/non-fitted equipment for flue gas cleaning, improvement in combustion	EF	Accuracy Transparency	Medium
1.A.2.k	Improvement of time series consistency and split of fuels: the energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire time series. Emissions are allocated in IPCC/NFR subcategory 1.A.2.m Other.	AD	Accuracy Transparency	High
1.A.2.k	Cross-check of national and international data sources (Eurostat and UNSD)	AD	Consistency Transparency	Medium

3.2.6.12 Textile and Leather (IPCC category 1.A.2.l)

The IPCC category 1.A.2.l *Textile and Leather* includes GHG emissions resulting from fuel combustion activities in

Activities	Occurring in Montenegro
▪ ISIC Division 13 Manufacture of textiles	✓
o Spinning, weaving and finishing of textiles	
o Manufacture of other textiles	
▪ Manufacture of knitted and crocheted fabrics, made-up textile articles (except apparel)	
▪ Manufacture of carpets and rugs, cordage, rope, twine and netting	
▪ Manufacture of other textiles n.e.c.	
▪ ISIC Division 14 Manufacture of wearing apparel	✓
o Manufacture of wearing apparel, except fur apparel	
o Manufacture of articles of fur	
o Manufacture of knitted and crocheted apparel	
▪ ISIC Division 15 Manufacture of leather and related products	✓
o Tanning and dressing of leather; manufacture of luggage, handbags, saddlery and harness; dressing and dyeing of fur	
o Manufacture of footwear	

3.2.6.12.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.l	√*	√*	NO	NO	NO	NO	√*	√*	NO	NO	NO	NO	√*	√*	NO	NO	NO	NO
Key category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

A '✓' indicates: emissions from this sub-category have been estimated.
Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF

* data provided not for all years; for those years IE

Use of notation key

IE	1.A.2.l (liquid, solid)	The energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire timeseries. Emissions are currently allocated in IPCC subcategory 1.A.2.m *Other*.

An overview of the emissions from fuel combustion in IPCC sub-category *1.A.2.j Wood and wood products* is provided in the following figures and tables:

- annual emissions of GHGs;
- Trend of the periods 1990 – 2020, 2005 – 2021, 2020 – 2021.

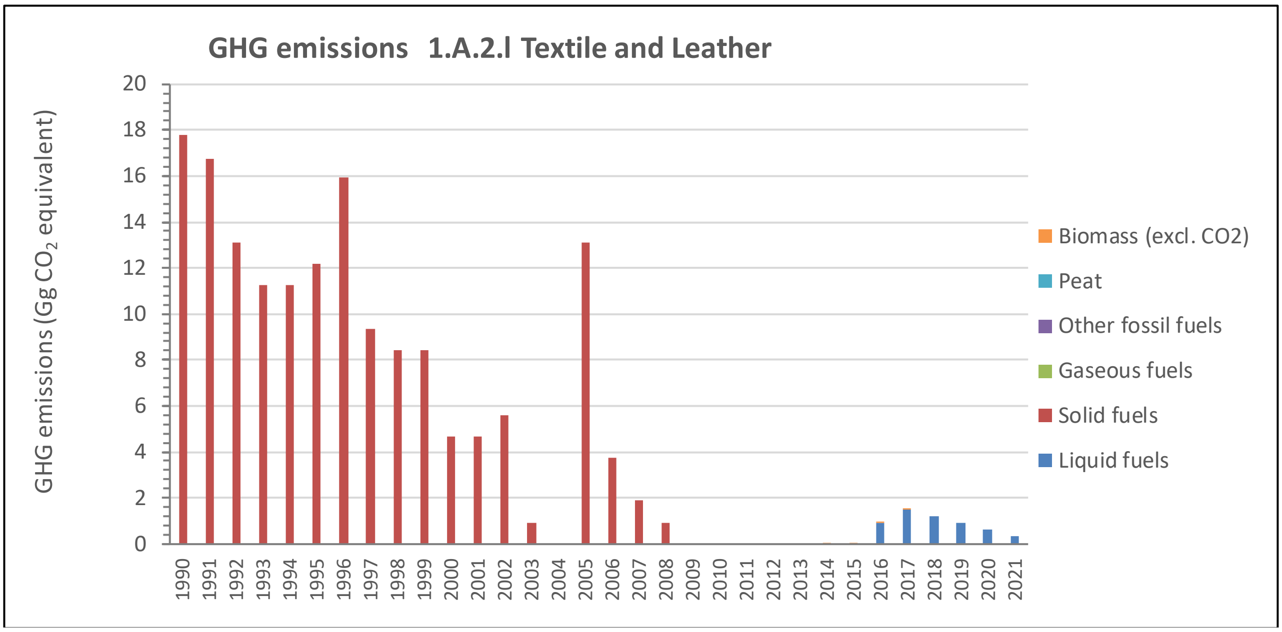


Figure 92 GHG emissions from sub-category 1.A.2.l Textile and Leather

Table 176 Emissions from IPCC sub-category 1.A.2.l Textile and Leather

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	kt CO2 equivalent	kt	kt CO2 equivalent	kt CO2 equivalent	kt
1990	17.80	17.67	0.078	0.0437	NO
1991	16.73	16.61	0.074	0.0411	NO
1992	13.11	13.02	0.058	0.0322	NO
1993	11.24	11.16	0.049	0.0276	NO
1994	11.24	11.16	0.049	0.0276	NO
1995	12.18	12.09	0.054	0.0299	NO
1996	15.92	15.81	0.070	0.0391	NO
1997	9.37	9.30	0.041	0.0230	NO
1998	8.43	8.37	0.037	0.0207	NO
1999	8.43	8.37	0.037	0.0207	NO
2000	4.68	4.65	0.021	0.0115	NO
2001	4.68	4.65	0.021	0.0115	NO
2002	5.62	5.58	0.025	0.0138	NO
2003	0.94	0.93	0.004	0.0023	NO
2004	IE	IE	IE	IE	NO
2005	13.11	13.02	0.058	0.0322	NO
2006	3.75	3.72	0.016	0.0092	NO
2007	1.87	1.86	0.008	0.0046	NO
2008	0.94	0.93	0.004	0.0023	NO
2009	IE	IE	IE	IE	NO
2010	IE	IE	IE	IE	NO
2011	IE	IE	IE	IE	NO
2012	IE	IE	IE	IE	NO
2013	IE	IE	IE	IE	NO
2014	0.00	IE	IE	0.0000	0.0003
2015	0.00	IE	IE	0.0000	0.0003
2016	0.89	0.89	0.002	0.0010	0.0006
2017	1.51	1.51	0.004	0.0016	0.0005
2018	1.21	1.20	0.003	0.0013	NO
2019	0.91	0.91	0.002	0.0009	NO
2020	0.60	0.60	0.002	0.0006	NO
2021	0.31	0.31	0.001	0.0003	NO
Trend					
1990 - 2021	*-96.6%*	*-96.6%*	*-98.1%*	*-98.6%*	*NA*
2005 - 2021	*-95.4%*	*-95.4%*	*-97.4%*	*-98.0%*	*NA*
2020 - 2021	*-33.7%*	*-33.7%*	*-32.9%*	*-32.9%*	*NA*

3.2.6.12.2 Methodological issues

3.2.6.12.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[61] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}$$

Where:

Emissions $_{GHG,\ fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG,\ fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ) For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, solid fuels, gaseous fuels, other fossil fuel, biomass, peat

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG} = \sum_{fuel} emissions_{GHG,\,fuel}$$

3.2.6.12.2.2 Choice of activity data

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 - 2021 were taken from Statistical Office of Montenegro (MONSTAT).

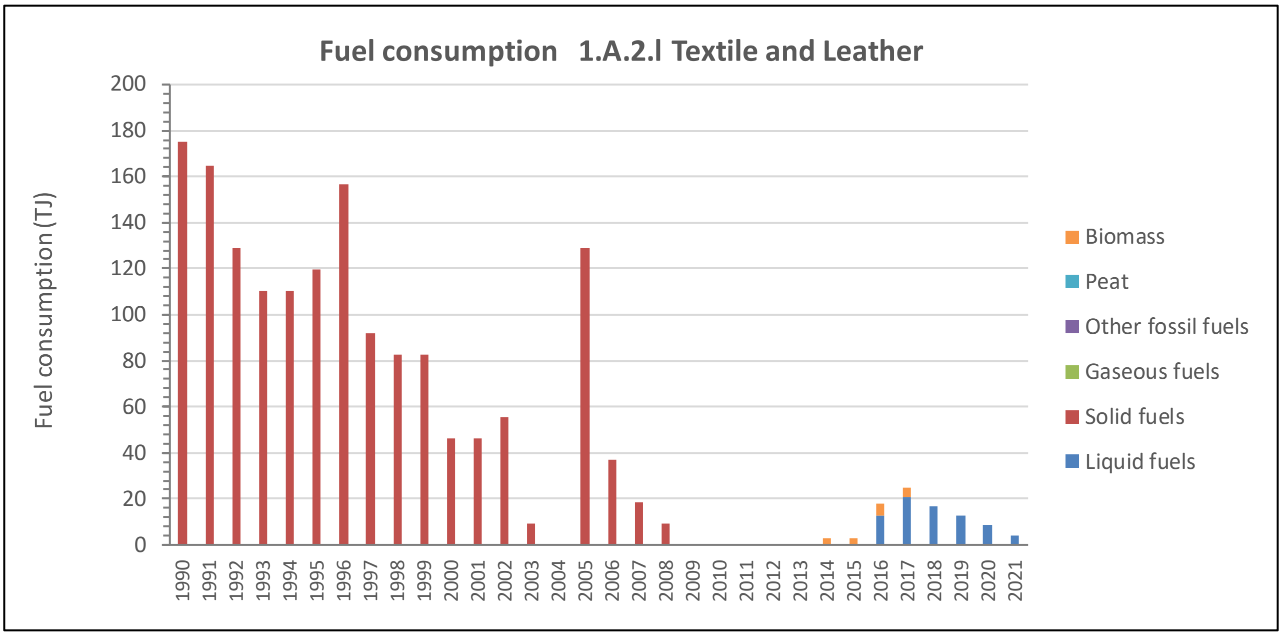


Figure 93 Activity data for sub-category 1.A.2.l Textile and Leather

<u>Use of notation key</u>

IE	1.A.2.l (liquid, solid)	The energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire timeseries. Emissions are currently allocated in IPCC subcategory 1.A.2.m *Other*.

[61] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method

Table 177 Activity data for sub-category 1.A.2.l Textile and Leather

Activity data 1.A.2.l	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	174.99	IE	174.99	NO	NO	NO	NO
1991	164.49	IE	164.49	NO	NO	NO	NO
1992	128.94	IE	128.94	NO	NO	NO	NO
1993	110.52	IE	110.52	NO	NO	NO	NO
1994	110.52	IE	110.52	NO	NO	NO	NO
1995	119.73	IE	119.73	NO	NO	NO	NO
1996	156.57	IE	156.57	NO	NO	NO	NO
1997	92.10	IE	92.10	NO	NO	NO	NO
1998	82.89	IE	82.89	NO	NO	NO	NO
1999	82.89	IE	82.89	NO	NO	NO	NO
2000	46.05	IE	46.05	NO	NO	NO	NO
2001	46.05	IE	46.05	NO	NO	NO	NO
2002	55.26	IE	55.26	NO	NO	NO	NO
2003	9.21	IE	9.21	NO	NO	NO	NO
2004	IE	IE	NO	NO	NO	NO	NO
2005	128.94	IE	128.94	NO	NO	NO	NO
2006	36.84	IE	36.84	NO	NO	NO	NO
2007	18.42	IE	18.42	NO	NO	NO	NO
2008	9.21	IE	9.21	NO	NO	NO	NO
2009	IE	IE	NO	NO	NO	NO	NO
2010	IE	IE	NO	NO	NO	NO	NO
2011	IE	IE	NO	NO	NO	NO	NO
2012	IE	IE	NO	NO	NO	NO	NO
2013	IE	IE	NO	NO	NO	NO	NO
2014	3.00	IE	NO	NO	NO	NO	3.00
2015	3.00	IE	NO	NO	NO	NO	3.00
2016	17.81	12.81	NO	NO	NO	NO	5.00
2017	24.90	20.90	NO	NO	NO	NO	4.00
2018	16.78	16.78	NO	NO	NO	NO	NO
2019	12.51	12.51	NO	NO	NO	NO	NO
2020	8.39	8.39	NO	NO	NO	NO	NO
2021	4.12	4.12	NO	NO	NO	NO	NO
Trend							
1990 - 2021	-95,2%	NA	NA	NA	NA	NA	NA
2005 - 2021	-93,5%	NA	NA	NA	NA	NA	NA
2020 - 2021	-1,7%	-1,7%	NA	NA	NA	NA	NA

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic meters. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in sub-category 1.A.2.l Textile and Leather.

Table 178 Net calorific values (NCVs) applied for conversion to energy units in sub-category 1.A.2.l Textile and Leather

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg) or *(TJ/m3)		Source
		NCV	type	
Gas/Diesel Oil	liquid	42.71	CS	Statistical Office of Montenegro (MONSTAT)
Residual fuel oil	liquid	41.20	CS	
Liquefied Petroleum Gases (LPG)	liquid	46.89	CS	
Petroleum Coke	liquid	40.19	CS	
Sub-Bituminous Coal	solid	16.75	CS	
Lignite	solid	9.21	CS	
Charcoal	biomass	29.30	CS	
Wood / Fuelwood	biomass	9.18*	CS	
Wood pellets	biomass	16.85	CS	

Note:
D Default CS Country specific PS Plant specific

3.2.6.12.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 179 GHG Emission factor TIER 1 for IPCC sub-category 1.A.2.l Textile and Leather

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source
		EF	type	EF	type	EF	type	2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)
Gas/Diesel Oil	liquid	74 100	D	3	D	0.6	D	**Table 2.3** Default emission factors for stationary combustion in manufacturing industries and construction (page 2.18)
Residual Fuel Oil / Total fuel oil	liquid	77 400	D	3	D	0.6	D	
Lignite	solid	101 000	D	10	D	1.5	D	
LPG	gaseous	63 100	D	1	D	0.1	D	
Natural gas	gaseous	56 100	D	1	D	0.1	D	
Wood pellets	biomass	112 000	D	30	D	4	D	

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

3.2.6.12.3 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- consistent use of energy balance data (energy statistic questionnaires),
- documented sources,

- o use of units,
- o strictly defined interfaces between spreadsheets/calculation modules,
- o unique structure of sheets which do the same,
- o record keeping, use of write protection,
- o unique use of formulas, special cases are documented/highlighted,
- o quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic, Eurostat and international energy statistics of UN

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.6.12.4 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission and relevant to sub-category 1.A.2.l Textile and Leather.

Table 180 Recalculations done in sub-category 1.A.2.l Textile and Leather

source category	Revisions of data	Type of revision	Type of improvement
1.A.2.l	Revision of NCV	AD	Consistency

3.2.6.12.5 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 181 Planned improvements for IPCC sub-category 1.A.2.l Textile and Leather

source category	Planned improvement	Type of improvement		Priority
1.A.2.l	Carbon content (%) of lignite, gas/diesel oil, residual fuel oil, etc. for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{CO2}$** [t/TJ] = (C [%] • 44 • Ox)/(NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	Medium
1.A.2.l	Information about fitted/non-fitted equipment for flue gas cleaning, improvement in combustion	EF	Accuracy Transparency	Medium
1.A.2.l	Improvement of time series consistency and split of fuels: the energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire time series. Emissions are allocated in IPCC/NFR subcategory 1.A.2.m Other.	AD	Accuracy Transparency	High
1.A.2.l	Cross-check of national and international data sources (Eurostat and UNSD)	AD	Consistency Transparency	Medium

3.2.6.13 Other (IPCC category 1.A.2.m)

3.2.6.13.1 Source category description

GHG emissions/ removals	CO₂						CH₄						N₂O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.2.m	✓	✓	NO	NO	NO	✓	✓	✓	NO	NO	NO	✓	✓	✓	NO	NO	NO	✓
Key catergory																		
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF																		
* data provided not for all years; for those years IE																		

The IPCC category 1.A.2.m *Other (not-specified industry)* includes GHG emissions resulting from fuel combustion activities in any manufacturing industry/construction not included in 1.A.2.a - 1.A.2.l when the energy balance was not disaggregated.

An overview of the emissions from fuel combustion in IPCC sub-category 1.A.2.m *Other* is provided in the following figures and tables:

- annual emissions of GHGs;
- Trend of the periods 1990 – 2020, 2005 – 2021, 2020 – 2021.

The main fuels used in 1.A.2.m were

- liquid fuels, such as gas/diesel oil and fuel oil,
- solid fuels, here lignite which come from the Pljevija basin,
- biomass.

Until 2004, GHG emissions decreased due to political situation in the region. The significant drop in GHG emissions in the period 2010-2012 were due to the global economic crisis.

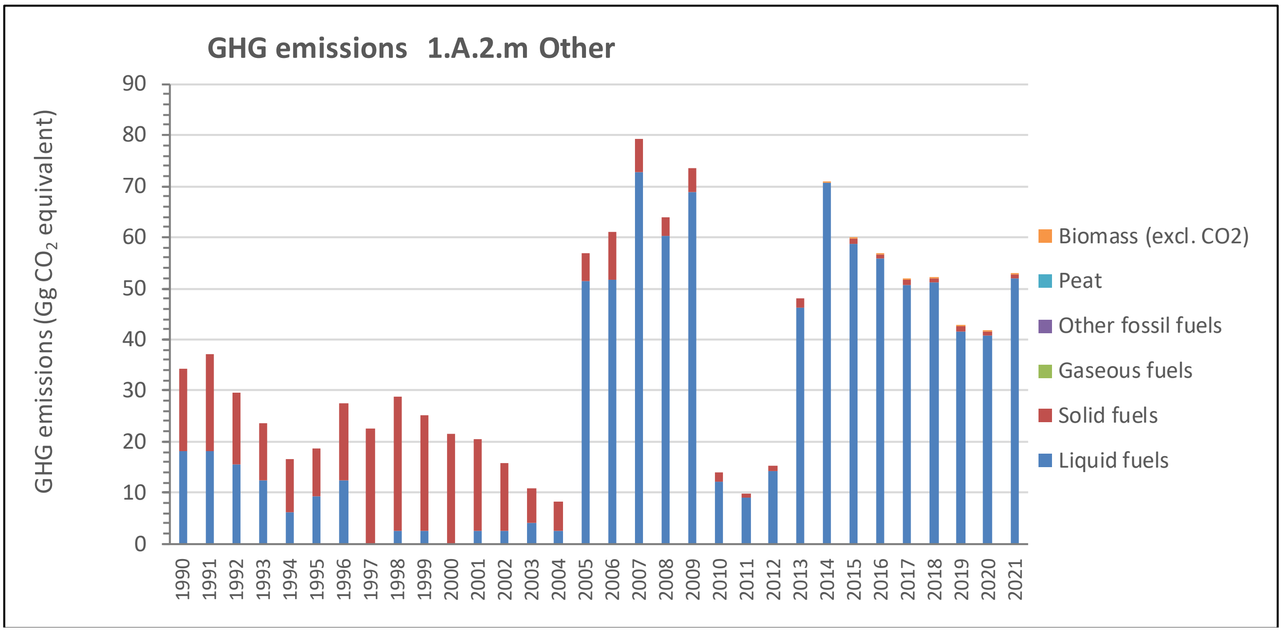


Figure 94 Emissions from IPCC sub-category 1.A.2.m Other

Table 182 Emissions from IPCC sub-category 1.A.2.m Other

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	kt CO2 equivalent	kt CO2 equivalent	kt CO2 equivalent	kt CO2 equivalent	kt CO2 equivalent
1990	34.16	34.00	0.107	0.055	NO
1991	37.20	37.01	0.121	0.063	NO
1992	29.65	29.51	0.098	0.050	NO
1993	23.72	23.61	0.078	0.040	NO
1994	16.54	16.45	0.060	0.031	NO
1995	18.73	18.63	0.063	0.032	NO
1996	27.47	27.33	0.095	0.049	NO
1997	22.48	22.33	0.099	0.055	NO
1998	28.86	28.68	0.117	0.066	NO
1999	25.11	24.96	0.100	0.056	NO
2000	21.54	21.39	0.095	0.053	NO
2001	20.43	20.30	0.080	0.045	NO
2002	15.75	15.65	0.059	0.033	NO
2003	10.75	10.70	0.034	0.019	NO
2004	8.25	8.21	0.026	0.015	NO
2005	56.99	56.83	0.103	0.052	NO
2006	61.14	60.99	0.092	0.053	NO
2007	79.36	79.12	0.159	0.076	NO
2008	64.00	63.76	0.167	0.072	NO
2009	73.53	73.25	0.195	0.085	NO
2010	13.94	13.89	0.038	0.017	NO
2011	9.94	9.90	0.027	0.012	NO
2012	15.21	15.16	0.030	0.014	NO
2013	47.98	47.85	0.084	0.040	NO
2014	70.75	70.51	0.163	0.070	0.0010
2015	59.71	59.51	0.137	0.060	0.0011
2016	56.77	56.58	0.130	0.057	0.0011
2017	51.72	51.55	0.117	0.051	0.0010
2018	52.01	51.84	0.118	0.052	0.0009
2019	42.49	42.35	0.096	0.042	0.0008
2020	41.48	41.34	0.095	0.041	0.0008
2021	52.80	52.62	0.123	0.054	0.0009
Trend					
1990 - 2021	*54.6%*	*54.8%*	*14.6%*	*-3.4%*	*NA*
2005 - 2021	*-7.4%*	*-7.4%*	*19.2%*	*2.9%*	*NA*
2020 - 2021	*27.3%*	*27.3%*	*29.6%*	*29.2%*	*14.3%*

3.2.6.13.2 Methodological issues

3.2.6.13.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[62] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}}$$

Where:

Emissions $_{GHG,\ fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG,\ fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ) For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, solid fuels, gaseous fuels, other fossil fuel, biomass, peat

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG} = \sum_{fuel} emissions_{GHG,\,fuel}}$$

3.2.6.13.2.2 Choice of activity data

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 - 2021 were taken from Statistical Office of Montenegro (MONSTAT).

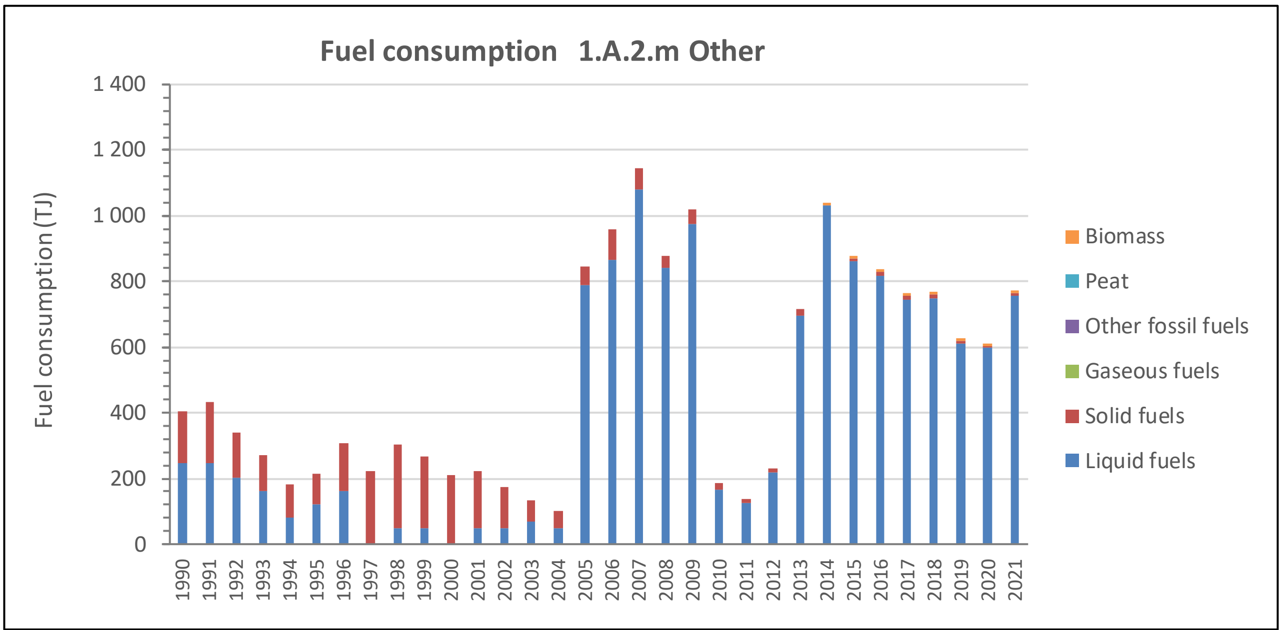


Figure 95 Activity data for IPCC sub-category 1.A.2.m Other

[62] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method

Table 183 Activity data for IPCC sub-category 1.A.2.m Other

Activity data 1.A.2.m	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	404.41	247.84	156.57	NO	NO	NO	NO
1991	434.26	247.84	186.42	NO	NO	NO	NO
1992	339.10	200.95	138.15	NO	NO	NO	NO
1993	271.28	160.76	110.52	NO	NO	NO	NO
1994	181.69	80.38	101.31	NO	NO	NO	NO
1995	212.67	120.57	92.10	NO	NO	NO	NO
1996	308.12	160.76	147.36	NO	NO	NO	NO
1997	221.04	IE	221.04	NO	NO	NO	NO
1998	304.77	46.89	257.88	NO	NO	NO	NO
1999	267.93	46.89	221.04	NO	NO	NO	NO
2000	211.83	IE	211.83	NO	NO	NO	NO
2001	221.88	46.89	174.99	NO	NO	NO	NO
2002	175.83	46.89	128.94	NO	NO	NO	NO
2003	131.46	66.99	64.47	NO	NO	NO	NO
2004	102.15	46.89	55.26	NO	NO	NO	NO
2005	846.04	790.78	55.26	NO	NO	NO	NO
2006	959.74	867.64	92.10	NO	NO	NO	NO
2007	1 143.64	1 079.17	64.47	NO	NO	NO	NO
2008	876.93	840.09	36.84	NO	NO	NO	NO
2009	1 019.82	973.77	46.05	NO	NO	NO	NO
2010	186.24	167.82	18.42	NO	NO	NO	NO
2011	135.83	126.62	9.21	NO	NO	NO	NO
2012	229.61	220.40	9.21	NO	NO	NO	NO
2013	715.42	697.00	18.42	NO	NO	NO	NO
2014	1 039.03	1 030.03	IE	NO	NO	NO	9.00
2015	879.91	860.70	9.21	NO	NO	NO	10.00
2016	837.47	817.99	9.48	NO	NO	NO	10.00
2017	764.03	745.52	9.51	NO	NO	NO	9.00
2018	767.28	749.79	9.49	NO	NO	NO	8.00
2019	627.19	611.93	8.26	NO	NO	NO	7.00
2020	610.90	597.87	6.04	NO	NO	NO	7.00
2021	772.29	755.27	9.02	NO	NO	NO	8.00
Trend							
1990 - 2021	*91.0%*	*204.7%*	*-94.2%*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*-8.7%*	*-4.5%*	*-83.7%*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*26.4%*	*26.3%*	*49.5%*	*NA*	*NA*	*NA*	*14.3%*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic meters. To convert these data to energy units, in

this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in sub-category 1.A.2.m Other.

Table 184 Net calorific values (NCVs) applied for conversion to energy units in sub-category 1.A.2.m Other

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg) or *(TJ/m3)		Source
		NCV	type	
Gas/Diesel Oil	liquid	42.71	CS	Statistical Office of Montenegro (MONSTAT)
Residual fuel oil	liquid	41.20	CS	
Liquefied Petroleum Gases (LPG)	liquid	46.89	CS	
Petroleum Coke	liquid	40.19	CS	
Sub-Bituminous Coal	solid	16.75	CS	
Lignite	solid	9.21	CS	
Charcoal	biomass	29.30	CS	
Wood / Fuelwood	biomass	9.18*	CS	
Wood pellets	biomass	16.85	CS	

Note:
D Default CS Country specific PS Plant specific

3.2.6.13.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 185 GHG Emission factor TIER 1 for IPCC sub-category 1.A.2 Manufacturing Industries and Construction

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source
		EF	type	EF	type	EF	type	**2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)**
Gas/Diesel Oil	liquid	74 100	D	3	D	0.6	D	**Table 2.3** Default emission factors for stationary combustion in manufacturing industries and construction (page 2.18)
Residual Fuel Oil / Total fuel oil	liquid	77 400	D	3	D	0.6	D	
Lignite	solid	101 000	D	10	D	1.5	D	
LPG	gaseous	63 100	D	1	D	0.1	D	
Natural gas	gaseous	56 100	D	1	D	0.1	D	
Wood pellets	biomass	112 000	D	30	D	4	D	

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

3.2.6.13.3 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- consistent use of energy balance data (energy statistic questionnaires),
- documented sources,
- use of units,
- strictly defined interfaces between spreadsheets/calculation modules,
- unique structure of sheets which do the same,

- o record keeping, use of write protection,
- o unique use of formulas, special cases are documented/highlighted,
- o quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic, Eurostat and international energy statistics of UN

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.6.13.4 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission and relevant to sub-category 1.A.2.m Other.

Table 186 Recalculations done in sub-category 1.A.2.m Other

source category	Revisions of data	Type of revision	Type of improvement
1.A.2.m	Revision of NCV	AD	Accuracy
1.A.2.m	Revision of energy balance in JQ (joint questionnaire) format for time series 1990-2006	AD	Consistency

3.2.6.13.5 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 187 Planned improvements for IPCC sub-category 1.A.2.m *Other*

source category	Planned improvement	Type of improvement		Priority
1.A.2.m	Carbon content (%) of lignite, gas/diesel oil, residual fuel oil, etc. for preparing country specific emission factor (CS EF) ⇒ **CS EF$_{CO2}$** [t/TJ] = (C [%] • 44 • Ox)/(NCV [TJ/t] • 12• 100)	EF	Accuracy Transparency	Medium
1.A.2.m	Information about fitted/non-fitted equipment for flue gas cleaning, improvement in combustion	EF	Accuracy Transparency	Medium
1.A.2.m	Improvement of time series consistency and split of fuels: the energy statistics is still under development; a split of the fuel combustion for this subcategory has to be reviewed for the entire time series. Emissions are allocated in IPCC/NFR subcategory 1.A.2.m Other from IPCC/NFR subcategory 1.A.2.a - 1.A.2.l.	AD	Accuracy Transparency	High
1.A.2.m	Cross-check of national and international data sources (Eurostat and UNSD)	AD	Consistency Transparency	Medium

3.2.7 Transport (IPCC category 1.A.3)

This section describes GHG emissions resulting from fuel combustion in transport sector, which originate from the following subcategories.

IPCC code	Description	Occurrent			Not occurrent (NO)
		Estimated	Not estimated (NE)	Included elsewhere (IE)	
1.A.3.a.i	Domestic Aviation (Civil)	✓			
1.A.3.b	Road Transportation				
1.A.3.b.i	Cars	✓			
1.A.3.b.ii	Light-duty trucks	✓			
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		✓		
1.A.3.c	Railways	✓			
1.A.3.d	Domestic Water-borne Navigation	✓			
1.A.3.e	Other Transportation				
1.A.3.e.i	Pipeline transport				✓
1.A.3.e.ii	Other				✓

3.2.7.1 Trend description

An overview of the GHG emission from fuel combustion in IPCC category 1.A.3 *Transport* is provided in the following figures and tables:

- annual GHG emissions;
- trend of the periods 1990 – 2021 , 2005 – 2021, 2019 – 2021.
-

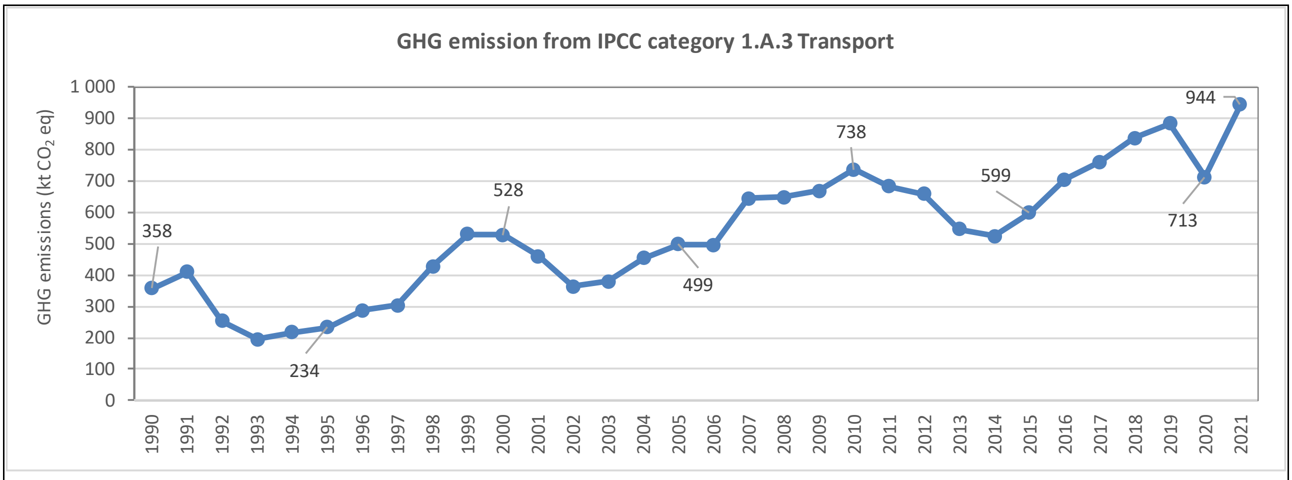


Figure 96 GHG Emissions from IPCC category 1.A.3 *Transport*

The greenhouse gas emissions from IPCC category 1.A.3 Transport amounted to 358.42 kt CO_2 equivalents in 1990, 499.21 kt CO_2 equivalents in 2005 and 943.65 kt CO_2 equivalents in 2021.

The overall trend in GHG emissions from the IPCC category 1.A.3 Transport shows an increase by 163.3% from 1990 to 2021, and 89.3% from 2005 to 2020 and by 32.3% from 2020 to 2021.

Fluctuation of emissions are due to overall situation in the country:

- breakup of Yugoslavia,
- overall economic downturn in the country;
- break-up of the union with Serbia;
- worldwide pandemic (2020).

In 2021, the IPCC category 1.A.3 *Transport* contribute with 20.9% to National Total GHG emissions.

In 2005, the IPCC category 1.A.3 *Transport* contribute with 13.0% to National Total GHG emissions.

In 1990, the IPCC category 1.A.3 *Transport* contribute with 7.9% to National Total GHG emissions.

The most important fuels are gas/diesel oil and motor gasoline. But also LPG becomes more important.

In 2021, the share in IPCC category 1.A.3 *Transport* in National Total GHG emissions contribute with

- 3.5% the IPCC category 1.A.3.a.i *Domestic Aviation (Civil)*
- 96.5% the IPCC category 1.A.3.b *Road Transportation*

No emissions occur from IPCC category 1.A.3.c *Railways* since 2014 as the railway was electrified.

No emissions are reported for all years from 1.A.3.d *Domestic Water-borne Navigation* as these emissions are reported in 1.A.3.b *Road Transportation*.

No emissions from IPCC category 1.A.3.e *Other Transportation – pipeline transport*, as this category does not exists in Montenegro

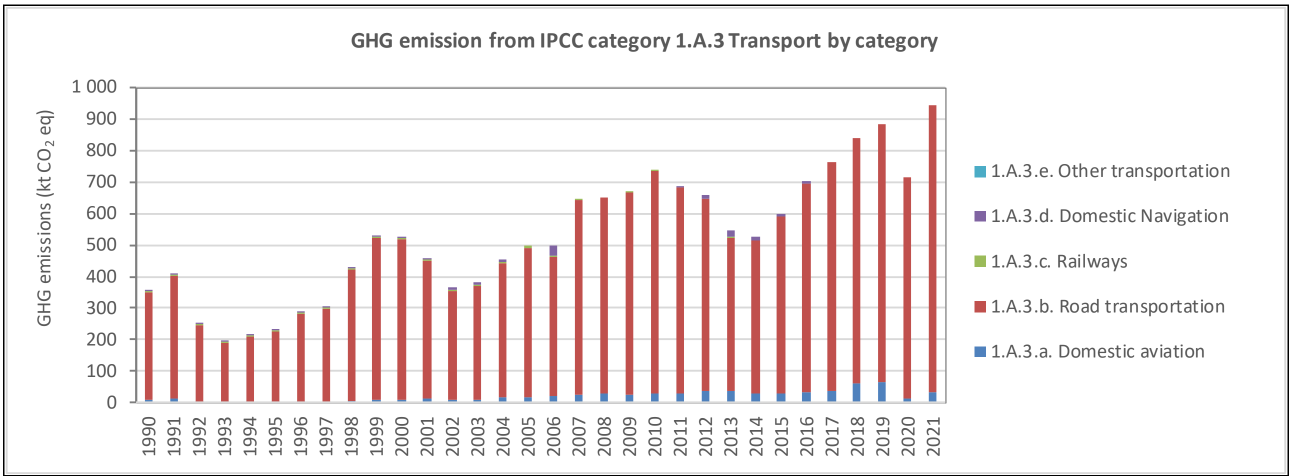


Figure 97 GHG Emissions from IPCC category 1.A.3 *Transport by category*

Figure 98 Emissions of CO2, CH4 and N2O from IPCC category 1.A.3 *Transport by category*

Table 188 GHG Emissions by gas from IPCC category 1.A.3 *Transport*

	Total GHG emissions	CO2 (excluding CO_2 from biomass)	CH4	N2O	Biomass (1)
1.A.3	**kt CO_2 eq**	**kt CO_2 eq**	**kt CO_2 eq**	**kt**	**kt**
1990	358.42	350.37	0.109	0.018	NO
1991	410.73	401.63	0.121	0.020	NO
1992	253.06	247.21	0.080	0.013	NO
1993	195.76	191.23	0.059	0.010	NO
1994	218.09	213.08	0.065	0.011	NO
1995	234.09	228.76	0.068	0.012	NO
1996	288.36	281.89	0.083	0.015	NO
1997	304.16	297.26	0.092	0.015	NO
1998	428.68	419.16	0.126	0.021	NO
1999	531.09	519.55	0.148	0.026	NO
2000	528.34	517.15	0.129	0.027	NO
2001	459.27	449.61	0.110	0.023	NO
2002	364.31	356.63	0.086	0.019	NO
2003	380.66	372.43	0.101	0.019	NO
2004	453.57	444.09	0.105	0.023	NO
2005	499.21	488.94	0.094	0.027	NO
2006	497.12	487.36	0.097	0.025	NO
2007	645.62	633.21	0.104	0.033	NO
2008	649.00	636.96	0.099	0.032	NO
2009	669.56	656.48	0.118	0.034	NO
2010	737.62	723.61	0.112	0.038	NO
2011	682.71	670.37	0.087	0.034	NO
2012	658.64	646.82	0.078	0.033	NO
2013	546.95	536.81	0.068	0.028	NO
2014	524.88	515.16	0.089	0.025	NO
2015	599.47	588.45	0.097	0.029	NO
2016	704.82	692.03	0.104	0.034	NO
2017	761.76	748.01	0.108	0.037	NO
2018	838.52	823.62	0.110	0.041	NO
2019	883.29	867.61	0.115	0.043	NO
2020	713.46	700.68	0.091	0.035	NO
2021	943.65	926.76	0.122	0.046	NO
Trend					
1990 - 2021	*163.3%*	*164.5%*	*12.18%*	*159.67%*	*NA*
2005 - 2021	*89.0%*	*89.5%*	*30.33%*	*74.64%*	*NA*
2020 - 2021	*32.3%*	*32.3%*	*34.08%*	*31.78%*	*NA*

Note: (1) Emissions of CO_2 from biomass fuels are estimated and reported in sector Land use, Land use Change and Forestry (LULUCF) as part of the as part of net changes in carbon stocks. Therefore emissions from combustion of biofuels are reported as **information items** but **not included in the sectoral or national totals** to avoid double counting.

Table 189 CO_2 Emissions from IPCC category 1.A.3 *Transport* by category

CO_2	CO_2 emissions (excluding CO_2 from biomass)						CO2 from Biomass from Transport (1)
	1.A.3 Transport	1.A.3.a. Domestic aviation	1.A.3.b. Road transportation	1.A.3.c. Railways	1.A.3.d. Domestic Navigation	1.A.3.e. Other transportation	
	kt	kt	kt	kt	kt	kt	kt
1990	350.37	10.42	333.48	3.16	3.30	NO	NO
1991	401.63	11.48	383.68	3.16	3.30	NO	NO
1992	247.21	1.60	239.14	3.16	3.30	NO	NO
1993	191.23	0.80	183.96	3.16	3.30	NO	NO
1994	213.08	0.80	205.81	3.16	3.30	NO	NO
1995	228.76	0.80	221.49	3.16	3.30	NO	NO
1996	281.89	0.80	274.62	3.16	3.30	NO	NO
1997	297.26	0.80	289.99	3.16	3.30	NO	NO
1998	419.16	4.01	408.69	3.16	3.30	NO	NO
1999	519.55	10.42	502.66	3.16	3.30	NO	NO
2000	517.15	10.42	498.64	3.80	4.30	NO	NO
2001	449.61	12.82	428.01	3.48	5.29	NO	NO
2002	356.63	7.05	340.47	3.16	5.95	NO	NO
2003	372.43	8.47	354.52	3.16	6.28	NO	NO
2004	444.09	15.26	419.08	3.80	5.95	NO	NO
2005	488.94	14.94	467.67	6.33	IE	NO	NO
2006	487.36	18.58	435.87	3.16	29.74	NO	NO
2007	633.21	23.27	606.77	3.16	IE	NO	NO
2008	636.96	26.72	610.24	NO	IE	NO	NO
2009	656.48	25.14	628.18	3.16	IE	NO	NO
2010	723.61	28.45	692.00	3.16	IE	NO	NO
2011	670.37	27.73	642.63	NO	0.00	NO	NO
2012	646.82	35.41	598.77	NO	12.64	NO	NO
2013	536.81	35.67	478.73	3.16	19.24	NO	NO
2014	515.16	27.43	478.01	NO	9.72	NO	NO
2015	588.45	28.54	550.19	NO	9.72	NO	NO
2016	692.03	30.92	651.39	NO	9.72	NO	NO
2017	748.01	37.31	710.70	NO	IE	NO	NO
2018	823.62	59.06	764.55	NO	IE	NO	NO
2019	867.61	63.64	803.97	NO	IE	NO	NO
2020	700.68	14.55	686.13	NO	IE	NO	NO
2021	926.76	32.55	894.21	NO	IE	NO	NO
Trend							
1990 - 2021	*164.5%*	*212.4%*	*168.1%*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*89.5%*	*117.9%*	*91.2%*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*32.3%*	*123.7%*	*30.3%*	*NA*	*NA*	*NA*	*NA*

Note: (1) Emissions of CO_2 from biomass fuels are estimated and reported in sector Land use, Land use Change and Forestry (LULUCF) as part of the as part of net changes in carbon stocks. Therefore emissions from combustion of biofuels are reported as **information items** but **not included in the sectoral or national totals** to avoid double counting.

Table 190 CH4 Emissions from IPCC category 1.A.3 *Transport* by category

CH4	CO_2 emissions (excluding CO_2 from biomass)						CO2 from Biomass from Transport (1)
	1.A.3 Transport	1.A.3.a. Domestic aviation	1.A.3.b. Road transportation	1.A.3.c. Railways	1.A.3.d. Domestic Navigation	1.A.3.e. Other transportation	
	kt	kt	kt	kt	kt	kt	kt
1990	0.1088	0.0004	0.1079	0.0002	0.0003	NO	NA
1991	0.1206	0.0004	0.1197	0.0002	0.0003	NO	NA
1992	0.0796	0.0001	0.0790	0.0002	0.0003	NO	NA
1993	0.0586	0.0000	0.0581	0.0002	0.0003	NO	NA
1994	0.0650	0.0000	0.0645	0.0002	0.0003	NO	NA
1995	0.0685	0.0000	0.0679	0.0002	0.0003	NO	NA
1996	0.0830	0.0000	0.0825	0.0002	0.0003	NO	NA
1997	0.0917	0.0000	0.0912	0.0002	0.0003	NO	NA
1998	0.1256	0.0002	0.1249	0.0002	0.0003	NO	NA
1999	0.1478	0.0004	0.1469	0.0002	0.0003	NO	NA
2000	0.1294	0.0004	0.1283	0.0002	0.0004	NO	NA
2001	0.1101	0.0005	0.1089	0.0002	0.0005	NO	NA
2002	0.0860	0.0003	0.0849	0.0002	0.0006	NO	NA
2003	0.1012	0.0003	0.1001	0.0002	0.0006	NO	NA
2004	0.1048	0.0006	0.1035	0.0002	0.0006	NO	NA
2005	0.0936	0.0006	0.0927	0.0004	IE	NO	NA
2006	0.0973	0.0007	0.0936	0.0002	0.0028	NO	NA
2007	0.1037	0.0009	0.1026	0.0002	IE	NO	NA
2008	0.0986	0.0010	0.0976	NO	IE	NO	NA
2009	0.1180	0.0010	0.1168	0.0002	IE	NO	NA
2010	0.1123	0.0011	0.1110	0.0002	IE	NO	NA
2011	0.0872	0.0011	0.0862	NO	0.0000	NO	NA
2012	0.0779	0.0014	0.0760	NO	0.0006	NO	NA
2013	0.0685	0.0014	0.0658	0.0002	0.0012	NO	NA
2014	0.0895	0.0011	0.0877	NO	0.0007	NO	NA
2015	0.0974	0.0011	0.0956	NO	0.0007	NO	NA
2016	0.1041	0.0012	0.1022	NO	0.0007	NO	NA
2017	0.1082	0.0014	0.1067	NO	IE	NO	NA
2018	0.1103	0.0023	0.1080	NO	IE	NO	NA
2019	0.1150	0.0024	0.1126	NO	IE	NO	NA
2020	0.0910	0.0006	0.0904	NO	IE	NO	NA
2021	0.1220	0.0013	0.1207	NO	NE	NO	NA
Trend							
1990 - 2021	*12.2%*	*212.4%*	*11.9%*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*30.3%*	*117.9%*	*30.3%*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*34.1%*	*123.7%*	*33.5%*	*NA*	*NA*	*NA*	*NA*

Note: (1) Emissions of CO_2 from biomass fuels are estimated and reported in sector Land use, Land use Change and Forestry (LULUCF) as part of the as part of net changes in carbon stocks. Therefore emissions from combustion of biofuels are reported as **information items** but **not included in the sectoral or national totals** to avoid double counting.

Table 191 N2O Emissions from IPCC category 1.A.3 *Transport* by category

N2O	CO_2 emissions (excluding CO_2 from biomass)						CO2 from Biomass from Transport (1)
	1.A.3 Transport	1.A.3.a. Domestic aviation	1.A.3.b. Road transportation	1.A.3.c. Railways	1.A.3.d. Domestic Navigation	1.A.3.e. Other transportation	
	kt	kt	kt	kt	kt	kt	kt
1990	0.0179	0.0004	0.0162	0.0012	0.0001	NO	NA
1991	0.0204	0.0004	0.0187	0.0012	0.0001	NO	NA
1992	0.0129	0.0001	0.0116	0.0012	0.0001	NO	NA
1993	0.0103	0.0000	0.0089	0.0012	0.0001	NO	NA
1994	0.0114	0.0000	0.0100	0.0012	0.0001	NO	NA
1995	0.0121	0.0000	0.0108	0.0012	0.0001	NO	NA
1996	0.0148	0.0000	0.0134	0.0012	0.0001	NO	NA
1997	0.0154	0.0000	0.0141	0.0012	0.0001	NO	NA
1998	0.0214	0.0002	0.0199	0.0012	0.0001	NO	NA
1999	0.0263	0.0004	0.0246	0.0012	0.0001	NO	NA
2000	0.0267	0.0004	0.0247	0.0015	0.0001	NO	NA
2001	0.0232	0.0005	0.0212	0.0013	0.0001	NO	NA
2002	0.0185	0.0003	0.0169	0.0012	0.0002	NO	NA
2003	0.0191	0.0003	0.0174	0.0012	0.0002	NO	NA
2004	0.0230	0.0006	0.0208	0.0015	0.0002	NO	NA
2005	0.0266	0.0006	0.0236	0.0024	IE	NO	NA
2006	0.0246	0.0007	0.0219	0.0012	0.0008	NO	NA
2007	0.0330	0.0009	0.0309	0.0012	IE	NO	NA
2008	0.0321	0.0010	0.0311	NO	IE	NO	NA
2009	0.0340	0.0010	0.0318	0.0012	IE	NO	NA
2010	0.0376	0.0011	0.0353	0.0012	IE	NO	NA
2011	0.0341	0.0011	0.0330	NO	0.0000	NO	NA
2012	0.0331	0.0014	0.0308	NO	0.0009	NO	NA
2013	0.0283	0.0014	0.0246	0.0012	0.0011	NO	NA
2014	0.0251	0.0011	0.0236	NO	0.0005	NO	NA
2015	0.0288	0.0011	0.0272	NO	0.0005	NO	NA
2016	0.0342	0.0012	0.0326	NO	0.0005	NO	NA
2017	0.0371	0.0014	0.0356	NO	IE	NO	NA
2018	0.0407	0.0023	0.0385	NO	IE	NO	NA
2019	0.0430	0.0024	0.0405	NO	IE	NO	NA
2020	0.0352	0.0006	0.0347	NO	IE	NO	NA
2021	0.0464	0.0013	0.0452	NO	NE	NO	NA
Trend							
1990 - 2021	*159.7%*	*212.4%*	*179.4%*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*74.6%*	*117.9%*	*91.7%*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*31.8%*	*123.7%*	*30.3%*	*NA*	*NA*	*NA*	*NA*

Note: (1) Emissions of CO_2 from biomass fuels are estimated and reported in sector Land use, Land use Change and Forestry (LULUCF) as part of the as part of net changes in carbon stocks. Therefore emissions from combustion of biofuels are reported as **information items** but **not included in the sectoral or national totals** to avoid double counting.

3.2.7.2 Domestic aviation (IPCC category 1.A.3.a.ii)

3.2.7.2.1 Category description

As described in the 2006 IPCC Guidelines, the IPCC category 1.A.3.a.ii *Domestic Aviation* includes emissions from flights that depart in one country and arrive in the same country. Also, *Domestic Aviation* include IPCC category 1.A.3.a.ii take-offs and landings for these flight stages. It is *good practice*, that emissions from *Domestic Aviation* are reported separately from *Domestic aviation* and it it is *good practice* to apply the definition presented in the following table.

Table 192 Criteria for defining international and domestic *Aviation*

Criteria for defining international or domestic navigation (applies to individual legs of journeys with more than one take-off and landing)		
Journey type between two airports	**Domestic**	**International**
• Departs and arrives in same country	Yes	No
• Departs from one country and arrives in another	No	Yes
Source: 2006 IPCC Guidelines, Volume 2, Chapter 3: Mobile Combustion, 3.6.1.3 Choice of activity data, TABLE 3.6.		

This section describes GHG emissions resulting from fuel combustion in *Domestic Aviation* (IPCC category 1.A.3.a.ii).

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.3.a.ii	✓	NA	NA	NA	NA	NO	✓	NA	NA	NA	NA	NO	✓	NA	NA	NA	NA	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																		
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF																		

Domestic aviation includes domestic flights and Landing and Take Off Cycle (LTO) from international flights. No domestic flights occurred in the period 1990-2021 in Montenegro.

The greenhouse gas emissions from IPCC category 1.A.3.a.ii *Domestic aviation* amounted to 10.55 kt CO_2 equivalents in 1990, 15.13 kt CO_2 equivalents in 2005, and 32.95 kt CO_2 equivalents in 2021.

The overall trend in GHG emissions from the IPCC category 1.A.3.a.ii Domestic aviation shows an increase by 212.4% from 1990 to 2021 and an increase by 117.9% from 2005 to 2021.

Due to the worldwide COVID pandemic and the lockdown a decrease from 2020 to 2021 could be observed, whereas from 2020 to 2021 an increase by 123.7% could be observed.

GHG emissions from *Domestic aviation* increased in the period 1990 – 2021, which is mainly caused by increasing activities in passenger and freight transport.

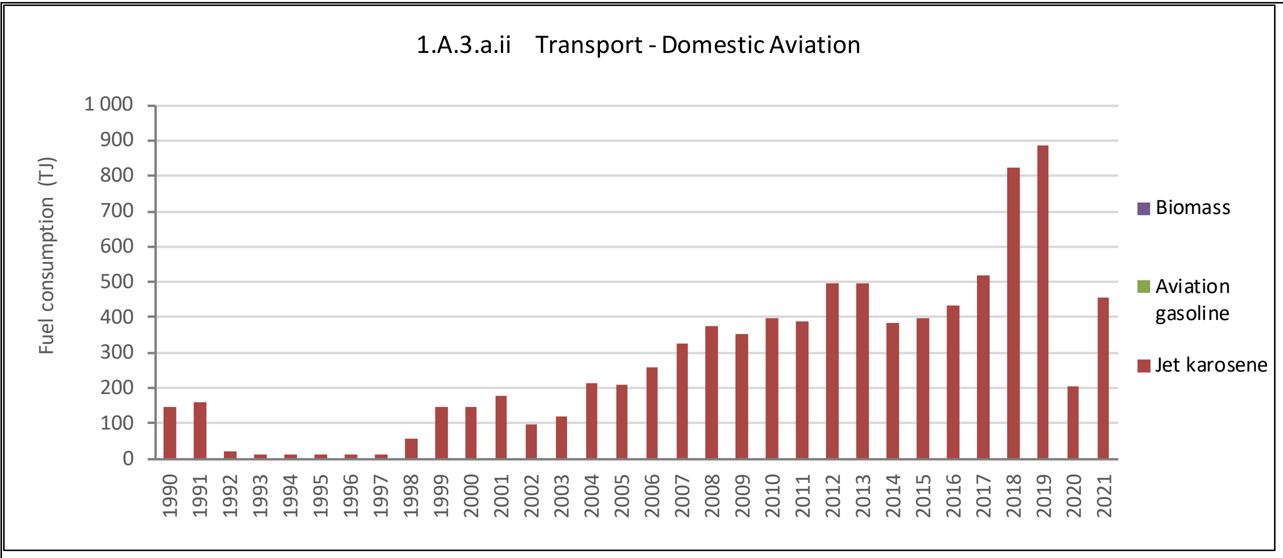


Figure 99 GHG emissions from IPCC category 1.A.3.a.ii Domestic aviation (domestic flights and LTO cycle)

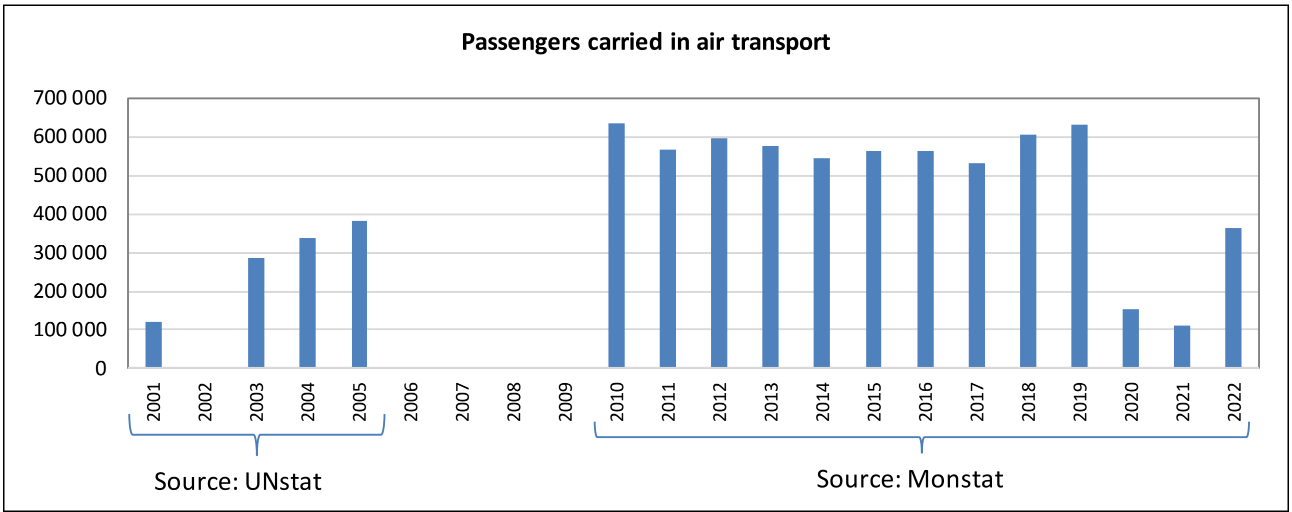


Figure 100 Passengers carried in air transport; sources UNstat and MONSTAT

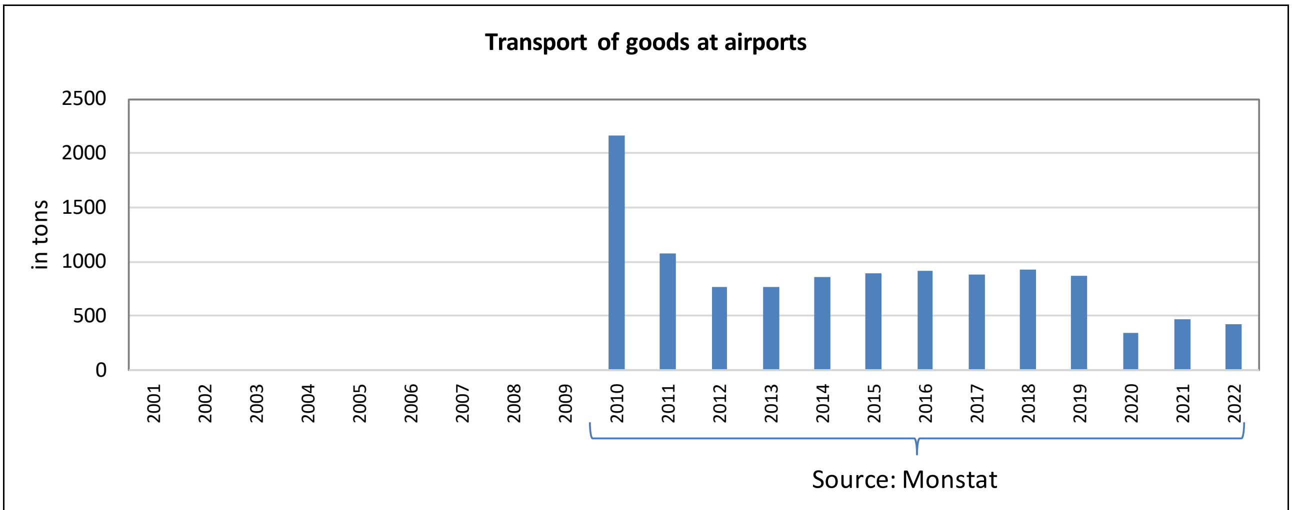


Figure 101 Transport of goods at airports; source MONSTAT

Table 193 Activity data and Emissions from *IPCC category 1.A.3.a.ii Domestic aviation (domestic flights and LTO cycle)*

1.A.3.a.ii Domestic aviation	Emissions				Activity data	
	GHG	CO_2	N_2O	CH_4	Jet Kerosene	Aviation fuel
	kt CO_2 equivalent	kt			[TJ]	
1990	10.55	10.42	0.0004	0.0004	145.33	NO
1991	11.62	11.48	0.0004	0.0004	160.14	NO
1992	1.62	1.60	0.0001	0.0001	22.36	NO
1993	0.81	0.80	0.0000	0.0000	11.18	NO
1994	0.81	0.80	0.0000	0.0000	11.18	NO
1995	0.81	0.80	0.0000	0.0000	11.18	NO
1996	0.81	0.80	0.0000	0.0000	11.18	NO
1997	0.81	0.80	0.0000	0.0000	11.18	NO
1998	4.06	4.01	0.0002	0.0002	55.90	NO
1999	10.55	10.42	0.0004	0.0004	145.33	NO
2000	10.55	10.42	0.0004	0.0004	145.33	NO
2001	12.98	12.82	0.0005	0.0005	178.87	NO
2002	7.14	7.05	0.0003	0.0003	98.39	NO
2003	8.57	8.47	0.0003	0.0003	118.09	NO
2004	15.45	15.26	0.0006	0.0006	212.92	NO
2005	15.13	14.94	0.0006	0.0006	208.39	NO
2006	18.82	18.58	0.0007	0.0007	259.24	NO
2007	23.56	23.27	0.0009	0.0009	324.55	NO
2008	27.05	26.72	0.0010	0.0010	372.75	NO
2009	25.45	25.14	0.0010	0.0010	350.67	NO
2010	28.80	28.45	0.0011	0.0011	396.80	NO
2011	28.08	27.73	0.0011	0.0011	386.86	NO
2012	35.85	35.41	0.0014	0.0014	493.88	NO
2013	36.11	35.67	0.0014	0.0014	497.51	NO
2014	27.77	27.43	0.0011	0.0011	382.65	NO
2015	28.90	28.54	0.0011	0.0011	398.14	NO
2016	31.30	30.92	0.0012	0.0012	431.25	NO
2017	37.77	37.31	0.0014	0.0014	520.40	NO
2018	59.80	59.06	0.0023	0.0023	823.88	NO
2019	64.43	63.64	0.0024	0.0024	887.67	NO
2020	14.73	14.55	0.0006	0.0006	202.95	NO
2021	32.95	32.55	0.0013	0.0013	454.03	NO
Trend						
1990 - 2021	212.4%	212.4%	212.4%	212.4%	212.4%	NA
2005 - 2021	117.9%	117.9%	117.9%	117.9%	117.9%	NA
2020 - 2021	123.7%	123.7%	123.7%	123.7%	123.7%	NA

3.2.7.2.2 Methodological issues

3.2.7.2.2.1 Choice of methods – TIER 1

For estimating the CO_2, CH_4 and N_2O emissions the 2006 IPCC Guidelines Tier 1 approach[63] has been applied:

Equation 3.6.1: Aviation equation (2006 IPCC GL, Vol. 3, Chap. 3.6.1.1)

$$\boldsymbol{Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}}$$

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG} = \sum_{fuel} emissions_{\mathbf{GHG,\,fuel}}}$$

Where:

Emissions $_{GHG,\,fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG,\,fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ)
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, e.g. jet kersosene, aviation gasoline

3.2.7.2.2.2 Choice of activity data

The following fuels are used in *Domestic aviation*:

Liquid fuels:
- Jet Kerosene

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 – 2021 were taken from MONSTAT. Activity data are provided in the tables above.

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic meters. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC category *Domestic aviation* are provided.

Table 194 Net calorific values (NCVs) and Conversion factors applied for conversion to energy units in IPCC category IPCC category 1.A.3.a.ii *Domestic aviation*

Fuel type	Fuel	Unit	Net calorific value (NCV)	
			Country specific (CS) NCV	2006 IPCC default NCV *
liquid	Jet Kerosene	TJ / Gg	43.96	44.1
			MONSTAT	2006 IPCC Guidelines, Vol. 2, Chap. 1 (1.4.1.3), Table 1.2

Note:		
D Default	CS Country specific	PS Plant specific
* For comparision		

[63] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 3: Mobile Combustion - 3.6.1.1 Methodological issues - Choice of method

3.2.7.2.2.3 Choice of emission factors

Default emission factors for CO_2, CH_4 and N_2O for Jet Kerosene were taken from EMEP/EEA GB 2019 and are presented in the following table.

Table 195 Fuel consumption factor for LTO and cruise for IPCC category 1.A.3.a.ii *Domestic aviation*

Fuel type	Fuel	Fuels consumption for LTO (kg/LTO)		Fuels consumption for cruise (kg/LTO)
		EF	type	EF
liquid	Jet Kerosene - LTO	825	D	-
liquid	Jet Kerosene - Cruise	-	D	Difference (Fuel_consumed - Fuel for LTO`s)
Source	EMEP/EEA GB 2019, Chapter Aviation 1.A.3.a, Page 18 Table 3–3 Emission factors and fuel use for the Tier 1 methodology using jet kerosene as fuel."			

Table 196 GHG Emission factors TIER 1 for IPCC category 1.A.3.a.ii *Domestic aviation*

Fuel type	Fuel	CO_2 (t/LTO)		CH_4 (t/LTO)		N_2O (t/LTO)	
		EF	type	EF	type	EF	type
liquid	Jet Kerosene	2.6	D	0.0001	D	0.0001	D
Source	EMEP/EEA GB 2019, Chapter Aviation 1.A.3.a Table 3–3 Emission factors and fuel use for the Tier 1 methodology using jet kerosene as fuel.						
Note:							
D Default		CS Country specific		PS Plant specific		IEF Implied emission factor	

3.2.7.2.3 Uncertainty assessment and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category IPCC category 1.A.3.a.ii *Domestic aviation* are presented in the following table.

Table 197 Uncertainty for IPCC category 1.A.3.a.ii *Domestic aviation.*

Uncertainty	Jet Kerosene			Reference
	CO_2	CH_4	N_2O	
Activity data (AD)	10%	10%	10%	2006 IPCC GL, Vol. 2, Chap. 3.6.1.7
Emission factor (EF)	5%	82%	133%	
Combined Uncertainty (U)	11%	83%	133%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period.

3.2.7.2.4 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- o consistent use of energy balance data (preparation of a time series),
- o documented sources,
- o use of units and conversion factors,
- o strictly defined interfaces between spreadsheets/calculation modules,
- o unique structure of sheets which do the same,
- o record keeping, use of write protection,
- o unique use of formulas, special cases are documented/highlighted,
- o quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from different sources:
- o national statistic published by MONSTAT and information from 'Airports of Montenegro'[64]
- o international energy statistics of UN statistics[65] and
- o Eurostat[66]

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.7.2.5 Category-specific recalculations including explanatory information and justifications for recalculations

The following table presents the main revisions and recalculations done since the last two submission to the UNFCCC and relevant to IPCC category IPCC category 1.A.3.a.ii *Domestic aviation.*

Table 198 Recalculations done since NC in IPCC category 1.A.3.a.ii *Domestic aviation*

Source category	Revisions of data	Type of revision	Type of improvement
1.3.1.a.ii	Application of 2006 IPCC Guidelines methodology and estimation of GHG emissions	EMI	Comparability Completeness

3.2.7.2.6 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 199 Planned improvements for IPCC category 1.A.3.a.ii *Domestic aviation*

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.3.a.i 1.A.3.a.ii	Energy balance (1990-2021) for all aviation related fuels • improvement of time series completeness and consistency (consumption and production, NCV, carbon content)	AD	Accuracy Completeness Comparability Transparency	high

[64] https://montenegroairports.com/en/airports-of-montenegro/business-information/statistical-data/

[65] United Nations - Department of Economic and Social Affairs - Statistics Division Statistics - Energy Statistics https://unstats.un.org/unsd/energystats/

[66] Data and statistics - https://ec.europa.eu/eurostat/web/main/data/database

GHG source & sink category	Planned improvement	Type of improvement		Priority
	• for all aviation related fuels o Jet kerosene o aviation gasoline • Investigation regarding fuel consumption of aviation gasoline used by small planes and helicopters.		Consistency	
1.A.3.a.i 1.A.3.a.ii	Collection of data on aircraft movement • international aviation by air craft and destination • domestic aviation by air craft and destination	AD	Accuracy Completeness Comparability Transparency	medium
1.A.3.a.i 1.A.3.a.ii	Application of Tier 3 methodology using data on aircraft movement • Estimate fuel consumption for LTO and cruise for o *International aviation* o domestic aviation • Estimate emissions from LTO and cruise phases for o *International aviation* o domestic *aviation*	M EF	Accuracy Completeness Comparability Transparency Consistency	medium
1.A.3.a.i 1.A.3.a.ii	Investigation regarding fuel consumption from domestic and international military aviation.	AD	Completeness	Medium

3.2.7.3 Road transportation (IPCC category 1.A.3.b)

3.2.7.3.1 Category description

This section describes GHG emissions resulting from fuel combustion in Road Transport (IPCC category 1.A.3.b). The mobile GHG source & sink category *Road Transportation* includes all types of vehicles such as light-duty vehicles such as automobiles and light trucks, and heavy-duty vehicles such as tractor trailers and buses, and on-road motorcycles (including mopeds, scooters, and three-wheelers).

IPCC category	description
1.A.3.b	Road Transportation
1.A.3.b.i	Cars
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

	CO_2							CH_4							N_2O						
Estimated	Gasoline	Diesel oil	LPG	Other liquid fuels	Gaseous fuels	Biomass	Other fossil fuels	Gasoline	Diesel oil	LPG	Other liquid fuels	Gaseous fuels	Biomass	Other fossil fuels	Gasoline	Diesel oil	LPG	Other liquid fuels	Gaseous fuels	Biomass	Other fossil fuels
1.A.3.b (i-iv)	✓	✓	✓	NO	NO	NO	NO	✓	✓	✓	NO	NO	NO	NO	✓	✓	✓	NO	NO	NO	NO
1.A.3.b.v	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.A.3.b.vi	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Key category																					
1.A.3.b (i-iv)																					
1.A.3.b.v																					
1.A.3.b.vi																					
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential																					
Key Category: LA – Level Assessment (in year); TA – Trend Assessment																					

An overview of the GHG emission from fuel combustion in IPCC category 1.A.3.b *Road transport* is provided in the following figures and tables:

- annual GHG emissions;
- Trend of the periods 2010 – 2020, 2019 – 2020.

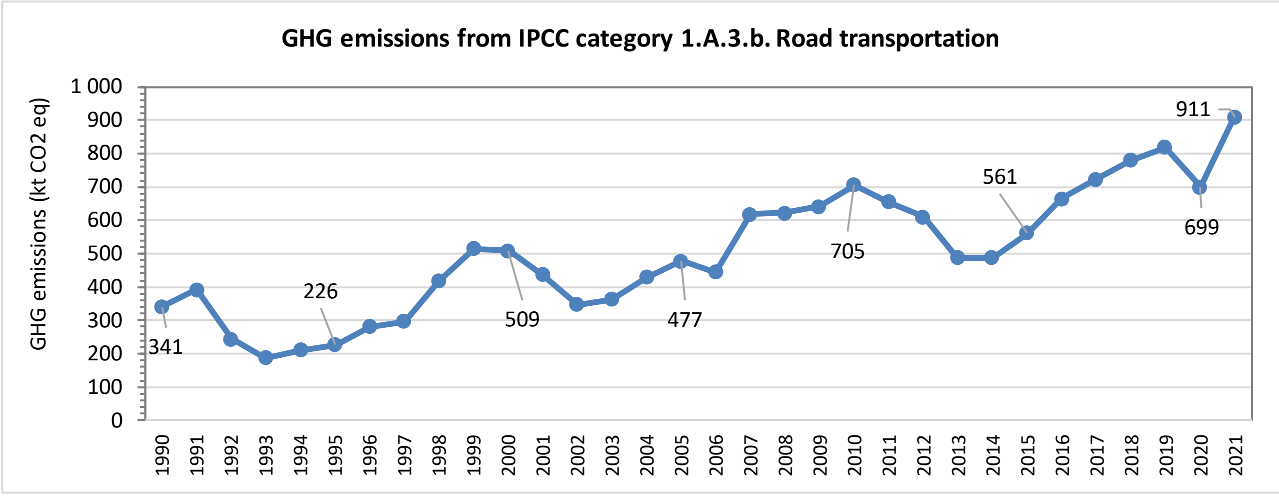


Figure 102 **GHG emissions from IPCC category 1.A.3.b Road transportation**

The greenhouse gas emissions from IPCC category 1.A.3.b *Road transport* increased by 167.1% from 341.00 kt CO_2 equivalent in 1990 to 910.70 kt CO_2 equivalent in 2021. Furthermore, the GHG emissions increased by 90.9% from 477.01 kt CO_2 equivalent (2005). The significant increase of GHG emissions is a result of growing mobility within cities but also between cities, growing freight transport due to increased national production but also due to imports and exports. This development is also reflected in the transport fleet, which is shown in the following figure.

In the period 2020 to 2021 GHG emissions from the IPCC category 1.A.3.b *Road transport* increased by 30.3% from 698.73 kt CO_2 equivalent in 2020 to 910.70 kt CO_2 equivalent in 2021 as a result after the nationwide lockdown due to the covid pandemic.

In 2021 about 76.9% of the registered road motor vehicles and trailers are fulling up gas/diesel oil.

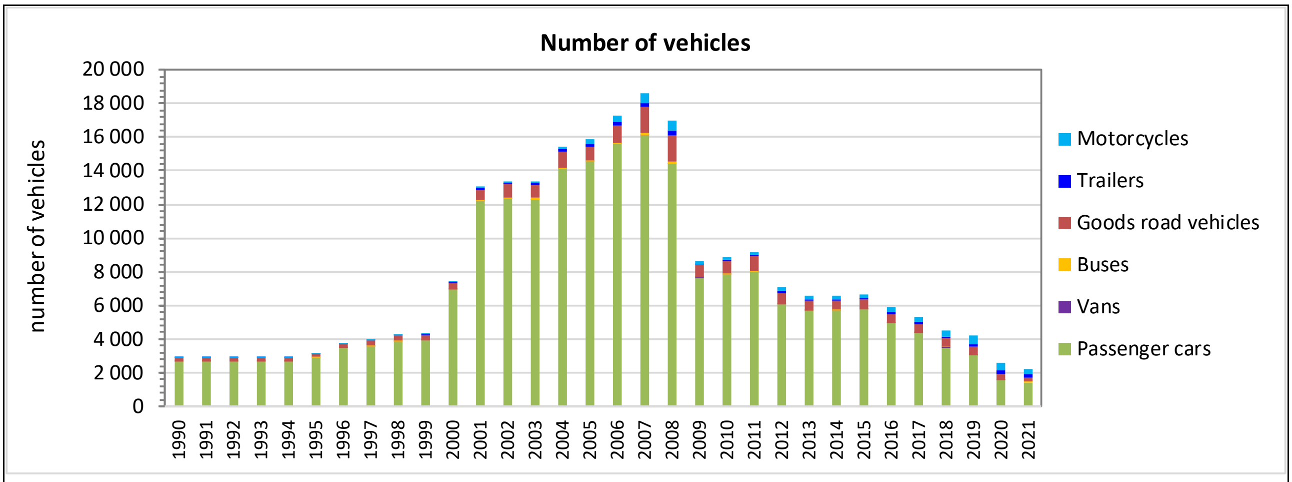


Figure 103 **Number of vehicles by vehicle category; Source MONSTAT**

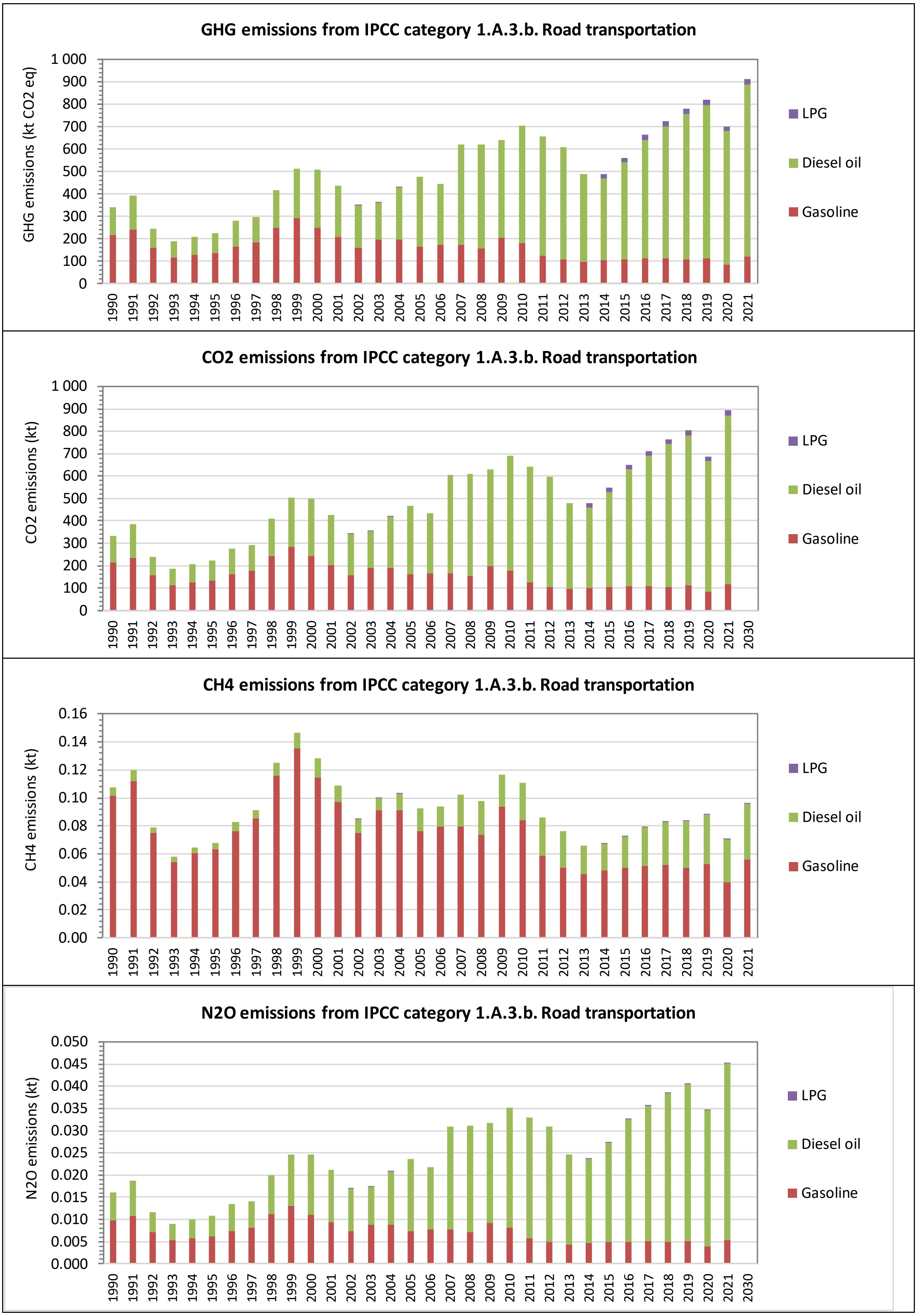


Figure 104 CH_4 emissions from IPCC category 1.A.3.b Road transportation

Table 200 GHG Emissions by fuels from IPCC category 1.A.3.b Road transportation

GHG	Total GHG emissions (excluding CO_2 from biomass)	GHG emission from						
		Gasoline	Diesel oil	LPG	Other liquid fuels	Gaseous fuels	Other fossil fuels	Biomass (1)
	kt CO_2 equivalent							
1990	341.00	218.69	122.31	NO	NO	NO	NO	NO
1991	392.24	240.96	151.27	NO	NO	NO	NO	NO
1992	244.56	160.88	83.68	NO	NO	NO	NO	NO
1993	188.08	117.27	70.81	NO	NO	NO	NO	NO
1994	210.41	129.95	80.47	NO	NO	NO	NO	NO
1995	226.41	136.28	90.12	NO	NO	NO	NO	NO
1996	280.68	164.81	115.87	NO	NO	NO	NO	NO
1997	296.48	183.82	112.65	NO	NO	NO	NO	NO
1998	417.75	250.38	167.37	NO	NO	NO	NO	NO
1999	513.67	291.58	222.08	NO	NO	NO	NO	NO
2000	509.21	247.21	262.00	NO	NO	NO	NO	NO
2001	437.06	209.18	227.88	NO	NO	NO	NO	NO
2002	347.62	161.64	185.71	0.27	NO	NO	NO	NO
2003	362.21	196.50	165.44	0.27	NO	NO	NO	NO
2004	427.87	196.50	231.10	0.27	NO	NO	NO	NO
2005	477.01	164.81	312.21	NO	NO	NO	NO	NO
2006	444.73	171.15	273.58	NO	NO	NO	NO	NO
2007	618.53	171.15	447.39	NO	NO	NO	NO	NO
2008	621.95	158.47	463.48	NO	NO	NO	NO	NO
2009	640.57	202.84	437.73	NO	NO	NO	NO	NO
2010	705.29	180.66	524.63	NO	NO	NO	NO	NO
2011	654.63	126.78	527.85	NO	NO	NO	NO	NO
2012	609.86	107.76	502.10	NO	NO	NO	NO	NO
2013	487.70	98.25	389.45	NO	NO	NO	NO	NO
2014	487.24	104.59	363.70	18.94	NO	NO	NO	NO
2015	560.70	107.76	431.29	21.65	NO	NO	NO	NO
2016	663.65	110.93	531.07	21.65	NO	NO	NO	NO
2017	723.98	112.20	589.33	22.46	NO	NO	NO	NO
2018	778.72	107.76	648.23	22.73	NO	NO	NO	NO
2019	818.86	113.78	682.35	22.73	NO	NO	NO	NO
2020	698.73	85.26	594.80	18.67	NO	NO	NO	NO
2021	910.70	120.754	766.674	23.272	NO	NO	NO	NO
Trend								
1990 - 2021	167.1%	-44.8%	526.8%	NA	NA	NA	NA	NA
2005 - 2021	90.9%	-26.7%	145.6%	NA	NA	NA	NA	NA
2020 - 2021	30.3%	41.6%	28.9%	24.6%	NA	NA	NA	NA

(1) Emissions of CO_2 from biomass fuels are estimated and reported in sector Land use, Land use Change and Forestry (LULUCF) as part of the as part of net changes in carbon stocks. Therefore emissions from combustion of biofuels are reported as **information items** but **not included in the sectoral or national totals** to avoid double counting.

Table 201 CO_2 Emissions by fuels from IPCC category 1.A.3.b Road transportation

CO_2	Total GHG emissions (excluding CO_2 from biomass)	CO_2 emission from						
		Gasoline	Diesel oil	LPG	Other liquid fuels	Gaseous fuels	Other fossil fuels	Biomass (1)
	kt							
1990	333.48	213.22	120.26	NO	NO	NO	NO	NO
1991	383.68	234.93	148.75	NO	NO	NO	NO	NO
1992	239.14	156.85	82.29	NO	NO	NO	NO	NO
1993	183.96	114.33	69.63	NO	NO	NO	NO	NO
1994	205.81	126.69	79.12	NO	NO	NO	NO	NO
1995	221.49	132.87	88.61	NO	NO	NO	NO	NO
1996	274.62	160.68	113.93	NO	NO	NO	NO	NO
1997	289.99	179.23	110.77	NO	NO	NO	NO	NO
1998	408.69	244.12	164.57	NO	NO	NO	NO	NO
1999	502.66	284.29	218.37	NO	NO	NO	NO	NO
2000	498.64	241.03	257.62	NO	NO	NO	NO	NO
2001	428.01	203.95	224.07	NE	NO	NO	NO	NO
2002	340.47	157.59	182.61	0.26	NO	NO	NO	NO
2003	354.52	191.59	162.67	0.26	NO	NO	NO	NO
2004	419.08	191.59	227.23	0.26	NO	NO	NO	NO
2005	467.67	160.68	306.99	NE	NO	NO	NO	NO
2006	435.87	166.86	269.01	NE	NO	NO	NO	NO
2007	606.77	166.86	439.91	NE	NO	NO	NO	NO
2008	610.24	154.50	455.73	NE	NO	NO	NO	NO
2009	628.18	197.77	430.41	NE	NO	NO	NO	NO
2010	692.00	176.13	515.86	NE	NO	NO	NO	NO
2011	642.63	123.60	519.03	NE	NO	NO	NO	NO
2012	598.77	105.06	493.71	NE	NO	NO	NO	NO
2013	478.73	95.79	382.94	NE	NO	NO	NO	NO
2014	478.01	101.97	357.62	18.41	NO	NO	NO	NO
2015	550.19	105.06	424.08	21.04	NO	NO	NO	NO
2016	651.39	108.15	522.19	21.04	NO	NO	NO	NO
2017	710.70	109.39	579.48	21.83	NO	NO	NO	NO
2018	764.55	105.06	637.39	22.10	NO	NO	NO	NO
2019	803.97	110.93	670.94	22.10	NO	NO	NO	NO
2020	686.13	83.12	584.86	18.15	NO	NO	NO	NO
2021	894.21	117.73	753.86	22.62	NO	NO	NO	NO
Trend								
1990 - 2021	*168.1%*	*-44.8%*	*526.8%*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*91.2%*	*-26.7%*	*145.6%*	*NA*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*30.3%*	*41.6%*	*28.9%*	*24.6%*	*NA*	*NA*	*NA*	*NA*

(1) Emissions of CO_2 from biomass fuels are estimated and reported in sector Land use, Land use Change and Forestry (LULUCF) as part of the as part of net changes in carbon stocks. Therefore emissions from combustion of biofuels are reported as **information items** but **not included in the sectoral or national totals** to avoid double counting.

Table 202 N_2O Emissions by fuels from IPCC category 1.A.3.b Road transportation

N_2O	Total GHG emissions	N_2O emissions from						
		Gasoline	Diesel oil	LPG	Other liquid fuels	Gaseous fuels	Other fossil fuels	Biomass
	kt							
1990	0.0162	0.0098	0.0063	NO	NO	NO	NO	NO
1991	0.0187	0.0108	0.0078	NO	NO	NO	NO	NO
1992	0.0116	0.0072	0.0043	NO	NO	NO	NO	NO
1993	0.0089	0.0053	0.0037	NO	NO	NO	NO	NO
1994	0.0100	0.0059	0.0042	NO	NO	NO	NO	NO
1995	0.0108	0.0061	0.0047	NO	NO	NO	NO	NO
1996	0.0134	0.0074	0.0060	NO	NO	NO	NO	NO
1997	0.0141	0.0083	0.0058	NO	NO	NO	NO	NO
1998	0.0199	0.0113	0.0087	NO	NO	NO	NO	NO
1999	0.0246	0.0131	0.0115	NO	NO	NO	NO	NO
2000	0.0247	0.0111	0.0136	NO	NO	NO	NO	NO
2001	0.0212	0.0094	0.0118	NE	NO	NO	NO	NO
2002	0.0169	0.0073	0.0096	<0.0001	NO	NO	NO	NO
2003	0.0174	0.0088	0.0086	<0.0001	NO	NO	NO	NO
2004	0.0208	0.0088	0.0120	<0.0001	NO	NO	NO	NO
2005	0.0236	0.0074	0.0162	NE	NO	NO	NO	NO
2006	0.0219	0.0077	0.0142	NE	NO	NO	NO	NO
2007	0.0309	0.0077	0.0232	NE	NO	NO	NO	NO
2008	0.0311	0.0071	0.0240	NE	NO	NO	NO	NO
2009	0.0318	0.0091	0.0227	NE	NO	NO	NO	NO
2010	0.0353	0.0081	0.0272	NE	NO	NO	NO	NO
2011	0.0330	0.0057	0.0273	NE	NO	NO	NO	NO
2012	0.0308	0.0049	0.0260	NE	NO	NO	NO	NO
2013	0.0246	0.0044	0.0202	NE	NO	NO	NO	NO
2014	0.0236	0.0047	0.0188	0.0001	NO	NO	NO	NO
2015	0.0272	0.0049	0.0223	0.0001	NO	NO	NO	NO
2016	0.0326	0.0050	0.0275	0.0001	NO	NO	NO	NO
2017	0.0356	0.0051	0.0305	0.0001	NO	NO	NO	NO
2018	0.0385	0.0049	0.0335	0.0001	NO	NO	NO	NO
2019	0.0405	0.0051	0.0353	0.0001	NO	NO	NO	NO
2020	0.0347	0.0038	0.0308	0.0001	NO	NO	NO	NO
2021	0.0452	0.0054	0.0397	0.0001	NO	NO	NO	NO
Trend								
1990 - 2021	*179.4%*	*-44.8%*	*526.8%*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*91.7%*	*-26.7%*	*145.6%*	*NA*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*30.3%*	*41.6%*	*28.9%*	*24.6%*	*NA*	*NA*	*NA*	*NA*

Table 203 CH_4 Emissions by fuels from IPCC category 1.A.3.b Road transportation

CH_4	Total GHG emissions	CH_4 emissions from						
		Gasoline	Diesel oil	LPG	Other liquid fuels	Gaseous fuels	Other fossil fuels	Biomass
	kt							
1990	0.108	0.102	0.006	NO	NO	NO	NO	NO
1991	0.120	0.112	0.008	NO	NO	NO	NO	NO
1992	0.079	0.075	0.004	NO	NO	NO	NO	NO
1993	0.058	0.054	0.004	NO	NO	NO	NO	NO
1994	0.064	0.060	0.004	NO	NO	NO	NO	NO
1995	0.068	0.063	0.005	NO	NO	NO	NO	NO
1996	0.083	0.077	0.006	NO	NO	NO	NO	NO
1997	0.091	0.085	0.006	NO	NO	NO	NO	NO
1998	0.125	0.116	0.009	NO	NO	NO	NO	NO
1999	0.147	0.135	0.011	NO	NO	NO	NO	NO
2000	0.128	0.115	0.014	NO	NO	NO	NO	NO
2001	0.109	0.097	0.012	NE	NO	NO	NO	NO
2002	0.085	0.075	0.010	<0.001	NO	NO	NO	NO
2003	0.100	0.091	0.009	<0.001	NO	NO	NO	NO
2004	0.103	0.091	0.012	<0.001	NO	NO	NO	NO
2005	0.093	0.077	0.016	NE	NO	NO	NO	NO
2006	0.094	0.079	0.014	NE	NO	NO	NO	NO
2007	0.103	0.079	0.023	NE	NO	NO	NO	NO
2008	0.098	0.074	0.024	NE	NO	NO	NO	NO
2009	0.117	0.094	0.023	NE	NO	NO	NO	NO
2010	0.111	0.084	0.027	NE	NO	NO	NO	NO
2011	0.086	0.059	0.027	NE	NO	NO	NO	NO
2012	0.076	0.050	0.026	NE	NO	NO	NO	NO
2013	0.066	0.046	0.020	NE	NO	NO	NO	NO
2014	0.088	0.049	0.019	0.020	NO	NO	NO	NO
2015	0.096	0.050	0.022	0.023	NO	NO	NO	NO
2016	0.102	0.052	0.027	0.023	NO	NO	NO	NO
2017	0.107	0.052	0.030	0.024	NO	NO	NO	NO
2018	0.108	0.050	0.034	0.024	NO	NO	NO	NO
2019	0.113	0.053	0.035	0.024	NO	NO	NO	NO
2020	0.090	0.040	0.031	0.020	NO	NO	NO	NO
2021	0.121	0.056	0.040	0.025				
Trend								
1990 - 2021	*11.9%*	*-44.8%*	*526.8%*	*NA*	NA	NA	NA	NA
2005 - 2021	*30.3%*	*-26.7%*	*145.6%*	*NA*	NA	NA	NA	NA
2020 - 2021	*33.5%*	*41.6%*	*28.9%*	*24.6%*	NA	NA	NA	NA

3.2.7.3.2 Methodological issues

3.2.7.3.2.1 Choice of methods

For estimating the CO_2, CH_4 and N_2O emissions the 2006 IPCC Guidelines Tier 1 approach[67] has been applied:

Equation 3.2.1: CO_2 from road transport (2006 IPCC GL, Vol. 3, Chap. 3.2.1.1)

Equation 3.2.3: Emissions of CH_4 and N_2O (2006 IPCC GL, Vol. 3, Chap. 3.2.1.1)

$$\boldsymbol{Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}}$$

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG} = \sum_{fuel} emissions_{GHG,\,fuel}}$$

Where:

Emissions $_{GHG,\ fuel}$	= emissions of a given GHG by type of fuel (Gg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ) (as represented by fuel sold)
Emission factor $_{GHG,\ fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ)
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, e.g. Gas/Diesel Oil, Motor Gasoline, LPG

3.2.7.3.2.2 Choice of activity data

The following fuels are used in Road transportation:

Liquid fuels:
- Gas/Diesel Oil* (only non- Gas/Diesel Oil)
- Motor Gasoline* (only non-biogasoline)
- Liquefied Petroleum Gases (LPG)

The total fuel consumption increased by 161.2% in the period 1990 – 2021 and from 2005 to 2021 the total fuel consumption increased by 90.0%. The significant increase of fuel consumption was a result of growing mobility within cities but also between cities, growing freight transport due to increased national production but also due to imports and exports.

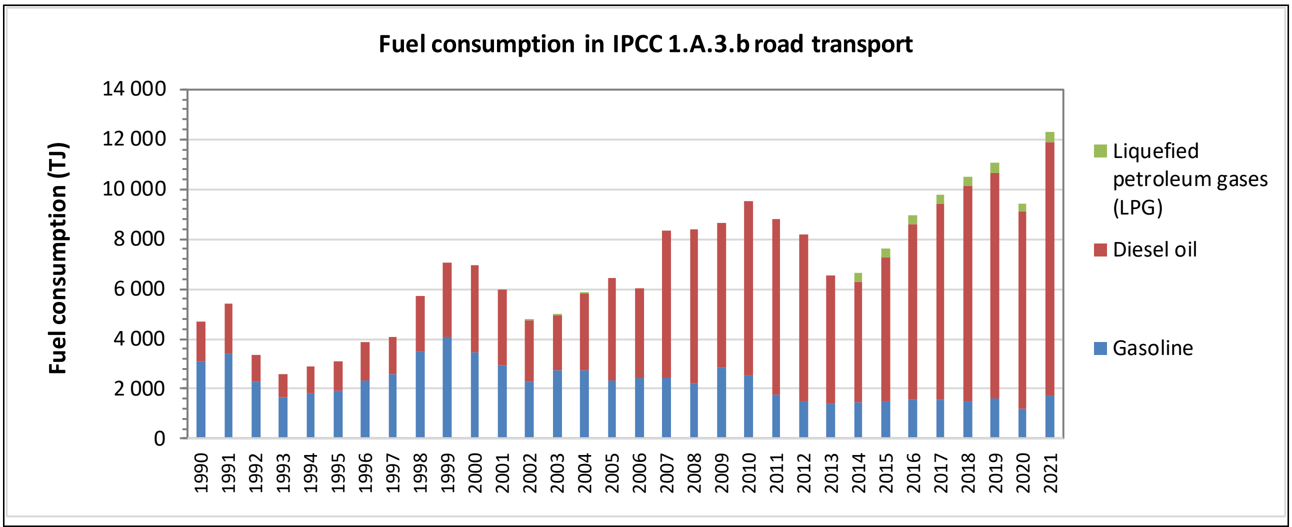


Figure 105 Activity data for IPCC category 1.A.3.b Road transportation

[67] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 3: Mobile Combustion - 3.6.1.1 Methodological issues - Choice of method

The following steps were undertaken in order to derive number of vehicles by type of motor energy per IPCC category.

Step 1 **Grouping existing vehicle categories from National Transport Statistics according to NFR categories**

NFR code	IPCC category	correlates which category in Statistics
1A3b Road Transport		
1A3b1	Passenger cars	Passenger cars
1A3b2	Light duty vehicles	-
1A3b3	Heavy duty vehicles	Buses + Goods vehicles + Road tractors
1A3b4	Mopeds & Motorcycles	Motorcycles
Off-road		
1A2g7	Mobile combustion in Manufacturing Industries and Construction	Work vehicles
1A4b2	Residential: Household and gardening (mobile)	not available
1A4c2	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	Tractors

Step 2 **List all values (number) per vehicle category out of all available statistical sources and analyse which category is included in which one**

	HDV	LDV	Motor-cycles	Off Road Agri	Off Road Industry	Cars	LDV	HDV	HDV	Trailer	TOTAL
	Buses	Van	Motor-cycles	Tractors	Work vehicles	Passenger cars	Special Passenger vehicle	Truck	Towing vehicle	Trailer	TOTAL
	Autobus	Kombi	Motocikl	Polj_ traktor	Radno vozilo	Putnički automobil	Specijalno putn. vozilo	Teretno vozilo	Vučno vozilo	prikljucno vozilo	Ukupno

Step 3 **Produce final fleet data per year (number of vehicles) per vehicle categories**

	Passenger Cars	Motor cycles	HDV	Buses	Truck	Towing vehicle	Light duty vehicles	Van	Special Passenger vehicle	Work vehicles	Tractors

Step 4 **Produce IPCC/NFR compatible final fleet data per year (number of vehicles) per vehicle categories**

number of vehicles	1A3b1	1A3b2	1A3b3	1A3b4
	Passenger cars	Light duty vehicles	Heavy duty vehicles	Mopeds & Motorcycles

Step 5 **Produce IPCC/NFR compatible final fleet data per year (number of vehicles) per vehicle categories by type of motor energy**

number of vehicles	1A3b1			1A3b2			1A3b3			1A3b4		
	Passenger cars			Light duty vehicles			Heavy duty vehicles			Mopeds & Motorcycles		
	gasoline	Diesel	LPG	gasoline	Diesel	LPG	gasoline	Diesel	LPG	gasoline	Diesel	LPG

Table 204 Activity data for IPCC category 1.A.3.b Road transportation

Activity data 1.A.3.b	Total Fuel consumption	Fuel consumption of						
		Gasoline	Diesel oil	LPG	Other liquid fuels	Gaseous fuels	Other fossil fuels	Biomass
	TJ							
1990	4 699.69	3 076.71	1 622.98	NO	NO	NO	NO	NO
1991	5 397.45	3 390.08	2 007.37	NO	NO	NO	NO	NO
1992	3 373.84	2 263.38	1 110.46	NO	NO	NO	NO	NO
1993	2 589.45	1 649.83	939.62	NO	NO	NO	NO	NO
1994	2 895.94	1 828.19	1 067.75	NO	NO	NO	NO	NO
1995	3 113.25	1 917.37	1 195.88	NO	NO	NO	NO	NO
1996	3 856.24	2 318.68	1 537.56	NO	NO	NO	NO	NO
1997	4 081.07	2 586.22	1 494.85	NO	NO	NO	NO	NO
1998	5 743.53	3 522.61	2 220.92	NO	NO	NO	NO	NO
1999	7 049.27	4 102.28	2 946.99	NO	NO	NO	NO	NO
2000	6 954.61	3 478.02	3 476.59	NO	NO	NO	NO	NO
2001	5 966.81	2 942.94	3 023.87	NE	NO	NO	NO	NO
2002	4 743.15	2 274.09	2 464.37	4.69	NO	NO	NO	NO
2003	4 964.56	2 764.58	2 195.29	4.69	NO	NO	NO	NO
2004	5 835.85	2 764.58	3 066.58	4.69	NO	NO	NO	NO
2005	6 461.55	2 318.68	4 142.87	NE	NO	NO	NO	NO
2006	6 038.21	2 407.86	3 630.35	NE	NO	NO	NO	NO
2007	8 344.55	2 407.86	5 936.69	NE	NO	NO	NO	NO
2008	8 379.74	2 229.50	6 150.24	NE	NO	NO	NO	NO
2009	8 662.32	2 853.76	5 808.56	NE	NO	NO	NO	NO
2010	9 503.36	2 541.63	6 961.73	NE	NO	NO	NO	NO
2011	8 788.04	1 783.60	7 004.44	NE	NO	NO	NO	NO
2012	8 178.82	1 516.06	6 662.76	NE	NO	NO	NO	NO
2013	6 550.20	1 382.29	5 167.91	NE	NO	NO	NO	NO
2014	6 625.93	1 471.47	4 826.23	328.23	NO	NO	NO	NO
2015	7 614.32	1 516.06	5 723.14	375.12	NO	NO	NO	NO
2016	8 982.92	1 560.65	7 047.15	375.12	NO	NO	NO	NO
2017	9 787.87	1 578.49	7 820.20	389.19	NO	NO	NO	NO
2018	10 511.73	1 516.06	8 601.79	393.88	NO	NO	NO	NO
2019	11 049.18	1 600.78	9 054.52	393.88	NO	NO	NO	NO
2020	9 415.82	1 199.47	7 892.81	323.54	NO	NO	NO	NO
2021	12 275.66	1 698.88	10 173.52	403.25	NO	NO	NO	NO
Trend								
1990 - 2021	*161.2%*	*-44.8%*	*526.8%*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*90.0%*	*-26.7%*	*145.6%*	*NA*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*30.4%*	*41.6%*	*28.9%*	*24.6%*	*NA*	*NA*	*NA*	*NA*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic meters. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC category *Domestic aviation* are provided.

Table 205 Net calorific values (NCVs) and Conversion factors applied for conversion to energy units in IPCC category 1.A.3.b Road transportation

Fuel type	Fuel	Unit	Net calorific value (NCV)	
			Country specific (CS) NCV	2006 IPCC default NCV (D)
liquid	Gas / Diesel Oil	TJ / Gg	42.710	43.0
	Motor Gasoline Essence automobile	TJ / Gg	44.590	44.3
	Liquefied Petroleum Gases (LPG)	TJ / Gg	46.890	47.3
Source	Net Caloric Value (NCV)	Energy Balance of Montenegro		
	Default Net Calorific values (NCVs)	2006 IPCC Guidelines, Vol. 2, Chap. 1 (1.4.1.3), Table 1.2		
Note:				
D	Default	CS Country specific	PS Plant specific	

3.2.7.3.2.3 Choice of emission factors

Default emission factors for CO_2, CH_4 and N_2O for Natural gas were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 206 GHG Emission factor TIER 1 for IPCC IPCC category 1.A.3.b Road transportation

Fuel type	Fuel	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)	
		EF	type	EF	type	EF	type
liquid	Gas / Diesel Oil	74,100	D	3	D	0.6	D
	Motor Gasoline	69,300	D	3	D	0.6	D
	Liquefied Petroleum Gases (LPG)	63,100	D	1	D	0.1	D
Source	2006 IPCC Guidelines Vol. 2, Chap. 3 (3.6.1.2) Table 3.6.4 CO_2 emission factors and Table 3.6.5 NON-CO_2						
Note:							
D Default	CS Country specific	PS Plant specific	IEF Implied emission factor				

3.2.7.3.3 Uncertainty assessment and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category IPCC category 1.A.3.b *Road transportation* are presented in the following table.

Table 207 Uncertainty for IPCC category 1.A.3.b Road transportation.

Uncertainty	Liquid fuels			Reference
	CO_2	CH_4	N_2O	
Activity data (AD)	7%	7%	7%	2006 IPCC GL, Vol. 2, Chap. 3.6.1.7
Emission factor (EF)	3%	150%	200%	
Combined Uncertainty (U)	8%	150%	200%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period.

3.2.7.3.4 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- o consistent use of energy balance data (preparation of a time series),
- o documented sources,
- o use of units and converson factors,
- o strictly defined interfaces between spreadsheets/calculation modules,
- o unique structure of sheets which do the same,
- o record keeping, use of write protection,
- o unique use of formulas, special cases are documented/highlighted,
- o quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from different sources:
- o national statistic published by MONSTAT and
- o international energy statistics of UN statistics[68] and International Energy Agency (IEA)[69]

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.7.3.5 Category-specific recalculations including explanatory information and justifications for recalculations

The following table presents the main revisions and recalculations done since the last two submission to the UNFCCC and relevant to IPCC category 1.A.3.b *Road transportation.*

Table 208 Recalculations done since NC in IPCC category 1.A.3.b Road transportation

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
1.A.3.b	Fuel consumption data (activity data) was revised due to revised fuel consumption data / revision of energy Balance	AD	Accuracy Transparency

[68] United Nations - Department of Economic and Social Affairs - Statistics Division Statistics - Energy Statistics https://unstats.un.org/unsd/energystats/

[69] Data and statistics - Data tools - Data tables Energy data by category, indicator, country or region https://www.iea.org/data-and-statistics/data-browser?country=WORLD&fuel=Energy%20supply&indicator=TESbySource

3.2.7.3.6 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 209 Planned improvements for IPCC category 1.A.3.b Road transportation

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.3.b	Application of Tier 2 (or higher) using the COPERT model[70]	AD	Accuracy Transparency Consistency Completeness Comparability	high
1.A.3.b	Collection of road transport related data for 1990 - 2021 Vehicle fleet: • Collect data on vehicle fleet in operation per category o Passenger transport o Freight transport • Collect or estimate data on vehicle fleet split per o fuel (energy) type o segment subcategories o technology/Euro standard • Collect or estimate data on vehicle fleet split per age distributions • Mileage: Collect or assume typical values for average annual distance driven for each vehicle (sub)category • Speeds: Estimate average travelling speeds in urban areas, rural areas and highways; Activity shares: Estimate share of activity (mileage) in urban areas (35%), rural areas (35%) and highways (30%);	AD	Accuracy Transparency Consistency Completeness Comparability	high
1.A.3.b	Energy balance - Survey on use of fuels in stationary and Off-road vehicles and other machinery	AD	Accuracy Transparency	Medium
1.A.3.b	Information about imported second hand vehicles	AD	Accuracy Transparency	Medium

3.2.7.4 Railways (IPCC category 1.A.c)

3.2.7.4.1 Category description

As described in the 2006 IPCC Guidelines, the IPCC category 1.A.c *Railways* includes emissions from railway transport for both freight and passenger traffic routes.

This section describes GHG emissions resulting from fuel combustion in IPCC category 1.A.c *Railways*.

[70] COPERT is the EU standard vehicle emissions calculator. It uses vehicle population, mileage, speed and other data such as ambient temperature and calculates emissions and energy consumption for a specific country or region.
https://www.emisia.com/utilities/copert/

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.3.c	✓	NO	NO	NO	NO	NO	✓	NO	NO	NO	NO	NO	✓	NO	NO	NO	NO	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

A '✓' indicates: emissions from this sub-category have been estimated.
Notation keys: IE - included elsewhere, NO – not occurrent, NE - not estimated, NA - not applicable, C – confidential

LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF

Emissions for the period 1990-2021 are presented in the following figure and tables.
However, Montenegro's railway was electrified. Since 2011, there are no GHG emission from IPCC category 1.A.c Railways.

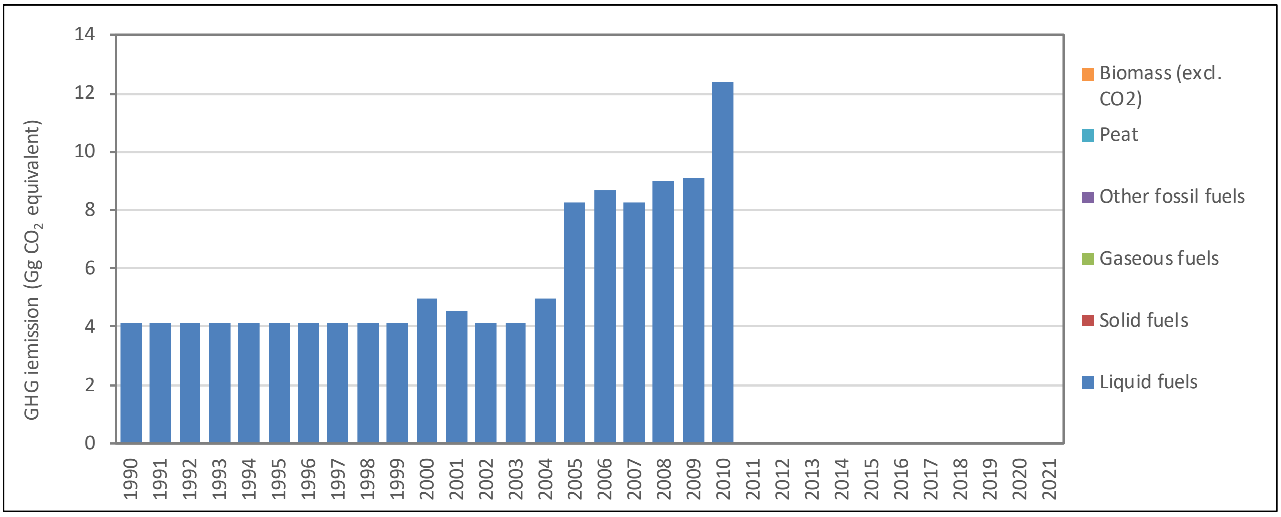


Figure 106 **GHG emissions from IPCC category 1.A.c Railways**

Table 210 GHG emissions and Activity data from IPCC category 1.A.3.c Railways

IPCC category 1.A.3.c	Emission				Fuel consumption			
	GHG	CO_2	N_2O	CH_4	Total	Gas/ Diesel Oil	Fuel oil	Other
	kt CO_2 equivalent	kt	kt	kt	[TJ]	[TJ]	[TJ]	[TJ]
1990	4.13	4.10	0.0001	0.0001	42.71	42.71	NO	NO
1991	4.13	4.10	0.0001	0.0001	42.71	42.71	NO	NO
1992	4.13	4.10	0.0001	0.0001	42.71	42.71	NO	NO
1993	4.13	4.10	0.0001	0.0001	42.71	42.71	NO	NO
1994	4.13	4.10	0.0001	0.0001	42.71	42.71	NO	NO
1995	4.13	4.10	0.0001	0.0001	42.71	42.71	NO	NO
1996	4.13	4.10	0.0001	0.0001	42.71	42.71	NO	NO
1997	4.13	4.10	0.0001	0.0001	42.71	42.71	NO	NO
1998	4.13	4.10	0.0001	0.0001	42.71	42.71	NO	NO
1999	4.13	4.10	0.0001	0.0001	42.71	42.71	NO	NO
2000	4.95	4.93	0.0001	0.0001	51.25	51.25	NO	NO
2001	4.54	4.51	0.0001	0.0001	46.98	46.98	NO	NO
2002	4.13	4.10	0.0001	0.0001	42.71	42.71	NO	NO
2003	4.13	4.10	0.0001	0.0001	42.71	42.71	NO	NO
2004	4.95	4.93	0.0001	0.0001	51.25	51.25	NO	NO
2005	8.25	8.21	0.0001	0.0002	85.42	85.42	NO	NO
2006	8.66	8.62	0.0001	0.0002	89.69	89.69	NO	NO
2007	8.25	8.21	0.0001	0.0002	85.42	85.42	NO	NO
2008	8.99	8.95	0.0001	0.0002	93.11	93.11	NO	NO
2009	9.08	9.03	0.0001	0.0002	93.96	93.96	NO	NO
2010	12.38	12.31	0.0002	0.0003	128.13	128.13	NO	NO
2011	NO	NO	NO	NO	NO	NO	NO	NO
⇩	⭣	⭣	⭣	⭣	⭣	⭣	⭣	⭣
2021	NO	NO	NO	NO	NO	NO	NO	NO
Trend								
1990 - 2021	NA	NA	NA	NA	NA	NA	NA	NA
2005 - 2021	NA	NA	NA	NA	NA	NA	NA	NA
2020 - 2021	NA	NA	NA	NA	NA	NA	NA	NA

3.2.7.4.2 Methodological issues

3.2.7.4.2.1 Choice of methods – TIER 1

For estimating the CO_2, CH_4 and N_2O emissions the 2006 IPCC Guidelines Tier 1 approach[71] has been applied:

Equation 3.4.1: General method for emissions from locomotivesaviation equation (2006 IPCC GL, Vol. 3, Chap. 3.4.1.1)

$$Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}$$

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG} = \sum_{fuel} emissions_{\mathrm{GHG,\,fuel}}$$

Where:

Emissions $_{GHG, fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG, fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ)
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, e.g. gas/diesel oil, motor gasoline

3.2.7.4.2.2 Choice of activity data

The following fuels are used in IPCC category 1.A.c *Railways*:

Liquid fuels:
- gas/diesel oil,

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 – 2021 were taken from MONSTAT. Activity data are provided in the table above.

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic meters. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC category *Railways* are provided.

Table 211 Net calorific values (NCVs) and Conversion factors applied for conversion to energy units in IPCC category 1.A.c *Railways*

Fuel type	Fuel	Unit	Net calorific value (NCV)	
			Country specific (CS) NCV	2006 IPCC default NCV *
liquid	Gas / Diesel Oil	TJ / Gg	42.71	43.0
Source			Monstat, Energy balance	2006 IPCC Guidelines, Vol. 2, Chap. 1 (1.4.1.3), Table 1.2

Note:

D Default	CS Country specific	PS Plant specific
* For comparision		

[71] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 3: Mobile Combustion - 3.4.1.1 Methodological issues - Choice of method

3.2.7.4.2.3 Choice of emission factors

Default emission factors for CO_2, CH_4 and N_2O for Natural gas were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 212 GHG Emission factor TIER 1 for IPCC category IPCC category 1.A.c *Railways*

Fuel type	Fuel	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)	
		EF	type	EF	type	EF	type
liquid	Gas / Diesel Oil	74,100	D	4.15	D	28.6	D
Source	2006 IPCC Guidelines Vol. 2, Chap. 3 (3.5.1.2) Table 3.5.2 CO_2 EF and Table 3.5.3 NON-CO_2 EF						
Note:							
D Default		CS Country specific		PS Plant specific		IEF Implied emission factor	

3.2.7.4.3 Uncertainty assessment and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category IPCC category 1.A.c *Railways* are presented in the following table.

Table 213 Uncertainty for IPCC category 1.A.c *Railways.*

Uncertainty	Gas/Diesel Oil			Reference
	CO_2	CH_4	N_2O	
Activity data (AD)	7%	7%	7%	2006 IPCC GL, Vol. 2, Chap. 3.6.1.7
Emission factor (EF)	141%	254%	304%	
Combined Uncertainty (U)	141%	254%	304%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period.

3.2.7.4.4 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- consistent use of energy balance data (preparation of a time series),
- documented sources,
- use of units and converson factors,
- strictly defined interfaces between spreadsheets/calculation modules,
- unique structure of sheets which do the same,
- record keeping, use of write protection,
- unique use of formulas, special cases are documented/highlighted,
- quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from different sources:
- national statistic published by MONSTAT
- international energy statistics of UN statistics[72] and Eurostat[73]

⇒ time series consistency - plausibility checks of dips and jumps.

[72] United Nations - Department of Economic and Social Affairs - Statistics Division Statistics - Energy Statistics https://unstats.un.org/unsd/energystats/

[73] Data and statistics - https://ec.europa.eu/eurostat/web/main/data/database

3.2.7.4.5 Category-specific recalculations including explanatory information and justifications for recalculations

The following table presents the main revisions and recalculations done since the last two submission to the UNFCCC and relevant to IPCC category 1.A.c *Railways.*

Table 214 Recalculations done since NC in IPCC category 1.A.c *Railways*

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
1.A.3.c	No revisions were performed		

3.2.7.4.6 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 215 Planned improvements for IPCC category 1.A.c *Railways*

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.3.c	No planned improvements			

3.2.7.5 Domestic navigation (IPCC category 1.A.3.d.ii)

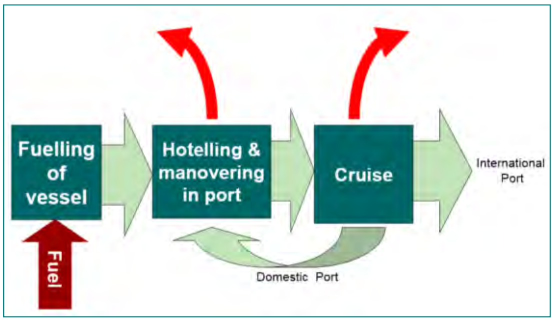
3.2.7.5.1 Category description

As described in the 2006 IPCC Guidelines, the IPCC category 1.A.3.d.ii *Domestic Water-borne Navigation (International bunkers)* includes emissions from fuels used by vessels of all flags that are engaged in international water-borne navigation. The Domestic navigation may take place at sea, on inland lakes and waterways and in coastal waters. This category includes emissions from journeys that depart in one country and arrive in the same country. The category exclude consumption by fishing vessels (see here Other Sector - Fishing). It is *good practice*, that emissions from domestic navigation are reported separately from international navigation and it it is *good practice* to apply the definition presented in the following table.

Table 216 Criteria for defining international or domestic water-borne navigation

Criteria for defining international or domestic water-borne navigation (applies to each segment of a voyage calling at more than two ports)		
Journey type between two ports	**Domestic**	**International**
• Departs and arrives in same country	Yes	No
• Departs from one country and arrives in another	No	Yes

Source: 2006 IPCC Guidelines, Volume 2, Chapter 3: Mobile Combustion, 3.5.1.3 Choice of activity data, TABLE 3.5.4.[74]



Source: EMEP/EEA air pollutant emission inventory guidebook 2019, Chapter 1.A.3.d Navigation (shipping) 2019, Figure 2 – 1 Flow diagram for the contribution from navigation to mobile sources combustion emissions [75]

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.3.d.ii	✓	NO	NO	NO	NO	NO	✓	NO	NO	NO	NO	NO	✓	NO	NO	NO	NO	NO
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

A '✓' indicates: emissions from this sub-category have been estimated.
Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF

Emissions for the period 1990-2021 are presented in the following figure and tables.

According to the energy balance, the emissions for the period 2005, 2007-2011 and 2017-2021 are included in 1.A.3.b Road transport

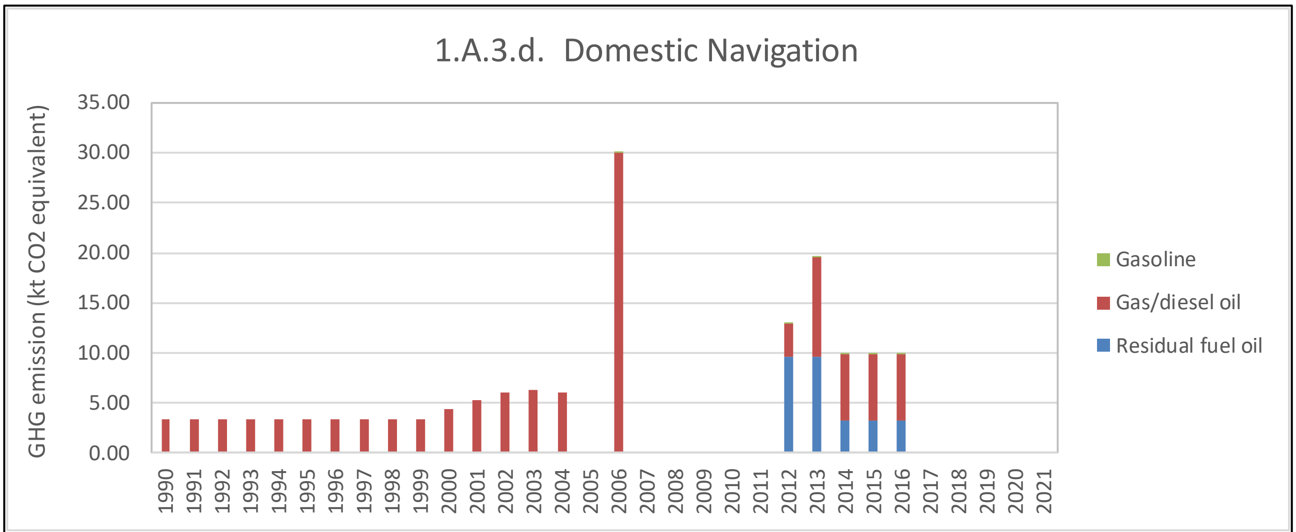


Figure 107 GHG emissions from IPCC category 1.A.3.d.ii *Domestic navigation*

[74] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf

[75] Source: EMEP/EEA air pollutant emission inventory guidebook 2019, Part B: sectoral guidance chapters, 1. Energy , 1.A Combustion, Chapter 1.A.3.d Navigation (shipping) 2019 https://www.eea.europa.eu/publications/emep-eea-guidebook-2016/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-d-navigation/view

Table 217 GHG emissions and Activity data from IPCC category 1.A.3.d.ii *Domestic navigation*

IPCC category 1.A.3.a.ii Domestic aviation	Emission				Fuel consumption				
	GHG	CO_2	N_2O	CH_4	Total	Residual fuel oil	Gas/diesel oil	Gasoline	Other
	kt CO_2 equivalent	kt	kt	kt	[TJ]	[TJ]	[TJ]	[TJ]	[TJ]
1990	**3.34**	3.30	0.0003	0.0001	**44.59**	IE	44.59	IE	NO
1991	**3.34**	3.30	0.0003	0.0001	**44.59**	IE	44.59	IE	NO
1992	**3.34**	3.30	0.0003	0.0001	**44.59**	IE	44.59	IE	NO
1993	**3.34**	3.30	0.0003	0.0001	**44.59**	IE	44.59	IE	NO
1994	**3.34**	3.30	0.0003	0.0001	**44.59**	IE	44.59	IE	NO
1995	**3.34**	3.30	0.0003	0.0001	**44.59**	IE	44.59	IE	NO
1996	**3.34**	3.30	0.0003	0.0001	**44.59**	IE	44.59	IE	NO
1997	**3.34**	3.30	0.0003	0.0001	**44.59**	IE	44.59	IE	NO
1998	**3.34**	3.30	0.0003	0.0001	**44.59**	IE	44.59	IE	NO
1999	**3.34**	3.30	0.0003	0.0001	**44.59**	IE	44.59	IE	NO
2000	**4.34**	4.30	0.0004	0.0001	**57.97**	IE	57.97	IE	NO
2001	**5.34**	5.29	0.0005	0.0001	**71.34**	IE	71.34	IE	NO
2002	**6.01**	5.95	0.0006	0.0002	**80.26**	IE	80.26	IE	NO
2003	**6.34**	6.28	0.0006	0.0002	**84.72**	IE	84.72	IE	NO
2004	**6.01**	5.95	0.0006	0.0002	**80.26**	IE	80.26	IE	NO
2005	**IE**	IE	IE	IE	**IE**	IE	IE	IE	NO
2006	**30.07**	29.76	0.0028	0.0008	**9 401.31**	IE	401.31	9 000.00	NO
2007	**IE**	IE	IE	IE	**IE**	IE	IE	IE	NO
2008	**IE**	IE	IE	IE	**IE**	IE	IE	IE	NO
2009	**IE**	IE	IE	IE	**IE**	IE	IE	IE	NO
2010	**IE**	IE	IE	IE	**IE**	IE	IE	IE	NO
2011	**IE**	IE	IE	IE	**IE**	IE	IE	IE	NO
2012	**12.93**	12.64	0.0006	0.0009	**1 165.16**	120.57	44.59	1 000.00	NO
2013	**19.61**	19.25	0.0012	0.0011	**3 254.34**	120.57	133.77	3 000.00	NO
2014	**9.88**	9.72	0.0007	0.0005	**2 129.37**	40.19	89.18	2 000.00	NO
2015	**9.88**	9.72	0.0007	0.0005	**2 129.37**	40.19	89.18	2 000.00	NO
2016	**9.88**	9.72	0.0007	0.0005	**2 129.37**	40.19	89.18	2 000.00	NO
2017	**IE**	IE	IE	IE	**IE**	IE	IE	IE	NO
2018	**IE**	IE	IE	IE	**IE**	IE	IE	IE	NO
2019	**IE**	IE	IE	IE	**IE**	IE	IE	IE	NO
2020	**IE**	IE	IE	IE	**IE**	IE	IE	IE	NO
2021	**IE**	IE	IE	IE	**NE**	IE	IE	IE	NO
Trend									
1990 - 2021	***NA***	*NA*	*NA*	*NA*	***NA***	*NA*	*NA*	*NA*	*NA*
2005 - 2021	***NA***	*NA*	*NA*	*NA*	***NA***	*NA*	*NA*	*NA*	*NA*
2020 - 2021	***NA***	*NA*	*NA*	*NA*	***NA***	*NA*	*NA*	*NA*	*NA*

3.2.7.5.2 Methodological issues

3.2.7.5.2.1 Choice of methods

For estimating the CO_2, CH_4 and N_2O emissions the 2006 IPCC Guidelines Tier 1 approach[76] has been applied:

Equation 3.5.1: Water-borne navigation equation (2006 IPCC GL, Vol. 3, Chap. 3.5.1.1)

$$\boldsymbol{Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}}$$

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG} = \sum_{fuel} emissions_{\mathbf{GHG,\,fuel}}}$$

Where:

Emissions $_{GHG,\ fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG,\ fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ)
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, e.g., Gas/diesel oil, motor gasoline

3.2.7.5.2.2 Choice of activity data

The following fuels are used in IPCC category 1.A.3.a.ii *Domestic navigation*:

Liquid fuels:
- Gas/Diesel Oil
- Motor gasoline
- Residual fuel oil

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 – 2021 were taken from MONSTAT. Activity data are provided in the table above.

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic meters. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC category 1.A.3.a.ii *Domestic navigation* are provided.

Table 218 Net calorific values (NCVs) and Conversion factors applied for conversion to energy units IPCC category 1.A.3.d.ii *Domestic navigation*

Fuel type	Fuel	Unit	Net calorific value (NCV)	
			Country specific (CS) NCV	2006 IPCC default NCV*
liquid	Gas / Diesel Oil	TJ / Gg	41.21	43.0
	Residual fuel Oil	TJ / Gg	40.07	40.4
	Gasoline	TJ / Gg		
Note:			Monstat, Energy balance	2006 IPCC Guidelines, Vol. 2,

[76] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 3: Mobile Combustion - 3.5.1.1 Methodological issues - Choice of method

Fuel type	Fuel	Unit	Net calorific value (NCV)	
			Country specific (CS) NCV	2006 IPCC default NCV*
				Chap. 1 (1.4.1.3), Table 1.2
D Default		CS Country specific		PS Plant specific
* For comparision				

3.2.7.5.2.3 Choice of emission factors

Default emission factors for CO_2, CH_4 and N_2O for Natural gas were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 219 GHG Emission factor TIER 1 for IPCC category 1.A.3.d.ii *Domestic navigation*

Fuel type	Fuel	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)	
		EF	type	EF	type	EF	type
liquid	Gas / Diesel Oil* Gasoil / Diesel	74,100	D	4.15	D	28.6	D
	Residual fuel Oil*	77 400	D	10	D	0.6	D
Source	2006 IPCC Guidelines Vol. 2, Chap. 3 (3.5.1.2) Table 3.5.2 CO_2 EF and Table 3.5.3 NON-CO_2 EF						
Note:							
D Default		CS Country specific		PS Plant specific		IEF Implied emission factor	

3.2.7.5.3 Uncertainty assessment and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 1.A.3.d.ii *Domestic navigation* are presented in the following table.

Table 220 Uncertainty for IPCC category 1.A.3.d.ii *Domestic navigation.*

Uncertainty	Gas/Diesel Oil			Residual Fuel Oil			Reference
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	
Activity data (AD)	15%	15%	15%	15%	15%	15%	2006 IPCC GL, Vol. 2, Chap. 3.5.1.7
Emission factor (EF)	1.5%	+/-50%	-40% to 140%	3.0%	+/-50%	-40% to 140%	
Combined Uncertainty (U)	15%	72%	135%	15%	72%	135%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period.

3.2.7.5.4 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- o consistent use of energy balance data (preparation of a time series),
- o documented sources,
- o use of units and converson factors,

- o strictly defined interfaces between spreadsheets/calculation modules,
- o unique structure of sheets which do the same,
- o record keeping, use of write protection,
- o unique use of formulas, special cases are documented/highlighted,
- o quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from different sources (e.g. 1.A.3.d.i International navigation):

- o national statistic published by MEM and Office National des Statistiques (ONS)[77] and
- o international energy statistics of UN statistics[78] and International Energy Agency (IEA)[79]

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.7.5.5 Category-specific recalculations

The following table presents the main revisions and recalculations done since the last two submission to the UNFCCC and relevant to IPCC category 1.A.3.a.ii *Domestic navigation*.

Table 221 Recalculations done since NC in IPCC category 1.A.3.d.ii *Domestic navigation*

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
1.A.3.d.ii	NO revisions were performed		

3.2.7.5.6 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 222 Planned improvements for IPCC category 1.A.3.d.ii *Domestic navigation*

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.3.d.i 1.A.3.d.ii	Revision of the energy balance (1990-2020) • improvement of time series completeness and consistency • for all navigation related fuels o motor gasoline, o gas/diesel oil o fuel oil	AD	Accuracy Comparability Transparency Consistency	high
1.A.3.d.i 1.A.3.d.ii	Application of *good practice* approach to separate the activity data (fuel consumption) consistent with the definition of Table 3.6 of the 2006 IPCC Guidelines, Volume 2, Chapter 3: Mobile Combustion, 3.5.1.3 Choice of activity data.	AD	Accuracy Comparability Transparency Consistency	high
1.A.3.d.i 1.A.3.d.ii	Data on fuel consumption by fuel type and engine type • Surveys of shipping companies (including ferry and freight)	AD	Accuracy Completeness	medium

[77] https://www.ons.dz/spip.php?rubrique6 and https://www.ons.dz/IMG/pdf/CH8-ENERGIE.pdf; https://www.ons.dz/spip.php?rubrique127

[78] United Nations - Department of Economic and Social Affairs - Statistics Division Statistics - Energy Statistics https://unstats.un.org/unsd/energystats/

[79] Data and statistics - Data tools - Data tables Energy data by category, indicator, country or region https://www.iea.org/data-and-statistics/data-browser?country=WORLD&fuel=Energy%20supply&indicator=TESbySource

GHG source & sink category	Planned improvement	Type of improvement		Priority
	• Surveys of individual port and marine authorities		Comparability Transparency Consistency	
1.A.3.d.i 1.A.3.d.ii	• Ship movement data and standard passenger and freight ferry schedules • Fischery boot movements	AD	Transparency	medium
1.A.3.d.i 1.A.3.d.ii	Application of Tier 2 methodology • Estimate fuel consumption for hotelling & movements and cruise for navigation. • Estimate emissions from for hotelling & movements and cruise for navigation.	M EF	Accuracy Completeness Comparability Transparency Consistency	medium
1.A.3.d.ii	Investigation regarding fuel consumption from military navigation.	AD	Completeness	Medium

3.2.7.6 Other transportation (IPCC category 1.A.3.e)

3.2.7.6.1 Category description

As described in the 2006 IPCC Guidelines, the IPCC category 1.A.3.e O*ther transportation* includes GHG emissions from

IPCC code		Description
1.A.3.e.i	Pipeline transport	which include fuel combustion related emissions from the operation of pump stations and maintenance of pipelines. Transport via pipelines includes transport of gases, liquids, slurry and other commodities via pipelines. ⇒ Distribution of natural or manufactured gas, water or steam from the distributor to final users is excluded and should be reported in 1.A.1.c.ii or 1.A.4.a.
1.A.3.e.ii	Other	which include fuel combustion emissions from Other Transportation excluding Pipeline Transport.

GHG emissions/ removals estimated	CO_2						CH_4						N_2O					
	liquid	solid	gaseous	other fossil fuel	Peat	biomass	liquid	solid	gaseous	other fossil fuel	Peat	biomass	liquid	solid	gaseous	other fossil fuel	Peat	biomass
1.A.3.e.i	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.3.e.ii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Key Category																		
1.A.3.e.i	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.A.3.e.i	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

A '✓' indicates: emissions from this sub-category have been estimated.
Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF

The IPCC category 1.A.3.e.i Other transportation does not exist in Montenegro.

3.2.8 Other Sectors (IPCC category 1.A.4)

Category 1.A.4 *Other sectors* comprise emissions from stationary fuel combustion in the small combustion sector including combustion for the generation of electricity and heat for own use in these sectors. It also includes emissions from mobile sources in households and gardening as well as from agriculture and forestry.

IPCC category Code	IPCC category description
1.A.4	Other Sectors
1.A.4.a	Commercial/Institutional
1.A.4.a.i	Stationary combustion
1.A.4.a.ii	Off-road vehicles and other machinery
1.A.4.b	Residential
1.A.4.b.i	Stationary combustion
1.A.4.b.ii	Off-road vehicles and other machinery
1.A.4.c	Agriculture/Forestry/Fishing/Fish Farms
1.A.4.c.i	Stationary
1.A.4.c.ii	Off-road vehicles and other machinery
1.A.4.c.iii	Fishing

The national energy statistics currently do not provide information regarding the use of fuels in the different IPCC subcategories. Therefore, all emissions are reported under IPCC subcategory 1.A.4.b *Residential*.

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	Liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.4.a																		
1.A.4.a.i	✓	✓	NO	NO	NO	✓	✓	✓	NO	NO	NO	✓	✓	✓	NO	NO	NO	✓
1.A.4.a.ii	IE	IE	NO	NO	NO	NO	IE	IE	NO	NO	NO	NO	IE	IE	NO	NO	NO	NO
1.A.4.b																		
1.A.4.b.i	✓	✓	NO	NO	NO	✓	✓	✓	NO	NO	NO	✓	✓	✓	NO	NO	NO	✓
1.A.4.b.ii	IE	IE	NO	NO	NO	NO	IE	IE	NO	NO	NO	NO	IE	IE	NO	NO	NO	NO
1.A.4.c																		
1.A.4.c.i	IE	NO	NO	NO	NO	NO	IE	NO	NO	NO	NO	NO	IE	NO	NO	NO	NO	NO
1.A.4.c.ii	✓	NO	NO	NO	NO	NO	✓	NO	NO	NO	NO	NO	✓	NO	NO	NO	NO	NO
1.A.4.c.iii	IE	NO	NO	NO	NO	NO	IE	NO	NO	NO	NO	NO	IE	NO	NO	NO	NO	NO

A '✓' indicates: emissions from this sub-category have been estimated.
Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential

An overview of the emissions from fuel combustion in IPCC category 1.A.4 *Other Sectors* is provided in the following figures and tables:

- annual GHG, CO2, CH4 and N2O emissions
- Trend of the periods 1990 – 2020, 2005 – 2021, 2020 – 2021
- by sub-category.

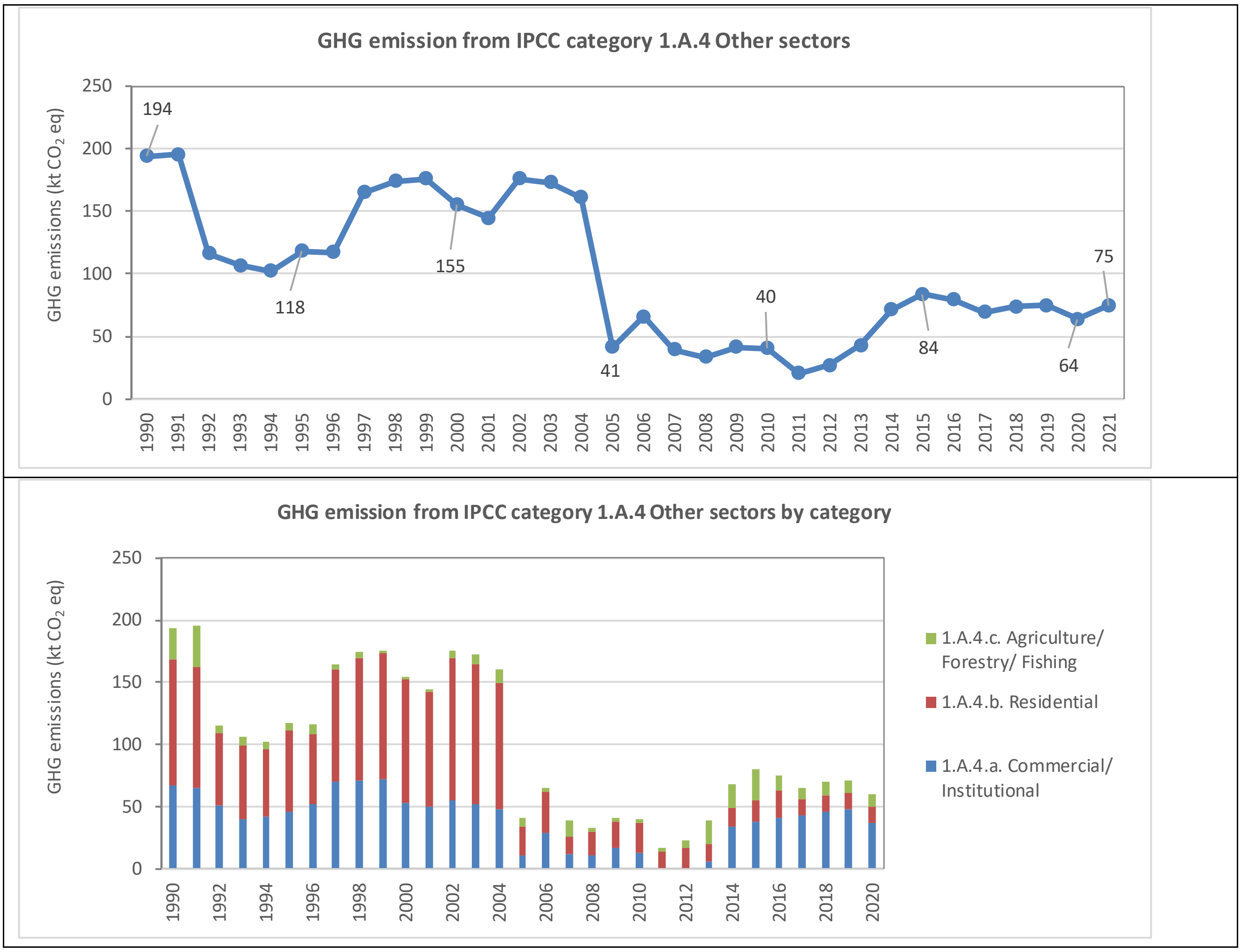


Figure 108 **GHG Emissions from IPCC sub-category 1.A.4 Other Sectors by category**

The main fuels used in IPCC category 1.A.4 *Other sectors* were biomass, lignite and liquid fuels. However, the GHG emissions from lignite and liquid fuels make up the majority.

The fluctuation of the GHG emissions and related activity data for 2005-2013 can be explained by implementation of legislation related to air quality, new survey, allocation of fuels, and the new methodology in energy statistics.

The share of CO2 emissions from biomass increased significantly after 2011 due to implementation of legislation related to air quality related to heavy fuel oil.

The main sector within category 1.A.4 Other sectors is 1.A.4.a *Residentials*, which use mainly biomass. The emissions from sub-category 1.A.4.a Commercial/Institutional originate mostly from lignite and liquid fuels and dropped down in 2011 due to national legislation. The increase of the emissions from 1.A.4.a in the last decade can be explained by increase of new commercial buildings.

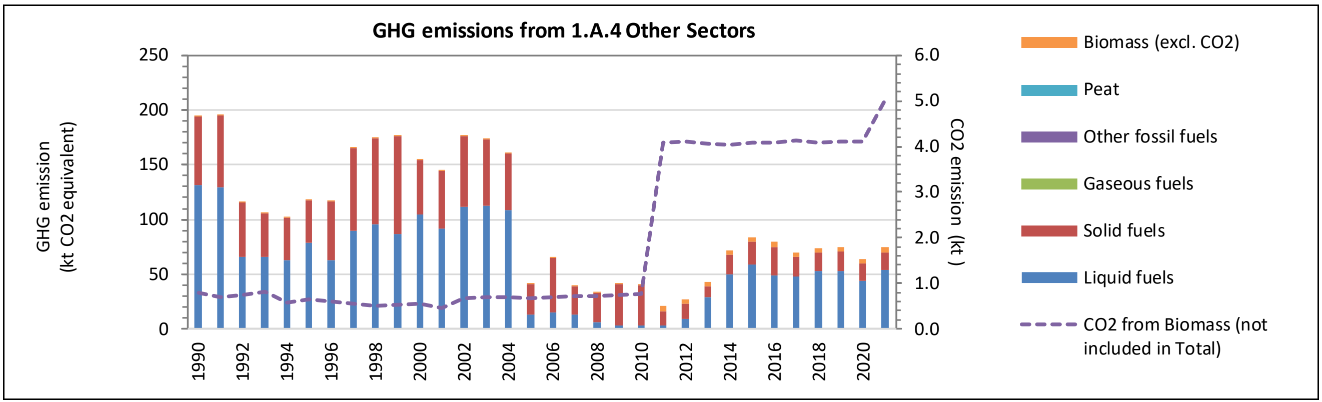


Figure 109 CO2 Emissions from IPCC sub-category 1.A.4 Other Sectors

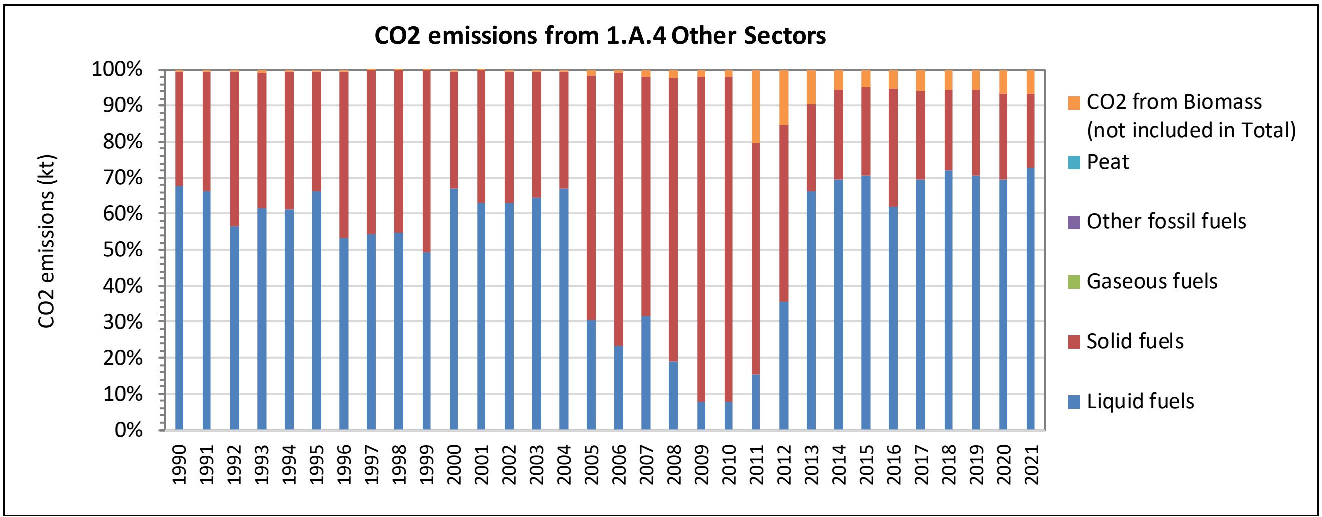


Figure 110 Share of CO2 Emissions from IPCC sub-category 1.A.4 Other Sectors by fuel type.

Table 223 Emissions from IPCC sub-category 1.A.4 Other Sectors

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass) not included in Total
	kt CO2 equivalent	kt	kt	kt	kt
1990	194.54	193.38	0.002	0.025	0.801
1991	195.91	194.76	0.002	0.024	0.685
1992	116.29	115.52	0.001	0.016	0.741
1993	106.84	106.13	0.001	0.015	0.816
1994	102.61	101.95	0.001	0.014	0.564
1995	118.33	117.57	0.001	0.016	0.643
1996	117.38	116.62	0.001	0.015	0.608
1997	165.50	164.44	0.002	0.021	0.551
1998	174.83	173.72	0.002	0.022	0.499
1999	176.46	175.31	0.002	0.022	0.518
2000	155.31	154.33	0.002	0.020	0.542
2001	145.29	144.37	0.002	0.019	0.455
2002	176.39	175.27	0.002	0.023	0.662
2003	173.69	172.60	0.002	0.022	0.684
2004	161.48	160.48	0.002	0.021	0.697
2005	41.39	41.07	0.001	0.006	0.671
2006	65.75	65.28	0.001	0.009	0.686
2007	39.51	39.20	0.001	0.006	0.715
2008	33.36	33.09	0.000	0.005	0.715
2009	41.45	41.12	0.001	0.006	0.748
2010	40.53	40.20	0.001	0.006	0.755
2011	20.53	20.20	0.000	0.010	4.092
2012	26.91	26.54	0.000	0.011	4.101
2013	43.04	42.59	0.000	0.013	4.063
2014	71.64	71.03	0.001	0.016	4.031
2015	83.83	83.15	0.001	0.018	4.083
2016	79.33	78.68	0.001	0.017	4.081
2017	69.60	69.00	0.001	0.016	4.132
2018	73.82	73.21	0.001	0.016	4.093
2019	74.77	74.16	0.001	0.016	4.112
2020	63.70	63.15	0.001	0.015	4.116
2021	74.91	74.27	0.002	0.018	4.980
Trend					
1990 - 2021	*-61.5%*	*-61.6%*	*-63.7%*	*-27.4%*	*522.0%*
2005 - 2021	*81.0%*	*80.8%*	*23.9%*	*188.2%*	*641.7%*
2020 - 2021	*17.6%*	*17.6%*	*13.7%*	*18.2%*	*21.0%*

3.2.8.1 Commercial/Institutional (IPCC category 1.A.4.a)

3.2.8.1.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	Liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.4.a																		
1.A.4.a.i	✓	✓	NO	NO	NO	✓	✓	✓	NO	NO	NO	✓	✓	✓	NO	NO	NO	✓
1.A.4.a.ii	IE	IE	NO	NO	NO	NO	IE	IE	NO	NO	NO	NO	IE	IE	NO	NO	NO	NO
Key category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

A '✓' indicates: emissions from this sub-category have been estimated.
Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF

1.A.4.a	Commercial/Institutional
1.A.4.a.i	Stationary combustion
1.A.4.a.ii	Off-road vehicles and other machinery

An overview of the emissions from fuel combustion in IPCC sub-category *1.A.4.a Commercial/Institutional* is provided in the following figures and tables:

- annual GHG emissions
- Trend of the periods 1990 – 2020, 2005 – 2021, 2020 – 2021.

The main fuels used in IPCC category 1.A.4.a *Commercial/Institutional* were lignite and liquid fuels but also biomass. However, the GHG emissions from lignite and liquid fuels make up the majority.
The fluctuation of the GHG emissions and related activity data for 2005-2013 can be explained by implementation of legislation related to air quality, new survey, allocation of fuels, and the new methodology in energy statistics.

The share of CO2 emissions from biomass increased significantly after 2011 due to implementation of legislation related to air quality related to heavy fuel oil.

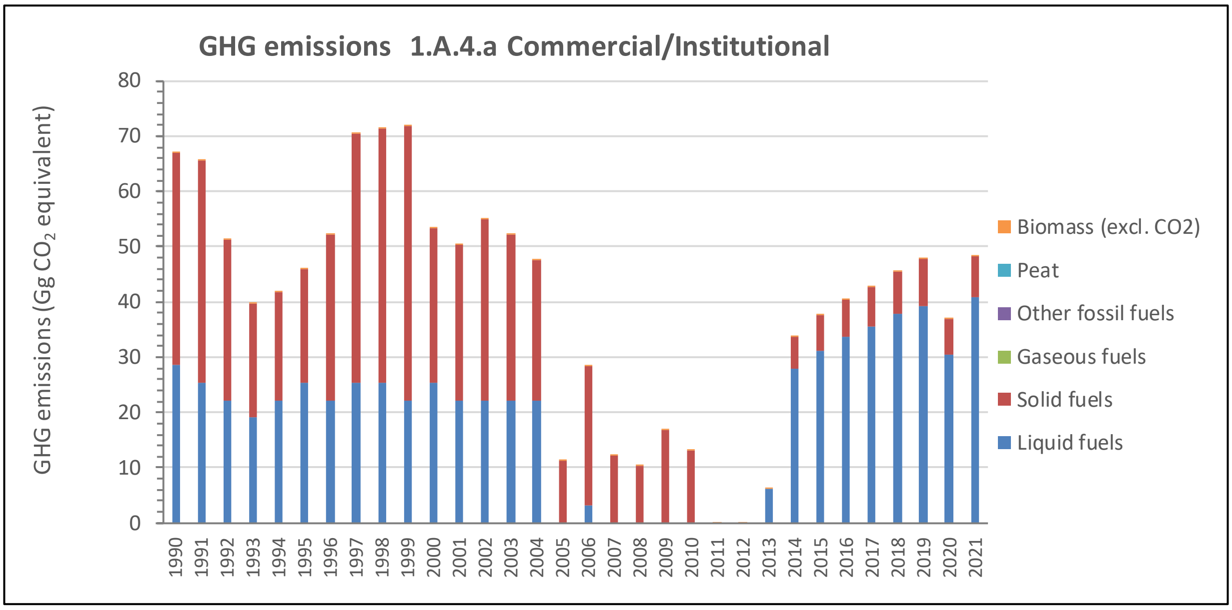


Figure 111 Emissions from IPCC sub-category 1.A.4.a Commercial for the period 1990-2021

Table 224 Emissions from IPCC sub-category 1.A.4.a Commercial for the period 1990-2021

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	kt CO2 equivalent	kt	kt CO2 equivalent	kt CO2 equivalent	kt
1990	**66.99**	66.57	0.237	0.190	0.001
1991	**65.56**	65.14	0.237	0.184	0.001
1992	**51.26**	50.94	0.181	0.146	0.001
1993	**39.65**	39.40	0.136	0.114	0.001
1994	**41.90**	41.63	0.139	0.123	0.001
1995	**46.02**	45.73	0.151	0.136	0.003
1996	**52.20**	51.87	0.185	0.148	0.001
1997	**70.37**	69.91	0.258	0.195	0.002
1998	**71.30**	70.84	0.262	0.198	0.001
1999	**71.87**	71.40	0.271	0.196	0.002
2000	**53.43**	53.10	0.184	0.154	0.001
2001	**50.33**	50.01	0.177	0.143	0.002
2002	**55.01**	54.66	0.197	0.155	0.002
2003	**52.20**	51.87	0.185	0.148	0.003
2004	**47.52**	47.22	0.164	0.136	0.003
2005	**11.24**	11.16	0.049	0.028	0.005
2006	**28.47**	28.28	0.119	0.074	0.011
2007	**12.18**	12.09	0.054	0.032	0.035
2008	**10.31**	10.23	0.045	0.028	0.035
2009	**16.86**	16.74	0.074	0.044	0.033
2010	**13.11**	13.02	0.058	0.033	0.009
2011	**0.00**	IE	IE	0.002	0.029
2012	**0.00**	IE	IE	0.002	0.028
2013	**6.26**	6.22	0.015	0.023	0.031
2014	**33.61**	33.42	0.087	0.106	0.021
2015	**37.62**	37.40	0.098	0.119	0.027
2016	**40.45**	40.23	0.101	0.126	0.028
2017	**42.63**	42.39	0.109	0.134	0.030
2018	**45.57**	45.31	0.116	0.143	0.032
2019	**47.88**	47.61	0.123	0.150	0.036
2020	**36.98**	36.77	0.094	0.115	0.027
2021	**48.19**	47.92	0.120	0.152	0.035
Trend					
1990 – 2021	**-28.1%**	*-28.0%*	*-49.3%*	*-20.2%*	*3148.5%*
2005 – 2021	**328.8%**	*329.3%*	*143.3%*	*442.4%*	*663.4%*
2020 - 2021	**30.3%**	*30.3%*	*28.0%*	*31.5%*	*28.8%*

3.2.8.1.2 Methodological issues

3.2.8.1.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[80] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}$$

Where:

Emissions $_{GHG,\,fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG,\,fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ) For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, solid fuels, gaseous fuels, other fossil fuel, biomass, peat

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG} = \sum_{fuel} emissions_{GHG,\,fuel}$$

3.2.8.1.2.2 Choice of activity data

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 - 2021 were taken from Statistical Office of Montenegro (MONSTAT).

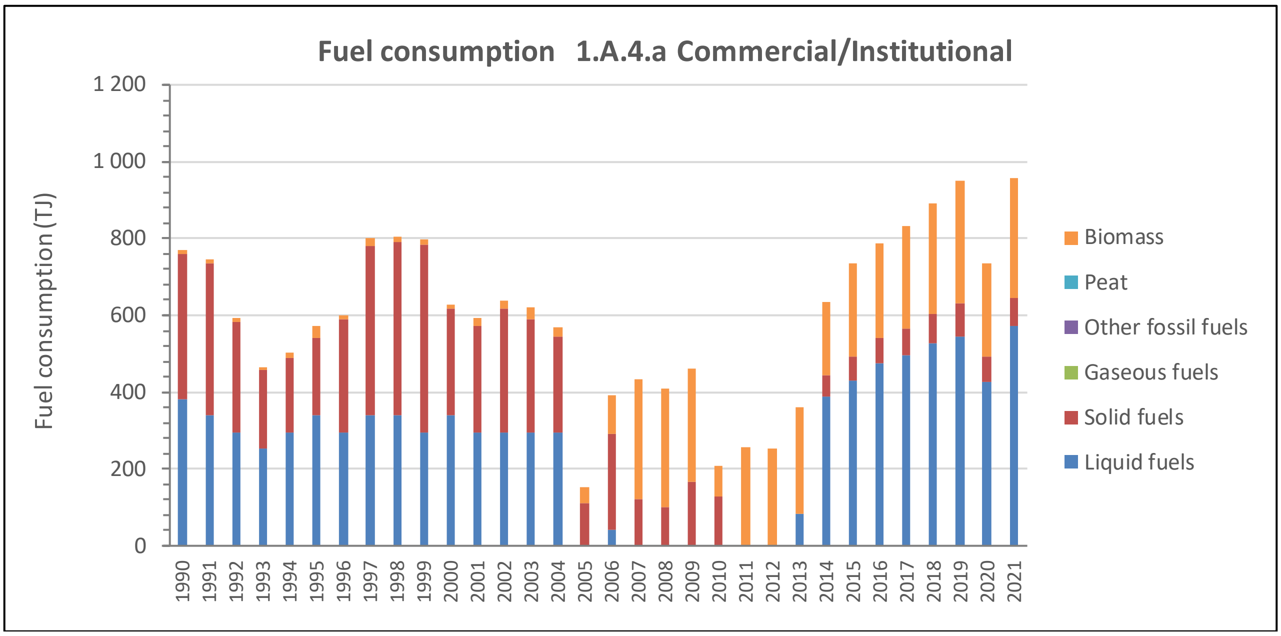


Figure 112 Activity data for IPCC sub-category 1.A.4.a Commercial/Institutional for the period 1990-2021

[80] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method

Table 225 Activity data for IPCC sub-category 1.A.4.a Commercial/Institutional for the period 1990-2021

Activity data 1.A.1.a	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	769.12	381.87	377.61	NO	NO	NO	9.64
1991	744.94	339.16	394.77	NO	NO	NO	11.01
1992	594.30	296.45	285.51	NO	NO	NO	12.34
1993	466.25	253.74	202.62	NO	NO	NO	9.89
1994	501.50	296.45	193.41	NO	NO	NO	11.64
1995	570.61	339.16	202.62	NO	NO	NO	28.83
1996	601.08	296.45	294.72	NO	NO	NO	9.91
1997	801.53	339.16	442.08	NO	NO	NO	20.29
1998	803.09	339.16	451.29	NO	NO	NO	12.64
1999	798.34	296.45	488.13	NO	NO	NO	13.76
2000	627.43	341.04	276.30	NO	NO	NO	10.09
2001	593.86	296.45	276.30	NO	NO	NO	21.11
2002	638.99	296.45	322.35	NO	NO	NO	20.19
2003	621.45	296.45	294.72	NO	NO	NO	30.28
2004	568.06	296.45	248.67	NO	NO	NO	22.94
2005	151.52	IE	110.52	NO	NO	NO	41.00
2006	392.38	42.71	248.67	NO	NO	NO	101.00
2007	431.73	IE	119.73	NO	NO	NO	312.00
2008	410.31	IE	101.31	NO	NO	NO	309.00
2009	462.78	IE	165.78	NO	NO	NO	297.00
2010	207.94	IE	128.94	NO	NO	NO	79.00
2011	257.00	IE	IE	NO	NO	NO	257.00
2012	253.00	IE	IE	NO	NO	NO	253.00
2013	360.91	83.91	IE	NO	NO	NO	277.00
2014	633.32	387.06	55.26	NO	NO	NO	191.00
2015	734.73	428.26	64.47	NO	NO	NO	242.00
2016	787.54	475.15	66.39	NO	NO	NO	246.00
2017	830.75	494.38	70.37	NO	NO	NO	266.00
2018	889.62	528.66	74.96	NO	NO	NO	286.00
2019	948.86	546.17	85.70	NO	NO	NO	317.00
2020	734.04	426.65	64.39	NO	NO	NO	243.00
2021	956.66	572.48	71.18	NO	NO	NO	313.00
Trend							
1990 - 2021	*24.4%*	*49.9%*	*-81.1%*	*NA*	*NA*	*NA*	*3148.5%*
2005 - 2021	*531.4%*	*NA*	*-35.6%*	*NA*	*NA*	*NA*	*663.4%*
2020 - 2021	*30.3%*	*34.2%*	*10.6%*	*NA*	*NA*	*NA*	*28.8%*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic meters. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in Sub-category 1.A.4.a *Commercial/Institutional*.

Table 226 Net calorific values (NCVs) applied for conversion to energy units in sub-category 1.A.4.a Commercial/ Institutional

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg) or * (TJ/m^3)		Source
		NCV	type	
Lignite	solid	9.21	CS	Statistical Office of Montenegro (MONSTAT)
Residual fuel oil	Liquid	41.20	CS	
Gas/Diesel Oil	Liquid	42.71	CS	
Liquefied Petroleum Gases (LPG)	Liquid	46.89	CS	
Charcoal	biomass	46.00	CS	
Wood/ Fuelwood*	biomass	9.1764	CS	
Wood Waste*	biomass	7.4124	CS	
Wood pellets	biomass	16.85	CS	
Wood Briquettes	biomass	16.85	CS	
Note:				
D Default	CS Country specific	PS Plant specific		

3.2.8.1.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 227 GHG Emission factor TIER 1 for IPCC sub-category 1.A.4.a Commercial/Institutional

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source
		EF	type	EF	type	EF	type	2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)
Gas/Diesel Oil	liquid	74 100	D	3	D	0.6	D	**Table 2.4** Default emission factors for stationary combustion in Commercial/Institutional (page 2.20)
Residual Fuel Oil / Total fuel oil	liquid	77 400	D	10	D	0.6	D	
Lignite	solid	101 000	D	10	D	1.5	D	
LPG	gaseous	63 100	D	5	D	0.1	D	
Wood/Wood waste	biomass	112 000	D	300	D	4	D	
Charcoal	biomass	112 000	D	200	D	1	D	
Note:								
D Default	CS Country specific	PS Plant specific	IEF Implied emission factor					

3.2.8.1.3 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
  - consistent use of energy balance data (energy statistic questionnaires),
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic, Eurostat and international energy statistics of UN

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions.

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.8.1.4 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC sub-category 1.A.4.a *Commercial/Institutional*.

Table 228 Recalculations done in IPCC sub-category 1.A.4.a Commercial/Institutional.

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
1.A.4.a	Revision of NCV		

3.2.8.1.5 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 229 Planned improvements for IPCC sub-category 1.A.4.a Commercial/Institutional.

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.4.a	Survey on fuel used: • solid, liquid fuels, other fossil fuels, biomass, etc. • combustion technologies (stoves, boilers, etc.)	EF	Transparency	high
1.A.4.a	Cross-check of national, Eurostat, FAO and international data sources and feedback to UNSD	AD	Completeness	medium

3.2.8.2 Residential (IPCC category 1.A.4.b)

3.2.8.2.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.4.b																		
1.A.4.b.i	✓	✓	NO	NO	NO	✓	✓	✓	NO	NO	NO	✓	✓	✓	NO	NO	NO	✓
1.A.4.b.ii	IE	IE	NO	NO	NO	NO	IE	IE	NO	NO	NO	NO	IE	IE	NO	NO	NO	NO
Key category	LA																	

A '✓' indicates: emissions from this sub-category have been estimated.
Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF

1.A.4.b	Residential	1.A.4.b.i	Stationary combustion	1.A.4.b.ii	Off-road vehicles and other machinery

This section describes GHG emissions resulting from fuel combustion activities for cooking, heating and lightning in households. An overview of the GHG emission from fuel combustion in IPCC sub-category 1.A.4.b *residentials* is provided in the following figure and table.

The main fuels used in IPCC category 1.A.4.b *Residential* were biomass, lignite and liquid fuels. However, the GHG emissions from lignite and liquid fuels make up the majority.

The fluctuation of the GHG emissions and related activity data for 2005-2013 can be explained by implementation of legislation related to air quality, new survey, allocation of fuels, and the new methodology in energy statistics.

The share of CO2 emissions from biomass increased significantly after 2011 due to implementation of legislation related to air quality related to heavy fuel oil.

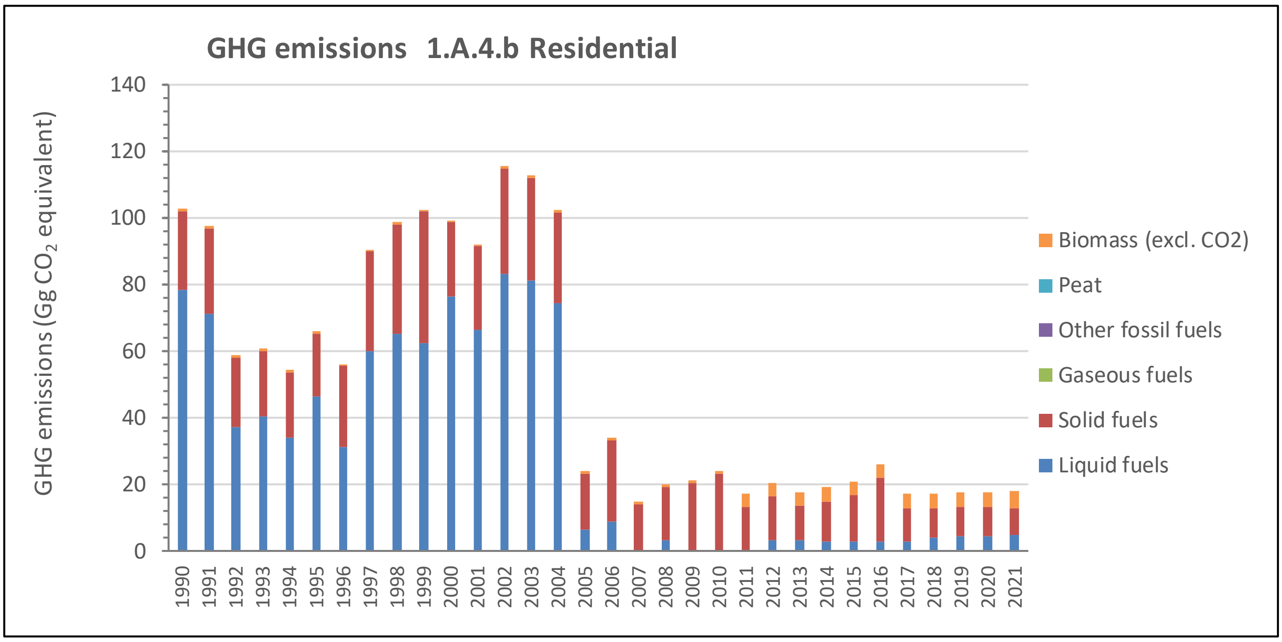


Figure 113 **Emissions from IPCC sub-category 1.A.4.b Residential for the period 1990-2021**

Table 230 Emissions from IPCC sub-category 1.A.4.b Residential for the period 1990-2021

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	kt CO2 equivalent	kt	kt CO2 equivalent	kt CO2 equivalent	kt
1990	102.76	101.31	0.279	0.365	0.80
1991	97.65	96.34	0.277	0.342	0.68
1992	58.70	57.55	0.179	0.224	0.74
1993	60.86	59.62	0.182	0.237	0.82
1994	54.39	53.46	0.168	0.200	0.56
1995	65.99	64.91	0.193	0.244	0.64
1996	56.22	55.22	0.181	0.204	0.61
1997	90.65	89.51	0.274	0.309	0.55
1998	98.74	97.61	0.299	0.331	0.50
1999	102.44	101.26	0.321	0.338	0.52
2000	99.42	98.25	0.280	0.344	0.54
2001	92.20	91.16	0.269	0.313	0.45
2002	115.67	114.27	0.337	0.398	0.66
2003	112.83	111.43	0.329	0.391	0.68
2004	102.37	101.01	0.296	0.360	0.69
2005	23.83	22.97	0.088	0.106	0.67
2006	34.08	33.15	0.124	0.132	0.67
2007	14.78	13.95	0.062	0.080	0.68
2008	19.84	18.98	0.078	0.095	0.68
2009	21.38	20.46	0.091	0.099	0.71
2010	24.22	23.26	0.103	0.108	0.75
2011	17.39	13.02	0.058	0.231	4.06
2012	20.58	16.19	0.065	0.242	4.07
2013	17.73	13.40	0.053	0.232	4.03
2014	19.03	14.72	0.055	0.231	4.01
2015	20.96	16.58	0.063	0.238	4.06
2016	26.20	21.79	0.086	0.251	4.05
2017	17.09	12.69	0.045	0.232	4.10
2018	17.11	12.76	0.041	0.229	4.06
2019	17.65	13.28	0.042	0.231	4.07
2020	17.48	13.11	0.041	0.231	4.09
2021	18.10	12.84	0.038	0.266	4.94
Trend					
1990 - 2021	*-82.4%*	*-87.3%*	*-86.3%*	*-27.3%*	*518.2%*
2005 - 2021	*-24.1%*	*-44.1%*	*-56.6%*	*150.2%*	*641.1%*
2020 - 2021	*3.5%*	*-2.1%*	*-5.5%*	*14.9%*	*21.0%*

3.2.8.2.2 Methodological issues

3.2.8.2.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[81] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}}$$

Where:

Emissions $_{GHG,\ fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG,\ fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ) For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, solid fuels, gaseous fuels, other fossil fuel, biomass, peat

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$\boldsymbol{Emissions_{GHG} = \sum_{fuel} emissions_{GHG,\,fuel}}$$

3.2.8.2.2.2 Choice of activity data

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 - 2021 were taken from Statistical Office of Montenegro (MONSTAT).

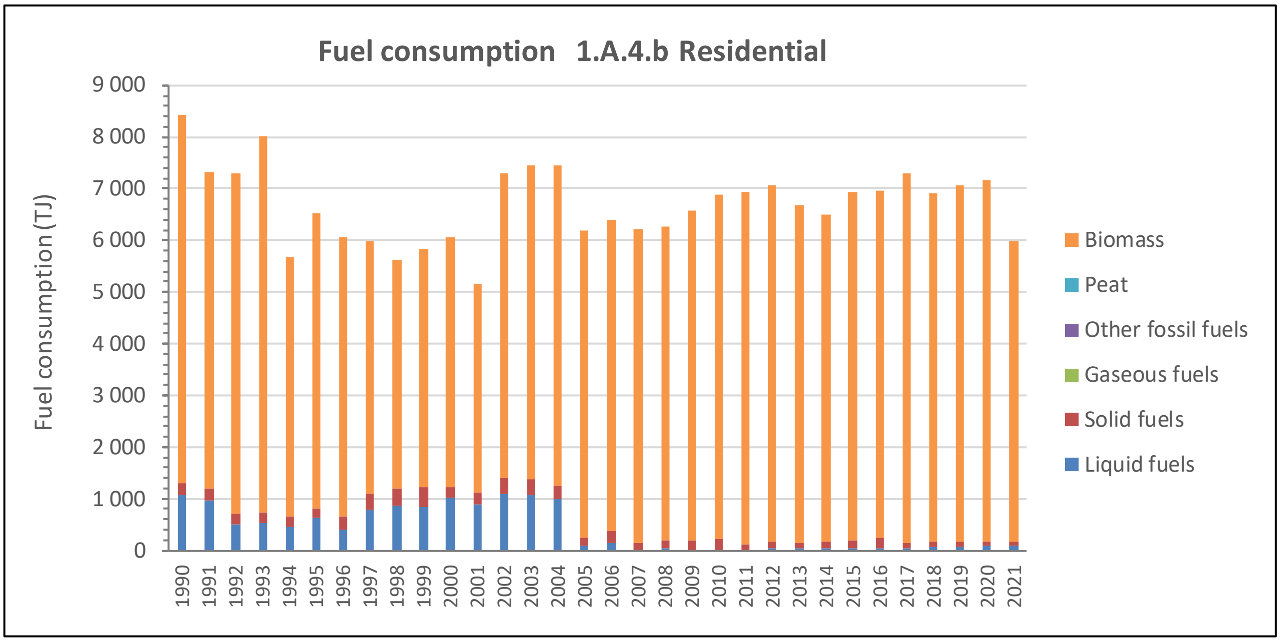


Figure 114 Activity data for IPCC sub-category 1.A.4.b Other Sectors for the period 1990-2021

[81] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method

Table 231 Activity data for IPCC sub-category 1.A.4.b Residentials for the period 1990-2021

Activity data 1.A.4.b	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	8 433.40	1 064.48	230.25	NO	NO	NO	7 138.68
1991	7 311.52	955.28	252.21	NO	NO	NO	6 104.03
1992	7 304.22	496.91	202.62	NO	NO	NO	6 604.69
1993	8 009.28	535.59	193.41	NO	NO	NO	7 280.28
1994	5 673.62	454.20	193.41	NO	NO	NO	5 026.01
1995	6 512.55	619.50	184.20	NO	NO	NO	5 708.85
1996	6 073.39	413.50	239.46	NO	NO	NO	5 420.43
1997	5 993.21	795.55	294.72	NO	NO	NO	4 902.94
1998	5 633.37	867.10	322.35	NO	NO	NO	4 443.92
1999	5 826.55	828.51	386.82	NO	NO	NO	4 611.22
2000	6 061.43	1 011.40	221.04	NO	NO	NO	4 829.00
2001	5 171.01	880.56	248.67	NO	NO	NO	4 041.78
2002	7 304.04	1 102.04	313.14	NO	NO	NO	5 888.87
2003	7 462.29	1 078.73	303.93	NO	NO	NO	6 079.63
2004	7 452.46	986.77	267.09	NO	NO	NO	6 198.59
2005	6 200.16	80.38	165.78	NO	NO	NO	5 954.00
2006	6 396.77	132.31	239.46	NO	NO	NO	6 025.00
2007	6 212.15	IE	138.15	NO	NO	NO	6 074.00
2008	6 273.28	42.71	156.57	NO	NO	NO	6 074.00
2009	6 583.62	IE	202.62	NO	NO	NO	6 381.00
2010	6 892.25	IE	230.25	NO	NO	NO	6 662.00
2011	6 936.44	IE	128.94	NO	NO	NO	6 807.50
2012	7 062.15	42.71	128.94	NO	NO	NO	6 890.50
2013	6 674.52	42.71	101.31	NO	NO	NO	6 530.50
2014	6 496.12	46.89	119.73	NO	NO	NO	6 329.50
2015	6 923.54	46.89	138.15	NO	NO	NO	6 738.50
2016	6 961.07	46.89	189.68	NO	NO	NO	6 724.50
2017	7 304.08	51.58	97.00	NO	NO	NO	7 155.50
2018	6 922.12	70.34	87.29	NO	NO	NO	6 764.50
2019	7 068.35	75.02	89.83	NO	NO	NO	6 903.50
2020	7 177.73	79.71	85.52	NO	NO	NO	7 012.50
2021	5 980.96	84.40	80.21	NO	NO	NO	5 816.35
Trend							
1990 - 2021	*-29.1%*	*-92.1%*	*-65.2%*	*NA*	*NA*	*NA*	*-18.5%*
2005 - 2021	*-3.5%*	*5.0%*	*-51.6%*	*NA*	*NA*	*NA*	*-2.3%*
2020 - 2021	*-16.7%*	*5.9%*	*-6.2%*	*NA*	*NA*	*NA*	*-17.1%*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g., in tonnes or cubic meters. To convert these data to energy units, in this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in IPCC sub-category 1.A.4.b *Residentials*.

Table 232 Net calorific values (NCVs) applied for conversion to energy units in IPCC sub-category 1.A.4.b Residentials

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg) or * (TJ/m³)		Source
		NCV	type	
Lignite	solid	9.24	CS	Statistical Office of Montenegro (MONSTAT)
Sub-bituminous coal	solid	16.75	CS	
Residual fuel oil	liquid	41.20	CS	
Gas/Diesel Oil	liquid	42.71	CS	
Liquefied Petroleum Gases (LPG)	liquid	46.89	CS	
Charcoal	biomass	46.00	CS	
Wood/ Fuelwood*	biomass	9.1764	CS	
Wood Waste*	biomass	7.4124	CS	
Wood pellets	biomass	16.85	CS	
Wood Briquette	biomass	16.85	CS	

Note:
D Default CS Country specific PS Plant specific

3.2.8.2.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 233 GHG Emission factor TIER 1 for IPCC sub-category 1.A.4.a Commercial/Institutional

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source
		EF	type	EF	type	EF	type	2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)
Gas/Diesel Oil	liquid	74 100	D	3	D	0.6	D	**Table 2.4** Default emission factors for stationary combustion in Commercial/Institutional (page 2.20)
Residual Fuel Oil / Total fuel oil	liquid	77 400	D	10	D	0.6	D	
Lignite	solid	101 000	D	10	D	1.5	D	
LPG	gaseous	63 100	D	5	D	0.1	D	
Wood/Wood waste	biomass	112 000	D	300	D	4	D	
Charcoal	biomass	112 000	D	200	D	1	D	

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

3.2.8.2.3 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
  - o consistent use of energy balance data (energy statistic questionnaires),
  - o documented sources,
  - o use of units,
  - o strictly defined interfaces between spreadsheets/calculation modules,
  - o unique structure of sheets which do the same,
  - o record keeping, use of write protection,
  - o unique use of formulas, special cases are documented/highlighted,
  - o quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic, Eurostat and international energy statistics of UN

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.8.2.4 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC sub-category 1.A.4.b *Residentials*.

Table 234 Recalculations done in IPCC sub-category 1.A.4.b Residentials.

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
1.A.4.b	No revisions were performed.		

3.2.8.2.5 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 235 Planned improvements for IPCC sub-category 1.A.4.b Residentials.

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.4	Split of fuel consumption to different sub-categories	EF	Transparency	medium
	Survey on fuel used (solid, natural gas, liquid fuels, other fossil fuels, biomass, etc.): • annual amount of fuel consumption by fuel type • combustion technologies (stoves, boilers, etc.)		Transparency Accuracy	high
1.A.4.b	Survey on fuel used and relevant characteristics: • Waste – biomass fraction / non-biomass fraction	AD	Completeness	high
1.A.4.b	Cross-check of national, Eurostat, FAO and international data sources and feedback to UNSD	AD	Completeness	medium
1.A.4.b	Time-series of fuel consumption	AD	Consistency	high

3.2.8.3 Agriculture/Forestry/Fishing/Fish Farms (IPCC category 1.A.4.c)

3.2.8.3.1 Source category description

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	Liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.4.c																		
1.A.4.c.i	IE	NO	NO	NO	NO	IE	IE	NO	NO	NO	NO	IE	IE	NO	NO	NO	NO	IE
1.A.4.c.ii	√	NO	NO	NO	NO	NO	√	NO	NO	NO	NO	NO	√	NO	NO	NO	NO	NO
1.A.4.c.iii	IE	NO	NO	NO	NO	NO	IE	NO	NO	NO	NO	NO	IE	NO	NO	NO	NO	NO
Key category	LA 1990	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

A '✓' indicates: emissions from this sub-category have been estimated.
Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF

1.A.4.c.i	Stationary
1.A.4.c.ii	Off-road vehicles and other machinery
1.A.4.c.iii	Fishing

Use of notation key

IE	1.A.4.c.i	reported under 1.A.4.b Residential - stationary
IE	1.A.4.c.iii	reported under 1.A.4.cii – offroad vehicles

An overview of the GHG emission from fuel combustion in IPCC sub-category 1.A.4.c *Agriculture/Forestry/ Fishing/Fish Farms* is provided in the following figure and table.

The main fuels used in IPCC category 1.A.4.b *Residential* were liquid fuels.

The fluctuation of the GHG emissions and related activity data can be explained by implementation of legislation related to air quality, new survey, allocation of fuels, and the new methodology in energy statistics.

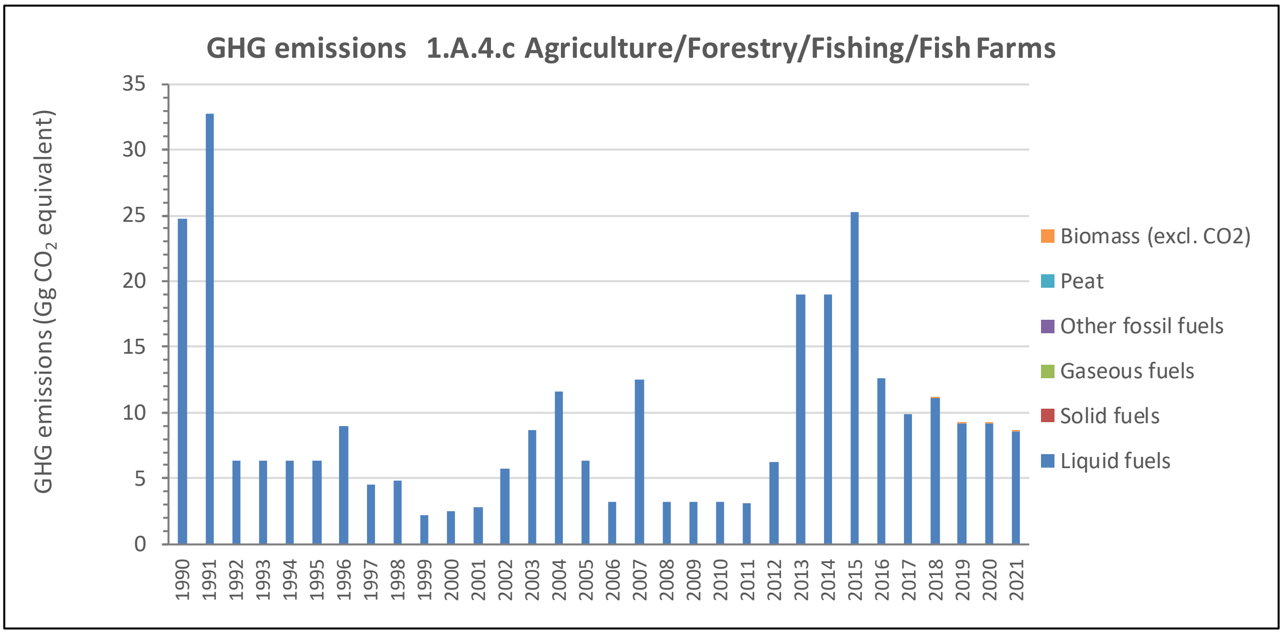


Figure 115 Emissions from IPCC sub-category 1.A.4.c Agriculture/Forestry/Fishing/Fish Farms for the period 1990-2021

Table 236 Emissions from IPCC sub-category 1.A.4. cii Agriculture/Forestry/Fishing/Fish Farms for the period 1990-2021

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	kt CO2 equivalent	kt CO2 equivalent	kt CO2 equivalent	kt CO2 equivalent	kt CO2 equivalent
1990	24.79	24.71	0.020	0.059	NO
1991	32.70	32.60	0.024	0.077	NO
1992	6.32	6.29	0.010	0.018	NO
1993	6.32	6.29	0.010	0.018	NO
1994	6.32	6.29	0.010	0.018	NO
1995	6.32	6.29	0.010	0.018	NO
1996	8.96	8.92	0.012	0.024	NO
1997	4.48	4.46	0.006	0.012	NO
1998	4.79	4.77	0.007	0.013	NO
1999	2.15	2.14	0.005	0.007	NO
2000	2.46	2.44	0.006	0.008	NO
2001	2.76	2.75	0.007	0.009	NO
2002	5.71	5.68	0.009	0.016	NO
2003	8.65	8.62	0.011	0.023	NO
2004	11.60	11.56	0.013	0.030	NO
2005	6.31	6.28	0.015	0.021	NO
2006	3.18	3.16	0.008	0.011	NO
2007	12.51	12.44	0.029	0.040	NO
2008	3.18	3.16	0.008	0.011	NO
2009	3.18	3.16	0.008	0.011	NO
2010	3.18	3.16	0.008	0.011	NO
2011	3.11	3.09	0.008	0.011	IE
2012	6.29	6.25	0.016	0.022	NO
2013	19.02	18.91	0.046	0.065	NO
2014	18.97	18.86	0.046	0.064	NO
2015	25.22	25.08	0.061	0.085	NO
2016	12.66	12.58	0.031	0.043	NO
2017	9.85	9.79	0.024	0.033	NO
2018	11.11	11.05	0.027	0.038	0.0022
2019	9.21	9.16	0.022	0.031	0.0027
2020	9.21	9.16	0.022	0.031	0.0027
2021	8.58	8.53	0.021	0.029	0.0027
Trend					
1990 - 2021	*-65.4%*	*-65.5%*	*3.3%*	*-50.9%*	*NA*
2005 - 2021	*36.0%*	*35.9%*	*39.6%*	*40.4%*	*NA*
2020 - 2021	*-6.8%*	*-6.8%*	*-7.0%*	*-7.0%*	*0.0%*

3.2.8.3.2 Methodological issues

3.2.8.3.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[82] has been applied:

Equation 2.1: GHG emissions from stationary combustion (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG,\,fuel} = Fuel\ Consumption_{fuel} \times Emission\ Factor_{GHG,\,fuel}$$

Where:

Emissions $_{GHG,\ fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission factor $_{GHG,\ fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ) For CO_2, it includes the carbon oxidation factor, assumed to be 1.
GHG	= CO_2, CH_4, N_2O
Fuel	= liquid fuels, solid fuels, gaseous fuels, other fossil fuel, biomass, peat

Equation 2.2: Total emissions by greenhouse gas (2006 IPCC GL, Vol. 2, Chap. 2)

$$Emissions_{GHG} = \sum_{fuel} emissions_{GHG,\,fuel}$$

3.2.8.3.2.2 Choice of activity data

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 - 2021 were taken from Statistical Office of Montenegro (MONSTAT).

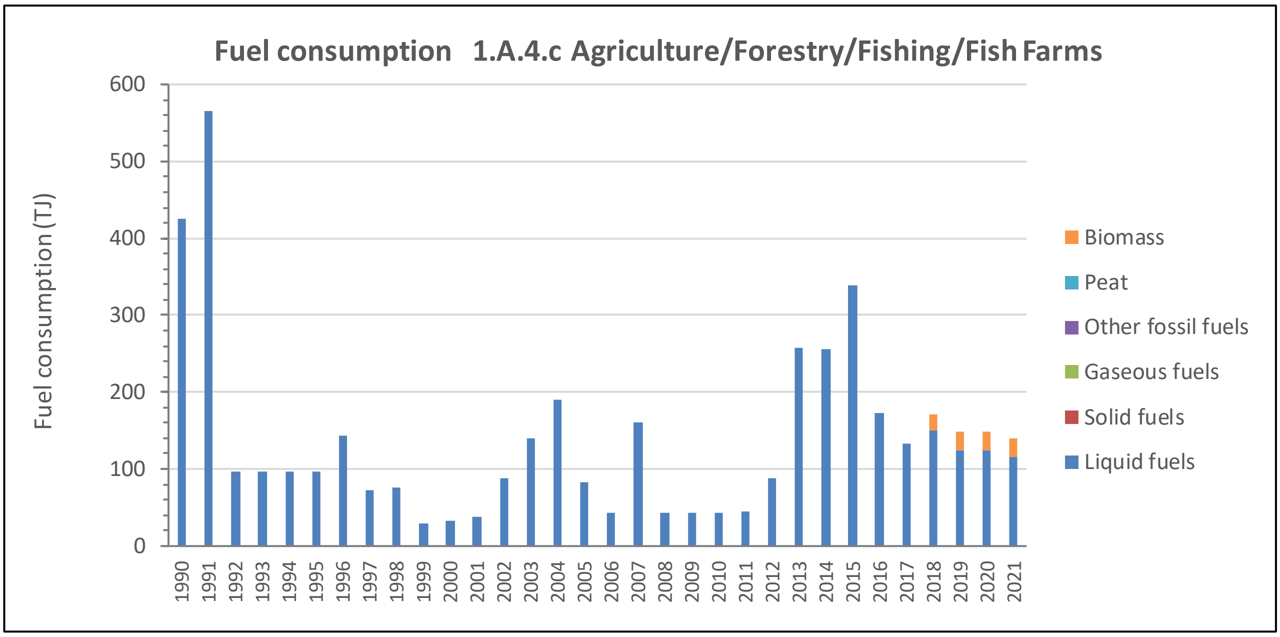


Figure 116 Activity data for IPCC sub-category 1.A.4.cii Agriculture/Forestry/Fishing/Fish Farms for the period 1990-2021

[82] Source: 2006 IPCC Guidelines, Volume 2: Energy, Chapter 2: Stationary Combustion - 2.3.1 Methodological issues - Choice of method

Table 237 Activity data for IPCC sub-category 1.A.4.c Agriculture/Forestry/Fishing/Fish Farms for the period 1990-2021

Activity data 1.A.4.b	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	424.56	424.56	NO	NO	NO	NO	NO
1991	565.23	565.23	NO	NO	NO	NO	NO
1992	96.33	96.33	NO	NO	NO	NO	NO
1993	96.33	96.33	NO	NO	NO	NO	NO
1994	96.33	96.33	NO	NO	NO	NO	NO
1995	96.33	96.33	NO	NO	NO	NO	NO
1996	143.22	143.22	NO	NO	NO	NO	NO
1997	71.61	71.61	NO	NO	NO	NO	NO
1998	75.73	75.73	NO	NO	NO	NO	NO
1999	28.84	28.84	NO	NO	NO	NO	NO
2000	32.96	32.96	NO	NO	NO	NO	NO
2001	37.08	37.08	NO	NO	NO	NO	NO
2002	88.09	88.09	NO	NO	NO	NO	NO
2003	139.10	139.10	NO	NO	NO	NO	NO
2004	190.11	190.11	NO	NO	NO	NO	NO
2005	82.90	82.90	NO	NO	NO	NO	NO
2006	42.71	42.71	NO	NO	NO	NO	NO
2007	160.76	160.76	NO	NO	NO	NO	NO
2008	42.71	42.71	NO	NO	NO	NO	NO
2009	42.71	42.71	NO	NO	NO	NO	NO
2010	42.71	42.71	NO	NO	NO	NO	NO
2011	44.59	44.59	NO	NO	NO	NO	NO
2012	87.30	87.30	NO	NO	NO	NO	NO
2013	258.14	258.14	NO	NO	NO	NO	NO
2014	255.62	255.62	NO	NO	NO	NO	NO
2015	339.53	339.53	NO	NO	NO	NO	NO
2016	172.72	172.72	NO	NO	NO	NO	NO
2017	132.97	132.97	NO	NO	NO	NO	NO
2018	170.24	150.24	NO	NO	NO	NO	20.00
2019	148.42	124.42	NO	NO	NO	NO	24.00
2020	148.42	124.42	NO	NO	NO	NO	24.00
2021	139.69	115.69	NO	NO	NO	NO	24.00
Trend							
1990 - 2021	*-67.1%*	*-72.7%*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*68.5%*	*39.6%*	*NA*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*-5.9%*	*-7.0%*	*NA*	*NA*	*NA*	*NA*	*0.0%*

In energy statistics, production, transformation and consumption of solid, liquid, gaseous and renewable fuels are specified in physical units, e.g. in tonnes or cubic meters. To convert these data to energy units, in

this case terajoules, requires calorific values. The emission calculations are bases on net calorific values. In the following table the applied net calorific values (NCVs) for conversion to energy units in Sub-category 1.A.4.c.ii Agriculture/Forestry/Fishing/Fish Farms - Off-road.

Table 3.238 Net calorific values (NCVs) applied for conversion to energy units in sub-category 1.A.4.c. Agriculture/Forestry/Fishing/Fish Farms - Off-road

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg) or * (TJ/m³)		Source
		NCV	type	
Residual fuel oil	liquid	41.20	CS	Statistical Office of Montenegro (MONSTAT)
Gas/Diesel Oil	liquid	42.71	CS	
Motor gasoline	liquid		CS	

Note:
D Default CS Country specific PS Plant specific

3.2.8.3.2.3 Choice of emission factors

Default emission factors for greenhouse gases were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 239 GHG Emission factor TIER 1 for IPCC sub-category 1.A.4.c.ii Agriculture/Forestry/Fishing/Fish Farms - Off-road

Fuel	Fuel type	CO_2 (kg/TJ)		CH_4 (kg/TJ)		N_2O (kg/TJ)		Source
		EF	type	EF	type	EF	type	**2006 IPCC Guidelines Vol. 2, Chap. 2 (2.3.2.1)**
Gas/Diesel Oil	liquid	74 100	D	3	D	0.6	D	**Table 2.4** Default emission factors for stationary combustion in Commercial/Institutional (page 2.20)
Residual Fuel Oil / Total fuel oil	liquid	77 400	D	10	D	0.6	D	
Lignite	solid	101 000	D	10	D	1.5	D	
LPG	gaseous	63 100	D	5	D	0.1	D	
Wood/Wood waste	biomass	112 000	D	300	D	4	D	
Charcoal	biomass	112 000	D	200	D	1	D	

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

3.2.8.3.3 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- consistent use of energy balance data (energy statistic questionnaires),
- documented sources,
- use of units,
- strictly defined interfaces between spreadsheets/calculation modules,
- unique structure of sheets which do the same,
- record keeping, use of write protection,
- unique use of formulas, special cases are documented/highlighted,
- quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic, Eurostat and international energy statistics of UN

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ time series consistency - plausibility checks of dips and jumps.

3.2.8.3.4 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC sub-category 1.A.4.cii Agriculture/Forestry/Fishing/Fish Farms - Off-road

Table 240 Recalculations done in IPCC sub-category 1.A.4.c.ii Agriculture/Forestry/Fishing/Fish Farms - Off-road.

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
1.A.4.c	Revision of NCV	AD	Accuracy

3.2.8.3.5 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 241 Planned improvements for IPCC sub-category 1.A.4.c.ii Agriculture/Forestry/Fishing/Fish Farms - Off-road.

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.4.c	Split of fuel consumption to different sub-categories	EF	Transparency	medium
	Survey on fuel used (solid, natural gas, liquid fuels, other fossil fuels, biomass, etc.): • annual amount of fuel consumption by fuel type • combustion technologies (stoves, boilers, etc.)		Transparency Accuray	high
1.A.4.c	Survey on fuel used and relevant characteristics: • Waste – biomass fraction / non-biomass fraction	AD	Completeness	high
1.A.4.c	Cross-check of national, Eurostat, FAO and international data sources and feedback to UNSD	AD	Completeness	medium
1.A.4.c	Time-series of fuel consumption	AD	Consistency Completeness	high

3.2.9 Non-Specified (IPCC category 1.A.5)

This section describes GHG emissions resulting from fuel combustion that are not specified elsewhere. Include emissions from fuel delivered to the military in the country and delivered to the military of other countries that are not engaged in multilateral operations.

IPCC code	Description	
1.A.5.a	Stationary	Emissions from fuel combustion in stationary sources that are not specified elsewhere.
1.A.5.b	Mobile	Emissions from vehicles and other machinery, marine and aviation (not included in 1.A.4c.ii or elsewhere).
1.A.5.b.i	Mobile (aviation component)	All remaining aviation emissions from fuel combustion that are not specified elsewhere. Include emissions from fuel delivered to the country's military as well as fuel delivered within that country but used by the militaries of other countries that are not engaged in multilateral operations.
1.A.5.b.ii	Mobile (water-borne component)	All remaining water-borne emissions from fuel combustion that are not specified elsewhere. Include emissions from fuel delivered to the country's military as well as fuel delivered within that country but used by the militaries of other countries that are not engaged in multilateral operations.
1.A.5.b.iii	Mobile (Other)	All remaining emissions from mobile sources not included elsewhere.
1.A.5.c	Multilateral Operations (Memo item[83])	Emissions from fuels used in multilateral operations pursuant to the Charter of the United Nations. Include emissions from fuel delivered to the military in the country and delivered to the military of other countries.

GHG emissions/ removals	CO_2						CH_4						N_2O					
Estimated	Liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass	liquid	solid	gaseous	Other fossil fuel	Peat	biomass
1.A.5.a	NE	NE	NE	NE	NO	NE	NE	NE	NE	NE	NO	NE	NE	NE	NE	NE	NO	NE
1.A.5.b	NE	NO	NO	NO	NO	NO	NE	NO	NO	NO	NO	NO	NE	NO	NO	NO	NO	NO
1.A.5.b.i	NE	NO	NO	NO	NO	NO	NE	NO	NO	NO	NO	NO	NE	NO	NO	NO	NO	NO
1.A.5.b.ii	NE	NO	NO	NO	NO	NO	NE	NO	NO	NO	NO	NO	NE	NO	NO	NO	NO	NO
1.A.5.b.iii	NE	NO	NO	NO	NO	NO	NE	NO	NO	NO	NO	NO	NE	NO	NO	NO	NO	NO
1.A.5.c	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Key Category	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

A '✓' indicates: emissions from this sub-category have been estimated.
Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF

The national energy statistics currently do not provide information regarding the use of fuels in the different IPCC subcategories.

[83] Not included in National Total

3.3 Fugitive emissions from fuels (IPCC category 1.B)

This section describes GHG emissions resulting from the extraction, processing and delivery of fossil fuels to the point of final use, also known as fugitive emissions. Both GHG emissions from surface and underground mining activities are accounted for.

Methane (CH_4) is produced naturally in the process of coal formation and thus is considered the most important fugitive emission for coal mining and handling.

Furthermore, methane and CO_2 emitted during mining from breakage of coal and associated strata and leakage from the pit floor and highwall.

Fugitive emissions of CH_4 and CO_2 from the production, transmission and distribution of oil and natural gas are estimated based on the quantity reported in the energy statistics.

3.3.1 Solid Fuels (IPCC category 1.B.1)

This section describes GHG emissions resulting from the fugitive CH_4 emissions from coal mining and handling activities in underground and surface mines.

IPCC code	Description	Occurrent			Not occurrent (NO)
		Estimated	Not estimated (NE)	Included elsewhere (IE)	
1.B.1.a	Coal mining and handling				
1.B.1.a.i	Underground mines				
1.B.1.a.i.1	Mining				✓
1.B.1.a.i.2	Post-mining seam gas emissions				✓
1.B.1.a.i.3	Abandoned underground mines				✓
1.B.1.a.i.4	Flaring of drained methane or conversion of methane to CO_2				✓
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	✓			
1.B.1.b	Uncontrolled combustion and burning coal dumps		✓		
1.B.1.c	Solid fuel transformation				
	Coke production				✓
	Charcoal production		✓		

3.3.1.1 Coal mining and handling - Underground mines (IPCC category 1.B.1.a.i)

3.3.1.1.1 Source category description

GHG emissions/removals	CO_2	CH_4	N_2O
Estimated	NA	NO	NA
Key Category	-	-	-

A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential

3.3.1.2 Coal mining and handling - Surface mines (IPCC category 1.B.1.a.ii)

3.3.1.2.1 Source category description

GHG emissions/removals	CO_2	CH_4	N_2O
Estimated	NA	✓	NA
Key Category	-	LA 2021	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential			

As described in the 2019 Refinements to the 2006 IPCC Guidelines[84], CH4 is the major greenhouse gas emitted from coal mining and handling.

The major stages for the emission of greenhouse gases for both underground and surface coal mines are:

- Mining emissions – These emissions result from the liberation of stored gas during the breakage of coal, and the surrounding strata, during mining operations.
- Post-mining emissions – Not all gas is released from coal during the process of coal breakage during mining. Emissions, during subsequent handling, processing and transportation of coal are termed post-mining emissions. Therefore coal normally continues to emit gas even after it has been mined, although more slowly than during the coal breakage stage.
- Low temperature oxidation - These emissions arise because once coal is exposed to oxygen in air, the coal oxidizes to produce CO2. However, the rate of formation of CO2 by this process is low.
- Uncontrolled combustion – On occasions, when the heat produced by low temperature oxidation is trapped, the temperature rises and an active fire may result. This is commonly known as uncontrolled combustion and is the most extreme manifestation of oxidation. Uncontrolled combustion is characterised by rapid reactions, sometimes visible flames and rapid CO2 formation, and may be natural or anthropogenic. It is noted that uncontrolled combustion only due to coal exploitation activities is considered here.
- Exploration emissions – These emissions result from boreholes drilled through carbonaceous strata for the purposes of coal exploration. This is distinct from gas drainage boreholes which form part of a degasification system.

After mining has ceased left over coals in, abandoned coal mines may also continue to emit methane.

An overview of the GHG emission from fuel combustion in IPCC category 1.B.1.a.ii *Coal mining and handling - Surface mines* is provided in the following figure and tables:

- annual GHG emissions;
- Trend of the periods 1990 - 2021.

[84] 2019 Refinements to the 2006 IPCC Guidelines, Volume 2: Energy, Chapter 4: Fugitive Emissions, p. 4.10

The greenhouse gas emissions from IPCC category IPCC category 1.B.1.a.ii *Coal mining and handling - Surface mines* increased by 167.1% from 11.55 kt CO_2 equivalent in 1990 to 10.59 kt CO_2 equivalent in 2021. Furthermore, the GHG emissions decreased by -8.4% in the period 1990 - 2021.

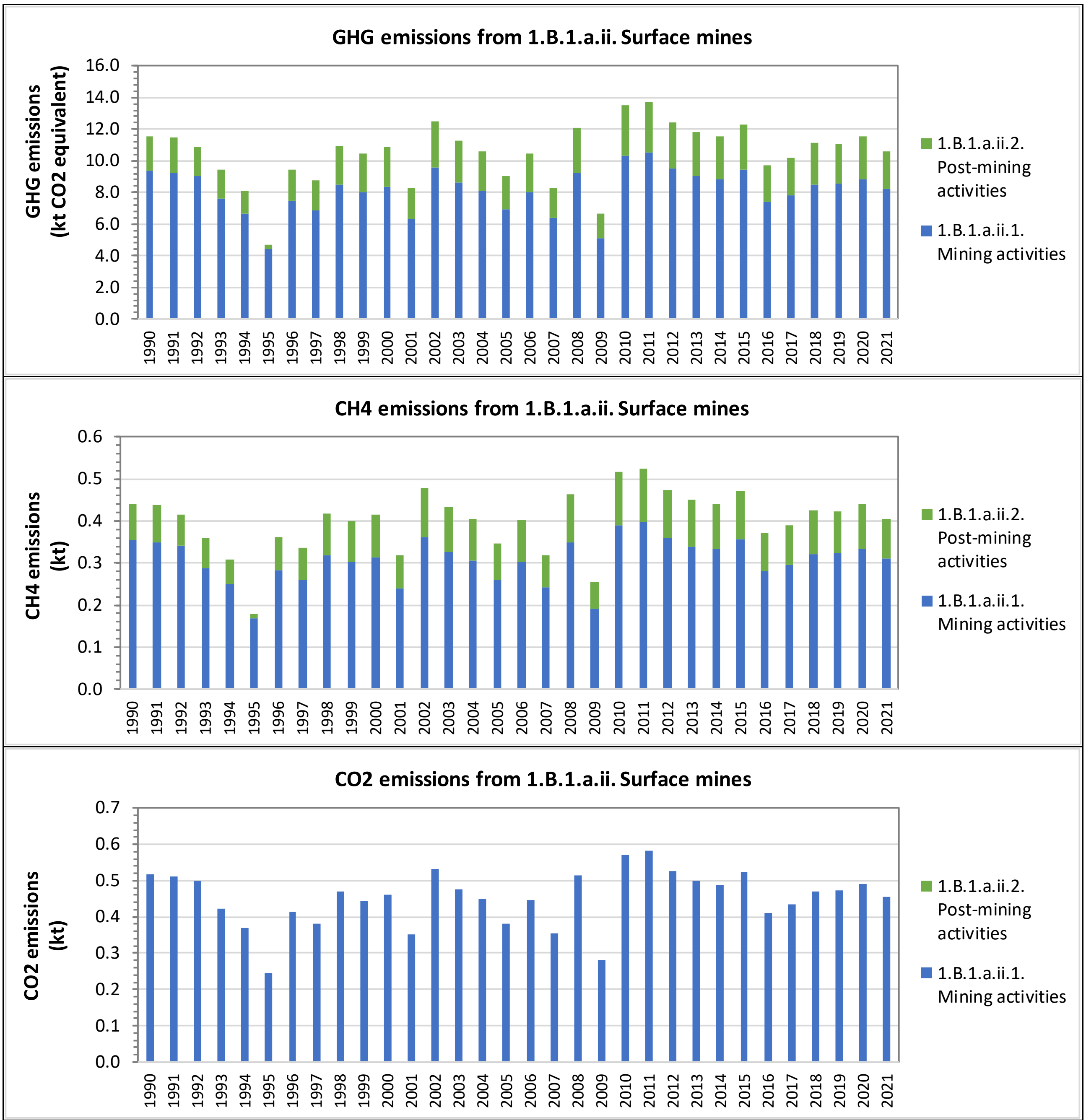


Figure 117 GHG emissions from lignite mining (1.B.1.a) for the period 1990-2021

Table 242 GHG emissions from Solid fuels (IPCC category 1.B.1) for the period 1990-2021

GHG emissions	1.B.1	1.B.1.a.i	1.B.1.a.ii		1.B.1.c	1.B.1.c
	Total	Underground Mines	Surface Mines		Uncontrolled combustion and burning coal dumps	Charcoal
		All	Mining	Post-mining		
	kt CO2 equivalent					
1990	11.55	NO	9.34	2.21	NE	NE
1991	11.49	NO	9.24	2.26	NE	NE
1992	10.89	NO	9.01	1.89	NE	NE
1993	9.41	NO	7.63	1.78	NE	NE
1994	8.07	NO	6.64	1.43	NE	NE
1995	4.68	NO	4.44	0.25	NE	NE
1996	9.47	NO	7.48	1.99	NE	NE
1997	8.79	NO	6.86	1.93	NE	NE
1998	10.92	NO	8.46	2.46	NE	NE
1999	10.43	NO	8.02	2.41	NE	NE
2000	10.84	NO	8.33	2.51	NE	NE
2001	8.30	NO	6.33	1.97	NE	NE
2002	12.51	NO	9.61	2.90	NE	NE
2003	11.28	NO	8.61	2.67	NE	NE
2004	10.61	NO	8.11	2.50	NE	NE
2005	9.06	NO	6.90	2.16	NE	NE
2006	10.49	NO	8.04	2.45	NE	NE
2007	8.29	NO	6.40	1.89	NE	NE
2008	12.10	NO	9.26	2.85	NE	NE
2009	6.66	NO	5.09	1.57	NE	NE
2010	13.51	NO	10.31	3.20	NE	NE
2011	13.73	NO	10.50	3.23	NE	NE
2012	12.40	NO	9.50	2.90	NE	NE
2013	11.80	NO	9.00	2.80	NE	NE
2014	11.53	NO	8.80	2.73	NE	NE
2015	12.31	NO	9.43	2.88	NE	NE
2016	9.72	NO	7.44	2.28	NE	NE
2017	10.16	NO	7.85	2.32	NE	NE
2018	11.12	NO	8.49	2.63	NE	NE
2019	11.04	NO	8.54	2.50	NE	NE
2020	11.53	NO	8.86	2.67	NE	NE
2021	10.59	NO	8.24	2.35	NE	NE
Trend						
1990 - 2021	-8.4%	NA	-11.8%	6.2%	*NA*	*NA*
2005 - 2021	16.9%	NA	19.4%	9.0%	*NA*	*NA*
2020 - 2021	-8.2%	NA	-7.0%	-11.9%	*NA*	*NA*

Table 243 CH_4 emissions from Solid fuels (IPCC category 1.B.1) for the period 1990-2021

CH4 emissions	1.B.1	1.B.1.a.i	1.B.1.a.ii		1.B.1.c	1.B.1.c
	Total	Underground Mines	Surface Mines		Uncontrolled combustion and burning coal dumps	Charcoal
		All	Mining	Post-mining		
	kt					
1990	0.441	NO	0.353	0.089	NE	NE
1991	0.439	NO	0.349	0.090	NE	NE
1992	0.416	NO	0.340	0.076	NE	NE
1993	0.359	NO	0.288	0.071	NE	NE
1994	0.308	NO	0.251	0.057	NE	NE
1995	0.178	NO	0.168	0.010	NE	NE
1996	0.362	NO	0.283	0.080	NE	NE
1997	0.336	NO	0.259	0.077	NE	NE
1998	0.418	NO	0.320	0.098	NE	NE
1999	0.399	NO	0.303	0.096	NE	NE
2000	0.415	NO	0.315	0.101	NE	NE
2001	0.318	NO	0.239	0.079	NE	NE
2002	0.479	NO	0.363	0.116	NE	NE
2003	0.432	NO	0.325	0.107	NE	NE
2004	0.406	NO	0.306	0.100	NE	NE
2005	0.347	NO	0.261	0.086	NE	NE
2006	0.402	NO	0.304	0.098	NE	NE
2007	0.317	NO	0.242	0.076	NE	NE
2008	0.464	NO	0.350	0.114	NE	NE
2009	0.255	NO	0.192	0.063	NE	NE
2010	0.517	NO	0.390	0.128	NE	NE
2011	0.526	NO	0.397	0.129	NE	NE
2012	0.475	NO	0.359	0.116	NE	NE
2013	0.452	NO	0.340	0.112	NE	NE
2014	0.442	NO	0.333	0.109	NE	NE
2015	0.472	NO	0.356	0.115	NE	NE
2016	0.372	NO	0.281	0.091	NE	NE
2017	0.389	NO	0.296	0.093	NE	NE
2018	0.426	NO	0.321	0.105	NE	NE
2019	0.423	NO	0.323	0.100	NE	NE
2020	0.442	NO	0.335	0.107	NE	NE
2021	0.405	NO	0.311	0.094	NE	NE
Trend						
1990 - 2021	*-8.2%*	*NA*	*-11.8%*	*6.2%*	*NA*	*NA*
2005 - 2021	*16.8%*	*NA*	*19.4%*	*9.0%*	*NA*	*NA*
2020 - 2021	*-8.2%*	*NA*	*-7.0%*	*-11.9%*	*NA*	*NA*

Table 244 CO2 emissions from Solid fuels (IPCC category 1.B.1) for the period 1990-2021

CO2 emissions	1.B.1	1.B.1.a.i	1.B.1.a.ii		1.B.1.c	1.B.1.c
	Total	Underground Mines	Surface Mines		Uncontrolled combustion and burning coal dumps	Charcoal
		All	Mining	Post-mining		
	kt					
1990	0.518	NO	0.518	NE	NE	NE
1991	0.512	NO	0.512	NE	NE	NE
1992	0.499	NO	0.499	NE	NE	NE
1993	0.423	NO	0.423	NE	NE	NE
1994	0.368	NO	0.368	NE	NE	NE
1995	0.246	NO	0.246	NE	NE	NE
1996	0.414	NO	0.414	NE	NE	NE
1997	0.380	NO	0.380	NE	NE	NE
1998	0.469	NO	0.469	NE	NE	NE
1999	0.445	NO	0.445	NE	NE	NE
2000	0.461	NO	0.461	NE	NE	NE
2001	0.351	NO	0.351	NE	NE	NE
2002	0.532	NO	0.532	NE	NE	NE
2003	0.477	NO	0.477	NE	NE	NE
2004	0.449	NO	0.449	NE	NE	NE
2005	0.382	NO	0.382	NE	NE	NE
2006	0.446	NO	0.446	NE	NE	NE
2007	0.355	NO	0.355	NE	NE	NE
2008	0.513	NO	0.513	NE	NE	NE
2009	0.282	NO	0.282	NE	NE	NE
2010	0.571	NO	0.571	NE	NE	NE
2011	0.582	NO	0.582	NE	NE	NE
2012	0.527	NO	0.527	NE	NE	NE
2013	0.499	NO	0.499	NE	NE	NE
2014	0.488	NO	0.488	NE	NE	NE
2015	0.523	NO	0.523	NE	NE	NE
2016	0.412	NO	0.412	NE	NE	NE
2017	0.435	NO	0.435	NE	NE	NE
2018	0.470	NO	0.470	NE	NE	NE
2019	0.473	NO	0.473	NE	NE	NE
2020	0.491	NO	0.491	NE	NE	NE
2021	0.457	NO	0.457	NE	NE	NE
Trend						
1990 - 2021	*-11.8%*	*NA*	*-11.8%*	*NA*	*NA*	*NA*
2005 - 2021	*19.4%*	*NA*	*19.4%*	*NA*	*NA*	*NA*
2020 - 2021	*-7.0%*	*NA*	*-7.0%*	*NA*	*NA*	*NA*

3.3.1.2.2 Methodological issues

3.3.1.2.2.1 Choice of methods

For estimating the GHG emissions based on coal production activity data from underground coal mining and post-mining, the 2006 IPCC Guidelines method for has been applied *(2006 IPCC GL, Vol. 2, Chap. 4)*[85]:

TIER 2 Surface mining emissions of CH4
TIER 1 Surface mining emissions of CO2, CH4 Post-mining mining emissions

Equation 4.1.6 (updated): General equation for estimating fugitive emissions from surface coal mining

$$CH_4\textbf{emissions} = Surface\ mining\ emissions\ of\ CH_4 + \ Post - mining\ mining\ emissions\ of\ CH_4$$

$$CO_2\textbf{emissions} = Surface\ mining\ emissions\ of\ CO_2 + \ Post - mining\ mining\ emissions\ of\ CO_2$$

Equation 4.1.7 (updated): TIER 1 Global average method – surface mines – methane

$$CH_4\ emissions = CH_4\textbf{emission factor}\ \times Surface\ coal\ production\ \ \times Conversion\ factor$$

Where:

CH4 Emissions	= methane emissions for mining activities (kt)
Surface coal production	= amount of coal produced (tonnes)
CH4 Emission factor	= methane emission factor (m^3 $tonne^{-1}$)
Unites conversion factor	= density of lignite - conversion factor by type of gas (kt/m^3)

Equation 4.1.7A (new): TIER 1 Global average method – surface mines – methane

$$CO_2\ emissions = CO_2\ \textbf{emission factor}\ \times Surface\ coal\ production\ \ \times Conversion\ factor$$

Where:

CO2 Emissions	= carbon dioxide emissions for mining activities (kt)
Surface coal production	= amount of coal produced (tonnes)
CO2 Emission factor	= carbon dioxide emission factor (m^3 $tonne^{-1}$)
Unites conversion factor	= density of lignite - conversion factor by type of gas (kt/m^3)

Equation 4.1.8: TIER 1 Global average method – post-mining emissions – surface mines

$$CH_4\ emissions = CH_4\textbf{emission factor}\ \times Surface\ coal\ production\ \ \times Conversion\ factor$$

Where:

CH4 Emissions	= methane emissions for post-mining activities (kt)
Surface coal production	= amount of coal produced (tonnes)
CH4 Emission factor	= methane emission factor (m^3 $tonne^{-1}$)
Unites conversion factor	= density of lignite - conversion factor by type of gas (kt/m^3)

Unites conversion factor - Density

This is the density of CH4 and converts volume of CH4 to mass of CH4. The density is taken at 20˚C and 1 atmosphere pressure and has a value of 0.67×10^{-6} kt m^{-3}

[85] *Vol. 2, Chap. 4, 2019 Refinement to the 2006 IPCC Guidelines*

3.3.1.2.2.2 Choice of activity data

National production data for lignite were taken from MONSTAT.

Table 245 Lignite production

Years	Lignite production	Density Lignite	Lignite production
	kg	kg/m3	m3
1990	1 756.00	0.67	1 176.52
1991	1 736.00		1 163.12
1992	1 693.00		1 134.31
1993	1 434.00		960.78
1994	1 249.00		836.83
1995	834.00		558.78
1996	1 406.00		942.02
1997	1 290.00		864.30
1998	1 591.00		1 065.97
1999	1 508.00		1 010.36
2000	1 565.00		1 048.55
2001	1 190.00		797.30
2002	1 806.00		1 210.02
2003	1 618.00		1 084.06
2004	1 524.00		1 021.08
2005	1 297.00		868.99
2006	1 512.00		1 013.04
2007	1 203.00		806.01
2008	1 740.00		1 165.80
2009	957.00		641.19
2010	1 938.00		1 298.46
2011	1 973.00		1 321.91
2012	1 786.00		1 196.62
2013	1 692.00		1 133.64
2014	1 655.00		1 108.85
2015	1 773.00		1 187.91
2016	1 398.00		936.66
2017	1 474.80		988.12
2018	1 595.90		1 069.25
2019	1 605.20		1 075.48
2020	1 665.40		1 115.82
2021	1 548.60		1 037.56
Trend			
1990 - 2021	*-11.81%*		*-11.81%*
2005 - 2021	*19.40%*		*19.40%*
2018 - 2021	*-7.01%*		*-7.01%*

3.3.1.2.2.3 Choice of emission factors

The following emissions factors were applied.

Coal mining - *Surface mines*		Emission factors Mining (m³/t)	Emission factors Post-Mining (m³/t)	Source
CS EF CH4		0.3	0.1	
IPCC default	Low CH4	0.3	0	2019 Refinement to the 2006 IPCC GL, Vol. 2, Chap.4, p. 4.25/4.26
	Average CH4	1.2	0.1	
	High CH4	2.0	0.2	
IPCC default	Low CO2	0.01	NE	
	Average CO2	0.44	NE	
	High CO2	0.94	NE	

The country specific CH4 emission factor for mining activities is based on the genesis of Montenegrin lignite.

Post mining activities: For CH4, the IPCC average is applied.
For CO2, the IPCC average is applied.

3.3.1.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 1.B.1 are presented in the following table.

Table 246 Uncertainty for IPCC sub-category 1.B.1 CH_4 emissions from Solid fuels

Uncertainty	CH_4 Surface Mining		CO2 Surface Mining		Source
	Mining	Post-mining	Mining	Post-mining	
Activity data (AD)					2019 Refinement to the 2006 IPCC GL, Vol. 2, Chap.4, TABLE 4.1.4 (UPDATED)
Emission factor (EF)					
Combined Uncertainty (U)	200%	50%	-67% to +200%	NA	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as the same methodology is applied to the whole period. Activity data are considered to be consistent as national and international data were always compared.

3.3.1.4 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed:

⇒ Checked of calculations by spreadsheets
- consistent use of energy balance data (energy statistic questionnaires),
- documented sources,
- use of units,
- strictly defined interfaces between spreadsheets/calculation modules,

  - o unique structure of sheets which do the same,
  - o record keeping, use of write protection,
  - o unique use of formulas, special cases are documented/highlighted,
  - o quick-control checks for data consistency through all steps of calculation.
- ⇒ time series consistency - plausibility checks of dips and jumps.

3.3.1.5 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC sub-category 1.B.1 CH_4 emissions from Solid fuels.

Table 247 Recalculations done since submission 2017 IPCC sub-category 1.B.1 CH_4 emissions from Solid fuels

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
1.B.1	Application of CS emissions factor	AD	Accuracy
1.B.1	Application of Guidance provided by 2019 Refinement to the 2006 IPCC GL	EMI	Accuracy

3.3.1.6 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 248 Planned improvements for IPCC sub-category 1.B.1 CH_4 emissions from Solid fuels

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.B.1.a.i.2, 1.B.1.a.i.2	Survey on post-mining activities (surface and underground mining)	AD	accuracy	medium
1.B.1.a.i.3 & 1.B.1.a.i.4	Survey on Abandoned underground mines and on flaring of drained methane	AD	accuracy	medium
1.B.1.b	Uncontrolled combustion and burning coal dumps	AD	accuracy	medium

3.3.2 Oil and Natural Gas (IPCC category 1.B.2)

This section describes the fugitive GHG emissions from oil and gas systems except contributions from fuel combustion. Oil and natural gas systems consist of infrastructure required to produce, collect, process or refine and deliver natural gas and petroleum products to market. The scope of the inventory includes all relevant processes from the well head, or oil and gas source, to the final sales point to the consumer.

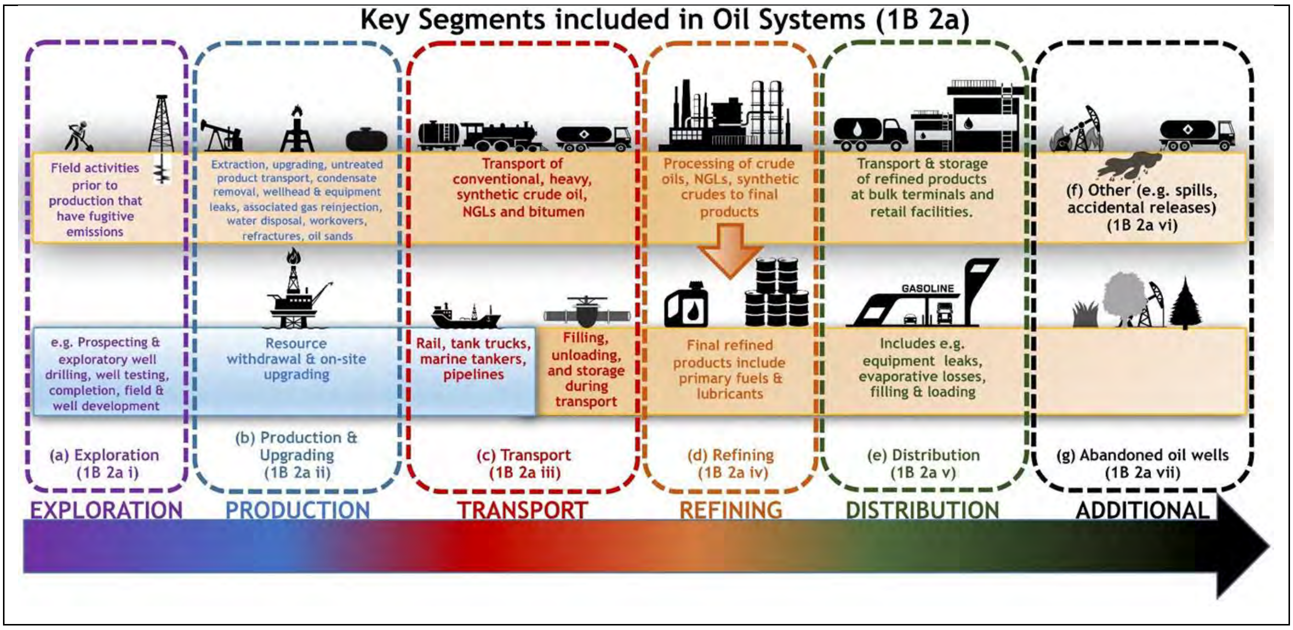


Figure 118 Key segments included in oil and natural gas systems

Source: 2019 Refinement to the 2006 IPCC GL, Chapter 4: Fugitive Emissions, Figure 4.2.0, page 4.36[86]

In the following table is the status of reporting of sources of IPCC category 1.B.2 Oil and natural gas provided.

Table 249 Status of reporting and key category of IPCC category 1.B.2

IPCC code	Description		CH_4		CO_2		NMVOC		N_2O	
			Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
1.B.2.a	**Oil**									
1.B.2.a.i	Exploration	Leaks	NA		NA		NA		NA	
		Venting	NO							
		Flaring	NO							
1.B.2.a.ii	Production and upgrading	Leaks	NO		NA		NO		NA	
		Venting	NO							
		Flaring	NO							
1.B.2.a.iii	Transport	All	NO		NO		NO		NA	
1.B.2.a.iv	Refining/storage	Leaks	NO		NO		NO		NO	
		Venting	NO							
		Flaring	NO							
1.B.2.a.v	Distribution of oil products	All	NA		NA		✓		NA	
1.B.2.a.vi	Other									
1.B.2.a.vi.1	Abandoned wells	All	NO		NO		NO		NO	
1.B.2.a.vi.2	Other	All	NO		NO		NO		NO	

[86] https://www.ipcc-nggip.iges.or.jp/public/2006gl/french/pdf/2_Volume2/V2_4_CH4_Fugitive_Emissions.pdf

IPCC code	Description		CH_4		CO_2		NMVOC		N_2O	
			Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
1.B.2.b	**Natural gas**									
1.B.2.b.i	Exploration	Leaks	NA		NA		NA		NA	
		Venting	NO							
		Flaring	NO							
1.B.2.b.ii	Production and gathering	All	NO		NO		NO		NO	
1.B.2.b.iii	Processing	All	NO		NO		NO		NO	
1.B.2.b.iv	Transmission and storage	All	NO		NO		NO		NA	
1.B.2.b.v	Distribution	All	NO		NO		NO		NA	
1.B.2.b.vi	Other									
1.B.2.b.vi.1	Gas post-meter	All	NE		NE		NE		NE	
1.B.2.b.vi.2	Abandoned wells	All	NE		NE		NE		NE	
1.B.2.b.vi.3	Other	All	NE		NE		NE		NE	
1.B.2.c.	**Venting and flaring**									
1.B.2.c.i.	Venting									
1.B.2.c.i.1.	Oil		NO		NO		NO		NO	
1.B.2.c.i.2.	Gas		NO		NO		NO		NO	
1.B.2.c.i.3.	Combined		NO		NO		NO		NO	
1.B.2.c.ii.	Flaring									
1.B.2.c.ii.1.	Oil		NO		NO		NO		9-*9+6666666 66	
1.B.2.c.ii.2.	Gas		NO		NO		NO		NO	
1.B.2.c.ii.3.	Combined		NO		NO		NO		NO	
1.B.2.d.	**Other**									
1.B.2.d.	Other	All	NO		NO		NO		NO	

All: sum of leak, venting and flaring	A '✓' indicates: emissions from this category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF	

Table 250 NMVOC emissions from the Distribution of Oil (IPCC sub-category 1.B.2.) for the period 1990-2021

	1.B.2.a Oil - 1.B.2.a.v. Distribution of oil products	
	Fuel consumption	NMVOC emissions
	PJ	(kt)
1990	6.39	0.22
1991	7.04	0.25
1992	4.18	0.16
1993	3.19	0.12
1994	3.56	0.13
1995	3.88	0.14
1996	4.61	0.17
1997	5.11	0.19
1998	7.06	0.26
1999	8.68	0.30
2000	8.84	0.26
2001	7.76	0.22
2002	6.53	0.17
2003	6.65	0.21
2004	7.22	0.21
2005	7.64	0.18
2006	8.66	0.19
2007	9.85	0.19
2008	11.16	0.19
2009	10.72	0.23
2010	10.78	0.21
2011	10.17	0.16
2012	10.12	0.15
2013	9.94	0.13
2014	10.24	0.14
2015	10.98	0.15
2016	12.48	0.15
2017	13.77	0.16
2018	14.64	0.16
2019	15.39	0.17
2020	12.66	0.13
2021	14.53	0.05
Trend		
1990-2021	*98.27%*	-42.7%
2005-2021	*65.63%*	-28.5%
2020-2021	*-17.72%*	-22.6%

3.3.2.1 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC sub-category 1.A.4.a *Commercial/Institutional*.

Table 251 Recalculations done since last submission in IPCC category 1.B.2 Oil and Natural Gas

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
1.B.2	Application of Guidance provided by 2019 Refinement to the 2006 IPCC Guidelines	method	Accuracy

3.3.2.2 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 252 Planned improvements for IPCC category 1.B.2 Oil and Natural Gas

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.B.2	No improvements planned			

3.4 Carbon dioxide Transport and Storage (IPCC category 1.C)

This section describes GHG emissions resulting from carbon dioxide transport, injection and geological storage (CCGS) only.

All these activities are not existing in Montenegro.

4 Industrial Processes and Product Use (IPPU) (IPCC sector 2)

4.1 Sector Overview

In the Sector *Industrial Processes and Product Use (IPPU),* emissions originating from industrial processes, from the use of greenhouse gases in products, and from non-energy uses of fossil fuel carbon are considered. Emissions from this sector comprise emissions from the following sub categories:

- 2.A Mineral Industry
- 2.B Chemical Industry
- 2.C Metal Industry
- 2.D Other Production
- 2.E Production of HFC/PFC and SF6
- 2.F Consumption of HFC/PFC and SF6
- 2.G Other product manufacture and use
- 2 H Other

Greenhouse gas emissions are produced from a wide variety of industrial activities. The main emission sources are releases from industrial processes that chemically or physically transform materials like

- Lime industry in category 2.A Mineral Industry,
- Iron and steel from scraps and Aluminum industry in category 2.C Metal Industry,
- Refrigeration and Stationary Air Conditioning in category 2.F Consumption of HFC/PFC and SF6;
- Use of Electrical Equipment 2.G Other product manufacture and use.

In the following table, an overview of the IPCC sub-categories included in this chapter is given and is provided information on the status of emission estimates of all subcategories. A „✓" indicates that emissions from this sub-category have been estimated. None sub-category is key category.

Table 253 Overview of categories of IPCC sector 2 *Industrial Processes and Product Use (IPPU) and* status of estimation.

IPCC Code	IPCC category	CO_2	CH_4	N_2O	HFC	PFC	SF6	NF3
2.A	Mineral Industry	NA	NA	NA	NA	NA	NA	NA
2.B	Chemical Industry	✓	NA	NA	NA	NA	NA	NA
2.C	Metal Industry	✓	✓	NO	NO	✓	NO	NA
2.D	Other Production	NE	NA	NA	NA	NA	NA	NA
2.E	Production of HFC/PFC and SF6	✓	NA	NA	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NA	NA	✓*	NE	NE	NE
2.G	Other Product Manufacture and Use	✓	NO	NE	NA	NA	✓	NA
2.H	Other	NA	NO	NA	NA	NA	NA	NA

** Only 2.G.1.b Refrigeration and Stationary Air Conditioning*

Other Industries of the IPCC sector *Industrial Processes and Product Use (IPPU)*, such as primary iron and steel industry, electronic industries (e.g. semiconductor), or production of Electrical Equipment are not existing in Montenegro.

During these processes, many different greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), can be produced.

The so-called F-gases hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), sulfur hexafluoride (SF6) and Other halogenated gases are oftentimes used in products such as refrigerators, foams or aerosol cans as well as electrical equipment.

Due to lack of data and resources GHG emissions from the use of greenhouse gases (HFC, PFC) and Other halogenated gases used in products except for subcategory 2.G.1.b Refrigeration and Stationary Air Conditioning were not estimated for all subcategories from in this inventory cycle (2.F Consumption of HFC/PFC and SF6).

4.1.1 Emission trend

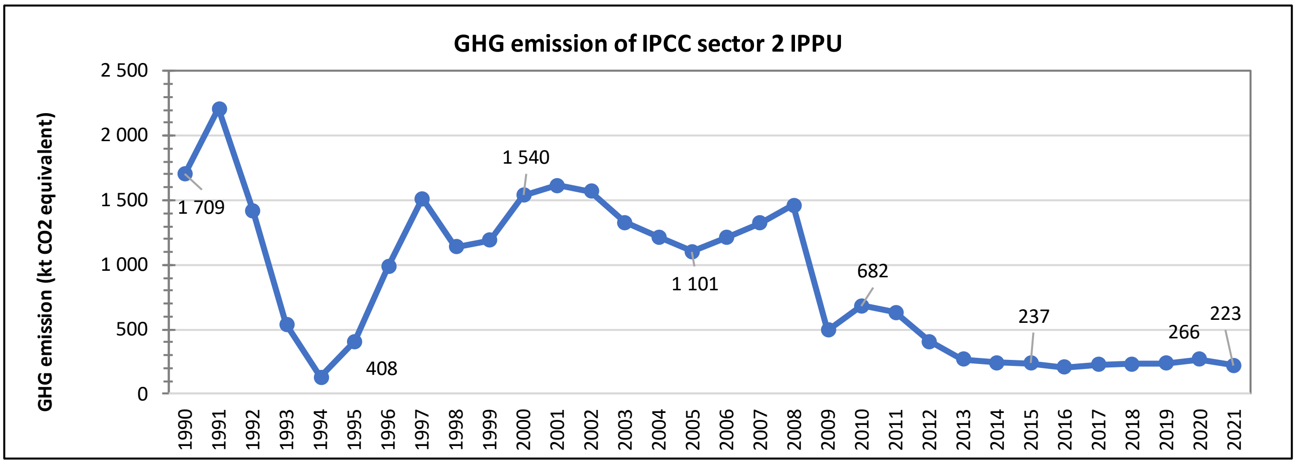


Figure 119 Trend of GHG emissions from IPCC sector 2 IPPU: 1990 – 2021

In 2021 greenhouse gas emissions from sector *Industrial Processes and Other Product Use* amounted to 223.19 kt CO_2 equivalent, which correspond to 7.8% of total national emissions.

The most important sub-categories of this sector are 2.C *Metal industry* (mainly metal/aluminium production and 2.F Consumption of HFC/PFC and SF6, generating 37.5% and 61.0% of total sectoral emissions, respectively. An important greenhouse gas of this sector is CO_2 with a contribution of 26.5% to total sectoral emissions, however emission from the use of HFCs contribute with 60.8% to this sector. Emission from the use of PFCs contribute with 9% and emissions from the use of SF6 contribute with 2.3 to this sector. N_2O does not occur from sector IPPU.

In 2005 greenhouse gas emissions from sector *Industrial Processes and Other Product Use* amounted to 1 100.54 kt CO_2 equivalent, which correspond to 37.6% of total national emissions. The overall trend in GHG emissions from *Industrial Processes and Other Product Use* is an decrease of -79.7% from 2005 to 2021 due to reduced aluminium production, in the same time increased emissions of HFC.

In 1990 greenhouse gas emissions from sector *Industrial Processes and Other Product Use* amounted to 1 708.51 kt CO_2 equivalent, which correspond to 28.6% of total national emissions.

The most important sub-category of this sector is 2.C *Metal industry* (aluminium production). Important greenhouse gases of this sector are CO_2 with a contribution of 12.5% and PFCs with a contribution of 87.2% to this sector.

The general trend is marked by significant dips and jumps due to the break-up of Yugoslavia (1992), break-up of the union with Serbia (2006), world economic crisis (2009), shut down of alumina plant (2009) and shutdown of one electrolysis line (2016) and worldwide pandemics in 2020/2021.

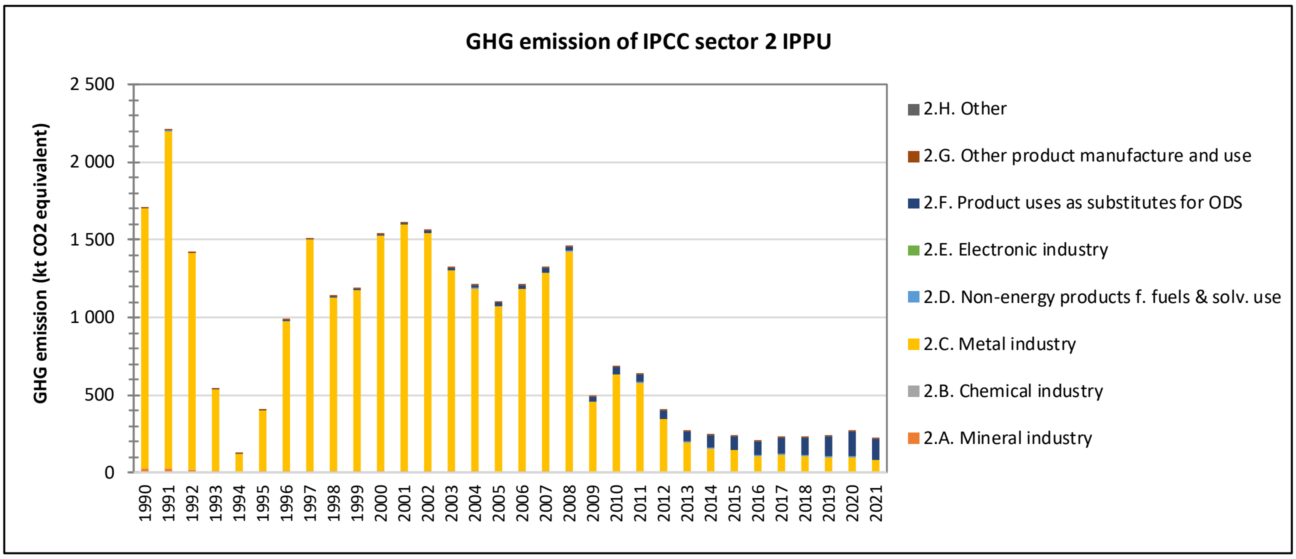


Figure 120 Trend of GHG emissions of IPCC sector 2 IPPU by category for the period 1990 – 2021

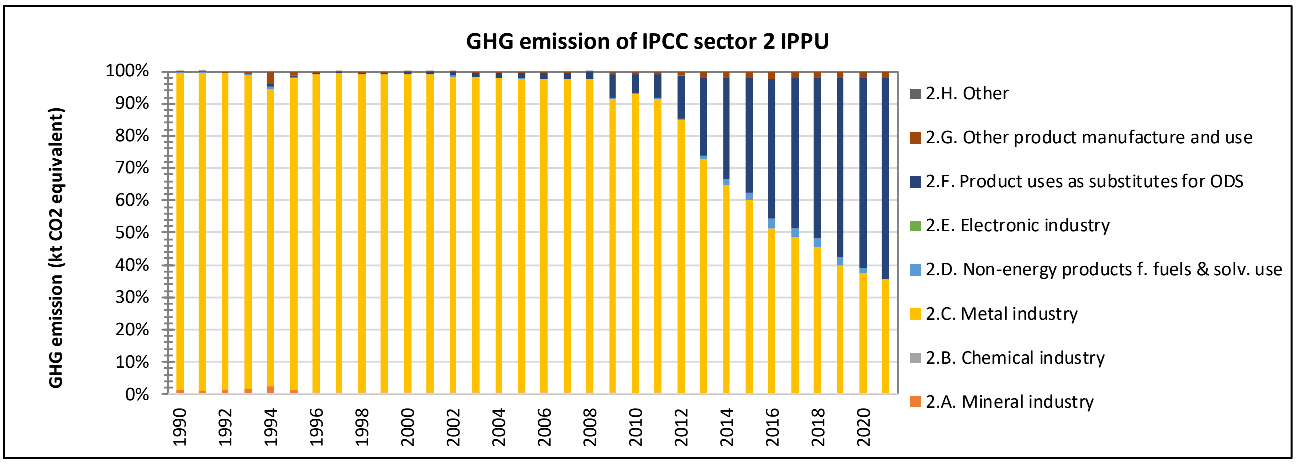


Figure 121 Trend and share GHG emissions of IPCC sector 2 IPPU by category for the period 1990 – 2021

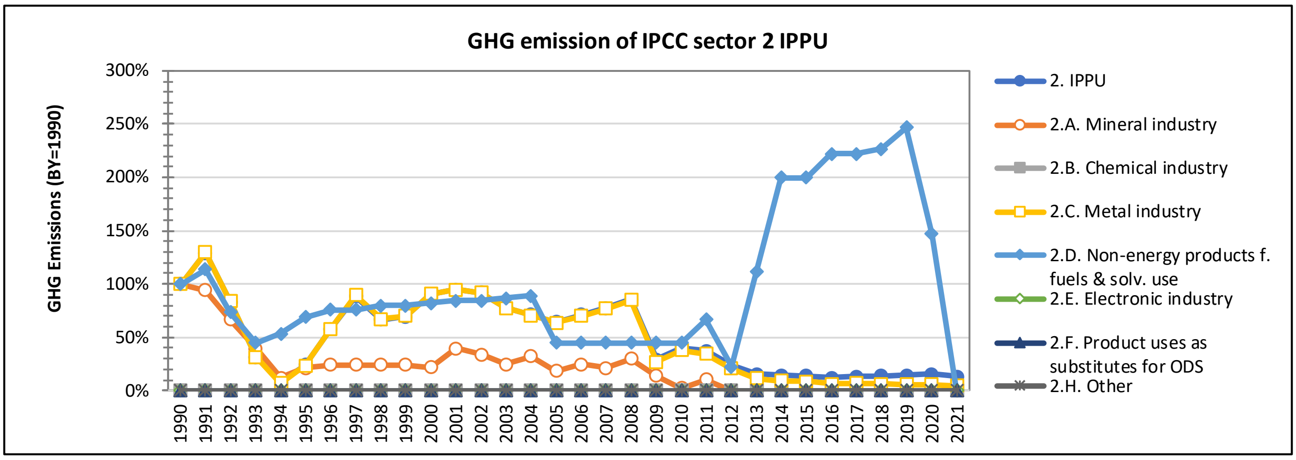


Figure 122 Trend of emissions from IPCC sector 2 IPPU in index form (base year = 100) by category

Table 254 GHG Emissions from IPCC sub-category 2 IPPU by sub-categories for the period 1990-2021

GHG emissions	2 Industrial Processes and Other Product Use (IPPU)	2.A Mineral industry	2.B Chemical industry	2.C Metal industry	2.D Non-energy products from fuels and solvent use	2.E Electronic industry	2.F Product uses as substitutes for ODS	2.G Other product manufacture and use	2.H Other
	kt CO_2 equivalent								
1990	**1 708.51**	24.85	NO	1 675.97	2.65	NA	NA	5.04	NO
1991	**2 208.60**	23.34	NO	2 177.20	3.01	NA	0.01	5.04	NO
1992	**1 422.63**	16.57	NO	1 398.96	1.95	NA	0.12	5.04	NO
1993	**541.07**	9.79	NO	524.72	1.18	NA	0.34	5.04	NO
1994	**129.01**	3.01	NO	118.66	1.42	NA	0.89	5.04	NO
1995	**407.51**	5.27	NO	393.88	1.83	NA	1.50	5.04	NO
1996	**986.15**	6.02	NO	970.82	2.01	NA	2.27	5.04	NO
1997	**1 511.99**	6.02	NO	1 495.77	2.01	NA	3.16	5.04	NO
1998	**1 140.79**	6.02	NO	1 123.45	2.12	NA	4.16	5.04	NO
1999	**1 189.99**	6.02	NO	1 171.57	2.12	NA	5.24	5.04	NO
2000	**1 540.25**	5.36	NO	1 521.35	2.18	NA	6.32	5.04	NO
2001	**1 613.78**	9.78	NO	1 589.32	2.24	NA	7.40	5.04	NO
2002	**1 567.61**	8.38	NO	1 535.75	2.24	NA	16.20	5.04	NO
2003	**1 328.43**	6.13	NO	1 297.72	2.30	NA	17.24	5.04	NO
2004	**1 213.16**	7.98	NO	1 179.57	2.36	NA	18.28	5.04	NO
2005	**1 100.54**	4.52	NO	1 070.17	1.18	NA	19.68	5.04	NO
2006	**1 210.95**	6.11	NO	1 176.34	1.18	NA	22.38	5.04	NO
2007	**1 322.70**	5.34	NO	1 285.12	1.18	NA	26.11	5.04	NO
2008	**1 463.79**	7.41	NO	1 419.58	1.18	NA	30.68	5.04	NO
2009	**495.03**	3.39	NO	449.67	1.18	NA	35.85	5.04	NO
2010	**681.62**	0.63	NO	633.23	1.18	NA	41.62	5.04	NO
2011	**634.32**	2.60	NO	577.24	1.77	NA	47.76	5.04	NO
2012	**404.66**	NO	NO	344.41	0.59	NA	54.72	5.04	NO
2013	**267.29**	NO	NO	194.37	2.95	NA	65.02	5.04	NO
2014	**242.16**	NO	NO	156.26	5.31	NA	75.63	5.04	NO
2015	**236.98**	NO	NO	142.95	5.31	NA	83.77	5.04	NO
2016	**208.13**	NO	NO	107.16	5.90	NA	90.11	5.04	NO
2017	**229.31**	NO	NO	111.79	5.90	NA	106.67	5.04	NO
2018	**231.23**	NO	NO	105.21	6.01	NA	115.04	5.04	NO
2019	**239.75**	NO	NO	95.36	6.54	NA	132.88	5.04	NO
2020	**266.19**	NO	NO	99.88	3.89	NA	157.45	5.04	NO
2021	**223.19**	NO	NO	79.43	0.00	NA	138.80	5.04	NO
Trend									
1990 - 2021	*-86.9%*	*NA*	*NA*	*-95.3%*	*-99.9%*	*NA*	*NA*	*0.0%*	*NA*
2005 - 2021	*-79.7%*	*NA*	*NA*	*-92.6%*	*-99.9%*	*NA*	*605.4%*	*0.0%*	*NA*
2020 - 2021	*-16.2%*	*NA*	*NA*	*-20.5%*	*-100.0%*	*NA*	*-11.8%*	*0.0%*	*NA*

Table 255 CO_2 Emissions from IPCC sub-category 2 IPPU by sub-categories for the period 1990-2021

CO_2 emissions	2 Industrial Processes and Other Product Use (IPPU)	2.A Mineral industry	2.B Chemical industry	2.C Metal industry	2.D Non-energy products from fuels and solvent use	2.E Electronic industry	2.F Product uses as substitutes for ODS	2.G Other product manufacture and use	2.H Other
	kt								
1990	**212.78**	24.85	NO	185.28	2.65	NA	NA	NA	NO
1991	**205.79**	23.34	NO	179.43	3.01	NA	NA	NA	NO
1992	**172.60**	16.57	NO	154.08	1.95	NA	NA	NA	NO
1993	**81.16**	9.79	NO	70.19	1.18	NA	NA	NA	NO
1994	**31.77**	3.01	NO	27.34	1.42	NA	NA	NA	NO
1995	**55.90**	5.27	NO	48.80	1.83	NA	NA	NA	NO
1996	**97.95**	6.02	NO	89.92	2.01	NA	NA	NA	NO
1997	**147.58**	6.02	NO	139.55	2.01	NA	NA	NA	NO
1998	**141.95**	6.02	NO	133.81	2.12	NA	NA	NA	NO
1999	**144.65**	6.02	NO	136.51	2.12	NA	NA	NA	NO
2000	**167.16**	5.36	NO	159.62	2.18	NA	NA	NA	NO
2001	**193.80**	9.78	NO	181.78	2.24	NA	NA	NA	NO
2002	**203.62**	8.38	NO	193.00	2.24	NA	NA	NA	NO
2003	**205.49**	6.13	NO	197.06	2.30	NA	NA	NA	NO
2004	**215.62**	7.98	NO	205.29	2.36	NA	NA	NA	NO
2005	**206.49**	4.52	NO	200.79	1.18	NA	NA	NA	NO
2006	**215.08**	6.11	NO	207.78	1.18	NA	NA	NA	NO
2007	**219.20**	5.34	NO	212.68	1.18	NA	NA	NA	NO
2008	**202.88**	7.41	NO	194.29	1.18	NA	NA	NA	NO
2009	**114.25**	3.39	NO	109.68	1.18	NA	NA	NA	NO
2010	**137.77**	0.63	NO	135.96	1.18	NA	NA	NA	NO
2011	**158.45**	2.60	NO	154.08	1.77	NA	NA	NA	NO
2012	**121.70**	NO	NO	121.11	0.59	NA	NA	NA	NO
2013	**81.84**	NO	NO	78.90	2.95	NA	NA	NA	NO
2014	**74.88**	NO	NO	69.57	5.31	NA	NA	NA	NO
2015	**76.23**	NO	NO	70.93	5.31	NA	NA	NA	NO
2016	**67.39**	NO	NO	61.49	5.90	NA	NA	NA	NO
2017	**72.47**	NO	NO	66.57	5.90	NA	NA	NA	NO
2018	**73.82**	NO	NO	67.81	6.01	NA	NA	NA	NO
2019	**67.80**	NO	NO	61.25	6.54	NA	NA	NA	NO
2020	**68.20**	NO	NO	64.31	3.89	NA	NA	NA	NO
2021	**59.18**	NO	NO	59.18	0.00	NA	NA	NA	NO
Trend									
1990 - 2021	*-72.2%*	*NA*	*NA*	*-68.1%*	*-99.9%*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*-71.3%*	*NA*	*NA*	*-70.5%*	*-99.9%*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*-13.2%*	*NA*	*NA*	*-8.0%*	*-100.0%*	*NA*	*NA*	*NA*	*NA*

Table 256 CH_4 Emissions from IPCC sub-category 2 IPPU by sub-categories for the period 1990-2021

CH_4 emissions	2 Industrial Processes and Other Product Use (IPPU)	2.A Mineral industry	2.B Chemical industry	2.C Metal industry	2.D Non-energy products from fuels and solvent use	2.E Electronic industry	2.F Product uses as substitutes for ODS	2.G Other product manufacture and use	2.H Other
	kt								
1990	0.0021	NO	NO	0.0021	NA	NA	NA	NE	NO
1991	0.0020	NO	NO	0.0020	NA	NA	NA	NE	NO
1992	0.0014	NO	NO	0.0014	NA	NA	NA	NE	NO
1993	0.0012	NO	NO	0.0012	NA	NA	NA	NE	NO
1994	0.0011	NO	NO	0.0011	NA	NA	NA	NE	NO
1995	0.0009	NO	NO	0.0009	NA	NA	NA	NE	NO
1996	0.0010	NO	NO	0.0010	NA	NA	NA	NE	NO
1997	0.0013	NO	NO	0.0013	NA	NA	NA	NE	NO
1998	0.0014	NO	NO	0.0014	NA	NA	NA	NE	NO
1999	0.0009	NO	NO	0.0009	NA	NA	NA	NE	NO
2000	0.0008	NO	NO	0.0008	NA	NA	NA	NE	NO
2001	0.0011	NO	NO	0.0011	NA	NA	NA	NE	NO
2002	0.0008	NO	NO	0.0008	NA	NA	NA	NE	NO
2003	0.0006	NO	NO	0.0006	NA	NA	NA	NE	NO
2004	0.0015	NO	NO	0.0015	NA	NA	NA	NE	NO
2005	0.0010	NO	NO	0.0010	NA	NA	NA	NE	NO
2006	0.0016	NO	NO	0.0016	NA	NA	NA	NE	NO
2007	0.0017	NO	NO	0.0017	NA	NA	NA	NE	NO
2008	0.0020	NO	NO	0.0020	NA	NA	NA	NE	NO
2009	0.0010	NO	NO	0.0010	NA	NA	NA	NE	NO
2010	0.0005	NO	NO	0.0005	NA	NA	NA	NE	NO
2011	0.0006	NO	NO	0.0006	NA	NA	NA	NE	NO
2012	0.0003	NO	NO	0.0003	NA	NA	NA	NE	NO
2013	0.0002	NO	NO	0.0002	NA	NA	NA	NE	NO
2014	0.0001	NO	NO	0.0001	NA	NA	NA	NE	NO
2015	0.0004	NO	NO	0.0004	NA	NA	NA	NE	NO
2016	0.0005	NO	NO	0.0005	NA	NA	NA	NE	NO
2017	0.0005	NO	NO	0.0005	NA	NA	NA	NE	NO
2018	0.0005	NO	NO	0.0005	NA	NA	NA	NE	NO
2019	0.0002	NO	NO	0.0002	NA	NA	NA	NE	NO
2020	0.0003	NO	NO	0.0003	NA	NA	NA	NE	NO
2021	<0.0001	NO	NO	<0.0001	NA	NA	NA	NE	NO
Trend									
1990 - 2021	*-98.5%*	*NA*	*NA*	*-98.5%*	*-98.5%*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*-97.0%*	*NA*	*NA*	*-97.0%*	*-97.0%*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*-91.1%*	*NA*	*NA*	*-91.1%*	*-91.1%*	*NA*	*NA*	*NA*	*NA*

Table 257 Emissions of HFCs, PFCs and SF6 from IPCC sub-category 2 IPPU by sub-categories

GHG emissions	2 Industrial Processes and Other Product Use (IPPU)	2.A Mineral industry	2.B Chemical industry	2.C Metal industry	2.D Non-energy products from fuels & solvent use	2.E Electronic industry	2.F Product uses as substitutes for ODS	2.G Other product manufacture and use	2.H Other
	GHG			PFCs			HFCs	SF6	
	kt CO_2 equivalent								
1990	**1 495.67**	NA	NO	1 490.64	NA	NO	NA	5.04	NA
1991	**2 002.76**	NA	NO	1 997.72	NA	NO	0.01	5.04	NA
1992	**1 250.00**	NA	NO	1 244.84	NA	NO	0.12	5.04	NA
1993	**459.88**	NA	NO	454.50	NA	NO	0.34	5.04	NA
1994	**97.21**	NA	NO	91.29	NA	NO	0.89	5.04	NA
1995	**351.59**	NA	NO	345.05	NA	NO	1.50	5.04	NA
1996	**888.17**	NA	NO	880.87	NA	NO	2.27	5.04	NA
1997	**1 364.38**	NA	NO	1 356.19	NA	NO	3.16	5.04	NA
1998	**998.80**	NA	NO	989.61	NA	NO	4.16	5.04	NA
1999	**1 045.31**	NA	NO	1 035.04	NA	NO	5.24	5.04	NA
2000	**1 373.06**	NA	NO	1 361.71	NA	NO	6.32	5.04	NA
2001	**1 419.95**	NA	NO	1 407.51	NA	NO	7.40	5.04	NA
2002	**1 363.97**	NA	NO	1 342.74	NA	NO	16.20	5.04	NA
2003	**1 122.92**	NA	NO	1 100.65	NA	NO	17.24	5.04	NA
2004	**997.50**	NA	NO	974.19	NA	NO	18.28	5.04	NA
2005	**893.97**	NA	NO	869.31	NA	NO	19.62	5.04	NA
2006	**995.68**	NA	NO	968.42	NA	NO	22.23	5.04	NA
2007	**1 103.18**	NA	NO	1 072.31	NA	NO	25.83	5.04	NA
2008	**1 260.44**	NA	NO	1 225.15	NA	NO	30.25	5.04	NA
2009	**380.16**	NA	NO	339.87	NA	NO	35.25	5.04	NA
2010	**543.04**	NA	NO	497.18	NA	NO	40.83	5.04	NA
2011	**474.85**	NA	NO	423.06	NA	NO	46.76	5.04	NA
2012	**281.72**	NA	NO	223.21	NA	NO	53.48	5.04	NA
2013	**183.89**	NA	NO	115.39	NA	NO	63.46	5.04	NA
2014	**165.34**	NA	NO	86.61	NA	NO	73.70	5.04	NA
2015	**158.63**	NA	NO	71.93	NA	NO	81.66	5.04	NA
2016	**138.41**	NA	NO	45.58	NA	NO	87.79	5.04	NA
2017	**153.73**	NA	NO	45.13	NA	NO	103.56	5.04	NA
2018	**153.84**	NA	NO	37.32	NA	NO	111.49	5.04	NA
2019	**168.77**	NA	NO	34.03	NA	NO	129.70	5.04	NA
2020	**193.25**	NA	NO	35.49	NA	NO	152.72	5.04	NA
2021	**160.82**	NA	NO	20.18	NA	NO	135.60	5.04	NA
Trend									
1990 - 2021	***-89.2%***	*NA*	*NA*	-98.6%	*NA*	*NA*	NA	*0.0%*	*NA*
2005 - 2021	***-82.0%***	*NA*	*NA*	-97.7%	*NA*	*NA*	591.2%	*0.0%*	*NA*
2020 - 2021	***-16.8%***	*NA*	*NA*	-43.1%	*NA*	*NA*	-11.2%	*0.0%*	*NA*

4.2 Mineral Industry (IPCC category 2.A)

The IPCC category 2.A comprises the process-related carbon dioxide (CO_2) emissions resulting from the use of carbonate raw materials such as limestone and dolomite in the production and use of a variety of mineral industry products. As described in the 2006 IPCC Guidelines, Vol. 3, Chap 1, there are two broad pathways for release of CO_2 from carbonates:

(1) Calcination, and
(2) acid-induced release of CO_2.

Ad (1): The primary process resulting in the release of CO_2 is the calcination of carbonate compounds, during which, through heating, a metallic oxide is formed. A typical calcination reaction, here shown for the mineral calcite or calcium carbonate, would be:

$$CACO_3 + heat \rightarrow CaO + CO_2$$

Ad (2): Acid-induced release of CO_2 as a result of small quantities of carbonate being present as an impurity in an acidification process to upgrade a non-carbonate material. The formation of CO_2 can be via an equation such as:

$$CACO_3 + H_2SO_4 \rightarrow CaSO4 + H_2O + CO_2$$

In the following table, an overview of the IPCC sub-categories included in this chapter is given and is provided information on the status of emission estimates of all subcategories. A „✓" indicates that emissions from this sub-category have been estimated. None sub-category is key category.

Table 258 Overview of sub-categories of category 2.A. *Mineral Industry* and status of estimation.

IPCC Code	IPCC Category	CO_2		CH_4		N_2O	
2.A	**Mineral Industry**	**Estimated**	**Key Category**	**Estimated**	**Key Category**	**Estimated**	**Key Category**
2.A.1	Cement production	NO	-	NA	-	NA	-
2.A.2	Lime production	✓	-	NA	-	NA	-
2.A.3	Glass Production	NO	-	NA	-	NA	-
2.A.4	Other Process Uses of Carbonates	NO	-	NA	-	NA	-
2.A.4.a	Ceramics	NO	-	NA	-	NA	-
2.A.4.b	Other Uses of Soda Ash	NO	-	NA	-	NA	-
2.A.4.c	Non Metallurgical Magnesia Production	NO	-	NA	-	NA	-
2.A.4.d	Other	NO	-	NA	-	NA	-
2.A.5	Other	NO	-	NA	-	NA	-

4.2.1 Cement production (IPCC subcategory 2.A.1)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.A.1	Cement production	NO	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The IPCC subcategory 2.A.1 *Cement production* does not exist in Montenegro.

4.2.2 Lime production (IPCC subcategory 2.A.2)

4.2.2.1 Source category description

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.A.2	Lime production	✓	LA1990	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

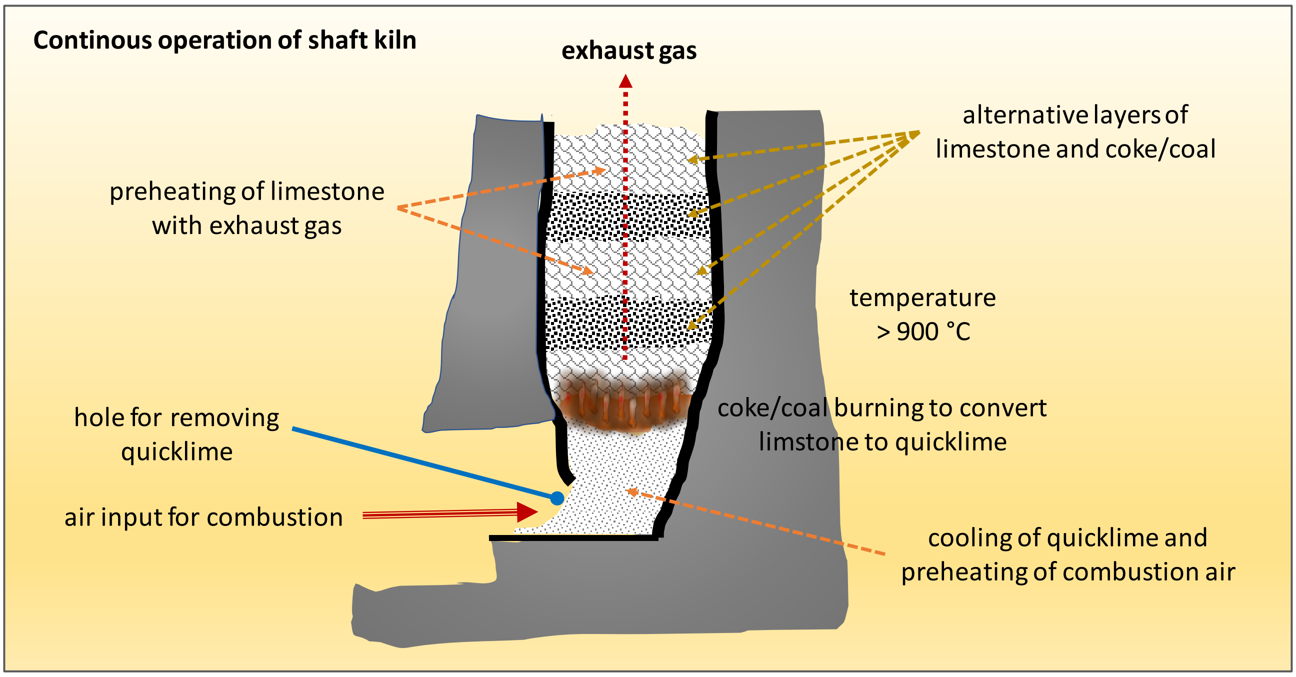


Figure 123 Illustration of a shaft kiln for lime production

This chapter includes the CO_2 emissions estimations from lime production. Process-related CO_2 emissions are released during (quick-)lime production. Calcium oxide (CaO), also called as quicklime, is formed by heating limestone to decompose the carbonates. This is usually done in shaft or rotary kilns at high temperatures and the process releases CO_2. Depending on the product requirements (e.g., metallurgy, pulp and paper, construction materials, effluent treatment, water softening, pH control, and soil stabilisation), primarily high calcium limestone (calcite) is utilized in accordance with the following reaction:

$$CaCO_3 \text{ (high-purity limestone)} + \text{heat} \rightarrow CaO \text{ (quicklime)} + CO_2$$

Lime production is not a key source. Emissions from lime production are only occurring until 2011 in Montenegro. Since 2011 all lime used is imported.

An overview of the lime production (IPCC sub-category 2.A.2) related CO_2 emissions is provided in the following figure and table.

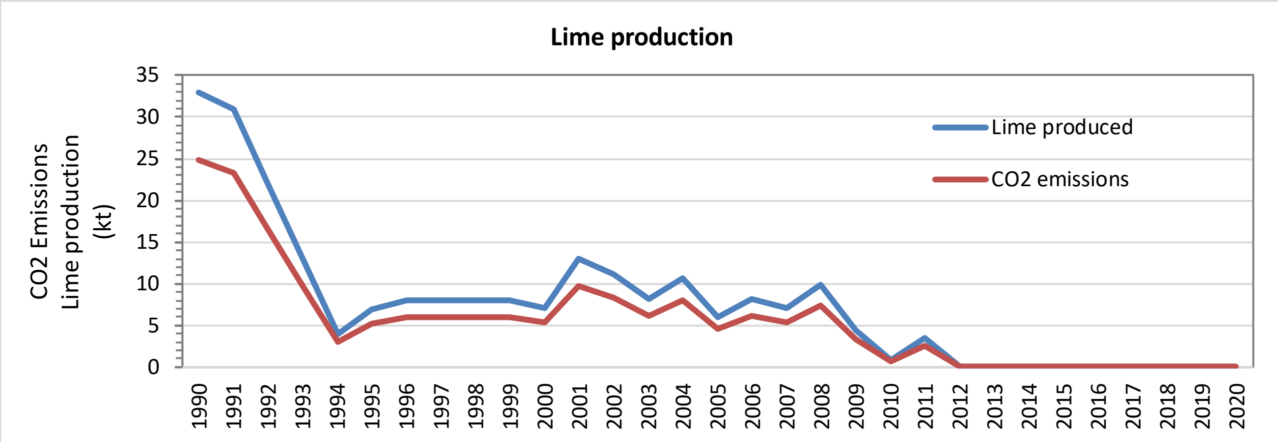


Figure 124 **CO_2 emissions and lime production from IPCC sub-category 2.A.2 Lime production 1990-2021**

Table 259 **Activity data (AD), CO_2 emission factors (EF) and CO_2 emissions from Lime production (IPCC sub-category 2.A.2)**

Year	Lime production	Share of lime type		CO_2 Emission factor (EF) for			CO_2 emissions
		high calcium lime	dolomitic lime	high calcium lime	dolomitic lime	lime	
	tonnes	%		(tonne CO_2 / t lime)			Gg
1990	33.00	100	0	0.75	0.77	0.753	24.85
1991	31.00	100	0	0.75	0.77	0.753	23.34
1992	22.00	100	0	0.75	0.77	0.753	16.57
1993	13.00	100	0	0.75	0.77	0.753	9.79
1994	4.00	100	0	0.75	0.77	0.753	3.01
1995	7.00	100	0	0.75	0.77	0.753	5.27
1996	8.00	100	0	0.75	0.77	0.753	6.02
1997	8.00	100	0	0.75	0.77	0.753	6.02
1998	8.00	100	0	0.75	0.77	0.753	6.02
1999	8.00	100	0	0.75	0.77	0.753	6.02
2000	7.11	100	0	0.75	0.77	0.753	5.36
2001	12.99	100	0	0.75	0.77	0.753	9.78
2002	11.12	100	0	0.75	0.77	0.753	8.38
2003	8.14	100	0	0.75	0.77	0.753	6.13
2004	10.59	100	0	0.75	0.77	0.753	7.98
2005	6.01	100	0	0.75	0.77	0.753	4.52
2006	8.12	100	0	0.75	0.77	0.753	6.11
2007	7.09	100	0	0.75	0.77	0.753	5.34
2008	9.84	100	0	0.75	0.77	0.753	7.41
2009	4.50	100	0	0.75	0.77	0.753	3.39
2010	0.84	100	0	0.75	0.77	0.753	0.63
2011	3.45	100	0	0.75	0.77	0.753	2.60
2012	NO	NO	NO	NA	NA	NA	NO
2013	NO	NO	NO	NA	NA	NA	NO
2014	NO	NO	NO	NA	NA	NA	NO

Year	Lime production	Share of lime type		CO_2 Emission factor (EF) for			CO_2 emissions
		high calcium lime	dolomitic lime	high calcium lime	dolomitic lime	lime	
	tonnes	%		(tonne CO_2 / t lime)			Gg
2015	NO	NO	NO	NA	NA	NA	NO
2016	NO	NO	NO	NA	NA	NA	NO
2017	NO	NO	NO	NA	NA	NA	NO
2018	NO	NO	NO	NA	NA	NA	NO
2019	NO	NO	NO	NA	NA	NA	NO
2020	NO	NO	NO	NA	NA	NA	NO
2021	NO	NO	NO	NA	NA	NA	NO
Trend							
1990 – 2021	*NA*						*NA*
2005 - 2021	*NA*						*NA*
2020 - 2021	*NA*						*NA*

4.2.2.2 Methodological issues

4.2.2.2.1 Choice of methods

As is the case for emissions from cement production, there are three basic methodologies for estimating emissions from lime production: an output-based approach that uses default values (Tier 1), an output-based approach that estimates emissions from CaO and CaO·MgO production and country-specific information for correction factors (Tier 2) and an input-based carbonate approach (Tier 3).

The 2006 IPCC Guidelines Tier 1 approach[87] has been applied:

Equation: Tier 1 - Emissions based on national lime production data

(2006 IPCC Guidelines, Vol. 3, Chapter 2, sub-chapter 2.3.1.1)

$$CO_2\ emissions = Mass_{lime} \times Emission\ \mathrm{Factor_{lime}}$$

based on

Equation 2.6: Tier 2 - Emissions based on national lime production data by type

$$CO_2\ emissions = \sum_i Mass_{lime,\mathrm{i}} \times Emission\ \mathrm{Factor_{lime,i}} \times CF_{LKD,\mathrm{i}} \times C_{H,\mathrm{i}}$$

Where:

CO_2 Emissions = emissions of CO_2 from lime production (tonnes)

$Mass_{lime}$ = weight (mass) of lime produced (tonnes)

EF_{lime} = emission factor for lime (tonnes CO_2/tonne lime) (see Equation 2.9)

$CF_{Lkd,i}$ = emissions correction factor for Lime Kiln Dust (CKD) (dimensionless)

$C_{h,i}$ = correction factor for hydrated lime of the type i of lime (dimensionless)

[87] Source: 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 2: Mineral Industry Emissions, Sub-chapter 2.3.1.1 Lime Production - Choice of method

According to 2006 IPCC Guidelines, Vol. 3, Chap. 2.3.1.1, the Tier 1 method is based on applying a default emission factor to national level lime production data. While country-specific information on lime production by type (e.g., high calcium lime, dolomitic lime, or hydraulic lime) is not necessary for *good practice* in Tier 1, where data are available to identify the specific types of lime produced in the country, this may be used. It is not necessary for *good practice* to account for LKD in Tier 1.

4.2.2.2.2 Choice of activity data

For Montenegro it was possible to collect country specific data on lime production and the chemical characteristics of limestone. The data used in the inventory are based on data for lime production is provided for the years 1990 – 2020 by MONSTAT.

A cross-check with US Geological Survey (USGS) Minerals Yearbook (different years) was done[88].

It is assumed that 100 % of production is high calcium lime.

4.2.2.2.3 Choice of emission factors

Tier 1 is an output-based method and applies an emission factor to the total quantity of lime produced. The emission factor is based on the stoichiometric ratios.

The 2006 IPCC Guidelines Tier 1 approach[89] has been applied:

Equation 2.8: Tier 1 Default emission factor for lime production

(2006 IPCC Guidelines, Vol. 3, Chapter 2, sub-chapter 2.3.1.1)

$$EF_{Lime} = \frac{Share_{\text{high\_calcium}}}{100} \times EF_{high\ calcium\ lime} + \frac{Share_{\text{dolomitic}}}{100} \times EF_{dolomitic\ lime}$$

Where:

EF_{Lime} = emission factor for lime (tonnes CO_2 / tonne lime)

Share = default share of produced type of lime (%)

$EF_{high\ calcium\ lime}$ = emission factor for high-calcium lime (tonnes CO_2/tonne CaO)

$EF_{dolomitic\ lime}$ = emission factor for dolomitic lime (tonnes CO_2/tonne CaO·MgO)

Table 260 Basic parameters for the calculation of emission factors for lime production

Lime Type	Stoichiometric Ratio		Range of		Share (default)	CO_2 Emission factor (EF)		
	tonnes CO_2 / tonne CaO	tonnes CO_2 / CaO·MgO]	CaO Content	MgO Content		High-calcium lime	Dolomitic lime	Default lime
			%		%	(tonne CO_2 / t lime)		
High-calcium lime	0.785	-	93-98	0.3-2.5	100	0.75	-	-
Dolomitic lime	-	0.913	55-57	38-41	0	-	0.77	-
Default Lime								0.75

Source: Table 2.4 of 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 2: Mineral Industry Emissions, sub-chapter 2.3.1.2 - Choice of emission factor (Lime Production)

[88] Available (16 March 2020) on https://www.usgs.gov/science-explorer-results?es=Montenegro+Minerals+Yearbook

[89] 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 2: Mineral Industry Emissions, Sub-chapter 2.3.1.1 Lime Production - Choice of method

4.2.2.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 2.A.2 Lime *production* are presented in the following table.

Table 261 Uncertainty for IPCC sub-category 2.A.2 Lime production.

Uncertainty	CO_2	Reference
Activity data (AD)	10%	
• *Uncertainty in assuming an average CaO in lime*	*8%*	2006 IPCC GL, Vol. 3, Chap.2, Table 2.5 Default uncertainty values for lime production, page 2.25 and sub-chapter 2.3.2.2, page 2.26.
• *Emission factor high calcium lime*	*2%*	2006 IPCC GL, Vol. 3, Chap.2, Table 2.5 Default uncertainty values for lime production, page 2.25 and sub-chapter 2.3.2.1, page 2.25.
• *Emission factor dolomitic lime*	*2%*	
Emission factor (EF)	3%	
Combined Uncertainty (U)	10%	$U_{Total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as Tier 1 approach is applied to the entire time series.

4.2.2.4 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed:

⇒ Checked of calculations by spreadsheets
  - consistent use of production statistics from MONSTAT
  - documented sources,
  - use of units,
  - record keeping; use of write protection,
  - unique use of formulas; special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from two sources: national statistic and US Geological Survey (USGS) Minerals Yearbook;

⇒ cross checks with other relevant sectors (sugar production) are performed to avoid double counting or omissions,

⇒ emission factors check – IEF;

⇒ time series consistency - plausibility checks of dips and jumps.

4.2.2.5 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC sub-category 2.A.2 *Lime production*.

Table 262 Recalculations done since submission 2017 IPCC sub-category 2.C.1 *Iron and Steel Production*

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
2.A.2	No revisions were performed.		

4.2.2.6 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 263 Planned improvement for IPCC sub-category 2.A.2 Lime production

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.A.2	Analysis of lime types for application Tier 2	AD	Completeness	Medium
2.A.2	Analysis of industries that produce non-marketed, e.g. sugar production, pulp and paper manufacturing facilities, metallurgy, water softeners.	AD	Accuracy Transparency	Medium
2.A.2	Further investigation of the drop in lime production in 2010.	AD	Accuracy	Medium
2.A.2	Compare inventory data to data from NC3 (stored in recalculation sheet of 2A2 calculation sheet) and describe reasons for discrepancies in next NIR		Accuracy	High

4.2.3 Glass Production (IPCC subcategory 2.A.3)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.A.3	Glass production	NO	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The IPCC subcategory 2.A.3 *Glass Production* does not exist in Montenegro.

4.2.4 Other Process Uses of Carbonates (IPCC subcategory 2.A.4)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.A.4	Other Process Uses of Carbonates	NO	-	NA	-	NA	-
2.A.4.a	Ceramics	NO	-	NA	-	NA	-
2.A.4.b	Other Uses of Soda Ash	NO	-	NA	-	NA	-
2.A.4.c	Non-Metallurgical Magnesia Production	NO	-	NA	-	NA	-
2.A.4.d	Other (please specify)	NO	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The IPCC subcategory 2.A.4 *Other Process Uses of Carbonates* does not exist in Montenegro.

4.2.5 Other (IPCC subcategory 2.A.5)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.A.3	Other (please specify)	NO	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The IPCC subcategory 2.A.5 *Other* does not exist in Montenegro.

4.3 Chemical Industry (IPCC category 2.B)

The IPCC category 2.B comprises the production of various inorganic and organic chemicals. The following tables provides information which of the chemical industries are occurrent in Montenegro.

Table 264 Overview of chemical industries occurring in Montenegro.

IPCC code	Description	Occurrent		Not occurrent NO
		Estimated	Not estimated (NE)	
2.B.1	Ammonia Production (*including Urea production*)			NO
2.B.2	Nitric Acid Production			NO
2.B.3	Adipic Acid Production			NO
2.B.4	Caprolactam, Glyoxal and Glyoxylic Acid Production			NO
2.B.5	Carbide Production			NO
2.B.6	Titanium Dioxide Production			NO
2.B.7	Soda Ash Production			NO
2.B.8	Petrochemical and Carbon Black Production			NO
2.B.8.a	Methanol			NO
2.B.8.b	Ethylene			NO
2.B.8.c	Ethylene Dichloride and Vinyl Chloride Monomer			NO
2.B.8.d	Ethylene Oxide			NO
2.B.8.e	Acrylonitrile			NO
2.B.8.f	Carbon Black			NO
2.B.9	Fluorochemical Production			NO
2.B.9.a	By product emissions			NO
2.B.9.b	Fugitive Emissions			NO
2.B.10	Other (Please specify)			NO

4.3.1.1 Ammonia Production (IPCC subcategory 2.B.1)

4.3.1.2 Source category description

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.B.1	Ammonia production	NO	-	NA	-	NA	-
A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The IPCC subcategory 2.B.1 *Ammonia Production* does not exist in Montenegro.

4.3.2 Nitric Acid Production (IPCC subcategory 2.B.2)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.B.2	Nitric Acid Production	NA	-	NA	-	NE	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The IPCC subcategory 2.B.2 *Nitric Acid Production* does not exist in Montenegro.

4.3.3 Adipic Acid Production (IPCC subcategory 2.B.3)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.B.3	Adipic Acid Production	NO	-	NA	-	NO	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The IPCC subcategory 2.B.3 *Adipic Acid Production* does not exist in Montenegro.

4.3.4 Caprolactam, Glyoxal and Glyoxylic Acid Production (IPCC subcategory 2.B.4)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.B.4	Caprolactam, Glyoxal and Glyoxylic Acid Production	NO	-	NA	-	NO	-
A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The IPCC subcategory 2.B.4 *Caprolactam, Glyoxal and Glyoxylic Acid Production* does not exist in Montenegro.

4.3.5 Carbide Production (IPCC subcategory 2.B.5)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.B.5	Carbide Production	NO	-	NO	-	NA	-
A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The IPCC subcategory 2.B.5 *Carbide Production* does not exist in Montenegro.

4.3.6 Titanium Dioxide Production (IPCC subcategory 2.B.6)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.B.6	Titanium Dioxide Production	NO	-	NA	-	NA	-
A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The IPCC subcategory 2.B.6 *Titanium Dioxide Production* does not exist in Montenegro.

4.3.7 Soda Ash Production (IPCC subcategory 2.B.7)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.B.7	Soda Ash Production	NO	-	NA	-	NA	-
A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The IPCC subcategory 2.B.7 *Soda Ash Production* does not exist in Montenegro.

4.3.8 Petrochemical and Carbon Black Production (IPCC subcategory 2.B.8)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.B.8	Petrochemical and Carbon Black Production	NO	-	NO	-	NA	-
2.B.8.a	Methanol	NO	-	NO	-	NA	-
2.B.8.b	Ethylene	NO	-	NO	-	NA	-
2.B.8.c	Ethylene Dichloride and Vinyl Chloride Monomer	NO	-	NO	-	NA	-
2.B.8.d	Ethylene Oxide	NO	-	NO	-	NA	-
2.B.8.e	Acrylonitrile	NO	-	NO	-	NA	-
2.B.8.f	Carbon Black	NO	-	NO	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The IPCC subcategory 2.B.8 *Petrochemical and Carbon Black Production* does not exist in Montenegro.

4.3.9 Fluorochemical Production (IPCC subcategory 2.B.9)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.B.9	Fluorochemical Production	NA	-	NA	-	NA	-
2.B.9.a	By product emissions	NA	-	NA	-	NA	-
2.B.9.b	Fugitive Emissions	NA	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The IPCC subcategory 2.B.9 *Fluorochemical Production* does not exist in Montenegro.

4.3.10 Other (IPCC subcategory 2.B.10)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.B.10	Other	NO	-	NO	-	NO	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The IPCC subcategory 2.B.10 *Other* does not exist in Montenegro.

4.4 Metal Industry (IPCC category 2.C)

The IPCC category 2.C comprises the production of various ferrous and non-ferrous producing industries, where GHG emissions are rising. In Montenegro steel and Aluminium is produced.

4.4.1 Iron and Steel Production (IPCC subcategory 2.C.1)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.C.1	Iron and Steel Production	√	-	NO	-	NO	-
A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

In Montenegro the steel production takes place in electric arc furnaces.

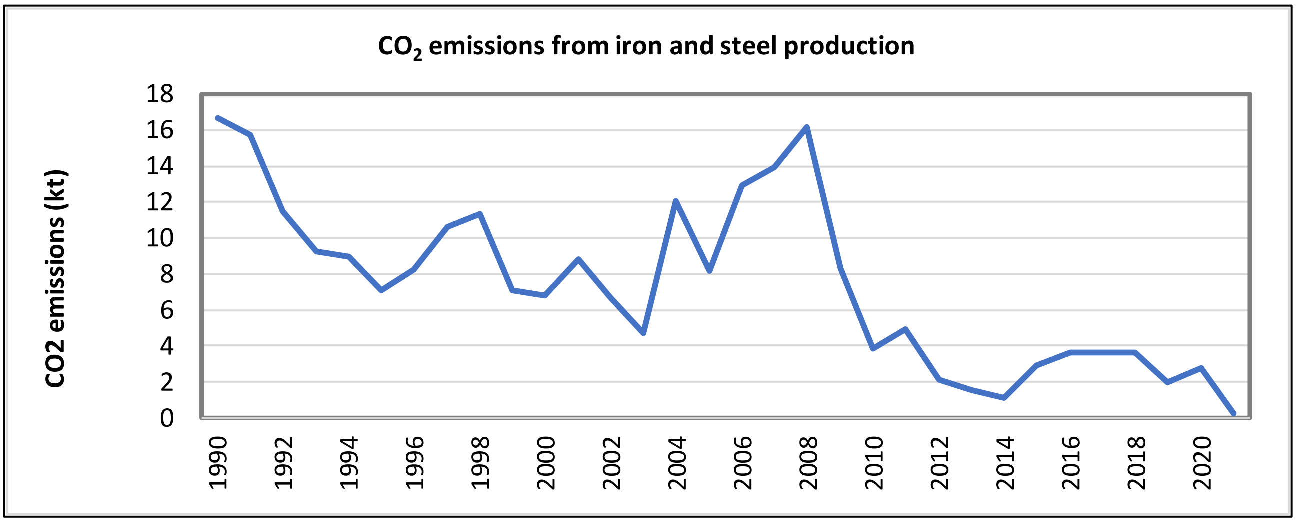


Figure 125 **CO_2 emissions from IPCC sub-category 2.C.1 Iron and Steel production for the period 1990-2021**

Table 265 **Activity data (AD), CO_2 emission factors (EF) and CO_2 emissions from Iron and Steel production (IPCC sub-category 2.C.1)**

Year	steel produced	CO_2 EF	CO_2 emissions
	t	t / t steel produced	kt
1990	207 642	0.08	16.61
1991	196 365	0.08	15.71
1992	142 775	0.08	11.42
1993	115 301	0.08	9.22
1994	111 821	0.08	8.95
1995	88 591	0.08	7.09
1996	102 487	0.08	8.20
1997	132 362	0.08	10.59
1998	141 445	0.08	11.32

Year	steel produced	CO_2 EF	CO_2 emissions
1999	88 002	0.08	7.04
2000	84 789	0.08	6.78
2001	109 757	0.08	8.78
2002	82 832	0.08	6.63
2003	59 036	0.08	4.72
2004	150 165	0.08	12.01
2005	102 247	0.08	8.18
2006	161 333	0.08	12.91
2007	173 913	0.08	13.91
2008	201 690	0.08	16.14
2009	103 479	0.08	8.28
2010	48 272	0.08	3.86
2011	61 164	0.08	4.89
2012	26 161	0.08	2.09
2013	19 723	0.08	1.58
2014	14 330	0.08	1.15
2015	36 602	0.08	2.93
2016	45 168	0.08	3.61
2017	45 223	0.08	3.62
2018	45 193	0.08	3.62
2019	24 262	0.08	1.94
2020	34 273	0.08	2.74
2021	3 042	0.08	0.24
Trend			
1990 – 2021	-98.5%		-83.5%
2005 - 2021	-97.0%		-98.5%
2020 - 2021	-91.1%		-97.0%

4.4.1.1 Methodological issues

4.4.1.1.1 Choice of methods

The 2006 IPCC Guidelines Tier 1 approach for Electric Arc furnaces EAFs has been applied. See chapter (2006 IPCC Guidelines, Vol. 3, Chapter 2, sub-chapter 4.2.1)

4.4.1.1.2 Choice of activity data

There is only electro steel production in Montenegro. The activity data are provided by the steel producing facilities.

4.4.1.1.3 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed:

⇒ Checked of calculations by spreadsheets
   - consistent use of production statistics
   - documented sources,
   - use of units,
   - record keeping; use of write protection,
   - unique use of formulas; special cases are documented/highlighted,
   - quick-control checks for data consistency through all steps of calculation.

⇒ emission factors check – IEF;

⇒ time series consistency - plausibility checks of dips and jumps.

4.4.1.2 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC sub-category 2.C.1 *Iron and Steel Production*.

Table 266 Recalculations done since submission 2017 IPCC sub-category 2.C.1 *Iron and Steel Production*

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
2.C.1	No revisions were performed		

4.4.1.3 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 267 Planned improvement for IPCC sub-category 2.C.1 *Iron and Steel Production*

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.C.1.f	Reference CH4 emission factor		Transparency	medium

4.4.2 Ferroalloys Production (IPCC subcategory 2.C.2)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.C.2	Ferroalloys Production	NO	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The IPCC subcategory 2.C.2 *Ferroalloys Production* does not exist in Montenegro.

4.4.3 Aluminum Production (IPCC subcategory 2.C.3)

4.4.3.1 Source category description

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.C.3	Aluminium production	✓	LA1990, LA2021	NA	-	NA	-

A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF

IPCC code	Description	HFC		PFC		SF_6	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.C.3	Aluminium production	NO		✓	LA1990	NA	-

A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year); TA – Trend Assessment without LULUCF

This category includes emissions of CO_2 and PCFs from primary aluminium production.

Primary aluminium has been produced in Montenegro since the 1970s, after significant quantities of high-quality bauxite ore had been discovered. Uniprom KAP (Kombinat Aluminijuma Podgorica) is situated in Podgorica, and is an important employer of the region, and aluminium is an important export commodity. Until 2005, the company was state owned, and from December 2005 onwards it was privatized. In 2013, the company went bankrupt, and was bought by the current owner in 2014. It consisted of two production sites, of which one closed in 2016.

Emissions from category 2.C.3. are depicted in the Figure belowe. The strong decrease of emissions in 1994 was due to the temporary closure of plant B, decreased production from 1992 – 1995 was due to break-up of Yugoslavia and limited electricity production in the country. The dip around 2005 was during the time of privatization of the company, and the world economic crisis also affected production in 2009, which explains the dip there. In 2013, the company officially went bankrupt (it was subsidized between 2009 – 2013 by the government). In July 2014, the company was sold to another company, and in 2016, plant A closed down for good.

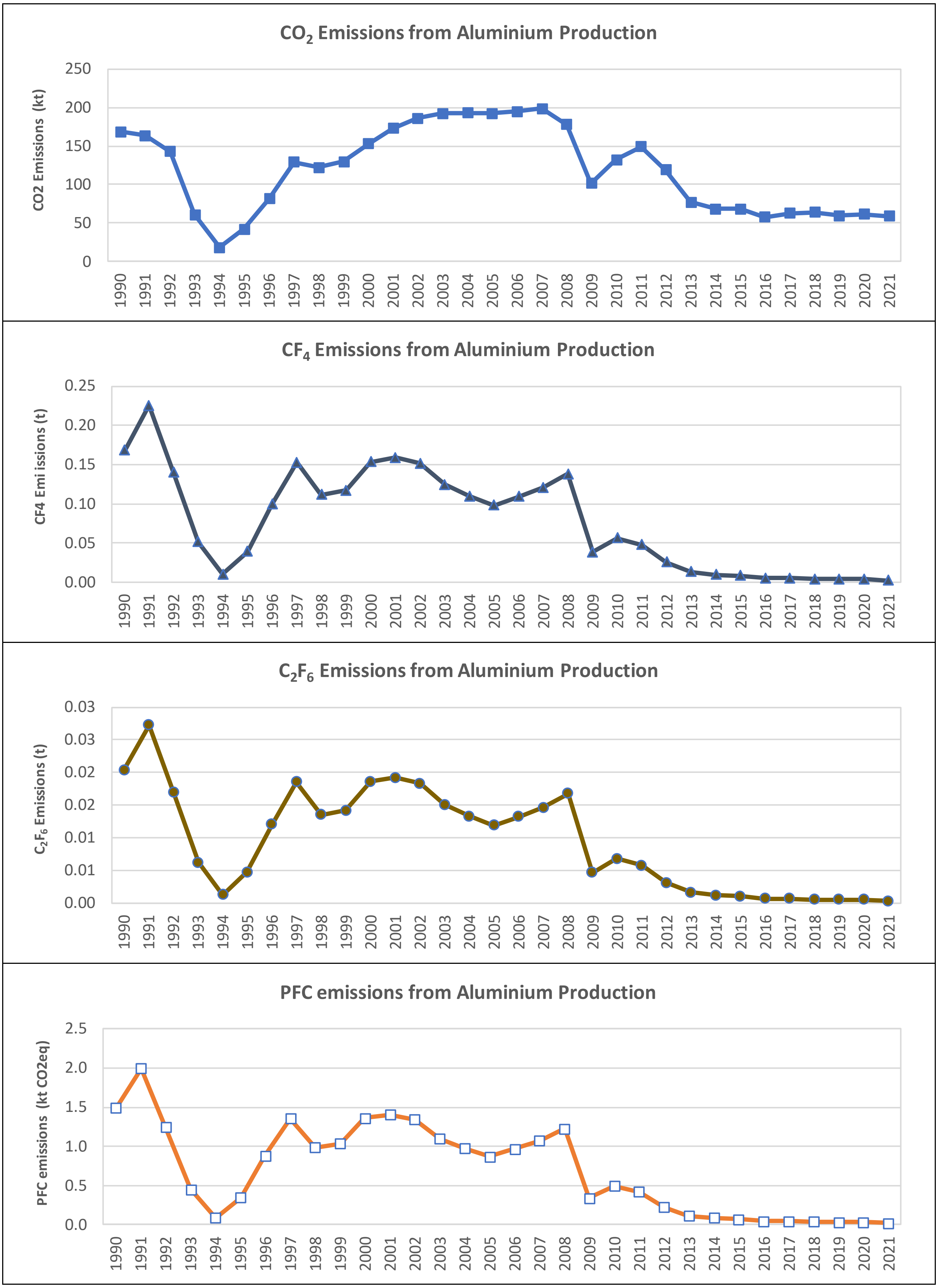


Figure 126 **GHG emissions for IPCC category 2.C.3 Primary Aluminium Production**

Table 268 Emissions from Primary Aluminium Production (IPCC category 2.C.3) for the period 1990-2021

Year	Production	GHG	CO_2	PFC	CF4	C2F6
	(kt aluminum)	(kt)	(kt)	(kt CO_2 eq)	t	t
1990	105.42	1 659.30	168.67	1 490.64	168.13	20.34
1991	102.33	2 161.44	163.73	1 997.72	225.32	27.26
1992	89.16	1 387.50	142.66	1 244.84	140.40	16.99
1993	38.10	515.46	60.97	454.50	51.26	6.20
1994	11.50	109.68	18.39	91.29	10.30	1.25
1995	26.07	386.77	41.71	345.05	38.92	4.71
1996	51.08	962.60	81.73	880.87	99.35	12.02
1997	80.60	1 485.15	128.96	1 356.19	152.96	18.51
1998	76.56	1 112.10	122.49	989.61	111.62	13.51
1999	80.92	1 164.51	129.47	1 035.04	116.74	14.13
2000	95.53	1 514.55	152.84	1 361.71	153.58	18.58
2001	108.12	1 580.51	173.00	1 407.51	158.75	19.21
2002	116.48	1 529.11	186.37	1 342.74	151.44	18.32
2003	120.21	1 292.99	192.34	1 100.65	124.14	15.02
2004	120.80	1 167.46	193.28	974.19	109.88	13.30
2005	120.38	1 061.92	192.61	869.31	98.05	11.86
2006	121.80	1 163.29	194.88	968.42	109.23	13.22
2007	124.23	1 271.08	198.77	1 072.31	120.94	14.63
2008	111.34	1 403.30	178.15	1 225.15	138.18	16.72
2009	63.38	441.28	101.41	339.87	38.33	4.64
2010	82.56	629.27	132.10	497.18	56.08	6.79
2011	93.24	572.25	149.19	423.06	47.72	5.77
2012	74.38	342.22	119.02	223.21	25.17	3.05
2013	48.32	192.70	77.32	115.39	13.01	1.57
2014	42.77	155.03	68.43	86.61	9.77	1.18
2015	42.50	139.93	68.00	71.93	8.11	0.98
2016	36.17	103.46	57.88	45.58	5.14	0.62
2017	39.35	108.09	62.95	45.13	5.09	0.62
2018	40.12	101.51	64.19	37.32	4.21	0.51
2019	37.07	93.34	59.31	34.03	3.84	0.46
2020	38.48	97.06	61.57	35.49	4.00	0.48
2021	36.83	79.12	58.93	20.18	2.28	0.28
Trend						
1990 - 2021	*-63.5%*	*-95.2%*	*-65.1%*	*-98.6%*	*-98.6%*	*-98.6%*
2005 - 2021	*-68.0%*	*-92.5%*	*-69.4%*	*-97.7%*	*-97.7%*	*-97.7%*
2020 - 2021	*3.8%*	*-18.5%*	*-4.3%*	*-43.1%*	*-43.1%*	*-43.1%*

4.4.3.2 Methodological issues

4.4.3.2.1 Choice of methods

For estimating the GHG emissions based on aluminium production, the 2006 IPCC Guidelines Tier 1 methodology has been applied *(2006 IPCC GL, Vol. 3, Chap. 4).* In Montenegro only Prebake technology is used.

CO_2 emissions

Equation 4.20: CO_2 emissions from prebaked anode consumption (Tier 1)

$$E_{CO2} = EF_P * MP_P + EF_S * MP_S$$

Where:

E_{CO2} = CO_2 emissions from prebaked anode consumption, tonnes CO_2

EF_P = Prebake technology specific emission factor (tonnes CO_2/tonne aluminium produced)

MP_P = total metal production, tonnes Al

EF_S = Søderberg technology specific emission factor (tonnes CO_2/tonne aluminium produced)

MP_S = metal production from Søderberg process (tonnes Al)

PFC emissions:

Equation 4.26: PFC emissions by slope method (Tier 2)

$$ECF_4 = SCF_4 * AEM * MP \quad \text{and} \quad E_{C2F6} = ECF_4 * F_{C2F6}/CF_4$$

Where:

$E\ CF_4$ = emissions of CF_4 from aluminium production, kg CF_4

E_{C2F6} = emissions of C_2F_6 from aluminium production, kg C_2F_6

S_{C2F6} = slope coefficient for CF_4, (kg CF_4/tonne Al)/(AE-Mins/cell-day), 0.143 for CF_4 (Table 4.16, 2006 GL)

AEM = anode effect minutes per cell-day, AE-Mins/cell-day

MP = metal production, tonnes Al

F_{C2F6}/CF_4 = weight fraction of C_2F_6/CF_4, kg C_2F_6/kg CF_4

4.4.3.2.2 Choice of activity data

Data on aluminium produced is based on plant specific data from 2010 onwards. Data on aluminium production from 1990 – 2010 was taken from national statistics, and the share applied between the two plants (Electrolyze A&B) was based on the average split of reported data for the years 2010 – 2015, when plant Electrolyze A was closed.

Production in plant Electrolyze B closed down temporarily in 1994 – 1995 due to the economic sanctions imposed on Montenegro between 1992 - 1995 . Production plant Electrolyze A closed down in 2016, after the plant had been sold to the new owner.

4.4.3.2.3 Choice of emission factors

For estimating CO_2 emissions default emission from 2006 IPCC GL was used.

Technology	EF	Value	Unit	Source
Prebake	CO_2 Emission Factor	1.6	tonnes CO_2/tonne Al	*2006 IPCC GL, Vol. 3, Chap. 4; TABLE 4.10*

For estimating PFC emission plant specific data were used.

Elektroliza A	Unit	2015	Remark
IPCC const		1.698	
p		0.08	
CE -Electicity ef.	CE	0.91	
slope coefficient for CF_4	kg $_{PFC}$/t$_{Al}$) / (AE-Mins/cellday	0.143	Calculated
Number of AE/Total number of anodes effects by year		C	PS
Pots per days (electrolytic cells per day)		C	PS
AEF	num of AE / pot days	1.24	Calculated
AED -Estimation of anodes effects duration [min]		C	PS
EF		0.80	Calculated
AEM - anode effect minutes per cell-day	AE-Mins/cell-day	C	Calculated
IPCC range - up to 380%		99%	*2006 IPCC GL, Vol. 3, Chap. 4;* TABLE 4.15
Metal production EL A	t	5 123	PS
CF_4 emissions	t	4.1	Calculated
C_2F_6/CF_4 ratio		0.121	*2006 IPCC GL, Vol. 3, Chap. 4;* TABLE 4.16
C_2F_6 emissions	t	0.5	Calculated
GWP CF_4		7 390	
GWP C_2F_6		12 200	
CF_4	t CO_2eq	30 102	Calculated
C_2F_6	t CO_2eq	6 013	Calculated
TOTAL Elektroliza A	t CO_2eq	36 115	Calculated

4.4.3.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 2.C.3 *Aluminium production* are presented in the following table.

Table 269 Uncertainty for IPCC sub-category 2.C.3 Aluminium production.

Uncertainty	CO_2	CF_4	C_2F_6	Reference
Activity data (AD)				
• *Alumimum production*	<1%	<1%	<1%	*2006 IPCC GL, Vol. 3, Chap. 4;* 4.4.3.2 Activity data uncertainties
• *Anode consumption*	<2%	<2%	<2%	
Emission factor (EF) • *Prebake technology*	10%			
• *Slope Coefficient*		6%		
• *Weight Fraction C_2F_6 / CF_4*			11%	
Combined Uncertainty (U)	10.2%	17.1%		$U_{Total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as Tier 1 approach is applied to the entire time series.

4.4.3.4 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed:

⇒ Checked of calculations by spreadsheets
  - consistent use of data,
  - documented sources,
  - use of units,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ time series consistency - plausibility checks of dips and jumps.

4.4.3.5 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC sub-category 2.C.3 *Aluminium production*.

Table 270 Recalculations done since submission 2021 IPCC sub-category 2.C.3 *Aluminium production*

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
2.C.3	Now recalculations were performed		

4.4.3.6 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 271 Planned improvement for IPCC sub-category 2.C.3 *Aluminium production*

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.C.3	No improvements planned		Transparency	High

4.4.4 Magnesium Production (IPCC subcategory 2.C.4)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.C.4	Magnesium production	NO	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The IPCC subcategory 2.C.4 *Magnesium Production* does not exist in Montenegro.

4.4.5 Lead Production (IPCC subcategory 2.C.5)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.C.5	Lead Production	NO	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The IPCC subcategory 2.C.5 *Lead Production* does not exist in Montenegro.

4.4.6 Zinc Production (IPCC subcategory 2.C.6)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.C.6	Zinc Production	NO	-	NA	-	NA	-
A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The IPCC subcategory 2.C.6 *Zinc Production* does not exist in Montenegro.

4.4.7 Other (IPCC subcategory 2.C.7)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.C.7	Other (please specify)	NO	-	NO	-	NO	-
A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The IPCC subcategory 2.C.7 *Other* does not exist in Montenegro.

4.5 Non-Energy Products from Fuels and Solvent Use (IPCC category 2.D)

The IPCC category 2.D comprises the non-energy products use such as lubricants, paraffin waxes, and bitumen/asphalt, as well as solvents uses where GHG emissions are arising.

The IPCC category 2.D does not cover emissions from the first use of fossil fuels as a product for primary purposes other than

i) combustion for energy purposes	accounted for in IPCC category 1.A. Fuel Combustion activities
ii) use as feedstock or reducing agent	accounted for in IPCC sub-category 2.B. Chemical industry and in IPCC sub-category 2.C. Metal industry

4.5.1 Lubricant Use (IPCC subcategory 2.D.1)

Lubricants are mostly used in industrial and transportation applications. Lubricants are produced either at refineries through separation from crude oil or at petrochemical facilities. They can be subdivided into

(a) motor oils and industrial oils, and

(b) greases, which differ in terms of physical characteristics (e.g., viscosity), commercial applications, and environmental fate.

4.5.1.1 Source category description

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.D.1	Lubricant Use	v	-	NA	-	NA	-
A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

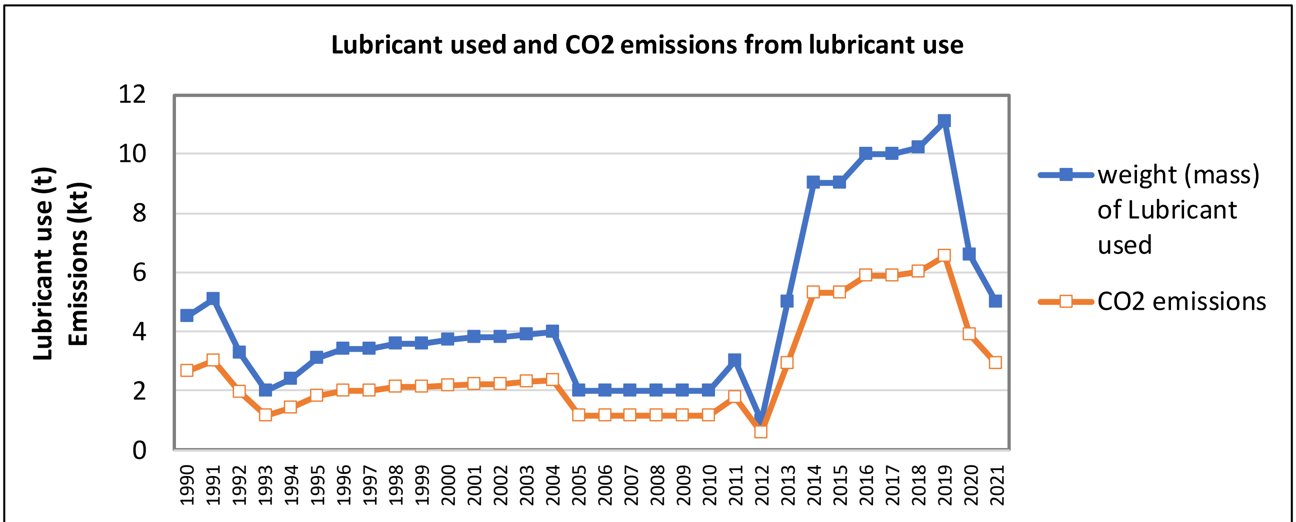


Figure 127 **GHG emissions for IPCC sub-category 2.D.1 Lubricant use for the period 1990-2021**

Table 272 CO2 Emissions from Lubricant Use (IPCC sub-category 2.D.1)

Year	Weight of lubricant used	CO_2 emissions
	(kt)	(kt)
1990	4.50	2.65
1991	5.10	3.01
1992	3.30	1.95
1993	2.00	1.18
1994	2.40	1.41
1995	3.10	1.83
1996	3.40	2.00
1997	3.40	2.00
1998	3.60	2.12
1999	3.60	2.12
2000	3.70	2.18
2001	3.80	2.24
2002	3.80	2.24
2003	3.90	2.30
2004	4.00	2.36
2005	2.00	1.18
2006	2.00	1.18
2007	2.00	1.18
2008	2.00	1.18
2009	2.00	1.18
2010	2.00	1.18
2011	3.00	1.77
2012	1.00	0.59
2013	5.00	2.95
2014	9.00	5.31
2015	9.00	5.31
2016	10.00	5.89
2017	10.00	5.89
2018	10.20	6.01
2019	11.10	6.54
2020	6.60	3.89
2021	5.00	2.95
Trend		
1990 - 2021	11.1%	11.1%
2005 - 2021	150.0%	150.0%
2020 - 2021	-24.2%	-24.2%

4.5.1.2 Methodological issues

4.5.1.2.1 Choice of methods

The 2006 IPCC Guidelines Tier 1 approach has been applied.

4.5.1.2.2 Choice of activity data

AD was updated by connecting it with non-energy use of lubricants. AD from 1990-2010 was taken from JQ MNE, and from 2010 onwards, ME-A-Oil was used. In the past few years, non-energy use of lubricants increased, which was due to the building of a highway and possibly the use of additional heavy machinery. The decrease in 2021 was due to the pandemic.

4.5.1.2.3 Uncertainty

Table 273 Uncertainty for IPCC sub-category 2.D.1 Lubricant use.

There is a high uncertainty of CO2 emissions from 2.D.1 due to an obvious inconsistency in time series.

Uncertainty	CO_2	Reference
Activity data (AD) *Lubricant Use+*	80%	*2006 IPCC GL*
Emission factor (EF)	50%	*2006 IPCC GL*
Combined Uncertainty (U)	94%	$U_{Total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

4.5.1.2.4 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed:

⇒ Checked of calculations by spreadsheets
  - consistent use of production statistics
  - documented sources,
  - use of units,
  - record keeping; use of write protection,
  - unique use of formulas; special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ emission factors check – IEF;

⇒ time series consistency - plausibility checks of dips and jumps.

4.5.1.3 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC sub-category 2.D.1 *Lubricant use*.

Table 274 Recalculations done since last submission in IPCC category 2.D.1 Lubricant use

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
2D1_Lubricants	No revisions were performed		

4.5.1.4 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 275 Planned improvement for IPCC sub-category 2.D.1 *Lubricant Use*

GHG source & sink category	Planned improvement	Type of improvement	Priority
2D1 Lubricants	Check of time series consistency, it is not plausible that lubricant use e.g is now about 10 times higher than 10 years ago - maybe correlate lubricant use with gasoline and diesel use	Time series consistency	medium
2D1 Lubricants	Check two stroke engine use because it needs to be taken off the total (because emissions are covered by emissions of two stroke engines in the transport sector)	Accuracy	medium

4.5.2 Paraffin Wax Use (IPCC subcategory 2.D.2)

Waxes are used in a number of different applications. Paraffin waxes are used in applications such as:

- candles,
- corrugated boxes,
- paper coating,
- board sizing,
- food production,
- wax polishes,
- surfactants (as used in detergents),
- etc.

Emissions from the use of waxes derive primarily when the waxes or derivatives of paraffins are combusted during use (e.g., candles), and when they are incinerated with or without heat recovery or in wastewater treatment (for surfactants). In the cases of incineration and wastewater treatment the emissions should be reported in the Energy or Waste Sectors, respectively.

4.5.2.1 Source category description

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.D.2	Paraffin Wax Use	NE	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

4.5.2.2 Category-specific planned improvements for IPCC sub-category 2.D.2 Paraffin Wax Use

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.D.2	Investigation of import and export data of the entire time series	AD	Accuracy Transparency	High
2.D.2	Cross-check of national import and export statistics with international data (energy balance) of EUROSTAT and UN statistics of item non-energy use	AD	Accuracy Transparency Consistency	Medium

4.5.3 Solvent Use (IPCC subcategory 2.D.3)

This chapter describes the methodology used for calculating air emissions from Solvent Use. Solvents are chemical compounds, which are used to dissolve substances such as paint, glues, ink, rubber, plastic, pesticides or for cleaning purposes (degreasing). After application of these substances or other procedures of solvent use most of the solvents are released into air. Because solvents consist mainly of Non-Methane Volatile Organic Compounds (NMVOC). Besides the sources burning of fossil fuels, particularly for road transport and , energy production and distribution, solvent use is a major source for anthropogenic NMVOC emissions in Montenegro. Once released into the atmosphere, NMVOCs react with reactive molecules (mainly HO-radicals) or high energetic light to finally form CO_2.

4.5.3.1 Source category description

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.D.3	Solvent Use						
2.D.3.a	Domestic solvent use including fungicides	✓	-	NA	-	NA	-
2.D.3.b	Road paving with asphalt	✓	-	NA	-	NA	-
2.D.3.c	Asphalt roofing	NE	-	NA	-	NA	-
2.D.3.d.i	Coating applications	✓	-	NA	-	NA	-
2.D.3.e.ii	Degreasing	NE	-	NA	-	NA	-
2.D.3.f.iii	Dry cleaning	NE	-	NA	-	NA	-
2.D.3.g.iv	Chemical products	NO	-	NA	-	NA	-
2.D.3.h.v	Printing	NE	-	NA	-	NA	-
2.D.3.i.vi	Other solvent and product use	NE	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The subcategory 2.D.3 *Solvent Use* has high contribution to national total NMVOC emissions but is only a small source of CO_2 and GHG respectively.

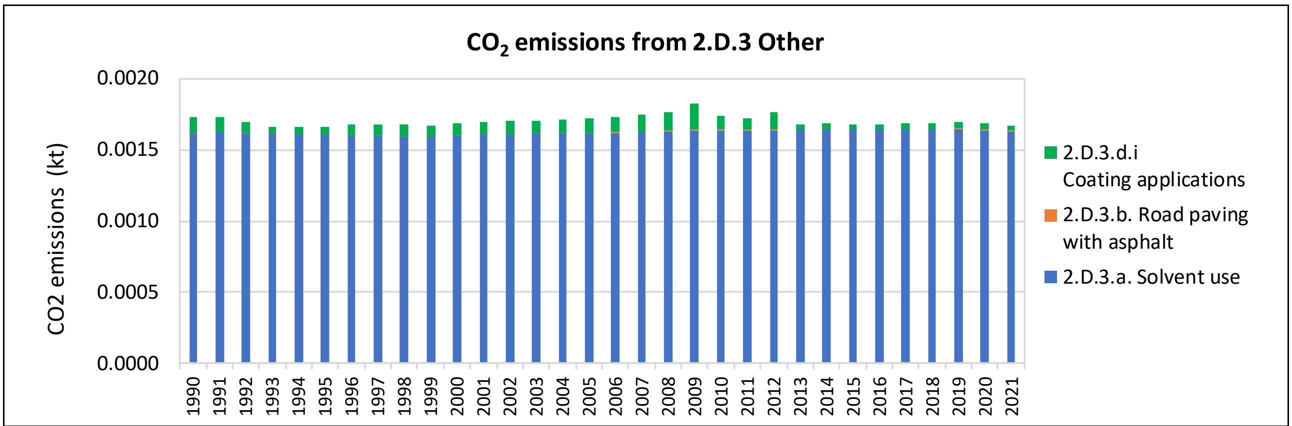


Figure 128 GHG emissions for IPCC sub-category 2.D.3 Solvent use for the period 1990-2021

Table 276 CO2 Emissions from Solvent Use (IPCC sub-category 2.D.3)

Year	CO_2 emissions			
	2.D.3. Other	2.D.3.a. Solvent use	2.D.3.b. Road paving with asphalt	2.D.3.d. Coating applications
	(kt)			
1990	0.00173	0.00162	<0.00001	0.00011
1991	0.00173	0.00162	<0.00001	0.00010
1992	0.00170	0.00162	<0.00001	0.00008
1993	0.00167	0.00162	<0.00001	0.00005
1994	0.00166	0.00161	<0.00001	0.00005
1995	0.00167	0.00161	<0.00001	0.00006
1996	0.00168	0.00160	<0.00001	0.00007
1997	0.00168	0.00160	<0.00001	0.00008
1998	0.00168	0.00160	<0.00001	0.00008
1999	0.00167	0.00159	<0.00001	0.00008
2000	0.00169	0.00160	<0.00001	0.00009
2001	0.00169	0.00161	<0.00001	0.00009
2002	0.00170	0.00161	<0.00001	0.00009
2003	0.00171	0.00162	<0.00001	0.00009
2004	0.00172	0.00162	<0.00001	0.00010
2005	0.00172	0.00162	<0.00001	0.00010
2006	0.00173	0.00162	<0.00001	0.00011
2007	0.00174	0.00163	0.00001	0.00011
2008	0.00176	0.00163	0.00001	0.00012
2009	0.00183	0.00163	0.00001	0.00019
2010	0.00174	0.00164	0.00001	0.00010
2011	0.00172	0.00164	0.00001	0.00007
2012	0.00176	0.00164	<0.00001	0.00012
2013	0.00168	0.00164	<0.00001	0.00003
2014	0.00169	0.00164	<0.00001	0.00004
2015	0.00168	0.00164	<0.00001	0.00004
2016	0.00168	0.00164	<0.00001	0.00003
2017	0.00169	0.00164	0.00001	0.00004
2018	0.00169	0.00164	0.00001	0.00004
2019	0.00170	0.00164	0.00001	0.00005
2020	0.00169	0.00164	0.00001	0.00004
2021	0.00167	0.00163	0.00001	0.00004
Trend				
1990 - 2021	*-3.3%*	*0.9%*	*1268.4%*	*-69.4%*
2005 - 2021	*-2.6%*	*0.7%*	*655.8%*	*-64.4%*
2020 - 2021	*-1.0%*	*-0.5%*	*6.7%*	*-20.0%*

4.5.3.2 Methodological issues

4.5.3.2.1 Choice of methods

The 2006 IPCC Guidelines Tier 1 approach has been applied.

As described in the 2006 IPCC Guidelines, Vol. 1, Chap. 7 (7.2.1.5 Carbon emitted in gases other than CO_2) and Vol. 3, Chap. 5 (5.5 Solvent use) Most of the carbon emitted in the form of non-CO_2 species eventually oxidized to CO_2 in the atmosphere and this amount can be estimated from the emissions estimates of the non-CO_2 gases.is the default fossil carbon content fraction of NMVOC 60 percent by mass.

Equation Calculating CO_2 inputs to the atmosphere from emissions of carbon-containing compounds

From NMVOC: $Inputs_{CO2} = Emissions_{NMVOC} \bullet C \bullet 44/12$

Where

$Inputs_{CO2}$ = CO_2 emissions (Gg)

$Emissions_{NMVOC}$ = estimation of NMVOC (Gg)

C = fraction carbon in NMVOC by mass (default = 0.6)

44/12 = conversion factor from C to CO_2

4.5.3.3 Category-specific planned improvements for IPCC sub-category 2.D.3 Solvent Use

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 277 Planned improvements for IPCC sub-category 2.D.3 Solvent use.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.D.3	Analysis of subcategories which are occurring in Montenegro (see Table 278)	AD	Accuracy Transparency	High / Medium
2.D.3	Investigation of data on production, import and export of the solvents and solvent containing products for the recent years and for pillar years (e.g. 1990, 1995, 2000, 2005. 2010) (see Table 278)	AD	Accuracy Transparency	High / Medium

Table 278 Activity data needed for IPCC sub-category 2.D.3 Solvent use.

GHG source category	Subcategories	Activity data	
		TIER 1	TIER 2
2.D.3.a	**Domestic solvent use including fungicides**	kg/capita	
	• Agrochemical uses		kg solvent
	• Blowing agents		g/kg solvent
	• De-icing		g/kg solvent
	• Binder and release agents		g/kg solvent
	• Professional consumer cleaning		g/kg solvent
	• Industrial, professional and consumer coatings		g/kg solvent
	• Road and construction		g/kg solvent

GHG source category	Subcategories	Activity data	
		TIER 1	TIER 2
	• Other consumer uses (households, aerosols, cosmetics)		g/kg solvent
	• Cosmetics and toiletries (general)		g/kg solvent
	• Cosmetics and toiletries (hair sprays)		g/kg solvent
	• Cosmetics and toiletries (toilet waters)		g/kg solvent
	• Cosmetics and toiletries (after shaves)		g/kg solvent
	• Cosmetics and toiletries (perfumes)		g/kg solvent
	• Cosmetics and toiletries (face care)		g/kg solvent
	• Cosmetics and toiletries (personal deodorants & antiperspirants)		g/kg solvent
	• Cosmetics and toiletries (body care)		g/kg solvent
	• Household products (all)		g/kg solvent
	• Household products (soaps: liquid or paste)		g/kg solvent
	• Household products (polishes and creams for floors)		g/kg solvent
	• Household products (show polishes and creams)		g/kg solvent
	• Car care products (all)		g/kg solvent
	• Car care products (antifreeze agents in windscreen wiper systems)		g/kg solvent
	• Do it yourself (DIY)/buildings (all)		g/kg solvent
	• Do it yourself (DIY)/buildings (adhesives)		g/kg solvent
	• Do it yourself (DIY)/buildings (paint/varnish removers & solvents)		g/kg solvent
	• Do It Yourself (DIY)/buildings (sealants, filling agents)		g/kg solvent
	• Pesticides		g/kg solvent
2.D.3.b	Road paving with asphalt	g/Mg asphalt	g/Mg asphalt
2.D.3.c	Asphalt roofing (materials)	g/Mg shingle	g/Mg shingle
2.D.3.d	Coating applications	g/kg paint applied	
	• Coating applications		g/kg paint applied
	o Decorative coating application		g/kg paint
	o Industrial coating application		g/kg paint
	o Other coating application		g/kg paint
	• Paint application		g/kg paint
	• Manufacture of automobiles		kg/car
	• Car repairing		g/kg paint
	• Construction and buildings		g/kg paint
	• Domestic use		g/kg paint
	• Coil coating		g/kg paint applied
	• Boat building		g/m2
	• Wood		g/kg paint applied
	• Other industrial paint application		g/kg paint
	• Other non-industrial paint application		g/kg paint
2.D.3.e	Degreasing	g/kg cleaning products	
	• Metal degreasing		g/kg cleaning

GHG source category	Subcategories	Activity data	
		TIER 1	TIER 2
			products
	• Electronic components		kg/ton wafer
	• Other industrial cleaning		
2.D.3.f	Dry cleaning	g/kg textile treated	g/kg textiles cleaned
2.D.3.g	Chemical products	g/kg product	
	• Polyester processing		g/kg monomer used
	• Polyvinylchloride processing		
	• Polyurethane foam processing		g/kg foam processed
	• Polystyrene foam processing		g/kg polystyrene
	• Rubber processing		g/kg rubber produced
	• Pharmaceutical products manufacturing		g/kg solvents used
	• Paints manufacturing		g/kg product
	• Inks manufacturing		g/kg product
	• Glues manufacturing		g/kg product
	• Asphalt blowing		g/Mg asphalt
	• Adhesive, magnetic tapes, films and photographs manufacturing		g/m2
	• Textile finishing		kg/pair of shoes
	• Leather tanning		g/kg raw hid
	• Other		g/kg tyres
2.D.3.h	Printing	g/kg ink	
	• Heat set offset		g/kg ink
	• Publication gravure		g/kg ink non diluted
	• Packaging, small flexography		g/kg ink ready to use
	• Packaging, large flexography		g/kg ink ready to use
	• Packaging, rotogravure		g/kg ink ready to use
2.D.3.i, 2.G	Other solvent and product use	kg/Mg product used	
	• Other use of solvents and related activities		g/kg solvent
	o Glass wool enduction		g/t glass wool
	o Mineral wool enduction		g/t mineral wool
	o Fat, edible and non-edible oil extraction		g/kg seed
	o Application of glues and adhesives		g/kg adhesives
	o Preservation of wood		g/kg creosote or preservative
	o Underseal treatment and conservation of vehicles		g/kg underseal agent
	o Vehicles dewaxing		kg/car
	o Other		Kg/ton deicing fluid used g/kg product
	• Use of HFC, N_2O, NH3, PFC & SF6		
	o Other		

GHG source category	Subcategories	Activity data	
		TIER 1	TIER 2
	• Other product use		g/t product
	o Use of fireworks		g/t product
	o Use of tobacco		kg/Mg tobacco
	o Use of shoes		g/pair
	o Other		g/t product

4.5.4 Other (IPCC subcategory 2.D.4)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.D.4	Other	NE	-	NA	-	NA	-
A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The IPCC subcategory 2.D.4 *Other* does not exist in Montenegro.

4.6 Electronics Industry (IPCC category 2.E)

This section describes GHG emissions resulting from gases used in manufacturing different types of electronic devices, the process used (or more roughly, process type (e.g., CVD or etch)), the brand of process tool used, and the implementation of emission reduction technology.

All these activities are not existing in Montenegro.

4.6.1 Integrated Circuit or Semiconductor (IPCC subcategory 2.E.1)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.E.1	Integrated Circuit or Semiconductor	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.E.1	Integrated Circuit or Semiconductor	NO	-	NO	-	NO	-	NO	-

A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF

The IPCC subcategory 2.E.1 *Integrated Circuit or Semiconductor* does not exist in Montenegro.

4.6.2 TFT Flat Panel Display (IPCC subcategory 2.E.2)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.E.3	TFT Flat Panel Display	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.E.3	TFT Flat Panel Display	NO	-	NO	-	NO	-	NO	-

A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF

The IPCC subcategory 2.C.2 *TFT Flat Panel Display* does not exist in Montenegro.

4.6.3 Photovoltaics (IPCC subcategory 2.E.3)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.E.3	Photovoltaics	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.E.3	Photovoltaics	NO	-	NO	-	NO	-	NO	-
A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF									

The IPCC subcategory 2.C.3 *Photovoltaics* does not exist in Montenegro.

4.6.4 Heat Transfer Fluid (IPCC subcategory 2.E.4)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.E.4	Heat Transfer Fluid	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.E.4	Heat Transfer Fluid	NO	-	NO	-	NO	-	NO	-
A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF									

The IPCC subcategory 2.E.4 *Heat Transfer Fluid* does not exist in Montenegro.

4.6.5 Other (IPCC subcategory 2.E.5)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.E.5	Other	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.E.5	Other	NO	-	NO	-	NO	-	NO	-
A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF									

The IPCC subcategory 2.F.5 *Other* does not exist in Montenegro.

4.7 Product Uses as Substitutes for Ozone Depleting Substances (IPCC category 2.F)

The IPCC category 2.F *Product Uses as Substitutes for Ozone Depleting Substances* (ODS) comprises emissions of HFC, PFC and SF6 from different product in use and applications.

IPCC code	Description	HFC	PFC	SF_6	NF_3
2.F.1	Refrigeration and Air Conditioning				
2.F.1.a	Refrigeration and Stationary Air Conditioning	✓	NE	NE	NE
2.F.1.b	Mobile Air Conditioning	NE	NE	NE	NE
2.F.2	Foam Blowing Agents	NE	NE	NE	NE
2.F.3	Fire Protection	✓	NE	NE	NE
2.F.4	Aerosols	✓	NE	NE	NE
2.F.5	Solvents	✓	NE	NE	NE
2.F.6	Other Application	NE	NE	NE	NE
A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE - included elsewhere NE - not estimated, NA - not applicable, C – confidential					

4.7.1 Emissions trend

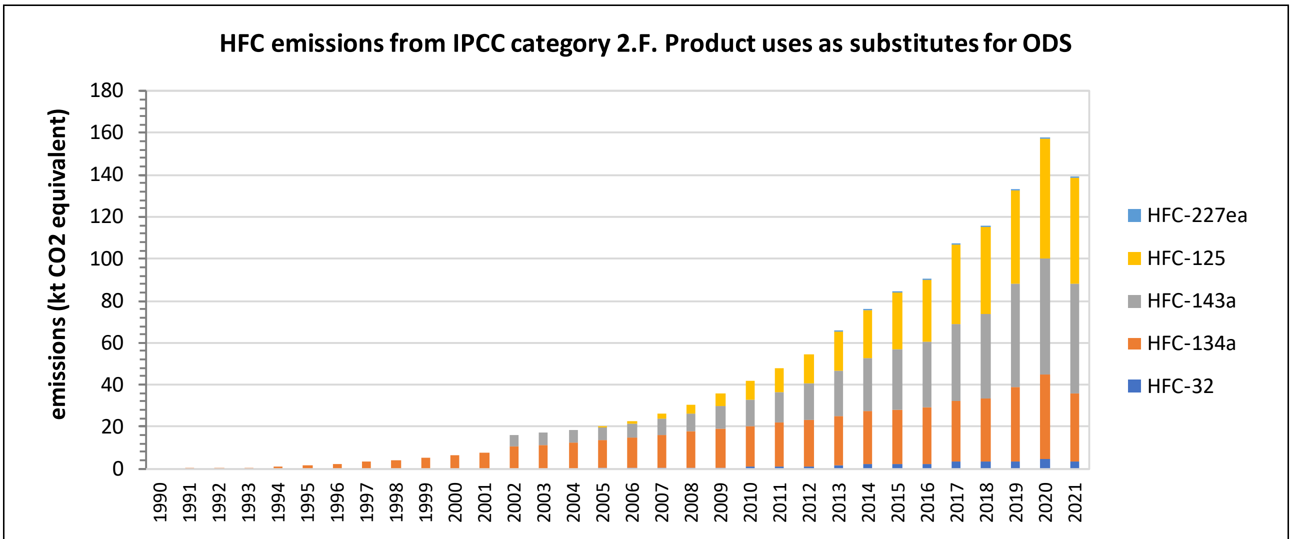


Figure 129 HFC emissions from IPCC category 2.F. Product uses as substitutes for ODS

In **2021**, GHG emissions from IPCC category 2.F. *Product uses as substitutes for ODS* amounted to 138.88 kt CO_2 equivalent, which correspond to 4.6% of total national emissions. In the period 2005 to 2021 GHG emissions from the IPCC category 2.F. *Product uses as substitutes for ODS* increased by 605.4% from 19.68 kt CO_2 eq in 2005 due to increasing use of refrigeration and air Conditioning equipment as well as use of aerosols and fire protection e protection equipment containing HFC as a result of increasing population, improved living conditions but also due to increasing economic activities.

Table 279 HFC emissions from IPCC category 2.F. Product uses as substitutes for ODS for the period 1990-2021

	2.F. Product uses as substitutes for ODS					
	GHG	HFC-32	HFC-134a	HFC-143a	HFC-125	HFC-227ea
	kt CO2 equivalent	*t*	*t*	*t*	*t*	*t*
1990	NA	NO	NO	NO	NO	NO
1991	0.01	NO	0.01	NO	NO	NO
1992	0.12	NO	0.09	NO	NO	NO
1993	0.34	NO	0.24	NO	NO	NO
1994	0.89	NO	0.62	NO	NO	NO
1995	1.50	NO	1.05	NO	NO	NO
1996	2.27	NO	1.59	NO	NO	NO
1997	3.16	NO	2.21	NO	NO	NO
1998	4.16	NO	2.91	NO	NO	NO
1999	5.24	NO	3.66	NO	NO	NO
2000	6.32	NO	4.42	NO	NO	NO
2001	7.40	NO	5.18	NO	NO	NO
2002	16.20	NO	7.23	1.31	NO	NO
2003	17.24	NO	7.96	1.31	NO	NO
2004	18.28	NO	8.68	1.31	NO	NO
2005	19.68	0.09	9.36	1.32	0.10	NO
2006	22.38	0.23	10.24	1.43	0.33	NO
2007	26.11	0.41	11.15	1.66	0.71	NO
2008	30.68	0.63	12.07	1.97	1.20	NO
2009	35.85	0.88	12.92	2.36	1.78	NO
2010	41.62	1.17	13.77	2.81	2.45	NO
2011	47.76	1.49	14.55	3.31	3.19	NO
2012	54.72	1.84	15.47	3.86	4.02	NO
2013	65.02	2.39	16.52	4.73	5.32	0.02
2014	75.63	2.92	17.69	5.63	6.62	0.01
2015	83.77	3.28	18.15	6.44	7.66	0.03
2016	90.11	3.56	18.85	7.00	8.42	0.02
2017	106.67	4.75	20.09	8.31	10.73	0.03
2018	115.04	5.40	21.01	8.91	11.86	0.03
2019	132.88	4.84	25.08	11.02	12.72	0.03
2020	157.45	7.13	27.89	12.47	16.29	0.02
2021	138.80	4.86	22.60	11.70	14.54	0.02
Trend						
1990-2021	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005-2021	*605.4%*	*5378.1%*	*141.4%*	*787.0%*	*15157.6%*	*NA*
2020-2021	*-11.8%*	*-31.8%*	*-19.0%*	*-6.2%*	*-10.7%*	*-2.0%*

4.7.2 General remarks related to F-gases

HFC and PFC as Substitutes for ODS – so called F-gases

(A) refrigeration and air-conditioning are by far the main application

HFC and partially PFC are used in fire suppression, aerosols, solvents, foam etc.

⇒ see tables below

(B) F-gases occur as pure substances or as blends.

⇒ see tables below

(C) emissions arise from:

- production (by-product, fugitive)
  - Manufacturing or assembly emissions
    - Leaks at filling
  - Intended release during use of products
- during use (intended, leakage)
  - Prompt emissions (< 2 years after being charged into a product)
    - as aerosols or propellants
  - Leaks during use / operation of products
  - Container losses
- Release at the end of life of products / decommissioning

(D) F-gases are traded products (no formation in processes)

(E) development of long-lived banks makes the calculation difficult.

Table 280 Main application areas for HFCs and PFCs as ODS substitutes.

Chemical	Refrigeration and Air Conditioning	Fire Suppression and Explosion Protection	Aerosols		Solvent Cleaning	Foam Blowing	Other Applications
			Propellants	Solvents			
HFC-23	X	X					
HFC-32	X						
HFC-125	X	X					
HFC-134a	X	X	X			X	X
HFC-143a	X						
HFC-152a	X		X			X	
HFC-227ea	X	X	X			X	X
HFC-236fa	X	X					
HFC-245fa				X		X	
HFC-365mfc				X	X	X	
HFC-43-10mee				X	X		
PFC-14 (CF_4)		X					
PFC-116 (C_2F_6)							X
PFC-218 (C_3F_8)							
PFC-31-10 (C_4F_{10})		X					

Chemical	Refrigeration and Air Conditioning	Fire Suppression and Explosion Protection	Aerosols		Solvent Cleaning	Foam Blowing	Other Applications
			Propellants	Solvents			
PFC-51-14 (C_6F_{14})					X		

Remarks Main application areas for HFCs and PFCs as ODS substitutes: Several applications use HFCs and PFCs as components of blends. The other components of these blends are sometimes ODSs and/or non-greenhouse gases. Several HFCs, PFCs and blends are sold under various trade names; only generic designations are used in this chapter.

Other applications include sterilization equipment, tobacco expansion applications, plasma etching of electronic chips (PFC-116) and as solvents in the manufacture of adhesive coatings and inks.

PFC-14 (chemically CF_4) is used as a minor component of a proprietary blend. Its main use is for semiconductor etching.

PFC-51-14 is an inert material, which has little or nil ability to dissolve soils. It can be used as a carrier for other solvents or to dissolve and deposit disk drive lubricants. PFCs are also used to test that sealed components are hermetically sealed.

Source: 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 7: Emissions of Fluorinated Substitutes for Ozone Depleting Substances. Table 7.1. Page 7.1.

Table 281 ASHRE name and chemical formula of HFCs, PFCs, CFCs and other refrigerants

PFC (fully fluorinated hydrocarbons)		
ASHRAE name	**chemical formula**	**name**
R 14	CF_4	perfluormethan
R 116	C_2F_6	perfluorethan
R 218	C3F8	perfluorpropan
RC 318	C4F8	perfluorcyclobutane
R 3110	C4F10	perfluorbutan
HFCs (partly fluorinated hydrocarbons)		
ASHRAE name	**Chemical formula**	**name**
R 23	CHF3	trifluormethan
R 32	CH2F2	difluormethan
R 41	CH3F	fluormethan
R 43 10mee	C5H2F10	dekaflouropentan
R 125	CHF2CF3	pentafluoroethan
R 134a	CF3CHF	tetrafluorethan
R 143a	CF3CH3	trifluorethan
R 152a	CHF2CH3	difluorethan
R 227ea	CF3CFHCF3	heptafluoropropan
R 236fa	C3H2F6	hexafluoropropan
R 245ea	CF3CH2CF2H	pentafluoropropan

ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers

CFCs (chlorofluorocarbons)		
ASHRAE name	**Chemical formula**	
R 11	CCl3F	trichlorflourmethan
R 12	CCl2F2	dichlordiflourmethan
R 13	CClF3	chlortriflourmethan
R 22	CHClF2	chlordiflourmethan
R 113	CClF2CCl2F	trichlortriflourethan
R 114	CClF2CClF2	dichlortetraflourethan
R 115	CClF2CF3	chlorpentaflourethan
R 123	CHCl2CF3	dichlortriflourethan
R 124	CHClFCF3	chlortriflourethan
R 141b	CCl2FCH3	dichlorflourethan
R 142b	CClF2CH3	chlordiflourethan
Other refrigerants		
ASHRAE name	**Chemical formula**	**name**
R 12B1	CBrClF2	halon 1221
R 13B1	CBrF3	halon 1301
R 50	CH_4	methane
R 290	C3H8	propane
RC 318	C4F8	perfluorocyclobutane
R 600a	CH3CH(CH3)2	iso-butane
R 717	NH3	ammonia
R 718	H2O	water
R1270		propene

4.7.3 Refrigeration and Air Conditioning (IPCC subcategory 2.F.1)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.1	Refrigeration and Air Conditioning	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.1	Refrigeration and Air Conditioning		LA2021		-				-
2.F.1.a	Refrigeration and Stationary Air Conditioning	✓		NE		NE		NE	
2.F.1.b	Mobile Air Conditioning	NE		NE		NE		NE	

A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF

The following information were used:

- UNIDO Study 2016: Survey of consumption, distribution and uses of various alternatives to ODSs for Montenegro; UNIDO Project ID: 150271; Ref No: 21435; Index No: 00684640, November 2016
- Import and export data, based on information from EPA, Montreal Unit

In the following the country specific approach to estimate emissions from manufacturing / new product, stocks and disposal is presented for the year 2015. It is assumed, that only R134a is used.

Table 282 Country specific approach to estimate emissions from the use refrigeration equipment using R134a

Description	Item	Information / Comment	2015
			kg
New Production		only these amounts lead to emissions from NEW (production), the rest of the stock is imported pre-filled; not added to stock as for total equipment in use a bottom up estimate was made	
	domestic refrigeration	UNIDO 2016, p53/54 R134a Manufacturing; p27: freezer production	5 100
Emissions from new production			
		2%; UNIDO2016; p38	102
Banks=Stock			
	fridges	as there is no refilling, emissions from stocks are subtracted!	11 405
	freezers		2 797
	total		**14 202**
HFC quota			
	fridges	UNIDO2016	50%
	freezers		40%

Description	Item	Information / Comment		2015
				kg
Charge in NEW equipment (prefilled imported)				
	fridges	10000 new appliances per year 0.15 kg charge per applicant	UNIDO 2016, p37; "for calculation only" - not reported as "new" as no emissions arise from this new equipment which is imported pre-filled	750
	freezers	3000 new appliances per year 0.2 kg charge per applicant		240
	total			**990**
Emissions from banks				
	fridges	3%; Expert judgement		342
	freezers			84
	total			**426**
Charge in disposed equipment				
	fridges			408
	freezers			98
	total			506
Emissions from disposal				
	fridges	**30 %** amounts already emitted over the lifetime is subtracted from initial charge		122
	freezers			29
	total			**152**

4.7.3.1 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission and relevant to IPCC sub-category 2.F.1 Refrigeration and Air Conditioning.

Table 283 Recalculations done in IPCC category 2.F.1 Refrigeration and Air Conditioning

GHG source & sink category	Revisions	Type of revision	Type of improvement
2.F.1	No revisions were performed		

4.7.3.2 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 284 Planned improvements for IPCC sub-category 2.F.1 Refrigeration and Air Conditioning.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.F	Elaborate more detailed table for NIR		transparency	medium
2.F	Implementation of recycled and recovered amounts presented in the UNIDO 2016 study		accuracy	low
2.F.1	Small amounts of export in 2013 could be verified and disaggregated to refrigerants		accuracy	low
2.F.1	MACs: verification of decrease of share of R134a MACs		update	medium

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.F.1	MAC: try to get registration data for cars/trucks seperately for vehicles with and without AC (ministry of intenal affairs)		accuracy	medium
2.F.1	Separate estimate of transport refrigeration, currently amounts are included in commercial refrigeration		accuracy	medium
2.F.1	Domestic: verification of phase out		update	medium
2.F.1	Domestic new production (Obod Ice): update value of 5,1 R134a for the years after 2015		update	medium
2.F.1	AC: comparison of per capita emissions with Croatia for verification		verification	medium
2.F.1	Room AC: verification of HFC shares		update	medium
2.F.1	Stationary AC: as emissions are calculated from previous year stocks there is a single value of below 3% in the CRT			medium

Table 285 Relevant commodity relevant to IPCC sub-category 2.F.1 Refrigeration and Air Conditioning

Commodity	HS-Code	Name of Commodity
Air-condition	**8415**	**Air conditioning machines; comprising a motor driven fan and elements for changing the temperature and humidity, including those machines in which the humidity cannot be separately regulated**
	841510	Air conditioning machines; comprising a motor-driven fan and elements for changing the temperature and humidity, of a kind designed to be fixed to a window, wall, ceiling or floor, self-contained or "split-system"
	841520	Air conditioning machines; comprising a motor driven fan and elements for changing the temperature and humidity, of a kind used for persons, in motor vehicles
	841581	Air conditioning machines; containing a motor driven fan, other than window or wall types, incorporating a refrigerating unit and a valve for reversal of the cooling/heat cycle (reversible heat pumps)
	841582	Air conditioning machines; containing a motor driven fan, other than window or wall types, incorporating a refrigerating unit
	841583	Air conditioning machines; containing a motor driven fan, other than window or wall types, not incorporating a refrigerating unit
	841590	Air conditioning machines; with motor driven fan and elements for temperature control, parts thereof
Refrigerators	**8418**	**Refrigerators, freezers and other refrigerating or freezing equipment, electric or other; heat pumps other than air conditioning machines of heading no. 8415**
	841810	Refrigerators and freezers; combined refrigerator-freezers, fitted with separate external doors, electric or other
	841821	Refrigerators; for household use, compression-type, electric or other
	841829	Refrigerators; household, electric or not, other than compression-type
	841830	Freezers; of the chest type, not exceeding 800l capacity
	841840	Freezers; of the upright type, not exceeding 900l capacity
	841850	Furniture incorporating refrigerating or freezing equipment; for storage and display, n.e.c. in item no. 8418.1, 8418.2, 8418.3 or 8418.4 (chests, cabinets, display counters, show-cases and the like)
	841861	Heat pumps; other than air conditioning machines of heading no. 8415
	841869	Refrigerating or freezing equipment; n.e.c. in heading no. 8418
	841891	Refrigerating or freezing equipment; parts, furniture designed to receive refrigerating or freezing equipment
	841899	Refrigerating or freezing equipment; parts thereof, other than furniture

4.7.4 Foam Blowing Agents (IPCC subcategory 2.F.2)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.2	Foam Blowing Agents	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.2	Foam Blowing Agents	NE	-	NE	-	NE	-	NE	-
A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF									

The IPCC subcategory 2.F.2 *Foam Blowing Agents* is not estimated (NE) due to lack of data.

4.7.4.1 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission and relevant to IPCC category 2.F.2 *Foam Blowing Agents*.

Table 286 Recalculations done in IPCC category 2.F.2 *Foam Blowing Agents*

GHG source & sink category	Revisions	Type of revision	Type of improvement
2.F.2	No revisions were performed		

4.7.4.2 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 287 Planned improvements for IPCC sub-category 2.F.2 Foam Blowing Agents.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.F.2	Investigate foam blowing: according to UNIDO 2016 study R152a is used for foam blowing (50 t per year), however there is no import (where does this come from, from when till when was R152a in use?	AD	accuracy	medium
2.F.2	UNIDO Study 2016 p 20/27: Obod Ice MNE co imports R365 - investigate and implement	AD	accuracy	low
2.F.2	Foams: most probably there was a use of PU foam spray cans (to e.g. install windows), investigate this issue (CRT category is already prepared for easy incorporation)	AD	accuracy	medium

4.7.5 Fire Protection (IPCC subcategory 2.F.3)

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.3	Fire Protection	✓	-	NE	-	NE	-	NE	-
A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF									

According to the UNIDO 2016 study small amounts of HFC227ea imported were used in the fire subcategory. From the import data “new charge” and “stock” were calculated, and emissions were calculated using IPCC default EFs (1% new, 2% stock, 100% end-of-life).

Lifetime is assumed 25 years (based on default values given for different systems in the 2006 GL).

4.7.5.1 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission and relevant to IPCC category 2.F.3 Fire Protection.

Table 288 Recalculations done in IPCC category *2.F.3 Fire Protection*

GHG source & sink category	Revisions	Type of revision	Type of improvement
2.F.3	No revisions were performed		

4.7.5.2 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 289 Planned improvements for IPCC sub-category 2.F.3 Fire Protection.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.F.3	No improvements planned			

4.7.6 Aerosols (IPCC subcategory 2.F.4)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.4	Aerosols	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.4	Aerosols	✓	-	NE	-	NE	-	NE	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF									

The mean value of consumed/emitted aerosols of Croatia reported for the years 2003-2019 was scaled to MNE population and used for all years 2003 onwards.

Croatia mean value (consumption = emissions)	6 559 kg
Scaling to MNE inhabitants	1 312 kg

4.7.6.1 Category-specific planned improvements for IPCC sub-category 2.F.4 Aerosols

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 290 Planned improvements for IPCC sub-category 2.F.4 Aerosols.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.F.4	No improvements planned			

4.7.7 Solvents (IPCC subcategory 2.F.5)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.5	Solvents	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.5	Solvents	NE	-	NE	-	NE	-	NE	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF									

The IPCC subcategory 2.F.5 *Solvents* is not estimated (NE) due to lack of data.

4.7.7.1 Category-specific planned improvements for IPCC sub-category 2.F.5 Solvents

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 291 Planned improvements for IPCC sub-category 2.F.5 Solvents.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.F.5	Investigation of the use and consumption (by chemical composition) of solvents containing HFC and/or PFC products for (i) Precision Cleaning, (ii) Electronics Cleaning, (iii) Metal Cleaning, (iv) Deposition applications.	AD	Accuracy Transparency Completeness	High
2.F.5	Application of methodology of 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 7: Emissions of Fluorinated Substitutes for Ozone Depleting Substances. (7.3 AEROSOLS (PROPELLANTS AND SOLVENTS) Page 7.28.	AD	Accuracy Transparency Completeness Comparability	High

4.7.8 Other Application (IPCC subcategory 2.F.6)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.6	Other Application	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.F.6	Other Application	NE	-	NE	-	NE	-	NE	-

A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF

The IPCC subcategory 2.F.6 *Other Application* is not estimated (NE) due to lack of data.

4.7.8.1 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 292 Planned improvements for IPCC sub-category 2.F.6 Other Application.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.F.6	Investigation of the use and consumption (by chemical composition) of various products containing HFC and/or PFC	AD	Accuracy Transparency Completeness	High
2.F.6	Application of methodology of 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 7: Emissions of Fluorinated Substitutes for Ozone Depleting Substances. (7.7 OTHER APPLICATIONS) Page 7.66.	AD	Accuracy Transparency Completeness Comparability	High

4.8 Other Product Manufacture and Use (IPCC category 2.G)

The IPCC category 2.G *Other Product Manufacture and Use* comprises.

- PFC and SF6 emissions from Electrical Equipment (2.G.1),
- PFC and SF6 emissions from Other Product Uses (2.G.2),
- N_2O emissions from Product Uses (2.G.3).

4.8.1 Electrical Equipment (IPCC subcategory 2.G.1)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.G.1	Electrical Equipment						
2.G.1.a	Manufacture of Electrical Equipment	NA	-	NA	-	NA	-
2.G.1.b	Use of Electrical Equipment	NA	-	NA	-	NA	-
2.G.1.c	Disposal of Electrical Equipment	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.G.1	Electrical Equipment								
2.G.1.a	Manufacture of Electrical Equipment	NO	-	NO	-	NO	-	NO	-
2.G.1.b	Use of Electrical Equipment	NO	-	NO	-	✓	-	NO	-
2.G.1.c	Disposal of Electrical Equipment	NO	-	NO	-	NE	-	NO	-

A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF

4.8.1.1 Manufacture of Electrical Equipment (IPCC category 2.G.1.a)

The IPCC subcategory 2.G.1.a *Manufacture of Electrical Equipment* does not exist in Montenegro.

4.8.1.2 Use of Electrical Equipment (IPCC category 2.G.1.b)

SF_6 in electrical equipment is used as an arc quenching and insulating gas in high-voltage (36kV and medium voltage (1-36 kV) switchgear and control gear. The equipment is not produced in Montenegro but is imported. High-voltage Gas-Insulated Systems (GIS) operate with a high operating pressure (up to 7 bar) and large gas quantities, they are usually imported partially filled, and then filled on site. Medium voltage switchgear is usually imported prefilled and hermetically closed (sealed for life). Both categories of equipment have lifetimes of 30-40 years.

In Montenegro, stocks of SF_6 in switchgear was reported to the Environmental Protection Agency, by the only producer of Electricity, responsible for the production and transmission of electricity, as well as by the only producer of hydropower in Montenegro.

4.8.1.2.1 Methodological issues

Time series was split into two parts:

- the suppliers of high voltage electricity that are not subsumed under Crnogorski Elektroprenosni sistem AD (the biggest producer), and
- transformers, which is medium voltage, were split. For both producers, data was only collected for one year (additional information on which year it was, is still required).

The information for both only concerns the quantity of SF_6 in equipment of the plant, but not of the equipment in reserve and also not SF_6 storage for refilling. For Crnogorski Elektroprenosni sistem AD for High Voltage switchgear, stock data – and not annual consumption – seems to be provided (needs to be verified). In last year's submission, consumption was calculated by taking changes in stock into account, which was most probably the wrong approach. In the new approach, information provided by the energy providers was summed up in order to calculate a stock, and this was combined with EFs from the 2006 IPCC guidelines, depending on HV or MV. Emissions were then compared to those of Austria, which were both in the same range for Stock/Consumption. However, as the calculation is based on one year and on an unproven assumption regarding data from transmission, the uncertainty of this estimate is high (95%).

Table 293 Emissions from IPCC category 2.G.1.b, SF_6 used in Switchgear for the period 1990-2021

Year	Stock SF6	SF6 emissions from use	Emissions
	t	t	t CO_2 eq
1990	10,86	0,22	5,04
1991	10,86	0,22	5,04
1992	10,86	0,22	5,04
1993	10,86	0,22	5,04
1994	10,86	0,22	5,04
1995	10,86	0,22	5,04
1996	10,86	0,22	5,04
1997	10,86	0,22	5,04
1998	10,86	0,22	5,04
1999	10,86	0,22	5,04
2000	10,86	0,22	5,04
2001	10,86	0,22	5,04
2002	10,86	0,22	5,04
2003	10,86	0,22	5,04
2004	10,86	0,22	5,04

Year	Stock SF6	SF6 emissions from use	Emissions
	t	t	t CO_2 eq
2005	10,86	0,22	5,04
2006	10,86	0,22	5,04
2007	10,86	0,22	5,04
2008	10,86	0,22	5,04
2009	10,86	0,22	5,04
2010	10,86	0,22	5,04
2011	10,86	0,22	5,04
2012	10,86	0,22	5,04
2013	10,86	0,22	5,04
2014	10,86	0,22	5,04
2015	10,86	0,22	5,04
2016	10,86	0,22	5,04
2017	10,86	0,22	5,04
2018	10,86	0,22	5,04
2019	10,86	0,22	5,04
2020	10,86	0,22	5,04
2021	10,86	0,22	5,04

4.8.1.2.2 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission and relevant to IPCC sub-category *2.G.1.b Use of Electrical Equipment*.

Table 294 Recalculations done in IPCC sub-category *2.G.1.b Use of Electrical Equipment*

GHG source & sink category	Revisions	Type of revision	Type of improvement
2.G.1.b	No revisions were performed		

4.8.1.2.3 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 295 Planned improvements for IPCC sub-category *2.G.1.a Use of Electrical Equipment*

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.G.1.b	In order to provide more information and to increase accuracy, more information will be tried to be obtained from the power company in question: information on the stock, the age of equipment, and actual data on filled in amounts of SF6 if available from their servicing companies will be tried to be obtained.	EMI	completeness	High
2.G.1.b/c	Preparation of questionnaire to power companies	EMI	completeness	High

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.G.1.b	• Include information from what year the value used for all years is reported • Include and archive reference of primary data (values for one year for production and transformers, and time series for transmission)	AD	Transparency	Medium
2.G.1.b	• Check whether assumption for time series for transmission is correct • Link stock data with electricity consumption if no historical data can be found	AD	Accuracy	Medium

4.8.1.3 Disposal of Electrical Equipment (IPCC category 2.G.1.c)

The IPCC subcategory 2.G.1.c *Disposal of Electrical Equipment* is not estimated (NE) due to lack of data.

4.8.1.3.1 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 296 Planned improvements for IPCC sub-category 2.G.1 Electrical Equipment

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.G.1.c	Estimation of emissions from decommissioning	EMI	Completeness	high
2.G.1.c	Stock of new and former decommissioning	AD	Accuracy	Medium
2.G.1.c	Investigation regarding import of old electrical Equipment	AD	Transparency	Medium

4.8.2 SF6 and PFCs from Other Product Uses (IPCC subcategory 2.G.2)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.G.2	SF6 and PFCs from Other Product Uses						
2.G.2.a	Military Applications	NA	-	NA	-	NA	-
2.G.2.b	Accelerators						
2.G.2.b.i	University and Research Particle Accelerators	NA	-	NA	-	NA	-
2.G.2.b.ii	Industrial and Medical Particle Accelerators	NA	-	NA	-	NA	-
2.G.2.c	Other	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.G.2	SF6 and PFCs from Other Product Uses								
2.G.2.a	Military Applications	NO	-	NO	-	NE	-	NO	-
2.G.2.b	Accelerators								
2.G.2.b.i	University & Research Particle Accelerators	NO	-	NO	-	NO	-	NO	-
2.G.2.b.ii	Industrial and Medical Particle Accelerators	NO	-	NO	-	NO	-	NO	-
2.G.2.c	Other	NO	-	NO	-	NE	-	NO	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF									

The IPCC subcategory 2.G.2 *SF6 and PFCs from Other Product Uses* is not estimated due to lack of data.

4.8.2.1 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 297 Planned improvements for IPCC sub-category 2.G.2 SF6 and PFCs from Other Product Use.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.G.2	Analysis of production, import and export of 'other products' containing SF6 and PFCs, e.g. • SF6 and PFCs used in military applications • SF6 used in sound-proof windows • SF6 used in shoes	AD	Accuracy Transparency Completeness Comparability	High
2.G.2	Estimation of SF6 and PFCs emissions from use of 'other products' containing SF6 and PFCs according to 2006 IPCC Guidelines, Vol. 3, Chapter 8: Other Product Manufacture and Use (8.3 USE OF SF6 AND PFCs IN OTHER PRODUCTS)	AD	Accuracy Transparency Completeness Comparability	High

4.8.3 N_2O from Product Uses (IPCC subcategory 2.G.3)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.G.3	N_2O from Product Uses						
2.G.3.a	Medical Applications	NA	-	NA	-	NE	-
2.G.3.b	Propellant for pressure and aerosol products	NA	-	NA	-	NE	-
2.G.3.c	Other	NA	-	NA	-	NE	-
A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF							

The IPCC subcategory 2.G.3 *N_2O from Product Uses* is not estimated due to lack of data.

4.8.3.1 Category-specific planned improvements for IPCC sub-category 2.G.3 N_2O from Product Uses

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 298 Planned improvements for IPCC sub-category 2.G.3 N_2O from Product Use.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.G.3	Estimation of N_2O emissions from the use of products containing N_2O applying Tier 1 of 2006 IPCC Guidelines, Vol. 3, Chapter 8: Other Product Manufacture and Use (N_2O FROM PRODUCT USES)	AD	Accuracy Transparency Completeness Comparability	High

4.8.4 Other (IPCC subcategory 2.G.4)

IPCC code	Description	CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.G.4	Other	NA	-	NA	-	NA	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.G.4	Other	NO	-	NO	-	NO	-	NO	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF									

The IPCC subcategory 2.G.4 *Other* does not exist in Montenegro.

4.9 Other (IPCC category 2.H)

The IPCC category 2.H *Other* comprises activities withing Pulp and paper as well as Food and drink industry, where GHG emissions are arising. These industries emit only process related GHGs of biogenic origin and those have not been accounted for according to the guidelines.

4.9.1 Pulp and Paper Industry (IPCC subcategory 2.H.1)

IPCC code	Description	Fossil CO_2		Biogenic CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.H.1	Pulp and Paper Industry	NA	-	NE	-	NA	-	NA	-
A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF									

The IPCC subcategory 2.H.1 *Pulp and Paper Industry* exists in Montenegro. The pulp and paper industry emit only processes related to GHGs of biogenic origin and those have not been accounted for according to the 2006 IPCC guidelines. Relevant GHG emission from fuel combustion activities in *Pulp and Paper Industry* are reported in IPCC category 1.A.2 *Manufacturing Industries and Construction - Pulp, Paper and Print* (IPCC sub-category 1.A.2.d).

4.9.2 Food and Beverages Industry (IPCC subcategory 2.H.2)

IPCC code	Description	Fossil CO_2		Biogenic CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.H.2	Food and Beverages Industry	NA	-	NE	-	NA	-	NA	-
A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF									

The IPCC subcategory 2.D.2 *Food and Beverages Industry* exist in Montenegro. The Food and Beverages Industry emit only process related GHGs of biogenic origin and those have not been accounted for according to the 2006 IPCC guidelines. Relevant GHG emission from fuel combustion activities in *Food and Beverages Industry* are reported in IPCC category 1.A.2 *Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco* (IPCC subcategory 1.A.2.e).

4.9.3 Other (IPCC subcategory 2.H.3)

IPCC code	Description	Fossil CO_2		Biogenic CO_2		CH_4		N_2O	
		Estimated	Key Category	Estimated	Key Category	Estimated	Key Category	Estimated	Key Category
2.H.3	Other (please specify)	NA	-	NE	-	NA	-	NA	-
A '✓' indicates emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere NE -not estimated, NA -not applicable, C – confidential									
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF									

The IPCC subcategory 2.H.3 *Other* does not exist in Montenegro.

5 Agriculture (IPCC sector 3)

This chapter includes information on and description of methodologies used for estimating GHG emissions as well as references to activity data and emission factors reported under IPCC Sector 3 Agriculture for the period 1990 to 2020.

GHG emissions from this sector comprise emissions from the following categories:

IPCC Code	Description	CO_2	CH_4	N_2O
3.A.1	Enteric Fermentation	NA	✓	NA
3.B.2	Manure Management	NA	✓	✓
3.C	Rice Cultivation	NA	NO	NA
3.D.a	Direct N_2O emissions from managed soils	NA	NA	✓
3.D.b	Indirect N_2O Emissions from managed soils	NA	NA	✓
3.E	Prescribed burning of savannas	NO*	NO	NO
3.F	Field burning of agricultural residues	✓*	✓	✓
3.G	Liming	✓	NA	NA
3.H	Urea application	✓	NA	NA
3.I	Other carbon-containing fertilizers	NO	NA	NA
3.J	Other (please specify)	NO	NA	NA

A '✓' indicates emissions from this sub-category have been estimated.
* CO_2 from biomass burning is not accounted in this categories
Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential

Emission trends

In **2021**, greenhouse gas emissions from IPCC sector 3 *Agriculture* amounted to 208.40 kt CO2 equivalent, which correspond to 6.5% of total national emissions.

In **2005**, greenhouse gas emissions from IPCC sector 3 *Agriculture* amounted to 379.41 kt CO2 equivalent, which correspond to 9.9% of total national emissions.

In **1990**, greenhouse gas emissions from IPCC sector 3 *Agriculture* amounted to 601.90kt CO2 equivalent, which correspond to 13.3% of total national emissions.

The most important sub-categories of this sector are *3.A Enteric fermentation* and *3.B Manure Management*. IPCC sector 3 *Agriculture* is the largest source of national N_2O and CH_4 emissions.

The overall trend in GHG emissions from *Agriculture* shows a decrease of -65.4% from 1990 to 2021 and -45.1% from 2005 to 2021. The main drivers for this trend are decreasing livestock.

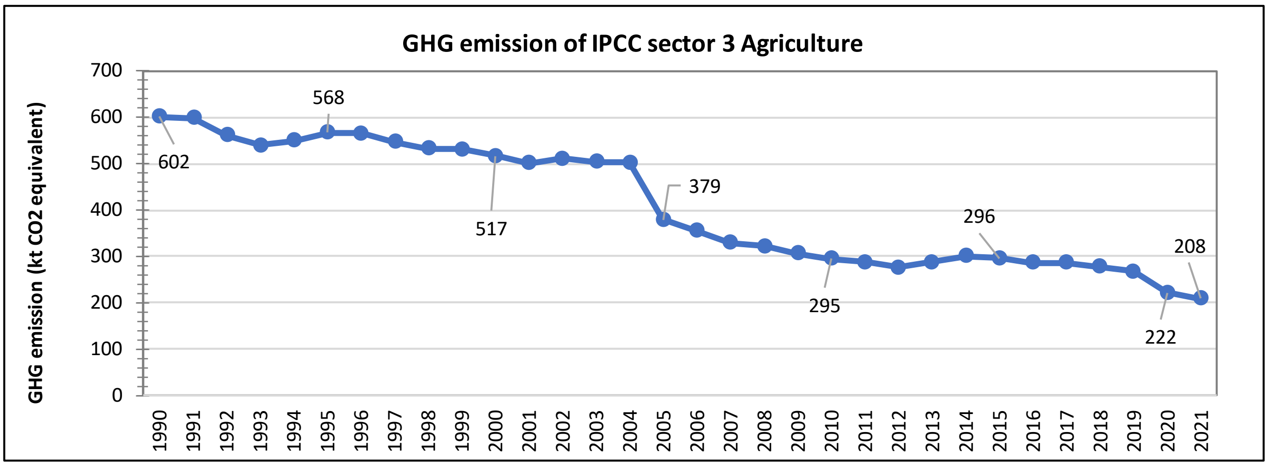


Figure 130 Trend of GHG emission of IPCC sector 3 Agriculture for the period 1990 – 2021

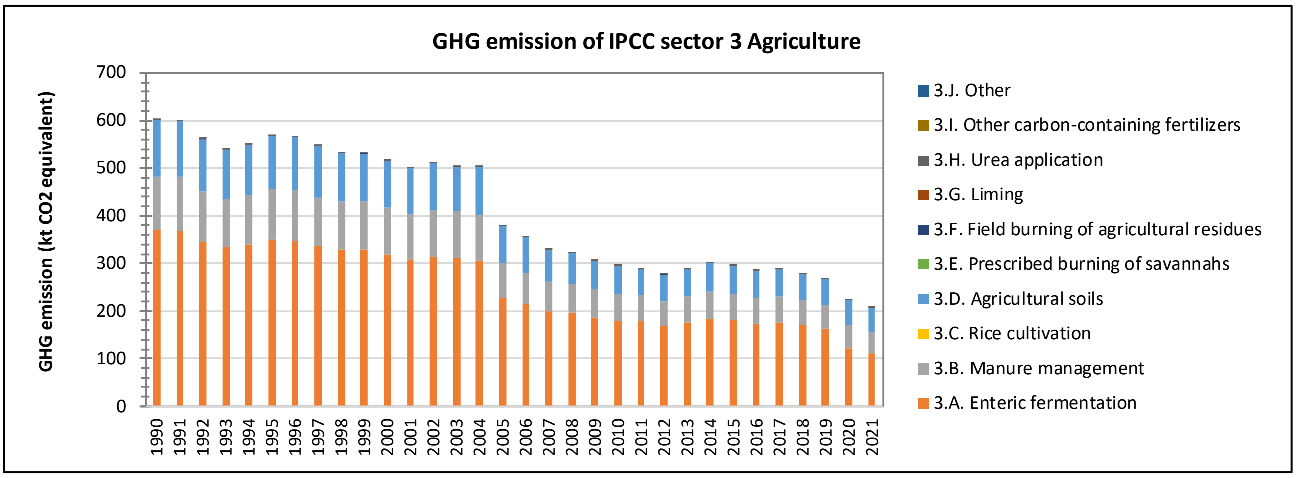


Figure 131 Trend of GHG emission of IPCC sector 3 Agriculture by category for the period 1990 – 2021

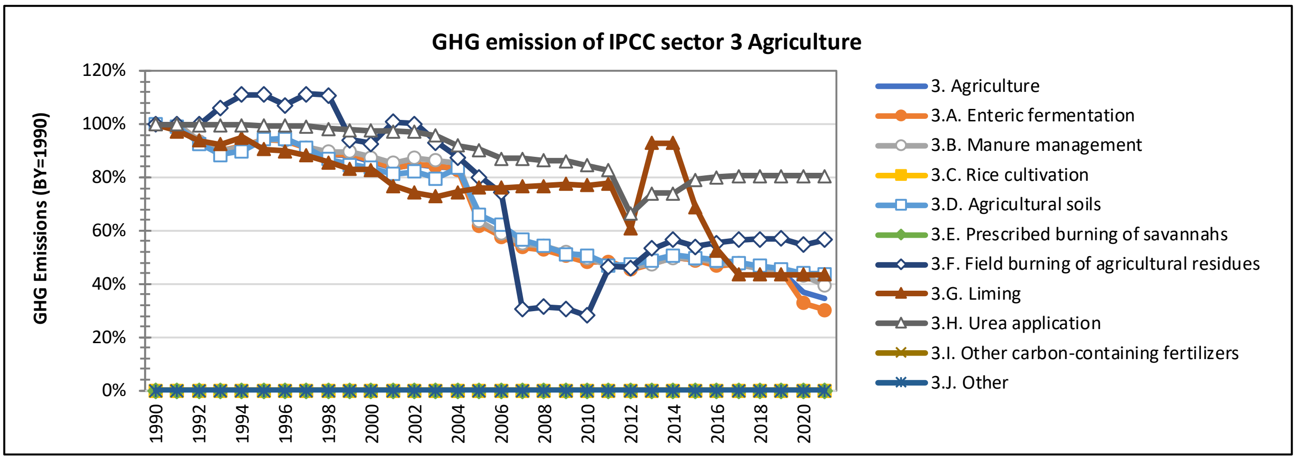


Figure 132 Trend of emissions from IPCC sector 3 Agriculture in index form (base year = 100) by category for the period 1990 – 2021

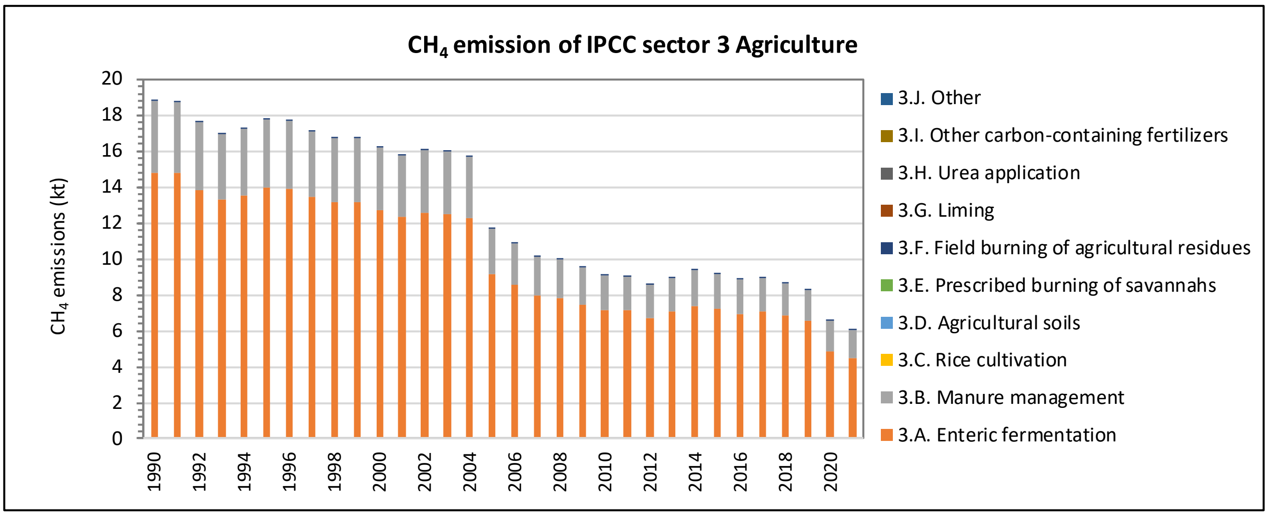


Figure 133 Trend of CH_4 emission of IPCC sector 3 Agriculture by category for the period 1990 – 2021

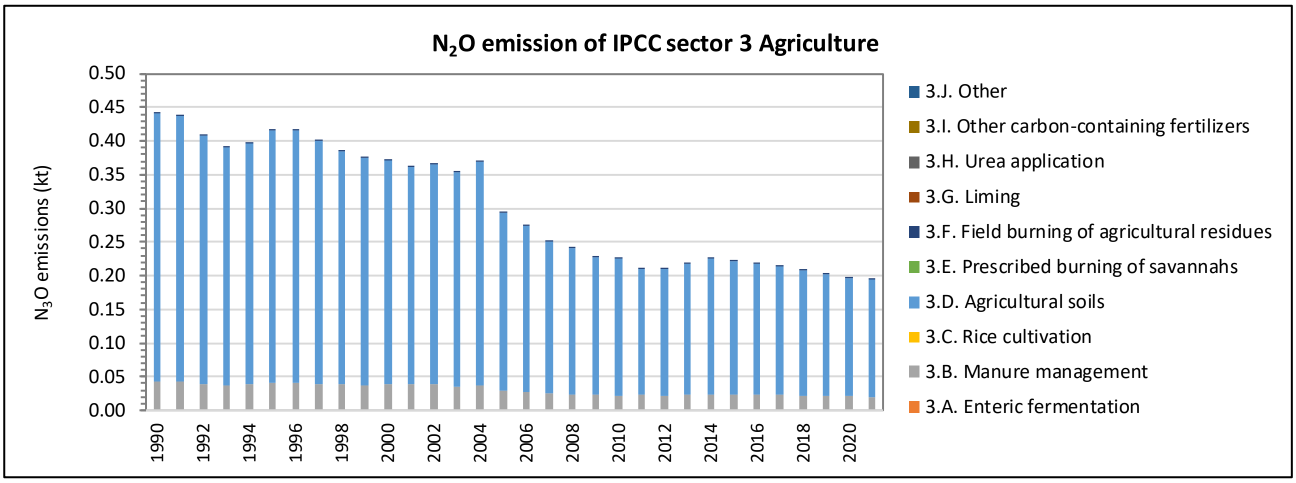


Figure 134 Trend of N_2O emission of IPCC sector 3 Agriculture by category for the period 1990 – 2021

Table 299 GHG Emissions from IPCC sub-category 3 Agriculture by sub-categories for the period 1990-2021

GHG emissions	3 Agriculture	3.A Enteric Fermentation	3.B Manure Management	3.C Rice Cultivation	3.D Agricultural soils	3.E Prescribed burning of savannas	3.F Field burning of agricultural residues	3. Liming	3.H Urea application	3.I Other carbon-containing fertilizers	3.J Other
	kt $_{CO_2\ equivalent}$										
1990	**601.90**	370.03	112.53	NO	118.80	NO	0.05	0.06	0.43	NO	NO
1991	**599.19**	369.00	112.02	NO	117.64	NO	0.05	0.06	0.42	NO	NO
1992	**561.91**	345.94	105.33	NO	110.10	NO	0.05	0.06	0.42	NO	NO
1993	**540.24**	333.40	101.30	NO	105.00	NO	0.05	0.06	0.42	NO	NO
1994	**549.32**	339.08	103.06	NO	106.65	NO	0.05	0.06	0.42	NO	NO
1995	**567.80**	348.96	106.20	NO	112.11	NO	0.05	0.06	0.42	NO	NO
1996	**565.85**	347.17	105.86	NO	112.28	NO	0.05	0.06	0.42	NO	NO
1997	**547.08**	335.68	102.69	NO	108.17	NO	0.06	0.06	0.42	NO	NO
1998	**532.93**	328.42	100.86	NO	103.12	NO	0.05	0.06	0.42	NO	NO
1999	**530.74**	328.58	100.90	NO	100.74	NO	0.05	0.05	0.42	NO	NO
2000	**516.79**	318.62	98.45	NO	99.20	NO	0.05	0.05	0.42	NO	NO
2001	**501.61**	308.49	96.10	NO	96.49	NO	0.05	0.05	0.41	NO	NO
2002	**511.00**	314.67	98.20	NO	97.62	NO	0.05	0.05	0.41	NO	NO
2003	**504.47**	312.20	97.13	NO	94.64	NO	0.05	0.05	0.41	NO	NO
2004	**502.25**	306.48	96.12	NO	99.16	NO	0.04	0.05	0.39	NO	NO
2005	**379.41**	229.13	71.48	NO	78.31	NO	0.04	0.05	0.38	NO	NO
2006	**354.44**	213.79	66.30	NO	73.89	NO	0.04	0.05	0.37	NO	NO
2007	**328.65**	199.07	61.96	NO	67.20	NO	0.02	0.05	0.37	NO	NO
2008	**321.64**	195.77	61.04	NO	64.40	NO	0.02	0.05	0.37	NO	NO
2009	**306.25**	186.60	58.40	NO	60.82	NO	0.02	0.05	0.37	NO	NO
2010	**295.17**	178.36	56.05	NO	60.33	NO	0.01	0.05	0.36	NO	NO
2011	**288.01**	179.10	52.73	NO	55.76	NO	0.02	0.05	0.35	NO	NO
2012	**276.26**	167.71	51.98	NO	56.24	NO	0.02	0.04	0.28	NO	NO
2013	**288.11**	176.26	53.36	NO	58.08	NO	0.03	0.06	0.31	NO	NO
2014	**301.28**	184.76	55.95	NO	60.16	NO	0.03	0.06	0.31	NO	NO
2015	**295.91**	180.91	55.53	NO	59.06	NO	0.03	0.04	0.34	NO	NO
2016	**286.23**	173.38	54.33	NO	58.12	NO	0.03	0.03	0.34	NO	NO
2017	**286.76**	176.41	53.12	NO	56.83	NO	0.03	0.03	0.34	NO	NO
2018	**277.92**	170.60	51.42	NO	55.50	NO	0.03	0.03	0.34	NO	NO
2019	**268.14**	163.50	50.09	NO	54.15	NO	0.03	0.03	0.34	NO	NO

GHG emissions	3 Agriculture	3.A Enteric Fermentation	3.B Manure Management	3.C Rice Cultivation	3.D Agricultural soils	3.E Prescribed burning of savannas	3.F Field burning of agricultural residues	3. Liming	3.H Urea application	3.I Other carbon-containing fertilizers	3.J Other
	kt $_{CO_2\ equivalent}$										
2020	**222.12**	121.32	48.30	NO	52.11	NO	0.03	0.03	0.34	NO	NO
2021	**208.40**	111.59	44.54	NO	51.87	NO	0.03	0.03	0.34	NO	NO
Trend											
1990 - 2021	*-65.4%*	*-69.8%*	*-60.4%*	*NA*	*-56.3%*	*NA*	*-43.5%*	*-56.4%*	*-19.4%*	*NA*	*NA*
2005 - 2021	*-45.1%*	*-51.3%*	*-37.7%*	*NA*	*-33.8%*	*NA*	*-29.4%*	*-42.7%*	*-10.8%*	*NA*	*NA*
2020 - 2021	*-6.2%*	*-8.0%*	*-7.8%*	*NA*	*-0.5%*	*NA*	*3.6%*	*0.0%*	*0.0%*	*NA*	*NA*

Table 300 CO_2 Emissions from IPCC sub-category 3 Agriculture by sub-categories for the period 1990-2021

CO_2 emissions	3 Agriculture	3.A Enteric Fermentation	3.B Manure Management	3.C Rice Cultivation	3.D Agricultural soils	3.E Prescribed burning of savannas	3.F Field burning of agricultural residues	3. Liming	3.H Urea application	3.I Other carbon-containing fertilizers	3.J Other
	kt										
1990	**0.490**	NA	NA	NA	NA	NA	NA	0.065	0.425	NO	NO
1991	**0.488**	NA	NA	NA	NA	NA	NA	0.063	0.425	NO	NO
1992	**0.485**	NA	NA	NA	NA	NA	NA	0.061	0.424	NO	NO
1993	**0.484**	NA	NA	NA	NA	NA	NA	0.060	0.424	NO	NO
1994	**0.485**	NA	NA	NA	NA	NA	NA	0.062	0.424	NO	NO
1995	**0.482**	NA	NA	NA	NA	NA	NA	0.059	0.423	NO	NO
1996	**0.481**	NA	NA	NA	NA	NA	NA	0.058	0.423	NO	NO
1997	**0.479**	NA	NA	NA	NA	NA	NA	0.057	0.422	NO	NO
1998	**0.473**	NA	NA	NA	NA	NA	NA	0.055	0.418	NO	NO
1999	**0.470**	NA	NA	NA	NA	NA	NA	0.054	0.416	NO	NO
2000	**0.469**	NA	NA	NA	NA	NA	NA	0.054	0.415	NO	NO
2001	**0.464**	NA	NA	NA	NA	NA	NA	0.050	0.414	NO	NO
2002	**0.461**	NA	NA	NA	NA	NA	NA	0.048	0.413	NO	NO
2003	**0.454**	NA	NA	NA	NA	NA	NA	0.047	0.407	NO	NO
2004	**0.440**	NA	NA	NA	NA	NA	NA	0.048	0.392	NO	NO
2005	**0.434**	NA	NA	NA	NA	NA	NA	0.049	0.384	NO	NO
2006	**0.420**	NA	NA	NA	NA	NA	NA	0.049	0.370	NO	NO
2007	**0.420**	NA	NA	NA	NA	NA	NA	0.050	0.370	NO	NO
2008	**0.417**	NA	NA	NA	NA	NA	NA	0.050	0.367	NO	NO

CO_2 emissions	3 Agriculture	3.A Enteric Fermentation	3.B Manure Management	3.C Rice Cultivation	3.D Agricultural soils	3.E Prescribed burning of savannas	3.F Field burning of agricultural residues	3. Liming	3.H Urea application	3.I Other carbon-containing fertilizers	3.J Other
	kt										
2009	**0.417**	NA	NA	NA	NA	NA	NA	0.050	0.367	NO	NO
2010	**0.409**	NA	NA	NA	NA	NA	NA	0.050	0.359	NO	NO
2011	**0.402**	NA	NA	NA	NA	NA	NA	0.050	0.352	NO	NO
2012	**0.322**	NA	NA	NA	NA	NA	NA	0.039	0.282	NO	NO
2013	**0.375**	NA	NA	NA	NA	NA	NA	0.060	0.315	NO	NO
2014	**0.375**	NA	NA	NA	NA	NA	NA	0.060	0.315	NO	NO
2015	**0.382**	NA	NA	NA	NA	NA	NA	0.045	0.337	NO	NO
2016	**0.375**	NA	NA	NA	NA	NA	NA	0.034	0.341	NO	NO
2017	**0.371**	NA	NA	NA	NA	NA	NA	0.028	0.343	NO	NO
2018	**0.371**	NA	NA	NA	NA	NA	NA	0.028	0.343	NO	NO
2019	**0.371**	NA	NA	NA	NA	NA	NA	0.028	0.343	NO	NO
2020	**0.371**	NA	NA	NA	NA	NA	NA	0.028	0.343	NO	NO
2021	**0.371**	NA	NA	NA	NA	NA	NA	0.028	0.343	NO	NO
Trend											
1990 - 2021	*-24.3%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*-56.4%*	*-19.4%*	*NA*	*NA*
2005 - 2021	*-14.4%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*-42.7%*	*-10.8%*	*NA*	*NA*
2020 - 2021	*0.0%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*0.0%*	*0.0%*	*NA*	*NA*

Table 301 CH_4 Emissions from IPCC sub-category 3 Agriculture by sub-categories for the period 1990-2021

CH4 emissions	3 Agriculture	3.A Enteric Fermentation	3.B Manure Management	3.C Rice Cultivation	3.D Agricultural soils	3.E Prescribed burning of savannas	3.F Field burning of agricultural residues	3. Liming	3.H Urea application	3.I Other carbon-containing fertilizers	3.J Other
	kt										
1990	**18.79**	14.80	3.99	NO	NA	NO	0.0015	NA	NA	NO	NO
1991	**18.74**	14.76	3.98	NO	NA	NO	0.0015	NA	NA	NO	NO
1992	**17.58**	13.84	3.74	NO	NA	NO	0.0015	NA	NA	NO	NO
1993	**16.94**	13.34	3.60	NO	NA	NO	0.0016	NA	NA	NO	NO
1994	**17.23**	13.56	3.67	NO	NA	NO	0.0017	NA	NA	NO	NO
1995	**17.73**	13.96	3.77	NO	NA	NO	0.0017	NA	NA	NO	NO
1996	**17.65**	13.89	3.76	NO	NA	NO	0.0016	NA	NA	NO	NO
1997	**17.08**	13.43	3.65	NO	NA	NO	0.0017	NA	NA	NO	NO
1998	**16.72**	13.14	3.58	NO	NA	NO	0.0017	NA	NA	NO	NO

CH4 emissions	3 Agriculture	3.A Enteric Fermentation	3.B Manure Management	3.C Rice Cultivation	3.D Agricultural soils	3.E Prescribed burning of savannas	3.F Field burning of agricultural residues	3. Liming	3.H Urea application	3.I Other carbon-containing fertilizers	3.J Other
	kt										
1999	**16.74**	13.14	3.59	NO	NA	NO	0.0014	NA	NA	NO	NO
2000	**16.22**	12.74	3.48	NO	NA	NO	0.0014	NA	NA	NO	NO
2001	**15.73**	12.34	3.39	NO	NA	NO	0.0015	NA	NA	NO	NO
2002	**16.06**	12.59	3.47	NO	NA	NO	0.0015	NA	NA	NO	NO
2003	**15.95**	12.49	3.46	NO	NA	NO	0.0014	NA	NA	NO	NO
2004	**15.67**	12.26	3.41	NO	NA	NO	0.0013	NA	NA	NO	NO
2005	**11.67**	9.17	2.50	NO	NA	NO	0.0012	NA	NA	NO	NO
2006	**10.88**	8.55	2.33	NO	NA	NO	0.0011	NA	NA	NO	NO
2007	**10.13**	7.96	2.17	NO	NA	NO	0.0005	NA	NA	NO	NO
2008	**9.98**	7.83	2.15	NO	NA	NO	0.0005	NA	NA	NO	NO
2009	**9.53**	7.46	2.06	NO	NA	NO	0.0005	NA	NA	NO	NO
2010	**9.11**	7.13	1.98	NO	NA	NO	0.0004	NA	NA	NO	NO
2011	**9.01**	7.16	1.84	NO	NA	NO	0.0007	NA	NA	NO	NO
2012	**8.53**	6.71	1.82	NO	NA	NO	0.0007	NA	NA	NO	NO
2013	**8.92**	7.05	1.87	NO	NA	NO	0.0008	NA	NA	NO	NO
2014	**9.35**	7.39	1.96	NO	NA	NO	0.0009	NA	NA	NO	NO
2015	**9.18**	7.24	1.94	NO	NA	NO	0.0008	NA	NA	NO	NO
2016	**8.83**	6.94	1.90	NO	NA	NO	0.0008	NA	NA	NO	NO
2017	**8.91**	7.06	1.85	NO	NA	NO	0.0009	NA	NA	NO	NO
2018	**8.63**	6.82	1.80	NO	NA	NO	0.0009	NA	NA	NO	NO
2019	**8.29**	6.54	1.75	NO	NA	NO	0.0009	NA	NA	NO	NO
2020	**6.54**	4.85	1.69	NO	NA	NO	0.0008	NA	NA	NO	NO
2021	**6.01**	4.46	1.55	NO	NA	NO	0.0009	NA	NA	NO	NO
Trend											
1990 - 2021	*-68.0%*	*-69.8%*	*-61.2%*	*NA*	*NA*	*NA*	*-43.5%*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*-48.5%*	*-51.3%*	*-38.1%*	*NA*	*NA*	*NA*	*-29.4%*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*-8.1%*	*-8.0%*	*-8.2%*	*NA*	*NA*	*NA*	*3.6%*	*NA*	*NA*	*NA*	*NA*

Table 302 N_2O Emissions from IPCC sub-category 3 Agriculture by sub-categories for the period 1990-2021

N_2O emissions	3 Agriculture	3.A Enteric Fermentation	3.B Manure Management	3.C Rice Cultivation	3.D Agricultural soils	3.E Prescribed burning of savannas	3.F Field burning of agricultural residues	3. Liming	3.H Urea application	3.I Other carbon-containing fertilizers	3.J Other
	kt										
1990	**0.441**	NA	0.043	NA	0.399	NO	0.00004	NA	NA	NO	NO
1991	**0.437**	NA	0.042	NA	0.395	NO	0.00004	NA	NA	NO	NO
1992	**0.409**	NA	0.040	NA	0.369	NO	0.00004	NA	NA	NO	NO
1993	**0.390**	NA	0.038	NA	0.352	NO	0.00004	NA	NA	NO	NO
1994	**0.396**	NA	0.038	NA	0.358	NO	0.00004	NA	NA	NO	NO
1995	**0.416**	NA	0.040	NA	0.376	NO	0.00004	NA	NA	NO	NO
1996	**0.417**	NA	0.040	NA	0.377	NO	0.00004	NA	NA	NO	NO
1997	**0.401**	NA	0.038	NA	0.363	NO	0.00004	NA	NA	NO	NO
1998	**0.384**	NA	0.038	NA	0.346	NO	0.00004	NA	NA	NO	NO
1999	**0.375**	NA	0.037	NA	0.338	NO	0.00004	NA	NA	NO	NO
2000	**0.371**	NA	0.039	NA	0.333	NO	0.00004	NA	NA	NO	NO
2001	**0.362**	NA	0.038	NA	0.324	NO	0.00004	NA	NA	NO	NO
2002	**0.366**	NA	0.039	NA	0.328	NO	0.00004	NA	NA	NO	NO
2003	**0.353**	NA	0.036	NA	0.318	NO	0.00004	NA	NA	NO	NO
2004	**0.370**	NA	0.037	NA	0.333	NO	0.00003	NA	NA	NO	NO
2005	**0.293**	NA	0.030	NA	0.263	NO	0.00003	NA	NA	NO	NO
2006	**0.275**	NA	0.027	NA	0.248	NO	0.00003	NA	NA	NO	NO
2007	**0.252**	NA	0.026	NA	0.225	NO	0.00001	NA	NA	NO	NO
2008	**0.240**	NA	0.024	NA	0.216	NO	0.00001	NA	NA	NO	NO
2009	**0.227**	NA	0.023	NA	0.204	NO	0.00001	NA	NA	NO	NO
2010	**0.225**	NA	0.022	NA	0.202	NO	0.00001	NA	NA	NO	NO
2011	**0.209**	NA	0.022	NA	0.187	NO	0.00002	NA	NA	NO	NO
2012	**0.210**	NA	0.022	NA	0.189	NO	0.00002	NA	NA	NO	NO
2013	**0.217**	NA	0.022	NA	0.195	NO	0.00002	NA	NA	NO	NO
2014	**0.226**	NA	0.024	NA	0.202	NO	0.00002	NA	NA	NO	NO
2015	**0.222**	NA	0.024	NA	0.198	NO	0.00002	NA	NA	NO	NO
2016	**0.218**	NA	0.023	NA	0.195	NO	0.00002	NA	NA	NO	NO
2017	**0.214**	NA	0.023	NA	0.191	NO	0.00002	NA	NA	NO	NO
2018	**0.208**	NA	0.021	NA	0.186	NO	0.00002	NA	NA	NO	NO
2019	**0.203**	NA	0.021	NA	0.182	NO	0.00002	NA	NA	NO	NO

N_2O emissions	3 Agriculture	3.A Enteric Fermentation	3.B Manure Management	3.C Rice Cultivation	3.D Agricultural soils	3.E Prescribed burning of savannas	3.F Field burning of agricultural residues	3. Liming	3.H Urea application	3.I Other carbon-containing fertilizers	3.J Other
	kt										
2020	**0.195**	NA	0.020	NA	0.175	NO	0.00002	NA	NA	NO	NO
2021	**0.193**	NA	0.019	NA	0.174	NO	0.00002	NA	NA	NO	NO
Trend											
1990 - 2021	*-56.2%*	*NA*	*-54.6%*	*NA*	*-56.3%*	*NA*	*-43.5%*	*NA*	*NA*	*NA*	*NA*
2005 - 2021	*-33.9%*	*NA*	*-35.0%*	*NA*	*-33.8%*	*NA*	*-29.4%*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*-0.9%*	*NA*	*-5.1%*	*NA*	*-0.5%*	*NA*	*3.6%*	*NA*	*NA*	*NA*	*NA*

5.1 Agricultural data collected and used

5.1.1 Country-specific issues

Montenegro has an area of 13,812 km^2. As stated by the Convention on Biological Diversity Montenegro is home to diverse geological bases, landscapes, soils and climates. It can be divided into two main bio-geographical regions (Mediterranean and alpine) with a variety of ecosystems falling within these two eco-regions. Although there is no formal, widely recognized classification of ecosystems in Montenegro, from the point of view of biodiversity conservation, the following ecosystems are distinguished in the NBSAP: alpine, forest, dry grasslands, freshwater and marine and, among these, habitats include: coastal, caves, canyons, and karst as a specific geological formation. Within its land cover, 54% is covered by forests with natural forests covering 45% of the territory.[90]

According to FAO The Montenegrin landscape is only partly used for intensive agriculture due to its natural conditions and the specific development of agriculture in the past. Intensive farming is practiced only in the vicinity of the capital Podgorica and close to the urban area of Nikšić (second largest city in the country). In almost all regions of Montenegro the majority of the farming areas are used extensively and can be regarded as High Nature Value (HNV) farmland. It is comprised mostly of semi-natural grasslands which are the main part of agricultural land. A substantial area of the country is covered by semi-natural vegetation communities. For many of these, farming practices, especially the grazing and browsing of livestock, continue to be amongst the dominant factors in their maintenance. Montenegrin herbaceous pastures range from the Alpine grasslands of the highest mountains, through Mediterranean-montane Nardus grasslands to dry grasslands on the alluvial plains. The latter are now very restricted in area, found for example on Ćemovsko polje, including Karabuško, Tuško and Dinoško polje and the lower part of the canyon of the River Cijevna, but they are significant for stone curlew (Burrhinus oedicnemus) and tawny pipit (Anthus campestris). Some of the most extensive areas of mountain pastures are found in the Durmitor region. There are also some important areas of wet pastures and meadows between Plav and

[90] Available (12. Mart 2021) on https://www.cbd.int/countries/profile/?country=me

Gusinje.[91]

5.1.2 Sources of data

The original data provider for the national and international agricultural data is the Ministry of Agriculture and Rural Development and Statistical Office of Montenegro (MONSTAT)[92]. The agricultural data used and presented in this inventory are taken from the following national and international sources:

Census of Agriculture[93] — In 2010 the Agricultural Census was conducted at the whole territory of the country, using the "door-to-door" approach, and was the first independent Agricultural Census in Montenegro. It was conducted by Statistical Office of Montenegro MONSTAT in cooperation with the Food and Agriculture Organization of the United Nations (FAO) consultants.

Statistical yearbook [94] — The official statistics (several years) of MONSTAT provides information on

- usable land area and cultivated land area
- crop production, crop yield of agricultural products
- fruit and vegetable cultivated land area
- fruit area and production by province
- area and production of wheat, barley, maize etc
- annual livestock numbers
- livestock production by type

FAO agricultural data base[95] — The FAO agricultural data base (FAOSTAT) provides worldwide harmonized data (FAO AGRICULTURE STATISTICAL SYSTEM 2001).[96] The FAO data base provides data for the entire time series 1990 – 2021, even some data are based on estimates done by FAO.

The results of these QA/QC checks are presented in the following chapters under "Category-specific QA/QC and verification".

5.1.3 Livestock

According to the 2019 Refinement to the 2006 IPCC Guidelines, the method for estimating methane emission from enteric fermentation requires three basic steps:

Step 1: Divide the livestock population into subgroups and characterize each subgroup (as described in Section 10.2. of Volume 4: AFOLU of the 2006 IPCC Guidelines) and presented in chapter 5.2.2.2

Step 2: Estimate emission factors for each subgroup in terms of kilograms of methane per animal per year.

Step 3: Multiply the subgroup emission factors by the subgroup populations to estimate subgroup emission, and sum across the subgroups to estimate total emission.

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[91] Available (12. Mart 2021) on http://www.fao.org/family-farming/detail/en/c/284679/

[92] Available (3. Januar 2021) on https://www.monstat.org/eng/index.php

[93] Available (3. Januar 2021) on https://www.monstat.org/eng/page.php?id=58&pageid=58

[94] Available (3. Januar 2021) on http://www.monstat.org/eng/novosti.php?id=2961

[95] Available (3. Januar 2021) on http://www.fao.org/statistics/en/

[96] Available (3. Januar 2021) on http://www.fao.org/faostat/en/#data

Cattle

In **1990**, the total number of **cattle** amounted to 71 166 and in **2021** the total number of cattle amounted to 188 509. In 2021, 69 % of the cattle were dairy cows. The number of **cattle** decreased significantly by 64 % in the period 1990 – 2021 and decreased by 39% in the period 2005 – 2021. The number of **dairy cattle** decreased significantly by -61.6% in the period 1990 – 2021 and decreased by -39.9% in the period 2005 – 2021. However, the dip in 2005 is due to a change in statistical methodology.

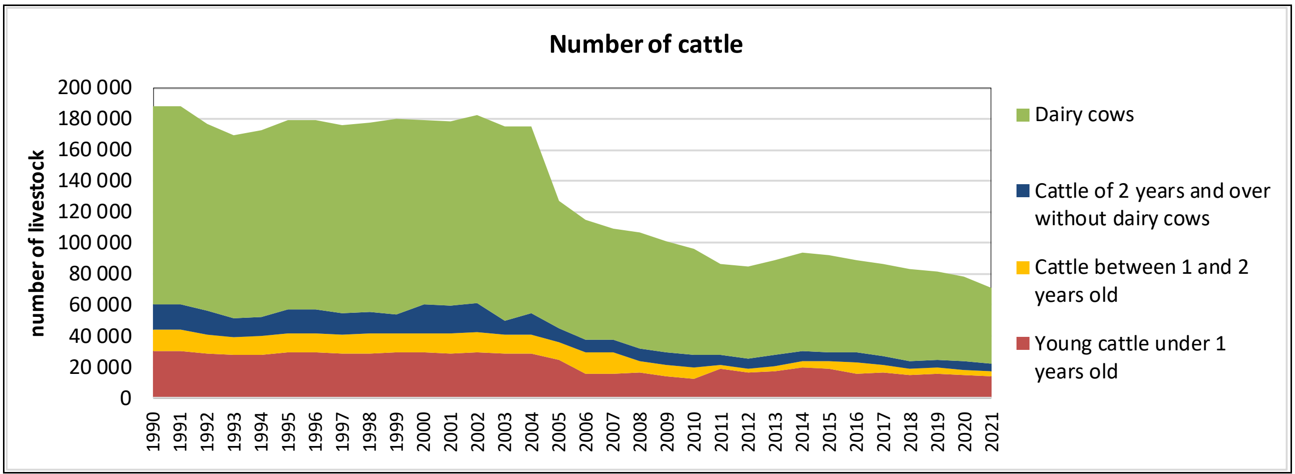


Figure 135 **Cattle - dairy and non-dairy (calves, bulls, bovines) population for the period of 1990–2021**

Sheep

In **1990**, the total number of **sheep** amounted to 486 634 and in **2021** the total number of sheep amounted to 165 918. In 2021, 55% of the sheep were **dairy breeding ewes**. The number of **sheep** decreased significantly by -65.9% in the period 1990 – 2021 and decreased by -35.3% in the period 2005 – 2021. The number of **breeding ewes** decreased significantly by -65.9% in the period 1990 – 2021 and decreased by -29.7% in the period 2005 – 2021.

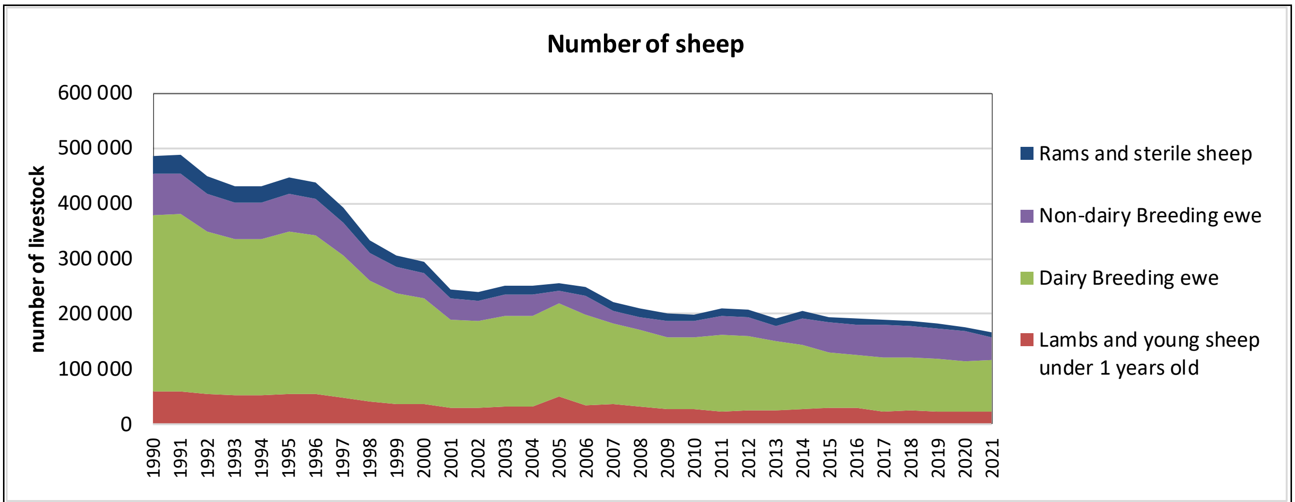


Figure 136 **Sheep and Goats - population for the period of 1990–2021**

Goats

In **1990**, the total number of **goats** amounted to 32 692 and in **2021** the total number of goats amounted to 7 722. In 2021, 70% of the goats were **goats already kidded**. The number of **goats** decreased significantly by -46.7% in the period 1990 – 2021 and increased by 13.3% in the period 2005 – 2021.

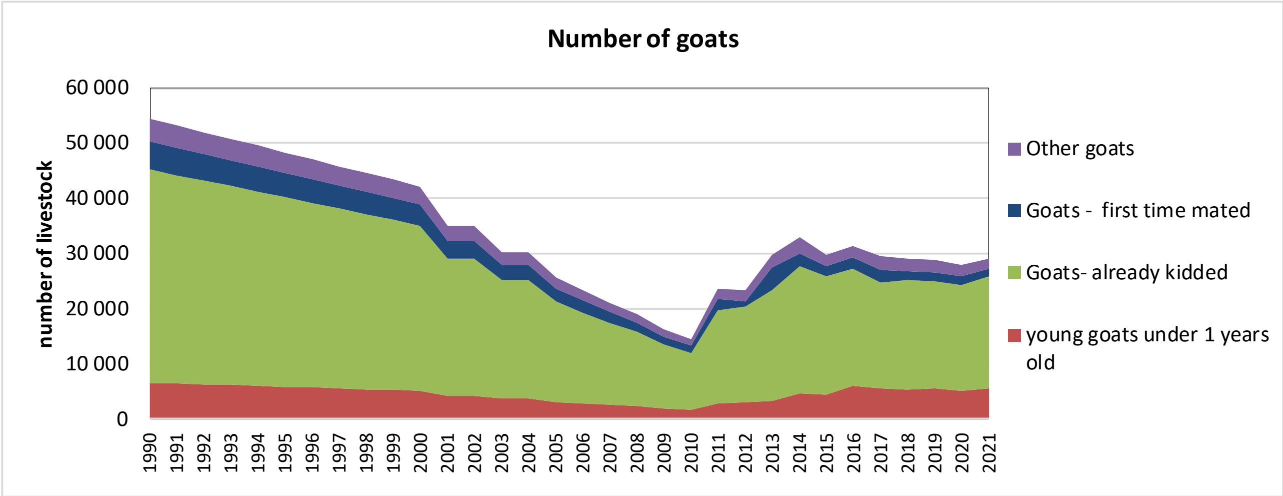


Figure 137 **Goats - population for the period of 1990–2021**

Swine

In **1990**, the total number of **swine** amounted to 24 228 and in **2021** the total number of **swine** amounted to 24 329. In 2021, about 42% of the swine were **fattening pigs**. The number of **fattening pigs** increased significantly by 56.0% in the period 1990 – 2021. The jumps can be explained on hand with the swine influenza and foot-and-mouth disease (FMD) in this period, and on the other hand with changes in statistical methodology.

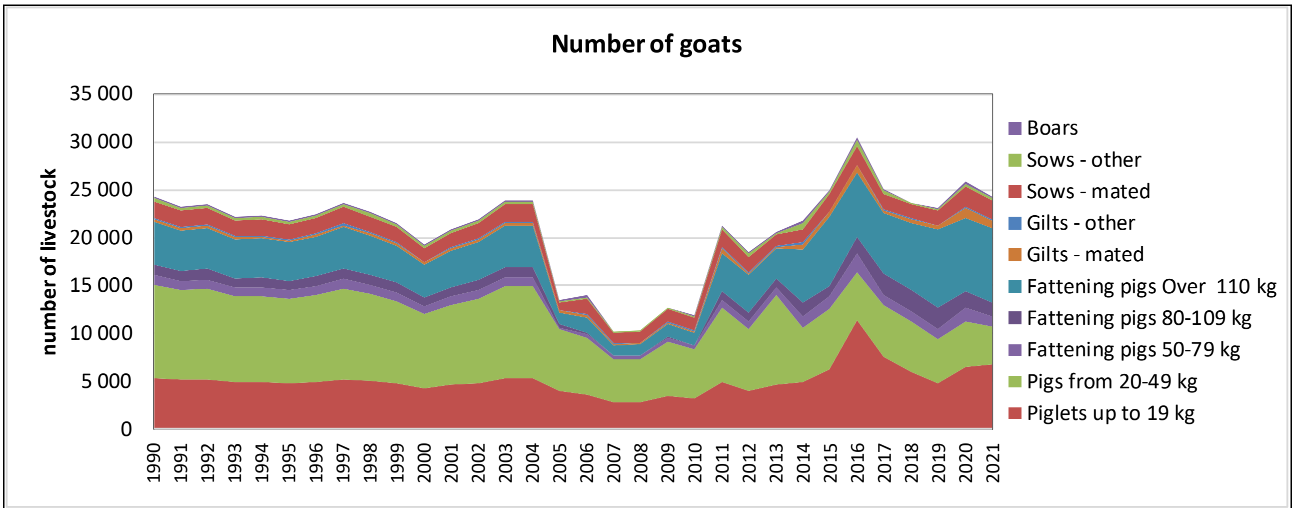


Figure 138 **Swine - population for the period of 1990–2021**

Poultry

In **1990**, the total number of **poultry** amounted to 917 084 and in **2021** the total number of poultry amounted to 596 752. In 2021, about 88% of the poultry were **hens**. The number of **hens** decreased significantly by -21.9% in the period 1990 – 2021. The jumps can be explained on hand with the avian influenza in this period, and on the other hand with changes in statistical methodology.

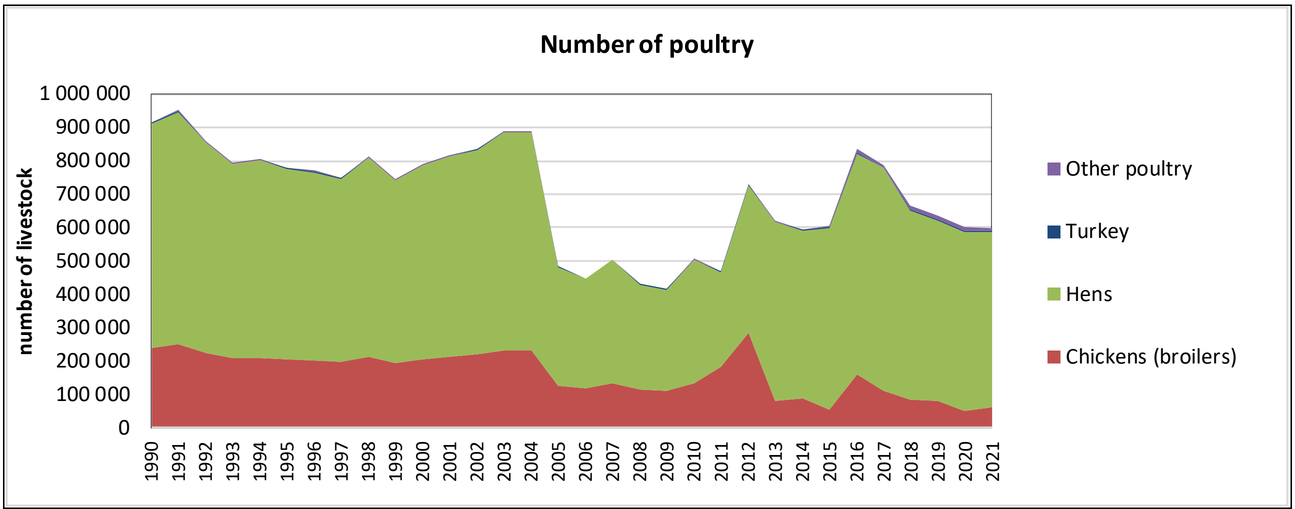


Figure 139 **Swine - population for the period of 1990–2021**

Horses, Mules, and Asses

The number of **horses** include including m**ules and asses.** In **1990**, the total number of **Horses, Mules and Asses** amounted to 19 914 and in **2021** the total number of Horses, Mules and Asses amounted to 3 618. The number of **Horses, Mules and Asses** decreased significantly by -81.8% in the period 1990 – 2021. The decrease can be explained by less use of horses, mules and asses as working animals.

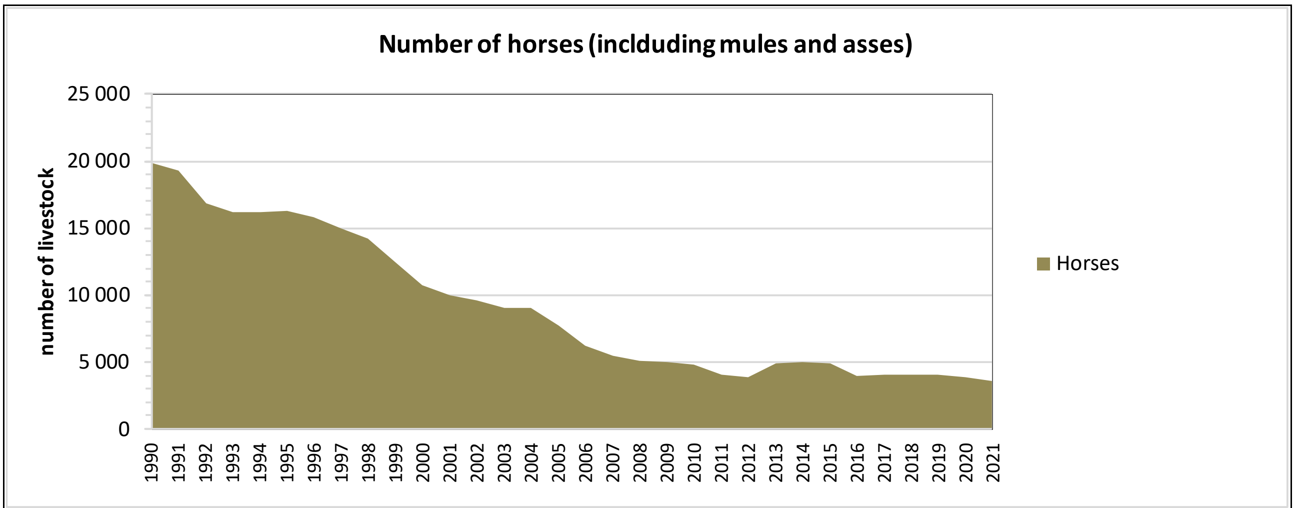


Figure 140 **Swine - population for the period of 1990–2021**

Table 303 Cattle: livestock population for the period of 1990–2021

	Cattle (total)		Dairy cows		Other cattle																	
							Young cattle under 1 years old				Cattle between 1 and 2 years old				Cattle of 2 years and over (without dairy cows)							
							Calves for slaughter	Other female	Other male		Male	Heifers	Heifers for slaughter		Heifers		Heifers for slaughter		Other cows		Male (Oxen and Bullocks)	
1990	**188 509**	calculated	128 004	Statistical Yearbook	60 505	Statistical Yearbook (YB)	15 526	15 168	4 302	Calculated based on share of 2014	1 374	6 503	383	Calculated based on share of 2014	5 786	Calculated based on share of 2004	7 456	Calculated based on share of 2014	2 140	ed on	6 108	Calculated based on share of 2004
1991	**187906**		127 790		60 116		15 476	15 120	4 288		1 370	6 482	381		5 767		7 234		2 136		6 088	
1992	**176 946**		120 745		56 201		14 573	14 238	4 038		1 290	6 104	359		5 431		6 397		2 018		5 733	
1993	**169 324**		117 734		51 590		13 946	13 625	3 864		1 234	5 841	344		5 197		3 894		1 968		5 486	
1994	**172 839**		120 687		52 152		14 235	13 907	3 945		1 260	5 962	351		5 305		3 458		2 017		5 600	
1995	**179 524**		122 519		57 005		14 786	14 445	4 097		1 309	6 193	364		5 510		6 475		2 048		5 816	
1996	**179 581**		122 411		57 170		14 790	14 450	4 098		1 309	6 195	364		5 512		6 626		2 046		5 818	
1997	**176 043**		121 443		54 600		14 499	14 165	4 018		1 283	6 073	357		5 403		5 028		2 030		5 704	
1998	**177 693**		122 328		55 365		14 635	14 298	4 055		1 295	6 130	361		5 454		5 332		2 045		5 757	
1999	**179 706**		126 072		53 634		14 801	14 460	4 101		1 310	6 199	365		5 516		2 996		2 107		5 822	
2000	**179 071**		119 070		60 001		14 748	14 409	4 087		1 305	6 177	363		5 496		9 651		1 990		5 802	
2001	**178 064**		118 447		59 617		14 666	14 328	4 064		1 298	6 142	361		5 465		9 549		1 980		5 769	
2002	**182 680**		121 503		61 177		15 046	14 699	4 169		1 332	6 302	371		5 607		9 811		2 031		5 919	
2003	**174 954**		124 899		50 055		14 409	14 078	3 993		1 275	6 035	355		5 370		719		2 088		5 668	
2004	**174 954**	Statistical Yearbook	120 029	Statistical Yearbook	54 925	calculated	14 409	9 390	2 663		189	897	53		5 370	Statistical Yearbook	-534		1 406		4 103	Statistical Yearbook
2005	**127 045**		81 815		45 230		12 458	10 678	3 029		287	1 359	80		4 089		3 182		1 362		3 914	
2006	**114 922**		77 066		37 856		8 073	11 135	3 158		216	1 024	60		3 852		4 604		1 308		3 316	
2007	**109 378**		71 494		37 884		8 067	11 390	3 230		188	890	52		3 573		6 341		1 203		4 080	
2008	**106 494**		74 609		31 885		8 284	8 955	2 540		765	3 620	213		3 729		4 100		1 208		3 860	
2009	**100 835**		71 437		29 398		6 929	8 141	2 309		795	3 761	221		3 570		3 423		1 159		3 247	

	Cattle (total)		Dairy cows		Other cattle																	
							Young cattle under 1 years old				Cattle between 1 and 2 years old				Cattle of 2 years and over (without dairy cows)							
							Calves for slaughter	Other female	Other male		Male	Heifers	Heifers for slaughter		Heifers		Heifers for slaughter		Other cows		Male (Oxen and Bullocks)	
2010	**95 963**	MONSTAT - Statistical Yearbook	68 277	MONSTAT - Statistical Yearbook	27 686	calculated	6 123	7 624	2 162	MONSTAT - Statistical Yearbook	827	3 914	230	MONSTAT - Statistical Yearbook	3 412	MONSTAT - Statistical Yearbook	3 358	MONSTAT - Statistical Yearbook	1 106	MONSTAT - Statistical Yearbook	2 578	MONSTAT - Statistical Yearbook
2011	**86 576**		58 643		27 933		9 553	7 200	2 042		487	2 305	136		2 931		2 179		979		3 252	
2012	**84 674**		58 986		25 688		8 266	6 230	1 767		449	2 125	125		2 948		142		986		2 650	
2013	**89 058**		60 998		28 060		7 551	7 268	2 109		467	2 929	130		3 213		548		833		3 012	
2014	**93 550**		63 097		30 453		8 473	7 935	3 243		529	3 399	171		2 756		459		793		2 697	
2015	**92452**		62812		29 640		7171	8850	2877		607	4312	69		2350		281		450		2 673	
2016	**89 269**		59 583		29 686		7 244	5 861	2 598		2 114	4 585	350		3 313		237		457		2 927	
2017	**86 649**		60 042		26 607		5 369	8 837	2 301		1 640	2 764	215		2 500		230		567		2 184	
2018	**83 264**		59 469		23 795		5 425	7 316	2 064		1 414	2 490	105		2 230		86		390		2 275	
2019	**81 432**		57 244		24 188		5 944	7 274	2 057		1 330	2 555	104		2 214		87		402		2 221	
2020	**77 889**		54 173		23 716		5 565	7 052	2 018		1 097	2 430	100		1 939		90		1 326		2 099	
2021	**71 166**		49 168		21 998		5 346	6 882	1 638		519	2 609	228		1 933		89		929		1 825	
Trend																						
1990 – 2021	*-62.2%*		*-61.6%*		*-63.6%*		*-65.6%*	*-41.2%*	*-50.6%*		*-76.6%*	*-75.1%*	*-63.0%*		*-66.6%*		*-97.0%*		*-56.6%*		*-68.5%*	
2005 – 2021	*-44.0%*		*-39.9%*		*-51.4%*		*-57.1%*	*-26.7%*	*-38.5%*		*-72.6%*	*-70.9%*	*-56.8%*		*-52.7%*		*-54.8%*		*-32.1%*		*-50.3%*	
2020– 2021	*-8.6%*		*-9.2%*		*-7.2%*		*-3.9%*	*-2.4%*	*-18.8%*		*-52.7%*	*7.4%*	*128.0%*		*-0.3%*		*-1.1%*		*-29.9%*		*-13.1%*	

Table 304 Sheep and goats: livestock population for the period of 1990-2021

	Sheep										Goats						
	Sheep (total)		Lambs & young sheep under 1 years old		Breeding ewe		of which dairy		Rams and sterile sheep		Goats - total		young goats under 1 years old	Goats- already kidded	Goats - first time mated	Other goats	
1990	486 634	Statistical Yearbook	80 400	Calculated based on share of 2004	375 801	Calculated based on share of 2004	320 039	Calculated based on share of 2012	30 433	Calculated based on share of 2004	54 431	Statistical Yearbook	6 943	38 689	4 627	4 428	Calculated based on share of 2012
1991	487 500		80 543		376 470		320 609		30 487		53 201		6 786	37 815	4 522	4 328	
1992	448 543		74 107		346 386		294 988		28 051		51 971		6 629	36 941	4 418	4 228	
1993	430 498		71 125		332 451		283 121		26 922		50 741		6 472	36 066	4 313	4 128	
1994	430 847		71 183		332 720		283 350		26 944		49 511		6 315	35 192	4 209	4 027	
1995	447 909		74 002		345 896		294 571		28 011		48 281		6 158	34 318	4 104	3 927	
1996	438 881		72 510		338 924		288 634		27 446		47 051		6 001	33 443	3 999	3 827	
1997	392 058		64 774		302 765		257 841		24 518		45 821		5 844	32 569	3 895	3 727	
1998	332 795		54 983		257 000		218 866		20 812		44 591		5 687	31 695	3 790	3 627	
1999	305 707		50 508		236 081		201 051		19 118		43 361		5 531	30 821	3 686	3 527	
2000	293 197		48 441		226 420		192 824		18 336		42 131		5 374	29 946	3 581	3 427	
2001	243 524		40 234		188 061		160 156		15 229		35 001		4 464	24 878	2 975	2 847	
2002	240 531		39 740		185 749		158 187		15 042				4 165	24 878	2 776	2 656	
2003	252 007		41 636		194 612		165 735		15 760		30 311		3 866	21 545	2 577	2 466	
2004	256 602	Statistical Yearbook	50 117	Statistical Yearbook	191 493	Statistical Yearbook	165 735		14 992	Statistical Yearbook	27 966		3 567	21 545	2 377	2 275	
2005	254 898		41 349		197 970		168 757		15 579		25 621		3 268	18 211	2 178	2 084	
2006	249 281		34 431		197 882		163 942		16 968		23 276		2 969	16 544	1 979	1 893	
2007	222 244		35 935		169 926		146 161		16 383		21 077		2 688	14 981	1 792	1 715	
2008	209 354		32 438		160 912		137 684		16 004		18 932		2 415	13 457	1 609	1 540	
2009	199 764		26 451		159 905		131 377		13 408		16 175		2 063	11 497	1 375	1 316	
2010	198 165		28 076		158 503		130 325		11 586		14 427		1 840	10 255	1 226	1 174	

	Sheep										Goats						
	Sheep (total)		Lambs & young sheep under 1 years old		Breeding ewe		of which dairy		Rams and sterile sheep		Goats - total		young goats under 1 years old	Goats-already kidded	Goats - first time mated	Other goats	
2011	208 771	MONSTAT - Statistical Yearbook	23 786	MONSTAT - Statistical Yearbook	172 924	MONSTAT - Statistical Yearbook	137 300	MONSTAT - Statistical Yearbook	12 061	MONSTAT - Statistical Yearbook	23 660	MONSTAT - Statistical Yearbook	3 018	16 817	2 011	1 925	MONSTAT - Statistical Yearbook
2012	207 047		24 391		169 295		135 144		13 361		23 273		3 068	17 331	987	1 887	
2013	190 843		24 067		153 450		126 452		13 326		29 675		3 261	20 087	4 192	2 135	
2014	204 403		27 025		165 351		116 876		12 028		32 997		4 650	22 990	2 354	3 003	
2015	194 636		28 518		155 543		101 242		10 575		29 678		4 454	21 516	1 688	2 020	
2016	191 992		29 087		151 697		95 243		11 208		31 458		5 920	21 429	2 003	2 106	
2017	189 008		23 566		157 284		97 276		8 158		29 595		5 644	18 987	2 401	2 563	
2018	187 021		25 105		153 426		96 741		8 490		29 040		5 307	19 839	1 611	2 283	
2019	182 127		23 228		150 955		95 029		7 994		28754		5 531	19 426	1 512	2 285	
2020	176 580		23 440		145 595		91 647		7 545		27 823		5 025	19 336	1 536	1 926	
2021	165 918		23 564		134 632		91 970		7 722		29 032		5 506	20 263	1 585	1 678	
Trend																	
1990 – 2021	*-65.9%*		*-60.3%*		*-65.9%*		*-71.3%*		*-76.4%*		*-46.7%*		*-16.3%*	*-47.6%*	*-68.3%*	*-59.7%*	
2005 – 2021	*-35.3%*		*-53.0%*		*-29.7%*		*-45.5%*		*-48.5%*		*13.3%*		*77.8%*	*11.3%*	*-32.6%*	*-14.4%*	
2020 – 2021	*-6.0%*		*0.5%*		*-7.5%*		*0.4%*		*2.3%*		*4.3%*		*9.6%*	*4.8%*	*3.2%*	*-12.9%*	

Table 305 Pigs: livestock population for the period of 1990–2021

	Pigs (total)		Piglets up to 19 kg	Pigs from 20-49 kg		Fattening pigs					Sows and sows of the first farrow							Boars	
							From 50-79 kg	From 80-109 kg	Over 110 kg				Gilts mated	Gilts other	Sows mated	Sows other			
1990	22 831	Statistical Yearbook	4 462	9 711	Calculated based on share of 2010	6 068	2 686	1 687	1 695	Calculated based on share of 2010	2 464	Calculated (sum)	224	104	1783	410	Calculated based on share of 2010	237	Calculated based on share of 2004
1991	21 941		4 288	9 332		5 831	2 581	1 621	1 629		2 366		215	100	1712	394		227	
1992	21 779		4 256	9 263		5 788	2 562	1 609	1 617		2 396		218	99	1734	391		226	
1993	20 624		4 031	8 772		5 481	2 426	1 524	1 532		2 258		206	94	1634	371		214	
1994	20 510		4 008	8 723		5 451	2 413	1 515	1 523		2 265		206	94	1639	369		212	
1995	20 219		3 952	8 600		5 374	2 378	1 494	1 501		2 220		202	92	1606	363		209	
1996	20 855		4 076	8 870		5 543	2 453	1 541	1 549		2 286		208	95	1654	375		216	
1997	22 107		4 321	9 403		5 875	2 600	1 633	1 642		2 404		219	101	1739	397		229	
1998	21 078		4 119	8 965		5 602	2 479	1 557	1 565		2 303		210	96	1666	379		218	
1999	19 852		3 880	8 444		5 276	2 335	1 467	1 474		2 188		199	91	1583	357		206	
2000	17 896		3 498	7 612		4 756	2 105	1 322	1 329		1 959		178	82	1418	322		185	
2001	19 663		3 843	8 363		5 226	2 313	1 453	1 460		2 123		193	90	1536	353		204	
2002	20 548		4 016	8 740		5 461	2 417	1 518	1 526		2 229		203	94	1613	369		213	
2003	22 094		4 318	9 397		5 872	2 599	1 632	1 641		2 428		221	101	1757	397		229	
2004	12 101	MONSTAT - Statistical Yearbook	2 365	5 147		3 216	1 423	894	899		2 428	Calculated (sum)	221	55	1757	217		107	MONSTAT - Statistical Yearbook
2005	10 697		2 091	4 123		2 843	1 258	790	794		1 266		253	68	823	267		85	
2006	13 294		2 598	4 578		3 533	1 564	982	987		2 395		479	104	1557	411		190	
2007	10 374		2 027	3 929		2 757	1 220	766	770		1 593		319	69	1035	274		67	
2008	10 017		1 958	3 664		2 662	1 178	740	744		1 676		335	73	1089	288		57	
2009	12 377		2 419	4 658		3 289	1 456	914	919		1 977		395	86	1285	340		34	

	Pigs (total)		Piglets up to 19 kg	Pigs from 20-49 kg		Fattening pigs					Sows and sows of the first farrow							Boars	
							From 50-79 kg	From 80-109 kg	Over 110 kg				Gilts mated	Gilts other	Sows mated	Sows other			
2010	11 205	MONSTAT - Statistical Yearbook	2 190	4 026	MONSTAT - Statistical Yearbook	2 978	1 318	828	832	MONSTAT - Statistical Yearbook	1 952		390	85	1269	335		59	
2011	21 398		4 182	8 494		5 687	2 517	1 581	1 589		2 799		560	128	1819	506	MONSTAT - Statistical Yearbook	90	
2012	18 451		4 017	6 437		5 599	793	926	3 880		2 317		227	101	1591	398		81	
2013	20 572		4 598	9 355		4 872	819	886	3 167		1 601		128	145	1254	74		146	
2014	22 053		4 869	5 675		8 267	1 240	1 381	5 647		2 663		469	316	1241	637		248	
2015	24 951		6 276	6 303		9 550	1 256	1 099	7 195		2 700		536	63	1799	302		123	
2016	55 841		11 356	5 068		35 642	1 924	9 841	23 877		3 448		796	110	1966	576		327	
2017	25 043		7 480	5 470		9 560	1 066	2 268	6 226		2 450		349	153	1522	426		83	
2018	23 651		5 892	5 323		10 336	1 086	2 217	7 033		2 013		398	32	1486	97		87	
2019	23 089		4,747	4583		11512	1106	2214	8192		2 155		425	34	1594	102		92	
2020	25 806		6 423	4 846		10 715	1 408	1 711	7 596		3 617		1 102	93	2 190	232		205	
2021	24 329		6 709	4 052		10 213	975	1 535	7 703		3 229		744	178	1 988	319		126	
Trend																			
1990 - 2021	*0.4%*		*25.5%*	*-58.4%*		*56.0%*	*-2.8%*	*35.9%*	*74.6%*		*31.0%*		*231.5%*	*17.3%*	*11.5%*	*4.6%*		*-9.5%*	
2005 - 2021	*101.0%*		*68.1%*	*-36.6%*		*2886.3%*	*1912.9%*	*2613.8%*	*3150.2%*		*155.1%*		*193.8%*	*181.2%*	*141.6%*	*152.0%*		*17.8%*	
2020 - 2021	*-5.7%*		*4.5%*	*-16.4%*		*-4.7%*	*-30.8%*	*-10.3%*	*1.4%*		*-10.7%*		*-32.5%*	*91.4%*	*-9.2%*	*37.5%*		*-38.5%*	

Table 306 Sheep: livestock population for the period of 1990–2021

	Poultry										
	Poultry - total		Chickens (broilers)	Hens	Turkey	Geese & Ducks	Other poultry		Horses - total	Asses	
1990	917 084	Calculated based on share of 2004	239 194	672 177	2 641	Included in Turkey	3 072	Calculated based on share of 2004	19 914	Included in horses	Calculated based on share of 2004
1991	953 273		248633	698702	2745		3193		19 318		
1992	859 543		224 186	630 002	2 475		2 879		16 864		
1993	794 435		207 205	582 282	2 288		2 661		16 160		
1994	806 196		210 272	590 902	2 321		2 700		16 209		
1995	781 265		203 770	572 629	2 250		2 617		16 327		
1996	770 826		201 047	564 977	2 220		2 582		15 812		
1997	750 074		195 635	549 767	2 160		2 513		14 997		
1998	813 358		212 140	596 151	2 342		2 724		14 182		
1999	745 017		194 316	546 061	2 145		2 496		12 474		
2000	790 577		206 199	579 454	2 276		2 648		10 703		
2001	817 445		213 206	599 147	2 354		2 738		9 967		
2002	837 542		218 448	613 877	2 412		2 805		9 568		
2003	890 045		232 142	652 359	2 563		2 981		9 028		
2004	485 042	MONSTAT - Statistical Yearbook	232 142	652 359	2 563		2 981	MONSTAT - Statistical Yearbook	7 688		MONSTAT - Statistical Yearbook
2005	462 149		126 509	355 512	1 397		1 625		7 119		
2006	448 502		116 978	328 730	1 291		1 502		6 260		
2007	505 355		131 807	370 400	1 455		1 693		5 463		
2008	432 264		112 743	316 828	1 245		1 448		5 124		
2009	416 737		108 694	305 448	1 200		1 396		4 951		
2010	506 520		132 111	371 254	1 458		1 697		4 828		

	Poultry												
	Poultry - total		Chickens (broilers)	Hens	Turkey	Geese & Ducks	Other poultry		Horses - total	Asses	
2011	470 047	MONSTAT - Statistical Yearbook	183 211	284 116	1 197	Included in Turkey	1 523	MONSTAT - Statistical Yearbook	4 035	Included in horses	MONSTAT - Statistical Yearbook
2012	732 091		285 349	442 506	1 864		2 372		3 905		
2013	620 354		81 805	534 410	1 993		2 146		4 858		
2014	595 675		89 142	501 913	2 652		1 968		4 968		
2015	606 225		54874	541928	4900		4523		4 927		
2016	835 705		159 615	659 613	5 466		11 011		3 947		
2017	788 309		111 573	666 550	2 611		7 575		4 071		
2018	666 339		82 198	568 511	3 364		12 266		4 005		
2019	635 882		79 977	540 906	3 644		11 355		4 008		
2020	601 628		50 265	536 765	3 026		11 572		3 889		
2021	596 752		61 855	525 087	2 368		7 442		3 618		
Trend											
1990 - 2021	*-34.9%*		*-74.1%*	*-21.9%*	*-10.3%*		*142.3%*		*-80.5%*		
2005 - 2021	*23.0%*		*-51.1%*	*47.7%*	*69.6%*		*358.0%*		*-49.4%*		
2020 - 2021	*-0.8%*		*23.1%*	*-2.2%*	*-21.7%*		*-35.7%*		*-3.0%*		

5.2 Enteric fermentation (IPCC category 3.A)

This section describes the estimation of methane emissions resulting from enteric fermentation from livestock. As described in the 2006 IPCC Guidelines (Volume 4, Chapter 10) methane is produced in herbivores (plant eaters) as a by-product of enteric fermentation, a digestive process by which carbohydrates are broken down by micro-organisms into simple molecules for absorption into the bloodstream. The amount of methane that is released depends on the type of digestive tract, age, and weight of the animal, and the quality and quantity of the feed consumed. Ruminant livestock are major sources of methane with moderate amounts produced from non-ruminant livestock:

- main ruminant livestock are cattle, buffalo, goats, sheep, deer and camels,
- non-ruminant livestock are horses, mules and asses;
- monogastric livestock are swine.

Methane is produced by the fermentation of feed within the animal's digestive system. Generally, the higher the feed intake, the higher the methane emission. Although, the extent of methane production may also be affected by the composition of the diet. Feed intake is positively related to animal size, growth rate, and production (e.g., milk production, wool growth, or pregnancy).

To reflect the variation in emission rates among animal species, the population of animals are divided into subgroups, and an emission rate per animal is estimated for each subgroup.

Natural wild ruminants are not considered in the derivation of a country’s emission estimate. Emissions should only be considered from animals under domestic management (e.g., farmed deer, elk, and buffalo).

5.2.1 Source category description

IPCC code	description	CO_2		CH_4		N_2O	
		Estimated	Key Category	estimated	Key category	estimated	Key category
3.A.1	**Enteric Fermentation**						
3.A.1.a	Cattle	NA	NA	**Option B**	LA 1990, LA 2021	NA	NA
3.A.1.a.i	Mature dairy cattle	NA	NA	✓ TIER 2		NA	NA
3.A.1.a.ii	Other mature cattle	NA	NA	✓ TIER 2		NA	NA
3.A.1.a.iil	Growing cattle	NA	NA	✓ TIER 2		NA	NA
3.A.1.a.iv	Other	NA	NA	NO		NA	NA
3.A.2.a	Sheep	NA	NA		-	NA	NA
3.A.2.a.i	Mature Sheep	NA	NA	✓TIER 1		NA	NA
3.A.2.a.ii	Growing Sheep (lambs)	NA	NA	✓TIER 1		NA	NA
3.A.3	Swine	NA	NA	✓ TIER 1	-	NA	NA
3.A.4	Other Livestock						
3.A.4.a	Buffalo	NA	NA	NO	NA	NA	NA
3.A.4.b	Camels	NA	NA	NO	NA	NA	NA
3.A.4.c	Deer	NA	NA	NO	NA	NA	NA
3.A.4.d	Goats	NA	NA	✓ TIER 1	-	NA	NA
3.A.4.e	Horses	NA	NA	✓ TIER 1	-	NA	NA
3.A.4.f	Mules and Asses	NA	NA	✓ TIER 1	IE	NA	NA
3.A.4.g	Poultry	NA	NA	NA	NA	NA	NA

IPCC code	description	CO_2		CH_4		N_2O	
		Estimated	Key Category	estimated	Key category	estimated	Key category
3.A.4.h	Other						
3.A.4.h.i	Rabbit	NA	NA	NA	NA	NA	NA
3.A.4.h.ii	Reindeer	NA	NA	NO	NA	NA	NA
3.A.4.h.iii	Ostrich	NA	NA	NO	NA	NA	NA
3.A.4.h.iv	Fur-bearing animals	NA	NA	NO	NA	NA	NA
3.A.4.h.v	Other	NA	NA	NO	NA	NA	NA
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

In 2021, the IPCC category 3.A Enteric fermentation was responsible for 3.6% of the total GHG emissions in CO_2eq (excluding LULUCF). In the period 1990 – 2021 the CH_4 emissions decreased by -69.0% and in the period 2005 – 2021 the CH_4 emissions decreased by -50.0% mainly due to decreased number of livestock. In 2021, CH4 emissions from IPCC category 3.A Enteric fermentation amounted to 114.54 kt CO2 equivalent.

Cattle are the most significant source of methane because of their high numbers, large size and ruminant digestive system, followed by sheep and goats. The significant drop is mainly due to statistical revisions.

An overview of the methane emissions resulting IPCC category 3.A *Enteric Fermentation* is provided in the following figure and tables.

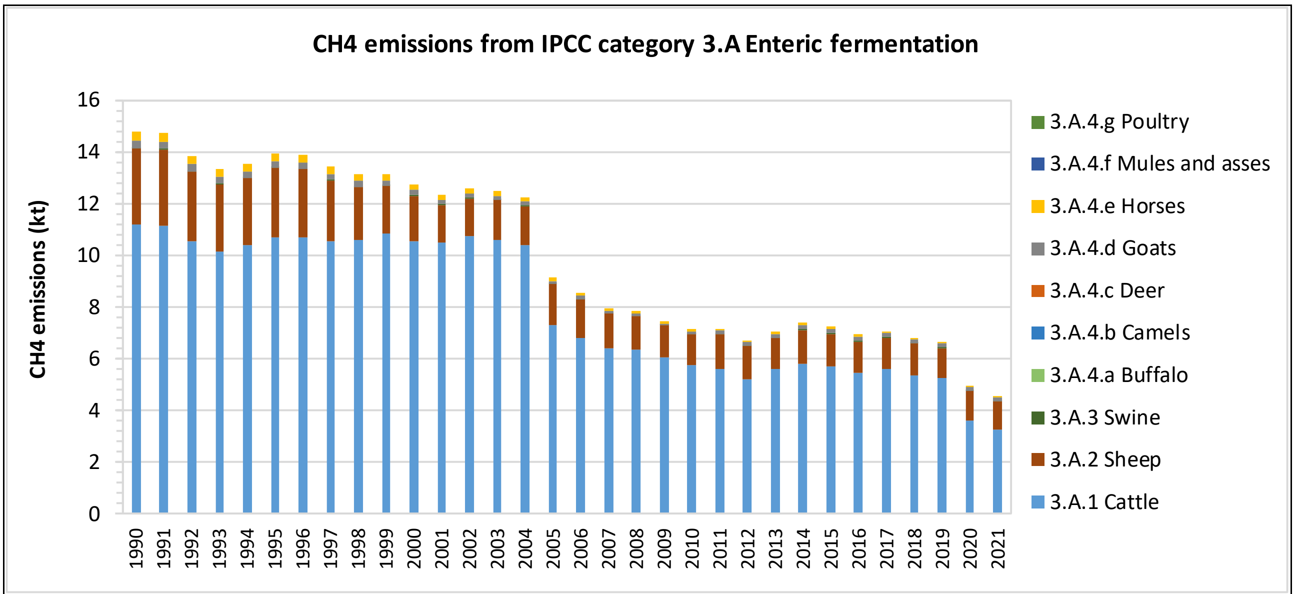


Figure 141 **CH4 emissions from 3.A Enteric fermentation for the period of 1990–2021**

Table 307 CH4 Emissions from IPCC category 3.A Enteric Fermentation for the period 1990-2021 (I)

CH_4 emissions	3.A.1	3.A.1.a	*3.A.1.a.i*	*3.A.1.a.ii*	*3.A.1.a.iii*	3.A.2	3.A.4.a	3.A.4.b
	Enteric Fermentation	Cattle	Mature dairy cattle	Other mature cattle	3.A.1.a.iii. Growing cattle	Sheep	Buffalo	Camels
	kt	kt	kt	kt	kt	kt	kt	kt
1990	**18.79**	11.21	9.75	0.83	0.63	2.94	NO	NO
1991	**18.74**	11.18	9.73	0.82	0.63	2.95	NO	NO
1992	**17.58**	10.54	9.19	0.75	0.60	2.71	NO	NO
1993	**16.94**	10.17	8.96	0.64	0.57	2.60	NO	NO
1994	**17.23**	10.40	9.19	0.63	0.58	2.60	NO	NO
1995	**17.73**	10.69	9.33	0.76	0.60	2.71	NO	NO
1996	**17.65**	10.69	9.32	0.77	0.60	2.65	NO	NO
1997	**17.08**	10.54	9.25	0.70	0.59	2.37	NO	NO
1998	**16.72**	10.62	9.31	0.71	0.60	2.01	NO	NO
1999	**16.74**	10.83	9.60	0.63	0.60	1.85	NO	NO
2000	**16.22**	10.55	9.06	0.88	0.60	1.77	NO	NO
2001	**15.73**	10.49	9.02	0.88	0.60	1.47	NO	NO
2002	**16.06**	10.76	9.25	0.90	0.61	1.45	NO	NO
2003	**15.95**	10.63	9.51	0.53	0.59	1.52	NO	NO
2004	**15.67**	10.41	9.10	0.72	0.59	1.51	NO	NO
2005	**11.67**	7.32	6.25	0.56	0.51	1.57	NO	NO
2006	**10.88**	6.80	5.87	0.60	0.33	1.51	NO	NO
2007	**10.13**	6.40	5.46	0.61	0.33	1.35	NO	NO
2008	**9.98**	6.37	5.61	0.42	0.34	1.27	NO	NO
2009	**9.53**	6.07	5.37	0.42	0.28	1.21	NO	NO
2010	**9.11**	5.77	5.09	0.42	0.25	1.20	NO	NO
2011	**9.01**	5.63	5.01	0.23	0.39	1.32	NO	NO
2012	**8.53**	5.21	4.63	0.24	0.34	1.30	NO	NO
2013	**8.92**	5.58	4.94	0.29	0.35	1.21	NO	NO
2014	**9.35**	5.83	5.14	0.28	0.41	1.29	NO	NO
2015	**9.18**	5.73	5.06	0.27	0.39	1.25	NO	NO
2016	**8.83**	5.44	4.75	0.37	0.33	1.24	NO	NO
2017	**8.91**	5.59	4.98	0.27	0.34	1.22	NO	NO
2018	**8.63**	5.37	4.84	0.23	0.31	1.21	NO	NO
2019	**8.41**	5.24	4.70	0.23	0.32	1.18	NO	NO
2020	**6.66**	3.59	3.05	0.24	0.30	1.14	NO	NO
2021	**6.13**	3.27	2.76	0.22	0.29	1.08	NO	NO
Trend								
1990 - 2021	*-67.4%*	*-70.8%*	*-71.6%*	*-73.7%*	*-54.6%*	*-63.4%*	*NA*	*NA*
2005 - 2021	*-47.4%*	*-55.3%*	*-55.8%*	*-61.5%*	*-43.4%*	*-31.2%*	*NA*	*NA*
2020 - 2021	*-7.9%*	*9.8%*	*10.2%*	*11.1%*	*5.5%*	*-5.8%*	*NA*	*NA*

Table 308 CH4 Emissions from IPCC category 3.A Enteric Fermentation for the period 1990-2021 (II)

CH_4 emissions	3.A.1	3.A.3	3.A.4.c	3.A.4.d	3.A.4.e	3.A.4.f	3.A.4.g	3.A.1.h
	Enteric Fermentation	Swine	Deer	Goats	Horses	Mules and Asses	Poultry	Other
	kt	kt	kt	kt	kt	kt	kt	kt
1990	**18.79**	0.024	NO	0.272	0.358	IE	NA	NO
1991	**18.74**	0.023	NO	0.266	0.348	IE	NA	NO
1992	**17.58**	0.024	NO	0.260	0.304	IE	NA	NO
1993	**16.94**	0.022	NO	0.254	0.291	IE	NA	NO
1994	**17.23**	0.022	NO	0.248	0.292	IE	NA	NO
1995	**17.73**	0.022	NO	0.241	0.294	IE	NA	NO
1996	**17.65**	0.022	NO	0.235	0.285	IE	NA	NO
1997	**17.08**	0.024	NO	0.229	0.270	IE	NA	NO
1998	**16.72**	0.023	NO	0.223	0.255	IE	NA	NO
1999	**16.74**	0.022	NO	0.217	0.225	IE	NA	NO
2000	**16.22**	0.019	NO	0.211	0.193	IE	NA	NO
2001	**15.73**	0.021	NO	0.175	0.179	IE	NA	NO
2002	**16.06**	0.022	NO	0.175	0.172	IE	NA	NO
2003	**15.95**	0.024	NO	0.152	0.163	IE	NA	NO
2004	**15.67**	0.024	NO	0.152	0.163	IE	NA	NO
2005	**11.67**	0.012	NO	0.128	0.138	IE	NA	NO
2006	**10.88**	0.013	NO	0.116	0.113	IE	NA	NO
2007	**10.13**	0.010	NO	0.105	0.098	IE	NA	NO
2008	**9.98**	0.010	NO	0.095	0.092	IE	NA	NO
2009	**9.53**	0.012	NO	0.081	0.089	IE	NA	NO
2010	**9.11**	0.011	NO	0.072	0.087	IE	NA	NO
2011	**9.01**	0.021	NO	0.118	0.073	IE	NA	NO
2012	**8.53**	0.018	NO	0.116	0.070	IE	NA	NO
2013	**8.92**	0.021	NO	0.148	0.087	IE	NA	NO
2014	**9.35**	0.022	NO	0.165	0.089	IE	NA	NO
2015	**9.18**	0.025	NO	0.148	0.089	IE	NA	NO
2016	**8.83**	0.031	NO	0.157	0.071	IE	NA	NO
2017	**8.91**	0.025	NO	0.148	0.073	IE	NA	NO
2018	**8.63**	0.024	NO	0.145	0.072	IE	NA	NO
2019	**8.41**	0.023	NO	0.144	0.072	IE	NA	NO
2020	**6.66**	0.026	NO	0.139	0.070	IE	NA	NO
2021	**6.13**	0.024	NO	0.145	0.065	IE	NA	NO
Trend								
1990 - 2021	*-67.4%*	*0.4%*	*NA*	*-46.7%*	*-81.8%*	*NA*	*NA*	*NA*
2005 - 2021	*-47.4%*	*101.0%*	*NA*	*13.3%*	*-52.9%*	*NA*	*NA*	*NA*
2020 - 2021	*-7.9%*	*6.1%*	*NA*	*-4.2%*	*7.5%*	*NA*	*NA*	*NA*

5.2.2 Methodological issues

5.2.2.1 Choice of methods

For estimating the CH_4 emissions from livestock the 2006 IPCC Guidelines approach[97] has been applied:

Tier 1 **swine, goats, horses, mules and asses**

Tier 2 **cattle, sheep**

It is *good practice* to choose the method for estimating CH_4 emissions from enteric fermentation according to the decision tree.

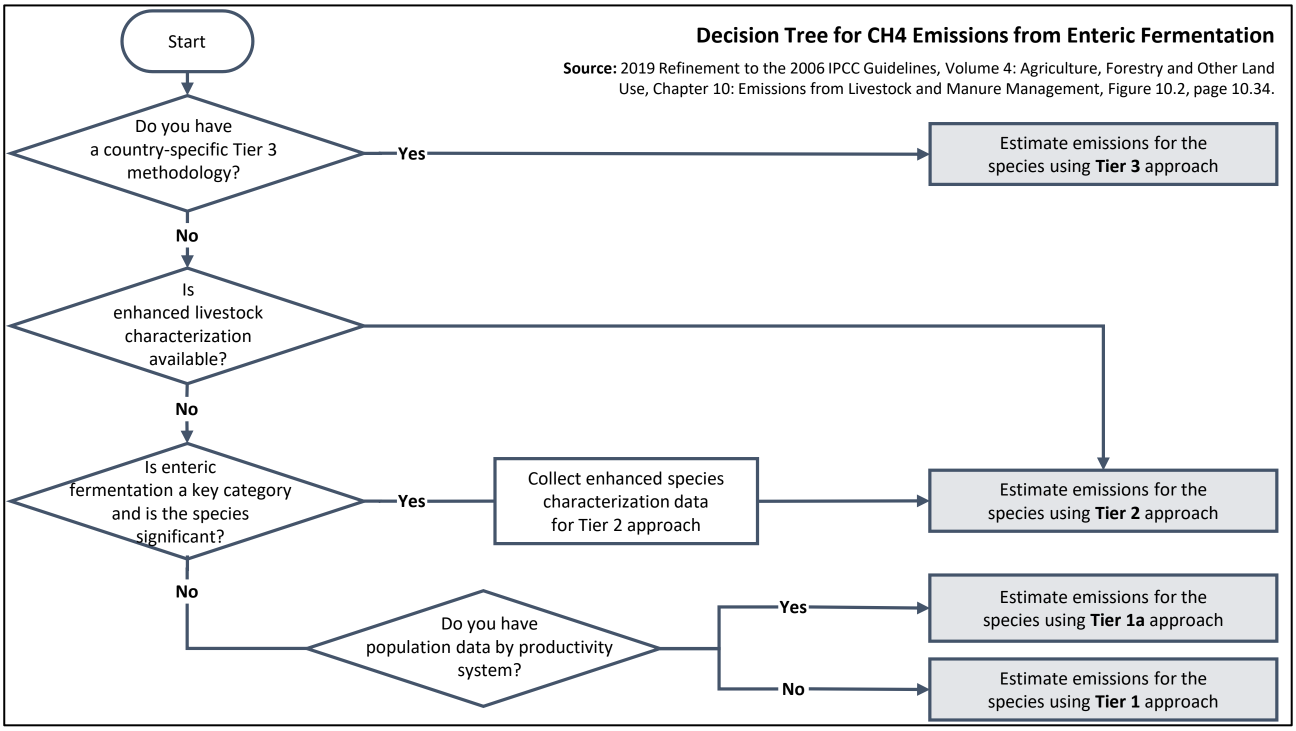


Figure 142 **Decision Tree for CH_4 Emissions from Enteric Fermentation**

Tier 1 approach was applied for the livestock categories goats, camels, horses, mules and asses. Tier 1 is a simplified approach that relies on default emission factors drawn from the literature.

Equation 10.19: CH_4 emissions from enteric fermentation from a livestock category
(2019 Refinement to 2006 IPCC GL, Vol. 4, Chap. 10)[108]

$$Emissions_{CH4} = \sum_T Livestock_{\ category} \times \left(\frac{Emission\ Factor_T}{10^6}\right)$$

Where:

Emissions $_{CH4}$	= CH_4 emissions (Gg CH_4)
Livestock $_{category}$	= number of head of livestock species / category T
Emission factor $_T$	= emission factor for the defined livestock population and, in kg CH_4 head^{-1} yr^{-1}.
T	= species/category of livestock

[97] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chap. 10 Emissions from Livestock and Manure Management; sub-chapter 10.2.2 Choice of method

Tier 2 approach was applied for the livestock categories cattle. This more complex approach that required detailed country-specific data on gross energy intake and methane conversion factors for specific livestock categories. It is *good practice* to apply Tier 2 method if enteric fermentation is a key source category for the animal category that represents a large portion of the country's total emissions.

Equation 10.19(updated): CH_4 emissions from enteric fermentation from a livestock category (2019 Refinement to 2006 IPCC GL, Vol. 4, Chap. 10) [108]

$$\boldsymbol{Emissions_{CH4}} = \sum_{(T,P)} \boldsymbol{Livestock}_{\ category} \times \left(\frac{\boldsymbol{CS\ Emission\ Factor_T}}{\boldsymbol{10^6}}\right)$$

Where:

Emissions $_{CH4}$ = CH_4 emissions (Gg CH_4)

Livestock $_{category}$ = number of head of livestock species / category T

CS Emission factor $_T$ = country specific emission factor (CS) for the defined livestock population and the productivity system P, in kg CH_4 head^{-1} yr^{-1}.

T = species/category of livestock

P = productivity system, either high or low productivity

5.2.2.2 Choice of activity data

As described in Chapters 5.1.2 and 5.1.3 above, the original data provider for the national and international agricultural data is the Ministry of Agriculture and Rural Development and Statistical Office of Montenegro (MONSTAT)[98]. The data are presented in the figures and tables in Chapter 5.1.3.

5.2.2.3 Choice of emission factors

For estimating the CH_4 emissions from cattle and all other livestock categories (goats, horses, mules and asses), the 2006 IPCC Guidelines Tier 1 approach[99] has been applied.

Table 309 Tier 1 Emission Factor for livestock for 3.A Enteric Fermentation

Livestock	Enteric fermentation emission factors for tier 1 method			
	EF	**Type**	**liveweight**	
	(kg CH_4 head-1 yr-1)		**kg**	
Swine	1		**31**	
Goats	5	**D**	40 kg	2006 IPCC GL
Horses	18	**D**	550 kg	2006 IPCC GL
Poultry	NA[1]			2006 IPCC GL
Note:	D	Default	CS	Country specific
[1] Insufficient data for calculation available.				
Source: • 2006 IPCC GL, Vol. 4, Chap. 10 (10.3.2), Table 10.10 (updated): Enteric fermentation emission factors for tier 1 method, (page 10.28)				

[98] Available (3. Januar 2021) on https://www.monstat.org/eng/index.php

[99] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10 Emissions from Livestock and Manure Management - sub-chapter 10.3.2 Choice of EF

For estimating the CH_4 emissions from the livestock categories cattle, the TIER 2 approach of the 2019 Refinement to 2006 IPCC Guidelines has been applied. The country specific emission factors for methane (CH_4) is estimated using the following equation.

Equation 10.21 (updated): CH_4 emission factors for enteric fermentation from a livestock category (2019 Refinement to 2006 IPCC GL, Vol. 4, Chap. 10) [108]

$$\boldsymbol{Emission\ factor_T} = \frac{\boldsymbol{GE} \times \frac{\boldsymbol{Y_m}}{\boldsymbol{100}} \times \boldsymbol{365}}{\boldsymbol{55.65}}$$

Where:

EF = emission factor, kg CH_4 head-1 yr-1

GE = gross energy intake, MJ head-1 day-1

Ym = methane conversion factor, per cent of gross energy in feed converted to methane

energy content of methane = 55.65 (MJ/kg CH_4)

The GE is estimated based on the following equation:

Equation 10.16 (updated): gross energy for cattle/buffalo (2019 Refinement to 2006 IPCC GL, Vol. 4, Chap. 10) [108]

$$\boldsymbol{GE} = \frac{\left(\frac{\boldsymbol{NE_m} + \boldsymbol{NE_a} + \boldsymbol{NE_l} + \boldsymbol{NE_{work}} + \boldsymbol{NE_p}}{\boldsymbol{REM}}\right) + \left(\frac{\boldsymbol{NE_g}}{\boldsymbol{REM}}\right)}{\boldsymbol{DE}}$$

Where:

Parameter	Description	Equations
GE	= gross energy, MJ day-1	
NE_m	= net energy required by the animal for maintenance (MJ day-1)	
NE_a	= net energy for animal activity (MJ day-1)	10.4 and 10.5
NE_l	= net energy for lactation (MJ day-1)	10.8, 10.9, 10.10
NE_{work}	= net energy for work (MJ day-1)	10.11
NE_p	= net energy required for pregnancy (MJ day-1)	10.13
REM	= ratio of net energy available in a diet for maintenance to digestible energy	10.14
NE_g	= net energy needed for growth (MJ day-1)	10.6, 10.7
REG	= ratio of net energy available for growth in a diet to digestible energy consumed	10.15
DE	= digestibility of feed expressed as a fraction of gross energy (digestible energy/gross energy)	

In the following tables the calculation of CH4 emissions from IPCC category 3.A.1 Cattle and IPCC category 3.A.2 Sheep are provided exemplary including relevant parameters.

Table 310 Exemplary calculation of CH4 remissions from 3.A.1 Cattle

			3A1a	3A1b1	3A1b2	3A1b3	3A1b4
			Dairy Cattle	Bulls	Calves	Replacement/growing (1- 2 years old)	Cattle of 2 years and over (excluding cows & Oxen/bulls)
L	**Livestock (# of animals)**	Monstat, Table 10.10 & 10.11	49 168	**1 825**	**13 866**	**3 356**	**2 951**
W (=MW)	**Live Weight**	2019 Refinements IPCC 'TABLE 10A.5 Default values for live weights for animal categories	520.9	600	180	350	500
BW	Live Body Weight	Eq. 7 - IPCC Ref Man_1996	37.25	41.65	16.09	27.21	36.06
WG	Average Daily Weight Gain		NA	NA	NA	NA	NA
AMiY	Annual Milk Yield	Monstat, Table 2, Statistical yearbook	0	NA	NA	NA	NA
DMiY	**Daily Milk Yield**		**0.00**	NA	NA	NA	NA
Fat	Fat Content of Milk	Expert Judgement	3.9%	NA	NA	NA	NA
DE	**Digestible Energy**	TABLE 10.2, Chap. 10, Vol. 4, 2006 IPCC Guidelines	**75%**	**75%**	**75%**	**75%**	**75%**
NEm	Net Energy for Maintenance	Equation 10.3 & Table 10.4, Chap. 10, Vol. 4, 2006 IPCC Guidelines	42.09	1.33	18.18	26.06	34.05
NEa	Net Energy for Activity	Equation 10.4 & Table 10.5, Chap. 10, Vol. 4, 2006 IPCC Guidelines	7.15	0.11	1.55	2.21	2.89
NEg	Net Energy for Growth	Equation 10.6, Chap. 10, Vol. 4, 2006 IPCC Guidelines	0.00	0.00	0.00	0.00	0.00
NEmobilised	Net Energy due to Weight Loss		NO	NO	NO	NO	NO
NEl	Net Energy for Lactation	Equation 10.8, Chap. 10, Vol. 4, 2006 IPCC Guidelines	0.00	NA	NA	NA	NA
NEw	Net Energy for Draft Power (Work)	Equation 10.11, Chap. 10, Vol. 4, 2006 IPCC Guidelines	NO	0.00	0.00	0.00	0.00
NEp	Net Energy for Pregnancy	Equation 10.13, Chap. 10, Vol. 4, 2006 IPCC Guidelines	4.21	0.00	0.00	0.00	0.00
REM (NEma/DE)	Ratio of Net Energy in a Diet for Maintenance to Digestible Energy Consumed	Equation 10.14, Chap. 10, Vol. 4, 2006 IPCC Guidelines	0.54	0.54	0.54	0.54	0.54
REG (NEga/DE)	Ratio of Net Energy Available for Growth in a Diet to Digestible Energy Consumed	Equation 10.15, Chap. 10, Vol. 4, 2006 IPCC Guidelines	0.35	0.35	0.35	0.35	0.35
GE	**Gross Energy Intake (average)**	Equation 10.16, Chap. 10, Vol. 4, 2006 IPCC Guidelines	**131.79**	**3.56**	**48.64**	**69.70**	**91.08**
Ym	**CH4 conversion rate (average)**	TABLE 10.12, Chap. 10, Vol. 4, 2006 IPCC Guidelines	**6.50%**	**6.50%**	**6.50%**	**6.50%**	**6.50%**
EF - CH4	**Emission Factor - CH4**	Equation 10.21, Chap. 10, Vol. 4, 2006 IPCC Guidelines	**56.22**	**1.52**	**20.75**	**29.74**	**38.86**
CH4 Emi	**CH4 Emissions**		**2.76**	**0.003**	**0.29**	**0.10**	**0.11**
M	**Method**		**T2**	**T2**	**T2**	**T2**	**T2**
EF used	**EF used**		**CS**	**CS**	**CS**	**CS**	**CS**

Table 311 Exemplary calculation of CH4 remissions from 3.A.2 Sheep

			3A2a1	3A2a2
			Dairy Sheep	**Non-Dairy Sheep**
L	**Livestock (# of animals)**	Monstat, Table 10.10 & 10.11	91 970	73 948
W (=MW)	**Live Weight**	2019 Refinements IPCC 'TABLE 10A.5 Default values for live weights for animal categories	55	31
BW	Live Body Weight	Eq. 7 - IPCC Ref Man_1996	6.31	4.01
WG	Average Daily Weight Gain		NA	NA
AMiY	Annual Milk Yield	expert judgment; TK 2019-05-02	97	-
DMiY	**Daily Milk Yield**		0.27	-
Fat	Fat Content of Milk		6.3%	NA
Wool	**Wool production**		1.9	1.9
DE	**Digestible Energy**	TABLE 10.2, Chap. 10, Vol. 4, 2006 IPCC Guidelines	**75%**	**50%**
NEm	Net Energy for Maintenance	Equation 10.3 & Table 10.4, Chap. 10, Vol. 4, 2006 IPCC Guidelines	4.38	2.85
NEa	Net Energy for Activity	Equation 10.4 & Table 10.5, Chap. 10, Vol. 4, 2006 IPCC Guidelines	0.05	0.33
NEg	Net Energy for Growth	Equation 10.6, Chap. 10, Vol. 4, 2006 IPCC Guidelines	0.00	0.00
NEmobilised	Net Energy due to Weight Loss		NO	NO
NEl	Net Energy for Lactation	Equation 10.8, Chap. 10, Vol. 4, 2006 IPCC Guidelines	0.00	NA
NEw	Net Energy for Wool	Equation 10.12, Chap. 10, Vol. 4, 2006 IPCC Guidelines	0.12	0.12
NEp	Net Energy for Pregnancy	Equation 10.13, Chap. 10, Vol. 4, 2006 IPCC Guidelines	0.44	0.00
REM (NEma/DE)	Ratio of Net Energy in a Diet for Maintenance to Digestible Energy Consumed	Equation 10.14, Chap. 10, Vol. 4, 2006 IPCC Guidelines	0.54	0.44
REG (NEga/DE)	Ratio of Net Energy Available for Growth in a Diet to Digestible Energy Consumed	Equation 10.15, Chap. 10, Vol. 4, 2006 IPCC Guidelines	0.35	0.19
GE	**Gross Energy Intake (average)**	Equation 10.16, Chap. 10, Vol. 4, 2006 IPCC Guidelines	**12.33**	**15.08**
Ym	**CH4 conversion rate (average)**	TABLE 10.12, Chap. 10, Vol. 4, 2006 IPCC Guidelines	**6.50%**	**6.50%**
IEF - CH4	**Implied Emission Factor - CH4**	Equation 10.21, Chap. 10, Vol. 4, 2006 IPCC Guidelines	**5.26**	**6.44**
CH4 Emi	CH4 Emissions (Tier 2)		**0.48**	**0.48**
M	**Method**	-	**T2**	**T2**
EF used	**EF used**	-	**CS**	**CS**

5.2.3 Uncertainties and time-series consistency for IPCC category 3.A.1 Enteric Fermentation

The uncertainties for activity data and emission factors used for IPCC category *3.A.1 Enteric Fermentation* are presented in the following table.

Table 312 Uncertainty for IPCC category 3.A.1 Enteric Fermentation.

Uncertainty	Cattle	sheep, goats, horses, mules and asses	Reference
	CH_4	CH_4	2006 IPCC GL, Vol. 4, Chap. 10
Activity data: Livestock	20%	20%	Chapter 10.2.3
Activity data: Feed digestibility (DE%)	20%	-	Chapter 10.2.3
Emission factor	20%	40%	Chapter 10.3.4
Combined Uncertainty	**35%**	**45%**	$U_{Total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent with the data reported by MONSTAT and FAO. The break in the time series is due to change in statistical methodology.

5.2.4 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
  - consistent use of livestock data (statistical yearbook and FAOstat- Live Animals),
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from different sources: national statistic (MONSTAT, Agricultural Census 2010) and international statistics (FAO)

⇒ consistency and completeness checks are performed;

⇒ time series consistency - plausibility checks of dips and jumps.

5.2.5 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC sub-category *3.A.1 Enteric Fermentation*.

Table 313 Recalculations done in IPCC category 3.A.1 Enteric Fermentation

GHG source & sink category	Revisions	Type of revision	Type of improvement
3.A	Correction of technical mistakes	AD, EF	Accuracy

5.2.6 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 314 Planned improvements for IPCC category 3.A.1 Enteric Fermentation

GHG source & sink category	Planned improvement	Type of improvement		Priority
3.A	Using Guidance provided by 2019 Refinement to 2006 IPCC Guidelines • Application of higher TIER methodology (Tier2) for cattle, sheep • Application of higher TIER methodology (Tier1) for swine, goats, horses	AD EF	Completeness Accuracy	high
3.A. 3.B. 3.D.	Husbandry and management practice with consideration • characteristics of Livestock Husbandry for the whole time series: o breed, o age distribution, o weight o milk wool yield, o wool yield, o working hours • characteristics of manure management practice: o stall / housed and Housing period o pasture/range/paddock (flat/hilly) o grazing large areas (flat/hilly) o daily spread o solid storage o dry lot o liquid/slurry with/without natural crust cover o uncovered anaerobic lagoon o pit storage below animal confinements o anaerobic digester o burned for fuel o cattle and swine deep bedding o composting o aerobic treatment	AD	Accuracy Consistency Comparability Transparency Completeness	high
3.A. 3.B.	Manure management by temperature for sheep, goats, horses, mules, and asses, and poultry	AD	Accuracy Comparability Transparency	medium
3.A.1.j 3.B. 3.D	Survey and/or research on Livestock which is not included in current statistics: e.g. buffalo, fur bearing animals	AD	Completeness	High
3.A.1	Correction of technical mistakes in calculation	AD EF	Completeness	high

5.3 Manure management (IPCC category 3.B)

This section describes the estimation of methane and nitrous oxide emissions resulting during the storage and treatment of manure, and from manure deposited on pasture. The term ‘manure’ is used here collectively to include both dung and urine (i.e., the solids and the liquids) produced by livestock. The following figure shows a schematic overview of manure management practices.

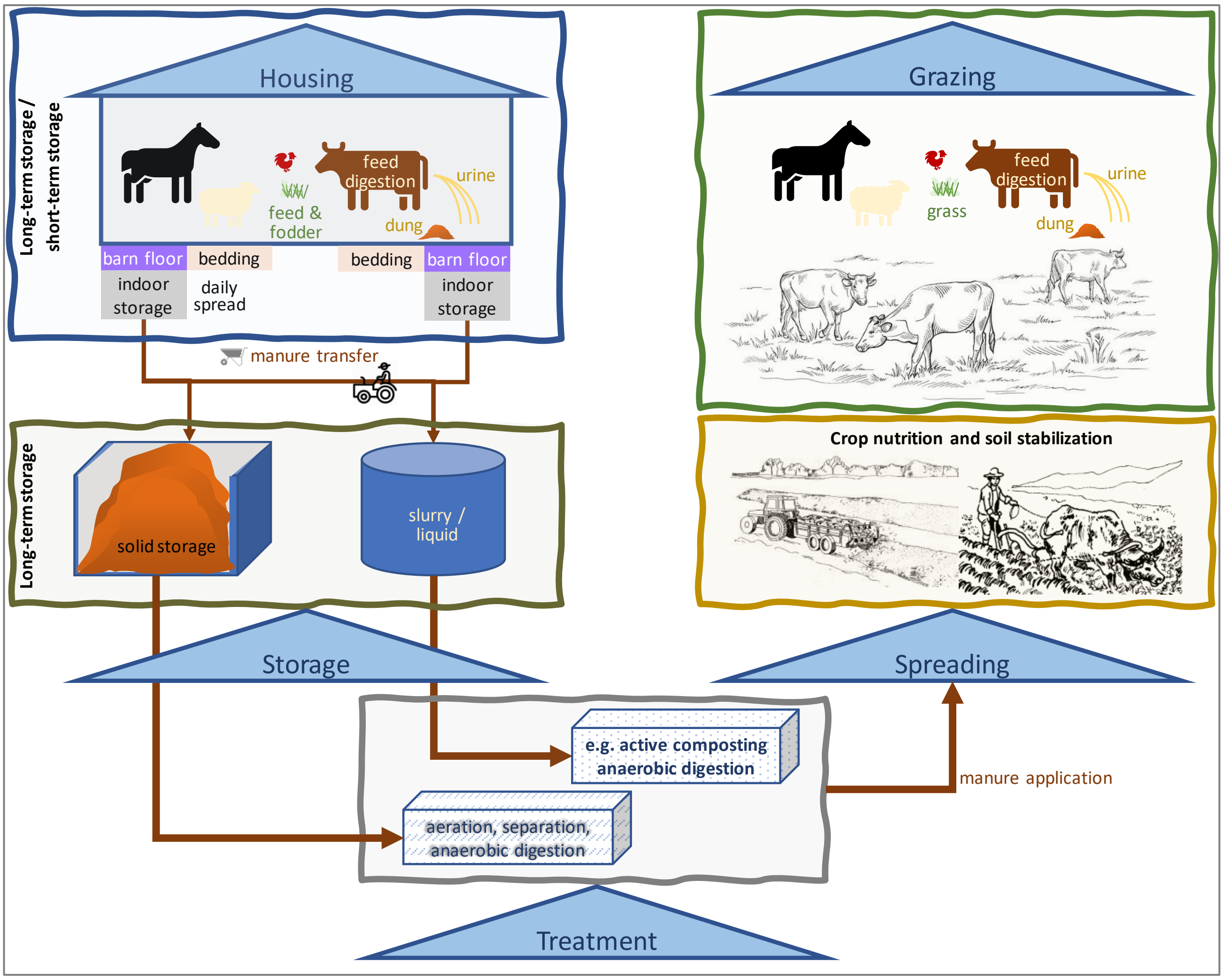


Figure 143 Schematic overview of manure management practices

As described in the 2006 IPCC Guidelines (Volume 4, Chapter 10.4) methane (CH_4) is produced during decomposition of manure under anaerobic conditions (i.e., in the absence of oxygen), during storage and treatment. These conditions occur most readily when large numbers of animals are managed in a confined area (e.g., dairy farms, beef feedlots, and swine and poultry farms), and where manure is disposed of in liquid-based systems.

The main factors affecting CH_4 emissions are

- the amount of manure produced:
  - ⇒ depending on the rate of waste production per animal and the number of animals
- the portion of the manure that decomposes anaerobically
  - ⇒ depending on how the manure is managed.
    - o when manure is stored or treated as a liquid (e.g., in lagoons, ponds, tanks, or pits), it

decomposes anaerobically and can produce a significant quantity of CH_4. The temperature and the retention time of the storage unit greatly affect the amount of methane produced.

- when manure is handled as a solid (e.g., in stacks or piles) or when it is deposited on pastures and rangelands, it tends to decompose under more aerobic conditions and less CH_4 is produced.

In the following table are the different manure management systems and their definitions presented. The table below provides information regarding the manure management system (MMS) in Montenegro as used in the inventory .

Table 315 Definitions of manure management systems

System		Definition	Storage time of manure
Pasture/ Range/ Paddock (PRP)		The manure from pasture and range grazing animals is allowed to lie as deposited, and is not managed.	-
Daily spread		Manure is routinely removed from a confinement facility and is applied to cropland or pasture within 24 hours of excretion.	-
Solid storage		The storage of manure, typically for a period of several months, in unconfined piles or stacks. Manure is able to be stacked due to the presence of a sufficient amount of bedding material or loss of moisture by evaporation.	long period of time (months)
Dry lot		A paved or unpaved open confinement area without any significant vegetative cover where accumulating manure may be removed periodically.	-
Liquid/Slurry		Manure is stored as excreted or with some minimal addition of water in either tanks or earthen ponds outside the animal housing, usually for periods less than one year.	≥ 6 months
Uncovered anaerobic lagoon		A type of liquid storage system designed and operated to combine waste stabilization and storage. Lagoon supernatant is usually used to remove manure from the associated confinement facilities to the lagoon. Anaerobic lagoons are designed with varying lengths of storage (up to a year or greater), depending on the climate region, the volatile solids loading rate, and other operational factors. The water from the lagoon may be recycled as flush water or used to irrigate and fertilize fields.	30 days to >200 days
Pit storage below animal confinements		Collection and storage of manure usually with little or no added water typically below a slatted floor in an enclosed animal confinement facility, usually for periods less than one year.	two categories: <1 month > 1 month
Anaerobic digester		Animal excreta with or without straw are collected and anaerobically digested in a large containment vessel or covered lagoon. Digesters are designed and operated for waste stabilization by the microbial reduction of complex organic compounds to CO_2 and CH_4, which is captured and flared or used as a fuel.	-
Burned for fuel		The dung and urine are excreted on fields. The sun dried dung cakes are burned for fuel.	-
Cattle and Swine deep bedding		As manure accumulates, bedding is continually added to absorb moisture over a production cycle and possibly for as long as 6 to 12 months. This manure management system also is known as a bedded pack manure management system and may be combined with a dry lot or pasture.	6 to 12 months
Composting	in- vessel	Composting, typically in an enclosed channel, with forced aeration and continuous mixing.	-
	Static pile	Composting in piles with forced aeration but no mixing.	-
	Intensive windrow	Composting in windrows with regular (at least daily) turning for mixing and aeration.	-
	Passive windrow	Composting in windrows with infrequent turning for mixing and aeration.	-

System	Definition	Storage time of manure
Poultry manure with litter	Similar to cattle and swine deep bedding except usually not combined with a dry lot or pasture. Typically used for all poultry breeder flocks and for the production of meat type chickens (broilers) and other fowl.	-
Poultry manure without litter	May be similar to open pits in enclosed animal confinement facilities or may be designed and operated to dry the manure as it accumulates. The latter is known as a high-rise manure management system and is a form of passive windrow composting when designed and operated properly.	-
Aerobic treatment	The biological oxidation of manure collected as a liquid with either forced or natural aeration. Natural aeration is limited to aerobic and facultative ponds and wetland systems and is due primarily to photosynthesis. Hence, these systems typically become anoxic during periods without sunlight.	-

Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10 Emissions from Livestock and Manure Management - sub-chapter 10.4.4 Uncertainty assessment. Table 10.18 Definitions of manure management systems. Page 10.48.

Table 316 Manure management system (MMS) in Montenegro

		Manure System								
		Pasture Range & Paddock	Daily Spread	Solid Storage	Dry Lot	Liquid/ Slurry System	Burned for fuel	An-aerobic Lagoon	Other	Total
3.B.2.a.i	**Dairy Cattle**	20%	2.5%	60%	0%	17.5%	0%	0%	0%	100%
3.B.2.a.ii	**Other Cattle**	45%	16%	16%	4%	23%	00%	0%	0%	100%
3.B.2.c	**Sheep**	80%	10%	10%	0%	0%	0%	0%	0%	100%
3.B.2.d	**Goats**	90%	5%	5%	0%	0%	0%	0%	0%	100%
3.B.2.f	**Horses**	90%	5%	5%	0%	0%	0%	0%	0%	100%
3.B.2.g	**Mules and Asses**	IE	IE	IE	IE	IE	IE	IE	IE	IE
3.B.2.h	**Swine**	5%	5%	50%	0%	35%	0%	3%	0%	100%
3.B.2.i	**Poultry**	30%	5%	9%	0%	56%	20%	0%	0%	100%

Source: Expert judgment and FAO (2018): Nitrogen inputs to agricultural soils from livestock manure New statistics. In : Integrated Crop Management. Vol. 24 – 2018. Rome. Page 56. Available (18.02.2019) at http://www.fao.org/3/I8153EN/i8153en.pdf

As described in the 2006 IPCC Guidelines (Volume 4, Chapter 10.5) nitrous oxide (N_2O) is produced, directly and indirectly, during the storage and treatment of manure before it is applied to land or otherwise used for feed, fuel, or construction purposes.

Direct N_2O emissions occur via combined nitrification and denitrification of nitrogen contained in the manure. The emission of N_2O from manure during storage and treatment depends on the nitrogen and carbon content of manure, and on the duration of the storage and type of treatment. Nitrification (the oxidation of ammonia nitrogen to nitrate nitrogen) is a necessary prerequisite for the emission of N_2O from stored animal manures. Nitrification is likely to occur in stored animal manures provided there is a sufficient supply of oxygen. Nitrification does not occur under anaerobic conditions. Nitrites and nitrates are transformed to N_2O and dinitrogen (N2) during the naturally occurring process of denitrification, an anaerobic process.

Indirect emissions result from volatile nitrogen losses that occur primarily in the forms of ammonia and NOx. The fraction of excreted organic nitrogen that is mineralized to ammonia nitrogen during manure collection and storage depends primarily on time, and to a lesser degree temperature. Simple forms of organic nitrogen such as urea (mammals) and uric acid (poultry) are rapidly mineralized to ammonia nitrogen, which is highly volatile and easily diffused into the surrounding air. Nitrogen losses begin at the point of excretion in houses and other animal production areas (e.g., milk parlors) and continue through on-site management in storage and treatment systems (i.e., manure management systems). Nitrogen is also lost through runoff and leaching into soils from the solid storage of manure at outdoor areas, in feedlots and where animals are grazing in pastures.

The CH_4 emissions generated by manure in the

- system 'buildings housing livestock, manure stores or yards' are reported under
  ⇒ 3.B *Manure Management*
- system 'manure handling and storage' are reported under
  ⇒ 3.B *Manure Management*

The N_2O emissions generated by manure in the

- system 'pasture, range, and paddock' occur directly and indirectly from the soil, and are therefore reported under the category
  ⇒ 3.D.a *Direct N_2O emissions from managed soils*
  ⇒ 3.D.a.2 *Organic N fertilizers*
  ⇒ *3.D.a.2.a Animal manure applied to soils*
  ⇒ 3.D.b *IndirectN_2O Emissions from managed soils*

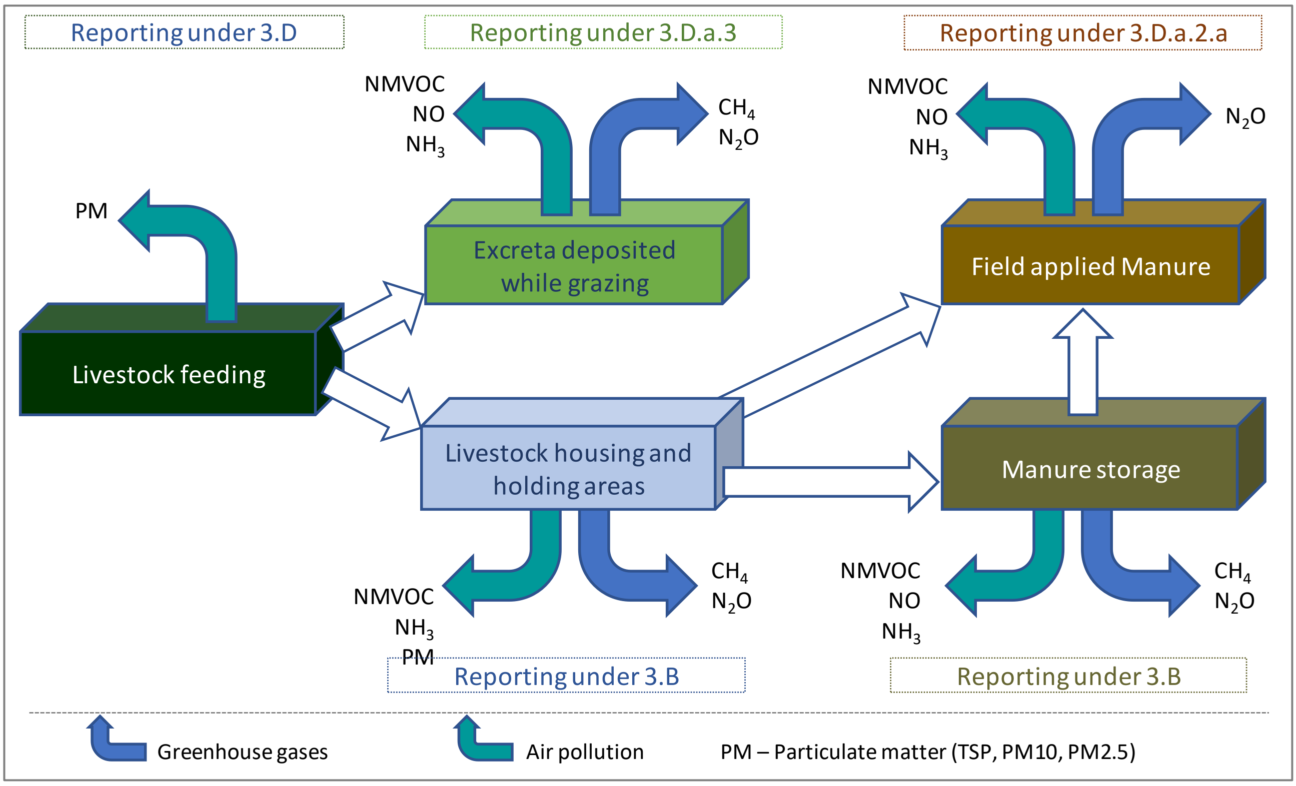


Figure 144 **Scheme for emissions resulting from livestock feeding, livestock excreta and manure management**

5.3.1 Source category description

IPCC code	description	CO_2		CH_4		N_2O	
		Estimated	Key Category	estimated	Key category	estimated	Key category
3.B.2	**Manure Management**						
3.B.2.a	**Cattle**						
3.B.2.a.i	**Dairy cows**	NA	-	✓		✓	-
3.B.2.a.ii	**Other cattle**	NA	-	✓		✓	-
3.B.2.b	**Buffalo**	NA	-	NO		NO	-
3.B.2.c	**Sheep**	NA	-	✓		✓	-
3.B.2.d	**Goats**	NA	-	✓		✓	-
3.B.2.e	**Camels**	NA	-	NO	-	✓	-
3.B.2.f	**Horses**	NA	-	✓	-	✓	-
3.B.2.g	**Mules and Asses**	NA	-	IE	-	✓	-
3.B.2.h	**Swine**	NA	-	NO	-	NO	-
3.B.2.i	**Poultry**	NA	-	✓	-	✓	-
3.B.2.j	**Other (e.g rabbit)**	NA	-	NE	-	NE	-

A '✓' indicates: emissions from this sub-category have been estimated.
Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential

LA – Level Assessment (in year); TA – Trend Assessment

In 2021, the IPCC category 3.B Manure management was responsible for 1.4% of the total GHG emissions in CO_2eq (excluding LULUCF). In the period 1990 – 2021 the CH_4 emissions decreased by -60.8% and in the period 2005 – 2021 the CH_4 emissions decreased by -37.9% mainly due to decreased number of livestock. In 2021, CH4 emissions from IPCC category 3.A Enteric fermentation amounted to 1.55 kt.

Cattle are the most significant source of methane because of their high numbers, large size and ruminant digestive system, followed by sheep and goats. The significant drop is mainly due to statistical revisions.

An overview of the methane emissions resulting from IPCC category 3.B *Manure Management* is provided in the following figure and tables.

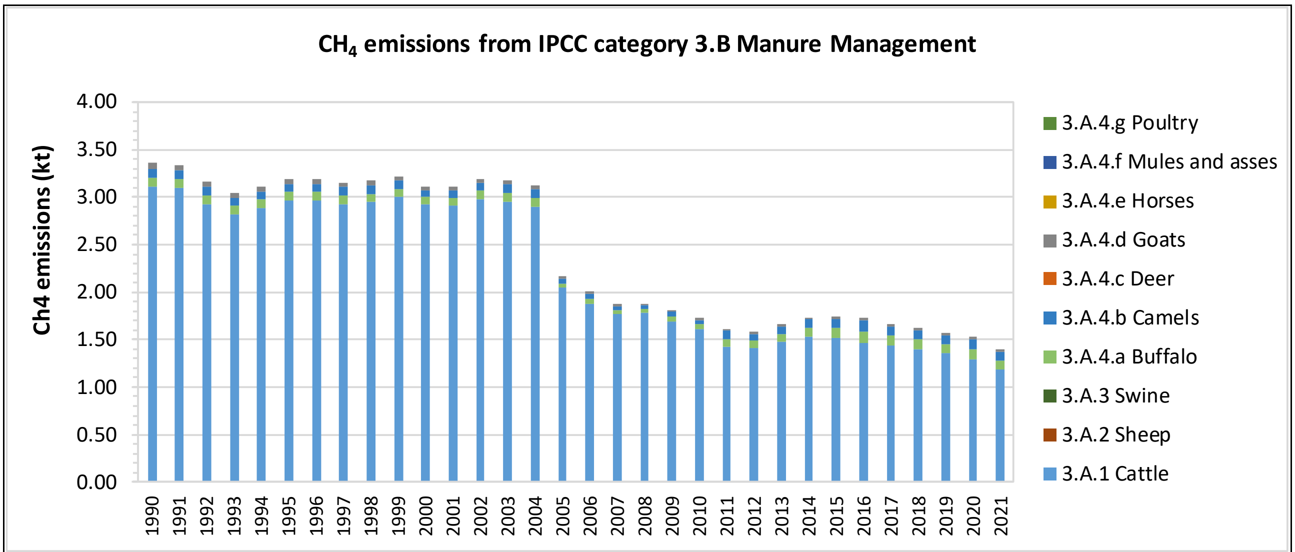


Figure 145 CH4 emissions from IPCC category 3.B Manure management for the period of 1990–2021

In 2021, the IPCC category 3.B Manure management was responsible for 1.4% of the total GHG emissions in CO_2eq (excluding LULUCF). In the period 1990 – 2021 the N2O emissions decreased by -57.2% and in the period 2005 – 2021 the N2O emissions decreased by -36.8% mainly due to decreased number of livestock. In 2021, N2O emissions from IPCC category 3.B Manure management amounted to 0.015 kt.

Cattle are the most significant source of methane because of their high numbers, large size and ruminant digestive system, followed by sheep and goats. The significant drop is mainly due to statistical revisions.

An overview of the N2O emissions resulting from IPCC category 3.B *Manure Management* is provided in the following figure and tables.

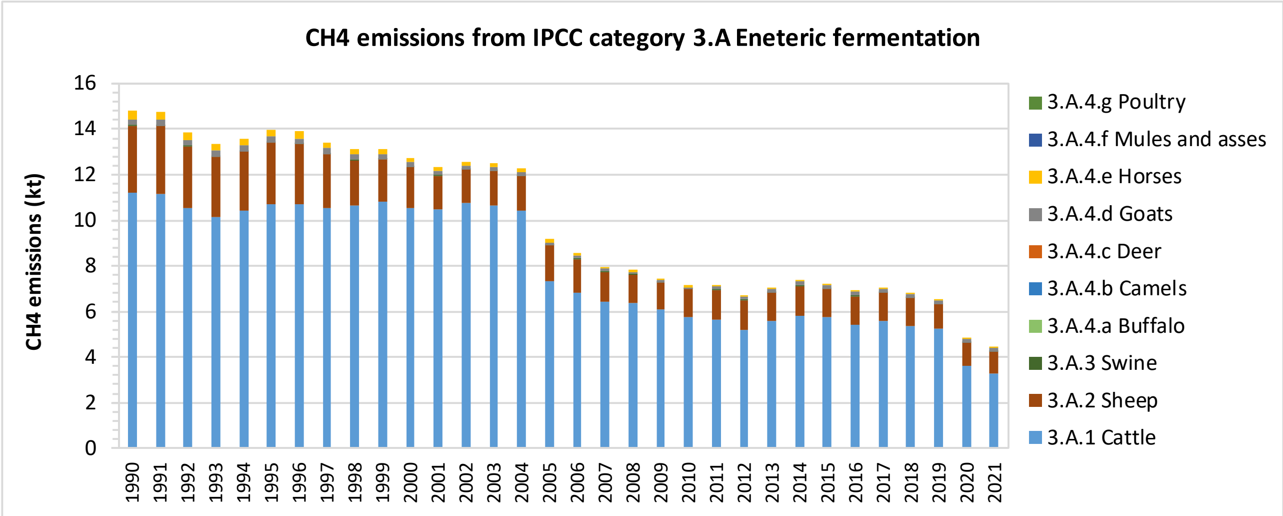


Figure 146 N2O emissions from IPCC category 3.B Manure management for the period of 1990–2021

Table 317 CH4 emissions from IPCC category 3.B Manure management – Main livestock

CH_4 emissions	3.B.1	3.B.1.a	3.B.1.a.	3.B.1.b.	3.B.2	3.B.3	3.B.4
	Manaure Management	Cattle	Dairy cattle	Non-dairy cattle	Sheep	Swine	Other livestock
	kt	kt	kt	kt	kt	kt	kt
1990	**3.99**	3.10	2.56	0.54	0.73	0.10	0.06
1991	**3.98**	3.10	2.56	0.54	0.73	0.09	0.06
1992	**3.74**	2.92	2.41	0.51	0.67	0.09	0.05
1993	**3.60**	2.82	2.35	0.46	0.65	0.09	0.05
1994	**3.67**	2.88	2.41	0.47	0.65	0.09	0.05
1995	**3.77**	2.96	2.45	0.51	0.67	0.09	0.05
1996	**3.76**	2.96	2.45	0.51	0.66	0.09	0.05
1997	**3.65**	2.92	2.43	0.49	0.59	0.09	0.05
1998	**3.58**	2.94	2.45	0.50	0.50	0.09	0.05
1999	**3.59**	3.00	2.52	0.48	0.46	0.09	0.04
2000	**3.48**	2.92	2.38	0.54	0.44	0.08	0.04
2001	**3.39**	2.91	2.37	0.54	0.37	0.08	0.04
2002	**3.47**	2.98	2.43	0.55	0.36	0.09	0.04
2003	**3.46**	2.95	2.50	0.45	0.38	0.10	0.04
2004	**3.41**	2.89	2.40	0.49	0.38	0.10	0.04
2005	**2.50**	2.04	1.64	0.41	0.38	0.05	0.03
2006	**2.33**	1.88	1.54	0.34	0.37	0.05	0.02
2007	**2.17**	1.77	1.43	0.34	0.33	0.04	0.02
2008	**2.15**	1.78	1.49	0.29	0.31	0.04	0.02
2009	**2.06**	1.69	1.43	0.26	0.30	0.05	0.02
2010	**1.98**	1.61	1.37	0.25	0.30	0.04	0.02
2011	**1.84**	1.42	1.17	0.25	0.31	0.09	0.02
2012	**1.82**	1.41	1.18	0.23	0.31	0.07	0.03
2013	**1.87**	1.47	1.22	0.25	0.29	0.08	0.03
2014	**1.96**	1.54	1.26	0.27	0.31	0.09	0.03
2015	**1.94**	1.52	1.26	0.27	0.29	0.10	0.03
2016	**1.90**	1.46	1.19	0.27	0.29	0.12	0.03
2017	**1.85**	1.44	1.20	0.24	0.28	0.10	0.03
2018	**1.80**	1.40	1.19	0.21	0.28	0.09	0.02
2019	**1.75**	1.36	1.14	0.22	0.27	0.09	0.02
2020	**1.69**	1.30	1.08	0.21	0.26	0.10	0.02
2021	**1.55**	1.18	0.98	0.20	0.25	0.10	0.02
Trend							
1990 - 2021	71.5%	-61.9%	-61.6%	-63.6%	-65.9%	0.4%	-62.2%
2005 - 2021	54.5%	-42.2%	-39.9%	-51.4%	-35.3%	101.0%	-14.5%
2020 - 2021	4.0%	-8.9%	-9.2%	-7.2%	-6.0%	-5.7%	-1.5%

Table 318 CH4 emissions from IPCC category 3.B Manure management – Other livestock

CH_4 emissions	3.B.1	3.B.4	3.B.4.a	3.B.4.b.	3.B.4.c.	3.B.4.d.	3.B.4.e.	3.B.4.f.	3.B.4.g	3.B.4.h
	Manure management	Other livestock	Buffalo	Camels	Deer	Goats	Horses	Mules and asses	Poultry	Other
	kt	kt	kt	kt		kt	kt	kt	kt	kt
1990	**3.99**	0.06	NO	NO	NO	0.009	0.033	IE	0.018	NO
1991	**3.98**	0.06	NO	NO	NO	0.009	0.032	IE	0.019	NO
1992	**3.74**	0.05	NO	NO	NO	0.009	0.028	IE	0.017	NO
1993	**3.60**	0.05	NO	NO	NO	0.009	0.027	IE	0.016	NO
1994	**3.67**	0.05	NO	NO	NO	0.008	0.027	IE	0.016	NO
1995	**3.77**	0.05	NO	NO	NO	0.008	0.027	IE	0.016	NO
1996	**3.76**	0.05	NO	NO	NO	0.008	0.026	IE	0.015	NO
1997	**3.65**	0.05	NO	NO	NO	0.008	0.025	IE	0.015	NO
1998	**3.58**	0.05	NO	NO	NO	0.008	0.023	IE	0.016	NO
1999	**3.59**	0.04	NO	NO	NO	0.007	0.020	IE	0.015	NO
2000	**3.48**	0.04	NO	NO	NO	0.007	0.018	IE	0.016	NO
2001	**3.39**	0.04	NO	NO	NO	0.006	0.016	IE	0.016	NO
2002	**3.47**	0.04	NO	NO	NO	0.006	0.016	IE	0.017	NO
2003	**3.46**	0.04	NO	NO	NO	0.005	0.015	IE	0.018	NO
2004	**3.41**	0.04	NO	NO	NO	0.005	0.015	IE	0.018	NO
2005	**2.50**	0.03	NO	NO	NO	0.004	0.013	IE	0.010	NO
2006	**2.33**	0.02	NO	NO	NO	0.004	0.010	IE	0.009	NO
2007	**2.17**	0.02	NO	NO	NO	0.004	0.009	IE	0.010	NO
2008	**2.15**	0.02	NO	NO	NO	0.003	0.008	IE	0.009	NO
2009	**2.06**	0.02	NO	NO	NO	0.003	0.008	IE	0.008	NO
2010	**1.98**	0.02	NO	NO	NO	0.002	0.008	IE	0.010	NO
2011	**1.84**	0.02	NO	NO	NO	0.004	0.007	IE	0.009	NO
2012	**1.82**	0.03	NO	NO	NO	0.004	0.006	IE	0.015	NO
2013	**1.87**	0.03	NO	NO	NO	0.005	0.008	IE	0.012	NO
2014	**1.96**	0.03	NO	NO	NO	0.006	0.008	IE	0.012	NO
2015	**1.94**	0.03	NO	NO	NO	0.005	0.008	IE	0.012	NO
2016	**1.90**	0.03	NO	NO	NO	0.005	0.006	IE	0.017	NO
2017	**1.85**	0.03	NO	NO	NO	0.005	0.007	IE	0.016	NO
2018	**1.80**	0.02	NO	NO	NO	0.005	0.007	IE	0.013	NO
2019	**1.75**	0.02	NO	NO	NO	0.005	0.007	IE	0.013	NO
2020	**1.69**	0.02	NO	NO	NO	0.005	0.006	IE	0.012	NO
	1.55	0.02	NO	NO	NO	0.005	0.006	IE	0.012	NO
Trend										
1990 - 2021	*71.5%*	*-62.2%*	*NA*	*NA*	*NA*	*-46.7%*	*-81.8%*	*NA*	-34.9%	*NA*
2005 - 2021	*54.5%*	*-14.5%*	*NA*	*NA*	*NA*	*13.3%*	*-52.9%*	*NA*	23.0%	*NA*
2020 - 2021	*4.0%*	*-1.5%*	*NA*	*NA*	*NA*	*4.3%*	*-7.0%*	*NA*	-0.8%	*NA*

Table 319 N2O emissions from IPCC category 3.B Manure management – Main livestock

N2O emissions	3.B.1	3.B.1.a	3.B.1.a.	3.B.1.b.	3.B.2	3.B.3	3.B.4
	Manaure Management	Cattle	Dairy cattle	Non-dairy cattle	Sheep	Swine	Other livestock
	kt	kt	kt	kt	kt	kt	kt
1990	**0.034**	0.030	0.010	0.020	0.0002	0.0003	0.004
1991	**0.034**	0.029	0.010	0.019	0.0002	0.0003	0.004
1992	**0.032**	0.028	0.010	0.018	0.0002	0.0003	0.003
1993	**0.030**	0.026	0.009	0.016	0.0001	0.0003	0.003
1994	**0.030**	0.026	0.010	0.017	0.0001	0.0003	0.003
1995	**0.032**	0.028	0.010	0.018	0.0002	0.0003	0.003
1996	**0.032**	0.028	0.010	0.018	0.0002	0.0003	0.003
1997	**0.031**	0.027	0.010	0.017	0.0002	0.0003	0.003
1998	**0.031**	0.027	0.010	0.018	0.0002	0.0003	0.003
1999	**0.031**	0.027	0.010	0.017	0.0001	0.0003	0.003
2000	**0.032**	0.029	0.009	0.019	0.0002	0.0002	0.003
2001	**0.032**	0.028	0.009	0.019	0.0002	0.0002	0.003
2002	**0.033**	0.029	0.010	0.020	0.0002	0.0002	0.003
2003	**0.030**	0.026	0.010	0.016	0.0001	0.0002	0.003
2004	**0.031**	0.027	0.010	0.018	0.0002	0.0002	0.003
2005	**0.023**	0.021	0.006	0.015	0.0001	0.0001	0.002
2006	**0.020**	0.018	0.006	0.012	0.0001	0.0002	0.002
2007	**0.020**	0.018	0.006	0.012	0.0001	0.0001	0.002
2008	**0.018**	0.016	0.006	0.010	0.0001	0.0001	0.002
2009	**0.017**	0.015	0.006	0.009	0.0001	0.0001	0.002
2010	**0.016**	0.014	0.005	0.009	0.0001	0.0001	0.002
2011	**0.016**	0.014	0.005	0.009	0.0001	0.0002	0.002
2012	**0.016**	0.013	0.005	0.008	0.0001	0.0002	0.003
2013	**0.017**	0.014	0.005	0.009	0.0001	0.0002	0.003
2014	**0.018**	0.015	0.005	0.010	0.0001	0.0002	0.002
2015	**0.018**	0.015	0.005	0.010	0.0001	0.0002	0.003
2016	**0.019**	0.014	0.004	0.010	0.0001	0.0002	0.005
2017	**0.018**	0.014	0.005	0.009	0.0001	0.0002	0.004
2018	**0.017**	0.013	0.005	0.008	0.0001	0.0002	0.005
2019	**0.017**	0.013	0.005	0.008	0.0001	0.0002	0.004
2020	**0.016**	0.012	0.004	0.008	0.0001	0.0002	0.004
2021	**0.015**	0.011	0.004	0.007	0.0001	0.0002	0.003
Trend							
1990 - 2021	*-57.23%*	*-63.49%*	*-61.59%*	*-64.45%*	*-71.30%*	*-27.62%*	*-8.42%*
2005 - 2021	*-36.83%*	*-47.80%*	*-39.90%*	*-51.32%*	*-48.81%*	*60.30%*	*76.01%*
2020 - 2021	*-10.25%*	*-7.08%*	*-9.24%*	*-5.84%*	*-12.43%*	*-5.12%*	*-19.34%*

Table 320 N2O emissions from IPCC category 3.B Manure management – Other livestock

N2O emissions	3.B.1	3.B.4	3.B.4.a	3.B.4.b.	3.B.4.c.	3.B.4.d.	3.B.4.e.	3.B.4.f.	3.B.4.g	3.B.4.h
	Manure management	Other livestock	Buffalo	Camels	Deer	Goats	Horses	Mules and asses	Poultry	Other
	kt	kt	kt	kt		kt	kt	kt	kt	kt
1990	**0.034**	0.004	NO	NO	NO	0.0005	0.001	IE	0.003	NO
1991	**0.034**	0.004	NO	NO	NO	0.0005	0.001	IE	0.003	NO
1992	**0.032**	0.003	NO	NO	NO	0.0004	0.001	IE	0.003	NO
1993	**0.030**	0.003	NO	NO	NO	0.0004	0.001	IE	0.002	NO
1994	**0.030**	0.003	NO	NO	NO	0.0004	0.001	IE	0.002	NO
1995	**0.032**	0.003	NO	NO	NO	0.0004	0.001	IE	0.002	NO
1996	**0.032**	0.003	NO	NO	NO	0.0004	0.001	IE	0.002	NO
1997	**0.031**	0.003	NO	NO	NO	0.0004	0.000	IE	0.002	NO
1998	**0.031**	0.003	NO	NO	NO	0.0003	0.001	IE	0.002	NO
1999	**0.031**	0.003	NO	NO	NO	0.0003	0.000	IE	0.002	NO
2000	**0.032**	0.003	NO	NO	NO	0.0003	0.001	IE	0.002	NO
2001	**0.032**	0.003	NO	NO	NO	0.0002	0.001	IE	0.002	NO
2002	**0.033**	0.003	NO	NO	NO	0.0002	0.001	IE	0.002	NO
2003	**0.030**	0.003	NO	NO	NO	0.0002	0.001	IE	0.003	NO
2004	**0.031**	0.003	NO	NO	NO	0.0002	0.001	IE	0.003	NO
2005	**0.023**	0.002	NO	NO	NO	0.0002	0.000	IE	0.001	NO
2006	**0.020**	0.002	NO	NO	NO	0.0002	0.000	IE	0.001	NO
2007	**0.020**	0.002	NO	NO	NO	0.0002	0.000	IE	0.001	NO
2008	**0.018**	0.002	NO	NO	NO	0.0002	0.000	IE	0.001	NO
2009	**0.017**	0.002	NO	NO	NO	0.0002	0.000	IE	0.001	NO
2010	**0.016**	0.002	NO	NO	NO	0.0002	0.000	IE	0.001	NO
2011	**0.016**	0.002	NO	NO	NO	0.0002	0.000	IE	0.001	NO
2012	**0.016**	0.003	NO	NO	NO	0.0002	0.000	IE	0.002	NO
2013	**0.017**	0.003	NO	NO	NO	0.0002	0.000	IE	0.002	NO
2014	**0.018**	0.002	NO	NO	NO	0.0002	0.000	IE	0.002	NO
2015	**0.018**	0.003	NO	NO	NO	0.0001	0.001	IE	0.002	NO
2016	**0.019**	0.005	NO	NO	NO	0.0002	0.002	IE	0.003	NO
2017	**0.018**	0.004	NO	NO	NO	0.0001	0.001	IE	0.002	NO
2018	**0.017**	0.005	NO	NO	NO	0.0001	0.002	IE	0.002	NO
2019	**0.017**	0.004	NO	NO	NO	0.0001	0.002	IE	0.002	NO
2020	**0.016**	0.004	NO	NO	NO	0.0001	0.002	IE	0.002	NO
2021	**0.015**	0.003	NO	NO	NO	0.0001	0.001	IE	0.002	NO
Trend										
1990 - 2021	*-57.23%*	*-8.42%*	*NA*	*NA*	*NA*	*-46.7%*	*-81.8%*	*NA*	-30.37%	*NA*
2005 - 2021	*-36.83%*	*76.01%*	*NA*	*NA*	*NA*	*13.3%*	*-52.9%*	*NA*	31.64%	*NA*
2020 - 2021	*-10.25%*	*-19.34%*	*NA*	*NA*	*NA*	*4.3%*	*-7.0%*	*NA*	-1.13%	*NA*

5.3.2 Methodological issues

5.3.2.1 Choice of methods

For estimating the

- The CH_4 emissions from all livestock the 2006 IPCC Guidelines Tier 1 approach[100] has been applied.
- direct and indirect N_2O emissions from all livestock the 2006 IPCC Guidelines Tier 1 approach[100] has been applied.

TIER 1 approach – methane emissions

Tier 1 is simplified method that only requires livestock population data by animal species/category and climate region or temperature, in combination with IPCC default emission factors, to estimate emissions. Because some emissions from manure management systems are highly temperature dependent, it is good practice to estimate the average annual temperature associated with the locations where manure is managed.

Equation 10.22: CH_4 emissions from manure management from a livestock category

$$\boldsymbol{Emissions_{CH4} = Livestock_{\,category} \times \left(\frac{Emission\ Factor_T}{10^6}\right)}$$

Where:

Emissions $_{CH4}$	= CH_4 emissions (Gg CH_4)
Livestock $_{category}$	= number of head of livestock species / category T
Emission factor $_T$	= default emission factor for a defined livestock population (kg CH_4 head^{-1}).
T	= species/category of livestock

Finally, the total emissions from the species/category of livestock was estimated applying the following equation:

Total emissions from livestock manure management

$$\boldsymbol{Emissions_{CH4\ manure} = \sum_i emissions_i}$$

Where:

Emissions $_{CH4\ manure}$	= total CH_4 emissions from Manure Management (Gg CH_4)
Emission $_i$	= emissions for the i^{th} livestock categories and subcategories.

TIER 1 approach – Direct N_2O emissions from Manure Management

The Tier 1 method entails multiplying the total amount of N excretion (from all livestock species/categories) in each type of manure management system by an emission factor for that type of manure management system (*see below Equation 10.25*). Emissions are then summed over all manure management systems. The Tier 1 method is applied using IPCC default N_2O emission factors, default nitrogen excretion data, and default manure management system data.

[100] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10 Emissions from Livestock and Manure Management, sub-chap 10.4.1 Choice of method

Equation 10.25: Direct N_2O emissions from Manure Management

$$\boldsymbol{Emissions_{N2O}} = \left[\sum_{S}\left[\sum_{T}\left(\boldsymbol{N_T} \times \boldsymbol{Nex_{(T)}} \times \boldsymbol{MS_{(T,S)}}\right)\right] \times \boldsymbol{EF_{3(S)}}\right] \times \frac{\mathbf{44}}{\mathbf{28}}$$

Where:

$N_2O_{D(mm)}$	= direct N_2O emissions from Manure Management in the country (kg N_2O)
$N_{(T)}$	= number of head of livestock species/category T in the country
$Nex_{(T)}$	= annual average N excretion per head of species/category T in the country (kg N / animal)
$MS_{(T,S)}$	= fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S in the country, dimensionless
$EF_{3(S)}$	= emission factor for direct N_2O emissions from manure management system S in the country (kg N_2O-N/kg N in manure management system S)
S	= manure management system
T	= species/category of livestock
44/28	= conversion of $(N_2O\text{-}N)_{(mm)}$ emissions to $N_2O_{(mm)}$ emissions

Following the guidance provided in the 2006 IPCCC guidelines (Volume 4, Chapter 10.5.1) the following five steps were used to estimate direct N_2O emissions from Manure Management:

Step 1: Collect population data from the Livestock Population Characterization;

Step 2: Use default values or develop the annual average nitrogen excretion rate per head (Nex(T)) for each defined livestock species/category T;

Step 3: Use default values or determine the fraction of total annual nitrogen excretion for each livestock species/category T that is managed in each manure management system S ($MS_{(T,S)}$);

Step 4: Use default values or develop N_2O emission factors for each manure management system S (EF3(S));

Step 5: For each manure management system type S, multiply its emission factor ($EF_{3(S)}$) by the total amount of nitrogen managed (from all livestock species/categories) in that system, to estimate N_2O emissions from that manure management system. Then sum over all manure management systems.

There may be losses of nitrogen in other forms (e.g., ammonia and NOx) as manure is managed on site. Nitrogen in the volatilized form of ammonia may be deposited at sites downwind from manure handling areas and contribute to indirect N_2O emissions (see below).

TIER 1 approach – Indirect N_2O emissions from Manure Management

The Tier 1 calculation of N volatilization in forms of NH_3 and NO_x from manure management systems is based on multiplication of the amount of nitrogen excreted (from all livestock categories) and managed in each manure management system by a fraction of volatilized nitrogen (see below Equation 10.26). Nitrogen (N) losses are then summed over all manure management systems.

The Tier 1 method was applied using

- default nitrogen excretion data,
- default manure management system data and
- default fractions of N losses from manure management systems due to volatilization.

Equation 10.26: Nitrogen (N) losses due to volatilization from manure management

$$N_{volatilzation-MMS} = \left[\sum_{S}\left[\sum_{T}\left(N_T \times Nex_{(T)} \times MS_{(T,S)}\right) \times \left(\frac{Frac_{GasMS}}{100}\right)_{(T,S)}\right]\right]$$

Where:

$N_{volatilization-MMS}$ = amount of manure nitrogen that is lost due to volatilization of NH_3 and NOx (kg N)

$N_{(T)}$ = number of head of livestock species/category T in the country

$Nex_{(T)}$ = annual average N excretion per head of species/category T in the country (kg N / animal)

$MS_{(T,S)}$ = fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S in the country, dimensionless

$Frac_{GasMS}$ = percent of managed manure nitrogen for livestock category T that volatilizes as NH_3 and NO_x in the manure management system S (%)

The indirect N_2O emissions from volatilisation of N in forms of NH_3 and NOx ($N_2O_{G(mm)}$) are estimated using the following equation:

Equation 10.27: Indirect N_2O emissions due to volatilization of N from manure management

$$Indirect\ emissions\ N_2O_{\ manure\ management} = (N_{\text{volatilization}-\text{MMS}} \times EF_4) \times \frac{44}{28}$$

Where:

$N_2O_{G(mm)}$ = indirect N_2O emissions due to volatilization of N from Manure Management in the country (kg N_2O)

EF_4 = emission factor for N_2O emissions from atmospheric deposition of nitrogen on soils and water surfaces (kg N_2O-N (kg NH3-N + NOx-N volatilised)$^{-1}$

with default value 0.01 kg N_2O-N (kg NH3-N +NOx-N volatilised)$^{-1}$

5.3.2.2 Choice of activity data

As described in Chapters 5.1.2 and 5.1.3 above, the original data provider for the national and international agricultural data is the Ministry of Agriculture and Rural Development and Statistical Office of Montenegro (MONSTAT)[101]. The data are presented in the figures and tables in Chapter 5.1.3.

[101] Available (3. Januar 2021) on https://www.monstat.org/eng/index.php

5.3.2.3 Choice of emission factors

Default emission factors for methane (CH_4)

The default emission factors for methane (CH_4) were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 321 Emission factors for Tier 1 for IPCC sub-category 3.B Manure Management

Livestock	CH_4 emission factor by average annual temperature (°C) (kg/head per year)		Region / average annual temperature	Source
	EF	type	EF	
Dairy Cows	15	D	Eastern Europe: 14/15°	**2006 IPCC Guidelines Vol. 4, Chap. 10 (10.4.2)** Table 10.14 Manure management methane emission factors by temperature (page 10.38ff)
Other Cattle	8	D		
Swine	3.0	D		
Sheep	0.15	D	Developing countries / Temperate (15 to 25°C)	**2006 IPCC Guidelines Vol. 4, Chap. 10 (10.4.2)** Table 10.15 Manure management methane emission factors by temperature (page 10.40)
Goats	0.17	D		
Horses	1.64	D		
Mules and Asses	0.9	D		
Poultry	0.02	D		

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

Nitrous oxide (N_2O) - Annual average nitrogen excretion rates ($Nex_{(T)}$)

The TIER 1 Annual average nitrogen excretion rates ($Nex_{(T)}$) was calculated according to Equation 10.30 of 2006 IPCC GL[102] and are presented in the following table.

Equation 10.30: Annual N excretion rates (2006 IPCC GL, Vol. 4, Chap. 10)

$$Nex_{(T)} = N_{rate(T)} \times \frac{TAM}{1000} \times 365$$

Where:

$Nex_{(T)}$ = annual N excretion for livestock category T (kg N animal^{-1} yr^{-1})

$N_{rate(T)}$ = default N excretion rate (kg N (1000 kg animal mass)$^{-1}$ day^{-1})

$TAM_{(T)}$ = typical animal mass for livestock category T (kg animal^{-1})

Annual average nitrogen excretion rate $N_{rate(T)}$

Annual nitrogen excretion rates should be determined for each livestock category defined by the livestock population characterization. As no country specific nitrogen excretion rate $N_{rate(T)}$ were available, the default N excretion rates were used. They are presented in the following table.

[102] 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10 Emissions from Livestock and Manure Management, sub-chap 10.5.2 Choice of emission factors. Equation 10.30. page 10.57.

Table 322 Typical animal mass, default nitrogen excretion rate and annual N excretion for livestock category

	Category of animal	Typical animal mass for livestock $TAM_{(T)}$ (kg)	Default values for nitrogen excretion rate ($N_{rate(T)}$) (kg N (1000 kg animal mass)$^{-1}$ day^{-1})	Annual N excretion for livestock category (kg N animal-1 $^{yr-1}$)
			Region – Eastern Europe	
3.B.2.a.i	Dairy Cattle	550	0.47	94.35
3.B.2.a.ii	Other Cattle	391	0.34	48.52
3.B.2.c	Other - Sheep	40.00	1.17	17.08
3.B.2.d	Other - Goats	35.00	1.37	17.50
3.B.2.f	Other - Horses	377	0.46	63.30
3.B.2.g	Other - Mules and Asses	245	0.46	41.14
3.B.2.h	Swine	120	0.42	18.40
3.B.2.i	Other - Poultry	1.6	0.82	0.48
Source:		*Monstat*	*Table 10.19 Default values for nitrogen excretion rate*[103]	*calculated*

The direct N_2O emissions are exemplarily calculated in (direct N_2O emissions) applying the default emission factors for direct N_2O emissions from manure management (see Table 323).

Table 323 Default emission factors for direct N_2O emissions from manure management

System	Definition		EF_3 [kg N_2O-N (kg Nitrogen excreted)$^{-1}$]
Pasture/Range/ Paddock	The manure from pasture and range grazing animals is allowed to lie as it is, and is not managed.		NA
Daily spread	Manure is routinely removed from a confinement facility and is applied to cropland or pasture within 24 hours of excretion. N_2O emissions during storage and treatment are assumed to be zero. N_2O emissions from land application are covered under the Agricultural Soils category.		0
Solid storage	The storage of manure, typically for a period of several months, in unconfined piles or stacks. Manure is able to be stacked due to the presence of a sufficient amount of bedding material or loss of moisture by evaporation.		0.005
Dry lot	A paved or unpaved open confinement area without any significant vegetative cover where accumulating manure may be removed periodically. Dry lots are most typically found in dry climates but also are used in humid climates.		0.02
Liquid/Slurry	Manure is stored as excreted or with some minimal addition of water to facilitate handling and is stored in either tanks or earthen ponds.	With natural crust cover	0.005
		Without natural crust cover	0
Uncovered anaerobic lagoon	Anaerobic lagoons are designed and operated to combine waste stabilization and storage. Lagoon supernatant is usually used to remove manure from the associated confinement facilities to the lagoon. Anaerobic lagoons are designed with varying lengths of storage (up to a year or greater), depending on the climate region, the volatile solids loading rate, and other operational factors. The water from the lagoon may be recycled as flush water or used to irrigate and fertilize fields.		0

[103] 2006 IPCC Guidelines, Vol. 4, Chap. 10, sub-chap. 10.5.2 Choice of emission factors, page 10.59.

System	Definition	EF_3 [kg N_2O-N (kg Nitrogen excreted)$^{-1}$]
Pit storage below animal confinements	Collection and storage of manure usually with little or no added water typically below a slatted floor in an enclosed animal confinement facility.	0.002
Remark: Direct and indirect N_2O emissions associated with the manure deposited on agricultural soils and pasture, range, paddock systems are treated under 3.D N_2O emissions from managed soils.		

Source: 2006 IPCC Guidelines, Vol. 4, Chap. 10, sub-chap. 10.5.3 Choice of emission factors, Table 10.21 Default emission factors for direct N_2O emissions from manure management; page 10.62.

Table 324 Exemplary calculation including parameter of CH4 and N2O emissions from 3.B Manure management

CH4 and N2O emissions from 3.B Manure management			3.B.1-Dairy Cattle
L	Livestock (# of animals)	-	49 168
TAM (W)	Typical Animal Mass (average) (also TAM)	-	550.00
MS1	Manure System - Pasture Range & Paddock		20%
MS2	Manure System - Daily Spread	2.6	2.5%
MS3	Manure System - Solid Storage	kg/hd/day	60%
MS4	Manure System - Dry Lot		0%
MS5	Manure System - Liquid/Slurry		17.5%
MS6	Manure System - Burned for fuel		0%
MS7	Manure System - Anaerobic Lagoon		0%
MS8	Manure System - other AWMS		0%
MS9	Manure System - other AWMS		0%
	Check Total MS		100%
GE	Gross Energy Intake (average)	{[(NEm+NEa+NEl+NEw+NEp)/REM] +[NEg/REG]}/(DE/100)	143.78
DE	Digestible Energy	-	55%
ASH	Ash Content of the Manure	-	0.08
VS	Volatile Solid Daily Excretion	GEx(1-(DE/100)+(1-(UE*GE))x(1-(ASH/18.45))	148.10
Bo	CH4 Producing Potential	-	0.13
EF_{CH4}	EF	-	20
CH4 Emi	CH4 Emissions	L x EF_{CH4} x 10^-6	0.98
M	Method	-	T1
EF used	EF used	-	D
Nrate(T)	N excretion rate	-	0.42
Nex(T)	Annual N excretion per head	Nrate(T)*TAM*10^-3*365	84.32
$NE_{MMS\,1}$	Nitrogen Excretion - Pasture Range & Paddock	N_TxNex_TxMS1	829 120
$NE_{MMS\,2}$	Nitrogen Excretion - Daily Spread	N_TxNex_TxMS2	103 640
$NE_{MMS\,3}$	Nitrogen Excretion - Solid Storage	N_TxNex_TxMS3	2 487 360
$NE_{MMS\,4}$	Nitrogen Excretion - Dry Lot	N_TxNex_TxMS4	0
$NE_{MMS\,5}$	Nitrogen Excretion - Liquid/Slurry System	N_TxNex_TxMS5	725 480
$NE_{MMS\,6}$	Nitrogen Excretion - Burned for fuel	N_TxNex_TxMS7	0
$NE_{MMS\,7}$	Nitrogen Excretion - Anaerobic Lagoon	N_TxNex_TxMS8	0
$NE_{MMS\,8}$	Nitrogen Excretion - other AWMS	N_TxNex_TxMS9	0
$NE_{MMS\,9}$	Nitrogen Excretion - other AWMS	N_TxNex_TxMS10	0
$EF_{N2O\,MMS\,1}$	emission factors for direct N2O Emi from Pasture Range & Paddock	-	NA

CH4 and N2O emissions from 3.B Manure management			3.B.1-Dairy Cattle
$EF_{N2O\ MMS\ 2}$	emission factors for direct N2O Emi from Daily Spread	-	0
$EF_{N2O\ MMS\ 3}$	emission factors for direct N2O Emi from Solid Storage	-	0.005
$EF_{N2O\ MMS\ 4}$	emission factors for direct N2O Emi from Dry Lot	-	0.020
$EF_{N2O\ MMS\ 5}$	emission factors for direct N2O Emi from Liquid/Slurry	-	0.00
$EF_{N2O\ MMS\ 6}$	emission factors for direct N2O Emi from Burned for fuel	-	NA
$EF_{N2O\ MMS\ 7}$	emission factors for direct N2O Emi from Anaerobic Lagoon	-	0
$EF_{N2O\ MMS\ 8}$	emission factors for direct N2O Emi from Other AWMS	-	NA
$EF_{N2O\ MMS\ 9}$	emission factors for direct N2O Emi from Other AWMS	-	NA
$EMI_{N2O\ MMS\ 1}$	emission for direct N2O Emi from Pasture Range & Paddock	$NE_{MMS\ 1} x EF_{N2O\ MMS\ 1}$ x44/28	NA
$EMI_{2O\ MMS\ 2}$	emission for direct N2O Emi from Daily Spread	$NE_{MMS\ 2} x EF_{N2O\ MMS\ 2}$ x44/28	0.00
$EMI_{N2O\ MMS\ 3}$	emission for direct N2O Emi from Solid Storage	$NE_{MMS\ 3} x EF_{N2O\ MMS\ 3}$ x44/28	19 543.54
$EMI_{N2O\ MMS\ 4}$	emission for direct N2O Emi from Dry Lot	$NE_{MMS\ 4} x EF_{N2O\ MMS\ 4}$ x44/28	0.00
$EMI_{N2O\ MMS\ 5}$	emission for direct N2O Emi from Liquid/Slurry	$NE_{MMS\ 5} x EF_{N2O\ MMS\ 5}$ x44/28	0.00
$EMI_{N2O\ MMS\ 6}$	emission for direct N2O Emi from Burned for fuel	$NE_{MMS\ 6} x EF_{N2O\ MMS\ 6}$ x44/28	NA
$EMI_{N2O\ MMS\ 7}$	emission for direct N2O Emi from Anaerobic Lagoon	$NE_{MMS\ 7} x EF_{N2O\ MMS\ 7}$ x44/28	0.00
$EMI_{N2O\ MMS\ 8}$	emission for direct N2O Emi from Other AWMS	$NE_{MMS\ 8} x EF_{N2O\ MMS\ 8}$ x44/28	NA
$EMI_{N2O\ MMS\ 9}$	emission for direct N2O Emi from Other AWMS	$NE_{MMS\ 9} x EF_{N2O\ MMS\ 9}$ x44/28	NA
$N2O_{D(mm)}$	Direct N2O emissions from MM	sum ($EMI_{N2O\ MMS\ 1}$: $EMI_{N2O\ MMS\ 1}$) /1000000	0.020
M	Method	-	T1
EF used	EF used	-	D
$Frac_{gas\ MS\ 1}$	% of managed manure N for livestock that volatilises as NH3 and NOx in Pasture Range & Paddock	-	NA
$Frac_{gas\ MS\ 2}$	% of managed manure N for livestock that volatilises as NH3 and NOx in Daily Spread	-	7%
$Frac_{gas\ MS\ 3}$	% of managed manure N for livestock that volatilises as NH3 and NOx in Solid Storage	-	30%
$Frac_{gas\ MS\ 4}$	% of managed manure N for livestock that volatilises as NH3 and NOx in Dry Lot	-	20%
$Frac_{gas\ MS\ 5}$	% of managed manure N for livestock that volatilises as NH3 and NOx in Liquid/Slurry	-	40%
$Frac_{gas\ MS\ 6}$	% of managed manure N for livestock that volatilises as NH3 and NOx in Burned for fuel	-	NA
$Frac_{gas\ MS\ 7}$	% of managed manure N for livestock that volatilises as NH3 and NOx in Anaerobic Lagoon	-	35%
$Frac_{gas\ MS\ 8}$	% of managed manure N for livestock that volatilises as NH3 and NOx in Other AWMS	-	NA
$N_{volatilization-MMS\ 1}$	N volatilization - Pasture Range & Paddock	$NE_{MMS\ 1}$ x ($Frac_{gas\ mms\ 1}$ / 100)	NA
$N_{volatilization-MMS\ 2}$	N volatilization - Daily Spread	$NE_{MMS\ 2}$ x ($Frac_{gas\ mms\ 2}$ / 100)	72.55
$N_{volatilization-MMS\ 3}$	N volatilization - Solid storage	$NE_{MMS\ 3}$ x ($Frac_{gas\ mms\ 3}$ / 100)	7 462.08
$N_{volatilization-MMS\ 4}$	N volatilization - Dry Lot	$NE_{MMS\ 4}$ x ($Frac_{gas\ mms\ 4}$ / 100)	0.00
$N_{volatilization-MMS\ 5}$	N volatilization - Liquid/Slurry	$NE_{MMS\ 5}$ x ($Frac_{gas\ mms\ 5}$ / 100)	2 901.92
$N_{volatilization-MMS\ 6}$	N volatilization - Burned for fuel	$NE_{MMS\ 6}$ x ($Frac_{gas\ mms\ 6}$ / 100)	NA
$N_{volatilization-MMS\ 7}$	N volatilization - Anaerobic	$NE_{MMS\ 7}$ x ($Frac_{gas\ mms\ 7}$ / 100)	0.00
$N_{volatilization-MMS\ 8}$	N volatilization - Other AWMS	$NE_{MMS\ 8}$ x ($Frac_{gas\ mms\ 8}$ / 100)	NA
EF_4	emission factor for N2O emissions from atmospheric deposition of nitrogen on soils and water surfaces		0.01
$EMI_{in-N2O\ MMS\ 1}$	indirect N2O emission from Pasture, Range & Paddock	($N_{volatilization\ MS\ 1}$ x EF_4) x 44/28	NA

CH4 and N2O emissions from 3.B Manure management			3.B.1-Dairy Cattle
$EMI_{in\text{-}N2O\ MMS\ 1}$	indirect N2O emissions due to volatilization of N from Daily Spread	($N_{volatilization\ MS\ 2}$ x EF_4) x 44/28	1.14
$EMI_{in\text{-}N2O\ MMS\ 1}$	indirect N2O emissions due to volatilization of N from Solid Storage	($N_{volatilization\ MS\ 3}$ x EF_4) x 44/28	117.26
$EMI_{in\text{-}N2O\ MMS\ 1}$	indirect N2O emissions due to volatilization of N from Dry Lot	($N_{volatilization\ MS\ 4}$ x EF_4) x 44/28	0.00
$EMI_{in\text{-}N2O\ MMS\ 1}$	indirect N2O emissions due to volatilization of N from Liquid/Slurry	($N_{volatilization\ MS\ 5}$ x EF_4) x 44/28	45.60
$EMI_{in\text{-}N2O\ MMS\ 1}$	indirect N2O emissions due to volatilization of N from Burned for fuel	($N_{volatilization\ MS\ 6}$ x EF_4) x 44/28	NA
$EMI_{in\text{-}N2O\ MMS\ 1}$	indirect N2O Emissions due to volatilization of N from Anaerobic Lagoon	($N_{volatilization\ MS\ 7}$ x EF_4) x 44/28	0.00
$EMI_{in\text{-}N2O\ MMS\ 1}$	indirect N2O emissions due to volatilization of N from Other AWMS	($N_{volatilization\ MS\ 8}$ x EF_4) x 44/28	NA
$N2O_{G(mm)}$	indirect N2O emissions due to volatilization of N from manure management system	sum($EMI_{in\text{-}N2O\ MMS\ 1}$: $EMI_{in\text{-}N2O\ MMS\ 8}$) /1000000	0.000
M	Method	-	T1
EF used	EF used	-	D

In Montenegro it is not common to use dung as fuel. When estimating the $Nex_{(T)}$ for animals whose manure is classified in the manure management system burned for fuel, it should be kept in mind that the dung is burned and the urine stays in the field. As a rule of thumb, 50% of the nitrogen excreted is in the dung and 50% is in the urine. The default emission factors for direct N_2O emissions from Manure Management are provided in the following table.

5.3.3 Uncertainties and time-series consistency for IPCC sub-category 3.B Manure management

The uncertainties for activity data and emission factors used for IPCC category 3.B *Manure management* are presented in the following table.

Table 325 Uncertainty for IPCC sub-category 3.B Manure management.

Uncertainty	CH_4	N_2O	N_2O	Reference
				2006 IPCC GL, Vol. 4, Chap. 10
Activity data: Livestock	20%	20%	20%	Chapter 10.2.3
Activity data: Manure Management System Usage	38%	38%	38%	Chapter 10.4.4
Emission factor	30%			Chapter 10.4.4
Emission factor (direct emission)		250%		Chapter 10.4.4
Emission factor (indirect emission)			50%	Chapter 10.4.4
Combined Uncertainty	52%	254%	502%	$U_{Total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

5.3.4 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
  - o consistent use of livestock data (statistical yearbook and FAOstat- Live Animals),
  - o documented sources,
  - o use of units,
  - o strictly defined interfaces between spreadsheets/calculation modules,
  - o unique structure of sheets which do the same,
  - o record keeping, use of write protection,
  - o unique use of formulas, special cases are documented/highlighted,
  - o quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from different sources: national statistic (Monstat, Agricultural Census 2003) and international statistics (FAO)

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ consistency and completeness checks are performed;

⇒ time series consistency - plausibility checks of dips and jumps.

5.3.5 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission (NC & BUR) to the UNFCCC and relevant to IPCC category 3.B *Manure management*.

Table 326 Recalculations done in IPCC category 3.B *Manure management*

GHG source & sink category	Revisions of data ⇒ submission 2020	Type of revision	Type of improvement
3.B	No recalculation were performed	method	Comparability

5.3.6 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 327 Planned improvements for IPCC category 3.B *Manure management*

GHG source & sink category	Planned improvement	Type of improvement		Priority
3.A.2	Correction of technical mistakes in calculation	AD, EF	Completeness	high
3.A. 3.B. 3.D.	Husbandry and Management Practice with consideration • characteristics of Livestock Husbandry for the whole time series: o breed, o age distribution, o weight o milk wool yield, o wool yield, o working hours • characteristics of manure management practice: o stall / housed and Housing period o pasture/range/paddock (flat/hilly) o grazing large areas (flat/hilly) o daily spread o solid storage o dry lot o liquid/slurry with/without natural crust cover o uncovered anaerobic lagoon o pit storage below animal confinements o anaerobic digester o burned for fuel o cattle and swine deep bedding o composting o aerobic treatment	AD	Accuracy Consistency Comparability Transparency Completeness	high
3.A. 3.B.	Manure management by temperature for sheep, goats, horses, mules, and asses, and poultry	AD	Accuracy Comparability Transparency	medium
3.A.2	Estimation of methane emissions applying TIER 2 approach as these sub-categories are key categories	method	Transparency Comparability	high
3.A.1.j 3.B. 3.D	Survey and/or research on Livestock which is not included in current statistics: e.g. buffalo, fur bearing animals	AD	Completeness	Medium
3.B	Survey and/or research on VS excretion rates		Accuracy	medium

5.4 Rice cultivation (IPCC category 3.C)

The IPCC category 3.C *Rice cultivation* does not exist in Montenegro.

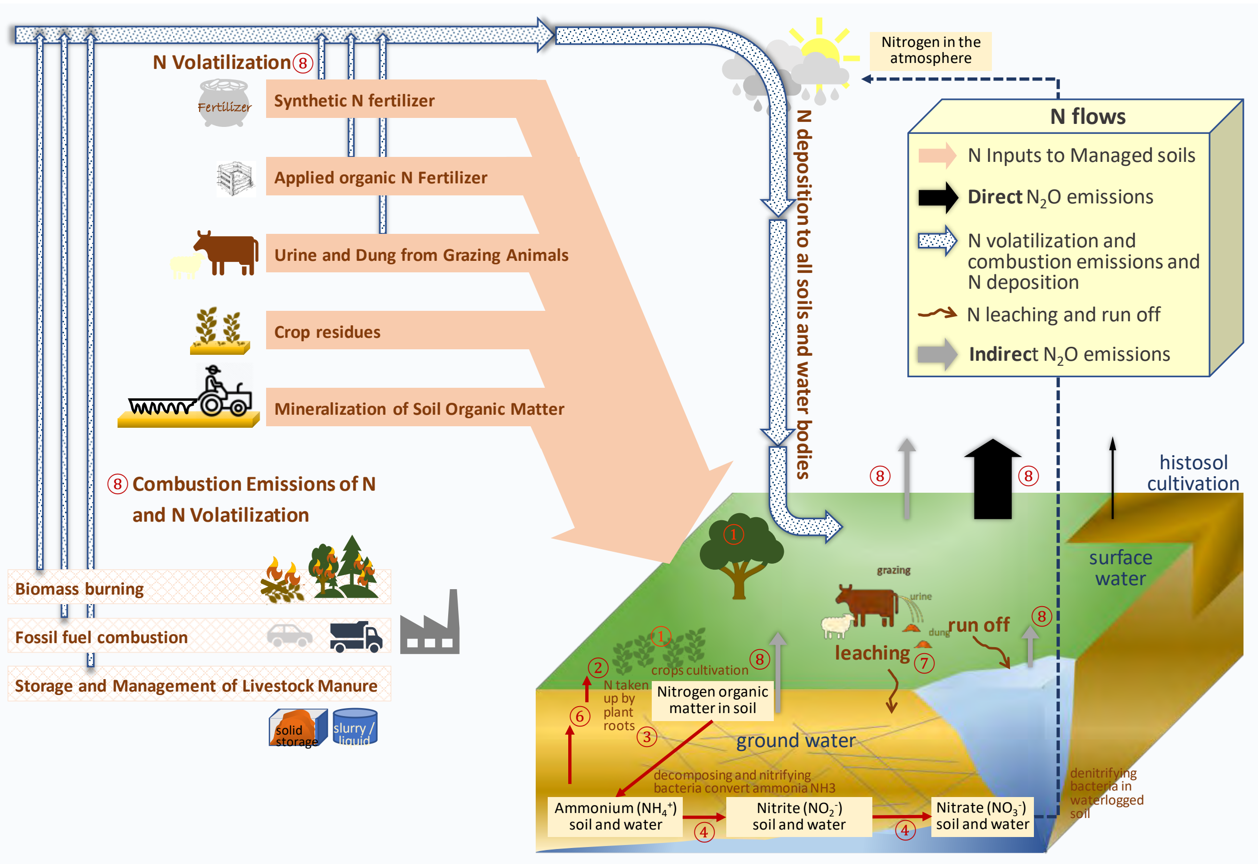
5.5 Agricultural soils (IPCC category 3.D)

This section describes the estimation of nitrous oxide emissions from managed soils due to nitrogen input, including indirect N_2O emissions from additions of N to land due to deposition and leaching. As defined in 2006 IPCC GL, Vol. 4, Chap. 1.1 managed land is land where human interventions and practices have been applied to perform production, ecological or social functions. The emissions of N_2O that result from anthropogenic N inputs or N mineralization occur through both:

- direct pathway: directly from the soils to which the N is added/released
- indirect pathways: (i) following volatilization of NH_3 and NO_x from managed soils and from fossil fuel combustion and biomass burning, and the subsequent redeposition of these gases and their products NH_4^+ and NO_3^- to soils and waters; and

  (ii) after leaching and runoff of N, mainly as NO_3^-, from managed soils.

The principal pathways are illustrated in the following figure. Direct emissions of N_2O from managed soils are estimated separately from indirect emissions, though using a common set of activity data.



The nitrogen cycle: (1) uptake of nitrogen by plants from the atmosphere: (2) uptake of ammonium and nitrate by plants from soil and water: nitrogen-fixing bacteria in humus and in root nodules of leguminous plants (3) ammonification, (4) nitrification, (5) denitrification, (6) nitrate immobilization by soil sorption, (7) nitrate leaching from the soil, (8) release of ammonia (NH3), gaseous nitrogen and nitrous oxide to the atmosphere.

Figure 147 Schematic diagram illustrating the sources and pathways of N that result in direct and indirect N_2O emissions from soils and waters

Source: After (1) 2006 IPCC Guidelines, Volume 4, Chapter 11, Figure 11.1, page 11.8. and
(2) Bednarek, A.; Szklarek, S. & Zalewski, M. (2014): Nitrogen pollution removal from areas of intensive farming—comparison of various denitrification biotechnologies. In: Ecohydrology & Hydrobiology 14 (2014) 132–141.

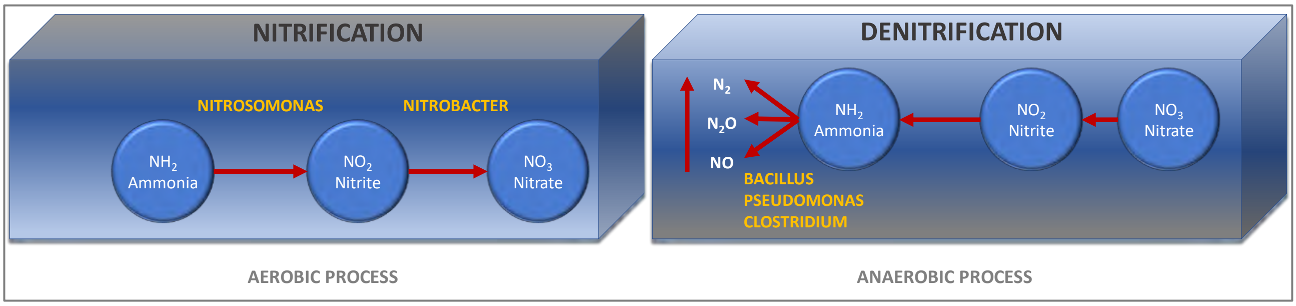


Figure 148 Nitrification and Denitrification

As described in Chapter 5.3 and in Figure 144 the N_2O emissions generated by manure in the

- system "livestock housing and holding areas" and "manure storage" are reported under the category

  ⇒ 3.B Manure management

- system 'pasture, range, and paddock' occur directly and indirectly from the soil, and are therefore reported under the category

  ⇒ 3.D.a *Direct N_2O emissions from managed soils*

  ⇒ 3.D.a.2 *Organic N fertilizers*

  ⇒ *3.D.a.2.a Animal manure applied to soils*

  ⇒ 3.D.b *IndirectN$_2$O Emissions from managed soils*

Beyond that further 'man-made' nitrogen applied to the soil are synthetic fertilizer application, crop residues, and mineralization of soil organic matter. Through nitrogen vitalization and combustion emissions of N from fossil fuels from all nitrogen sources a 'nitrogen stock in the atmosphere' is formed also depending of the amount and characteristics of the N-inputs.

The deposition of nitrogen (N) to soils and water bodies result from

- Nitrogen vitalization from
  - synthetic fertilizer application
  - application of organic N fertilizer
  - urine and dung from grazing animals
  - crop residues
  - mineralization of soil organic matter
- Nitrogen vitalization and combustion emission of N from
  - biomass burning
  - fossil fuel combustion
  - storage and management of livestock manure

5.5.1 Source category description

IPCC code	Description	Description	CO_2		CH_4		N_2O	
			Estimated	**Key Category**	**estimated**	**Key category**	**estimated**	**Key category**
3.D	**Manure Management**							
3.D.1	**Direct N_2O emissions from managed soils**			-		-		-
3.D.1.a	Inorganic N fertilizers	N input from application of inorganic fertilizers to cropland and grassland	NA	-	NA	-	✓	-
3.D.1.b	Organic N fertilizers	N input from organic N fertilizers to cropland and grassland	NA	-	NA	-	✓	-
3.D.1.b.i	Animal manure applied to soils	N input from manure applied to soils	NA	-	NA	-	✓	-
3.D.1.b.ii	Sewage sludge applied to soils	N input from sewage sludge applied to soils	NA	-	NA	-	NE	-
3.D.1.b.iii	Other organic fertilizers applied to soils	N input from application of other organic fertilizers	NA	-	NA	-	✓	-
3.D.1.b	Urine and dung deposited by grazing animals	N excretion on pasture, range and paddock	NA	-	NA	-	✓	-
3.D.1.a	Crop residues	N in crop residues returned to soils	NA	-	NA	-	✓	-
3.D.1.e	Mineralization/ immobiliza-tion associated with loss/gain of soil organic matter	N in mineral soils that is mineralized in association with loss of soil C	NA	-	NA	-	NO	-
3.D.1.f	Cultivation of organic soils	Area of cultivated organic soils (i.e, histosols)	NA	-	NA	-	NO	-
3.D.1.g	Other		NA	-	NA	-	NO	
3.D.b	**Indirect N_2O Emissions from managed soils**							
3.D.b.1	Atmospheric deposition	Volatilized N from agricultural inputs of N	NA	-	NA	-	NE	-
3.D.b.2	Nitrogen leaching and run-off	N from fertilizers and other agricultural inputs that is lost through leaching and run-off	NA	-	NA	-	NE	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential								
LA – Level Assessment (in year); TA – Trend Assessment								

N_2O emissions from IPCC category 3.D.1. Direct N2O emissions from managed soils amounted to 0.271 kt N2O in 1990 and 0.133 kt N_2O in 2020, which is a decrease of -51.0% due to

- decreased amount of manure from increased number of livestock,
- increased amount of inorganic fertilizer applied,
- area for crop production which implicates increased.

Table 328 N_2O emissions from IPCC category 3.D.1 *Direct N_2O emissions from managed soils*

N_2O	3.D.1	3.D.1.a	3.D.1.b	3.D.1.b.i	3.D.1.b.ii	3.D.1.b.iii	3.D.1.c	3.D.1.d
	Direct N_2O emissions from managed soils	Inorganic N fertilizers	Organic N fertilizers	Animal manure applied to soils	Sewage sludge applied to soils	Other organic fertilizers applied to soils	Urine and dung deposited by grazing animals	Crop residues
	N input from application of inorganic fertilizers to cropland and grassland	N input from organic N fertilizers to cropland and grassland	N input from manure applied to soils	N input from sewage sludge applied to soils	N input from application of other organic fertilizers	N excretion on pasture, range and paddock	N in crop residues returned to soils	N input from application of inorganic fertilizers to cropland and grassland
	kt	kt	kt	kt	kt	kt	kt	kt
1990	**0.271**	0.009	0.109	0.109	NE	NO	0.153	0.0006
1991	**0.268**	0.009	0.109	0.109	NE	NO	0.150	0.0006
1992	**0.252**	0.009	0.102	0.102	NE	NO	0.141	0.0006
1993	**0.239**	0.007	0.097	0.097	NE	NO	0.134	0.0006
1994	**0.244**	0.008	0.099	0.099	NE	NO	0.137	0.0007
1995	**0.260**	0.014	0.102	0.102	NE	NO	0.143	0.0008
1996	**0.263**	0.018	0.102	0.102	NE	NO	0.143	0.0007
1997	**0.260**	0.020	0.100	0.100	NE	NO	0.139	0.0008
1998	**0.258**	0.017	0.101	0.101	NE	NO	0.139	0.0008
1999	**0.257**	0.015	0.102	0.102	NE	NO	0.139	0.0007
2000	**0.258**	0.016	0.101	0.101	NE	NO	0.141	0.0006
2001	**0.263**	0.022	0.101	0.101	NE	NO	0.139	0.0008
2002	**0.268**	0.021	0.103	0.103	NE	NO	0.143	0.0008
2003	**0.255**	0.018	0.102	0.102	NE	NO	0.134	0.0006
2004	**0.272**	0.034	0.101	0.101	NE	NO	0.136	0.0009
2005	**0.198**	0.031	0.069	0.069	NE	NO	0.097	0.0008
2006	**0.186**	0.027	0.065	0.065	NE	NO	0.092	0.0015
2007	**0.172**	0.022	0.062	0.062	NE	NO	0.088	0.0002
2008	**0.166**	0.021	0.060	0.060	NE	NO	0.084	0.0003
2009	**0.156**	0.017	0.058	0.058	NE	NO	0.080	0.0003
2010	**0.156**	0.021	0.057	0.057	NE	NO	0.077	0.0003
2011	**0.133**	0.018	0.049	0.049	NE	NO	0.065	0.0004
2012	**0.139**	0.020	0.053	0.053	NE	NO	0.066	0.0004
2013	**0.147**	0.022	0.055	0.055	NE	NO	0.069	0.0005
2014	**0.148**	0.021	0.056	0.056	NE	NO	0.071	0.0005
2015	**0.148**	0.020	0.056	0.056	NE	NO	0.071	0.0005
2016	**0.151**	0.021	0.059	0.059	NE	NO	0.071	0.0006
2017	**0.146**	0.016	0.059	0.059	NE	NO	0.070	0.0006
2018	**0.143**	0.020	0.056	0.056	NE	NO	0.067	0.0006
2019	**0.139**	0.020	0.054	0.054	NE	NO	0.065	0.0005
2020	**0.134**	0.020	0.051	0.051	NE	NO	0.062	0.0006
2021	**0.133**	0.030	0.047	0.047	NE	NO	0.056	0.0005
Trend								
1990 - 2021	*-51.0%*	*244.9%*	*-57.1%*	*267.7%*	*NA*	*NA*	*-63.4%*	*-13.5%*
2005 - 2021	*-32.7%*	*-2.9%*	*-31.9%*	*37.7%*	*NA*	*NA*	*-42.7%*	*-31.3%*
2020 - 2021	*-0.5%*	*50.9%*	*-8.7%*	*1.5%*	*NA*	*NA*	*-10.0%*	*-2.9%*

5.5.2 Direct N_2O emissions (IPCC category 3.D.a)

The following sources are included in IPCC category 3.D.a *Direct N_2O emissions from managed soils.*

3.D.a	Direct N_2O emissions from managed soils	
3.D.a.1	Inorganic N fertilizers	N input from application of inorganic fertilizers to cropland and grassland
3.D.a.2	Organic N fertilizers	N input from organic N fertilizers to cropland and grassland
3.D.a.2.a	Animal manure applied to soils	N input from manure applied to soils
3.D.a.2.b	Sewage sludge applied to soils	N input from sewage sludge applied to soils
3.D.a.2.c	Other organic fertilizers applied to soils	N input from application of other organic fertilizers
3.D.a.3	Urine and dung deposited by grazing animals	N excretion on pasture, range and paddock
3.D.a.4	Crop residues	N in crop residues returned to soils
3.D.a.5	Mineralization/ immobilization associated with loss/gain of soil organic matter	N in mineral soils that is mineralized in association with loss of soil C
3.D.a.6	Cultivation of organic soils (i.e. histosols)	Area of cultivated organic soils
3.D.a.7	Other	

5.5.2.1 Methodological issues

5.5.2.1.1 Choice of methods

For estimating the direct N_2O emissions from managed soils the 2006 IPCC Guidelines Tier 1 approach[104] has been applied.

TIER 1 approach – direct N_2O emissions from managed soils

The Tier 1 method (Equation 11.1) entails adding up the

- annual direct N_2O–N emissions produced from managed soils (kg N_2O–N)
- annual direct N_2O–N emissions from N inputs to managed soils (kg N_2O–N)
- annual direct N_2O–N emissions from managed organic soils (kg N_2O–N)
- annual direct N_2O–N emissions from urine and dung inputs to grazed soils (kg N_2O–N)

and converting the N_2O–N emissions to N_2O emissions for reporting purposes.

Equation: Conversion N_2O emissions from of N_2O–N emissions (2006 IPCC GL, Vol. 4, Chap. 11)

$$N_2O\ emissions_{direct} = N_2O - N \times \frac{44}{28}$$

Equation 11.1: Direct N_2O emissions from managed soils

$$N_2O\ emissions_{direct} - N = N_2O - N_{N\ inputs} + N_2O - N_{OS} + N_2O - N_{PRP}$$

Where:

N_2O emissions $_{direct}$ = direct N_2O emissions from managed soils (kg N_2O)

N_2O_{Direct} –N = annual direct N_2O–N emissions produced from managed soils (kg N_2O–N)

N_2O–$N_{N\ inputs}$ = annual direct N_2O–N emissions from N inputs to managed soils (kg N_2O–N)

N_2O–N_{OS} = annual direct N_2O–N emissions from managed organic soils (kg N_2O–N)

N_2O–N_{PRP} = annual direct N_2O–N emissions from urine and dung inputs to grazed soils (kg N_2O–N) with PRP = pasture, range and paddock

[104] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 11: N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application, sub-chap 11.2.1.1 Choice of method. Page 11.6.

Equation 11.1: Direct N_2O emissions from managed soils (2006 IPCC GL, Vol. 4, Chap. 11)[105]

$$N_2O\ emissions_{direct} - N = N_2O - N_{N\ inputs} + N_2O - N_{OS} + N_2O - N_{PRP}$$

Where

Annual direct N_2O–N emissions from N inputs to managed soils **(11.1.a)**

$$N_2O - N_{N\ inputs} = \begin{bmatrix} [(F_{SN} + F_{ON} + F_{CR} + F_{SOM}) \times EF_1] + \\ [(F_{SN} + F_{ON} + F_{CR} + F_{SOM})_{FR} \times EF_{1FR}] \end{bmatrix}$$

Annual direct N_2O–N emissions from managed organic soils **(11.1.b)**

$$N_2O - N_{OS} = \begin{bmatrix} (F_{OS,CG,Temp} \times EF_{2CG,Temp}) + (F_{OS,CG,Trop} \times EF_{2CG,Trop}) + \\ (F_{OS,F,Temp,NR} \times EF_{2F,Temp,NR}) + (F_{OS,F,Temp,NP} \times EF_{2F,Temp,NP}) \\ +(F_{OS,F,Trop} \times EF_{2F,Trop}) \end{bmatrix}$$

Annual direct N_2O–N emissions from urine and dung inputs to grazed soils **(11.1.c)**

$$N_2O - N_{PRP} = [(F_{PRP,CPP} \times EF_{3PRP,CPP}) + (F_{PRP,SO} \times EF_{3PRP,SO})]$$

Where:

- N_2O emissions $_{direct}$ = direct N_2O emissions from managed soils (kg N_2O)
- N_2O_{Direct} –N = annual direct N_2O–N emissions produced from managed soils (kg N_2O–N)
- N_2O–$N_{N\ inputs}$ = annual direct N_2O–N emissions from N inputs to managed soils (kg N_2O–N)
- N_2O–N_{OS} = annual direct N_2O–N emissions from managed organic soils (kg N_2O–N)
- N_2O–N_{PRP} = annual direct N_2O–N emissions from urine and dung inputs to grazed soils (kg N_2O–N) with PRP = pasture, range and paddock
- F_{SN} = annual amount of synthetic fertiliser N applied to soils (kg N)
- F_{ON} = annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils
- F_{CR} = annual amount of N in crop residues (above-ground and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils, kg N yr^{-1}
- F_{SOM} = annual amount of N in mineral soils that is mineralised, in association with loss of soil C from soil organic matter as a result of changes to land use or management, kg N yr^{-1}
- F_{OS} = annual area of managed/drained organic soils, ha
  (Note: the subscripts CG, F, Temp, Trop, NR and NP refer to Cropland and Grassland, Forest Land, Temperate, Tropical, Nutrient Rich, and Nutrient Poor, respectively)
- F_{PRP} = annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr^{-1} (Note: the subscripts CPP and SO refer to Cattle, Poultry and Pigs, and Sheep and Other animals, respectively)
- EF_1 = emission factor for N_2O emissions from N inputs, kg N_2O–N (kg N input)$^{-1}$
- EF_{1FR} = emission factor for N_2O emissions from N inputs to flooded rice, kg N_2O–N (kg N input)$^{-1}$
- EF_2 = emission factor for N_2O emissions from drained/managed organic soils, kg N_2O–N ha-1 yr^{-1}
  (Note: the subscripts CG, F, Temp, Trop, NR and NP refer to Cropland and Grassland, Forest Land, Temperate, Tropical, Nutrient Rich, and Nutrient Poor, respectively)
- $EF_{3\ PRP}$ = emission factor for N_2O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals, kg N_2O–N (kg N input)$^{-1}$;
  (Note: the subscripts CPP and SO refer to Cattle, Poultry and Pigs, and Sheep and Other animals, respectively)

[105] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 11: N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application, sub-chap 11.2.1.1 Choice of method. Equation 11.1 direct N_2O emissions from managed soils (TIER 1). Page 11.7.

For better understanding the processes in soil and crust the following figures provide simplified illustration of nitrogen (N) transactions

• between the atmosphere and liquid manure with emphasis on critical processes involved in the emission of gases	Figure 149
• the atmosphere and the soil with emphasis on agronomic aspects related to plant fertilization and the reactions involved in the formation and emission of nitrous oxide (direct and indirect).	Figure 150

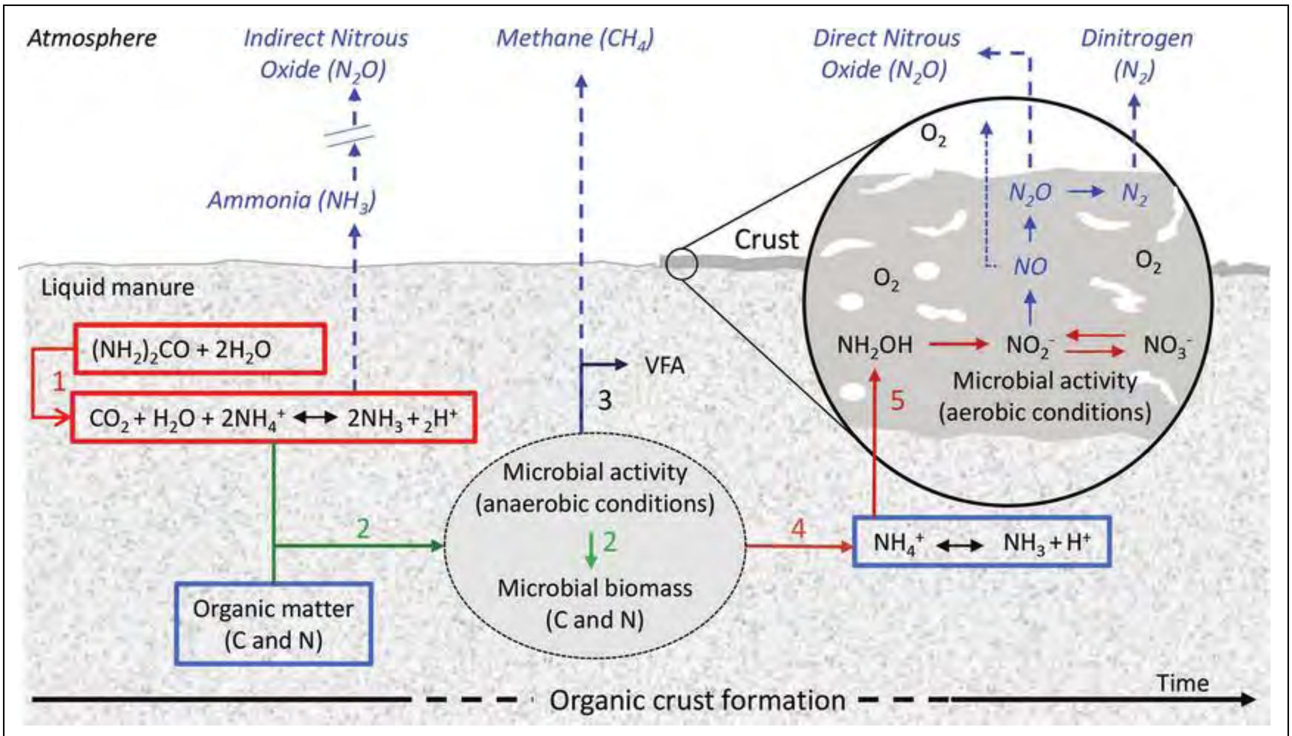


Figure 149 Simplified illustration of N transactions between the atmosphere and liquid manure with emphasis on critical processes involved in the emission of gases

Simplified illustration of N transactions between the atmosphere and liquid manure (data from Aguerre et al., 2012), with emphasis on critical processes involved in the emission of gases: (1) hydrolysis of urinary urea-N (giving rise to ammonia, which after emission and deposition on soils contributes to indirect nitrous oxide emission), microbial fermentation of OM under anaerobic conditions (giving rise to methane) associated with (2) microbial growth, (3) acidification of the medium through the formation of VFA, and (4) ammonia formation from the degradation of N-containing organic compounds. In addition, when an organic crust formed (5), the nitrification of ammonium under aerobic conditions was responsible for nitrous oxide and presumably dinitrogen emissions.

Nitrogen-containing structures are as follows:

$(NH_2)_2CO$ = urea; NH_4^+ = ammonium; NH_3 = ammonia; NH_2OH = hydroxylamine; NO_2^- = nitrite; NO_3^- = nitrate; NO = nitric oxide (emitted gas); N_2O = nitrous oxide; N_2 = dinitrogen.

Source: WATTIAUX, M. A.; PAS, UDDIN, M. E. ; LETELIER, P., JACKSON, R. D. & LARSON, R. A. (2019): Emission and mitigation of greenhouse gases from dairy farms: The cow, the manure, and the field. In: Applied Animal Science 35:238–254. Sustainability and Integrated Systems. https://doi.org/10.15232/aas.2018-01803

Available on 29.04.2019 at: https://www.researchgate.net/publication/331916870_Invited_Review_Emission_and_mitigation_of_greenhouse_gases_from_dairy_farms_The_cow_the_manure_and_the_field

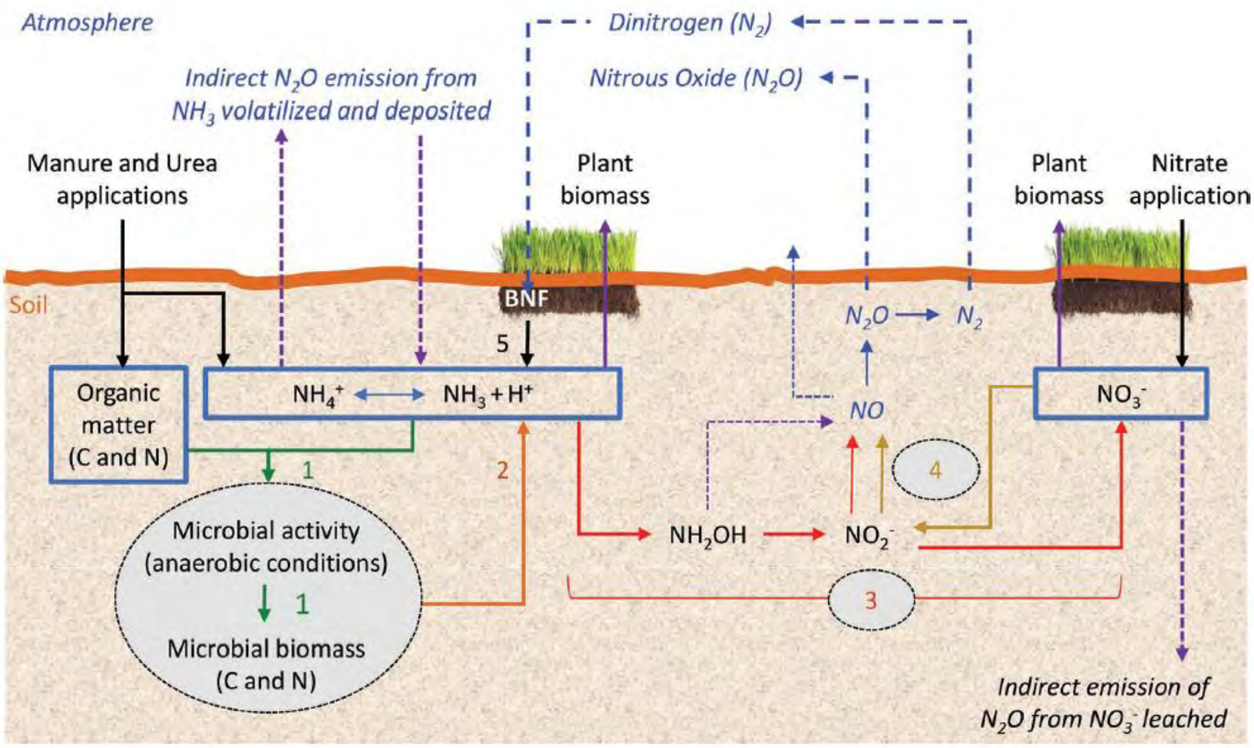


Figure 150 Simplified illustration of N transactions between the atmosphere and the soil with emphasis on agronomic aspects related to plant fertilization and the reactions involved in the formation and emission of nitrous oxide (direct and indirect)

Simplified illustration of N transactions between the atmosphere and the soil with emphasis on agronomic aspects related to plant fertilization and the reactions involved in the formation and emission of nitrous oxide (direct and indirect). Different types of arrows are used to identify the main transformations associated with (1) immobilization, (2) mineralization, (3) nitrification, (4) denitrification, and (5) biological nitrogen fixation (BNF) by legumes.

Nitrogen-containing structures are as follows:

N_2 = dinitrogen; NH_3 = ammonia; $NH4^+$ = ammonium; NH_2OH = hydroxylamine;

NO = nitric oxide (emitted gas); NO_2^- = nitrite; NO_3^- = nitrate; N_2O = nitrous oxide

Source: WATTIAUX, M. A.; PAS, UDDIN, M. E. ; LETELIER, P., JACKSON, R. D. & LARSON, R. A. (2019): Emission and mitigation of greenhouse gases from dairy farms: The cow, the manure, and the field. In: Applied Animal Science 35:238–254. Sustainability and Integrated Systems. https://doi.org/10.15232/aas.2018-01803

Available on 29.04.2019 at: https://www.researchgate.net/publication/331916870_Invited_Review_Emission_and_mitigation_of_greenhouse_gases_from_dairy_farms_The_cow_the_manure_and_the_field

5.5.2.1.2 Choice of activity data (AD) and emission factor (EF)

In the following subchapters/sections the activity data (AD) and emission factors (EF) as well as the emission calculations and results are presented separately for each N input from

1) Applied synthetic fertilizer (F_{SN})	$N_2O - N_{N\,inputs} = \begin{bmatrix} [(F_{SN}) \times EF_1] + \\ [(F_{SN})_{FR} \times EF_{1FR}] \end{bmatrix}$ *See above equation 11.1.a*[105]
2) Applied organic N fertilizer (F_{ON})	$N_2O - N_{N\,inputs} = \begin{bmatrix} [(F_{ON}) \times EF_1] + \\ [(F_{ON})_{FR} \times EF_{1FR}] \end{bmatrix}$ *See above equation 11.1.a*[105]
3) annual amount of N in crop residues, including N-fixing crops, and from forage/pasture renewal, returned to soils (F_{CR})	$N_2O - N_{N\,inputs} = \begin{bmatrix} [(F_{CR}) \times EF_1] + \\ [(F_{CR})_{FR} \times EF_{1FR}] \end{bmatrix}$ *See above equation 11.1.a*[105]
4) Mineralised N resulting from loss of soil organic C stocks in mineral soils through land-use change or management practices (F_{SOM})	$N_2O - N_{N\,inputs} = \begin{bmatrix} [(F_{SOM}) \times EF_1] + \\ [(F_{SOM})_{FR} \times EF_{1FR}] \end{bmatrix}$ *See above equation 11.1.a*[105]

5) Area of drained/managed organic soils (F_{OS})	*See above equation 11.1.b*[105]
6) Urine and dung from grazing animals (F_{PRP})	*See above equation 11.1.c*[105]

5.5.2.1.2.1 AD and calculation for *N Input from Applied synthetic fertilizer (F_{SN})*

Activity data, parameter and emission calculation for *N Input from Applied synthetic fertilizer (F_{SN})*

The data of annual amount of applied synthetic fertilizer (F_{SN}) consumption is taken from international source: FAO agricultural data base on synthetic fertilizer consumption[106].

The information on fertilizer consumption / distribution of the Montenegro Statistical yearbook was used only for crosscheck.

Default emission factors (EF_1) and (EF_{1FR}) were taken from Table 11.1 of 2006 IPCC Guidelines, Vol. 4, Chap. 11[107] and are presented in the following table.

[106] http://www.fao.org/faostat/en/#data

[107] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 11: N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application, sub-chap 11.2.1.2 Choice of emission factor. Table 11.1. Page 11.11.

Table 329 Default emission factors to estimate direct N_2O emissions from managed soils

Emission factor		N_2O (kg N_2O–N (kg N)$^{-1}$)		Source
		EF	type	2006 IPCC Guidelines Vol. 4, Chap. 11 (11.2.1.2)
EF_1 for N additions from mineral fertilizers, organic amendments and crop residues, and N mineralized from mineral soil as a result of loss of soil carbon	EF_1	0.01	D	**Table 11.1** Default emission factors to estimate direct N_2O emissions from managed soils (page 11.11)

Note:

D	Default	CS	Country specific	PS	Plant specific	IEF	Implied emission factor

With the Equation 11.1.a (see also in section 5.5.2.1.1 Choice of methods) and the equation for conversion N_2O-N tot N_2O the N_2O emissions from N inputs to managed soils

Annual direct N_2O–N emissions from N inputs to managed soils (2006 IPCC GL, Vol. 4, Chap. 11)[105]

$$N_2O - N_{N\,inputs} = [[(F_{SN}) \times EF_1] + [(F_{SN})_{FR} \times EF_{1FR}]] \qquad \textbf{(11.1.a)}$$

$$N_2O\ emissions_{direct} = N_2O - N \times \frac{44}{28}$$

Table 330 Annual amount of applied synthetic fertilizer (IPCC category 3.D.1.a. Inorganic N fertilizers)

	Nutrient nitrogen N (total)				
	Agricultural Use	Production	Import Quantity	Export Quantity	Source
	t	t	t	t	
1990	549.39	NO	549.39	NO	FAO database
1991	549.39	NO	549.39	NO	
1992	549.39	NO	549.39	NO	
1993	414.16	NO	414.16	NO	
1994	493.04	NO	493.04	NO	
1995	908.61	NO	908.61	NO	
1996	1 130.48	NO	1 130.48	NO	
1997	1 303.05	NO	1 303.05	NO	
1998	1 084.70	NO	1 084.70	NO	
1999	972.71	NO	972.71	NO	
2000	1 020.60	NO	1 020.60	NO	
2001	1 423.49	NO	1 423.49	NO	
2002	1 354.94	NO	1 354.94	NO	
2003	1 176.84	NO	1 176.84	NO	
2004	2 144.25	NO	2 144.25	NO	
2005	1 950.71	NO	1 950.71	NO	
2006	1 738.00	NO	1 738.00	NO	
2007	1 389.00	NO	1 389.00	NO	
2008	1 319.00	NO	1 319.00	NO	
2009	1 089.00	NO	1 089.00	NO	
2010	1 360.00	NO	1 360.00	NO	
2011	1 166.00	NO	1 166.00	NO	
2012	1 275.63	NO	1 275.63	NO	
2013	1 414.34	NO	1 414.34	NO	
2014	1 324.68	NO	1 324.68	NO	
2015	1 287.83	NO	1 287.83	NO	
2016	1 323.69	NO	1 323.69	NO	
2017	1 043.97	NO	1 043.97	NO	
2018	1 255.46	NO	1 255.46	NO	
2019	1 255.46	NO	1 255.46	NO	
2020	1 255.46	NO	1 255.46	NO	

5.5.2.1.2.2 AD and calculation for N Input from *Applied organic N fertilizer (F_{ON})*

Activity data, parameter and emission calculation for N Input from *Applied organic N fertilizer (F_{ON})*

The data of annual amount of applied organic fertilizer (F_{ON}) is calculated according the following equation taken from 2006 IPCC Guidelines, Vol. 4, Chap. 11[108] .

Equation 11.3: N from organic N additions applied to soils (TIER 1) (2006 IPCC GL, Vol. 4, Chap. 11) [108]

$$F_{ON} = F_{AM} + F_{SEW} + F_{COMP} + F_{OOA}$$

Where:

F_{ON} = total annual amount of organic N fertiliser applied to soils other than by grazing animals (kg N yr^{-1})

F_{AM} = annual amount of animal manure N applied to soils (kg N yr^{-1})

F_{SEW} = annual amount of total sewage N (coordinate with Waste Sector to ensure that sewage N is not double-counted) that is applied to soils (kg N yr^{-1})

F_{COMP} = annual amount of total compost N applied to soils (ensure that manure N in compost is not double-counted), kg N yr^{-1}

F_{OOA} = annual amount of other organic amendments used as fertiliser (e.g., rendering waste, guano, brewery waste, etc.) (kg N yr^{-1})

F_{AM} - annual amount of animal manure N applied to soils

The term F_{AM} is determined by adjusting the amount of manure N available (N_{MMS_Avb}) for the amount of

- managed manure used for feed ($Frac_{FEED}$),
- burned for fuel ($Frac_{FUEL}$), or
- used for construction ($F_{racCNST}$)

Equation 11.4: N from animal manure applied to soils (TIER 1)
(2006 IPCC GL, Vol. 4, Chap. 11)[109]

$$F_{AM} = N_{MMS\ Avb} \times [1 - (Frac_{Feed} + Frac_{Fuel} + Frac_{CNST})]$$

Where:

F_{AM} = annual amount of animal manure N applied to soils (kg N yr^{-1})

N_{MMS_Avb} = amount of managed manure N available for soil application, feed, fuel or construction, (kg N yr^{-1}) *(Equation 10.34 in Chapter 10 of Vol. 4 of 2006 IPCC GL[110])*

$Frac_{FEED}$ = fraction of managed manure used for feed

$Frac_{FUEL}$ = fraction of managed manure used for fuel

$Frac_{CNST}$ = fraction of managed manure used for construction

[108] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 11: N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application, sub-chap 11.2.1.3 Choice of activity data. Page 11.13.

[109] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10: N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application. Sub-chap. 11.2.1.3. Equation 11.4. Page 11.13.

[110] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10: Emissions from Livestock and Manure Management, sub-chap. 10.5.4 Coordination with reporting for N_2O emissions from managed soils. Page 10.64.

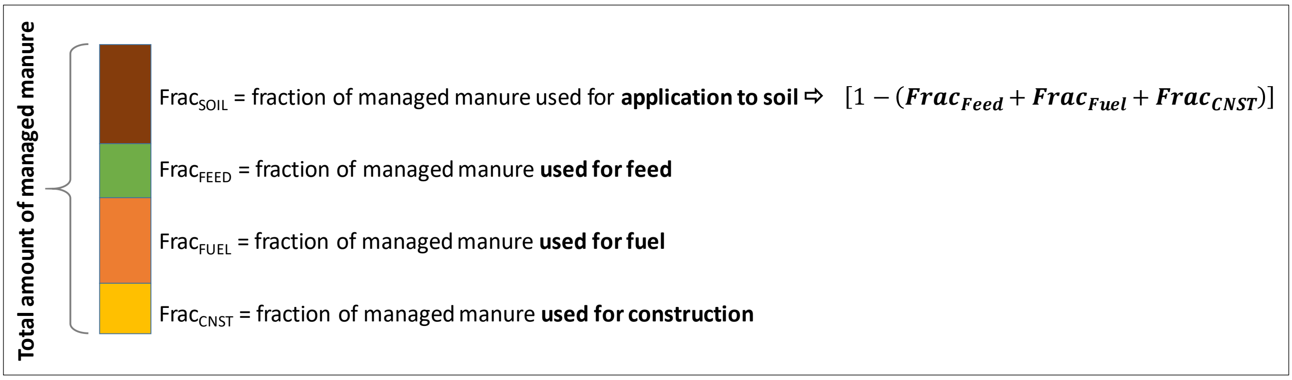


Figure 151 Fraction of of managed animal manure used for different purposes.

Data for $Frac_{FUEL}$, $Frac_{FEED}$, $Frac_{CNST}$ was not available therefore N_{MMS_Avb} was used as F_{AM} without adjusting for $Frac_{FUEL}$, $Frac_{FEED}$, $Frac_{CNST}$, which is also proposed by 2006 IPCC GL**Error! Bookmark not defined.**.

Finally, the managed manure nitrogen available for

- (a) application to managed soils,
- (b) for use in feed, fuel, or construction purposes (assumed be 0)

is estimated according to Equation 10.34 of Vol. 4 of 2006 IPCC GL[110].

Equation 10.34: Managed manure N available for application to managed soils, feed, fuel or construction uses (2006 IPCC GL, Vol. 4, Chap. 10.5.4)

$$N_{NMS\_Avb}=\sum_{S}\left\{\sum_{(T)}\left[\left[\left(N_{(T)}\times Nex_{(T)}\times MS_{(T,S)}\right)\times\left(1-\frac{Frac_{LossMS}}{100}\right)\right]+\left[N_{(T)}\times MS_{(T,S)}\times N_{beddingMS}\right]\right]\right\}$$

Where:

$NMMS_{\_Avb}$ = amount of managed manure nitrogen available for application to managed soils or for feed, fuel, or construction purposes (kg N yr^{-1})

$N_{(T)}$ = number of head of livestock species/category T

$Nex_{(T)}$ = annual average N excretion per animal of species/category T (kg N animal^{-1} $^{yr-1}$)

$MS_{(T,S)}$ = fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S, dimensionless

$Frac_{LossMS}$ = amount of managed manure nitrogen for livestock category T that is lost in the manure management system S (%)

$N_{beddingMS}$ = amount of nitrogen from bedding (to be applied for solid storage and deep bedding MMS if known organic bedding usage) (kg N animal-1 $^{yr-1}$)

S = manure management system

T = species/category of livestock

Data used for estimation the amount of managed manure nitrogen available for application to managed soils or for feed, fuel, or construction purposes were already used in other categories of IPCC Sector *Agriculture* and presented front sections.

$N_{(T)}$ - Number of head of livestock species/category T

The activity data are the same as used in category 3.A Enteric Fermentation and 3.B Manure Management.

$Nex_{(T)}$ - Annual average N excretion per animal of species/category T

The annual average N excretion per animal of species/category T ($Nex_{(T)}$) is calculated with Equation 10.30 of 2006 IPCC GL[111], presented in Table 323.

$MS_{(T,S)}$ - fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S

The fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S is defined in Table 315 and is presented in Table 316.

$Frac_{LossMS}$ - amount of managed manure nitrogen for livestock category T that is lost in the manure management systems

Default values for total nitrogen loss from manure management was taken from Table 10.23 of 2006 IPCC GL[112] and are presented in the following table. These default values include losses that occur from the point of excretion, including animal housing losses, manure storage losses, and losses from leaching and runoff at the manure storage system where applicable.

Table 331 Default values for nitrogen loss due to volatilization of NH_3 and NO_x from manure management

Animal type	Manure management system (MMS)	Total N loss from MMS ($Frac_{LossMS}$)
Dairy Cow	Liquid/Slurry	40%
	Solid storage	40%
	Daily spread	22%
Poultry	Poultry without litter	55%
	Poultry with litter	50%
Other Cattle	Solid storage	50%
	Deep bedding	40%
Other (includes sheep, horses, and fur-bearing animals)	Deep bedding	35%
	Solid storage	15%

Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10: Emissions from Livestock and Manure Management, sub-chapter 10.5.5 Uncertainty assessment, Table 10.22: Default values for nitrogen loss due to volatilization of NH_3 and NO_x from manure management, p. 10.67.

$N_{beddingMS}$ - amount of nitrogen from bedding

Bedding materials vary greatly and are depending on the characteristics of bedding material used in their livestock industries. Due to lack of data in this inventory cycle, it was assumed that this manure management did not exist in the country. See also planned improvements.

[111] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10: Emissions from Livestock and Manure Management, sub-chapter 10.5.2 Choice of emission factors, p. 10.57.

[112] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10: Emissions from Livestock and Manure Management, sub-chapter 10.5.5 Uncertainty assessment, Table 10.23 Default values for total nitrogen loss from manure management. P. 10.67.

F_{SEW} - Annual amount of total sewage N that is applied to soils

The annual amount of total sewage sludge applied to soil depends on the sewage practices which is quite different between rural and urban regions. Information about the amount of sewage sludge and related N content was not available. Therefore, this source of nitrogen was not estimated. (See also planned improvements in chapter **Error! Reference source not found.**.)

N_2O emissions from wastewater treatment is entirely estimated in Chapter 7.5.

Double counting is therefore excluded.

F_{COMP} - Annual amount of total compost N applied to soil

The annual amount of compost applied to soils depends on the composting activities within the country. However, information about amount of compost applied to soil and related N content was not available. Therefore, this source of nitrogen was not estimated. (See also planned improvement)

N_2O Emissions from biological treatment is entirely estimated in Chapter 7.3.

Double counting is therefore excluded.

F_{OOA} - annual amount of other organic amendments used as fertiliser

No information about the amount of other organic amendments (e.g., rendering waste, guano, brewery waste, etc.) used as fertilizer was not available. Therefore, this source of nitrogen was not estimated. (See also planned improvement).

5.5.2.1.2.3 AD and calculation for *N Input from annual amount of N in crop residues (F_{CR})*

Activity data, parameter and emission calculation for N Input from annual amount of *N in crop residues, including N-fixing crops, and from forage/pasture renewal, returned to soils (F_{CR})*

The term F_{CR} refers to the amount of N in crop residues (above-ground and below-ground), including N-fixing crops, returned to soils annually. It also includes the N from N-fixing and non-N-fixing forages mineralised during forage or pasture renewal. It is estimated from crop yield statistics and default factors for above-/ belowground residue: yield ratios and residue N contents.

Equation 11.6: N from crop residues and forage/pasture renewal (TIER 1)
2006 IPCC GL, Vol. 4, Chap. 11.2.1.3)

$$F_{CR} = \sum_T \{Crop_{(T)} \times Frac_{Renew(T)} \times [(Area_{(T)} - Area_{\,burnt\,(T)} \times C_F) \times R_{AG(T)} \times N_{AG(T)} \times (1 - Frac_{Remove(T)}) + Area_{(T)} - R_{BG(T)} \times N_{BG(T)}]\}$$

As no country specific data were available the recommended alternative approach was applied for estimating the amount of N in crop residues (above-ground and below-ground), including N-fixing crops, returned to soils annually.

Equation 11.7A: N from crop residues and forage/pasture renewal (TIER 1)
Alternative approach to estimate F_{CR} (using Table 11.2)
2006 IPCC GL, Vol. 4, Chap. 11.2.1.3

$$F_{CR} = \sum_T \{Frac_{Renew(T)} \times [(Area_{(T)} - Area_{\,burnt\,(T)} \times C_F) \times AG_{DM(T)} \times 1000 \times N_{AG(T)} \times (1 - Frac_{Remove(T)}) + Area_{(T)} \times (AG_{DM(T)} \times 1000 + Crop_{(T)}) \times R_{BG-BIO(T)} \times N_{BG(T)}]\}$$

Where:

F_{CR} = annual amount of N in crop residues (above and below ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually (kg N yr^{-1})

$Crop_{(T)}$ = harvested annual dry matter yield for crop T (kg d.m. ha-1)

$Area_{(T)}$ = total annual area harvested of crop T (ha $^{yr-1}$)

Area burnt $_{(T)}$ = annual area of crop T burnt (ha $^{yr-1}$)

C_f = combustion factor (dimensionless)
referred to 2006 IPCC GL, Vol. 4, Chapter 2, Table 2.6

$AG_{DM(T)}$ = above-ground residue dry matter (Mg/ha)
see equation below

$N_{AG(T)}$ = N content of above-ground residues for crop T (kg N (kg d.m.) $^{-1}$;
*see **Error! Reference source not found.** which is based on Table 11.2 of 2006 IPCC GL, Vol. 4, Chapter 11*

$Frac_{Remove(T)}$ = fraction of above-ground residues of crop T removed annually for purposes such as feed, bedding and construction, kg N (kg crop-N)$^{-1}$.
No data for $Frac_{Remove}$ were available, thus no removal is assumed.

$R_{BG\text{-}BIO(T)}$ = Ratio of belowground residues to above-ground biomass (kg d.m. (kg d.m.)$^{-1}$) by the ratio of total above-ground biomass to crop yield.

See *Table 11.2 of 2006 IPCC GL, Vol. 4, Chapter 11*

$N_{BG(T)}$ = N content of below-ground residues for crop T (kg N (kg d.m.)$^{-1}$)

See Table 11.2 of 2006 IPCC GL, Vol. 4, Chapter 11

T = crop or forage type: wheat, potatoes, beans, etc.

The term $AG_{DM(T)}$ refers to the above-ground residue dry matter and is calculated according to the following equation.

Equation for calculation of the above-ground residue dry matter ($AG_{DM(T)}$)
2006 IPCC GL, Vol. 4, Chap. 11.2.1.3, Table 11.2)

$$AG_{DM(T)} = \frac{Crop_{(T)}}{1000} \times slope_{(T)} \times + intercept_{(T)}$$

The yield statistics for all crops are reported as fresh weight, a correction factor needs to be applied to estimate dry matter yields ($Crop_{(T)}$) following the Equation 11.7 of 2006 IPCC GL, Vol. 4, Chap. 11. The default values for dry matter content given in the following tables and were taken from Table 11.2 of 2006 IPCC GL, Vol. 4, Chap. 11. may be used.

Equation 11.7: Dry-weight correction of reported crop yields
(2006 IPCC GL, Vol. 4, Chap. 11.2.1.3)

$$Crop_{(T)} = Yield\ Fresh_{(T)} \times DRY$$

Where:

$Crop_{(T)}$ = harvested dry matter yield for crop T (kg d.m. ha^{-1})

$Yield\_Fresh_{(T)}$ = harvested fresh yield for crop T (kg fresh weight ha^{-1})

DRY = dry matter fraction of harvested crop T (kg d.m. (kg fresh weight)-^{1})

Default factors for estimation of N added to soils from crop residues:

- Dry matter fraction of harvested product (DRY)
- Above-ground residue dry matter AG_{DM}(T)
- AGDM(T) = (Crop(T)/1000)*
- slope(T) +
- intercept(T)
- N content of above-ground residues (NAG)
- Ratio of below- ground residues to above-ground biomass (RBG-BIO)
- N content of below-ground residues (NBG)

With the Equation 11.1.a (see also above in 5.5.2.1.1 Choice of methods) and the Equation for conversion N_2O-N tot N_2O the N_2O emissions from N inputs to managed soils

Annual direct N_2O–N emissions from N inputs to managed soils (2006 IPCC GL, Vol. 4, Chap. 11) [105]

$$N_2O - N_{N\ inputs} = [[(F_{CR}) \times EF_1] + [(F_{CR})_{FR} \times EF_{1FR}]] \quad \textbf{(11.1.a)}$$

$$N_2O\ emissions_{direct} = N_2O - N \times \frac{44}{28}$$

5.5.2.1.2.4 AD and calculation for N Input from *Mineralised N (F_{SOM})*

Activity data, parameter and emission calculation for N Input from *Mineralised N resulting from loss of soil organic C stocks in mineral soils through land-use change or management practices (F_{SOM})*

The term F_{SOM} refers to the amount of N mineralised from loss in soil organic C in mineral soils through land use change or management practices.

According to 2006 IPCC GL, Vol. 4, Chap. 2[113], land-use change and a variety of management practices can have a significant impact on soil organic C storage. Organic C and N are intimately linked in soil organic matter. Where soil C is lost through oxidation as a result of land-use or management change, this loss will be accompanied by a simultaneous mineralisation of N. Where a loss of soil C occurs, this mineralised N is regarded as an additional source of N available for conversion to N_2O; just as mineral N released from decomposition of crop residues, for example, becomes a source.

For estimating changes and release in N supply from mineralisation due to land use change, where soil C losses occur (as calculated in 2006 IPCC GL, Vol. 4, Chap 2, Equation 2.25[114]), the Tier 1 method can be applied in 3 steps:

[113] 2006 IPCC GL, Vol. 4 AFOLU, Chap 2 Generic Methodologies Applicable to Multiple Land-Use Categories, Section 2.3.3 Change in carbon stocks in soils. Page 2.28

[114] 2006 IPCC GL, Vol. 4 AFOLU, Chap 2 Generic Methodologies Applicable to Multiple Land-Use Categories, Section 2.3.3.1 Soil C estimation methods. Equation 2.25 Annual change in organic carbon stocks in mineral soils. Page 2.30.

Step 1: Calculate the average annual loss of soil C ($\Delta C_{Mineral, LU}$) for the area, over the inventory period, using Equation 2.25. Using the Tier 1 approach, the value for $\Delta C_{Mineral, LU}$ will have a single value for all land-uses and management systems.

Equation 2.24 Annual change in organic carbon stocks in mineral soils[114]

(2006 IPCC GL, Vol. 4, Chap. 2)

$$\Delta C_{\text{Mineral}} = \frac{SOC_0 - SOC_{(0-T)}}{D}$$

with

$$SOC = \sum_{c,s,i} \left(SOC_{REFc,s,i} \times F_{LUc,s,i} \times F_{MGc,s,i} \times F_{Ic,s,i} \times A_{c,s,i} \right)$$

Where:

$\Delta C_{Mineral}$ = annual change in carbon stocks in mineral soils (tonnes C $^{yr-1}$)

SOC_0 = soil organic carbon stock in the last year of an inventory time period (tonnes C)

$SOC_{(0-T)}$ = soil organic carbon stock at the beginning of the inventory time period (tonnes C)

SOC_0 and $SOC_{(0-T)}$ are calculated using the SOC equation in the box where the reference carbon stocks and stock change factors are assigned according to the land-use and management activities and corresponding areas at each of the points in time (time = 0 and time = 0-T)

T = number of years over a single inventory time period, yr

D = Time dependence of stock change factors which is the default time period for transition between equilibrium SOC values, yr. Commonly 20 years, but depends on assumptions made in computing the factors FLU, FMG and FI. If T exceeds D, use the value for T to obtain an annual rate of change over the inventory time period (0-T years).

c = represents the climate zones, s the soil types, and i the set of management systems that are present.

SOC_{REF} = the reference carbon stock (tonnes C ha-1)

F_{LU} = stock change factor for land-use systems or sub-system for a particular land-use, dimensionless

F_{MG} = stock change factor for management regime, dimensionless

F_I = stock change factor for input of organic matter, dimensionless

A = land area of the stratum being estimated (ha)

Step 2: Estimate the N mineralised as a consequence of this loss of soil C (F_{SOM}), using Equation 11.8[115]:

Equation 11.8 N mineralized in mineral soils as a result of loss of soil c through change in land use or management (TIER1)

(2006 IPCC GL, Vol. 4, Chap. 11)

$$F_{SOM} = \sum_{LU} \left[\left(\Delta C_{Mineral,LU} \times \frac{1}{R} \right) \times 1000 \right]$$

Where:

F_{SOM} = the net annual amount of N mineralised in mineral soils as a result of loss of soil carbon through change in land use or management, kg N

$\Delta C_{Mineral, LU}$ = average annual loss of soil carbon for each land-use type (LU), tonnes C

Note: for Tier 1, $\Delta C_{mineral, LU}$ will have a single value for all land-uses and management systems.

R = C:N ratio of the soil organic matter.

A default value of 15 for the C:N ratio (R) may be used for situations involving land-use change from Forest Land or Grassland to Cropland, in the absence of more specific data for the area.

A default value of 10 may be used for situations involving management changes on Cropland Remaining Cropland. C:N ratio can change over time, land use, or management practice.

LU = land-use and/or management system type

Step 3: For Tier 1, the value for F_{SOM} is calculated in a single step.

In the following table is presented the exemplary calculation of direct N_2O emissions from managed soils (TIER 1) due to mineralised N resulting from loss of soil organic C stocks in mineral soils through land-use change or management practices (F_{SOM}).

[115] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 11: N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application, sub-chap 11.2.1.3 Choice of activity data. Equation 11.8, Page 11.16.

Table 332 Exemplary calculation of direct N_2O emissions from managed soils (TIER 1) due to mineralised N resulting from loss of soil organic C stocks in mineral soils through land-use change or management practices (F_{SOM})

Parameter	Parameter description	Unit	Formula	Parameter Source	2018
A_1	Perennials converted to annual crops	kha	-	From calculation in sector LULUCF	NE
SOC_0	Soil C after 20 years of LUC	t C/ha	-		NE
$SOC_{(0-T)}$	Soil C stock before LUC	t C/ha	-		NE
A_2	Annual croplands converted to perennials	kha	-		NE
SOC_0	Soil C after 20 years of LUC	t C/ha	-		NE
$SOC_{(0-T)}$	Soil C stock before LUC	t C/ha	-		NE
$\Delta C_{Mineral\ LUC-1}$	Net carbon stock change in soils	t C	$\Delta C_{mineral,\ LU}$ = (SOC_0 - $SOC_{(0-T)}$) / D	Equation 2.25, Chap. 2.3.3.1, Vol. 4, 2006 IPCC GL, p. 2.29	NE
$\Delta C_{Mineral\ LUC-2}$	Net carbon stock change in soils	t C	$\Delta C_{mineral,\ LU}$ = (SOC_0 - $SOC_{(0-T)}$) / D		NE
sum					NE
R	C:N ratio of soil organic matter			Explanation to Equation 11.8, Chap. 11.2.1.3, Vol. 4, 2006 IPCC GL, p. 11.16	10
F_{SOM}	Annual amount of N mineralised in mineral soils	kg N	($\Delta C_{mineral,\ LU}$ * 1/R) * 1000	Equation 11.8, Chap. 11.2.1.3, Vol. 4, 2006 IPCC GL, p. 11.16	NE
EF_1 - N_2O-N	Emission Factor - N_2O-N	kg N_2O-N/kg N	-	Table. 11.1, Chap. 11, Vol. 4, 2006 IPCC GL, p. 11.11 See also Table 329	0.01
N_2O-N	N_2O-N emissions	Gg	F_{SOM}*EF1	Equation 11.1, Chap. 11, Vol. 4, 2006 IPCC GL, p. 11.7	NE
N_2O	N_2O emissions	Gg	N_2O - N*44/28	Equation for conversion, Chap. 11, Vol. 4, 2006 IPCC GL, page 11.10	NE
N_2O	Method	-	-	-	T1
N_2O	EF used	-	-	-	D

5.5.2.1.2.5 AD and calculation for N Input from *area of drained/managed organic soils (F_{OS})*

Activity data, parameter and emission calculation for *N Input from area of drained/managed organic soils (FOS)*

The term F_{OS} refers to the total annual area (ha) of drained/managed organic soils (see footnote 4 for definition). This definition is applicable for both the Tier 1 and Tier 2 methods. For all land uses, the areas should be stratified by climate zone (temperate and tropical). In addition, for temperate Forest Land the areas should be further stratified by soil fertility (nutrient rich and nutrient poor). The area of drained/managed organic soils (FOS) may be collected from official national statistics. Alternatively, total areas of organic soils from each country are available from FAO (http://faostat.fao.org/), and expert advice may be used to estimate areas that are drained/managed. For Forest Land, national data will be available at soil survey organisations and from wetland surveys, e.g., for international conventions. In case no stratification by soil fertility is possible, countries may rely on expert judgment.

For this inventory cycle no information and data regarding cultivation of organic soils were available.

5.5.2.1.2.6 AD and calculation for N Input from *Urine and dung from grazing animals (F_{PRP})*

Activity data, parameter and emission calculation for *N Input from Urine and dung from grazing animals (FPRP)*

The term F_{PRP} refers to the annual amount of N deposited on pasture, range and paddock soils by grazing animals. It is important to note that the N from managed animal manure applied to soils is included in the F_{AM} term of F_{ON}. The annual amount of N deposited on pasture, range and paddock F_{PRP} is estimated using Equation 11.5 from 2006 IPCC GL, Volume 4, Chapter 11.

Equation 11.5: N in urine and dung deposited by grazing animals on pasture, range and paddock (PRP) (TIER 1) (2006 IPCC GL, Vol. 4, Chap. 11.2.1.3)

$$\boldsymbol{F_{PRP}} = \sum_{\boldsymbol{T}} \left[\left(\boldsymbol{N_{(T)}} \times \boldsymbol{Nex_{(T)}} \right) \times \boldsymbol{MS_{(T,PRP)}} \right]$$

Where:

- F_{PRP} = annual amount of urine and dung N deposited on pasture, range, paddock (PRP) and by grazing animals (kg N yr^{-1})
- $N_{(T)}$ = number of head of livestock species/category T
- $Nex_{(T)}$ = annual average N excretion per head of species/category T (kg N animal-1 $^{yr-1}$)
- $MS_{(T,PRP)}$ = fraction of total annual N excretion for each livestock species/category T that is deposited on pasture, range and paddock (PRP).

Data used for estimation the annual amount of urine and dung N deposited on pasture, range, paddock (PRP) and by grazing animals are already used in other categories of IPCC Sector *Agriculture* and presented above.

$N_{(T)}$ - Number of head of livestock species/category T

The activity data are the same as used in category 3.A Enteric Fermentation and 3.B Manure Management.

$Nex_{(T)}$ - Annual average N excretion per animal of species/category T

The annual average N excretion per animal of species/category T ($Nex_{(T)}$) is calculated with Equation 10.30 of 2006 IPCC GL[116], presented in Table 323.

$MS_{(T,PRP)}$ - fraction of total annual N excretion for each livestock species/category T that is deposited on pasture, range and paddock (PRP)

The fraction of total annual N excretion for each livestock species/category T that is deposited on pasture, range and paddock (PRP) is defined in Table 315 and is presented in Table 316.

[116] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10: Emissions from Livestock and Manure Management, sub-chapter 10.5.2 Choice of emission factors, p. 10.57.

With the Equation 11.1.a (see also above in 5.5.2.1.1 Choice of methods) and the Equation for conversion N_2O-N tot N_2O the N_2O emissions from N inputs to managed soils

Annual direct N_2O–N emissions from N inputs to managed soils (2006 IPCC GL, Vol. 4, Chap. 11)

$$N_2O - N_{N\ inputs} = [[(F_{PRP}) \times EF_1] + [(F_{PRP})_{FR} \times EF_{1FR}]] \quad \textbf{(11.1.a)}$$

$$N_2O\ emissions_{direct} = N_2O - N \times \frac{44}{28}$$

5.5.2.1.3 Uncertainties and time-series consistency for IPCC sub-category 3.D.a Direct N_2O emissions

The uncertainties for activity data and emission factors used for IPCC category 3.D Agricultural soils are presented in the following table.

Table 333 Uncertainty for IPCC sub-category 3.D.a Direct N_2O emissions

Uncertainty	CH_4	N_2O	N_2O	Reference
				2006 IPCC GL, Vol. 4, Chap. 10
Activity data	NA	20%	NA	Chapter 11.2.1.4
Emission factor (direct emission)		250%		Chapter 10.4.4
Combined Uncertainty		254%		

5.5.3 Indirect N_2O emissions from managed soils (IPCC category 3.D.b)

3.D.b	**Indirect N_2O Emissions from managed soils**	
3.D.b.1	Atmospheric deposition	Volatilized N from agricultural inputs of N
3.D.b.2	Nitrogen leaching and run-off	N from fertilizers and other agricultural inputs that is lost through leaching and run-off

In addition to the direct emissions of N_2O from managed soils, emissions of N_2O also take place through two indirect pathways.

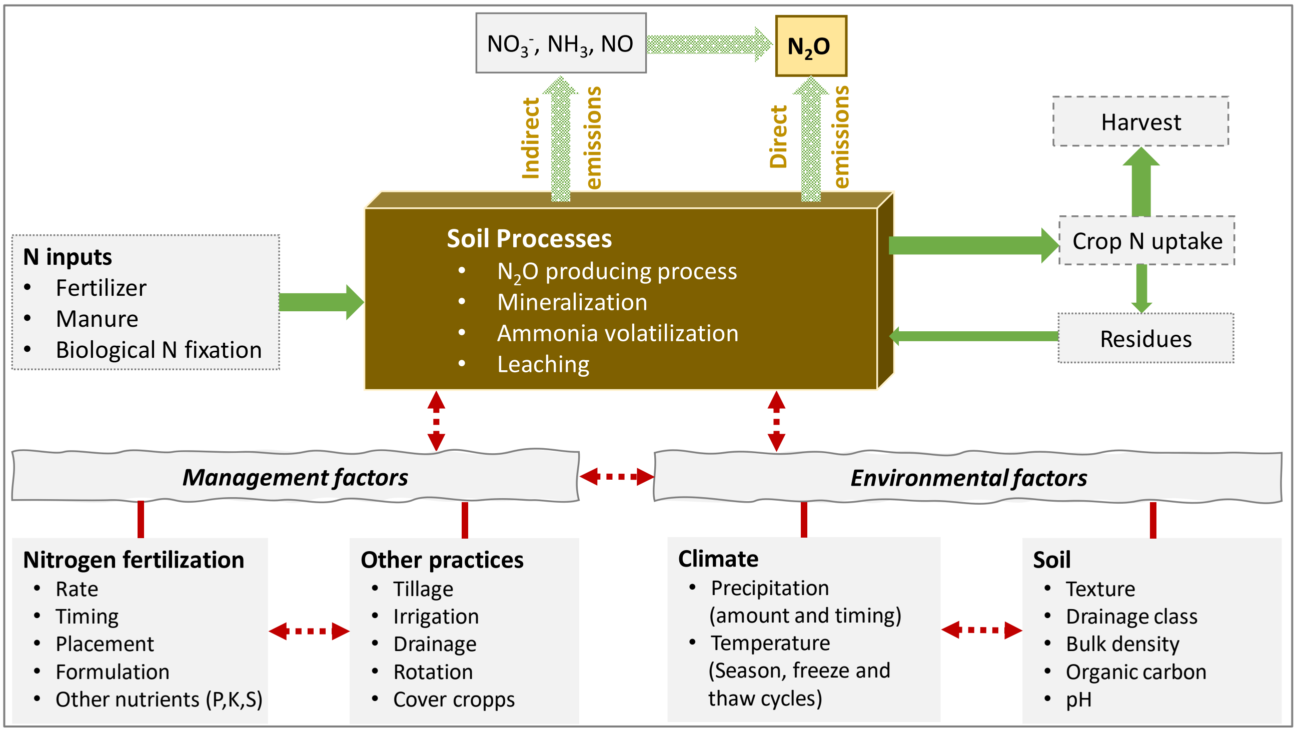


Figure 152 Factors influencing direct and indirect emissions of N_2O from agricultural soils

Source: WATTIAUX, M. A.; PAS, UDDIN, M. E. ; LETELIER, P., JACKSON, R. D. & LARSON, R. A. (2019): Emission and mitigation of greenhouse gases from dairy farms: The cow, the manure, and the field. In: Applied Animal Science 35:238–254. Sustainability and Integrated Systems. https://doi.org/10.15232/aas.2018-01803
Available on 29.04.2019 at: https://www.researchgate.net/publication/331916870_Invited_Review_Emission_and_mitigation_of_greenhouse_gases_from_dairy_farms_The_cow_the_manure_and_the_field

The first pathways is the volatilisation of N as NH_3 and oxides of N (NO_x), and the deposition of these gases and their products NH_4^+ and NO_3^- onto soils and the surface of lakes and other waters (see also Figure 152). As described in the 2006 IPCC GL, Vol. 4, Chapter 11.2.2 the sources of N as NH_3 and NO_x are not confined to agricultural fertilisers and manures, but also include fossil fuel combustion, biomass burning, and processes in the chemical industry. Thus, these processes cause N_2O emissions in an exactly analogous way to those resulting from deposition of agriculturally derived NH_3 and NO_x, following the application of synthetic and organic N fertilizers and /or urine and dung deposition from grazing animals (see also Figure 147).

The second pathway is the leaching and runoff from land of N from synthetic and organic fertilizer additions, crop residues, mineralization of N associated with loss of soil C in mineral and drained/managed organic soils through land-use change or management practices, and urine and dung deposition from grazing animals. As described in the 2006 IPCC GL, Vol. 4, Chapter 11.2.2 some of the inorganic N in or on the soil, mainly in the NO_3^- form, may bypass biological retention mechanisms in the soil/vegetation system by transport in overland water flow (runoff) and/or flow through soil macropores or pipe drains. Where NO_3^- is present in the soil in excess of biological demand, e.g., under cattle urine patches, the excess leaches through the soil profile. The nitrification and denitrification processes described at the beginning of this chapter transform some of the NH_4^+ and NO_3^- to N_2O. This may take place in the groundwater below the land to which the N was applied, or in riparian zones receiving drain or runoff water, or in the ditches, streams, rivers and estuaries (and their sediments) into which the land drainage water eventually flows.

Thus, agricultural nitrogen (N) sources of indirect N_2O emissions from managed soils arise from

- synthetic N fertilizers (F_{SN});
- organic N applied as fertilizer (e.g., applied animal manure, compost, sewage sludge, rendering waste and other organic amendments) (F_{ON});
- urine and dung N deposited on pasture, range and paddock by grazing animals (F_{PRP});
- N in crop residues (above- and below-ground), including N-fixing crops and forage/pasture renewal returned to soils (F_{CR}); and
- N mineralization associated with loss of soil organic matter resulting from change of land use or management on mineral soils (F_{SOM}).

5.5.3.1 Methodological issues

5.5.3.1.1 Choice of methods

TIER 1 approach - $N_2O_{(ATD)}$ Volatilization

For estimating the N_2O emissions from atmospheric deposition of N volatilized from managed the 2006 IPCC Guidelines Tier 1 approach[117] has been applied.

Equation 11.9: N_2O from atmospheric deposition of N volatilized from managed soils (TIER 1)
(2006 IPCC GL, Vol. 4, Chap. 11)

$$N_2O_{(ATD)} - N = \left[(F_{SN} \times Frac_{GASF}) + \left((F_{ON} \times Frac_{PRP}) \times Frac_{GASF}\right)\right] \times EF_4$$

Where:

$N_2O_{(ATD)}$–N = annual amount of N_2O–N produced from atmospheric deposition of N volatilized from managed soils (kg N_2O–N yr^{-1})

F_{SN} = annual amount of synthetic fertiliser N applied to soils (kg N yr^{-1})

$Frac_{GASF}$ = fraction of synthetic fertiliser N that volatilises as NH3 and NOx (kg N volatilized (kg of N applied)$^{-1}$)

F_{ON} = annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils (kg N yr^{-1})

F_{PRP} = annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock (kg N yr-1)

$Frac_{GASM}$ = fraction of applied organic N fertiliser materials (FON) and of urine and dung N deposited by grazing animals (FPRP) that volatilises as NH3 and NOx (kg N volatilized (kg of N applied or deposited)$^{-1}$) (Table 11.3)

EF_4 = emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces ([kg N–N_2O (kg NH3–N + NOx–N volatilized)$^{-1}$])

[117] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chap. 11, sub-chap. 11.2.2.1 Choice of method

Conversion of $N_2O_{(ATD)}$-N emissions to N_2O emissions for reporting purposes is performed by using the following equation:

Equation 11.10: Indirect N_2O emissions due to volatilization of N from manure management

$$N_2O_{(ATD)} = N_2O_{(ATD)} - N \times \frac{44}{28}$$

Where:

$N_2O_{(ATD)}$ = indirect N_2O emissions due to volatilization of N from Manure Management (kg N_2O)

$N_2O_{(ATD)}$–N = annual amount of N_2O–N produced from atmospheric deposition of N volatilized from managed soils (kg N_2O–N yr^{-1})

44/28 = conversion of kg N_2O-N into kg N_2O.

TIER 1 approach - $N_2O_{(L)}$ Leaching/Runoff

For estimating the N_2O emissions from leaching and runoff in regions where leaching and runoff occurs the 2006 IPCC Guidelines Tier 1 approach[118] has been applied.

Equation 11.10: N_2O from N leaching/runoff from managed soils in regions where leaching/runoff occurs (TIER 1)

(2006 IPCC GL, Vol. 4, Chap. 11)

$$N_2O_{(L)} - N = (F_{SN} + F_{ON} + F_{PRP} + F_{CR} + F_{SOM}) \times Frac_{LEACH-(H)} \times EF_5$$

Where:

$N_2O_{(L)}$–N = annual amount of N_2O–N produced from leaching and runoff of N additions to managed soils in regions where leaching/runoff occurs (kg N_2O–N yr-1)

F_{SN} = annual amount of synthetic fertilizer N applied to soils in regions where leaching/runoff occurs (kg N yr-1)

F_{ON} = annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils in regions where leaching/runoff occurs (kg N yr-1)

F_{PRP} = annual amount of urine and dung N deposited by grazing animals in regions where leaching/runoff occurs (kg N yr-1)

from Equation 11.5, page 11.13, Chap. 11.2.1.3 Choice of activity data, Vol. 4 of 2006 IPCC GL

F_{CR} = amount of N in crop residues (above- and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually in regions where leaching/runoff occurs (kg N yr-1)

F_{SOM} = annual amount of N mineralized in mineral soils associated with loss of soil C from soil organic matter as a result of changes to land use or management in regions where leaching/runoff occurs (kg N yr-1)

from Equation 11.8, page 11.16, Chap. 11.2.1.3 Choice of activity data, Vol. 4 of 2006 IPCC GL

$Frac_{LEACH-(H)}$ = fraction of all N added to/mineralized in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff (kg N (kg of N additions)-1)

from Table 11.3, page 11.23, Chap. 11.2.2.3 Choice of activity data, Vol. 4 of 2006 IPCC GL and presented in Table 334

EF_5 = emission factor for N_2O emissions from N leaching and runoff (kg N_2O–N (kg N leached & runoff)$^{-1}$)

from Table 11.3, page 11.23, Chap. 11.2.2.3 Choice of activity data, Vol. 4 of 2006 IPCC GL and presented in Table 334 in

[118] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chap. 11, sub-chap. 11.2.2.1 Choice of method

Conversion of $N_2O_{(L)}$-N emissions to N_2O emissions for reporting purposes is performed by using the following equation:

Equation 11.10: Indirect N_2O emissions due to volatilization of N from manure management

$$N_2O_{(AL)} = N_2O_{(L)} - N \times \frac{44}{28}$$

Where:

$N_2O_{(L)}$ = indirect N_2O emissions due to leaching and runoff of N additions to managed soils in regions where leaching/runoff occurs (kg N_2O)

$N_2O_{(L)}$–N = annual amount of N_2O–N produced from leaching and runoff of N additions to managed soils in regions where leaching/runoff occurs (kg N_2O–N yr^{-1})

44/28 = conversion of kg N_2O-N into kg N_2O.

5.5.3.1.2 Choice of emission, volatilization and leaching factors

The method for estimating indirect N_2O emissions includes two emission factors:

- associated with volatilised and re-deposited N (EF_4),
- associated with N lost through leaching/runoff (EF_5).

The method also requires values for the fractions of N that are lost through volatilisation ($Frac_{GASF}$ and $Frac_{GASM}$) or leaching/runoff ($Frac_{LEACH-(H)}$).

As no country specific emission factors and values for the fractions of N that are lost were available, default emission factors and parameter were used.

Table 334 Default emission, volatilization and leaching factors for indirect soil N_2O emissions

Factor	Description	Unit	Default value
EF_4	N volatilisation and re-deposition	kg N_2O–N / (kg NH3–N + NOX–N volatilised)	0.010
EF_5	leaching/runoff	kg N_2O–N / (kg N leaching/runoff)	0.0075
$Frac_{GASF}$	Volatilization from synthetic fertilizer	(kg NH3–N + NOx–N) / (kg N applied)	0.10
$Frac_{GASM}$	Volatilization from all organic N fertilizers applied , and dung and urine deposited by grazing animals	(kg NH3–N + NOx–N) / (kg N applied or deposited)	0.20
$Frac_{LEACH-(H)}$	N losses by leaching/runoff for regions where ∑ (rain in rainy season) - ∑ (PE in same period) > soil water holding capacity, OR where irrigation (except drip irrigation) is employed	kg N / (kg N additions or deposition by grazing animals)	0.30
	N losses by leaching/runoff for dryland regions where precipitation is lower than evapotranspiration throughout most of the year and leaching is unlikely to occur		0

Source: 2006 IPCC GL, Vol. 4, Chap. 11, sub-chap. 11.2.2.3, Choice of activity data, Table 11.3, page 11.23

5.5.3.1.3 Choice of activity data

In order to estimate indirect N_2O emissions from the various N additions to managed soils, the parameters F_{SN}, F_{ON}, F_{PRP}, F_{CR}, F_{SOM} need to be estimated. These parameters are already described in Chapter 5.5.2.1.2 of this report described.

Applied synthetic fertiliser (F_{SN})

The term F_{SN} refers to the annual amount of synthetic fertiliser N applied to soils.
Relevant information is provided in Chapter 5.5.2.1.2.1 of this report.

Applied organic N fertilisers (F_{ON})

The term FON refers to the amount of organic N fertiliser materials intentionally applied to soils.
Relevant information is provided in Chapter 5.5.2.1.2.15.5.2.1.2.20 of this report.

Urine and dung from grazing animals (F_{PRP})

The term F_{PRP} refers to the amount of N deposited on soil by animals grazing on pasture, range and paddock.
Relevant information is provided in Chapter 5.5.2.1.2.6 of this report.

Crop residue N, including N from N-fixing crops and forage/pasture renewal, returned to soils (F_{CR})

The term FCR refers to the amount of N in crop residues (above- and below-ground), including N-fixing crops, returned to soils annually. It also includes the N from N-fixing and non-N-fixing forages mineralised during forage/pasture renewal.
Relevant information is provided in Chapter 5.5.2.1.2.1 of this report.

Mineralised N resulting from loss of soil organic C stocks in mineral soils (F_{SOM})

The term F_{SOM} refers to the amount of N mineralised from the loss of soil organic C in mineral soils through land-use change or management practices.
Relevant information is provided in Chapter 5.5.2.1.2.4 of this report.

5.5.4 Uncertainties and time-series consistency for IPCC category 3.D Agricultural soils

The uncertainties for activity data and emission factors used for IPCC category 3.D Agricultural soils are presented in the following table.

Table 335 Uncertainty for IPCC sub-category 3.D Agricultural soils.

Uncertainty		N_2O	Reference
			2006 IPCC GL, Vol. 4, Chap. 11
Activity data			
$Frac_{loss}$	amount of managed manure nitrogen for livestock category that is lost in the manure management system	20%	Table 10.32 p 10.67
F_{sn}	activity data on synthetic fertilizer	20%	Expert judgment
F_{cr}	activity data crop residues	20%	Expert judgment
EF_1	N_2O emission factor for soils	250%	Table 11.1, page 11.11
EF_{PRP}	emission factor N deposited by grazing animals on pasture, range and paddock	200%	Table 11.1 page 11.11
EF_4	N volatilization and re-deposition	50%	Table 11.1 page 11.11
Combined Uncertainty		326%	$U_{Total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

5.5.5 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
  - consistent use of livestock data (statistical yearbook and FAOstat- Live Animals),
  - consistent use of data on area and yield of crops (statistical yearbook and FAOstat- crops),
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked of different sources: national statistic (Monstat) and international statistics (FAO)

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ consistency and completeness checks are performed;

⇒ time series consistency - plausibility checks of dips and jumps.

5.5.6 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission (NC & BUR) to the UNFCCC and relevant to IPCC sub-category 3.D Agricultural soils.

Table 336 Recalculations done since NC & BUR in IPCC sub-category 3.D Agricultural soils

GHG source & sink category	Revisions of data NC / BUR ⇒ submission 2020	Type of revision	Type of improvement
3.D	application of • 2019 refinements to the 2006 IPCC Guidelines, and • EMEP/EEA air pollutant emission inventory guidebook 2019	AD EF EMI	Accuracy

5.5.7 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 337 Planned improvements for IPCC sub-category 3.D Agricultural soils

GHG source & sink category	Planned improvement	Type of improvement		Priority
3.D	F_{SN} - Annual amount of applied synthetic fertilizer consumption applied to soils. • amount and type (fertilizers by product and/or nutrient) of annual amount of applied synthetic fertilizer	AD	Accuracy Consistency Transparency	high
3.D	F_{ON} - annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils. • amount of animal manure and N content, • amount of compost and N content, • amount of sewage sludge and N content (cross-check with Waste Sector to ensure there is no double counting), • annual amount of other organic amendments used as fertiliser (e.g., rendering waste, guano, brewery waste, etc.) and N content	AD	Accuracy Consistency Transparency	high
3.D	(1) $Area_{(T)}$ - Total annual area harvested of crops (types) (2) $Yield_{\_Fresh(T)}$ - Harvested fresh yield for crop T (3) Area burnt $_{(T)}$ - annual area of crop T burned (4) Dry matter (d.m.) fraction (DRY) • grains: e.g. wheat (split in winter and summer harvest), barley, oats, rice, rye, millet, maize (corn), sorghum, spelt, teff, (wild) rice, etc. • beans & pulses: e.g. beans, lentils, peas, etc. • tubers: e.g. (sweet) potato, yam, cassava, sweet lupins, etc. • root crops: beets-roots, sugar beet, pigweed, sunflower, mustard, carrots, etc. • N-fixing forages • Non-N-fixing forages • Perennial grasses • Grass-clover mixtures	AD	Accuracy Consistency Transparency	high
3.D	SOC_0 - soil organic carbon stock in the last year of an inventory time period (tonnes C) $SOC_{(0-T)}$ - soil organic carbon stock at the beginning of the inventory time period (tonnes C) *See Planned Improvements for LULUCF*	AD	Accuracy Transparency Consistency Comparability Completeness	medium
3.D	(1) number of head of livestock species/category T fraction of total annual N excretion for each livestock (2) species/category T that is deposited on pasture, range and paddock (PRP) (3) annual average N excretion per head of species/category T *see Planned Improvements for 3.B. Enteric Fermentation and 3.A. Manure management*	AD	Accuracy Consistency	High

5.6 Prescribed burning of savannas (IPCC category 3.E)

GHG emission from IPCC category 3.E *Prescribed burning of savannas* were not estimated due to lack of detailed information and resources. However, according to national experts prescribed fires and wildfires occurs occasionally in Montenegro.

GHG emissions from this sector comprise emissions from the following categories:

IPCC code	description	CO_2		CH_4		N_2O	
		Estimated	Key Category	estimated	Key category	estimated	Key category
3.E	**Prescribed burning of savannas**	NA	-	NO	-	NO	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE - included elsewhere, NO – not occurrent, NE - not estimated, NA - not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC category 3.E *Prescribed burning of savannas* does not exist in Montenegro.

5.7 Field burning of agricultural residues (IPCC category 3.F)

Crop residue burning, which is a kind of biomass burning, are sometimes burned, for convenience and as a means of disease control through residue removals. As described in the *2006 IPCC Guidelines Volume 4, Chapter 5.2.4,* CH_4 and N_2O emissions from *Cropland* are usually associated with burning of agriculture residues, which vary by crop and management system. Field burning of agricultural residues emits CH_4 and N_2O. CO_2 emissions from biomass burning do not have to be reported, since the carbon released during the combustion process is assumed to be reabsorbed by the vegetation during the next growing season.

This chapter includes information on and description of methodologies used for estimating GHG emissions as well as references to activity data and emission factors reported under IPCC category *Field burning of agricultural residues* for the period 1990 to 2021.

5.7.1 Source category description

IPCC code	description	CO_2		CH_4		N_2O	
		Estimated	Key Category	estimated	Key category	estimated	Key category
3.F	**Field burning of agricultural residues**	NA	-	✓	-	✓	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

An overview of the CO_2 emissions resulting IPCC category 3.F *Field burning of agricultural residues* is provided in the following figure and table.

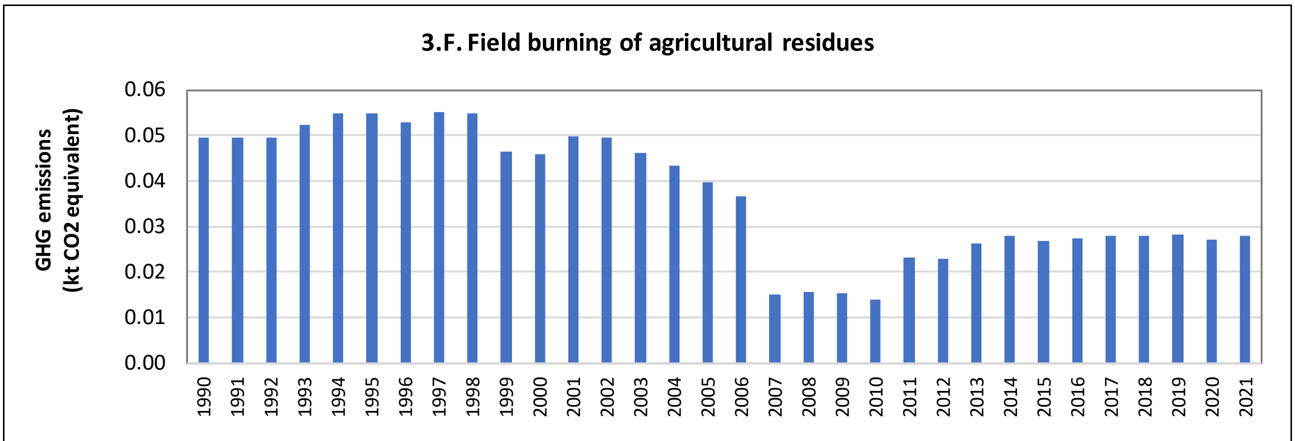


Figure 153 GHG Emissions from IPCC category 3.F *Field burning of agricultural residues* for the period 1990-2021

In 2021, GHG emissions from IPCC category 3.F *Field burning of agricultural residues* amount to 0.028 kt, which correspond to less than 0.001% of National Total GHG emissions (without LULUCF). In the period 1990 to 2021 GHG emissions from the 3.F *Field burning of agricultural residues* decreased by -43.5% from 0.049 kt in 1990 due to reduced field burning of agricultural residues.

Table 338 GHG Emissions from IPCC category 3.F *Field burning of agricultural residues* for the period 1990-2021

	GHG emissions	CO_2	CH_4	N_2O
	kt CO2 eq	kt	kt	kt
1990	0.049	NA	0.0015	0.00004
1991	0.049	NA	0.0015	0.00004
1992	0.049	NA	0.0015	0.00004
1993	0.052	NA	0.0016	0.00004
1994	0.055	NA	0.0017	0.00004
1995	0.055	NA	0.0017	0.00004
1996	0.053	NA	0.0016	0.00004
1997	0.055	NA	0.0017	0.00004
1998	0.055	NA	0.0017	0.00004
1999	0.047	NA	0.0014	0.00004
2000	0.046	NA	0.0014	0.00004
2001	0.050	NA	0.0015	0.00004
2002	0.050	NA	0.0015	0.00004
2003	0.046	NA	0.0014	0.00004
2004	0.043	NA	0.0013	0.00003
2005	0.040	NA	0.0012	0.00003
2006	0.037	NA	0.0011	0.00003
2007	0.015	NA	0.0005	0.00001
2008	0.016	NA	0.0005	0.00001
2009	0.015	NA	0.0005	0.00001
2010	0.014	NA	0.0004	0.00001
2011	0.023	NA	0.0007	0.00002
2012	0.023	NA	0.0007	0.00002
2013	0.026	NA	0.0008	0.00002
2014	0.028	NA	0.0009	0.00002
2015	0.027	NA	0.0008	0.00002
2016	0.027	NA	0.0008	0.00002
2017	0.028	NA	0.0009	0.00002
2018	0.028	NA	0.0009	0.00002
2019	0.028	NA	0.0009	0.00002
2020	0.027	NA	0.0008	0.00002
2021	0.028	NA	0.0009	0.00002
Trend				
1990 - 2021	*-43.5%*	*NA*	*-43.5%*	*-43.5%*
2005 - 2021	*-29.4%*	*NA*	*-29.4%*	*-29.4%*
2020 - 2021	*3.6%*	*NA*	*3.6%*	*3.6%*

5.7.2 Methodological issues

5.7.2.1 Choice of methods

TIER 1 approach

For estimating the CH_4 and N_2O emissions from *Field burning of agricultural residues* the 2006 IPCC Guidelines Tier 1 approach[119] has been applied.

As described in chapter 5.7.2.3 the estimation of the emission factor is following the *Reference Manual* of the *Revised 1996 IPCC Guidelines* (Vol. 3, Chap, 4.4.3 Field Burning of Agricultural Residues).

Equation 5.1: CH_4 and N_2O emissions from Field burning of agricultural residues

(2006 IPCC Guidelines, Vol. 4, Chap 5.2.4.1 and Chap. 2.4)

$$\boldsymbol{Emissions_{GHG} = \sum AD_{burnt} \times \frac{EF_{GHG}}{1000} \times Frac_{oxidized}}$$

with

$$\boldsymbol{AD_{burnt}} = \sum_{\boldsymbol{T}} (\boldsymbol{production_T} \times \boldsymbol{DRY} \times \mathrm{Res}_{\boldsymbol{O}} \times \boldsymbol{Frac_{burnt}})$$

with

$$\boldsymbol{EF_{CH4} = C\ Fraction_{residue\ T} \times emission\ ratio \times \frac{16}{12}}$$

$$\boldsymbol{EF_{N2O} = C\ Fraction_{residue\ T} \times (N/C\ ratio) \times emission\ ratio \times \frac{44}{28}}$$

Where:

Emissions GHG, fuel	= emissions of a given GHG by type of crop (Gg GHG)
GHG	= CH4, N2O
AD_{Burnt}	= amount of biomass (crop residue) burnt from crop T (Mg dry matter)
EF_{GHG}	= emission factor of a given GHG by type of crop based on dry matter burnet (g kg-1 dry matter burnt)
$Frac_{oxidized}$	= fraction oxidized
Production T	= production of crop T (Mg)
DRY	= dry matter fraction of Harvested product
Res	= Residue/Crop Ratio (unitless)
Frac	= fraction of crop residue that is subject to field burning for crop T
C fraction of residues	= C fraction of residues - Carbon content of the residue (tonnes of carbon / tonnes of dry matter)
Emission ratios	= Emission ratios for agricultural residue burning calculations
N/C ratio	= N-C ratio of the fuel (crop residues) by weight to yield the total amount of nitrogen (N) released

In the following table is provided an exemplary calculation of CH4 and N2O emissions from Field burning of agricultural residues (TIER 1) from wheat.

[119] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 5 Cropland, sub-chap 5.2.4.1 Choice of method and chapter 2.4 Non-CO_2 emissions

Table 339 Exemplary calculation (TIER 1) of CH4 and N2O emissions from Field burning of agricultural residues of wheat

Parameter	Parameter	Unit	Formula	Parameter Source	2021
Area(T)	Area harvested (annual)	ha		Ministry/FAO	774
$Crop_F$	Yield (harvested fresh yield)	kg/ha		Ministry/FAO	3 091
Prod	Crop Production	tonnes		Ministry/FAO	2 392
$Area_{burned\text{-}share}$	Share area burned (annual)	%		Expert judgement	3%
$Area_{burned}$	Area burned (annual)	ha	$=Area_{(T)} * Area_{burned\text{-}share}$		39
DRY	dry matter fraction of harvested crop	kg d.m. (kg fresh weight)$^{-1}$			0.89
$Crop_{(T)}$	harvested annual dry matter yield	kg d.m. ha^{-1}	Yield Fresh(T) · DRY	Equation 11.7, Chap. Vol. 4, 2019 Refinements to 2006 IPCC GL	2750.72
Mb*Cf	fuel (dead organic matter plus live biomass) biomass consumption values	tonnes dm/ha		Table 2.4, Chap. 2, Vol 4, 2019 Refinements to 2006 IPCC GL	4.00
$AGR_{(T)}$	Total amount of above-ground crop residue	Mg d.m. yr-1.	$Crop_{(T)}+AG_{DM(T)}$	Doctoral dissertations University of Tennessee, Knoxville	6 904.83
$Frac_{Burnt\ (T)}$	fraction of annual harvested area of crop *T* burnt	-			0.05
Cf	combustion factor	-		Table 2.6, Chap. 2, Vol. 4, 2019 Refinements to 2006 IPCC GL	0.9
EF CO2	CO2 emission factor from Agricultural residues	g kg-1 d.m burnt		Table 2.5, Chap. 2, Vol. 4, 2019 Refinements to 2006 IPCC GL	1515
CO2	CO2 emission from Agricultural residues	1000 tonnes	$Area_{burned}$* Mb*Cf* EF_{CO2}	Equation 2.27, Chap. 2, Vol. 4	0.23
EF CH4	CH4 emission factor from Agricultural residues	g kg-1 d.m burnt		Table 2.5, Chap. 2, Vol. 4	2.7
CH4	CH4 emission from Agricultural residues	1000 tonnes	$Area_{burned}$* Mb*Cf* EF_{CH4}	Equation 2.27, Chap. 2, Vol. 4, 2019 Refinements to 2006 IPCC GL	0.00042
EF N2O	N2O emission factor from Agricultural residues	g kg-1 d.m burnt		Table 2.5, Chap. 2, Vol. 4	0.07
N2O	N2O emission from Agricultural residues	1000 tonnes	$Area_{burned}$* Mb*Cf* EF_{N2O}	Equation 2.27, Chap. 2, Vol. 4, 2019 Refinements to 2006 IPCC GL	0.00001

5.7.2.2 Choice of activity data

The agricultural data used and presented in this inventory are taken from national and international sources:

- Montenegro Statistical yearbook
- FAO agricultural data base[120]

In the following Figures and Tables are provided the data on cultivated and harvested crops presented.

[120] Available (03. March 2019) on http://www.fao.org/faostat/en/#data/QC

Table 340 GHG Emissions from IPCC category 3.F *Field burning of agricultural residues* for the period 1990-2021

	Wheat		Barley		Oats	
	Area harvested	Area burned	Area harvested	Area burned	Area harvested	Area burned
	kha	kha	kha	kha	kha	kha
		⇨ 3%		⇨ 5%		⇨ 5%
1990	1.012	0.051	1.048	0.052	0.369	0.018
1991	1.012	0.051	1.048	0.052	0.369	0.018
1992	1.012	0.051	1.048	0.052	0.369	0.018
1993	1.337	0.067	0.951	0.048	0.340	0.017
1994	1.357	0.068	1.039	0.052	0.355	0.018
1995	1.290	0.064	1.103	0.055	0.356	0.018
1996	0.871	0.044	1.303	0.065	0.410	0.021
1997	1.199	0.060	1.212	0.061	0.351	0.018
1998	1.190	0.059	1.230	0.062	0.341	0.017
1999	0.925	0.046	1.066	0.053	0.321	0.016
2000	0.976	0.049	1.008	0.050	0.303	0.015
2001	1.036	0.052	1.194	0.060	0.294	0.015
2002	1.039	0.052	1.204	0.060	0.279	0.014
2003	0.916	0.046	1.009	0.050	0.340	0.017
2004	0.952	0.048	1.011	0.051	0.243	0.012
2005	0.843	0.042	0.957	0.048	0.221	0.011
2006	0.808	0.040	0.860	0.043	0.205	0.010
2007	0.313	0.016	0.206	0.010	0.167	0.008
2008	0.313	0.016	0.208	0.010	0.180	0.009
2009	0.321	0.016	0.214	0.011	0.163	0.008
2010	0.278	0.014	0.194	0.010	0.159	0.008
2011	0.504	0.025	0.432	0.022	0.184	0.009
2012	0.516	0.026	0.414	0.021	0.180	0.009
2013	0.670	0.034	0.405	0.020	0.207	0.010
2014	0.739	0.037	0.424	0.021	0.210	0.011
2015	0.736	0.037	0.370	0.019	0.203	0.010
2016	0.747	0.037	0.386	0.019	0.207	0.010
2017	0.766	0.038	0.395	0.020	0.210	0.011
2018	0.769	0.038	0.395	0.020	0.212	0.011
2019	0.770	0.039	0.394	0.020	0.214	0.011
2020	0.735	0.037	0.328	0.016	0.232	0.012
2021	0.774	0.039	0.364	0.018	0.222	0.011
Trend						
1990 - 2021	-23.5%	-23.5%	-65.3%	-65.26%	-39.8%	-39.8%
2005 - 2021	-8.2%	-8.2%	-62.0%	-65.3%	0.6%	0.6%
2020 - 2021	5.3%	5.3%	11.0%	-62.0%	-4.3%	-4.3%

The percentage of the agricultural crop residues burnt on-site, which is the mass of fuel available for burning, should be estimated taking into account the fractions removed before burning due to animal consumption, decay in the field, and use in other sectors (e.g., biofuel, domestic livestock feed, building materials, etc.). This is important to eliminate the possibility of double counting.

For estimating the biomass burnt on field the parameter (1) Residue/Crop Ratio, (2) Dry Matter Fraction andp (3) Fraction of Crop Residue Burnt in Fields were used and presented in the following Table.

Table 341 **Fraction of Crop Residue Burned in Fields, Dry Matter Fraction and Residue/Crop Ratio**

Fuel	Residue/Crop Ratio	Dry Matter Fraction (DRY)	Fraction of Crop Residue Burnt in Fields
	unit	unit	unit
Wheat	1.3	0.89	0.03
Barley	1.2	0.89	0.03
Maize	1.0	0.87	0.03
Rice	1.4	0.89	0.03
Peas	1.5	0.87 [b]	0.03
Potatoes	0.4 *	0.22	0.03
Sugar beet	2.2	0.72 [b]	0.03
Cotton	1.3 **	0.85	0.03
Feetbeet	0.3 *	0.86 *	0.03
Peanuts	1.0 *	0.86 [b]	0.03
Sunflower	1.3 *	0.85 [c]	0.03
Source	Table 4.16, IPCC GPG 2000, Chap. 4_Agriculture, page 4.58.[121] * as of beans & soybeans ** as of wheat	Table 11.2, 2006 IPCC GL, Vol. 4, Chap. 11, page 11.17 [b] Table 4.16, IPCC GPG 2000, Chap. 4, page 4.58. [c] Table 11.1A, 2019 Refinement to the 2006 IPCC GL, Vol. 4. Chap. 11, page 11.17.[122]	Based on expert judgment and Table 4.19, 1996 IPCC GL, Reference Manual, Vol. 3, Chap, 4.4.3 Field Burning of Agricultural Residues, page 4.83.[123]

5.7.2.3 Choice of emission factors

The rationale for using the approach of the *Reference Manual* of the *Revised 1996 IPCC Guidelines* (Vol. 3, Chap, 4.4.3 Field Burning of Agricultural Residues), and not the approach of the 2006 IPCC GL, Vol. 4. Chap. 5 and 2, is as follows:

(1) the 2006 IPCC GL equation was developed to be broadly applicable to all types of biomass burning, and, thus, is not specific to agricultural residues; and

(2) the 2006 IPCC GL default factors are provided only for four crops (corn, rice, sugarcane, and wheat), while this inventory analyses emissions from much more crops.

[121] https://www.ipcc-nggip.iges.or.jp/public/gp/english/4_Agriculture.pdf

[122] https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch11_Soils_N2O_CO2.pdf

[123] https://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/CH4ref6.pdf

Equation: Emission factor for CH_4 and Emission factor for N_2O from Field burning of agricultural residues

(*Reference Manual* of the *Revised 1996 IPCC Guidelines* (Vol. 3, Chap, 4.4.3))

$$EF_{CH4} = C\ Fraction_{residue\ T} \times emission\ ratio \times \frac{16}{12}$$

$$EF_{N2O} = N\ Fraction_{residue\ T} \times (N/C\ ratio) \times emission\ ratio \times \frac{44}{28}$$

Where:

EF_{GHG}	= emission factor of a given GHG by type of crop based on dry matter burnet (g kg^{-1} dry matter burnt)
GHG	= CH_4, N_2O
C fraction of residues	= C fraction of residues - Carbon content of the residue (tonnes of carbon / tonnes of dry matter)
N fraction of residues	= N fraction of residues - Nitrogen content of the residue (tonnes of nitrogen / tonnes of dry matter)
Emission ratios	= Emission ratios for agricultural residue burning calculations
N/C ratio	= N-C ratio of the fuel (crop residues) by weight to yield the total amount of nitrogen (N) released
16/12	= conversion factor to full molecular weights
44/28	= conversion factor to full molecular weights

Default values of emission ratios are presented in the following table.

Table 342 Emission ratios for agricultural residue burning calculations

	Emission ratio
CH_4	0.005
N_2O	0.005
CO	0.06
NOx	0.121
Source	Table 4.16, 1996 IPCC GL, Reference Manual, Vol. 3, Chap, 4.4.3 Field Burning of Agricultural Residues, page 4.83. [124]

Data on carbon content and nitrogen content of residues and the nitrogen-carbon ratio in biomass residues are provided in the following table.

Table 343 C Fraction of Residue, N Fraction of Residue and N-C ratio in Biomass Residue

Fuel	C Fraction of Residue	N Fraction of Residue	N-C ratio in Biomass Residue
	(tonnes of carbon / tonnes of dry matter)	(tonnes of nitrogen / tonnes of dry matter)	(tonnes of carbon / tonnes of nitrogen)
Wheat	0.4853	0.0028	0.0058
Barley	0.4567	0.0043	0.0094
Maize	0.4709	0.0172	0.0365
Rice	0.4144	0.0067	0.0162
Peas	0.4446	0.0142	0.0319

[124] https://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/CH4ref6.pdf

Fuel	C Fraction of Residue	N Fraction of Residue	N-C ratio in Biomass Residue
	(tonnes of carbon / tonnes of dry matter)	(tonnes of nitrogen / tonnes of dry matter)	(tonnes of carbon / tonnes of nitrogen)
Potatoes	0.4642	0.0168	0.0362
Sugar beet	0.5378	0.0073	0.0136
Cotton	0.4853	0.0150	0.0309
Feetbeet	0.4072	0.0228	0.0560
Peanuts	0.4612	0.0106	0.0230
Sunflower	0.4853	0.0150	0.0309
Source	Table 4.16, IPCC GPG 2000, Chap. 4_Agriculture, page 4.58.[125]	Table 4.19, 1996 IPCC GL, Reference Manual, Vol. 3, Chap, 4.4.3 Field Burning of Agricultural Residues, page 4.83.[126]	calculated

5.7.3 Uncertainties and time-series consistency for IPCC sub-category 3.F Field burning of agricultural residues

The uncertainties for activity data and emission factors used for IPCC category 3.F Field burning of agricultural residues are presented in the following table.

Table 344 Uncertainty for IPCC sub-category 3.F Field burning of agricultural residues.

Uncertainty	CO_2	CH_4	N_2O	Reference
				2006 IPCC GL, Vol. 4, Chap. 11
Activity data (AD)	-	20%	20%	Expert judgment on Chapter 11.2.1.4
Emission factor (EF)	-	180%	180%	Table 11.1 Chapter 1.2.1.2
Combined Uncertainty	-	181%	181%	$U_{Total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

5.7.4 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- o consistent use of data on area under crop cultivation (statistical yearbook and FAO STAT),
- o documented sources,
- o use of units,
- o strictly defined interfaces between spreadsheets/calculation modules,
- o unique structure of sheets which do the same,
- o record keeping, use of write protection,
- o unique use of formulas, special cases are documented/highlighted,
- o quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from different sources: national statistic (Monstat) and international statistics (FAO)

⇒ consistency and completeness checks are performed;

⇒ time series consistency - plausibility checks of dips and jumps.

[125] https://www.ipcc-nggip.iges.or.jp/public/gp/english/4_Agriculture.pdf
[126] https://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/CH4ref6.pdf

5.7.5 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC category 3.F *Field burning of agricultural residues*.

Table 345 Recalculations done in IPCC sub-category 3.F *Field burning of agricultural residues.*

GHG source & sink category	Revisions	Type of revision	Type of improvement
3.F	Application of 2006 IPCC Guidelines and Guidance provided by the 2019 Refinements of the 2006 IPCC Guidelines	method	Comparability
3.F	• Revision of Fraction of crop residues burnt in field • Revision of Dry matter fraction • Consideration of more crops	AD	Comparability Transparency Accuracy

5.7.6 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 346 Planned improvements for IPCC category 3.F *Field burning of agricultural residues.*

GHG source & sink category	Planned improvement	Type of improvement		Priority
3.F	Application of 2006 IPCC Guidelines and guidance provided by the 2019 Refinements of the 2006 IPCC Guidelines	AD	Accuracy	high
3.F	Consideration of cultivated crops and crop residues which are burnt • Crops where crop residues are burned • Use of crop residues: biofuel, domestic livestock feed, building materials, burning in the field etc. • Dry matter fraction • Estimation of above-ground (and below ground) biomass, dead organic matter (dead wood and litter)	AD	Transparency Accuracy	high
3.F	Cross-check with FAO statistics[127] (Emissions – Agriculture) where emissions from crop residues were estimated		Consistency	medium

[127] Available (03. March 2019) on http://www.fao.org/faostat/en/#data/GA

5.8 Liming (IPCC category 3.G)

This section the estimation of CO_2 emission from liming. In general liming is used to reduce soil acidity and improve plant growth in managed systems, particularly agricultural lands and managed forests. The adding of carbonates to soils in the form of lime (e.g., calcic limestone ($CaCO_3$), or dolomite ($CaMg(CO_3)_2$) leads to CO_2 emissions as the carbonate limes dissolve and release bicarbonate ($2HCO_3^-$), which evolves into CO_2 and water (H_2O) (IPCC 2006).

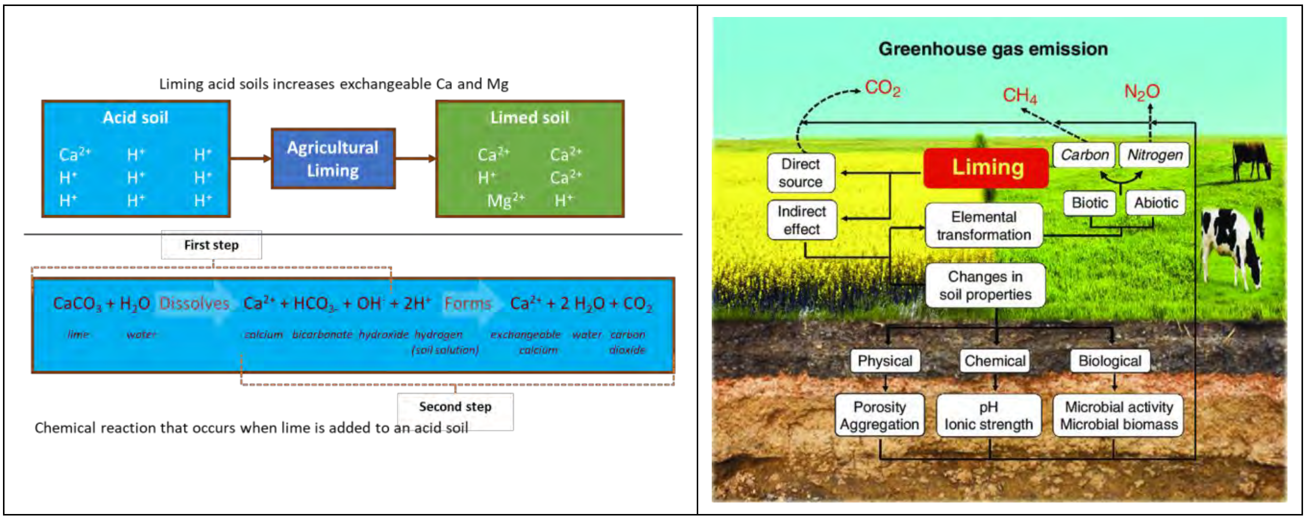


Figure 154 Conceptual flow diagram showing the effect of liming on greenhouse gases

Source (left Figure): Ritchey, E.L.; Murdock, L.W.; Ditsch, D. and McGrath, J.M. (2016): Agricultural Lime Recommendations Based on Lime Quality. In: Plant and Soil Sciences; F.J. Sikora, Division of Regulatory Services. In: Cooperative extension service university of Kentucky College of Agriculture, food and environment, Lexington, KY, 40546. ID-163.

Source (right Figure): Kunhikrishnan, A.; Thangarajan, R. ; Bolan, N.S.; Xu, Y.; Mandal, S.; Gleeson, D.B.; Seshadri, B.; Zaman; M.; Barton; L.; Tang; C.; Luo; J.; Dalal; R.; Ding; W.; Kirkham; M.B.; Naidu; R. (2016): Functional Relationships of Soil Acidification, Liming, and Greenhouse Gas Flux. In: Advances in Agronomy. Volume 139, 2016, Pages 1-71.

5.8.1 Source category description

IPCC code	description	CO_2		CH_4		N_2O	
		Estimated	Key Category	estimated	Key category	estimated	Key category
3.G	**Liming**	✓	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

An overview of the CO_2 emissions resulting IPCC category 3.G Liming is provided in the following figure and table.

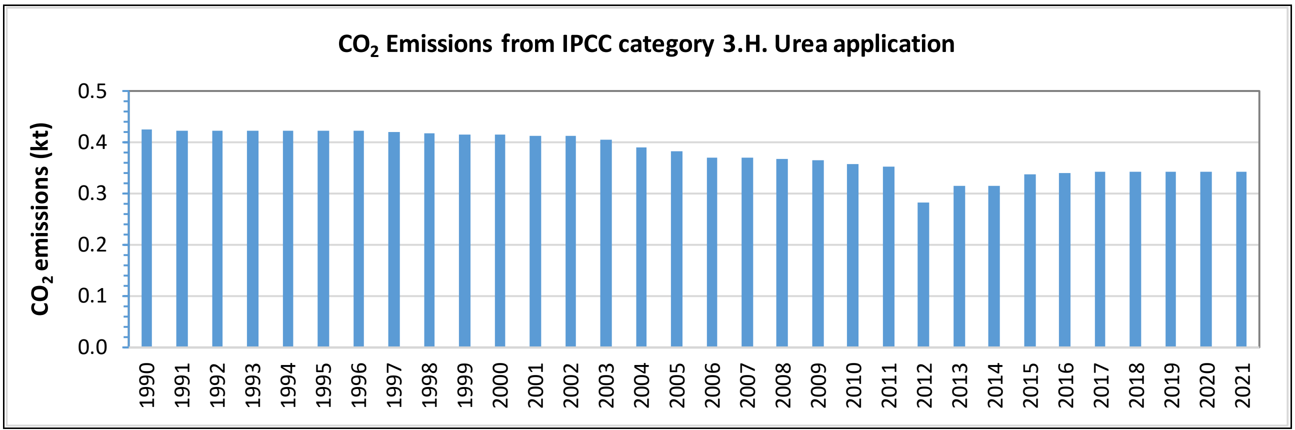


Figure 155 CO_2 Emissions from IPCC sub-category 3.G *Liming* for the period 1990-2021

In 2021, CO2 emissions from IPCC category 3.G *Liming* amount to 0.028 kt, which correspond to less than 0.001% of National Total GHG emissions (without LULUCF). In the period 1990 to 2021 GHG emissions from the 3.G *Liming* decreased by -56.4% from 0.065 kt in 1990 due to reduced consumption of urea.

Table 347 GHG Emissions from IPCC category 3.G *Liming* for the period 1990-2021

	Activity data			Emissions		
	Limestone $CaCO_3$	Dolomite $CaMg(CO_3)$	Total Limestone used	CO_2	CH_4	N_2O
	t	t	t	kt	kt	kt
1990	147.12	NO	147.12	0.065	NA	NA
1991	143.35	NO	143.35	0.063	NA	NA
1992	138.06	NO	138.06	0.061	NA	NA
1993	135.90	NO	135.90	0.060	NA	NA
1994	139.91	NO	139.91	0.062	NA	NA
1995	133.32	NO	133.32	0.059	NA	NA
1996	132.25	NO	132.25	0.058	NA	NA
1997	129.91	NO	129.91	0.057	NA	NA
1998	126.04	NO	126.04	0.055	NA	NA
1999	122.27	NO	122.27	0.054	NA	NA
2000	122.05	NO	122.05	0.054	NA	NA
2001	112.90	NO	112.90	0.050	NA	NA
2002	109.23	NO	109.23	0.048	NA	NA
2003	107.08	NO	107.08	0.047	NA	NA
2004	109.64	NO	109.64	0.048	NA	NA
2005	111.94	NO	111.94	0.049	NA	NA
2006	112.00	NO	112.00	0.049	NA	NA
2007	112.80	NO	112.80	0.050	NA	NA
2008	112.90	NO	112.90	0.050	NA	NA
2009	113.91	NO	113.91	0.050	NA	NA

	Activity data			Emissions		
	Limestone $CaCO_3$	Dolomite $CaMg(CO_3)$	Total Limestone used	CO_2	CH_4	N_2O
	t	t	t	kt	kt	kt
2010	113.49	NO	113.49	0.050	NA	NA
2011	114.24	NO	114.24	0.050	NA	NA
2012	89.50	NO	89.50	0.039	NA	NA
2013	136.80	NO	136.80	0.060	NA	NA
2014	136.80	NO	136.80	0.060	NA	NA
2015	101.50	NO	101.50	0.045	NA	NA
2016	77.40	NO	77.40	0.034	NA	NA
2017	64.10	NO	64.10	0.028	NA	NA
2018	64.10	NO	64.10	0.028	NA	NA
2019	64.10	NO	64.10	0.028	NA	NA
2020	64.10	NO	64.10	0.028	NA	NA
2021	64.10	NO	64.10	0.028	NA	NA
Trend						
1990 - 2021	-19.4%	-19.4%	*NA*	*-56.4%*	*NA*	*NA*
2005 - 2021	-10.8%	-10.8%	*NA*	*-42.7%*	*NA*	*NA*
2020 - 2021	0.00%	0.00%	*NA*	*0.0%*	*NA*	*NA*

5.8.2 Methodological issues

5.8.2.1 Choice of methods

TIER 1 approach

For estimating the CO_2 emissions from *Liming* the 2006 IPCC Guidelines Tier 1 approach[128] has been applied.

Equation 11.12: CO_2 emissions from Lime Application

$$CO_2 - C\ emissions = (M_{Limestone} * EF_{Limestone}) + (M_{Dolomite} * EF_{Dolomite})$$

$$CO_2\ emission = CO_2 - C\ emissions * \frac{44}{12}$$

Where:

CO_2–C Emission	= annual C emissions from lime application, tonnes C yr-1
M	= annual amount (tonnes yr-1) of
	o calcic limestone ($CaCO_3$)
	o dolomite ($CaMg(CO_3)_2$)
EF	= emission factor (tonne of C per tonne of limestone or dolomite)
44/12	= to convert CO_2–C emissions into CO_2; conversion factor to full molecular weights

[128] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 11: N2O Emissions from Managed Soils, and CO2 Emissions from Lime and Urea Application, sub-chap 11.3.1 Choice of method

5.8.2.2 Choice of activity data

The amount of lime applied to soil was taken from MONSTAT and is presented in the table above.

5.8.2.3 Choice of emission factors

For the Tier 1 approach the default emission factors (EF), provided by the 2006 IPCC GL[129], were used:

- 0.12 tonne of C per tonne of limestone;
- 0.13 tonne of C per tonne of dolomite.

5.8.3 Uncertainties and time-series consistency for IPCC sub-category 3.G Liming

The uncertainties for activity data and emission factors used for IPCC category 3.G Liming are presented in the following table.

Table 348 Uncertainty for IPCC sub-category 3.G Liming.

Uncertainty	CO_2	CH_4	N_2O	Reference
				2006 IPCC GL, Vol. 4, Chap. 11
Activity data (AD)	20%	NA	NA	Expert judgment based on Chapter 11.3.4
Emission factor (EF)	50%	NA	NA	
Combined Uncertainty	54%	NA	NA	$U_{Total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

5.8.4 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- o documented sources,
- o use of units,
- o strictly defined interfaces between spreadsheets/calculation modules,
- o unique structure of sheets which do the same,
- o record keeping, use of write protection,
- o unique use of formulas, special cases are documented/highlighted,
- o quick-control checks for data consistency through all steps of calculation.

⇒ consistency and completeness checks are performed;

⇒ time series consistency - plausibility checks of dips and jumps.

5.8.5 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC sub-category 3.G Liming.

[129] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 11: N2O Emissions from Managed Soils, and CO2 Emissions from Lime and Urea Application, sub-chap 11.3.2 Choice of emission factors

Table 349 Recalculations done since NC & BUR in IPCC sub-category 3.G Liming

GHG source & sink category	Revisions	Type of revision	Type of improvement
3.G	No recalculation were performed		

5.8.6 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 350 Planned improvements for IPCC sub-category 3.F Field burning of agricultural residues

GHG source & sink category	Planned improvement	Type of improvement		Priority
3.G	Improvement of description of activity data	AD	Transparency	medium

5.9 Urea application (IPCC category 3.H)

This chapter includes information on and description of methodologies used for estimating GHG emissions as well as references to activity data and emission factors reported under IPCC category *Urea application*.

As described in the 2006 IPCC GL, Col. 4, Chap. 11, adding urea to soils during fertilisation leads to a loss of CO_2 that was fixed in the industrial production process. Urea ($CO(NH_2)_2$) is converted into ammonium (NH_4^+), hydroxyl ion (OH^-), and bicarbonate (HCO_3^-), in the presence of water and urease enzymes. Similar to the soil reaction following addition of lime, bicarbonate that is formed evolves into CO_2 and water.

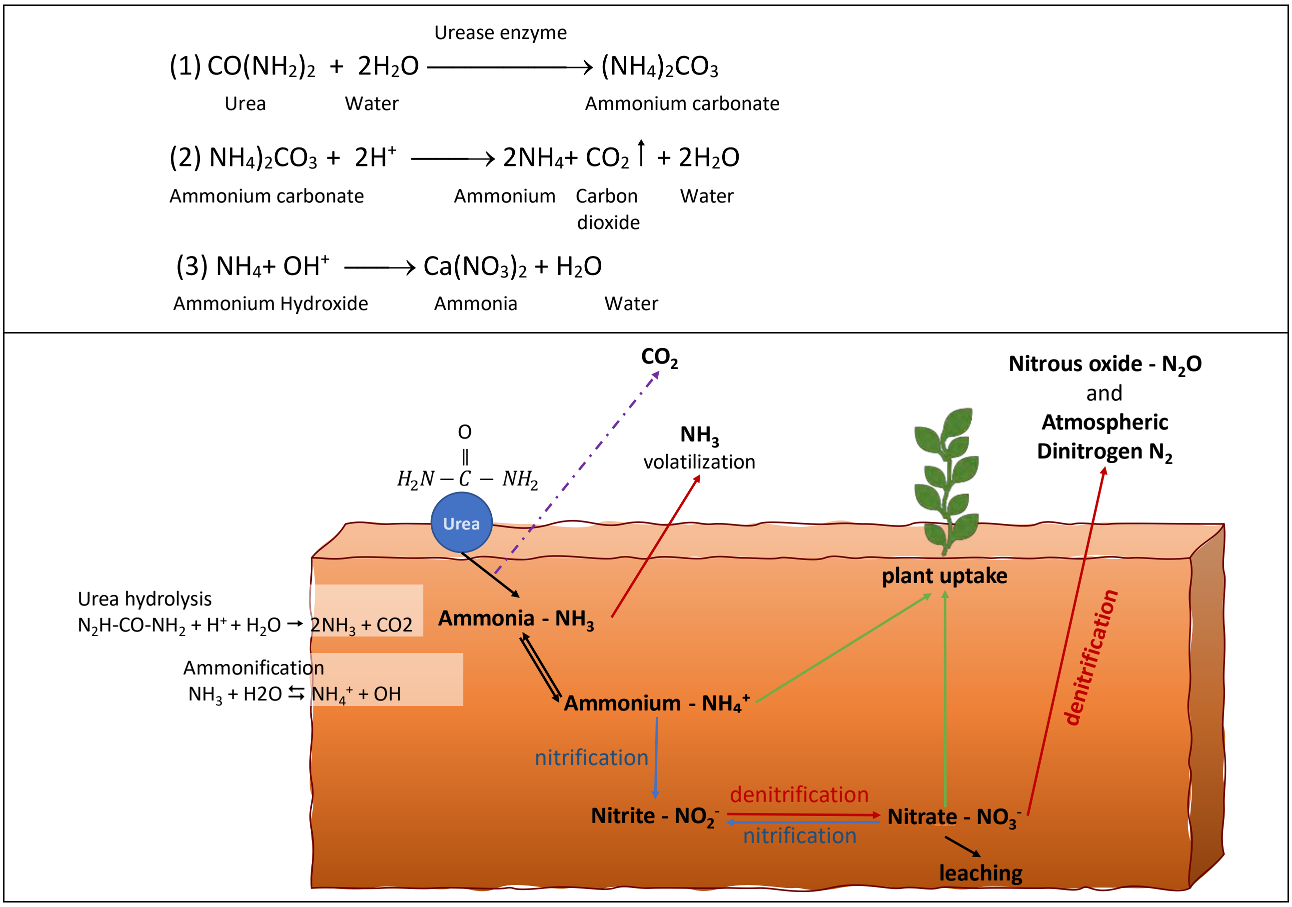


Figure 156 Urea hydrolysis reaction (equation)

This source category is included because the CO_2 removal from the atmosphere during urea manufacturing is estimated in the IPCC sector *Industrial Processes and Product Use Sector (IPPU).*

5.9.1 Source category description

GHG emissions from this sector comprise emissions from the following categories:

IPCC code	description	CO_2		CH_4		N_2O	
		Estimated	Key Category	estimated	Key category	estimated	Key category
3.H	**Urea application**	✓	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

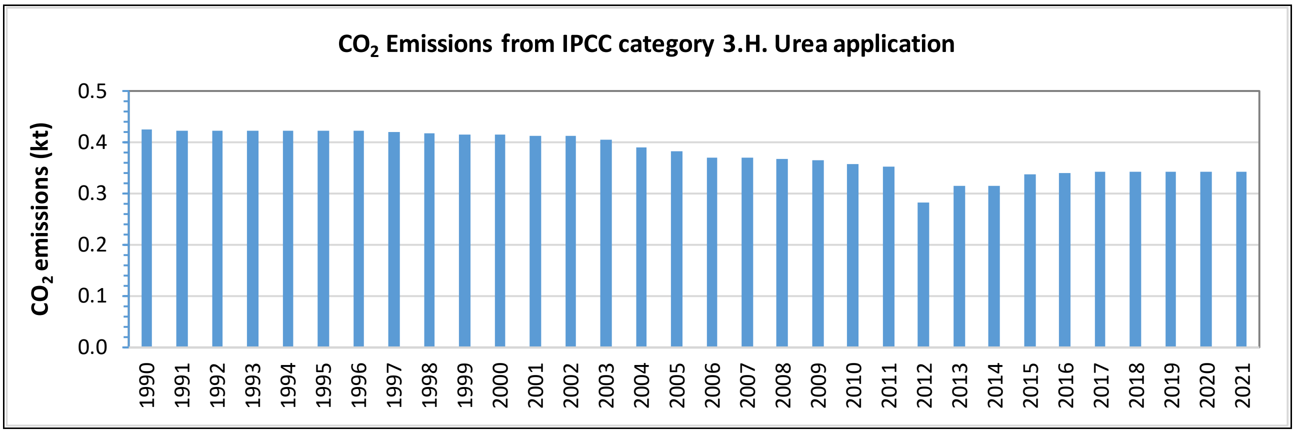


Figure 157 CO_2 **Emissions from IPCC category 3.H Urea application for the period 1990-2021**

In 2021, CO2 emissions from IPCC category 3.H Urea application amount to 0.343 kt, which correspond to less than 0.01% of National Total GHG emissions (without LULUCF). In the period 1990 to 2021 GHG emissions from the 3.H *Urea application* decreased by -19.4% from 0.425 kt in 1990 due to reduced consumption of urea.

Table 351 **Annual amount of urea applied, emission factor and** CO_2 **emissions from IPCC category 3.H Urea application for the period of 1990-2021**

	Urea application	Emission factor N_2O-N	CO_2-C emissions	CO_2 emissions	Method	EF used
	tonnes	t of C/t of urea	Gg	Gg	Gg	Gg
1990	580.0	0.20	0.116	0.425	T1	D
1991	579.0	0.20	0.116	0.425	T1	D
1992	578.0	0.20	0.116	0.424	T1	D
1993	578.0	0.20	0.116	0.424	T1	D
1994	578.0	0.20	0.116	0.424	T1	D
1995	577.0	0.20	0.115	0.423	T1	D
1996	577.0	0.20	0.115	0.423	T1	D
1997	575.0	0.20	0.115	0.422	T1	D
1998	570.0	0.20	0.114	0.418	T1	D
1999	567.0	0.20	0.113	0.416	T1	D
2000	566.0	0.20	0.113	0.415	T1	D
2001	565.0	0.20	0.113	0.414	T1	D
2002	563.0	0.20	0.113	0.413	T1	D
2003	555.0	0.20	0.111	0.407	T1	D
2004	534.0	0.20	0.107	0.392	T1	D
2005	524.0	0.20	0.105	0.384	T1	D
2006	505.0	0.20	0.101	0.370	T1	D
2007	505.0	0.20	0.101	0.370	T1	D
2008	501.0	0.20	0.100	0.367	T1	D
2009	500.0	0.20	0.100	0.367	T1	D

	Urea application	Emission factor N_2O-N	CO_2-C emissions	CO_2 emissions	Method	EF used
	tonnes	t of C/t of urea	Gg	Gg	Gg	Gg
2010	490.0	0.20	0.098	0.359	T1	D
2011	480.0	0.20	0.096	0.352	T1	D
2012	385.0	0.20	0.077	0.282	T1	D
2013	429.3	0.20	0.086	0.315	T1	D
2014	429.3	0.20	0.086	0.315	T1	D
2015	459.7	0.20	0.092	0.337	T1	D
2016	465.0	0.20	0.093	0.341	T1	D
2017	467.3	0.20	0.093	0.343	T1	D
2018	467.3	0.20	0.093	0.343	T1	D
2019	467.3	0.20	0.093	0.343	T1	D
2020	467.3	0.20	0.093	0.343	T1	D
2021	467.3	0.20	0.093	0.343	T1	D
Trend						
1990 - 2021	*-19.4%*			*-19.4%*		
2005 - 2021	*-10.8%*			*-10.8%*		
2020 - 2021	*0.0%*			*0.0%*		

5.9.2 Methodological issues

5.9.2.1 Choice of methods

TIER 1 approach

For estimating the CO_2 emissions from urea application, the 2006 IPCC Guidelines Tier 1 approach[130] has been applied.

Equation 11.13: CO_2 emissions from urea application
(2006 IPCC GL, Vol. 4, Chap. 11)

$$CO_2 - C\ emission = AD \times EF$$

$$CO_2\ emissions = \frac{CO_2O - C \times \frac{44}{12}}{1000}$$

Where:

CO_2 emission	= annual CO_2 emissions from urea application (Gg)
CO_2–C emission	= annual C emissions from urea application (tonnes C)
AD	= annual amount of urea fertilisation (tonnes urea)
EF	= emission factor (tonne of C / tonne of urea)
44/12	= conversion factor from C to CO_2

[130] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 11 - N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application, sub-chap. 11.4.1, page 11.32.

5.9.2.2 Choice of activity data

The agricultural data used and presented in this inventory are taken from national and international sources:

- MONSTAT
- FAO agricultural data base[131]

The annual amount of urea in used IPCC sector Agriculture is determined by national production, import and export, as well as 'other uses of urea'.

Agricultural use of Urea = Pproduction + Iimport – Export – Other Uses of Urea

5.9.2.3 Choice of emission factors

The default emission factor was taken from IPCC 2006 Guidelines and presented in presented in the following table.

Table 352 CO_2 Emission factor TIER 1 for IPCC category 3.H Urea application

	EF CO_2-C (t of carbon/t of urea)			Source
	Method	EF	type	
Urea application	T1	0.20	D	2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 11 - N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application, sub-chap. 11.4.2, page 11.34.

Note:
D Default CS Country specific PS Plant specific IEF Implied emission factor

5.9.3 Uncertainties and time-series consistency for IPCC sub-category 3.D Urea application

The uncertainties for activity data and emission factors used for IPCC category 3.D Urea application are presented in the following table.

Table 353 Uncertainty for IPCC sub-category 3.D Urea application.

Uncertainty	CO_2	CH_4	N_2O	Reference
Activity data (AD)	10%	NA	NA	Table 2.15 and Table 3.1, 2006 IPCC GL, Vol. 2, Chap. 2 (2.4.2)
Emission factor (EF)	50%	NA	NA	Chapter 11.4.4, 2006 IPCC GL, Vol. 4, Chap. 11
Combined Uncertainty	51%	NA	NA	$U_{Total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

131 https://www.fao.org/faostat/en/#data/RFB

5.9.4 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from different sources: national statistic (MONSTAT) and international statistics (FAO)

⇒ time series consistency - plausibility checks of dips and jumps.

5.9.5 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC category 3.H *Urea application*.

Table 354 Recalculations done since last submission IPCC category 3.H *Urea application*

GHG source & sink category	Revisions	Type of revision	Type of improvement
3.H	No recalculation were performed	-	-

5.9.6 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 355 Planned improvements for IPCC category 3.H *Urea application*

GHG source & sink category	Planned improvement	Type of improvement		Priority
3.H	Detailed cross-check of national data and international data (FAO, Eurostat)	AD	Transparency Consistency Comparability	High
3.H	Improvement of description of activity data	AD	Transparency	medium

5.10 Other carbon-containing fertilizers (IPCC category 3.I)

GHG emissions from this sector comprise emissions from the following categories:

IPCC code	description	CO_2		CH_4		N_2O	
		Estimated	Key Category	estimated	Key category	estimated	Key category
3.I	**Other carbon-containing fertilizers**	NO	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC category 3.I *Other carbon-containing fertilizers* does not exist in Montenegro.

5.11 Other (IPCC category 3.J)

GHG emissions from this sector comprise emissions from the following categories:

IPCC code	description	CO_2		CH_4		N_2O	
		Estimated	Key Category	estimated	Key category	estimated	Key category
3.J	**Other**	NO	-	NA	-	NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential							
LA – Level Assessment (in year); TA – Trend Assessment							

The IPCC category 3.J *Other* does not exist in Montenegro.

6 Land Use, Land Use Change and Forestry (LULUCF) (IPCC sector 4)

6.1 Sector Overview

This chapter describes the GHG emissions and removals arising from land use, land use change and forestry (LULUCF). As presented in the following table, LULUCF is a significant sector in the Montenegrin GHG balance with total sector net GHG removals ranging from -1 243.54 to -2 663.66 kt CO_2eq. The sector is dominated by fluxes of CO_2, with emissions of CH_4 and N_2O contributing only marginally to the sector's total GHG balance. The sector is driven by the net removals from Forest land, which dwarf the net emission/removals of the other subcategories of the sector. In 2021, Forest land contributed net removals of -2 503.01 kt CO_2eq. The next most significant subcategories are Harvested Wood Products and Settlements, which in 2021 contributed removals of -12.69 kt CO_2eq and emissions of 61.84 kt CO_2eq, respectively.

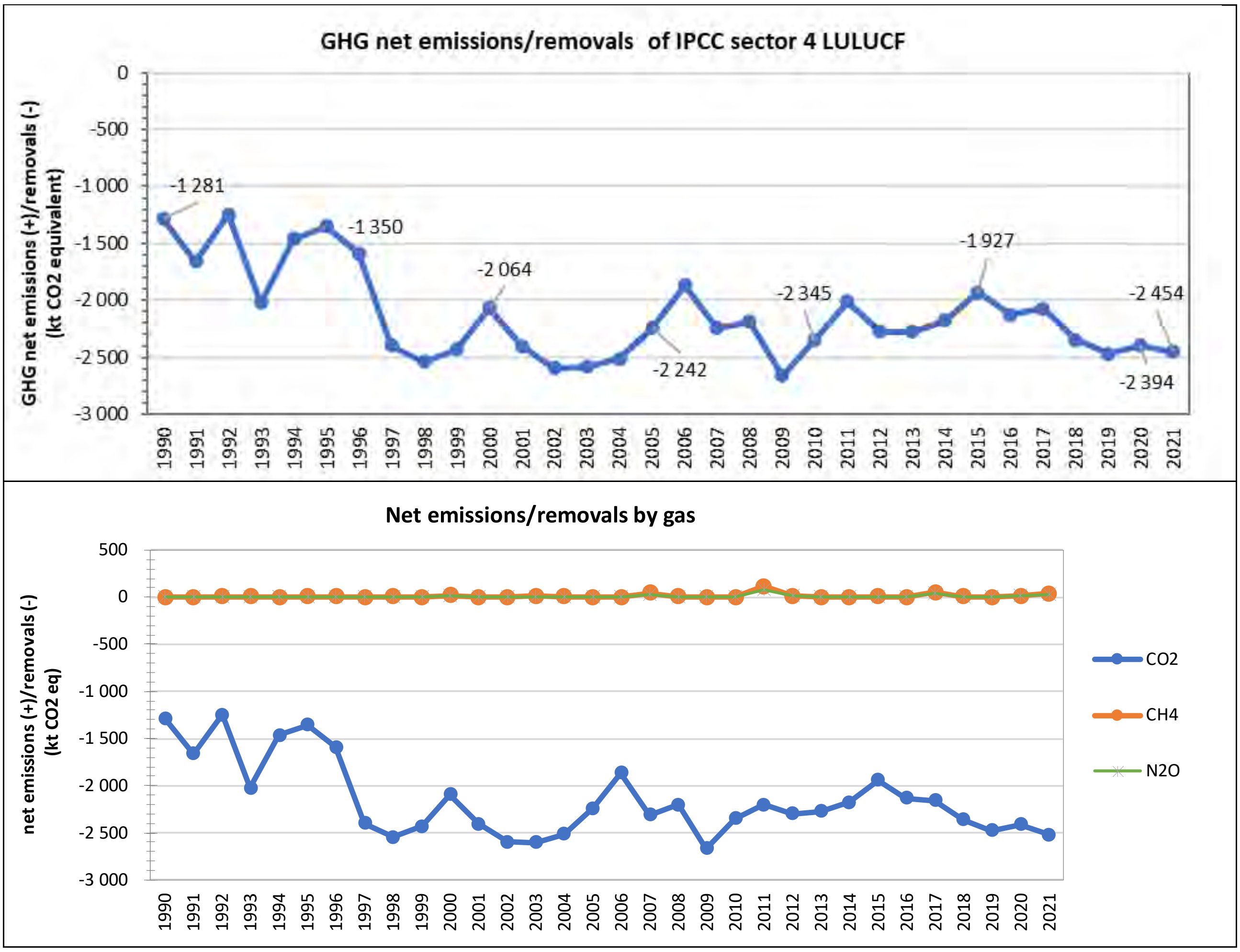


Figure 158 **Trend of GHG net emissions / removals of IPCC sector 4 LULUCF for the period 1990 – 2021**

Table 356 Total net emissions/removals per gas

Net emissions / removals	GHG	CO2	CH4	N2O	CH4	N2O
	kt CO2eq	kt	kt CO2eq		kt	kt
1990	**-1 281.34**	-1 285.46	1.68	2.45	0.067	0.008
1991	**-1 658.20**	-1 660.86	0.80	1.87	0.032	0.006
1992	**-1 243.54**	-1 249.96	3.06	3.36	0.122	0.011
1993	**-2 020.14**	-2 026.18	2.83	3.21	0.113	0.011
1994	**-1 463.02**	-1 466.54	1.31	2.21	0.052	0.007
1995	**-1 349.73**	-1 355.92	2.92	3.27	0.117	0.011
1996	**-1 585.28**	-1 591.99	3.24	3.48	0.130	0.012
1997	**-2 395.37**	-2 398.18	0.88	1.92	0.035	0.006
1998	**-2 541.30**	-2 548.70	3.65	3.75	0.146	0.013
1999	**-2 428.10**	-2 429.93	0.29	1.54	0.012	0.005
2000	**-2 063.74**	-2 094.05	17.45	12.85	0.698	0.043
2001	**-2 402.42**	-2 405.60	1.11	2.07	0.044	0.007
2002	**-2 595.48**	-2 598.36	0.93	1.95	0.037	0.007
2003	**-2 584.82**	-2 601.59	9.29	7.47	0.372	0.025
2004	**-2 510.81**	-2 517.46	3.20	3.45	0.128	0.012
2005	**-2 241.63**	-2 243.37	0.24	1.50	0.010	0.005
2006	**-1 865.70**	-1 867.85	0.49	1.66	0.020	0.006
2007	**-2 240.99**	-2 313.09	42.60	29.51	1.704	0.099
2008	**-2 188.18**	-2 203.67	8.44	7.05	0.338	0.024
2009	**-2 663.66**	-2 665.56	0.20	1.70	0.008	0.006
2010	**-2 344.67**	-2 348.99	1.62	2.70	0.065	0.009
2011	**-2 011.18**	-2 202.10	114.02	76.89	4.561	0.258
2012	**-2 276.61**	-2 299.77	12.89	10.28	0.515	0.034
2013	**-2 274.07**	-2 276.62	0.40	2.15	0.016	0.007
2014	**-2 174.07**	-2 176.31	0.14	2.10	0.006	0.007
2015	**-1 927.02**	-1 941.20	7.27	6.91	0.291	0.023
2016	**-2 124.53**	-2 131.00	2.56	3.91	0.102	0.013
2017	**-2 071.61**	-2 155.85	49.36	34.88	1.974	0.117
2018	**-2 349.70**	-2 365.33	7.95	7.69	0.318	0.026
2019	**-2 469.76**	-2 476.84	2.72	4.35	0.109	0.015
2020	**-2 394.44**	-2 415.04	10.80	9.79	0.432	0.033
2021	**-2 454.32**	-2 523.12	39.79	29.01	1.592	0.097
Trend						
1990 – 2021	**-19.4%**	96.3%	2275.3%	1086.0%	2275.3%	1086.0%
2005 – 2021	**-10.8%**	12.5%	16503.9%	1834.5%	16503.9%	1834.5%
2020 - 2021	**0.0%**	4.5%	268.3%	196.3%	268.3%	196.3%

6.1.1 Emission trends

The sink strength of the LULUCF sector has increased by 91.5% between 1990 -1 281.34 kt CO_2eq) and 2021 (-2 454.32 kt CO_2eq). Generally land use has been rather stable in Montenegro, with only a small proportion of the total territory undergoing land use change (see following figure). Nevertheless, significant dynamics in Forest land remaining Forest land have driven the aforementioned substantial long-term trend as well as considerable inter-annual variability (Figure 161). Principally, this variation has been driven by year-to-year changes in total drain due to timber harvest and biomass losses due to forest fires. It is likely that this variation is however missing a significant contribution from increment – due to the only recent implementation of a National Forest Inventory (NFI), only a static per-ha long-term increment could be employed in the GHG inventory calculation. It is also noteworthy that the removals in Forest land have also been complemented by a recent increase in the Harvested Wood Products sink since 2010.

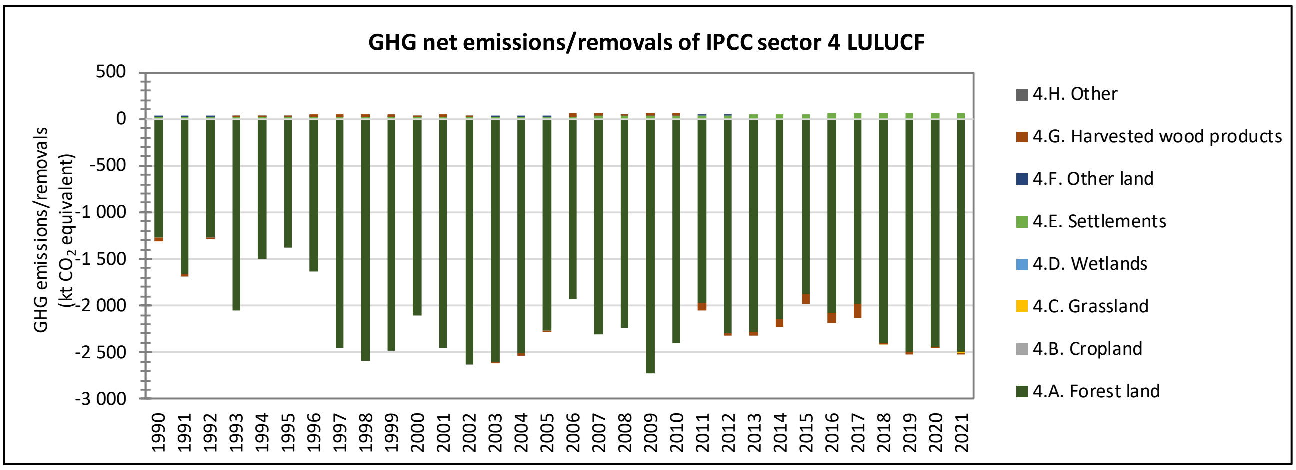


Figure 159 Net emissions/ removals in IPCC sector LULUCF from 1990 – 2021

Beyond Forest land and Harvest wood product (HWPs), the other subcategories (both individually and combined) contribute only marginally to the LULUCF sector GHG balance. Of the non-forest subcategories, it is interesting to note that the increased rate of land conversion to Settlements has of course produced an increase in the net emissions from the Settlements subcategory in the last years.

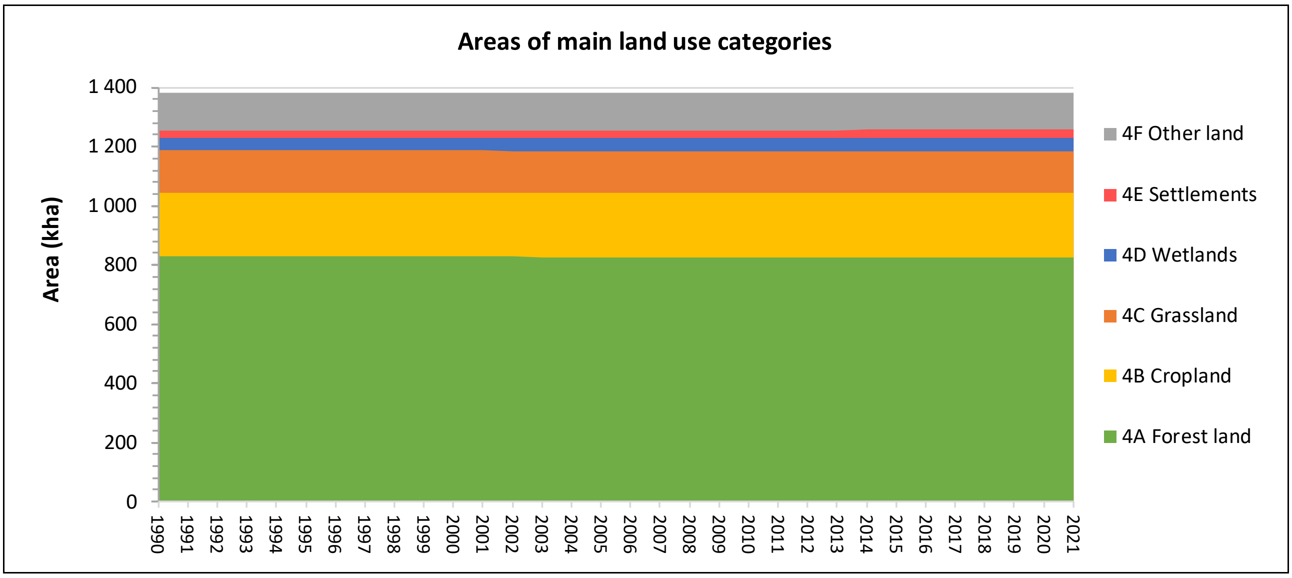


Figure 160 Areas of main land use categories in 1000 ha (kha) for the period of 1990-2021

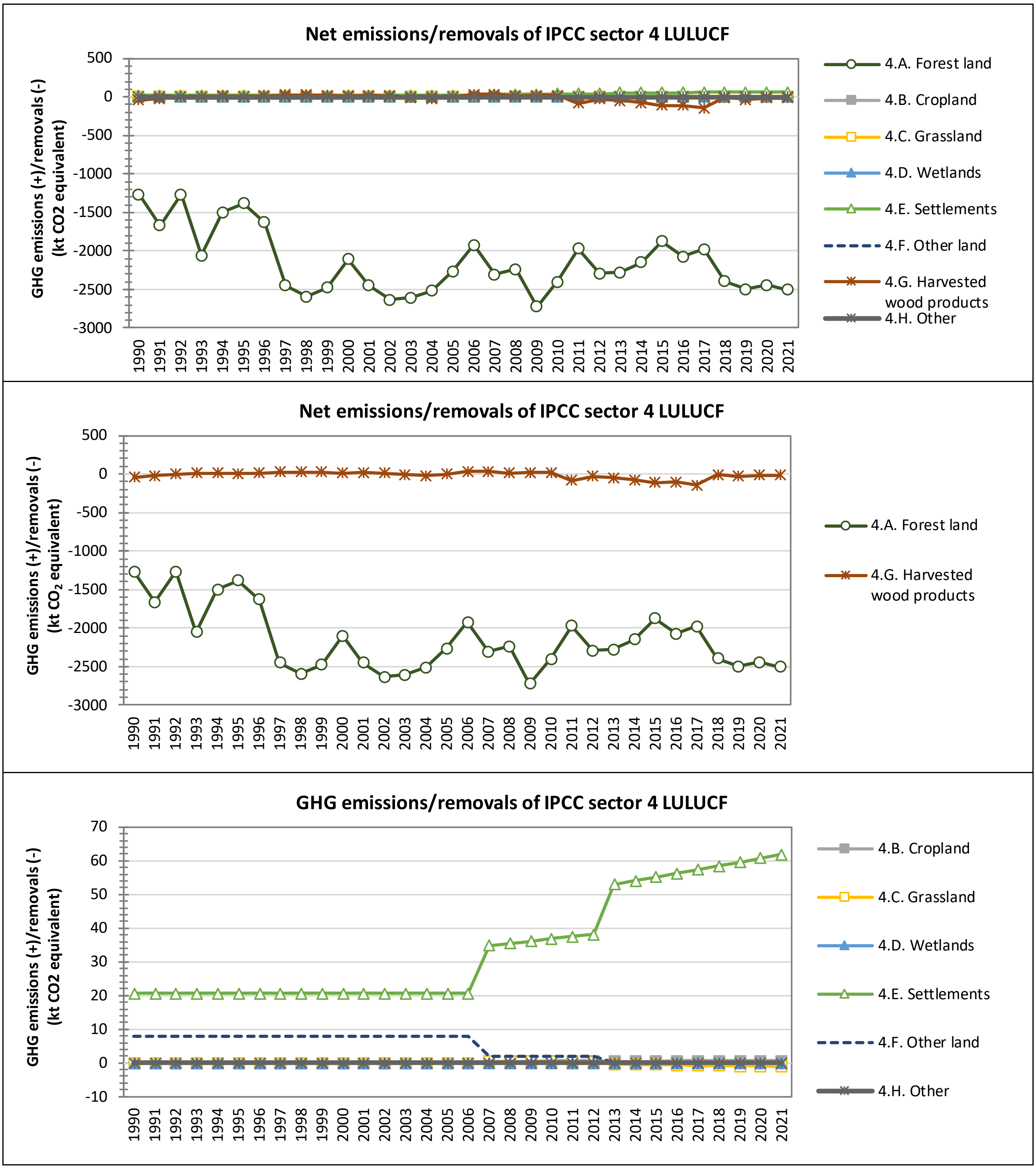


Figure 161 Total net emissions/removals (in kt CO_2eq) of the sector LULUCF and its main categories for the period of 1990-2021

Table 357 Areas of main land use categories in 1000 ha (kha) for the period of 1990-2021

Area	TOTAL Land	4.A Forest land	4.B Cropland	4.C Grassland	4.D Wetlands	4.E Settlements	4.F Other land
	kha						
1990	1381.20	827.76	215.89	143.12	43.05	25.84	125.55
1991		827.72	215.89	143.10	43.05	25.93	125.53
1992		827.68	215.89	143.08	43.05	26.01	125.50
1993		827.64	215.89	143.05	43.05	26.10	125.48
1994		827.60	215.89	143.03	43.05	26.18	125.46
1995		827.55	215.89	143.01	43.05	26.27	125.43
1996		827.51	215.89	142.99	43.05	26.36	125.41
1997		827.47	215.89	142.96	43.05	26.44	125.39
1998		827.43	215.89	142.94	43.05	26.53	125.37
1999		827.39	215.89	142.92	43.05	26.61	125.34
2000		827.35	215.89	142.90	43.05	26.70	125.32
2001		827.31	215.89	142.87	43.05	26.79	125.30
2002		827.27	215.89	142.85	43.05	26.87	125.27
2003		827.23	215.89	142.83	43.05	26.96	125.25
2004		827.19	215.89	142.81	43.05	27.04	125.23
2005		827.15	215.89	142.78	43.05	27.13	125.20
2006		827.11	215.89	142.76	43.05	27.21	125.18
2007		827.03	215.89	142.71	43.05	27.35	125.18
2008		826.95	215.88	142.67	43.05	27.48	125.18
2009		826.86	215.88	142.62	43.05	27.61	125.17
2010		826.78	215.88	142.58	43.05	27.74	125.17
2011		826.70	215.88	142.53	43.05	27.87	125.17
2012		826.62	215.88	142.49	43.05	28.00	125.17
2013		826.60	215.85	142.47	43.04	28.17	125.08
2014		826.58	215.81	142.45	43.03	28.34	124.99
2015		826.56	215.77	142.44	43.03	28.50	124.90
2016		826.54	215.74	142.42	43.02	28.67	124.81
2017		826.52	215.70	142.40	43.01	28.84	124.72
2018		826.51	215.66	142.39	43.01	29.01	124.63
2019		826.49	215.63	142.37	43.00	29.17	124.54
2020		826.47	215.59	142.35	42.99	29.34	124.45
2021		826.45	215.56	142.33	42.99	29.51	124.37
Share							
Share in 1990		*59.9%*	*15.6%*	*10.4%*	*3.1%*	*1.9%*	*9.1%*
Share in 2005		*59.9%*	*15.6%*	*10.3%*	*3.1%*	*2.0%*	*9.1%*
Share in 2021		*59.8%*	*15.6%*	*10.3%*	*3.1%*	*2.1%*	*9.0%*

Table 358 GHG Emissions/removals from IPCC sub-category 4 LULUCF by subcategories for the period 1990 - 2021

GHG emissions	4 TOTAL LULUCF	4.A Total Forest land	4.B Cropland	4.C Grassland	4.D Wetlands	4.E Settlements	4.F Other land	4.G Harvested Wood Products
	kt CO_2 equivalent							
1990	**-1 281.34**	-1 269.70	0.03	NO	NO	20.67	7.87	-40.22
1991	**-1 658.20**	-1 667.20	0.03	NO	NO	20.67	7.87	-19.57
1992	**-1 243.54**	-1 268.88	0.03	NO	NO	20.67	7.87	-3.24
1993	**-2 020.14**	-2 057.24	0.03	NO	NO	20.67	7.87	8.52
1994	**-1 463.02**	-1 501.75	0.03	NO	NO	20.67	7.87	10.15
1995	**-1 349.73**	-1 382.78	0.03	NO	NO	20.67	7.87	4.47
1996	**-1 585.28**	-1 628.67	0.03	NO	NO	20.67	7.87	14.82
1997	**-2 395.37**	-2 450.23	0.03	NO	NO	20.67	7.87	26.28
1998	**-2 541.30**	-2 596.72	0.03	NO	NO	20.67	7.87	26.84
1999	**-2 428.10**	-2 478.75	0.03	NO	NO	20.67	7.87	22.08
2000	**-2 063.74**	-2 104.92	0.03	NO	NO	20.67	7.87	12.60
2001	**-2 402.42**	-2 450.96	0.03	NO	NO	20.67	7.87	19.97
2002	**-2 595.48**	-2 633.33	0.03	NO	NO	20.67	7.87	9.28
2003	**-2 584.82**	-2 607.87	0.03	NO	NO	20.67	7.87	-5.53
2004	**-2 510.81**	-2 515.56	0.03	NO	NO	20.67	7.87	-23.82
2005	**-2 241.63**	-2 267.07	0.03	NO	NO	20.67	7.87	-3.13
2006	**-1 865.70**	-1 925.35	0.03	NO	NO	20.67	7.87	31.07
2007	**-2 240.99**	-2 308.99	0.38	0.43	NO	34.83	1.92	30.44
2008	**-2 188.18**	-2 237.47	0.44	0.41	NO	35.50	1.92	11.02
2009	**-2 663.66**	-2 723.65	0.50	0.39	NO	36.16	1.92	21.02
2010	**-2 344.67**	-2 405.02	0.56	0.37	NO	36.83	1.92	20.67
2011	**-2 011.18**	-1 969.63	0.61	0.35	NO	37.50	1.92	-81.94
2012	**-2 276.61**	-2 290.50	0.67	0.33	NO	38.17	1.92	-27.20
2013	**-2 274.07**	-2 280.08	0.47	-0.36	NO	52.95	NO	-47.05
2014	**-2 174.07**	-2 150.20	0.49	-0.45	NO	54.06	NO	-77.97
2015	**-1 927.02**	-1 873.88	0.51	-0.54	NO	55.17	NO	-108.28
2016	**-2 124.53**	-2 073.28	0.54	-0.63	NO	56.28	NO	-107.44
2017	**-2 071.61**	-1 980.68	0.56	-0.73	NO	57.39	NO	-148.16
2018	**-2 349.70**	-2 396.96	0.58	-0.82	NO	58.51	NO	-11.00
2019	**-2 469.76**	-2 497.04	0.60	-0.91	NO	59.62	NO	-32.04
2020	**-2 394.44**	-2 441.89	0.63	-1.00	NO	60.73	NO	-12.90
2021	**-2 454.32**	-2 503.01	0.65	-1.10	NO	61.84	NO	-12.69
Trend								
1990 – 2021	*91.5%*	*97.1%*	*1952.7%*	*NA*	*NA*	*199.1%*	*NA*	*-68.4%*
2005 – 2021	*9.5%*	*10.4%*	*1952.7%*	*NA*	*NA*	*199.1%*	*NA*	*305.8%*
2020 - 2021	*2.5%*	*2.5%*	*3.6%*	*9.2%*	*NA*	*1.8%*	*NA*	*-1.6%*

Table 359 CO_2 Emissions/removals from IPCC sub-category 4 LULUCF by subcategories for the period 1990 - 2021

CO_2 emissions	4 TOTAL LULUCF	4.A Total Forest land	4.B Cropland	4.C Grassland	4.D Wetlands	4.E Settlements	4.F Other land	4.G Harvested Wood Products
	kt							
1990	**-1 285.46**	-1 272.48	-0.01	NO	NO	19.37	7.87	-40.22
1991	**-1 660.86**	-1 668.52	-0.01	NO	NO	19.37	7.87	-19.57
1992	**-1 249.96**	-1 273.95	-0.01	NO	NO	19.37	7.87	-3.24
1993	**-2 026.18**	-2 061.94	-0.01	NO	NO	19.37	7.87	8.52
1994	**-1 466.54**	-1 503.93	-0.01	NO	NO	19.37	7.87	10.15
1995	**-1 355.92**	-1 387.63	-0.01	NO	NO	19.37	7.87	4.47
1996	**-1 591.99**	-1 634.04	-0.01	NO	NO	19.37	7.87	14.82
1997	**-2 398.18**	-2 451.70	-0.01	NO	NO	19.37	7.87	26.28
1998	**-2 548.70**	-2 602.77	-0.01	NO	NO	19.37	7.87	26.84
1999	**-2 429.93**	-2 479.23	-0.01	NO	NO	19.37	7.87	22.08
2000	**-2 094.05**	-2 133.88	-0.01	NO	NO	19.37	7.87	12.60
2001	**-2 405.60**	-2 452.80	-0.01	NO	NO	19.37	7.87	19.97
2002	**-2 598.36**	-2 634.87	-0.01	NO	NO	19.37	7.87	9.28
2003	**-2 601.59**	-2 623.29	-0.01	NO	NO	19.37	7.87	-5.53
2004	**-2 517.46**	-2 520.87	-0.01	NO	NO	19.37	7.87	-23.82
2005	**-2 243.37**	-2 267.47	-0.01	NO	NO	19.37	7.87	-3.13
2006	**-1 867.85**	-1 926.16	-0.01	NO	NO	19.37	7.87	31.07
2007	**-2 313.09**	-2 379.68	0.33	0.43	NO	33.46	1.92	30.44
2008	**-2 203.67**	-2 251.48	0.38	0.41	NO	34.06	1.92	11.02
2009	**-2 665.56**	-2 723.99	0.44	0.39	NO	34.66	1.92	21.02
2010	**-2 348.99**	-2 407.70	0.49	0.37	NO	35.26	1.92	20.67
2011	**-2 202.10**	-2 158.83	0.54	0.35	NO	35.87	1.92	-81.94
2012	**-2 299.77**	-2 311.89	0.59	0.33	NO	36.47	1.92	-27.20
2013	**-2 276.62**	-2 280.74	0.38	-0.36	NO	51.14	NO	-47.05
2014	**-2 176.31**	-2 150.44	0.41	-0.45	NO	52.14	NO	-77.97
2015	**-1 941.20**	-1 885.95	0.43	-0.54	NO	53.15	NO	-108.28
2016	**-2 131.00**	-2 077.52	0.45	-0.63	NO	54.15	NO	-107.44
2017	**-2 155.85**	-2 062.58	0.47	-0.73	NO	55.15	NO	-148.16
2018	**-2 365.33**	-2 410.15	0.49	-0.82	NO	56.15	NO	-11.00
2019	**-2 476.84**	-2 501.55	0.51	-0.91	NO	57.15	NO	-32.04
2020	**-2 415.04**	-2 459.82	0.53	-1.00	NO	58.15	NO	-12.90
2021	**-2 523.12**	-2 569.04	0.56	-1.10	NO	59.15	NO	-12.69

Table 360 CH_4 Emissions from IPCC sub-category 4 LULUCF by subcategories for the period 1990 - 2021

CH_4 emissions	4 TOTAL LULUCF	4.A Total Forest land	4.B Cropland	4.C Grassland	4.D Wetlands	4.E Settlements	4.F Other land	4.G Harvested Wood Products
	kt							
1990	**0.067**	0.067	NO	NO	NO	NO	NO	NA
1991	**0.032**	0.032	NO	NO	NO	NO	NO	NA
1992	**0.122**	0.122	NO	NO	NO	NO	NO	NA
1993	**0.113**	0.113	NO	NO	NO	NO	NO	NA
1994	**0.052**	0.052	NO	NO	NO	NO	NO	NA
1995	**0.117**	0.117	NO	NO	NO	NO	NO	NA
1996	**0.130**	0.130	NO	NO	NO	NO	NO	NA
1997	**0.035**	0.035	NO	NO	NO	NO	NO	NA
1998	**0.146**	0.146	NO	NO	NO	NO	NO	NA
1999	**0.012**	0.012	NO	NO	NO	NO	NO	NA
2000	**0.698**	0.698	NO	NO	NO	NO	NO	NA
2001	**0.044**	0.044	NO	NO	NO	NO	NO	NA
2002	**0.037**	0.037	NO	NO	NO	NO	NO	NA
2003	**0.372**	0.372	NO	NO	NO	NO	NO	NA
2004	**0.128**	0.128	NO	NO	NO	NO	NO	NA
2005	**0.010**	0.010	NO	NO	NO	NO	NO	NA
2006	**0.020**	0.020	NO	NO	NO	NO	NO	NA
2007	**1.704**	1.704	NO	NO	NO	NO	NO	NA
2008	**0.338**	0.338	NO	NO	NO	NO	NO	NA
2009	**0.008**	0.008	NO	NO	NO	NO	NO	NA
2010	**0.065**	0.065	NO	NO	NO	NO	NO	NA
2011	**4.561**	4.561	NO	NO	NO	NO	NO	NA
2012	**0.515**	0.515	NO	NO	NO	NO	NO	NA
2013	**0.016**	0.016	NO	NO	NO	NO	NO	NA
2014	**0.006**	0.006	NO	NO	NO	NO	NO	NA
2015	**0.291**	0.291	NO	NO	NO	NO	NO	NA
2016	**0.102**	0.102	NO	NO	NO	NO	NO	NA
2017	**1.974**	1.974	NO	NO	NO	NO	NO	NA
2018	**0.318**	0.318	NO	NO	NO	NO	NO	NA
2019	**0.109**	0.109	NO	NO	NO	NO	NO	NA
2020	**0.432**	0.432	NO	NO	NO	NO	NO	NA
2021	**1.592**	1.592	NO	NO	NO	NO	NO	NA
Trend								
1990 – 2021	*2275.3%*	*2275.3%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 – 2021	*16503.9%*	*16503.9%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2020 - 2021	*268.3%*	*268.3%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

Table 361 N_2O Emissions from IPCC sub-category 4 LULUCF by subcategories for the period 1990 - 2021

N_2O emissions	4 TOTAL LULUCF	4.A Total Forest land	4.B Cropland	4.C Grassland	4.D Wetlands	4.E Settlements	4.F Other land	4.G Harvested Wood Products
	kt							
1990	**0.441**	NA	0.043	NA	0.399	NO	0.000	0.441
1991	**0.437**	NA	0.042	NA	0.395	NO	0.000	0.437
1992	**0.409**	NA	0.040	NA	0.369	NO	0.000	0.409
1993	**0.390**	NA	0.038	NA	0.352	NO	0.000	0.390
1994	**0.396**	NA	0.038	NA	0.358	NO	0.000	0.396
1995	**0.416**	NA	0.040	NA	0.376	NO	0.000	0.416
1996	**0.417**	NA	0.040	NA	0.377	NO	0.000	0.417
1997	**0.401**	NA	0.038	NA	0.363	NO	0.000	0.401
1998	**0.384**	NA	0.038	NA	0.346	NO	0.000	0.384
1999	**0.375**	NA	0.037	NA	0.338	NO	0.000	0.375
2000	**0.371**	NA	0.039	NA	0.333	NO	0.000	0.371
2001	**0.362**	NA	0.038	NA	0.324	NO	0.000	0.362
2002	**0.366**	NA	0.039	NA	0.328	NO	0.000	0.366
2003	**0.353**	NA	0.036	NA	0.318	NO	0.000	0.353
2004	**0.370**	NA	0.037	NA	0.333	NO	0.000	0.370
2005	**0.293**	NA	0.030	NA	0.263	NO	0.000	0.293
2006	**0.275**	NA	0.027	NA	0.248	NO	0.000	0.275
2007	**0.252**	NA	0.026	NA	0.225	NO	0.000	0.252
2008	**0.240**	NA	0.024	NA	0.216	NO	0.000	0.240
2009	**0.227**	NA	0.023	NA	0.204	NO	0.000	0.227
2010	**0.225**	NA	0.022	NA	0.202	NO	0.000	0.225
2011	**0.209**	NA	0.022	NA	0.187	NO	0.000	0.209
2012	**0.210**	NA	0.022	NA	0.189	NO	0.000	0.210
2013	**0.217**	NA	0.022	NA	0.195	NO	0.000	0.217
2014	**0.226**	NA	0.024	NA	0.202	NO	0.000	0.226
2015	**0.222**	NA	0.024	NA	0.198	NO	0.000	0.222
2016	**0.218**	NA	0.023	NA	0.195	NO	0.000	0.218
2017	**0.214**	NA	0.023	NA	0.191	NO	0.000	0.214
2018	**0.208**	NA	0.021	NA	0.186	NO	0.000	0.208
2019	**0.203**	NA	0.021	NA	0.182	NO	0.000	0.203
2020	**0.195**	NA	0.020	NA	0.175	NO	0.000	0.195
2021	**0.193**	NA	0.019	NA	0.174	NO	0.000	0.193
Trend								
1990 – 2021	*-56.2%*	*NA*	*-54.6%*	*NA*	*-56.3%*	*NA*	*-43.5%*	*-56.2%*
2005 – 2021	*-33.9%*	*NA*	*-35.0%*	*NA*	*-33.8%*	*NA*	*-29.4%*	*-33.9%*
2020 - 2021	*-0.9%*	*NA*	*-5.1%*	*NA*	*-0.5%*	*NA*	*3.6%*	*-0.9%*

6.1.2 Applied Methodology

6.1.2.1 Activity data

To generate a complete land use and land use change time series from 1970 to 2021, geographical data from different sources were synthesized. Land use changes were taken from the CORINE Land Cover (CLC) product of the EU's Copernicus Land Monitoring Service, with the IPCC land use categories assigned to the CLC classes as shown in Due to the assumption of no net carbon stock changes in Cropland remaining cropland, a split between annual and perennial cropland was only made for the land use changes to and from Cropland. This split was done by calculating the relative fraction of annual and perennial cropland from the 2018 CLC status layer, and applying this fraction to land use changes to and from Cropland over the time series. Based on national expert judgement, the CLC class 211, and 50% of the area of CLC classes 241, 242 and 243 were considered as annual cropland. The CLC classes 221, 222, 223 and 50% of the area of CLC class classes 241, 242 and 243 were considered as perennial cropland.

The CLC-change layers, which track CLC class changes between 2000 and 2006, between 2006 and 2012, and between 2012 and 2018 were used to derive the respective land use changes. Annual land use changes were calculated by dividing the total change areas by the respective 6-year intervals. National expert judgement considered that using the 1990-2000 CLC change layer would be inappropriate due to data gaps and inconsistencies. Therefore, the annual land use changes calculated from the 2000-2006 CLC change layer were extrapolated back to 1970.

To calculate annual total areas of the respective land use categories, a hierarchical approach was applied which starts with the official total area of the country (1381.2 kha), which is the same for all years of the GHG inventory time series. The first land use category for which the annual total area time series was constructed was Forest land, starting with the 826.782 kha total forest area measured by the country's first national forest inventory (NFI) in 2010 (Montenegro Ministry of Agriculture and Rural Development, 2013). The annual total Forest land areas for 2011 onwards were calculated by successively adding the annual net land use change to Forest land (annual total CLC land use changes to forests minus the annual total CLC land use changes from Forest land to the other land use categories). Likewise, the annual total Forest land areas for 2010 back to 1970 were calculated by successively subtracting the annual net land use change to Forest land.

To calculate the annual total areas for Cropland, Grassland, Wetlands, Settlements and Other land, the respective 1970-2018 time series were constructed starting with 2018. Subtracting the 2018 total Forest land area from the total official area of Montenegro yielded a 2018 total non-forest area that was subsequently distributed between Cropland, Grassland, Wetlands, Settlements and Other land according to the respective area contributions to non-forest land (in percent) as derived from the 2018 CLC status layer. The annual areas for 2017 back to 1970 were then subsequently calculated by successively subtracting the respective annual net land use changes from CLC to the corresponding categories. For instance, Cropland total areas for 2017 back to 1970 were calculated by successively subtracting the annual net land use change to Cropland (annual total CLC land use changes to Cropland minus the annual total CLC land use changes from Cropland to the other land use categories). For the years 2019-2021, the same extrapolation principle was applied. As no new CLC land use changes are available, the yearly LUCs from CLC change layer 2012/2018 were extrapolated and used to calculate the respective land use and land-use change areas in 2019 and 2020, again using the 2018 areas as the starting reference.

Due to the assumption of no net carbon stock changes in Cropland remaining cropland, a split between annual and perennial cropland was only made for the land use changes to and from Cropland. This split was done by calculating the relative fraction of annual and perennial cropland from the 2018 CLC status layer, and applying this fraction to land use changes to and from Cropland over the time series. Based on national expert judgement, the CLC class 211, and 50% of the area of CLC classes 241, 242 and 243 were considered as annual cropland. The CLC classes 221, 222, 223 and 50% of the area of CLC class classes 241, 242 and 243 were considered as perennial cropland.

Montenegro considers all its land as managed except some wetland subcategories as can be seen in the following table. For these unmanaged wetland subcategories, no emissions/removals are estimated.

Table 362 Country-specific cross-walk between the CORINE land Cover classes and the main IPCC land use categories

CLC class code	CLC class name	IPCC category	Comments
111	Continuous urban fabric	Settlements	
112	Discontinuous urban fabric	Settlements	
121	Industrial or commercial units	Settlements	
122	Road and rail networks and associated land	Settlements	
123	Port areas	Settlements	
124	Airports	Settlements	
131	Mineral extraction sites	Settlements	
132	Dump sites	Settlements	
133	Construction sites	Settlements	
141	Green urban areas	Settlements	
142	Sport and leisure facilities	Settlements	
211	Non-irrigated arable land	Cropland	
212	Permanently irrigated land	Cropland	
213	Rice fields	Cropland	NO
221	Vineyards	Cropland	
222	Fruit trees and berry plantations	Cropland	
223	Olive groves	Cropland	
231	Pastures	Grassland	
241	Annual crops associated with permanent crops	Cropland	
242	Complex cultivation patterns	Cropland	
243	Land principally occupied by agriculture, with significant areas of natural vegetation	Cropland	
244	Agro-forestry areas	Cropland	NO
311	Broad-leaved forest	Forest land	
312	Coniferous forest	Forest land	
313	Mixed forest	Forest land	
321	Natural grassland	Grassland	
322	Moors and heathland	Grassland	
323	Sclerophyllous vegetation	Forest land	UNMANAGED
324	Transitional woodland-scrub	Forest land	

CLC class code	CLC class name	IPCC category	Comments
331	Beaches, dunes, sands	Other land	
332	Bare rocks	Other land	
333	Sparsely vegetated areas	Other land	
334	Burnt areas	Forest land	
335	Glaciers and perpetual snow	Other land	NO
411	Inland marshes	Wetlands	Managed
412	Peat bogs	Wetlands	NO
421	Salt marshes	Wetlands	UNMANAGED
422	Salines	Wetlands	UNMANAGED
423	Intertidal flats	Wetlands	NO
511	Water courses	Wetlands	UNMANAGED
512	Water bodies	Wetlands	UNMANAGED
521	Coastal lagoons	Wetlands	NO
522	Estuaries	Wetlands	UNMANAGED
523	Sea and ocean	Wetlands	UNMANAGED
NO: not occuring			

6.1.2.2 Emission factors

The calculations of the LULUCF emissions and removals are aligned with the methods described in the IPCC 2006 Guidelines (Vol 4). Generally, the inventory relies heavily on the Guidelines for the most of the carbon stock, carbon stock changes and emission factors required for compiling the GHG balance of this sector. For some categories, Tier 2 approaches were implemented in the current submission. Due to the country´s NFI in 2010 the biomass change in the subcategory Forest land is now based on national data. Furthermore, the emission factors for biomass change concerning grassland and annual cropland are based on national agricultural harvest statistics.

6.1.3 Quality Assurance and Quality Control (QA/QC)

The following checks were implemented applying the four eyes principle (one person estimates, second person checks) and are included in an Excel QC checklist:

- Are the correct values used (check for transcription errors …)
- Check of plausibility of input data (activity data and their trend, emission factors, order of magnitude)
- Check of the correctness of all equations in the estimate files
- Check of the correctness of all interim results
- Is the data set complete for the whole time series
- Check of calculation units
- Check of plausibility of results (time-series, order of magnitude)
- Are all references clearly made
- Are all assumptions documented

6.1.4 Uncertainty assessment

A formal uncertainty analysis of the sector emissions and removals has not been implemented.

6.1.5 Recalculations

The following table presents the main revisions and recalculations done since the last submission and relevant to IPCC category 4.A *Forestland*.

Table 363 Recalculations done in IPCC sub-category 4.A Forestland.

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
4.	In contrast to the previous GHG inventory, emission factors for grassland and annual cropland biomass were estimated based on national harvest statistics derived from MONSTAT. Further, due to an update of FAO data concerning the quantities of HWPs, the removals in this category declined substantially for the year 2018-2021.	AD	Accuracy

6.1.6 Completeness

Table 364 gives an overview of the IPCC categories included in this chapter and the corresponding sub-divisions for which the calculations are made. It also provides information on the status of emission and removals estimates of all subcategories. The symbol „✓" indicates that emissions/removals from this subcategory have been estimated.

Table 364: IPCC categories according to the IPCC 2006 Guidelines and status of the estimates made.

IPCC categories[132]/ Sub division for calculation	Description	Status for CO_2	Other GHG
4 A	Forest land	✓	
4.A.1	Forest land remaining forest land	✓	
	Net carbon stock change in dead organic matter	NO	
	Net carbon stock change in soils	NO	
4.A.2	Land converted to forest land	✓	
4.A.2.1	Cropland converted to forest land	✓	
	Carbon stock change in biomass	✓	
	Carbon stock change in dead organic matter	✓	
	Carbon stock change in soils	✓	
4.A.2.2	Grassland converted to forest land	✓	
	Carbon stock change in biomass	✓	
	Carbon stock change in dead organic matter	✓	
	Carbon stock change in soils	✓	
4.A.2.3	Wetlands converted to forest land	NO	
4.A.2.4	Settlements converted to forest land	✓	
	Carbon stock change in biomass	✓	

[132] IPCC categories – applied according to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

IPCC categories[132]/ Sub division for calculation	Description	Status for CO_2	Other GHG
	Carbon stock change in dead organic matter	✓	
	Carbon stock change in soils	✓	
4.A.2.5	Other land converted to forest land	✓	
	Carbon stock change in biomass	✓	
	Carbon stock change in dead organic matter	✓	
	Carbon stock change in soils	✓	
4.B	Cropland	✓	
4.B.1	Cropland remaining cropland	✓	
	Carbon stock change in living biomass	NO	
	Carbon stock change in soils	NO	
4.B.2	Land converted to cropland	✓	
4.B.2.1	Forest land converted to cropland	✓	
	Carbon stock change in biomass	✓	
	Carbon stock change in dead organic matter	✓	
	Carbon stock change in soils	✓	✓ N_2O
4.B.2.2	Grassland converted to cropland	✓	
	Carbon stock change in living biomass	✓	
	Carbon stock change in soils	✓	✓ N_2O
4.B.2.3	Wetland converted to cropland	NO	
	Carbon stock change in living biomass	✓	
	Carbon stock change in soils	NE	
4.B.2.4	Settlements converted to cropland	NO	
4.B.2.5	Other land converted to cropland	NO	
	Carbon stock change in living biomass	✓	
	Carbon stock change in soils	NE	
4.C	Grassland	✓	
4.C.1	Grassland remaining grassland	✓	
	Carbon stock change in living biomass	NO	
	Carbon stock change in soils	NO	
4.C.2	Land converted to grassland	✓	
4.C.2.1	Forest land converted to grassland	✓	
	Carbon stock change in biomass	✓	
	Carbon stock change in dead organic matter	✓	
	Carbon stock change in soils	✓	
4.C.2.2	Cropland converted to grassland	✓	
	Carbon stock change in living biomass	✓	
	Carbon stock change in soil	✓	
4.C.2.3	Wetland converted to grassland	NO	
4.C.2.4	Settlements converted to grassland	✓	
	Carbon stock change in living biomass	✓	
	Carbon stock change in soil	✓	
4.C.2.5	Other land converted to grassland	NO	

IPCC categories[132]/ Sub division for calculation	Description	Status for CO_2	Other GHG
4.D	Wetlands	✓	
4.D.1	Wetlands remaining wetlands	NE/NO	
4.D.2.1	Forest land converted to wetlands	NO	
4.D.2.2	Cropland converted to wetlands	NO	
4.D.2.3	Grassland converted to wetlands	NO	
4.D.2.4	Settlements converted to wetlands	NO	
4.D.2.5	Other land converted to wetlands	NO	
4.E	Settlements	✓	
4.E.1	Settlements remaining settlements	NE	
4.E.2.1	Forest land converted to settlements	✓	
	Carbon stock change in living biomass	✓	
	Carbon stock change in dead organic matter	✓	
	Carbon stock change in soil	✓	✓ N_2O
4.E.2.2	Cropland converted to settlements	✓	
	Carbon stock change in living biomass	✓	
	Carbon stock change in soil	✓	✓ N_2O
4.E.2.3	Grassland converted to settlements	✓	
	Carbon stock change in living biomass	✓	
	Carbon stock change in soil	✓	✓ N_2O
4.E.2.4	Wetlands converted to settlements	NO	
4.E.2.5	Other land converted to settlements	NO	
4.F	Other Land		
4.F.1	Other land remaining other land	NE	
4.F.2.1	Forest land converted to other land	✓	
	Carbon stock change in living biomass	✓	
	Carbon stock change in soil	NE	
4.F.2.2	Cropland converted to other land	NO	
4.F.2.3	Grassland converted to other land	NO	
4.F.2.4	Wetlands converted to other land	NO	
4.F.2.5	Settlements converted to other land	NO	
4.G	Harvested wood products		
4.G.1	Solid wood	✓	
4.G.1.1	Sawn wood	✓	
4.G.1.2	Wood panels	NO	
4.G.2	Paper and paper board	✓	
4(I)	Direct nitrous oxides emissions from nitrogen inputs to managed soil	NO	
4(II)	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	NO/NA	

IPCC categories[132]/ Sub division for calculation	Description	Status for CO_2	Other GHG
4(III)	Direct nitrous oxide emissions from nitrogen mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils	NO	✓ N_2O
4(III)B.2	Land converted to cropland		
4(III)B.2.1	Forest land converted to cropland	✓	✓ N_2O
4(III)B.2.2	Grassland converted to cropland	✓	✓ N_2O
4(IV)	Indirect nitrous oxide emissions from managed soils	NO	✓ N_2O
4(V) 4 A 1 BiomassBurn_controlled	Biomass burning: controlled: Forest land remaining forest land	NO	NO
4(V) 4 A 1 BiomassBurn_wildfires	Biomass burning: Wildfires: Forest land remaining forest land	IE (1)	✓ N_2O ✓ CH_4
4(V) 4 B 1 BiomassBurn_controlled	Biomass burning: controlled: residues of perennial cropland	NE	NE
4(G)	C stock changes in Harvested Wood Products	✓	

(1) CO_2 emissions caused by wildfires (CRF Table 4(V)) are included in the category 4.A.1. Data on the area affected by wildfires are available for the years 1990 to 2021.

6.1.7 Planned improvements

In the interest of improving LULUCF emissions estimates the used input parameters and applied methods are continuously re-evaluated. A number of potential future improvements have been identified and will be step-by-step implemented in the future. These include:

Table 365 Planned improvements for IPCC sub-category 5.A Solid Waste Disposal

GHG source & sink category	Planned improvement	Type of improvement		Priority
4	Montenegro intends a re-assessment of its 1st NFI in the next years	AD	Accuracy Transparency Comparability Completeness Consistency	high
4	A more detailed analysis of the land-use changes between CLC sub-categories and a related adjustment of the emission estimates.	AD		medium
4.B 4.C 4.E	A survey for the availability and derivation of country-specific soil C stocks for cropland, grassland and other land.	EF		medium
4.B 4.C	A survey for information on cropland and grassland management and its changes in Montenegro in order to carry out estimates for related soil C stock changes.	EF		medium
4	An uncertainty analysis of the LULUCF sector will be carried out.			medium
4	Incorporate biomass estimates related to the settlement category (changes from and to settlements) as soon as results are available.	AD		medium

6.2 Forest land (Category 4.A)

6.2.1 Category description

According to the country's first National Forest Inventory (NFI), the total area of forests in 2010 amounted to 826.78 kha (59.9 % of Montenegro's total area). According to land use changes derived from the CLC change products, forest area has been decreasing very slightly (Table 366). On the other hand, the net GHG removals from Forest land have varied significantly.

The sink strength of Forest land (see next table) has increased by 101.9% between 1990 -1 269.70 kt CO_2eq) and 2021 (-2 503.01 kt CO_2eq). This trend together with substantial inter-annual variations has been driven by changes in timber harvest and forest fires on Forest land remaining forest land (see following table). It is likely that this variation is however missing a significant contribution from biomass increment gains – due to the only recent initiation of the Montenegrin NFI, only a static long-term per-ha increment could be employed in the GHG inventory calculation. It should also be pointed out that potentially significant changes in soil carbon stocks of Forest land remaining forest land have not been estimated.

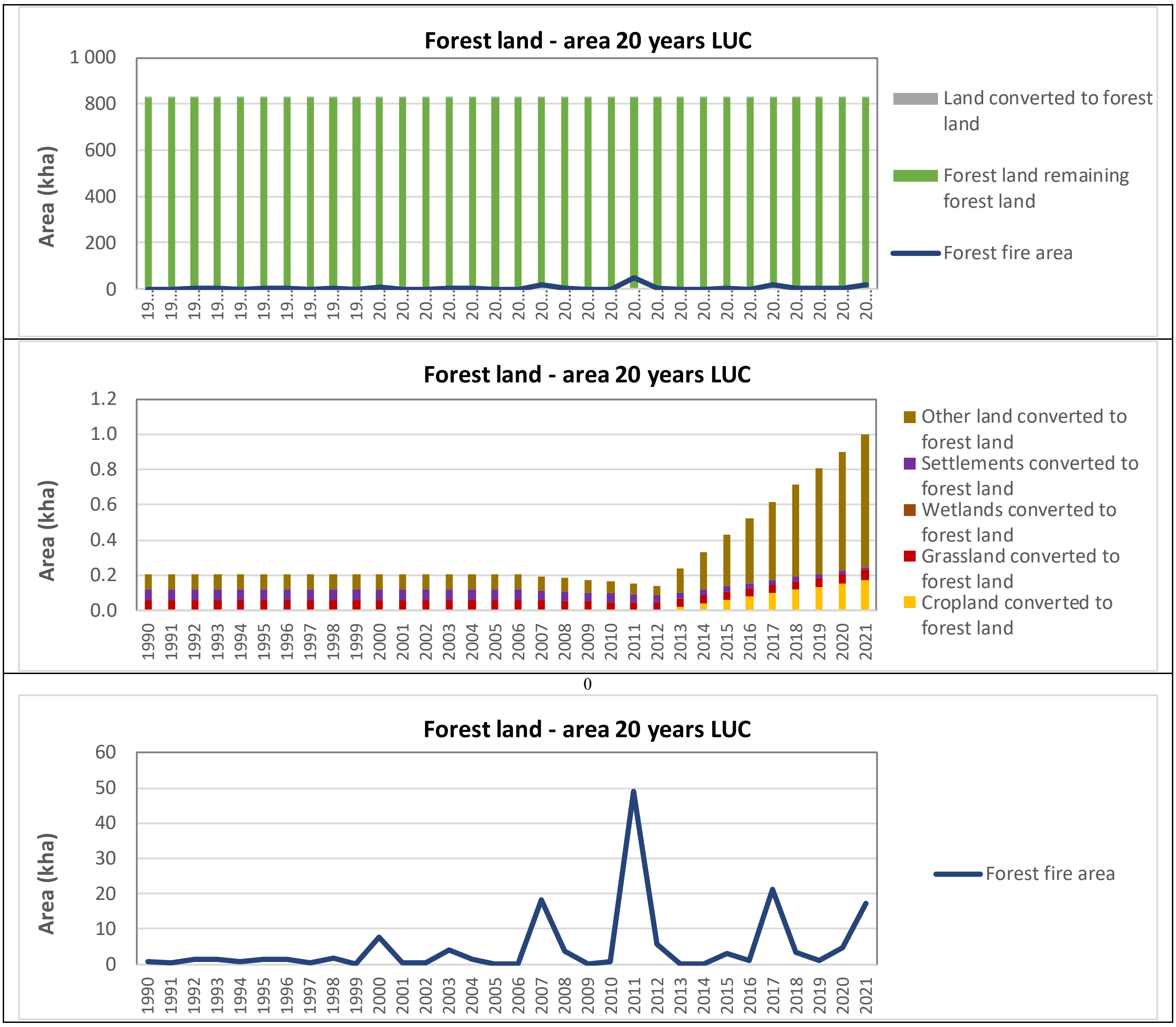


Figure 162 **Areas of Forestland remaining forestland and Land converted to forestland (land use change (LUC) areas are presented in the 20 years transition period)**

Table 366 Areas of total Forest land and related sub-categories (land use change (LUC) areas are presented in the 20 years transition period) in 1000 ha (kha)

	4A	4A1	4A2	4A21	4A21a	4A21b	4A22	4A23	4A24	4A25	4(V)A1
	Forest land	Forest land remaining forest land	Land converted to forest land	Cropland converted to forest land	Annual cropland converted to forest land	Perennial cropland converted to forest land	Grassland converted to forest land	Wetlands converted to forest land	Settlements converted to forest land	Other land converted to forest land	Forest fire area
	area 20 years LUC										
	kha										
1990	**827.76**	827.55	0.20	NO	NO	NO	0.06	NO	0.06	0.08	0.72
1991	**827.72**	827.51	0.20	NO	NO	NO	0.06	NO	0.06	0.08	0.34
1992	**827.68**	827.47	0.20	NO	NO	NO	0.06	NO	0.06	0.08	1.32
1993	**827.64**	827.43	0.20	NO	NO	NO	0.06	NO	0.06	0.08	1.22
1994	**827.60**	827.39	0.20	NO	NO	NO	0.06	NO	0.06	0.08	0.56
1995	**827.55**	827.35	0.20	NO	NO	NO	0.06	NO	0.06	0.08	1.26
1996	**827.51**	827.31	0.20	NO	NO	NO	0.06	NO	0.06	0.08	1.39
1997	**827.47**	827.27	0.20	NO	NO	NO	0.06	NO	0.06	0.08	0.38
1998	**827.43**	827.23	0.20	NO	NO	NO	0.06	NO	0.06	0.08	1.57
1999	**827.39**	827.19	0.20	NO	NO	NO	0.06	NO	0.06	0.08	0.13
2000	**827.35**	827.15	0.20	NO	NO	NO	0.06	NO	0.06	0.08	7.50
2001	**827.31**	827.11	0.20	NO	NO	NO	0.06	NO	0.06	0.08	0.48
2002	**827.27**	827.07	0.20	NO	NO	NO	0.06	NO	0.06	0.08	0.40
2003	**827.23**	827.03	0.20	NO	NO	NO	0.06	NO	0.06	0.08	4.00
2004	**827.19**	826.99	0.20	NO	NO	NO	0.06	NO	0.06	0.08	1.38
2005	**827.15**	826.95	0.20	NO	NO	NO	0.06	NO	0.06	0.08	0.10
2006	**827.11**	826.91	0.20	NO	NO	NO	0.06	NO	0.06	0.08	0.21
2007	**827.03**	826.84	0.19	NO	NO	NO	0.06	NO	0.06	0.08	18.31
2008	**826.95**	826.76	0.18	NO	NO	NO	0.06	NO	0.05	0.07	3.63
2009	**826.86**	826.69	0.17	NO	NO	NO	0.05	NO	0.05	0.07	0.09

	4A	4A1	4A2	4A21	4A21a	4A21b	4A22	4A23	4A24	4A25	4(V)A1
	Forest land	Forest land remaining forest land	Land converted to forest land	Cropland converted to forest land	Annual cropland converted to forest land	Perennial cropland converted to forest land	Grassland converted to forest land	Wetlands converted to forest land	Settlements converted to forest land	Other land converted to forest land	Forest fire area
	area 20 years LUC										
	kha										
2010	**826.78**	826.62	0.16	NO	NO	NO	0.05	NO	0.05	0.07	0.70
2011	**826.70**	826.55	0.15	NO	NO	NO	0.05	NO	0.04	0.06	49.01
2012	**826.62**	826.47	0.14	NO	NO	NO	0.04	NO	0.04	0.06	5.54
2013	**826.60**	826.36	0.24	0.02	0.01	0.01	0.04	NO	0.04	0.14	0.17
2014	**826.58**	826.25	0.33	0.04	0.02	0.02	0.05	NO	0.04	0.21	0.06
2015	**826.56**	826.13	0.43	0.06	0.03	0.03	0.05	NO	0.03	0.29	3.12
2016	**826.54**	826.02	0.52	0.08	0.04	0.04	0.05	NO	0.03	0.37	1.10
2017	**826.52**	825.91	0.62	0.10	0.05	0.05	0.05	NO	0.03	0.44	21.22
2018	**826.51**	825.79	0.71	0.12	0.06	0.06	0.05	NO	0.02	0.52	3.42
2019	**826.49**	825.68	0.81	0.14	0.07	0.07	0.05	NO	0.02	0.60	1.17
2020	**826.47**	825.57	0.90	0.15	0.08	0.08	0.05	NO	0.02	0.68	4.64
2021	**826.45**	825.45	1.00	0.17	0.09	0.09	0.05	NO	2<0.01	0.75	17.10
Trend											
1990 - 2021	***-0.2%***	*-0.3%*	*391.5%*	*NA*	*NA*	*NA*	*-11.2%*	*NA*	*34139%*	*810.7%*	*2275%*
2005 - 2021	***-0.1%***	*-0.2%*	*391.5%*	*NA*	*NA*	*NA*	*-11.2%*	*NA*	*34139%*	*810.7%*	*16503%*
2020 - 2021	***0.0%***	*0.0%*	*10.5%*	*12.5%*	*12.5%*	*12.5%*	*2.4%*	*NA*	*114032%*	*11.4%*	*268%*

Table 367 Net emissions/removals of Forest land in kt CO_2, CH_4, N_2O and CO_2eq for the period of 1990-2021

Code	**4A**	4A	4A1	4A2	4A21	4A22	4A23	4A24	4A25	4(V)A1	4(V)A1	4(V)A1
Category name	**Total Forest land**	Total Forest land	Forest land remaining Forest land	Land converted to Forest land	Cropland converted to Forest land	Grassland converted to Forest land	Wetlands converted to Forest land	Settlements converted to Forest land	Other Land converted to Forest land	Forest land remaining Forest land		
Unit	**kt CO2eq**	kt CO2								kt CO2	kt N2O	kt CH4
1990	**-1 247.33**	-1 272.48	-1 271.18	-1.30	NO	-0.19	NO	-0.79	-0.31	22.37	<0.01	0.07
1991	**-1 656.54**	-1 668.52	-1 667.23	-1.30	NO	-0.19	NO	-0.79	-0.31	10.66	<0.01	0.03
1992	**-1 228.02**	-1 273.95	-1 272.66	-1.30	NO	-0.19	NO	-0.79	-0.31	40.85	0.01	0.12
1993	**-2 019.43**	-2 061.94	-2 060.64	-1.30	NO	-0.19	NO	-0.79	-0.31	37.81	0.01	0.11
1994	**-1 484.23**	-1 503.93	-1 502.63	-1.30	NO	-0.19	NO	-0.79	-0.31	17.52	<0.01	0.05
1995	**-1 343.79**	-1 387.63	-1 386.33	-1.30	NO	-0.19	NO	-0.79	-0.31	38.99	0.01	0.12
1996	**-1 585.43**	-1 634.04	-1 632.75	-1.30	NO	-0.19	NO	-0.79	-0.31	43.24	0.01	0.13
1997	**-2 438.46**	-2 451.70	-2 450.40	-1.30	NO	-0.19	NO	-0.79	-0.31	11.77	<0.01	0.04
1998	**-2 548.01**	-2 602.77	-2 601.48	-1.30	NO	-0.19	NO	-0.79	-0.31	48.71	0.01	0.15
1999	**-2 474.83**	-2 479.23	-2 477.94	-1.30	NO	-0.19	NO	-0.79	-0.31	3.91	<0.01	0.01
2000	**-1 871.86**	-2 133.88	-2 132.58	-1.30	NO	-0.19	NO	-0.79	-0.31	233.06	0.04	0.70
2001	**-2 436.18**	-2 452.80	-2 451.51	-1.30	NO	-0.19	NO	-0.79	-0.31	14.79	<0.01	0.04
2002	**-2 620.93**	-2 634.87	-2 633.57	-1.30	NO	-0.19	NO	-0.79	-0.31	12.40	<0.01	0.04
2003	**-2 483.76**	-2 623.29	-2 622.00	-1.30	NO	-0.19	NO	-0.79	-0.31	124.11	0.02	0.37
2004	**-2 472.81**	-2 520.87	-2 519.58	-1.30	NO	-0.19	NO	-0.79	-0.31	42.75	0.01	0.13
2005	**-2 263.87**	-2 267.47	-2 266.18	-1.30	NO	-0.19	NO	-0.79	-0.31	3.20	<0.01	0.01
2006	**-1 918.82**	-1 926.16	-1 924.86	-1.30	NO	-0.19	NO	-0.79	-0.31	6.52	<0.01	0.02
2007	**-1 740.13**	-2 379.68	-2 378.41	-1.27	NO	-0.22	NO	-0.75	-0.30	568.85	0.09	1.70
2008	**-2 124.76**	-2 251.48	-2 250.27	-1.21	NO	-0.21	NO	-0.71	-0.28	112.71	0.02	0.34
2009	**-2 720.92**	-2 723.99	-2 722.85	-1.14	NO	-0.20	NO	-0.68	-0.27	2.73	<0.01	0.01
2010	**-2 383.42**	-2 407.70	-2 406.63	-1.07	NO	-0.19	NO	-0.64	-0.25	21.60	<0.01	0.06
2011	**-447.09**	-2 158.83	-2 157.83	-1.01	NO	-0.18	NO	-0.60	-0.24	1 522.53	0.25	4.56

Code	**4A**	4A	4A1	4A2	4A21	4A22	4A23	4A24	4A25	4(V)A1	4(V)A1	4(V)A1
Category name	**Total Forest land**	Total Forest land	Forest land remaining Forest land	Land converted to Forest land	Cropland converted to Forest land	Grassland converted to Forest land	Wetlands converted to Forest land	Settlements converted to Forest land	Other Land converted to Forest land	Forest land remaining Forest land		
Unit	**kt CO2eq**	kt CO2								kt CO2	kt N2O	kt CH4
2012	**-2 118.43**	-2 311.89	-2 310.95	-0.94	NO	-0.16	NO	-0.56	-0.22	172.07	0.03	0.52
2013	**-2 274.76**	-2 280.74	-2 279.51	-1.23	0.38	-0.10	NO	-0.52	-0.51	5.32	<0.01	0.02
2014	**-2 148.28**	-2 150.44	-2 148.85	-1.59	0.26	-0.11	NO	-0.48	-0.81	1.92	<0.01	0.01
2015	**-1 776.83**	-1 885.95	-1 883.99	-1.95	0.15	-0.11	NO	-0.44	-1.10	97.05	0.02	0.29
2016	**-2 039.11**	-2 077.52	-2 075.21	-2.32	0.03	-0.12	NO	-0.40	-1.39	34.16	0.01	0.10
2017	**-1 321.58**	-2 062.58	-2 059.91	-2.68	-0.09	-0.12	NO	-0.36	-1.68	659.10	0.11	1.97
2018	**-2 290.82**	-2 410.15	-2 407.12	-3.04	-0.20	-0.13	NO	-0.32	-1.98	106.14	0.02	0.32
2019	**-2 460.69**	-2 501.55	-2 498.16	-3.40	-0.32	-0.13	NO	-0.28	-2.27	36.35	0.01	0.11
2020	**-2 297.62**	-2 459.82	-2 456.06	-3.76	-0.43	-0.14	NO	-0.24	-2.56	144.27	0.02	0.43
2021	**-1 971.72**	-2 569.04	-2 564.92	-4.12	-0.55	-0.14	NO	-0.20	-2.85	531.29	0.09	1.59
Trend												
1990 - 2021	**58.1%**	101.9%	101.8%	217.6%	NA	-24.0%	NA	-75.0%	810.7%	2275.3%	2275.3%	2275.3%
2005 - 2021	**-12.9%**	13.3%	13.2%	217.6%	NA	-24.0%	NA	-75.0%	810.7%	16503.9%	16503.9%	16503.9%
2020 - 2021		4.4%	4.4%	9.6%	26.7%	3.5%	NA	-16.7%	11.4%	268.3%	268.3%	268.3%

6.2.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The Montenegrin National Forest Inventory (NFI) provided a first comprehensive nation-wide forest assessment. The land was surveyed in 2010 with the application of a 2 x 2 km systematic sampling grid. At each grid point, a cluster of 4 sample plots were surveyed, with both quantitative and qualitative site data collected.

As only one cycle of the NFI has took place so far, additional data was required to construct the required annual time series for total forest area. As described in chapter 6.1.2.1, this time series between 1970 and 2020 was constructed using the 2010 NFI forest area as a starting reference, which was developed back to 1970 and forward to 2021 using a time series of land use changes to and from Forest land derived from the CLC change layers. For this purpose, national experts assigned specific CLC classes to Forest land (Table 366).

Starting with the 826.278 kha total forest area measured by the NFI in 2010, the annual total Forest land areas from 2011 onwards were calculated by successively adding the annual net land use change to Forest land (annual total CLC land use changes to forests minus the annual total CLC land use changes from Forest land to the other land use categories). Likewise, the annual total Forest land areas from 2009 back to 1970 were calculated by successively subtracting the annual net land use change to Forest land.

6.2.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

According to the NFI and the 2010 Forest Law of Montenegro, *Forests* are "land spanning more than 0.5 ha with trees higher than 5 meters and a crown cover of more than 10%, or trees able to reach these thresholds in situ. For tree rows or shelterbelts, a minimum width of 20 m is required. It does not include land that is predominantly under agricultural or urban land use". Furthermore, forest roads, firebreaks, landings and other comparable areas serving forests are also included. It is considered that these lands correspond to the IPCC Forest land category.

In the NFI, there is also a type of land referred to as *Forestland*, which do not meet the criteria above. This type of land is not included in the Forest land category of the GHG inventory.

6.2.4 Methodological issues

6.2.4.1 Forest Land remaining forest land (4.A.1)

Biomass

Increment

Gross biomass carbon stock gains in Forest land remaining forest land were calculated using increment data from the NFI. While there has only been one inventory cycle so far, increment estimates were derived based on increment borer measurements of sample trees. In brief, the method applied was used to estimate the past diameter of the sample trees (10 years previous). Using the diameter values from the two points in time, corresponding height estimates were derived from empirical NFI diameter-height functions. The diameter and height variables for each point in time were subsequently used to estimate volume (and thus volume increment) using Schumacher-Hall allometric functions. The increment estimates from the sample trees were subsequently upscaled to be representative of the accessible national forest area.

Further details are provided in the final report of *The First National Forest Inventory of Montenegro* (Montenegro Ministry of Agriculture and Rural Development, 2013). It is important to note that the detailed NFI measurements (e.g. for deciduous and coniferous forest types) are available only for the accessible forest area, which contributes ca. 88 % of the total forest area. 12 % of the total forests are inaccessible areas. Therefore, biomass C stocks and stock changes had to be estimated for the inaccessible areas and adjusted for total forest land to be representative for both, accessible and inaccessible forest areas (Table 368).

Table 368 Total area and increment statistics for accessible and inaccessible Forests

Accessibility	Area (%)	Volume (%)	Increment (%)
Accessible	88.1	95.7	95.7
Inaccessible	11.9	4.3	4.3

Table 369 Area statistics and average increment values for accessible forests

Forest type	Area (ha)	Volume (1000 m^3)	Volume (m^3 ha^{-1})	Increment (1000 m^3)	Increment (m^3 ha^{-1})
Area with trees below BDH threshold	58316.9				
Coniferous	159307.4	46758.8	293.5	1295.9	8.1
Deciduous	509500.8	69457.8	136.3	1484.1	2.9
Total	727125.0	116216.7	159.8	2780.0	3.8

To derive carbon stock changes for Forest land remaining forest land, the assumption is that the NFI increment per ha is stable over the time series. Carbon stock changes in above ground biomass were first estimated for the coniferous and deciduous forest separately, by multiplying the respective increment estimates (Table 369) with the corresponding type-specific wood densities (Table 370), biomass expansion factors, and carbon fractions (Table 371). Note that because detailed increment measurements per forest type (i.e. deciduous and coniferous) are only available for accessible forests, the increment per ha for the forest land remaining forest land was reduced by a tiny fraction (by -8 %), to ensure that it represents the average increment per ha for accessible and inaccessible forests.

The wood densities were derived from national estimates of species-specific wood densities. Weighted average wood density values for coniferous and deciduous trees were then calculated based on the relative species contributions to standing stock and increment as given in the NFI. The applied biomass expansion factors and carbon fractions were sourced from the 2003 IPCC Good Practise Guidance (Table 3A.1.10, Chapter 3, page 3.178) and the 2006 IPCC Guidelines (Table 4.3 Vol 4, Chapter 4, page 4.48), respectively.

Changes in below-ground biomass C stocks for coniferous and deciduous forests were calculated from the above-ground biomass carbon stock changes using selected root: shoot ratios (Table 372) which were sourced from the 2006 IPCC Guidelines (Table 4.4 Vol 4, Chapter 4, page 4.48). Finally, total biomass C changes for coniferous and deciduous forests were derived from the sum of the above-ground and below ground pool changes.

Table 370 Weighted wood densities of coniferous and deciduous trees for standing stock, stem wood increment and stem wood harvest

Tree type	Weighted average wood density of the standing stock	Weighted average wood density of the stem wood increment	Weighted average wood density of the stem wood harvest
	[t dm m-3] (weighted by species contribution to the standing stock, NFI data)	[t dm m-3] (weighted by species contribution to the standing stock, NFI data)	[t dm m-3] (weighted by species contribution to the standing stock, MONSTAT data)
Coniferous	0.45	0.44	0.43
Deciduous	0.67	0.67	0.68

Table 371 Biomass expansion factors and carbon fractions for coniferous and deciduous trees.

Tree type	Biomass expansion factor [-] (applied to the standing stock)	Biomass expansion factor [-] (applied to the increment)	Carbon fraction [t C t dm-1]
Coniferous	1.3	1.13[133]	0.51
Deciduous	1.4	1.2	0.48

Table 372 Root: shoot ratios for coniferous and deciduous trees.

Forest Type	Root: shoot ratio for Standing stock/increment [-]	Root: shoot ratio for LUC to Forest land (Afforestation) [-]
Coniferous	0.29	0.4
Deciduous	0.23	0.46

An initial weighted average biomass C stock increment gain was subsequently calculated based on the area contributions of coniferous (21.9 %) and deciduous forests (70.1 %) to the total accessible national forest area (Table 369). This value per ha was subsequently reduced taken into account the inaccessible forest area as well. This results in a final average biomass C stock increment gain for Forest land remaining forest land of 1.42 t C ha^{-1} a^{-1}.

Drain

Gross biomass carbon stock losses in Forest land remaining forest land due to harvest (drain) were calculated using annual harvest statistics

In the past, there were two different official harvest statistics available for Montenegro: the Cutting of trees[134] and the Monstat Yearbook[135]. However, the cutting of trees statistics did not distinguish between deciduous and coniferous wood, but overall the dataset seem to better represent the overall harvest in Montenegro than the data presented in the Monstat Yearbook. On the other hand, a split in deciduous and coniferous trees was provided in the Monstat Yearbook dataset. Therefore, for estimating the carbon stock losses, the total harvest from the Cutting of trees statistic was split between wood from coniferous and deciduous trees using a long term split (44 % deciduous, 56 % coniferous) for the time series 2001 to 2018 from the MONSTAT statistical yearbook. These long term shares were then applied to the time series 1990-2018 to split the more accurate harvest data derived from the cutting of trees statistic, for which just the

[133] Weighted average value. The 2003 IPCC GPG gives separate BEF_1 values for Spruce-Fir and Pines. Weighted average thus calculated based on the ca. 80:20 contribution of Spruce-Fir and Pine species to the standing coniferous stock as reported in the NFI.

[134] https://www.monstat.org/uploads/files/sumarstvo/2021/Table%203.%20Cutting%20of%20trees.xls

[135] Statistical Office of Montenegro - MONSTAT: https://www.monstat.org/eng/novosti.php?id=3218

total harvest amounts are available (Table 373). Since 2019, the values from Monstat Yearbook were harmonised with those from the Cutting of Trees statistics and the Yearbook also provides information on the deciduous and coniferous trees harvested. Therefore, from 2019 onwards, the values to calculate the carbon stock losses due to harvest (drain) were used from the Monstat Yearbook. It is important to note that these values underestimate informal yet significant harvest by private persons for, inter alia, fuel wood. A national publication 'Wood Fuel Consumption for 2011 in Montenegro – New Energy Balances for Wood Fuels'[136] was thus established to provide annual consumption-based estimates of total harvest and these figures were used for the purpose of the LULUCF Inventory. Further, the respective coniferous and deciduous harvest values were subsequently multiplied by corresponding type-specific wood densities (Table 370), biomass expansion factors, and carbon fractions (Table 371) to arrive at above-ground biomass carbon stock losses.

Changes in belowground biomass C stocks due to coniferous and deciduous harvest were calculated from the above-ground biomass carbon stock changes using selected root-to-shoot ratios (Table 372) which were sourced from the 2006 IPCC Guidelines (Table 4.4 Vol 4, Chapter 4, page 4.48). Finally, annual total biomass C drain values were derived from the sum of the respective coniferous and deciduous aboveground and belowground biomass C losses.

Table 373 Annual harvest from Forest land for the period 1990-2021

	Total Harvest	Harvest - Deciduous	Harvest - Coniferous
	m^3		
1990	1 836 451	799 587	1 036 864
1991	1 597 002	695 331	901 671
1992	1 835 307	799 088	1 036 218
1993	1 359 016	591 713	767 303
1994	1 696 085	738 471	957 613
1995	1 766 237	769 016	997 221
1996	1 617 205	704 127	913 077
1997	1 122 986	488 946	634 040
1998	1 031 567	449 142	582 425
1999	1 106 092	481 590	624 502
2000	1 314 658	572 399	742 259
2001	1 121 811	488 434	633 377
2002	1 011 665	440 477	571 188
2003	1 018 533	443 467	575 066
2004	1 080 298	470 359	609 939
2005	1 233 296	536 974	696 322
2006	1 439 419	626 720	812 699
2007	1 165 096	507 280	657 816
2008	1 242 271	540 882	701 389
2009	956 442	416 433	540 009

[136] 'Wood Fuel Consumption for 2011 in Montenegro – New Energy Balances for Wood Fuels' http://www.monstat.org/eng/publikacije_page.php?id=1056&pageid=100

	Total Harvest	Harvest - Deciduous	Harvest - Coniferous
	m^3		
2010	1 147 274	499 521	647 754
2011	1 297 366	564 870	732 496
2012	1 204 582	524 472	680 110
2013	1 223 484	532 702	690 782
2014	1 302 342	567 037	735 305
2015	1 462 291	636 678	825 613
2016	1 346 645	586 326	760 319
2017	1 355 792	590 309	765 483
2018	1 145 883	498 915	646 968
2019	1 092 786	470 991	621 795
2020	1 112 569	492 868	619 701
2021	1 004 595	453 932	598 011
Trend			
1990 – 2021	-45.3%	-43.2%	-42.3%
2005 – 2021	-18.5%	-15.5%	-14.1%
2020 - 2021	-9.7%	-7.9%	-3.5%

Dead wood

As there has only been one NFI cycle, no data are available on the changes in dead wood in forests. Therefore, the dead wood pool of Forest land remaining forest land is assumed not to change following Tier 1 of the IPCC 2006 Guidelines.

Litter and soil

Due to a lack of data on litter and soil carbon (thus lack of validation data for potential soil C modelling), the litter and soil pools of Forest land remaining forest land are assumed not to change following Tier 1 of the IPCC 2006 Guidelines.

Biomass burning (4V)

Estimates of forest fire emissions were calculated using equation 2.27 (Tier 1 method) described in the 2006 IPCC Guidelines:

$$L_{fire}\ (t\ GHG) = A * M_B * C_f * G_{ef} * 10^{-3}$$

A *area burnt (ha)*
M_B *mass of available fuel, t dm* ha^{-1} *(Table 2.4)*
C_f *combustion factor*
G_{ef} *emission factor, g* kg^{-1} *dm (Table 2.5)*

Data on the annual area affected by wildfires are available for the years 1990 to 2021 from MONSTAT and range between 62 and 18309 ha/year. According to the references in the IPCC 2006 Guidelines a mean value of 19.8 t ha^{-1} biomass consumption was applied. This represents the product of available biomass density on the land before combustion (M_B) and the combustion factor (C_f). The applied emission factors (G_{ef}) were taken from table 2.5 of IPCC 2006 Guidelines.

6.2.4.2 Land use changes to Forest land (4.A.2)

Biomass

In conversions to Forest land, the biomass C stock of the previous land use category is assumed to be lost in year of the conversion (Table 374). For annual cropland, weighted biomass stock of 3.45 t C ha $^{-1}$ was calculated using biomass C stocks of annual crops, considering their quantitative occurrence in Montenegro. For perennial cropland, a weighted biomass C stock (above and below ground) of 10.32 t C ha^{-1} was calculated using the biomass C stocks for vineyards, fruit trees and olive groves from the MediNet Life Project (Canaveira et al., 2018). These values were subsequently weighted by the relative contributions of these crop types to total perennial land as derived from the CLC 2018 status layer. A gross biomass loss of 4.025 t C ha^{-1} for Grasslands was calculated, based on the Montenegrin yield statistics for meadows and expert judgement on the carbon content of the vegetation. Finally, no gross biomass C stock losses were assumed for conversions from Settlements to Forest land or Other land to Forest land, while conversions from Wetlands to Forest land were not occurring.

Table 374: Gross biomass carbon losses following land conversion to Forest land

Conversion	Biomass C loss in year of conversion to Forest land (i.e. biomass C stock of previous land use) [t C ha]
Annual Cropland to Forest land	3.45
Perennial Cropland to Forest land	10.32
Grassland to Forest land	4.025
Wetlands to Forest land	NO
Settlements to Forest land	0
Other land to Forest land	0

After the initial gross biomass C loss following conversion, gains in biomass C stock are assumed to take place over the 20 year transition period. For this period an average annual stem wood increment of 0.4 m^3 ha^{-1} a^{-1} was calculated from the sapling (0.1 m^3 ha^{-1} a^{-1}) and thicket phase (0.7 m^3 ha^{-1} a^{-1}) increments given in the NFI. This value was split into coniferous and deciduous stem wood increments based on the average contributions of conifers (0.47) and broadleaf trees (0.53) to the total forest increment, as given by the NFI. Separate average annual carbon stock gains in above ground biomass of coniferous and deciduous trees per ha of land converted to Forest land were calculated by multiplying the respective increment estimates by corresponding type-specific wood densities (Table 370), biomass expansion factors, and carbon fractions (Table 371). Parallel gains in below-ground biomass C stocks were calculated from the above-ground biomass carbon stock changes using conifer- and deciduous-specific root-to-shoot ratios for LUC to Forest land (Table 372). A final average annual total biomass C stock increment for the 20 year conversion of 0.186 t C ha^{-1} a^{-1} was calculated from the sum of the respective above-ground and below ground pool gains.

Unlike the increments in biomass C for Forest land remaining forest land, here no correction for the inaccessible land was applied given the assumption that land use change involving forests takes place on accessible land only. Furthermore, it is assumed that no drain on the lands converted to Forest land takes place during the transition period.

Dead wood

It is assumed that no accumulation or loss of dead wood takes place on lands converted to forest land takes place during the transition period. Therefore, the carbon stock change in the dead wood pool of land converted to Forest land is assumed to be zero.

Litter and soil

For conversions to Forest land, it is assumed that litter was not occurring in the previous land use and thus no gross loss in litter C is assumed.

Gains in litter carbon on conversion to Forest land are in contrast assumed to occur. Using the default IPCC litter C stocks for coniferous and deciduous forests (Table 2.2 Vol 4, Chapter 2, *cold temperature, wet*), a weighted average forest litter C stock of 18.38 t C ha was calculated based on the relative contributions of coniferous and deciduous forests to the total forest area, as described in the NFI. This average litter C stock was divided by 20 to give an annual gain in litter C stock of 0.919 t C ha^{-1} a^{-1} for land converted to Forest land.

Changes in mineral soil C stocks in 0-30 cm depth following land conversion were calculated according to the Tier 1 default method described in the IPCC 2006 Guidelines. Given the lack of national data on soil C, representative soil C stocks for each land use category were calculated according to reference stocks (Table 2.3, Vol 4, Chapter 2) and cropland and grassland management factors (Table 5.5, Vol 4, Chapter 5; Table 6.2, Vol 4, Chapter 6) given in the IPCC 2006 Guidelines. According to national expert judgement, *high activity clay* (ecoregion – *cold temperate, moist*) soils, with a default reference stock of 95 kt C ha^{-1}, were assumed to be representative of the soils in Montenegro. This stock was assumed to be representative of Forest land soils, as well as the soils of Grasslands and Perennial Cropland, due to the assigned management factors from the IPCC Guidelines. Annual cropland, on the other hand, was assigned a soil C stock of 70.8 kt C ha^{-1}, assuming that the land has been cultivated for long periods with the application of reduced tillage and medium inputs which were assumed by national experts to be representative for Montenegro (Table 375).

Table 375 IPCC management factors used for calculating the soil C stocks of annual cropland, perennial cropland and grassland. The table also reports the soil C stock for Forest land.

Land use category	Management factors [-]			Soil C Stock [t C ha^{-1}]
	Land use (F_{LU})	Management (F_{MG})	Input (F_I)	
Forest land	NA	NA	NA	95
Annual Cropland	0.69 (*Long-term cultivated*)	1.08 (*Tillage – Reduced*)	1 (*Input Medium*)	70.8
Perennial Cropland	1 (*Perennial/ Tree Crop*)	NA	NA	95
Grassland	1 (*All*)	1 (*Nominally managed – non-degraded*)	NA	95

The soil C stocks for Settlements were calculated based on assumptions of the fraction of green areas within the 2018 CLC classes assigned to Settlements. As the Table 376 reports, of the total 26453 ha Settlement area in 2018, 11545 ha (43.64 %) are assumed to constitute the green (vegetated) part of the Settlement area. The other ca. 56% fraction is considered to be sealed. Assuming that the green fraction has a soil C stock the same as Grassland (95 kt C ha^{-1}) and that the sealed fraction has no organic C in the upper 30 cm horizon (0 kt C ha^{-1}) yields a weighted average soil C stock for Settlements of 41.46 kt C ha^{-1}.

Table 376 Total 2018 areas of the CLC classes assigned to Settlements together with expert estimations on the respective green fractions (% and ha) of each class.

CLC class code	CLC class name	Total area in 2018 [ha]	Assumed green fraction [%]	Total green area in 2018 [ha]
111	(>80%) Continuous urban fabric	176	10	18
112	(<80%) Discontinuous urban fabric	19288	50	9644
121	Industrial or commercial units	1636	20	327
122	Road and rail networks and associated land	257	20	51
123	Port areas	175	0	0
124	Airports	463	30	139
131	Mineral extraction sites	1731	10	173
132	Dump sites	523	10	52
133	Construction sites	644	0	0
141	Green urban areas	481	80	385
142	Sport and leisure facilities	1080	70	756
	Total Settlements	*26453*		*11545*

The soil C stocks for Wetlands and Other land were not estimated due to a lack of reliable soil data for these lands. Consequently, no soil C stock changes are estimated for all lands converted to/from Wetlands and Other land.

Based on the above C stock estimates and the assumption that the net change in soil C occurs linearly over the 20 year land conversion period allowed a soil C stock change matrix to be established (Table 377). Changes in mineral soil C stocks in 0-30 cm depth following land conversion were subsequently calculated by multiplying the respective 20 year land use change areas by corresponding annual soil C stock change values.

Table 377 Matrix of annual mineral SOC stock changes [t C ha^{-1} a^{-1}] for all possible land use conversions assuming a 20 year conversion period.

			Conversion to						
			Forest land	Annual Cropland	Perennial Cropland	Grassland	Wetlands	Settlements	Other land
		Stocks [t C ha-1]	*95.00*	*70.79*	*95.00*	*95.00*	*NE*	*41.46*	*NE*
Conversion from	Forest land	*95.00*		-1.21	0.00	0.00	NO	-2.68	NE
	Annual Cropland	*70.79*	1.21			1.21	NO	-1.47	NO
	Perennial Cropland	*95.00*	0.00			0.00	NO	-2.68	NO
	Grassland	*95.00*	0.00	-1.21	0.00		NO	-2.68	NO
	Wetlands	*NE*	NO	NE	NE	NO		NE	NO
	Settlements	*41.46*	2.68	NO	NO	2.68	NO		NO
	Other land	*NE*	NE	NE	NE	NO	NO	NE	

Direct N_2O emissions from N mineralization/immobilization associated with loss of soil organic matter resulting from land use change on mineral soils (4(III))

Land conversion to Forest land does not cause any losses in soil C (Table 377). As such, direct N_2O emissions (caused by increased mineralisation of soil organic N due to potential soil C losses and associated increases in N availability) are zero.

Indirect N_2O emissions from N leaching and runoff (4(IV))

Land conversion to Forest land does not cause any losses in soil C (Table 377). As such, indirect N_2O emissions (caused by increased mineralisation of leached soil organic N due to potential soil C losses and associated increases in N leached from the soil) are zero.

6.2.5 Recalculation

The following table presents the main revisions and recalculations done since the last submission and relevant to IPCC category 4.A *Forestland*.

Table 378 Recalculations done in IPCC sub-category 4.A Forestland.

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
4.A.	Due to an update of the harvest statistics and to a minor extent due to the update of the emission factor concerning grassland and annual cropland biomass, the reported emissions from the forest land category changed for the respective time series.	AD	Accuracy

6.3 Cropland (Category 4.B)

6.3.1 Category description

In 2021, total Cropland area was estimated at 215.59 kha which corresponds to 15.6 % of the total area of Montenegro (Table 357). According to land use changes derived from the CLC change products, Cropland area has been decreasing, but only very marginally. Overall, the Cropland area has thus been stable.

Given that only a small amount of land has been converted to Cropland and the assumption that carbon gains and carbon losses in Cropland remaining cropland in equilibrium, Cropland's contribution to the LULUCF GHG balance is marginal. Due to increasing conversion of Grassland to Cropland (as well as decreasing conversion from Other land to Cropland), the net emissions have been increasing. However, as mentioned earlier emission are relatively low and in 2021 amounted to only 0.65 kt CO_2 eq (see following figures and tables).

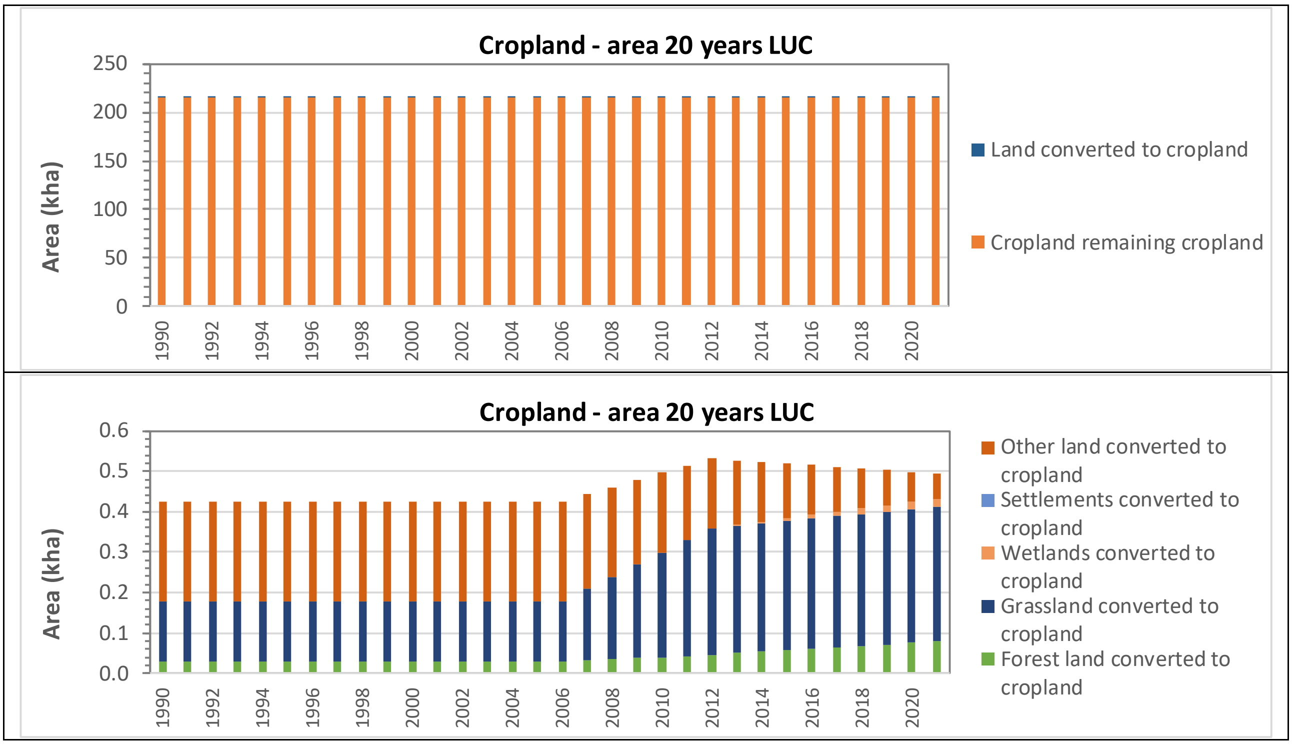


Figure 163 Areas of Cropland remaining Cropland and Land converted to Cropland (land use change (LUC) areas are presented in the 20 years transition period)

Table 379 Areas of Total Cropland and related sub-categories (land use change (LUC) areas are presented in the 20 years transition period) in 1000 ha (kha)

	4B	4B1	4B11	4B12	4B13	4B14	4B2	4B21	4B21a	4B21b	4B22	4B22a	4B22b	4B23	4B24	4B25	4B25a	4B25b
	Cropland	Cropland remaining cropland	Annual cropland remaining annual cropland	Perennial cropland remaining perennial cropland	Perennial cropland to annual cropland	Annual cropland to perennial cropland	Land converted to cropland	Forest land converted to cropland	Forest land converted to annual cropland	Forest land converted to perennial cropland	Grassland converted to cropland	Grassland converted to annual cropland	Grassland converted to perennial cropland	Wetlands converted to cropland	Settlements converted to cropland	Other land converted to cropland	Other land converted to annual cropland	Other land converted to perennial cropland
	area 20 years LUC																	
	kha																	
1990	215.89	215.46	NE	NE	NE	NE	0.43	0.03	0.01	0.01	0.15	0.07	0.08	NO	NO	0.25	0.12	0.13
1991	215.89	215.46	NE	NE	NE	NE	0.43	0.03	0.01	0.01	0.15	0.07	0.08	NO	NO	0.25	0.12	0.13
1992	215.89	215.46	NE	NE	NE	NE	0.43	0.03	0.01	0.01	0.15	0.07	0.08	NO	NO	0.25	0.12	0.13
1993	215.89	215.46	NE	NE	NE	NE	0.43	0.03	0.01	0.01	0.15	0.07	0.08	NO	NO	0.25	0.12	0.13
1994	215.89	215.46	NE	NE	NE	NE	0.43	0.03	0.01	0.01	0.15	0.07	0.08	NO	NO	0.25	0.12	0.13
1995	215.89	215.46	NE	NE	NE	NE	0.43	0.03	0.01	0.01	0.15	0.07	0.08	NO	NO	0.25	0.12	0.13
1996	215.89	215.46	NE	NE	NE	NE	0.43	0.03	0.01	0.01	0.15	0.07	0.08	NO	NO	0.25	0.12	0.13
1997	215.89	215.46	NE	NE	NE	NE	0.43	0.03	0.01	0.01	0.15	0.07	0.08	NO	NO	0.25	0.12	0.13
1998	215.89	215.46	NE	NE	NE	NE	0.43	0.03	0.01	0.01	0.15	0.07	0.08	NO	NO	0.25	0.12	0.13
1999	215.89	215.46	NE	NE	NE	NE	0.43	0.03	0.01	0.01	0.15	0.07	0.08	NO	NO	0.25	0.12	0.13
2000	215.89	215.46	NE	NE	NE	NE	0.43	0.03	0.01	0.01	0.15	0.07	0.08	NO	NO	0.25	0.12	0.13
2001	215.89	215.46	NE	NE	NE	NE	0.43	0.03	0.01	0.01	0.15	0.07	0.08	NO	NO	0.25	0.12	0.13
2002	215.89	215.46	NE	NE	NE	NE	0.43	0.03	0.01	0.01	0.15	0.07	0.08	NO	NO	0.25	0.12	0.13
2003	215.89	215.46	NE	NE	NE	NE	0.43	0.03	0.01	0.01	0.15	0.07	0.08	NO	NO	0.25	0.12	0.13
2004	215.89	215.46	NE	NE	NE	NE	0.43	0.03	0.01	0.01	0.15	0.07	0.08	NO	NO	0.25	0.12	0.13
2005	215.89	215.46	NE	NE	NE	NE	0.43	0.03	0.01	0.01	0.15	0.07	0.08	NO	NO	0.25	0.12	0.13
2006	215.89	215.46	NE	NE	NE	NE	0.43	0.03	0.01	0.01	0.15	0.07	0.08	NO	NO	0.25	0.12	0.13
2007	215.89	215.44	NE	NE	NE	NE	0.44	0.03	0.02	0.02	0.18	0.09	0.09	NO	NO	0.23	0.12	0.12

	4B	4B1	4B11	4B12	4B13	4B14	4B2	4B21	4B21a	4B21b	4B22	4B22a	4B22b	4B23	4B24	4B25	4B25a	4B25b
	Cropland	Cropland remaining cropland	Annual cropland remaining annual cropland	Perennial cropland remaining perennial cropland	Perennial cropland to annual cropland	Annual cropland to perennial cropland	Land converted to cropland	Forest land converted to cropland	Forest land converted to annual cropland	Forest land converted to perennial cropland	Grassland converted to cropland	Grassland converted to annual cropland	Grassland converted to perennial cropland	Wetlands converted to cropland	Settlements converted to cropland	Other land converted to cropland	Other land converted to annual cropland	Other land converted to perennial cropland
	area 20 years LUC																	
	kha																	
2008	215.88	215.42	NE	NE	NE	NE	0.46	0.03	0.02	0.02	0.20	0.10	0.10	NO	NO	0.22	0.11	0.11
2009	215.88	215.41	NE	NE	NE	NE	0.48	0.04	0.02	0.02	0.23	0.11	0.12	NO	NO	0.21	0.10	0.11
2010	215.88	215.39	NE	NE	NE	NE	0.50	0.04	0.02	0.02	0.26	0.13	0.13	NO	NO	0.20	0.10	0.10
2011	215.88	215.37	NE	NE	NE	NE	0.51	0.04	0.02	0.02	0.29	0.14	0.14	NO	NO	0.18	0.09	0.09
2012	215.88	215.35	NE	NE	NE	NE	0.53	0.05	0.02	0.02	0.31	0.15	0.16	NO	NO	0.17	0.09	0.09
2013	215.85	215.32	NE	NE	NE	NE	0.53	0.05	0.02	0.03	0.31	0.16	0.16	<0.01	NO	0.16	0.08	0.08
2014	215.81	215.29	NE	NE	NE	NE	0.52	0.05	0.03	0.03	0.32	0.16	0.16	<0.01	NO	0.15	0.07	0.08
2015	215.77	215.25	NE	NE	NE	NE	0.52	0.06	0.03	0.03	0.32	0.16	0.16	0.01	NO	0.14	0.07	0.07
2016	215.74	215.22	NE	NE	NE	NE	0.51	0.06	0.03	0.03	0.32	0.16	0.16	0.01	NO	0.12	0.06	0.06
2017	215.70	215.19	NE	NE	NE	NE	0.51	0.06	0.03	0.03	0.32	0.16	0.16	0.01	NO	0.11	0.05	0.06
2018	215.66	215.16	NE	NE	NE	NE	0.51	0.07	0.03	0.03	0.33	0.16	0.17	0.01	NO	0.10	0.05	0.05
2019	215.63	215.13	NE	NE	NE	NE	0.50	0.07	0.04	0.04	0.33	0.16	0.17	0.02	NO	0.09	0.04	0.04
2020	215.59	215.09	NE	NE	NE	NE	0.50	0.08	0.04	0.04	0.33	0.16	0.17	0.02	NO	0.07	0.04	0.04
2021	215.56	215.06	NE	NE	NE	NE	0.49	0.08	0.04	0.04	0.33	0.16	0.17	0.02	NO	0.06	0.03	0.03
Trend																		
1990 - 2021	-0.2%	-0.2%	NA	NA	NA	NA	16.3%	177.5%	177.5%	177.5%	122.4%	122.4%	122.4%	NA	NA	-75.0%	-75.0%	-75.0%
2005 - 2021	-0.2%	-0.2%	NA	NA	NA	NA	16.3%	177.5%	177.5%	177.5%	122.4%	122.4%	122.4%	NA	NA	-75.0%	-75.0%	-75.0%
2020 - 2021	0.0%	0.0%	NA	NA	NA	NA	-0.8%	4.8%	4.8%	4.8%	0.7%	0.7%	0.7%	12.5%	NA	-16.7%	-16.7%	-16.7%

Table 380 Net emissions/removals of Cropland in kt CO2, N2O, and CO2eq for the period 1990-2021

Code	4B	4B	4B1	4B2	4B22	4B23	4B24	4B25	4(III)B21	4(III)B22	4(IV)B21	4(IV)B22
Category name	Total Cropland	Total Cropland	Cropland remaining Cropland	Land converted to Cropland	Grassland converted to cropland	Wetlands converted to Cropland	Settlements converted to Cropland	Other Land converted to Cropland	Forest land converted to cropland	Grassland converted to cropland	Forest land converted to cropland	Grassland converted to cropland
	kt CO2eq	kt CO2							kt N2O			
1990	**0.032**	-0.009	NO	-0.009	0.247	NO	NO	-0.316	0.000	0.000	0.000	0.000
1991	**0.032**	-0.009	NO	-0.009	0.247	NO	NO	-0.316	0.000	0.000	0.000	0.000
1992	**0.032**	-0.009	NO	-0.009	0.247	NO	NO	-0.316	0.000	0.000	0.000	0.000
1993	**0.032**	-0.009	NO	-0.009	0.247	NO	NO	-0.316	0.000	0.000	0.000	0.000
1994	**0.032**	-0.009	NO	-0.009	0.247	NO	NO	-0.316	0.000	0.000	0.000	0.000
1995	**0.032**	-0.009	NO	-0.009	0.247	NO	NO	-0.316	0.000	0.000	0.000	0.000
1996	**0.032**	-0.009	NO	-0.009	0.247	NO	NO	-0.316	0.000	0.000	0.000	0.000
1997	**0.032**	-0.009	NO	-0.009	0.247	NO	NO	-0.316	0.000	0.000	0.000	0.000
1998	**0.032**	-0.009	NO	-0.009	0.247	NO	NO	-0.316	0.000	0.000	0.000	0.000
1999	**0.032**	-0.009	NO	-0.009	0.247	NO	NO	-0.316	0.000	0.000	0.000	0.000
2000	**0.032**	-0.009	NO	-0.009	0.247	NO	NO	-0.316	0.000	0.000	0.000	0.000
2001	**0.032**	-0.009	NO	-0.009	0.247	NO	NO	-0.316	0.000	0.000	0.000	0.000
2002	**0.032**	-0.009	NO	-0.009	0.247	NO	NO	-0.316	0.000	0.000	0.000	0.000
2003	**0.032**	-0.009	NO	-0.009	0.247	NO	NO	-0.316	0.000	0.000	0.000	0.000
2004	**0.032**	-0.009	NO	-0.009	0.247	NO	NO	-0.316	0.000	0.000	0.000	0.000
2005	**0.032**	-0.009	NO	-0.009	0.247	NO	NO	-0.316	0.000	0.000	0.000	0.000
2006	**0.032**	-0.009	NO	-0.009	0.247	NO	NO	-0.316	0.000	0.000	0.000	0.000
2007	**0.378**	0.331	NO	0.331	0.511	NO	NO	-0.227	0.000	0.000	0.000	0.000
2008	**0.438**	0.383	NO	0.383	0.544	NO	NO	-0.215	0.000	0.000	0.000	0.000
2009	**0.497**	0.435	NO	0.435	0.577	NO	NO	-0.203	0.000	0.000	0.000	0.000
2010	**0.556**	0.488	NO	0.488	0.610	NO	NO	-0.191	0.000	0.000	0.000	0.000
2011	**0.615**	0.540	NO	0.540	0.643	NO	NO	-0.179	0.000	0.000	0.000	0.000

Code	4B	4B	4B1	4B2	4B22	4B23	4B24	4B25	4(III)B21	4(III)B22	4(IV)B21	4(IV)B22
Category name	Total Cropland	Total Cropland	Cropland remaining Cropland	Land converted to Cropland	Grassland converted to cropland	Wetlands converted to Cropland	Settlements converted to Cropland	Other Land converted to Cropland	Forest land converted to cropland	Grassland converted to cropland	Forest land converted to cropland	Grassland converted to cropland
	kt CO2eq	kt CO2							kt N2O			
2012	**0.674**	0.592	NO	0.592	0.676	NO	NO	-0.167	0.000	0.000	0.000	0.000
2013	**0.467**	0.384	NO	0.384	0.467	-0.016	NO	-0.155	0.000	0.000	0.000	0.000
2014	**0.490**	0.405	NO	0.405	0.470	-0.018	NO	-0.143	0.000	0.000	0.000	0.000
2015	**0.513**	0.427	NO	0.427	0.473	-0.021	NO	-0.131	0.000	0.000	0.000	0.000
2016	**0.536**	0.448	NO	0.448	0.476	-0.023	NO	-0.119	0.000	0.000	0.000	0.000
2017	**0.558**	0.470	NO	0.470	0.478	-0.025	NO	-0.108	0.000	0.000	0.000	0.000
2018	**0.581**	0.491	NO	0.491	0.481	-0.027	NO	-0.096	0.000	0.000	0.000	0.000
2019	**0.604**	0.513	NO	0.513	0.484	-0.029	NO	-0.084	0.000	0.000	0.000	0.000
2020	**0.627**	0.534	NO	0.534	0.487	-0.031	NO	-0.072	0.000	0.000	0.000	0.000
2021	**0.650**	0.556	NO	0.556	0.490	-0.034	NO	-0.060	0.000	0.000	0.000	0.000
Trend												
1990 - 2021	**1953%**	-6247%	NA	-6247%	98.6%	NA	NA	-81.1%	177.5%	122.4%	177.5%	122.4%
2005 - 2021	**1953%**	-6247%	NA	-6247%	98.6%	NA	NA	-81.1%	177.5%	122.4%	177.5%	122.4%
2020 - 2021	**3.6%**	4.0%	NA	4.0%	0.6%	6.9%	NA	-16.7%	4.8%	0.7%	4.8%	0.7%

6.3.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

As described in chapter 6.1.2.1, to calculate the annual total areas for Cropland, Grassland, Wetlands, Settlements and Other land, the respective 1970-2021 time series was constructed starting with 2018. Subtracting the 2018 total Forest land area from the total official area of Montenegro yielded a 2018 total non-forest area that was subsequently distributed between Cropland, Grassland, Wetlands, Settlements and Other land according to the respective area contributions to non-forest land (in percent) as derived from the 2018 CLC status layer. The annual areas for 2017 back to 1970 were then subsequently calculated by successively subtracting the respective annual net land use changes to the corresponding categories. For instance, Cropland total areas for 2017 back to 1970 were calculated by successively subtracting the annual net land use change to Cropland (annual total CLC land use changes to Cropland minus the annual total CLC land use changes from Cropland to the other land use categories). For the years 2019-2021, the same extrapolation principle was applied. As no new CLC land use changes are available, the yearly LUCs from CLC change layer 2012/2018 were extrapolated and used to calculate the respective land use and land-use change areas in 2019 - 2021, again using the 2018 areas as the starting reference.

Due to the assumption of no net C stock changes in Cropland remaining cropland, a split between annual and perennial cropland was only made for the land use changes to and from Cropland. This split was done by calculating the relative fraction of annual and perennial cropland from the 2018 CLC status layer, and applying this fraction to land use changes to and from Cropland over the time series. Based on national expert judgement, the CLC class 211, and 50% of the area of CLC classes 241, 242 and 243 were considered as annual cropland. The CLC classes 221, 222, 223 and 50% of the area of CLC class classes 241, 242 and 243 were considered as perennial cropland.

6.3.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

As described in chapter 6.1.2.1, for the purpose of the LULUCF Inventory national experts assigned specific CLC classes to the IPCC category Cropland (**Error! Reference source not found.**).

6.3.4 Methodological issues

6.3.4.1 Cropland remaining cropland (4.B.1)

Biomass

In both annual cropland remaining cropland and perennial cropland remaining cropland, the biomass C stocks are assumed to be in equilibrium. Conversions between annual and perennial cropland and subsequent changes in biomass C were not estimated.

Dead wood

Dead wood is assumed to be not occurring on croplands remaining croplands

Litter and soil

Litter is assumed to be not occurring on croplands remaining croplands.

Due to the lack of data on changes in management practices, changes in soil carbon stocks of croplands remaining croplands are not estimated.

6.3.4.2 Land use changes to Cropland (4.B.2)

Biomass

In conversions to Cropland, the biomass C stock of the previous land use category is assumed to be lost in year of the conversion For conversions from Grassland, a gross biomass loss of 4.025t C ha-1 was calculated based on the Montenegrin yield statistic for meadows. Finally, no gross biomass C stock losses were assumed for Conversions from Settlements to Cropland or Other land to Cropland, while changes in carbon stocks from conversions from Wetlands to Croplands were not estimated. So far such a change was detected only once for a 13 ha area between 2012 and 2018 and this change requires further expert inspection.

Table 381).

For Forest land an average biomass C stock of 77.665 t C ha was calculated from the average coniferous and deciduous forest standing stocks as given by the NFI (Table 369). As with the biomass increment in Forest land remaining forest land, the average above ground biomass C stocks of coniferous and deciduous forests were calculated by multiplying the respective average coniferous and deciduous forest standing stocks by corresponding type-specific wood densities (Table 370), biomass expansion factors, and carbon fractions (Table 371). The below-ground biomass C stocks for coniferous and deciduous were calculated from the above-ground biomass carbon stocks using corresponding root-to-shoot ratios (Table 372). The final weighted average total biomass C stock was calculated from the coniferous and deciduous forest biomass carbon stocks (above and below-ground) based on the area contributions of coniferous (21.9 %) and deciduous forests (70.1 %) to the total accessible national forest area as given in the NFI (Table 369). No correction for lower stocks on the inaccessible Forest land was applied given the assumption that land use change involving forests takes place on accessible land only.

For conversions from Grassland, a gross biomass loss of 4.025t C ha^{-1} was calculated based on the Montenegrin yield statistic for meadows. Finally, no gross biomass C stock losses were assumed for Conversions from Settlements to Cropland or Other land to Cropland, while changes in carbon stocks from conversions from Wetlands to Croplands were not estimated. So far such a change was detected only once for a 13 ha area between 2012 and 2018 and this change requires further expert inspection.

Table 381 Gross biomass carbon losses following land conversion to Cropland

Conversion	Biomass C loss in year of conversion to Cropland (i.e. biomass C stock of previous land use) [t C ha]
Forest land to Cropland	77.665
Grassland to Cropland	4.025
Wetlands to Cropland	NE
Settlements to Cropland	0
Other land to Cropland	0

In the submission 2022, a new country specific factor for annual biomass in cropland was estimated based on national harvest statistics and expansion factors derived from literature.

For the annual cropland biomass losses in the year of conversion from annual cropland to another land use (sub-)category, the country specific average biomass stock in annual cropland was calculated from national crop harvest statistics of eight consecutive years published in two editions of the Statistical Year Book from the Statistical Office of Montenegro (MONSTAT 2016; MONSTAT 2019, table 11 – 4) . For all annual crops mentioned in those two reports, the harvested yield biomass has been taken and the related biomass of straw, leaves or other aboveground plant parts not covered by the yield biomass have been estimated on basis of plant specific expansion factors to expand the yield biomass to the total aboveground biomass. Root-to-shoot ratios for the individual crops are available from a study conducted by the United States Department of Agriculture (WEST 2008), and were applied to estimate the total plant biomass. As there are no other sources known which provides such factors, it was assumed that the use of the U.S. root-to-shoot ratios seem to be appropriate since the U.S. are also located in the temperate region. The estimated Montenegrin aboveground biomass in annual crops was multiplied with the root-to-shoot ratios to provide an estimate of the below-ground biomass. The means of the annual aboveground and below ground biomass of the crops were calculated and weighted by the related area of these crops in Montenegro to get the average annual cropland biomass. The estimated annual cropland biomass stock represents the peak annual cropland biomass during the growing season.

This led to a figure of 3.45 t C ha^{-1} for the biomass in annual cropland that is used for the estimates of LUCs to and from annual cropland. This country specific value is 31 % smaller than the 2006 IPCC GL default value (5.0 t C ha $^{-1}$).

After the initial gross biomass C loss following conversion, gains in biomass C stock depend on whether land was converted to annual or perennial cropland. For those lands converted to annual cropland, gross gain in annual cropland biomass C (3.45 t C ha^{-1}) takes place in the year of the conversion. For lands converted to perennial cropland, the gain in biomass C is assumed to take place over the 20 year transition period. For these lands, an average annual total biomass C gain of 0.5211 t C ha^{-1} a^{-1} was calculated by dividing the 10.32 t C ha^{-1} biomass C stock for perennial cropland given in Table 374 (i.e. the value derived from the MediNet carbon stocks) by 20.

Dead wood

Changes in the dead wood carbon stock only occur for Forest lands converted to Croplands. According to the NFI, dead wood stocks of coniferous and deciduous trees were estimated at 4.05 and 3.15 m^3 ha^{-1}, respectively. Multiplying these figures by respective type-specific wood densities (Table 370) and carbon fractions (Table 371) and summing the resulting two values gives an average dead wood C stock (stem wood only) of 1.938 t C ha^{-1}. On conversion from Forest land to other land uses, it is assumed that this C stock is lost in the year of the conversion.

Litter and soil

For conversions to Cropland, it is assumed that litter in the previous land use was occurring only in the case of Forest land convert to Cropland. For these lands, the weighted average forest litter C stock of 18.38 t C ha (default IPCC litter C stocks for coniferous and deciduous forests weighted by relative contributions of coniferous and deciduous forests to the total forest area) is lost in the year of the land conversion.

For all conversions to Cropland, it is considered that subsequent gains in litter C do not occur.

As previously described in the subchapter *Land conversion to Forest land,* changes in mineral soil C stocks in 0-30 cm depth following land conversion to Cropland were calculated by multiplying respective 20 year land use change areas with corresponding annual soil C stock change values given Table 377.

Direct N_2O emissions from N mineralization/immobilization associated with loss of soil organic matter resulting from land use change on mineral soils (4(III))

Conversions from Forest land or Grassland to Cropland lead to net losses in soil C (Table 377). As such, direct N_2O emissions (caused by increased mineralisation of soil organic N due to potential soil C losses and associated increases in N availability) are estimated using the Tier 1 method described in the 2006 IPCC Guidelines (Eq.11.1, Vol 4, Chapter 11):

$$N_2O\text{-}N = F_{SOM} * EF_1 \ (Eq.11.1)$$

To calculate the net annual amount of N mineralized (F_{SOM}, eq. 11.1) from the net carbon stock change (CSC) due to the land use change in the mineral soil, the CSC was divided by default C/N ratio of Forest land and Grassland soils (15) given in 2006 IPCC Guidelines (Vol 4, Chapter 11). To derive mass of N emitted in the form of N_2O, the subsequent F_{SOM} are multiplied by the default emission factor (EF_1) given in 2006 IPCC Guidelines (Table 11.1, Vol 4, Chapter 11), with the result finally converted from the mass of N_2O-N to mass of N_2O.

Indirect N_2O emissions from N leaching and runoff (4(IV))

Conversions from Forest land or Grassland to Cropland lead to net losses in soil C (Table 377. As such, indirect N_2O emissions (caused by increased mineralisation of leached soil organic N due to potential soil C losses and associated increases in N leached from the soil) are estimated following the Tier 1 method described in the 2006 IPPC Guidelines (Eq.11.10, Vol 4, Chapter 11):

$$N_2O\text{-}N = F_{SOM} * Frac_{LEACH} * EF_5 \ (eq.11.10)$$

In this case, F_{SOM} (as described above) was multiplied by a relative fraction of N that is leached away ($Frac_{LEACH}$) and subsequent emission factor (EF_5). The default values for $Frac_{LEACH}$ and EF_5 provided in the 2006 IPPC Guidelines (Table 11.3, Vol 4, Chapter 11) were applied, with the result finally converted from the mass of N_2O-N to mass of N_2O.

6.3.5 Recalculation

The following table presents the main revisions and recalculations done since the last submission and relevant to IPCC category 4.B *Cropland*.

Table 382 Recalculations done in IPCC sub-category 4.B Cropland.

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
4.B.	No recalculations were performed.	AD	Accuracy

6.4 Grassland (Category 4.C)

6.4.1 Category description

In 2021, total Grassland area was estimated at 142.33 kha, which corresponds to 10.3 % of the total area of Montenegro (see table below). According to land use changes derived from the CLC change products, Grassland area has been decreasing since 1990; however, the change has been marginal. As with Cropland, the Grassland area has been rather stable since 1990.

Similar to Cropland, the contribution of Grassland to the LULUCF GHG balance is marginal. In 2021, net removals amounted to only -1.01 kt CO2 eq (see figures and tables below). In terms of trend, the post-2006 increase in Forest land conversion to Grassland led to a small peak in net emissions in 2007 (0.43 kt CO_2eq). Since then, emissions have decreased and since 2012 past zero to net removals due to increased conversion to Grasslands from Settlements and Cropland.

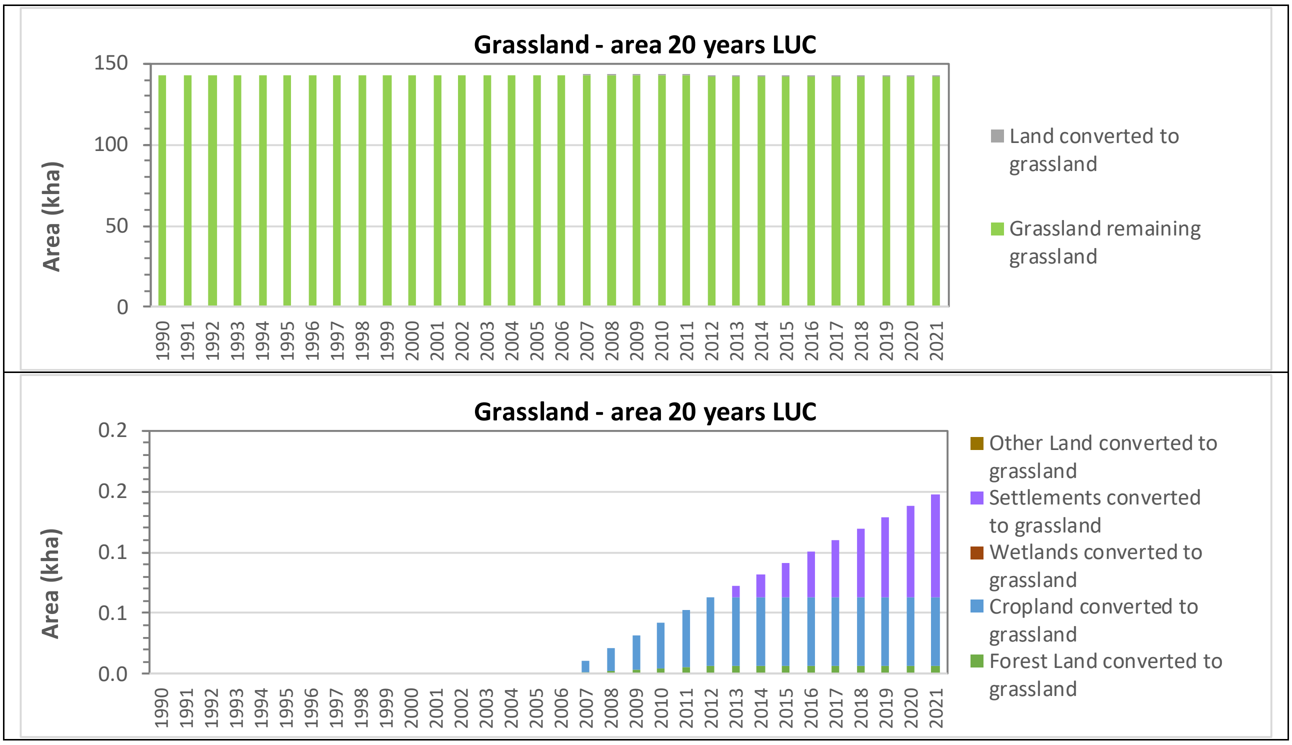


Figure 164 Areas of Grassland remaining Grassland and Land converted to Grassland (land use change (LUC) areas are presented in the 20 years transition period)

Table 383 Areas of Total Grassland and related sub-categories (land use change (LUC) areas are presented in the 20 years transition period) in 1000 ha (kha)

	4C	4C1	4C2	4C21	4C22	4C22a	4C22b	4C23	4C24	4C25
	Grassland	Grassland remaining grassland	Land converted to grassland	Forest Land converted to grassland	Cropland converted to grassland	Annual cropland converted to grassland	Perennial cropland converted to grassland	Wetlands converted to grassland	Settlements converted to grassland	Other Land converted to grassland
	area 20 years LUC									
	kha									
1990	143.12	143.12	NO	NO	NO	NO	NO	NO	NO	NO
1991	143.10	143.10	NO	NO	NO	NO	NO	NO	NO	NO
1992	143.08	143.08	NO	NO	NO	NO	NO	NO	NO	NO
1993	143.05	143.05	NO	NO	NO	NO	NO	NO	NO	NO
1994	143.03	143.03	NO	NO	NO	NO	NO	NO	NO	NO
1995	143.01	143.01	NO	NO	NO	NO	NO	NO	NO	NO
1996	142.99	142.99	NO	NO	NO	NO	NO	NO	NO	NO
1997	142.96	142.96	NO	NO	NO	NO	NO	NO	NO	NO
1998	142.94	142.94	NO	NO	NO	NO	NO	NO	NO	NO
1999	142.92	142.92	NO	NO	NO	NO	NO	NO	NO	NO
2000	142.90	142.90	NO	NO	NO	NO	NO	NO	NO	NO
2001	142.87	142.87	NO	NO	NO	NO	NO	NO	NO	NO
2002	142.85	142.85	NO	NO	NO	NO	NO	NO	NO	NO
2003	142.83	142.83	NO	NO	NO	NO	NO	NO	NO	NO
2004	142.81	142.81	NO	NO	NO	NO	NO	NO	NO	NO
2005	142.78	142.78	NO	NO	NO	NO	NO	NO	NO	NO
2006	142.76	142.76	NO	NO	NO	NO	NO	NO	NO	NO
2007	142.71	142.70	0.01	0.00	0.01	0.00	0.00	NO	NO	NO
2008	142.67	142.65	0.02	0.00	0.02	0.01	0.01	NO	NO	NO
2009	142.62	142.59	0.03	0.00	0.03	0.01	0.01	NO	NO	NO

	4C	4C1	4C2	4C21	4C22	4C22a	4C22b	4C23	4C24	4C25
	Grassland	Grassland remaining grassland	Land converted to grassland	Forest Land converted to grassland	Cropland converted to grassland	Annual cropland converted to grassland	Perennial cropland converted to grassland	Wetlands converted to grassland	Settlements converted to grassland	Other Land converted to grassland
	area 20 years LUC									
	kha									
2010	142.58	142.54	0.04	0.00	0.04	0.02	0.02	NO	NO	NO
2011	142.53	142.48	0.05	0.01	0.05	0.02	0.02	NO	NO	NO
2012	142.49	142.42	0.06	0.01	0.06	0.03	0.03	NO	NO	NO
2013	142.47	142.40	0.07	0.01	0.06	0.03	0.03	NO	0.01	NO
2014	142.45	142.37	0.08	0.01	0.06	0.03	0.03	NO	0.02	NO
2015	142.44	142.35	0.09	0.01	0.06	0.03	0.03	NO	0.03	NO
2016	142.42	142.32	0.10	0.01	0.06	0.03	0.03	NO	0.04	NO
2017	142.40	142.29	0.11	0.01	0.06	0.03	0.03	NO	0.05	NO
2018	142.39	142.27	0.12	0.01	0.06	0.03	0.03	NO	0.06	NO
2019	142.37	142.24	0.13	0.01	0.06	0.03	0.03	NO	0.07	NO
2020	142.35	142.21	0.14	0.01	0.06	0.03	0.03	NO	0.08	NO
2021	142.33	142.19	0.15	0.01	0.06	0.03	0.03	NO	0.08	NO
Trend										
1990 - 2021	-0.6%	-0.7%	NA	NA	NA	NA	NA	NA	NA	NA
2005 - 2021	-0.3%	-0.4%	NA	NA	NA	NA	NA	NA	NA	NA
2020 - 2021	0.0%	0.0%	6.8%	0.0%	0.0%	0.0%	0.0%	NA	12.5%	NA

Table 384 N Net emissions/removals of Grassland in kt CO2/CO2eq for the period of1990-2021

Code	4C	4C	4C1	4C2	4C21	4C22	4C23	4C24	4C25
Category name	Total Grassland	Total Grassland	Grassland remaining Grassland	Land converted to Grassland	Forest Land converted to Grassland	Cropland converted to Grassland	Wetlands converted to Grassland	Settlements converted to Grassland	Other Land converted to Grassland
	kt CO2eq	kt CO2							
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO	NO	NO	NO	NO
1995	NO	NO	NO	NO	NO	NO	NO	NO	NO
1996	NO	NO	NO	NO	NO	NO	NO	NO	NO
1997	NO	NO	NO	NO	NO	NO	NO	NO	NO
1998	NO	NO	NO	NO	NO	NO	NO	NO	NO
1999	NO	NO	NO	NO	NO	NO	NO	NO	NO
2000	NO	NO	NO	NO	NO	NO	NO	NO	NO
2001	NO	NO	NO	NO	NO	NO	NO	NO	NO
2002	NO	NO	NO	NO	NO	NO	NO	NO	NO
2003	NO	NO	NO	NO	NO	NO	NO	NO	NO
2004	NO	NO	NO	NO	NO	NO	NO	NO	NO
2005	NO	NO	NO	NO	NO	NO	NO	NO	NO
2006	NO	NO	NO	NO	NO	NO	NO	NO	NO
2007	0.435	0.435	NO	0.435	0.355	0.080	NO	NO	NO
2008	0.414	0.414	NO	0.414	0.355	0.059	NO	NO	NO
2009	0.394	0.394	NO	0.394	0.355	0.039	NO	NO	NO
2010	0.373	0.373	NO	0.373	0.355	0.018	NO	NO	NO
2011	0.352	0.352	NO	0.352	0.355	-0.003	NO	NO	NO

Code	4C	4C	4C1	4C2	4C21	4C22	4C23	4C24	4C25
Category name	Total Grassland	Total Grassland	Grassland remaining Grassland	Land converted to Grassland	Forest Land converted to Grassland	Cropland converted to Grassland	Wetlands converted to Grassland	Settlements converted to Grassland	Other Land converted to Grassland
	kt CO2eq	kt CO2							
2012	0.332	0.332	NO	0.332	0.355	-0.023	NO	NO	NO
2013	-0.356	-0.356	NO	-0.356	NO	-0.124	NO	-0.232	NO
2014	-0.448	-0.448	NO	-0.448	NO	-0.124	NO	-0.324	NO
2015	-0.541	-0.541	NO	-0.541	NO	-0.124	NO	-0.417	NO
2016	-0.634	-0.634	NO	-0.634	NO	-0.124	NO	-0.510	NO
2017	-0.726	-0.726	NO	-0.726	NO	-0.124	NO	-0.602	NO
2018	-0.819	-0.819	NO	-0.819	NO	-0.124	NO	-0.695	NO
2019	-0.911	-0.911	NO	-0.911	NO	-0.124	NO	-0.787	NO
2020	-1.004	-1.004	NO	-1.004	NO	-0.124	NO	-0.880	NO
2021	-1.097	-1.097	NO	-1.097	NO	-0.124	NO	-0.973	NO
Trend									
1990 - 2021	NA	NA	NA	NA	NA	NA	NA	NA	NA
2005 - 2021	NA	NA	NA	NA	NA	NA	NA	NA	NA
2020 - 2021	9.2%	9.2%	NA	9.2%	NA	0.0%	NA	10.5%	NA

6.4.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

As described in chapter 6.1.2.1, to calculate the annual total areas for Cropland, Grassland, Wetlands, Settlements and Other land, the respective 1970-2018 time series was constructed starting with 2018. Subtracting the 2018 total Forest land area from the total official area of Montenegro yielded a 2018 total non-forest area that was subsequently distributed between Cropland, Grassland, Wetlands, Settlements and Other land according to the respective area contributions to non-forest land (in percent) as derived from the 2018 CLC status layer. The annual areas for 2017 back to 1970 were then subsequently calculated by successively subtracting the respective annual net land use changes to the corresponding categories. For instance, Grassland total areas for 2017 back to 1970 were calculated by successively subtracting the annual net land use change to Grassland (annual total CLC land use changes to Grassland minus the annual total CLC land use changes from Grassland to the other land use categories). For the years 2019-2021, the same extrapolation principle was applied. As no new CLC land use changes are available, the yearly LUCs from CLC change layer 2012/2018 were extrapolated and used to calculate the respective land use and land-use change areas in 2019 - 2021, again using the 2018 areas as the starting reference.

6.4.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

As described in chapter 6.1.2.1, for the purpose of the LULUCF Inventory national experts assigned specific CLC classes to the IPCC category Grassland (Table 362).

6.4.4 Methodological issues

6.4.4.1 Grassland remaining grassland (4.C.1)

Biomass

The biomass C stock of Grassland remaining grassland is assumed to be in equilibrium. Therefore changes in biomass C are assumed to be zero.

Dead wood

Dead wood is assumed to be not occurring on Grassland remaining grassland.

Litter and soil

Litter is assumed to be not occurring on Grassland remaining grassland.

Due to the lack of data on changes in management practises, changes in soil carbon stocks of Grassland remaining grassland are not estimated.

6.4.4.2 Land use changes to Grassland (4.C.2)

Biomass

In conversions to Grassland, the biomass C stock of the previous land use category is assumed to be lost in year of the conversion (Table 385). Biomass stock losses for Forest land and Cropland are explained in the previous chapters. No gross biomass C stock losses were assumed for conversions from Settlements to Grassland, while conversions from Wetlands and Other land to Grassland are not occurring.

Table 385: Gross biomass carbon losses following land conversion to Grassland

Conversion	Biomass C loss in year of conversion to Grassland (i.e. biomass C stock of previous land use)
Unit	t C ha
Forest land to Grassland	77.665
Annual Cropland to Grassland	3.45
Perennial Cropland to Grassland	10.32
Wetlands to Grassland	NO
Settlements to Grassland	0
Other land to Grassland	NO

After the initial gross biomass C loss following conversion, gross gains in Grassland biomass C of 4.025 t C ha^{-1} are assumed to take place in the year of the conversion. This factor was updated in the 2022 submission.

A country specific carbon stock for the grassland biomass was estimated based on using the annual yield statistics for meadows from national harvest statistics of eight consecutive years published in two editions of the Statistical Year Book from the Statistical Office of Montenegro (MONSTAT 2016; MONSTAT 2019, table 11- 9).

The calculation led to an average biomass yield per year of 2.85 t dm ha^{-1} for grasslands, which is equivalent to 1.43 t C ha^{-1}.

Expansion factors for stubble and root biomass were derived from Austria's most recent National Inventory Report (Austria's National Inventory Report 2021), due to a lack of national data sources and it was assumed based on expert judgement that the Austrian values are also suitable for Montenegrin grasslands. Therefore, the above ground stubble biomass is 1.0 t dm ha^{-1} (0.5 t C ha^{-1}) and the root biomass is 4.2 t dm ha^{-1} (2.1 t C ha^{-1}).

The total grassland biomass amounts to 4.03 t C ha^{-1}, which comprises the above ground biomass (1.43 t C ha^{-1}) plus the root biomass (2.1 t C ha^{-1}) and the stubble biomass (0.5 t C ha^{-1}). This value is 67 % lower than the IPCC default value (6.4 t C ha^{-1}) for cold temperate wet regions (IPCC 2006; table 6.4).

Dead wood

Changes in the dead wood carbon stock only occur for Forest lands converted to Grasslands. On conversion from Forest land to other land uses, it is assumed that this C stock (1.938 t C ha^{-1}, see previous chapters) is lost in the year of the conversion.

Litter and soil

For conversions to Grassland, it is assumed that litter in the previous land use was occurring only in the case of Forest land converted to Grassland. For these lands, the weighted average forest litter C stock of 18.38 t C ha (default IPCC litter C stocks for coniferous and deciduous forests weighted by relative contributions of coniferous and deciduous forests to the total forest area) is lost in the year of the land conversion.

For all conversions to Grassland, it is considered that subsequent gains in litter C do not occur.

As previously described in the subchapter *Land conversion to Forest land,* changes in mineral soil C stocks in 0-30 cm depth following land conversion to Grassland were calculated by multiplying respective 20 year land use change areas were by corresponding annual soil C stock change values given Table 377.

Direct N_2O emissions from N mineralization/immobilization associated with loss of soil organic matter resulting from land use change on mineral soils (4(III))

Land conversion to Grassland does not cause any losses in soil C (Table 377). As such, direct N_2O emissions (caused by increased mineralisation of soil organic N due to potential soil C losses and associated increases in N availability) are zero.

Indirect N_2O emissions from N leaching and runoff (4(IV))

Land conversion to Grassland does not cause any losses in soil C (Table 377). As such, indirect N_2O emissions (caused by increased mineralisation of leached soil organic N due to potential soil C losses and associated increases in N leached from the soil) are zero.

6.4.5 Recalculations

The following table presents the main revisions and recalculations done since the last submission and relevant to IPCC category 4.A *Grassland.*

Table 386 Recalculations done in IPCC category 4.C Grassland.

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
4.C.	No recalculations were performed	AD	Accuracy

6.5 Wetlands (Category 4.D)

6.5.1 Category description

In 2021, total Wetlands area was estimated at 42.99 kha which corresponds to 3.1 % of the total area of Montenegro (Table 387). According to land use changes derived from the CLC change products, the area of Wetlands was unchanged up to 2012. However, since then the area of Wetlands declined steadily and has decreased slightly (0.1 % decrease compared to 1990).

In contrast to land use change from Wetlands, until now no land conversion to Wetlands has occurred. Therefore, only Wetlands remaining wetlands are potentially relevant in terms of GHG emissions/removals. Only the CLC class *inland marshes* (ca. 25 % of the total Wetland area in Montenegro) is considered by national experts to be managed. Despite assumed management of these lands, no peat extraction or drainage of these lands is assumed to take place. It is thus assumed that carbon gains and losses in Wetlands remaining wetlands are in equilibrium and that the subcategory is GHG-neutral.

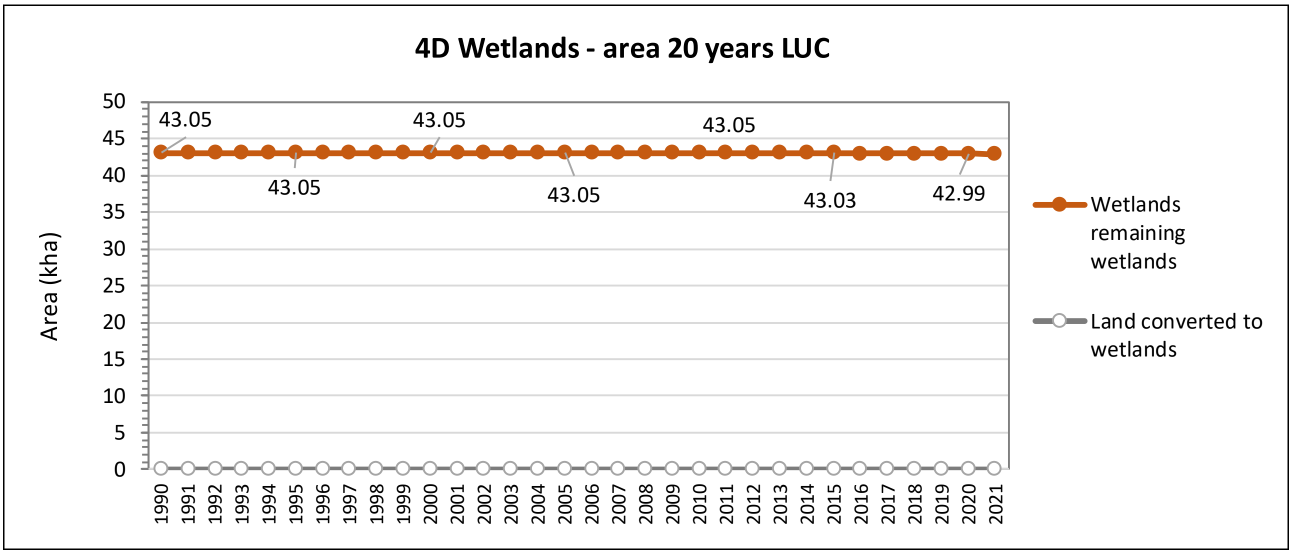


Figure 165 Areas of Wetlands remaining wetland and Land converted to wetlands (land use change (LUC) areas are presented in the 20 years transition period)

Table 387 Areas of Total Wetlands and related sub-categories (land use change (LUC) areas are presented in the 20 years transition period) in 1000 ha (kha)

	4D	4D1	4D2
	Wetlands	Wetlands remaining wetlands	Land converted to wetlands
	area 20 years LUC		
	kha		
1990	43.05	43.05	NO
1991	43.05	43.05	NO
1992	43.05	43.05	NO
1993	43.05	43.05	NO
1994	43.05	43.05	NO
1995	43.05	43.05	NO
1996	43.05	43.05	NO
1997	43.05	43.05	NO
1998	43.05	43.05	NO

	4D	4D1	4D2
	Wetlands	Wetlands remaining wetlands	Land converted to wetlands
	area 20 years LUC		
	kha		
1999	43.05	43.05	NO
2000	43.05	43.05	NO
2001	43.05	43.05	NO
2002	43.05	43.05	NO
2003	43.05	43.05	NO
2004	43.05	43.05	NO
2005	43.05	43.05	NO
2006	43.05	43.05	NO
2007	43.05	43.05	NO
2008	43.05	43.05	NO
2009	43.05	43.05	NO
2010	43.05	43.05	NO
2011	43.05	43.05	NO
2012	43.05	43.05	NO
2013	43.04	43.04	NO
2014	43.03	43.03	NO
2015	43.03	43.03	NO
2016	43.02	43.02	NO
2017	43.01	43.01	NO
2018	43.01	43.01	NO
2019	43.00	43.00	NO
2020	42.99	42.99	NO
2021	42.99	42.99	NO
Trend			
1990 – 2021	-0.1%	-0.1%	NA
2005 – 2021	-0.1%	-0.1%	NA
2020 - 2021	0.0%	0.0%	NA

6.5.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

As described in chapter 6.1.2.1, to calculate the annual total areas for Cropland, Grassland, Wetlands, Settlements and Other land, the respective 1970-2018 time series was constructed starting with 2018. Subtracting the 2018 total Forest land area from the total official area of Montenegro yielded a 2018 total non-forest area that was subsequently distributed between Cropland, Grassland, Wetlands, Settlements and Other land according to the respective area contributions to non-forest land (in percent) as derived from the 2018 CLC status layer. The annual areas for 2017 back to 1970 were then subsequently calculated by successively subtracting the respective annual net land use changes to the corresponding categories. For instance, Wetlands total areas for 2017 back to 1970 were calculated by successively subtracting the annual net land use change to Wetlands (annual total CLC land use changes to Wetlands minus the annual total CLC land use changes from Wetlands to the other land use categories). For the years 2019-2021, the same extrapolation principle was applied. As no new CLC land use changes are available, the yearly LUCs from CLC change layer 2012/2018 were extrapolated and used to calculate the respective land use and land-use change areas in 2019 - 2021, again using the 2018 areas as the starting reference.

6.5.3 Land-use definitions and classification systems used and their correspondence to the LULUCF categories

As described in chapter 6.1.2.1, for the purpose of the LULUCF Inventory national experts assigned specific CLC classes to the IPCC category Wetlands (**Error! Reference source not found.**).

6.5.4 Methodological issues

6.5.4.1 Wetlands remaining wetlands (4.D.1)

Most of the CLC classes assigned to the Wetlands category are considered unmanaged, although the CLC class 411 (inland marshes) is considered by national experts to be managed (**Error! Reference source not found.**). These areas constitute ca. 25 % of the total Wetland area in Montenegro. Despite assumed management of these lands, no peat extraction or drainage of these lands is assumed to take place. It is thus assumed that no net C stock changes occur in the biomass, deadwood, litter and soil pools of Wetlands remaining wetlands.

6.5.4.2 Land use changes to Wetlands (4.D.2)

Since 1990 no land use conversions to Wetlands have been observed or documented. As such, emissions/removals from the subcategory Land use changes to Wetlands are not occurring.

6.5.5 Recalculations

The following table presents the main revisions and recalculations done since the last submission and relevant to IPCC category 4.D *Wetlands*.

Table 388 Recalculations done in IPCC category 4.D Wetlands.

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
4.D.	No recalculations were performed.	AD	Accuracy

6.6 Settlements (Category 4.E)

6.6.1 Category description

In 2021, total Settlement area was estimated at 29.51 kha which corresponds to 2.1 % of the total area of Montenegro (see Figure ## in chapter 6.2.1 above). Despite its small area in absolute terms, the Settlement area has undergone a significant relative increase since 1990 (1990-2021 increase of 14.2%). Due to this increase in land conversion to Settlements, emissions from this category have also been increasing (see tables and figure below). Compared to 1990, emissions from the Settlements have increased from 20.67 to 61.84 kt CO_2eq in 2021 (a 199.1% increase). The most significant driver of emissions from this category has been the conversion of Forest land to Settlements. Of the 61.84 kt CO_2eq emissions in 2021, the conversion of Forest land to Settlements contributed to emissions of 59.15 kt CO_2.

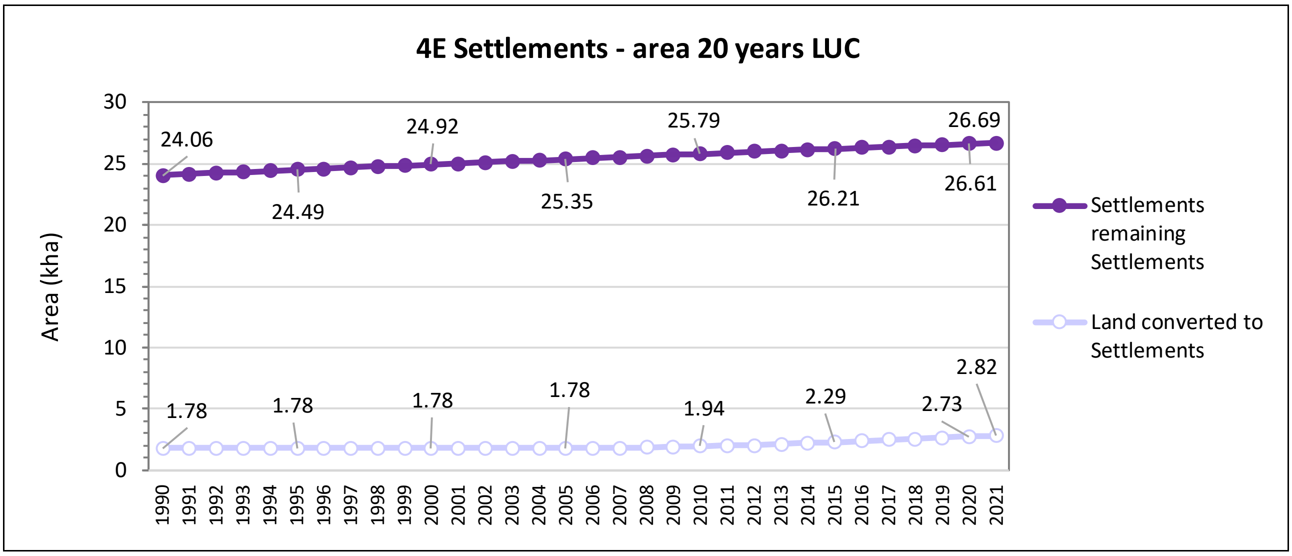


Figure 166 Areas of Settlements remaining settlements and Land converted to settlements (land use change (LUC) areas are presented in the 20 years transition period)

Table 389 Areas of Total Settlements and related sub-categories (land use change (LUC) areas are presented in the 20 years transition period) in 1000 ha (kha)

	4E	4E1	4E2	4E21	4E22	4E22a	4E22b	4E23	4E24	4E25
	Settlements	Settlements remaining Settlements	Land converted to Settlements	Forest Land converted to Settlements	Cropland converted to Settlements	Annual cropland converted to Settlements	Perennial cropland converted to Settlements	Grassland converted to Settlements	Wetlands converted to Settlements	Other Land converted to Settlements
	area 20 years LUC									
	kha									
1990	25.84	24.06	1.78	0.53	0.43	0.21	0.22	0.24	NO	0.58
1991	25.93	24.15	1.78	0.53	0.43	0.21	0.22	0.24	NO	0.58
1992	26.01	24.24	1.78	0.53	0.43	0.21	0.22	0.24	NO	0.58
1993	26.10	24.32	1.78	0.53	0.43	0.21	0.22	0.24	NO	0.58
1994	26.18	24.41	1.78	0.53	0.43	0.21	0.22	0.24	NO	0.58
1995	26.27	24.49	1.78	0.53	0.43	0.21	0.22	0.24	NO	0.58
1996	26.36	24.58	1.78	0.53	0.43	0.21	0.22	0.24	NO	0.58
1997	26.44	24.67	1.78	0.53	0.43	0.21	0.22	0.24	NO	0.58
1998	26.53	24.75	1.78	0.53	0.43	0.21	0.22	0.24	NO	0.58
1999	26.61	24.84	1.78	0.53	0.43	0.21	0.22	0.24	NO	0.58
2000	26.70	24.92	1.78	0.53	0.43	0.21	0.22	0.24	NO	0.58
2001	26.79	25.01	1.78	0.53	0.43	0.21	0.22	0.24	NO	0.58
2002	26.87	25.09	1.78	0.53	0.43	0.21	0.22	0.24	NO	0.58
2003	26.96	25.18	1.78	0.53	0.43	0.21	0.22	0.24	NO	0.58
2004	27.04	25.27	1.78	0.53	0.43	0.21	0.22	0.24	NO	0.58
2005	27.13	25.35	1.78	0.53	0.43	0.21	0.22	0.24	NO	0.58
2006	27.21	25.44	1.78	0.53	0.43	0.21	0.22	0.24	NO	0.58
2007	27.35	25.53	1.82	0.58	0.43	0.21	0.22	0.25	NO	0.55
2008	27.48	25.62	1.86	0.62	0.44	0.22	0.22	0.26	NO	0.53
2009	27.61	25.70	1.90	0.67	0.45	0.22	0.23	0.27	NO	0.51

	4E	4E1	4E2	4E21	4E22	4E22a	4E22b	4E23	4E24	4E25
	Settlements	Settlements remaining Settlements	Land converted to Settlements	Forest Land converted to Settlements	Cropland converted to Settlements	Annual cropland converted to Settlements	Perennial cropland converted to Settlements	Grassland converted to Settlements	Wetlands converted to Settlements	Other Land converted to Settlements
	area 20 years LUC									
	kha									
2010	27.74	25.79	1.94	0.71	0.46	0.23	0.23	0.28	NO	0.49
2011	27.87	25.88	1.99	0.76	0.47	0.23	0.24	0.29	NO	0.47
2012	28.00	25.97	2.03	0.80	0.48	0.24	0.24	0.30	NO	0.45
2013	28.17	26.05	2.12	0.90	0.49	0.24	0.25	0.30	0.00	0.43
2014	28.34	26.13	2.21	0.99	0.51	0.25	0.26	0.30	0.01	0.41
2015	28.50	26.21	2.29	1.08	0.52	0.26	0.26	0.30	0.01	0.39
2016	28.67	26.29	2.38	1.17	0.53	0.26	0.27	0.30	0.02	0.36
2017	28.84	26.37	2.47	1.26	0.54	0.27	0.28	0.30	0.02	0.34
2018	29.01	26.45	2.56	1.36	0.56	0.27	0.28	0.30	0.03	0.32
2019	29.17	26.53	2.65	1.45	0.57	0.28	0.29	0.30	0.03	0.30
2020	29.34	26.61	2.73	1.54	0.58	0.29	0.29	0.30	0.03	0.28
2021	29.51	26.69	2.82	1.63	0.59	0.29	0.30	0.30	0.04	0.26
Trend										
1990 - 2021	14.2%	10.9%	58.9%	205.2%	39.6%	39.6%	39.6%	24.0%	NA	-55.0%
2005 - 2021	8.8%	5.3%	58.9%	205.2%	39.6%	39.6%	39.6%	24.0%	NA	-55.0%
2020 - 2021	0.6%	0.3%	3.2%	6.0%	2.2%	2.2%	2.2%	0.1%	12.5%	-7.5%

Table 390 Net emissions/removals of Settlements in kt CO_2, N_2O and CO_2eq for the period of 1990-2021

Code	4E	4E	4E1	4E2	4E21	4E22	4E23	4E24	4E25	4(III)E21	4(III)E22	4(III)E23	4(IV)E21	4(IV)E22	4(IV)E23
Category name	Total Settle-ments	Total Settle-ments	Settle-ments remaining Settle-ments	Land converted to Settle-ments	Forest Land converted to Settle-ments	Cropland converted to Settle-ments	Grassland converted to Settle-ments	Wetlands converted to Settle-ments	Other Land converted to Settle-ments	Forest Land converted to Settle-ments	Cropland converte d to Settle-ments	Grassland converte d to Settle-ments	Forest Land converte d to Settle-ments	Cropland converte d to Settle-ments	Grassland converte d to Settle-ments
Unit	kt CO2eq	kt CO2								kt N2O					
1990	20.67	19.37	NO	19.37	13.05	3.78	2.54	NO	NO	0.001	0.001	0.001	<0.001	<0.001	<0.001
1991	20.67	19.37	NO	19.37	13.05	3.78	2.54	NO	NO	0.001	0.001	0.001	<0.001	<0.001	<0.001
1992	20.67	19.37	NO	19.37	13.05	3.78	2.54	NO	NO	0.001	0.001	0.001	<0.001	<0.001	<0.001
1993	20.67	19.37	NO	19.37	13.05	3.78	2.54	NO	NO	0.001	0.001	0.001	<0.001	<0.001	<0.001
1994	20.67	19.37	NO	19.37	13.05	3.78	2.54	NO	NO	0.001	0.001	0.001	<0.001	<0.001	<0.001
1995	20.67	19.37	NO	19.37	13.05	3.78	2.54	NO	NO	0.001	0.001	0.001	<0.001	<0.001	<0.001
1996	20.67	19.37	NO	19.37	13.05	3.78	2.54	NO	NO	0.001	0.001	0.001	<0.001	<0.001	<0.001
1997	20.67	19.37	NO	19.37	13.05	3.78	2.54	NO	NO	0.001	0.001	0.001	<0.001	<0.001	<0.001
1998	20.67	19.37	NO	19.37	13.05	3.78	2.54	NO	NO	0.001	0.001	0.001	<0.001	<0.001	<0.001
1999	20.67	19.37	NO	19.37	13.05	3.78	2.54	NO	NO	0.001	0.001	0.001	<0.001	<0.001	<0.001
2000	20.67	19.37	NO	19.37	13.05	3.78	2.54	NO	NO	0.001	0.001	0.001	<0.001	<0.001	<0.001
2001	20.67	19.37	NO	19.37	13.05	3.78	2.54	NO	NO	0.001	0.001	0.001	<0.001	<0.001	<0.001
2002	20.67	19.37	NO	19.37	13.05	3.78	2.54	NO	NO	0.001	0.001	0.001	<0.001	<0.001	<0.001
2003	20.67	19.37	NO	19.37	13.05	3.78	2.54	NO	NO	0.001	0.001	0.001	<0.001	<0.001	<0.001
2004	20.67	19.37	NO	19.37	13.05	3.78	2.54	NO	NO	0.001	0.001	0.001	<0.001	<0.001	<0.001
2005	20.67	19.37	NO	19.37	13.05	3.78	2.54	NO	NO	0.001	0.001	0.001	<0.001	<0.001	<0.001
2006	20.67	19.37	NO	19.37	13.05	3.78	2.54	NO	NO	0.001	0.001	0.001	<0.001	<0.001	<0.001
2007	34.83	33.46	NO	33.46	26.61	4.09	2.77	NO	NO	0.002	0.001	0.001	<0.001	<0.001	<0.001
2008	35.50	34.06	NO	34.06	27.05	4.16	2.86	NO	NO	0.002	0.001	0.001	<0.001	<0.001	<0.001
2009	36.16	34.66	NO	34.66	27.49	4.22	2.95	NO	NO	0.002	0.001	0.001	<0.001	<0.001	<0.001

Code	4E	4E	4E1	4E2	4E21	4E22	4E23	4E24	4E25	4(III)E21	4(III)E22	4(III)E23	4(IV)E21	4(IV)E22	4(IV)E23
Category name	Total Settle-ments	Total Settle-ments	Settle-ments remaining Settle-ments	Land converted to Settle-ments	Forest Land converted to Settle-ments	Cropland converted to Settle-ments	Grassland converted to Settle-ments	Wetlands converted to Settle-ments	Other Land converted to Settle-ments	Forest Land converted to Settle-ments	Cropland converte d to Settle-ments	Grassland converte d to Settle-ments	Forest Land converte d to Settle-ments	Cropland converte d to Settle-ments	Grassland converte d to Settle-ments
Unit	kt CO2eq	kt CO2								kt N2O					
2010	36.83	35.26	NO	35.26	27.93	4.29	3.04	NO	NO	0.002	0.002	0.001	<0.001	<0.001	<0.001
2011	37.50	35.87	NO	35.87	28.37	4.36	3.13	NO	NO	0.002	0.002	0.001	<0.001	<0.001	<0.001
2012	38.17	36.47	NO	36.47	28.81	4.43	3.22	NO	NO	0.002	0.002	0.001	<0.001	<0.001	<0.001
2013	52.95	51.14	NO	51.14	43.43	4.62	3.09	NO	NO	0.003	0.002	0.001	<0.001	<0.001	<0.001
2014	54.06	52.14	NO	52.14	44.34	4.71	3.09	NO	NO	0.003	0.002	0.001	<0.001	<0.001	<0.001
2015	55.17	53.15	NO	53.15	45.24	4.81	3.09	NO	NO	0.003	0.002	0.001	<0.001	<0.001	<0.001
2016	56.28	54.15	NO	54.15	46.14	4.91	3.10	NO	NO	0.003	0.002	0.001	<0.001	<0.001	<0.001
2017	57.39	55.15	NO	55.15	47.04	5.00	3.10	NO	NO	0.004	0.002	0.001	<0.001	<0.001	<0.001
2018	58.51	56.15	NO	56.15	47.95	5.10	3.10	NO	NO	0.004	0.002	0.001	<0.001	<0.001	<0.001
2019	59.62	57.15	NO	57.15	48.85	5.20	3.10	NO	NO	0.004	0.002	0.001	<0.001	<0.001	<0.001
2020	60.73	58.15	NO	58.15	49.75	5.29	3.11	NO	NO	0.004	0.002	0.001	<0.001	<0.001	<0.001
2021	61.84	59.15	NO	59.15	50.65	5.39	3.11	NO	NO	0.005	0.002	0.001	<0.001	<0.001	<0.001
Trend															
1990 - 2021	199.1%	205.3%	NA	205.3%	288.2%	42.4%	22.5%	NA	NA	205.2%	39.6%	24.0%	205.2%	39.6%	24.0%
2005 - 2021	199.1%	205.3%	NA	205.3%	288.2%	42.4%	22.5%	NA	NA	205.2%	39.6%	24.0%	205.2%	39.6%	24.0%
2020 - 2021	1.8%	1.7%	NA	1.7%	1.8%	1.8%	0.1%	NA	NA	6.0%	2.2%	0.1%	6.0%	2.2%	0.1%

6.6.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

As described in chapter 6.1.2.1, to calculate the annual total areas for Cropland, Grassland, Wetlands, Settlements and Other land, the respective 1970-2021 time series as constructed starting with 2018. Subtracting the 2018 total Forest land area from the total official area of Montenegro yielded a 2018 total non-forest area that was subsequently distributed between Cropland, Grassland, Wetlands, Settlements and Other land according to the respective area contributions to non-forest land (in percent) as derived from the 2018 CLC status layer. The annual areas for 2017 back to 1970 were then subsequently calculated by successively subtracting the respective annual net land use changes to the corresponding categories. For instance, Settlements total areas for 2017 back to 1970 were calculated by successively subtracting the annual net land use change to Settlements (annual total CLC land use changes to Settlements minus the annual total CLC land use changes from Settlements to the other land use categories). For the years 2019-2021, the same extrapolation principle was applied. As no new CLC land use changes are available, the yearly LUCs from CLC change layer 2012/2018 were extrapolated and used to calculate the respective land use and land-use change areas in 2019 - 2021, again using the 2018 areas as the starting reference.

6.6.3 Land-use definitions and classification systems used and their correspondence to the LULUCF categories

As described in chapter 6.1.2.1, for the purpose of the LULUCF Inventory national experts assigned specific CLC classes to the IPCC category Settlements (**Error! Reference source not found.**).

6.6.4 Methodological issues

6.6.4.1 Settlements remaining settlements (4.E.1)

Consistent with the Tier 1 method outlined in the 2006 IPCC Guidelines (Vol 4, Chapter 8), it is assumed that no net C stock changes occur in the biomass, deadwood, litter and soil pools of Settlements remaining settlements.

6.6.4.2 Land use changes to Settlements (4.E.2)

Biomass

On conversion to Settlements, the biomass C stock of the previous land use category is assumed to be lost in year of the conversion (Table 391). Biomass stock losses for Forest land, Cropland and Grassland are explained in the previous chapters. Gross biomass C stock losses for conversions from Wetlands and Other land to Settlements are not estimated.

Table 391: Gross biomass carbon losses following land conversion to Settlements

Conversion	Biomass C loss in year of conversion to Settlements (i.e. biomass C stock of previous land use)
	t C ha
Forest land to Settlements	77.665
Annual Cropland to Settlements	3.45
Perennial Cropland to Settlements	10.32
Grassland to Settlements	4.025
Wetlands to Settlements	NE
Other land to Settlements	NE

After the initial gross biomass C loss following conversion, subsequent gains in Settlement biomass C are not estimated due to the lack of data.

Deadwood

Changes in the dead wood carbon stock only occur for Forest lands converted to Settlements. On conversion from Forest land to other land uses, it is assumed that this C stock (1.938 t C ha^{-1}, see previous chapters) is lost in the year of the conversion.

Litter and soil

For conversions to Settlements, it is assumed that litter in the previous land use was occurring only in the case of Forest land converted to Settlements. For these lands, the weighted average forest litter C stock of 18.38 t C ha (default IPCC litter C stocks for coniferous and deciduous forests weighted by relative contributions of coniferous and deciduous forests to the total forest area) is lost in the year of the land conversion.

For all conversions to Settlements, it is considered that subsequent gains in litter C do not occur.

As previously described in the subchapter *Land conversion to Forest land,* changes in mineral soil C stocks in 0-30 cm depth following land conversion to Settlements were calculated by multiplying respective 20 year land use change areas were by corresponding annual soil C stock change values given Table 377.

Direct N_2O emissions from N mineralization/immobilization associated with loss of soil organic matter resulting from land use change on mineral soils (4(III))

Conversions from Forest land, Cropland and Grasslands to Settlements lead to net losses in soil C (Table 377). As such, direct N_2O emissions (caused by increased mineralisation of soil organic N due to potential soil C losses and associated increases in N availability) are estimated using the Tier 1 method described in the 2006 IPCC Guidelines (Eq.11.1, Vol 4, Chapter 11):

$N_2O\text{-}N = F_{SOM} * EF_1$ *(Eq.11.1)*

To calculate the net annual amount of N mineralized (F_{SOM}, eq. 11.1) from the net carbon stock change (CSC) due to the land use change in the mineral soil, the CSC was divided by respective default C/N ratio (15 for conversions from Forest land and Grassland, 12 for conversion from Cropland) given in the 2006 IPPC Guidelines (Vol 4, Chapter 11). To derive mass of N emitted in the form of N_2O, the subsequent F_{SOM} are multiplied by the default emission factor (EF_1) given in 2006 IPCC Guidelines (Table 11.1, Vol 4, Chapter 11), with the result finally converted from the mass of N_2O-N to mass of N_2O.

Indirect N_2O emissions from N leaching and runoff (4(IV))

Conversions from Forest land, Cropland and Grasslands to Settlements lead to net losses in soil C (Table 377). As such, indirect N_2O emissions (caused by increased mineralisation of leached soil organic N due to potential soil C losses and associated increases in N leached from the soil) are estimated following the Tier 1 method described in the 2006 IPCC Guidelines (Eq.11.10, Vol 4, Chapter 11):

$N_2O\text{-}N = F_{SOM} * Frac_{LEACH} * EF_5$ *(eq.11.10)*

In this case, F_{SOM} (as described above) was multiplied by a relative fraction of N that is leached away ($Frac_{LEACH}$) and subsequent emission factor (EF_5). The default values for $Frac_{LEACH}$ and EF_5 provided in the 2006 IPCC Guidelines (Table 11.3, Vol 4, Chapter 11) were applied, with the result finally converted from the mass of N_2O-N to mass of N_2O.

6.6.5 Recalculations

The following table presents the main revisions and recalculations done since the last submission and relevant to IPCC category 4.E *Settlements*.

Table 392 Recalculations done in IPCC category 4.E Settlements.

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
4.E.	No recalculations were performed.	AD	Accuracy

6.7 Other land (Category 4.F)

6.7.1 Category description

In 2021, the total area of Other land was estimated at 124.37 kha which corresponds to 9 % of the total area of Montenegro (Table 357). Over the time series, only land conversions of Forest land to Other land have been observed. This category has thus contributed a small source of GHG emissions to the LULUCF sector balance (annual emissions of 7.87 kt CO_2eq between 1990 and 2006). However, since 2006, conversions of Forest land to Other land have ceased. As a result, the subcategory has been GHG-neutral since 2013.

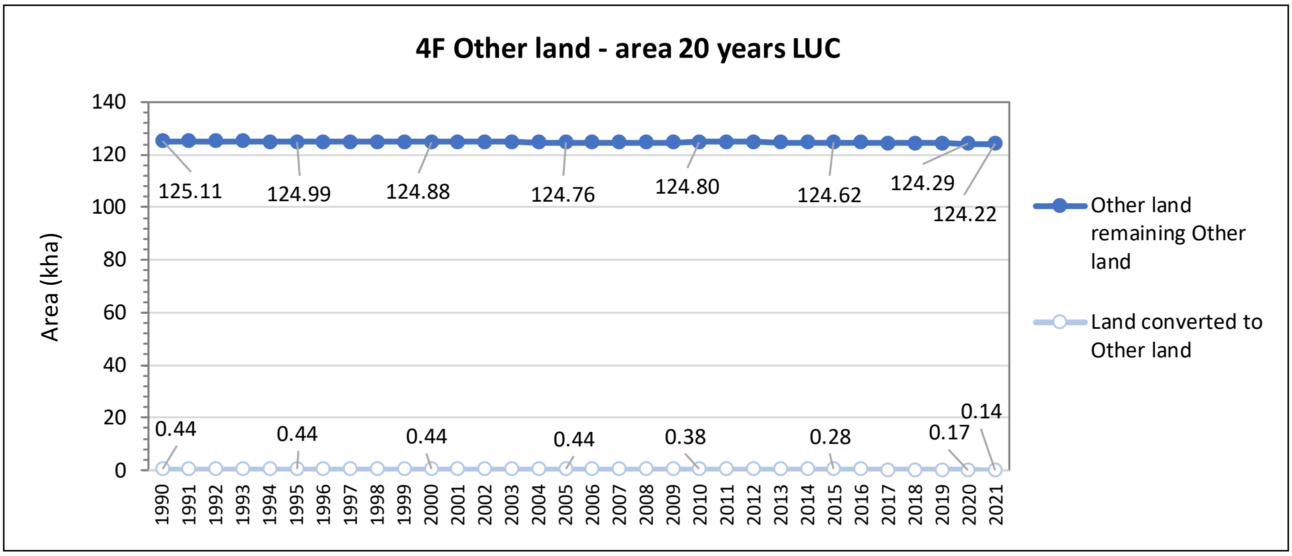


Figure 167 Areas of Other Land remaining Other Land and Land converted to Other Land (land use change (LUC) areas are presented in the 20 years transition period)

Table 393 Areas of Total Other land and related sub-categories (land use change (LUC) areas are presented in the 20 years transition period) in 1000 ha (kha)

	4F	4F1	4F2	4F21	4F22	4F22a	4F22b	4F23	4F24	4F25
	Other land	Other land remaining Other land	Land converted to Other land	Forest Land converted to Other land	Cropland converted to Other land	Annual cropland converted to Other land	Perennial cropland converted to Other land	Grassland converted to Other land	Wetlands converted to Other land	Settlements converted to Other land
	area 20 years LUC									
	kha									
1990	125.55	125.11	0.44	0.44	NO	NO	NO	NO	NO	NO
1991	125.53	125.08	0.44	0.44	NO	NO	NO	NO	NO	NO
1992	125.50	125.06	0.44	0.44	NO	NO	NO	NO	NO	NO
1993	125.48	125.04	0.44	0.44	NO	NO	NO	NO	NO	NO
1994	125.46	125.01	0.44	0.44	NO	NO	NO	NO	NO	NO
1995	125.43	124.99	0.44	0.44	NO	NO	NO	NO	NO	NO
1996	125.41	124.97	0.44	0.44	NO	NO	NO	NO	NO	NO
1997	125.39	124.94	0.44	0.44	NO	NO	NO	NO	NO	NO
1998	125.37	124.92	0.44	0.44	NO	NO	NO	NO	NO	NO
1999	125.34	124.90	0.44	0.44	NO	NO	NO	NO	NO	NO
2000	125.32	124.88	0.44	0.44	NO	NO	NO	NO	NO	NO
2001	125.30	124.85	0.44	0.44	NO	NO	NO	NO	NO	NO
2002	125.27	124.83	0.44	0.44	NO	NO	NO	NO	NO	NO
2003	125.25	124.81	0.44	0.44	NO	NO	NO	NO	NO	NO
2004	125.23	124.78	0.44	0.44	NO	NO	NO	NO	NO	NO
2005	125.20	124.76	0.44	0.44	NO	NO	NO	NO	NO	NO
2006	125.18	124.74	0.44	0.44	NO	NO	NO	NO	NO	NO
2007	125.18	124.75	0.43	0.43	NO	NO	NO	NO	NO	NO
2008	125.18	124.77	0.41	0.41	NO	NO	NO	NO	NO	NO
2009	125.17	124.78	0.39	0.39	NO	NO	NO	NO	NO	NO

	4F	4F1	4F2	4F21	4F22	4F22a	4F22b	4F23	4F24	4F25
	Other land	Other land remaining Other land	Land converted to Other land	Forest Land converted to Other land	Cropland converted to Other land	Annual cropland converted to Other land	Perennial cropland converted to Other land	Grassland converted to Other land	Wetlands converted to Other land	Settlements converted to Other land
	area 20 years LUC									
	kha									
2010	125.17	124.80	0.38	0.38	NO	NO	NO	NO	NO	NO
2011	125.17	124.81	0.36	0.36	NO	NO	NO	NO	NO	NO
2012	125.17	124.82	0.34	0.34	NO	NO	NO	NO	NO	NO
2013	125.08	124.76	0.32	0.32	NO	NO	NO	NO	NO	NO
2014	124.99	124.69	0.30	0.30	NO	NO	NO	NO	NO	NO
2015	124.90	124.62	0.28	0.28	NO	NO	NO	NO	NO	NO
2016	124.81	124.56	0.25	0.25	NO	NO	NO	NO	NO	NO
2017	124.72	124.49	0.23	0.23	NO	NO	NO	NO	NO	NO
2018	124.63	124.42	0.21	0.21	NO	NO	NO	NO	NO	NO
2019	124.54	124.36	0.19	0.19	NO	NO	NO	NO	NO	NO
2020	124.45	124.29	0.17	0.17	NO	NO	NO	NO	NO	NO
2021	124.37	124.22	0.14	0.14	NO	NO	NO	NO	NO	NO
Trend										
1990 - 2021	-0.9%	-0.7%	-67.7%	-67.7%	NA	NA	NA	NA	NA	NA
2005 - 2021	-0.7%	-0.4%	-67.7%	-67.7%	NA	NA	NA	NA	NA	NA
2020 - 2021	-0.1%	-0.1%	-13.4%	-13.4%	NA	NA	NA	NA	NA	NA

Table 394 Net emissions/removals of Other land in kt CO2/CO2eq for the period of 1990-2021

Code	4F	4F	4F1	4F2	4F21	4F22	4F23	4F24	4F25	4(III)F21	4(IV)F21
Category name	Total Other land	Total Other land	Other land remaining Other land	Land converted to Other land	Forest Land converted to Other land	Cropland converted to Other land	Grassland converted to Other land	Wetlands converted to Other land	Settlements converted to Other land	Forest Land converted to Other land	Forest Land converted to Other land
Unit	kt CO2eq	kt CO2								kt N2O	
1990	7.87	NO	7.87	7.87	NO	NO	NO	NO	NO	NO	7.87
1991	7.87	NO	7.87	7.87	NO	NO	NO	NO	NO	NO	7.87
1992	7.87	NO	7.87	7.87	NO	NO	NO	NO	NO	NO	7.87
1993	7.87	NO	7.87	7.87	NO	NO	NO	NO	NO	NO	7.87
1994	7.87	NO	7.87	7.87	NO	NO	NO	NO	NO	NO	7.87
1995	7.87	NO	7.87	7.87	NO	NO	NO	NO	NO	NO	7.87
1996	7.87	NO	7.87	7.87	NO	NO	NO	NO	NO	NO	7.87
1997	7.87	NO	7.87	7.87	NO	NO	NO	NO	NO	NO	7.87
1998	7.87	NO	7.87	7.87	NO	NO	NO	NO	NO	NO	7.87
1999	7.87	NO	7.87	7.87	NO	NO	NO	NO	NO	NO	7.87
2000	7.87	NO	7.87	7.87	NO	NO	NO	NO	NO	NO	7.87
2001	7.87	NO	7.87	7.87	NO	NO	NO	NO	NO	NO	7.87
2002	7.87	NO	7.87	7.87	NO	NO	NO	NO	NO	NO	7.87
2003	7.87	NO	7.87	7.87	NO	NO	NO	NO	NO	NO	7.87
2004	7.87	NO	7.87	7.87	NO	NO	NO	NO	NO	NO	7.87
2005	7.87	NO	7.87	7.87	NO	NO	NO	NO	NO	NO	7.87
2006	7.87	NO	7.87	7.87	NO	NO	NO	NO	NO	NO	7.87
2007	1.92	NO	1.92	1.92	NO	NO	NO	NO	NO	NO	1.92
2008	1.92	NO	1.92	1.92	NO	NO	NO	NO	NO	NO	1.92
2009	1.92	NO	1.92	1.92	NO	NO	NO	NO	NO	NO	1.92
2010	1.92	NO	1.92	1.92	NO	NO	NO	NO	NO	NO	1.92
2011	1.92	NO	1.92	1.92	NO	NO	NO	NO	NO	NO	1.92

Code	4F	4F	4F1	4F2	4F21	4F22	4F23	4F24	4F25	4(III)F21	4(IV)F21
Category name	Total Other land	Total Other land	Other land remaining Other land	Land converted to Other land	Forest Land converted to Other land	Cropland converted to Other land	Grassland converted to Other land	Wetlands converted to Other land	Settlements converted to Other land	Forest Land converted to Other land	Forest Land converted to Other land
Unit	kt CO2eq	kt CO2								kt N2O	
2012	1.92	NO	1.92	1.92	NO	NO	NO	NO	NO	NO	1.92
2013	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2014	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2015	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2016	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2017	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2018	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2019	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2020	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2021	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Trend											
1990 - 2021	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2005 - 2021	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2020 - 2021	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

6.7.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

As described in chapter 6.1.2.1, to calculate the annual total areas for Cropland, Grassland, Wetlands, Settlements and Other land, the respective 1970-2021 time series was constructed starting with 2018. Subtracting the 2018 total Forest land area from the total official area of Montenegro yielded a 2018 total non-forest area that was subsequently distributed between Cropland, Grassland, Wetlands, Settlements and Other land according to the respective area contributions to non-forest land (in percent) as derived from the 2018 CLC status layer. The annual areas for 2017 back to 1970 were then subsequently calculated by successively subtracting the respective annual net land use changes to the corresponding categories. For instance, Other land total areas for 2017 back to 1970 were calculated by successively subtracting the annual net land use change to Other land (annual total CLC land use changes to Other land minus the annual total CLC land use changes from Other land to the other land use categories). For the years 2019-2021, the same extrapolation principle was applied. As no new CLC land use changes are available, the yearly LUCs from CLC change layer 2012/2018 were extrapolated and used to calculate the respective land use and land-use change areas in 2019 - 2021, again using the 2018 areas as the starting reference.

6.7.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

As described in chapter 6.1.2.1, for the purpose of the LULUCF Inventory national experts assigned specific CLC classes to the IPCC category Other land (**Error! Reference source not found.**).

6.7.4 Methodological issues

6.7.4.1 Other land remaining other land (4.F.1)

Consistent with the 2006 IPCC Guidelines (Vol 4, Chapter 9), no GHG emissions/removals are estimated for Other land remaining other land.

6.7.4.2 Land use changes to other land (4.F.2)

Biomass

On conversion to Other land, the biomass C stock of the previous land use category is assumed to be lost in year of the conversion (Table 395). Since 1990, only conversions from Forest land to other land have occurred. Biomass stock losses for Forest land are explained in the previous chapters.

Table 395: Gross biomass carbon losses following land conversion to Other land

Conversion	Biomass C loss in year of conversion to Other land (i.e. biomass C stock of previous land use) [t C ha]
Forest land to Other land	77.665
Annual Cropland to Other land	NO
Perennial Cropland to Other land	NO
Grassland to Other land	NO
Wetlands to Other land	NO
Settlements to Other land	NO

After the initial gross biomass C loss following conversion, subsequent gains in Other land biomass C are not estimated.

Deadwood

Changes in the dead wood carbon stock only occur for Forest lands converted to Other land. On conversion from Forest land to other land uses, it is assumed that this C stock (1.938 t C ha^{-1}, see previous chapters) is lost in the year of the conversion.

Litter and soil

For conversions from Forest land to Other land, it is assumed that litter C (average forest litter C stock of 18.38 t C ha calculated from default IPCC litter C stocks for coniferous and deciduous forests and weighted by relative contributions of coniferous and deciduous forests to the total forest area) is lost in the year of the land conversion. It is considered that subsequent gains in litter C do not occur.

As previously described in the subchapter *Land conversion to Forest land,* a soil C stock estimate for Other land was not estimated due to a lack of reliable soil data for these lands (Table 377). As such, changes in soil C stocks following conversion from Forest land to Other land are not estimated.

6.7.5 Recalculations

The following table presents the main revisions and recalculations done since the last submission and relevant to IPCC category 4.F *Other Land*.

Table 396 Recalculations done in IPCC category 4.F Other Land.

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
4.F.	No recalculations were performed.	AD	Accuracy

6.8 Harvested Wood Products (Category 4.G)

6.8.1 Category description

The Harvest Wood Products (HWPs) contribute quite significantly to the overall LULUCF GHG balance. HWP is the second most important category in the GHG inventory of Montenegro after Forest Land. In 2021, HWPs contributed net removals of -12.69 kt CO_2 which is a quarter of 1990. Over the reporting period, the HWP category showed a noteworthy variability. The sink capacity peaked 2017, declined rapidly and constitutes a of -68.4% increased sink in comparison to 1990.

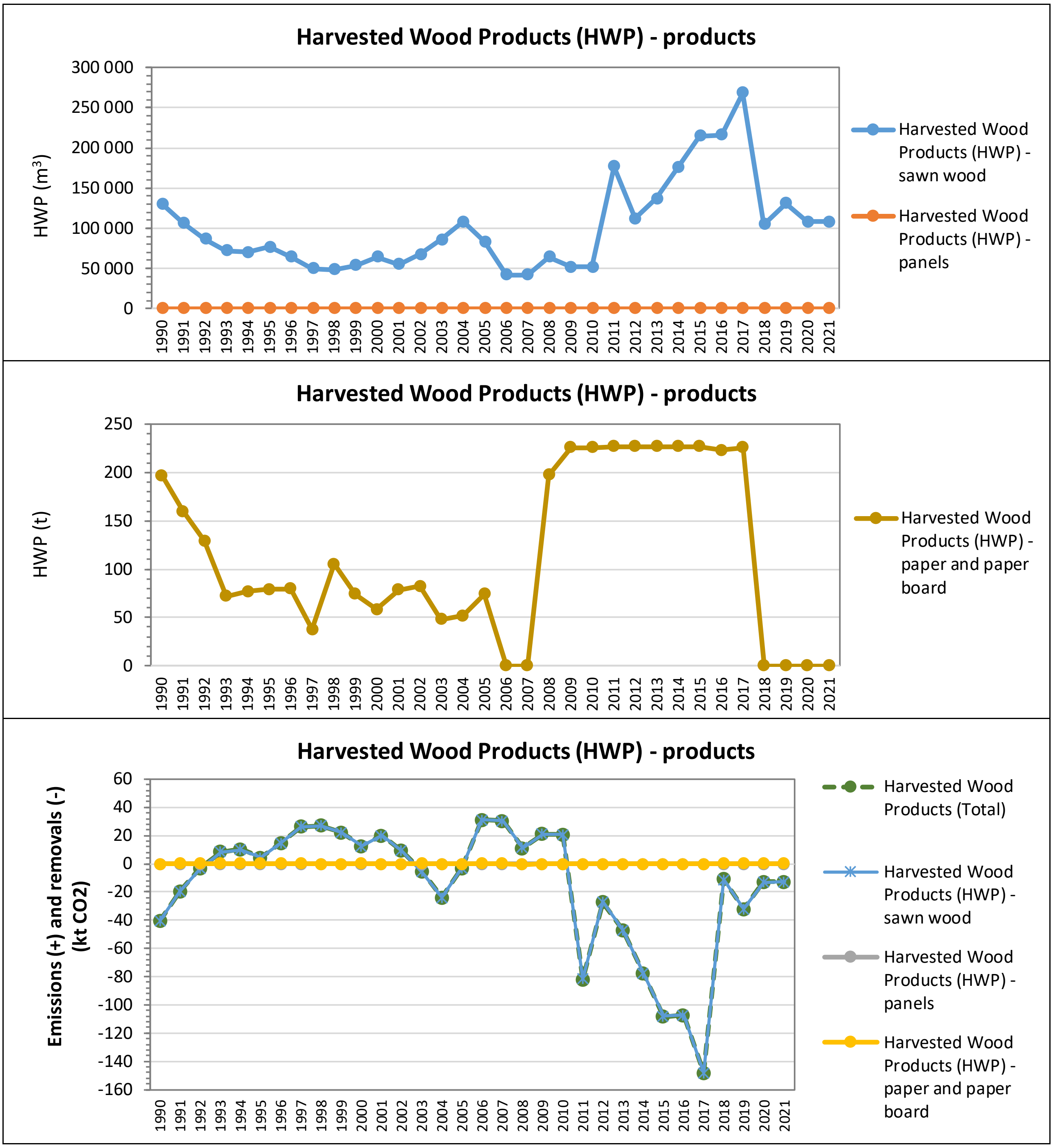


Figure 168 **Emissions/removals from HWPs and well harvested wood products**

Table 397 Harvested Wood Products: Net emissions/removals and domestic production of sawn wood, wood panels and paper/paper board as calculated from production and trade data from the FAO Stat database

	4G	4Gi	4Gii	4Giii	4G1	4G2	4G3
	Harvested Wood Products	HWP - sawn wood	HWP - panels	HWP - paper and paper board	HWP - sawn wood	HWP - panels	HWP - paper and paper board
	kt CO2				m³		t
1990	-40.22	-40.23	NO	0.02	130 228.10	NO	197.03
1991	-19.57	-19.64	NO	0.06	105 978.17	NO	159.59
1992	-3.24	-3.33	NO	0.09	86 485.21	NO	129.25
1993	8.52	8.38	NO	0.14	72 230.56	NO	71.75
1994	10.15	10.06	NO	0.09	69 974.05	NO	76.98
1995	4.47	4.41	NO	0.06	76 649.82	NO	78.84
1996	14.82	14.77	NO	0.04	63 857.40	NO	79.71
1997	26.28	26.19	NO	0.09	49 522.02	NO	37.64
1998	26.84	26.87	NO	-0.03	48 063.13	NO	105.18
1999	22.08	22.05	NO	0.02	53 316.23	NO	74.07
2000	12.60	12.56	NO	0.04	64 410.14	NO	58.19
2001	19.97	19.97	NO	0.00	55 030.98	NO	78.19
2002	9.28	9.28	NO	-0.01	67 641.57	NO	82.15
2003	-5.53	-5.57	NO	0.04	85 600.28	NO	47.84
2004	-23.82	-23.85	NO	0.03	108 108.96	NO	51.48
2005	-3.13	-3.11	NO	-0.01	83 299.72	NO	74.05
2006	31.07	30.98	NO	0.09	41 636.30	NO	NO
2007	30.44	30.37	NO	0.07	41 636.30	NO	NO
2008	11.02	11.25	NO	-0.23	64 315.79	NO	197.82
2009	21.02	21.22	NO	-0.20	51 836.27	NO	226.07
2010	20.67	20.81	NO	-0.14	51 836.27	NO	226.07
2011	-81.94	-81.84	NO	-0.10	176 998.80	NO	227.00
2012	-27.20	-27.12	NO	-0.07	111 979.19	NO	226.96
2013	-47.05	-47.00	NO	-0.05	136 966.43	NO	226.94
2014	-77.97	-77.93	NO	-0.04	175 957.63	NO	226.95
2015	-108.28	-108.26	NO	-0.03	214 948.25	NO	226.95
2016	-107.44	-107.42	NO	-0.01	216 526.96	NO	223.42
2017	-148.16	-148.15	NO	-0.01	268 959.52	NO	226.13
2018	-11.00	-11.31	NO	0.31	105 001.17	NO	NO
2019	-32.04	-32.25	NO	0.22	130 912.57	NO	NO
2020	-12.90	-13.06	NO	0.15	108 187.30	NO	NO
2021	-12.69	-12.80	NO	0.11	108 187.30	NO	NO
Trend							
1990 - 2021	-68.4%	-68.2%	NA	537.6%	-16.9%	NA	NA
2005 - 2021	305.8%	311.0%	NA	-903.8%	29.9%	NA	NA
2020 - 2021	-1.6%	-2.0%	NA	-29.3%	0.0%	NA	NA

Asdfsadf

6.8.2 Methodological issues

Emissions/removals from HWPs are based on calculation of the stocks derived from domestic harvest by applying the production approach (or approach B) of the 2006 IPCC Guidelines. Production data have been derived from the FAO Stat database on forestry production and trade statistics. For Montenegro data is available only from 2006 to 2021. The rest of the time series from 1961-2005 was gap-filled in two steps:

- 1992-2005: The FAO Stat database provides a dataset aggregated for Montenegro and Serbia from 1992 to 2005. As a first step the share of Montenegro's production and trade of this aggregate was calculated for the sum of Serbia and Montenegro for the period 2005 to 2018 for each product type. In the second step this average share of Montenegro's production and trade of the period 2005 to 2018 was applied to the aggregated figures for Montenegro and Serbia for the time series 1992-2005.
- 1961-1991: For this period the FAO Stat database provides data for Former Yugoslavia. The annual change rates were calculated for this time series and an average was calculated for the period 1961 – 1989. If available, for the years 1989-1991 the annual changes were considered to reflect the impacts of the breakup of Former Yugoslavia which can be clearly seen in the data for these years. Based on these change rates the time series for Montenegro was counted back starting with the year 1992.

For plywood production there is a single value occurring for 2008 in the FAO Stat database. It was assumed that this is an error and the value has been deleted.

As the original FAO production data does not differentiate the product categories between wood originating from domestic and imported harvest, the share for the domestic harvest needs to be obtained (equation 2.8.1 of chapter 2 of the IPCC (2014) KP supplement):

$$f_{IRW,i} = \frac{IRW_{p,i} - IRW_{ex,i}}{IRW_{p,i} + IRW_{im,i} - IRW_{ex,i}}$$

Where:

$f_{IRW,\,I}$ = share of wood from domestic harvest for year i, dimensionless

$IRW_{p,i}$ = Industrial roundwood production (wood in the rough) for year i, $m^3\ a^{-1}$

$IRW_{ex,\,i}$ = Industrial roundwood – export quantity for year i, $m^3\ a^{-1}$

$IRW_{im,\,i}$ = Industrial roundwood – import quantity for year i, $m^3\ a^{-1}$

The original FAO production data for the diverse wood products are then multiplied by the $f_{IRW,I}$ factor and aggregated to derive the production data on basis of domestic harvest presented in the Table above. It should be noted that there is no data available for pulp production in the FAO Stat database, therefore only the factor $f_{IRW,I}$ has been taken to estimate the paper production based on domestic harvest. For calculating the annual carbon stock inflow associated with the domestically produced wood products, the derived data are multiplied by the respective default C conversion factors in kt C m^{-3} or kt C t dm^{-1} from the IPCC 2006 Guidelines, Vol. 4, chapter 12, Table 12.4.

The production approach requires a time series of C stock in domestically produced wood starting with year 1990 in order to reflect current emissions from HWPs which were harvested many decades ago. As the FAO statistics start from 1961, the annual carbon stock inflow from domestic wood production needs to be extrapolated backwards to obtain a full time series from the 1990 onwards.

This is done by applying equation 12.6 of Vol. 4, chapter 12 of the 2006 IPCC Guidelines separately to the sawn wood, wood panels and paper time series:

$$inflow_t = inflow_{1961} * e^{[U*(t-1961)]}$$

Where

$inflow_t$ = annual C inflow from production on basis of domestic harvest of aggregated sawn wood, wood panels, or paper for year t (pre 1961), kt C yr^{-1}

t = year (pre 1961)

$inflow_{1961}$ = annual C inflow from production on basis of domestic harvest of aggregated sawn wood, wood panels, or paper for the year 1961, kt C yr^{-1}

U = estimated continuous rate of change in industrial roundwood consumption for the region that includes the reporting country between 1900 and 1961 (Table 12.3 of Vol 4, chapter 12 of the 2006 IPCC Guidelines), 0.0151

For each of the three wood product categories, an associated annual total C stock is calculated by starting in 1900, and applying the equation below (equation 12.1 of Vol 4, chapter 12 of the IPCC 2006 Guidelines) to each subsequent year up to the present:

$$C_i = e^{-k} * C_{i-1} + \left[\frac{\left(1-e^{-k}\right)}{k}\right] * inflow_i$$

Where:

C_i = the carbon stock of the HWP pool for the year i, kt C

Ci-1 = the carbon stock of the HWP pool for the previous year i, kt C

k = decay constant of first-order decay given in units, yr-1 (k = ln(2)/HL, where HL is half-life of the HWP pool in years. Default half-lives are used for sawn wood, wood panels and paper according to Table 2.8.2 of the KP supplement.

Finally, emissions/removals from the HWPs for a given year are calculated from the annual carbon stock change in the HWP pool ($\Delta C_i = C_i - C_{i-1}$).

6.8.3 Recalculations

The following table presents the main revisions and recalculations done since the last submission and relevant to IPCC category 4.G *Harvest Wood Products (HWPs)*.

Table 398 Recalculations done in IPCC category 4.G Harvest Wood Products (HWPs) Wetlands.

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
4.D.	Due to an update of FAO data since the last submission in 2021, reported emissions concerning the HWP category changed for the time series 2017-2020.	AD	Accuracy

7 Waste (IPCC sector 5)

7.1 Overview of sector

This chapter includes information on and description of methodologies used for estimating GHG emissions, as well as references to activity data and emission factors reported under IPCC Sector *5 – Waste* for the period 1990 to 2021. In the Waste sector emissions of CO_2, CH_4 and N_2O originate from the IPCC categories:

- 5.A *Solid waste disposal*,
- 5.B *Biological treatment of solid waste*,
- 5.C *Incineration and open burning of waste*,
- 5.D *Wastewater treatment and discharge*.

7.1.1 Emission trends

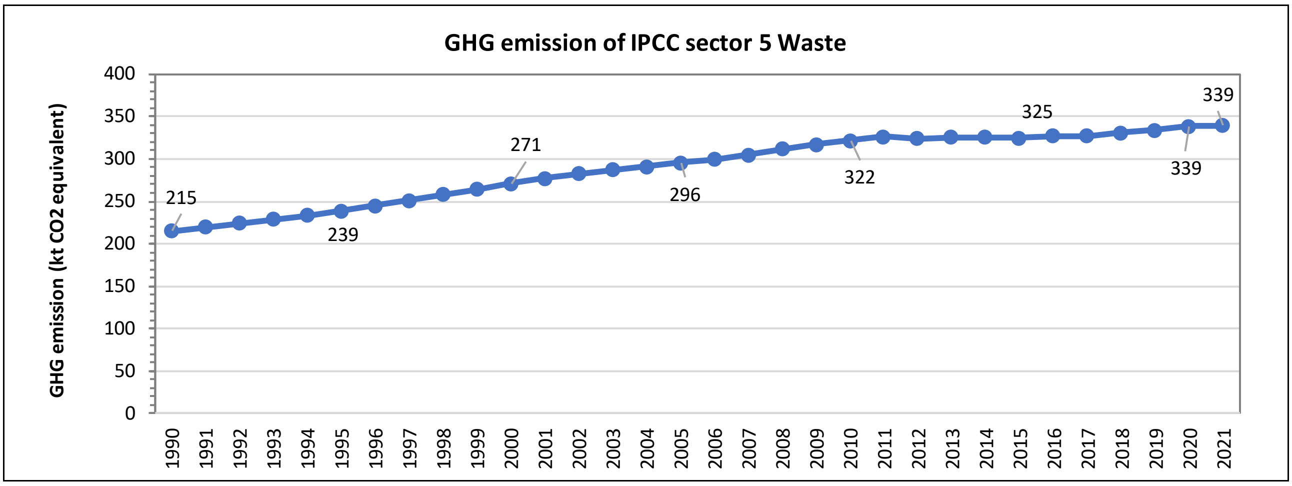


Figure 169 Trend of GHG emission of IPCC sector 5 Waste for the period 1990 – 2021

In **2021**, GHG emissions from IPCC sector 5 *Waste* amounted to 339.34 kt CO_2 equivalent, which correspond to 9.9% of total national emissions. In the period 1990 to 2021 GHG emissions from the IPCC sector 5 *Waste* increased by 57.7% from 215.12 kt CO_2 eq in 1990 due to increasing landfilling activities (IPCC category 5.A *Solid waste disposal*) as a result of increasing population and growing waste generation rates. Also, the reduction of illegal disposal (sites) or open burning results in increasing landfilling. In the same period GHG emissions from the IPCC category 5.D *Wastewater treatment and discharge* increased slightly due to increasing number of population connected to sewage systems and waste water treatment plants (WWTPs) and due to growing population and higher protein consumption per capita.

The most important categories of *Waste* is *solid waste disposal* followed by *wastewater treatment and discharge*. The most important greenhouse gas is CH_4.

Emissions from the categories 5.B *Biological Treatment of Solid Waste* and 5.C *Incineration and Open Burning of Waste* were not estimated due to lack of data.

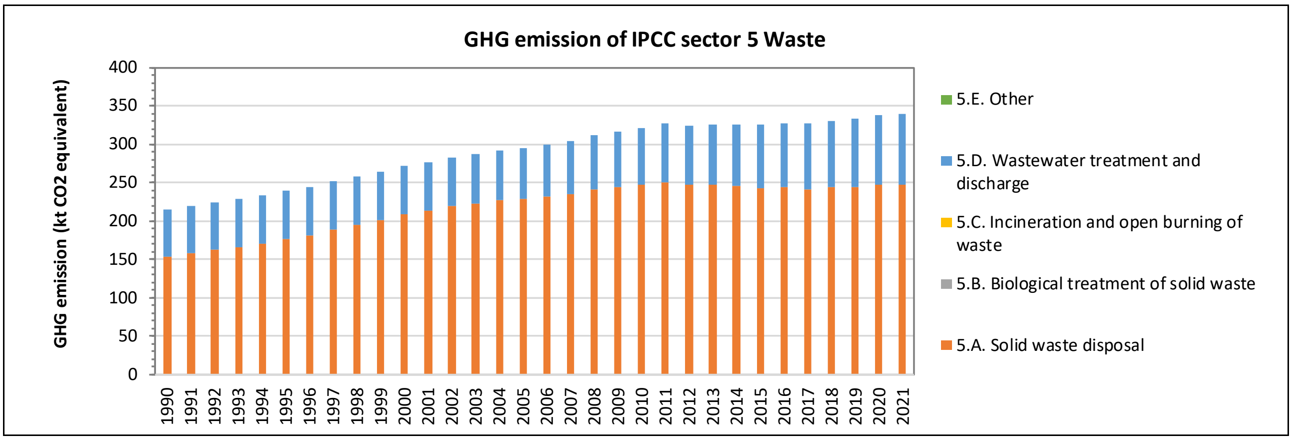


Figure 170 Trend of GHG emission of IPCC sector 5 Waste by category for the period 1990 – 2021

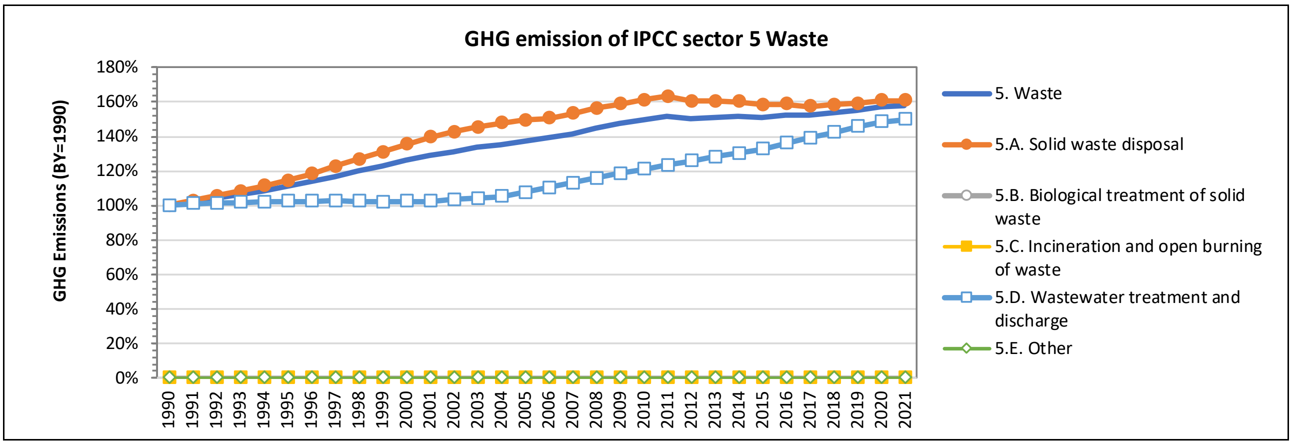


Figure 171 Trend of emissions from IPCC sector 5 waste in index form (base year = 100) by category

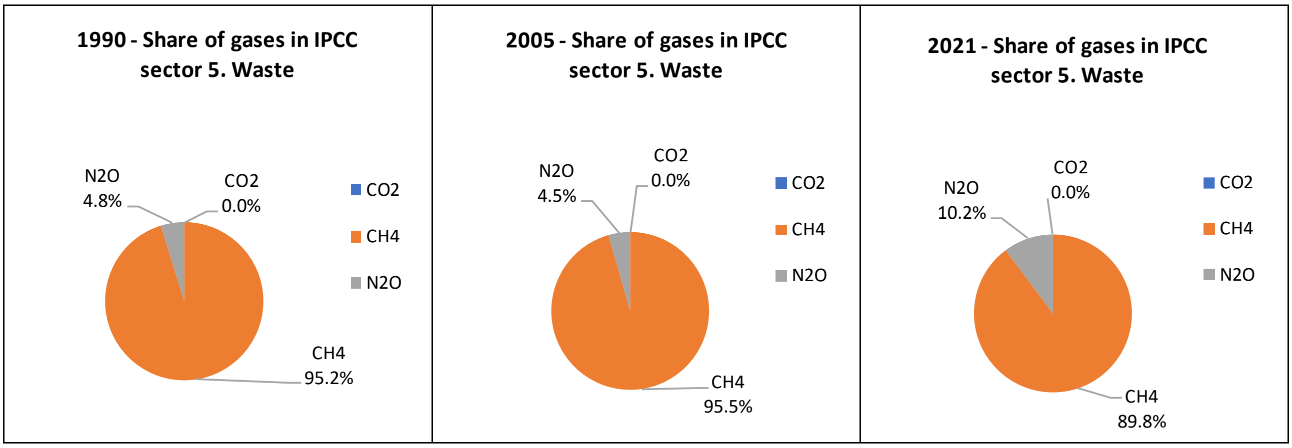


Figure 172 Share of gases in from IPCC sector 5 waste

Table 399 Emissions from IPCC sector 5 Waste by gas

GHG emissions	TOTAL GHG	CO_2	CH_4	N_2O
	kt CO_2 equivalent	kt	kt	kt
1990	215.12	NE	8.19	0.034
1991	219.88	NE	8.38	0.035
1992	224.35	NE	8.55	0.035
1993	228.92	NE	8.73	0.036
1994	233.56	NE	8.91	0.036
1995	238.94	NE	9.13	0.036
1996	244.90	NE	9.36	0.036
1997	251.46	NE	9.62	0.037
1998	257.73	NE	9.87	0.037
1999	264.12	NE	10.12	0.037
2000	271.13	NE	10.39	0.038
2001	277.15	NE	10.63	0.038
2002	282.73	NE	10.84	0.039
2003	287.45	NE	11.03	0.039
2004	291.38	NE	11.18	0.040
2005	295.52	NE	11.29	0.044
2006	299.24	NE	11.39	0.049
2007	304.69	NE	11.55	0.053
2008	311.68	NE	11.78	0.058
2009	316.90	NE	11.93	0.063
2010	321.72	NE	12.07	0.067
2011	326.54	NE	12.21	0.072
2012	324.05	NE	12.05	0.076
2013	325.49	NE	12.05	0.081
2014	325.99	NE	12.02	0.086
2015	325.05	NE	11.93	0.090
2016	327.52	NE	11.97	0.095
2017	327.45	NE	11.92	0.099
2018	331.08	NE	12.01	0.104
2019	334.01	NE	12.07	0.108
2020	338.55	NE	12.20	0.112
2021	339.34	NE	12.19	0.116
Trend				
1990 - 2021	*57.7%*	*NA*	*48.7%*	*237.5%*
2005 - 2021	*14.8%*	*NA*	*7.9%*	*162.7%*
2020 - 2021	*0.2%*	*NA*	*-0.1%*	*3.5%*

Table 400 Total GHG Emissions from IPCC sector Waste for the period 1990 - 2021

GHG emissions	5 TOTAL Waste	5.A Solid Waste Disposal	5.B Biological Treatment of Solid Waste	5.C Incineration and Open Burning of Waste	5.D Wastewater Treatment and Discharge
	kt CO_2 equivalent	kt CO_2 equivalent	kt CO_2 equivalent	kt CO_2 equivalent	kt CO_2 equivalent
1990	**215.12**	153.58	NE	NE	61.54
1991	**219.88**	157.71	NE	NE	62.17
1992	**224.35**	161.98	NE	NE	62.37
1993	**228.92**	166.35	NE	NE	62.57
1994	**233.56**	170.82	NE	NE	62.74
1995	**238.94**	176.00	NE	NE	62.94
1996	**244.90**	181.80	NE	NE	63.10
1997	**251.46**	188.17	NE	NE	63.29
1998	**257.73**	194.69	NE	NE	63.04
1999	**264.12**	201.36	NE	NE	62.75
2000	**271.13**	208.18	NE	NE	62.95
2001	**277.15**	214.08	NE	NE	63.07
2002	**282.73**	219.09	NE	NE	63.64
2003	**287.45**	223.32	NE	NE	64.13
2004	**291.38**	226.77	NE	NE	64.61
2005	**295.52**	229.39	NE	NE	66.13
2006	**299.24**	231.39	NE	NE	67.85
2007	**304.69**	235.18	NE	NE	69.51
2008	**311.68**	240.43	NE	NE	71.25
2009	**316.90**	244.03	NE	NE	72.87
2010	**321.72**	247.35	NE	NE	74.38
2011	**326.54**	250.70	NE	NE	75.84
2012	**324.05**	246.73	NE	NE	77.32
2013	**325.49**	246.69	NE	NE	78.81
2014	**325.99**	245.73	NE	NE	80.25
2015	**325.05**	243.41	NE	NE	81.64
2016	**327.52**	243.86	NE	NE	83.66
2017	**327.45**	241.80	NE	NE	85.66
2018	**331.08**	243.44	NE	NE	87.63
2019	**334.01**	244.42	NE	NE	89.59
2020	**338.55**	247.13	NE	NE	91.42
2021	**339.34**	247.03	NE	NE	92.31
Trend					
1990 - 2021	57.7%	*60.9%*	*NA*	*NA*	*50.0%*
2005 - 2021	14.8%	*7.7%*	*NA*	*NA*	*39.6%*
2020 - 2021	0.2%	*<0.1%*	*NA*	*NA*	*1.0%*

Table 401 CH_4 Emissions from IPCC sector 5 Waste for the period 1990 - 2021

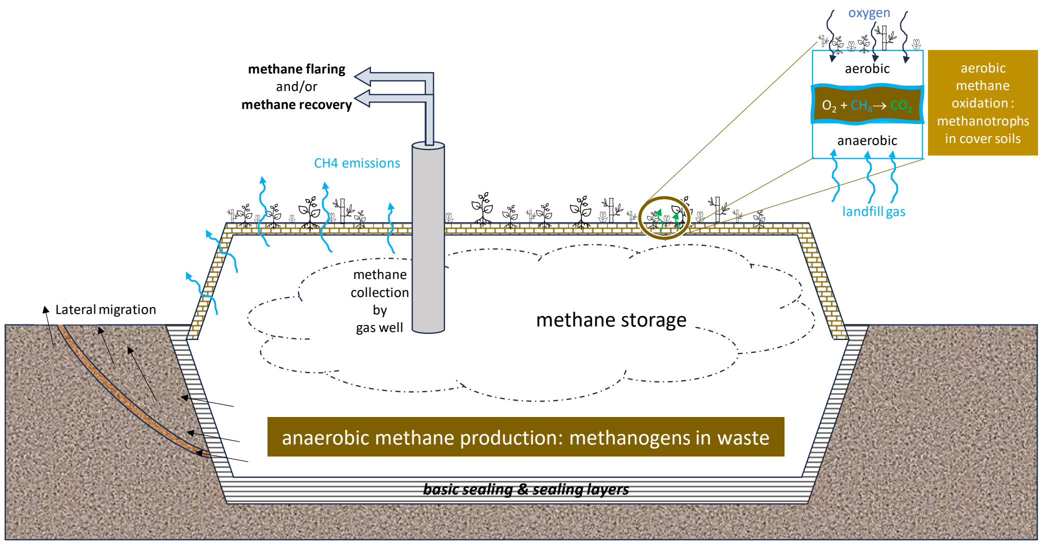
CH_4 emissions	5 TOTAL Waste	5.A Solid Waste Disposal	5.B Biological Treatment of Solid Waste	5.C Incineration and Open Burning of Waste	5.D Wastewater Treatment and Discharge
	kt CO_2 equivalent	kt CO_2 equivalent	kt CO_2 equivalent	kt CO_2 equivalent	kt CO_2 equivalent
1990	**8.19**	6.14	NE	NE	2.05
1991	**8.38**	6.31	NE	NE	2.07
1992	**8.55**	6.48	NE	NE	2.07
1993	**8.73**	6.65	NE	NE	2.08
1994	**8.91**	6.83	NE	NE	2.08
1995	**9.13**	7.04	NE	NE	2.09
1996	**9.36**	7.27	NE	NE	2.09
1997	**9.62**	7.53	NE	NE	2.09
1998	**9.87**	7.79	NE	NE	2.08
1999	**10.12**	8.05	NE	NE	2.07
2000	**10.39**	8.33	NE	NE	2.07
2001	**10.63**	8.56	NE	NE	2.07
2002	**10.84**	8.76	NE	NE	2.08
2003	**11.03**	8.93	NE	NE	2.10
2004	**11.18**	9.07	NE	NE	2.11
2005	**11.29**	9.18	NE	NE	2.12
2006	**11.39**	9.26	NE	NE	2.13
2007	**11.55**	9.41	NE	NE	2.14
2008	**11.78**	9.62	NE	NE	2.16
2009	**11.93**	9.76	NE	NE	2.17
2010	**12.07**	9.89	NE	NE	2.17
2011	**12.21**	10.03	NE	NE	2.18
2012	**12.05**	9.87	NE	NE	2.18
2013	**12.05**	9.87	NE	NE	2.19
2014	**12.02**	9.83	NE	NE	2.19
2015	**11.93**	9.74	NE	NE	2.19
2016	**11.97**	9.75	NE	NE	2.22
2017	**11.92**	9.67	NE	NE	2.24
2018	**12.01**	9.74	NE	NE	2.27
2019	**12.07**	9.78	NE	NE	2.29
2020	**12.20**	9.89	NE	NE	2.32
2021	**12.19**	9.88	NE	NE	2.31
Trend					
1990 - 2021	***48.7%***	*60.9%*	*NA*	*NA*	*12.4%*
2005 - 2021	***7.9%***	*7.7%*	*NA*	*NA*	*8.9%*
2020 - 2021	***-0.1%***	*0.0%*	*NA*	*NA*	*-0.5%*

Table 402 Total N_2O Emissions from IPCC sector Waste for the period 1990 - 2021

N_2O emissions	5 TOTAL Waste	5.A Solid Waste Disposal	5.B Biological Treatment of Solid Waste	5.C Incineration and Open Burning of Waste	5.D Wastewater Treatment and Discharge
	kt	kt	kt	kt	kt
1990	**0.034**	NA	NE	NE	0.034
1991	**0.035**	NA	NE	NE	0.035
1992	**0.035**	NA	NE	NE	0.035
1993	**0.036**	NA	NE	NE	0.036
1994	**0.036**	NA	NE	NE	0.036
1995	**0.036**	NA	NE	NE	0.036
1996	**0.036**	NA	NE	NE	0.036
1997	**0.037**	NA	NE	NE	0.037
1998	**0.037**	NA	NE	NE	0.037
1999	**0.037**	NA	NE	NE	0.037
2000	**0.038**	NA	NE	NE	0.038
2001	**0.038**	NA	NE	NE	0.038
2002	**0.039**	NA	NE	NE	0.039
2003	**0.039**	NA	NE	NE	0.039
2004	**0.040**	NA	NE	NE	0.040
2005	**0.044**	NA	NE	NE	0.044
2006	**0.049**	NA	NE	NE	0.049
2007	**0.053**	NA	NE	NE	0.053
2008	**0.058**	NA	NE	NE	0.058
2009	**0.063**	NA	NE	NE	0.063
2010	**0.067**	NA	NE	NE	0.067
2011	**0.072**	NA	NE	NE	0.072
2012	**0.076**	NA	NE	NE	0.076
2013	**0.081**	NA	NE	NE	0.081
2014	**0.086**	NA	NE	NE	0.086
2015	**0.090**	NA	NE	NE	0.090
2016	**0.095**	NA	NE	NE	0.095
2017	**0.099**	NA	NE	NE	0.099
2018	**0.104**	NA	NE	NE	0.104
2019	**0.108**	NA	NE	NE	0.108
2020	**0.112**	NA	NE	NE	0.112
2021	**0.116**	NA	NE	NE	0.116
Trend					
1990 - 2021	*237.5%*	*NA*	*NA*	*NA*	*237.5%*
2005 - 2021	*162.7%*	*NA*	*NA*	*NA*	*162.7%*
2020 - 2021	*3.5%*	*NA*	*NA*	*NA*	*3.5%*

7.2 Solid Waste Disposal (IPCC category 5.A)

Methane gas is a by-product of landfilling municipal solid wastes (MSW). It is produced via methanogens mainly under anaerobic conditions. Most of the global MSW is dumped in non-managed landfills and the generated methane is emitted to the atmosphere. Some of the modern managed landfills attempt to capture and utilize landfill “bio”-gas, a renewable energy source, to generate electricity or heat.



simplified landfill methane mass balance

Methane (CH_4) produced (mass/time) = Σ(CH_4 collected (flared and/or recovered) + CH_4 emitted + CH_4 oxidized

Figure 173 Simplified landfill methane mass

The following section describes GHG emissions resulting from solid waste disposal on land. According to 2006 IPCC Guidelines, the solid waste disposal sites (SWDS) can be divided into five groups.

⇒ **5.A.1 Managed Waste Disposal Sites**

Anaerobic managed solid waste disposal sites must have controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) levelling of the waste.

Semi-aerobic managed solid waste disposal sites must have controlled placement of waste and will include all of the following structures for introducing air to waste layer: (i) permeable cover material; (ii) leachate drainage system; (iii) regulating pondage; and (iv) gas ventilation system.

⇒ **5.A.2 Unmanaged Waste Disposal Sites**

Unmanaged solid waste disposal sites – deep and/or with high water table are all SWDS not meeting the criteria of managed SWDS and which have depths of greater than or equal to 5 *meters* and/or high-water table at near ground level. Latter situation corresponds to filling inland water, such as pond, river or wetland, by waste.

Unmanaged shallow solid waste disposal sites are all SWDS not meeting the criteria of managed SWDS *and* which have depths of less than 5 meters.

⇒ **5.A.3 Uncategorized Waste Disposal Sites**

Uncategorised solid waste disposal sites are those SWDS where countries cannot categorize their landfills into above four categories of managed and unmanaged SWDS.

*The 2006 IPCC Guidelines present the **basic concept of First Order Decay (FOD)** as "…..The basis for the calculation is the amount of **Decomposable Degradable Organic Carbon (DDOCm)** as defined in Equation 3.2.*

$$DDOCm = W \times DOC \times DOC_f \times MCF$$

DDOCm is the part of the organic carbon that will degrade under the anaerobic conditions in SWDS. It is used in the equations and spreadsheet models as DDOCm. The index m is used for mass.

*DDOCm equals the product of the **waste amount (W)**, the **fraction of degradable organic carbon (DOC)** in the waste, the **fraction of the degradable organic carbon that decomposes (DOCf),** and the part of the waste that will decompose under aerobic conditions (prior to the conditions becoming anaerobic) in the SWDS, which is interpreted with the **methane correction factor (MCF)**…..". The parameter that is related to aerobic condition is expressed in terms of MCF.* [137]

The methodology used to estimate emissions from waste management activities requires country- specific knowledge on waste generation, composition and management practice. The main parameters that influence the estimation of the emissions from landfills, apart from the amount of the disposed waste, is the waste composition.

These parameters are strictly dependent on the waste management policies throughout the waste streams which start from waste generation through collection and transportation, separation for resource recovery, recycling and energy recovery and terminate at landfill sites. Improvements of quality and quantity of data is needed. However, it with the available information and expert judgement it was possible to evaluate and compile data coming from different sources and adjust them to recommended IPCC methodology which is used for GHGs emissions estimation. Currently country specific data was used where they are available. Default values were used when country specific data were not available.

[137] Source: 2006 IPCC Guidelines, Volume 5: Waste, Chapter 3: Solid Waste Disposal - 3.2.1.1 FIRST ORDER DECAY (FOD)

7.2.1 Source category description

GHG emissions/ removals	**CO_2**		**CH_4**		**N_2O**	
Estimated	**Estimated**	**Key category**	**Estimated**	**Key category**	**Estimated**	**Key category**
5.A.1 Managed Waste Disposal Sites	NA	-	✓	LA 1990 LA 2021	NA	-
5.A.2 Unmanaged Waste Disposal Sites	NA	-	✓		NA	-
5.A.3 Uncategorized Waste Disposal Sites	NA	-	✓		NA	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential						
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF						

An overview of the GHG emissions from IPCC category 5.A *Solid Waste Disposal* is provided in the following figure and table.

In 2021, the CH_4 emissions IPCC category 5.A *Solid Waste Disposal* amounted to 238.94 kt CO_2 equivalent and in the period 1990 – 2021 the CH_4 emissions increased by 55.6%. In the period 2005 – 2021 the CH_4 emissions increased by 4.2% mainly due to increasing landfilling activities which is a result of increasing population and growing waste generation rates. Also, the reduction of illegal disposal (sites) or open burning results in increasing landfilling. However, since 2008 methane collection takes place and the methane is flared without any energy recovery.

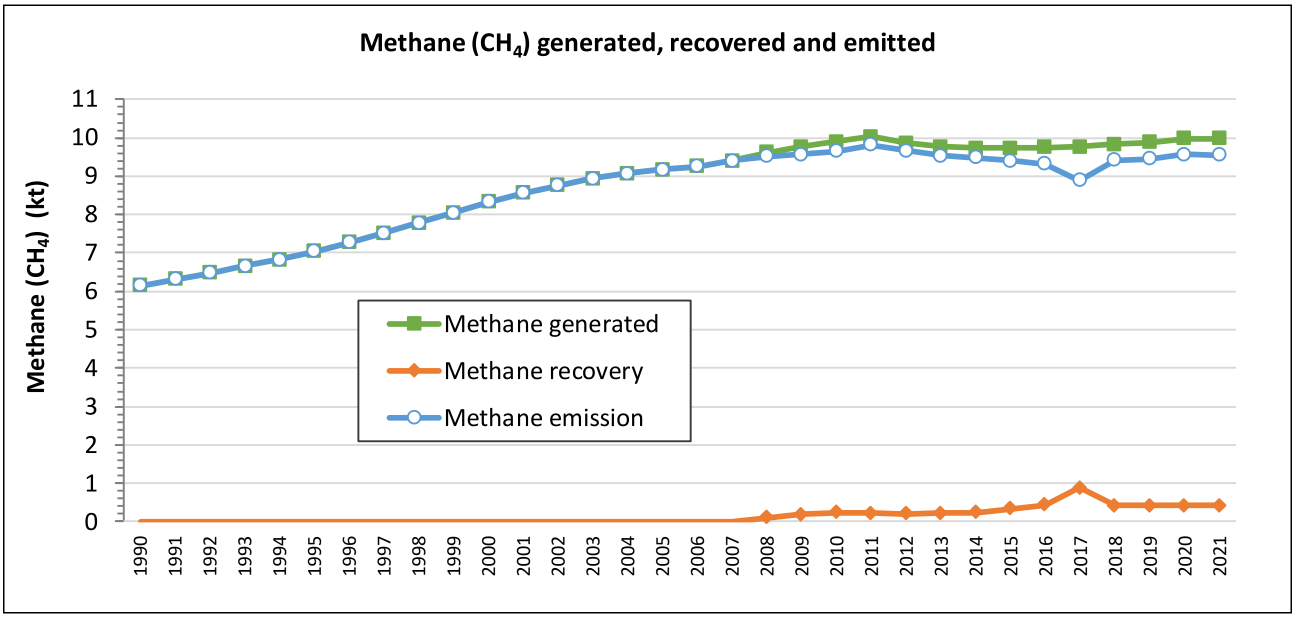


Figure 174 CH_4 emissions from IPCC category 5.A *Solid Waste Disposal* for the period 1950 - 2021

Table 403 GHG emissions from IPCC sub-category 5.A Solid Waste Disposal for the period of 1990 - 2021

	GHG emissions	CH_4			CO_2 emissions	N_2O emissions
		Generation (G)	Recovery (R)	Emissions E=(G-R)*(1-OX)		
	kt CO_2 equivalent	kt	kt	kt	kt	kt
1990	153.58	6.14	NO	6.14	NA	NA
1991	157.71	6.31	NO	6.31	NA	NA
1992	161.98	6.48	NO	6.48	NA	NA
1993	166.35	6.65	NO	6.65	NA	NA
1994	170.82	6.83	NO	6.83	NA	NA
1995	176.00	7.04	NO	7.04	NA	NA
1996	181.80	7.27	NO	7.27	NA	NA
1997	188.17	7.53	NO	7.53	NA	NA
1998	194.69	7.79	NO	7.79	NA	NA
1999	201.36	8.05	NO	8.05	NA	NA
2000	208.18	8.33	NO	8.33	NA	NA
2001	214.08	8.56	NO	8.56	NA	NA
2002	219.09	8.76	NO	8.76	NA	NA
2003	223.32	8.93	NO	8.93	NA	NA
2004	226.77	9.07	NO	9.07	NA	NA
2005	229.39	9.18	NO	9.18	NA	NA
2006	231.39	9.26	NO	9.26	NA	NA
2007	235.18	9.41	NO	9.41	NA	NA
2008	237.75	9.62	0.11	9.51	NA	NA
2009	239.16	9.76	0.20	9.57	NA	NA
2010	241.41	9.89	0.24	9.66	NA	NA
2011	245.27	10.03	0.22	9.81	NA	NA
2012	241.67	9.87	0.20	9.67	NA	NA
2013	238.53	9.77	0.23	9.54	NA	NA
2014	237.16	9.73	0.25	9.49	NA	NA
2015	235.05	9.74	0.33	9.40	NA	NA
2016	233.15	9.75	0.43	9.33	NA	NA
2017	222.22	9.77	0.88	8.89	NA	NA
2018	235.31	9.84	0.42	9.41	NA	NA
2019	236.30	9.88	0.42	9.45	NA	NA
2020	239.04	9.99	0.42	9.56	NA	NA
2021	238.94	9.98	0.42	9.56	NA	NA
Trend						
1990 - 2021	*55.6%*	*62.5%*	*NA*	*55.6%*	*NA*	*NA*
2005 – 2021	*4.2%*	*8.8%*	*NA*	*4.2%*	*NA*	*NA*
2020 - 2021	*<0.1%*	*<-0.1%*	*0.0%*	*<0.1%*	*NA*	*NA*

7.2.2 Methodological issues

7.2.2.1 Choice of methods

CH_4 Emissions from solid waste disposal on land have been calculated using the First Order Decay (FOD) method, the IPCC Tier 1 method, given in the 2006 IPCC Guidelines. The choice of a *good practice* method depends on national circumstances.

- Tier 1: The estimations of the Tier 1 methods are based on the IPCC FOD method using mainly default activity data and default parameters.
- Tier 2: Tier 2 methods use the IPCC FOD method and some default parameters but require good quality country-specific activity data on current and historical waste disposal at SWDS. Historical waste disposal data for 10 years or more should be based on country-specific statistics, surveys or other similar sources. Data are needed on amounts disposed at the SWDS.

Influencing factors of CH_4 Emissions generation and relevant data required:

- Waste amounts deposited / waste generated (starting year 1950)
- Waste treatment (collection, deposition/landfilling, composting, incineration/burning, recycling)
- Management practices at landfill sites – Methane correction factor (MCF)
- Conditions at landfill sites + Composition of waste deposited
- Organic carbon in landfill sites – degradable organic carbon (DOC)
- Methane generation rate constant (k)
- Landfill gas recovery, Oxidation
- National waste management policy

For estimating the CH_4 emissions the 2006 IPCC Guidelines Tier 1 approach[138] has been applied:

EQUATION 3.1 CH_4 emission from SWDS (2006 IPCC GL, Vol. 5, Chap.3)

$$\boldsymbol{CH_4\ Emissions} = \left[\sum \boldsymbol{CH_4\ generated_{x,T}} - \boldsymbol{R_T}\right] \times (\boldsymbol{1} - \boldsymbol{OX_T})$$

Where:

CH_4 Emissions	= CH_4 emitted in year T (Gg)
T	= inventory year
x	= waste category or type /material
R_T	= recovered CH_4 in year T (Gg)
OX_T	= oxidation factor in year T (fraction)

Methane generation: The CH_4 generation potential of the waste that is disposed in a certain year will decrease gradually throughout the following decades. In this process, the release of CH_4 from this specific amount of waste decreases gradually. The FOD model is built on an exponential factor that describes the fraction of degradable material which each year is degraded into CH_4.

The quantity of CH_4 emitted during decomposition process is directly proportional to the fraction of degradable organic carbon (DOC), which is defined as the carbon content of different types of organic biodegradable wastes such as paper and textiles, garden and park waste, food waste, wood and straw waste. The equations for estimating the CH_4 generation are given below. As the mathematics are the same

[138] Source: 2006 IPCC Guidelines, Volume 5: Waste, Chapter 3: Solid Waste Disposal - 3.2.1.1 FIRST ORDER DECAY (FOD)

for estimating the CH_4 emissions from all waste categories/waste types/materials, no indexing referring to the different categories/waste materials/types is used in the equations below.

Equation 3.2: Decomposable DOC from waste disposal data (2006 IPCC GL, Vol. 5, Chap.3)

$$DDOCm = W \times DOC \times DOC_f \times MCF$$

Where

DDOCm	= mass of decomposable DOC deposited (Gg)
W	= mass of waste deposited (Gg)
DOC	= degradable organic carbon in the year of deposition, fraction (Gg C/Gg waste)
DOC_f	= fraction of DOC that can decompose (fraction)
MCF	= CH_4 correction factor for aerobic decomposition in the year of deposition (fraction)

Although CH_4 generation potential (Lo)[2] is not used explicitly in the 2006 IPCC Guidelines, it equals the product of DDOCm, the CH_4 concentration in the gas (F) and the molecular weight ratio of CH_4 and C.

Equation 3.2: Transformation from DDOCm to L_O (2006 IPCC GL, Vol. 5, Chap.3)

$$L_o = DDOCm \times F \times \frac{16}{12}$$

Where:

Lo	= CH_4 generation potential (Gg CH_4)
DDOCm	= mass of decomposable DOC (Gg)
F	= fraction of CH_4 in generated landfill gas (volume fraction)
16/12	= molecular weight ratio CH_4/C (ratio)

FIRST ORDER DECAY BASICS

With a first order reaction, the amount of product is always proportional to the amount of reactive material. This means that the year in which the waste material was deposited in the SWDS is irrelevant to the amount of CH_4 generated each year. It is only the total mass of decomposing material currently in the site that matters.

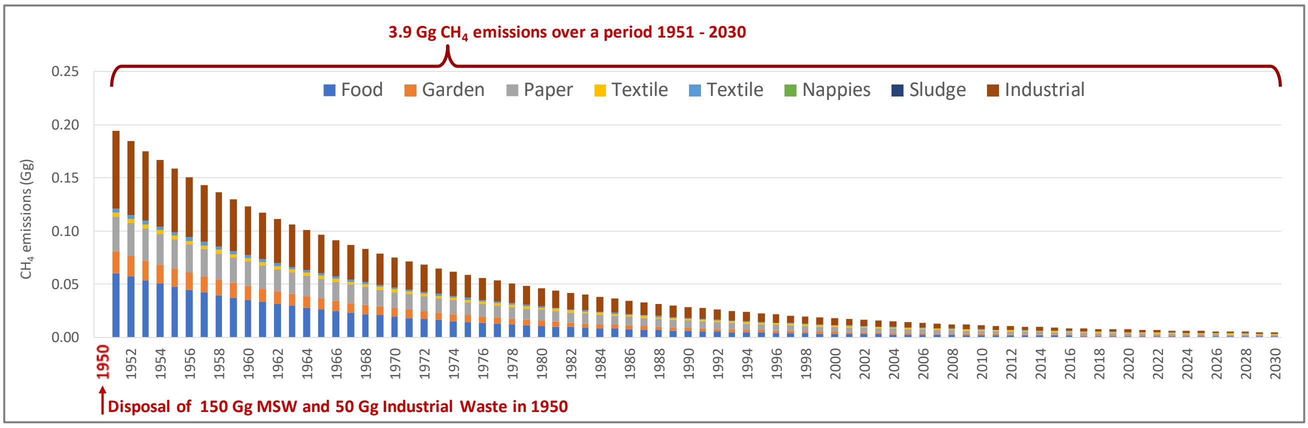


Figure 175 **CH_4 emissions from IPCC sub-category 5.A Solid Waste Disposal of the disposal of waste in 1950**

This also means that when the amount of decomposing material in the SWDS at the start of the year is known, every year can be regarded as year number 1 in the estimation method, and the **basic first order calculations** can be done by these two simple equations, with the decay reaction beginning on the 1st of January the year after deposition.

Equation 3.4: DDOCm accumulated in the SWDS at the end of year T (2006 IPCC GL, Vol. 5, Chap.3)

$$DDOCma_T = DDOCmd_T + (DDOCmd_T \times e^{-k})$$

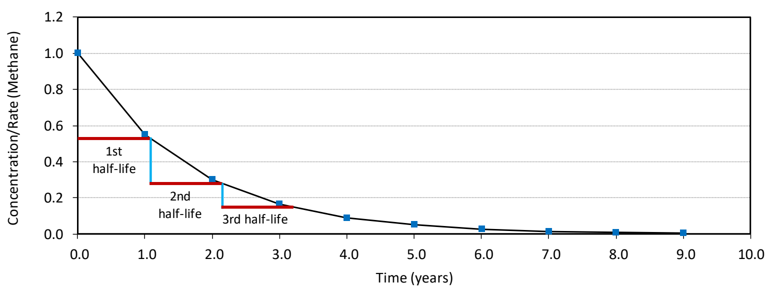
Equation 3.5: DDOCm decomposed in the SWDS at the end of year T (2006 IPCC GL, Vol. 5, Chap.3)

$$DDOCm\ decomp_T = DDOCma_{T-1} \times (1 - e^{-k})$$

Where:

T	= inventory year
DDOCmaT	= DDOCm accumulated in the SWDS at the end of year T (Gg)
DDOCmaT-1	= DDOCm accumulated in the SWDS at the end of year (T-1) (Gg)
DDOCmdT	= DDOCm deposited into the SWDS in year T (Gg)
DDOCm decompT	= DDOCm decomposed in the SWDS in year T (Gg)
k	= reaction constant,
k	= $\ln(2)/t_{1/2}$ (y-1)
$t_{1/2}$	= half-life time (y)

The half-life of a reaction, $t_{1/2}$, is the amount of time needed for a reactant concentration to decrease by half compared to its initial concentration.



In a First order reactions, the graph represents the half-life is different from zero order reaction in a way that the slope continually decreases as time progresses until it reaches zero. We can also easily see that the length of half-life will be constant, independent of concentration. For example, it takes the same amount of time for the concentration to decrease from one point to another point.

Figure 176 **First order reaction**

CH_4 GENERATED FROM DECOMPOSABLE DDOCm

The amount of CH_4 formed from decomposable material is found by multiplying the CH_4 fraction in generated landfill gas and the CH_4 /C molecular weight ratio.

Equation 3.6: CH_4 generated from decayed DDOCm (2006 IPCC GL, Vol. 5, Chap.3)

$$CH_4\ generated_T = DDOCm\ decomp_T \times F \times \frac{16}{12}$$

Where:

CH_4 $generated_T$	= amount of CH_4 generated from decomposable material
DDOCm $decomp_T$	= DDOCm decomposed in year T (Gg)
F	= fraction of CH_4, by volume, in generated landfill gas (fraction)
16/12	= molecular weight ratio CH_4/C (ratio)

7.2.2.2 Choice of activity data and emission factor

No national data on amounts of municipal waste generation and disposal were available for the years 1950 to 2019. Based on the national population and country specific waste generation rates for urban and rural population the total amount of waste which is disposed on land could be estimated.

Table 404 Municipal solid waste (MSW) landfilled on solid waste disposal sites (SWDS)

	Population	Source	Waste per capita	Source	Total Municipal Solid Waste (MSW)	Source	% to Solid Waste Disposal Sites (SWDS)	Source	Total amount of waste to SWDS
	Millions		kg/cap/yr		kt		%		kt
1948	0.377	Statistics							
1949	0.384	Inter-polations							
1950	0.394		279.3	extrapolations	110.11	Calculate based on waste generation rate	90.0%	Constant value of 1989	99.10
1951	0.403		284.1		114.42		90.0%		102.98
1952	0.411		288.8		118.81		90.0%		106.93
1953	0.420	Statistics	293.6		123.28		90.0%		110.95
1954	0.426	inter-polations	298.4		127.23		90.0%		114.51
1955	0.433		303.2		131.24		90.0%		118.12
1956	0.439		308.0		135.31		90.0%		121.78
1957	0.446		312.7		139.45		90.0%		125.50
1958	0.452		317.5		143.64		90.0%		129.28
1959	0.459		322.3		147.90		90.0%		133.11
1960	0.465		327.1		152.22		90.0%		137.00
1961	0.472	Statistics	331.9		156.60		90.0%		140.94
1962	0.478	inter-polations	336.6		160.80		90.0%		144.72
1963	0.483		341.4		165.05		90.0%		148.55
1964	0.489		346.2		169.36		90.0%		152.43
1965	0.495		351.0		173.73		90.0%		156.35
1966	0.501		355.8		178.15		90.0%		160.33
1967	0.507		360.5		182.62		90.0%		164.36
1968	0.512		365.3		187.15		90.0%	[illegible]	168.44
1969	0.518		370.1		191.73		90.0%		172.56
1970	0.524		374.9		196.37		90.0%		176.74
1971	0.530	Statistics	379.7		201.07		90.0%		180.96
1972	0.535	inter-po extrapolati ons j lations	384.4		205.70		90.0%		185.13
1973	0.541		389.2		210.39		90.0%		189.35
1974	0.546		394.0		215.13		90.0%		193.62
1975	0.551		398.8		219.92		90.0%		197.93
1976	0.557		403.6		224.77		90.0%		202.29
1977	0.562		408.3		229.66		90.0%		206.70
1978	0.568		413.1		234.61		90.0%		211.15

	Population	Source	Waste per capita	Source	Total Municipal Solid Waste (MSW)	Source	% to Solid Waste Disposal Sites (SWDS)	Source	Total amount of waste to SWDS
	Millions		kg/cap/yr		kt		%		kt
1979	0.573		417.9		239.61		90.0%		215.65
1980	0.579		422.7		244.66		90.0%		220.20
1981	0.584	Statistics	427.5		249.77		90.0%		224.79
1982	0.587		432.2		253.89		90.0%		228.50
1983	0.590		437.0		258.04		90.0%		232.24
1984	0.594		441.8	extrapolation	262.22	Calculate based on waste generation rate	90.0%	Constant value of 1989	236.00
1985	0.597	inter-polations	446.6		266.43		90.0%		239.79
1986	0.600		451.4		270.67		90.0%		243.60
1987	0.603		456.1		274.94		90.0%		247.44
1988	0.606		460.9		279.23		90.0%		251.31
1989	0.609		465.7		283.56		90.0%		255.20
1990	0.612	Statistics	470.6		287.99		83.8%		241.33
1991	0.615		475.1		292.20		83.9%		245.18
1992	0.614		480.0		294.50		84.5%		248.86
1993	0.612		484.9		296.79		85.1%		252.68
1994	0.611		502.5		306.82		85.9%		263.62
1995	0.609		520.4		316.97		86.7%		274.78
1996	0.608		538.4		327.14		87.5%		286.15
1997	0.606		549.9		333.31		88.0%		293.41
1998	0.605		561.6	MONSTAT	339.56	National Statistics Data on municipal waste. collected by public waste removal scheme including gap filling and correction	88.5%	National Statistics: Data on municipal waste. collected by public waste removal scheme including gap filling and correction	300.60
1999	0.603		573.5		345.91		89.1%		308.08
2000	0.606	MONSTAT	561.8		340.44		89.0%		302.88
2001	0.608		549.6		334.41		88.9%		297.41
2002	0.611		537.0		327.84		89.0%		291.65
2003	0.612		522.8		320.07		89.1%		285.06
2004	0.613		508.0		311.62		88.9%		277.10
2005	0.613		496.1		304.16		89.1%		271.01
2006	0.615		483.9		297.42		88.5%		263.24
2007	0.616		532.6		327.84		88.5%		290.19
2008	0.617		501.6		309.57		88.4%		273.80
2009	0.619		514.7		318.60		87.9%		280.21

	Population	Source	Waste per capita	Source	Total Municipal Solid Waste (MSW)	Source	% to Solid Waste Disposal Sites (SWDS)	Source	Total amount of waste to SWDS
	Millions		kg/cap/yr		kt		%		kt
2010	0.620	MONSTAT	516.2	MONSTAT	319.97		87.5%	Monstat. Waste statitsics (2010: opening of recycling center)	279.93
2011	0.620		524.2		325.17	MONSTAT	71.4%		232.24
2012	0.621		494.4		306.97		75.9%		232.84
2013	0.622		496.7		308.71		83.2%		256.93
2014	0.622		483.7		300.91		85.4%		256.83
2015	0.622		502.6		312.73		85.6%		267.82
2016	0.622		517.9		322.33		85.3%		274.99
2017	0.622		520.8		324.12		82.7%		268.03
2018	0.622		487.7		303.44		86.0%		260.90
2019	0.622		518.6		322.50		87.6%		282.38
2020	0.621		462.4		287.03		87.4%		250.80
2021	0.618		462.4		287.03		87.4%		250.80
Trend									
1990 - 2021	*0.9%*		*6.3%*		*7.3%*				*16.0%*
2005 - 2021	*0.7%*		*0.8%*		*1.6%*				*3.3%*
2020- 2021	*-0.5%*		*8.2%*		*7.6%*				*11.6%*

Waste composition

Waste composition is one of the main factors influencing emissions from solid waste treatment, as different waste types contain different amount of degradable organic carbon (DOC) and fossil carbon.

Waste types such as food waste, garden waste, paper and cardboard, wood, textiles, and nappies (disposable diapers) contain most of the DOC in MSW. Ash, dust, rubber and leather contain also certain amounts of non-fossil carbon, but this is hardly degradable. Some textiles, plastics (including plastics in disposable nappies), rubber and electronic waste contain the bulk part of fossil carbon in MSW. Paper (with coatings) and leather (synthetic) can also include small amounts of fossil carbon.

Table 405 Decomposition duration of different trash in the Municipal Solid Waste (MSW)

Waste	Decomposition duration	Waste	Decomposition duration
Vegetables	5 days –1 month	Leather shoes	25–40 years
Paper	2–5 months	Nylon fabric	30–40 years
Cotton T-shirt	6 months	Tin cans	50–100 years
Orange peels	6 months	Aluminium cans	80–100 years
Tree leaves	1 year	Glass bottles	1 million years
Wool socks	1–5 years	Styrofoam cup	500 years to forever
Plastic-coated paper milk cartons	5 years	Plastic bags	500 years to forever

Source: Science Learning Hub New Zealand [139]

[139] Available (23.01.2020) on https://www.sciencelearn.org.nz/resources/1543-measuring-biodegradability

For Montenegro it was possible to collect country specific data on waste composition. In the following table the IPCC default value is also provided for comparison. The country specific data on waste composition is in the range of the IPCC default.

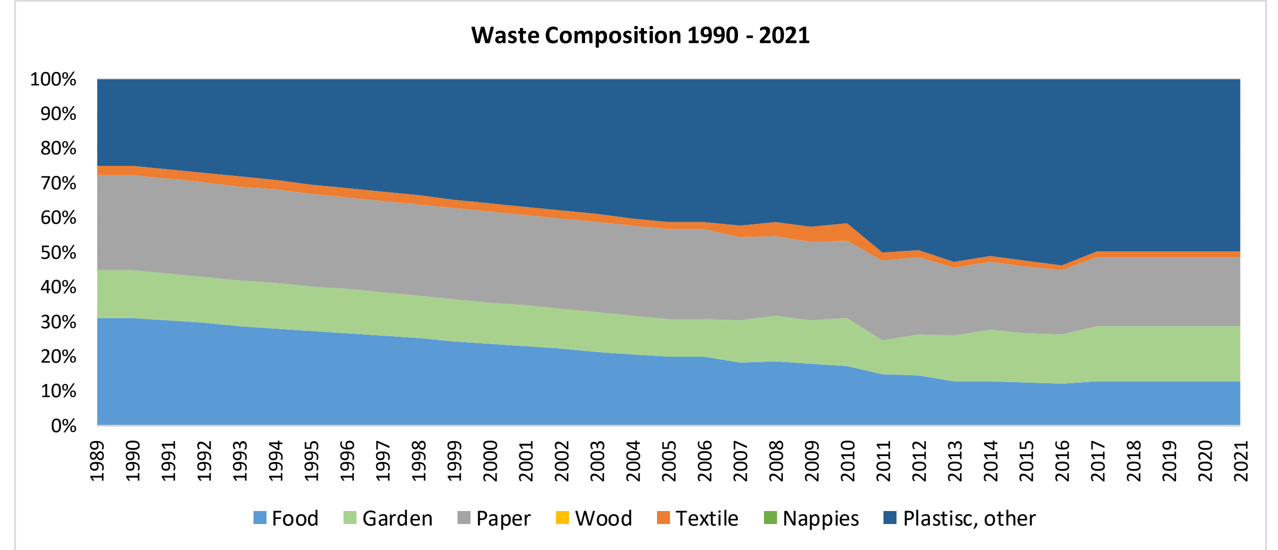


Figure 177 Composition of waste going to solid waste disposal sites for the period of 1990-2021

Table 406 Composition of waste going to solid waste disposal sites for the period of 1990-2021

	Waste composition							
	Food	**Garden**	**Paper**	**Wood**	**Textile**	**Disposable napples**	**Plastisc, other**	**Source**
IPCC default	30.1		21.8	7.5	6.1*		34.5	Table 2.3, 2006 IPCC GL, Vol. 5, Chap. 2
1950	46.9%	17.7%	29.3%	0.0%	2.9%	0.0%	3.2%	extrapolation
:	:	:	:	:	:	:	:	
1989	31.2%	13.8%	27.3%	0.0%	2.9%	0.0%	24.8%	Based on MONSTAT's survey OT-KOM 03 for 1989 including gap filling and expert judgment
1990	31.2%	13.8%	27.3%	0.0%	2.9%	0.0%	24.8%	
1991	30.4%	13.6%	27.2%	0.0%	2.9%	0.0%	25.9%	
1992	29.7%	13.4%	27.1%	0.0%	2.8%	0.0%	27.0%	
1993	28.9%	13.2%	27.0%	0.0%	2.8%	0.0%	28.1%	
1994	28.2%	13.1%	26.9%	0.0%	2.7%	0.0%	29.1%	
1995	27.4%	12.9%	26.8%	0.0%	2.7%	0.0%	30.2%	
1996	26.7%	12.7%	26.7%	0.0%	2.6%	0.0%	31.3%	
1997	25.9%	12.5%	26.6%	0.0%	2.6%	0.0%	32.4%	
1998	25.2%	12.3%	26.5%	0.0%	2.5%	0.0%	33.5%	
1999	24.4%	12.1%	26.4%	0.0%	2.5%	0.0%	34.6%	
2000	23.7%	11.9%	26.3%	0.0%	2.4%	0.0%	35.7%	
2001	22.9%	11.8%	26.1%	0.0%	2.4%	0.0%	36.8%	
2002	22.2%	11.5%	26.1%	0.0%	2.3%	0.0%	37.9%	
2003	21.4%	11.4%	26.0%	0.0%	2.3%	0.0%	38.9%	
2004	20.7%	11.2%	25.9%	0.0%	2.2%	0.0%	40.0%	
2005	19.9%	11.0%	25.8%	0.0%	2.2%	0.0%	41.1%	

	Waste composition							
	Food	Garden	Paper	Wood	Textile	Disposable nappies	Plastisc, other	Source
2006	19.9%	11.0%	25.8%	0.0%	2.2%	0.0%	41.1%	
2007	18.4%	12.2%	23.7%	0.0%	3.7%	0.0%	42.0%	
2008	18.7%	13.2%	22.8%	0.0%	4.1%	0.0%	41.2%	
2009	17.9%	12.7%	22.5%	0.0%	4.3%	0.0%	42.6%	
2010	17.2%	13.9%	22.4%	0.0%	5.0%	0.0%	41.5%	
2011	14.8%	9.9%	23.0%	0.0%	2.2%	0.0%	50.1%	
2012	14.5%	11.9%	22.2%	0.0%	2.1%	0.0%	49.3%	
2013	12.7%	13.4%	19.4%	0.0%	1.7%	0.0%	52.8%	
2014	12.8%	15.0%	19.6%	0.0%	1.7%	0.0%	50.9%	
2015	12.6%	14.0%	19.5%	0.0%	1.7%	0.0%	52.2%	
2016	12.0%	14.3%	18.6%	0.0%	1.6%	0.0%	53.5%	
2017	13.0%	15.7%	20.1%	0.0%	1.7%	0.0%	49.5%	
2018	13.0%	15.7%	20.1%	0.0%	1.7%	0.0%	49.5%	
2019	13.0%	15.7%	20.1%	0.0%	1.7%	0.0%	49.5%	
2020	13.0%	15.7%	20.1%	0.0%	1.7%	0.0%	49.5%	
2021	13.0%	15.7%	20.1%	0.0%	1.7%	0.0%	49.5%	
* Includes rubber/leather								

The waste statistics from the recent years are based on the waste classification in the EU and listed in the European List of Wastes (LoW). The following waste components are used.

Table 407 Types of waste as of the European List of Wastes (LoW)

Group	Codes	description
Paper and cardboard	15 01 01 20 01 01	paper and cardboard packaging paper and cardboard
Textiles	15 01 09 20 01 10 20 01 11	textile packaging Clothes Textiles
Plastics	15 01 02 20 01 39	plastic packaging Plastics
Glass	15 01 07 20 01 02	glass packaging Glass
Metals	15 01 04 15 01 11 20 01 40	metallic packaging metallic packaging containing a hazardous solid porous matrix (for example asbestos), including empty pressure containers
Other inorganic materials	15 01 05 15 01 06 15 01 10 20 01 13 - 20 01 23 20 01 27 - 20 01 36	composite packaging mixed packaging packaging containing residues of or contaminated by hazardous substances Solvents, Acids, Alkalines, Photochemicals, Pesticides, fluorescent tubes and other mercury-containing waste, discarded equipment containing chlorofluorocarbons paint, inks, adhesives and resins containing hazardous substances, paint, inks, adhesives and resins other than those mentioned in 20 01 27, detergents containing hazardous substances, detergents other than those mentioned in 20 01 29, cytotoxic and cytostatic medicines, medicines other than those mentioned in 20 01 31, batteries and

Group	Codes	description
	20 01 41, 20 01 99 20 02 03 20 03 01 (60%) 20 03 03 20 03 07 20 03 99	accumulators included in 16 06 01, 16 06 02 or 16 06 03 and unsorted batteries and accumulators containing these batteries, batteries and accumulators other than those mentioned in 20 01 33, discarded electrical and electronic equipment other than those mentioned in 20 01 21 and 20 01 23 containing hazardous components (1), discarded electrical and electronic equipment other than those mentioned in 20 01 21, 20 01 23 and 20 01 35 wastes from chimney sweeping other fractions not otherwise specified other non-biodegradable wastes mixed municipal waste street-cleaning residues bulky waste municipal wastes not otherwise specified
Organic materials	15 01 03 20 01 08 20 01 25 20 01 37 20 01 38 20 01 26, 20 02 01 20 03 01 (40%) 20 03 04 20 03 06	wooden packaging biodegradable kitchen and canteen waste edible oil and fat wood containing hazardous substances wood other than that mentioned in 20 01 37 oil and fat other than those mentioned in 20 01 25 biodegradable waste mixed municipal waste septic tank sludge waste from sewage cleaning

Degradable organic carbon (DOC)

The IPCC default values of Degradable organic carbon (DOC) were applied and is in the following table presented.

EQUATION 3.7 Estimates DOC using default carbon content values (2006 IPCC GL, Vol. 5, Chap.3)

$$DOC = \sum_i DOC_i \times W_i$$

Where:

DOC = fraction of degradable organic carbon in bulk waste, Gg C/Gg waste

DOCi = fraction of degradable organic carbon in waste type i

Wi = fraction of waste type i by waste category

Table 408 Degradable organic carbon (DOC)

Degradable organic carbon (DOC) (weight fraction, wet basis)	Food	Garden	Paper	Wood	Textile	Disposable nappies	Plastics, other inert	Source
IPCC Default	0.15	0.2	0.4	0.43	0.24	0.24	0.15	Based on TABLE 2.4, Chapter 2, and EQUATION 3.7, Chapter 3, Vol. 5, 2006 IPCC Guidelines

Table 409 Default dry matter content, DOC content, total carbon content and fossil carbon fraction of different MSW components

MSW component	Dry matter content in % of wet weight [1]	DOC content in % of wet waste		DOC content in % of dry waste		Total carbon content in % of dry weight		Fossil carbon fraction in % of total carbon	
	Default	Default	Range	Default	Range [2]	Default	Range	Default	Range
Paper/cardboard	90	40	*36 - 45*	44	*40 - 50*	46	*42 - 50*	1	*0 - 5*
Textiles [3]	80	24	*20 - 40*	30	*25 - 50*	50	*25 - 50*	20	*0 - 50*
Food waste	40	15	*8 - 20*	38	*20 - 50*	38	*20 - 50*	-	-
Wood	85 4	43	*39 - 46*	50	*46 - 54*	50	*46 - 54*	-	-
Garden & Park waste	40	20	*18 - 22*	49	*45 - 55*	49	*45 - 55*	0	*0*
Nappies	40	24	*18 - 32*	60	*44 - 80*	70	*54 - 90*	10	*10*
Rubber and Leather	84	(39) [5]	*(39) [5]*	(47) [5]	*(47) [5]*	67	*67*	20	*20*
Plastics	100	-	-	-	-	75	*67 - 85*	100	*95 - 100*
Metal [6]	100	-	-	-	-	NA	*NA*	NA	*NA*
Glass [6]	100	-	-	-	-	NA	*NA*	NA	*NA*
Other, inert waste	90	-	-	-	-	3	*0 - 5*	100	*50 - 100*

Remark: for footnotes see 2006 IPCC Guidelines Source: Table 2.4, Vol. 5, Chapter 2, 2006 IPCC Guidelines

Methane Correction Factor (MCF)

The Methane Correction Factor (MCF) reflects the way in which MSW is managed and the effect of management practices on CH_4 generation. MCF accounts for the fact that unmanaged SWDS produce less CH_4 from a given amount of waste than anaerobic managed SWDS. The methodology requires countries to provide data or estimates of the quantity of waste that is disposed of to each of categories of solid waste disposal sites. 2006 IPCC Guidelines provides default values for MCF (2006 IPCC, Vol.5, Table 3.1, p.6.8).

Table 410 SWDS classification and methane correction factors (MCF)

Type of Site		Methane Correction Factor (MCF) Default Values	Source
1	**Managed – anaerobic**	1.0	TABLE 3.1, Vol. 5, Chapter 3, 2006 IPCC Guidelines
2	**Managed – semi-aerobic**	0.5	
3	**Unmanaged – deep (>5 m waste) and /or high-water table**	0.8	
4	**Unmanaged – shallow (<5 m waste)**	0.4	
5	**Uncategorised SWD 5**	0.6	

1 **Anaerobic managed solid waste disposal sites:** These must have controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) levelling of the waste.

2 **Semi-aerobic managed solid waste disposal sites:** These must have controlled placement of waste and will include all of the following structures for introducing air to waste layer: (i) permeable cover material; (ii) leachate drainage system; (iii) regulating pondage; and (iv) gas ventilation system.

3 **Unmanaged solid waste disposal sites – deep and/or with high water table:** All SWDS not meeting the criteria of managed SWDS and which have depths of greater than or equal to 5 meters and/or high-water table at near ground level. Latter situation corresponds to filling inland water, such as pond, river or wetland, by waste.

4 **Unmanaged shallow solid waste disposal sites:** All SWDS not meeting the criteria of managed SWDS and which have depths of less than 5 meters.

5 **Uncategorised solid waste disposal sites:** Only if countries cannot categorise their SWDS into above four categories of managed and unmanaged SWDS, the MCF for this category can be used.

Distribution of Waste by Waste Management Type

In the following table is provided the distribution of waste by waste management types.

Table 411 Distribution of Waste by Waste Management Type for the period of 1990-2021

	Un-managed. shallow	Un-managed. deep	Managed	Managed. semi-aerobic	Uncate-gorised	Source
IPCC Default	30.1%	0%	21.8%	7.5%	4.7%	TABLE 2.3. Vol. 5. Chapter 2. 2006 IPCC Guidelines
1950	100.0%	0.0%	0.0%	0.0%	0.0%	
⋮	*constant*	*constant*	*constant*	*constant*	*constant*	
1979	100.0%	0.0%	0.0%	0.0%	0.0%	Based on MONSTAT's surveys and interviews of landfill managers
1980	96.5%	3.3%	0.0%	0.0%	0.2%	
1981	93.0%	6.7%	0.0%	0.0%	0.4%	
1982	89.4%	10.0%	0.0%	0.0%	0.6%	
1983	85.9%	13.3%	0.0%	0.0%	0.7%	
1984	82.4%	14.8%	0.0%	0.0%	2.8%	
1985	78.9%	18.1%	0.0%	0.0%	3.0%	
1986	75.4%	23.3%	0.0%	0.0%	1.3%	
1987	71.9%	26.7%	0.0%	0.0%	1.5%	
1988	68.3%	30.0%	0.0%	0.0%	1.7%	
1989	64.8%	33.3%	0.0%	0.0%	1.9%	
1990	61.3%	36.7%	0.0%	0.0%	2.0%	
1991	57.8%	40.0%	0.0%	0.0%	2.2%	
1992	54.3%	43.3%	0.0%	0.0%	2.4%	
1993	50.7%	46.7%	0.0%	0.0%	2.6%	
1994	47.2%	50.0%	0.0%	0.0%	2.8%	
1995	43.7%	53.5%	0.0%	0.0%	2.8%	
1996	40.2%	56.7%	0.0%	0.0%	3.1%	
1997	36.7%	60.0%	0.0%	0.0%	3.3%	
1998	33.1%	63.3%	0.0%	0.0%	3.5%	
1999	29.6%	66.7%	0.0%	0.0%	3.7%	
2000	26.1%	70.0%	0.0%	0.0%	3.9%	
2001	22.6%	73.3%	0.0%	0.0%	4.1%	
2002	19.1%	76.7%	0.0%	0.0%	4.3%	
2003	15.6%	80.0%	0.0%	0.0%	4.4%	
2004	12.0%	83.3%	0.0%	0.0%	4.6%	
2005	8.5%	86.7%	0.0%	0.0%	4.8%	
2006	5.0%	55.0%	35.0%	0.0%	5.0%	
2007	5.0%	55.0%	35.0%	0.0%	5.0%	
2008	5.0%	55.0%	35.0%	0.0%	5.0%	
2009	5.0%	55.0%	35.0%	0.0%	5.0%	
2010	5.0%	55.0%	35.0%	0.0%	5.0%	
2011	7.0%	60.0%	31.0%	0.0%	2.0%	
2012	1.0%	57.0%	37.0%	0.0%	5.0%	
2013	1.0%	45.0%	50.0%	0.0%	5.0%	
2014	1.0%	43.0%	52.0%	0.0%	5.0%	

	Un-managed. shallow	Un-managed. deep	Managed	Managed. semi-aerobic	Uncate-gorised	Source
IPCC Default	30.1%	0%	21.8%	7.5%	4.7%	TABLE 2.3. Vol. 5. Chapter 2. 2006 IPCC Guidelines
2015	1.0%	43.0%	52.0%	0.0%	4.0%	Based on MONSTAT's surveys and interviews of landfill managers
2016	1.0%	42.0%	52.0%	0.0%	5.0%	
2017	1.0%	37.0%	56.0%	0.0%	5.0%	
2018	1.0%	37.0%	56.0%	0.0%	5.0%	
2019	1.0%	37.0%	56.0%	0.0%	5.0%	
2020	1.0%	37.0%	56.0%	0.0%	5.0%	
2021	1.0%	37.0%	56.0%	0.0%	5.0%	

Furthermore, the following default parameter were applied.

DOC dissimilated (DOCf)

Fraction of DOC dissimilated (DOCf) is an estimate of the fraction of carbon that is ultimately degraded and released from SWDS, and reflects the fact that some organic carbon does not degrade, or degrades very slowly, when deposited in SWDS. It is *good practice* to use a value of 0.5 (including lignin C) as the default (TABLE 3.1, Vol. 5, Chapter 3, 2006 IPCC Guidelines).

Fraction of methane (F) in developed gas

Most waste in SWDS generates a gas with approximately 50% CH_4. Only material including substantial amounts of fat or oil can generate gas with substantially more than 50 percent CH_4. Montenegro is using the IPCC default value 0.5 for the fraction of CH_4 in landfill gas. (Vol. 5, Chapter 3, 2006 IPCC GL, page 3.15)

Delay time

In most solid waste disposal sites, waste is deposited continuously throughout the year, usually on a daily basis. However, there is evidence that production of CH_4 does not begin immediately after deposition of the waste. Montenegro uses the default delay of six months. (Vol. 5, Chapter 3, 2006 IPCC GL, page 3.19).

Oxidation factor (OX)

The oxidation factor (OX) reflects the amount of CH_4 from SWDS that is oxidized in the soil or other material covering the waste. (TABLE 3.2, Vol. 5, Chapter 3, 2006 IPCC Guidelines)

Type of Site	Oxidation Factor (OX) Default Values	Source
Managed [1], unmanaged and uncategorised SWDS	0	TABLE 3.2, Vol. 5, Chapter 3, 2006 IPCC Guidelines
Managed covered with CH4 oxidising material [2]	0.1	
[1] Managed but not covered with aerated material ; [2] Examples: soil, compost		

Methane generation rate (k)

The default methane generation rate for the temperate – wet climate zone is used.

Table 412 Recommended default methane generation rate (k) values under Tier 1

Type of Waste		Climate Zone*			
		Boreal and Temperate (MAT ≤ 20°C)			
		Dry (MAP/PET < 1)		Wet (MAP/PET > 1)	
		Default	Range[2]	Default	Range[2]
Slowly degrading waste	**Paper/textiles waste**	**0.04**	0.03[3,5] – 0.05[3,4]	0.06	0.05 – 0.07[3,5]
	Wood/ straw waste	**0.02**	0.01[3,4] – 0.03[6,7]	0.03	0.02 – 0.04
Moderately degrading waste	**Other (non – food) organic putrescible/ Garden and park waste**	**0.05**	0.04 – 0.06	0.1	0.06 – 0.1[8]
Rapidly degrading waste	**Food waste/Sewage sludge**	**0.06**	0.05 – 0.08	0.185[4]	0.1[3,4] – 0.2[9]
Bulk Waste		**0.05**	0.04 – 0.06	0.09	0.08[8] – 0.1
Remark: for footnotes see 2006 IPCC Guidelines;		Source: Table 3.3, Vol. 5, Chapter 3, 2006 IPCC Guidelines			

Half-life ($t_{1/2}$)

The default half-life (t1/2) for the temperate – wet climate zone is used.

Table 413 Recommended default half-life ($t_{1/2}$) values (YR) under Tier 1

Type of Waste		Climate Zone*			
		Boreal and Temperate (MAT ≤ 20°C)			
		Dry (MAP/PET < 1)		Wet (MAP/PET > 1)	
		Default	Range[2]	Default	Range[2]
Slowly degrading waste	**Paper/textiles waste**	**17**	14[3,5] –23[3,4]	12	10 – 14[3,5]
	Wood/ straw waste	**35**	23[3,4] –69[6,7]	23	17 – 35
Moderately degrading waste	**Other (non – food) organic putrescible/ Garden & park waste**	**14**	12 – 17	7	6 – 9[8]
Rapidly degrading waste	**Food waste/Sewage sludge**	**12**	9 – 14	44	3[3,4] – 6[9]
Bulk Waste		**14**	12 – 17	7	6 – 9[8]
Remark: for footnotes see 2006 IPCC Guidelines,		Source: Table 3.4, Vol. 5, Chapter 3, 2006 IPCC Guidelines			

Methane recovery (R)

CH_4 generated at SWDS can be recovered and combusted in a flare or energy device.

In Montenegro, methane recovery (R) started in 2008. The methane is fared without energy recovery.

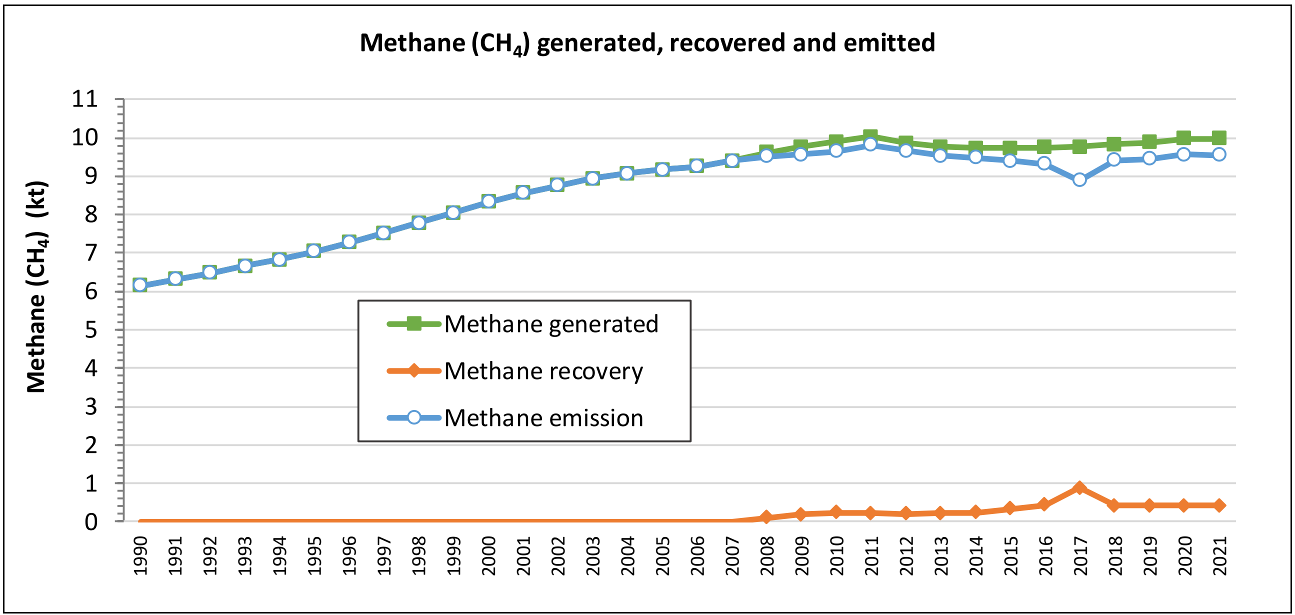


Figure 178 Methane (CH_4) recovered from SWDS for the period of 2008-2021

Table 414 Amount of methane recovered from SWDS for the period of 2008-2021

	Amount of Methane Recovered from SWDS (kt)	Fraction recovered methane	Source
2008	0.10715	0.01114	EPA (different years) based on site data
2009	0.19500	0.01998	
2010	0.23758	0.02401	
2011	0.21739	0.02168	
2012	0.20224	0.02049	
2013	0.22870	0.02341	
2014	0.24556	0.02523	
2015	0.33423	0.03433	
2016	0.42839	0.04392	
2017	0.88083	0.09016	
2018	0.42354	0.04306	
2019	0.46251	0.04683	
2020	0.50590	0.05067	
2021	0.50590	0.05067	As of 2020

7.2.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 5.A *Solid Waste Disposal* are presented in the following table.

Table 415 Uncertainty for IPCC sub-category 5.A Solid Waste Disposal.

Uncertainty	CH_4	**Reference** 2006 IPCC GL, Vol. 5, Chap. 3.7
Activity data (AD)	147%	Based on Table 3.5
Emission factor (EF)	98%	Based on Table 3.4 & 3.5
Combined Uncertainty (U)	177%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent with the data reported in the population statistics, GDP statistics, which were used as surrogate data.

7.2.4 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
  - consistent use of energy balance data (energy statistic questionnaires),
  - documented sources,
  - use of units,
  - strictly defined interfaces between spreadsheets/calculation modules,
  - unique structure of sheets which do the same,
  - record keeping, use of write protection,
  - unique use of formulas, special cases are documented/highlighted,
  - quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from three sources: national statistic and EUROST data

⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;

⇒ time series consistency

⇒ plausibility checks of dips and jumps.

7.2.5 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC sub-category *5.A Solid Waste Disposal*.

Table 416 Recalculations done in IPCC sub-category 5.A Solid Waste Disposal

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
5.A.	Waste statistics revised by MONSTAT	AD	Accuracy

7.2.6 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 417 Planned improvements for IPCC sub-category 5.A Solid Waste Disposal

GHG source & sink category	Planned improvement	Type of improvement		Priority
5	Further investigation on waste flow: collection, disposal, recycling, incineration with energy and without energy recovery, open burning, composting, etc. • Urban population • Rural population	AD	Accuracy Transparency Comparability Completeness Consistency	high
5	Further investigation on waste generation (rate) • by urban and rural population • by climate zone (see • Half-life **(t1/2)** The default half-life (t1/2) for the temperate – wet climate zone is used. • Table 413 & Table 412) • by composition	AD		high
5	Further investigation on amount and waste management practices regarding clinic waste, sludge, hazardous waste, etc.	AD		high
5	Further investigation on industrial waste generation and industrial waste management practices	AD		high
5	Further investigation on illegal dumping in districts/ villages - garbage pit, illegal dumping in rivers / lakes, backyard dumping Further investigation on litering	AD		high
5.A	Application of TIER 2 methodology	Meth		high
5.A	Further investigation on waste management practices (managed, unmanaged, unspecified) (see Table 410)	AD		high
5.A	In-depth analysis of existing data on waste collection and disposal from municipalities for application of higher TIER methodology (TIER 2): good quality country-specific activity data on current and historical waste disposal at SWDS (data for the last 30 years (or more))	AD		medium

7.3 Biological treatment of solid waste (IPCC category 5.B)

The following section describes GHG emissions resulting from biological treatment of solid waste, which originates from three different processes:

- Composting,
- anaerobic digestion of organic waste, and
- mechanical-biological (MB) treatment.

Composting and anaerobic digestion of organic waste, such as food waste, garden and park waste and sludge, is common in many countries. Advantages of the biological treatment include:

- reduced volume in the waste material,
- stabilization of the waste,
- destruction of pathogens in the waste material, and
- production of biogas for energy use.

The end products of the biological treatment can, depending on its quality, be recycled as fertilizer and soil amendment, or be disposed in Solid waste disposal sites (SWDS).

Anaerobic treatment is usually linked with methane (CH_4) recovery and combustion for energy, and thus the greenhouse gas emissions from the process should be reported in the Energy Sector.

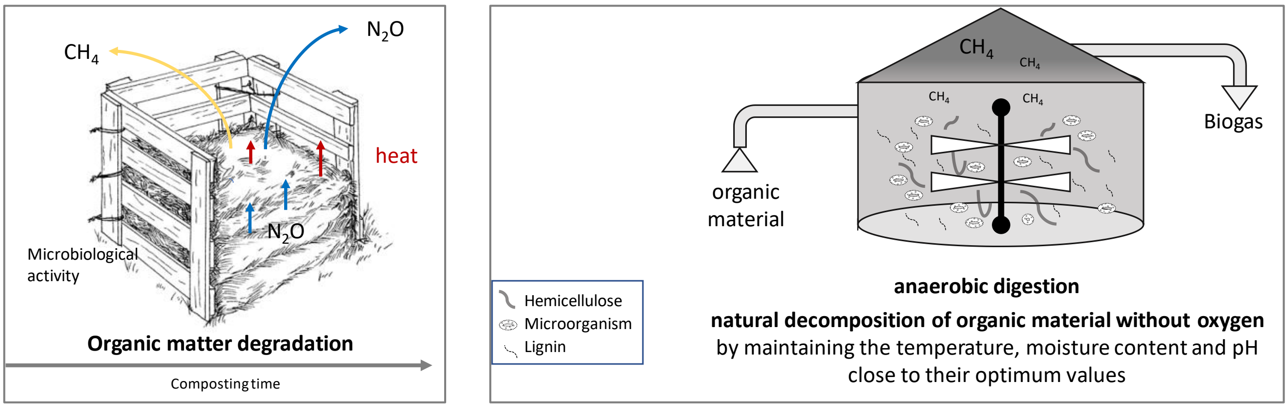


Figure 179 Scheme of composting and anaerobic digestion

Composting is a preferred method of solid waste disposal in rural area, mainly due to the high percentage of organic material in the waste composition. As no specific information on composting activities in Montenegro were available, this sources has not been estimated.

7.3.1 Source category description

GHG emissions/ removals	CO_2	CH_4	N_2O
5.B. Biological treatment of solid waste	NA	NE	NE
Key Category	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential			
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF			

7.3.2 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 418 Planned improvements for IPCC sub-category 5.B Biological treatment of solid waste.

GHG source & sink category	Planned improvement	Type of improvement		Priority
5.B	Investigation on composting activities especially in the rural area and the use of compost in agriculture	AD	Accuracy Completeness	High
5.B	Literature study on GHG emissions from (small-scale) illegal dumping and backyard dumping, especially in the period 1990 - 2010	EF		High

7.4 Incineration and Open Burning of Waste (IPCC category 5.C)

The following section describes GHG emissions resulting from waste incineration and open burning of waste, which originates from:

⇒ 5.C.1 Waste Incineration

⇒ 5.C.2 Open Burning of Waste

Emissions from waste incineration without energy recovery are reported in the Waste Sector, while emissions from incineration with energy recovery are reported in the Energy Sector, both with a distinction between fossil and biogenic CO_2 emissions.

Open burning of waste can be defined as the combustion of unwanted combustible materials such as paper, wood, plastics, textiles, rubber, waste oils and other debris in nature (open-air) or in open dumps, where smoke and other emissions are released directly into the air without passing through a chimney or stack. Open burning of municipal solid waste (MSW) is not well described and an underestimated source of air pollution in developing countries due to lack of information and country specific data:

- MSW generation rates
- fraction of waste, which is combustible,
- fraction of population burning waste outside their houses and fraction of MSW burned at dump sites.

According to the 2006 IPCC Guidelines waste incineration and open burning of waste produces emissions of CO_2, CH_4 and N_2O.

GHG emissions from 5.C.1 Waste incineration were not occurring in Montenegro in the period 1990 – 2021.

GHG emissions from 5.C.2 Open Burning of Waste were not estimated due to lack of data.

7.4.1 Source category description

GHG emissions/ removals	CO_2	CH_4	N_2O
Estimated			
5.C.1 Waste incineration			
Municipal Solid waste	NO	NO	NO
Industrial Waste	NO	NO	NO
Sewage Sludge	NO	NO	NO

GHG emissions/ removals	CO_2	CH_4	N_2O
Clinical Waste	NO	NO	NO
Hazardous Waste	NO	NO	NO
5.C.2 Open Burning of Waste			
Municipal Solid waste	NE	NE	NE
Industrial Waste	NE	NE	NE
Sewage Sludge	NO	NO	NO
Clinical Waste	NO	NO	NO
Hazardous Waste	NO	NO	NO
Key Category			-
5.C.1 Waste incineration	-	-	-
5.C.2 Open Burning of Waste	-	-	-
A '✓' indicates: emissions from this sub-category have been estimated. Notation keys: IE - included elsewhere, NO – not occurrent, NE - not estimated, NA - not applicable, C – confidential			
LA – Level Assessment (in year) without LULUCF; TA – Trend Assessment without LULUCF			

7.4.2 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 419 Planned improvements for IPCC sub-category 5.C.2 Open burning

GHG source & sink category	Planned improvement	Type of improvement		Priority
5.C	Investigation on open burning activities: fraction of population burning waste outside their houses and fraction of MSW burned at dump sites	AD	Accuracy Completeness	High
5.C	Investigation on fraction of waste, which is combustible	AD		High

7.5 Wastewater Treatment and Discharge (IPCC category 5.D)

7.5.1 Source category description

The following section describes GHG emissions resulting from Wastewater Treatment and Discharge. According to 2006 IPCC Guidelines wastewater can be a source of methane (CH_4) when treated or disposed anaerobically. It can also be a source of nitrous oxide (N_2O) emissions. Carbon dioxide (CO_2) emissions from wastewater are not considered because these are of biogenic origin and should not be included in national total emissions.

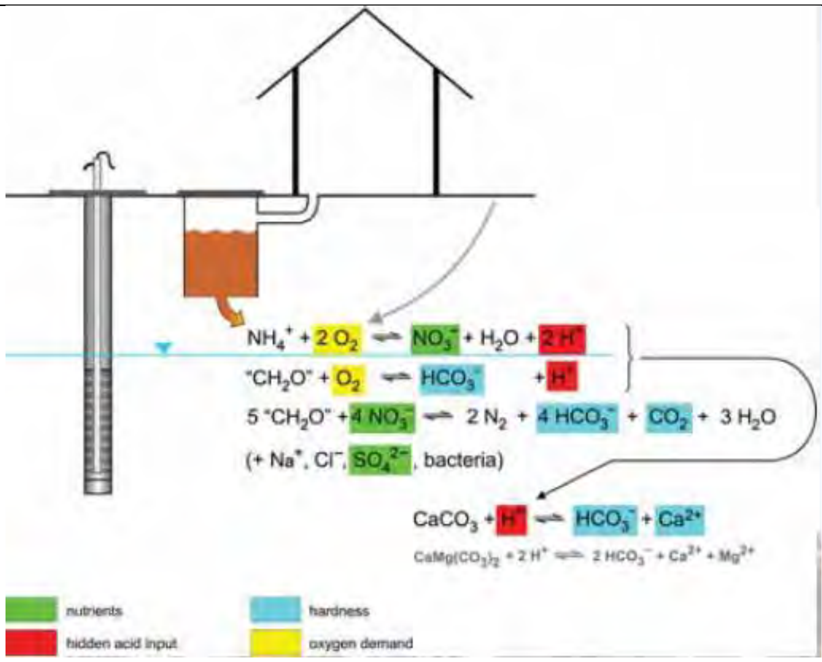


Figure 180 Main process of wastewater influence on shallow groundwater[140]

Nitrous Oxide (N_2O)

There are two sources of N_2O emissions:

- Indirect N_2O emissions from discharge of effluent into waterways, lakes and sea;
- Direct N_2O emissions from treatment plants which are low compared to indirect emissions.

Nitrous oxide (N_2O) is associated with the degradation of nitrogen components in the wastewater, e.g., urea, nitrate and protein. Domestic wastewater includes human sewage mixed with other household wastewater, which can include effluent from shower drains, sink drains, washing machines, etc.

Methane (CH_4)

Wastewater as well as its sludge components can produce CH_4 if it degrades anaerobically. The extent of CH_4 production depends primarily on the quantity of degradable organic material in the wastewater, the temperature, and the type of treatment system. With increases in temperature, the rate of CH_4 production increases. This is especially important in uncontrolled systems and in warm climates.

[140] Source: Federal Institute for Geosciences and Natural Resources (BGR): Groundwater resources at risk. Germany

The term “s

anitation chain” which refers to the sequence according to which wastewater is “handled” along the way from production at the level of the households until its disposal is shown in in the following figures.

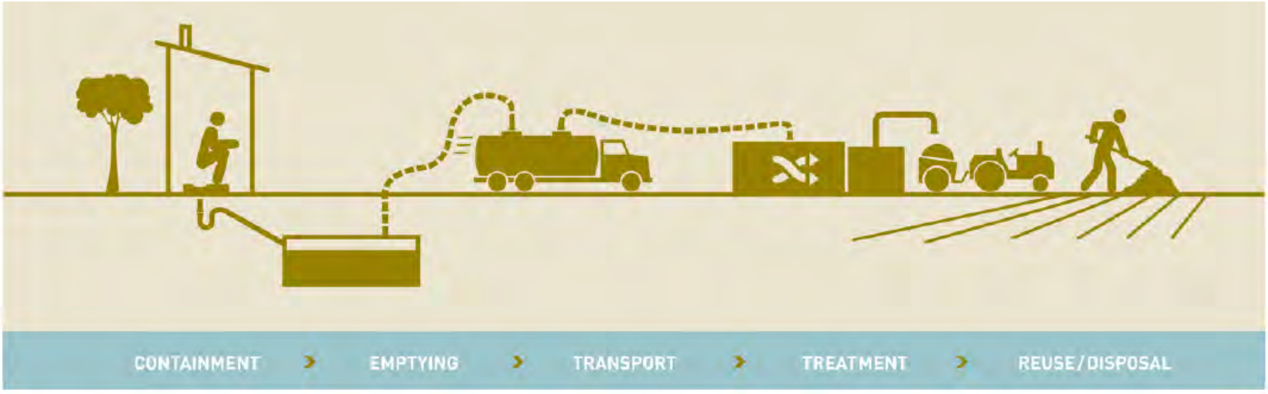


Figure 181 The Sanitation Chain

Wastewater is defined as

- domestic effluent consisting of blackwater (excreta, urine and fecal sludge) and grey-water (kitchen and bathing wastewater), or
- water from commercial establishments and institutions, including hospitals, or
- industrial effluent, storm water and other urban run-off.

Sanitation services have, mainly understandably, been given less priority than water supply since people tend to grant more urgency to the provision of water. Access to improved sanitation can have different interpretations from one country to another. Septic tanks, latrines, river and lake discharge and sewer are om many developing countries the main domestic treatment and discharge facilities. In 2016, among the five treatment and discharge systems, latrine facilities were the commonest.

In most developing countries, data on urban and rural areas are generally scarce and, if available, reliable only for the last year. However, according to available data, wastewater collection in rural areas is very low compared to urban areas.

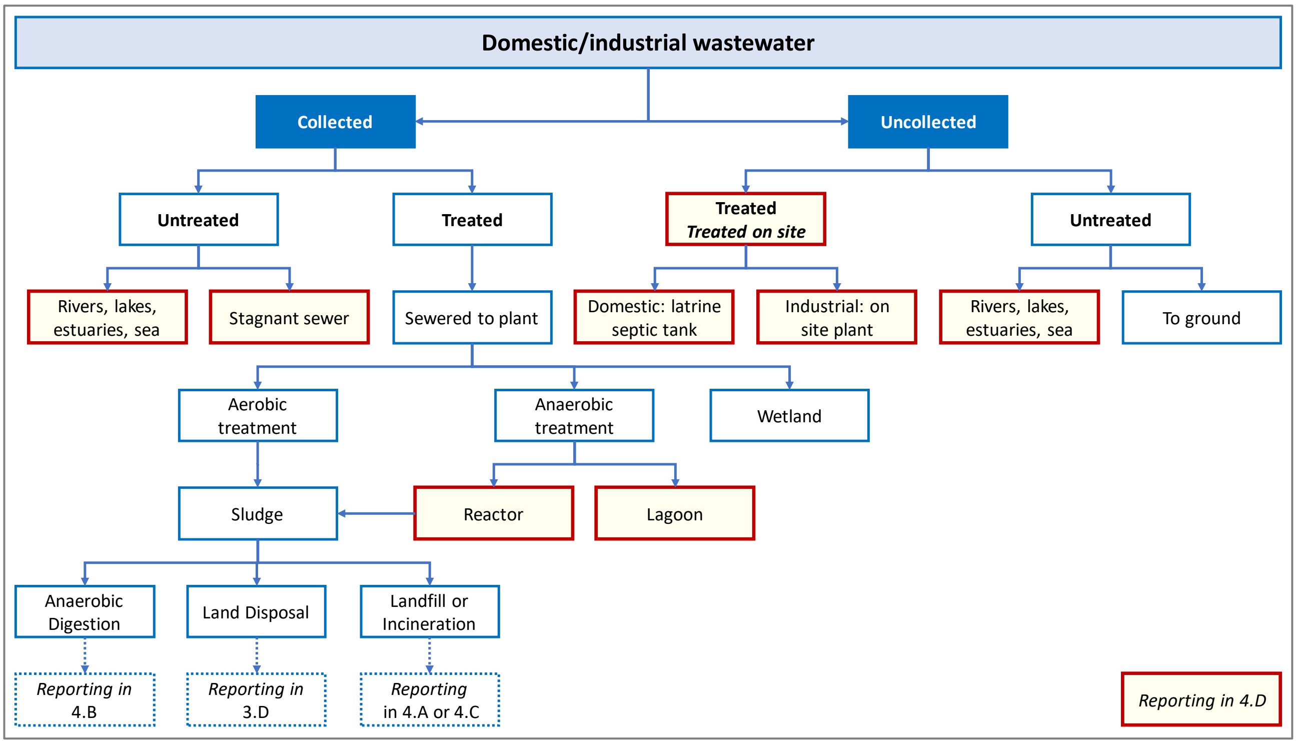


Figure 182 Wastewater treatment systems and discharge pathways[141]

In the period 1990 to 2021 GHG emissions from the IPCC category 5.D *Wastewater treatment and discharge* increased by 50.0% from 61.54 kt CO_2 eq in 1990 to 92.31 kt CO_2 eq in 2021. In the period 2005 to 2021 GHG emissions from the Waste sector increased by 39.6%. The increase of N_2O emissions are the result of the increased protein supply.

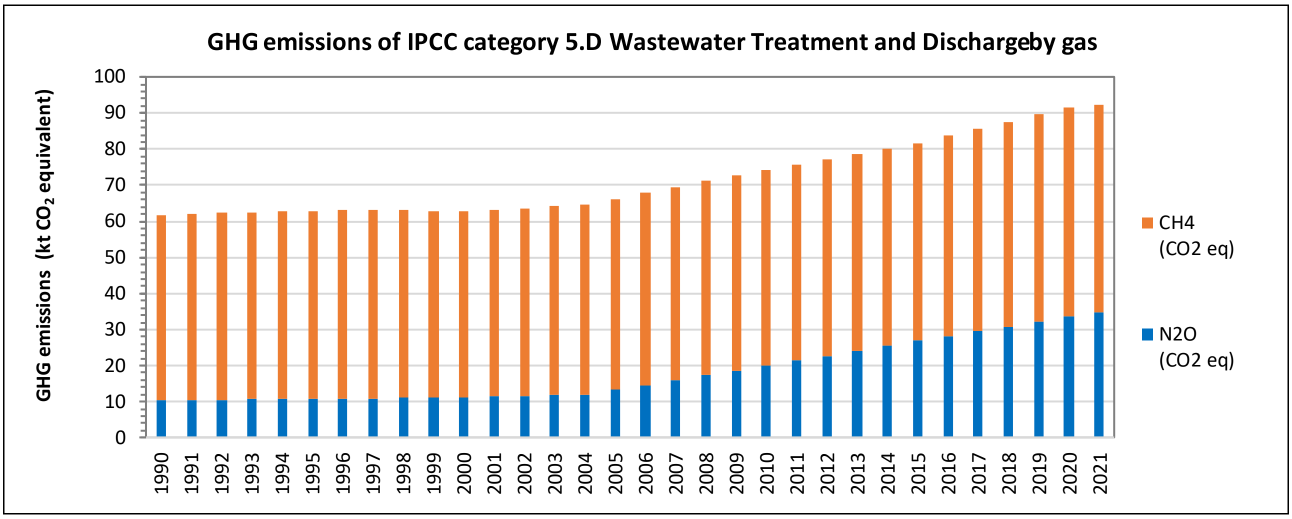


Figure 183 GHG emissions IPCC category 5.D Wastewater Treatment and Discharge by gas

[141] Source: 2006 IPCC Guidelines, Volume 5: Waste, Chapter 6: Wastewater Treatment and Discharge - Figure 6.1

Table 420 **CH_4 and N_2O emission from IPCC category 5.D Wastewater Treatment and Discharge**

	GHG emissions	CH_4 emissions	N_2O emissions
Unit	kt CO_2 equivalent	kt	kt
1990	**61.54**	2.05	0.034
1991	**62.17**	2.07	0.035
1992	**62.37**	2.07	0.035
1993	**62.57**	2.08	0.036
1994	**62.74**	2.08	0.036
1995	**62.94**	2.09	0.036
1996	**63.10**	2.09	0.036
1997	**63.29**	2.09	0.037
1998	**63.04**	2.08	0.037
1999	**62.75**	2.07	0.037
2000	**62.95**	2.07	0.038
2001	**63.07**	2.07	0.038
2002	**63.64**	2.08	0.039
2003	**64.13**	2.10	0.039
2004	**64.61**	2.11	0.040
2005	**66.13**	2.12	0.044
2006	**67.85**	2.13	0.049
2007	**69.51**	2.14	0.053
2008	**71.25**	2.16	0.058
2009	**72.87**	2.17	0.063
2010	**74.38**	2.17	0.067
2011	**75.84**	2.18	0.072
2012	**77.32**	2.18	0.076
2013	**78.81**	2.19	0.081
2014	**80.25**	2.19	0.086
2015	**81.64**	2.19	0.090
2016	**83.66**	2.22	0.095
2017	**85.66**	2.24	0.099
2018	**87.63**	2.27	0.104
2019	**89.59**	2.29	0.108
2020	**91.42**	2.32	0.112
2021	**92.31**	2.31	0.116
Trend			
1990 - 2021	*50.0%*	*12.4%*	237.5%
2005 - 2021	*39.6%*	*8.9%*	162.7%
2020 - 2021	*1.0%*	*-0.5%*	3.5%

7.5.2 Methodological issues

7.5.2.1 Choice of methods – CH_4 emissions

The steps for *good practice* in inventory preparation for CH_4 from domestic wastewater are as follows:

Step 1: Use Equation 6.3 to estimate total organically degradable carbon in wastewater (TOW).

Step 2: Select the pathway and systems (See Figure 182 Wastewater treatment systems and discharge pathways (Figure 6.1 in 2006 IPCC GL, Vol. 5, Chapter 6) according to country activity data. Use Equation 6.2 to obtain the emission factor for each domestic wastewater treatment/discharge pathway or system.

Step 3: Use Equation 6.1 to estimate emissions, adjust for possible sludge removal and/or CH_4 recovery and sum the results for each pathway/system.

Total CH_4 emissions from domestic wastewater

Equation 6.1, 2006 IPCC GL, Vol. 5, Chapter 6, page 6.11

$$CH_4\ emissions = \left[\sum_{i,j}\left(U_i * T_{i,j} * EF_j\right)\right](TOW - S) - R$$

where

CH_4 Emissions	= CH_4 emissions in inventory year, kg CH_4/yr
TOW	= total organics in wastewater in inventory year, kg BOD/yr
S	= organic component removed as sludge in inventory year, kg BOD/yr
Ui	= fraction of population in income group i in inventory year, See Table 6.5.
Ti,j	= degree of utilisation of treatment/discharge pathway or system, j, for each income group fraction i in inventory year, See Table 6.5.
i	= income group: rural, urban high income and urban low income
j	= each treatment/discharge pathway or system
EFj	= emission factor, kg CH_4 / kg BOD
R	= amount of CH_4 recovered in inventory year, kg CH_4/yr

7.5.2.2 Choice of CH_4 emission factor

CH_4 Emission Factor for each Domestic Wastewater Treatment/Discharge Pathway or System

Equation 6.2, 2006 IPCC GL, Vol. 5, Chapter 6, page 6.12

$$EF_J = B_o * MCF_j$$

where

EFj	= emission factor, kg CH_4/kg BOD
j	= each treatment/discharge pathway or system
Bo	= maximum CH_4 producing capacity, kg CH_4/kg BOD
MCFj	= methane correction factor (fraction) (MCF = 0)

Table 421 Producing capacity (B_o) for domestic wastewater

Parameter	Value	Source
Bo Producing capacity for domestic wastewater	0.6 kg CH_4/kg BOD	Table 6.2, 2006 IPCC GL, Vol. 5, Chap. 6, page 6.12

Table 422 Type of treatment and discharge pathway or system

Type of treatment and discharge pathway or system	Comments	MCF Default values for domestic wastewater
Untreated system		
Sea, river and lake discharge	Rivers with high organics loadings can turn anaerobic.	0.1
Stagnant sewer	Open and warm	0.5
Flowing sewer (open or closed)	Fast moving, clean. (Insignificant amounts of CH_4 from pump stations, etc)	0
Treated system		
Centralized, aerobic treatment plant	Must be well managed. Some CH_4 can be emitted from settling basins and other pockets.	0
Centralized, aerobic treatment plant	Not well managed. Overloaded.	0.3
Anaerobic digester for sludge	CH_4 recovery is not considered here.	0.8
Anaerobic reactor	CH_4 recovery is not considered here.	0.8
Anaerobic shallow lagoon	Depth less than 2 meters, use expert judgment.	0.2
Anaerobic deep lagoon	Depth more than 2 meters	0.8
Septic system	Half of BOD settles in anaerobic tank.	0.5
Latrine	Dry climate, ground water table lower than latrine, small family (3-5 persons)	0.1
Latrine	Dry climate, ground water table lower than latrine, communal (many users)	0.5
Latrine	Wet climate/flush water use, ground water table higher than latrine	0.7
Latrine	Regular sediment removal for fertilizer	0.1
Source : TABLE 6.3, 2006 IPCC GL, Vol. 5, Chapter 6, page 6.13		

7.5.2.3 Choice of activity data – CH_4 emission

The activity data for this source category is the total amount of organically degradable material in the wastewater (TOW). This parameter is a function of human population and BOD generation per person. It is expressed in terms of biochemical oxygen demand (kg BOD/year). The equation for TOW is:

Total Organically Degradable Material In Domestic Wastewater

Equation 6.3, 2006 IPCC GL, Vol. 5, Chapter 6, page 6.13

$$TOW = P * BOD * 0.001 * I * 365$$

where

TOW = total organics in wastewater in inventory year, kg BOD/yr

P = country population in inventory year, (person)

BOD = country-specific per capita BOD in inventory year, g/person/day

0.001 = conversion from grams BOD to kg BOD

I = correction factor for additional industrial BOD discharged into sewers (for collected the default is 1.25, for uncollected the default is 1.00.)

The default biochemical oxygen demand of 60 kg BOD/year was used.

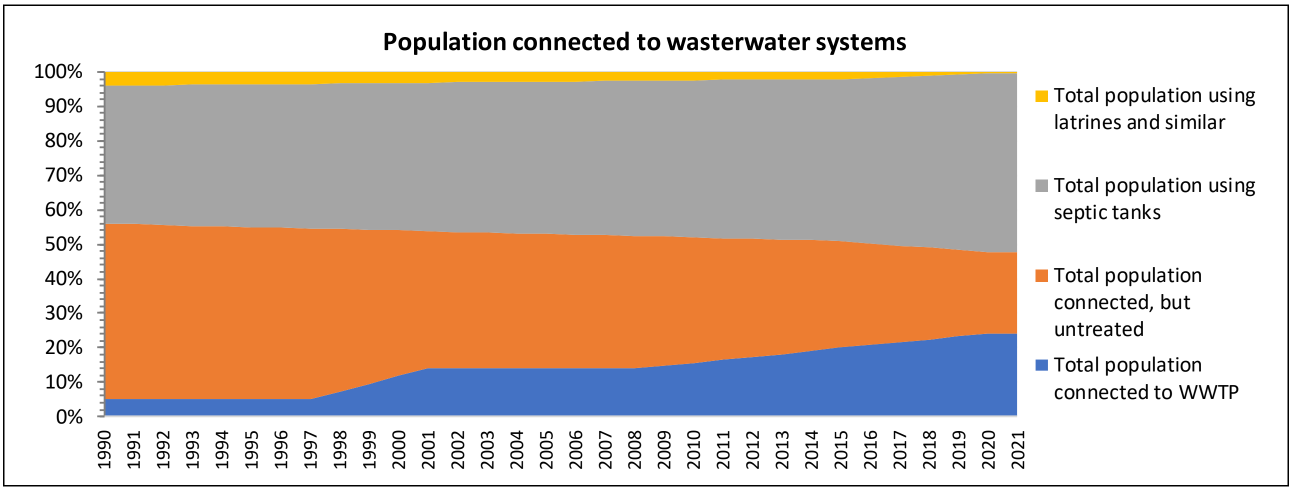


Figure 184 **Composition of waste going to solid waste disposal sites for the period of 1990-2021**

Table 423 **Total population and share of population connected to WWTP, using septic tanks or latrines**

	Total population	Total population connected to WWTP	Total population connected, but untreated	Total population using septic tanks	Total population using latrines and similar
Unit	heads	%			
1990	611 963	5.0	51.0	40.0	4.0
1991	615 035	5.0	50.8	40.3	3.9
1992	613 550	5.0	50.6	40.6	3.8
1993	612 064	5.0	50.4	40.8	3.8
1994	610 579	5.0	50.2	41.1	3.7
1995	609 094	5.0	50.0	41.4	3.6
1996	607 608	5.0	49.8	41.7	3.5
1997	606 123	5.0	49.6	42.0	3.4
1998	604 637	7.3	47.2	42.2	3.4
1999	603 152	9.5	44.7	42.5	3.3
2000	605 988	11.8	42.3	42.8	3.2
2001	608 460	14.0	39.8	43.1	3.1
2002	610 510	14.0	39.6	43.4	3.0
2003	612 214	14.0	39.4	43.6	3.0
2004	613 420	14.0	39.2	43.9	2.9
2005	613 109	14.0	39.0	44.2	2.8
2006	614 624	14.0	38.8	44.5	2.7
2007	615 543	14.0	38.6	44.8	2.6
2008	617 157	14.0	38.4	45.0	2.6
2009	619 001	14.8	37.4	45.3	2.5
2010	619 850	15.6	36.4	45.6	2.4
2011	620 308	16.4	35.4	45.9	2.3
2012	620 893	17.2	34.4	46.2	2.2
2013	621 521	18.0	33.4	46.4	2.2
2014	622 099	19.0	32.2	46.7	2.1

	Total population	Total population connected to WWTP	Total population connected, but untreated	Total population using septic tanks	Total population using latrines and similar
Unit	**heads**	**%**			
2015	622 218	20.0	31.0	47.0	2.0
2016	622 387	20.8	29.5	48.0	1.7
2017	622 359	21.6	28.1	49.0	1.3
2018	622 182	22.4	26.6	50.0	1.0
2019	621 873	23.2	25.1	51.0	0.7
2020	620 739	24.0	23.7	52.0	0.4
2021	617 683	24.0	23.7	52.0	0.4
Trend					
1990-2021	0.9%	380.0%	-53.6%	30.0%	-91.3%
2005-2021	0.7%	71.4%	-39.4%	17.6%	-87.5%
2020-2021	-0.5%	0.0%	0.0%	0.0%	0.0%
Source	*MONSTAT*	*Monstat, environment indicators, interpolation*	*calculated*	*2015, 2020 WHO sanitation, 1990 assumption, interpolation*	

7.5.2.4 Choice of methods – N_2O emissions

The N_2O emissions are estimated according to TIER 1 methdologogy from 2006 IPCC GL:

Total N_2O emissions from wastewater effluent

Equation 6.7, 2006 IPCC GL, Vol. 5, Chapter 6, page 6.25

$$N_2O\ emissions = N_{effluent} * EF_{effluent} * \frac{44}{28}$$

Where

N_2O emissions = N_2O emissions in inventory year, kg N_2O/yr

$N_{EFFLUENT}$ = nitrogen in the effluent discharged to aquatic environments, kg N/yr

$EF_{EFFLUENT}$ = emission factor for N_2O emissions from discharged to wastewater, kg N_2O-N/kg N

44/28 = The factor 44/28 is the conversion of kg N_2O-N into kg N_2O.

7.5.2.5 Choice of N_2O emission factor

The default IPCC emission factor for N_2O emissions from domestic wastewater nitrogen effluent is 0.005 kg N_2O-N/kg N.

7.5.2.6 Choice of activity data – N_2O emission

The CH_4 emissions are estimated according to TIER 1 methdologogy from 2006 IPCC GL:

CH_4 Emission Factor for each Domestic Wastewater Treatment/Discharge Pathway or System

Equation 6.2, 2006 IPCC GL, Vol. 5, Chapter 6, page 6.12

$$N_{Effluent} = (P * Protein * F_{NRP} * F_{non-con}) - N_{sludge}$$

Where:

$N_{EFFLUENT}$ = total annual amount of nitrogen in the wastewater effluent, kg N/yr P = human population

Protein = annual per capita protein consumption, kg/person/yr

F_{NPR} = fraction of nitrogen in protein, default = 0.16, kg N/kg protein

$F_{NON-CON}$ = factor for non-consumed protein added to the wastewater

$F_{IND-COM}$ = factor for industrial and commercial co-discharged protein into the sewer system

N_{SLUDGE} = nitrogen removed with sludge (default = zero), kg N/yr

Table 424 Total population and Per capita protein consumption

	Total population	Per capita protein consumption	Source	For comparision: FAO Per capita protein supply (3year average)
Unit	heads	kg/person/ year		kg/person/ year
1990	611 963	32.6	MSDT (2019): 2nd BUR. Submission under UNFCCC	
1991	615 035	32.9		
1992	613 550	33.3		
1993	612 064	33.7		
1994	610 579	34		
1995	609 094	34.4		
1996	607 608	34.7		
1997	606 123	35.1		
1998	604 637	35.5		
1999	603 152	35.8		
2000	605 988	36.2		
2001	608 460	36.50		
2002	610 510	36.90		
2003	612 214	37.20		
2004	613 420	37.60		33.7
2005	613 109	41.80	interpolation	103.5
2006	614 624	46.00		105.7
2007	615 543	50.20		108.3
2008	617 157	54.40		110
2009	619 001	58.60		110.3
2010	619 850	62.80		109.3
2011	620 308	67.00		109.3
2012	620 893	71.20		108.3

	Total population	Per capita protein consumption	Source	For comparision: FAO Per capita protein supply (3year average)
Unit	heads	kg/person/ year		kg/person/ year
2013	621 521	75.40	interpolation	109.3
2014	622 099	79.60		109.3
2015	622 218	83.80		111
2016	622 387	88.00		112.7
2017	622 359	92.20		112.7
2018	622 182	96.40		112.7
2019	621 873	100.60		
2020	620 739	104.80		
2021	617 683	109.00	Average of FAO data	

7.5.3 Uncertainties and time-series consistency

The uncertainties for activity data and emission factors used for IPCC category 5.D *Wastewater Treatment and Discharge* are presented in the following table.

Table 425 Uncertainty for IPCC category 5.D Wastewater Treatment and Discharge.

Uncertainty	CH_4	N2O	**Reference** 2006 IPCC GL, Vol. 5, Chap. 6
Activity data (AD)	71%		Table 6.7
		71%	Table 6.11
Emission factor (EF)	129%		Table 6.7
		261%	Table 6.11
Combined Uncertainty (U)	142%	270%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent with the data reported in the population statistics.

7.5.4 Category-specific QA/QC and verification

The following source-specific QA/QC activities were performed out:

⇒ Checked of calculations by spreadsheets
- consistent use of energy balance data (energy statistic questionnaires),
- documented sources,
- use of units,
- strictly defined interfaces between spreadsheets/calculation modules,
- unique structure of sheets which do the same,
- record keeping, use of write protection,
- unique use of formulas, special cases are documented/highlighted,
- quick-control checks for data consistency through all steps of calculation.

⇒ cross-checked from three sources: national statistic and EUROST data
⇒ cross checks with other relevant sectors are performed to avoid double counting or omissions;
⇒ time series consistency
⇒ plausibility checks of dips and jumps.

7.5.5 Category-specific recalculations including explanatory information and justifications

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC category 5.D *Wastewater Treatment and Discharge*.

Table 426 Recalculations done in IPCC category 5.D *Wastewater Treatment and Discharge*

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
5.D	Correction of average protein supply using data from 2nd BUR, FAO and expert judgment	AD	Accuracy

7.5.6 Category-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 427 Planned improvements for IPCC category 5.D Wastewater Treatment and Discharge

<table>
<tr><th>GHG source & sink category</th><th>Planned improvement</th><th colspan="2">Type of improvement</th><th>Priority</th></tr>
<tr><td>5.D</td><td>Investigation on wastewater flow: collection – treatment and discharge pathways and systems
• Urban population (high / low income)
• Rural population</td><td>AD</td><td rowspan="5">Accuracy
Transparency
Comparability
Completeness
Consistency</td><td>High</td></tr>
<tr><td>5.D</td><td>Estimation of amount of wastewater treated
• Urban population (high / low income)
• Rural population</td><td>AD</td><td>High</td></tr>
<tr><td>5.D</td><td>Use of metadata prepared for and submitted to WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP)</td><td>AD</td><td>High</td></tr>
<tr><td>5.D</td><td>Investigation of flow and amount of industrial wastewater</td><td>AD</td><td>High</td></tr>
<tr><td>5.D</td><td>Sludge separation and annual amount of sludge removal that is
• dumped
• applied to soil (agriculture)
• incinerated</td><td>AD</td><td>Medium</td></tr>
</table>

8 Other (IPCC sector 6)

Montenegro does not report any emissions under IPCC sector 6 Other.

9 References

Austria's National Inventory Report 2021 – Submission under the United Nations Framework Convention of Climate Change and under the Kyoto Protocol. Report REP-0724. Umweltbundesamt, Vienna

CANAVEIRA, P., MANSO, S., PELLIS, G., PERUGINI, L., DE ANGELIS, P., NEVES, R., PAPALE, D., PAULINO, J., PEREIRA, T., PINA, A., PITA, G., SANTOS, E., SCARASCIA-MUGNOZZA, G., DOMINGOS, T., AND CHITI, T. (2018): Biomass Data on Cropland and Grassland in the Mediterranean Region. Final Report for Action A4 of Project MediNet.

Available (02 March 2020) on http://www.lifemedinet.com/

EUROPEAN ENVIRONMENT AGENCY - EEA (2019): EMEP/EEA air pollutant emission inventory guidebook 2019. EEA Report No 21/2019. Copenhagen, Denmark.

Available (02 January 2020) on https://www.eea.europa.eu/publications/emep-eea-guidebook-2016

EUROPEAN ENVIRONMENT AGENCY (EEA)(2019): Computer programme to calculate emissions from road transport (COPERT), http:/vergina.eng.auth.gr/mech/lat/copert/copert.htm

FOOD AND AGRICULTURE ORGANIZATION STATISTICS DIVISION - FAOSTAT (1985): Production, Inputs, Emissions – Agriculture, Emissions - Land Use, Forestry. Investment. Rome, Italy.

Available (02 January 2020) on: http://www.fao.org/faostat/en/#home

FOOD AND AGRICULTURE ORGANIZATION - FAO (2001): FAO AGRICULTURE STATISTICAL SYSTEM 2001. Rome, Italy.

Available on 02 January 2020 at: http://www.fao.org/faostat/en/#data

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE – IPCC (1997). IPCC software for the 1996 Guidelines has been updated by the UNFCCC to include the GPG LULUCF.

Available (02 January 2020) on https://unfccc.int/greenhouse-gas-inventory-software-for-non-annex-i-parties-naiis

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE – IPCC (2000). Good Practice Guidance and Uncertianty Management in National Greenhouse Gas Inventories. Penman, J., Kruger, D., Galbally, I., Hiraishi, T., Nyenzi, B., Enmanuel, S., Buendia, L., Hoppaus, R., Martinsen, T., Meijer, J., Miwa, K. and Tanabe, K. (Eds). Intergovernmental Panel on Climate Change (IPCC), IPCC/OECD/IEA/IGES, Hayama, Japan.

Available (02 January 2020) on https://www.ipcc-nggip.iges.or.jp/public/gp/english/index.html

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE – IPCC (2003). Good Practice Guidance for Land Use, land-Use Change and Forestry. Penman, J., Gytarsky, M., Hiraishi, T., Kruger, D., Pipatti, R., Buendia, L., Miwa, K., Ngara, T., Tanabe, K. and Wagner, F. (Eds). Intergovernmental Panel on Climate Change (IPCC), IPCC/IGES, Hayama, Japan.

Available (02 January 2020) on https://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE - IPCC (2014): Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp

Available (02 January 2020) on https://www.ipcc.ch/report/ar5/syr/ and https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE – IPCC (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

Available (02 January 2020) on https://www.ipcc-nggip.iges.or.jp/public/2006gl/

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE – IPCC (2007): IPCC Fourth Assessment Report (AR4). Climate Change 2007 - The Physical Science Basis Contribution of Working Group I to the Fourth Assessment Report of the IPCC. (Table TS.2).

Available (02 January 2020) at: https://www.ipcc.ch/site/assets/uploads/2018/05/ar4_wg1_full_report-1.pdf

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE – IPCC (2014): 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands, Hiraishi, T., Krug, T., Tanabe, K., Srivastava, N., Baasansuren, J., Fukuda, M. and Troxler, T.G. (eds). Published: IPCC, Switzerland.

Available (02 January 2020) on https://www.ipcc-nggip.iges.or.jp/public/wetlands/index.html

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE - IPCC (2018): Global Warming of 1.5°C.An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. Published: IPCC, Switzerland.

Available (02 January 2020) on https://www.ipcc.ch/sr15/

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE – IPCC (2019): 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Calvo Buendia, E., Tanabe, K., Kranjc, A., Baasansuren, J., Fukuda, M., Ngarize S., Osako, A., Pyrozhenko, Y., Shermanau, P. and Federici, S. (eds). Published: IPCC, Switzerland.

Available (02 January 2020) on https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol1.html

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE - IPCC (2019): IPCC Inventory Software User Manual Version 2.69. Compiled by: SPIRIT Inc., Bratislava, Slovak Republic, January 2013. Supervised by: Technical Support Unit of the IPCC Task Force on National Greenhouse Gas Inventories Revised: September 2019 (Version 2.69). Published: IPCC, Switzerland.

Available (02 January 2020) on https://www.ipcc-nggip.iges.or.jp/software/index.html

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE - IPCC (2019): IPCC Emission Factor Database - EFDB. Version 3.0. Supporting material prepared for consideration by the Intergovernmental Panel on Climate Change. Compiled by: SPIRIT Inc., Bratislava, Slovak Republic Supervised by: Technical Support Unit of the IPCC Task Force on National Greenhouse Gas Inventories Published: IPCC, Switzerland.

Available (02 January 2020) on https://www.ipcc-nggip.iges.or.jp/EFDB/main.php

INTERNATIONAL ENERGY AGENCY (IEA) (2019): Gas documentation, Oil documentation, Coal documentation. Paris, France.

Available (02 January 2020) on https://www.iea.org/statistics/resources/documentation/

MONSTAT – Statistical Office of Montenegro (2016): 2016 Statistical Yearbook. Statistical Office of Montenegro, Podgorica, Montenegro. http://monstat.org/eng/publikacije_page.php?id=1402

MONSTAT – Statistical Office of Montenegro (2019): 2019 Statistical Yearbook. Statistical Office of Montenegro, Podgorica, Montenegro. http://www.monstat.org/eng/novosti.php?id=2961

MONSTAT – Statistical Office of Montenegro (2020): 2020 Statistical Yearbook. Statistical Office of Montenegro, Podgorica, Montenegro.

Available (21 January 2021) on http://www.monstat.org/eng/novosti.php?id=2961; http://www.monstat.org/eng/publikacije_page.php?id=1586

MONSTAT – Statistical Office of Montenegro (2021): 2020 Statistical Yearbook. Statistical Office of Montenegro, Podgorica, Montenegro.

Available (30 March 2021) on http://monstat.org/eng/publikacije_page.php?id=1674&pageid=1

MONSTAT – Statistical Office of Montenegro (2022): 2021 Statistical Yearbook. Statistical Office of Montenegro, Podgorica, Montenegro.

MONSTAT – Statistical Office of Montenegro (2021 - 2006): Statistical Yearbook. Statistical Office of Montenegro, Podgorica, Montenegro.

Available (21 January 2021) on http://www.monstat.org/eng/publikacije_page.php?id=196

MONTENEGRO MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT (2013): The first national forest inventory of Montenegro: Final Report. Ministry of Agriculture and Rural Development of Montenegro, Podgorica, Montenegro.

Available (02 March 2020) on https://www.researchgate.net/publication/296561640_The_First_National_Forest_Inventory_of_Montenegro_-_Final_Report/link/5bf12f50299bf1124fdb5d71/download

West, T.O. (2008): Country-level estimates for Carbon distribution in U.S. croplands, 1990-2005. Environmental Science Division, Oak Ridge National Laboratory. http://cdiac.ornl.gov/carbonmanagement/cropcarbon/

10 Units and abbreviations

10.1 Units and abbreviations, and standard equivalents

Unit	Abbreviation	Equivalents	Equivalents
1 tonne of oil equivalent (toe)	1 toe	1 x 10^{10} calories	1 x 10^{10} cal
1 ktoe		41.868 terajoules	41.868 TJ
1 short ton	1 sh t	0.9072 tonne	0.9072 t
1 tonne	1 t	1.1023 short tons	1.1023 sh t
1 kilogram	1 kg	2.2046 pounds	2.2046 lb
1 hectare	1 ha	10^4 square meters	10^4 m^2
1 $calorie_{IT}$	1 cal_{IT}	4.1868 Joules	4.1868 J
1 atmosphere	1 atm	101.325 kilopascal	101.325 kPa
1 gram	1 g	0.002205 pounds	0.00205 lb
1 pound	1 lb	453.6 gram	453.6 g
1 terajoule	1 TJ	2.78 x 10^5 kiloWatt hour	2.78 x 10^5 kWh
1 kilowatt hour	1 kWh	3.6 x 10^6 Joules	3.6 x 10^6 J

Source: 2006 IPCC Guidelines, Volume 1: General Guidance and Reporting, Annex 8A.1: Prefixes, units and abbreviations, standard equivalents

10.2 Derived units

Tons			Grams			Equivalents*				
Multiple	Name	Symbol	Multiple	Name	Symbol	Tonnes (t)	Kilograms (kg)	Grams (g)	US/short tons (ST)†	Imperial/long tons (LT)†
10^0	tonne	t	10^6	megagram	Mg	1 t	1 000 kg	1 million g	1.1023 ST	0.98421 LT
10^3	kilotonne	kt	10^9	gigagram	Gg	1 000 t	1 million kg	1 billion g	1 102.3 ST	984.21 LT
10^6	megatonne	Mt	10^{12}	teragram	Tg	1 million t	1 billion kg	1 trillion g	1.1023 million ST	984,210 LT
10^9	gigatonne	Gt	10^{15}	petagram	Pg	1 billion t	1 trillion kg	1 quadrillion g	1.1023 billion ST	984.21 million LT
10^{12}	teratonne	Tt	10^{18}	exagram	Eg	1 trillion t	1 quadrillion kg	1 quintillion g	1.1023 trillion ST	984.21 billion LT
10^{15}	petatonne	Pt	10^{21}	zettagram	Zg	1 quadrillion t	1 quintillion kg	1 sextillion g	1.1023 quadrillion ST	984.21 trillion LT
10^{18}	exatonne	Et	10^{24}	yottagram	Yg	1 quintillion t	1 sextillion kg	1 septillion g	1.1023 quintillion ST	984.21 quadrillion LT

(*The equivalent units columns use the short scale large-number naming system currently used in most English-language countries, e.g. 1 billion = 1 000 million = 1 000 000 000)

Source: https://en.wikipedia.org/wiki/Tonne

10.3 Prefixes and multiplication factors

Multiplication Factor	Abbreviation	Prefix	Symbol
1 000 000 000 000 000	10^{15}	peta	P
1 000 000 000 000	10^{12}	tera	T
1 000 000 000	10^{9}	giga	G
1 000 000	10^{6}	mega	M
1 000	10^{3}	kilo	k
100	10^{2}	hecto	h
10	10^{1}	deca	da
0.1	10^{-1}	deci	d
0.01	10^{-2}	centi	c
0.001	10^{-3}	milli	m
0.000 001	10^{-6}	micro	µ

Source: 2006 IPCC Guidelines, Volume 1: General Guidance and Reporting, Annex 8A.1: Prefixes, units and abbreviations, standard equivalents

10.4 Chemical formulae

Chemical formula	Gas
C	Carbon
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
H_2	Hydrogen
H_2S	Hydrogen sulphide
N_2O	Nitrous oxide
NO_X	Nitrogen oxides
SO_x	Sulphur oxides
SO_2	Sulphur dioxide
NMVOC	Non-methane volatile organic compound
F-gases	

Source: 2006 IPCC Guidelines, Volume 1: General Guidance and Reporting, Annex 8A.1: Prefixes, units and abbreviations, standard equivalents