National Inventory Report 2021 of Montenegro

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

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1.1 Background information on greenhouse gas (GHG) inventory and climate change

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.

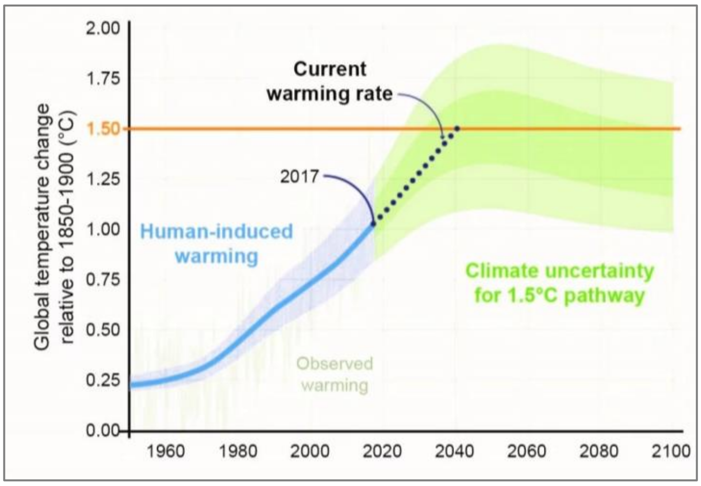


Figure 1 Human-induced warming reached approximately 1°C above pre-industrial levels in 2018.

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.

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

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

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.

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

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 Ocober 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.

- 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.

  Some of the key aspects of the Agreement are set out below:

Article 2	Long-term temperature goal
Article 4	Global peaking and 'climate neutrality'
Article 4	Mitigation
Article5	Sinks and reservoirs
Article 7	Adaptation
Article 8	Loss and damage
Articles 9, 10 & 11	Finance, technology and capacity-building support
Article 12	Climate change education, training as well as public awareness, participation and access to information
Article 13	**Transparency**
Article 15	implementation and compliance
Article 14	Global Stocktake

In the following tables are presented

- the Convention, Kyoto Protocol and Paris Agreement with the dates of entry into force and the current status.
- the submissions – reports and data sets – under the UN Framework Convention on Climate Change.

[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

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)

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)	GHG inventory (tables) as part of NC and BUR - *(Time series) based on*		National Inventory Report (NIR)
				1996 revised IPCC GL & IPCC GPG	2006 IPCC Guidelines	
NC1 = INC	12 Oct 2010[10]			X (2005) UNFCCC software		
NC2	28 May 2015[11]			NC (1990-2011) X (2013) UNFCCC software		
NC3	12 Oct 2020[12]				NC (1990-2017) IPCC software	
NC4	Planned for 2025					
1st BUR		13 Jan 2016[13]			BUR (1990 – 2013) IPCC software	
2nd BUR		3 May 2019[14]			BUR (1990 – 2015) IPCC software	
3nd BUR		End 2021			Excel-based calculation tool	This report: NIR 2021

[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

[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

UNFCCC Reporting obligation	National Communication (NC)	Biennial Update Report (BUR)	Biennial transparency report (BTR)	GHG inventory (tables) as part of NC and BUR - *(Time series) based on*		National Inventory Report (NIR)
				1996 revised IPCC GL & IPCC GPG	2006 IPCC Guidelines	
4nd BUR		Planned for end 2023				
First BTR			Planned for 2024			

UNFCCC Reporting obligation	Nationally Determined Contribution (INDC) / Nationally Determined Contribution (NDC)
INDC	September 2015[15]
NDC	21 December 2017[Error! Bookmark not defined.]
Updated NDC	25 June 2021[16]

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 the Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention, section III[17], 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 Inventories. The First National Communication (INC) was prepared for the year 2010, the Second National Communication (SNC) was prepared for the year 2015. The First Biennial Update Report (1st BUR) was submitted in 2016 and covers the years 1990 to 2013. The Second Biennial Update Report (2nd BUR) was submitted in 2019 and covers the

[15] Available (08 January 2020) on https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Montenegro%20First/INDCSubmission_%20Montenegro.pdf
[16] Available (28 June 2021) on https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Montenegro%20First/Updated%20NDC%20for%20Montenegro.pdf
[17] Available (30 January 2019) on FCCC/CP/2002/7/Add.2, section III., paragraph 6.

years 1990 to 2015. The Third National Communication (3rd NC) was submitted in 2020 and covers the years 1990 to 2017. The Third Biennial Update Report (3rd BUR) was submitted in 2021 and covers the years 1990 to 2019.

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.

(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) 2021’, covering the period 1990 to 2019.

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 Nature and Environmental Protection Agency (NEPA) is the Single National Entity (SNE) responsible for the preparation of emission inventories. NEPA has the overall responsibility and submits the inventory report to

- the United Nations Framework Convention on Climate Change (UNFCCC), and
- the UNECE[18] Convention on Long-range Transboundary Air Pollution (CLRTAP).

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

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

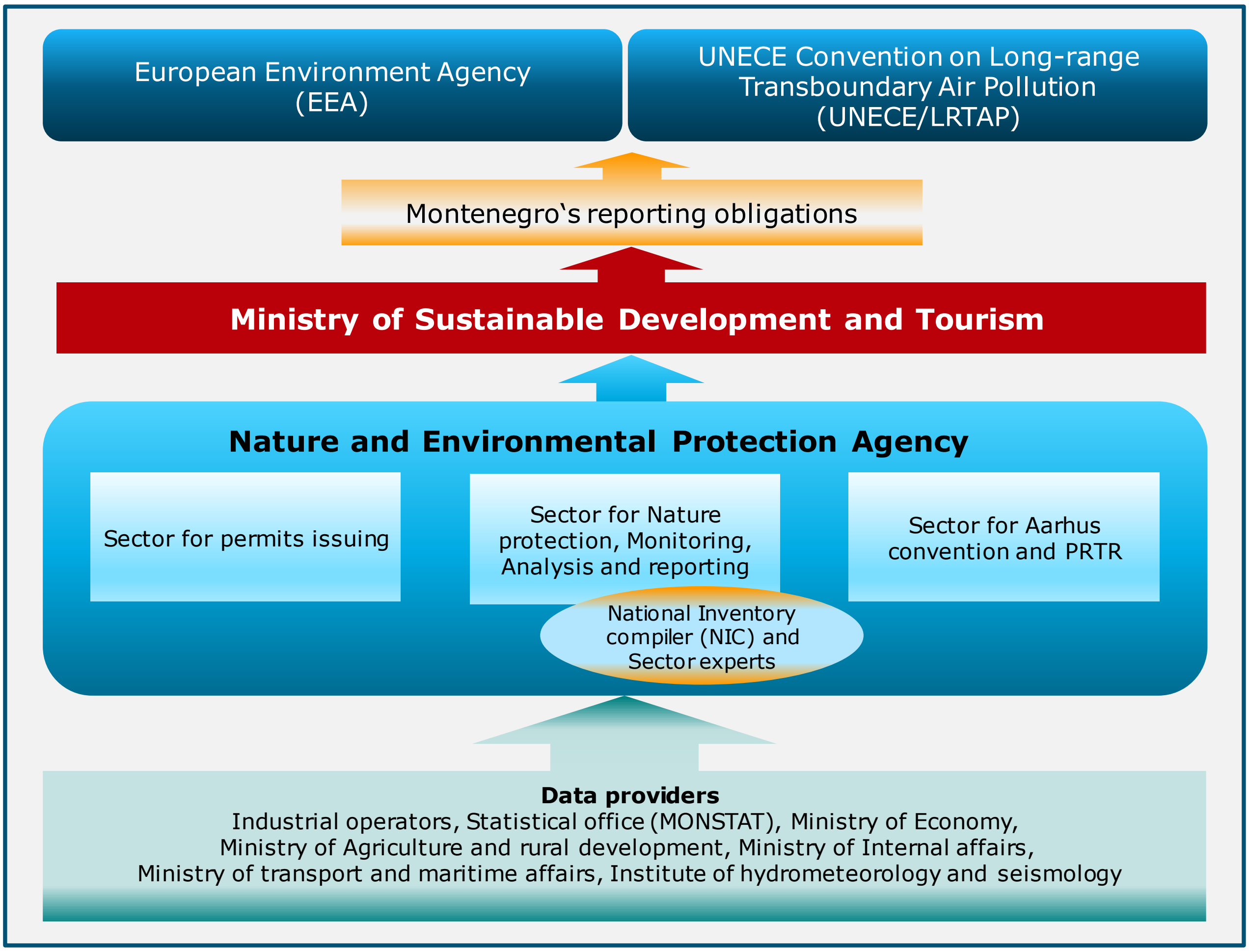


Figure 2 National System

Within the NEPA, 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 Economy,
- Ministry of Agriculture and rural development,
- Ministry of Internal affairs,
- Ministry of transport and maritime affairs,
- Institute of hydrometeorology and seismology.

NEPA has signed memorandum of understanding on mutual cooperation data with the 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.

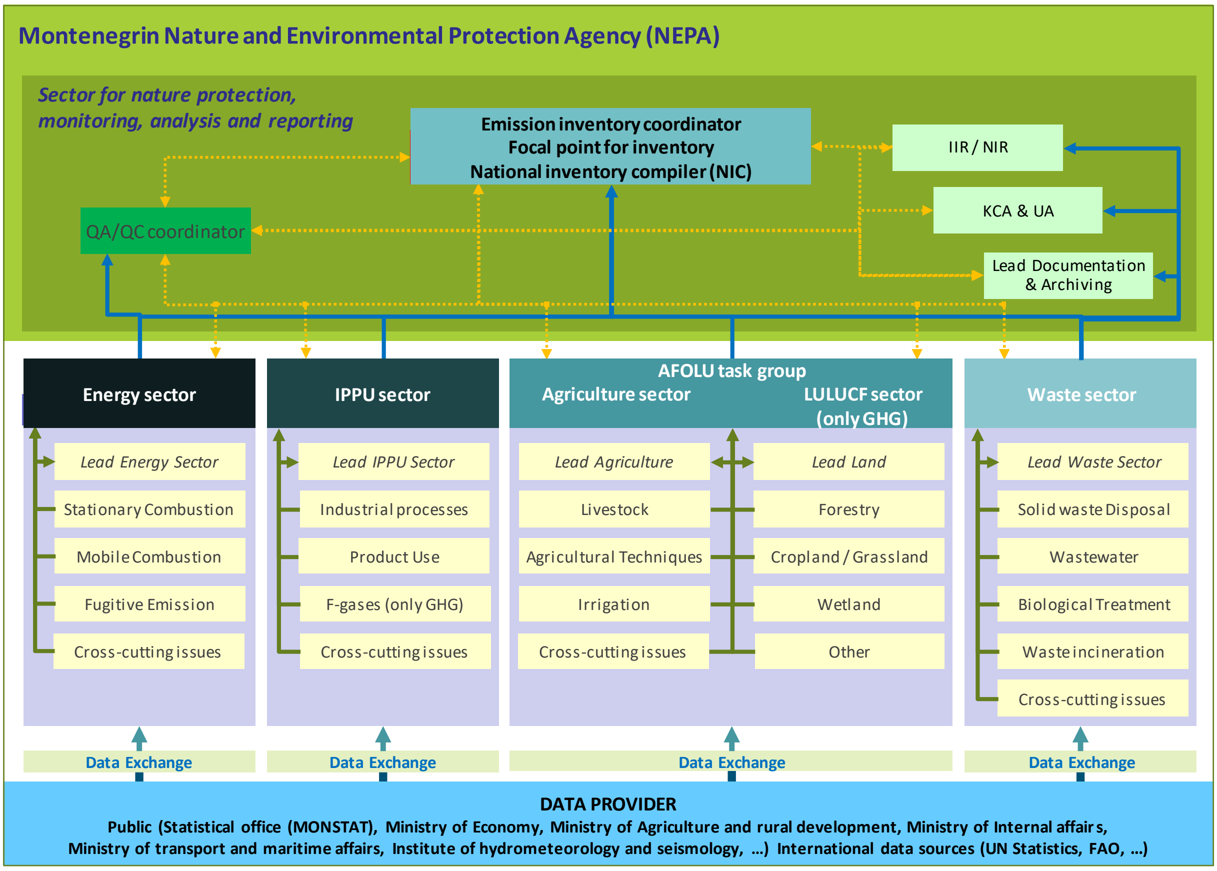


Figure 3 National system - detailed

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 or Non-Annex I Tables																													
National Inventory report (NIR)																													
EU Greenhouse gas Monitoring Mechanism Regulation (MMR)*																													
Data – CRF																													
National Inventory report (NIR)																													
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 2019 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)[19];

  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[20])

  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 – 2019 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'[21] 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:

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

[20] 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

[21] 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.

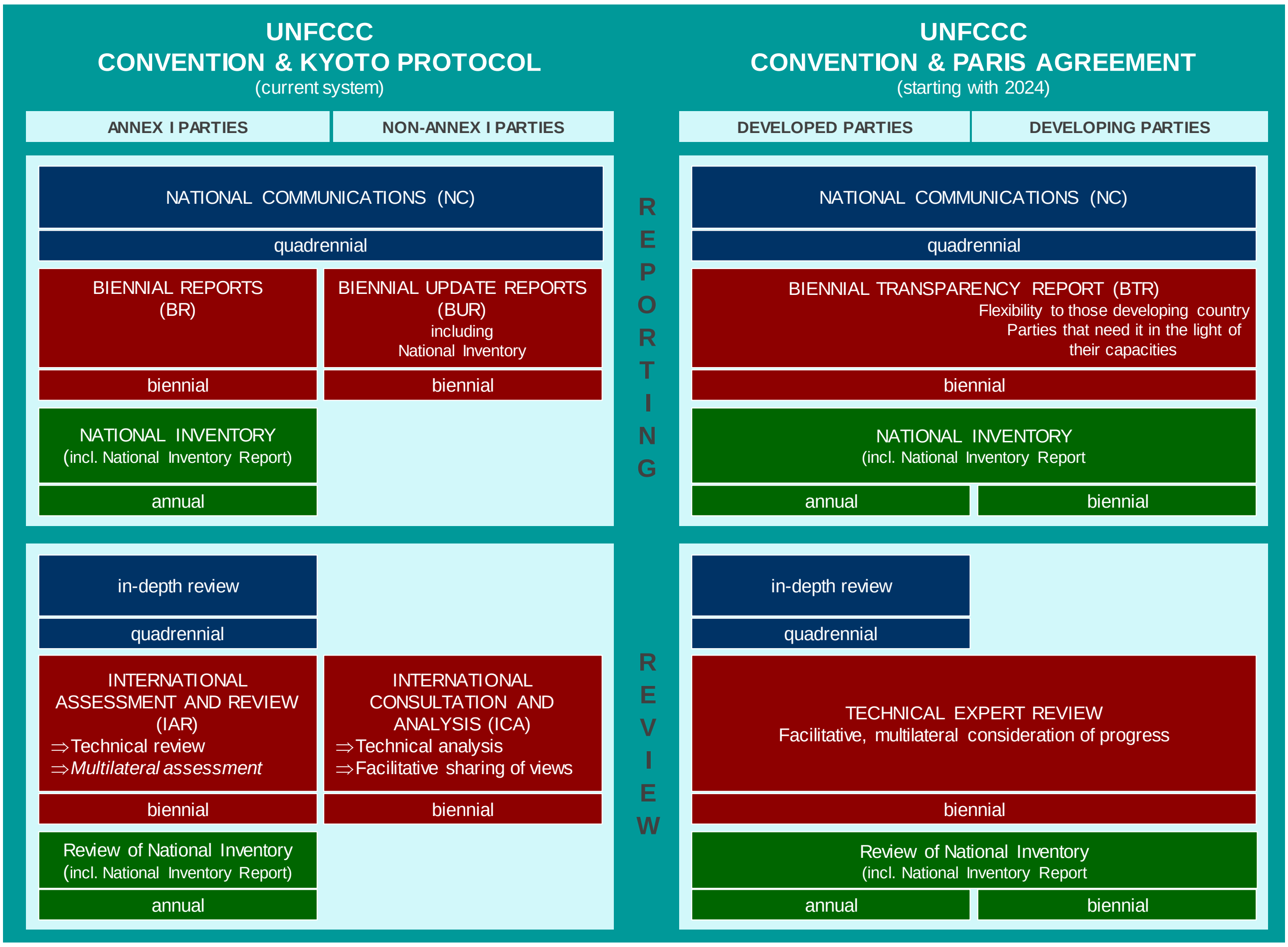


Figure 4 Comparison of the current reporting and review obligations and the reporting and review obligations under the Paris Agreement (current status of negotiations).

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 sector the documentation of the methodology and actual emission calculation (e.g. 1A2m_OtherTool_MNE.xlsx) includes:

- Description (source/sink category, emissions, key source, completeness, uncertainty),
- Methodology (decision tree).
- „Logbook” (who did what and when) (see Table 15 National Inventory preparation schedule / guidance)
- References for activity data, emission factors and/or emissions, respectively,
- Documentation of assumptions, sources of data and information, expert judgements etc. to allow full reproduction and understanding of choices made,
- Recalculations,
- Planned improvements,
- QC activities.

Table 4 ReadMe of emission calculation sheets

	A	B	C	D	E	F	G
1		This calculation tool is prepared by	umweltbundesamt®	© Umweltbundesamt GmbH (Envionmental Agency Austria) The Inventory Tool is Umweltbundesamt copyright may not be modified or reproduced without permission from Umweltbundesamt.			
2		Integrated inventory for Greenhouse gas (GHG) and Air pollutant emissio		Feedback and questions can be sent to **trainingcenter@umweltbundesamt.at**			
3		project-name:	**Integrated inventory for GHG and Air pollutants Emissions**				
4		project-number					
5		prepared by:	Traute Köther				
6		Last changes	11.03.2020				
7		QM-link:					
8		file name:	**1A2a_InventoryTool_MNE.xls**	*older versions always with date; e.g. 1A2a_InventoryTool_MNE_20200214.xlsx*			
9		status	**in progress**	*drop down*			
10		timeseries	1990-2018				
11		IPCC-Sources:	1 A 2 a - Manufacturing Industries and Construction - Iron and Steel				
12		file linked to:	MNE_EnergyBalance_1990-2018-v1.xlsx MNE_NCV-data.xlsx				
13		description/content:					
14							
15		**Sheet name**	**Content**	**Content description**	**Susanne2018**	**IPCC**	**Other remarks**
16					Password		
17		ChangeLog	Information regarding updating / modification / changes	*Information*	*unprotected worksheet*		
18		worksheet_1A	Activity data for transfer to IPCC software	*Activity data*	*protected worksheet*	1.A.2.a	
19		1A2a_CRT	**GHG** emissions (automatised) for CRT reporting	*(intermediate) **result***	*protected worksheet*	1.A.2.a	CRT - Common Reporting Tables
20		1A2a_NFR	**Air Pollutants** emissions (automatised) for NFR	*(intermediate) **result***	*protected worksheet*	1.A.2.a	Nomenclature Format for Reporting (NFR) tables
21		**1A2a_AD**	**Calculation of emissions by fuel and GHG / Pollutants**	***Input data***	*unprotected worksheet but occasional protected cells*	1.A.2.a	
22		Uncertainty	Information related to Uncertainties for transfer to Uncertainty_MNE.xlsx NIR sectoral Chapter	Uncertainty data	*unprotected worksheet*	1.A.2.a	Uncertainty_MNE.xlsx NIR sectoral Chapter
23		PlannedImprovements	Information related to Planned improvements for transfer to NIR sectoral Chapter for transfer to Chapter Recalculation & Planned	Planned improvements	*unprotected worksheet*	1.A.2.a	
24		Recalculation	Information related to Recalculation for transfer to NIR sectoral Chapter for transfer to Chapter Recalculation & Planned improvements	Recalculation	*unprotected worksheet*	1.A.2.a	
25		EF IPCC	Emission factors of 2006 IPCC GL for sector 1 A	*Emission factors*	*protected worksheet*		
26		EF EMEP-EEA 1A1	Emission factors of EMEP/EEA GB for sector 1.A.2	*Emission factors*	*protected worksheet*		
27		ExcelSuport	Excel support regarding used formulars	*Information*	*unprotected worksheet*		
28		Matrix_EBxCRF	Correspondance of activities of Energy Balance (IEA/EUROSTAT Questionnaire) and CRF sub categories	*Information*	*unprotected worksheet*		
29		DropDown&Definition	List for DropDown and Definitions of sectors and fuels	*Information*	*protected worksheet*		

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 takes place on a central server within the folder 'GHG inventory' and relevant subfolders. The 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.

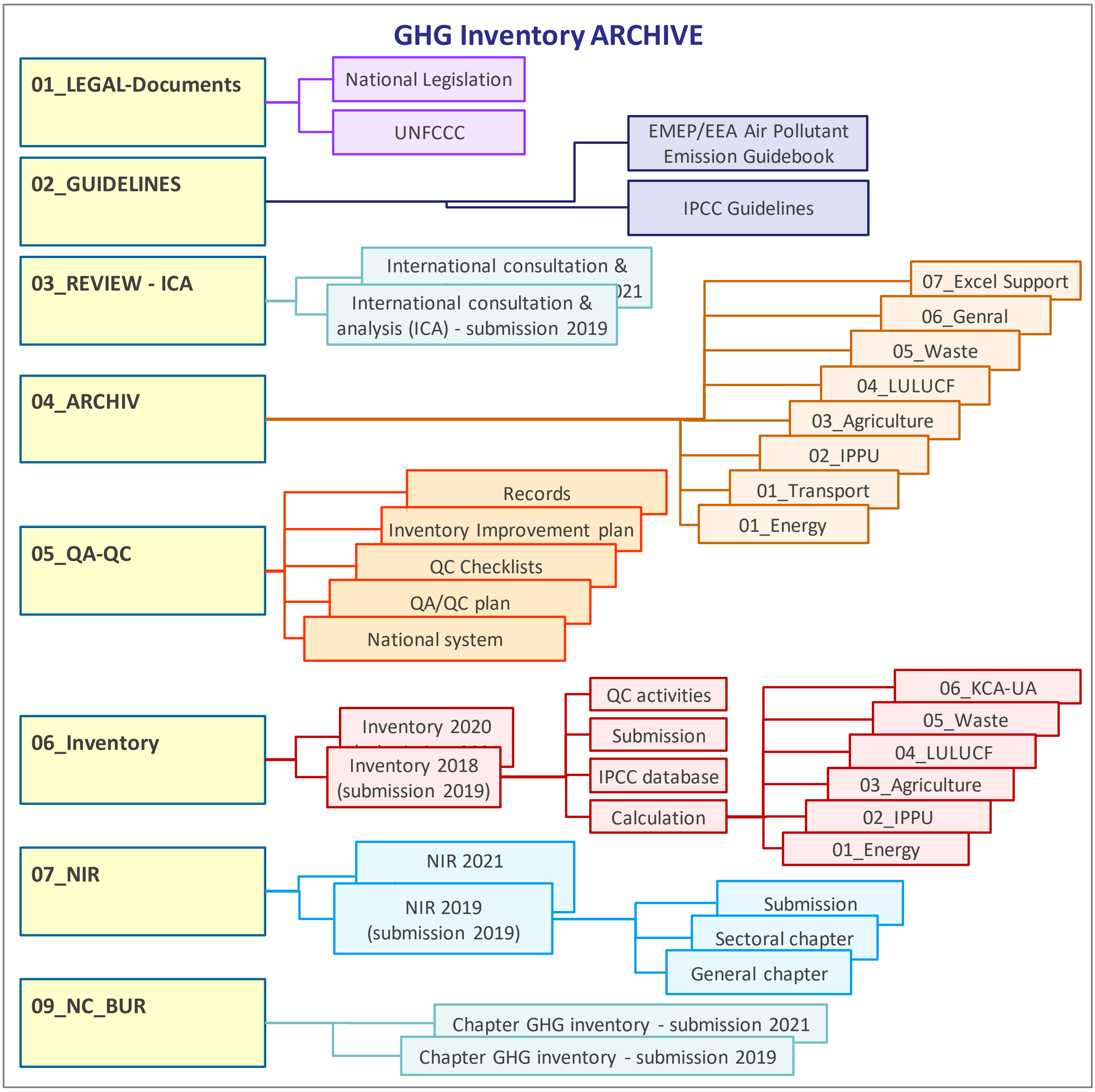


Figure 5 GHG Inventory Archive

1.2.4 Processes for official consideration and approval of inventory

The processes for official consideration and approval of inventory needs to be further outlined.

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. 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 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 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.

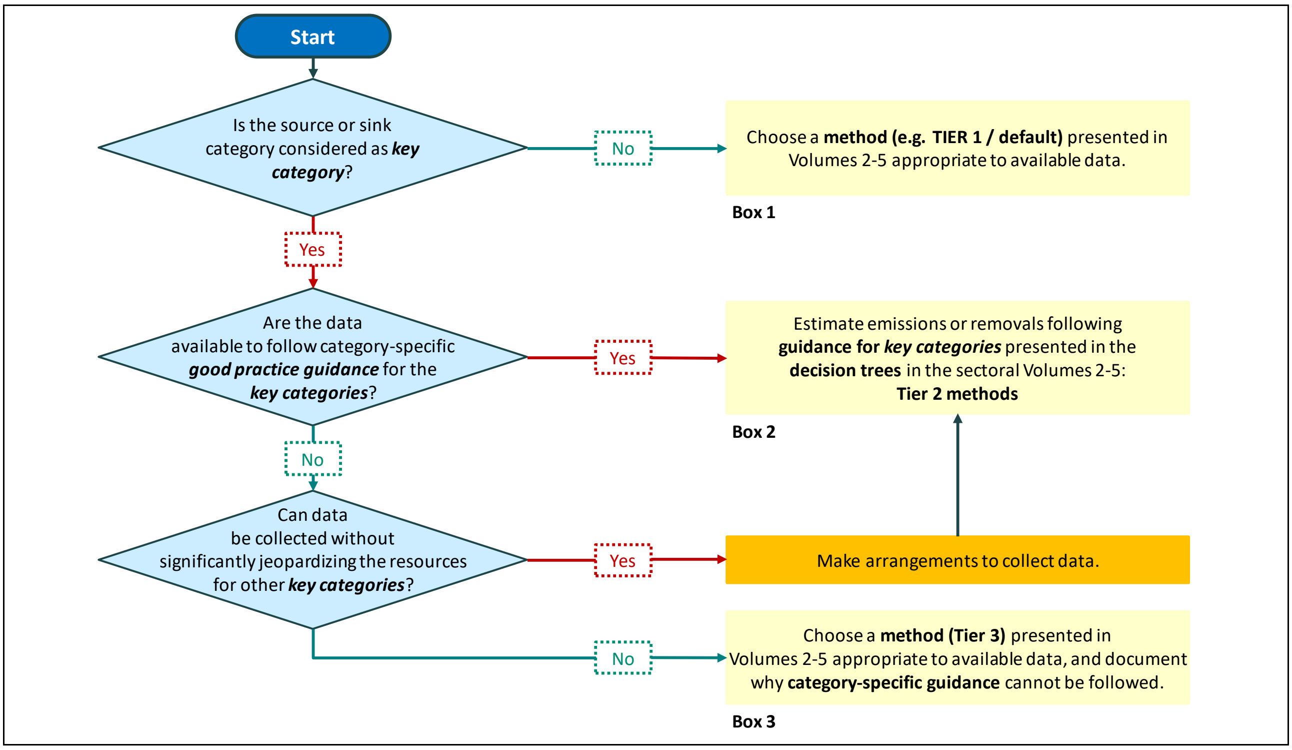


Figure 6 Decision Tree to choose a Good Practice method

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.

Table 5 Summary report for methods and emission factors used and source of activity data

Greenhouse gas source and sink categories	CO_2			CH_4			N_2O		
	Method applied	Emission factor	Activity data	Emission factor	Emission factor	Activity data	Emission factor	Emission factor	Activity data
1. Energy									
A. Fuel combustion									
1. Energy industries	T1	D	PS/Q/MONSTAT	T1	D	PS/Q/MONSTAT	T1	D	PS/Q/MONSTAT
2. Manufacturing industries and construction	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
3. Transport	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
4. Other sectors	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
5. Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NE	NE
B. Fugitive emissions from fuels									
1. Solid fuels	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
2. Oil and natural gas	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
2. Industrial processes process and Product Use (IPPU)									
A. Mineral products	T1	CS	MONSTAT						
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal production	T1	D	PS/MONSTAT	NO	NO	NO	NO	NO	NO
D. Other production	NE	NE	NE				NE	NE	NE
E. Production of halocarbons and SF6	NO	NO	NO						
F. Consumption of halocarbons and SF6	NO	NO	NO						
G. Other Product Manufacture and Use	NO	NO	NO	NO	NO	NO	NO	NO	NO
H. Other	T2	CS	MONSTAT	NO	NO	NO	NO	NO	NO
3. Agriculture									
A. Enteric fermentation				T1	D/CS	MONSTAT /CS/FAO			
B. Manure management				T1	D/CS	MONSTAT /CS/FAO	T1	D	MONSTAT /CS/FAO
C. Rice cultivation				NO	NO	MONSTAT /FAO			
D. Agricultural soils				T1	D	MONSTAT /FAO	T1	T1	MONSTAT /CS/FAO

Greenhouse gas source and sink categories	CO_2			CH_4			N_2O		
	Method applied	Emission factor	Activity data	Emission factor	Emission factor	Activity data	Emission factor	Emission factor	Activity data
E. Prescribed burning of savannahs				NO	NO	NO	NO	NO	NO
F. Field burning of agricultural residues				T1	D	MONSTAT	T1	D	MONSTAT
G. Other (Urea application)	T1	D	MONSTAT/FAO						
4. Land-use, Land-use change and forestry (LULUCF)									
Land-use, Land-use change and forestry (LULUCF)	T1	D/CS	MONSTAT EPA	T1	D/CS	MONSTAT EPA	T1	D/CS	MONSTAT EPA
5. Waste									
A. Solid waste disposal on land				T1	D	MONSTAT/CS			
B. Other - Composting				NE	NE	NE	NE	NE	NE
C. Waste incineration	NE	NE	NE	NE	NE	NE	NE	NE	NE
D. Waste-water handling				T1	D	MONSTAT	T1	D	MONSTAT
6. Other									
Other	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items									
International bunkers									
Aviation	T1	D	MONSTAT	T1	D	MONSTAT	T1	D	MONSTAT
Marine	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 emissions from biomass									
CO_2 emissions from biomass	T1	D	MONSTAT /CS/FAO						

Notation keys	
NA	Not applicable
NO	Not occurring
NE	Not estimated
IE	Included elsewhere
C	Confidential

Notation keys to specify the method applied			
D	IPCC default	**CS**	Country Specific
T1	IPCC Tier 1	**CR**	CORINAIR
T1a, T1b, T1c	IPCC Tier 1a, Tier 1b and Tier 1c, respectively	**RA**	Reference Approach
T2	IPCC Tier 2	**OTH**	Other
T3	IPCC Tier 3	**M**	Model

Notation keys to specify the emission factor used	
D	IPCC default
CS	Country specific
PS	Plant specific
OTH	Other
M	Model

Notation keys to specify the activity data used			
Q	Specific Questionnaire	**PS**	Plant specific
MONSTAT	Statistical Office of Montenegro	**EJ**	Expert Judgement
UNSD	United Nations Statistics Division (UNSD)		
FAO	FAO Statistics Division (FAOSTAT)		

Greenhouse gas source and sink categories	HFC			PFC			SF_6		
	Method applied	Emission factor	Activity data	Emission factor	Emission factor	Activity data	Emission factor	Emission factor	Activity data
1. Energy									
2. Industrial processes process and Product Use (IPPU)									
A. Mineral products									
B. Chemical industry									
C. Metal production	NO	NO	NO	T2	D	PS/MONSTAT	NO	NO	NO
D. Other production									
E. Production of halocarbons and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	D	D	MONSTAT/NEPA	D	D	MONSTAT/NEPA	D	D	MONSTAT/NEPA
G. Other Product Manufacture and Use									
H. Other									
3. Agriculture									
4. Land-use, Land-use change and forestry (LULUCF)									
5. Waste									
6. Other									

Notation keys	
NA	Not applicable
NO	Not occurring
NE	Not estimated
IE	Included elsewhere
C	Confidential

Notation keys to specify the method applied			
D	IPCC default	**CS**	Country Specific
T1	IPCC Tier 1	**CR**	CORINAIR
T1a, T1b, T1c	IPCC Tier 1a, Tier 1b and Tier 1c, respectively	**RA**	Reference Approach
T2	IPCC Tier 2	**OTH**	Other
T3	IPCC Tier 3	**M**	Model

Notation keys to specify the emission factor used	
D	IPCC default
CS	Country specific
PS	Plant specific
OTH	Other
M	Model

Notation keys to specify the activity data used			
Q	Specific Questionnaire	**PS**	Plant specific
MONSTAT	Statistical Office of Montenegro	**EJ**	Expert Judgement
UNSD	United Nations Statistics Division (UNSD)		
FAO	FAO Statistics Division (FAOSTAT)		

1.4 Brief description of key categories

The identification of key categories (KCA) is prepared in accordance with 2006 IPCC Guidelines[22]. 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:

Lx,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

[22] 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)

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

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)
$\lvert Ex,0 \rvert$	= 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

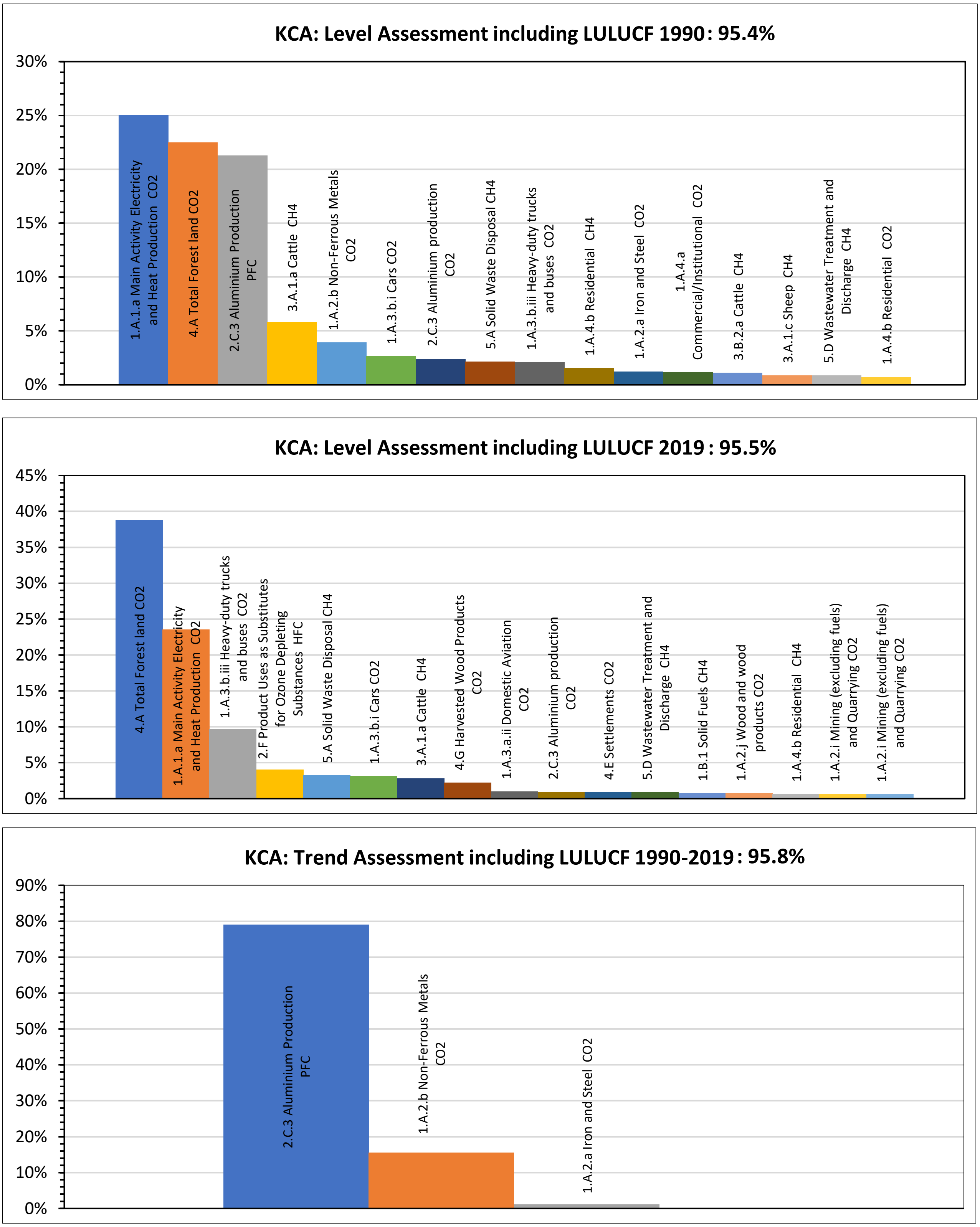


Figure 7 Key Categories including LULUCF

Table 6 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			
1.A.1.a	Main Activity Electricity and Heat Production	CO_2	1 754	1 754	25,0%	25,0%
4.A	Total Forest land	CO_2	-1 578	-1 578	22,5%	47,5%
2.C.3	Aluminium Production	PFC	1 491	1 491	21,3%	68,8%
3.A.1.a	Cattle	CH_4	407	407	5,8%	74,6%
1.A.2.b	Non-Ferrous Metals	CO_2	274	274	3,9%	78,5%
1.A.3.b.i	Cars	CO_2	184	184	2,6%	81,1%
2.C.3	Aluminium production	CO_2	169	169	2,4%	83,5%
5.A	Solid Waste Disposal	CH_4	150	150	2,1%	85,7%
1.A.3.b.iii	Heavy-duty trucks and buses	CO_2	145	145	2,1%	87,8%
1.A.4.b	Residential	CH_4	109	109	1,6%	89,3%
1.A.2.a	Iron and Steel	CO_2	86	86	1,2%	90,5%
1.A.4.a	Commercial/Institutional	CO_2	81	81	1,2%	91,7%
3.B.2.a	Cattle	CH_4	78	78	1,1%	92,8%
3.A.1.c	Sheep	CH_4	61	61	0,9%	93,7%
5.D	Wastewater Treatment and Discharge	CH_4	60	60	0,9%	94,5%
1.A.4.b	Residential	CO_2	51	51	0,7%	95,3%

Table 7 Level Assessment: Key categories including LULUCF 2019

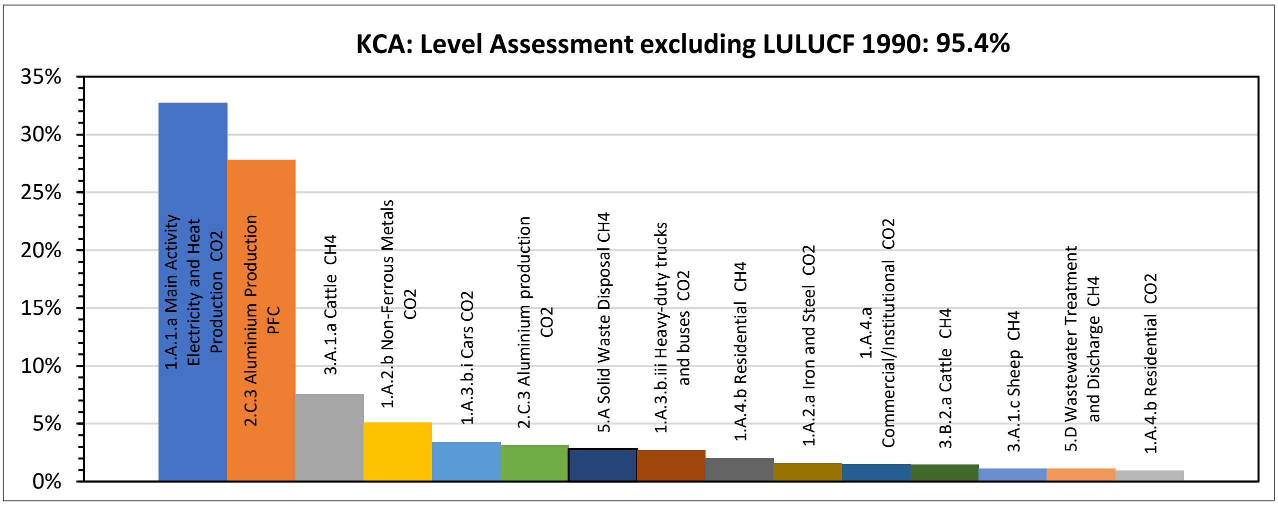
Level Assessment - 2019		GHG	Year 2019 Estimate Ex,t	Absolute Value of Year 2019 Estimate Ex,t	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
IPCC Code	IPCC Category		Gg CO_2-equivalent			
4.A	Total Forest land	CO_2	-2 428	2 428	38,8%	38,8%
1.A.1.a	Main Activity Electricity and Heat Production	CO_2	1 474	1 474	23,5%	62,3%
1.A.3.b.iii	Heavy-duty trucks and buses	CO_2	604	604	9,6%	72,0%
2.F	Product Uses as Substitutes for Ozone Depleting Substances	HFC	252	252	4,0%	76,0%
5.A	Solid Waste Disposal	CH_4	205	205	3,3%	79,3%
1.A.3.b.i	Cars	CO_2	195	195	3,1%	82,4%
3.A.1.a	Cattle	CH_4	177	177	2,8%	85,2%
4.G	Harvested Wood Products	CO_2	-140	140	2,2%	87,4%
1.A.3.a.ii	Domestic Aviation	CO_2	64	64	1,0%	88,5%
2.C.3	Aluminium production	CO_2	58	58	0,9%	89,4%
4.E	Settlements	CO_2	57	57	0,9%	90,3%
5.D	Wastewater Treatment and Discharge	CH_4	55	55	0,9%	91,2%

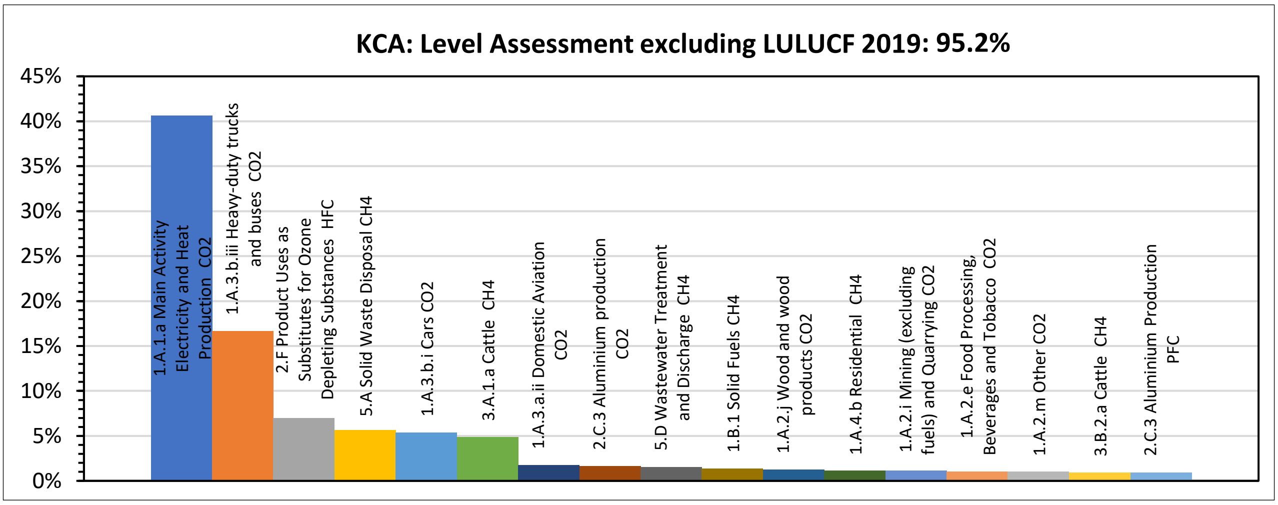
Level Assessment - 2019		GHG	Year 2019 Estimate Ex,t	Absolute Value of Year 2019 Estimate Ex,t	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
IPCC Code	IPCC Category		Gg CO_2-equivalent			
1.B.1	Solid Fuels	CH_4	49	49	0,8%	92,0%
1.A.2.j	Wood and wood products	CO_2	46	46	0,7%	92,7%
1.A.4.b	Residential	CH_4	41	41	0,7%	93,4%
1.A.2.i	Mining (excluding fuels) and Quarrying	CO_2	41	41	0,6%	94,0%

Table 8 Trend Assessment: Key categories including LULUCF 2019

Trend Assessment		GHG	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2018) 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	34	9,073	79,0%	79,0%
1.A.2.b	Non-Ferrous Metals	CO_2	274	6	1,787	15,6%	94,6%
1.A.2.a	Iron and Steel	CO_2	86	7	0,132	1,2%	95,8%

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





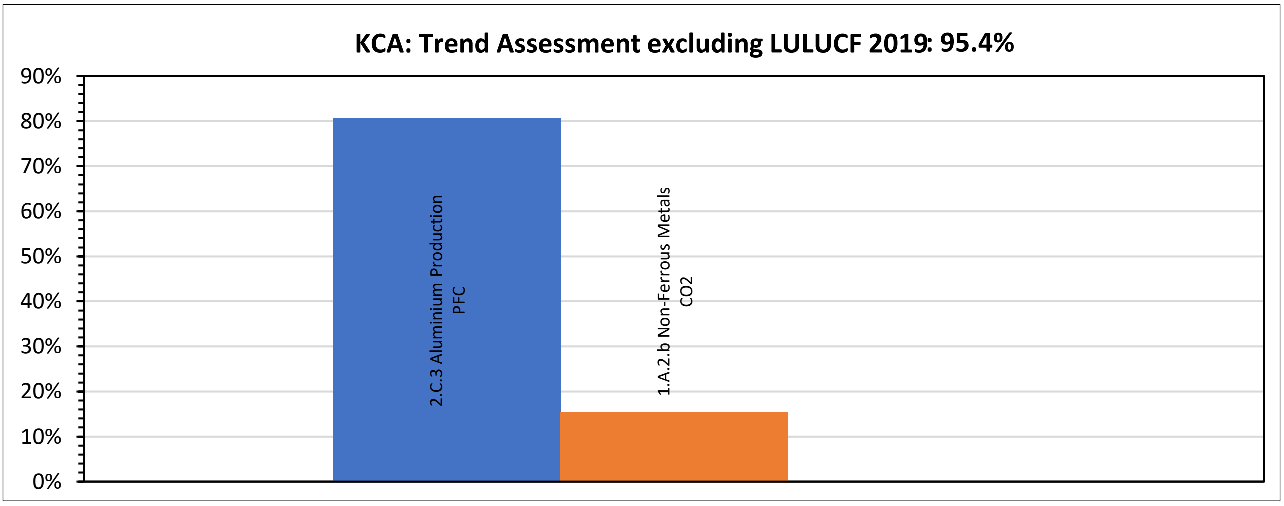


Figure 8 Key Categories without LULUCF

Table 9 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		
1.A.1.a	Main Activity Electricity and Heat Production	CO_2	1 754	32,7%	32,7%
2.C.3	Aluminium Production	PFC	1 491	27,8%	60,6%
3.A.1.a	Cattle	CH_4	407	7,6%	68,2%
1.A.2.b	Non-Ferrous Metals	CO_2	274	5,1%	73,3%
1.A.3.b.i	Cars	CO_2	184	3,4%	76,7%
2.C.3	Aluminium production	CO_2	169	3,1%	79,9%
5.A	Solid Waste Disposal	CH_4	150	2,8%	82,7%
1.A.3.b.iii	Heavy-duty trucks and buses	CO_2	145	2,7%	85,4%
1.A.4.b	Residential	CH_4	109	2,0%	87,4%
1.A.2.a	Iron and Steel	CO_2	86	1,6%	89,0%
1.A.4.a	Commercial/Institutional	CO_2	81	1,5%	90,5%
3.B.2.a	Cattle	CH_4	78	1,5%	92,0%
3.A.1.c	Sheep	CH_4	61	1,1%	93,1%
5.D	Wastewater Treatment and Discharge	CH_4	60	1,1%	94,2%
1.A.4.b	Residential	CO_2	51	0,9%	95,2%

Table 10 Level Assessment: Key categories without LULUCF 2019

Level Assessment - 2019		GHG	Year 2019 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	Main Activity Electricity and Heat Production	CO_2	1 474	40,6%	40,6%
1.A.3.b.iii	Heavy-duty trucks and buses	CO_2	604	16,7%	57,3%
2.F	Product Uses as Substitutes for ODS	HFC	252	6,9%	64,2%
5.A	Solid Waste Disposal	CH_4	205	5,6%	69,9%
1.A.3.b.i	Cars	CO_2	195	5,4%	75,3%
3.A.1.a	Cattle	CH_4	177	4,9%	80,1%
1.A.3.a.ii	Domestic Aviation	CO_2	64	1,8%	81,9%
2.C.3	Aluminium production	CO_2	58	1,6%	83,5%
5.D	Wastewater Treatment and Discharge	CH_4	55	1,5%	85,0%
1.B.1	Solid Fuels	CH_4	49	1,3%	86,4%
1.A.2.j	Wood and wood products	CO_2	46	1,3%	87,7%
1.A.4.b	Residential	CH_4	41	1,1%	88,8%
1.A.2.i	Mining (excluding fuels) and Quarrying	CO_2	41	1,1%	89,9%
1.A.2.e	Food Processing, Beverages and Tobacco	CO_2	37	1,0%	90,9%
1.A.2.m	Other	CO_2	36	1,0%	91,9%
3.B.2.a	Cattle	CH_4	34	0,9%	92,9%
2.C.3	Aluminium Production	PFC	34	0,9%	93,8%
1.A.4.a	Commercial/Institutional	CO_2	32	0,9%	94,7%

Level Assessment - 2019		GHG	Year 2019 Estimate Ex,t	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
IPCC Code	IPCC Category		Gg CO_2-equivalent		
2.D.1	Lubricant Use	CO_2	29	0,8%	95,5%

Table 11 Trend Assessment: Key categories without LULUCF 2019

Trend Assessment		GHG	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2019) 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	34	11,797	80,6%	80,6%
1.A.2.b	Non-Ferrous Metals	CO_2	274	6	2,255	15,4%	96,0%

1.4.6 Ranking of Key Categories

Table 12 Tier 1 - KCA: Ranking including LULUCF

IPCC Code	IPCC Category	GHG	Tier 1 Level Assessment 1990	Tier 1 Level Assessment 2019	Tier 1 Trend Assessment 1990-2019	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2019) Estimate Ex,t
1.A.1.a	Main Activity Electricity and Heat Production	CO_2	1	2		1 754	1 474
1.A.2.a	Iron and Steel	CO_2	11		3	86	7
1.A.2.b	Non-Ferrous Metals	CO_2	5		2	274	6
1.A.2.i	Mining (excluding fuels) and Quarrying	CO_2		16		NO	41
1.A.2.j	Wood and wood products	CO_2		14		NO	46
1.A.2.m	Other	CO_2				22	36
1.A.3.a.ii	Domestic Aviation	CO_2		9		10	64
1.A.3.b.i	Cars	CO_2	6	6		184	195
1.A.3.b.iii	Heavy-duty trucks and buses	CO_2	9	3		145	604
1.A.4.a	Commercial/Institutional	CO_2	12			81	32
1.A.4.b	Residential	CH_4	10	15		109	41
1.A.4.b	Residential	CO_2	16			51	13
1.B.1	Solid Fuels	CH_4		13		47	49
2.C.3	Aluminium Production	PFC	3		1	1 491	34
2.C.3	Aluminium production	CO_2	7	10		169	58
2.F	Product Uses as Substitutes for Ozone Depleting Substances	HFC		4		NO	252
3.A.1.a	Cattle	CH_4	4	7		407	177
3.B.2.a	Cattle	CH_4	13			78	34
3.B.2.h	Swine	CH_4				2	2
4.A	Total Forest land	CO_2	2	1		-1 578	-2 428
4.E	Settlements	CO_2		11		20	57

IPCC Code	IPCC Category	GHG	Tier 1 Level Assessment 1990	Tier 1 Level Assesment 2019	Tier 1 Trend Assessment 1990-2019	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2019) Estimate Ex,t
4.G	Harvested Wood Products	CO_2		8		-43	-140
5.A	Solid Waste Disposal	CH_4	8	5		150	205

Table 13 Tier 1 - KCA: Ranking without LULUCF

IPCC Code	IPCC Category	GHG	Tier 1 Level Assessment 1990	Tier 1 Level Assesment 2019	Tier 1 Trend Assessment 1990-2019	Base Year (1990) Estimate $E_{x,0}$	Latest Year (2019) Estimate Ex,t
1.A.1.a	Main Activity Electricity and Heat Production	CO_2	1	1		1 754	1 474
1.A.2.a	Iron and Steel	CO_2	10			86	7
1.A.2.b	Non-Ferrous Metals	CO_2	4		2	274	6
1.A.2.e	Food Processing, Beverages and Tobacco	CO_2		14		5	37
1.A.2.i	Mining (excluding fuels) and Quarrying	CO_2		13		NO	41
1.A.2.j	Wood and wood products	CO_2		11		NO	46
1.A.2.m	Other	CO_2		15		22	36
1.A.3.a.ii	Domestic Aviation	CO_2		7		10	64
1.A.3.b.i	Cars	CO_2	5	5		184	195
1.A.3.b.iii	Heavy-duty trucks and buses	CO_2	8	2		145	604
1.A.4.a	Commercial/Institutional	CO_2	11	18		81	32
1.A.4.b	Residential	CH_4	9	12		109	41
1.A.4.b	Residential	CO_2	15			51	13
1.B.1	Solid Fuels	CH_4		10		47	49
2.C.3	Aluminium Production	PFC	2	17	1	1 491	34
2.C.3	Aluminium production	CO_2	6	8		169	58
2.D.1	Lubricant Use	CO_2		19		3	29
2.F	Product Uses as Substitutes for Ozone Depleting Substances	HFC		3		NO	252
3.A.1.a	Cattle	CH_4	3	6		407	177
3.B.2.a	Cattle	CH_4	12	16		78	34
3.B.2.h	Swine	CH_4				2	2
5.A	Solid Waste Disposal	CH_4	7	4		150	205

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 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.

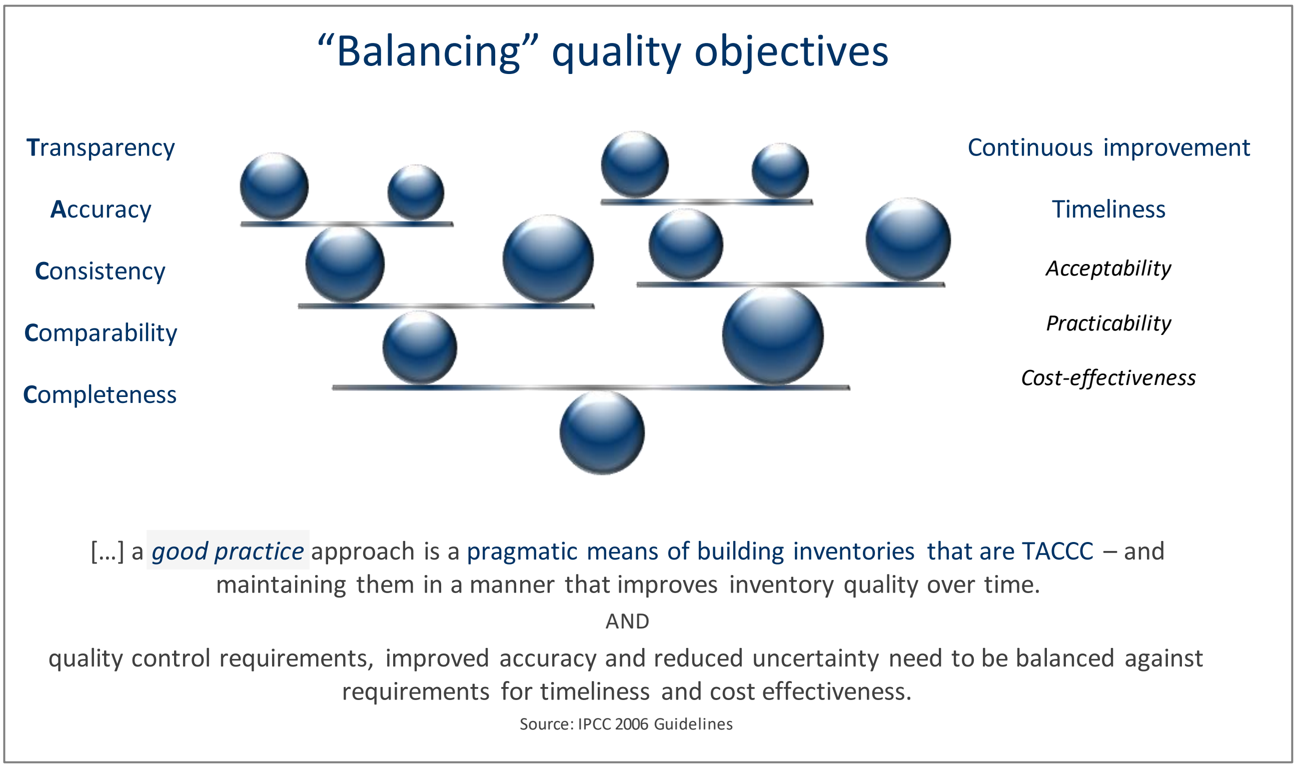


Figure 9 Balancing quality objectives

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)[23], 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.

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

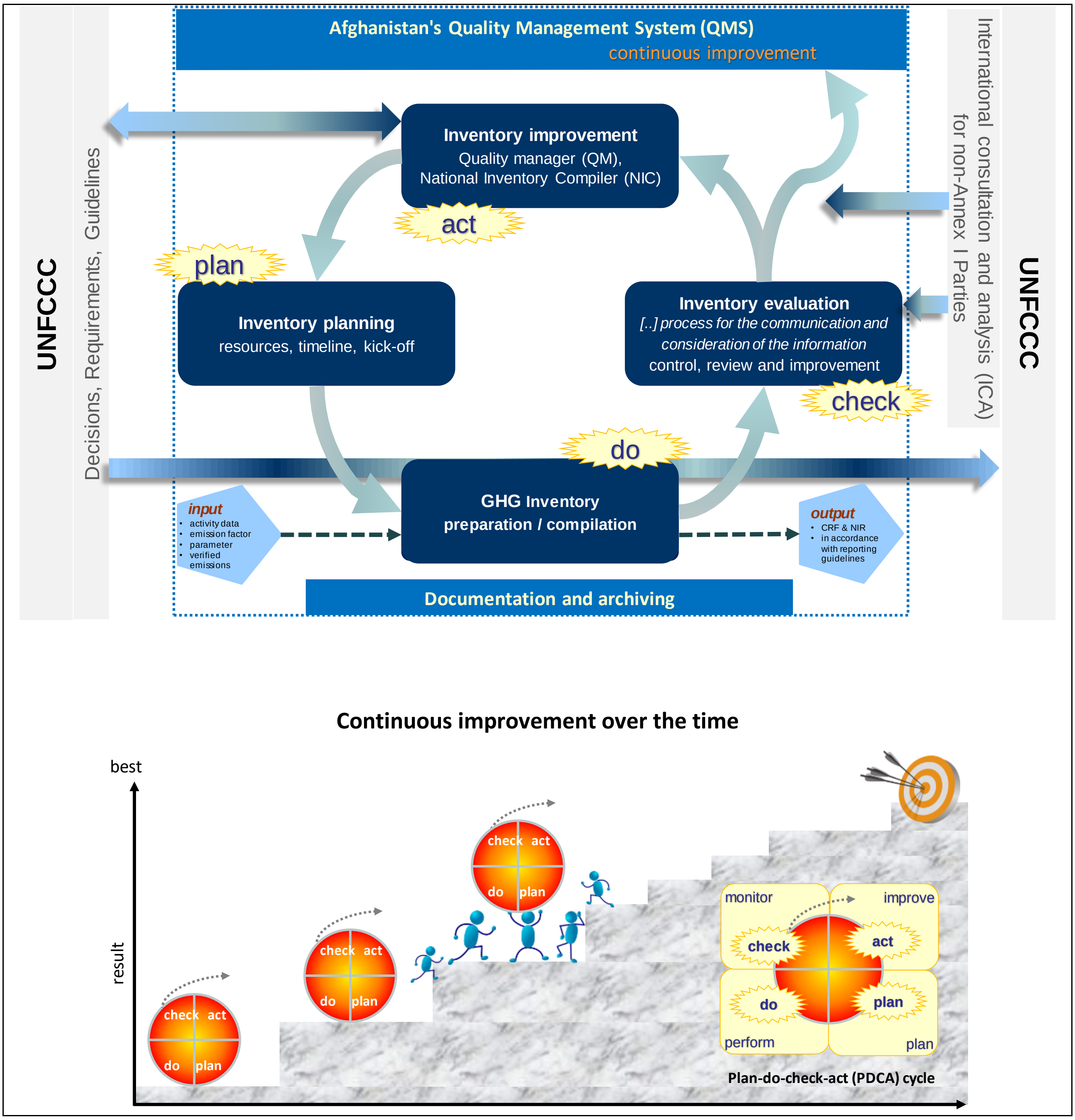


Figure 10 **Continuous improvement**

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 14 **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											

Original quote of the (review) reports!

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

Text for NIR!

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!!!

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

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)

- 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!!!

name of responsible experts/persons (and name of institutions)

- 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!!!

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).

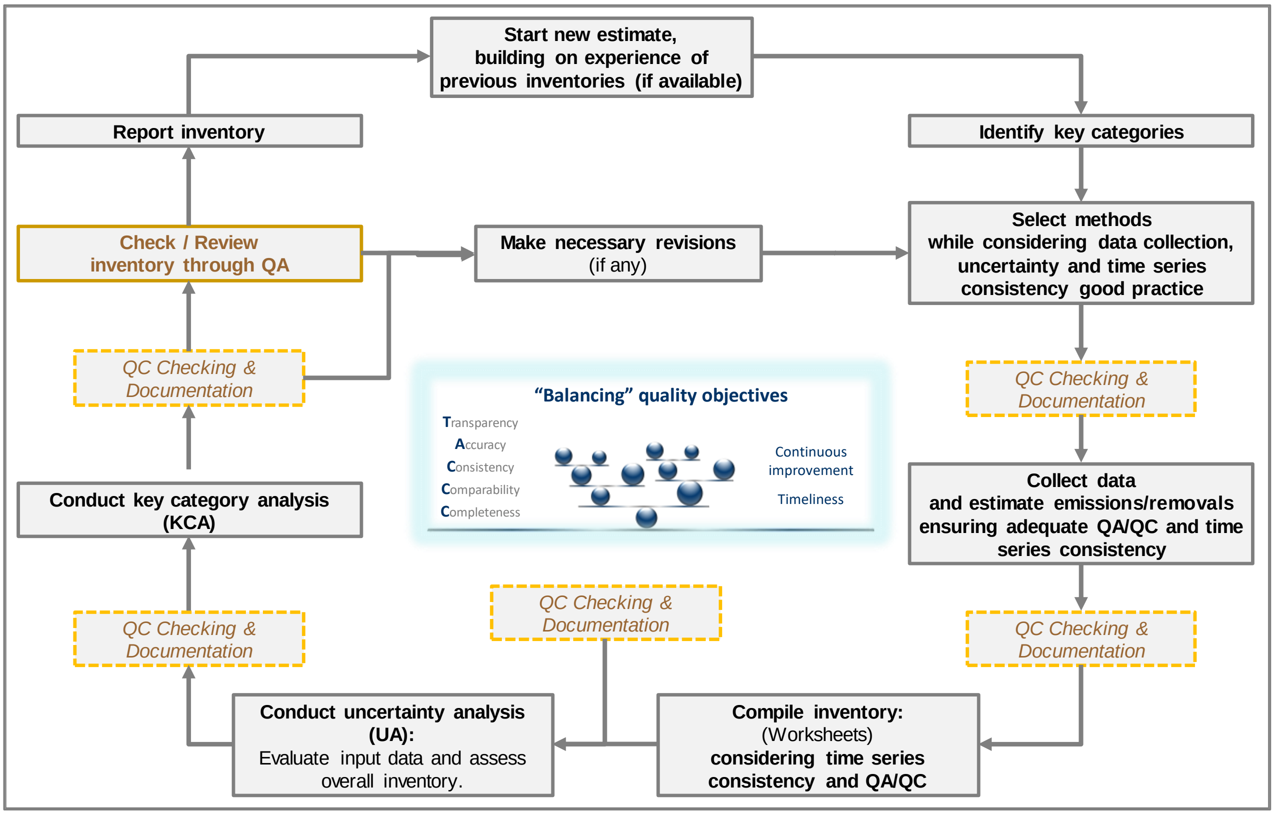


Figure 11 Inventory development cycle

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.[24] 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 16- Table 28).

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.

[24] 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 15 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 12 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 16 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 17 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 18 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	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NF_3	SO_2	NOx	NMVOC	NH_3	CO	Remarks Comments, Corrective measures	Check done Date	Finding Y/ N/ NR	Correction Date	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 19 QC TIER 1 & 2 Checklist - (2a) Check regarding content: Activity data / Emission factors / Emissions

Y = Yes N = No
NC = not checked
NA = not applicable
NR = nor relevant
NO = not occurent
IE = Included

	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6			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 20 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	Finding Y/ N/ NR	Correction Date	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 21 QC TIER 1 & 2 Checklist – (2c) Check completeness

Y = Yes N = No
NC = not checked
NA = not applicable
NR = nor relevant
NO = not occurent
IE = Included

	QC TIER 1 & 2 CHECKLIST according to IPCC 2006 Guidelines, Chapter 6		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
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 22 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 23 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 24 QC TIER 1 & 2 Checklist – (3b) Check for transcription errors in data input and reference

Row	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 25 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	Finding Y/ N/ NR	Correction Date	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 26 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 27 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		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
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 28 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	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NF_3	SO_2	NOx	NMVOC	NH_3	CO	Remarks Comments, Corrective measures	Check done: Date	Check done: Finding Y/ N/ NR	Correction: Date	Correction: Person	References
248	**6 Check the integrity of database files**																				
249	Are the data relationships and processing steps correct (e.g., equations) in the spreadsheets? Confirm the correctness of calculations (formulas)!		*calc sheets*																		
250																					
251	Are data path and data coherence understandable?		*calc sheets*																		
252																					
253	Are input data and calculated data (e.g. intra/extrapolated data) clearly differentiated in the spreadsheets?		*calc sheets*																		
254																					
255	Is a representative sample of calculations checked by hand or electronically (only for models and complex calculations)?		*calc sheets*																		
256																					
257	Is it ensued that data fields are properly labelled and have the correct design specifications?		*calc sheets*																		
258																					
259	Are the calculations cross-checked (tested) with “quick” calculations?		*calc sheets*																		
260																					
261	Is it ensured that adequate documentation of database and model structure and operation are archived.		*calc sheets*																		
262																					
263	**7 Review of internal documentation/calculation sheet and archiving.**																				
264	Is a detailed internal documentation to support the estimates and enable reproduction of the emission, removal and uncertainty estimates available?																				
265																					
266	Is the archiving of primary data – acticity data, other parameters and records - ensured?	properly labelled																			
267		stored																			
268	Are the originals of new citations (e-mails, mails, literature sources, statistics, etc.) in the archive and stored to facilitate detailed review?	properly labelled																			
269		stored																			
270																					
271	Is the archive closed and retained in secure place following completion of the inventory?																				
272																					
273	Is the integrity of any data archiving arrangements of outside organisations involved in inventory preparation ensured?																				
274																					

1.5.3 QA and review procedures, and verification activities

As stated in the 2006 IPCCC Guidelines, Chapter 6.8, and presented in Figure 12, 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 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 16- Table 28) 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 29 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[25] and MPG[26]:

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 30 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	Road Transportation						
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

[25] 2006 IPCC Guidelines, Volume 1: General Guidance and Reporting, Chapter 8: Reporting Guidance and Tables, TABLE 8, page 8.7.

[26] 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
1.B	Fugitive emissions from fuels						
1.B.2	Oil and Natural Gas	NE	NA	NE	NA	NA	NA
2	**Industrial processes**						
2.D	Non Energy Products from Fuels and Solvent Use						
2.D.2	Paraffin Wax Use	NE	NE	NE	NA	NA	NA
2.D.3	Solvent Use	NE	NE	NE	NA	NA	NA
2.F	Product Uses as Substitutes for Ozone Depleting Substances						
2.F.1	Refrigeration and Air Conditioning						
2.F.1.b	Mobile Air Conditioning	NA	NA	NA	NE	NA	NA
2.F.2	Foam Blowing Agents	NA	NA	NA	NE	NA	NA
2.F.3	Fire Protection	NA	NA	NA	NE	NA	NA
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	NE	NE	NE	NE	NE	NA
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

IPCC Code	IPCC description	CO_2	N_2O	CH_4	HFC/PFC	SF_6	NF_3
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
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						
	International Aviation (International Bunkers)	NE	NE	NE	NA	NA	NA
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)[27] based on the effects of GHGs over a 100-year time horizon.

Table 31 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) and perfluorocarbons (PFCs) consist of different substances, therefore GWPs have to be calculated individually depending on the
Perfluorocarbons	PFC	

[27] 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

Gas name	Chemical formula / Abbreviation	Global Warming Potential (Time Horizon) based on the effects of GHGs over a 100-year time horizon
		substances
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.

2 Trends in greenhouse gas emissions and removals

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

In 2019 Montengro's total greenhouse gas (GHG) emissions (without LULUCF) amounted to 3,623.25 kt CO_2 equivalents (CO_2eq). Compared to 1990 GHG emissions decreased by 31.5%, compared to 2005 GHG emissions decreased by 11.6%, compared to 2018 GHG emissions decreased by 3.2%.

In 2019 Montengro's total greenhouse gas (GHG) emissions (with LULUCF) amounted to 1,119.31 kt CO_2 equivalents (CO_2eq). Compared to 1990 GHG emissions decreased by 69.8%, compared to 2005 GHG emissions decreased by 31.7%, compared to 2018 GHG emissions decreased by 13.0%.

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)
- breack-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);
- growing population;
- increasing road transport.

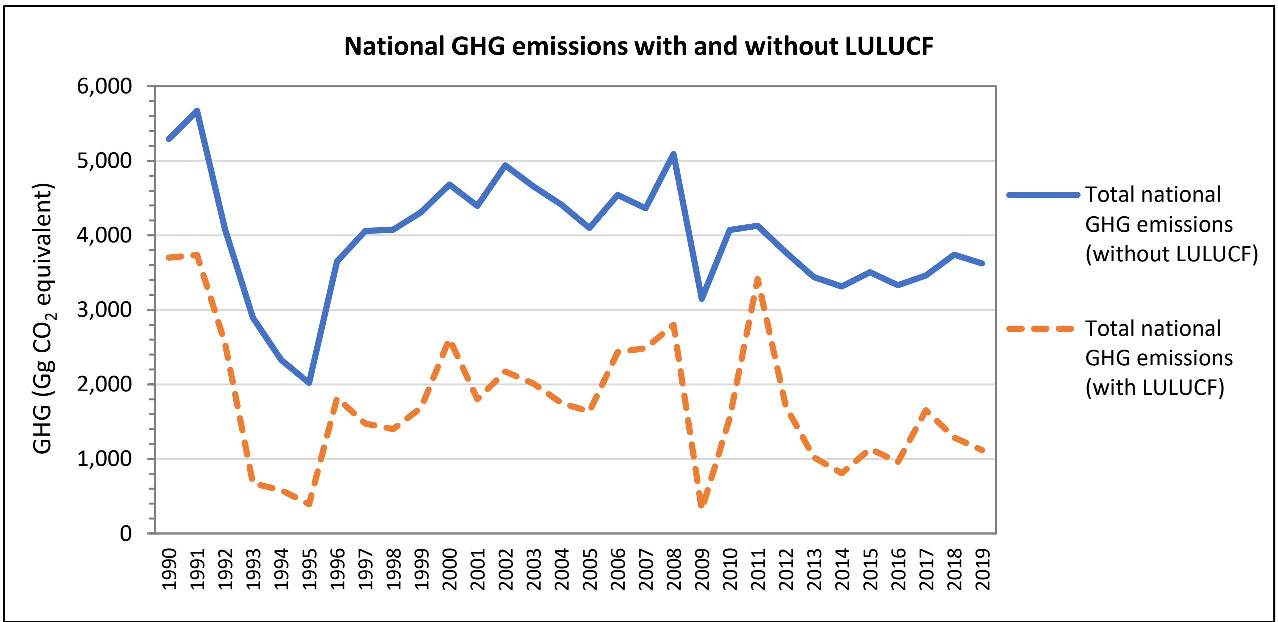


Figure 13 Trend of national total GHG emissions with LULUCF: 1990 – 2019

Table 32 National total GHG emissions with and tithout LULUCF: 1990 - 2019

1000 t CO_2-equivalent	1990	1995	2000	2005	2010	2015	2019
Total GHG emissions with LULUCF	5,292.40	2,018.49	4,681.58	4,099.20	4,071.72	3,507.82	3,623.25
Total GHG emissions without LULUCF	3,702.56	392.86	2,612.87	1,638.26	1,547.47	1,133.68	1,119.31

In 1990, the most important GHG in Montenegro was CO_2 with a share of 53.5%. The CO_2 emissions primarily result from combustion activities, here mainly in the coal-fired power plant. CH_4, which mainly arises from livestock farming and waste disposal, contributes 17.0% to total national GHG emissions; N_2O with agricultural soils and other sector (households) as the main source contributes 1.3% in 1990. The remaining 28.2% are emissions of fluorinated compounds, which are mostly emitted from the use of PFC in aluminium production.

In 2019, the most important GHG in Montenegro remains CO_2 with a share of 73.7%. The CO_2 emissions primarily result from combustion activities. CH_4 contributes 16.7% to total national GHG emissions; N_2O contributes 1.7% in 2019. The remaining 7.9% are emissions of fluorinated compounds, which are mostly emitted from the use of HFC as substitutes for ODS in refrigeration equipment.

Compared to 1990, CO_2 and N_2O emission decreased slightly by about 6%. However, PFC emissions decreased by 98% compared to 1990, whereas SF6 increased by 341% and HFC by 18591%.

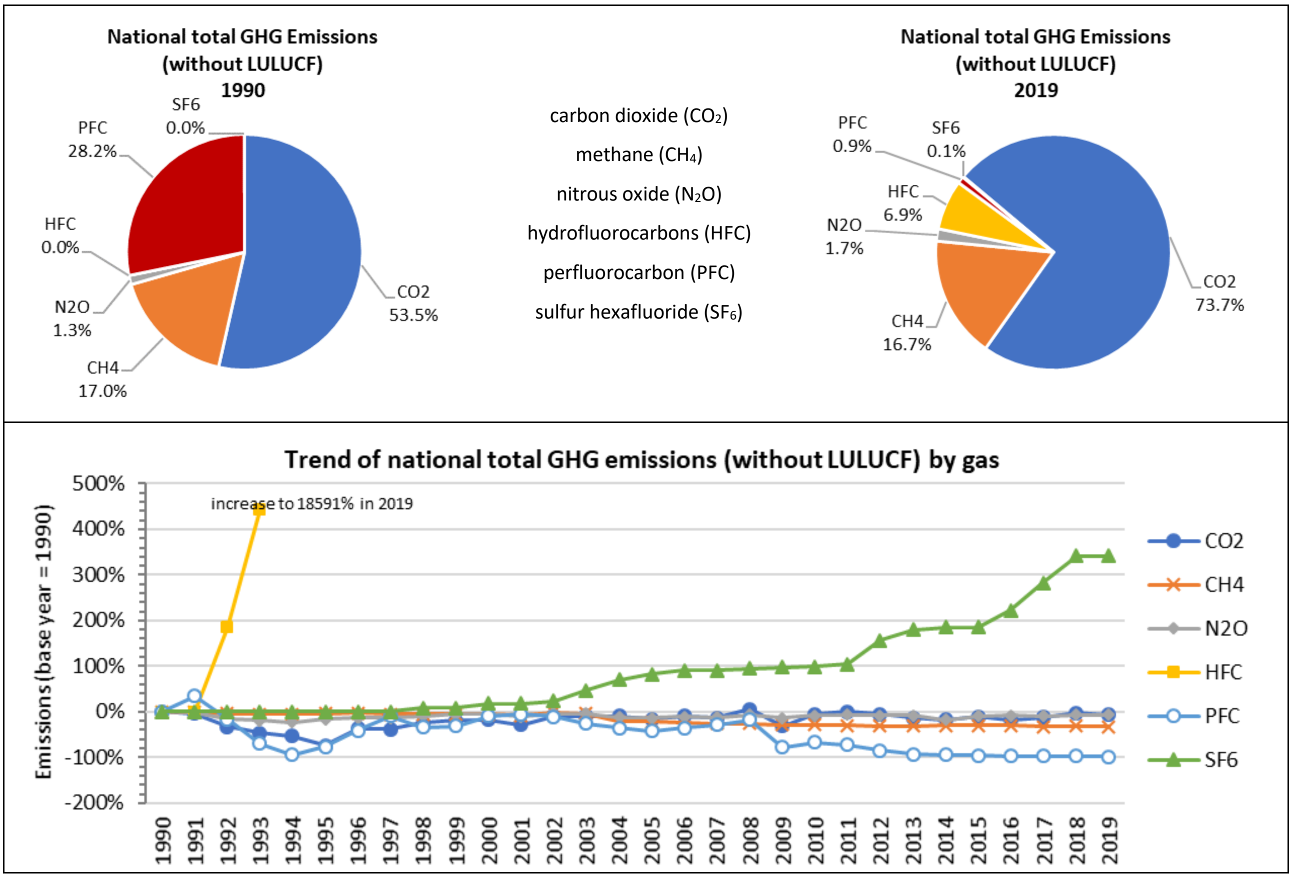


Figure 14 Trend and share of National total GHG emissions (without LULUCF) by greenhouse gas

Table 33 National total GHG emissions (without LULUCF) by greenhouse gas

1000 t CO_2-equivalent	1990	1995	2000	2005	2010	2015	2019
greenhouse gas (GHG)	5,292.40	2,018.49	4,681.58	4,099.20	4,071.72	3,507.82	3,623.25
carbon dioxide (CO_2)	2,833.89	731.59	2,356.92	2,378.54	2,704.46	2,518.96	2,670.01
methane (CH_4)	900.73	869.06	850.13	702.41	647.71	633.50	605.78
nitrous oxide (N_2O)	66.35	55.55	62.75	57.13	61.05	60.58	61.63
hydrofluorocarbons (HFC)	0.00	16.46	49.15	90.37	159.77	220.62	248.35
perfluorocarbon (PFC)	1,490.64	345.05	1,361.71	869.31	497.18	71.93	34.03
sulfur hexafluoride (SF_6)	0.78	0.78	0.92	1.43	1.55	2.23	3.44

Table 34 National total GHG Emissions with LULUCF: 1990 - 2019

GHG emissions with LULUCF	TOTAL GHG (excluding biomass)	CO_2 (excluding biomass)	CH_4 (including biomass)	N_2O (including biomass)	CH_4 (including biomass)	N_2O (including biomass)	MEMO ITEM CO_2 (biomass)
	Gg CO_2 equivalent	Gg	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg	Gg	Gg
1990	3,702.56	2,833.89	900.73	66.35	36.03	0.22	799.54
1991	3,738.05	2,719.27	888.57	65.47	35.54	0.22	683.66
1992	2,554.85	1,914.80	866.17	56.78	34.65	0.19	739.74
1993	673.57	1,525.57	856.87	53.44	34.27	0.18	815.40
1994	580.76	1,323.88	849.44	51.56	33.98	0.17	562.92
1995	392.86	731.59	869.06	55.55	34.76	0.19	639.40
1996	1,817.71	1,813.43	874.58	57.95	34.98	0.19	607.10
1997	1,475.73	1,764.45	854.13	57.88	34.17	0.19	549.14
1998	1,399.24	2,143.17	849.91	60.42	34.00	0.20	497.73
1999	1,690.13	2,312.32	860.45	62.56	34.42	0.21	516.46
2000	2,612.87	2,356.92	850.13	62.75	34.01	0.21	540.85
2001	1,804.21	2,037.75	831.07	59.62	33.24	0.20	452.69
2002	2,174.82	2,580.91	886.99	63.99	35.48	0.21	659.56
2003	2,011.73	2,555.86	862.38	63.90	34.50	0.21	680.93
2004	1,750.90	2,586.88	712.56	58.42	28.50	0.20	694.25
2005	1,638.26	2,378.54	702.41	57.13	28.10	0.19	666.92
2006	2,298.40	2,576.58	698.53	59.60	27.94	0.20	674.85
2007	2,487.95	2,440.50	670.03	58.44	26.80	0.20	680.28
2008	2,801.34	2,998.09	671.93	61.67	26.88	0.21	680.33
2009	308.91	1,949.08	640.15	57.69	25.61	0.19	714.65
2010	1,547.47	2,704.46	647.71	61.05	25.91	0.20	746.22
2011	3,415.00	2,846.58	628.53	61.67	25.14	0.21	766.02
2012	1,702.48	2,675.46	620.57	60.80	24.82	0.20	775.74
2013	1,022.14	2,440.37	617.80	61.21	24.71	0.21	734.57
2014	807.94	2,325.36	628.65	54.52	25.15	0.18	704.75
2015	1,133.68	2,518.96	633.50	60.58	25.34	0.20	720.88
2016	960.77	2,352.87	628.63	61.46	25.15	0.21	708.51
2017	1,653.58	2,490.91	614.10	60.24	24.56	0.20	697.42
2018	1,287.25	2,763.37	620.25	62.08	24.81	0.21	633.30
2019	1,119.31	2,670.01	605.78	61.63	24.23	0.21	601.67
Trend							
1990 - 2019	*-69.8%*	*-5.8%*	*-32.7%*	*-7.1%*	*-32.7%*	*-7.1%*	*-24.7%*
2005 - 2019	*-31.7%*	*12.3%*	*-13.8%*	*7.9%*	*-13.8%*	*7.9%*	*-9.8%*
2018 - 2019	*-13.0%*	*-3.4%*	*-2.3%*	*-0.7%*	*-2.3%*	*-0.7%*	*-5.0%*

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

Table 35 National total GHG Emissions without LULUCF: 1990 - 2019

GHG emissions without LULUCF	TOTAL GHG (excluding biomass)	CO_2 (excluding biomass)	CH_4 (including biomass)	N_2O (including biomass)	CH_4 (including biomass)	N_2O (including biomass)	MEMO ITEM CO_2 (biomass)
	Gg CO_2 equivalent	Gg	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg	Gg	Gg
1990	5,292.40	2,833.89	900.73	66.35	36.03	0.22	799.54
1991	5,673.14	2,719.27	888.57	65.47	35.54	0.22	683.66
1992	4,087.16	1,914.80	866.17	56.78	34.65	0.19	739.74
1993	2,898.37	1,525.57	856.87	53.44	34.27	0.18	815.40
1994	2,328.42	1,323.88	849.44	51.56	33.98	0.17	562.92
1995	2,018.49	731.59	869.06	55.55	34.76	0.19	639.40
1996	3,649.67	1,813.43	874.58	57.95	34.98	0.19	607.10
1997	4,061.63	1,764.45	854.13	57.88	34.17	0.19	549.14
1998	4,078.73	2,143.17	849.91	60.42	34.00	0.20	497.73
1999	4,313.01	2,312.32	860.45	62.56	34.42	0.21	516.46
2000	4,681.58	2,356.92	850.13	62.75	34.01	0.21	540.85
2001	4,393.71	2,037.75	831.07	59.62	33.24	0.20	452.69
2002	4,940.36	2,580.91	886.99	63.99	35.48	0.21	659.56
2003	4,656.91	2,555.86	862.38	63.90	34.50	0.21	680.93
2004	4,414.78	2,586.88	712.56	58.42	28.50	0.20	694.25
2005	4,099.20	2,378.54	702.41	57.13	28.10	0.19	666.92
2006	4,410.83	2,576.58	698.53	59.60	27.94	0.20	674.85
2007	4,364.29	2,440.50	670.03	58.44	26.80	0.20	680.28
2008	5,094.81	2,998.09	671.93	61.67	26.88	0.21	680.33
2009	3,136.85	1,949.08	640.15	57.69	25.61	0.19	714.65
2010	4,071.72	2,704.46	647.71	61.05	25.91	0.20	746.22
2011	4,131.71	2,846.58	628.53	61.67	25.14	0.21	766.02
2012	3,774.16	2,675.46	620.57	60.80	24.82	0.20	775.74
2013	3,441.41	2,440.37	617.80	61.21	24.71	0.21	734.57
2014	3,314.35	2,325.36	628.65	54.52	25.15	0.18	704.75
2015	3,507.82	2,518.96	633.50	60.58	25.34	0.20	720.88
2016	3,330.64	2,352.87	628.63	61.46	25.15	0.21	708.51
2017	3,462.82	2,490.91	614.10	60.24	24.56	0.20	697.42
2018	3,743.49	2,763.37	620.25	62.08	24.81	0.21	633.30
2019	3,623.25	2,670.01	605.78	61.63	24.23	0.21	601.67
Trend							
1990 - 2019	*-31.5%*	*-5.8%*	-32.7%	-7.1%	-32.7%	-7.1%	*-24.7%*
2005 - 2019	*-11.6%*	*12.3%*	-13.8%	7.9%	-13.8%	7.9%	*-9.8%*
2018 - 2019	*-3.2%*	*-3.4%*	-2.3%	-0.7%	-2.3%	-0.7%	*-5.0%*

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

Table 36 National total Emissions of HFC, PFC and SF6: 1990 - 2019

GHG emissions without LULUCF	TOTAL GHG (excluding biomass)	F-gases	HFC	PFC	SF6	NF3
	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent
1990	5,292.40	1,491.42	0.00	1,490.64	0.78	NO
1991	5,673.14	1,999.83	1.33	1,997.72	0.78	NO
1992	4,087.16	1,249.41	3.79	1,244.84	0.78	NO
1993	2,898.37	462.50	7.22	454.50	0.78	NO
1994	2,328.42	103.55	11.48	91.29	0.78	NO
1995	2,018.49	362.29	16.46	345.05	0.78	NO
1996	3,649.67	903.71	22.06	880.87	0.78	NO
1997	4,061.63	1,385.16	28.19	1,356.19	0.78	NO
1998	4,078.73	1,025.24	34.79	989.61	0.84	NO
1999	4,313.01	1,077.67	41.79	1,035.04	0.84	NO
2000	4,681.58	1,411.78	49.15	1,361.71	0.92	NO
2001	4,393.71	1,465.26	56.82	1,407.51	0.92	NO
2002	4,940.36	1,408.48	64.78	1,342.74	0.97	NO
2003	4,656.91	1,174.77	72.98	1,100.65	1.15	NO
2004	4,414.78	1,056.92	81.40	974.19	1.33	NO
2005	4,099.20	961.12	90.37	869.31	1.43	NO
2006	4,410.83	1,076.12	106.22	968.42	1.49	NO
2007	4,364.29	1,195.32	121.52	1,072.31	1.49	NO
2008	5,094.81	1,363.13	136.45	1,225.15	1.52	NO
2009	3,136.85	489.94	148.53	339.87	1.54	NO
2010	4,071.72	658.50	159.77	497.18	1.55	NO
2011	4,131.71	594.93	170.28	423.06	1.60	NO
2012	3,774.16	417.33	192.12	223.21	2.00	NO
2013	3,441.41	322.04	204.47	115.39	2.19	NO
2014	3,314.35	305.83	217.00	86.61	2.23	NO
2015	3,507.82	294.78	220.62	71.93	2.23	NO
2016	3,330.64	287.67	239.57	45.58	2.52	NO
2017	3,462.82	297.56	249.44	45.13	2.99	NO
2018	3,743.49	297.78	257.02	37.32	3.44	NO
2019	3,623.25	285.82	248.35	34.03	3.44	NO
Trend						
1990 - 2019	*-31.5%*	*-80.8%*	*NA*	*-97.7%*	*340.9%*	*NA*
2005 - 2019	*-11.6%*	*-70.3%*	*174.8%*	*-96.1%*	*140.8%*	*NA*
2018 - 2019	*-3.2%*	*-4.0%*	*-3.4%*	*-8.8%*	*0.0%*	*NA*

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

2.2 Description of emission and removal trends by sector

Total emissions without emissions from sector LULUCF

The dominant sector regarding GHG emissions in Montenegro is Energy, causing 74.6% of total national GHG emissions in 2019 (51.9% in 1990), followed by the sectors Industrial Processes and Other Product Use (10.4% in 2019, 32.2% in 1990), Agriculture (7.5% in 2019, 11.7% in 1990), and Waste (7.5% in 2019, 4.1% in 1990).

Total emissions with emissions from sector LULUCF

The dominant sectors regarding GHG emissions in Montenegro are Energy and LULUCF, followed by the sectors Industrial Processes and Other Product Use, Agriculture, and Waste.

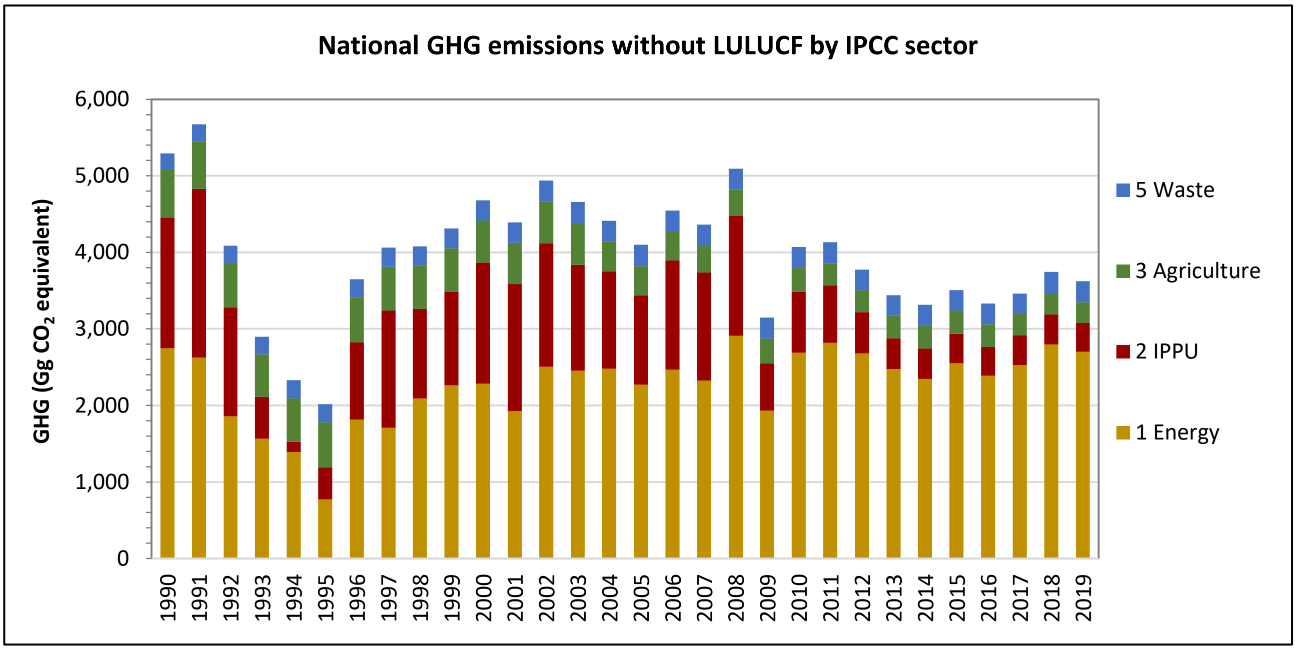


Figure 15 Trend of National GHG emissions without LULUCF by IPCC sector from 1990 – 2019

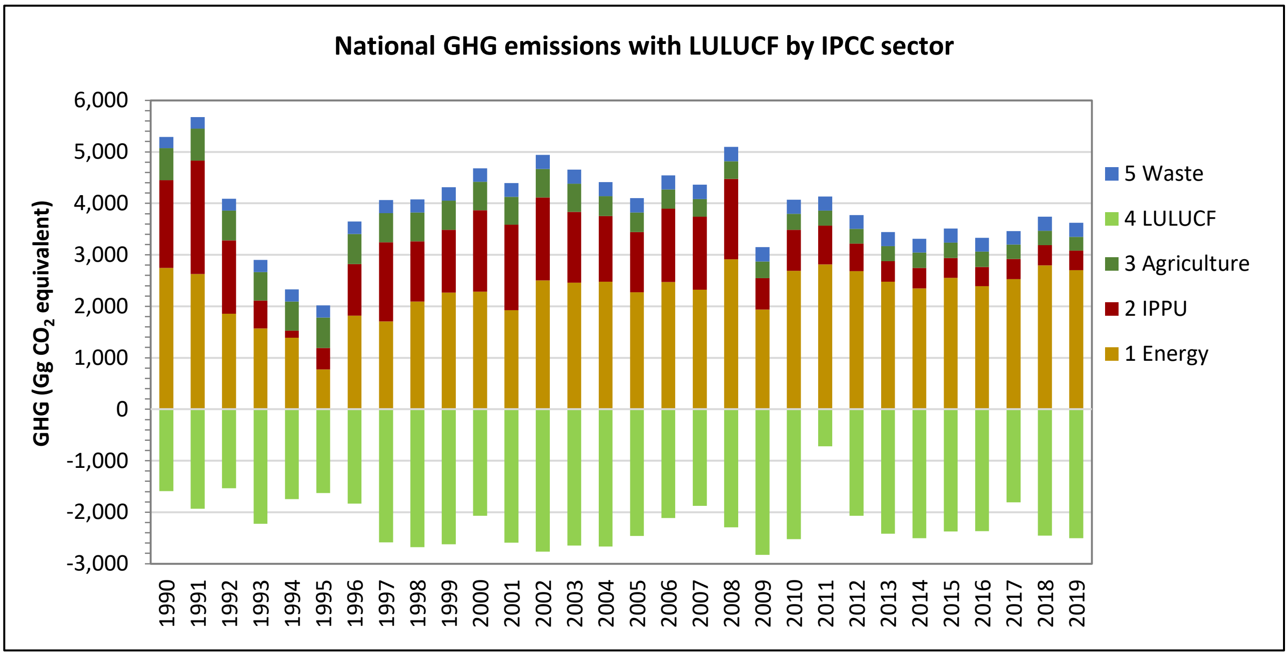


Figure 16 Trend of National GHG emissions with LULUCF by IPCC sector from 1990 – 2019

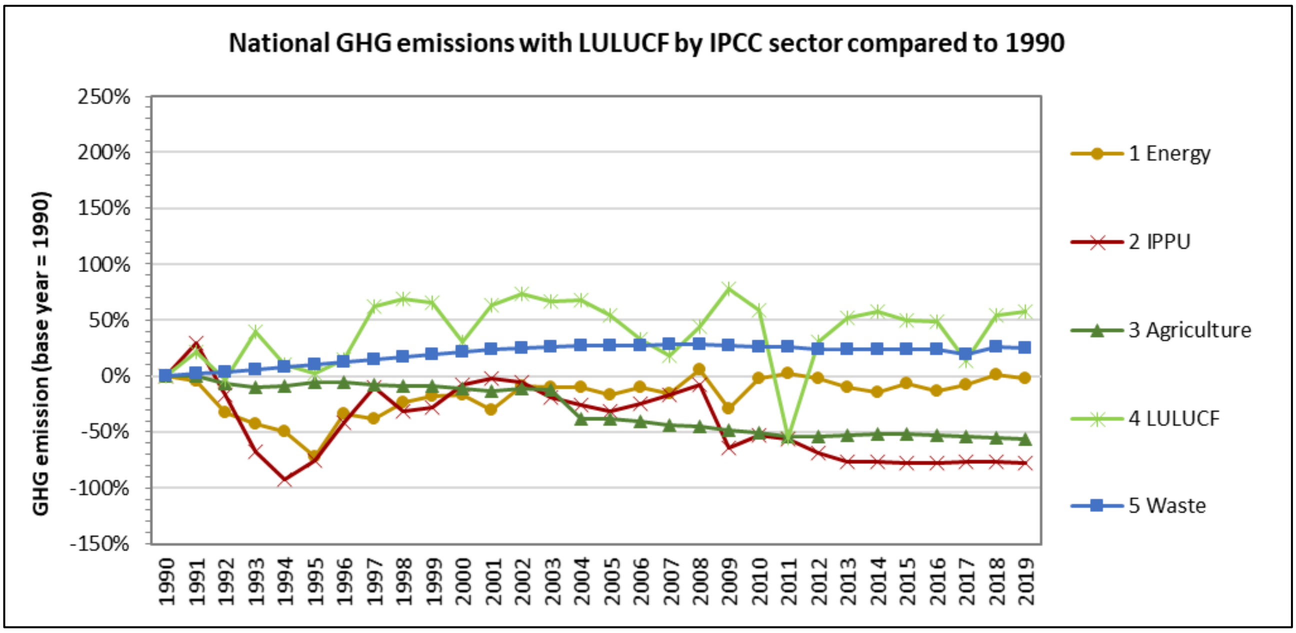


Figure 17 **Trend of National GHG emissions with LULUCF in index form (base year = 100) by IPCC sector with LULUCF for the period 1990 – 2019**

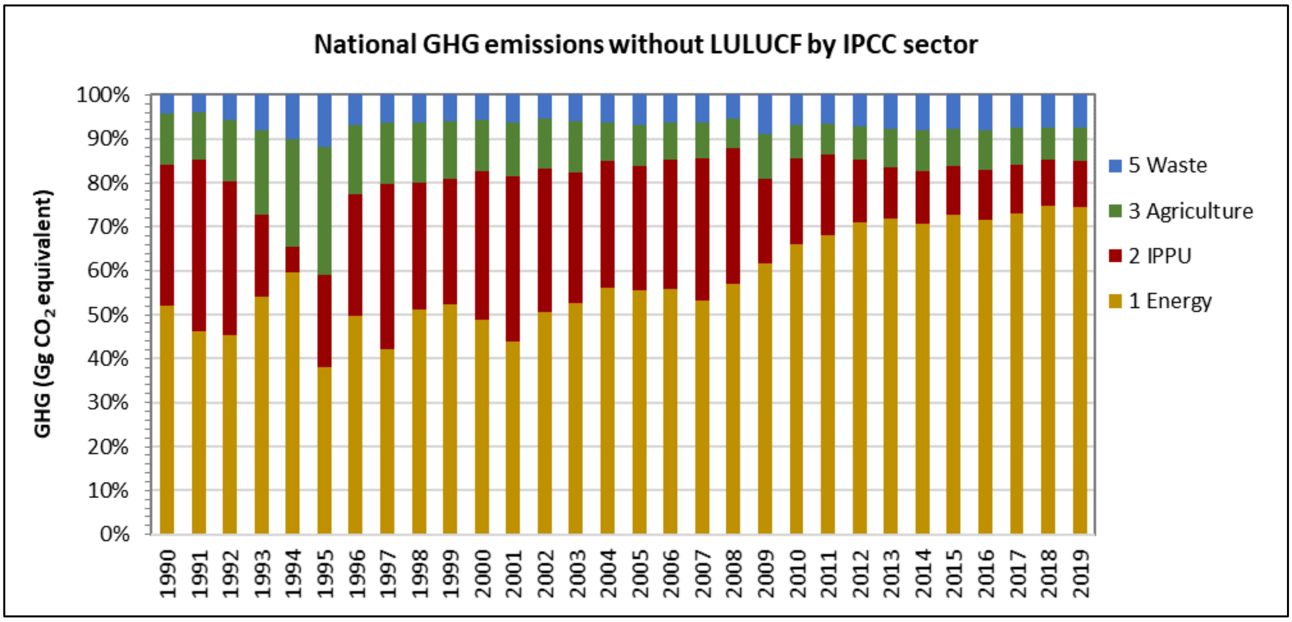


Figure 18 **Share of IPCC sectors in National GHG emissions with and without LULUCF in 1990 and 2019**

In 1990, the IPCC sector Energy accounted for 52% of the national total GHG emissions. The IPCC sector Industrial Processes and Product Use (IPPU) accounted for 32% of the national total GHG emissions. The remaining 16% of the national total GHG emissions are split between agriculture (12%) and waste (4%).

Table 37 National GHG Emissions by IPCC sector from 1990 - 2019

GHG emissions	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
	Gg $_{CO_2\ equivalent}$					
1990	2,748.26	1,704.68	621.50	-1,593.96	217.97	NO
1991	2,624.50	2,206.15	620.12	-1,937.75	222.37	NO
1992	1,859.10	1,422.12	579.28	-1,538.72	226.66	NO
1993	1,567.50	543.76	556.23	-2,230.84	230.89	NO
1994	1,390.88	135.53	566.97	-1,751.18	235.05	NO
1995	771.55	418.51	588.73	-1,631.82	239.70	NO
1996	1,818.33	1,002.21	584.35	-1,838.67	244.78	NO
1997	1,708.46	1,533.24	569.73	-2,588.70	250.20	NO
1998	2,092.57	1,167.70	563.31	-2,686.89	255.15	NO
1999	2,264.10	1,222.78	566.06	-2,624.70	260.06	NO
2000	2,285.04	1,579.41	552.22	-2,099.01	264.92	NO
2001	1,924.95	1,659.46	540.33	-2,592.68	268.97	NO
2002	2,503.63	1,612.45	551.74	-2,768.42	272.54	NO
2003	2,456.86	1,380.59	544.20	-2,661.95	275.26	NO
2004	2,480.59	1,272.88	384.32	-2,670.53	276.99	NO
2005	2,272.63	1,167.11	381.61	-2,462.68	277.85	NO
2006	2,469.45	1,291.38	371.95	-2,114.58	278.05	NO
2007	2,324.32	1,414.15	346.42	-1,948.44	279.40	NO
2008	2,911.28	1,565.61	338.67	-2,308.96	279.25	NO
2009	1,934.38	603.63	321.91	-2,829.84	276.94	NO
2010	2,690.59	795.64	309.72	-2,528.57	275.77	NO
2011	2,816.92	752.29	287.16	-907.62	275.34	NO
2012	2,680.96	539.12	283.32	-2,094.84	270.75	NO
2013	2,477.19	401.61	292.97	-2,421.82	269.64	NO
2014	2,347.67	395.06	301.38	-2,508.65	270.24	NO
2015	2,551.11	385.96	301.42	-2,388.32	269.34	NO
2016	2,388.97	376.18	295.89	-2,376.34	269.60	NO
2017	2,525.25	391.83	285.40	-1,893.48	260.33	NO
2018	2,796.59	393.52	278.70	-2,471.87	274.68	NO
2019	2,701.70	376.89	271.57	-2,511.01	273.08	NO
Trend						
1990 - 2019	*-1.7%*	*-77.9%*	-56.3%	57.5%	25.3%	*NA*
2005 - 2019	*18.9%*	*-67.7%*	-28.8%	1.7%	-1.7%	*NA*
2018 - 2019	*-3.4%*	*-4.2%*	-2.6%	1.9%	-0.6%	*NA*

2.2.1 Description of emission trends: sector 1 Energy

In 2019, greenhouse gas emissions from sector *Energy* amounted to 2,701.7 kt CO_2 equivalents which corresponds to 74.6% of the total national emissions (without LULUCF). 95% of the emissions from this sector originate from fuel combustion (1.A) while fugitive emissions from fuels (1.B) contribute with about 5 %.

The most important sub-category is *Energy Industries* with a share of 41% in 2019, followed by *Transport* (24%), *Manufacturing industries and construction* (5%) and the sub-category *Other sectors* (3%).

The most important greenhouse gas is CO_2, contributing 97% to total sectoral GHG emissions, followed by CH_4 (2%) and N_2O (1.0%).

The **overall trend** in GHG emissions from the sector *Energy* shows slight decreasing emissions with a 1.7% drop from 1990 to 2019. Greenhouse gas emissions from *Transport* are 148.4% higher than 1990.

Fugitive emissions increased by 4.3% since 1990 due to increased mining activities.

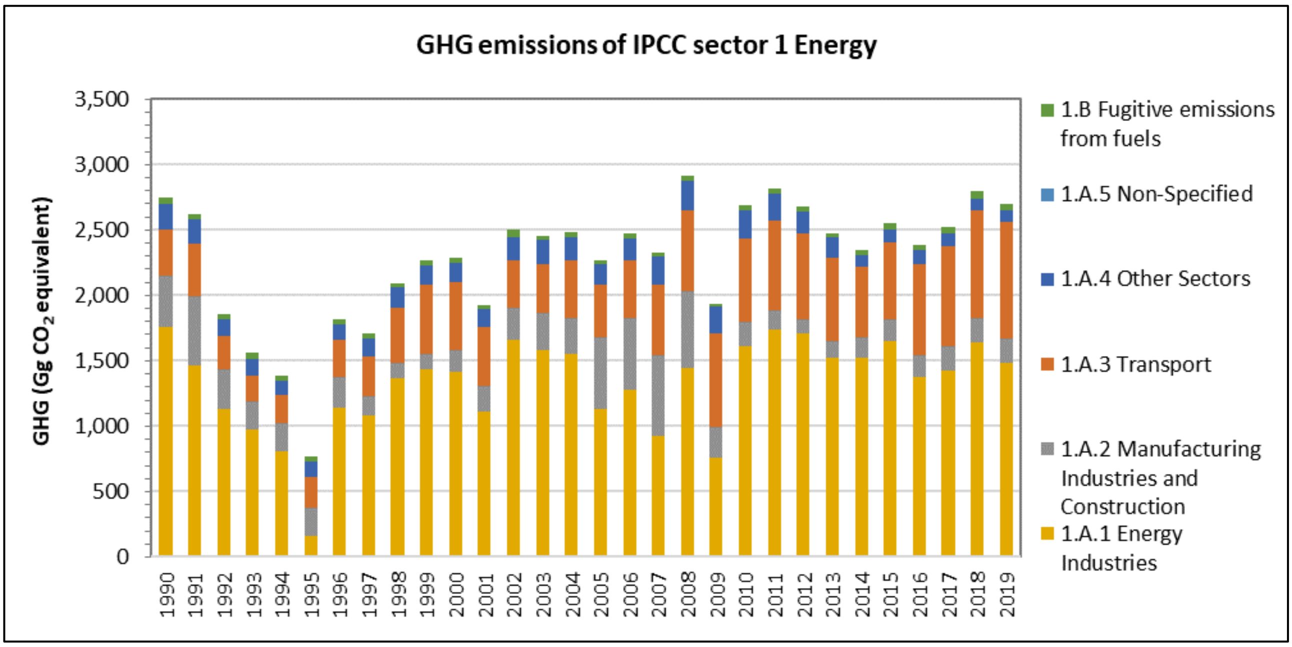


Figure 19 Trend of GHG emission of IPCC sector 1 Energy by category for the period 1990 – 2019

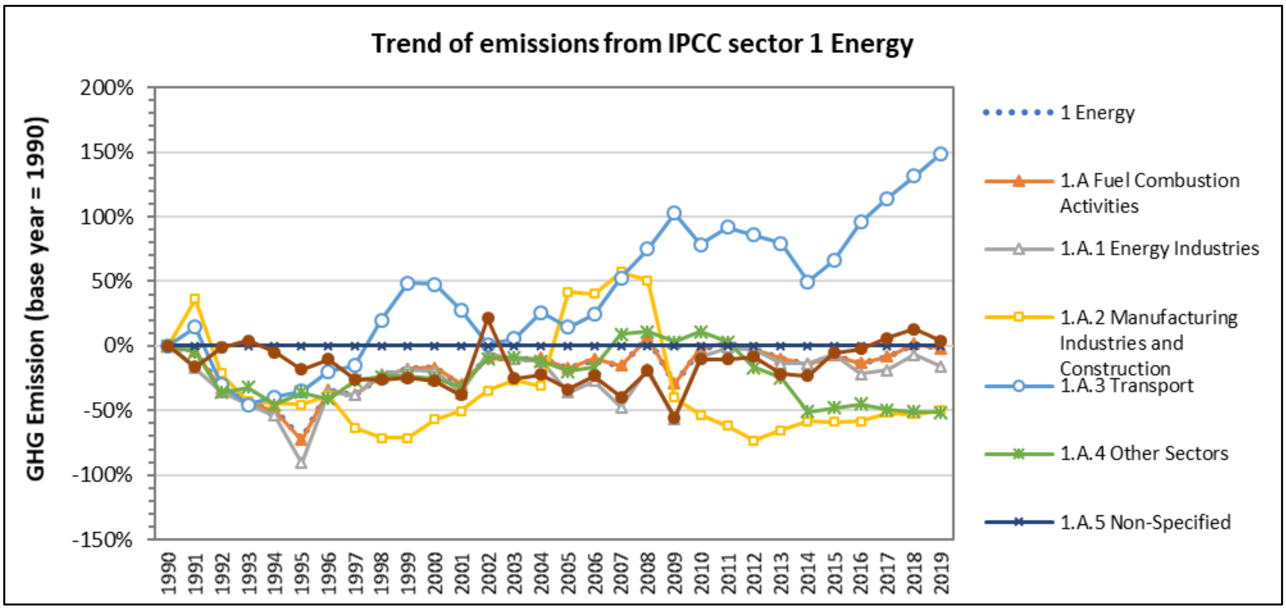


Figure 20 Trend of emissions from IPCC sector 1Energy in index form (base year = 100) by category

Table 38 GHG Emissions from IPCC sub-category 1 Energy by sub-categories

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
	Gg $_{CO_2\ equivalent}$							
1990	2,748.26	2,701.34	1,761.87	387.77	355.53	196.17	NE	46.92
1991	2,624.50	2,585.09	1,462.53	528.07	407.83	186.66	NE	39.41
1992	1,859.10	1,812.91	1,132.27	305.00	250.29	125.35	NE	46.19
1993	1,567.50	1,518.58	971.78	220.45	193.00	133.35	NE	48.91
1994	1,390.88	1,346.31	807.81	215.74	215.34	107.42	NE	44.56
1995	771.55	733.13	165.59	210.96	231.33	125.25	NE	38.42
1996	1,818.33	1,776.14	1,136.67	238.35	285.60	115.52	NE	42.19
1997	1,708.46	1,673.61	1,087.34	141.55	301.40	143.32	NE	34.84
1998	2,092.57	2,057.92	1,370.31	111.79	425.88	149.94	NE	34.64
1999	2,264.10	2,228.69	1,437.80	112.00	528.20	150.68	NE	35.41
2000	2,285.04	2,250.96	1,411.15	168.02	524.57	147.22	NE	34.08
2001	1,924.95	1,895.82	1,116.26	191.26	454.41	133.90	NE	29.13
2002	2,503.63	2,446.62	1,656.63	253.88	358.89	177.22	NE	57.01
2003	2,456.86	2,421.63	1,583.00	284.40	374.91	179.32	NE	35.23
2004	2,480.59	2,444.19	1,555.70	267.34	448.27	172.88	NE	36.40
2005	2,272.63	2,241.49	1,127.11	549.48	407.64	157.26	NE	31.14
2006	2,469.45	2,433.31	1,283.27	544.53	442.29	163.22	NE	36.14
2007	2,324.32	2,295.88	928.79	609.59	543.39	214.10	NE	28.45
2008	2,911.28	2,873.40	1,448.12	585.31	621.64	218.32	NE	37.89
2009	1,934.38	1,913.54	758.37	231.79	721.22	202.17	NE	20.84
2010	2,690.59	2,648.39	1,615.16	180.51	635.09	217.63	NE	42.20
2011	2,816.92	2,774.72	1,742.23	147.03	682.85	202.61	NE	42.20
2012	2,680.96	2,638.00	1,710.25	103.23	661.43	163.08	NE	42.96
2013	2,477.19	2,440.35	1,519.92	134.52	638.40	147.51	NE	36.84
2014	2,347.67	2,311.63	1,522.14	160.53	533.02	95.94	NE	36.04
2015	2,551.11	2,506.74	1,654.08	159.39	591.21	102.07	NE	44.36
2016	2,388.97	2,343.17	1,378.14	160.72	696.71	107.59	NE	45.80
2017	2,525.25	2,475.38	1,428.09	186.45	761.76	99.09	NE	49.87
2018	2,796.59	2,743.57	1,642.42	182.18	822.57	96.40	NE	53.02
2019	2,701.70	2,652.76	1,480.67	193.69	883.29	95.11	NE	48.94
Trend								
1990 - 2019	*-1.7%*	*-1.8%*	*-16.0%*	*-50.1%*	*148.4%*	*-51.5%*	*NA*	*4.3%*
2005 - 2019	*18.9%*	*18.3%*	*31.4%*	*-64.8%*	*116.7%*	*-39.5%*	*NA*	*57.2%*
2018 - 2019	*-3.4%*	*-3.3%*	*-9.8%*	*6.3%*	*7.4%*	*-1.3%*	*NA*	*-7.7%*

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

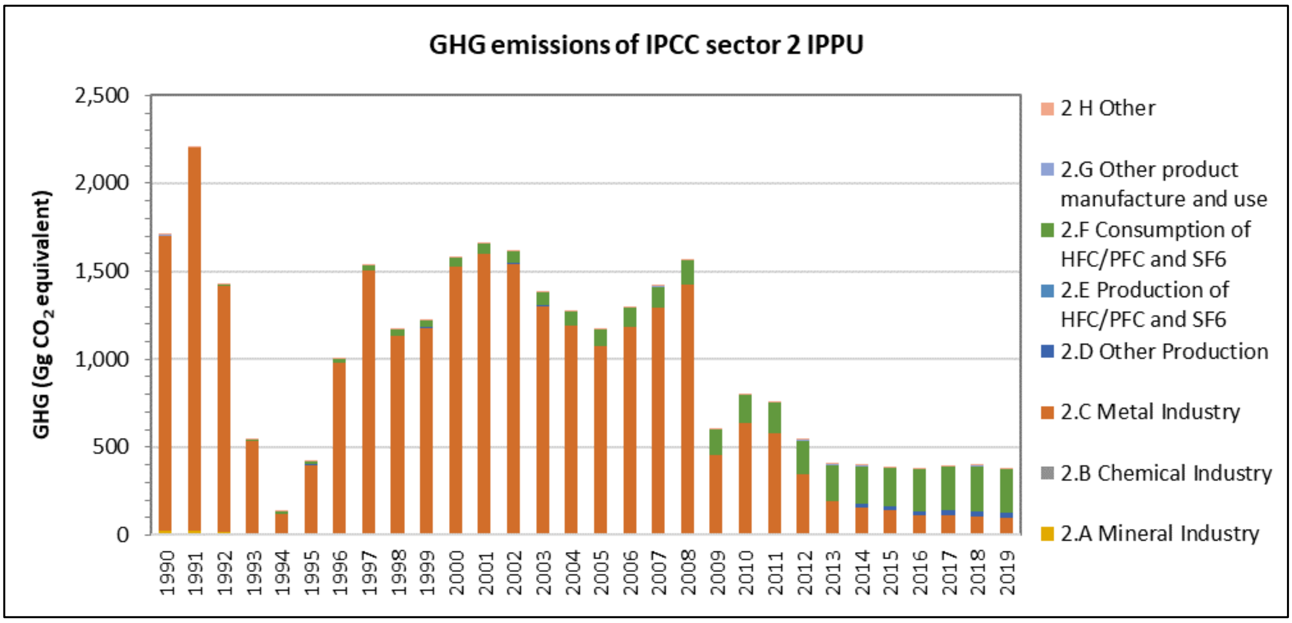


Figure 21 Trend of GHG emission of IPCC sector 2 IPPU by category for the period 1990 – 2019

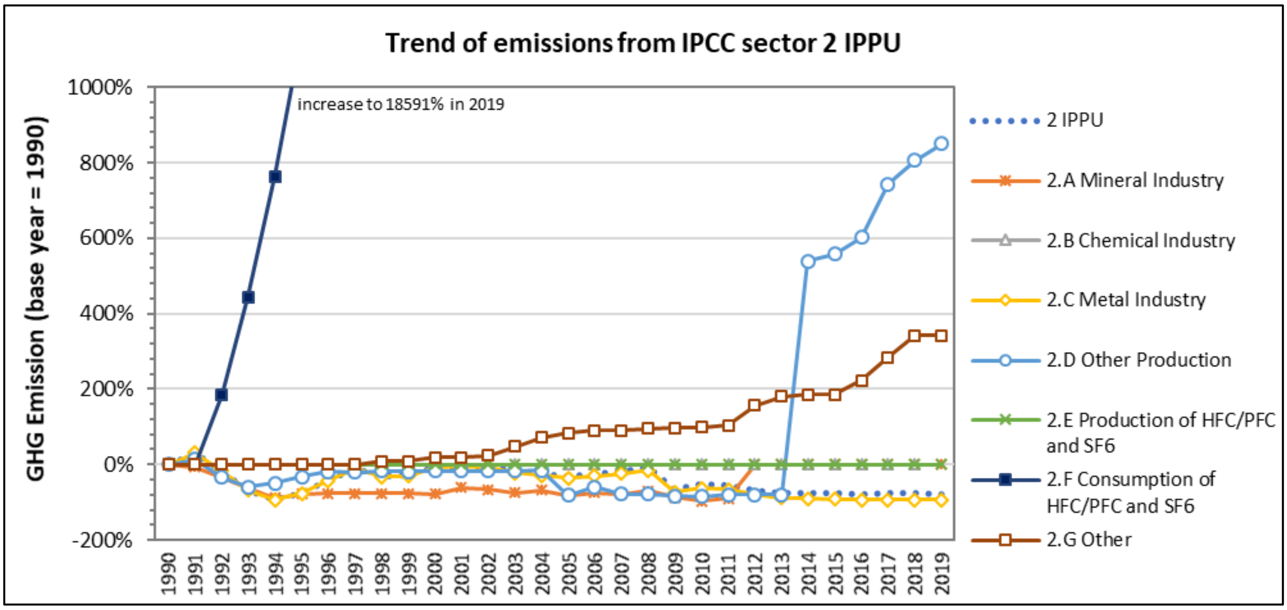


Figure 22 Trend of emissions from IPCC sector 2 IPPU in index form (base year = 100) by category

In 2019 greenhouse gas emissions from sector *Industrial Processes and Other Product Use* amounted to 376.89 Gg CO_2 equivalent, which correspond to 10.4% of total national emissions.

The most important sub-categories of this sector are 2.C *Metal industry* (mainly Aluminum production and 2.F Consumption of HFC/PFC and SF6, generating 25.4% and 65.9% of total sectoral emissions, respectively. The most important greenhouse gas of this sector are HFCs with a contribution of 65.9% to total sectoral emissions, followed by CO_2 with 24.2%, PFC with 9%, and SF_6 with 0.9%, CH_4 with less than 0.1%. N_2O and NF3 does not occur from sector IPPU.

The overall trend in GHG emissions from *Industrial Processes and Other Product Use* is an decrease of 77.9% from 1990 to 2019 due to reduced aluminium production, which is also one of the main drivers. Another main driver for the trend in emissions from this sector is the a strong increase of HFC emissions.

Table 39 GHG Emissions from IPCC sub-category 2 IPPU by sub-categories

GHG emissions	2 IPPU	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
	Gg CO_2 equivalent							
1990	1,704.68	24.75	NO	1,675.97	3.07	NO	NO	0.78
1991	2,206.15	23.25	NO	2,177.20	3.48	NO	1.33	0.78
1992	1,422.12	16.50	NO	1,398.96	2.00	NO	3.79	0.78
1993	543.76	9.75	NO	524.72	1.24	NO	7.22	0.78
1994	135.53	3.00	NO	118.66	1.53	NO	11.48	0.78
1995	418.51	5.25	NO	393.88	2.06	NO	16.46	0.78
1996	1,002.21	6.00	NO	970.82	2.48	NO	22.06	0.78
1997	1,533.24	6.00	NO	1,495.77	2.42	NO	28.19	0.78
1998	1,167.70	6.00	NO	1,123.45	2.54	NO	34.79	0.84
1999	1,222.78	6.00	NO	1,171.57	2.48	NO	41.79	0.84
2000	1,579.41	5.33	NO	1,521.35	2.54	NO	49.15	0.92
2001	1,659.46	9.74	NO	1,589.32	2.54	NO	56.82	0.92
2002	1,612.45	8.34	NO	1,535.75	2.54	NO	64.78	0.97
2003	1,380.59	6.10	NO	1,297.72	2.54	NO	72.98	1.15
2004	1,272.88	7.94	NO	1,179.51	2.59	NO	81.40	1.33
2005	1,167.11	4.51	NO	1,070.13	0.58	NO	90.37	1.43
2006	1,291.38	6.09	NO	1,176.24	1.24	NO	106.22	1.49
2007	1,414.15	5.32	NO	1,285.04	0.68	NO	121.52	1.49
2008	1,565.61	7.38	NO	1,419.49	0.66	NO	136.45	1.52
2009	603.63	3.37	NO	449.58	0.52	NO	148.53	1.54
2010	795.64	0.63	NO	633.15	0.45	NO	159.77	1.55
2011	752.29	2.59	NO	577.15	0.59	NO	170.28	1.60
2012	539.12	NO	NO	344.32	0.59	NO	192.12	2.00
2013	401.61	NO	NO	194.29	0.59	NO	204.47	2.19
2014	395.06	NO	NO	156.18	19.57	NO	217.00	2.23
2015	385.96	NO	NO	142.87	20.16	NO	220.62	2.23
2016	376.18	NO	NO	112.50	21.52	NO	239.57	2.52
2017	391.83	NO	NO	113.50	25.82	NO	249.44	2.99
2018	393.52	NO	NO	105.20	27.77	NO	257.02	3.44
2019	376.89	NO	NO	95.90	29.13	NO	248.35	3.44
Trend								
1990 - 2019	*-77.9%*	*NO*	*NO*	*-94.3%*	*850.0%*	*NO*	*NA*	*340.9%*
2005 - 2019	*-67.7%*	*NO*	*NO*	*-91.0%*	*4935.7%*	*NO*	*174.8%*	*140.8%*
2018 - 2019	*-4.2%*	*NO*	*NO*	*-8.8%*	*4.9%*	*NO*	*-3.4%*	*0.0%*

2.2.3 Description of emission trends: sector 3 Agriculture

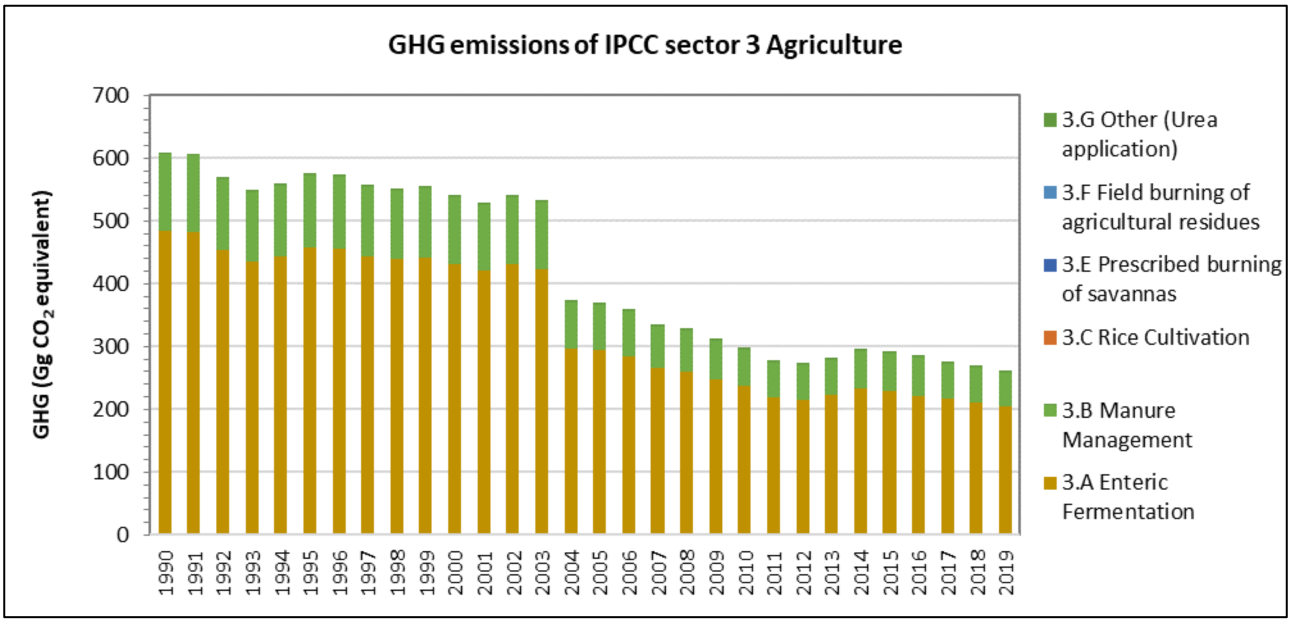


Figure 23 Trend of GHG emission of IPCC sector 5 Waste by category for the period 1990 – 2019

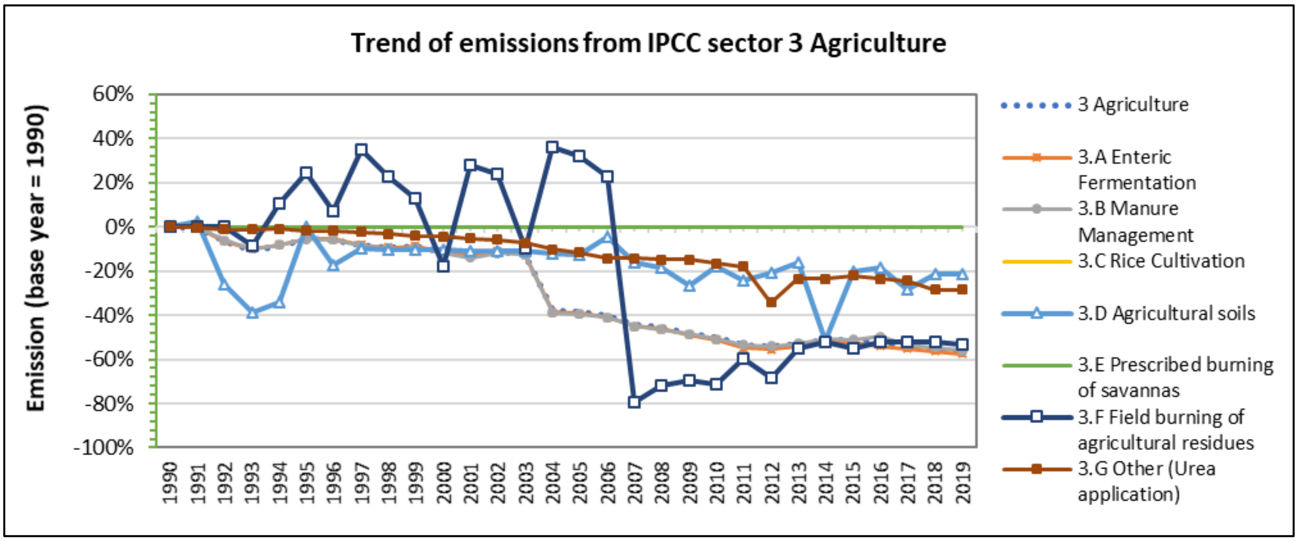


Figure 24 Trend of emissions from IPCC sector 3 Agriculture in index form (base year = 100) by category for the period 1990 – 2019

In 2019, greenhouse gas emissions from *Agriculture* amounted to 271.57 Gg CO_2 equivalent, which correspond to 7.5% of total national emissions.

The most important sub-categories of this sector are *Enteric fermentation* and *Manure Management*. *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 56.3% from 1990 to 2019 and 28,8% from 2005 to 2019. The main drivers for this trend are decreasing livestock.

Table 40 GHG Emissions from IPCC sub-category 3 Agriculture by sub-categories

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.G Other -Urea application
	Gg $_{CO_2\ equivalent}$							
1990	621.50	483.90	122.91	NO	14.13	NO	0.07	0.49
1991	620.12	482.47	122.60	NO	14.50	NO	0.07	0.49
1992	579.28	453.10	115.18	NO	10.45	NO	0.07	0.48
1993	556.23	436.16	110.85	NO	8.68	NO	0.06	0.48
1994	566.97	444.24	112.85	NO	9.31	NO	0.07	0.49
1995	588.73	457.87	116.15	NO	14.15	NO	0.08	0.48
1996	584.35	456.34	115.80	NO	11.66	NO	0.07	0.48
1997	569.73	443.86	112.55	NO	12.76	NO	0.09	0.48
1998	563.31	439.22	110.84	NO	12.70	NO	0.08	0.47
1999	566.06	441.70	111.14	NO	12.68	NO	0.07	0.47
2000	552.22	430.92	108.12	NO	12.66	NO	0.05	0.47
2001	540.33	421.42	105.76	NO	12.60	NO	0.08	0.46
2002	551.74	430.48	108.11	NO	12.61	NO	0.08	0.46
2003	544.20	423.75	107.34	NO	12.60	NO	0.06	0.45
2004	384.32	296.32	75.09	NO	12.38	NO	0.09	0.44
2005	381.61	294.33	74.38	NO	12.38	NO	0.09	0.43
2006	371.95	285.40	72.53	NO	13.52	NO	0.08	0.42
2007	346.42	266.70	67.46	NO	11.83	NO	0.01	0.42
2008	338.67	260.82	65.93	NO	11.48	NO	0.02	0.42
2009	321.91	247.97	63.13	NO	10.37	NO	0.02	0.42
2010	309.72	237.11	60.55	NO	11.62	NO	0.02	0.41
2011	287.16	218.83	57.20	NO	10.71	NO	0.03	0.40
2012	283.32	215.30	56.47	NO	11.22	NO	0.02	0.32
2013	292.97	222.77	57.92	NO	11.87	NO	0.03	0.38
2014	301.38	233.60	60.57	NO	6.80	NO	0.03	0.38
2015	301.42	229.78	59.93	NO	11.29	NO	0.03	0.38
2016	295.89	222.08	61.91	NO	11.48	NO	0.03	0.38
2017	285.40	217.55	57.32	NO	10.13	NO	0.03	0.37
2018	278.70	211.49	55.72	NO	11.11	NO	0.03	0.35
2019	271.57	205.90	54.19	NO	11.09	NO	0.03	0.35
Trend								
1990 - 2019	-56.3%	-57.4%	-55.9%	*NO*	-21.5%	*NO*	-53.1%	-28.5%
2005 - 2019	-28.8%	-30.0%	-27.1%	*NO*	-10.4%	*NO*	-64.4%	-19.2%
2018 - 2019	-2.6%	-2.6%	-2.8%	*NO*	-0.1%	*NO*	-1.7%	0.0%

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

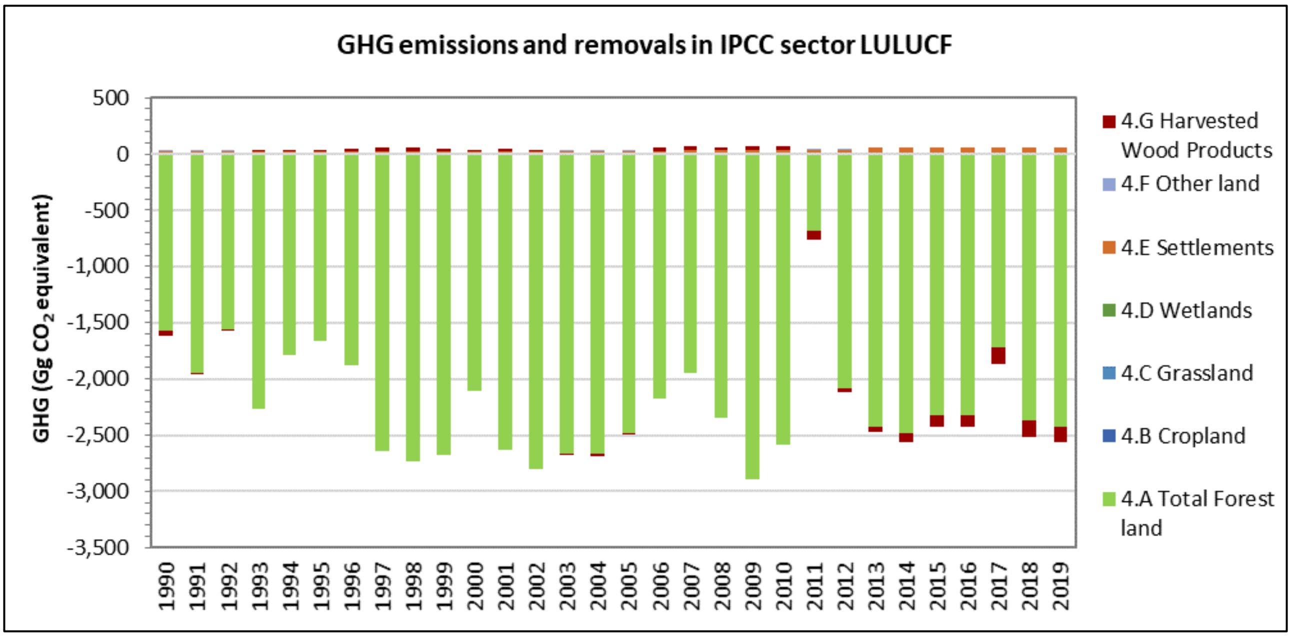


Figure 25 Net emissions/ removals in IPCC sector LULUCF from 1990 – 2019

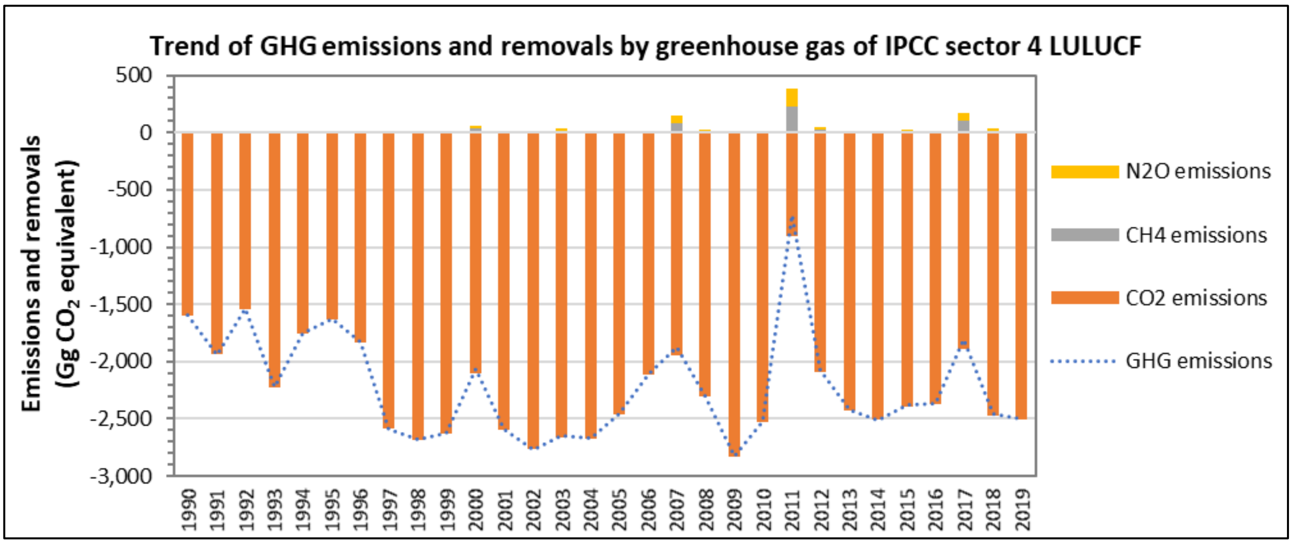


Figure 26 Trend of emissions and removals from IPCC sector 4 LULUCF by greenhouse gas for the period 1990 – 2019

In 2019**,** net removals from sector *LULUCF* amounted to -2,503.93 Gg CO_2 equivalent, which correspond to 14.1% of national total GHG emissions (without LULUCF) in 2019 compared to 3.7% in 1990.

With regard to the overall trend of net removals from *LULUCF*, the removals increased by 57.5% 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.

Table 41 GHG Emissions from IPCC sub-category 4 LULUCF by subcategories: 1990 - 2019

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
	Gg CO_2 equivalent							
1990	-1,589.84	-1,575.29	0.04	0.00	0.00	20.84	7.87	-43.31
1991	-1,935.08	-1,941.73	0.04	0.00	0.00	20.84	7.87	-22.10
1992	-1,532.30	-1,555.78	0.04	0.00	0.00	20.84	7.87	-5.28
1993	-2,224.80	-2,262.12	0.04	0.00	0.00	20.84	7.87	8.57
1994	-1,747.66	-1,787.11	0.04	0.00	0.00	20.84	7.87	10.70
1995	-1,625.64	-1,659.21	0.04	0.00	0.00	20.84	7.87	4.82
1996	-1,831.95	-1,874.22	0.04	0.00	0.00	20.84	7.87	13.52
1997	-2,585.90	-2,638.99	0.04	0.00	0.00	20.84	7.87	24.34
1998	-2,679.50	-2,732.21	0.04	0.00	0.00	20.84	7.87	23.97
1999	-2,622.87	-2,672.35	0.04	0.00	0.00	20.84	7.87	20.73
2000	-2,068.71	-2,106.62	0.04	0.00	0.00	20.84	7.87	9.16
2001	-2,589.50	-2,636.50	0.04	0.00	0.00	20.84	7.87	18.25
2002	-2,765.54	-2,801.59	0.04	0.00	0.00	20.84	7.87	7.30
2003	-2,645.18	-2,665.64	0.04	0.00	0.00	20.84	7.87	-8.29
2004	-2,663.88	-2,665.72	0.04	0.00	0.00	20.84	7.87	-26.91
2005	-2,460.94	-2,484.11	0.04	0.00	0.00	20.84	7.87	-5.58
2006	-2,112.43	-2,175.87	0.04	0.00	0.00	20.84	7.87	34.69
2007	-1,876.34	-1,948.28	0.59	0.37	0.00	35.10	1.92	33.97
2008	-2,293.47	-2,346.63	0.64	0.35	0.00	35.77	1.92	14.48
2009	-2,827.94	-2,891.74	0.70	0.33	0.00	36.43	1.92	24.41
2010	-2,524.25	-2,588.33	0.76	0.31	0.00	37.10	1.92	23.98
2011	-716.71	-678.81	0.82	0.29	0.00	37.77	1.92	-78.70
2012	-2,071.68	-2,089.16	0.88	0.27	0.00	38.44	1.92	-24.02
2013	-2,419.27	-2,428.57	0.52	-0.44	0.00	53.15	0.00	-43.94
2014	-2,506.41	-2,485.77	0.54	-0.53	0.00	54.26	0.00	-74.92
2015	-2,374.14	-2,324.17	0.57	-0.62	0.00	55.37	0.00	-105.29
2016	-2,369.87	-2,321.73	0.59	-0.72	0.00	56.49	0.00	-104.50
2017	-1,809.24	-1,721.35	0.61	-0.81	0.00	57.60	0.00	-145.28
2018	-2,456.24	-2,372.25	0.64	-0.90	0.00	58.71	0.00	-142.43
2019	-2,503.93	-2,423.78	0.66	-0.99	0.00	59.82	0.00	-139.64
Trend								
1990 - 2019	57.5%	53.9%	1462.3%	-99.3%	0.0%	187.1%	-100.0%	222.4%
2005 - 2019	1.7%	-2.4%	1462.3%	-99.3%	0.0%	187.1%	-100.0%	2401.1%
2018 - 2019	1.9%	2.2%	3.6%	10.3%	0.0%	1.9%	0.0%	-2.0%

2.2.5 Description of emission trends: sector 5 Waste

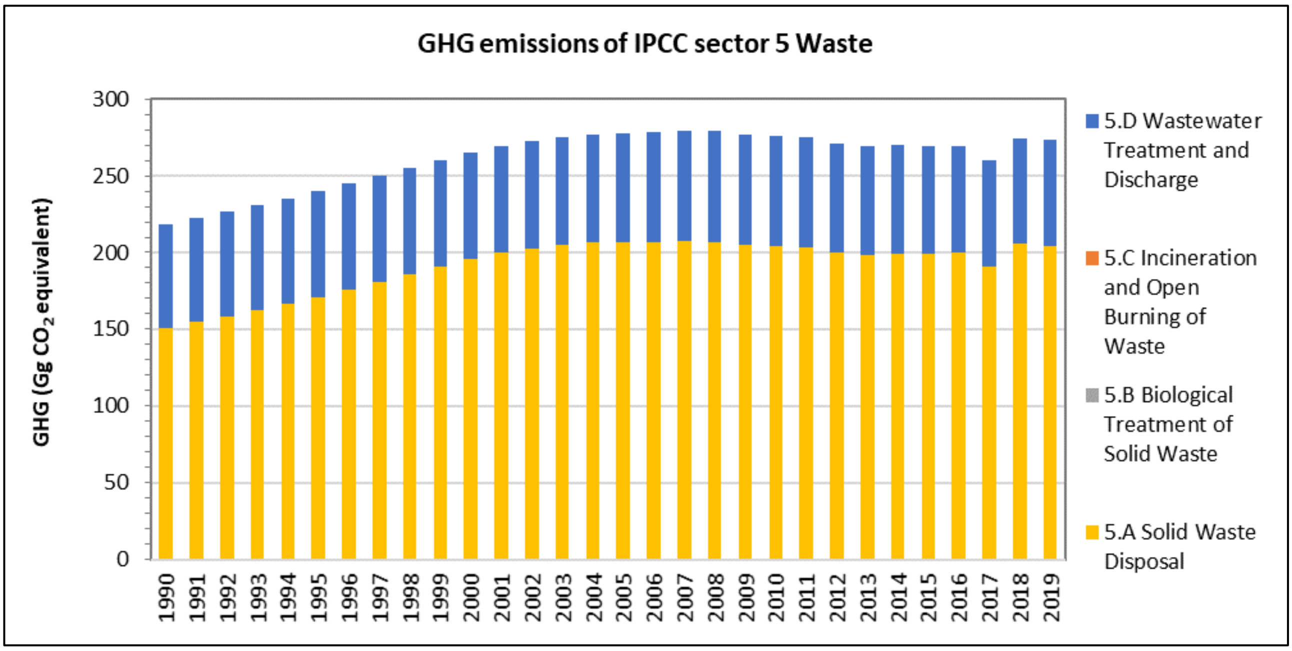


Figure 27 Trend of GHG emission of IPCC sector 5 Waste by category for the period 1990 – 2019

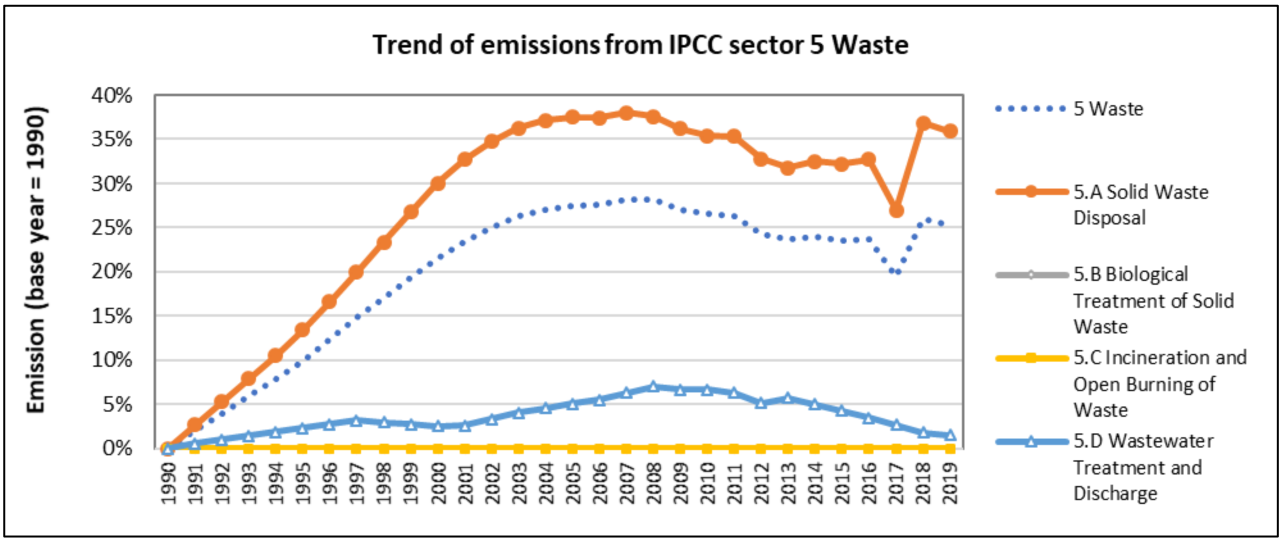


Figure 28 Trend of emissions from IPCC sector 5 waste in index form (base year = 100) by category for the period 1990 – 2019

In 2019, GHG emissions from sector *Waste* amounted to 273.08 Gg CO_2 equivalent, which correspond to 7.5% of total national emissions. In the period 1990 to 2019 GHG emissions from the Waste Sector increased by 25% from 217.97 Gg CO_2 eq in 1990 due to increasing landfilling activities 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 category 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 per capita protein consumption.

The most important sub-category of *Waste* is *solid waste disposal* followed by *waste water treatment and discharge*. The most important greenhouse gas is CH_4.

Table 42 Total GHG Emissions from IPCC sector Waste: 1990 - 2019

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
	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent
1990	217.97	150.49	NE	NE	67.47
1991	222.37	154.52	NE	NE	67.85
1992	226.66	158.51	NE	NE	68.15
1993	230.89	162.44	NE	NE	68.44
1994	235.05	166.31	NE	NE	68.74
1995	239.70	170.66	NE	NE	69.04
1996	244.78	175.44	NE	NE	69.33
1997	250.20	180.56	NE	NE	69.63
1998	255.15	185.67	NE	NE	69.49
1999	260.06	190.72	NE	NE	69.34
2000	264.92	195.73	NE	NE	69.18
2001	268.97	199.74	NE	NE	69.23
2002	272.54	202.81	NE	NE	69.73
2003	275.26	205.04	NE	NE	70.22
2004	276.99	206.42	NE	NE	70.57
2005	277.85	206.96	NE	NE	70.89
2006	278.05	206.86	NE	NE	71.20
2007	279.40	207.66	NE	NE	71.73
2008	279.25	207.04	NE	NE	72.21
2009	276.94	204.94	NE	NE	71.99
2010	275.77	203.80	NE	NE	71.97
2011	275.34	203.62	NE	NE	71.73
2012	270.75	199.79	NE	NE	70.96
2013	269.64	198.28	NE	NE	71.36
2014	270.24	199.37	NE	NE	70.87
2015	269.34	198.98	NE	NE	70.36
2016	269.60	199.78	NE	NE	69.82
2017	260.33	191.06	NE	NE	69.27
2018	274.68	205.98	NE	NE	68.70
2019	273.08	204.56	NE	NE	68.52
Trend					
1990 - 2019	*25.3%*	*35.9%*	*NE*	*NE*	*1.5%*
2005 - 2019	*-1.7%*	*-1.2%*	*NE*	*NE*	*-3.3%*
2018 - 2019	*-0.6%*	*-0.7%*	*NE*	*NE*	*-0.3%*
Share in National Total					
1990	*4.1%*	*2.8%*	*NE*	*NE*	*1.3%*
2005	*6.8%*	*5.0%*	*NE*	*NE*	*1.7%*
2019	*7.5%*	*5.6%*	*NE*	*NE*	*1.9%*

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 UNECE/CLRTAP Convention. 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) 2021 of Montenegro, Submission under the UNECE/CLRTAP Convention*, published in spring 2021.

https://www.ceip.at/status-of-reporting-and-review-results/2021-submission

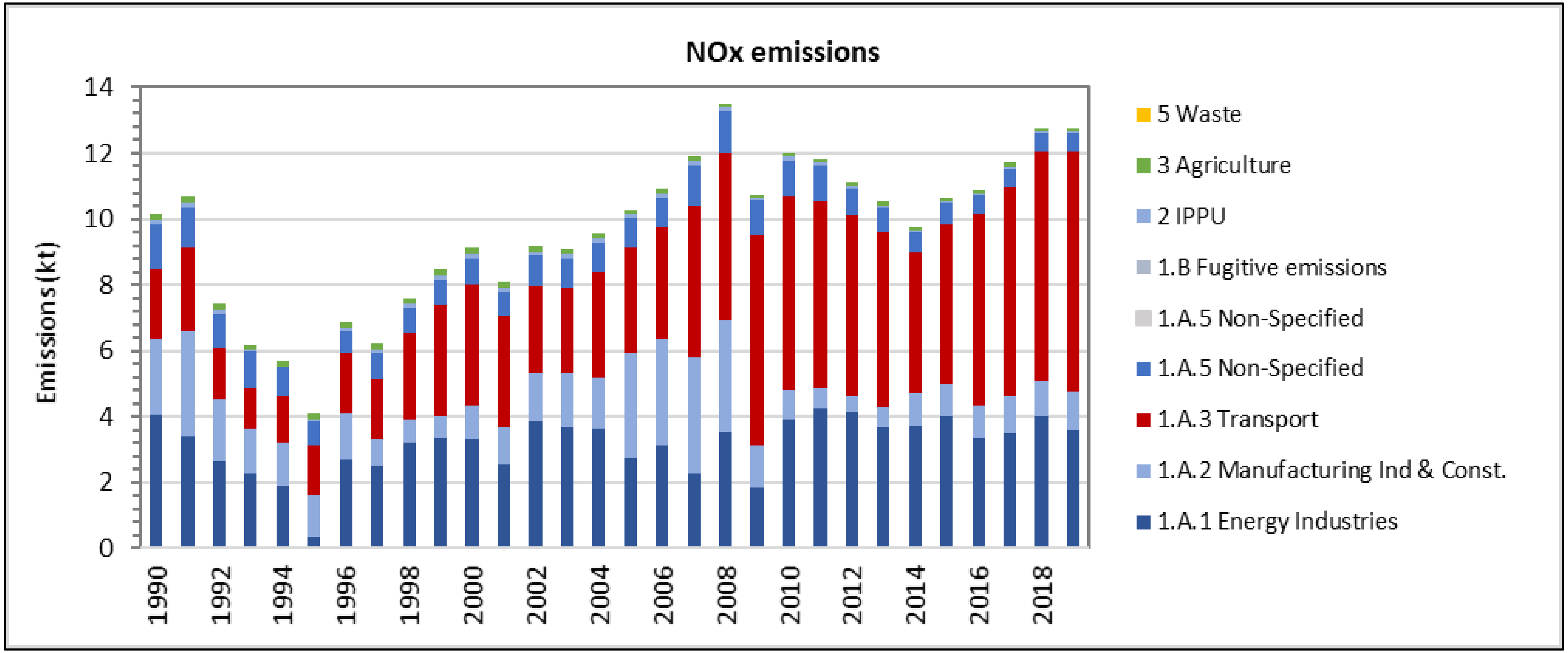


Figure 29 Nitrogen oxides (NOx) Emissions 1990 - 2019

Table 43 Nitrogen oxides (NOx) Emissions 1990 - 2019

NOx		1	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	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	10.18	9.85	4.08	2.29	2.09	1.39	NE	NA/NO	0.13	0.20	0.0552	0.15	NE	NA	NE/NA	NA
1991	10.68	10.35	3.39	3.21	2.52	1.22	NE	NA/NO	0.13	0.20	0.0550	0.15	NE	NA	NE/NA	NA
1992	7.42	7.13	2.66	1.88	1.53	1.07	NE	NA/NO	0.11	0.18	0.0515	0.13	NE	NA	NE/NA	NA
1993	6.19	5.98	2.29	1.35	1.22	1.12	NE	NA/NO	0.05	0.16	0.0493	0.11	NE	NA	NE/NA	NA
1994	5.69	5.50	1.89	1.35	1.36	0.90	NE	NA/NO	0.03	0.17	0.0502	0.12	NE	NA	NE/NA	NA
1995	4.11	3.88	0.32	1.31	1.47	0.77	NE	NA/NO	0.04	0.19	0.0513	0.14	NE	NA	NE/NA	NA
1996	6.88	6.58	2.69	1.41	1.82	0.66	NE	NA/NO	0.12	0.18	0.0512	0.13	NE	NA	NE/NA	NA
1997	6.20	5.92	2.52	0.78	1.83	0.79	NE	NA/NO	0.10	0.18	0.0501	0.13	NE	NA	NE/NA	NA
1998	7.60	7.32	3.22	0.70	2.62	0.79	NE	NA/NO	0.09	0.18	0.0499	0.13	NE	NA	NE/NA	NA
1999	8.46	8.16	3.36	0.64	3.41	0.75	NE	NA/NO	0.12	0.18	0.0495	0.13	NE	NA	NE/NA	NA
2000	9.11	8.82	3.30	1.03	3.68	0.82	NE	NA/NO	0.11	0.18	0.0481	0.14	NE	NA	NE/NA	NA
2001	8.09	7.78	2.56	1.11	3.37	0.73	NE	NA/NO	0.12	0.18	0.0477	0.14	NE	NA	NE/NA	NA
2002	9.19	8.88	3.89	1.42	2.66	0.90	NE	NA/NO	0.13	0.19	0.0488	0.14	NE	NA	NE/NA	NA
2003	9.10	8.80	3.70	1.62	2.58	0.90	NE	NA/NO	0.13	0.17	0.0485	0.13	NE	NA	NE/NA	NA
2004	9.54	9.28	3.62	1.55	3.23	0.88	NE	NA/NO	0.14	0.13	0.0326	0.09	NE	NA	NE/NA	NA
2005	10.28	10.01	2.74	3.21	3.19	0.87	NE	NA/NO	0.13	0.13	0.0320	0.10	NE	NA	NE/NA	NA
2006	10.90	10.63	3.12	3.23	3.42	0.86	NE	NA/NO	0.14	0.13	0.0314	0.10	NE	NA	NE/NA	NA
2007	11.90	11.64	2.25	3.55	4.57	1.26	NE	NA/NO	0.15	0.12	0.0294	0.09	NE	NA	NE/NA	NA
2008	13.51	13.26	3.52	3.42	5.05	1.27	NE	NA/NO	0.14	0.12	0.0285	0.09	NE	NA	NE/NA	NA
2009	10.75	10.57	1.84	1.28	6.39	1.05	NE	NA/NO	0.08	0.11	0.0276	0.08	NE	NA	NE/NA	NA
2010	11.99	11.77	3.93	0.90	5.85	1.10	NE	NA/NO	0.11	0.11	0.0267	0.08	NE	NA	NE/NA	NA

NOx		1	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	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	11.83	11.62	4.24	0.64	5.66	1.09	NE	NA/NO	0.10	0.10	0.0261	0.08	NE	NA	NE/NA	NA
2012	11.09	10.91	4.16	0.44	5.54	0.77	NE	NA/NO	0.08	0.10	0.0261	0.08	NE	NA	NE/NA	NA
2013	10.52	10.36	3.70	0.61	5.30	0.75	NE	NA/NO	0.05	0.11	0.0276	0.08	NE	NA	NE/NA	NA
2014	9.74	9.61	3.71	1.01	4.28	0.62	NE	NA/NO	0.04	0.08	0.0282	0.06	NE	NA	NE/NA	NA
2015	10.63	10.47	4.03	0.98	4.82	0.65	NE	NA/NO	0.05	0.11	0.0285	0.08	NE	NA	NE/NA	NA
2016	10.89	10.73	3.36	0.97	5.83	0.57	NE	NA/NO	0.05	0.12	0.0311	0.09	NE	NA	NE/NA	NA
2017	11.70	11.55	3.48	1.14	6.36	0.56	NE	NA/NO	0.05	0.10	0.0280	0.07	NE	NA	NE/NA	NA
2018	12.73	12.59	4.01	1.10	6.92	0.56	NE	NA/NO	0.05	0.10	0.0265	0.07	NE	NA	NE/NA	NA
2019	12.74	12.59	3.60	1.18	7.28	0.53	NE	NA/NO	0.04	0.10	0.0256	0.07				
Trend																
1990 - 2019	25.1%	27.9%	-11.6%	-48.7%	248.7%	-61.7%	NA	NA	-68.3%	-51.2%	-53.7%	-50.3%	NA	NA	NA	NA
2005 - 2019	23.9%	25.8%	31.6%	-63.4%	128.2%	-39.0%	NA	NA	-68.6%	-22.5%	-20.2%	-23.3%	NA	NA	NA	NA
2018 - 2019	0.0%	0.1%	-10.0%	6.9%	5.2%	-4.5%	NA	NA	-8.7%	-1.5%	-3.5%	-0.8%	NA	NA	NA	NA
Share in National Total																
1990	100%	96.7%	40.0%	22.5%	20.5%	13.6%	NA	NA	1.3%	2.0%	0.5%	1.5%	NA	NA	NA	NA
2005	100%	97.5%	26.7%	31.3%	31.1%	8.5%	NA	NA	1.3%	1.2%	0.3%	0.9%	NA	NA	NA	NA
2019	100%	98.9%	28.3%	9.2%	57.2%	4.2%	NA	NA	0.3%	0.8%	0.2%	0.6%	NA	NA	NA	NA

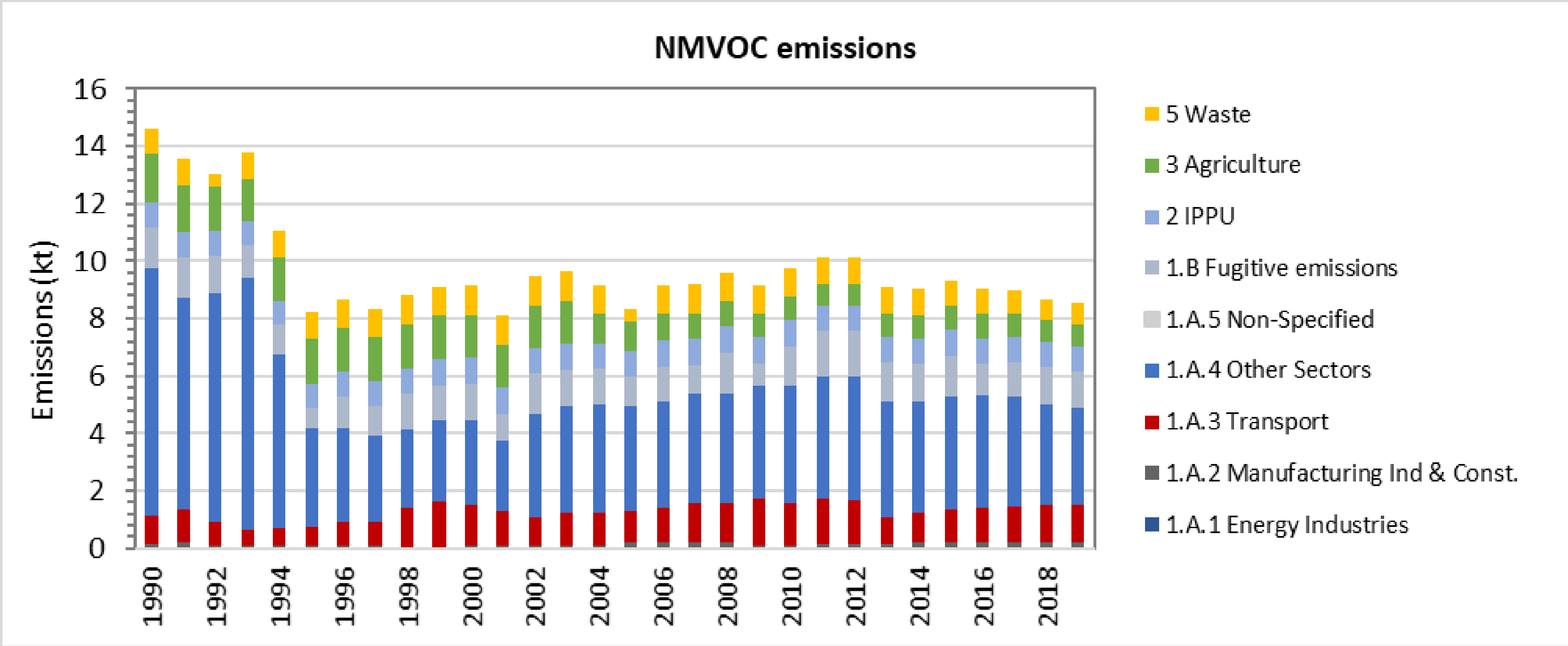


Figure 30 Non-Methane Volatile Organic Compounds (NMVOC) Emissions 1990 – 2019

Table 44 Non-Methane Volatile Organic Compounds (NMVOC) Emissions 1990 - 2019

NMVOC		1	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	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	14.61	11.17	0.03	0.12	0.99	8.63	NE	1.4048	0.89	1.66	1.63	0.04	NE	NA	0.89	NA
1991	13.56	10.11	0.02	0.16	1.16	7.38	NE	1.3888	0.88	1.66	1.62	0.04	NE	NA	0.90	NA
1992	13.05	10.21	0.02	0.10	0.78	7.97	NE	1.3544	0.84	1.56	1.52	0.04	NE	NA	0.44	NA
1993	13.79	10.57	0.02	0.07	0.56	8.77	NE	1.1472	0.80	1.50	1.46	0.04	NE	NA	0.92	NA
1994	11.08	7.78	0.01	0.07	0.62	6.07	NE	0.9992	0.84	1.53	1.49	0.04	NE	NA	0.94	NA
1995	8.25	4.87	0.00	0.07	0.66	3.48	NE	0.6672	0.85	1.56	1.52	0.04	NE	NA	0.96	NA
1996	8.69	5.31	0.02	0.09	0.79	3.29	NE	1.1248	0.85	1.55	1.51	0.04	NE	NA	0.98	NA
1997	8.33	4.95	0.02	0.06	0.85	2.99	NE	1.032	0.85	1.52	1.48	0.04	NE	NA	1.00	NA
1998	8.80	5.39	0.02	0.04	1.35	2.72	NE	1.2728	0.87	1.53	1.49	0.04	NE	NA	1.01	NA
1999	9.12	5.67	0.02	0.04	1.58	2.81	NE	1.2064	0.90	1.52	1.49	0.04	NE	NA	1.03	NA
2000	9.15	5.73	0.02	0.05	1.44	2.96	NE	1.252	0.91	1.48	1.45	0.04	NE	NA	1.02	NA
2001	8.11	4.70	0.02	0.06	1.19	2.47	NE	0.952	0.93	1.47	1.43	0.04	NE	NA	1.01	NA
2002	9.47	6.11	0.03	0.08	0.97	3.59	NE	1.4448	0.86	1.50	1.46	0.04	NE	NA	1.00	NA
2003	9.63	6.23	0.03	0.08	1.13	3.70	NE	1.2944	0.91	1.50	1.46	0.04	NE	NA	0.99	NA
2004	9.15	6.24	0.03	0.08	1.14	3.77	NE	1.2192	0.90	1.02	0.98	0.04	NE	NA	0.98	NA
2005	8.36	5.97	0.02	0.19	1.10	3.63	NE	1.0376	0.91	1.00	0.97	0.04	NE	NA	0.48	NA
2006	9.16	6.30	0.02	0.18	1.20	3.69	NE	1.2096	0.92	0.96	0.94	0.02	NE	NA	0.98	NA
2007	9.20	6.35	0.01	0.20	1.36	3.81	NE	0.9624	0.93	0.89	0.88	0.01	NE	NA	1.03	NA
2008	9.61	6.79	0.02	0.20	1.37	3.81	NE	1.392	0.93	0.87	0.86	0.01	NE	NA	1.02	NA
2009	9.18	6.45	0.01	0.07	1.63	3.97	NE	0.7656	0.91	0.83	0.82	0.01	NE	NA	0.99	NA
2010	9.74	7.05	0.02	0.05	1.49	4.08	NE	1.4048	0.89	0.81	0.80	0.01	NE	NA	1.00	NA

NMVOC		1	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	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	10.15	7.54	0.02	0.12	1.60	4.25	NE	1.5504	0.89	0.75	0.74	0.01	NE	NA	0.96	NA
2012	10.16	7.55	0.02	0.11	1.56	4.28	NE	1.5784	0.89	0.78	0.77	0.01	NE	NA	0.94	NA
2013	9.11	6.49	0.02	0.12	0.93	4.06	NE	1.3536	0.88	0.80	0.79	0.01	NE	NA	0.94	NA
2014	9.07	6.43	0.02	0.17	1.05	3.87	NE	1.324	0.87	0.83	0.81	0.01	NE	NA	0.93	NA
2015	9.30	6.72	0.02	0.17	1.13	3.98	NE	1.41832	0.88	0.82	0.81	0.01	NE	NA	0.87	NA
2016	9.05	6.44	0.02	0.17	1.24	3.90	NE	1.118	0.88	0.85	0.84	0.01	NE	NA	0.89	NA
2017	8.98	6.48	0.02	0.17	1.27	3.84	NE	1.17984	0.88	0.81	0.80	0.01	NE	NA	0.81	NA
2018	8.69	6.30	0.02	0.17	1.33	3.51	NE	1.27672	0.88	0.78	0.76	0.01	NE	NA	0.73	NA
2019	8.55	6.18	0.02	0.18	1.35	3.34	NE	1.28416	0.87	0.75	0.74	0.01	NE	NA	0.74	NA
Trend																
1990 - 2019	-41.5%	-44.6%	-29.3%	53.9%	37.0%	-61.3%	NA	-8.6%	-1.8%	-54.9%	-54.6%	-68.3%	NA	NA	-16.9%	NA
2005 - 2019	2.3%	3.5%	30.4%	-3.7%	23.1%	-7.9%	NA	23.8%	-4.2%	-25.1%	-23.5%	-67.0%	NA	NA	56.5%	NA
2018 - 2019	-1.6%	-1.9%	-7.4%	8.5%	2.1%	-4.8%	NA	0.6%	-0.5%	-3.2%	-3.2%	-1.1%	NA	NA	1.2%	NA
Share in National Total																
1990	100%	76.4%	0.2%	0.8%	6.8%	59.0%	NA	9.6%	6.1%	11.4%	11.1%	0.3%	NA	NA	6.1%	NA
2005	100%	71.4%	0.2%	2.3%	13.2%	43.4%	NA	12.4%	10.9%	12.0%	11.5%	0.4%	NA	NA	5.7%	NA
2019	100%	72.3%	0.2%	2.1%	15.8%	39.1%	NA	15.0%	10.2%	8.8%	8.6%	0.1%	NA	NA	8.7%	NA

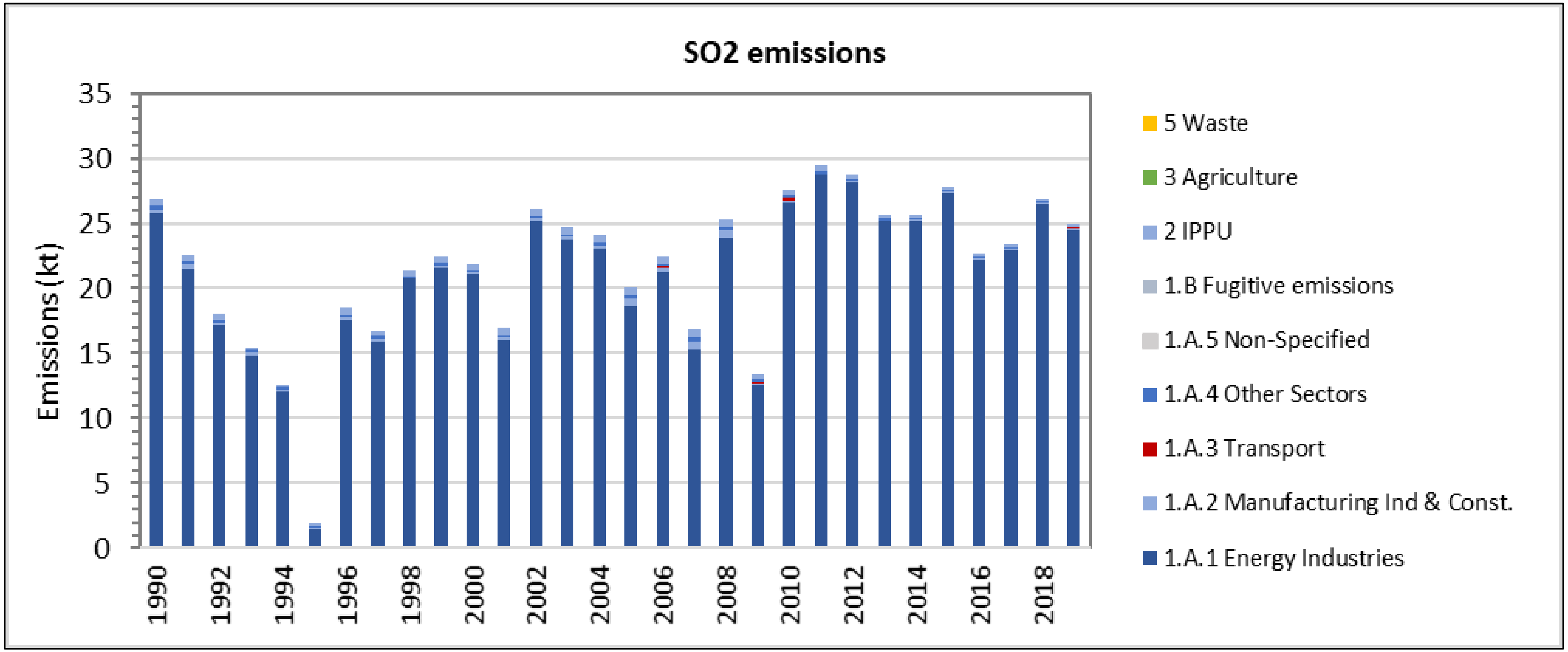


Figure 31 Sulphur dioxide (SO2) Emissions 1990 - 2019

Table 45 Sulphur dioxide (SO2) Emissions 1990 - 2019

SO2		1	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	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	26.87	26.33	25.81	0.25	0.00	0.26	NE	NA/NO	0.54	NA	NA	NA	NA	NA	NE/NA	NA
1991	22.61	22.09	21.52	0.34	0.00	0.23	NE	NA/NO	0.52	NA	NA	NA	NA	NA	NE/NA	NA
1992	18.01	17.55	17.14	0.22	0.00	0.20	NE	NA/NO	0.45	NA	NA	NA	NA	NA	NE/NA	NA
1993	15.46	15.26	14.87	0.18	0.00	0.21	NE	NA/NO	0.20	NA	NA	NA	NA	NA	NE/NA	NA
1994	12.47	12.40	12.08	0.17	0.00	0.16	NE	NA/NO	0.06	NA	NA	NA	NA	NA	NE/NA	NA
1995	1.90	1.76	1.46	0.18	0.00	0.13	NE	NA/NO	0.14	NA	NA	NA	NA	NA	NE/NA	NA
1996	18.48	17.95	17.53	0.32	0.00	0.10	NE	NA/NO	0.53	NA	NA	NA	NA	NA	NE/NA	NA
1997	16.73	16.31	15.89	0.29	0.00	0.13	NE	NA/NO	0.41	NA	NA	NA	NA	NA	NE/NA	NA
1998	21.33	20.94	20.74	0.06	0.00	0.14	NE	NA/NO	0.39	NA	NA	NA	NA	NA	NE/NA	NA
1999	22.44	21.91	21.60	0.18	0.00	0.13	NE	NA/NO	0.53	NA	NA	NA	NA	NA	NE/NA	NA
2000	21.88	21.40	21.15	0.09	0.00	0.15	NE	NA/NO	0.48	NA	NA	NA	NA	NA	NE/NA	NA
2001	16.92	16.38	16.00	0.19	0.05	0.13	NE	NA/NO	0.55	NA	NA	NA	NA	NA	NE/NA	NA
2002	26.17	25.59	25.14	0.25	0.02	0.17	NE	NA/NO	0.59	NA	NA	NA	NA	NA	NE/NA	NA
2003	24.74	24.14	23.75	0.19	0.02	0.17	NE	NA/NO	0.60	NA	NA	NA	NA	NA	NE/NA	NA
2004	24.08	23.46	23.09	0.19	0.02	0.17	NE	NA/NO	0.61	NA	NA	NA	NA	NA	NE/NA	NA
2005	20.01	19.40	18.59	0.59	0.06	0.17	NE	NA/NO	0.61	NA	NA	NA	NA	NA	NE/NA	NA
2006	22.48	21.86	21.20	0.44	0.05	0.16	NE	NA/NO	0.62	NA	NA	NA	NA	NA	NE/NA	NA
2007	16.82	16.19	15.27	0.58	0.10	0.24	NE	NA/NO	0.63	NA	NA	NA	NA	NA	NE/NA	NA
2008	25.24	24.67	23.89	0.53	0.01	0.25	NE	NA/NO	0.57	NA	NA	NA	NA	NA	NE/NA	NA
2009	13.38	13.06	12.51	0.16	0.17	0.22	NE	NA/NO	0.32	NA	NA	NA	NA	NA	NE/NA	NA
2010	27.60	27.17	26.64	0.08	0.22	0.23	NE	NA/NO	0.43	NA	NA	NA	NA	NA	NE/NA	NA

SO2		1	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	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	29.50	29.03	28.75	0.06	0.01	0.22	NE	NA/NO	0.47	NA	NA	NA	NA	NA	NE/NA	NA
2012	28.81	28.44	28.21	0.04	0.01	0.18	NE	NA/NO	0.37	NA	NA	NA	NA	NA	NE/NA	NA
2013	25.64	25.39	25.16	0.05	0.01	0.17	NE	NA/NO	0.24	NA	NA	NA	NA	NA	NE/NA	NA
2014	25.62	25.40	25.20	0.09	0.01	0.10	NE	NA/NO	0.21	NA	NA	NA	NA	NA	NE/NA	NA
2015	27.82	27.61	27.39	0.11	0.01	0.11	NE	NA/NO	0.21	NA	NA	NA	NA	NA	NE/NA	NA
2016	22.62	22.42	22.20	0.10	0.01	0.11	NE	NA/NO	0.20	NA	NA	NA	NA	NA	NE/NA	NA
2017	23.39	23.19	22.95	0.11	0.01	0.11	NE	NA/NO	0.21	NA	NA	NA	NA	NA	NE/NA	NA
2018	26.88	26.68	26.45	0.11	0.01	0.11	NE	NA/NO	0.20	NA	NA	NA	NA	NA	NE/NA	NA
2019	24.94	24.76	24.51	0.12	0.02	0.10	NE	NA/NO	0.19	NA	NA	NA	NA	NA	NE/NA	NA
Trend																
1990 - 2019	-7.2%	-6.0%	-5.0%	-52.6%	519.0%	-60.3%	NA	NA	-65.7%	NA	NA	NA	NA	NA	NA	NA
2005 - 2019	24.6%	27.6%	31.9%	-79.5%	-64.8%	-38.8%	NA	NA	-69.5%	NA	NA	NA	NA	NA	NA	NA
2018 - 2019	-7.2%	-7.2%	-7.3%	9.0%	66.2%	-1.2%	NA	NA	-9.0%	NA	NA	NA	NA	NA	NA	NA
Share in National Total																
1990	100%	98.0%	96.1%	0.9%	0.0%	1.0%	NA	NA	2.0%	NA	NA	NA	NA	NA	NA	NA
2005	100%	97.0%	92.9%	2.9%	0.3%	0.8%	NA	NA	3.0%	NA	NA	NA	NA	NA	NA	NA
2019	100%	99.3%	98.3%	0.5%	0.1%	0.4%	NA	NA	0.7%	NA	NA	NA	NA	NA	NA	NA

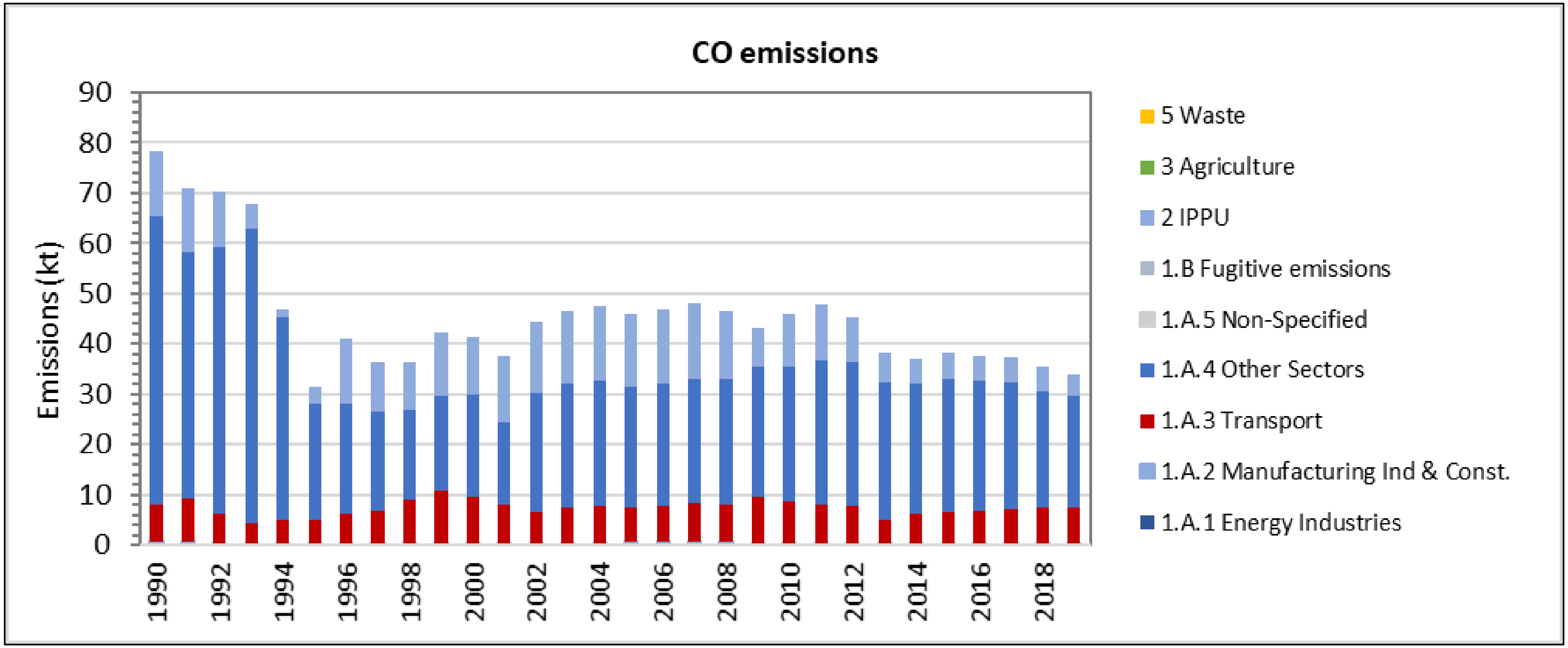


Figure 32 Carbon monoxide (CO) Emissions 1990 - 2019

Table 46 Carbon monoxide (CO) Emissions 1990 - 2019

CO		1	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	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	78.39	65.38	0.19	0.34	7.51	57.34	NE	NA	13.00	NA	NA	NA	NA	NA	NO	NA
1991	70.97	58.36	0.15	0.46	8.70	49.05	NE	NA	12.61	NA	NA	NA	NA	NA	NO	NA
1992	70.13	59.19	0.11	0.29	5.80	52.99	NE	NA	10.94	NA	NA	NA	NA	NA	NO	NA
1993	67.67	62.90	0.10	0.23	4.19	58.38	NE	NA	4.77	NA	NA	NA	NA	NA	NO	NA
1994	46.86	45.29	0.08	0.22	4.64	40.35	NE	NA	1.57	NA	NA	NA	NA	NA	NO	NA
1995	31.41	28.13	0.03	0.23	4.86	23.01	NE	NA	3.28	NA	NA	NA	NA	NA	NO	NA
1996	40.99	28.16	0.11	0.38	5.85	21.82	NE	NA	6.30	NA	NA	NA	NA	NA	NO	NA
1997	36.51	26.62	0.12	0.33	6.37	19.80	NE	NA	9.90	NA	NA	NA	NA	NA	NO	NA
1998	36.25	26.82	0.14	0.09	8.62	17.97	NE	NA	9.43	NA	NA	NA	NA	NA	NO	NA
1999	42.37	29.57	0.15	0.21	10.59	18.62	NE	NA	9.86	NA	NA	NA	NA	NA	NO	NA
2000	41.40	29.80	0.14	0.13	9.24	20.28	NE	NA	11.61	NA	NA	NA	NA	NA	NO	NA
2001	37.63	24.47	0.12	0.24	7.76	16.35	NE	NA	13.16	NA	NA	NA	NA	NA	NO	NA
2002	44.38	30.26	0.17	0.31	6.02	23.76	NE	NA	14.12	NA	NA	NA	NA	NA	NO	NA
2003	46.62	32.10	0.16	0.26	7.15	24.53	NE	NA	14.53	NA	NA	NA	NA	NA	NO	NA
2004	47.44	32.69	0.16	0.25	7.29	24.99	NE	NA	14.75	NA	NA	NA	NA	NA	NO	NA
2005	46.01	31.39	0.10	0.72	6.54	24.03	NE	NA	14.62	NA	NA	NA	NA	NA	NO	NA
2006	46.88	31.99	0.11	0.57	6.96	24.34	NE	NA	14.89	NA	NA	NA	NA	NA	NO	NA
2007	48.23	33.03	0.08	0.72	7.46	24.77	NE	NA	15.20	NA	NA	NA	NA	NA	NO	NA
2008	46.59	32.89	0.13	0.68	7.31	24.78	NE	NA	13.70	NA	NA	NA	NA	NA	NO	NA
2009	43.16	35.38	0.07	0.22	9.18	25.92	NE	NA	7.78	NA	NA	NA	NA	NA	NO	NA
2010	45.84	35.58	0.14	0.12	8.38	26.94	NE	NA	13.00	NA	NA	NA	NA	NA	NO	NA

CO		1	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	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	47.91	36.61	0.15	0.24	7.72	28.50	NE	NA	11.29	NA	NA	NA	NA	NA	NO	NA
2012	45.46	36.49	0.15	0.22	7.38	28.74	NE	NA	8.97	NA	NA	NA	NA	NA	NO	NA
2013	38.21	32.37	0.13	0.24	4.73	27.28	NE	NA	5.83	NA	NA	NA	NA	NA	NO	NA
2014	37.16	32.00	0.13	0.35	5.61	25.91	NE	NA	5.16	NA	NA	NA	NA	NA	NO	NA
2015	38.28	33.12	0.14	0.37	6.01	26.60	NE	NA	5.16	NA	NA	NA	NA	NA	NO	NA
2016	37.62	32.79	0.12	0.36	6.49	25.82	NE	NA	4.82	NA	NA	NA	NA	NA	NO	NA
2017	37.45	32.51	0.12	0.36	6.67	25.36	NE	NA	4.93	NA	NA	NA	NA	NA	NO	NA
2018	35.45	30.55	0.14	0.36	6.88	23.17	NE	NA	4.90	NA	NA	NA	NA	NA	NO	NA
2019	33.96	29.50	0.13	0.39	7.01	21.97	NE	NA	4.46	NA	NA	NA	NA	NA	NO	NA
Trend																
1990 - 2019	-56.7%	-54.9%	-31.8%	13.4%	-6.7%	-61.7%	NA	NA	-65.7%	NA	NA	NA	NA	NA	NA	NA
2005 - 2019	-26.2%	-6.0%	30.3%	-46.1%	7.2%	-8.5%	NA	NA	-69.5%	NA	NA	NA	NA	NA	NA	NA
2018 - 2019	-4.2%	-3.4%	-10.1%	8.9%	1.9%	-5.2%	NA	NA	-9.0%	NA	NA	NA	NA	NA	NA	NA
Share in National Total																
1990	100%	83.4%	0.2%	0.4%	9.6%	73.2%	NA	NA	16.6%	NA	NA	NA	NA	NA	NA	NA
2005	100%	68.2%	0.2%	1.6%	14.2%	52.2%	NA	NA	31.8%	NA	NA	NA	NA	NA	NA	NA
2019	100%	86.9%	0.4%	1.1%	20.6%	64.7%	NA	NA	13.1%	NA	NA	NA	NA	NA	NA	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. However, fugitive emissions make up less than 1% of the total emissions from this sector.

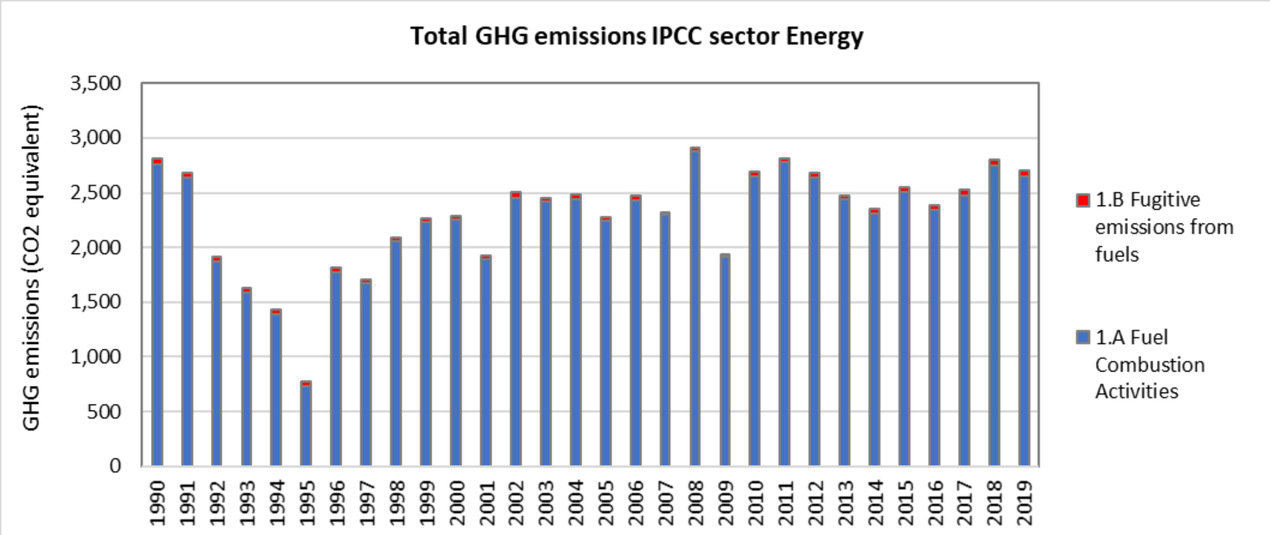


Figure 33 **Trend of GHG emissions from 1990 – 2019 for energy**

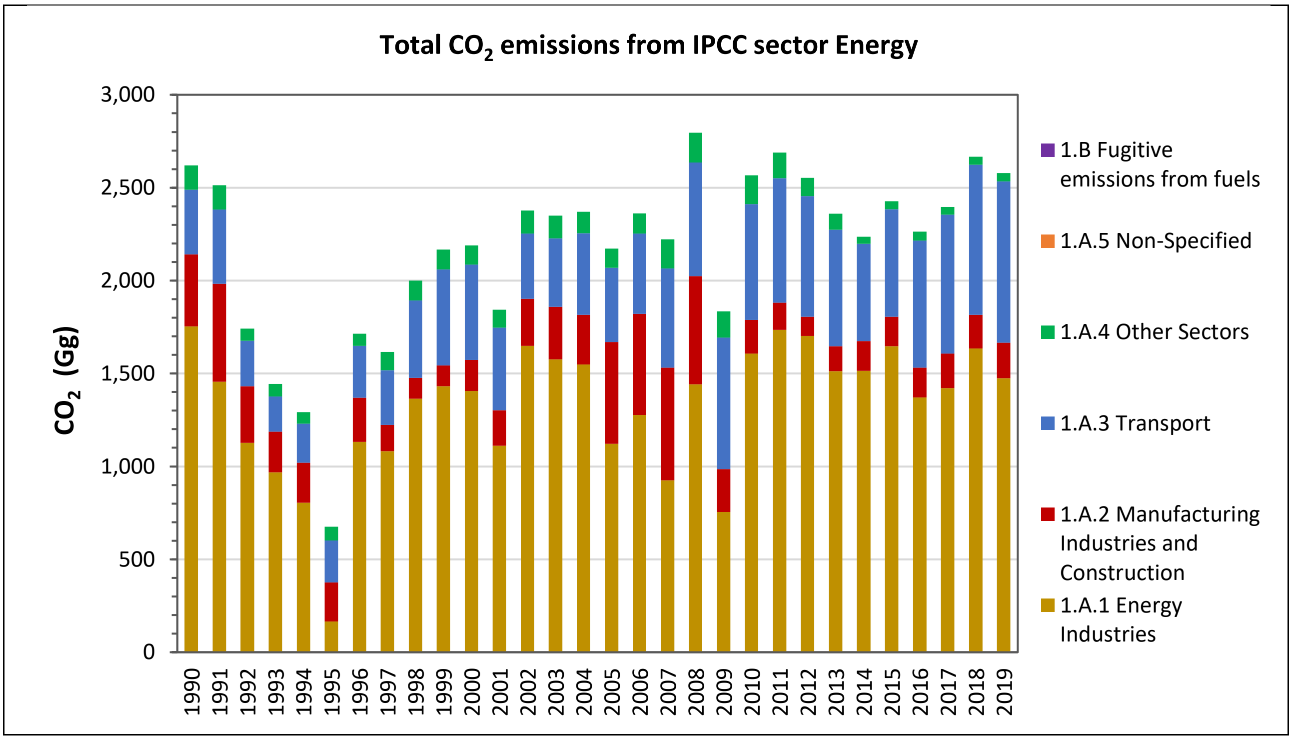


Figure 34 **Total national CO_2 emissions by category of sector Energy (1990-2019)**

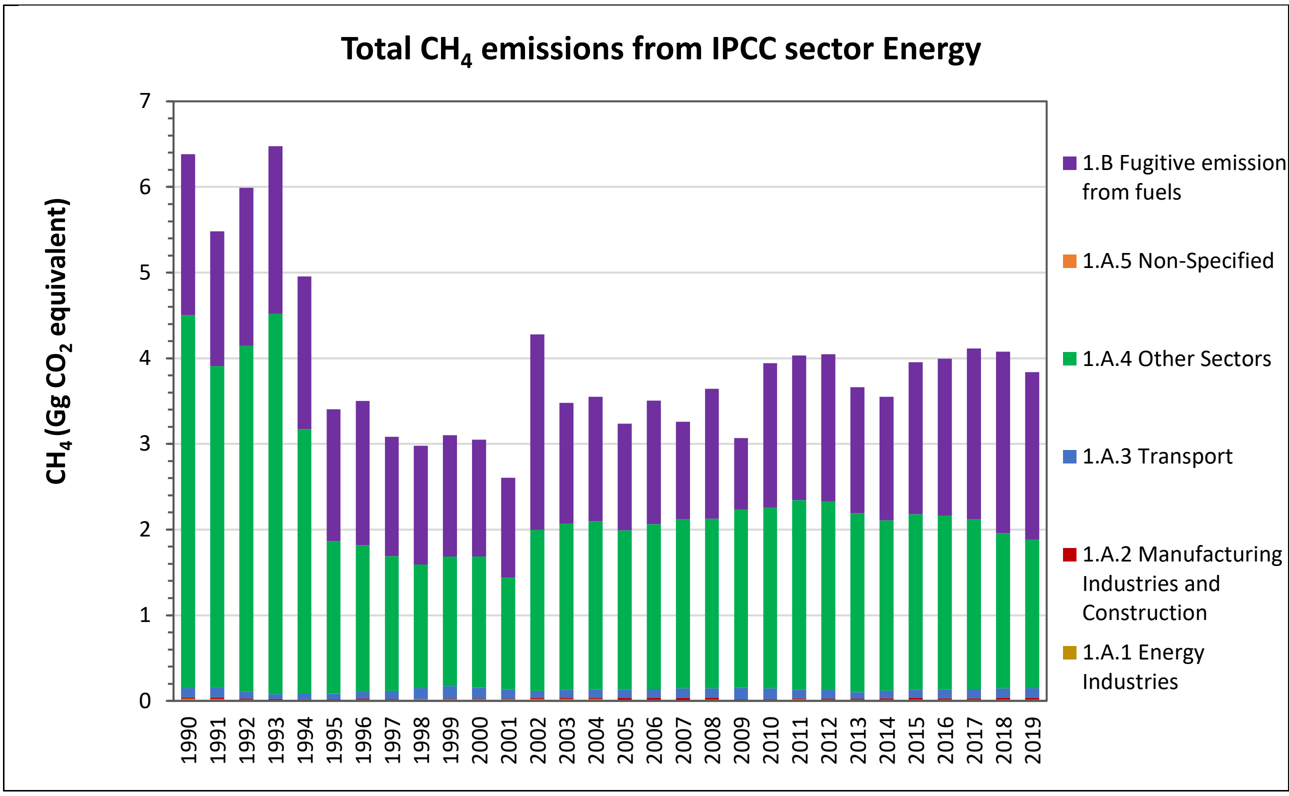


Figure 35 **Total national CH_4 emissions by category of sector Energy (1990-2019)**

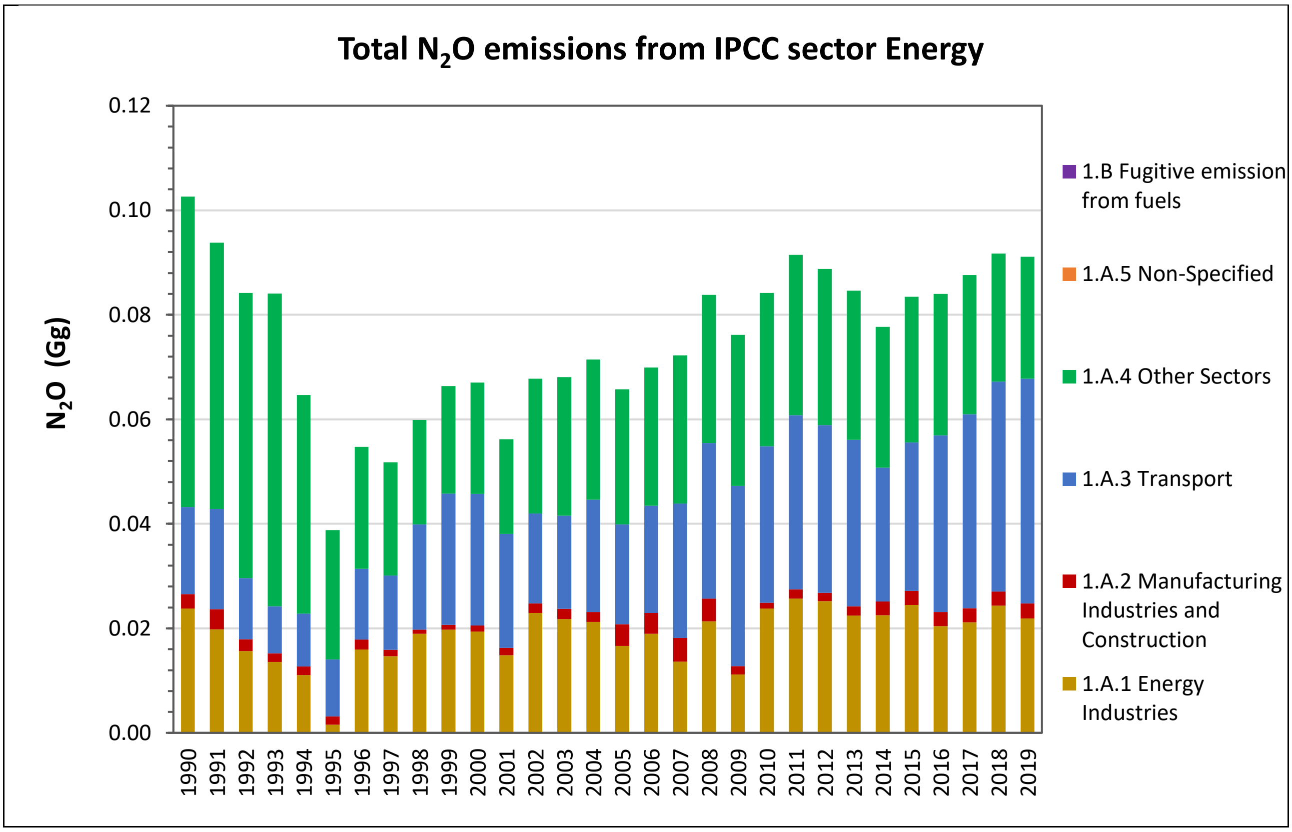


Figure 36 **Total national N_2O emissions by category of sector Energy (1990-2019)**

Table 47 Emissions from IPCC sub-category 1 Energy: 1990 - 2019

GHG emissions	TOTAL GHG (excluding biomass)	CO_2 (excluding biomass)	CH_4 (including biomass)	N_2O (including biomass)	CH_4 (including biomass)	N_2O (including biomass)	MEMO ITEM CO_2 (biomass)
	Gg CO_2 equivalent	Gg	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg	Gg	Gg
1990	2,810.31	2,620.20	159.53	30.58	6.38	0.10	1,599.08
1991	2,677.56	2,512.51	137.10	27.95	5.48	0.09	1,367.32
1992	1,916.51	1,741.65	149.79	25.08	5.99	0.08	1,479.47
1993	1,630.78	1,443.85	161.88	25.04	6.48	0.08	1,630.81
1994	1,434.56	1,291.45	123.85	19.27	4.95	0.06	1,125.84
1995	771.55	674.91	85.07	11.56	3.40	0.04	639.40
1996	1,818.33	1,714.47	87.56	16.30	3.50	0.05	607.10
1997	1,708.46	1,615.92	77.09	15.44	3.08	0.05	549.14
1998	2,092.57	2,000.27	74.46	17.84	2.98	0.06	497.73
1999	2,264.10	2,166.76	77.57	19.77	3.10	0.07	516.46
2000	2,285.04	2,188.85	76.21	19.98	3.05	0.07	540.85
2001	1,924.95	1,843.12	65.09	16.74	2.60	0.06	452.69
2002	2,503.63	2,376.50	106.94	20.19	4.28	0.07	659.56
2003	2,456.86	2,349.60	86.98	20.28	3.48	0.07	680.93
2004	2,480.59	2,370.52	88.78	21.30	3.55	0.07	694.25
2005	2,272.63	2,172.13	80.90	19.60	3.24	0.07	666.92
2006	2,469.45	2,360.94	87.68	20.83	3.51	0.07	674.85
2007	2,324.32	2,221.29	81.51	21.52	3.26	0.07	680.28
2008	2,911.28	2,795.24	91.07	24.98	3.64	0.08	680.33
2009	1,934.38	1,835.00	76.69	22.69	3.07	0.08	714.65
2010	2,690.59	2,566.92	98.59	25.08	3.94	0.08	746.22
2011	2,816.92	2,688.84	100.81	27.27	4.03	0.09	766.02
2012	2,680.96	2,553.36	101.15	26.46	4.05	0.09	775.74
2013	2,477.19	2,360.43	91.56	25.21	3.66	0.08	734.57
2014	2,347.67	2,235.76	88.76	23.16	3.55	0.08	704.75
2015	2,551.09	2,427.41	98.82	24.86	3.95	0.08	720.67
2016	2,388.95	2,264.00	99.92	25.04	4.00	0.08	708.27
2017	2,525.23	2,396.28	102.84	26.11	4.11	0.09	697.13
2018	2,796.59	2,667.29	101.97	27.33	4.08	0.09	633.30
2019	2,701.70	2,578.60	95.95	27.15	3.84	0.09	601.67
Trend							
1990 - 2019	-3.9%	-1.6%	16.7%	-11.2%	-36.1%	-11.2%	-62.4%
2005 - 2019	18.9%	18.7%	11.5%	38.6%	26.0%	38.6%	-9.8%
2018 - 2019	-3.4%	-3.3%	15.8%	-0.6%	-0.8%	-0.6%	-5.0%

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

Table 48 GHG Emissions in Gg CO_2 equivalent from IPCC sub-category 1 Energy by sub-categories: 1990 - 2019

GHG emissions in Gg CO_2 equivalent	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	1.B.1 Solid Fuels	1.B.2 Oil and Natural Gas
	Gg CO_2 equivalent									
1990	2 810,31	2 763,39	1 761,87	387,77	355,53	258,22	NE	46,92	46,92	NE
1991	2 677,56	2 638,15	1 462,53	528,07	407,83	239,72	NE	39,41	39,41	NE
1992	1 916,51	1 870,32	1 132,27	305,00	250,29	182,76	NE	46,19	46,19	NE
1993	1 630,78	1 581,87	971,78	220,45	193,00	196,63	NE	48,91	48,91	NE
1994	1 434,56	1 390,00	807,81	215,74	215,34	151,11	NE	44,56	44,56	NE
1995	771,55	733,13	165,59	210,96	231,33	125,25	NE	38,42	38,42	NE
1996	1 818,33	1 776,14	1 136,67	238,35	285,60	115,52	NE	42,19	42,19	NE
1997	1 708,46	1 673,61	1 087,34	141,55	301,40	143,32	NE	34,84	34,84	NE
1998	2 092,57	2 057,92	1 370,31	111,79	425,88	149,94	NE	34,64	34,64	NE
1999	2 264,10	2 228,69	1 437,80	112,00	528,20	150,68	NE	35,41	35,41	NE
2000	2 285,04	2 250,96	1 411,15	168,02	524,57	147,22	NE	34,08	34,08	NE
2001	1 924,95	1 895,82	1 116,26	191,26	454,41	133,90	NE	29,13	29,13	NE
2002	2 503,63	2 446,62	1 656,63	253,88	358,89	177,22	NE	57,01	57,01	NE
2003	2 456,86	2 421,63	1 583,00	284,40	374,91	179,32	NE	35,23	35,23	NE
2004	2 480,59	2 444,19	1 555,70	267,34	448,27	172,88	NE	36,40	36,40	NE
2005	2 272,63	2 241,49	1 127,11	549,48	407,64	157,26	NE	31,14	31,14	NE
2006	2 469,45	2 433,31	1 283,27	544,53	442,29	163,22	NE	36,14	36,14	NE
2007	2 324,32	2 295,88	928,79	609,59	543,39	214,10	NE	28,45	28,45	NE
2008	2 911,28	2 873,40	1 448,12	585,31	621,64	218,32	NE	37,89	37,89	NE

GHG emissions in Gg CO_2 equivalent	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	1.B.1 Solid Fuels	1.B.2 Oil and Natural Gas
	Gg CO_2 equivalent									
2009	1 934,38	1 913,54	758,37	231,79	721,22	202,17	NE	20,84	20,84	NE
2010	2 690,59	2 648,39	1 615,16	180,51	635,09	217,63	NE	42,20	42,20	NE
2011	2 816,92	2 774,72	1 742,23	147,03	682,85	202,61	NE	42,20	42,20	NE
2012	2 680,96	2 638,00	1 710,25	103,23	661,43	163,08	NE	42,96	42,96	NE
2013	2 477,19	2 440,35	1 519,92	134,52	638,40	147,51	NE	36,84	36,84	NE
2014	2 347,67	2 311,63	1 522,14	160,53	533,02	95,94	NE	36,04	36,04	NE
2015	2 551,09	2 506,73	1 654,08	159,39	591,21	102,05	NE	44,36	44,36	NE
2016	2 388,95	2 343,15	1 378,14	160,72	696,71	107,57	NE	45,80	45,80	NE
2017	2 525,23	2 475,36	1 428,09	186,45	761,76	99,06	NE	49,87	49,87	NE
2018	2 796,59	2 743,57	1 642,42	182,18	822,57	96,40	NE	53,02	53,02	NE
2019	2 701,70	2 652,76	1 480,67	193,69	883,29	95,11	NE	48,94	48,94	NE
Trend										
1990 - 2019	*-3,9%*	*-4,0%*	*-16,0%*	*-50,1%*	*148,4%*	*-63,2%*	*NA*	*4,3%*	*4,3%*	*NA*
2005 - 2019	*18,9%*	*18,3%*	*31,4%*	*-64,8%*	*116,7%*	*-39,5%*	*NA*	*57,2%*	*57,2%*	*NA*
2018 - 2019	*-3,4%*	*-3,3%*	*-9,8%*	*6,3%*	*7,4%*	*-1,3%*	*NA*	*-7,7%*	*-7,7%*	*NA*

Table 49 CO_2 Emissions in Gg from IPCC sub-category 1 Energy by sub-categories: 1990 - 2019

CO_2 emissions in Gg	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	1.B.1 Solid Fuels	1.B.2 Oil and Natural Gas
	Gg									
1990	2 620,20	2 620,20	1 754,11	386,60	347,86	131,62	NE	NE	NA	NE
1991	2 512,51	2 512,51	1 456,08	526,44	399,11	130,88	NE	NE	NA	NE
1992	1 741,65	1 741,65	1 127,22	304,04	244,82	65,57	NE	NE	NA	NE
1993	1 443,85	1 443,85	967,42	219,74	188,85	67,84	NE	NE	NA	NE
1994	1 291,45	1 291,45	804,23	215,04	210,71	61,46	NE	NE	NA	NE
1995	674,91	674,91	164,99	210,28	226,38	73,27	NE	NE	NA	NE
1996	1 714,47	1 714,47	1 131,55	237,51	279,51	65,89	NE	NE	NA	NE
1997	1 615,92	1 615,92	1 082,57	141,01	294,89	97,46	NE	NE	NA	NE
1998	2 000,27	2 000,27	1 364,19	111,45	416,75	107,88	NE	NE	NA	NE
1999	2 166,76	2 166,76	1 431,41	111,60	517,05	106,71	NE	NE	NA	NE
2000	2 188,85	2 188,85	1 404,88	167,51	513,85	102,60	NE	NE	NA	NE
2001	1 843,12	1 843,12	1 111,39	190,64	445,18	95,91	NE	NE	NA	NE
2002	2 376,50	2 376,50	1 649,22	253,09	351,63	122,56	NE	NE	NA	NE
2003	2 349,60	2 349,60	1 575,96	283,57	367,09	122,98	NE	NE	NA	NE
2004	2 370,52	2 370,52	1 548,81	266,54	439,27	115,90	NE	NE	NA	NE
2005	2 172,13	2 172,13	1 121,88	547,68	399,53	103,04	NE	NE	NA	NE
2006	2 360,94	2 360,94	1 277,30	542,83	433,51	107,30	NE	NE	NA	NE
2007	2 221,29	2 221,29	924,49	607,65	532,93	156,23	NE	NE	NA	NE
2008	2 795,24	2 795,24	1 441,40	583,46	610,01	160,38	NE	NE	NA	NE

CO_2 emissions in Gg	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	1.B.1 Solid Fuels	1.B.2 Oil and Natural Gas
	Gg									
2009	1 835,00	1 835,00	754,84	231,12	707,51	141,52	NE	NE	NA	NE
2010	2 566,92	2 566,92	1 607,66	180,05	623,06	156,15	NE	NE	NA	NE
2011	2 688,84	2 688,84	1 734,14	146,21	670,33	138,16	NE	NE	NA	NE
2012	2 553,36	2 553,36	1 702,31	102,48	649,43	99,13	NE	NE	NA	NE
2013	2 360,43	2 360,43	1 512,85	133,72	627,07	86,79	NE	NE	NA	NE
2014	2 235,76	2 235,76	1 515,06	159,31	523,15	38,23	NE	NE	NA	NE
2015	2 427,41	2 427,41	1 646,38	158,13	580,32	42,57	NE	NE	NA	NE
2016	2 264,00	2 264,00	1 371,71	159,48	684,02	48,78	NE	NE	NA	NE
2017	2 396,28	2 396,28	1 421,43	185,21	748,01	41,64	NE	NE	NA	NE
2018	2 667,29	2 667,29	1 634,76	180,96	807,80	43,77	NE	NE	NA	NE
2019	2 578,60	2 578,60	1 473,78	192,37	867,61	44,84	NE	NE	NA	NE
Trend										
1990 - 2019	*-1,6%*	*-1,6%*	*-16,0%*	*-50,2%*	*149,4%*	*-65,9%*	*NA*	*NA*	*NA*	*NA*
2005 - 2019	*18,7%*	*18,7%*	*31,4%*	*-64,9%*	*117,2%*	*-56,5%*	*NA*	*NA*	*NA*	*NA*
2018 - 2019	*-3,3%*	*-3,3%*	*-9,8%*	*6,3%*	*7,4%*	*2,5%*	*NA*	*NA*	*NA*	*NA*

Table 50 CH₄ Emissions in Gg from IPCC sub-category 1 Energy by sub-categories: 1990 - 2019

CH_4 emissions in Gg	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	1.B.1 Solid Fuels	1.B.2 Oil and Natural Gas
	Gg									
1990	6,38	4,50	0,03	0,01	0,11	4,36	NE	1,88	1,88	NE
1991	5,48	3,91	0,02	0,02	0,12	3,75	NE	1,58	1,58	NE
1992	5,99	4,14	0,02	0,01	0,08	4,04	NE	1,85	1,85	NE
1993	6,48	4,52	0,01	0,01	0,06	4,44	NE	1,96	1,96	NE
1994	4,95	3,17	0,01	0,01	0,06	3,09	NE	1,78	1,78	NE
1995	3,40	1,87	0,01	0,01	0,07	1,78	NE	1,54	1,54	NE
1996	3,50	1,81	0,01	0,01	0,08	1,71	NE	1,69	1,69	NE
1997	3,08	1,69	0,02	0,01	0,09	1,58	NE	1,39	1,39	NE
1998	2,98	1,59	0,02	0,00	0,13	1,44	NE	1,39	1,39	NE
1999	3,10	1,69	0,02	0,01	0,15	1,51	NE	1,42	1,42	NE
2000	3,05	1,69	0,02	0,01	0,13	1,53	NE	1,36	1,36	NE
2001	2,60	1,44	0,02	0,01	0,11	1,30	NE	1,17	1,17	NE
2002	4,28	2,00	0,02	0,01	0,09	1,88	NE	2,28	2,28	NE
2003	3,48	2,07	0,02	0,01	0,10	1,94	NE	1,41	1,41	NE
2004	3,55	2,10	0,02	0,01	0,10	1,96	NE	1,46	1,46	NE
2005	3,24	1,99	0,01	0,02	0,10	1,86	NE	1,25	1,25	NE
2006	3,51	2,06	0,01	0,02	0,11	1,92	NE	1,45	1,45	NE
2007	3,26	2,12	0,01	0,02	0,11	1,98	NE	1,14	1,14	NE
2008	3,64	2,13	0,01	0,02	0,11	1,98	NE	1,52	1,52	NE

CH_4 emissions in Gg	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	1.B.1 Solid Fuels	1.B.2 Oil and Natural Gas
	Gg									
2009	3,07	2,23	0,01	0,01	0,14	2,08	NE	0,83	0,83	NE
2010	3,94	2,26	0,02	0,01	0,12	2,11	NE	1,69	1,69	NE
2011	4,03	2,34	0,02	0,01	0,10	2,21	NE	1,69	1,69	NE
2012	4,05	2,33	0,02	0,01	0,10	2,20	NE	1,72	1,72	NE
2013	3,66	2,19	0,01	0,01	0,07	2,09	NE	1,47	1,47	NE
2014	3,55	2,11	0,02	0,02	0,09	1,99	NE	1,44	1,44	NE
2015	3,95	2,18	0,02	0,02	0,10	2,05	NE	1,77	1,77	NE
2016	4,00	2,16	0,01	0,02	0,10	2,03	NE	1,83	1,83	NE
2017	4,11	2,12	0,01	0,02	0,11	1,98	NE	1,99	1,99	NE
2018	4,08	1,96	0,02	0,02	0,11	1,81	NE	2,12	2,12	NE
2019	3,84	1,88	0,01	0,02	0,12	1,73	NE	1,96	1,96	NE
Trend										
1990 - 2019	*-36,1%*	*-58,3%*	*-45,0%*	*33,2%*	*6,2%*	*-60,2%*	*NE*	*4,3%*	*4,3%*	*NE*
2005 - 2019	*26,0%*	*-5,5%*	*29,0%*	*-15,5%*	*18,7%*	*-6,9%*	*NE*	*57,2%*	*57,2%*	*NE*
2018 - 2019	*-0,8%*	*-4,0%*	*-10,1%*	*8,6%*	*2,8%*	*-4,4%*	*NE*	*-7,7%*	*-7,7%*	*NE*

Table 51 CH_4 Emissions in Gg CO_2 equivalent from IPCC sub-category 1 Energy by sub-categories: 1990 - 2019

CH_4 emissions in Gg CO_2 equivalent	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	1.B.1 Solid Fuels	1.B.2 Oil and Natural Gas
	Gg									
1990	159,53	112,61	0,66	0,35	2,71	108,89	NE	46,92	46,92	NE
1991	137,10	97,69	0,55	0,48	3,01	93,65	NE	39,41	39,41	NE
1992	149,79	103,60	0,39	0,29	1,98	100,94	NE	46,19	46,19	NE
1993	161,88	112,97	0,32	0,21	1,46	110,98	NE	48,91	48,91	NE
1994	123,85	79,28	0,29	0,21	1,62	77,17	NE	44,56	44,56	NE
1995	85,07	46,65	0,13	0,21	1,70	44,61	NE	38,42	38,42	NE
1996	87,56	45,37	0,37	0,26	2,07	42,68	NE	42,19	42,19	NE
1997	77,09	42,25	0,41	0,17	2,28	39,38	NE	34,84	34,84	NE
1998	74,46	39,82	0,47	0,10	3,13	36,11	NE	34,64	34,64	NE
1999	77,57	42,16	0,51	0,13	3,68	37,84	NE	35,41	35,41	NE
2000	76,21	42,13	0,50	0,15	3,22	38,25	NE	34,08	34,08	NE
2001	65,09	35,96	0,45	0,19	2,74	32,59	NE	29,13	29,13	NE
2002	106,94	49,93	0,57	0,24	2,13	46,99	NE	57,01	57,01	NE
2003	86,98	51,74	0,56	0,25	2,51	48,42	NE	35,23	35,23	NE
2004	88,78	52,38	0,56	0,24	2,60	48,97	NE	36,40	36,40	NE
2005	80,90	49,76	0,28	0,55	2,42	46,51	NE	31,14	31,14	NE
2006	87,68	51,54	0,32	0,51	2,67	48,04	NE	36,14	36,14	NE
2007	81,51	53,06	0,24	0,59	2,81	49,42	NE	28,45	28,45	NE
2008	91,07	53,18	0,36	0,56	2,77	49,48	NE	37,89	37,89	NE

CH_4 emissions in Gg CO_2 equivalent	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	1.B.1 Solid Fuels	1.B.2 Oil and Natural Gas
	Gg									
2009	76,69	55,85	0,19	0,20	3,43	52,03	NE	20,84	20,84	NE
2010	98,59	56,39	0,40	0,14	3,10	52,74	NE	42,20	42,20	NE
2011	100,81	58,61	0,44	0,29	2,60	55,29	NE	42,20	42,20	NE
2012	101,15	58,19	0,43	0,27	2,44	55,04	NE	42,96	42,96	NE
2013	91,56	54,71	0,37	0,29	1,83	52,22	NE	36,84	36,84	NE
2014	88,76	52,72	0,38	0,43	2,24	49,67	NE	36,04	36,04	NE
2015	98,82	54,46	0,41	0,45	2,42	51,19	NE	44,36	44,36	NE
2016	99,92	54,11	0,34	0,44	2,62	50,71	NE	45,80	45,80	NE
2017	102,84	52,97	0,35	0,43	2,70	49,48	NE	49,87	49,87	NE
2018	101,97	48,95	0,41	0,43	2,80	45,32	NE	53,02	53,02	NE
2019	95,95	47,01	0,36	0,46	2,88	43,30	NE	48,94	48,94	NE
Trend										
1990 - 2019	*-39,9%*	*-58,3%*	*-45,0%*	*33,2%*	*6,2%*	*-60,2%*	*NE*	*4,3%*	*4,3%*	*NE*
2005 - 2019	*18,6%*	*-5,5%*	*29,0%*	*-15,5%*	*18,7%*	*-6,9%*	*NE*	*57,2%*	*57,2%*	*NE*
2018 - 2019	*-5,9%*	*-4,0%*	*-10,1%*	*8,6%*	*2,8%*	*-4,4%*	*NE*	*-7,7%*	*-7,7%*	*NE*

Table 52 N_2O Emissions from IPCC sub-category 1 Energy by sub-categories: 1990 - 2019

N_2O emissions in Gg	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	1.B.1 Solid Fuels	1.B.2 Oil and Natural Gas
	Gg									
1990	0,10	0,10	0,02	0,00	0,02	0,06	NE	NE	NA	NE
1991	0,09	0,09	0,02	0,00	0,02	0,05	NE	NE	NA	NE
1992	0,08	0,08	0,02	0,00	0,01	0,05	NE	NE	NA	NE
1993	0,08	0,08	0,01	0,00	0,01	0,06	NE	NE	NA	NE
1994	0,06	0,06	0,01	0,00	0,01	0,04	NE	NE	NA	NE
1995	0,04	0,04	0,00	0,00	0,01	0,02	NE	NE	NA	NE
1996	0,05	0,05	0,02	0,00	0,01	0,02	NE	NE	NA	NE
1997	0,05	0,05	0,01	0,00	0,01	0,02	NE	NE	NA	NE
1998	0,06	0,06	0,02	0,00	0,02	0,02	NE	NE	NA	NE
1999	0,07	0,07	0,02	0,00	0,03	0,02	NE	NE	NA	NE
2000	0,07	0,07	0,02	0,00	0,03	0,02	NE	NE	NA	NE
2001	0,06	0,06	0,01	0,00	0,02	0,02	NE	NE	NA	NE
2002	0,07	0,07	0,02	0,00	0,02	0,03	NE	NE	NA	NE
2003	0,07	0,07	0,02	0,00	0,02	0,03	NE	NE	NA	NE
2004	0,07	0,07	0,02	0,00	0,02	0,03	NE	NE	NA	NE
2005	0,07	0,07	0,02	0,00	0,02	0,03	NE	NE	NA	NE
2006	0,07	0,07	0,02	0,00	0,02	0,03	NE	NE	NA	NE
2007	0,07	0,07	0,01	0,00	0,03	0,03	NE	NE	NA	NE
2008	0,08	0,08	0,02	0,00	0,03	0,03	NE	NE	NA	NE

N_2O emissions in Gg	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	1.B.1 Solid Fuels	1.B.2 Oil and Natural Gas
	Gg									
2009	0,08	0,08	0,01	0,00	0,03	0,03	NE	NE	NA	NE
2010	0,08	0,08	0,02	0,00	0,03	0,03	NE	NE	NA	NE
2011	0,09	0,09	0,03	0,00	0,03	0,03	NE	NE	NA	NE
2012	0,09	0,09	0,03	0,00	0,03	0,03	NE	NE	NA	NE
2013	0,08	0,08	0,02	0,00	0,03	0,03	NE	NE	NA	NE
2014	0,08	0,08	0,02	0,00	0,03	0,03	NE	NE	NA	NE
2015	0,08	0,08	0,02	0,00	0,03	0,03	NE	NE	NA	NE
2016	0,08	0,08	0,02	0,00	0,03	0,03	NE	NE	NA	NE
2017	0,09	0,09	0,02	0,00	0,04	0,03	NE	NE	NA	NE
2018	0,09	0,09	0,02	0,00	0,04	0,02	NE	NE	NA	NE
2019	0,09	0,09	0,02	0,00	0,04	0,02	NE	NE	NA	NE
Trend										
1990 - 2019	*-11,2%*	*-11,2%*	*-8,1%*	*5,0%*	*158,3%*	*-60,7%*	*NE*	*NE*	*NA*	*NE*
2005 - 2019	*38,6%*	*38,6%*	*31,8%*	*-31,2%*	*125,1%*	*-9,6%*	*NE*	*NE*	*NA*	*NE*
2018 - 2019	*-0,6%*	*-0,6%*	*-10,1%*	*8,4%*	*6,9%*	*-4,6%*	*NE*	*NE*	*NA*	*NE*

Table 53 N_2O Emissions in Gg CO_2 equivalent from IPCC sub-category 1 Energy by sub-categories: 1990 - 2019

N_2O emissions in Gg CO_2 equivalent	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	1.B.1 Solid Fuels	1.B.2 Oil and Natural Gas
	Gg CO_2 equivalent									
1990	30,58	30,58	7,10	0,82	4,96	17,71	NE	NE	NA	NE
1991	27,95	27,95	5,91	1,14	5,71	15,19	NE	NE	NA	NE
1992	25,08	25,08	4,67	0,67	3,49	16,25	NE	NE	NA	NE
1993	25,04	25,04	4,04	0,50	2,69	17,82	NE	NE	NA	NE
1994	19,27	19,27	3,29	0,49	3,01	12,47	NE	NE	NA	NE
1995	11,56	11,56	0,47	0,48	3,25	7,37	NE	NE	NA	NE
1996	16,30	16,30	4,75	0,58	4,03	6,95	NE	NE	NA	NE
1997	15,44	15,44	4,36	0,37	4,23	6,48	NE	NE	NA	NE
1998	17,84	17,84	5,64	0,24	6,00	5,95	NE	NE	NA	NE
1999	19,77	19,77	5,89	0,28	7,47	6,13	NE	NE	NA	NE
2000	19,98	19,98	5,77	0,36	7,50	6,36	NE	NE	NA	NE
2001	16,74	16,74	4,42	0,43	6,49	5,40	NE	NE	NA	NE
2002	20,19	20,19	6,84	0,55	5,13	7,68	NE	NE	NA	NE
2003	20,28	20,28	6,49	0,59	5,30	7,91	NE	NE	NA	NE
2004	21,30	21,30	6,33	0,56	6,40	8,01	NE	NE	NA	NE
2005	19,60	19,60	4,95	1,25	5,69	7,71	NE	NE	NA	NE
2006	20,83	20,83	5,64	1,19	6,11	7,88	NE	NE	NA	NE
2007	21,52	21,52	4,07	1,35	7,65	8,45	NE	NE	NA	NE
2008	24,98	24,98	6,36	1,29	8,87	8,46	NE	NE	NA	NE

N_2O emissions in Gg CO_2 equivalent	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	1.B.1 Solid Fuels	1.B.2 Oil and Natural Gas
	Gg CO_2 equivalent									
2009	22,69	22,69	3,33	0,47	10,28	8,62	NE	NE	NA	NE
2010	25,08	25,08	7,09	0,32	8,94	8,73	NE	NE	NA	NE
2011	27,27	27,27	7,65	0,52	9,93	9,16	NE	NE	NA	NE
2012	26,46	26,46	7,51	0,48	9,56	8,90	NE	NE	NA	NE
2013	25,21	25,21	6,70	0,52	9,50	8,50	NE	NE	NA	NE
2014	23,16	23,16	6,71	0,79	7,63	8,04	NE	NE	NA	NE
2015	24,86	24,86	7,29	0,81	8,47	8,29	NE	NE	NA	NE
2016	25,04	25,04	6,09	0,80	10,07	8,08	NE	NE	NA	NE
2017	26,11	26,11	6,31	0,81	11,04	7,94	NE	NE	NA	NE
2018	27,33	27,33	7,26	0,79	11,97	7,30	NE	NE	NA	NE
2019	27,15	27,15	6,52	0,86	12,80	6,97	NE	NE	NA	NE
Trend										
1990 - 2019	-11,2%	-11,2%	-8,1%	5,0%	158,3%	-60,7%	NE	NE	NA	NE
2005 - 2019	38,6%	38,6%	31,8%	-31,2%	125,1%	-9,6%	NE	NE	NA	NE
2018 - 2019	-0,6%	-0,6%	-10,1%	8,4%	6,9%	-4,6%	NE	NE	NA	NE

3.2 Fuel combustion

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

The “Reference Approach” is and checks that all fuell carbon has been accounted for.

3.2.1.1 Methodology

The default methodology is applied according to 2006 IPCC Guidelines[28]. 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)

$$CO_2Emissions = \sum_{all\ fuels}\left[\left(\left(\textbf{Apparent Consumption}_{fuel} \times \textbf{ConversionFactor}_{fuel} \times \textbf{Carbon Content}_{fuel}\right) \times \mathbf{10^{-3}} - \textbf{Excluded Carbon}_{fuel}\right) \times \textbf{Fraction of carbon oxidised}_{fuel} \times \frac{\mathbf{44}}{\mathbf{12}}\right]$$

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

[28] 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**[29] (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 availbale.

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 metres. 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.

[29] 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.3 If countries have other fossil fuel carbon products which should be excluded they should be taken into consideration and documented.

Table 54 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)	
	Refinery gas	
	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	
	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 55 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)					
Crude Oil		42.3	20	1	
Orimulsion		27.5	21	1	
Natural Gas Liquids		44.2	17.5	1	
Gasoline	Motor Gasoline	44.3	18.9	1	X
	Aviation Gasoline	44.3	19.1	1	
	Jet Gasoline	44.3	19.1	1	
Jet Kerosene		44.1	19.5	1	X
Other Kerosene		43.8	19.6	1	
Shale Oil		38.1	20	1	
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
Ethane		46.4	16.8	1	
Naphtha		44.5	20	1	
Bitumen		40.2	22	1	x
Lubricants		40.2	20	1	x
Petroleum Coke		32.5	26.6	1	x
Refinery Feedstocks		43.0	20	1	
Other Oil	Refinery Gas [2]	49.5	15.7	1	
	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)					
Anthracite		26.7	26.8	1	
Coking Coal		28.2	25.8	1	
Other Bituminous Coal		25.8	25.8	1	
Sub-Bituminous Coal		18.9	26.2	1	x
Lignite		11.9	27.6	1	x
Oil Shale and Tar Sands		8.9	29.1	1	
Brown Coal Briquettes		20.7	26.6	1	
Patent Fuel		20.7	26.6	1	
Coke	Coke Oven Coke and Lignite Coke	28.2	29.2	1	
	Gas Coke	28.2	29.2	1	

		Default Net Calorific Values (NCVs)	Default values of Carbon Content (CC)	Default Fraction of carbon oxidized	Fuel used in Montenegro
		TJ/Gg	kg/GJ	%	
Coal Tar		28.0	22.0	1	
Derived Gases	Gas Works Gas 4	38.7	12.1	1	
	Coke Oven Gas 5	38.7	12.1	1	
	Blast Furnace Gas 6	2.5	70.8	1	
	Oxygen Steel Furnace Gas 7	7.1	49.6	1	
GAS (Natural Gas)					
Natural Gas		48.0	15.3	1	x
OTHER FOSSIL FUELS					
Municipal Wastes (non-biomass fraction)		10.0	25.0	1	
Industrial Wastes		NA	39.0	1	
Waste Oil 8		40.2	20.0	1	
PEAT					
Peat		9.8	28.9	1	
BIOMASS					
Solid Biofuels	Wood/Wood Waste 9	15.6	30.5	1	x
	Sulphite lyes (black liquor) 10	11.8	26.0	1	
	Other Primary Solid Biomass 11	11.6	27.3	1	
	Charcoal 12	29.5	30.5	1	x
Liquid Biofuels	Biogasoline 13	27.0	19.3	1	
	Biodiesels 14	27.0	19.3	1	
	Other Liquid Biofuels 15	27.4	21.7	1	
Gas Biomass	Landfill Gas 16	50.4	14.9	1	
	Sludge Gas 17	50.4	14.9	1	
	Other Biogas 18	50.4	14.9	1	
Other non-fossil fuels	Municipal Wastes (biomass fraction)	11.6	27.3	1	
Source *Footnote (above) in this tables are reffered to footenotes provided in tables in 2006 IPCC Guidelines.*		*TABLE 1.2* [30]	*TABLE 1.3* [31]	*TABLE 1.4* [32]	

[30] 2006 IPCC Guidelines, Volume 2: Energy, Chapter 1: Introduction, sub-chapter 1.4.1.3 ACTIVITY DATA SOURCES, page 1.17

[31] 2006 IPCC Guidelines, Volume 2: Energy, Chapter 1: Introduction, sub-chapter 1.4.2.1 CO2 EMISSION FACTORS, page 1.20

[32] 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

Due to lack of data and resources no emissions from International navigation was estimated.

Table 56 Emissions from International Bunkers

	International bunkers	International Aviation			International navigation
	TOTAL GHG	CO_2	N_2O	CH_4	GHG
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
1990	**30.91**	**30.67**	**0.24**	NE	NE
1991	34.06	33.80	0.26	NE	NE
1992	4.76	4.72	0.04	NE	NE
1993	2.38	2.36	0.02	NE	NE
1994	2.38	2.36	0.02	NE	NE
1995	2.38	2.36	0.02	NE	NE
1996	2.38	2.36	0.02	NE	NE
1997	2.38	2.36	0.02	NE	NE
1998	11.89	11.80	0.09	NE	NE
1999	30.91	30.67	0.24	NE	NE
2000	**30.91**	**30.67**	**0.24**	NE	NE
2001	38.04	37.75	0.29	NE	NE
2002	40.36	40.20	0.16	NE	NE
2003	32.68	32.49	0.19	NE	NE
2004	7.14	6.79	0.35	NE	NE
2005	29.51	29.17	0.34	NE	NE
2006	32.25	31.82	0.43	NE	NE
2007	10.67	10.13	0.53	NE	NE
2008	**18.00**	**17.39**	**0.61**	NE	NE
2009	**13.25**	**12.67**	**0.58**	NE	NE
2010	32.07	31.42	0.65	NE	NE
2011	17.01	16.38	0.64	NE	NE
2012	3.22	2.41	0.81	NE	NE
2013	6.12	5.30	0.82	NE	NE
2014	27.39	26.76	0.63	NE	NE
2015	29.14	28.49	0.65	NE	NE
2016	28.40	27.69	0.71	NE	NE
2017	**26.57**	**25.71**	**0.86**	NE	NE
2018	34.42	33.54	0.88	NE	NE
2019	59.48	58.02	1.46	NE	NE
Trend					
1990 - 2019	92.4%	89.2%	519.0%	-45.0%	NA

	International bunkers	International Aviation			International navigation
	TOTAL GHG	CO_2	N_2O	CH_4	GHG
	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent
2005 - 2019	101.6%	98.9%	326.0%	29.0%	NA
2018 - 2019	72.8%	73.0%	66.2%	-10.1%	NA

3.2.4 Feedstocks and non-energy use of fuels

Feedstocks and non-energ 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.[33]

An overview on fuel used as non-energy products in Montenegro is provided in **Error! Reference source not found.**.

- Bitumen was used as road surface
- Lubricants were used as feedstock by the chemical.

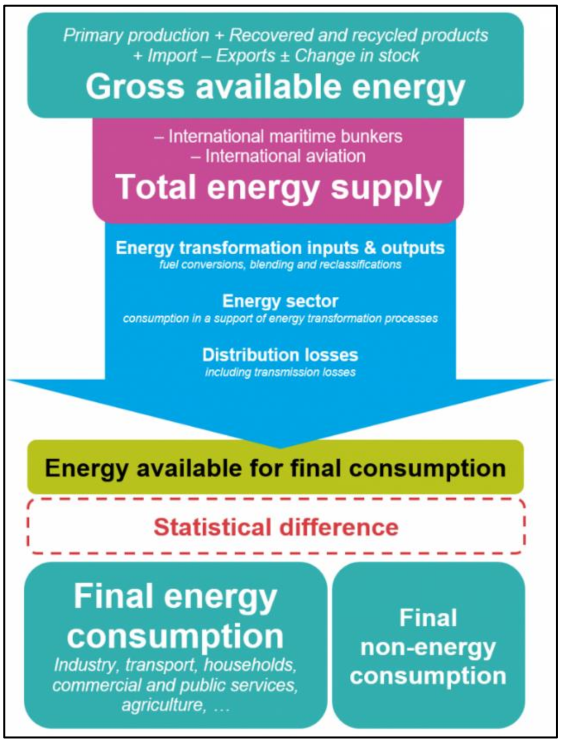


Figure 37 Simplified scheme of Eurostat's energy balances (Eurostat)

[33] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_balance_-_new_methodology#What_is_an_energy_balance.3F

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[34]. 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);
- petroleum refining (IPCC category 1.A.1.b);
- manufacturing of solid fuels (IPCC category 1.A.1.c).

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

3.2.5.1.1 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
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 2019		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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

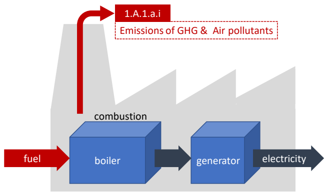
This section describes GHG emissions resulting from fuel combustion activities in energy industries which, originate from public electricity and heat production plants. Two types of producers can be distinguished: Main activity producer and auto-producer. According to 2006 IPCC Guidelines main activity 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;	

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

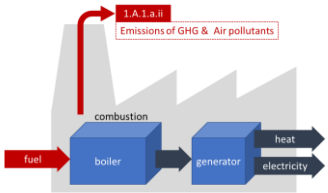
The following sub-categories are defined in the 2006 IPCC Guidelines:

1.A.1.a.i Electricity Generation



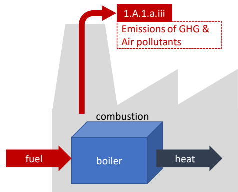
Comprises emissions from <u>all</u> fuel use for electricity generation from main activity producers except those from combined heat and power plants.

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.

An overview of the GHG emission from fuel combustion in Sub-category 1.A.1.a *Main Activity Electricity and Heat Production* is provided in the following figures and tables:

- annual GHG emissions;
- Trend of the periods 1990 – 2019, 2005 – 2019, 2018 – 2019;

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,
- overall economic downturn in the country;
- break-up of the union with Serbia;
- world-wide economic crisis;
- reconstruction of the power plant.

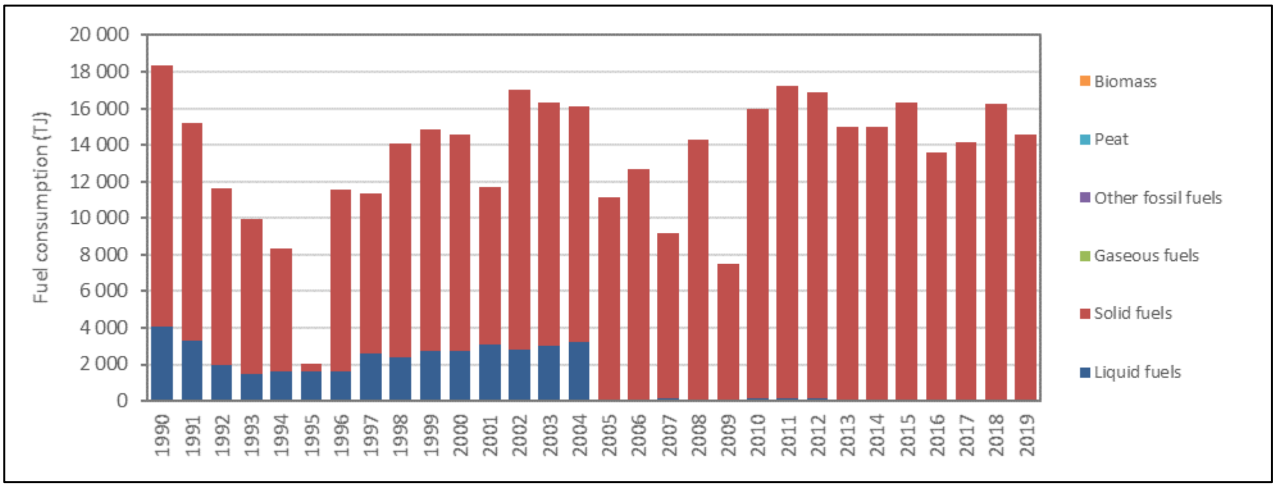


Figure 38 Emissions from IPCC sub-category 1.A.1.a Main Activity Electricity and Heat Production

Table 57 Emissions from IPCC sub-category 1.A.1.a Main Activity Electricity and Heat Production

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent
1990	1 762	1 754	7.10	0.66	NO
1991	1 463	1 456	5.91	0.55	NO
1992	1 132	1 127	4.67	0.39	NO
1993	972	967	4.04	0.32	NO
1994	808	804	3.29	0.29	NO
1995	166	165	0.47	0.13	NO
1996	1 137	1 132	4.75	0.37	NO
1997	1 087	1 083	4.36	0.41	NO
1998	1 370	1 364	5.64	0.47	NO
1999	1 438	1 431	5.89	0.51	NO
2000	1 411	1 405	5.77	0.50	NO
2001	1 116	1 111	4.42	0.45	NO
2002	1 657	1 649	6.84	0.57	NO
2003	1 583	1 576	6.49	0.56	NO
2004	1 556	1 549	6.33	0.56	NO
2005	1 127	1 122	4.95	0.28	NO
2006	1 283	1 277	5.64	0.32	NO
2007	929	924	4.07	0.24	NO
2008	1 448	1 441	6.36	0.36	NO
2009	758	755	3.33	0.19	NO
2010	1 615	1 608	7.09	0.40	NO
2011	1 742	1 734	7.65	0.44	NO
2012	1 710	1 702	7.51	0.43	NO
2013	1 520	1 513	6.70	0.37	NO
2014	1 522	1 515	6.71	0.38	NO
2015	1 654	1 646	7.29	0.41	NO
2016	1 378	1 372	6.09	0.34	NO
2017	1 428	1 421	6.31	0.35	NO
2018	1 642	1 635	7.26	0.41	NO
2019	1 481	1 474	6.52	0.36	NO
Trend					
1990 - 2019	-16.0%	-16.0%	-8.1%	-45.0%	*NA*
2005 - 2019	31.4%	31.4%	31.8%	29.0%	*NA*
2018 - 2019	-9.8%	-9.8%	-10.1%	-10.1%	*NA*

3.2.5.1.2 Methodological issues

3.2.5.1.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[35] 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, gasous fuels, other fossil fuel, biomass, peat

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

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

3.2.5.1.2.2 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 58 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 - 2019 are **plant specific data** and were taken from prepared by Statistical Office of Montenegro (MONSTAT).

[35] 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% in the period 1990 – 2019. From 2005 to 2019 the total fuel consumption increased by 31%. From 2018 to 2019 the total fuel consumption decreased by 10% due to an increase in hydropower for 2019. 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).

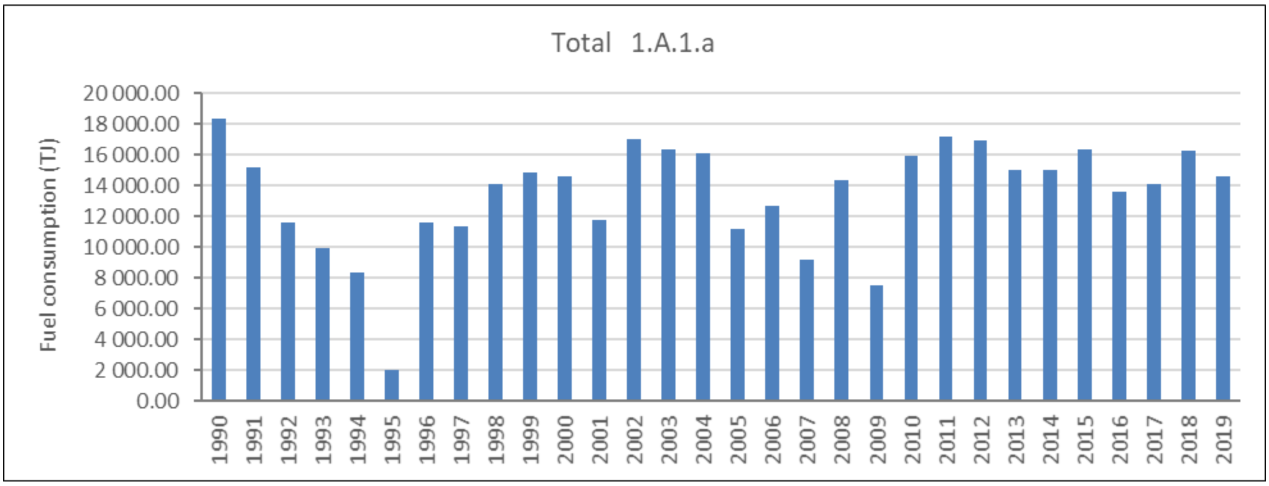


Figure 39 **Activity data for IPCC sub-category 1.A.1.a Main Activity Electricity and Heat Production**

Table 59 Activity data for IPCC sub-category 1.A.1.a Main Activity Electricity and Heat Production and Public gross electricity production - Electricity plants

Activity data 1.A.1.a.i	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	18 334	4 096	14 238	NO	NO	NO	NO
1991	15 196	3 307	11 889	NO	NO	NO	NO
1992	11 625	1 970	9 654	NO	NO	NO	NO
1993	9 933	1 506	8 427	NO	NO	NO	NO
1994	8 343	1 622	6 721	NO	NO	NO	NO
1995	2 010	1 606	404	NO	NO	NO	NO
1996	11 579	1 597	9 983	NO	NO	NO	NO
1997	11 335	2 626	8 709	NO	NO	NO	NO
1998	14 075	2 420	11 655	NO	NO	NO	NO
1999	14 816	2 741	12 075	NO	NO	NO	NO
2000	14 556	2 754	11 803	NO	NO	NO	NO
2001	11 723	3 057	8 666	NO	NO	NO	NO
2002	16 996	2 840	14 156	NO	NO	NO	NO
2003	16 312	3 002	13 310	NO	NO	NO	NO
2004	16 101	3 244	12 857	NO	NO	NO	NO
2005	11 129	91	11 038	NO	NO	NO	NO
2006	12 660	58	12 602	NO	NO	NO	NO

Activity data 1.A.1.a.i	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
2007	9 184	132	9 052	NO	NO	NO	NO
2008	14 297	111	14 186	NO	NO	NO	NO
2009	7 488	59	7 428	NO	NO	NO	NO
2010	15 946	124	15 823	NO	NO	NO	NO
2011	17 199	124	17 075	NO	NO	NO	NO
2012	16 886	136	16 750	NO	NO	NO	NO
2013	14 979	NO	14 979	NO	NO	NO	NO
2014	15 001	NO	15 001	NO	NO	NO	NO
2015	16 301	NO	16 301	NO	NO	NO	NO
2016	13 620	NO	13 620	NO	NO	NO	NO
2017	14 117	NO	14 117	NO	NO	NO	NO
2018	16 232	NO	16 232	NO	NO	NO	NO
2019	14 592	NO	14 592	NO	NO	NO	NO
Trend							
1990 - 2019	*-20.4%*	*NA*	*2.5%*	*NA*	*NA*	*NA*	*NA*
2005 - 2019	*31.1%*	*NA*	*32.2%*	*NA*	*NA*	*NA*	*NA*
2018 - 2019	*-10.1%*	*NA*	*-10.1%*	*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 metres. 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 *Main Activity Electricity and Heat Production*.

Table 60 Net calorific values (NCVs) applied for conversion to energy units in IPCC sub-category 1.A.1.a Main Activity Electricity and Heat Production

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg)		Source
		NCV	type	
Lignite	solid	10.28	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				

3.2.5.1.2.3 Choice of emission factors

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

Table 61 GHG Emission factor TIER 1 for IPCC sub-category 1.A.1.a Main Activity Electricity and Heat Production

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								

3.2.5.1.3 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 62 Uncertainty for IPCC sub-category 1.A.1.a Main Activity Electricity and Heat Production.

Uncertainty	Solid 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)	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.

3.2.5.1.4 Source-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;

3.2.5.1.5 Source-specific recalculations

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 Main Activity Electricity and Heat Production*.

Table 63 Recalculations done since NC & BUR in IPCC sub-category 1.A.1.a Main Activity Electricity and Heat Production

source category	Revisions of data	Type of revision	Type of improvement
1.A.1.a	Use of PS NCV	AD	Accuracy
1.A.1.a	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy

3.2.5.1.6 Source-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 64 Planned improvements for IPCC sub-category 1.A.1.a Main Activity Electricity and Heat Production

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	high
1.A.1.a	Cross-check of national and international data sources (Eurostat and UNSD)	AD	Consistency Transparency	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

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

3.2.5.2.1 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.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.

3.2.5.3 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*

3.2.5.3.1 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.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.

3.2.5.3.2 Source-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 65 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				

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

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 Cattegory	LA1990		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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 emission 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 – 2019, 2005 – 2019, 2018 – 2019;

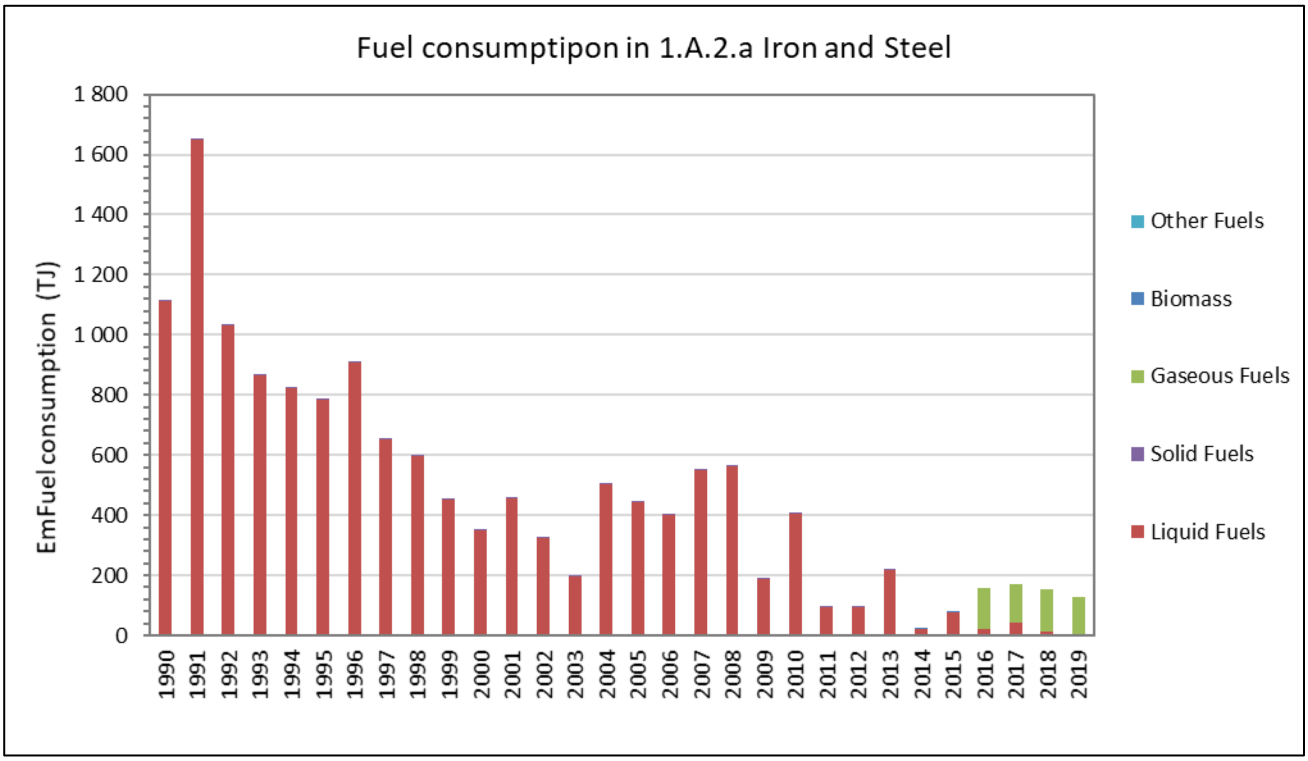


Figure 40 Emissions from IPCC sub-category 1.A.2.a Main Activity Iron and Steel

Table 66 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)
	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent
1990	86.41	86.12	0.20	0.08	NO
1991	127.99	127.57	0.29	0.12	NO
1992	80.00	79.74	0.18	0.08	NO
1993	67.20	66.98	0.15	0.06	NO
1994	64.00	63.79	0.15	0.06	NO
1995	60.80	60.60	0.14	0.06	NO
1996	70.41	70.17	0.16	0.07	NO
1997	50.65	50.49	0.11	0.05	NO
1998	46.16	46.02	0.10	0.04	NO
1999	34.34	34.24	0.07	0.03	NO
2000	26.34	26.26	0.06	0.02	NO
2001	34.66	34.55	0.07	0.03	NO
2002	24.43	24.36	0.05	0.02	NO
2003	15.39	15.34	0.04	0.01	NO
2004	39.06	38.93	0.09	0.04	NO
2005	33.70	33.60	0.07	0.03	NO
2006	31.05	30.95	0.07	0.03	NO
2007	41.45	41.33	0.08	0.04	NO
2008	43.53	43.38	0.10	0.04	NO
2009	11.86	11.85	0.01	0.00	NO
2010	30.19	30.11	0.06	0.03	NO
2011	5.93	5.93	0.00	0.00	NO
2012	5.93	5.93	0.00	0.00	NO
2013	15.53	15.49	0.02	0.01	NO
2014	1.67	1.53	0.00	0.00	0.13
2015	5.38	5.24	0.01	0.00	0.13
2016	9.23	9.22	0.01	0.00	NO
2017	9.95	9.91	0.01	0.04	NO
2018	10.27	8.79	0.00	0.00	NO
2019	8.44	7.21	0.00	0.00	NO
Trend					
1990 - 2019	*-89.0%*	*-91.6%*	*-98.1%*	*-96.2%*	*NA*
2005 - 2019	*-71.7%*	*-78.5%*	*-94.7%*	*-89.6%*	*NA*
2018 - 2019	*-17.3%*	*-18.0%*	*-17.3%*	*-17.3%*	*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[36] 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, gasous fuels, other fossil fuel, biomass, peat

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

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

3.2.6.1.2.2 Choice of activity data

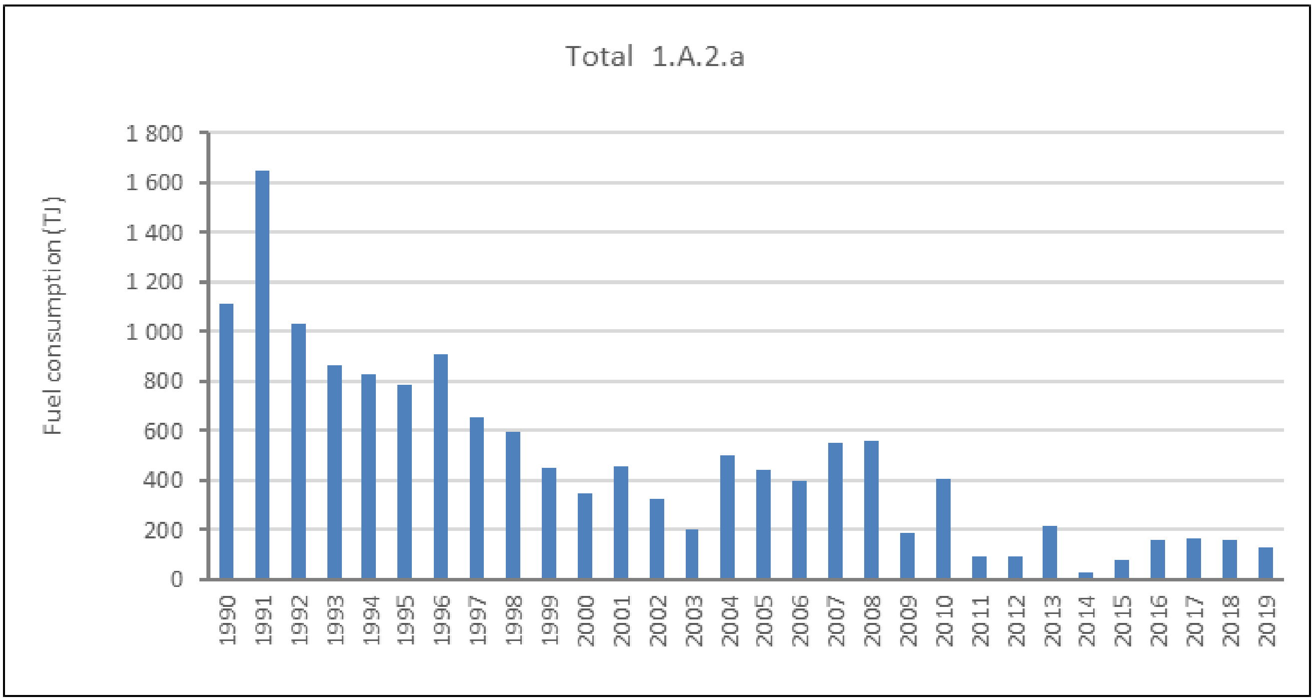


Figure 41 Activity data for sub-category 1.A.2.a Iron and Steel

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

Table 67 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	1 112.63	1 112.40	0.23	NO	NO	NO	NO
1991	1 648.19	1 648.00	0.19	NO	NO	NO	NO
1992	1 030.18	1 030.00	0.18	NO	NO	NO	NO
1993	865.35	865.20	0.15	NO	NO	NO	NO
1994	824.15	824.00	0.15	NO	NO	NO	NO
1995	782.96	782.80	0.16	NO	NO	NO	NO
1996	906.59	906.40	0.19	NO	NO	NO	NO
1997	654.12	653.81	0.31	NO	NO	NO	NO
1998	595.51	595.26	0.25	NO	NO	NO	NO
1999	450.95	450.65	0.30	NO	NO	NO	NO
2000	347.89	347.65	0.24	NO	NO	NO	NO
2001	454.97	454.77	0.20	NO	NO	NO	NO
2002	323.24	322.93	0.31	NO	NO	NO	NO
2003	198.07	197.76	0.31	NO	NO	NO	NO
2004	502.90	502.64	0.26	NO	NO	NO	NO
2005	442.64	442.41	0.23	NO	NO	NO	NO
2006	399.84	399.64	0.20	NO	NO	NO	NO
2007	551.23	551.10	0.13	NO	NO	NO	NO
2008	560.47	560.32	0.15	NO	NO	NO	NO
2009	187.68	187.56	0.12	NO	NO	NO	NO
2010	406.32	406.24	0.08	NO	NO	NO	NO
2011	93.86	93.78	0.08	NO	NO	NO	NO
2012	93.89	93.78	0.11	NO	NO	NO	NO
2013	217.47	217.38	0.09	NO	NO	NO	NO
2014	23.57	22.31	0.09	NO	NO	NO	1.18
2015	76.56	75.16	0.22	NO	NO	NO	1.18
2016	158.34	21.74	0.20	136.40	NO	NO	NO
2017	168.27	40.49	0.17	127.60	NO	NO	NO
2018	154.92	14.07	0.05	140.80	NO	NO	NO
2019	127.95	4.69	0.06	123.20	NO	NO	NO
Trend							
1990 - 2019	*-88.5%*	*-99.6%*	*-74.4%*	*NA*	*NA*	*NA*	*NA*
2005 - 2019	*-71.1%*	*-98.9%*	*-74.4%*	*NA*	*NA*	*NA*	*NA*
2018 - 2019	*-17.4%*	*-66.7%*	*14.3%*	*-12.5%*	*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 metres. 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 68 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 69 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		

3.2.6.1.3 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 70 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 Source-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 Source-specific recalculations

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 71 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	use of CS NCV	AD	Accuracy
1.A.2.a	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy

3.2.6.1.6 Source-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 72 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 timesseries. 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)

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																		

<u>Use of notation key</u>

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

An overview of the emission 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 air pollutants;
- Trend of the periods 1990 – 2019, 2005 – 2019, 2018 – 2019.

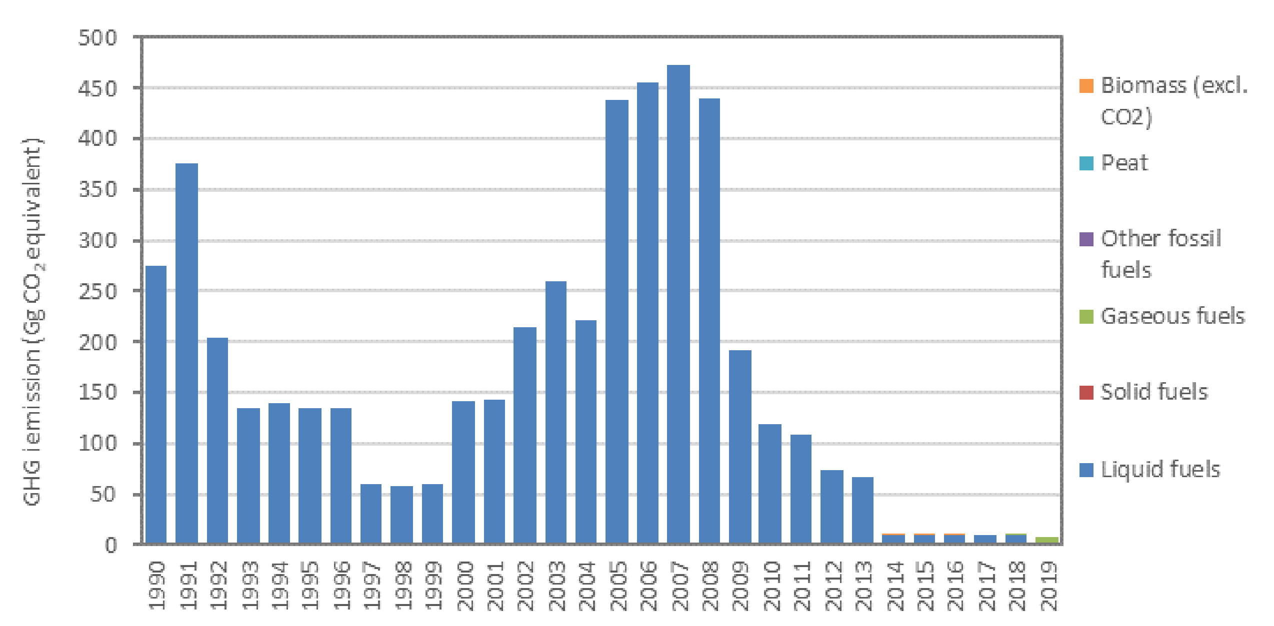


Figure 42 Emissions from IPCC sub-category 1.A.2.b Non-Ferrous Metals

Table 73 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)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
1990	274.55	273.75	0.56	0.23	NO
1991	376.22	375.11	0.78	0.33	NO
1992	204.11	203.50	0.43	0.18	NO
1993	133.95	133.55	0.28	0.12	NO
1994	140.46	140.02	0.30	0.13	NO
1995	134.06	133.65	0.29	0.12	NO
1996	134.04	133.63	0.29	0.12	NO
1997	59.46	59.27	0.14	0.06	NO
1998	57.54	57.35	0.13	0.06	NO
1999	59.78	59.58	0.14	0.06	NO
2000	141.64	141.21	0.30	0.13	NO
2001	143.88	143.44	0.31	0.13	NO
2002	213.50	212.88	0.44	0.18	NO
2003	259.58	258.84	0.52	0.22	NO
2004	220.45	219.81	0.45	0.19	NO
2005	437.91	436.57	0.95	0.40	NO
2006	455.73	454.33	0.99	0.41	NO
2007	473.54	472.10	1.02	0.43	NO
2008	440.01	438.67	0.95	0.40	NO
2009	191.38	190.80	0.41	0.17	NO
2010	119.02	118.70	0.22	0.09	NO
2011	108.02	107.74	0.20	0.08	NO

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
2012	73.07	72.88	0.13	0.06	NO
2013	66.72	66.54	0.12	0.05	NO
2014	9.69	9.56	0.02	0.01	0.09
2015	9.94	9.88	0.02	0.01	0.02
2016	8.66	8.61	0.02	0.01	0.02
2017	8.64	8.61	0.02	0.01	NO
2018	11.61	7.39	0.01	0.01	NO
2019	6.90	5.75	0.00	0.00	NO
Trend					
1990 - 2019	*-97.5%*	*-97.9%*	*-99.4%*	*-98.8%*	*NA*
2005 - 2019	*-98.4%*	*-98.7%*	*-99.6%*	*-99.3%*	*NA*
2018 - 2019	*-40.6%*	*-22.2%*	*-73.4%*	*-55.7%*	*NA*

3.2.6.2.1 Methodological issues

3.2.6.2.1.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[37] 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, gasous fuels, other fossil fuel, biomass, peat

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

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

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

3.2.6.2.1.2 Choice of activity data

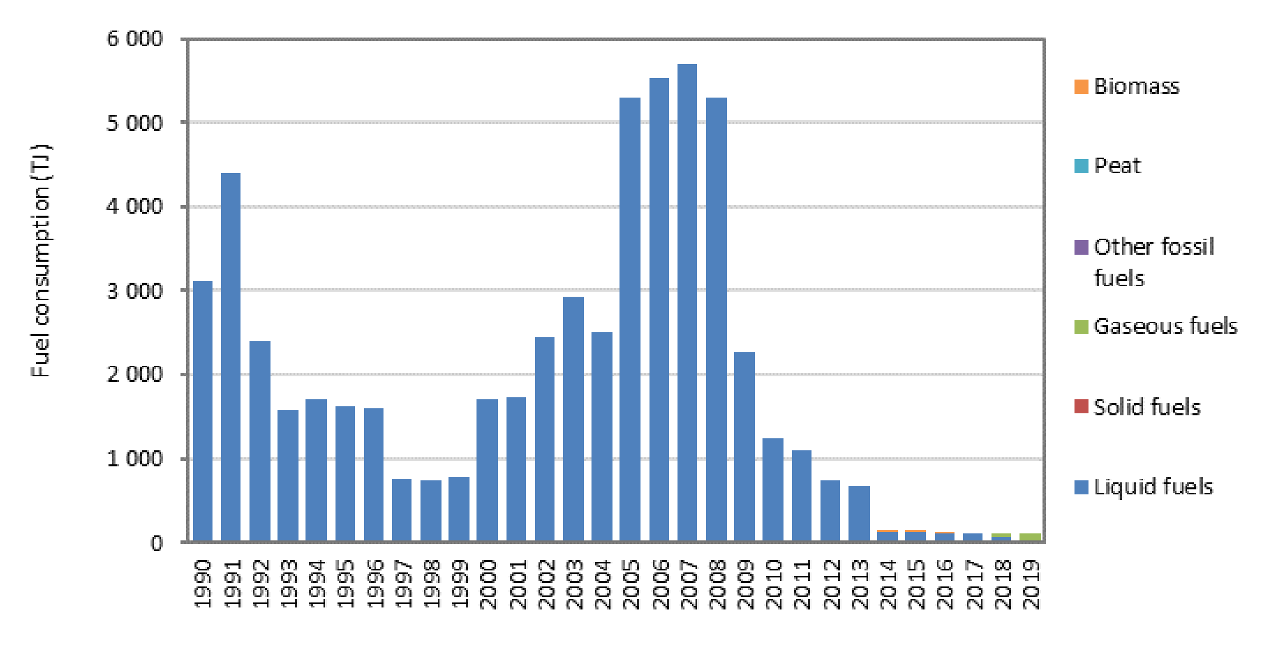


Figure 43 Activity data for IPCC sub-category 1.A.2.b Non-Ferrous

Table 74 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	3 123.99	3 123.99	NO	NO	NO	NO	NO
1991	4 387.63	4 387.63	NO	NO	NO	NO	NO
1992	2 404.92	2 404.92	NO	NO	NO	NO	NO
1993	1 575.31	1 575.31	NO	NO	NO	NO	NO
1994	1 701.21	1 701.21	NO	NO	NO	NO	NO
1995	1 618.81	1 618.81	NO	NO	NO	NO	NO
1996	1 610.11	1 610.11	NO	NO	NO	NO	NO
1997	769.34	769.34	NO	NO	NO	NO	NO
1998	744.62	744.62	NO	NO	NO	NO	NO
1999	773.46	773.46	NO	NO	NO	NO	NO
2000	1 703.31	1 703.31	NO	NO	NO	NO	NO
2001	1 732.15	1 732.15	NO	NO	NO	NO	NO
2002	2 450.22	2 450.22	NO	NO	NO	NO	NO
2003	2 925.82	2 925.82	NO	NO	NO	NO	NO
2004	2 504.32	2 504.32	NO	NO	NO	NO	NO
2005	5 291.85	5 291.85	NO	NO	NO	NO	NO
2006	5 521.37	5 521.37	NO	NO	NO	NO	NO
2007	5 687.58	5 687.58	NO	NO	NO	NO	NO
2008	5 308.09	5 308.09	NO	NO	NO	NO	NO
2009	2 274.74	2 274.74	NO	NO	NO	NO	NO
2010	1 253.01	1 253.01	NO	NO	NO	NO	NO

Activity data 1.A.1.b	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
2011	1 105.00	1 105.00	NO	NO	NO	NO	NO
2012	747.50	747.50	NO	NO	NO	NO	NO
2013	682.50	682.50	NO	NO	NO	NO	NO
2014	124.61	123.75	NO	NO	NO	NO	0.86
2015	128.07	127.87	NO	NO	NO	NO	0.20
2016	111.57	111.39	NO	NO	NO	NO	0.18
2017	111.39	111.39	NO	NO	NO	NO	NO
2018	105.54	70.34	NO	35.20	NO	NO	NO
2019	100.92	4.12	NO	96.80	NO	NO	NO
Trend							
1990 - 2019	*-96.8%*	*-99.9%*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2019	*-98.1%*	*-99.9%*	*NA*	*NA*	*NA*	*NA*	*NA*
2018 - 2019	*-4.4%*	*-94.1%*	*NA*	*175.0%*	*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 metres. 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 75 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

3.2.6.2.1.3 Choice of emission factors

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

Table 76 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

3.2.6.2.2 Source-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.

3.2.6.2.3 Source-specific recalculations

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 77 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	use of CS NCV	AD	Accuracy
1.A.2.b	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy

3.2.6.2.4 Source-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 78 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 timesseries. 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)

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	IE*	✓	✓**	NO	NO	NO	IE*	✓	✓**	NO	NO	NO	IE*
Key cattegory	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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 2005-2008, all other years IE; ** data provided only in the period 2014-2018, all other years IE;																		

Use of notation key

IE 1.A.2.c (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 timesseries. Emissions are currently allocated in IPCC/NFR subcategory 1.A.2.m *Other*.

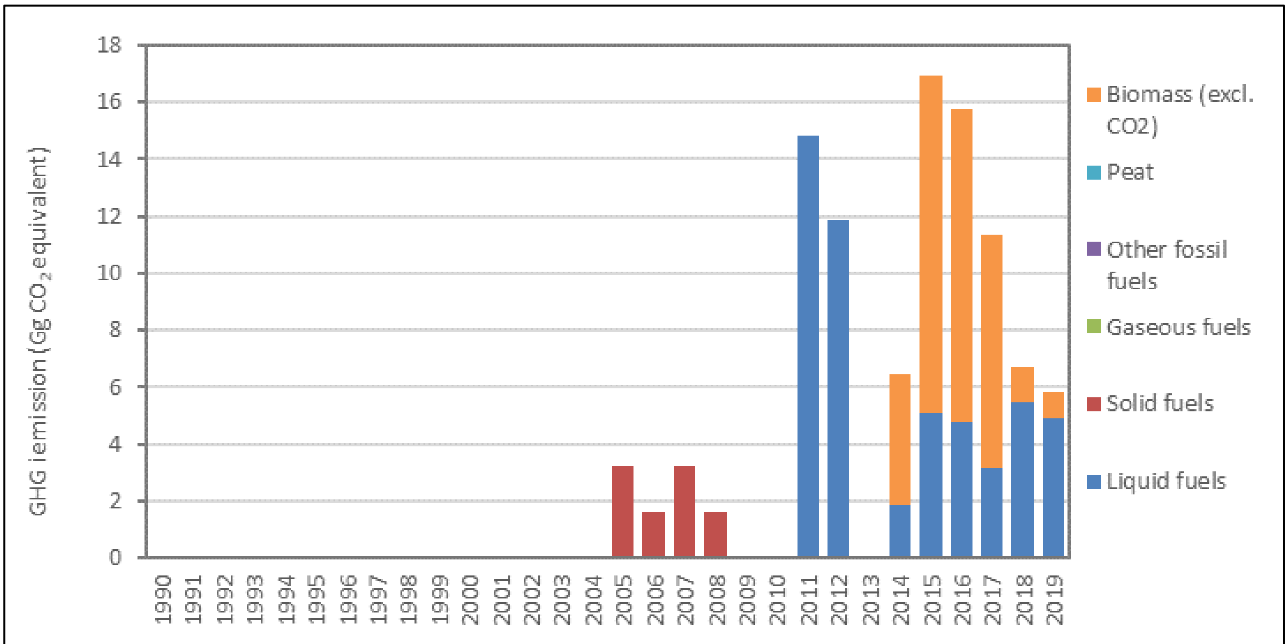


Figure 44 Emissions from IPCC sub-category 1.A.2.c Chemical industry

Table 79 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)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
1990	IE	IE	IE	IE	IE
1991	IE	IE	IE	IE	IE
1992	IE	IE	IE	IE	IE

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
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	3.24	3.22	0.01	0.01	IE
2006	1.62	1.61	0.01	0.00	IE
2007	3.24	3.22	0.01	0.01	IE
2008	1.62	1.61	0.01	0.00	IE
2009	IE	IE	IE	IE	IE
2010	IE	IE	IE	IE	IE
2011	14.81	14.79	0.01	0.01	IE
2012	11.85	11.84	0.01	0.00	IE
2013	IE	IE	IE	IE	IE
2014	6.43	1.86	0.00	0.03	4.57
2015	16.95	5.09	0.01	0.08	11.85
2016	15.78	4.77	0.01	0.08	10.99
2017	11.32	3.18	0.01	0.60	8.13
2018	6.73	3.18	0.01	0.05	1.25
2019	5.86	2.87	0.01	0.04	0.93
Trend					
1990 - 2019	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2019	*80.6%*	*-11.0%*	*-55.4%*	*376.8%*	*NA*
2018 - 2019	*-12.9%*	*-9.9%*	*-10.3%*	*-24.6%*	*-26%*

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[38] 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, gasous fuels, other fossil fuel, biomass, peat

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

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

3.2.6.3.2.2 Choice of activity data

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 - 2019 were taken from prepared by Statistical Office of Montenegro (MONSTAT).

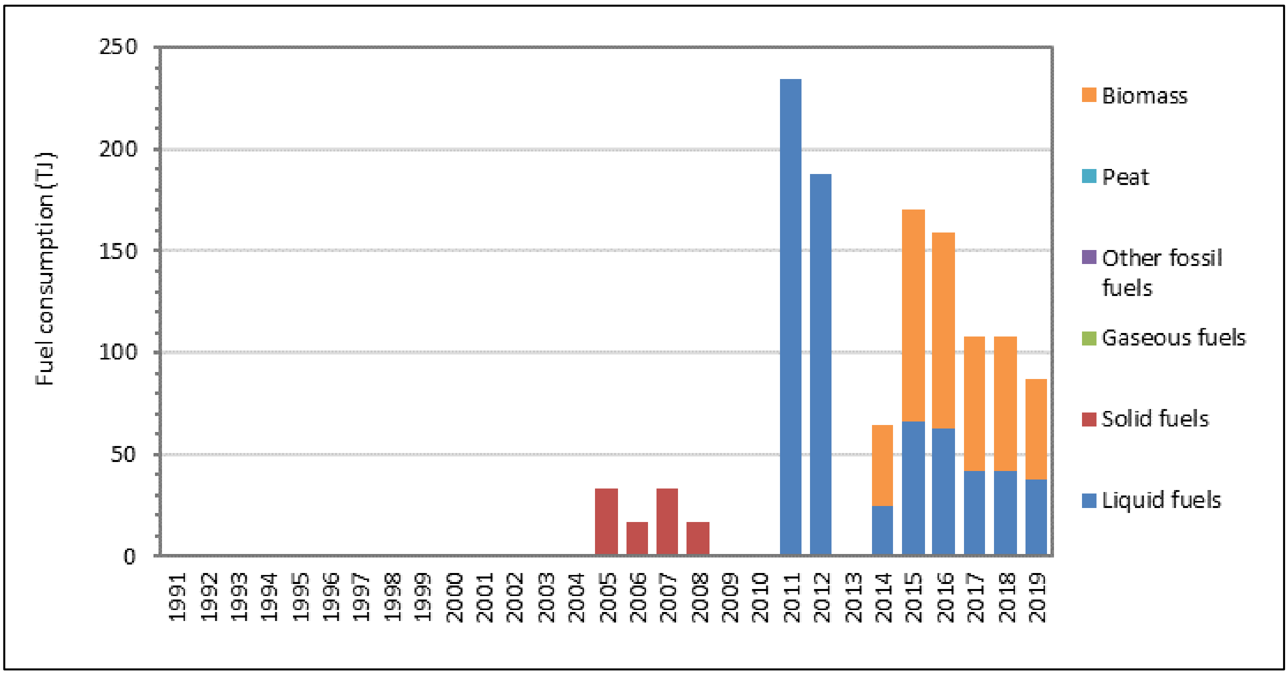


Figure 45 Activity data for IPCC sub-category 1.A.2.c Chemical industry

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

Table 80 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	IE
1991	IE	IE	IE	NO	NO	NO	IE
1992	IE	IE	IE	NO	NO	NO	IE
1993	IE	IE	IE	NO	NO	NO	IE
1994	IE	IE	IE	NO	NO	NO	IE
1995	IE	IE	IE	NO	NO	NO	IE
1996	IE	IE	IE	NO	NO	NO	IE
1997	IE	IE	IE	NO	NO	NO	IE
1998	IE	IE	IE	NO	NO	NO	IE
1999	IE	IE	IE	NO	NO	NO	IE
2000	IE	IE	IE	NO	NO	NO	IE
2001	IE	IE	IE	NO	NO	NO	IE
2002	IE	IE	IE	NO	NO	NO	IE
2003	IE	IE	IE	NO	NO	NO	IE
2004	IE	IE	IE	NO	NO	NO	IE
2005	33.50	IE	33.50	NO	NO	NO	IE
2006	16.75	IE	16.75	NO	NO	NO	IE
2007	33.50	IE	33.50	NO	NO	NO	IE
2008	16.75	IE	16.75	NO	NO	NO	IE
2009	IE	IE	IE	NO	NO	NO	IE
2010	IE	IE	IE	NO	NO	NO	IE
2011	234.45	234.45	IE	NO	NO	NO	IE
2012	187.56	187.56	IE	NO	NO	NO	IE
2013	IE	IE	IE	NO	NO	NO	IE
2014	64.63	24.53	IE	NO	NO	NO	40.10
2015	170.65	66.68	IE	NO	NO	NO	103.98
2016	159.05	62.56	IE	NO	NO	NO	96.49
2017	108.24	41.65	IE	NO	NO	NO	66.58
2018	108.11	41.65	IE	NO	NO	NO	66.46
2019	86.89	37.38	IE	NO	NO	NO	49.51
Trend							
1990 - 2019	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2019	*159.4%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2018 - 2019	*-19.6%*	*-10.3%*	*NA*	*NA*	*NA*	*NA*	*-25.5%*

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 metres. 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 81 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 82 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 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

3.2.6.3.3 Source-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.

3.2.6.3.4 Source-specific recalculations

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 83 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	Changes due to a technical revision in the energy balance	AD	Accuracy

3.2.6.3.5 Source-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 84 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 timesseries. 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)

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																		

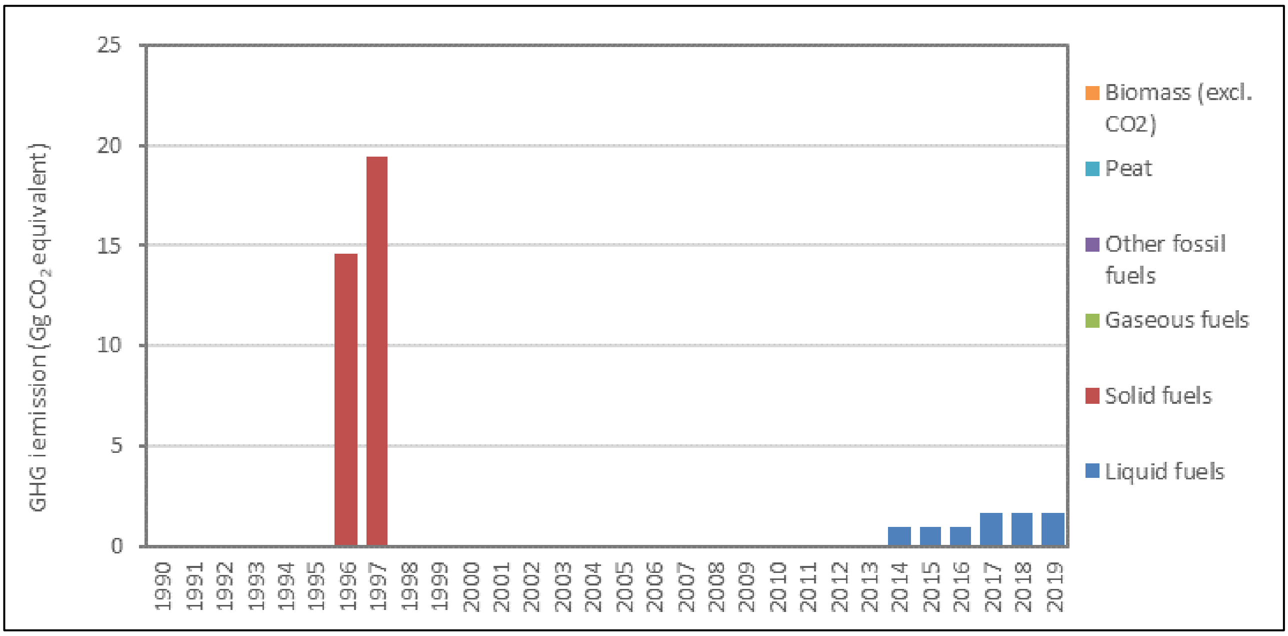


Figure 46 GHG emissions from IPCC sub-category 1.A.2.d Pulp, Paper and Printing

Table 85 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)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
1990	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO
1995	NO	NO	NO	NO	NO
1996	14.59	14.49	0.07	0.04	NO
1997	19.46	19.32	0.09	0.05	NO
1998	0.014	0.014	0.000062	0.000035	NO
1999	0.011	0.011	0.000050	0.000028	NO
2000	0.007	0.007	0.000029	0.000016	NO

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
2001	0.006	0.006	0.000025	0.000014	NO
2002	0.003	0.003	0.000012	0.000007	NO
2003	0.002	0.002	0.000008	0.000005	NO
2004	0.002	0.002	0.000008	0.000005	NO
2005	0.002	0.002	0.000008	0.000005	NO
2006	0.001	0.001	0.000004	0.000002	NO
2007	0.001	0.001	0.000004	0.000002	NO
2008	0.002	0.002	0.000008	0.000005	NO
2009	NO	NO	NO	NO	NO
2010	NO	NO	NO	NO	NO
2011	NO	NO	NO	NO	NO
2012	NO	NO	NO	NO	NO
2013	NO	NO	NO	NO	NO
2014	0.91	0.90	0.002	0.001	NO
2015	0.96	0.96	0.002	0.001	NO
2016	0.96	0.96	0.002	0.001	NO
2017	1.60	1.59	0.004	0.002	NO
2018	1.64	0.96	0.002	0.001	NO
2019	1.64	0.96	0.002	0.001	NO
Trend					
1990 - 2019	NA	NA	NA	NA	*NA*
2005 - 2019	87038%	51131%	26641%	19955%	*NA*
2018 - 2019	0%	0%	0%	0%	*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[39] 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, gasous fuels, other fossil fuel, biomass, peat

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

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

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

3.2.6.4.2.2 Choice of activity data

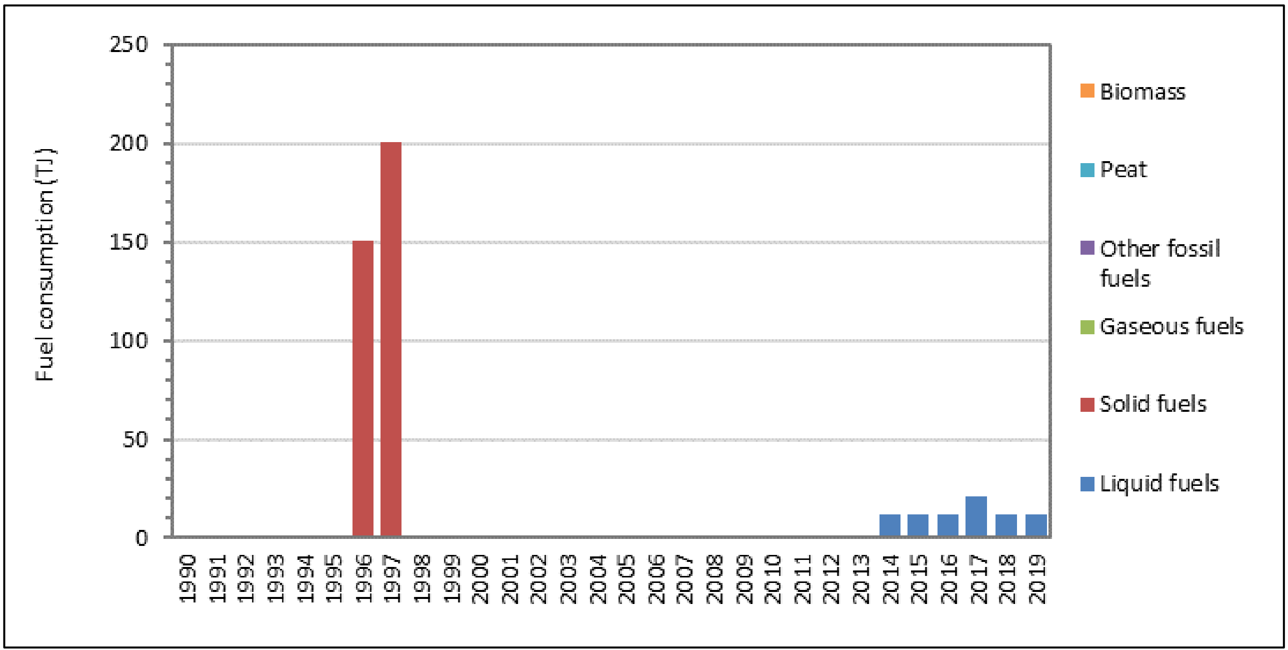


Figure 47 Activity data for sub-category 1.A.2.d Pulp, Paper and Print

Table 86 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	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO	NO	NO
1995	NO	NO	NO	NO	NO	NO	NO
1996	150.75	NO	150.75	NO	NO	NO	NO
1997	201.00	NO	201.00	NO	NO	NO	NO
1998	0.14	NO	0.14	NO	NO	NO	NO
1999	0.11	NO	0.11	NO	NO	NO	NO
2000	0.06	NO	0.06	NO	NO	NO	NO
2001	0.06	NO	0.06	NO	NO	NO	NO
2002	0.03	NO	0.03	NO	NO	NO	NO
2003	0.02	NO	0.02	NO	NO	NO	NO
2004	0.02	NO	0.02	NO	NO	NO	NO

Activity data 1.A.1.d	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
2005	0.02	NO	0.02	NO	NO	NO	NO
2006	0.01	NO	0.01	NO	NO	NO	NO
2007	0.01	NO	0.01	NO	NO	NO	NO
2008	0.02	NO	0.02	NO	NO	NO	NO
2009	NO	NO	NO	NO	NO	NO	NO
2010	NO	NO	NO	NO	NO	NO	NO
2011	NO	NO	NO	NO	NO	NO	NO
2012	NO	NO	NO	NO	NO	NO	NO
2013	NO	NO	NO	NO	NO	NO	NO
2014	12.17	12.17	NO	NO	NO	NO	NO
2015	12.36	12.36	NO	NO	NO	NO	NO
2016	12.36	12.36	NO	NO	NO	NO	NO
2017	20.60	20.60	NO	NO	NO	NO	NO
2018	12.36	12.36	NO	NO	NO	NO	NO
2019	12.36	12.36	NO	NO	NO	NO	NO
Trend							
1990 - 2019	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2019	*66751%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2018 - 2019	*0.0%*	*0.0%*	*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 tons or cubic metres. 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 87 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 88 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 Source-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.

3.2.6.4.4 Source-specific recalculations

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 89 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	use of CS NCV	AD	Accuracy
1.A.2.d	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy

3.2.6.4.5 Source-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 90 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) ⇒ **CS EF_{CO2}** [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 timesseries. 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)

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 2019						-	-	-	-	-	-	-	-	-	-	-	-
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																		

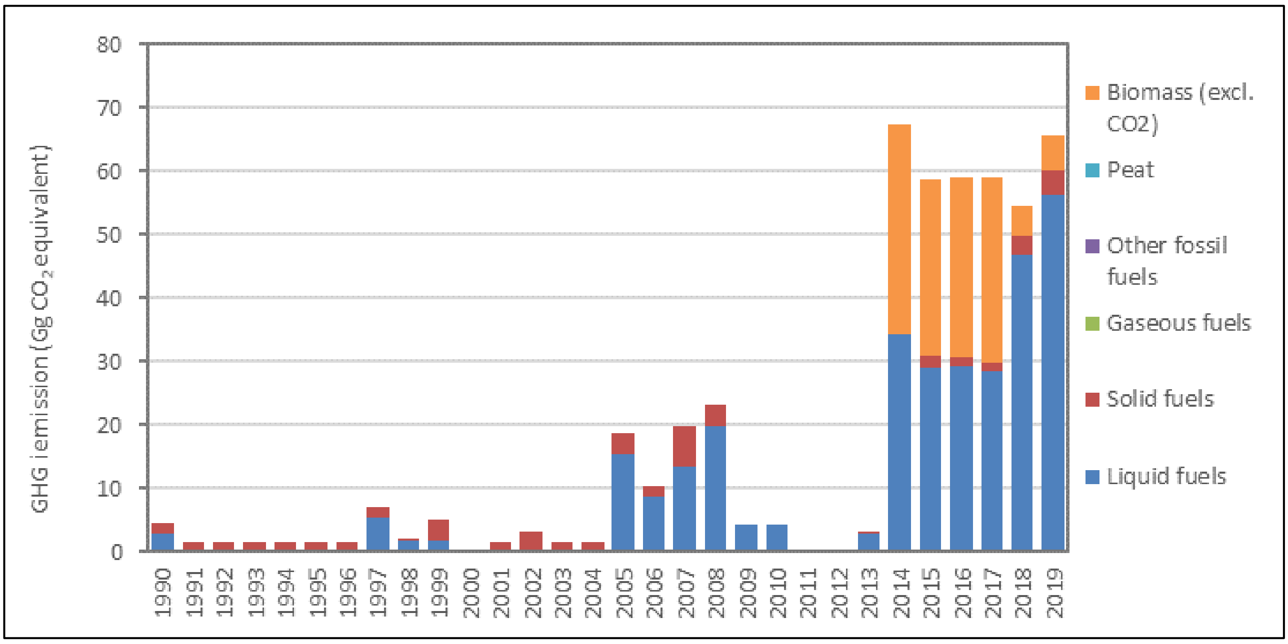


Figure 48: GHG Emissions from sub-category 1.A.2.e Food Processing, Beverages and Tobacco

Table 91 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)
	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent
1990	4.58	4.57	0.01	0.01	IE
1991	1.62	1.61	0.01	0.00	IE
1992	1.62	1.61	0.01	0.00	IE
1993	1.62	1.61	0.01	0.00	IE
1994	1.62	1.61	0.01	0.00	IE
1995	1.62	1.61	0.01	0.00	IE
1996	1.62	1.61	0.01	0.00	IE
1997	7.13	7.10	0.01	0.01	IE
1998	1.91	1.90	0.00	0.00	IE
1999	5.15	5.12	0.02	0.01	IE
2000	0.00	0.00	0.00	0.00	IE

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
2001	1.62	1.61	0.01	0.00	IE
2002	3.24	3.22	0.01	0.01	IE
2003	1.62	1.61	0.01	0.00	IE
2004	1.62	1.61	0.01	0.00	IE
2005	18.60	18.53	0.05	0.02	IE
2006	10.26	10.22	0.03	0.01	IE
2007	19.92	19.83	0.06	0.03	IE
2008	23.16	23.08	0.06	0.03	IE
2009	4.16	4.15	0.01	0.00	IE
2010	4.16	4.15	0.01	0.00	IE
2011	NO	NO	NO	NO	IE
2012	0.00	0.00	0.00	0.00	IE
2013	2.96	2.96	0.00	0.00	IE
2014	67.27	34.28	0.07	0.25	32.90
2015	58.61	30.78	0.06	0.21	27.74
2016	58.91	30.61	0.06	0.21	28.21
2017	59.07	29.68	0.06	2.17	29.30
2018	54.44	30.61	0.062	0.214	4.63
2019	65.77	36.88	0.075	0.257	5.56
Trend					
1990 - 2019	*1335.0%*	*707.1%*	*748.3%*	*4690.9%*	*NA*
2005 - 2019	*254%*	*99%*	*50%*	*1007%*	*NA*
2018 - 2019	*20.8%*	*20.5%*	*21.5%*	*20.3%*	*20.1%*

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[40] 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, gasous fuels, other fossil fuel, biomass, peat

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

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

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

3.2.6.5.2.2 Choice of activity data

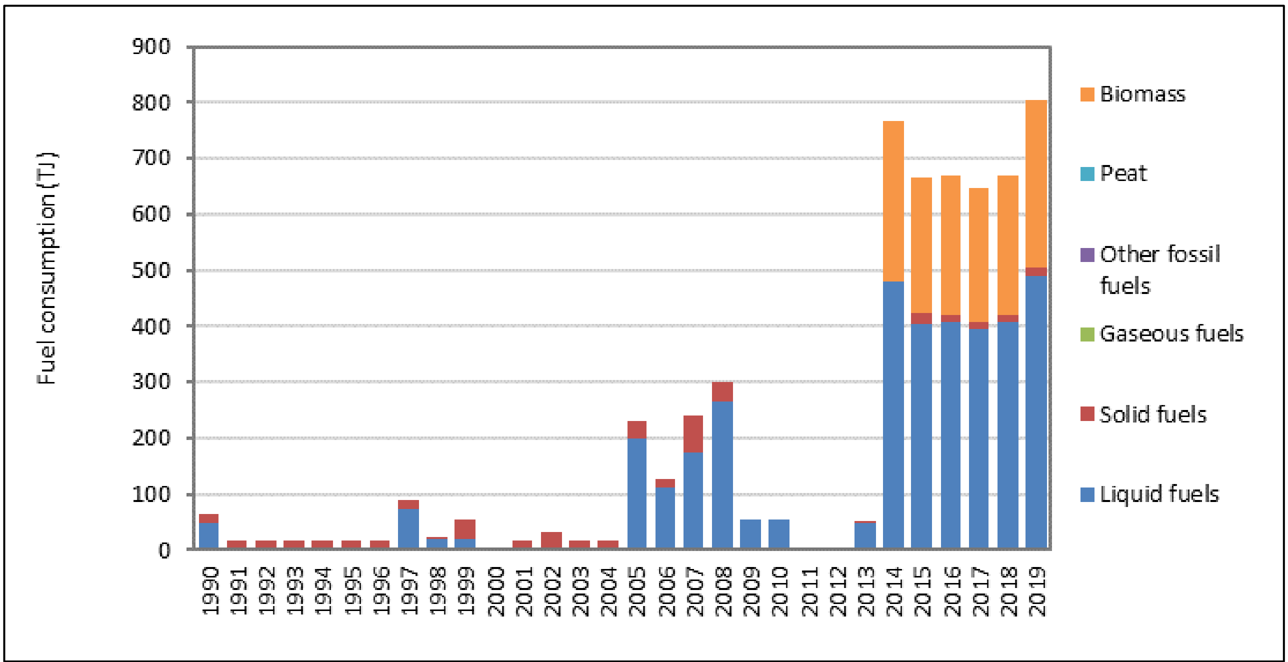


Figure 49 Activity data for sub-category 1.A.2.e Food Processing, Beverages and Tobacco

Table 92 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	63.65	46.89	16.76	NO	NO	NO	IE
1991	16.76	IE	16.76	NO	NO	NO	IE
1992	16.76	IE	16.76	NO	NO	NO	IE
1993	16.76	IE	16.76	NO	NO	NO	IE
1994	16.76	IE	16.76	NO	NO	NO	IE
1995	16.76	IE	16.76	NO	NO	NO	IE
1996	16.77	IE	16.77	NO	NO	NO	IE
1997	89.65	72.89	16.76	NO	NO	NO	IE
1998	19.52	19.50	0.02	NO	NO	NO	IE
1999	53.02	19.50	33.52	NO	NO	NO	IE
2000	0.02	IE	0.02	NO	NO	NO	IE
2001	16.76	IE	16.76	NO	NO	NO	IE
2002	33.51	IE	33.51	NO	NO	NO	IE
2003	16.75	IE	16.75	NO	NO	NO	IE
2004	16.75	IE	16.75	NO	NO	NO	IE

Activity data 1.A.1.e	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
2005	231.26	197.76	33.50	NO	NO	NO	IE
2006	127.99	111.24	16.75	NO	NO	NO	IE
2007	240.04	173.04	67.00	NO	NO	NO	IE
2008	298.75	265.25	33.50	NO	NO	NO	IE
2009	53.56	53.56	IE	NO	NO	NO	IE
2010	53.56	53.56	IE	NO	NO	NO	IE
2011	IE	IE	IE	NO	NO	NO	IE
2012	0.02	IE	0.02	NO	NO	NO	IE
2013	46.90	46.89	0.01	NO	NO	NO	IE
2014	767.97	479.17	0.03	NO	NO	NO	288.76
2015	664.88	403.01	18.44	NO	NO	NO	243.43
2016	668.27	407.28	13.42	NO	NO	NO	247.57
2017	647.51	394.20	13.42	NO	NO	NO	239.89
2018	667.80	407.28	13.42	NO	NO	NO	247.10
2019	802.74	489.19	16.78	NO	NO	NO	296.76
Trend							
1990 - 2019	*1161.2%*	*943.3%*	*0.1%*	*NA*	*NA*	*NA*	*NA*
2005 - 2019	*247.1%*	*147.4%*	*-49.9%*	*NA*	*NA*	*NA*	*NA*
2018 - 2019	*20.2%*	*20.1%*	*25.0%*	*NA*	*NA*	*NA*	*20.1%*

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 metres. 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 93 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 94 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

3.2.6.5.3 Source-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.

3.2.6.5.4 Source-specific recalculations

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 95 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	use of CS NCV	AD	Accuracy
1.A.2.e	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy

3.2.6.5.5 Source-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 96 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 timesseries. 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)

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																		

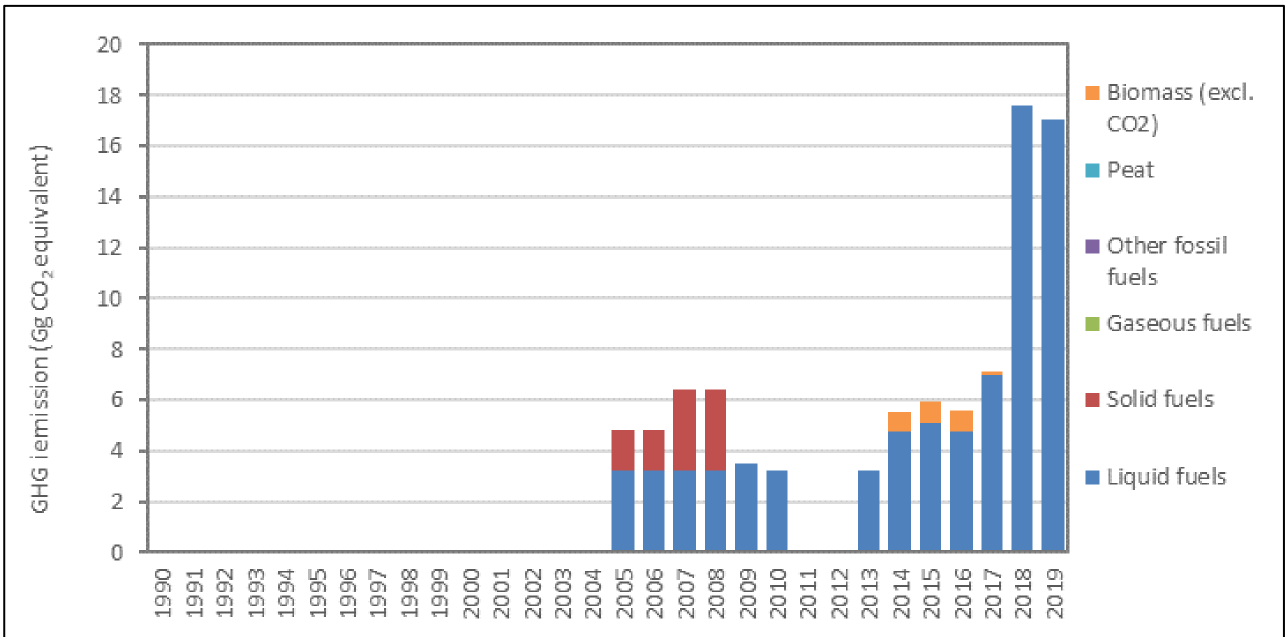


Figure 50: GHG Emissions from sub-category 1.A.2.f Non-Metallic Minerals

Table 97 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)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
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

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
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	4.82	4.80	0.01	0.01	IE
2006	4.82	4.80	0.01	0.01	IE
2007	6.44	6.41	0.02	0.01	IE
2008	6.44	6.41	0.02	0.01	IE
2009	3.52	3.51	0.01	0.00	IE
2010	3.20	3.19	0.01	0.00	IE
2011	IE	IE	IE	IE	IE
2012	IE	IE	IE	IE	IE
2013	3.20	3.19	0.01	0.00	IE
2014	5.50	4.75	0.01	0.01	0.73
2015	5.95	5.08	0.01	0.01	0.86
2016	5.58	4.76	0.01	0.01	0.81
2017	7.11	6.98	0.02	0.02	0.11
2018	17.61	10.15	0.02	0.01	IE
2019	17.05	9.83	0.02	0.01	IE
Trend					
1990 - 2019	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2019	*254%*	*105%*	*58%*	*35%*	*NA*
2018 - 2019	*-3.1%*	*-3.1%*	*-3.2%*	*-3.2%*	*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[41] 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, gasous fuels, other fossil fuel, biomass, peat

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

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

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

3.2.6.6.2.2 Choice of activity data

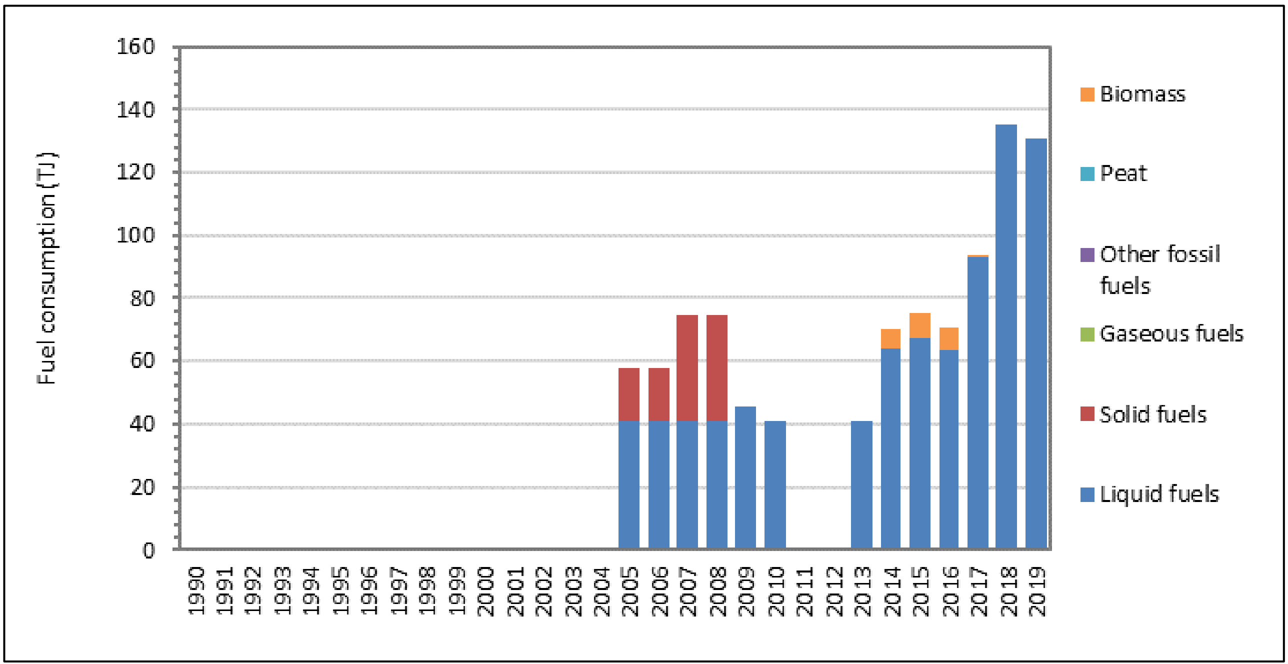


Figure 51 Activity data for sub-category 1.A.2.f Non-Metallic Minerals

Table 98 Activity data for sub-category 1.A.2.f Non-Metallic Minerals

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	NO	NO	IE	NO	IE
1991	IE	IE	NO	NO	IE	NO	IE
1992	IE	IE	NO	NO	IE	NO	IE
1993	IE	IE	NO	NO	IE	NO	IE
1994	IE	IE	NO	NO	IE	NO	IE
1995	IE	IE	NO	NO	IE	NO	IE
1996	IE	IE	NO	NO	IE	NO	IE
1997	IE	IE	NO	NO	IE	NO	IE
1998	IE	IE	NO	NO	IE	NO	IE
1999	IE	IE	NO	NO	IE	NO	IE
2000	IE	IE	NO	NO	IE	NO	IE
2001	IE	IE	NO	NO	IE	NO	IE
2002	IE	IE	NO	NO	IE	NO	IE
2003	IE	IE	NO	NO	IE	NO	IE
2004	IE	IE	NO	NO	IE	NO	IE
2005	57.95	41.20	16.75	NO	NO	NO	IE

Activity data 1.A.1.e	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
2006	57.95	41.20	16.75	NO	IE	NO	IE
2007	74.70	41.20	33.50	NO	IE	NO	IE
2008	74.70	41.20	33.50	NO	IE	NO	IE
2009	45.32	45.32	NO	NO	IE	NO	IE
2010	41.20	41.20	NO	NO	IE	NO	IE
2011	IE	IE	NO	NO	IE	NO	IE
2012	IE	IE	NO	NO	IE	NO	IE
2013	41.20	41.20	NO	NO	IE	NO	IE
2014	70.38	63.95	NO	NO	IE	NO	6.42
2015	75.18	67.58	NO	NO	IE	NO	7.60
2016	70.47	63.31	NO	NO	IE	NO	7.16
2017	93.90	92.91	NO	NO	IE	NO	1.00
2018	135.16	135.16	NO	NO	IE	NO	IE
2019	130.89	130.89	NO	NO	IE	NO	IE
Trend							
1990 - 2019	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2019	*125.9%*	*217.7%*	*NA*	*NA*	*NA*	*NA*	*NA*
2018 - 2019	*-3.2%*	*-3.2%*	*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 metres. 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 99 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 100 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

3.2.6.6.3 Source-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.

3.2.6.6.4 Source-specific recalculations

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 101 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	use of CS NCV	AD	Accuracy
1.A.2.e	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy

3.2.6.6.5 Source-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 102 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 timesseries. 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)

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	IE*	✓	✓	✓	NO	NO	IE*	✓	✓	✓	NO	NO	IE*
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 2014-2016																		

3.2.6.7.2 Source-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 103 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)

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	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																		

3.2.6.9 Mining (excluding fuels) and Quarrying (IPCC category 1.A.2.i)

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 2018																	
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																		
*Since 2005																		

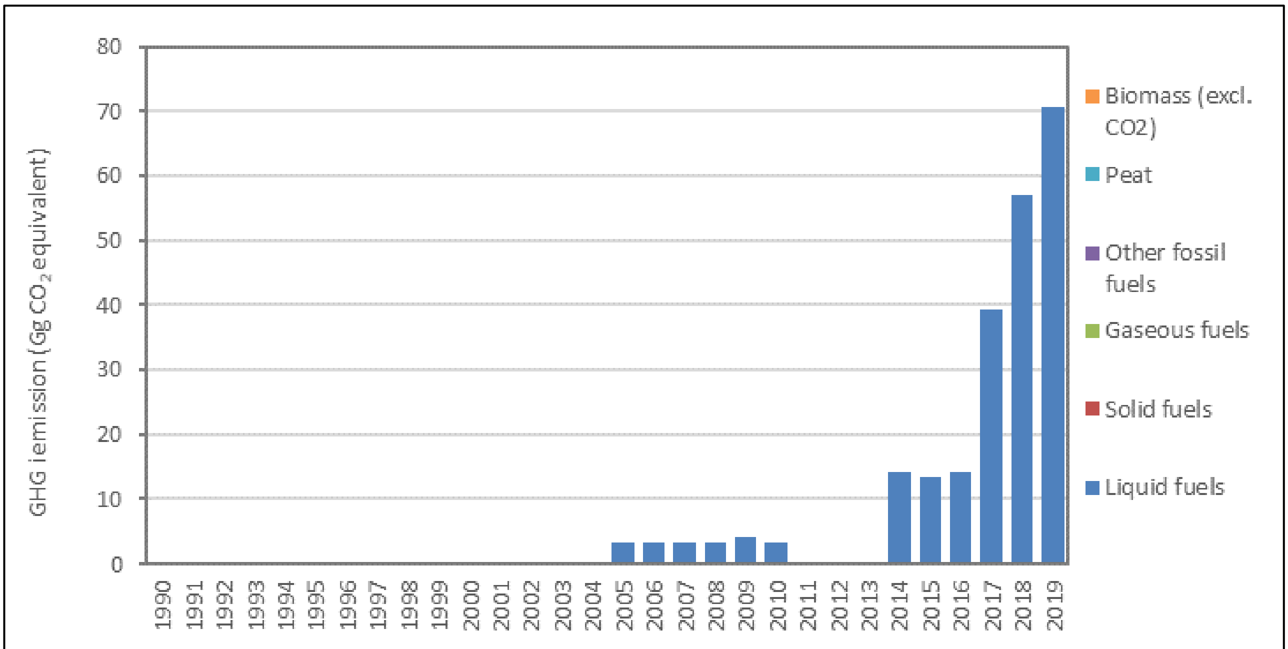


Figure 52 GHG Emissions from IPCC sub-category 1.A.2.i Mining and quarrying product: Salt, marble, stucco, stone mortar, sand and gravel in the period 2005 – 2019

Table 104 GHG Emissions from IPCC sub-category 1.A.2.i Mining and quarrying product

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
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

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
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	3.20	3.19	0.01	0.00	NO
2006	3.20	3.19	0.01	0.00	NO
2007	3.20	3.19	0.01	0.00	NO
2008	3.20	3.19	0.01	0.00	NO
2009	4.16	4.15	0.01	0.00	NO
2010	3.20	3.19	0.01	0.00	NO
2011	NO	NO	NO	NO	NO
2012	NO	NO	NO	NO	NO
2013	NO	NO	NO	NO	NO
2014	14.30	14.25	0.03	0.01	NO
2015	13.34	13.29	0.03	0.01	NO
2016	14.29	14.24	0.03	0.01	NO
2017	39.38	39.24	0.09	0.04	NO
2018	56.86	32.60	0.079	0.033	NO
2019	70.66	40.51	0.098	0.041	NO
Trend					
1990 - 2019	*NA*	*NA*	*NA*	*NA*	-
2005 - 2019	*2109%*	*1170%*	*1227%*	*1227%*	-
2018 - 2019	*24.3%*	*24.3%*	*24.3%*	*24.3%*	-

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[42] 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, gasous fuels, other fossil fuel, biomass, peat

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

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

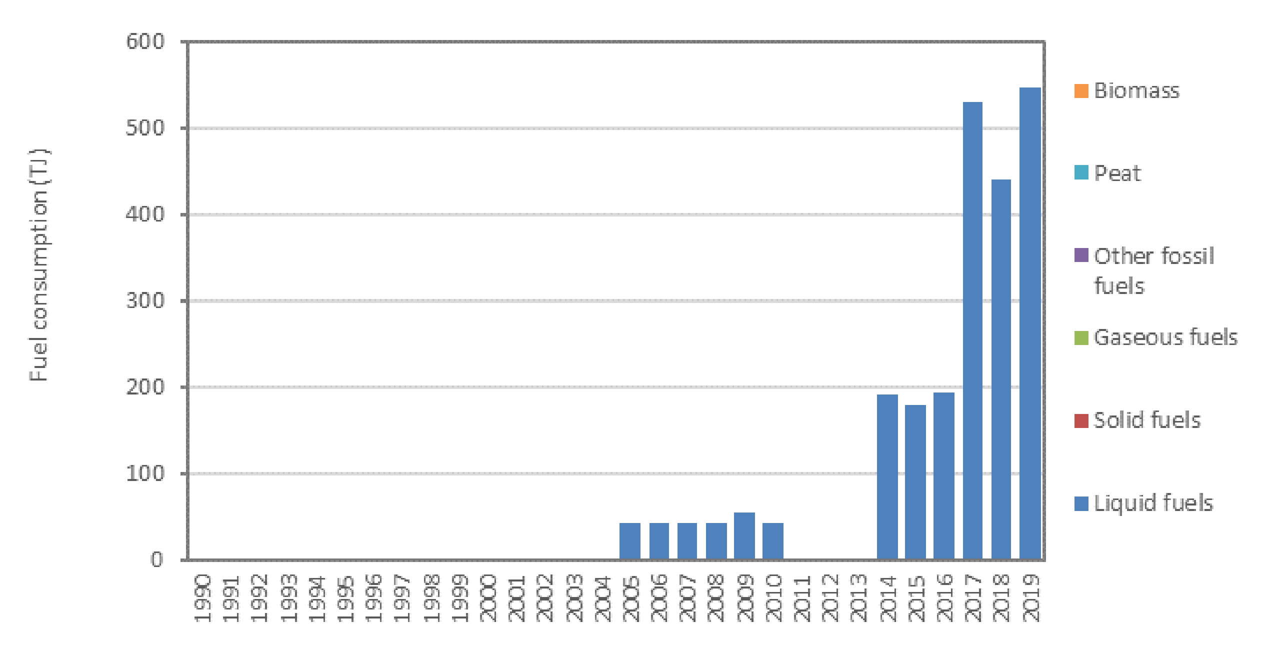


Figure 53: Activity data for sub-category 1.A.2.i Mining (excluding fuels) and Quarrying

Table 105: 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	41.20	41.20	NO	NO	NO	NO	NO

Activity data 1.A.2.i	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
2006	41.20	41.20	NO	NO	NO	NO	NO
2007	41.20	41.20	NO	NO	NO	NO	NO
2008	41.20	41.20	NO	NO	NO	NO	NO
2009	53.56	53.56	NO	NO	NO	NO	NO
2010	41.20	41.20	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	191.86	191.86	NO	NO	NO	NO	NO
2015	179.38	179.38	NO	NO	NO	NO	NO
2016	192.20	192.20	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					
Trend							
1990 - 2019	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2019	*967.8%*	*967.8%*	*967.8%*	*NA*	*NA*	*NA*	*NA*
2018 - 2019	*-16.9%*	*-16.9%*	*-16.9%*	*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 metres. 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 106 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 107 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 Source-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.

3.2.6.9.4 Source-specific recalculations

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 108 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	use of CS NCV	AD	Accuracy
1.A.2.i	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy

3.2.6.9.5 Source-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 109 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** $\mathbf{EF_{CO2}}$ [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 timesseries. 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)

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 2019						-	-	-	-	-	-	-	-	-	-	-	-
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																		

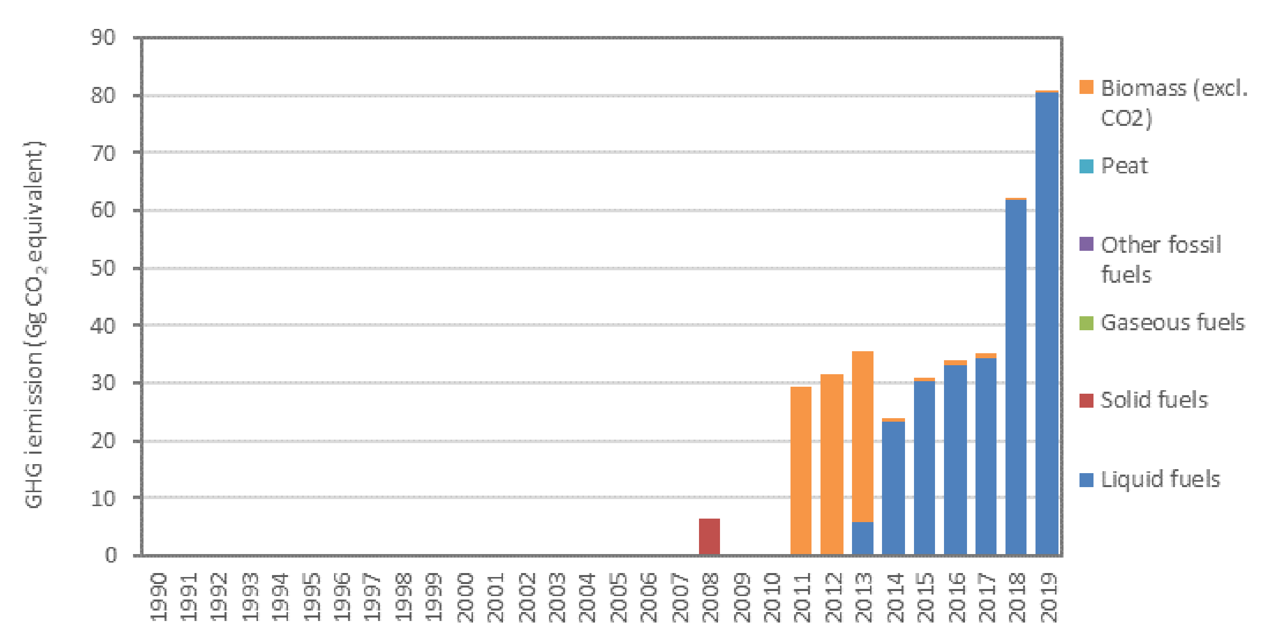


Figure 54 GHG emissions from sub-category 1.A.2.j Wood and wood products

Table 110 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)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
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

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
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	IE	IE	IE	IE	IE
2007	IE	IE	IE	IE	IE
2008	6.49	6.44	0.03	0.02	IE
2009	IE	IE	IE	IE	IE
2010	IE	IE	IE	IE	IE
2011	29.52	IE	IE	0.19	29.52
2012	31.41	IE	IE	0.21	31.41
2013	35.45	5.92	0.00	0.20	29.53
2014	23.76	23.11	0.06	0.03	0.56
2015	30.91	30.07	0.07	0.04	0.74
2016	33.84	32.91	0.08	0.04	0.81
2017	35.19	34.18	0.08	0.10	0.90
2018	61.98	35.45	0.09	0.04	0.14
2019	80.79	46.21	0.11	0.05	0.19
Trend					
1990 - 2019	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2019	*NA*	*NA*	*NA*	*NA*	*NA*
2018 - 2019	*30.4%*	*30.4%*	*30.4%*	*30.4%*	*30.4%*

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[43] 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.

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

GHG = CO_2, CH_4, N_2O
Fuel = liquid fuels, solid fuels, gasous fuels, other fossil fuel, biomass, peat

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

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

3.2.6.10.2.2 Choice of activity data

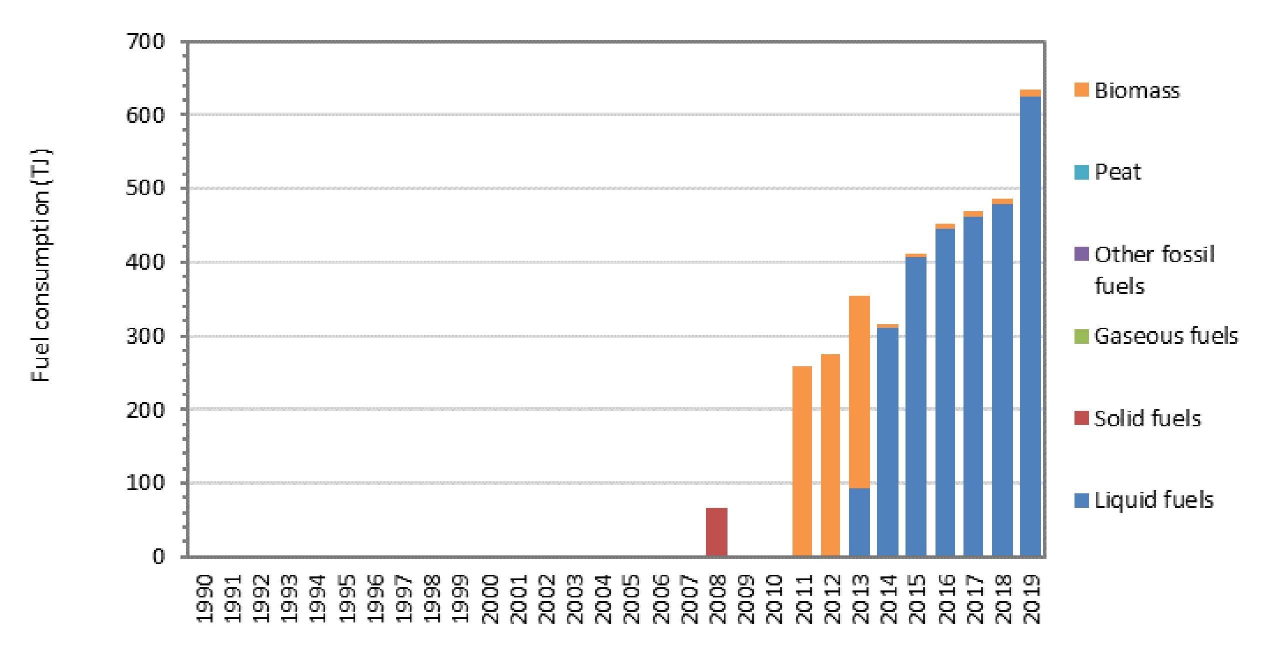


Figure 55: Activity data for sub-category 1.A.2.j *Wood and wood products*

Table 111: 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	IE
1991	IE	IE	IE	NO	NO	NO	IE
1992	IE	IE	IE	NO	NO	NO	IE
1993	IE	IE	IE	NO	NO	NO	IE
1994	IE	IE	IE	NO	NO	NO	IE
1995	IE	IE	IE	NO	NO	NO	IE
1996	IE	IE	IE	NO	NO	NO	IE
1997	IE	IE	IE	NO	NO	NO	IE
1998	IE	IE	IE	NO	NO	NO	IE
1999	IE	IE	IE	NO	NO	NO	IE
2000	IE	IE	IE	NO	NO	NO	IE
2001	IE	IE	IE	NO	NO	NO	IE

Activity data 1.A.2.j	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
2002	IE	IE	IE	NO	NO	NO	IE
2003	IE	IE	IE	NO	NO	NO	IE
2004	IE	IE	IE	NO	NO	NO	IE
2005	IE	IE	IE	NO	NO	NO	IE
2006	IE	IE	IE	NO	NO	NO	IE
2007	IE	IE	IE	NO	NO	NO	IE
2008	67.00	IE	67.00	NO	NO	NO	IE
2009	NO	IE	IE	NO	NO	NO	IE
2010	NO	IE	IE	NO	NO	NO	IE
2011	259.09	IE	IE	NO	NO	NO	259.09
2012	275.70	IE	IE	NO	NO	NO	275.70
2013	352.94	93.78	IE	NO	NO	NO	259.16
2014	316.19	311.23	IE	NO	NO	NO	4.96
2015	412.21	405.75	0.01	NO	NO	NO	6.46
2016	451.29	444.18	0.01	NO	NO	NO	7.10
2017	468.62	461.27	0.01	NO	NO	NO	7.34
2018	485.97	478.35	0.01	NO	NO	NO	7.61
2019	633.50	623.57	0.01	NO	NO	NO	9.92
Trend							
1990 - 2018	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2018	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
1990 - 2018	*30.4%*	*30.4%*	*40.0%*	*NA*	*NA*	*NA*	*30.4%*

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 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 112 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 113 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

3.2.6.10.3 Source-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 Source-specific recalculations

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 114 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	use of CS NCV	AD	Accuracy
1.A.2.j	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy

3.2.6.10.5 Source-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 115 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 timesseries. 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)

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	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

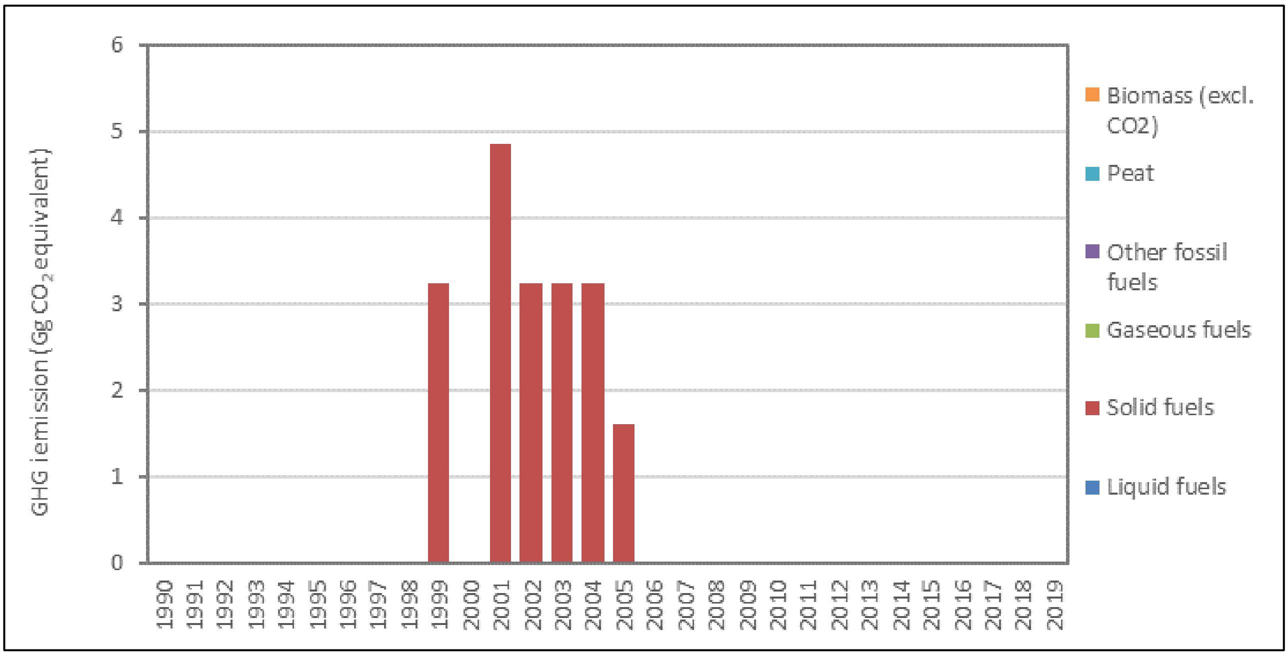


Figure 56 GHG emissions from sub-category 1.A.2.k Construction

Table 116 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)
	Gg $_{CO_2 \text{ equivalent}}$	Gg $_{CO_2 \text{ equivalent}}$	Gg $_{CO_2 \text{ equivalent}}$	Gg $_{CO_2 \text{ equivalent}}$	Gg $_{CO_2 \text{ equivalent}}$
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	3.24	IE	0.01	0.01	NO
2000	IE	IE	IE	IE	NO

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
2001	4.86	IE	0.01	0.02	NO
2002	3.24	IE	0.01	0.01	NO
2003	3.24	IE	0.01	0.01	NO
2004	3.24	IE	0.01	0.01	NO
2005	1.62	IE	0.00	0.01	NO
2006	IE	IE	IE	IE	NO
2007	IE	3.22	IE	IE	NO
2008	IE	3.22	IE	IE	NO
2009	IE	3.22	IE	IE	NO
2010	IE	1.61	IE	IE	NO
2011	IE	IE	IE	IE	NO
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
Trend					
1990 - 2019	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2019	*NA*	*NA*	*NA*	*NA*	*NA*
2018 - 2019	*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[44] 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, gasous fuels, other fossil fuel, biomass, peat

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

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

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

3.2.6.11.2.2 Choice of activity data

Fuel consumption used for estimating the GHG and non-GHG emissions for the years 1990 - 2019 were taken from prepared by Statistical Office of Montenegro (MONSTAT).

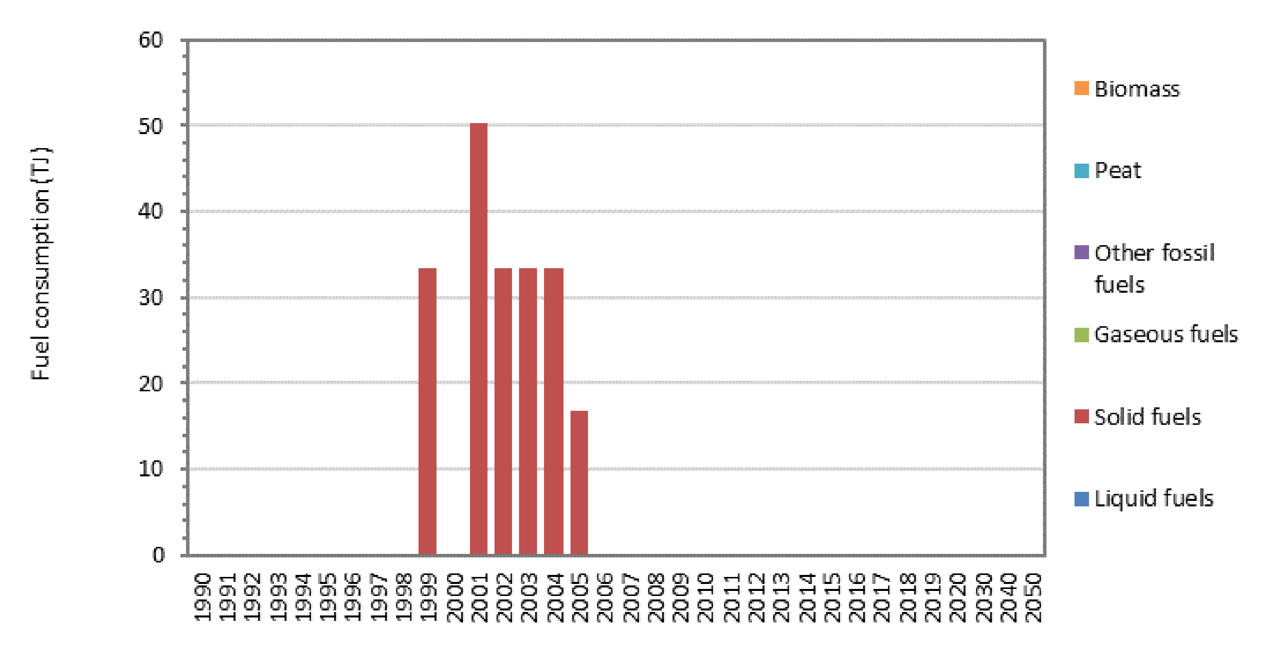


Figure 57 Activity data for sub-category 1.A.2.k *Construction* 1990 - 2018

Table 117 Activity data for sub-category 1.A.2.k *Construction* 1990 - 2018

Activity data 1.A.2.k	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	IE	NO	IE	NO	NO	NO	NO
1991	IE	NO	IE	NO	NO	NO	NO
1992	IE	NO	IE	NO	NO	NO	NO
1993	IE	NO	IE	NO	NO	NO	NO
1994	IE	NO	IE	NO	NO	NO	NO
1995	IE	NO	IE	NO	NO	NO	NO
1996	IE	NO	IE	NO	NO	NO	NO
1997	IE	NO	IE	NO	NO	NO	NO
1998	IE	NO	IE	NO	NO	NO	NO
1999	33.50	NO	33.50	NO	NO	NO	NO
2000	IE	NO	IE	NO	NO	NO	NO
2001	50.25	NO	50.25	NO	NO	NO	NO
2002	33.50	NO	33.50	NO	NO	NO	NO
2003	33.50	NO	33.50	NO	NO	NO	NO

Activity data 1.A.2.k	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
2004	33.50	NO	33.50	NO	NO	NO	NO
2005	16.75	NO	16.75	NO	NO	NO	NO
2006	IE	NO	IE	NO	NO	NO	NO
2007	IE	NO	IE	NO	NO	NO	NO
2008	IE	NO	IE	NO	NO	NO	NO
2009	IE	NO	IE	NO	NO	NO	NO
2010	IE	NO	IE	NO	NO	NO	NO
2011	IE	NO	IE	NO	NO	NO	NO
2012	IE	NO	IE	NO	NO	NO	NO
2013	IE	NO	IE	NO	NO	NO	NO
2014	IE	NO	IE	NO	NO	NO	NO
2015	IE	NO	IE	NO	NO	NO	NO
2016	IE	NO	IE	NO	NO	NO	NO
2017	IE	NO	IE	NO	NO	NO	NO
2018	IE	NO	IE	NO	NO	NO	NO
2019	IE	NO	IE	NO	NO	NO	NO
Trend							
1990 - 2019	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2019	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2018 - 2019	*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 metres. 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 118 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)		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

3.2.6.11.2.3 Choice of emission factors

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

Table 119 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

3.2.6.11.3 Source-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.

3.2.6.11.4 Source-specific recalculations

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 120 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.e	use of CS NCV	AD	Accuracy
1.A.2.e	Fuel consumption data (activity data) was revised due to revised fuel	AD	Accuracy

source category	Revisions of data	Type of revision	Type of improvement
	consumption data – plant specific data		

3.2.6.11.5 Source-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 121 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.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 timesseries. 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)

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	√
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

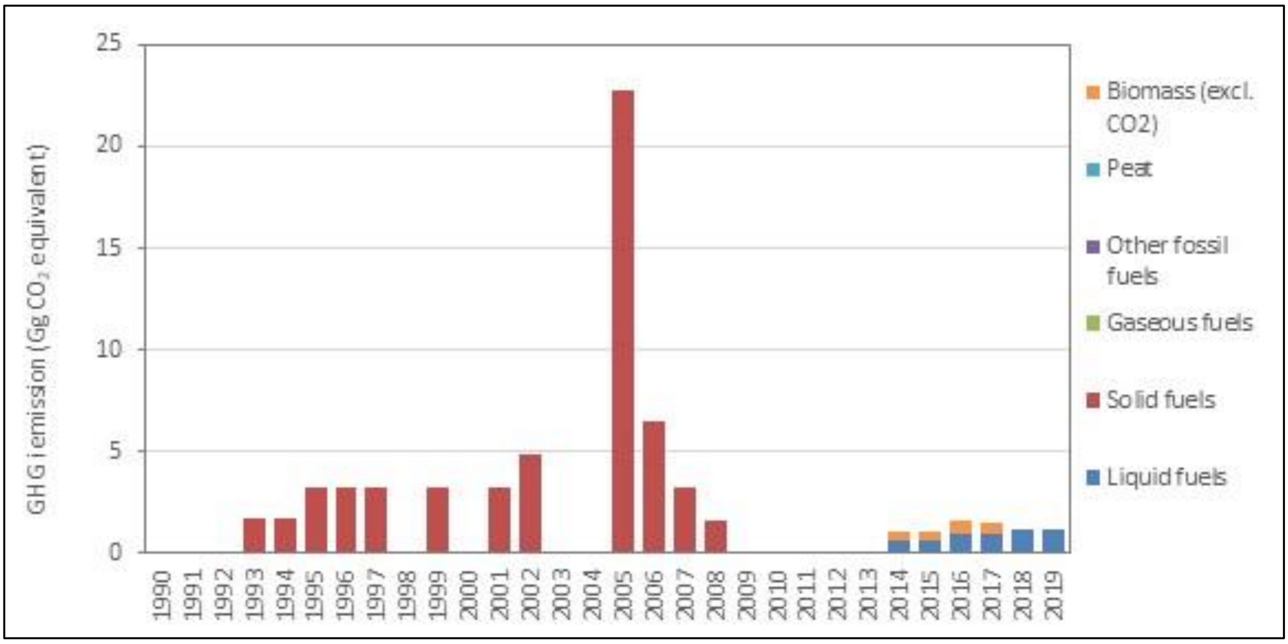


Figure 58 GHG emissions from sub-category 1.A.2.l Textile and Leather

Table 122 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)
	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent
1990	0.02	0.02	0.00	0.00	NO
1991	0.01	0.01	0.00	0.00	NO
1992	0.01	0.01	0.00	0.00	NO
1993	1.63	1.62	0.01	0.00	NO
1994	1.63	1.62	0.01	0.00	NO
1995	3.25	3.23	0.02	0.01	NO
1996	3.26	3.23	0.02	0.01	NO
1997	3.25	3.23	0.02	0.01	NO
1998	0.01	0.01	0.00	0.00	NO
1999	3.25	3.23	0.02	0.01	NO
2000	0.00	0.00	0.00	0.00	NO

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
2001	3.25	3.22	0.01	0.01	NO
2002	4.87	4.83	0.02	0.01	NO
2003	0.00	0.00	0.00	0.00	NO
2004	NO	NO	NO	NO	NO
2005	22.70	22.54	0.10	0.06	NO
2006	6.49	6.44	0.03	0.02	NO
2007	3.24	3.22	0.01	0.01	NO
2008	1.62	1.61	0.01	0.00	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	1.01	0.60	0.00	0.00	0.41
2015	1.05	0.64	0.00	0.00	0.41
2016	1.53	0.96	0.00	0.00	0.57
2017	1.50	0.96	0.00	0.04	0.54
2018	1.09	0.64	0.001	0.001	IE
2019	1.09	0.64	0.001	0.001	IE
Trend					
1990 - 2019	6014.9%	3495.1%	1776.5%	1307.4%	NA
2005 - 2019	-95%	-97%	-99%	-99%	NA
2018 - 2019	0.0%	0.0%	0.0%	0.0%	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[45] 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, gasous fuels, other fossil fuel, biomass, peat

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

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

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

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 - 2018 were taken from prepared by Statistical Office of Montenegro (MONSTAT).

The total fuel consumption increased by 4591.3% in the period 1990 – 2019. From 2005 to 2018 the total fuel consumption decreased by 96.5%.

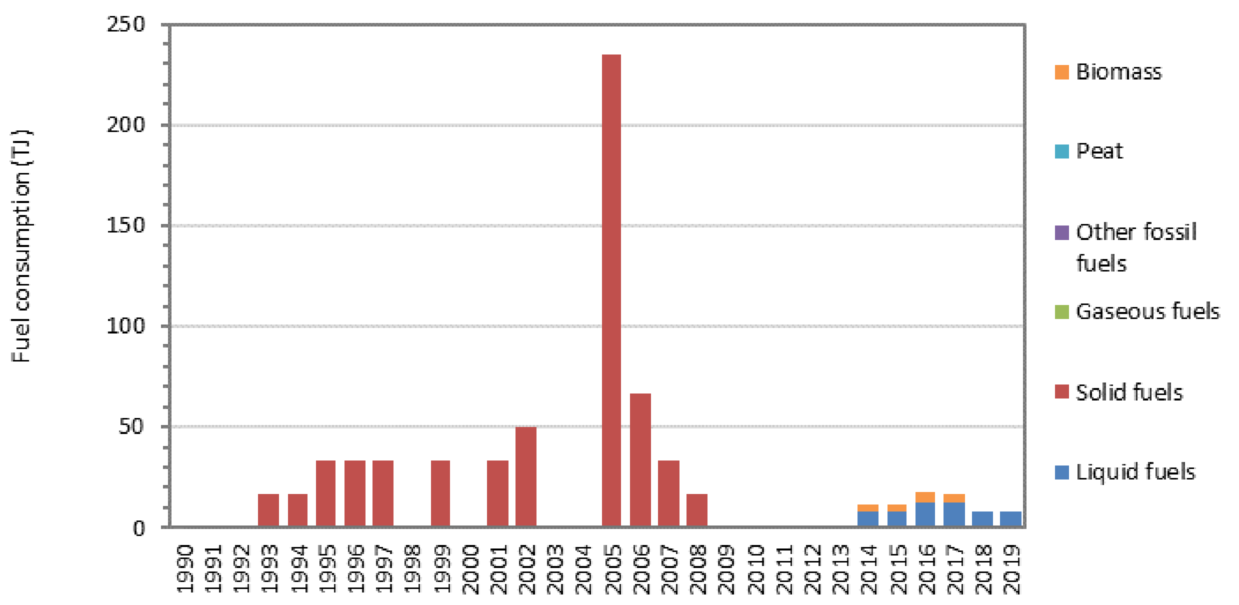


Figure 59 Activity data for sub-category 1.A.2.l Textile and Leather

Table 123 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	0.18	IE	0.18	NO	NO	NO	IE
1991	0.14	IE	0.14	NO	NO	NO	IE
1992	0.13	IE	0.13	NO	NO	NO	IE
1993	16.85	IE	16.85	NO	NO	NO	IE
1994	16.85	IE	16.85	NO	NO	NO	IE
1995	33.60	IE	33.60	NO	NO	NO	IE
1996	33.64	IE	33.64	NO	NO	NO	IE
1997	33.57	IE	33.57	NO	NO	NO	IE
1998	0.08	IE	0.08	NO	NO	NO	IE
1999	33.56	IE	33.56	NO	NO	NO	IE
2000	0.05	IE	0.05	NO	NO	NO	IE

Activity data 1.A.2.l	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
2001	33.53	IE	33.53	NO	NO	NO	IE
2002	50.28	IE	50.28	NO	NO	NO	IE
2003	0.01	IE	0.01	NO	NO	NO	IE
2004	IE	IE	IE	NO	NO	NO	IE
2005	234.50	IE	234.50	NO	NO	NO	IE
2006	67.00	IE	67.00	NO	NO	NO	IE
2007	33.50	IE	33.50	NO	NO	NO	IE
2008	16.75	IE	16.75	NO	NO	NO	IE
2009	IE	IE	IE	NO	NO	NO	IE
2010	IE	IE	IE	NO	NO	NO	IE
2011	IE	IE	IE	NO	NO	NO	IE
2012	IE	IE	IE	NO	NO	NO	IE
2013	IE	IE	IE	NO	NO	NO	IE
2014	11.71	8.11	IE	NO	NO	NO	3.60
2015	11.84	8.24	IE	NO	NO	NO	3.60
2016	17.45	12.36	IE	NO	NO	NO	5.09
2017	16.86	12.36	IE	NO	NO	NO	4.50
2018	8.24	8.24	IE	NO	NO	NO	IE
2019	8.24	8.24	IE	NO	NO	NO	IE
Trend							
1990 - 2019	*4591.3%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2019	*-96.5%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2018 - 2019	*0.0%*	*0.0%*	*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 metres. 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 124 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	

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg) or *(TJ/m3)		Source
		NCV	type	
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 125 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

3.2.6.12.3 Source-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.

3.2.6.12.4 Source-specific recalculations

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 126 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	use of CS NCV	AD	Accuracy
1.A.2.l	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy

3.2.6.12.5 Source-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 127 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 timesseries. 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	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.m	✓	✓	NO	NO	NO	✓	✓	✓	NO	NO	NO	✓	✓	✓	NO	NO	NO	✓
Key catergory	LA 2018																	

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

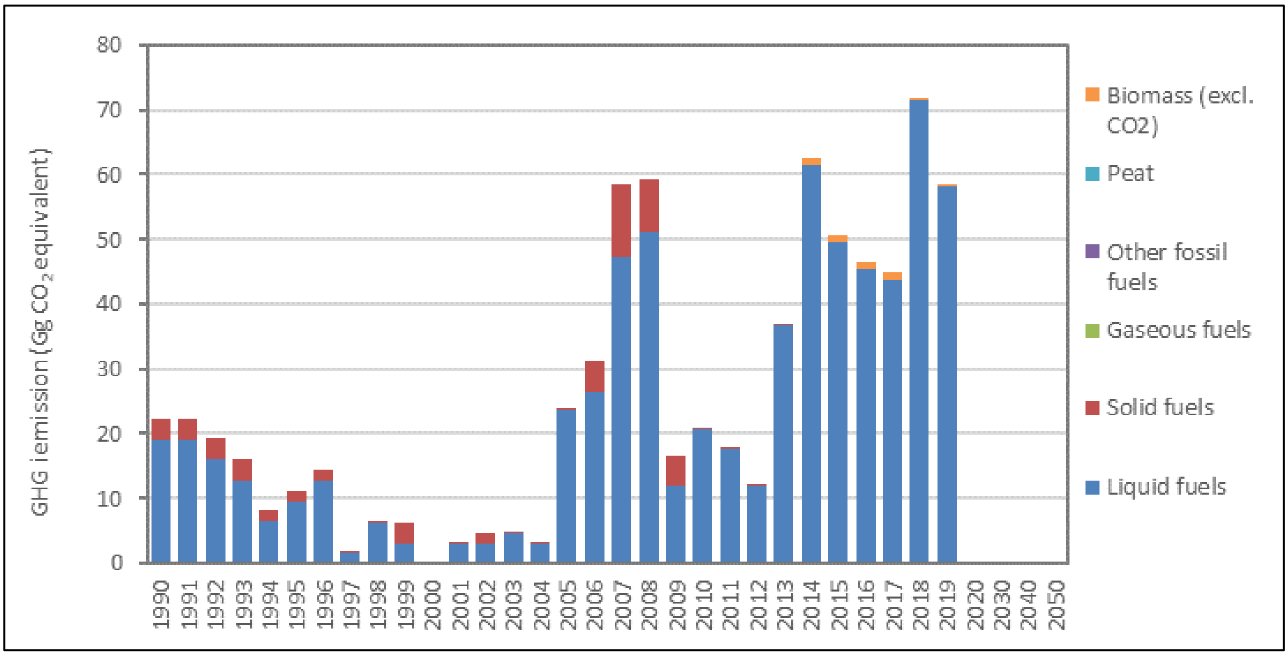


Figure 60 Emissions from IPCC sub-category 1.A.2.m Other

Table 128 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)
	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent
1990	22.21	22.14	0.05	0.03	IE
1991	22.21	22.14	0.05	0.03	IE
1992	19.25	19.18	0.05	0.02	IE
1993	16.05	15.98	0.04	0.02	IE
1994	8.03	8.00	0.02	0.01	IE
1995	11.23	11.18	0.03	0.01	IE
1996	14.43	14.38	0.04	0.02	IE
1997	1.61	1.61	0.00	0.00	IE
1998	6.16	6.15	0.01	0.00	IE
1999	6.22	6.20	0.02	0.01	IE

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent
2000	0.02	0.02	0.00	0.00	IE
2001	2.98	2.98	0.00	0.00	IE
2002	4.59	4.58	0.01	0.01	IE
2003	4.57	4.56	0.01	0.00	IE
2004	2.97	2.96	0.00	0.00	IE
2005	23.69	23.64	0.03	0.02	IE
2006	31.36	31.29	0.05	0.03	IE
2007	58.55	58.36	0.13	0.06	IE
2008	59.24	59.07	0.11	0.06	IE
2009	16.71	16.67	0.03	0.02	IE
2010	20.73	20.71	0.01	0.01	IE
2011	17.77	17.75	0.01	0.01	IE
2012	11.85	11.84	0.01	0.00	IE
2013	36.73	36.66	0.05	0.02	IE
2014	62.55	61.39	0.13	0.06	0.97
2015	50.70	49.42	0.10	0.05	1.14
2016	46.53	45.36	0.09	0.05	1.03
2017	45.01	43.79	0.09	0.13	1.08
2018	71.65	44.11	0.09	0.04	0.15
2019	58.37	35.97	0.07	0.04	0.13
Trend					
1990 - 2019	*162.8%*	*62.5%*	*35.3%*	*47.7%*	*NA*
2005 - 2019	*146%*	*52%*	*119%*	*129%*	*NA*
2018 - 2019	*-18.5%*	*-18.5%*	*-18.7%*	*-17.5%*	*-9.8%*

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[46] 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, gasous fuels, other fossil fuel, biomass, peat

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

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

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

3.2.6.13.2.2 Choice of activity data

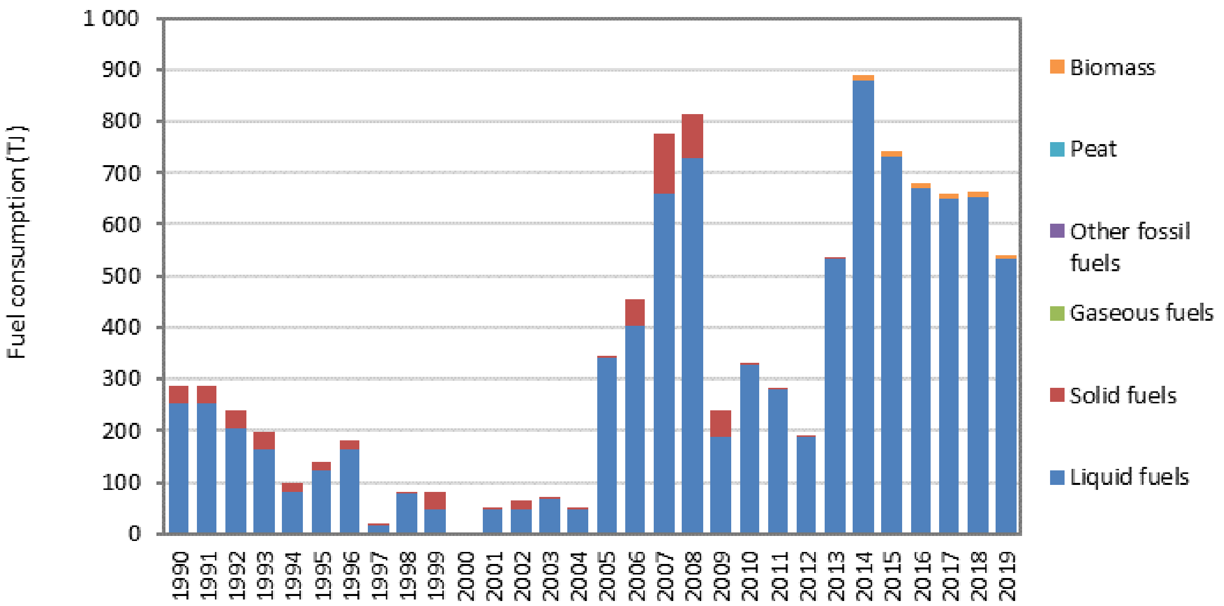


Figure 61 Activity data for IPCC sub-category 1.A.2.m Other

Table 129 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	286.53	252.89	33.64	NO	NO	NO	IE
1991	286.53	252.89	33.64	NO	NO	NO	IE
1992	239.62	206.00	33.62	NO	NO	NO	IE
1993	198.39	164.80	33.59	NO	NO	NO	IE
1994	99.24	82.40	16.84	NO	NO	NO	IE
1995	140.43	123.60	16.83	NO	NO	NO	IE
1996	181.69	164.80	16.89	NO	NO	NO	IE
1997	16.47	16.25	0.22	NO	NO	NO	IE
1998	79.65	79.39	0.26	NO	NO	NO	IE
1999	80.59	46.89	33.70	NO	NO	NO	IE
2000	0.21	NO	0.21	NO	NO	NO	IE
2001	47.07	46.89	0.18	NO	NO	NO	IE
2002	63.76	46.89	16.87	NO	NO	NO	IE
2003	67.55	67.49	0.06	NO	NO	NO	IE

Activity data 1.A.2.m	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
2004	46.95	46.89	0.06	NO	NO	NO	IE
2005	340.06	340.00	0.06	NO	NO	NO	IE
2006	452.70	402.39	50.31	NO	NO	NO	IE
2007	777.63	660.38	117.25	NO	NO	NO	IE
2008	812.27	728.52	83.75	NO	NO	NO	IE
2009	237.83	187.56	50.27	NO	NO	NO	IE
2010	328.25	328.23	0.02	NO	NO	NO	IE
2011	281.36	281.34	0.02	NO	NO	NO	IE
2012	187.57	187.56	0.01	NO	NO	NO	IE
2013	534.25	534.23	0.02	NO	NO	NO	IE
2014	888.87	880.22	IE	NO	NO	NO	8.65
2015	741.90	731.77	0.01	NO	NO	NO	10.11
2016	680.21	670.99	0.01	NO	NO	NO	9.21
2017	658.30	649.37	0.01	NO	NO	NO	8.93
2018	661.53	653.64	0.01	NO	NO	NO	7.88
2019	539.61	532.49	0.01	NO	NO	NO	7.11
Trend							
1990 - 2019	*88.3%*	*110.6%*	*-100.0%*	*NA*	*NA*	*NA*	*NA*
2005 - 2019	*58.7%*	*56.6%*	*-86.7%*	*NA*	*NA*	*NA*	*NA*
2018 - 2019	*-18.4%*	*-18.5%*	*-20.0%*	*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 metres. 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 130 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 131 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 Source-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.

3.2.6.13.4 Source-specific recalculations

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 132 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	use of CS NCV	AD	Accuracy
1.A.2.m	Fuel consumption data (activity data) was revised due to revised fuel	AD	Accuracy

source category	Revisions of data	Type of revision	Type of improvement
	consumption data – plant specific data		

3.2.6.13.5 Source-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 133 Planned improvements for IPCC sub-category 1.A.2.l Textile and Leather

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 timesseries. 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.

This section describes GHG emissions resulting from fuel combustion in transport sector, which originate from the following subcategories.

IPCC code	Description	Occurrent		Not occurrent
		Estimated	Not estimated	
1.A.3.a	Civil Aviation	✓		
1.A.3.b	Road Transportation	✓		
1.A.3.c	Railways	✓		
1.A.3.d	Water-borne Navigation	✓		
1.A.3.e	Other Transportation			✓

3.2.7.1 Civil Aviation (IPCC category 1.A.3.a)

3.2.7.1.1 Source category description

This section describes GHG emissions resulting from fuel combustion in Civil Aviation (IPCC category 1.A.3.a), which originate from the following subcategories.

- International Aviation (International Bunkers) (1.A.3.a.i)
- Domestic Aviation (IPCC subcategory 1.A.3.a.ii)

According to the 2006 IPCC Guidelines the GHG emissions from domestic aviation are reported separately from international aviation.

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.i	✓	NA	NA	NA	NA	NO	✓	NA	NA	NA	NA	NO	✓	NA	NA	NA	NA	NO
Key Category																		
1.A.3.a.ii	✓	NA	NA	NA	NA	NO	✓	NA	NA	NA	NA	NO	✓	NA	NA	NA	NA	NO
Key Category	LA 2018																	

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

GHG emissions from aviation arise from the combustion of jet fuel (jet kerosene and jet gasoline) and aviation gasoline. As presented in the 2006 IPCC Guidelines the emissions that are emitted depend on the

- number and type of aircraft operations;
- types and efficiency of the aircraft engines;
- fuel used;
- length of flight;
- power setting;
- time spent at each stage of flight;
- altitude at which exhaust gases (to a lesser degree).

In the following table the criteria for defining international or domestic aviation is provided.

Table 134 Criteria for defining international or domestic aviation

IPCC code	Description	Journey type between two airports	
		Departs and arrives in same country	Departs from one country and arrives in another
1.A.3.a.i	International Aviation (International Bunkers)	No	**Yes**
1.A.3.a.ii	Domestic Aviation	**Yes**	No

Source: TABLE 3.6.6, 2006 IPCC Guidelines, Vol. 2, Chap. 3.

An overview of the GHG emissions from IPCC sub-category 1.A.3.a *Civil Aviation* are provided in the following figure and tables.

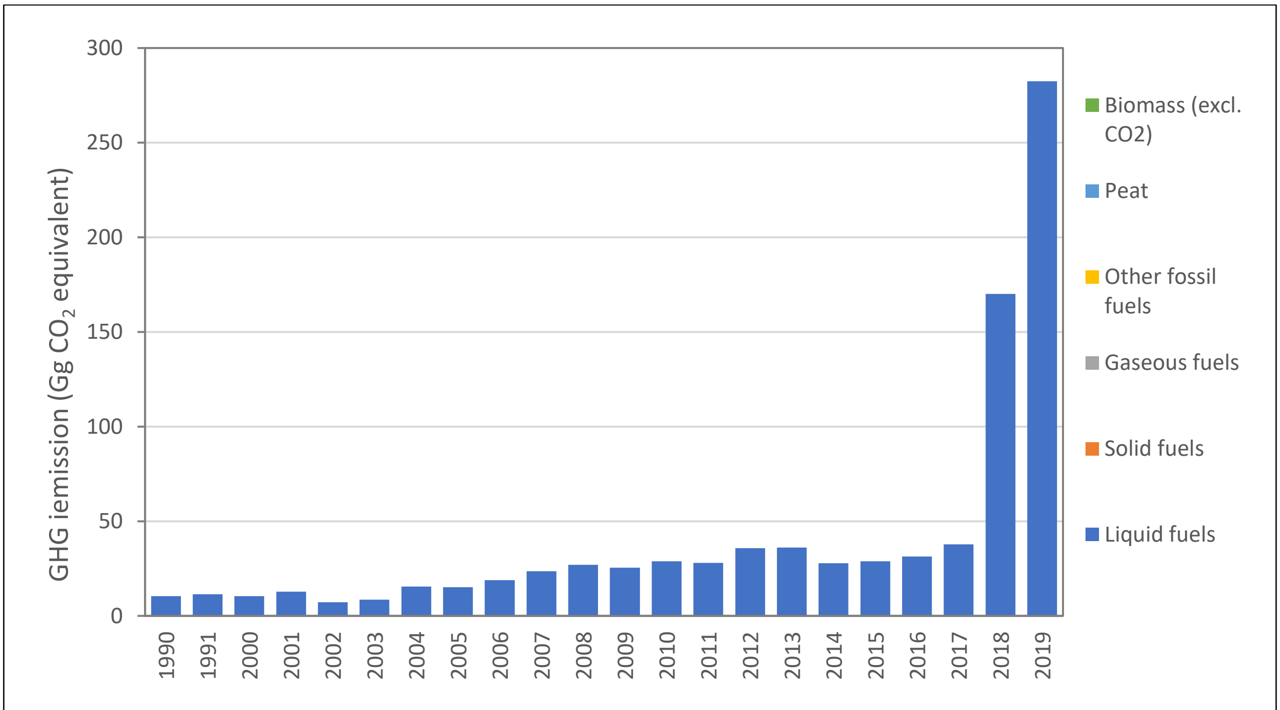


Figure 62 GHG Emissions from IPCC sub-category 1.A.3.ai International Aviation

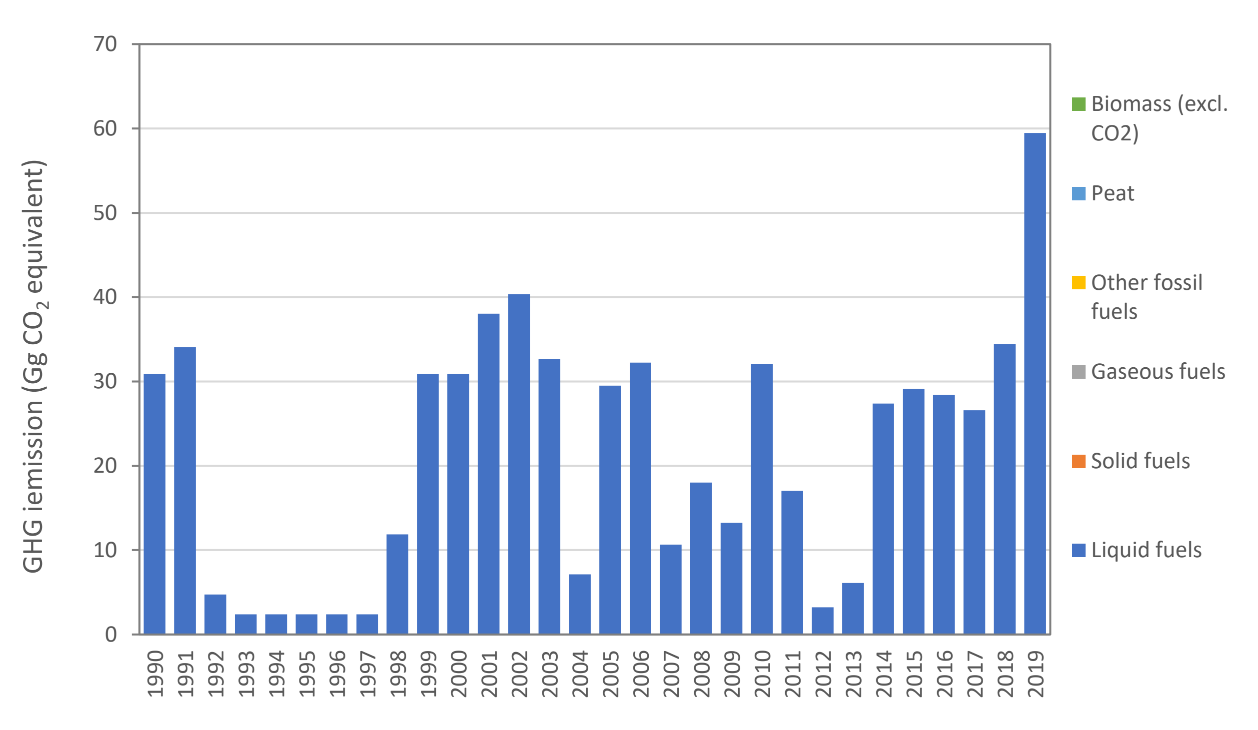


Figure 63 GHG Emissions from IPCC sub-category 1.A.3.aii Domestic Aviation

Table 135 **Emissions from IPCC sub-category 1.A.3.a.ii Domestic Aviation**

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent
1990	30,91	30,67	0,24	NO	NO
1991	34,06	33,80	0,26	NO	NO
1992	4,76	4,72	0,04	NO	NO
1993	2,38	2,36	0,02	NO	NO
1994	2,38	2,36	0,02	NO	NO
1995	2,38	2,36	0,02	NO	NO
1996	2,38	2,36	0,02	NO	NO
1997	2,38	2,36	0,02	NO	NO
1998	11,89	11,80	0,09	NO	NO
1999	30,91	30,67	0,24	NO	NO
2000	30,91	30,67	0,24	NO	NO
2001	38,04	37,75	0,29	NO	NO
2002	40,36	40,20	0,16	NO	NO
2003	32,68	32,49	0,19	NO	NO
2004	7,14	6,79	0,35	NO	NO
2005	29,51	29,17	0,34	NO	NO
2006	32,25	31,82	0,43	NO	NO
2007	10,67	10,13	0,53	NO	NO
2008	18,00	17,39	0,61	NO	NO

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent
2009	13,25	12,67	0,58	NO	NO
2010	32,07	31,42	0,65	NO	NO
2011	17,01	16,38	0,64	NO	NO
2012	3,22	2,41	0,81	NO	NO
2013	6,12	5,30	0,82	NO	NO
2014	27,39	26,76	0,63	NO	NO
2015	29,14	28,49	0,65	NO	NO
2016	28,40	27,69	0,71	NO	NO
2017	26,57	25,71	0,86	NO	NO
2018	34,42	33,54	0,88	NO	NO
2019	59,48	58,02	1,46	NO	NO
Trend					
1990 - 2019	92%	89%	519%	NA	NA
2005 - 2019	102%	99%	326%	NA	NA
2018 - 2019	73%	73%	66%	NA	NA

3.2.7.1.2 Methodological issues

3.2.7.1.2.1 Choice of methods

For estimating the GHG emissions (CO_2, CH_4, N_2O) the 2006 IPCC Guidelines Tier 1 approach[47] has been applied:

Equation 3.6.1: Aviation equation 1 (2006 IPCC GL, Vol. 2, Chap. 3)

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

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

3.2.7.1.2.2 Choice of activity data – Civil aviation

Liquid fuels: Kerosene-type Jet Fuel

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

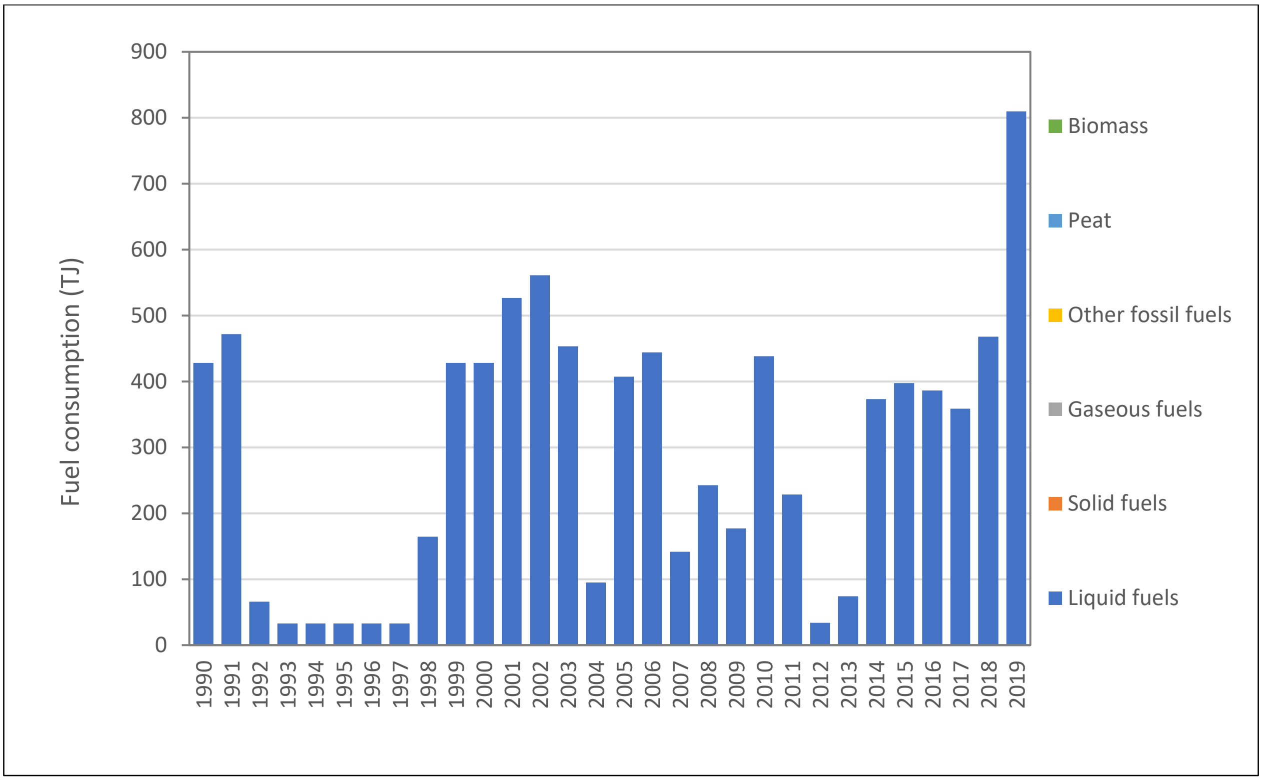


Figure 64 Activity data for IPCC sub-category 1.A.3.aii Domestic Aviation

Table 136 Calculation of fuel consumption per LTO and Cruise

	Number of LTO cycles			Source	**Energy Balance**		**Fuel consumption** Reference[48]				
						NCV	LTO [t]	LTO [GJ]	Cruise	Cruise [GJ]	Cruise
					Kersosene	43.96	825	43.96		43.96	0.0011
						[GJ/t]	[kg/LTO]	[GJ/t]	[t]	[GJ/t]	t/t Fuel
					International civil aviation	CS NCV		CS NCV	Difference (F_sold-Fuel for LTO`s)	CS NCV	1 A 3 a i (ii)
Airport	**PDG LTO**	**TIV LTO**	**TOTAL LTO**		**t**	**GJ**		t		t	t
1990			3954	Calculated based on ratio to fuelconsumption to LTO in 2005	13,000	571,480	3,262	143,409	9,738	428,071	125
1991			4357		14,324	629,686	3,595	158,016	10,730	471,670	137
1992			608		2,000	87,920	502	22,063	1,498	65,857	19
1993			304		1,000	43,960	251	11,031	749	32,929	10
1994			304		1,000	43,960	251	11,031	749	32,929	10
1995			304		1,000	43,960	251	11,031	749	32,929	10
1996			304		1,000	43,960	251	11,031	749	32,929	10
1997			304		1,000	43,960	251	11,031	749	32,929	10
1998			1521		5,000	219,800	1,255	55,157	3,745	164,643	48
1999			3954		13,000	571,480	3,262	143,409	9,738	428,071	125
2000			3954		13,000	571,480	3,262	143,409	9,738	428,071	125
2001			4867		16,000	703,360	4,015	176,504	11,985	526,856	153
2002	2713	0	2713	Airprot statistics	15,000	659,400	2,238	98,392	12,762	561,008	163
2003	3256	0	3256		13,000	571,480	2,686	118,085	10,314	453,395	132
2004	3550	2321	5871		7,000	307,720	4,844	212,924	2,156	94,796	28
2005	3296	2450	5746		14,000	615,440	4,740	208,390	9,260	407,050	119
2006	3887	3261	7148		16,000	703,360	5,897	259,237	10,103	444,123	129
2007	4870	4079	8949		10,600	465,976	7,383	324,553	3,217	141,423	41
2008	5670	4608	10278		14,000	615,440	8,479	372,752	5,521	242,688	71

[48] EMEP/EEA GB 2013, 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.

	Number of LTO cycles			Source	Energy Balance			Fuel consumption Reference[48]				
						NCV		LTO [t]	LTO [GJ]	Cruise	Cruise [GJ]	Cruise
					Kersosene	43.96		825	43.96		43.96	0.0011
						[GJ/t]		[kg/LTO]	[GJ/t]	[t]	[GJ/t]	t/t Fuel
					International civil aviation	CS NCV			CS NCV	Difference (F_sold-Fuel for LTO`s)	CS NCV	1 A 3 a i (ii)
Airport	PDG LTO	TIV LTO	TOTAL LTO		t	GJ			t		t	t
2009	5439	4230	9669		12,000	527,520		7,977	350,666	4,023	176,854	51
2010	0	0	10941		19,000	835,240		9,026	396,797	9,974	438,443	128
2011	0	0	10667		14,000	615,440		8,800	386,860	5,200	228,580	67
2012	5523	8095	13618		12,000	527,520		11,235	493,884	765	33,636	10
2013	5584	8134	13718		13,000	571,480		11,317	497,511	1,683	73,969	22
2014	0	0	10551		17,200	756,112		8,705	382,653	8,495	373,459	109
2015	5545	5433	10978		18,100	795,676		9,057	398,139	9,043	397,537	116
2016	5958	5933	11891		18,600	817,656		9,810	431,251	8,790	386,405	113
2017	8025.5	6323.5	14349		20,000	879,200		11,838	520,395	8,162	358,805	104
2018	0	0	14731		22,800	1,002,288		12,153	534,249	10,647	468,039	136
2019	13208	11268	24476		38,612	1,697,378		20,193	887,671	18,419	809,707	236

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 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.3.a. *Domestic aviation and International Aviation*.

Table 137 Net calorific values (NCVs) applied for conversion to energy units in IPCC sub-category 1.A.3.a. Domestic aviation and International Aviation

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg)		Source
		NCV	type	
Kerosene	liquid	44.10	D	**2006 IPCC Guidelines, Vol. 2, Chap. 1, Table 1.2** Default net calorific values (NCVs) and lower and upper limits of the 95% confidence intervals
Note:				
D Default	CS Country specific	PS Plant specific		

3.2.7.1.2.3 Choice of emission factors

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

Table 138 GHG Emission factor TIER 1 for IPCC sub-category 1.A.3.a. Civil Aviation

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)**
Kerosene (Jet fuel)	liquid	71 500	D					**TABLE 3.6.4** CO_2 emission factors (page 3.64)
				0.5	D	2	D	**TABLE 3.6.5** Non-CO_2 emission factors (page 3.64)
Note:								
D Default	CS Country specific	PS Plant specific	IEF Implied emission factor					

3.2.7.1.3 Source-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,
- 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;

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

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

3.2.7.1.4 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission and relevant to sub-category *1.A.3.a Aviation*.

Table 139 Recalculations done in sub-category 1.A.3.a Aviation

source category	Revisions of data	Type of revision	Type of improvement
1.A.3.a	Application of EMEP/EEA air pollutant emission inventory guidebook 2013	method	Comparability
1.A.3.a	use of default EF of EMEP/EEA air pollutant emission inventory guidebook 2013	EF	Comparability
1.A.3.a	use of CS NCVd	AD	Accuracy
1.A.3.a	Fuel consumption data (activity data) was revised	AD	Accuracy

3.2.7.1.5 Source-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 140 Planned improvements for sub-category 1.A.3.a Aviation

Source category	Planned improvement	Type of improvement		Priority
1.A.3.a	Application of EMEP/EEA air pollutant emission inventory guidebook 2019, TIER 2	method	Comparability	high
1.A.3.a	use of default EF of EMEP/EEA air pollutant emission inventory guidebook 2019, TIER 2	EF	Comparability	medium
1.A.3.a	Investigation on Flight movements Investigation on fleet	AD	Comparability	high

3.2.7.2 Road Transportation (IPCC category 1.A.3.b)

3.2.7.2.1 Activity data

Step 1	Grouping existing vehicle categories from National Transport Statistics according to NFR categories

1A3b Road Transport		
NFR code	**NFR**	**correlates which category in Statistics**
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	Agricutlure/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
1998	590	893	596	12	562	150220	663	10645	310	697	164491
1999	1127	813	365	22	883	118243	848	10612	568	1398	133481
2000	996	809	595	10	2719	128319	857	12116	916	2108	147337
2001	598	638	360	16	1616	93959	652	8147	539	1606	106525
2002	588	653	596	4	1550	100501	768	8637	522	1529	113819
2003	640	733	1445	23	1484	110047	814	8888	526	1395	124600
2004	588	689	995	3	1305	104220	718	8431	438	1333	117387
2005	741	721	1246	8	1293	126570	800	9189	422	1249	140990
2006	656	768	1425	10	992	154319	787	9623	349	1221	168929
2007	1210	832	3032	7	1592	193875	1118	13214	603	1519	215483
2008	1283	1224	4797	28	2059	199542	1608	14574	877	1827	225992
2009	1202	1265	4879	64	1808	179937	1854	12851	931	1477	204791
2010	1140	1040	4572	63	1830	164728	1857	12105	933	1422	188268
2011	1174	1048	4529	169	1859	166878	1957	12018	937	1751	190569

	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
2012	1180	1003	4524	164	1898	170557	2140	12366	1003	1705	194835
2013	1238	953	5013	222	1884	177646	2395	12744	1030	2071	203125
2014	1234	764	3650	220	1976	172170	2411	11836	1055	1976	195316
2015	1242	649	4172	272	2125	174526	2663	12390	1157	2150	199196
2016	1309	622	4364	141	2401	184952	1110	14956	1290	2413	211145
2017	1370	562	4744	351	1046	187777	482	16426	1405	2524	214163
2018	1283	475	6710	645	1126	197213	494	17415	1442	2769	229572
2019	1490	468	6300	202		217959	585	17494	1681	3122	249301

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
1998	150,220	596	11,545	590	10,645	310	1,556	893	663	12	562
1999	118,243	365	12,307	1,127	10,612	568	1,661	813	848	22	883
2000	128,319	595	14,028	996	12,116	916	1,666	809	857	10	2,719
2001	93,959	360	9,284	598	8,147	539	1,290	638	652	16	1,616
2002	100,501	596	9,747	588	8,637	522	1,421	653	768	4	1,550
2003	110,047	1,445	10,054	640	8,888	526	1,547	733	814	23	1,484
2004	104,220	995	9,457	588	8,431	438	1,407	689	718	3	1,305
2005	126,570	1,246	10,352	741	9,189	422	1,521	721	800	8	1,293
2006	154,319	1,425	10,628	656	9,623	349	1,555	768	787	10	992
2007	193,875	3,032	15,027	1,210	13,214	603	1,950	832	1,118	7	1,592
2008	199,542	4,797	16,734	1,283	14,574	877	2,832	1,224	1,608	28	2,059
2009	179,937	4,879	14,984	1,202	12,851	931	3,119	1,265	1,854	64	1,808
2010	164,728	4,572	14,178	1,140	12,105	933	2,897	1,040	1,857	63	1,830
2011	166,878	4,529	14,129	1,174	12,018	937	3,005	1,048	1,957	169	1,859
2012	170,557	4,524	14,549	1,180	12,366	1,003	3,143	1,003	2,140	164	1,898
2013	177,646	5,013	15,012	1,238	12,744	1,030	3,348	953	2,395	222	1,884
2014	172,170	3,650	14,125	1,234	11,836	1,055	3,175	764	2,411	220	1,976
2015	174,526	4,172	14,789	1,242	12,390	1,157	3,312	649	2,663	272	2,125
2016	184,952	4,364	17,555	1,309	14,956	1,290	1,732	622	1,110	141	2,401
2017	187,777	4,744	19,201	1,370	16,426	1,405	1,044	562	482	351	1,046
2018	197,213	6,710	20,140	1,283	17,415	1,442	969	475	494	645	1,126

	Passenger Cars	Motor cycles	HDV	Buses	Truck	Towing vehicle	Light duty vehicles	Van	Special Passenger vehicle	Work vehicles	Tractors
2019	217,959	6,300	20,665	1,490	17,494	1,681	1,053	468	585	202	NA

Step 4 **Produce NFR compatible final fleet data per year (number of vehicles) per vehicle categories**

number of veh.	1A3b1	1A3b2	1A3b3	1A3b4
	Passenger cars	Light duty vehicles	Heavy duty vehicles	Mopeds & Motorcycles
1998	150,220	1,556	11,545	596
1999	118,243	1,661	12,307	365
2000	128,319	1,666	14,028	595
2001	93,959	1,290	9,284	360
2002	100,501	1,421	9,747	596
2003	110,047	1,547	10,054	1,445
2004	104,220	1,407	9,457	995
2005	126,570	1,521	10,352	1,246
2006	154,319	1,555	10,628	1,425
2007	193,875	1,950	15,027	3,032
2008	199,542	2,832	16,734	4,797
2009	179,937	3,119	14,984	4,879
2010	164,728	2,897	14,178	4,572
2011	166,878	3,005	14,129	4,529
2012	170,557	3,143	14,549	4,524
2013	177,646	3,348	15,012	5,013
2014	172,170	3,175	14,125	3,650
2015	174,526	3,312	14,789	4,172
2016	184,952	1,732	17,555	4,364
2017	187,777	1,044	19,201	4,744
2018	197,213	969	20,140	6,710
2019	217,959	1,053	20,665	6,300

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 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.3.b. *Road transport*.

Table 141 Net calorific values (NCVs) applied for conversion to energy units in IPCC sub-category 1.A.3.b. Road transport

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg)		Source
		NCV	type	
Gas/ Diesel Oil	liquid	43.00	D	**2006 IPCC Guidelines, Vol. 2, Chap. 1, Table 1.2** Default net calorific values (NCVs) and lower and upper limits of the 95% confidence intervals
Motor Gasoline	liquid	44.30	D	
Liquefied Petroleum Gases (LPG)	liquid	47.30	D	
Note: D Default CS Country specific PS Plant specific				

3.2.7.2.2 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.3.b. Road transport

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. 3 (3.2.1.2)
Gas/ Diesel Oil	liquid	74,100	D	-	-	-	-	**TABLE 3.2.1** CO_2 emission factors (page 3.16)
Motor Gasoline		69,300	D	-	-	-	-	
LPG		63,100	D	-	-	-	-	
Gas/ Diesel Oil	liquid	-	-	3.9	D	3.9	D	**TABLE 3.2.2** CO_2 emission factors (page 3.21)
Motor Gasoline		-	-	33	D	3.2	D	
LPG		-	-	62	D	0.2	D	
Note: D Default CS Country specific PS Plant specific IEF Implied emission factor								

3.2.7.2.3 Source-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, interpolation and documented assumption
  - consistent use of vehicle fleet data, interpolation and documented assumption
  - 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;

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

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

3.2.7.2.4 Source-specific recalculations

The following table presents the main revisions and recalculations done since the last submission in 2013 and relevant to sub-category *1.A.3.b Road transport*.

Table 143 Recalculations done in sub-category *1.A.3.b Road transport*

source category	Revisions of data	Type of revision	Type of improvement
1.A.3.b	Application of EMEP/EEA air pollutant emission inventory guidebook 2012 and 2006 IPCC Guidelines	method	Comparability
1.A.3.b	use of default EF of EMEP/EEA air pollutant emission inventory guidebook 2013 and 2006 IPCC Guidelines	EF	Comparability
1.A.3.b	use of CS NCV	AD	Accuracy
1.A.3.b	Fuel consumption data (activity data) was revised	AD	Accuracy

3.2.7.2.5 Source-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.3.b Road transport*

Source category	Planned improvement	Type of improvement		Priority
1.A.3.b	Application of IPCC 2006 Guidelines, TIER 2/3 **Use of COPERT model**	method	Comparability	high
1.A.3.b	• Investigation on vehecile movements (milage, age technology of vehicles) • Investigation on vehicle fleet	AD	Comparability	High
1.A.3.b	Road vehicle categories and relevant Legislation/ Technology classes • Passenger Cars • Light Commercial Vehicles (LDV) • Heavy-Duty Vehicles (HDV) • Mopeds and Motorcycles		Completeness Accuracy Transparency	High
1.A.3.b	Time-series of fuel consumption ⇒ completing time series and gap filling for some years	AD	Consistency Completeness	High

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.

- 1.A.4.a Commercial/Institutional
- 1.A.4.b Residential
- 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 (mobile combustion)

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*.

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	√	√	NO	NO	NO	√	√	√	NO	NO	NO	√	√	√	NO	NO	NO	√
Key category	LA 1990, LA 2019						-	-	-	-	-	-	-	-	-	-	-	-
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																		

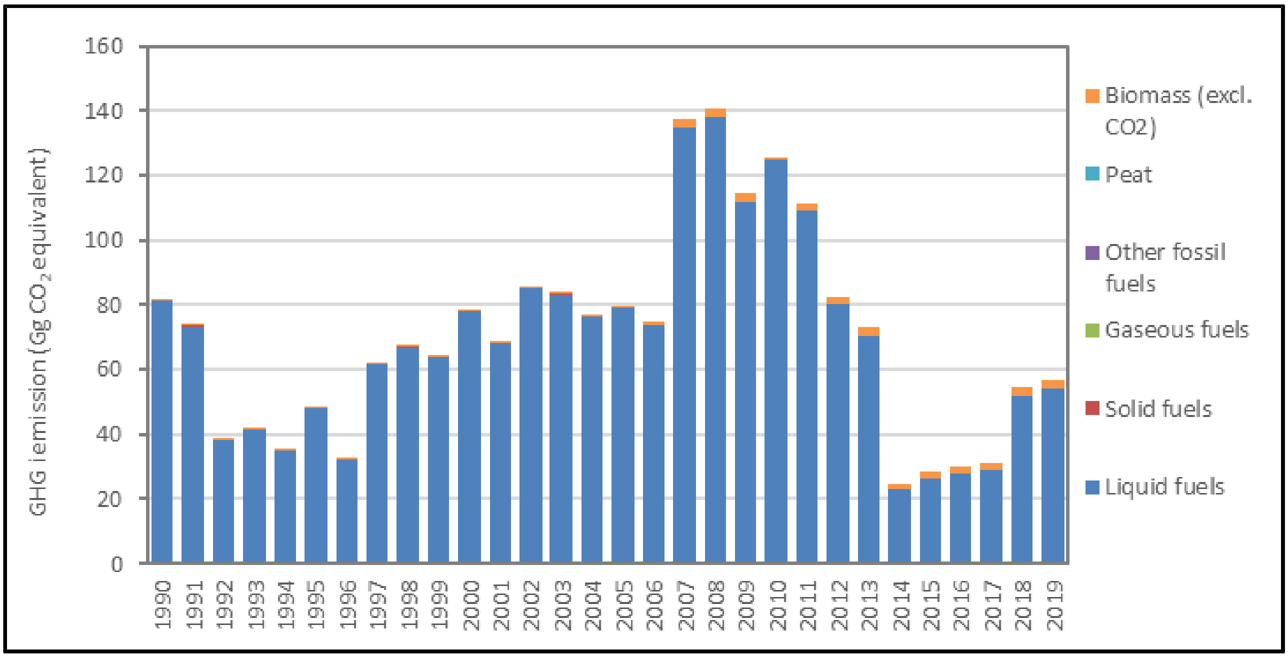


Figure 65 Emissions from IPCC sub-category 1.A.4.a Commercial

Table 145 Emissions from IPCC sub-category 1.A.4.a Commercial

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
1990	81.35	80.75	0.18	0.40	0.17
1991	73.60	73.00	0.17	0.40	0.19
1992	38.65	38.22	0.09	0.31	0.21
1993	41.83	41.43	0.10	0.28	0.17
1994	35.45	35.05	0.08	0.29	0.20
1995	48.30	47.78	0.11	0.37	0.25
1996	32.11	31.85	0.07	0.18	0.09
1997	61.63	61.10	0.14	0.36	0.18
1998	66.99	66.50	0.16	0.32	0.11
1999	64.14	63.66	0.15	0.32	0.12
2000	78.15	77.62	0.18	0.33	0.09
2001	68.37	67.81	0.16	0.38	0.18
2002	85.29	84.64	0.20	0.43	0.18
2003	83.45	82.72	0.19	0.50	0.26
2004	76.72	76.10	0.18	0.42	0.20
2005	79.35	78.56	0.18	0.56	0.35
2006	74.49	73.20	0.17	1.00	0.88
2007	137.19	133.73	0.31	2.78	2.71
2008	140.39	136.94	0.32	2.77	2.69
2009	114.62	111.41	0.26	2.60	2.59
2010	125.52	124.14	0.29	1.00	0.69
2011	111.16	108.41	0.25	2.21	2.15
2012	82.23	79.67	0.18	2.09	2.12
2013	72.84	70.13	0.16	2.23	2.32
2014	24.67	22.87	0.05	1.53	1.68
2015	28.63	26.35	0.05	1.93	2.14
2016	29.91	27.60	0.06	1.96	2.16
2017	31.34	28.85	0.06	2.12	2.35
2018	54.63	30.73	0.06	2.30	2.54
2019	56.85	31.98	0.07	2.44	2.70
Trend					
1990 - 2019	*-30.1%*	*-60.4%*	*-62.8%*	*504.3%*	*1301%*
2005 - 2019	*-28%*	*-59%*	*-64%*	*334%*	*515%*
2018 - 2019	*4.1%*	*4.1%*	*3.8%*	*6.2%*	*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[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, gasous fuels, other fossil fuel, biomass, peat

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

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

3.2.8.1.2.2 Choice of activity data

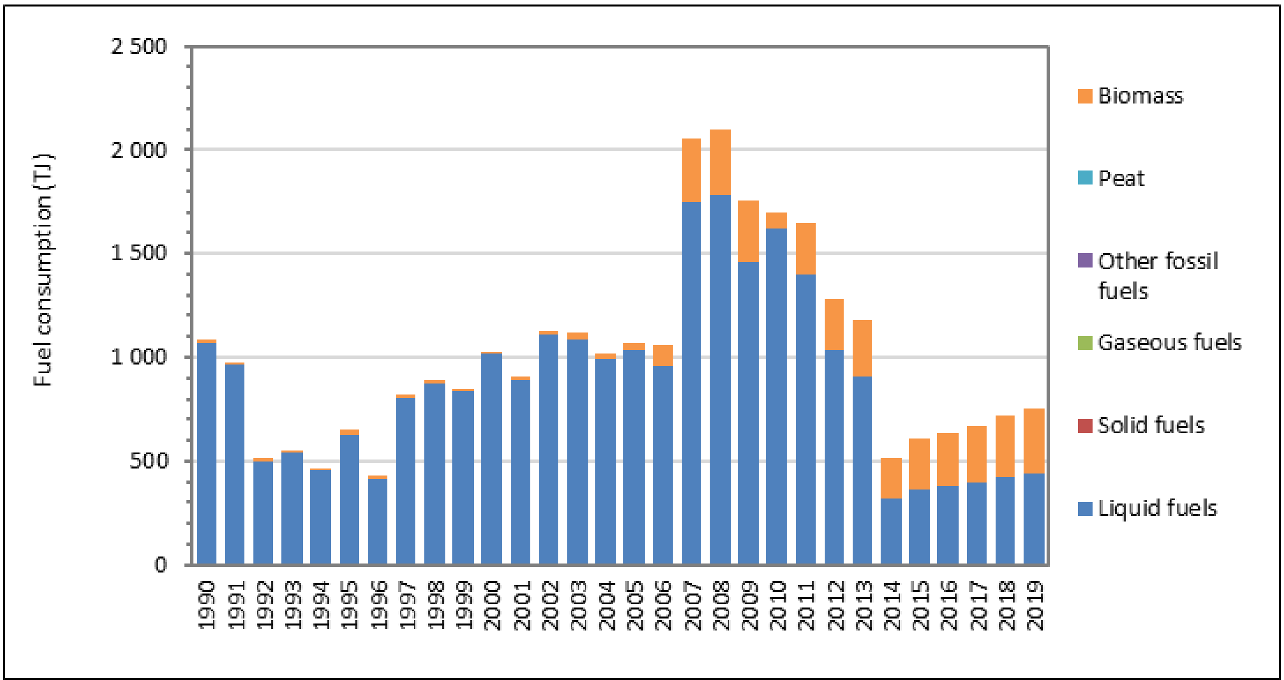


Figure 66 Activity data for IPCC sub-category 1.A.4.a Commercial/Institutuitonal

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

Table 146 Activity data for IPCC sub-category 1.A.4.ai Commercial/Institutional

Activity data 1.A.1.a	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	1 081.05	1 071.04	0.38	NO	NO	NO	9.64
1991	973.69	962.35	0.33	NO	NO	NO	11.01
1992	511.56	498.93	0.29	NO	NO	NO	12.34
1993	548.72	538.62	0.20	NO	NO	NO	9.89
1994	468.05	456.22	0.19	NO	NO	NO	11.64
1995	651.57	622.53	0.20	NO	NO	NO	28.83
1996	426.74	416.53	0.30	NO	NO	NO	9.91
1997	822.34	801.61	0.44	NO	NO	NO	20.29
1998	886.25	873.16	0.45	NO	NO	NO	12.64
1999	848.82	834.57	0.49	NO	NO	NO	13.76
2000	1 029.24	1 018.87	0.28	NO	NO	NO	10.09
2001	908.00	886.62	0.28	NO	NO	NO	21.11
2002	1 130.02	1 109.51	0.32	NO	NO	NO	20.19
2003	1 115.37	1 084.79	0.30	NO	NO	NO	30.28
2004	1 016.93	993.74	0.25	NO	NO	NO	22.94
2005	1 071.81	1 031.23	0.11	NO	NO	NO	40.47
2006	1 059.46	958.17	0.25	NO	NO	NO	101.04
2007	2 056.09	1 743.99	0.12	NO	NO	NO	311.98
2008	2 093.03	1 783.68	0.10	NO	NO	NO	309.24
2009	1 753.48	1 455.59	0.17	NO	NO	NO	297.72
2010	1 700.95	1 621.90	0.13	NO	NO	NO	78.92
2011	1 649.63	1 402.31	0.13	NO	NO	NO	247.19
2012	1 276.60	1 033.02	IE	NO	NO	NO	243.58
2013	1 174.78	907.91	IE	NO	NO	NO	266.87
2014	515.14	316.34	0.05	NO	NO	NO	198.74
2015	612.97	361.45	0.06	NO	NO	NO	251.46
2016	633.19	378.80	0.07	NO	NO	NO	254.32
2017	672.15	396.15	0.07	NO	NO	NO	275.93
2018	718.91	421.89	0.07	NO	NO	NO	296.95
2019	755.84	439.39	0.08	NE	NE	NE	316.37
Trend							
1990 - 2019	*-30.1%*	*-59.0%*	*-79.8%*	*NA*	*NA*	*NA*	*3183.5%*
2005 - 2019	*-29.5%*	*-57.4%*	*-30.8%*	*NA*	*NA*	*NA*	*681.8%*
2018 - 2019	*5.1%*	*4.1%*	*5.1%*	*NA*	*NA*	*NA*	*6.5%*

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 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.i *Commercial/Institutional*.

Table 147 Net calorific values (NCVs) applied for conversion to energy units in sub-category 1.A.4.a.i Commercial/ Institutional

Fuel	Fuel type	Net calorific value (NCV) (TJ/Gg) or * (TJ/m³)		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	
WoodBriquette	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 148 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	
Natural gas	gaseous	56 100	D	1	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 Source-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,

- 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.

3.2.8.1.4 Source-specific recalculations

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 149 Recalculations done since NC & BUR in IPCC sub-category 1.A.4.a Commercial/Institutional.

GHG source & sink category	Revisions of data in NC & BUR ⇒ GHG inventory submission 2020	Type of revision	Type of improvement
1.A.4.a	Fuel consumption data (activity data) was revised due to revised activity data	AD	Accuracy
1.A.4.a	use of CS NCV	AD	Comparability

3.2.8.1.5 Source-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.4.a Commercial/Institutional.

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.4.a	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.a	Survey on fuel used and relevant characteristics: • Waste – biomass fraction / non-biomass fraction	AD	Completeness	high
1.A.4.a	Cross-check of national, Eurostat, FAO and international data sources and feedback to UNSD	AD	Completeness	medium
1.A.4.a	Time-series of fuel consumption	AD	Consistency Completeness	high

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	✓	✓	✓	NO	NO	✓	✓	✓	✓	NO	NO	✓	✓	✓	✓	NO	NO	✓
Key category	LA 1990						LA 1990, LA 2019											
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																		

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.

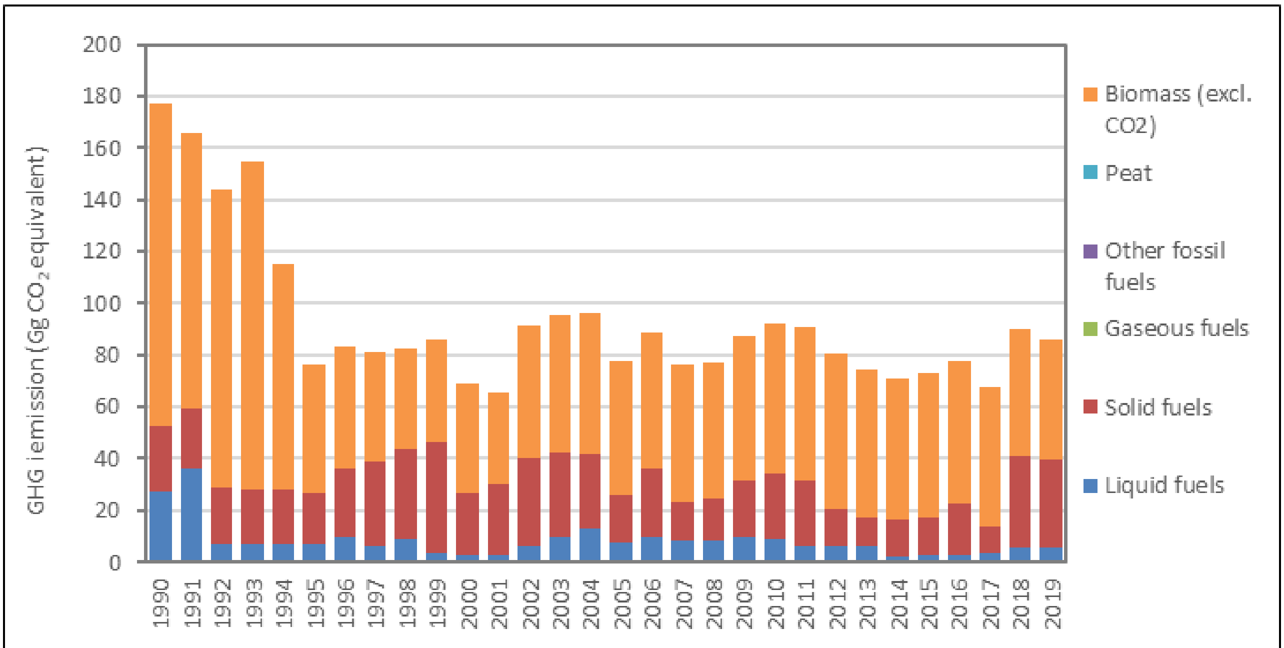


Figure 67 Emissions from IPCC sub-category 1.A.4.b Residential

Table 151 Emissions from IPCC sub-category 1.A.4.b Residential

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
1990	176.86	50.84	0.12	108.87	124.10
1991	165.75	57.85	0.12	93.23	106.11
1992	143.79	27.33	0.10	100.62	114.82
1993	154.53	26.39	0.10	110.68	126.56

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent
1994	115.34	26.39	0.10	76.87	87.37
1995	76.58	25.46	0.09	44.22	49.62
1996	83.08	34.02	0.12	42.48	47.11
1997	81.33	36.33	0.14	39.01	42.62
1998	82.59	41.36	0.16	35.78	38.63
1999	86.22	43.03	0.18	37.51	40.08
2000	68.71	24.96	0.11	37.89	41.97
2001	65.21	28.08	0.12	32.20	35.13
2002	91.60	37.89	0.15	46.54	51.19
2003	95.54	40.24	0.15	47.91	52.84
2004	95.83	39.78	0.13	48.53	53.88
2005	77.58	24.46	0.09	45.93	51.76
2006	88.41	34.08	0.12	47.02	52.37
2007	76.41	22.46	0.08	46.62	52.79
2008	77.43	23.41	0.09	46.69	52.80
2009	87.22	30.09	0.11	49.41	55.46
2010	91.79	31.99	0.12	51.73	57.91
2011	91.04	29.72	0.12	53.05	59.45
2012	80.72	19.45	0.07	52.94	60.20
2013	74.50	16.65	0.06	49.97	57.01
2014	71.01	15.35	0.06	48.12	54.64
2015	73.15	16.20	0.06	49.23	55.88
2016	77.51	21.17	0.08	48.74	54.91
2017	67.58	12.78	0.04	47.35	54.04
2018	90.24	13.03	0.04	43.01	49.09
2019	86.18	12.86	0.04	40.86	46.63
Trend					
1990 - 2019	*-51.3%*	*-74.7%*	*-69.0%*	*-62.5%*	*-62.4%*
2005 - 2019	*11%*	*-47%*	*-59%*	*-11%*	*-10%*
2018 - 2019	*-4.5%*	*-1.3%*	*-4.8%*	*-5.0%*	*-5.0%*

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[50] 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, gasous fuels, other fossil fuel, biomass, peat

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

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

3.2.8.2.2.2 Choice of activity data

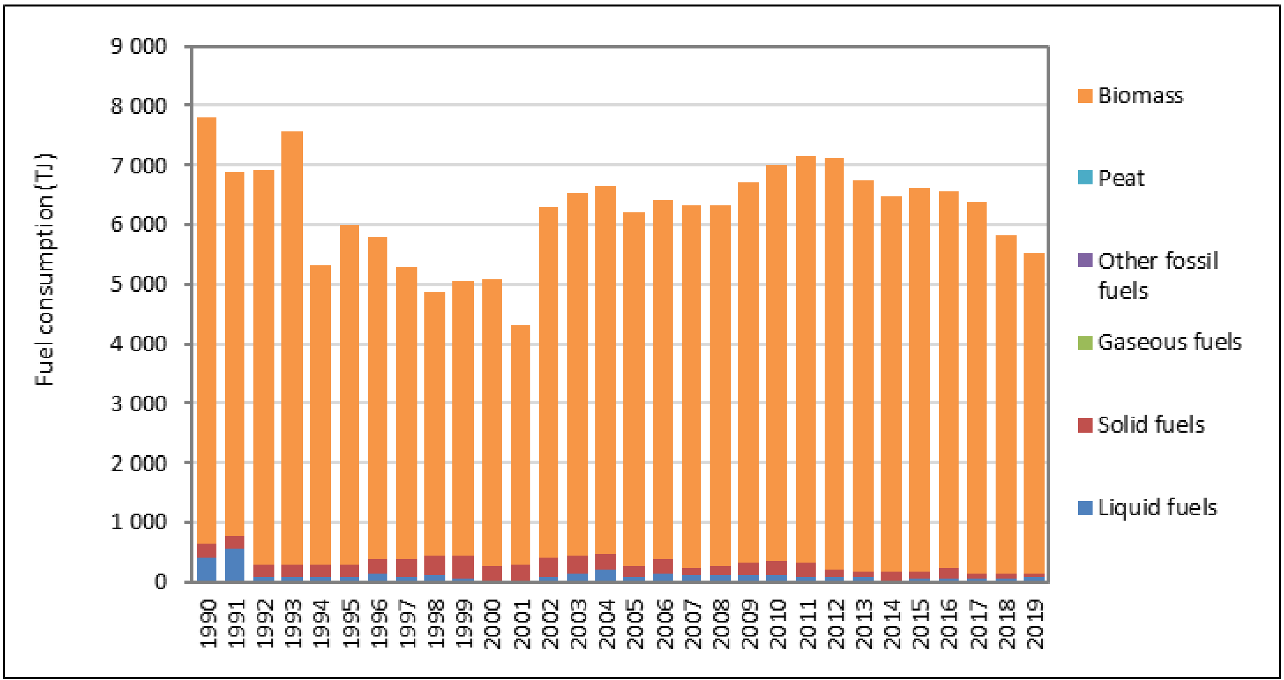


Figure 68 Activity data for IPCC sub-category 1.A.4.b Other Sectors

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

Table 152 Activity data for IPCC sub-category 1.A.4.b Residentials

Activity data 1.A.4.b	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	7 794.44	424.56	231.11	NO	NO	NO	7 138.77
1991	6 881.96	565.23	212.62	NO	NO	NO	6 104.11
1992	6 904.48	96.33	203.38	NO	NO	NO	6 604.78
1993	7 570.84	96.33	194.13	NO	NO	NO	7 280.38
1994	5 316.54	96.33	194.13	NO	NO	NO	5 026.08
1995	5 990.14	96.33	184.89	NO	NO	NO	5 708.92
1996	5 804.07	143.22	240.35	NO	NO	NO	5 420.50
1997	5 286.69	87.86	295.82	NO	NO	NO	4 903.01
1998	4 879.02	111.48	323.55	NO	NO	NO	4 443.98
1999	5 044.63	45.09	388.26	NO	NO	NO	4 611.28
2000	5 083.89	32.96	221.86	NO	NO	NO	4 829.06
2001	4 328.52	37.08	249.60	NO	NO	NO	4 041.84
2002	6 291.34	88.09	314.31	NO	NO	NO	5 888.95
2003	6 523.88	139.10	305.06	NO	NO	NO	6 079.71
2004	6 656.87	190.11	268.09	NO	NO	NO	6 198.68
2005	6 219.89	98.88	166.40	NO	NO	NO	5 954.61
2006	6 401.09	135.31	240.35	NO	NO	NO	6 025.44
2007	6 321.84	109.26	138.67	NO	NO	NO	6 073.91
2008	6 331.66	109.39	147.91	NO	NO	NO	6 074.36
2009	6 707.58	123.39	203.38	NO	NO	NO	6 380.81
2010	7 005.57	111.78	231.11	NO	NO	NO	6 662.68
2011	7 153.00	82.40	231.11	NO	NO	NO	6 839.49
2012	7 138.07	82.40	129.42	NO	NO	NO	6 926.25
2013	6 742.73	82.40	101.69	NO	NO	NO	6 558.64
2014	6 458.44	37.51	128.50	NO	NO	NO	6 292.43
2015	6 612.69	42.20	134.04	NO	NO	NO	6 436.45
2016	6 553.09	46.89	180.27	NO	NO	NO	6 325.94
2017	6 372.83	51.58	94.29	NO	NO	NO	6 226.96
2018	5 809.84	70.34	85.05	NO	NO	NO	5 654.46
2019	5 527.52	75.02	80.43	NO	NO	NO	5 372.07
Trend							
1990 - 2019	*-18.2%*	*-87.9%*	*-59.2%*	*NA*	*NA*	*NA*	*-12.8%*
2005 - 2019	*2.5%*	*-47.8%*	*-43.3%*	*NA*	*NA*	*NA*	*6.2%*
2018 - 2019	*-2.8%*	*10.0%*	*-47.7%*	*NA*	*NA*	*NA*	*-1.6%*

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 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 153 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	
WoodBriquette	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 154 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	
Natural gas	gaseous	56 100	D	1	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 Source-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.

3.2.8.2.4 Source-specific recalculations

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 155 Recalculations done since NC & BUR in IPCC sub-category 1.A.4.b Residentials.

GHG source & sink category	Revisions of data in NC & BUR ⇒ GHG inventory submission 2020	Type of revision	Type of improvement
1.A.4.b	Fuel consumption data (activity data) was revised due to revised activity data	AD	Accuracy
1.A.4.b	use of CS NCV	AD	Comparability

3.2.8.2.5 Source-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 156 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 Accuray	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

Agriculture/Forestry/Fishing/Fish Farms (IPCC category 1.A.4.c)

3.2.8.2.6 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.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
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																		

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

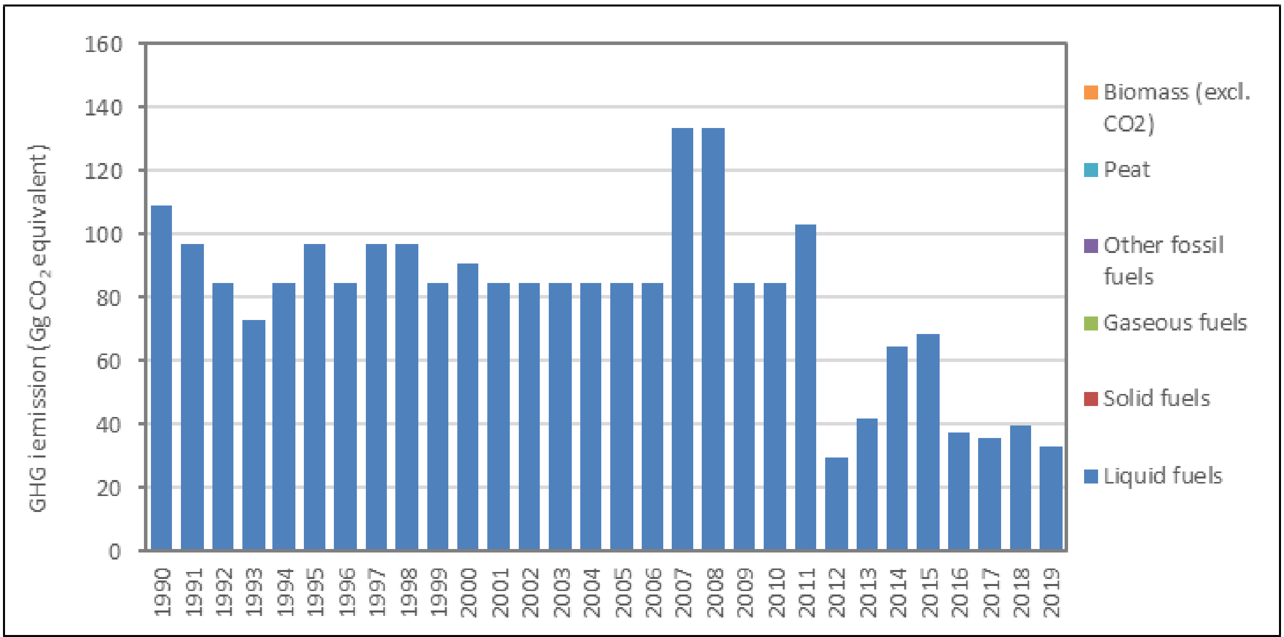


Figure 69 Emissions from IPCC sub-category 1.A.4.cii Agriculture/Forestry/Fishing/Fish Farms

Table 157 Emissions from IPCC sub-category 1.A.4. cii Agriculture/Forestry/Fishing/Fish Farms

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg CO_2 equivalent
1990	109.21	0.03	0.36	0.02	NO
1991	97.08	0.03	0.32	0.02	NO
1992	84.94	0.02	0.28	0.02	NO
1993	72.81	0.02	0.24	0.01	NO
1994	84.94	0.02	0.28	0.02	NO

GHG emissions	TOTAL GHG	CO_2 (excluding biomass)	N_2O (including biomass)	CH_4 (including biomass)	CO_2 (biomass)
	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$
1995	97.08	0.03	0.32	0.02	NO
1996	84.94	0.02	0.28	0.02	NO
1997	97.08	0.03	0.32	0.02	NO
1998	97.08	0.03	0.32	0.02	NO
1999	84.94	0.02	0.28	0.02	NO
2000	90.60	0.03	0.30	0.03	NO
2001	84.94	0.02	0.28	0.02	NO
2002	84.94	0.02	0.28	0.02	NO
2003	84.94	0.02	0.28	0.02	NO
2004	84.94	0.02	0.28	0.02	NO
2005	84.94	0.02	0.28	0.02	NO
2006	84.94	0.02	0.28	0.02	NO
2007	133.48	0.03	0.45	0.02	NO
2008	133.48	0.03	0.45	0.02	NO
2009	84.94	0.02	0.28	0.02	NO
2010	84.94	0.02	0.28	0.02	NO
2011	102.74	0.03	0.34	0.03	NO
2012	29.93	0.01	0.10	0.02	NO
2013	42.06	0.01	0.14	0.02	NO
2014	64.64	0.02	0.21	0.02	NO
2015	68.84	0.02	0.23	0.02	NO
2016	37.45	0.01	0.12	0.01	NO
2017	35.68	0.01	0.12	0.01	NO
2018	39.88	0.01	0.13	0.01	NO
2019	33.25	0.01	0.11	0.01	NO
Trend					
1990 - 2019	*-67.3%*	*-65.5%*	*-67.4%*	*-43.4%*	*NA*
2005 - 2019	*-58.0%*	*-52.8%*	*-56.1%*	*-14.9%*	*NA*
2018 - 2019	*-4.8%*	*-6.1%*	*-4.7%*	*-14.5%*	*NA*

3.2.8.2.7 Methodological issues

3.2.8.2.7.1 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)

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

Where:

Emissions $_{GHG,\ fuel}$ = emissions of a given GHG by type of fuel (kg GHG)

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

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, gasous fuels, other fossil fuel, biomass, peat

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

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

3.2.8.2.7.2 Choice of activity data

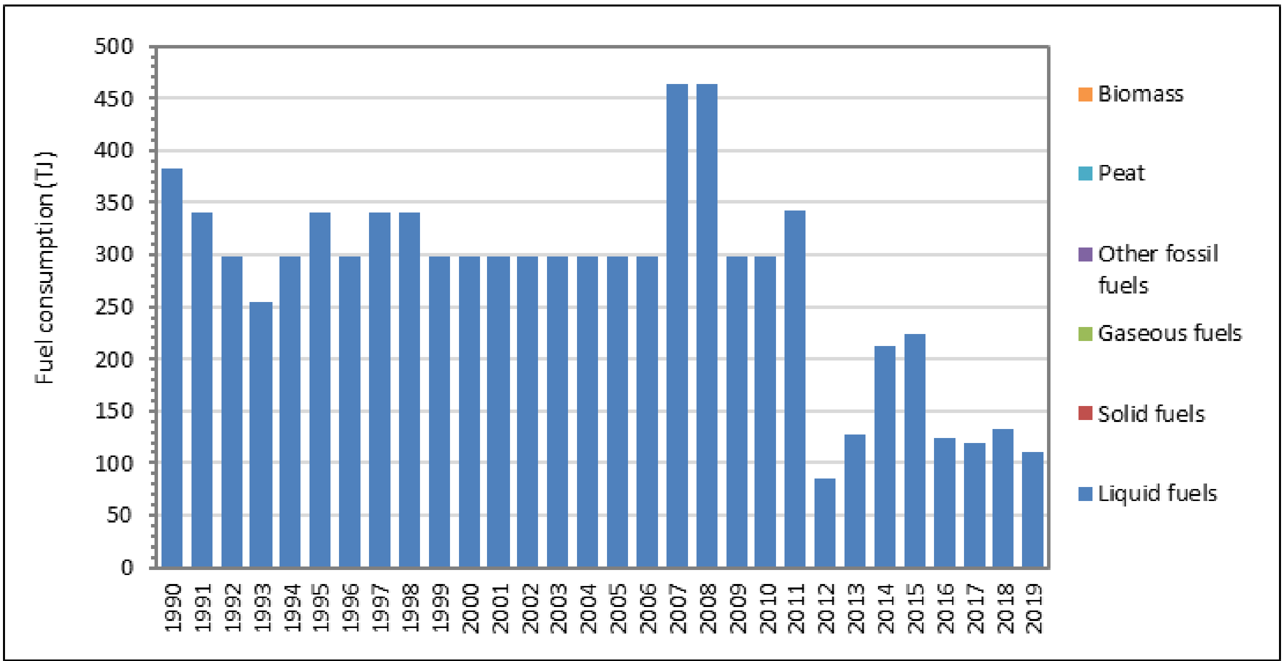


Figure 70 Activity data for IPCC sub-category 1.A.4.cii Agriculture/Forestry/Fishing/Fish Farms

Table 158 Activity data for IPCC sub-category 1.A.4.cii Agriculture/Forestry/Fishing/Fish Farms

Activity data 1.A.4.b	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
1990	382.88	382.88	NO	NO	NO	NO	NO
1991	340.17	340.17	NO	NO	NO	NO	NO
1992	297.46	297.46	NO	NO	NO	NO	NO
1993	254.75	254.75	NO	NO	NO	NO	NO
1994	297.46	297.46	NO	NO	NO	NO	NO
1995	340.17	340.17	NO	NO	NO	NO	NO
1996	297.46	297.46	NO	NO	NO	NO	NO
1997	340.17	340.17	NO	NO	NO	NO	NO
1998	340.17	340.17	NO	NO	NO	NO	NO
1999	297.46	297.46	NO	NO	NO	NO	NO
2000	297.50	297.50	NO	NO	NO	NO	NO

Activity data 1.A.4.b	Total fuels (incl. biomass)	Liquid fuels	Solid fuels	Gaseous fuels	Other fossil fuels	Peat	Biomass
	TJ						
2001	297.46	297.46	NO	NO	NO	NO	NO
2002	297.46	297.46	NO	NO	NO	NO	NO
2003	297.46	297.46	NO	NO	NO	NO	NO
2004	297.46	297.46	NO	NO	NO	NO	NO
2005	297.46	297.46	NO	NO	NO	NO	NO
2006	297.46	297.46	NO	NO	NO	NO	NO
2007	463.77	463.77	NO	NO	NO	NO	NO
2008	463.77	463.77	NO	NO	NO	NO	NO
2009	298.97	298.97	NO	NO	NO	NO	NO
2010	298.97	298.97	NO	NO	NO	NO	NO
2011	341.72	341.72	NO	NO	NO	NO	NO
2012	85.46	85.46	NO	NO	NO	NO	NO
2013	128.17	128.17	NO	NO	NO	NO	NO
2014	212.06	212.06	NO	NO	NO	NO	NO
2015	224.44	224.44	NO	NO	NO	NO	NO
2016	123.88	123.88	NO	NO	NO	NO	NO
2017	119.60	119.60	NO	NO	NO	NO	NO
2018	132.42	132.42	NO	NO	NO	NO	NO
2019	111.06	111.06	NO	NO	NO	NO	NO
Trend							
1990 - 2019	*-71.0%*	*-71.0%*	*NA*	*NA*	*NA*	*NA*	*NA*
2005 - 2019	*-62.7%*	*-62.7%*	*NA*	*NA*	*NA*	*NA*	*NA*
2018 - 2019	*-16.1%*	*-16.1%*	*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 metres. 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 3.159 Net calorific values (NCVs) applied for conversion to energy units in sub-category 1.A.4.c.ii 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

3.2.8.2.7.3 Choice of emission factors

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

Table 160 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	
Natural gas	gaseous	56 100	D	1	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

3.2.8.2.8 Source-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.

3.2.8.2.9 Source-specific recalculations

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 161 Recalculations done since NC & BUR in IPCC sub-category 1.A.4.c.ii Agriculture/Forestry/Fishing/Fish Farms - Off-road.

GHG source & sink category	Revisions of data in NC & BUR ⇒ GHG inventory submission 2020	Type of revision	Type of improvement
1.A.4.c	Fuel consumption data (activity data) was revised due to revised activity data	AD	Accuracy
1.A.4.c	use of CS NCV	AD	Comparability

3.2.8.2.10 Source-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 162 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 4 c 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[52])	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.

[52] 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
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

3.3.1.1 Coal mining and handling (IPCC category 1.B.1.a)

3.3.1.1.1 Source category description

GHG emissions/removals	CO_2	CH_4	N_2O
Estimated	NA	✓	NA
Key Category	-	LA 1990, LA 2019	-
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			

Table 163 CH_4 emissions from Solid fuels (IPCC sub-category 1.B.1.)

Year	CH_4 emission					
	1.B.1 Solid Fuels (Total)	1.B.1.a Coal Mining and Handling				1.B.1.b Solid Fuel Transformation
		i. Underground Mines		ii. Surface Mines		
		Mining	Post-mining	Mining	Post-mining	Charcoal
	Gg	Gg	Gg	Gg	Gg	Gg
1990	1756	0.33	0.05	1.39	0.12	NE
1991	1736	0.06	0.01	1.39	0.12	NE
1992	1693	0.35	0.05	1.34	0.11	NE
1993	1434	0.66	0.09	1.11	0.09	NE
1994	1249	0.65	0.09	0.96	0.08	NE
1995	834	0.76	0.11	0.62	0.05	NE
1996	1406	0.43	0.06	1.10	0.09	NE
1997	1290	0.25	0.04	1.02	0.09	NE
1998	1591	0.00	0.00	1.28	0.11	NE
1999	1508	0.10	0.01	1.21	0.10	NE
2000	1565	0.00	0.00	1.26	0.10	NE
2001	1190	0.12	0.02	0.95	0.08	NE
2002	1806	0.66	0.09	1.41	0.12	NE
2003	1618	0.00	0.00	1.30	0.11	NE
2004	1524	0.12	0.02	1.22	0.10	NE
2005	1297	0.11	0.02	1.04	0.09	NE
2006	1512	0.12	0.02	1.21	0.10	NE
2007	1203	0.08	0.01	0.96	0.08	NE
2008	1740	0.00	0.00	1.40	0.12	NE
2009	957	0.00	0.00	0.77	0.06	NE
2010	1938	0.00	0.00	1.56	0.13	NE
2011	1938	0.00	0.00	1.56	0.13	NE
2012	1973	0.00	0.00	1.59	0.13	NE
2013	1692	0.00	0.00	1.36	0.11	NE
2014	1655	0.00	0.00	1.33	0.11	NE
2015	1773	0.22	0.03	1.41	0.12	NE
2016	1398	0.58	0.08	1.09	0.09	NE
2017	1475	0.67	0.09	1.14	0.10	NE
2018	1596	0.69	0.10	1.24	0.10	NE
2019	1605	0.52	0.07	1.26	0.10	NE
Trend						
1990 - 2019	*-8.6%*	*61.1%*	*61.1%*	*-9.7%*	*-9.7%*	*NA*
2005 - 2019	*23.8%*	*383.3%*	*383.3%*	*21.3%*	*21.3%*	*NA*
2018 - 2019	*0.6%*	*-23.4%*	*-23.4%*	*1.5%*	*1.5%*	*NA*

3.3.1.1.2 Methodological issues

3.3.1.1.2.1 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 Tier 1 method has been applied *(2006 IPCC GL, Vol. 2, Chap. 4)*:

Equation 4.1.1: Estimating emissions from underground coal mines for Tier 1 and Tier 2

$$GHG\ emissions = Raw\ coal\ production \times Emission\ \text{Factor} \times Units\ conversion\ factor$$

Where:

GHG Emissions	= emissions of a given GHG by type
Raw coal production	= amount of coal produced (tonnes)
Emission factor	= default emission factor by type of mining (m^3 $tonne^{-1}$)
Unites conversion factor	= conversion factor by type of gas (Gg/m^3)

3.3.1.1.2.2 Choice of activity data

Data on national coal production – lignite and sub-bituminous coal - are taken from MONSTAT.

Table 164 National hard coal production

Years	Hard coal production					
	Total		Underground Mines		Surface Mines	
	Gg	Source	Gg	Source	Gg	Source
1990	1729		1729		27	
1991	1731		1731		5	
1992	1664		1664		29	
1993	1379		1379		55	
1994	1195		1195		54	
1995	771		771		63	
1996	1370		1370		36	
1997	1269		1269		21	
1998	1591		1591		0	
1999	1500		1500		8	
2000	1565		1565		0	
2001	1180		1180		10	
2002	1751		1751		55	
2003	1618		1618		0	
2004	1514		1514		10	
2005	1288		1288		9	
2006	1502		1502		10	
2007	1196		1196		7	
2008	1740		1740		0	
2009	957		957		0	
2010	1938		1938		0	
2011	1938		1938		0	
2012	1973		1973		0	

Years	Hard coal production					
	Total		Underground Mines		Surface Mines	
	Gg	Source	Gg	Source	Gg	Source
2013	1692		1692		0	
2014	1655		1655		0	
2015	1755		1755		18	
2016	1350		1350		48	
2017	1420		1420		55	
2018	1539		1539		57	
2019	1562		1562		44	
Trend						
1990 - 2019	*-8.6%*		*-9.7%*		*61.1%*	
2005 - 2019	*23.8%*		*21.3%*		*383.3%*	
2018 - 2019	*0.6%*		*1.5%*		*-23.4%*	

3.3.1.1.2.3 Choice of emission factors

As country specific information was insufficient to derive CS factors, the following default emissions factors were applied:

Coal mining	Default EF (m^3/t)	Source
Underground mines		
Emission factors (CH_4) Mining	18	2006 IPCC GL, Vol. 2, Chap.4, p. 4.12
Emission factors (CH_4) Post-Mining	2.5	
Surface mines		
Emission factors (CH_4) Mining	1.2	2006 IPCC GL, Vol. 2, Chap.4, p. 4.19
Emission factors (CH_4) Post-Mining	0.1	

3.3.1.2 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 165 Uncertainty for IPCC sub-category 1.B.1 CH_4 emissions from Solid fuels

Uncertainty	CH_4				Reference
	Surface Mining		Underground mining		2006 IPCC GL, Vol. 2, Chap. 4 (4.1.4.6 & 4.3.6)
	Mining	Post-mining	Mining	Post-mining	
Activity data (AD)	10%		10%		Chap. 4.1.3.6 (p. 4.16)
Emission factor (EF)	200%		300%		Table 4.1.2 (p. 4.15)
		300%		300%	Table 4.1.4 (p. 4.20)
Combined Uncertainty (U)	200%	300%	300%	300%	$U_{total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

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.

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

3.3.1.4 Source-specific recalculations

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 166 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	No recalculation as this source is estimated the first time	method	Accuracy

3.3.1.5 Source-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 167 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 consists 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.

The IPCC category 1.B.2 Oil and Natural Gas was not estimated due to limited resources (see chapter planned improvements).

IPCC code	Description	Occurrent		Not occurrent
		Estimated	Not estimated	
1.B.2.a	Oil			
1.B.2.a.i	Venting			✓
1.B.2.a.ii	Flaring			✓
1.B.2.a.iii	All Other			
1.B.2.a.iii.1	Exploration			✓
1.B.2.a.iii.2	Production and Upgrading			✓
1.B.2.a.iii.3	Transport			✓
1.B.2.a.iii.4	Refining			✓
1.B.2.a.iii.5	Distribution of oil products		✓	
1.B.2.a.iii.6	Other			
1.B.2.b	Natural Gas			
1.B.2.b.i	Venting			✓
1.B.2.b.ii	Flaring			✓
1.B.2.b.iii	All Other			
1.B.2.b.iii.1	Exploration			✓
1.B.2.b.iii.2	Production			✓
1.B.2.b.iii.3	Processing			✓
1.B.2.b.iii.4	Transmission and Storage		✓	
1.B.2.b.iii.5	Distribution		✓	
1.B.2.b.iii.6	Other		✓	

3.3.2.1 Source-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 168 Planned improvements for IPCC sub-category 1.B.2 Oil and Natural Gas

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.B.2	Estimation of emission from transport, distribution and storage of oil and natural gas	EMI	Completeness	high

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 Aluminium 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.

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). The estimation of these greenhouse gases are planned for the next inventory cycle (see Chapter 4.7).

Categories where emissions are not occurring (NO) because there is no such production in Montenegro, and categories that are not estimated (NE) or included elsewhere (IE) are summarized in the following table, which gives an overview of the IPCC categories included in this sector and provides information on the status of emission estimates of all categories. A „✓" indicates that emissions from this sub-category have been estimated. None sub-category is key category.

Table 169 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
2.B	Chemical Industry	NA	NA	NA	NA	NA	NA	NA
2.C	Metal Industry	✓	NO	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	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	NE	NO	NE	NA	NA	NA	NA
2.H	Other	NA	NO	NA	NA	NA	NA	NA

** Only 2.G.1.b Refrigeration and Stationary Air Conditioning*

4.1.1 Emission trend

Montengro's greenhouse gas emissions from IPCC sector IPPU amounted to 376.89 Gg CO_2 equivalents in 2019 and 1,704.68 Gg CO_2 equivalents in 1990. Compared to 1990 GHG emissions decreased by -77.9%, compared to 2005 GHG emissions decreased by 67.7%, compared to 2018 GHG emissions decreased by 4.2%.

Until 2012, the dominant category in sector IPPU regarding GHG emissions in Montenegro was the Aluminum production, followed by the category 2.F Consumption of HFC/PFC and SF6.

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).

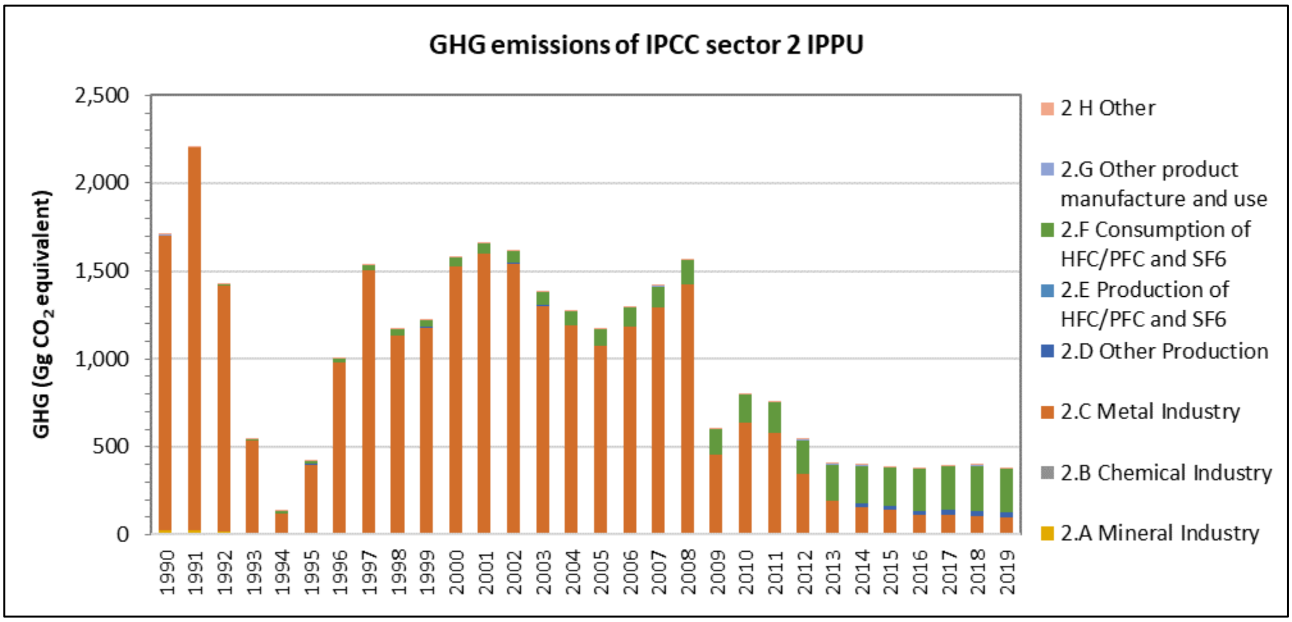


Figure 71 Trend of GHG emission of IPCC sector 2 IPPU by category for the period 1990 – 2019

Table 170 GHG Emissions from IPCC sub-category 2 IPPU by sub-categories

GHG emissions	2 IPPU	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
	Gg $_{CO_2\ equivalent}$							
1990	1,704.68	24.75	NO	1,675.97	3.07	NO	NO	0.78
1991	2,206.15	23.25	NO	2,177.20	3.48	NO	1.33	0.78
1992	1,422.12	16.50	NO	1,398.96	2.00	NO	3.79	0.78
1993	543.76	9.75	NO	524.72	1.24	NO	7.22	0.78
1994	135.53	3.00	NO	118.66	1.53	NO	11.48	0.78
1995	418.51	5.25	NO	393.88	2.06	NO	16.46	0.78
1996	1,002.21	6.00	NO	970.82	2.48	NO	22.06	0.78
1997	1,533.24	6.00	NO	1,495.77	2.42	NO	28.19	0.78
1998	1,167.70	6.00	NO	1,123.45	2.54	NO	34.79	0.84
1999	1,222.78	6.00	NO	1,171.57	2.48	NO	41.79	0.84
2000	1,579.41	5.33	NO	1,521.35	2.54	NO	49.15	0.92
2001	1,659.46	9.74	NO	1,589.32	2.54	NO	56.82	0.92
2002	1,612.45	8.34	NO	1,535.75	2.54	NO	64.78	0.97
2003	1,380.59	6.10	NO	1,297.72	2.54	NO	72.98	1.15
2004	1,272.88	7.94	NO	1,179.51	2.59	NO	81.40	1.33
2005	1,167.11	4.51	NO	1,070.13	0.58	NO	90.37	1.43
2006	1,291.38	6.09	NO	1,176.24	1.24	NO	106.22	1.49
2007	1,414.15	5.32	NO	1,285.04	0.68	NO	121.52	1.49
2008	1,565.61	7.38	NO	1,419.49	0.66	NO	136.45	1.52
2009	603.63	3.37	NO	449.58	0.52	NO	148.53	1.54
2010	795.64	0.63	NO	633.15	0.45	NO	159.77	1.55
2011	752.29	2.59	NO	577.15	0.59	NO	170.28	1.60
2012	539.12	NO	NO	344.32	0.59	NO	192.12	2.00
2013	401.61	NO	NO	194.29	0.59	NO	204.47	2.19
2014	395.06	NO	NO	156.18	19.57	NO	217.00	2.23
2015	385.96	NO	NO	142.87	20.16	NO	220.62	2.23
2016	376.18	NO	NO	112.50	21.52	NO	239.57	2.52
2017	391.83	NO	NO	113.50	25.82	NO	249.44	2.99
2018	393.52	NO	NO	105.20	27.77	NO	257.02	3.44
2019	376.89	NO	NO	95.90	29.13	NO	248.35	3.44
Trend								
1990 - 2019	*-77.9%*	*NO*	*NO*	*-94.3%*	*850.0%*	*NO*	*24834.8%*	*340.9%*
2005 - 2019	*-67.7%*	*NO*	*NO*	*-91.0%*	*4935.7%*	*NO*	*174.8%*	*140.8%*
2018 - 2019	*-4.2%*	*NO*	*NO*	*-8.8%*	*4.9%*	*NO*	*-3.4%*	*0.0%*

Table 171 CO_2 Emissions from IPCC sub-category 2 IPPU by sub-categories

CO_2 emissions	2 IPPU	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
	Gg							
1990	213.20	24.75	NO	185.28	3.07	NO	NA	NO
1991	206.27	23.25	NO	179.43	3.48	NO	NA	NO
1992	172.67	16.50	NO	154.08	2.00	NO	NA	NO
1993	81.23	9.75	NO	70.19	1.24	NO	NA	NO
1994	31.95	3.00	NO	27.34	1.53	NO	NA	NO
1995	56.20	5.25	NO	48.80	2.06	NO	NA	NO
1996	98.48	6.00	NO	89.92	2.48	NO	NA	NO
1997	148.05	6.00	NO	139.55	2.42	NO	NA	NO
1998	142.43	6.00	NO	133.81	2.54	NO	NA	NO
1999	145.09	6.00	NO	136.51	2.48	NO	NA	NO
2000	167.60	5.33	NO	159.62	2.54	NO	NA	NO
2001	194.17	9.74	NO	181.78	2.54	NO	NA	NO
2002	203.95	8.34	NO	193.00	2.54	NO	NA	NO
2003	205.80	6.10	NO	197.06	2.54	NO	NA	NO
2004	215.92	7.94	NO	205.29	2.59	NO	NA	NO
2005	205.97	4.51	NO	200.79	0.58	NO	NA	NO
2006	215.22	6.09	NO	207.78	1.24	NO	NA	NO
2007	218.78	5.32	NO	212.68	0.68	NO	NA	NO
2008	202.43	7.38	NO	194.29	0.66	NO	NA	NO
2009	113.67	3.37	NO	109.68	0.52	NO	NA	NO
2010	137.13	0.63	NO	135.96	0.45	NO	NA	NO
2011	157.34	2.59	NO	154.08	0.59	NO	NA	NO
2012	121.78	NO	NO	121.11	0.59	NO	NA	NO
2013	79.56	NO	NO	78.90	0.59	NO	NA	NO
2014	89.22	NO	NO	69.57	19.57	NO	NA	NO
2015	91.17	NO	NO	70.93	20.16	NO	NA	NO
2016	88.50	NO	NO	66.90	21.52	NO	NA	NO
2017	94.26	NO	NO	68.35	25.82	NO	NA	NO
2018	95.72	NO	NO	67.88	27.77	NO	NA	NO
2019	91.06	NO	NO	61.86	29.13	NO	NA	NO
Trend								
1990 - 2019	*7.5%*	*0.9%*	*NA*	*6.5%*	*0.1%*	*NA*	*NA*	*NA*
2005 - 2019	*8.7%*	*0.2%*	*NA*	*8.4%*	*0.0%*	*NA*	*NA*	*NA*
2018 - 2019	*3.4%*	*NA*	*NA*	*2.3%*	*1.1%*	*NA*	*NA*	*NA*

Table 172 CH_4 Emissions from IPCC sub-category 2 IPPU by sub-categories

CH_4 emissions	2 IPPU	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
	Gg $_{CO_2}$ equivalent							
1990	0.052	NO	NO	0.052	NO	NA	NA	NO
1991	0.049	NO	NO	0.049	NO	NA	NA	NO
1992	0.036	NO	NO	0.036	NO	NA	NA	NO
1993	0.029	NO	NO	0.029	NO	NA	NA	NO
1994	0.028	NO	NO	0.028	NO	NA	NA	NO
1995	0.022	NO	NO	0.022	NO	NA	NA	NO
1996	0.026	NO	NO	0.026	NO	NA	NA	NO
1997	0.033	NO	NO	0.033	NO	NA	NA	NO
1998	0.035	NO	NO	0.035	NO	NA	NA	NO
1999	0.022	NO	NO	0.022	NO	NA	NA	NO
2000	0.021	NO	NO	0.021	NO	NA	NA	NO
2001	0.027	NO	NO	0.027	NO	NA	NA	NO
2002	0.021	NO	NO	0.021	NO	NA	NA	NO
2003	0.015	NO	NO	0.015	NO	NA	NA	NO
2004	0.038	NO	NO	0.038	NO	NA	NA	NO
2005	0.026	NO	NO	0.026	NO	NA	NA	NO
2006	0.040	NO	NO	0.040	NO	NA	NA	NO
2007	0.043	NO	NO	0.043	NO	NA	NA	NO
2008	0.050	NO	NO	0.050	NO	NA	NA	NO
2009	0.026	NO	NO	0.026	NO	NA	NA	NO
2010	0.012	NO	NO	0.012	NO	NA	NA	NO
2011	0.015	NO	NO	0.015	NO	NA	NA	NO
2012	0.007	NO	NO	0.007	NO	NA	NA	NO
2013	0.005	NO	NO	0.005	NO	NA	NA	NO
2014	0.004	NO	NO	0.004	NO	NA	NA	NO
2015	0.009	NO	NO	0.009	NO	NA	NA	NO
2016	0.011	NO	NO	0.011	NO	NA	NA	NO
2017	0.011	NO	NO	0.011	NO	NA	NA	NO
2018	0.011	NO	NO	0.011	NO	NA	NA	NO
2019	0.011	NO	NO	0.011	NO	NA	NA	NO
Trend								
1990 - 2019	*-79.7%*	*NA*	*NA*	*-79.7%*	*NA*	*NA*	*NA*	*NA*
2005 - 2019	*-58.7%*	*NA*	*NA*	*-58.7%*	*NA*	*NA*	*NA*	*NA*
2018 - 2019	*-6.6%*	*NA*	*NA*	*-6.6%*	*NA*	*NA*	*NA*	*NA*

Table 173 N_2O Emissions from IPCC sub-category 2 IPPU by sub-categories

CH_4 emissions	2 IPPU	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
	Gg $_{CO_2\ equivalent}$							
1990	NE	NO	NO	NO	NE	NA	NA	NO
⋮	NE	NO	NO	NO	NE	NA	NA	NO
2019	NE	NO	NO	NO	NE	NA	NA	NO

Table 174 HFC, PFC and SF6 emissions from IPCC sub-category 2 IPPU by sub-categories

HFC, PFC and SF6 emissions	2 IPPU	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
	Gg CO_2 equivalent							
1990	1491.42	24.75	NO	1490.64	NO	NO	0.78	NO
1991	1999.83	23.25	NO	1997.72	1.33	NO	0.78	NO
1992	1249.41	16.50	NO	1244.84	3.79	NO	0.78	NO
1993	462.50	9.75	NO	454.50	7.22	NO	0.78	NO
1994	103.55	3.00	NO	91.29	11.48	NO	0.78	NO
1995	362.29	5.25	NO	345.05	16.46	NO	0.78	NO
1996	903.71	6.00	NO	880.87	22.06	NO	0.78	NO
1997	1385.16	6.00	NO	1356.19	28.19	NO	0.78	NO
1998	1025.24	6.00	NO	989.61	34.79	NO	0.84	NO
1999	1077.67	6.00	NO	1035.04	41.79	NO	0.84	NO
2000	1411.78	5.33	NO	1361.71	49.15	NO	0.92	NO
2001	1465.26	9.74	NO	1407.51	56.82	NO	0.92	NO
2002	1408.48	8.34	NO	1342.74	64.78	NO	0.97	NO
2003	1174.77	6.10	NO	1100.65	72.98	NO	1.15	NO
2004	1056.92	7.94	NO	974.19	81.40	NO	1.33	NO
2005	961.12	4.51	NO	869.31	90.37	NO	1.43	NO
2006	1076.12	6.09	NO	968.42	106.22	NO	1.49	NO
2007	1195.32	5.32	NO	1072.31	121.52	NO	1.49	NO
2008	1363.13	7.38	NO	1225.15	136.45	NO	1.52	NO
2009	489.94	3.37	NO	339.87	148.53	NO	1.54	NO
2010	658.50	0.63	NO	497.18	159.77	NO	1.55	NO
2011	594.93	2.59	NO	423.06	170.28	NO	1.60	NO
2012	417.33	NO	NO	223.21	192.12	NO	2.00	NO
2013	322.04	NO	NO	115.39	204.47	NO	2.19	NO
2014	305.83	NO	NO	86.61	217.00	NO	2.23	NO
2015	294.78	NO	NO	71.93	220.62	NO	2.23	NO
2016	287.67	NO	NO	45.58	239.57	NO	2.52	NO
2017	297.56	NO	NO	45.13	249.44	NO	2.99	NO
2018	297.78	NO	NO	37.32	257.02	NO	3.44	NO
2019	285.82	NO	NO	34.03	248.35	NO	3.44	NO
Trend								
1990 - 2019	-80.8%	*NA*	*NA*	-97.7%	NA	*NA*	340.9%	*NA*
2005 - 2019	-70.3%	*NA*	*NA*	-96.1%	174.8%	*NA*	140.8%	*NA*
2018 - 2019	-4.0%	*NA*	*NA*	-8.8%	-3.4%	*NA*	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 175 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	✓	-	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							

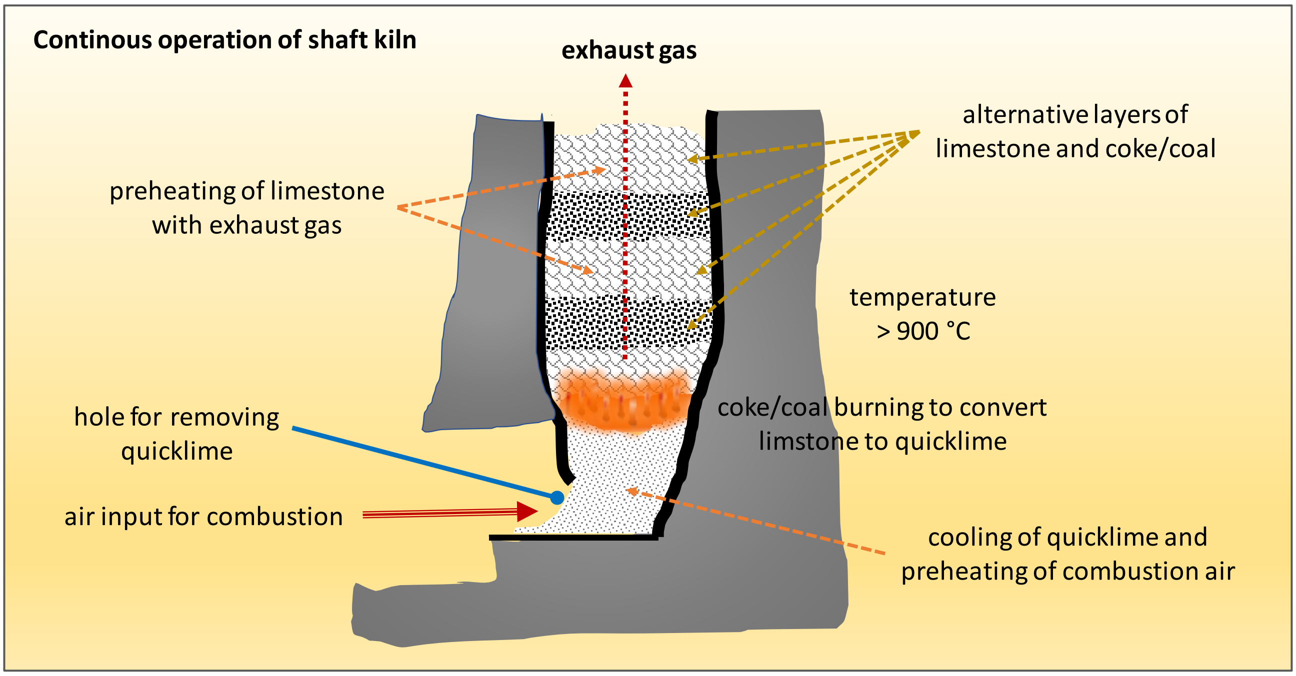


Figure 72 Illustration of a shaft kiln for lime production

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 occouring 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.

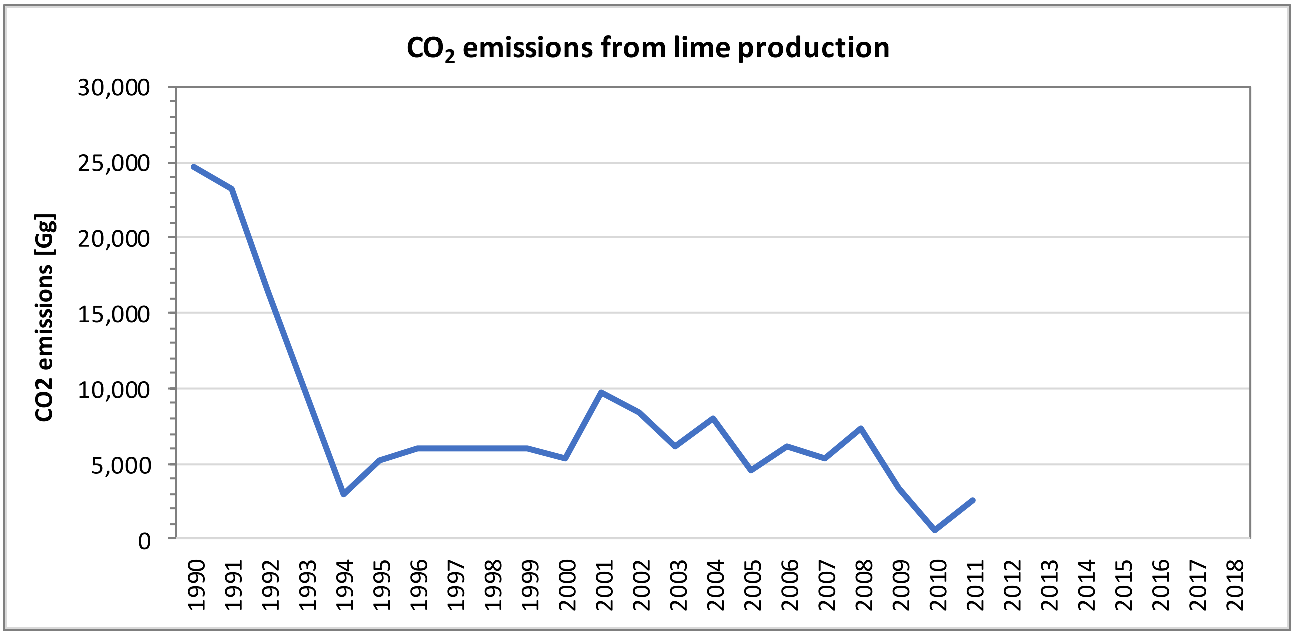


Figure 73 CO_2 emissions from IPCC sub-category 2.A.2 Lime production 1990-2019

Table 176 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	33,000	100	0	0.75	0.77	0.753	24.750
1991	31,000	100	0	0.75	0.77	0.753	23.250
1992	22,000	100	0	0.75	0.77	0.753	16.500
1993	13,000	100	0	0.75	0.77	0.753	9.750
1994	4,000	100	0	0.75	0.77	0.753	3.000
1995	7,000	100	0	0.75	0.77	0.753	5.250
1996	8,000	100	0	0.75	0.77	0.753	6.000
1997	8,000	100	0	0.75	0.77	0.753	6.000
1998	8,000	100	0	0.75	0.77	0.753	6.000
1999	8,000	100	0	0.75	0.77	0.753	6.000
2000	7,113	100	0	0.75	0.77	0.753	5.335
2001	12,989	100	0	0.75	0.77	0.753	9.742
2002	11,123	100	0	0.75	0.77	0.753	8.342
2003	8,136	100	0	0.75	0.77	0.753	6.102
2004	10,591	100	0	0.75	0.77	0.753	7.943
2005	6,008	100	0	0.75	0.77	0.753	4.506
2006	8,118	100	0	0.75	0.77	0.753	6.089
2007	7,089	100	0	0.75	0.77	0.753	5.317
2008	9,839	100	0	0.75	0.77	0.753	7.379
2009	4,497	100	0	0.75	0.77	0.753	3.373
2010	839	100	0	0.75	0.77	0.753	0.629

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
2011	3,448	100	0	0.75	0.77	0.753	2.586
2012	NO	NO	NO	0.75	0.77	0.753	NO
2013	NO	NO	NO	0.75	0.77	0.753	NO
2014	NO	NO	NO	0.75	0.77	0.753	NO
2015	NO	NO	NO	0.75	0.77	0.753	NO
2016	NO	NO	NO	0.75	0.77	0.753	NO
2017	NO	NO	NO	0.75	0.77	0.753	NO
2018	NO	NO	NO	0.75	0.77	0.753	NO
2019							
Trend							
1990 – 2019	*-100%*						*-100%*
2005 - 2019	*-100%*						*-100%*
2017 - 2019	*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[53] 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)

$$CO_2\ emissions = Mass_{lime} \times Emission\ \mathrm{Factor}_{\mathrm{lime}}$$

based on

Equation 2.6: Tier 2 - Emissions based on national lime production data by type

$$CO_2\ emissions = \sum_i Mass_{lime,\mathrm{i}} \times Emission\ \mathrm{Factor}_{\mathrm{lime,i}} \times CF_{LKD,\mathrm{i}} \times C_{H,\mathrm{i}}$$

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)

[53] 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

$C_{h,i}$ = correction factor for hydrated lime of the type i of lime (dimensionless)

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 – 2019 by MONSTAT.

A cross-check with US Geological Survey (USGS) Minerals Yearbook (different years) was done[54].

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[55] 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 177 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)

[54] Available (16 March 2020) on https://www.usgs.gov/science-explorer-results?es=Montenegro+Minerals+Yearbook

[55] 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 178 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 (1990 -2019).

4.2.2.4 Source-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 Source-specific recalculations

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 179 Recalculations done since submission 2017 IPCC sub-category 2.A.2 Lime production

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
2.A.2	Application of 2006 IPCC Guidelines	method	Accuracy Comparability
2.A.2	Application of default emission factors of 2006 IPCC Guidelines	EF	Accuracy Transparency

4.2.2.6 Source-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 180 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 Limeproduction in 2010.	AD	Accuracy,	Medium

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 181 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 Ammonia Production (IPCC subcategory 2.B.1)

4.3.1.1 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 arising. 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							

Emissions from the IPCC subcategory 2.C.1 *Iron and Steel Production* does occour in Montenegro.

In Montenegro the steel production takes place in electric Arc furnaces.

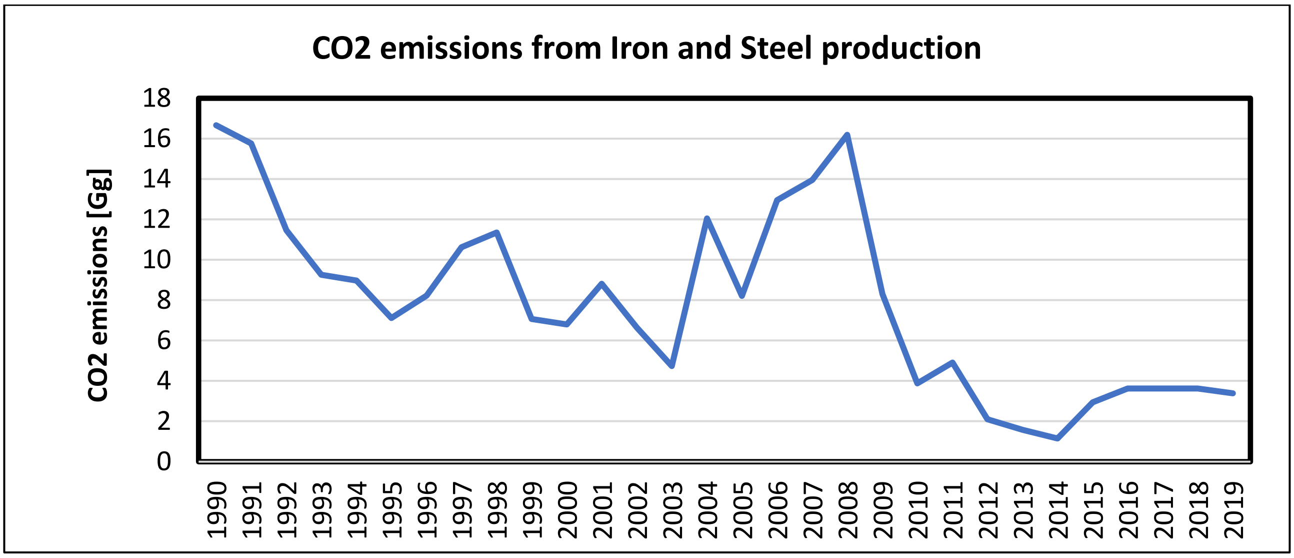


Figure 74 CO_2 emissions from IPCC sub-category 2.C.1 Iron and Steel production 1990-2019

Table 182 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	Gg
1990	207.642	0.08	16.6
1991	196.365	0.08	15.7
1992	142.775	0.08	11.4
1993	115.301	0.08	9.2
1994	111.821	0.08	8.9
1995	88.591	0.08	7.1

Year	steel produced	CO_2 EF	CO_2 emissions
	t	t / t steel produced	Gg
1996	102.487	0.08	8.2
1997	132.362	0.08	10.6
1998	141.445	0.08	11.3
1999	88.002	0.08	7.0
2000	84.789	0.08	6.8
2001	109.757	0.08	8.8
2002	82.832	0.08	6.6
2003	59.036	0.08	4.7
2004	150.165	0.08	12.0
2005	102.247	0.08	8.2
2006	161.333	0.08	12.9
2007	173.913	0.08	13.9
2008	201.690	0.08	16.1
2009	103.479	0.08	8.3
2010	48.272	0.08	3.9
2011	61.164	0.08	4.9
2012	26.161	0.08	2.1
2013	19.723	0.08	1.6
2014	14.330	0.08	1.1
2015	36.602	0.08	2.9
2016	45.168	0.08	3.6
2017	45.223	0.08	3.6
2018	45.193	0.08	3.6
2019	42.206	0.08	3.4
Trend			
1990 – 2019	*-79,7%*		*-79,7%*
2005 - 2018	*-58,7%*		*-58,7%*
2017 - 2018	*-6,6%*		*-6,6%*

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 Source-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 Source-specific recalculations

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 183 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.3	No revisions were performed		

4.4.1.3 Source-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 184 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.3	Detailed description of the methods used		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	✓	with & without LULUCF LA1990, LA2019	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	-	✓	with & without LULUCF LA1990, LA2019, TA	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 2015.

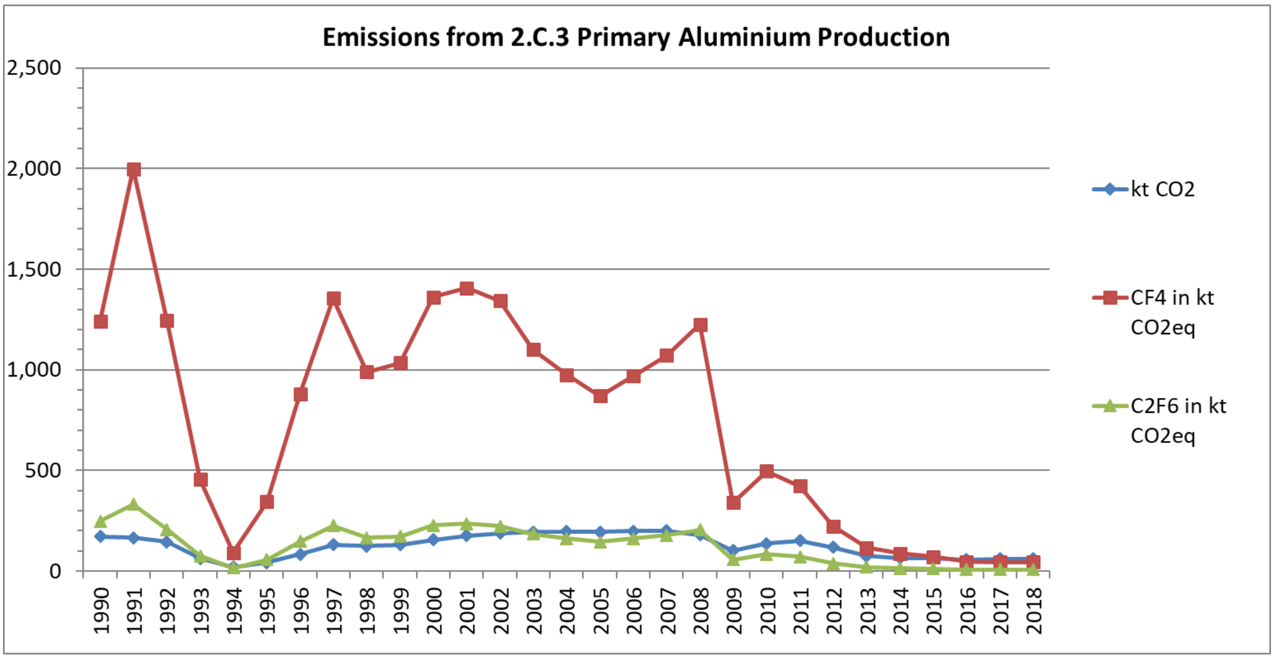


Figure 75 GHG emissions for IPCC sub-category 2.C.3 Primary Aluminium Production

Table 185 Emissions from Primary Aluminium Production (IPCC sub-category 2.C.3)

Year	2.C.3. Primary Aluminium Production				
	Production	Emissions			
		GHG	CO_2	CF_4	C_2F_6
	(kt Al)	(kt)	(kt)	(kt CO_2 eq)	(kt CO_2 eq)
1990	105.4	1 659.3	168.7	1 242.5	248.2
1991	102.3	2 161.4	163.7	1 665.1	332.6
1992	89.2	1 387.5	142.7	1 037.6	207.3
1993	38.1	515.5	61.0	378.8	75.7
1994	11.5	109.7	18.4	76.1	15.2
1995	26.1	386.8	41.7	287.6	57.5
1996	51.1	962.6	81.7	734.2	146.7
1997	80.6	1 485.1	129.0	1 130.4	225.8
1998	76.6	1 112.1	122.5	824.8	164.8
1999	80.9	1 164.5	129.5	862.7	172.3
2000	95.5	1 514.5	152.8	1 135.0	226.7
2001	108.1	1 580.5	173.0	1 173.2	234.3
2002	116.5	1 529.1	186.4	1 119.2	223.6
2003	120.2	1 293.0	192.3	917.4	183.3
2004	120.8	1 167.5	193.3	812.0	162.2
2005	120.4	1 061.9	192.6	724.6	144.7
2006	121.8	1 163.3	194.9	807.2	161.2
2007	124.2	1 271.1	198.8	893.8	178.5
2008	111.3	1 403.3	178.2	1 021.2	204.0
2009	63.4	441.3	101.4	283.3	56.6
2010	82.6	629.3	132.1	414.4	82.8
2011	93.2	572.2	149.2	352.6	70.4
2012	74.4	342.2	119.0	186.0	37.2
2013	48.3	192.7	77.3	96.2	19.2
2014	42.8	155.0	68.4	72.2	14.4
2015	42.5	139.9	68.0	60.0	12.0
2016	36.2	103.5	57.9	38.0	7.6
2017	39.3	108.1	63.0	37.6	7.5
2018	40.1	101.5	64.2	31.1	6.2
2019	37.1	93.3	59.3	28.4	5.7
Trend					
1990 - 2019	*-64.8%*	*-94.4%*	*-64.8%*	*-97.7%*	*-97.7%*
2005 - 2019	*-69.2%*	*-91.2%*	*-69.2%*	*-96.1%*	*-96.1%*
2018 - 2019	*-7.6%*	*-8.0%*	*-7.6%*	*-8.8%*	*-8.8%*

Emissions from category 2.C.3. are depicted in the Figure above. 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.

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)

$$E_{CF_4} = S_{CF_4} * AEM * MP$$

and

$$E_{C2F6} = E_{CF_4} * F_{C2F6/CF_4}$$

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 (Elektroliza A&B) was based on the average split of reported data for the years 2010 – 2015, when plant Electroliza A was closed.

Production in plant Elektroliza B closed down temporarily in 1994 – 1995 due to the economic sanctions imposed on Montenegro between 1992 - 1995 . Production plant Elektroliza A closed down in 2016, after the plant had been sold to the new owner.

Table 186 Activity data Primary Aluminium Production (IPCC sub-category 2.C.3)

Year	2.C.3 Aluminium Production		
	Elektroliza A	**Elektroliza B**	**Total (kt)**
	kt aluminium	*kt aluminium*	*kt aluminium*
1990	48	58	105
1995	26	0	26
2000	43	52	96
2001	49	59	108
2002	53	64	116
2003	54	66	120
2004	55	66	121
2005	54	66	120
2006	55	67	122
2007	56	68	124
2008	50	61	111
2009	29	35	63
2010	38	45	83
2011	42	52	93
2012	29	46	74
2013	9	40	48
2014	8	35	43
2015	5	37	42
2016	NO	36	36
2017	NO	39	39
2018	NO	40	40
2019	NO	37	37

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
num of AE/Ukupni godišnji broj anodnih efekata		C	PS
pot days/ostvareno ćelija dana		C	PS
AEF	num of AE / pot days	1.24	Calculated
AED -procena trajanja anodnog efekta [min]		C	PS
EF		0.80	Calculated
AEM - anode effect minutes per cell-day	AE-Mins/cell-day	C	Calculated

Elektroliza A	Unit	2015	Remark
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		7390	
GWP C_2F_6		12200	
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 187 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 consumpition*	<2%	<2%	<2%	
Emission factor (EF) • *Prebake technology*	10%			
• *Slope Coefficient*		6%		
• *Weight Fraction C_2F_6 / CF_4*			11%	
Combined Uncertainty (U)	53%			$U_{Total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

The time-series are considered to be consistent as Tier 1 approach is applied to the entire time series (1990 -2019).

4.4.3.4 Source-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 Source-specific recalculations

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 188 Recalculations done since submission 2017 IPCC sub-category 2.C.3 *Aluminium production*

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
2.C.3	No revisions were performed		

4.4.3.6 Source-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 189 Planned improvement for IPCC sub-category 2.C.3 *Aluminium production*

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.C.3	Detailed description of the methods used		Transparency	High
2.C.3	Estimation Tier 2 for CO_2 emissions		Accuracy	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	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

4.5.1.2 Source-specific planned improvements for IPCC sub-category 2.D.1 Lubricant use

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.D.1	Incorperation of the estimated based on the energy balance	AD	Completness	High

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 Source-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) ofEUROSTAT 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 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.

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	NE	-	NA	-	NA	-
2.D.3.b	Road paving with asphalt	NE	-	NA	-	NA	-
2.D.3.c	Asphalt roofing	NE	-	NA	-	NA	-
2.D.3.d	Coating applications	NE	-	NA	-	NA	-
2.D.3.e	Degreasing	NE	-	NA	-	NA	-
2.D.3.f	Dry cleaning	NE	-	NA	-	NA	-
2.D.3.g	Chemical products	NE	-	NA	-	NA	-
2.D.3.h	Printing	NE	-	NA	-	NA	-
2.D.3.i	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 IPCC subcategory 2.D.3 *Solvent Use* is not estimated due to lack of resources and data. The priority was given to categories with higher contribution to national total GHG emissions of Montenegro. 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.

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

4.5.3.1 Source-specific planned improvements for IPCC sub-category 2.D.2 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 190 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 191)	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 191)	AD	Accuracy Transparency	High / Medium

Table 191 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
	• 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

GHG source category	Subcategories	Activity data	
		TIER 1	TIER 2
	• 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
	○ Decorative coating application		g/kg paint
	○ Industrial coating application		g/kg paint
	○ 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 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

GHG source category	Subcategories	Activity data	
		TIER 1	TIER 2
	• 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
	○ Glass wool enduction		g/t glass wool
	○ Mineral wool enduction		g/t mineral wool
	○ Fat, edible and non-edible oil extraction		g/kg seed
	○ Application of glues and adhesives		g/kg adhesives
	○ Preservation of wood		g/kg creosote or preservative
	○ Underseal treatment and conservation of vehicles		g/kg underseal agent
	○ Vehicles dewaxing		kg/car
	○ Other		Kg/ton deicing fluid used g/kg product
	• Use of HFC, N_2O, NH3, PFC & SF6		
	○ Other		
	• Other product use		g/t product
	○ Use of fireworks		g/t product
	○ Use of tobacco		kg/Mg tobacco
	○ Use of shoes		g/pair
	○ 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

- HFC, PFC and SF6 emissions from Refrigeration and Air Conditioning units (2.F.1),
- HFC, PFC and SF6 emissions from Foam Blowing Agents (2.F.2),
- HFC, PFC and SF6 emissions from Fire Protection applications and products (2.F.3),
- HFC, PFC and SF6 emissions from Aerosols (2.F.4),
- HFC, PFC and SF6 emissions from Solvents (2.F.5),
- HFC, PFC and SF6 emissions from other applications (2.F.6).

All sub-categories are existing in Montenegro but are currently not estimated due to lack of resources and (sufficient) data.

4.7.1 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

Table 192

(B) F-gases occur as pure substances or as blends

$\Rightarrow$ see

Table 193 and

Table 194

(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 192 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					
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 193 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

Table 194 ASHRAE name and chemical formula of HFCs, PFCs, CFCs and other refrigerants

ASHRAE name	Components				Composition [%]			
R 401A	R22	R152a	R124		53	13	34	
R 401B	R22	R152a	R124		61	11	28	
R 401C	R22	R152a	R124		33	15	52	
R 402A	R22	R125	R290		38	60	2	
R 402B	R22	R125	R290		60	38	2	
R 403B	R22	R218	R290		56	39	5	
R 404A	R125	R143a	R134a		44	52	4	
R 405A	R22	R152a	R142b	RC318	45	7	5.5	42.5
R 406A	R22	R600a	R142b		55	4	41	
R 407A	R32	R125	R134a		20	40	40	
R 407B	R32	R125	R134a		10	70	20	
R 407C	R32	R125	R134a		23	25	52	
R 407D	R32	R125	R134a		15	15	70	
R 407E	R32	R125	R134a		25	15	60	
R 408A	R125	R143a	R22		7	46	47	
R 409A	R22	R124	R142b		60	25	15	
R 409B	R22	R124	R142b		65	25	10	
R 410A	R32	R125			50	50		
R 411A	R1270	R22	R152a			87.5	11	
R 411B	R1270	R22	R152a		3	94	3	
R 411C	R1270	R22	R152a		3	95.5	1.5	
R 412A	R22	R 218	R142b		70	5	25	
R 413A	R 218	R134a	R600		9	88	3	
R 414A	R22	R124	R600a	R142b	51	28.5	4	16.5
R 414B	R22	R124	R600a	R142b	50	39	1.5	9.5
R 416A	R134a	R124	R600		59	39.5	1.5	
R 417A	R125	R134a	R600		46.6	50		
R 422A	R125	R134a	R600a		85.1	11.5	3.4	
R 422D	R125	R134a	R600a		65.1	31.5	3.4	
R 437A	R125	R134a	R600	R601	19.5	78.5	1.4	0.6
R 500	R12	R152a						
R 502	R22	R115			48.8	51.2		
R 503	R23	R13			40	60		
R 507	R125	R143a			50	50		
R 508A	R23	R116			39	61		
R 508B	R23	R116			46	54		
R 509A	R22	R218			44	56		

4.7.2 Electrical Equipment (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						
2.F.1.a	Refrigeration and Stationary Air Conditioning	NA	-	NA	-	NA	-
2.F.1.b	Mobile 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								
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 IPCC subcategory 2.F.1 *Refrigeration and Air Conditioning* is estimated but the estimation of HFC, PFC and SF6 emissions from use, maintaining and disposal of refrigerators, freezers and air-condition machines containing HFC, PFC and SF6 is not complete.

The Environment Agency has been collecting data on imported synthetic gases since 2011. On the one hand, this data shows large dips and jumps that cannot be explained, on the other hand, no more information on the market, e.g. first placing on the market of certain blends is available, thus, with the information at hand, it is not yet possible to provide a time series of gases in use in Montenegro, and therefore not possible to calculate stocks and emissions. Due to limited resources the emissions estimated for Third National Communication (NC3) (time period 1990 – 2017) were used. Emissions from from IPCC sub-category 2.F.1.a - Refrigeration and Stationary Air Conditioning have been estimated simple TIER 1.

Table 195 Emissions from IPCC sub-category 2.F.1.a - Refrigeration and Stationary Air Conditioning

	TOTAL	HFC-32		HFC-125		HFC-134a	
			GWP = 670		GWP = 3,500		GWP = 1,430
	Gg CO_2 eq	t	Gg CO_2 eq	t	Gg CO_2 eq	t	Gg CO_2 eq
1990	0.00	NO	NO	NO	NO	NO	NO
1991	1.33	NO	NO	0.20	0.68	0.37	0.53
1992	3.79	NO	NO	0.56	1.95	1.05	1.50
1993	7.22	NO	NO	1.06	3.71	1.99	2.85
1994	11.48	NO	NO	1.68	5.89	3.17	4.53
1995	16.46	NO	NO	2.41	8.44	4.54	6.49
1996	22.06	NO	NO	3.23	11.31	6.07	8.68
1997	28.19	NO	NO	4.13	14.44	7.75	11.08

	TOTAL	HFC-32		HFC-125		HFC-134a	
			GWP = 670		GWP = 3,500		GWP = 1,430
	Gg CO_2 eq	t	Gg CO_2 eq	t	Gg CO_2 eq	t	Gg CO_2 eq
1998	34.79	NO	NO	5.09	17.81	9.54	13.65
1999	41.79	NO	NO	6.11	21.38	11.44	16.37
2000	49.15	NO	NO	7.18	25.12	13.44	19.21
2001	56.82	NO	NO	8.29	29.02	15.51	22.17
2002	64.78	NO	NO	9.44	33.05	17.64	25.23
2003	72.98	NO	NO	10.63	37.20	19.83	28.36
2004	81.40	NO	NO	11.84	41.45	22.08	31.57
2005	90.37	0.52	0.35	13.08	45.78	24.36	34.83
2006	106.22	1.48	1.00	15.28	53.48	28.45	40.68
2007	121.52	2.81	1.90	17.36	60.76	32.31	46.20
2008	136.45	4.46	3.01	19.34	67.71	35.97	51.44
2009	148.53	6.39	4.31	20.88	73.08	38.79	55.47
2010	159.77	8.54	5.77	22.26	77.92	41.31	59.07
2011	170.28	10.89	7.35	23.52	82.31	43.56	62.29
2012	192.12	14.84	10.02	26.88	94.07	46.69	66.77
2013	204.47	16.79	11.34	28.36	99.28	48.79	69.77
2014	217.00	18.80	12.69	29.99	104.96	50.80	72.65
2015	220.62	20.07	13.55	30.80	107.79	49.64	70.98
2016	239.57	22.17	14.96	33.33	116.66	51.82	74.11
2017	249.44	24.11	16.28	35.58	124.52	51.52	73.68
2018	257.02	23.40	15.80	34.89	122.10	52.36	74.87
2019	248.35	20.44	13.80	32.30	113.05	50.97	72.89
Trend							
1990 - 2019	NA	NA	NA	NA	NA	NA	NA
2005 - 2019	174.8%	3838.7%	3838.7%	146.9%	146.9%	109.2%	109.2%
2018 – 2019	-3.4%	-12.7%	-12.7%	-7.4%	-7.4%	-2.7%	-2.7%

	TOTAL	HFC-HFC-143a		HFC-227ea	
			GWP = 4,470		GWP = 3,220
	Gg CO_2 eq	t	Gg CO_2 eq	t	Gg CO_2 eq
1990	0.00	NO	NO	NO	NO
1991	1.33	0.03	0.12	NO	NO
1992	3.79	0.08	0.34	NO	NO
1993	7.22	0.15	0.66	NO	NO
1994	11.48	0.24	1.06	NO	NO
1995	16.46	0.34	1.53	NO	NO
1996	22.06	0.46	2.07	NO	NO
1997	28.19	0.60	2.67	NO	NO
1998	34.79	0.75	3.33	NO	NO
1999	41.79	0.90	4.04	NO	NO
2000	49.15	1.08	4.81	0.00	0.00
2001	56.82	1.26	5.61	0.00	0.01
2002	64.78	1.45	6.47	0.01	0.03

	TOTAL	HFC-32		HFC-125		HFC-134a	
			GWP = 670		GWP = 3,500		GWP = 1,430
	Gg CO_2 eq	t	Gg CO_2 eq	t	Gg CO_2 eq	t	Gg CO_2 eq
2003	72.98		1.65	7.36	0.02		0.06
2004	81.40		1.86	8.30	0.03		0.09
2005	90.37		2.07	9.27	0.04		0.13
2006	106.22		2.43	10.86	0.06		0.19
2007	121.52		2.77	12.40	0.08		0.26
2008	136.45		3.12	13.94	0.11		0.35
2009	148.53		3.40	15.21	0.14		0.45
2010	159.77		3.68	16.44	0.18		0.57
2011	170.28		3.94	17.62	0.22		0.70
2012	192.12		4.57	20.41	0.26		0.85
2013	204.47		5.16	23.08	0.31		1.01
2014	217.00		5.78	25.83	0.27		0.88
2015	220.62		6.10	27.28	0.32		1.02
2016	239.57		7.37	32.95	0.28		0.89
2017	249.44		7.64	34.14	0.25		0.82
2018	257.02		9.74	43.56	0.22		0.69
2019	248.35		10.74	48.03	0.18		0.59
Trend							
1990 - 2019	NA		NA	NA	NA		NA
2005 - 2019	174.8%		418.0%	418.0%	337.5%		337.5%
2018 – 2019	-3.4%		10.3%	10.3%	-15.0%		-15.0%

4.7.2.1 Source-specific planned improvements for IPCC sub-category 2.F.1 Refrigeration and Air Conditioning

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 196 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.1	In-depth analysis of (a) data on historic and current equipment (b) production, import & export of commodities of • HS code 8415 'Air-condition' • HS code 8418 'Refrigerator and freezer'	AD	Accuracy Transparency Completeness Comparability	High
2.F.1	In-depth analysis of (a) data on historic and current equipment (b) production, import & export of commodities of • Containing fluids / gases • Container size • Life time	AD	Accuracy Transparency Completeness Comparability	High

GHG source & sink category	Planned improvement	Type of improvement		Priority
	• usage pattern • maintenance • disposal			
2.F.1	Analysis of mobile air-conditioning units/equipment	AD	Accuracy Transparency Completeness Comparability	High
2.F.1	Application of methodology of 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 7: Emissions of Fluorinated Substitutes for Ozone Depleting Substances. (7.5 REFRIGERATION AND AIR CONDITIONING) Page 7.43.	AD	Accuracy Transparency Completeness Comparability	High

Table 197 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 sepaysrately 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

4.7.3 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) but the estimation of GHG emissions from Foam Blowing Agents is planned for next inventory cycle.

4.7.3.1 Source-specific planned improvements for IPCC sub-category 2.F.2 Foam Blowing Agents

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 198 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	Analysis of Foam Blowing Agents, e.g. • the amount of chemical used in foam manufacturing in a country and not subsequently exported • the amount of chemical contained in foam imported	AD	Accuracy Transparency Completeness Comparability	High
2.F.2	Investigation on applications • Polyurethane – Integral Skin / Polyurethane – Continuous Panel / Discontinuous Panel / Appliance / Injected / etc. • One Component Foam (OCF) • Extruded Polystyrene (XPS) • Phenolic – Discontinuous Block / Discontinuous Laminate	AD	Accuracy Transparency Completeness Comparability	High
2.F.2	Application of methodology of 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 7: Emissions of Fluorinated Substitutes for Ozone Depleting Substances. (7.4 FOAM BLOWING AGENTS) Page 7.32.	AD	Accuracy Transparency Completeness Comparability	High

4.7.4 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	-	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.3 *Fire Protection* is not estimated (NE) but the estimation of GHG emissions from the fire protection products and fire protection equipment is planned for next inventory cycle.

4.7.4.1 Source-specific planned improvements for IPCC sub-category 2.F.3 Fire Protection

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 sub-category 2.F.3 Fire Protection.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.F.3	Investigation of import and use of fire protection products and fire protection equipment	AD	Accuracy Transparency Completeness	High
2.F.3	Application of methodology of 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 7: Emissions of Fluorinated Substitutes for Ozone Depleting Substances. (7.6 FIRE PROTECTION) Page 7.61.	AD	Accuracy Transparency Completeness Comparability	High

4.7.5 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	-	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.4 *Aerosols* is not estimated (NE) but the estimation of GHG emissions from the use of aerosols containing HFC and/or PFC is planned for next inventory cycle.

4.7.5.1 Source-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 200 Planned improvements for IPCC sub-category 2.F.4 Aerosols.

GHG source & sink category	Planned improvement	Type of improvement		Priority
2.F.4	Investigation of • Domestic aerosol production • Imported aerosol production	AD	Accuracy Transparency Completeness	High
2.F.4	Investigation of the use and consumption (by chemical composition) of products containing HFC and/or PFC for cleaning: (i) Metered Dose Inhalers (MDIs); (ii) Personal Care Products (e.g., hair care, deodorant, shaving cream); (iii) Household Products (e.g., air-fresheners, oven and fabric cleaners); (iv) Industrial Products (e.g., special cleaning sprays such as those for operating electrical contact, lubricants, pipe-freezers); (v) Other General Products (e.g., silly string, tyre inflators, klaxons).	AD	Accuracy Transparency Completeness	High
2.F.4	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

4.7.6 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) but the estimation of GHG emissions from the use of solvents containing HFC and/or PFC for cleaning ((i) Precision Cleaning, (ii) Electronics Cleaning, (iii) Metal Cleaning, (iv) Deposition applications) is planned for next inventory cycle.

4.7.6.1 Source-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 201 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

4.7.7 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) but the estimation of GHG emissions from the use of various products is planned for next inventory cycle.

4.7.7.1 Source-specific planned improvements for IPCC sub-category 2.F.6 Other Application

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 202 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,	AD	Accuracy Transparency	High

GHG source & sink category	Planned improvement	Type of improvement		Priority
	Chapter 7: Emissions of Fluorinated Substitutes for Ozone Depleting Substances. (7.7 OTHER APPLICATIONS) Page 7.66.		Completeness Comparability	

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).

Whereas the sub-category 2.G.1 exist in Montenegro, the subcategories 2.G.2 and 2.G.3 are not estimated due to lack of resources and data.

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	-	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

4.8.1.1 Use of SF_6 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 Environment 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.

4.8.1.1.1 Methodological issues:

Estimated stocks of SF_6 in use in switchgear has been reported by the electricity provider, and the total sum is presented below. No information was provided on SF_6 filled into new high-voltage switchgear, or any amounts refilled. Also, it is unclear, how old the used equipment is, thus a tier 1 methodology has been applied, and an emission factor of 0.002 (*Table 8.2. Volume 3, Chapter 8 of the 2006 GL*) was applied.

Table 203 Emissions from IPCC category 2.G.1, SF_6 used in Switchgear

Year	Stock SF6	SF6 emissions from use	Emissions
	t	t	t CO_2 eq
1990	3.194	0.0064	145.6
1991	3.194	0.0064	145.6
1992	3.194	0.0064	145.6
1993	3.194	0.0064	145.6
1994	3.194	0.0064	145.6
1995	3.194	0.0064	145.6
1996	3.194	0.0064	145.6
1997	3.194	0.0064	145.6
1998	3.302	0.0066	150.6
1999	3.302	0.0066	150.6
2000	3.437	0.0069	156.7
2001	3.437	0.0069	156.7
2002	3.509	0.0070	160.0
2003	3.819	0.0076	174.1
2004	4.127	0.0083	188.2
2005	4.289	0.0086	195.6
2006	4.385	0.0088	200.0
2007	4.385	0.0088	200.0
2008	4.448	0.0089	202.8
2009	4.472	0.0089	203.9
2010	4.496	0.0090	205.0
2011	4.569	0.0091	208.3
2012	5.256	0.0105	239.7
2013	5.569	0.0111	253.9
2014	5.633	0.0113	256.9
2015	5.634	0.0113	256.9
2016	6.129	0.0123	279.5
2017	6.926	0.0139	315.8
2018	7.686	0.0154	350.5
2019	NE	NE	NE

4.8.1.2 Source-specific planned improvements

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 SF_6 if available from their servicing companies will be tried to be obtained.

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 and 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 but the estimation of SF6 and PFCs emissions from use of other products containing SF6 and PFCs is planned for next inventory cycle.

4.8.2.1 Source-specific planned improvements for IPCC sub-category 2.G.2 SF6 & PFCs from ODU

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 204 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	-

IPCC code	Description	HFC		PFC		SF_6		NF_3	
		Estimated	Key Category	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	-	NA	-	NA	-
2.G.3.b	Propellant for pressure and aerosol products	NA	-	NA	-	NA	-	NA	-
2.G.3.c	Other	NA	-	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.G.3 *N_2O from Product Uses* is not estimated but the estimation of N_2O emissions from the use of products containing N_2O is planned for next inventory cycle.

4.8.3.1 Source-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 205 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 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. Pulp and paper 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 *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* does not exist in Montenegro. 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 2019.

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 are not accounted in this categories
Notation keys: IE -included elsewhere, NO – not occurrent, NE -not estimated, NA -not applicable, C – confidential

Emissions from the Agriculture Sector are of important source of GHGs in Montenegro:

- in 1990 about 11.6% of the total national GHG (without LULUCF) emissions and 0.02% of total CO_2 emissions arose from the sector Agriculture, whereas N_2O and CH_4 emissions make up about 49.2% and 61.2%, respectively.
- in 2005 about 9.5% of the total national GHG emissions and 0.02% of total CO_2 emissions arose from the sector Agriculture, whereas N_2O and CH_4 emissions make up about 45.9% and 51.5%, respectively.
- in 2019 about 7.5% of the total national GHG emissions and 0.01% of total CO_2 emissions arose from the sector Agriculture, whereas N_2O and CH_4 emissions make up about 34.7% and 50.5%, respectively.

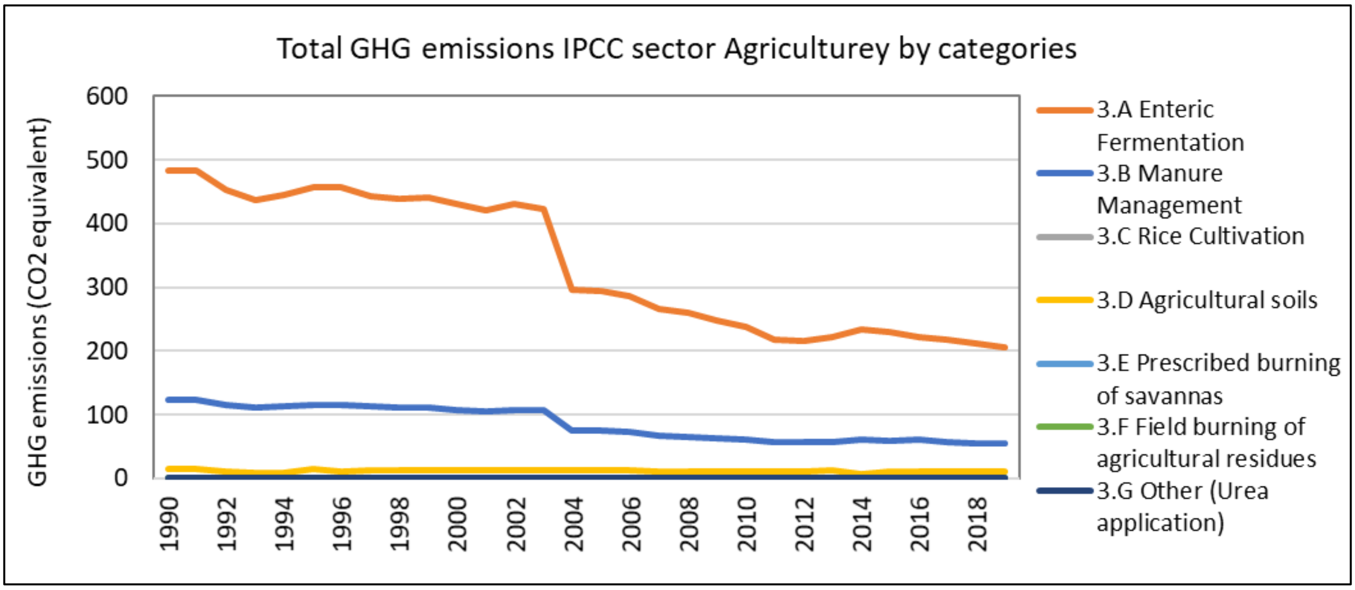


Figure 76 Trend of GHG emissions from 1990 – 2019 for sector Agriculture

Emission trends

In the period 1990 to 2019 GHG emissions from the Agriculture Sector decreased by 56.3%% from 621.5 Gg CO_2 eq in 1990 to 271.57 Gg CO_2 eq in 2019. In the period 2005 to 2019 GHG emissions from the Agriculture sector decreased by -28.8% from 381.61 Gg CO_2 equivalents in 2005 to 271.57 Gg CO_2 equivalents in 2019. The decrease of emissions is mainly caused by decreasing emissions from *Enteric Fermentation and Manure Management* (IPCC subcategory 3.A and 3.B) due to smaller number of livestock and Agricultural Soils (IPCC subcategory 3.D).

In the period 2018 to 2019 GHG emissions from the Agriculture Sector decreased by 2.6% from 278.7 Gg CO_2 eq in 2018 to 271.57 Gg CO_2 eq in 2019, which is mainly caused by decreasing emissions from livestock (IPCC subcategory 3.A & 3.B).

The most important sources of GHGs in the Agriculture Sector is *Enteric Fermentation*. With regards to CH_4 emission, the source *Enteric Fermentation* was the primary source. With regards to N_2O emission, the source *Agricultural Soils* was the primary source.

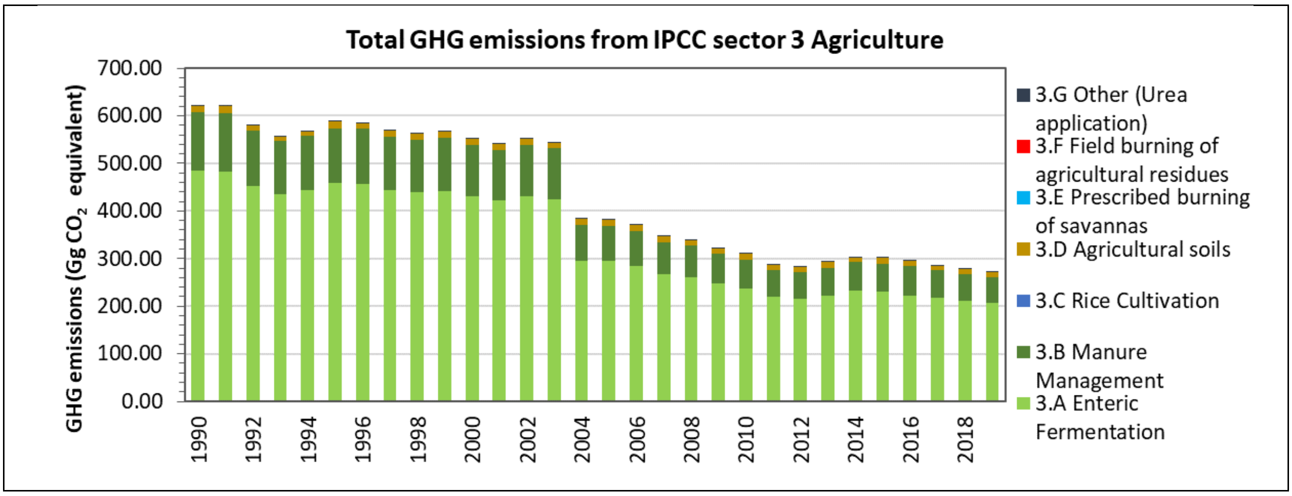


Figure 77 Total national GHG emissions by category of sector Agriculture (1990-2019)

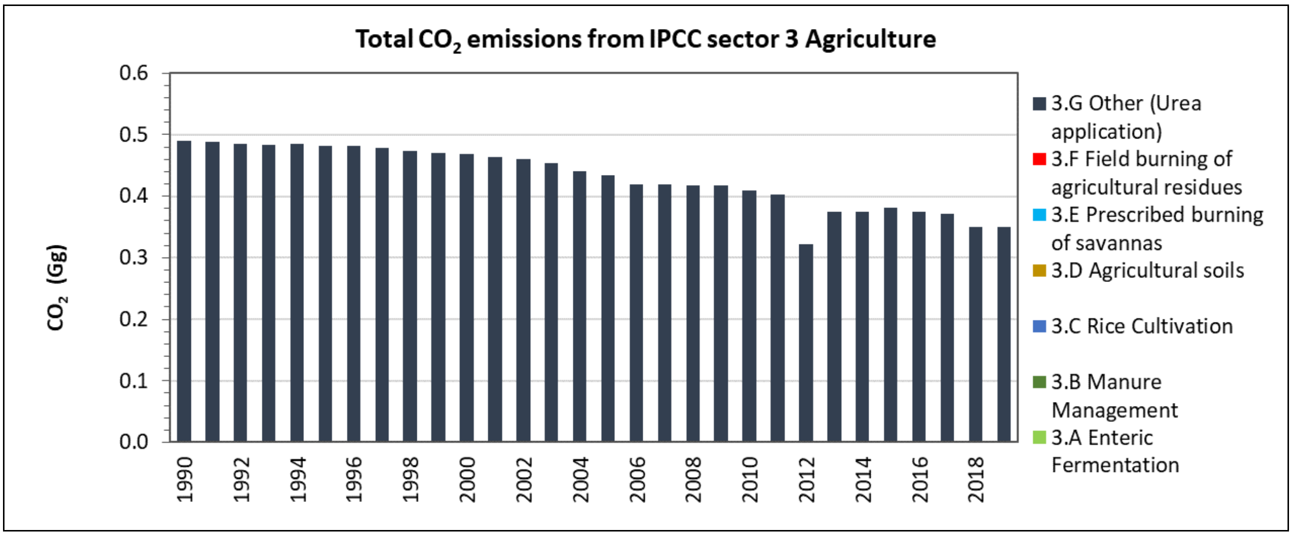


Figure 78 **Total national CO_2 emissions by category of sector Agriculture (1990-2019)**

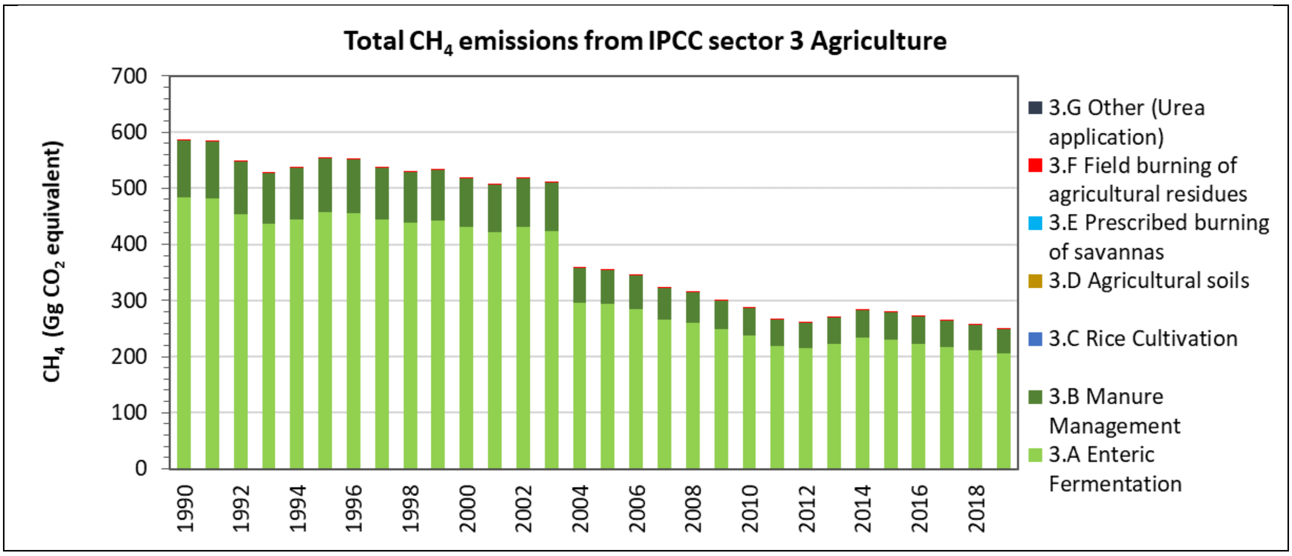


Figure 79 **Total national CH_4 emissions by category of sector Agriculture (1990-2019)**

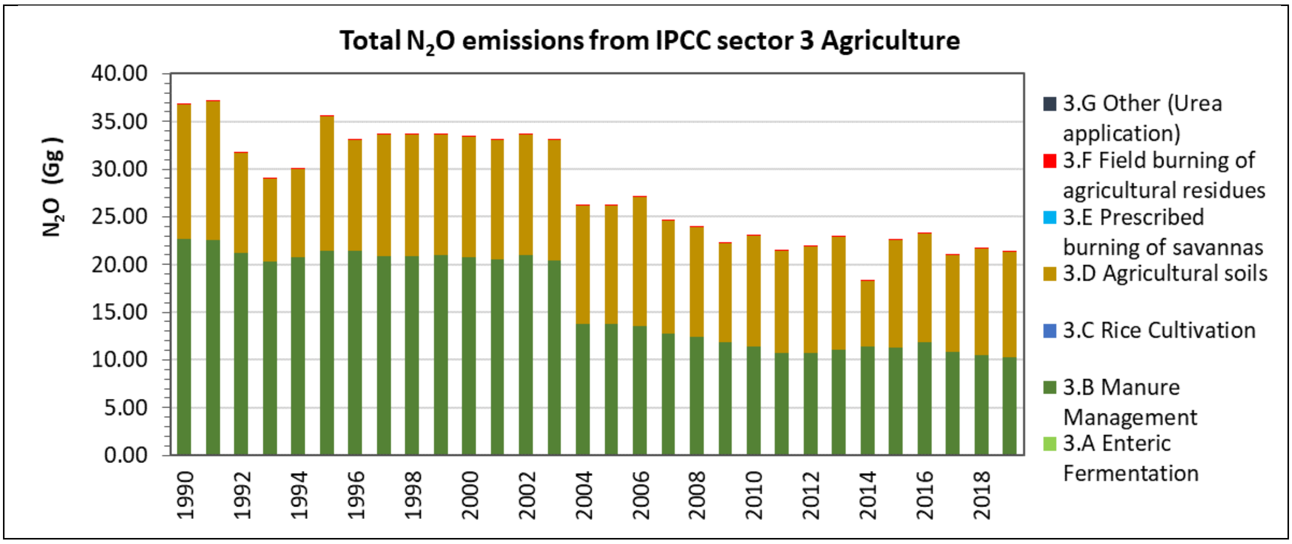


Figure 80 **Total national N_2O emissions by category of sector Agriculture (1990-2019)**

Table 206 Emissions from IPCC sub-category 3 Agriculture: 1990-2019

GHG emissions	TOTAL GHG	CO_2	CH_4	N_2O	CH_4	N_2O
	Gg $_{CO_2\ equivalent}$	Gg	Gg $_{CO_2\ equivalent}$	Gg $_{CO_2\ equivalent}$	Gg	Gg
1990	621.50	0.49	584.19	36.815	23.37	0.124
1991	620.12	0.49	582.49	37.142	23.30	0.125
1992	579.28	0.48	547.06	31.737	21.88	0.107
1993	556.23	0.48	526.70	29.048	21.07	0.097
1994	566.97	0.49	536.41	30.069	21.46	0.101
1995	588.73	0.48	552.66	35.589	22.11	0.119
1996	584.35	0.48	550.80	33.069	22.03	0.111
1997	569.73	0.48	535.59	33.670	21.42	0.113
1998	563.31	0.47	529.23	33.612	21.17	0.113
1999	566.06	0.47	531.95	33.641	21.28	0.113
2000	552.22	0.47	518.34	33.415	20.73	0.112
2001	540.33	0.46	506.73	33.135	20.27	0.111
2002	551.74	0.46	517.63	33.645	20.71	0.113
2003	544.20	0.45	510.68	33.063	20.43	0.111
2004	384.32	0.44	357.68	26.195	14.31	0.088
2005	381.61	0.43	354.95	26.225	14.20	0.088
2006	371.95	0.42	344.45	27.083	13.78	0.091
2007	346.42	0.42	321.37	24.630	12.85	0.083
2008	338.67	0.42	314.36	23.888	12.57	0.080
2009	321.91	0.42	299.26	22.232	11.97	0.075
2010	309.72	0.41	286.28	23.029	11.45	0.077
2011	287.16	0.40	265.30	21.460	10.61	0.072
2012	283.32	0.32	261.10	21.907	10.44	0.074
2013	292.97	0.38	269.69	22.907	10.79	0.077
2014	301.38	0.38	282.75	18.256	11.31	0.061
2015	301.42	0.38	278.43	22.610	11.14	0.076
2016	295.89	0.38	272.20	23.309	10.89	0.078
2017	285.40	0.37	264.01	21.017	10.56	0.071
2018	278.70	0.35	256.71	21.644	10.27	0.073
2019	271.57	0.35	249.84	21.374	9.99	0.072
Trend						
1990 - 2019	-56.3%	-28.5%	-57.2%	-41.9%	-56.1%	-41.9%
2005 - 2019	-28.8%	-19.2%	-29.6%	-18.5%	-27.7%	-18.5%
2018 - 2019	2.6%	0.0%	-2.7%	-1.3%	-2.8%	-1.3%

Table 207 GHG Emissions from IPCC sub-category 3 Agriculture by sub-categories

GHG emissions	3 Agriculture	3.A Enteric Fermentation	3.B Manure Managemen t	3.C Rice Cultivation	3.D Agricultural soils	3.E Prescribed burning of savannas	3.F Field burning of agricultural residues	3.G Other -Urea application
	Gg $_{CO_2 \text{ equivalent}}$							
1990	621.50	483.90	122.91	NO	14.13	NO	0.07	0.49
1991	620.12	482.47	122.60	NO	14.50	NO	0.07	0.49
1992	579.28	453.10	115.18	NO	10.45	NO	0.07	0.48
1993	556.23	436.16	110.85	NO	8.68	NO	0.06	0.48
1994	566.97	444.24	112.85	NO	9.31	NO	0.07	0.49
1995	588.73	457.87	116.15	NO	14.15	NO	0.08	0.48
1996	584.35	456.34	115.80	NO	11.66	NO	0.07	0.48
1997	569.73	443.86	112.55	NO	12.76	NO	0.09	0.48
1998	563.31	439.22	110.84	NO	12.70	NO	0.08	0.47
1999	566.06	441.70	111.14	NO	12.68	NO	0.07	0.47
2000	552.22	430.92	108.12	NO	12.66	NO	0.05	0.47
2001	540.33	421.42	105.76	NO	12.60	NO	0.08	0.46
2002	551.74	430.48	108.11	NO	12.61	NO	0.08	0.46
2003	544.20	423.75	107.34	NO	12.60	NO	0.06	0.45
2004	384.32	296.32	75.09	NO	12.38	NO	0.09	0.44
2005	381.61	294.33	74.38	NO	12.38	NO	0.09	0.43
2006	371.95	285.40	72.53	NO	13.52	NO	0.08	0.42
2007	346.42	266.70	67.46	NO	11.83	NO	0.01	0.42
2008	338.67	260.82	65.93	NO	11.48	NO	0.02	0.42
2009	321.91	247.97	63.13	NO	10.37	NO	0.02	0.42
2010	309.72	237.11	60.55	NO	11.62	NO	0.02	0.41
2011	287.16	218.83	57.20	NO	10.71	NO	0.03	0.40
2012	283.32	215.30	56.47	NO	11.22	NO	0.02	0.32
2013	292.97	222.77	57.92	NO	11.87	NO	0.03	0.38
2014	301.38	233.60	60.57	NO	6.80	NO	0.03	0.38
2015	301.42	229.78	59.93	NO	11.29	NO	0.03	0.38
2016	295.89	222.08	61.91	NO	11.48	NO	0.03	0.38
2017	285.40	217.55	57.32	NO	10.13	NO	0.03	0.37
2018	278.70	211.49	55.72	NO	11.11	NO	0.03	0.35
2019	271.57	205.90	54.19	NO	11.09	NO	0.03	0.35
Trend								
1990 - 2019	-56.3%	-57.4%	-55.9%	*NO*	-21.5%	*NO*	-53.1%	-28.5%
2005 - 2019	-28.8%	-30.0%	-27.1%	*NO*	-10.4%	*NO*	-64.4%	-19.2%
2018 - 2019	-2.6%	-2.6%	-2.8%	*NO*	-0.1%	*NO*	-1.7%	0.0%

Table 208 CO_2 Emissions from IPCC sub-category 3 Agriculture by sub-categories

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.G Other - Urea application
	Gg CO_2							
1990	0.49	NA	NA	NA	NA	NA	NA	0.49
1991	0.49	NA	NA	NA	NA	NA	NA	0.49
1992	0.48	NA	NA	NA	NA	NA	NA	0.48
1993	0.48	NA	NA	NA	NA	NA	NA	0.48
1994	0.49	NA	NA	NA	NA	NA	NA	0.49
1995	0.48	NA	NA	NA	NA	NA	NA	0.48
1996	0.48	NA	NA	NA	NA	NA	NA	0.48
1997	0.48	NA	NA	NA	NA	NA	NA	0.48
1998	0.47	NA	NA	NA	NA	NA	NA	0.47
1999	0.47	NA	NA	NA	NA	NA	NA	0.47
2000	0.47	NA	NA	NA	NA	NA	NA	0.47
2001	0.46	NA	NA	NA	NA	NA	NA	0.46
2002	0.46	NA	NA	NA	NA	NA	NA	0.46
2003	0.45	NA	NA	NA	NA	NA	NA	0.45
2004	0.44	NA	NA	NA	NA	NA	NA	0.44
2005	0.43	NA	NA	NA	NA	NA	NA	0.43
2006	0.42	NA	NA	NA	NA	NA	NA	0.42
2007	0.42	NA	NA	NA	NA	NA	NA	0.42
2008	0.42	NA	NA	NA	NA	NA	NA	0.42
2009	0.42	NA	NA	NA	NA	NA	NA	0.42
2010	0.41	NA	NA	NA	NA	NA	NA	0.41
2011	0.40	NA	NA	NA	NA	NA	NA	0.40
2012	0.32	NA	NA	NA	NA	NA	NA	0.32
2013	0.38	NA	NA	NA	NA	NA	NA	0.38
2014	0.38	NA	NA	NA	NA	NA	NA	0.38
2015	0.38	NA	NA	NA	NA	NA	NA	0.38
2016	0.38	NA	NA	NA	NA	NA	NA	0.38
2017	0.37	NA	NA	NA	NA	NA	NA	0.37
2018	0.35	NA	NA	NA	NA	NA	NA	0.35
2019	0.35	NA	NA	NA	NA	NA	NA	0.35
Trend								
1990 - 2019	-28.5%	NA	NA	NA	NA	NA	NA	-28.5%
2005 - 2019	-19.2%	NA	NA	NA	NA	NA	NA	-19.2%
2018 - 2019	0.0%	NA	NA	NA	NA	NA	NA	0.0%

Table 209 CH_4 Emissions from IPCC sub-category 3 Agriculture by sub-categories

CH_4 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.G Other (Urea application)
	Gg CH_4							
1990	23.37	19.36	4.01	NO	NA	NE	0.002	NE
1991	23.30	19.30	4.00	NO	NA	NE	0.002	NE
1992	21.88	18.12	3.76	NO	NA	NE	0.002	NE
1993	21.07	17.45	3.62	NO	NA	NE	0.002	NE
1994	21.46	17.77	3.68	NO	NA	NE	0.002	NE
1995	22.11	18.31	3.79	NO	NA	NE	0.002	NE
1996	22.03	18.25	3.78	NO	NA	NE	0.002	NE
1997	21.42	17.75	3.67	NO	NA	NE	0.003	NE
1998	21.17	17.57	3.60	NO	NA	NE	0.002	NE
1999	21.28	17.67	3.61	NO	NA	NE	0.002	NE
2000	20.73	17.24	3.50	NO	NA	NE	0.002	NE
2001	20.27	16.86	3.41	NO	NA	NE	0.002	NE
2002	20.71	17.22	3.48	NO	NA	NE	0.002	NE
2003	20.43	16.95	3.48	NO	NA	NE	0.002	NE
2004	14.31	11.85	2.45	NO	NA	NE	0.003	NE
2005	14.20	11.77	2.42	NO	NA	NE	0.002	NE
2006	13.78	11.42	2.36	NO	NA	NE	0.002	NE
2007	12.85	10.67	2.19	NO	NA	NE	0.000	NE
2008	12.57	10.43	2.14	NO	NA	NE	0.001	NE
2009	11.97	9.92	2.05	NO	NA	NE	0.001	NE
2010	11.45	9.48	1.97	NO	NA	NE	0.001	NE
2011	10.61	8.75	1.86	NO	NA	NE	0.001	NE
2012	10.44	8.61	1.83	NO	NA	NE	0.001	NE
2013	10.79	8.91	1.88	NO	NA	NE	0.001	NE
2014	11.31	9.34	1.97	NO	NA	NE	0.001	NE
2015	11.14	9.19	1.94	NO	NA	NE	0.001	NE
2016	10.89	8.88	2.00	NO	NA	NE	0.001	NE
2017	10.56	8.70	1.86	NO	NA	NE	0.001	NE
2018	10.27	8.46	1.81	NO	NA	NE	0.001	NE
2019	9.99	8.24	1.76				0.001	
Trend								
1990 - 2019	-56.1%	-56.3%	-54.9%	NO	NA	NA	-50.7%	NA
2005 - 2019	-27.7%	-28.1%	-25.4%	NO	NA	NA	-62.3%	NA
2018 - 2019	-2.8%	-2.8%	-2.7%	NO	NA	NA	-0.1%	NA

Table 210 N_2O Emissions from IPCC sub-category 3 Agriculture by sub-categories

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.G Other (Urea application)
	Gg N_2O							
1990	0.124	NA	0.076	NA	0.047	NE	NE	NA
1991	0.125	NA	0.076	NA	0.049	NE	NE	NA
1992	0.107	NA	0.071	NA	0.035	NE	NE	NA
1993	0.097	NA	0.068	NA	0.029	NE	NE	NA
1994	0.101	NA	0.070	NA	0.031	NE	NE	NA
1995	0.119	NA	0.072	NA	0.047	NE	NE	NA
1996	0.111	NA	0.072	NA	0.039	NE	NE	NA
1997	0.113	NA	0.070	NA	0.043	NE	NE	NA
1998	0.113	NA	0.070	NA	0.043	NE	NE	NA
1999	0.113	NA	0.070	NA	0.043	NE	NE	NA
2000	0.112	NA	0.070	NA	0.042	NE	NE	NA
2001	0.111	NA	0.069	NA	0.042	NE	NE	NA
2002	0.113	NA	0.071	NA	0.042	NE	NE	NA
2003	0.111	NA	0.069	NA	0.042	NE	NE	NA
2004	0.088	NA	0.046	NA	0.042	NE	NE	NA
2005	0.088	NA	0.046	NA	0.042	NE	NE	NA
2006	0.091	NA	0.045	NA	0.045	NE	NE	NA
2007	0.083	NA	0.043	NA	0.040	NE	NE	NA
2008	0.080	NA	0.042	NA	0.039	NE	NE	NA
2009	0.075	NA	0.040	NA	0.035	NE	NE	NA
2010	0.077	NA	0.038	NA	0.039	NE	NE	NA
2011	0.072	NA	0.036	NA	0.036	NE	NE	NA
2012	0.074	NA	0.036	NA	0.038	NE	NE	NA
2013	0.077	NA	0.037	NA	0.040	NE	NE	NA
2014	0.061	NA	0.038	NA	0.023	NE	NE	NA
2015	0.076	NA	0.038	NA	0.038	NE	NE	NA
2016	0.078	NA	0.040	NA	0.039	NE	NE	NA
2017	0.071	NA	0.037	NA	0.034	NE	NE	NA
2018	0.073	NA	0.035	NA	0.037	NE	NE	NA
2019	0.072	NA	0.034	NA	0.037	NE	NE	NA
Trend								
1990 - 2019	-41.9%	NA	-54.7%	NA	-21.5%	NA	NA	NA
2005 - 2019	-18.5%	NA	-25.7%	NA	-10.4%	NA	NA	NA
2018 - 2019	-1.3%	NA	-2.4%	NA	-0.1%	NA	NA	NA

5.1 Agricultural data collected and used

5.1.1 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)[56]. The agricultural data used and presented in this inventory are taken from the following national and international sources:

Census of Agriculture[57] 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) EU consultants.

Statistical yearbook [58] 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[59] The FAO agricultural data base (FAOSTAT) provides worldwide harmonized data (FAO AGRICULTURE STATISTICAL SYSTEM 2001).[60] The FAO data base provides data for the entire time series 1990 – 2019, even some data are based on estimates done by FAO.

The results of these QA/QC checks are presented in the following chapters under "Source-specific QA/QC and verification".

5.1.2 Country-specific issues

Montenegro has an area of 13,812 km^2. As stated by the Conention 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.[61]

According to FAO The Montenegrin landscape is only partly used for intensive agriculture due to its natural

[56] Available (03. Januar 2020) on https://www.monstat.org/eng/index.php
[57] Available (03. Januar 2020) on https://www.monstat.org/eng/page.php?id=58&pageid=58
[58] Available (03. Januar 2020) on http://www.monstat.org/eng/novosti.php?id=2961
[59] Available (03. Januar 2020) on http://www.fao.org/statistics/en/
[60] Available (03. Januar 2020) on http://www.fao.org/faostat/en/#data
[61] Available (12. March 2020) on https://www.cbd.int/countries/profile/?country=me

conditions and the specific development of agriculture in the past. Intensive farming is practiced only in vicinity of the capital Podgorica and close to urban area of Niksic (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 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 Cemovsko 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 Gusinje.[62]

As stated in the Statistical yearbook 2019 the sector Agriculture, hunting and forestry – covering both farming and livestock-related activities – had a share of 6.7% of the national GDP (at constant prices) in 2018. The share of the national GDP (at constant prices) in 2000 was 11.3%.

[62] Available (12. March 2020) on http://www.fao.org/family-farming/detail/en/c/284679/

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	-	✓	without LULUCF: LA 1990, LA 2018, TA with LULUCF: LA 1990, LA 2018	NA	-
3.A.1.a.i	Dairy Cows	NA	-	✓	(yes, see cattle)	NA	-
3.A.1.a.ii	Other Cattle	NA	-	✓	(yes, see cattle)	NA	-
3.A.1.b	Buffalo	NA	-	NO		NA	-
3.A.1.c	Sheep	NA	-	✓		NA	-
3.A.1.d	Goats	NA	-	✓		NA	-
3.A.1.e	Camels	NA	-	NO		NA	-
3.A.1.f	Horses	NA	-	✓		NA	-
3.A.1.g	Mules and Asses	NA	-	✓		NA	-
3.A.1.h	Swine	NA	-	NO		NA	-
3.A.1.j	Other (please specify)	NA	-	NO		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 2019, this source category was responsible for 41.2% of the total methane emissions estimated for Montenegro. It represented 7.5% of the total GHG emissions in CO_2eq (excluding LULUCF). In the period 1990 – 2019 the CH_4 emissions decreased by -55.2% and in the period 2005 – 2019 the CH_4 emissions decreased by -28.8% mainly due to decreased number of livestock. Cattle are the most significant source of methane because of their high numbers, large size and ruminant digestive system, followed by sheep and goats. An overview of the methane emissions resulting IPCC category 3.A *Enteric Fermentation* is provided in the following figure and tables. The significant drop is mainly due to statistical revisions.

Table 211 Emissions from IPCC category 3.A Enteric Fermentation by sub-categories

CH_4 emissions	3.A.1	3.A.1.a	3.A.1.a.i	3.A.1.a.ii	3.A.1.b	3.A.1.c	3.A.1.d	3.A.1.e	3.A.1.f	3.A.1.g	3.A.1.h	3.A.1.j
	Enteric Fermentation	Cattle	Dairy Cows	Other Cattle	Buffalo	Sheep	Goats	Camels	Horses	Mules and Asses	Swine	Other
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	16,27	16,27	12,88	3,39	NO	1,50	0,27	NO	0,36	IE	0,02	NO
1991	16,23	16,23	12,86	3,36	NO	1,50	0,27	NO	0,35	IE	0,02	NO
1992	15,30	15,30	12,15	3,14	NO	1,38	0,26	NO	0,30	IE	0,02	NO
1993	14,73	14,73	11,85	2,88	NO	1,33	0,25	NO	0,29	IE	0,02	NO
1994	15,06	15,06	12,15	2,91	NO	1,33	0,25	NO	0,29	IE	0,02	NO
1995	15,52	15,52	12,33	3,19	NO	1,38	0,24	NO	0,29	IE	0,02	NO
1996	15,52	15,52	12,32	3,20	NO	1,35	0,24	NO	0,28	IE	0,02	NO
1997	15,27	15,27	12,22	3,05	NO	1,21	0,23	NO	0,27	IE	0,02	NO
1998	15,41	15,41	12,31	3,09	NO	1,03	0,22	NO	0,26	IE	0,02	NO
1999	15,68	15,68	12,69	2,99	NO	0,94	0,22	NO	0,22	IE	0,02	NO
2000	15,35	15,35	11,98	3,36	NO	0,90	0,21	NO	0,19	IE	0,02	NO
2001	15,27	15,27	11,92	3,34	NO	0,75	0,18	NO	0,18	IE	0,02	NO
2002	15,66	15,66	12,23	3,43	NO	0,74	0,16	NO	0,17	IE	0,02	NO
2003	15,35	15,35	12,57	2,78	NO	0,78	0,15	NO	0,16	IE	0,02	NO
2004	10,28	10,28	8,46	1,82	NO	0,76	0,14	NO	0,14	IE	0,01	NO
2005	10,23	10,23	8,20	2,03	NO	0,79	0,13	NO	0,13	IE	0,01	NO
2006	9,93	9,93	7,88	2,05	NO	0,79	0,12	NO	0,11	IE	0,01	NO
2007	9,34	9,34	7,24	2,10	NO	0,68	0,11	NO	0,10	IE	0,01	NO
2008	9,19	9,19	7,27	1,91	NO	0,64	0,09	NO	0,09	IE	0,01	NO
2009	8,74	8,74	6,98	1,76	NO	0,64	0,08	NO	0,09	IE	0,01	NO

CH_4 emissions	3.A.1	3.A.1.a	3.A.1.a.i	3.A.1.a.ii	3.A.1.b	3.A.1.c	3.A.1.d	3.A.1.e	3.A.1.f	3.A.1.g	3.A.1.h	3.A.1.j
	Enteric Fermentation	Cattle	Dairy Cows	Other Cattle	Buffalo	Sheep	Goats	Camels	Horses	Mules and Asses	Swine	Other
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
2010	8,32	8,32	6,66	1,66	NO	0,63	0,07	NO	0,09	IE	0,01	NO
2011	7,50	7,50	5,89	1,60	NO	0,69	0,12	NO	0,07	IE	0,02	NO
2012	7,37	7,37	5,94	1,43	NO	0,68	0,12	NO	0,07	IE	0,02	NO
2013	7,70	7,70	6,12	1,58	NO	0,63	0,15	NO	0,09	IE	0,02	NO
2014	8,05	8,05	6,33	1,72	NO	0,58	0,16	NO	0,09	IE	0,02	NO
2015	7,96	7,96	6,26	1,69	NO	0,51	0,15	NO	0,09	IE	0,02	NO
2016	7,64	7,64	5,94	1,70	NO	0,48	0,16	NO	0,07	IE	0,06	NO
2017	7,51	7,51	6,00	1,51	NO	0,49	0,15	NO	0,07	IE	0,03	NO
2018	7,28	7,28	5,93	1,36	NO	0,48	0,15	NO	0,07	IE	0,02	NO
2019	7,09	7,09	5,71	1,38	NO	0,48	0,14	NO	0,07	IE	0,02	NO
Trend												
1990 - 2019	-55,2%	-56,4%	-55,7%	-59,2%	NA	-68,3%	-47,2%	NA	-79,9%	NA	1,1%	NA
2005 - 2019	-28,8%	-30,7%	-30,4%	-32,0%	NA	-39,8%	12,2%	NA	-43,7%	NA	115,8%	NA
2018 - 2019	-3,0%	-2,7%	-3,7%	1,6%	NA	-2,2%	-1,0%	NA	0,1%	NA	-2,4%	NA

5.2.2 Methodological issues

5.2.2.1 Choice of methods

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.

For estimating the CH_4 emissions from livestock the 2006 IPCC Guidelines approach[63] has been applied:

- Tier 1 approach: for all other livestock categories – cattle, sheep, goats, horses, mules and asses.

  A simplified approach that relies on default emission factors drawn from the literature. The Tier 1 method is likely to be suitable for most animal species in countries where enteric fermentation is not a key source category, or where enhanced characterization data are not available.

  A more complex approach that requires detailed country-specific data on gross energy intake and methane conversion factors for specific livestock categories. The Tier 2 method should be used if enteric fermentation is a key source category for the animal category that represents a large portion of the country's total emissions.

TIER 1

Equation 10.19: CH_4 emissions from enteric fermentation 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

5.2.2.2 Choice of activity data

As described in Chapter 5.1.1 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)[64]. The agricultural data used and presented in this inventory are taken from the following national and international sources:

- Census of Agriculture[65]
- Statistical yearbook [66]
- FAO agricultural data base[67]

[63] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chap. 10 Emissions from Livestock and Manure Management; sub-chapter 10.2.2 Choice of method
[64] Available (03. Januar 2020) on https://www.monstat.org/eng/index.php
[65] Available (03. Januar 2020) on https://www.monstat.org/eng/page.php?id=58&pageid=58
[66] Available (03. Januar 2020) on http://www.monstat.org/eng/novosti.php?id=2961
[67] Available (03. Januar 2020) on http://www.fao.org/statistics/en/

Cattle

The number of **cattle** decreased significantly by 56.8% in the period 1990 – 2019 and decreased by 29.3% in the period 2005 – 2019. The number of **dairy cattle** decreased significantly by -55.7% in the period 1990 – 2019 and decreased by -30.4% in the period 2005 – 2019.

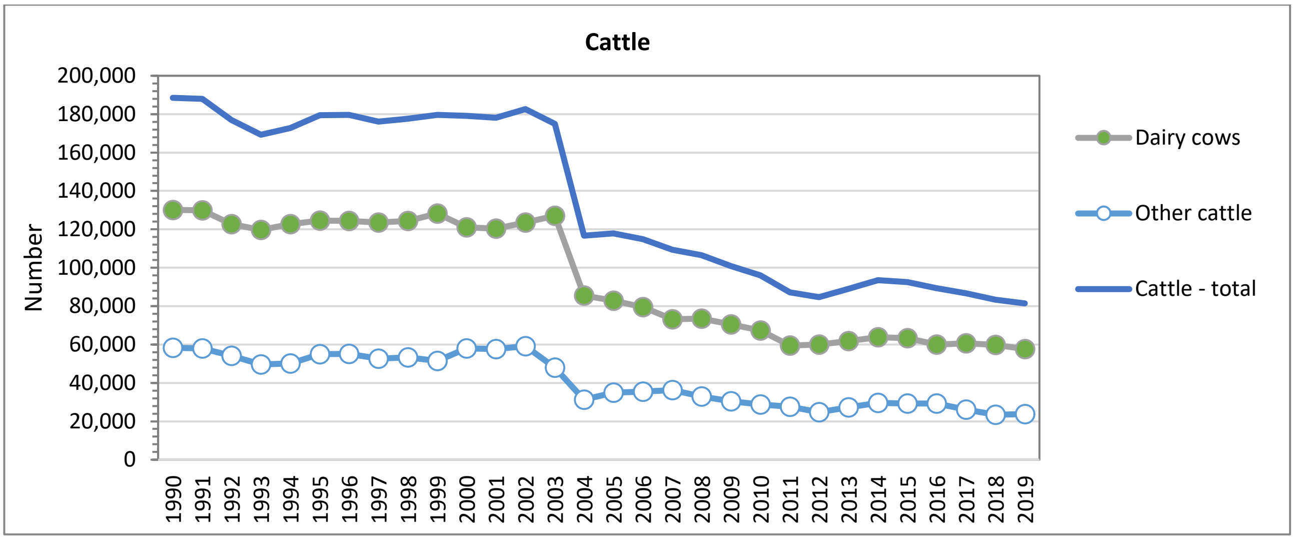


Figure 81 **Cattle - dairy and non-dairy (calves, bulls, bovines) population and its trend 1990–2019**

Sheep and goats

The number of **sheep** decreased significantly by 62.6% in the period 1990 – 2019 and decreased by 43.8% in the period 2005 – 2019.

The number of **goats** decreased significantly by 47.2% in the period 1990 – 2019 and increased by 63.8% in the period 2005 – 2019.

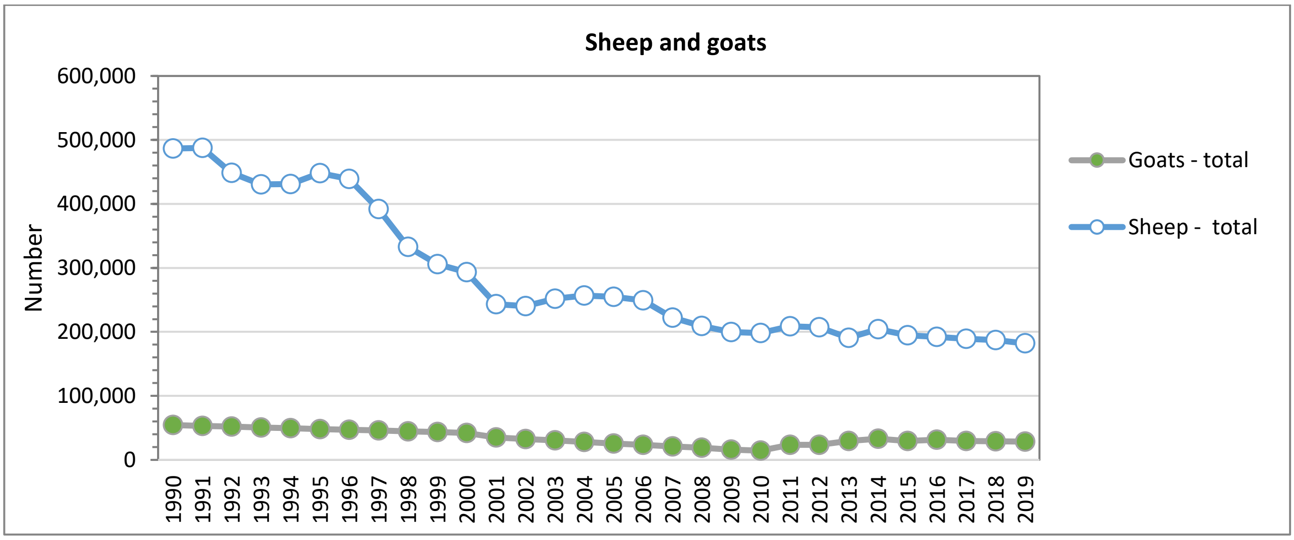


Figure 82 **Sheep and Goats - population and its trend 1990–2019**

Horses, Mules and Asses

The number of **Horses** including **Mules and Asses** decreased significantly by 79.9% in the period 1990 – 2019 and decreased by 47.5% in the period 2005 – 2019. Horses, mules and asses are for transportation, hauling agricultural products to market but also conveying of farmyard manure, soil and for other purposes.

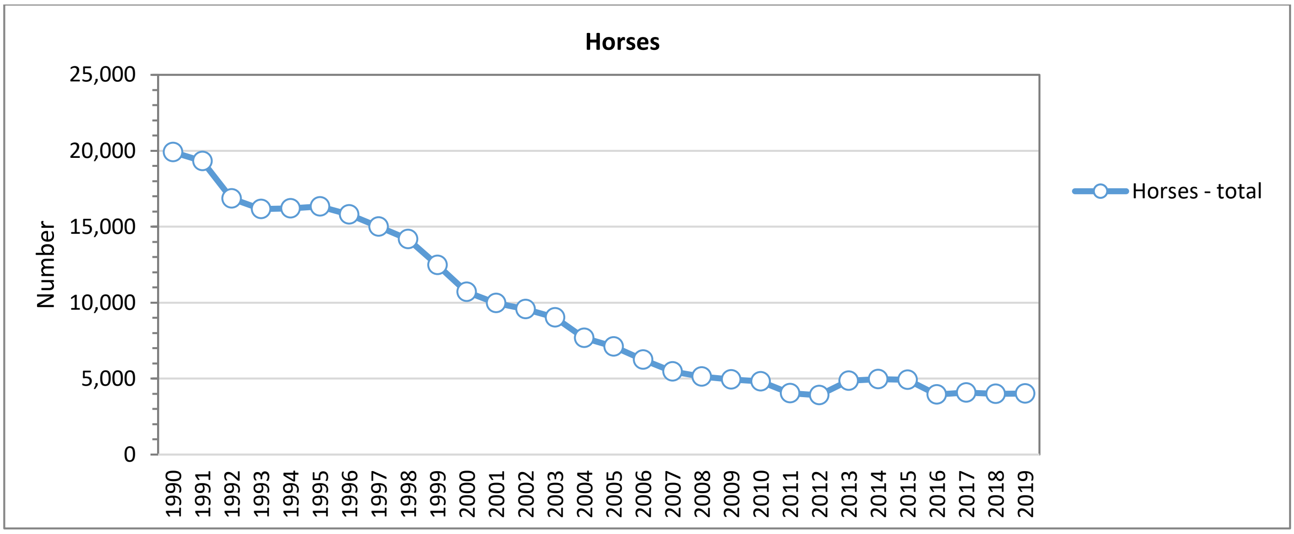


Figure 83 **Horses, mules and asses: population and its trend 1990–2019**

Poultry

The number of **Poultry birds** decreased significantly by 30.7% in the period 1990 – 2019 and decreased by 24.1% in the period 2005 – 2019. The poultry birds include chickens (broilers), hens, turkey, geese, ducks and other poultry.

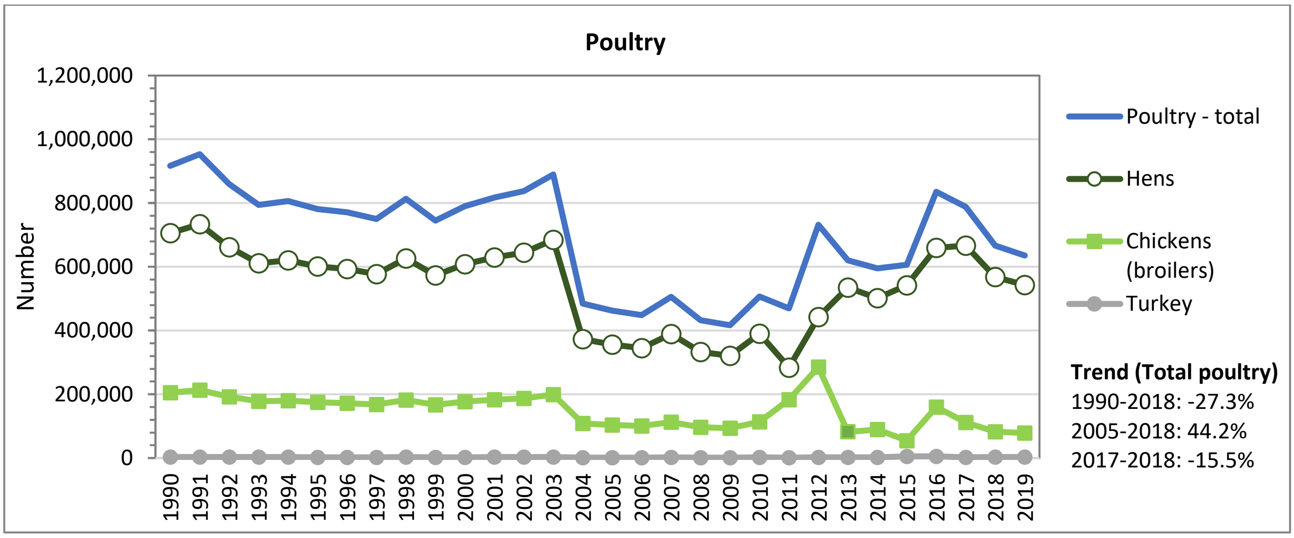


Figure 84 **Poultry birds population and its trend 1990–2019**

Table 212 Cattle: livestock population and its trend 1990–2019

	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	130 144	Statististical Yearbook	58 365	Statististical Yearbook	20 125	15 168	4 302	Calculated based on share of 2014	1,374	6,503	383	Calculated based on share of 2014	2 540	Calculated based on share of 2004	7,456	Calculated based on share of 2014	2,140	Calculated based on share of 2014	6 108	Calculated based on share of 2004
1991	187 906		129 926		57 980		20 061	15 120	4 288		1,370	6,482	381		2 531		7,234		2,136		6 088	
1992	176 946		122 763		54 183		18 891	14 238	4 038		1,290	6,104	359		2 384		6,397		2,018		5 733	
1993	169 324		119 702		49 622		18 077	13 625	3 864		1,234	5,841	344		2 281		3,894		1,968		5 486	
1994	172 839		122 704		50 135		18 452	13 907	3 945		1,260	5,962	351		2 328		3,458		2,017		5 600	
1995	179 524		124 567		54 957		19 166	14 445	4 097		1,309	6,193	364		2 419		6,475		2,048		5 816	
1996	179 581		124 457		55 124		19 172	14 450	4 098		1,309	6,195	364		2 419		6,626		2,046		5 818	
1997	176 043		123 473		52 570		18 795	14 165	4 018		1,283	6,073	357		2 372		5,028		2,030		5 704	
1998	177 693		124 373		53 320		18 971	14 298	4 055		1,295	6,130	361		2 394		5,332		2,045		5 757	
1999	179 706		128 179		51 527		19 186	14 460	4 101		1,310	6,199	365		2 421		2,996		2,107		5 822	
2000	179 071		121 060		58 011		19 118	14 409	4 087		1,305	6,177	363		2 412		9,651		1,990		5 802	
2001	178 064		120 427		57 637		19 010	14 328	4 064		1,298	6,142	361		2 399		9,549		1,980		5 769	
2002	182 680		123 534		59 146		19 503	14 699	4 169		1,332	6,302	371		2 461		9,811		2,031		5 919	
2003	174 954		126 987		47 967		18 678	14 078	3 993		1,275	6,035	355		2 357		719		2,088		5 668	

	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)	
2004	116 794		85 496		31 298		12 458	9 390	2 663		189	897	53		1 545		-534		1,406		4 103	
2005	117 842		82 851		34 991		14 168	10 678	3 029		287	1,359	80		1 476		3,182		1,362		3 914	
2006	114 922		79 553		35 369		14 774	11 135	3 158		216	1,024	60		1 685		4,604		1,308		3 316	
2007	109 378		73 142		36 236		15 112	11 390	3 230		188	890	52		1 294		6,341		1,203		4 080	
2008	106 494		73 477		33 017		11 882	8 955	2 540		765	3,620	213		1 182		4,100		1,208		3 860	
2009	100 835		70 467		30 368		10 802	8 141	2 309		795	3,761	221		1 092		3,423		1,159		3 247	
2010	95 963		67 259		28 704		10 115	7 624	2 162		827	3,914	230		1 254		3,358		1,106		2 578	
2011	87 173		59 532		27 641		9 553	7 200	2 042		487	2,305	136		2 667		2,179		979		3 252	
2012	84 701		59 972		24 729		8 266	6 230	1 767		449	2,125	125		2 948		142		986		2 650	
2013	89 058		61 830		27 228		7 551	7 268	2 109		467	2,929	130		3 213		548		833		3 012	
2014	93 550		63 889		29 660		8 473	7 935	3 243		529	3,399	171		2 756		459		793		2 697	
2015	92 452		63 262		29 190		7 171	8 850	2 877		607	4,312	69		2 350		281		450		2 673	
2016	89 269		60 040		29 229		7 244	5 861	2 598		2,114	4,585	350		3 313		237		457		2 927	
2017	86 649		60 609		26 040		5 369	8 837	2 301		1,640	2,764	215		2 500		230		567		2 184	
2018	83 264	MONSTAT - Statistical Yearbook	59 859	MONSTAT - Statistical Yearbook	23 405	calculated	5 425	7 316	2 064	MONSTAT - Statistical	1,414	2,490	105	MONSTAT - Statistical	2 230	MONSTAT - Statistical Yearbook	86	MONSTAT - Statistical	390	MONSTAT - Statistical	2 275	MONSTAT - Statistical Yearbook
2019	81 432		57 645		23 787		5 425	7 316	2 064			3 989			2 302						2 221	
Trend																						
1990 - 2019	-56,8%		-55,7%		-59,2%		-73,0%	-51,8%	-52,0%				-51,7%		-9,4%						-63,6%	
2005 - 2019	-30,9%		-30,4%		-32,0%		-61,7%	-31,5%	-31,9%				131,1%		56,0%						-43,3%	
2018 - 2019	-2,2%		-3,7%		1,6%		0,0%	0,0%	0,0%				-0,5%		3,2%						-2,4%	

Table 213 Sheep and goats: livestock population and its trend 1990–2019

	Sheep												Goats						
	Sheep (total)		Lambs & young sheep under 1 years old		Breeding ewe		of which dairy		Rams and sterile sheep		Other 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	299 993	Calculated based on share of 2012	30,433	Calculated based on share of 2004	-	Calculated based on share of 2012	54,431	Statistical Yearbook	6,943	38,434	4,627	4,428	Calculated based on share of 2012
1991	487 500		80 543		376 470		300 527		30,487		-		53,201		6,786	37,565	4,522	4,328	
1992	448 543		74 107		346 386		276 511		28,051		-		51,971		6,629	36,697	4,418	4,228	
1993	430 498		71 125		332 451		265 387		26,922		-		50,741		6,472	35,828	4,313	4,128	
1994	430 847		71 183		332 720		265 602		26,944		-		49,511		6,315	34,960	4,209	4,027	
1995	447 909		74 002		345 896		276 120		28,011		-		48,281		6,158	34,091	4,104	3,927	
1996	438 881		72 510		338 924		270 555		27,446		-		47,051		6,001	33,223	3,999	3,827	
1997	392 058		64 774		302 765		241 690		24,518		-		45,821		5,844	32,354	3,895	3,727	
1998	332 795		54 983		257 000		205 157		20,812		-		44,591		5,687	31,486	3,790	3,627	
1999	305 707		50 508		236 081		188 458		19,118		-		43,361		5,531	30,617	3,686	3,527	
2000	293 197		48 441		226 420		180 746		18,336		-		42,131		5,374	29,749	3,581	3,427	
2001	243 524		40 234		188 061		150 124		15,229		-		35,001		4,464	24,714	2,975	2,847	
2002	240 531		39 740		185 749		148 279		15 042		-				4 165	23 059	2 776	2 656	
2003	252 007		41 636		194 612		155 354		15 760		-		30 311		3 866	21 403	2 577	2 466	
2004	256 602	MONSTAT - Statistical Yearbook	50 117	MONSTAT - Statistical Yearbook	191 493	MONSTAT - Statistical Yearbook	152 864		14 992	MONSTAT - Statistical Yearbook	-		27 966		3 567	19 747	2 377	2 275	
2005	254 898		41 349		197 970		158 035		15 579		-		25 621		3 268	18 091	2 178	2 084	
2006	249 281		34 431		197 882		157 964		16 968		-		23 276		2 969	16 435	1 979	1 893	
2007	222 244		35 935		169 926		135 648		16 383		-		21 077		2 688	14 883	1 792	1 715	
2008	209 354		32 438		160 912		128 452		16 004		-		18 932		2 415	13 368	1 609	1 540	
2009	199 764		26 451		159 905		127 648		13 408		-		16 175		2 063	11 421	1 375	1 316	
2010	198 165		28 076		158 503		126 529		11 586		-		14 427		1 840	10 187	1 226	1 174	
2011	208 771		23 786		172 924		138 041	MONST	12 061		-	MONST	23 660	MONST	3 018	16 706	2 011	1 925	MONST
2012	207 047		24 391		169 295		135 144		13 361		-		23 273		3 068	17 331	987	1 887	

	Sheep												Goats						
	Sheep (total)		Lambs & young sheep under 1 years old		Breeding ewe		of which dairy		Rams and sterile sheep		Other Sheep		Goats - total		young goats under 1 years old	Goats-already kidded	Goats - first time mated	Other goats	
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		90 280		29 040		5 307	19 839	1 611	2 283	
2019	182 127		23 228		150 955		95 183		7 994		86 944		28754		5 531	23 223	IE	IE	
Trend																			
1990 - 2019	-62,6%		-71,1%		-59,8%		-68,3%		-73,9%		-53,4%		-47,2%		-22,9%	-42,7%	NA	NA	
2005 - 2019	-28,5%		-43,8%		-23,7%		-39,8%		-49,0%		-10,2%		12,2%		63,8%	21,7%	NA	NA	
2018 - 2019	-2,6%		-7,5%		-1,6%		-1,6%		-6,4%		-3,7%		-1,0%		4,2%	17,1%	NA	NA	

Table 214 Pigs: livestock population and its trend 1990–2019

	Pigs (total)		Piglets up to 19 kg	Pigs from 20-49 kg		Fattening pigs					Sows and sows of the first farrow							Boars	
							- 50-79 kg	- 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	2 389	Calculated (sum)	234	104	1 640	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		2 295		225	100	1 576	394		227	
1992	21 779		4 256	9 263		5 788	2 562	1 609	1 617		2 279		223	99	1 565	391		226	
1993	20 624		4 031	8 772		5 481	2 426	1 524	1 532		2 158		211	94	1 482	371		214	
1994	20 510		4 008	8 723		5 451	2 413	1 515	1 523		2 146		210	94	1 473	369		212	
1995	20 219		3 952	8 600		5 374	2 378	1 494	1 501		2 115		207	92	1 453	363		209	
1996	20 855		4 076	8 870		5 543	2 453	1 541	1 549		2 182		214	95	1 498	375		216	
1997	22 107		4 321	9 403		5 875	2 600	1 633	1 642		2 313		227	101	1 588	397		229	
1998	21 078		4 119	8 965		5 602	2 479	1 557	1 565		2 205		216	96	1 514	379		218	
1999	19 852		3 880	8 444		5 276	2 335	1 467	1 474		2 077		203	91	1 426	357		206	
2000	17 896		3 498	7 612		4 756	2 105	1 322	1 329		1 872		183	82	1 286	322		185	
2001	19 663		3 843	8 363		5 226	2 313	1 453	1 460		2 057		202	90	1 413	353		204	
2002	20 548		4 016	8 740		5 461	2 417	1 518	1 526		2 150		211	94	1 476	369		213	
2003	22 094		4 318	9 397		5 872	2 599	1 632	1 641		2 311		226	101	1 587	397		229	

	Pigs (total)		Piglets up to 19 kg	Pigs from 20-49 kg		Fattening pigs					Sows and sows of the first farrow							Boars	
							- 50-79 kg	- 80-109 kg	- Over 110 kg				Gilts - mated	Gilts - other	Sows - mated	Sows - other			
2004	12 101	MONSTAT - Statistical Yearbook	2 365	5 147		3 216	1 423	894	899		1 266	Calculated (sum)	124	55	869	217		107	MONSTAT - Statistical Yearbook
2005	10 697		2 091	4 123		2 843	1 258	790	794		1 555		152	68	1 068	267		85	
2006	13 294		2 598	4 578		3 533	1 564	982	987		2 395		235	104	1 645	411		190	
2007	10 374		2 027	3 929		2 757	1 220	766	770		1 593		156	69	1 094	274		67	
2008	10 017		1 958	3 664		2 662	1 178	740	744		1 676		164	73	1 151	288		57	
2009	12 377		2 419	4 658		3 289	1 456	914	919		1 977		194	86	1 358	340		34	
2010	11 205		2 190	4 026	MONSTAT - Statistical Yearbook	2 978	1 318	828	832	MONSTAT - Statistical Yearbook	1 952		191	85	1 340	335		59	
2011	21 398		4 182	8 494		5 687	2 517	1 581	1 589		2 945		289	128	2 022	506	MONSTAT - Statistical Yearbook	90	
2012	18 451		4 017	6 437		5 599	793	926	3 880		2 317		227	101	1 591	398		81	
2013	20 572		4 598	9 355		4 872	819	886	3 167		1 601		128	145	1 254	74		146	
2014	22 053		4 869	5 675		8 267	1 240	1 381	5 647		2 663		469	316	1 241	637		248	
2015	24 951		6 276	6 303		9 550	1 256	1 099	7 195		2 700		536	63	1 799	302		123	
2016	55 841		11 356	5 068		35 642	1 924	9 841	23 877		3 448		796	110	1 966	576		327	
2017	25 043		7 480	5 470		9 560	1 066	2 268	6 226		2 450		349	153	1 522	426		83	
2018	23 651		5 892	5 323		10 336	1 086	2 217	7 033		2 013		398	32	1 486	97		87	
2019	23 089		4182	4583		11512	1106	2214	8192		2155		IE	IE	IE	IE		92	
Trend																			
1990 - 2019	1,1%		6,4%	-52,8%		89,7%	-58,8%	31,2%	383,2%		-9,8%		NA	NA	NA	NA		-54,4%	
2005 - 2019	115,8%		127,1%	11,1%		304,9%	-12,1%	180,1%	931,3%		38,6%		NA	NA	NA	NA		8,2%	
2018 - 2019	-2,4%		-19,4%	-13,9%		11,4%	1,8%	-0,1%	16,5%		7,1%		NA	NA	NA	NA		5,7%	

Table 215 Poultry and Horses: livestock population and its trend 1990–2019

	Poultry								Horses						
	Poultry - total		Chickens (broilers)	Hens	Turkey	Geese & Ducks	Other poultry		Horses - total		Colts and yearlings	Mares and In-foal yearling mares	Studhorses and geldings	Mules & Asses	
1990	917,084	Calculated based on share of 2004	205,210	705,695	3,121	IE	3,058	Calculated based on share of 2004	19,914	Calculated based on share of 2004	753	3,285	15,876	IE	Calculated based on share of 2004
1991	953,273		213,307	733,542	3,245	IE	3,178		19,318		730	3,186	15,401	IE	
1992	859,543		192,334	661,417	2,926	IE	2,866		16,864		638	2,782	13,445	IE	
1993	794,435		177,765	611,317	2,704	IE	2,649		16,160		611	2,665	12,884	IE	
1994	806,196		180,397	620,367	2,744	IE	2,688		16,209		613	2,674	12,923	IE	
1995	781,265		174,818	601,182	2,659	IE	2,605		16,327		617	2,693	13,017	IE	
1996	770,826		172,483	593,150	2,624	IE	2,570		15,812		598	2,608	12,606	IE	
1997	750,074		167,839	577,181	2,553	IE	2,501		14,997		567	2,474	11,956	IE	
1998	813,358		182,000	625,878	2,768	IE	2,712		14,182		536	2,339	11,307	IE	
1999	745,017		166,707	573,290	2,536	IE	2,484		12,474		472	2,057	9,945	IE	
2000	790,577		176,902	608,348	2,691	IE	2,636		10,703		405	1,765	8,533	IE	
2001	817,445		182,914	629,023	2,782	IE	2,726		9,967		377	1,644	7,946	IE	
2002	837,542		187,411	644,488	2,851	IE	2,793		9,568		362	1,578	7,628	IE	
2003	890,045		199,159	684,889	3,029	IE	2,968		9,028		341	1,489	7,198	IE	
2004	485,042	MONSTAT - Statistical Yearbook	108,535	373,239	1,651	IE	1,617	MONSTAT - Statistical Yearbook	7,688	MONSTAT - Statistical Yearbook	355	1,236	6,097	IE	MONSTAT - Statistical Yearbook
2005	462,149		103,412	355,623	1,573	IE	1,541		7,119		282	1,051	5,786	IE	
2006	448,502		100,358	345,122	1,527	IE	1,495		6,260		173	1,167	4,920	IE	
2007	505,355		113,080	388,870	1,720	IE	1,685		5,463		212	1,417	3,834	IE	
2008	432,264		96,725	332,627	1,471	IE	1,441		5,124		192	1,224	3,708	IE	
2009	416,737		93,250	320,679	1,418	IE	1,390		4,951		114	929	3,908	IE	
2010	506,520		113,341	389,767	1,724	IE	1,689		4,828		96	669	4,063	IE	
2011	470,047		183,211	284,116	1,197	IE	1,567		4,035		245	799	2,991	IE	
2012	732,091		285,349	442,506	1,864	IE	2,372		3,905		164	636	3,105	IE	
2013	620,354		81,805	534,410	1,993	IE	2,146		4,858		429	1,133	3,296	IE	

	Poultry								Horses							
	Poultry - total		Chickens (broilers)	Hens	Turkey	Geese & Ducks	Other poultry		Horses - total		Colts and yearlings	Mares and In-foal yearling mares	Studhorses and geldings	Mules & Asses	
2014	595,675		89,142	501,913	2,652	IE	1,968		4,968		234	1,219	3,517	IE	
2015	606,225		54,874	541,928	4,900	IE	4,523		4,927		414	1,225	3,287	IE	
2016	835,705		159,615	659,613	5,466	IE	11,011		3,947		146	896	2,905	IE	
2017	788,309		111,573	666,550	2,611	IE	7,575		4,071		267	691	3,113	IE	
2018	666,339		82,198	568,511	3,364	IE	12,266		4,005		263	680	3,063	IE	
2019	635,882		78,441	542,525	3,210	IE	11,706		4,008		148	1011	2,849	IE	
Trend															
1990 - 2019	-30,7%		-61,8%	-23,1%	2,8%	NA	282,8%		-79,9%		-80,3%	-69,2%	-82,1%	NA	
2005 - 2019	37,6%		-24,1%	52,6%	104,1%	NA	659,6%		-43,7%		-47,5%	-3,8%	-50,8%	NA	
2018 - 2019	-4,6%		-4,6%	-4,6%	-4,6%	NA	-4,6%		0,1%		-43,7%	48,7%	-7,0%	NA	

5.2.2.3 Choice of emission factors

For estimating the CH_4 emissions from cattle and all other livestock categories (sheep, goats, horses, mules and asses), the 2006 IPCC Guidelines Tier 1 approach[68] has been applied.

The default emission factors methane (CH_4) were taken from IPCC 2006 Guidelines and are presented in the following table.

Table 216 Emission factors for Tier 1 for IPCC sub-category 3.A Enteric Fermentation

Livestock	CH_4 (kg/head)		Liveweight	Source
	EF	type		
Dairy Cattle	99	D	-	**2006 IPCC Guidelines Vol. 4, Chap. 10 (10.3.2)** TABLE 10.11 TIER 1 Enteric fermentation emission factors for cattle
Other Cattle (non-dairy)	56	D	-	
Buffalo	55	D	300 kg	**2006 IPCC Guidelines Vol. 4, Chap. 10 (10.3.2)** TABLE 10.10 Enteric fermentation emission factors for tier 1 method (page 10.28)
Sheep	5	D	45 kg	
Goats	5	D	40 kg	
Camels	46	D	570 kg	
Horses	18	D	550 kg	
Mules and Asses	10	D	245 kg	
Deer	20	D	120 kg	
Alpacas	8	D	65 kg	
Swine	1.0	D	-	
Poultry	NA[1]	-	-	
Other (e.g., Llamas)	To be determined[2]	-	-	

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

[1] Insufficient data for calculation available.

[2] One approach for developing the approximate emission factors is to use the Tier 1 emissions factor for an animal with a similar digestive system and to scale the emissions factor using the ratio of the weights of the animals raised to the 0.75 power. Liveweight values have been included for this purpose. Emission factors should be derived on the basis of characteristics of the livestock and feed of interest and should not be restricted solely to within regional characteristics.

5.2.3 Uncertainties and time-series consistency for IPCC sub-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.

[68] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10 Emissions from Livestock and Manure Management - sub-chapter 10.3.2 Choice of EF

Table 217 Uncertainty for IPCC sub-category 3.A.1 Enteric Fermentation.

Uncertainty	Cattle	Buffalo, sheep, goats, camels, 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 Source-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 Source-specific recalculations

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.A.1 Enteric Fermentation*.

Table 218 Recalculations done in IPCC sub-category 3.A.1 Enteric Fermentation

GHG source & sink category	Revisions of data since last NC and GHG inventory submission 2020	Type of revision	Type of improvement
3.A.1	application of 2006 IPCC Guidelines	method	Comparability
3.A.1.a	use of default emission factor of 2006 IPCC Guidelines	EF	Comparability
3.A.1.b-j	use of default emission factor of 2006 IPCC Guidelines	EF	Comparability
3.A.1.a.	split of cattle in dairy, bulls and other non-dairy cattle	AD	Comparability

5.2.6 Source-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 219 Planned improvements for IPCC sub-category 3.A.1 Enteric Fermentation

GHG source & sink category	Planned improvement	Type of improvement		Priority
3.A.1	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, camels, horses, mules, and asses, and poultry	AD	Accuracy Comparability Transparency	medium
3.A.1.c 3.A.1.d 3.A.1.e	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	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.

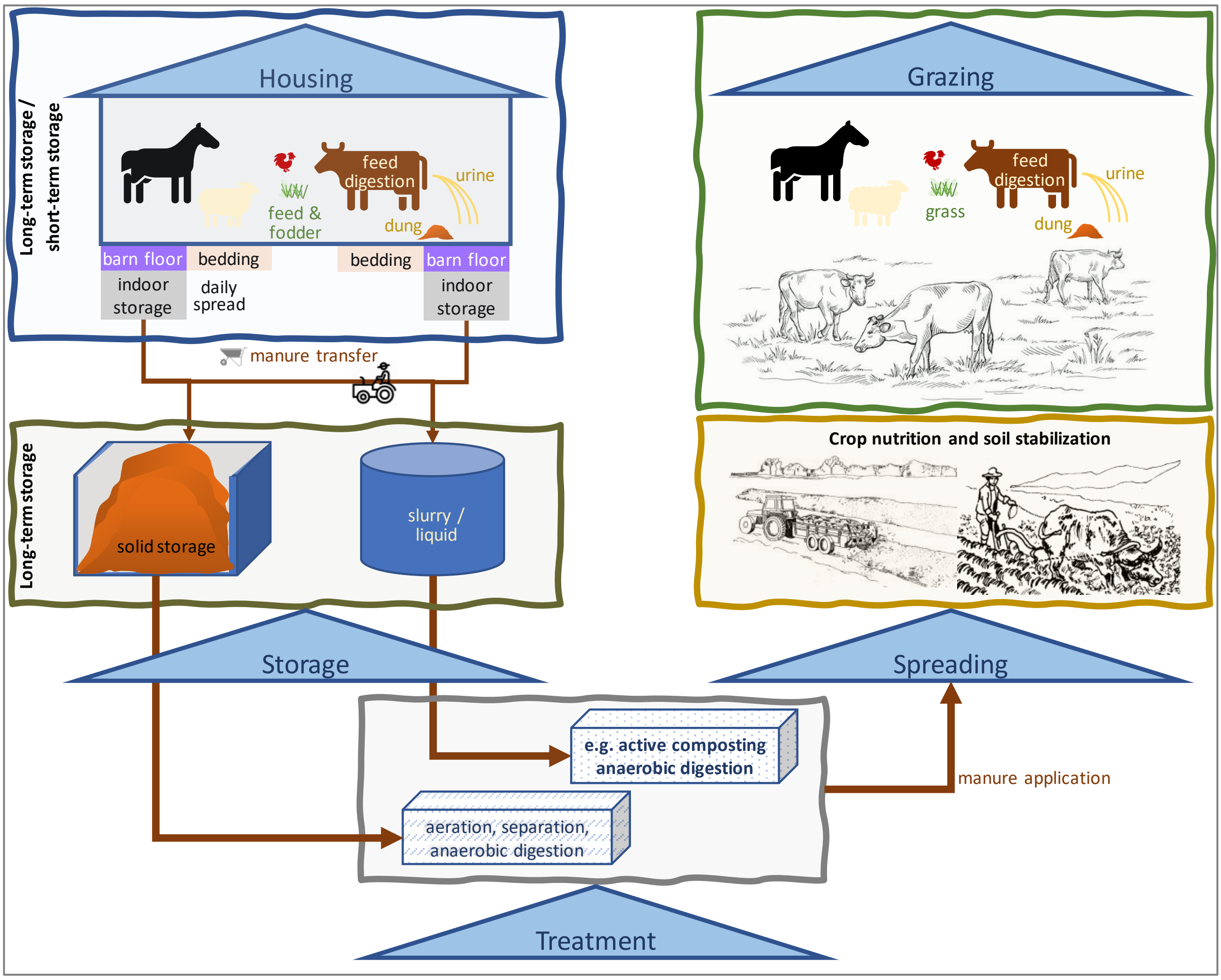


Figure 85 Schematic overview of manure management practices

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.
    - 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 220 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.	-
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.	-

System	Definition	Storage time of manure
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 221 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**	90%	5%	5%	0%	0%	0%	0%	0%	100%
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*

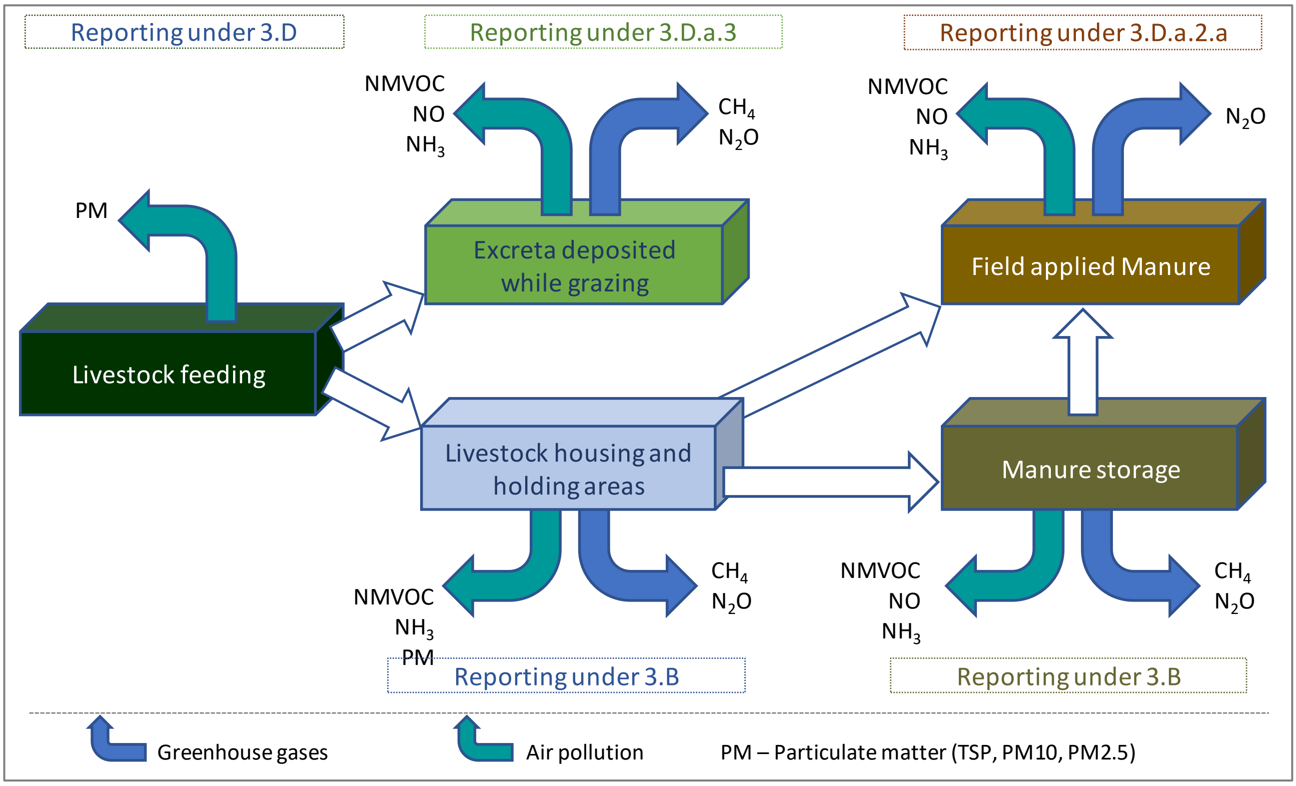


Figure 86 Scheme for emissions resulting from livestock feeding, livestock excreta and manure management

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	NA	-	✓	Without LULUCF: LA 1990, TA	✓	-

IPCC code	description	CO_2		CH_4		N_2O	
		Estimated	Key Category	estimated	Key category	estimated	Key category
					With LULUCF: LA 1990,		
3.B.2.a.i	**Dairy cows**	NA	-	✓	(yes, see cattle)	✓	-
3.B.2.a.ii	**Other cattle**	NA	-	✓	(yes, see cattle)	✓	-
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	-	NO	-
3.B.2.f	**Horses**	NA	-	✓	-	✓	-
3.B.2.g	**Mules and Asses**	NA	-	IE	-	IE	-
3.B.2.h	**Swine**	NA	-	NO	Without LULUCF: LA 1990, TA With LULUCF: LA 1990, TA	NO	-
3.B.2.i	**Poultry**	NA	-	✓	-	✓	-
3.B.2.i.i	**Laying hens**	NA	-	IE	-	IE	-
3.B.2.i.ii	**Broilers**	NA	-	IE	-	IE	-
3.B.2.i.iii	**Turkeys**	NA	-	IE	-	IE	-
3.B.2.i.iv	**Other poultry**	NA	-	IE	-	IE	-
3.B.2.j	**Other (please specify)**	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							

An overview of the methane emissions resulting IPCC category 3.B *Manure Management* is provided in the following figure and tables.

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[69] has been applied.
- direct and indirect N_2O emissions from all livestock the 2006 IPCC Guidelines Tier 1 approach[70] 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.

[69] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10 Emissions from Livestock and Manure Management, sub-chap 10.4.1 Choice of method

[70] Source: 2006 IPCC Guidelines, Volume 4: AFOLU, Chapter 10 Emissions from Livestock and Manure Management, sub-chap 10.5.1 Choice of method

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.

Equation 10.25: Direct N_2O emissions from Manure Management

$$\boldsymbol{Emissions_{N2O} = \left[\sum_S \left[\sum_T \left(N_T \times Nex_{(T)} \times MS_{(T,S)}\right)\right] \times EF_{3(S)}\right] \times \frac{44}{28}}$$

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

$$\boldsymbol{N_{volatilzation-MMS}} = \left[\sum_{\boldsymbol{S}}\left[\sum_{\boldsymbol{T}}\left(\boldsymbol{N_T} \times \boldsymbol{Nex_{(T)}} \times \boldsymbol{MS_{(T,S)}}\right) \times \left(\frac{\boldsymbol{Frac_{GasMS}}}{\boldsymbol{100}}\right)_{(\boldsymbol{T},\boldsymbol{S})}\right]\right]$$

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

$$\boldsymbol{Indirect\ emissions\ N_2O}_{\boldsymbol{manure\ management}} = (\boldsymbol{N}_{\mathrm{volatilization-MMS}} \times \boldsymbol{EF_4}) \times \frac{\boldsymbol{44}}{\boldsymbol{28}}$$

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 Chapter 5.1.1 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)[71]. The agricultural data used and presented in this inventory are taken from the following national and international sources:

- Census of Agriculture[72]
- Statistical yearbook [73]
- FAO agricultural data base[74]

Detailed data and relevant description are provided in Chapter 5.2.2.2.

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 222 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° temperate	**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) temperate	**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[75] and are presented in the following table.

[71] Available (03. Januar 2020) on https://www.monstat.org/eng/index.php

[72] Available (03. Januar 2020) on https://www.monstat.org/eng/page.php?id=58&pageid=58

[73] Available (03. Januar 2020) on http://www.monstat.org/eng/novosti.php?id=2961

[74] Available (03. Januar 2020) on http://www.fao.org/statistics/en/

[75] 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.

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.

Table 223 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*[76]	*calculated*

The direct N_2O emissions are exemplarily calculated in **Error! Reference source not found.** (direct N_2O e missions) applying the default emission factors for direct N_2O emissions from manure management (see Table 224).

Table 224 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

[76] 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)$^{-1}$]
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
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.

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 225 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 Source-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 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 Source-specific recalculations

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.B *Manure management*.

Table 226 Recalculations done since NC & BUR in IPCC sub-category 3.B *Manure management*

GHG source & sink category	Revisions of data ⇒ submission 2020	Type of revision	Type of improvement
3.B	application of 2006 IPCC Guidelines	method	Comparability
3.B	use of CH_4 default emission factor of 2006 IPCC Guidelines	EF	Comparability
3.B	use of N_2O default emission factor (direct emission) of 2006 IPCC Guidelines	EF	Comparability
3.B	use of N_2O default emission factor (indirect emission) of 2006 IPCC Guidelines	EF	Comparability

5.3.6 Source-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 227 Planned improvements for IPCC sub-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: ○ breed, ○ age distribution, ○ weight ○ milk wool yield, ○ wool yield, ○ working hours • characteristics of manure management practice: ○ stall / housed and Housing period ○ pasture/range/paddock (flat/hilly) ○ grazing large areas (flat/hilly) ○ daily spread ○ solid storage ○ dry lot ○ liquid/slurry with/without natural crust cover ○ uncovered anaerobic lagoon ○ pit storage below animal confinements ○ anaerobic digester ○ burned for fuel ○ cattle and swine deep bedding ○ composting ○ 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 esxists in Montenegro.

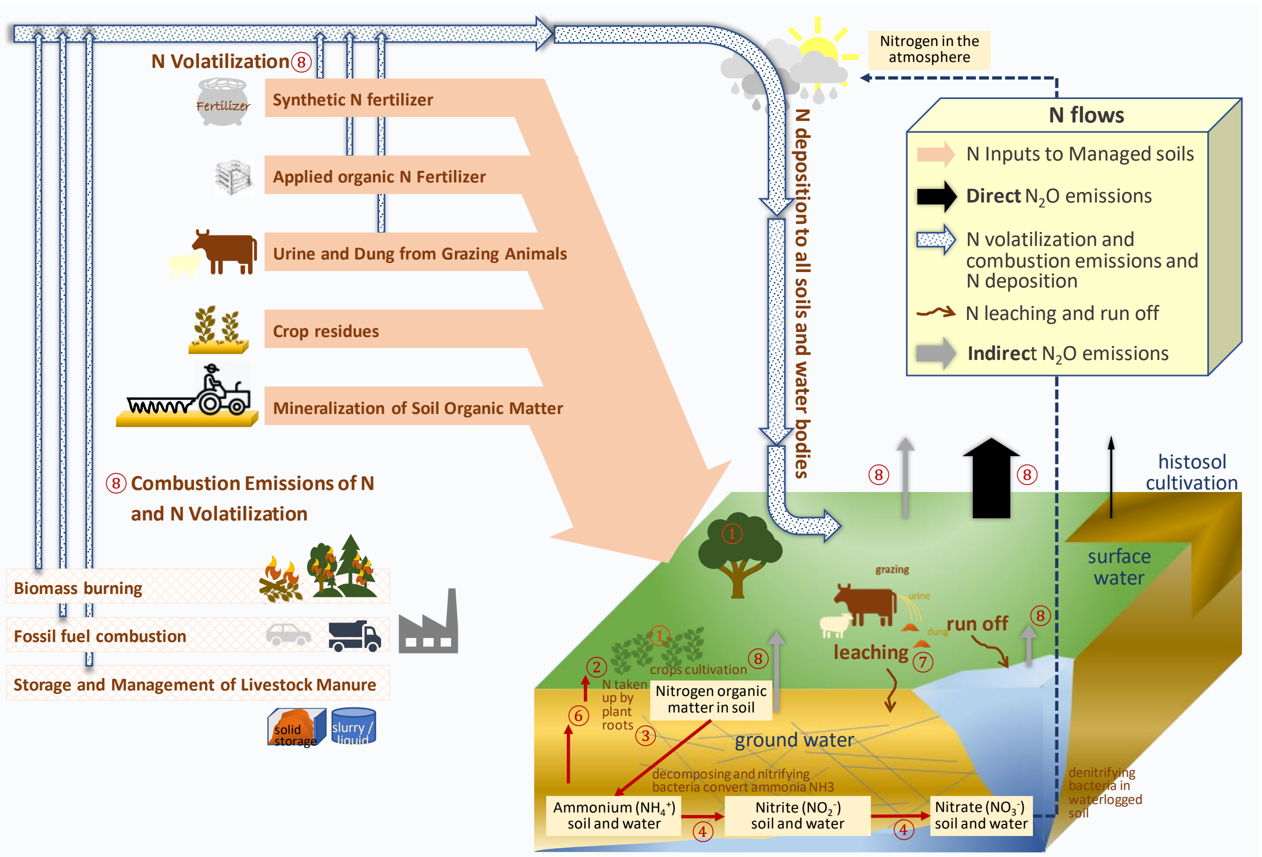
5.5 Agricultural soils (IPCC category 3.D)

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 87 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.

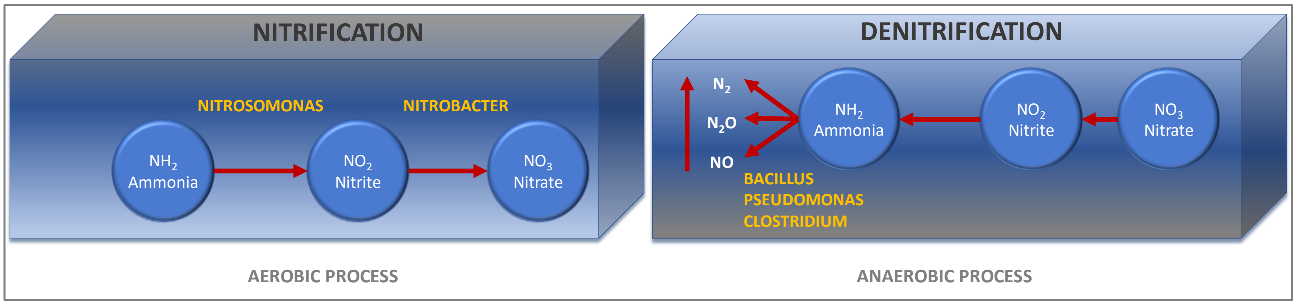


Figure 88 Nitrification and Denitrification

As described in Chapter 5.3 and in Figure 86 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_2O 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.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	NA	-	NA	-	✓	-

IPCC code	Description	Description	CO_2		CH_4		N_2O	
			Estimated	Key Category	estimated	Key category	estimated	Key category
3.D.a.2	Organic N fertilizers	N input from organic N fertilizers to cropland and grassland	NA	-	NA	-	✓	-
3.D.a.2.a	Animal manure applied to soils	N input from manure applied to soils	NA	-	NA	-	✓	-
3.D.a.2.b	Sewage sludge applied to soils	N input from sewage sludge applied to soils	NA	-	NA	-	NE	-
3.D.a.2.c	Other organic fertilizers applied to soils	N input from application of other organic fertilizers	NA	-	NA	-	✓	-
3.D.a.3	Urine and dung deposited by grazing animals	N excretion on pasture, range and paddock	NA	-	NA	-	✓	-
3.D.a.4	Crop residues	N in crop residues returned to soils	NA	-	NA	-	✓	-
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	NA	-	NA	-	NE	-
3.D.a.6	Cultivation of organic soils	Area of cultivated organic soils (i.e. histosols)	NA	-	NA	-	NE	-
3.D.a.7	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	-	✓	-
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	-	✓	-
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								

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	

In the period 1990 – 2019 the N_2O emissions increased. In the period 2005 – 2019 the N_2O emissions increased mainly due to increased

- amount of manure from increased number of livestock,
- amount of inorganic fertilizer,
- area for crop production which implicates increased
    - crop production,
    - crop residues.

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[77] 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

Equation 11.1: Direct N_2O emissions from managed soils (2006 IPCC GL, Vol. 4, Chap. 11)[78]

$$N_2O\ emissions_{direct} - N = N_2O - N_{N\ inputs} + N_2O - N_{OS} + N_2O - N_{PRP}$$

Where

[77] 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.

[78] 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.

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)

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 89
•	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 90

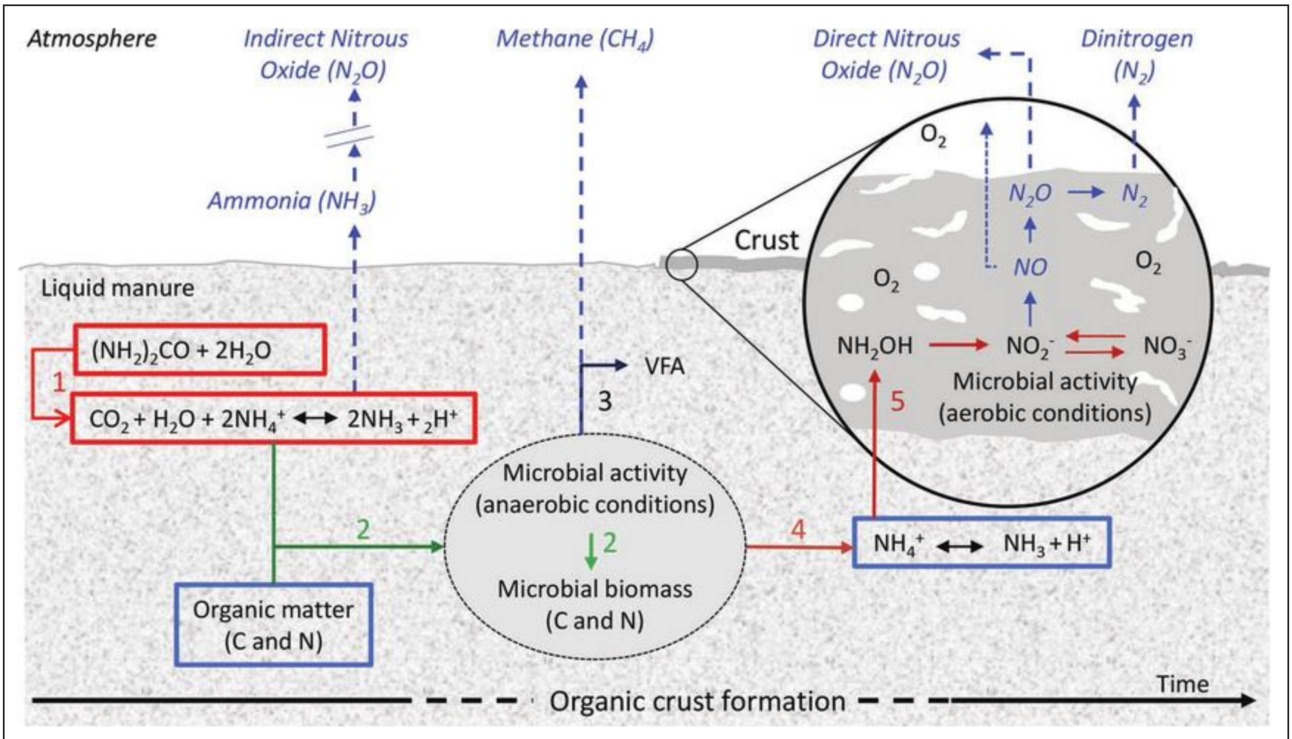


Figure 89 Simplified illustration of N transactions between the atmosphere and liquid manure with emphasis on critical processes involved in the emission of gases

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

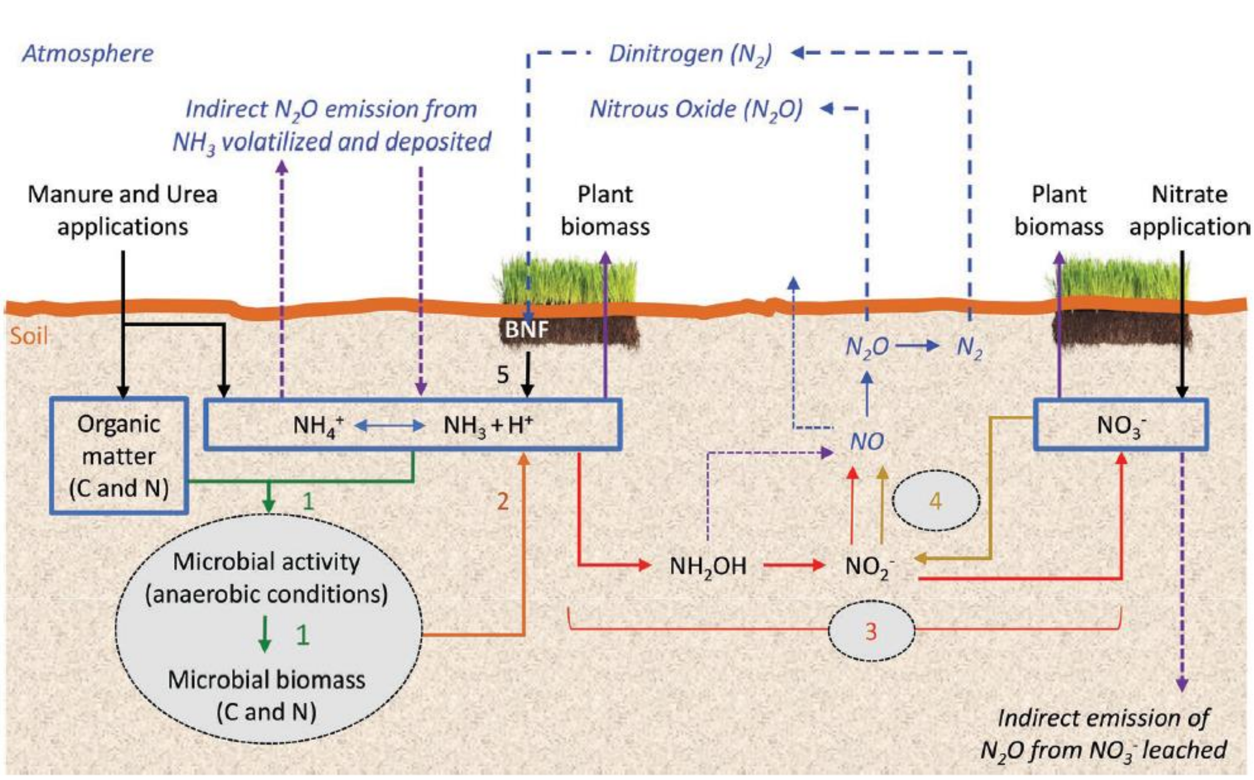


Figure 90 **Simplified illustration of N transactions between the atmosphere and the soil with emphasis on agronomic aspects related to plant fertilization and the reactions involved in the formation and**

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*[78]
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*[78]
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*[78]
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*[78]

5) Area of drained/managed organic soils (F_{OS})	*See above equation 11.1.b*[78]
6) Urine and dung from grazing animals (F_{PRP})	*See above equation 11.1.c*[78]

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[79].

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[80] and are presented in the following table.

Table 228 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)

[79] http://www.fao.org/faostat/en/#data

[80] 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.

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)

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) [78]

$$N_2O - N_{N\ inputs} = [[(F_{SN}) \times EF_1] + [(F_{SN})_{FR} \times EF_{1FR}]] \qquad \textbf{(11.1.a)}$$

$$N_2O\ emissions_{direct} = N_2O - N \times \frac{44}{28}$$

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[81] .

Equation 11.3: N from organic N additions applied to soils (TIER 1) (2006 IPCC GL, Vol. 4, Chap. 11) [81]

$$F_{ON} = F_{AM} + F_{SEW} + F_{COMP} + F_{OOA}$$

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)

[81] 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.

(2006 IPCC GL, Vol. 4, Chap. 11)[82]

$$F_{AM} = N_{MMS\,Avb} \times [1 - (Frac_{Feed} + Frac_{Fuel} + Frac_{CNST})]$$

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[83])*

$Frac_{FEED}$ = 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

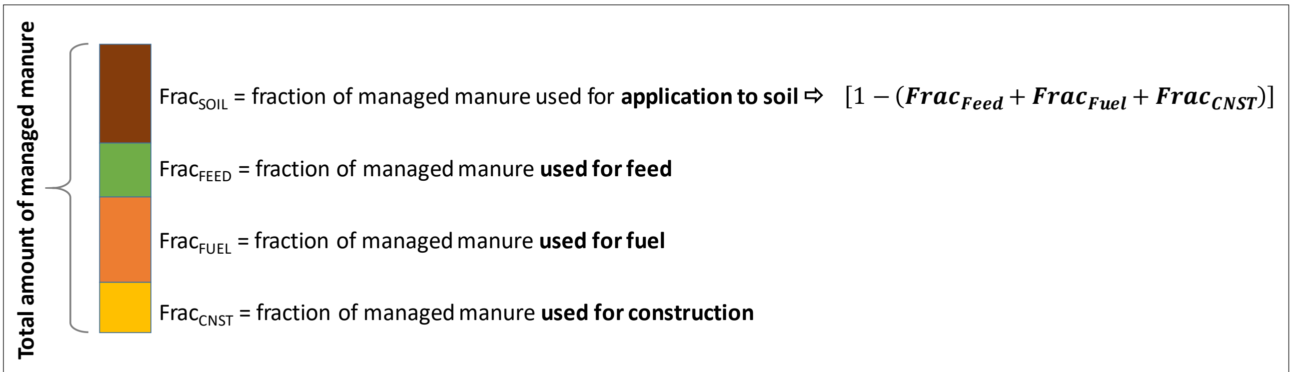


Figure 91 Fraction of of managed animal manure used for different purposes.

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[83].

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

[82] 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.

[83] 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.

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 and are presented in **Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**.

$Nex_{(T)}$ - 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[84], presented in Table 224 and exemplarily calculated in **Error! Reference source not found.** (direct N_2O emissions) in Chapter 5.3.2.

$MS_{(T,S)}$ - 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 220 and is presented in Table 221.

$Frac_{LossMS}$ - 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[85] 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 229 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%

[84] 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.

[85] 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.

Animal type	Manure management system (MMS)	Total N loss from MMS ($Frac_{LossMS}$)

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.

F_{SEW} - Annual amount of total sewage N that is applied to soils

The annual amount of total sewage sludge applied to soils depends on the sewage practices which is quite different between rural and urban regions. Information about amount sewage sludge and related N content was not available. Therefore, this source of nitrogen was not estimated. (See also planned improvements in chapter 5.5.7.)

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 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, V ol. 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.

$R_{BG-BIO(T)}$ = 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 ***Error! Reference source not found.*** *which is based on Table 11.2 of 2006 IPCC GL, V ol. 4, Chapter 11*

$N_{BG(T)}$ = N content of below-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, V ol. 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 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})

In **Error! Reference source not found.** are presented relevant default factors for estimation of N added to s oils 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) [78]

$$N_2O - N_{N\ inputs} = [[(F_{CR}) \times EF_1] + [(F_{CR})_{FR} \times EF_{1FR}]] \qquad \textbf{(11.1.a)}$$

$$N_2O\ emissions_{direct} = N_2O - N \times \frac{44}{28}$$

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[86], 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[87]), the Tier 1 method can be applied in 3 steps:

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[87]
(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)

[86] 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

[87] 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.

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[88]:

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}).

[88] 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 230 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 228	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 and are presented in **Error! Reference source not found.**, **Error! Reference source not fo und.**, **Error! Reference source not found.**.

$Nex_{(T)}$ - 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[89], presented in Table 224 and exemplarily calculated in **Error! Reference source not found.** (direct N_2O emissions) in Chapter 5.3.2.

$MS_{(T,PRP)}$ - 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 220 and is presented in Table 221.

[89] 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)

$$N_2O - N_{N\,inputs} = [[(F_{PRP}) \times EF_1] + [(F_{PRP})_{FR} \times EF_{1FR}]] \qquad \textbf{(11.1.a)}$$

$$N_2O\ emissions_{direct} = N_2O - N \times \frac{44}{28}$$

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 231 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.

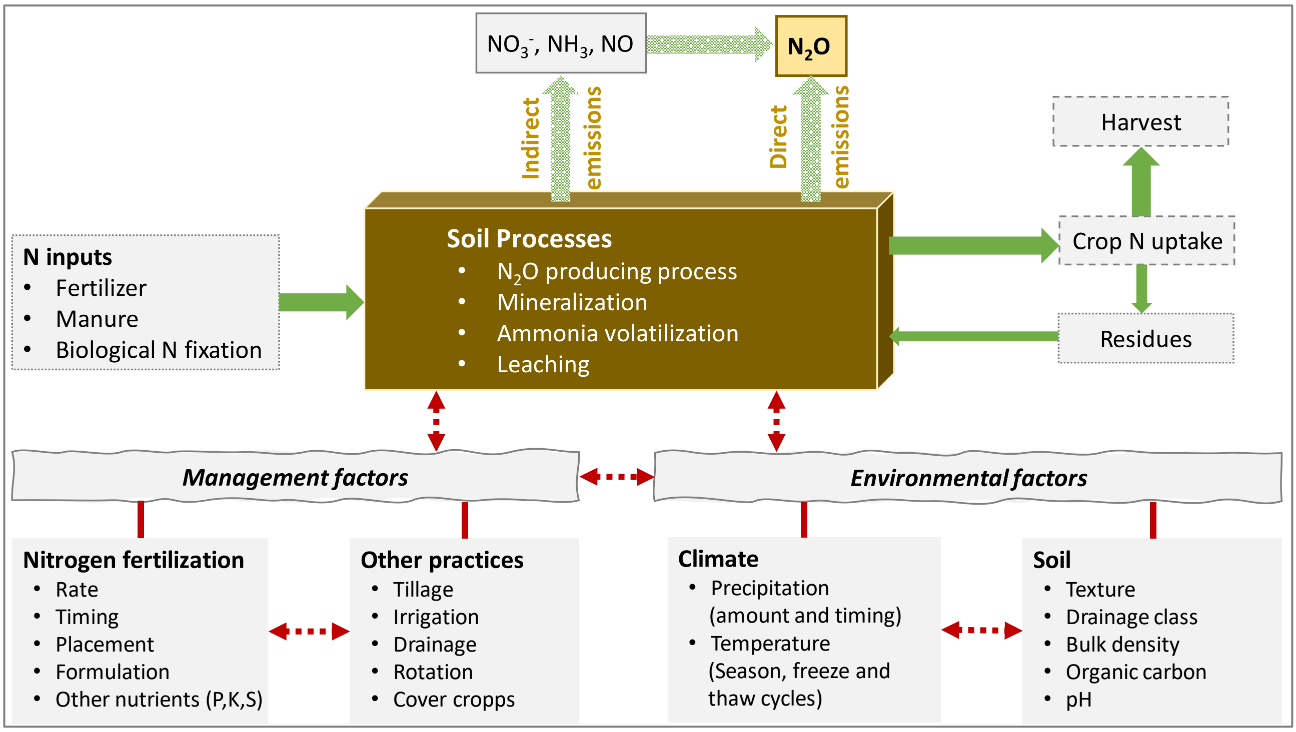


Figure 92 Factors influencing direct and indirect emissions of N_2O from agricultural soils

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 92). 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 87).

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[90] 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)

$$\boldsymbol{N_2O_{(ATD)} - N = \left[(F_{SN} \times Frac_{GASF}) + \left((F_{ON} \times Frac_{PRP}) \times Frac_{GASF}\right)\right] \times EF_4}$$

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)$^{-1}$])

[90] 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[91] 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 232

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 232 in

[91] 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 232 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 233 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 Source-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 Source-specific recalculations

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 234 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 2006 IPCC Guidelines	method	Comparability
3.D.a	use of N_2O default emission factor (direct emission) of 2006 IPCC Guidelines	EF	Comparability
3.D.b	use of N_2O default emission factor (indirect emission) of 2006 IPCC Guidelines	EF	Comparability

5.5.7 Source-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 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,	AD	Accuracy Consistency Transparency	high

GHG source & sink category	Planned improvement	Type of improvement		Priority
	• 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			
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	-	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							

5.6.1 Source-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 236 Planned improvements for IPCC sub-category 3.F Field burning of agricultural residues

GHG source & sink category	Planned improvement	Type of improvement		Priority
3.E	Analysis of relevant activity data regarding prescribed fires and wildfires and estimation of emissions	AD	Accuracy Consistency Comparability Transparency Completeness	high

5.7 Field burning of agricultural residues (IPCC category 3.F)

Crop residues 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 2019.

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							

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[92] 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)

$$Emissions_{GHG} = \sum AD_{burnt} \times \frac{EF_{GHG}}{1000} \times Frac_{oxidized}$$

with

$$AD_{burnt} = \sum_{T} (production_T \times DRY \times \mathrm{Res}_O \times Frac_{burnt})$$

with

$$EF_{CH4} = C\ Fraction_{residue\ T} \times emission\ ratio \times \frac{16}{12}$$

[92] 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

$$EF_{N2O} = C\ Fraction_{residue\ T} \times (N/C\ ratio) \times emission\ ratio \times \frac{44}{28}$$

Where:

Emissions $_{GHG,\ fuel}$	= emissions of a given GHG by type of crop (Gg GHG)
GHG	= CH_4, N_2O
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_O	= Residue/Crop Ratio (unitless)
$Frac_{burnt}$	= 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 **Error! Reference source not found.** is provided an exemplary calculation of CH_4 and N_2O emissions from *F ield burning of agricultural residues* (TIER 1) from wheat.

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[93]

In the following Figures and Tables are provided the data on cultivated and harvested crops presented.

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 and (3) Fraction of Crop Residue Burnt in Fields were used and presented in the following Table.

[93] Available (03. March 2019) on http://www.fao.org/faostat/en/#data/QC

Table 237 **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.[94] * 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.[95]	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.[96]

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 analyzes emissions from much more crops.

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:

[94] https://www.ipcc-nggip.iges.or.jp/public/gp/english/4_Agriculture.pdf

[95] https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch11_Soils_N2O_CO2.pdf

[96] https://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/CH4ref6.pdf

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

As described in the *Reference Manual* of the *Revised 1996 IPCC Guidelines*, the emissions of CH_4, CO, N_2O, and NOx can be calculated based on emission ratios.

> The amount of carbon released due to burning is multiplied by the emission ratios of CH_4 and CO relative to total carbon to yield emissions of CH_4 and CO (each expressed in units of C). The emissions of CH_4 and CO are multiplied by 16/12 and 28/12, respectively, to convert to full molecular weights.
>
> To calculate emissions of N_2O and NOx, first the total carbon released is multiplied by the estimated N-C ratio of the fuel by weight to yield the total amount of nitrogen (N) released. The total N released is then multiplied by the ratios of emissions of N_2O and NOx relative to the N content of the fuel to yield emissions of N_2O and NOx (expressed in units of N). To convert to full molecular weights, the emissions of N_2O and NOx are multiplied by 44/28 and 46/14, respectively.

Default values of emission ratios are presented in the following table.

Table 238 **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. [97]

Data on carbon content and nitrogen content of residues and the nitrogen-carbon ratio in biomass residues are provided in the following table.

Table 239 **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

[97] 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)
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
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.[98]	Table 4.19, 1996 IPCC GL, Reference Manual, Vol. 3, Chap, 4.4.3 Field Burning of Agricultural Residues, page 4.83.[99]	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 240 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 Source-specific QA/QC and verification

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

⇒ Checked of calculations by spreadsheets
- consistent use of data on area under crop cultivation (statistical yearbook and FAOstat),
- 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,

[98] https://www.ipcc-nggip.iges.or.jp/public/gp/english/4_Agriculture.pdf
[99] https://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/CH4ref6.pdf

  - 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)

⇒ consistency and completeness checks are performed;

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

5.7.5 Source-specific recalculations

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.F Field burning of agricultural residues.

Table 241 Recalculations done since NC & BUR in IPCC sub-category 3.F Field burning of agricultural residues

GHG source & sink category	Revisions of data in NC & BUR ⇒ GHG inventory submission 2020	Type of revision	Type of improvement
3.F	application of 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 Source-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 242 Planned improvements for IPCC sub-category 3.F Field burning of agricultural residues

GHG source & sink category	Planned improvement	Type of improvement		Priority
3.F	Correction of technical mistakes in calculation	AD	Accuracy	high
3.F	Consideration of cultivated crops and crop residues which are burnt and if possible, by provinces • 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[100] (Emissions – Agriculture) where emissions from crop residues were estimated		Consistency	medium

[100] 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).

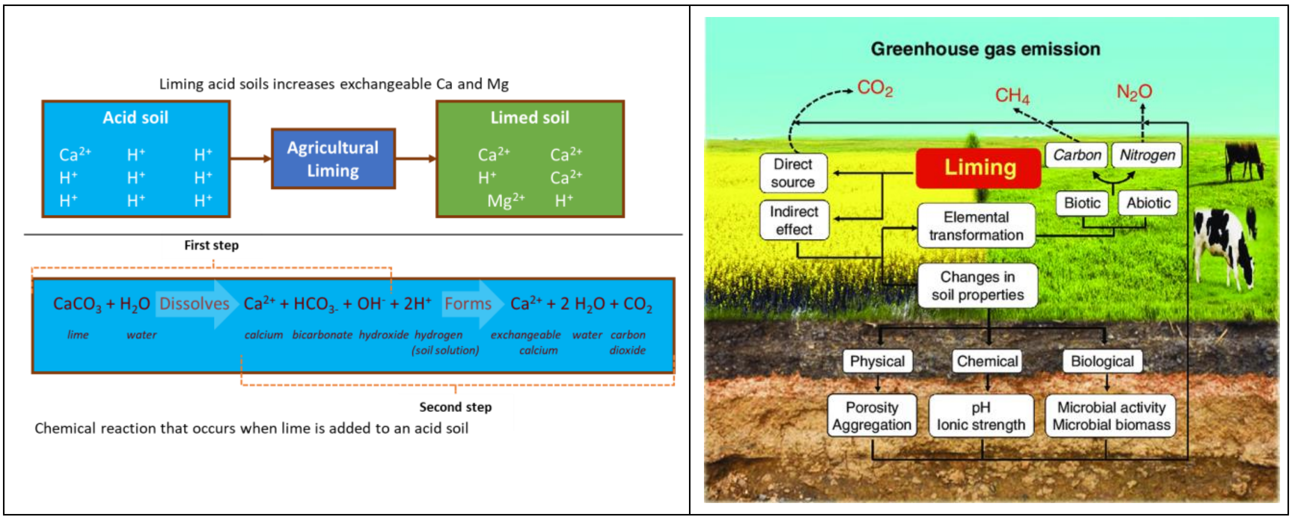


Figure 93 Conceptual flow diagram showing the effect of liming on greenhouse gases

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	-	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.

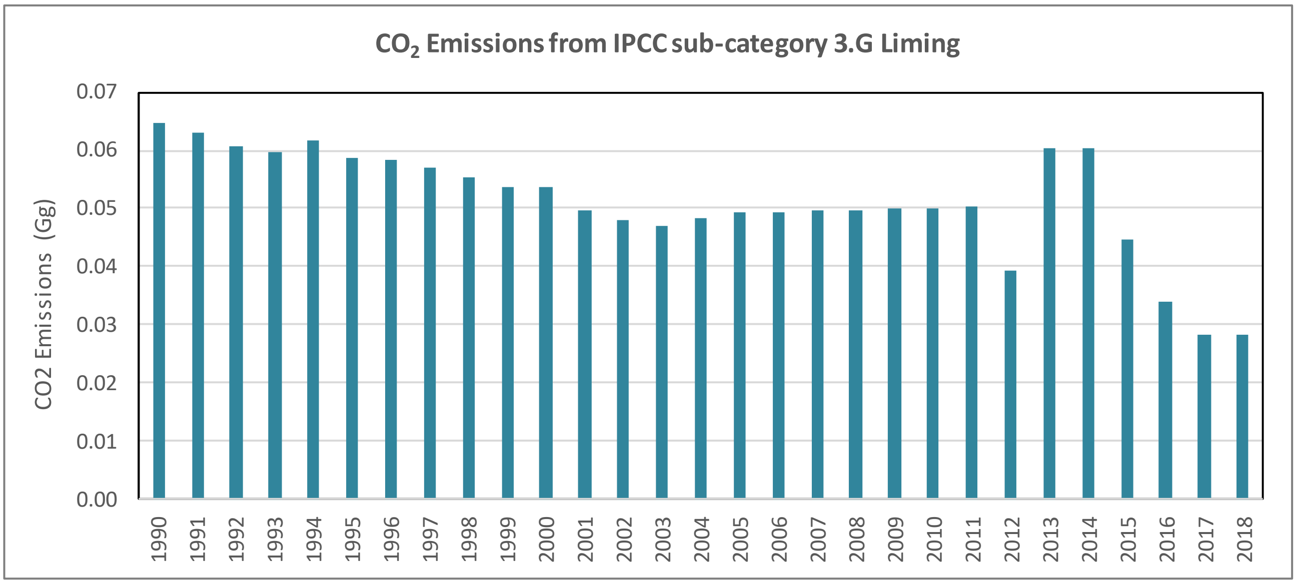


Figure 94 CO_2 Emissions from IPCC sub-category 3.G Liming

Table 243 GHG Emissions from IPCC category 3.G Liming

GHG emissions	TOTAL GHG	CO_2	CH_4	N_2O	CH_4	N_2O
	Gg CO2 equivalent	Gg	Gg CO2 equivalent	Gg CO2 equivalent	Gg	Gg
1990	0.065	0.065	NA	NA	NA	NA
1991	0.063	0.063	NA	NA	NA	NA
1992	0.061	0.061	NA	NA	NA	NA
1993	0.060	0.060	NA	NA	NA	NA
1994	0.062	0.062	NA	NA	NA	NA
1995	0.059	0.059	NA	NA	NA	NA
1996	0.058	0.058	NA	NA	NA	NA
1997	0.057	0.057	NA	NA	NA	NA
1998	0.055	0.055	NA	NA	NA	NA
1999	0.054	0.054	NA	NA	NA	NA
2000	0.054	0.054	NA	NA	NA	NA
2001	0.050	0.050	NA	NA	NA	NA
2002	0.048	0.048	NA	NA	NA	NA
2003	0.047	0.047	NA	NA	NA	NA
2004	0.048	0.048	NA	NA	NA	NA
2005	0.049	0.049	NA	NA	NA	NA
2006	0.049	0.049	NA	NA	NA	NA
2007	0.050	0.050	NA	NA	NA	NA
2008	0.050	0.050	NA	NA	NA	NA
2009	0.050	0.050	NA	NA	NA	NA
2010	0.050	0.050	NA	NA	NA	NA
2011	0.050	0.050	NA	NA	NA	NA
2012	0.039	0.039	NA	NA	NA	NA
2013	0.060	0.060	NA	NA	NA	NA

GHG emissions	TOTAL GHG	CO_2	CH_4	N_2O	CH_4	N_2O
	Gg CO2 equivalent	Gg	Gg CO2 equivalent	Gg CO2 equivalent	Gg	Gg
2014	0.060	0.060	NA	NA	NA	NA
2015	0.045	0.045	NA	NA	NA	NA
2016	0.034	0.034	NA	NA	NA	NA
2017	0.028	0.028	NA	NA	NA	NA
2018	0.028	0.028	NA	NA	NA	NA
2019	0.028	0.028	NA	NA	NA	NA
Trend						
1990 - 2019	*-56%*	*-56%*	*NA*	*NA*	*NA*	*NA*
2005 - 2019	*-43%*	*-43%*	*NA*	*NA*	*NA*	*NA*
2018 - 2019	*0%*	*0%*	*NA*	*NA*	*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[101] 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

- calcic limestone ($CaCO_3$)
- 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

5.8.2.2 Choice of activity data

The amount of lime applied to soil is presented in the following tables.

Table 244 Activity data of IPCC category 3.G Liming

	Agricultural area	Area with lime application	Limestone $CaCO_3$	Dolomite $CaMg(CO_3)_2$	Total amount of lime categories applied
	ha	ha	Mg	Mg	Mg
1990			147.12	NO	147.12
1991			143.35	NO	143.35

[101] 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

	Agricultural area	Area with lime application	Limestone $CaCO_3$	Dolomite $CaMg(CO_3)_2$	Total amount of lime categories applied
	ha	ha	Mg	Mg	Mg
1992			138.06	NO	138.06
1993			135.9	NO	135.9
1994			139.91	NO	139.91
1995			133.32	NO	133.32
1996			132.25	NO	132.25
1997			129.91	NO	129.91
1998			126.04	NO	126.04
1999			122.27	NO	122.27
2000			122.05	NO	122.05
2001			112.9	NO	112.9
2002			109.23	NO	109.23
2003			107.08	NO	107.08
2004			109.64	NO	109.64
2005			111.94	NO	111.94
2006			112	NO	112
2007			112.8	NO	112.8
2008			112.9	NO	112.9
2009			113.91	NO	113.91
2010			113.49	NO	113.49
2011			114.24	NO	114.24
2012			89.5	NO	89.5
2013			136.8	NO	136.8
2014			136.8	NO	136.8
2015			101.5	NO	101.5
2016			77.4	NO	101.5
2017			64.1	NO	101.5
2018			64.1	NO	101.5
2019			64.1	NO	101.5
Trend					
1990-2019			*-56%*	*NA*	*-56%*
2005-2019			*-43%*	*NA*	*-43%*
2018-2019			*0%*	*NA*	*0%*

5.8.2.3 Choice of emission factors

For the Tier 1 approach the default emission factors (EF), provided by the 2006 IPCC GL[102], 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 245 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%	-	-	Expert judgment on Chapter 11.3.4
Emission factor (EF)	50%	-	-	Expert judgment on Chapter 11.3.4
Combined Uncertainty	54%	-	-	$U_{Total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

5.8.4 Source-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.

⇒ consistency and completeness checks are performed;

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

5.8.5 Source-specific recalculations

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.G Liming.

Table 246 Recalculations done since NC & BUR in IPCC sub-category 3.G Liming

GHG source & sink category	Revisions of data in NC & BUR ⇒ GHG inventory submission 2020	Type of revision	Type of improvement
3.G	No recalculation		

5.8.6 Source-specific planned improvements

Considering the potential contribution of identified improvements in the total GHG emissions and the

[102] 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

corresponding resources needed to make these improvements effective, developments presented in following table will be explored.

Table 247 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 applicatio*.

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.

$$(1)\ \underset{\text{Urea}}{CO(NH_2)_2} + \underset{\text{Water}}{2H_2O} \xrightarrow{\text{Urease enzyme}} \underset{\text{Ammonium carbonate}}{(NH_4)_2CO_3}$$

$$(2)\ \underset{\text{Ammonium carbonate}}{(NH_4)_2CO_3} + 2H^+ \longrightarrow \underset{\text{Ammonium}}{2NH_4} + \underset{\text{Carbon dioxide}}{CO_2\uparrow} + \underset{\text{Water}}{2H_2O}$$

$$(3)\ \underset{\text{Ammonium Hydroxide}}{NH_4 + OH^+} \longrightarrow \underset{\text{Ammonia}}{Ca(NO_3)_2} + \underset{\text{Water}}{H_2O}$$

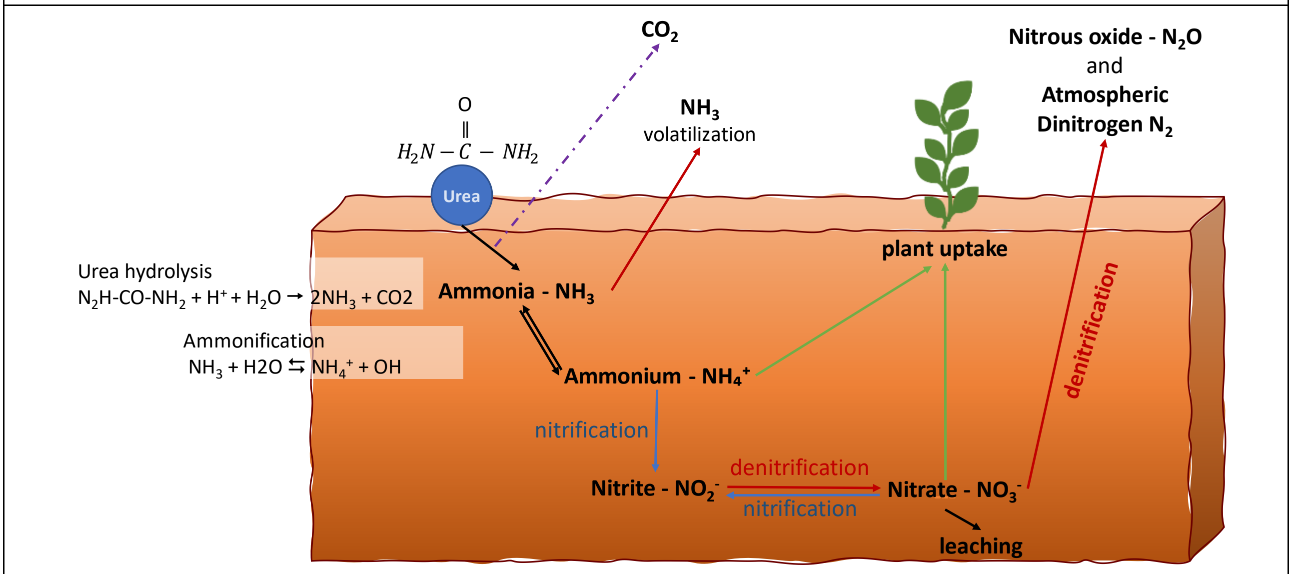


Figure 95 Urea hydrolysis reaction (equation)

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							

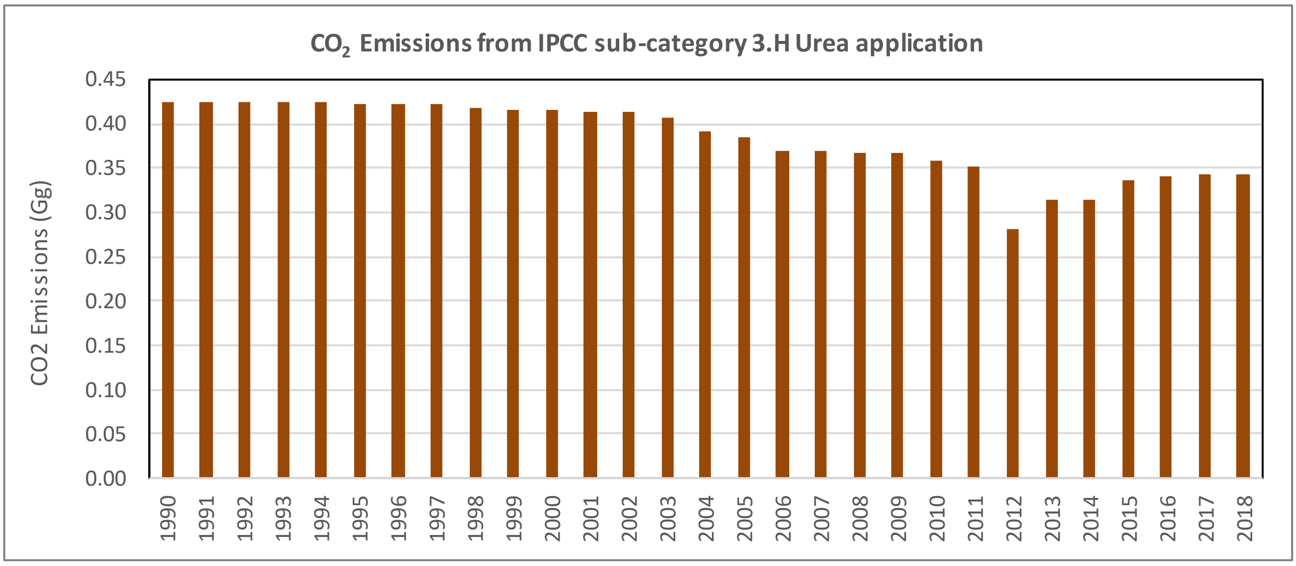


Figure 96 CO_2 Emissions from IPCC sub-category 3.H Urea application

Table 248 Annual amount of urea applied, emission factor and CO_2 emissions from IPCC category 3.H Urea application

	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		0.093	0.343		
Trend						
1990 - 2018	*-19.4%*	*NA*	*-19.4%*	*-19.4%*	-	-
2005 - 2018	*-10.8%*	*NA*	*-10.8%*	*-10.8%*	-	-
2017 - 2018	*0.0%*	*NA*	*0.0%*	*0.0%*	-	-
Source	FaoSTAT-Fertilizers by Product[103] P as of 2016	2006 IPCC GL, Vol. 4, Chap. 11, sub-chap. 11.4.2, page 11.34.	Equation 11.13, 2006 IPCC GL, Vol. 4, Chap. 11, sub-chap. 11.4.1, page 11.32.	Multiplication by 44/12 to convert CO_2–C emissions into CO_2 according to 2006 IPCC GL	Tier 1 (T1)	Default (D)

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[104] has been applied.

Equation 11.13: CO_2 emissions from urea application (2006 IPCC GL, Vol. 4, Chap. 11)

$$\boldsymbol{CO_2 - C\ emission = AD \times EF}$$

$$\boldsymbol{CO_2\ emissions = \frac{CO_2O - C \times \frac{44}{12}}{1000}}$$

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
1000	= conversion factor from tonnes to Gg

[103] FAO (2020): Available on 18.02.2020 at: http://www.fao.org/faostat/en/#data/RFB

[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. 11.4.1, 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[Error! Bookmark not defined.]

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 = production + import – 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 249 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 250 Uncertainty for IPCC sub-category 3.D Urea application .

Uncertainty	CO_2	CH_4	N_2O	Reference
Activity data (AD)	10%	-	-	Table 2.15 and Table 3.1, 2006 IPCC GL, Vol. 2, Chap. 2 (2.4.2)
Emission factor (EF)	50%	-	-	Chapter 11.4.4, 2006 IPCC GL, Vol. 4, Chap. 11
Combined Uncertainty	51%	-	-	$U_{Total} = \sqrt{U_{AD}^2 + U_{EF}^2}$

5.9.4 Source-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)

⇒ consistency and completeness checks are performed using the tools embedded in IPCC Software;

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

5.9.5 Source-specific recalculations

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.H Urea application .

Table 251 Recalculations done since submission 2017 IPCC category 3.H Urea application

GHG source & sink category	Revisions of data in NC & BUR ⇒ GHG inventory submission 2020	Type of revision	Type of improvement
3.H	No recalculation	-	-

5.9.6 Source-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 sub-category 3.C 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							

This source category 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							

This source category 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 Table 253 reports, LULUCF is a significant sector in the Montenegrin GHG balance with total sector net GHG removals ranging from 716 kt CO_2eq (in 2011) to 2,827 kt CO_2eq (in 2011). 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 (Table 254). 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 2019, Forest land contributed net removals of 2,424kt CO_2eq. The next most significant subcategories are Harvested Wood Products and Settlements, which in 2019 contributed removals of -139.6 kt CO_2eq and emissions of 59.8 kt CO_2eq, respectively.

Table 253 Total net emissions/removals (in kt CO_2eq) of the sector LULUCF and its main categories

GHG emissions	4	4.A	4.B	4.C	4.D	4.E	4.F	4.G
	Total LULUCF	Total Forest land	Total Cropland	Total Grassland	Total Wetlands	Total Settlements	Total Other land	Harvested Wood Products
	Gg CO_2 equivalent							
1990	-1,589.84	-1,575.29	0.04	0.00	0.00	20.84	7.87	-43.31
1991	-1,935.08	-1,941.73	0.04	0.00	0.00	20.84	7.87	-22.10
1992	-1,532.30	-1,555.78	0.04	0.00	0.00	20.84	7.87	-5.28
1993	-2,224.80	-2,262.12	0.04	0.00	0.00	20.84	7.87	8.57
1994	-1,747.66	-1,787.11	0.04	0.00	0.00	20.84	7.87	10.70
1995	-1,625.64	-1,659.21	0.04	0.00	0.00	20.84	7.87	4.82
1996	-1,831.95	-1,874.22	0.04	0.00	0.00	20.84	7.87	13.52
1997	-2,585.90	-2,638.99	0.04	0.00	0.00	20.84	7.87	24.34
1998	-2,679.50	-2,732.21	0.04	0.00	0.00	20.84	7.87	23.97
1999	-2,622.87	-2,672.35	0.04	0.00	0.00	20.84	7.87	20.73
2000	-2,068.71	-2,106.62	0.04	0.00	0.00	20.84	7.87	9.16
2001	-2,589.50	-2,636.50	0.04	0.00	0.00	20.84	7.87	18.25
2002	-2,765.54	-2,801.59	0.04	0.00	0.00	20.84	7.87	7.30
2003	-2,645.18	-2,665.64	0.04	0.00	0.00	20.84	7.87	-8.29
2004	-2,663.88	-2,665.72	0.04	0.00	0.00	20.84	7.87	-26.91
2005	-2,460.94	-2,484.11	0.04	0.00	0.00	20.84	7.87	-5.58
2006	-2,112.43	-2,175.87	0.04	0.00	0.00	20.84	7.87	34.69
2007	-1,876.34	-1,948.28	0.59	0.37	0.00	35.10	1.92	33.97
2008	-2,293.47	-2,346.63	0.64	0.35	0.00	35.77	1.92	14.48
2009	-2,827.94	-2,891.74	0.70	0.33	0.00	36.43	1.92	24.41
2010	-2,524.25	-2,588.33	0.76	0.31	0.00	37.10	1.92	23.98
2011	-716.71	-678.81	0.82	0.29	0.00	37.77	1.92	-78.70
2012	-2,071.68	-2,089.16	0.88	0.27	0.00	38.44	1.92	-24.02
2013	-2,419.27	-2,428.57	0.52	-0.44	0.00	53.15	0.00	-43.94

GHG emissions	4	4.A	4.B	4.C	4.D	4.E	4.F	4.G
	Total LULUCF	Total Forest land	Total Cropland	Total Grassland	Total Wetlands	Total Settlements	Total Other land	Harvested Wood Products
	Gg $_{CO_2\ equivalent}$							
2014	-2,506.41	-2,485.77	0.54	-0.53	0.00	54.26	0.00	-74.92
2015	-2,374.14	-2,324.17	0.57	-0.62	0.00	55.37	0.00	-105.29
2016	-2,369.87	-2,321.73	0.59	-0.72	0.00	56.49	0.00	-104.50
2017	-1,809.24	-1,721.35	0.61	-0.81	0.00	57.60	0.00	-145.28
2018	-2,456.24	-2,372.25	0.64	-0.90	0.00	58.71	0.00	-142.43
2019	-2,503.93	-2,423.78	0.66	-0.99	0.00	59.82	0.00	-139.64
Trend								
1990 - 2019	*57.5%*	*53.9%*	*1462.3%*	*-99.3%*	*0.0%*	*187.1%*	*-100.0%*	*222.4%*
2005 - 2019	*1.7%*	*-2.4%*	*1462.3%*	*-99.3%*	*0.0%*	*187.1%*	*-100.0%*	*2401.1%*
2017 - 2019	*1.9%*	*2.2%*	*3.6%*	*10.3%*	*0.0%*	*1.9%*	*0.0%*	*-2.0%*

Table 254 Total net emissions/removals per gas

	Total LULUCF					
	GHG	CO_2	CH_4	CH_4	N_2O	N_2O
	Gg $_{CO_2\ equivalent}$	kt	kt	kt $_{CO_2\ equivalent}$	kt	kt $_{CO_2\ equivalent}$
1990	-1,589.84	-1,593.96	0.07	1.68	0.01	2.45
1991	-1,935.08	-1,937.75	0.06	1.60	0.01	3.74
1992	-1,532.30	-1,538.72	0.24	6.12	0.02	6.72
1993	-2,224.80	-2,230.84	0.23	5.66	0.02	6.42
1994	-1,747.66	-1,751.18	0.10	2.62	0.01	4.41
1995	-1,625.64	-1,631.82	0.23	5.84	0.02	6.53
1996	-1,831.95	-1,838.67	0.26	6.48	0.01	3.48
1997	-2,585.90	-2,588.70	0.07	1.76	0.01	3.85
1998	-2,679.50	-2,686.89	0.29	7.30	0.03	7.49
1999	-2,622.87	-2,624.70	0.02	0.59	0.01	3.07
2000	-2,068.71	-2,099.01	1.40	34.91	0.09	25.70
2001	-2,589.50	-2,592.68	0.09	2.21	0.01	4.14
2002	-2,765.54	-2,768.42	0.07	1.86	0.01	3.91
2003	-2,645.18	-2,661.95	0.74	18.59	0.05	14.94
2004	-2,663.88	-2,670.53	0.26	6.40	0.02	6.91
2005	-2,460.94	-2,462.68	0.02	0.48	0.01	3.00
2006	-2,112.43	-2,114.58	0.04	0.98	0.01	3.33
2007	-1,876.34	-1,948.44	3.41	85.19	0.20	59.01
2008	-2,293.47	-2,308.96	0.68	16.88	0.05	14.11
2009	-2,827.94	-2,829.84	0.02	0.41	0.01	3.39
2010	-2,524.25	-2,528.57	0.13	3.23	0.02	5.40
2011	-716.71	-907.62	9.12	228.04	0.52	153.79

	Total LULUCF					
	GHG	CO_2	CH_4	CH_4	N_2O	N_2O
	Gg CO_2 equivalent	kt	kt	kt CO_2 equivalent	kt	kt CO_2 equivalent
2012	-2,071.68	-2,094.84	1.03	25.77	0.07	20.56
2013	-2,419.27	-2,421.82	0.03	0.80	0.01	4.31
2014	-2,506.41	-2,508.65	0.01	0.29	0.01	4.20
2015	-2,374.14	-2,388.32	0.58	14.54	0.05	13.81
2016	-2,369.87	-2,376.34	0.20	5.12	0.03	7.82
2017	-1,809.24	-1,893.48	3.95	98.72	0.23	69.77
2018	-2,456.24	-2,471.87	0.64	15.90	0.05	15.38
2019	-2,503.93	-2,511.01	0.22	5.44	0.03	8.70
Trend						
1990 - 2019	*57.5%*	*57.5%*	*225.0%*	*225.0%*	*255.8%*	*255.8%*
2005 - 2019	*1.7%*	*2.0%*	*1035.9%*	*1035.9%*	*190.1%*	*190.1%*
2017 - 2019	*1.9%*	*1.6%*	*-65.8%*	*-65.8%*	*-43.4%*	*-43.4%*

6.1.1 Emission trends

The sink strength of the LULUCF sector has increased by 55% between 1990 (-1589 kt CO_2eq) and 2019 (-2456 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 (Figure 97). 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 98). 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.

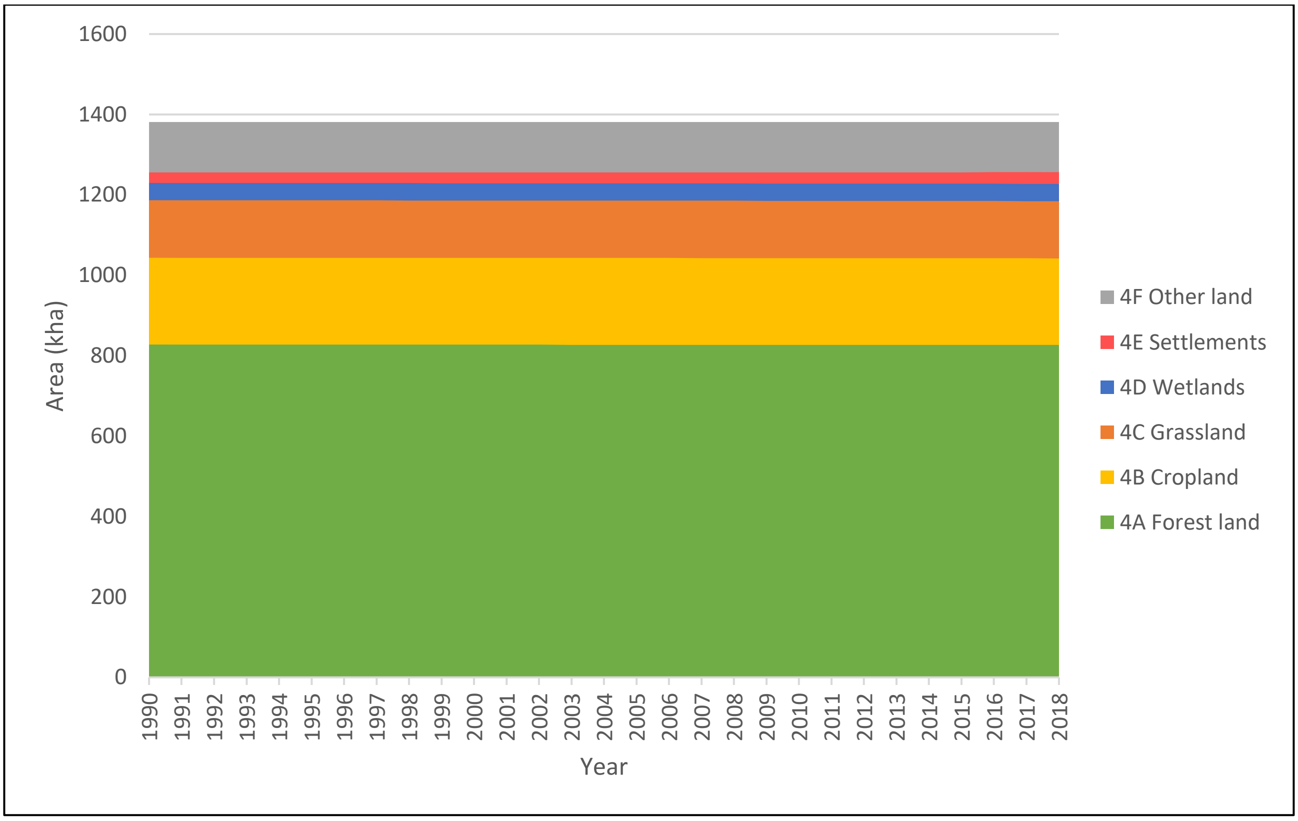


Figure 97 Areas of main land use categories in 1000 ha (kha)

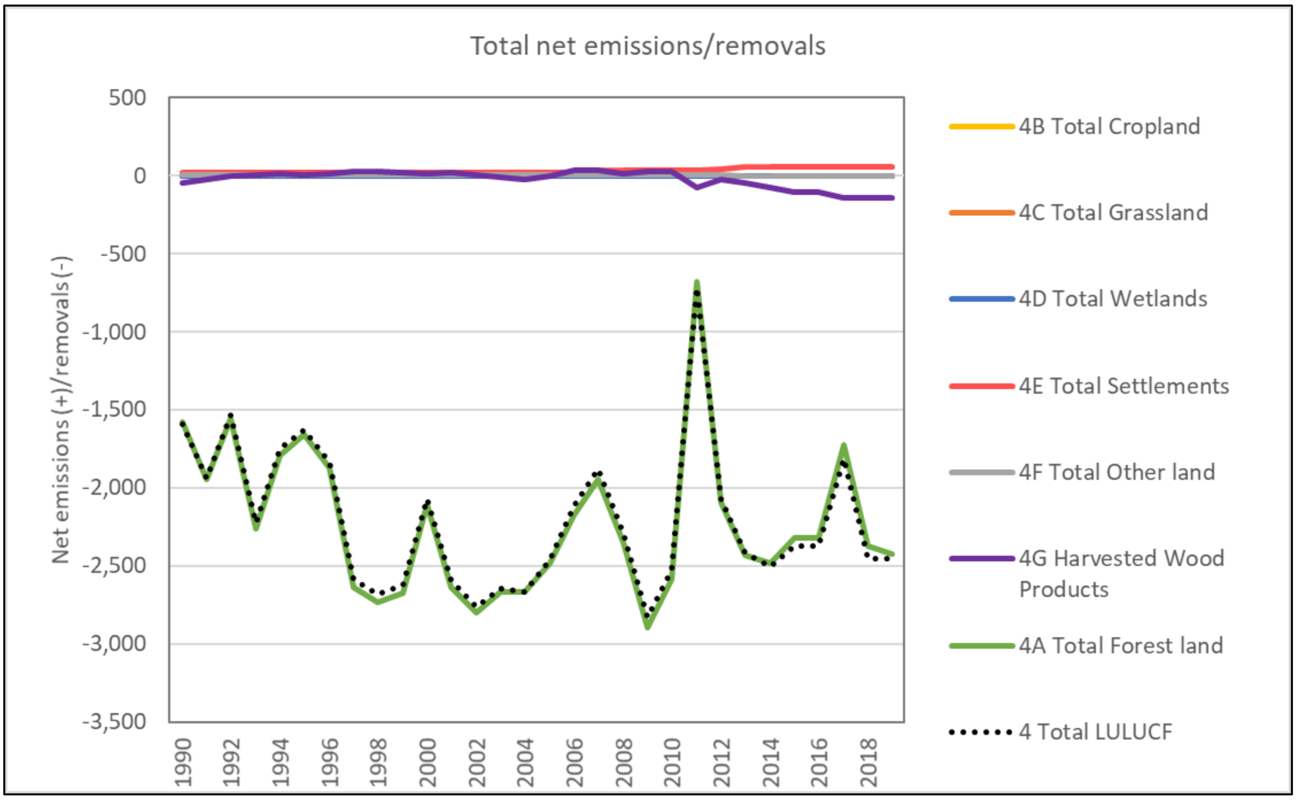


Figure 98 Total net emissions/removals (in kt CO_2eq) of the sector LULUCF and its main categories

Beyond Forest land and 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 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.

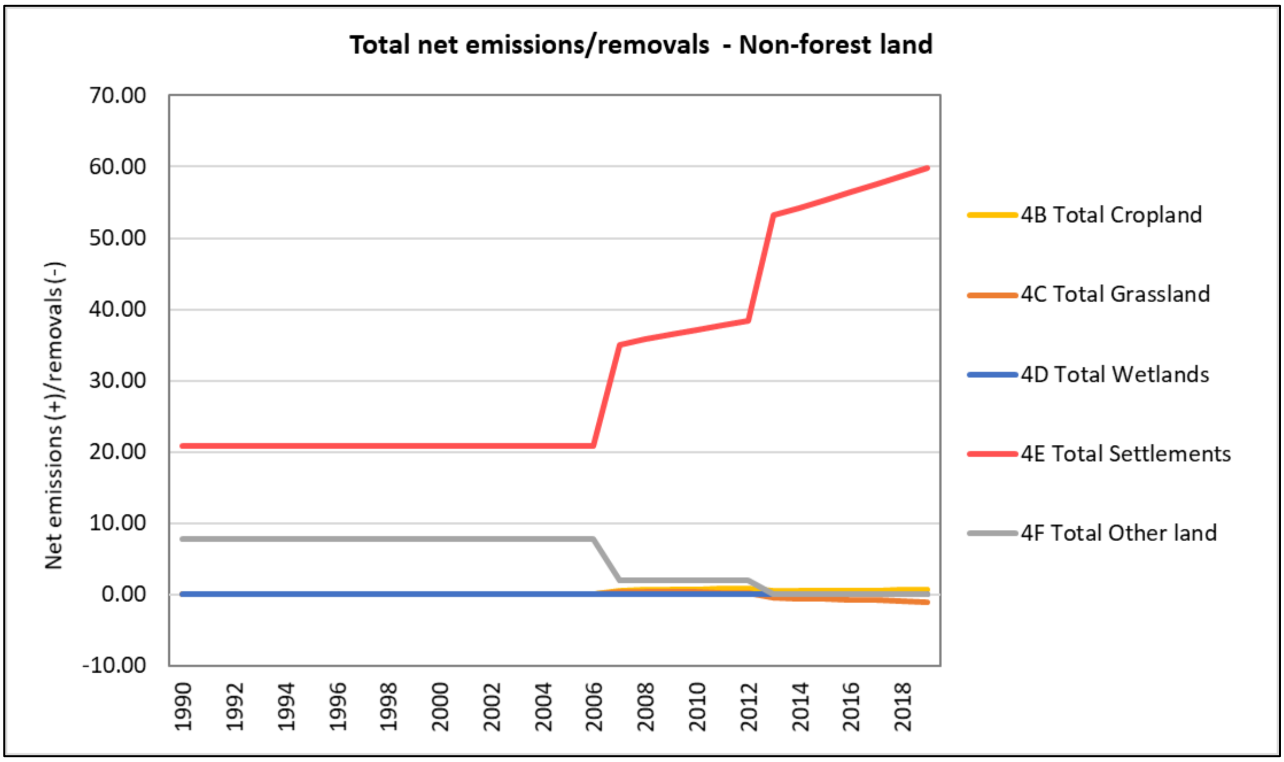


Figure 99 Total net emissions/removals (in kt CO_2eq) of the non-foresty subcategories

6.1.2 Completeness

Table 255 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 estimates of all subcategories. The symbol „✓" indicates that emissions/removals from this subcategory have been estimated.

Table 255: IPCC categories according to the IPCC 2006 Guidelines and status of the estimates made.

IPCC categories[105]/ 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	✓	

[105] IPCC categories – applied according to the 2006 IPCC 2006 Guidelines for National Greenhouse Gas Inventories

IPCC categories[105]/ Sub division for calculation	Description	Status for CO_2	Other GHG
	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	✓	
	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	✓	

IPCC categories[105]/ Sub division for calculation	Description	Status for CO_2	Other GHG
	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	
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	✓	

IPCC categories[105]/ Sub division for calculation	Description	Status for CO_2	Other GHG
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	
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_contr.	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 2018.*

6.1.3 Applied Methodology

6.1.3.1 Activity data

To generate a complete land use and land use change time series from 1970 to 2018, geographical data from different sources were synthesised. Land use changes were taken from the CORINE Land Cover[106] (CLC) product of the EU's Copernicus Land Monitoring Service, with the IPPC land use categories assigned to the CLC classes as shown in Table 256. 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 simply 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 (1,381.2 kha). 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).

[106] https://land.copernicus.eu/pan-european/corine-land-cover

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).

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.

Table 256 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	

CLC class code	CLC class name	IPCC category	Comments
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	
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

6.1.3.2 Emission factors

The calculations of the LULUCF emissions and removals are very much 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. Nonetheless, higher Tier methods could be implemented for the subcategory Forest land due to the data provided by the country’s NFI.

6.1.4 Quality Assurance and Quality Control (QA/QC)

The following checks were implemented applying the four eyes principle (one person estimates, second person checks):

- 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

6.1.5 Uncertainty assessment

A formal uncertainty analysis of the sector emissions and removals has not been implemented.

6.1.6 Sector-specific Recalculations

The following table presents the main revisions and recalculations done since the last submission to the UNFCCC and relevant to IPCC sector 4 *LULUCF*.

Table 257 Recalculations done in IPCC sector 4 LULUCF.

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
4	For this NIR a completely new LULUCF estimate was carried out by different experts and institutions than in previous GHG inventory submissions of Montenegro. The approaches of estimating the land use and land-use changes, emission factors and emissions/removals were changed to a large extent and estimates for further subcategories were introduced (e.g. for Harvested Wood Products). Consequently, it is no surprise that the LULUCF results differ significantly to previous submissions of Montenegro for this sector (NIR for the period 1990 to 2017, 2nd National Communication and 1st BUR, both in 2015). Particularly, the significant and constant removals for Forest Land of this submission are different to the results of last year's estimates where both net emissions and removals occurred in the time series.	AD EF method	Accuracy Completeness Comparability Consistency Transparency

6.1.7 Source-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.

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.

Table 258 Planned improvements for IPCC sector 4 LULUCF.

GHG source & sink category	Planned improvement	Type of improvement		Priority
4	• First of all, Montenegro intends a re-assessment of its 1st NFI in the next years	AD EF meth od	Accuracy Completeness Comparability Consistency Transparency	medium/ high
	• A more detailed analysis of the land-use changes between CLC sub-categories and a related adjustment of the emission estimates.			
	• A survey for the availability and derivation of country-specific emission factors for biomass stocks and stock change rates in cropland, grassland, settlement and other land.			
	• A survey for the availability and derivation of country-specific soil C stocks for cropland, grassland and other land.			
	• 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.			
	• An uncertainty analysis of the LULUCF sector will be carried out.			

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 (59.5 % of Montenegro's total area). According to land use changes derived from the CLC change products, forest area has been decreasing albeit very slightly (Table 259). While the forest area has been stable, the net GHG removals from Forest land have varied significantly.

The sink strength of Forest land (Table 260) has increased by 51% between 1990 (-1574.78kt CO_2eq) and 2019 -2371.91kt 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 (Table 266). 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 C stocks of Forest land remaining forest land have not been estimated.

Table 259 Areas of total Forest land and related sub-categories (land use change areas are presented in the 20 years transition period) in 1000 ha (kha)

CRF code	category name	unit	1990	1995	2000	2005	2010	2015	2019
4A	Forest land	kha	827.76	827.55	827.35	827.15	826.78	826.56	826.51
4A1	Forest land remaining forest land	kha	827.55	827.35	827.15	826.95	826.62	826.13	825.79
4A2	Land converted to forest land	kha	0.20	0.20	0.20	0.20	0.16	0.43	0.71
4A21	Cropland converted to forest land	kha	0.00	0.00	0.00	0.00	0.00	0.06	0.12
4A21a	Annual cropland converted to forest land	kha	0.00	0.00	0.00	0.00	0.00	0.03	0.06
4A21b	Perennial cropland converted to forest land	kha	0.00	0.00	0.00	0.00	0.00	0.03	0.06
4A22	Grassland converted to forest land	kha	0.06	0.06	0.06	0.06	0.05	0.05	0.05
4A23	Wetlands converted to forest land	kha	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4A24	Settlements converted to forest land	kha	0.06	0.06	0.06	0.06	0.05	0.03	0.02
4A25	Other land converted to forest land	kha	0.08	0.08	0.08	0.08	0.07	0.29	0.52
4(V)A1	Forest fire area	kha	0.72	1.26	7.50	0.10	0.70	3.12	3.42

Table 260 Net emissions/removals of Forest land in kt CO_2, CH_4, N_2O and CO_2eq

CRF code	category name	unit	1990	1995	2000	2005	2010	2015	2019
4A	Total Forest land	kt CO_2	-1599.93	-1702.55	-2368.28	-2487.36	-2612.28	-2432.93	-2491.25
4A1	Forest land remaining Forest land	kt CO_2	-1598.66	-1701.28	-2367.01	-2486.10	-2611.21	-2431.02	-2488.25

CRF code	category name	unit	1990	1995	2000	2005	2010	2015	2019
4A2	Land converted to Forest land	kt CO_2	-1.27	-1.27	-1.27	-1.27	-1.07	-1.92	-3.00
4A21	Cropland converted to Forest land	kt CO_2	0.00	0.00	0.00	0.00	0.00	0.20	-0.15
4A22	Grassland converted to Forest land	kt CO_2	-0.16	-0.16	-0.16	-0.16	-0.19	-0.08	-0.09
4A23	Wetlands converted to Forest land	kt CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4A24	Settlements converted to Forest land	kt CO_2	-0.79	-0.79	-0.79	-0.79	-0.64	-0.44	-0.32
4A25	Other Land converted to Forest land	kt CO_2	-0.31	-0.31	-0.31	-0.31	-0.25	-1.10	-1.98
4(V)A1	Forest land remaining Forest land	kt CO_2	22.37	38.99	233.06	3.20	21.59	97.05	106.15
4(V)A1	Forest land remaining Forest land	kt N_2O	0.00	0.01	0.04	0.00	0.00	0.02	0.02
4(V)A1	Forest land remaining Forest land	kt CH_4	0.07	0.12	0.70	0.01	0.06	0.29	0.32
4A	**Total Forest land**	**kt CO_2eq**	**-1574.78**	**-1658.72**	**-2106.26**	**-2483.77**	**-2588.01**	**-2323.82**	**-2371.91**

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 the country with its 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 were required to construct the required annual time series for total forest area. As described in chapter 6.1.3.1, this time series between 1970 and 2018 was constructed using the 2010 NFI forest area as a starting reference, which was developed back to 1970 and forward to 2018 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 256).

Starting with the 826.782 kha total forest area measured by the NFI in 2010, 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.

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 metres 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 including here in the IPCC Forest land category.

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. For further details, the reader is referred to 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 are representative of the accessible forest area, which contributes ca. 88 % of the total forest area (including inaccessible areas). Therefore all derived per ha biomass C stocks and stock changes had to be reduced due to the much lower average volume and increment per ha of the inaccessible forest areas (Table 261).

Table 261 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 262 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	58,316.9				
Coniferous	159,307.4	46,758.8	293.5	1,295.9	8.1
Deciduous	509,500.8	69,457.8	136.3	1,484.1	2.9
Total	727,125.0	116,216.7	159.8	2,780.0	3.8

To derive carbon stock changes for Forest land remaining forest land, the working 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 262) by corresponding type-specific wood densities (Table 263), biomass expansion factors, and carbon fractions (Table 264). Note that the per ha increments for coniferous and deciduous forests were reduced by a tiny fraction (<0.01 %), to ensure that increments in Forest land remaining forest land (4A1) and Land converted to Forest land (4A2) would produce an average per ha increment for total Forest land that was consistent with the NFI increment of 3.8 m^3 ha^{-1} for accessible forests given in Table 262.

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 IPPC 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 265) 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 263 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 264 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[107]	0.51
Deciduous	1.4	1.2	0.48

Table 265 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 262). This value per ha was subsequently reduced take into account the inaccessible forest area,

[107] 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.

where contribution to the total forest increment is lower than the contribution to the total forest area (Table 261). This calculation procedure yielded 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. Official total cut harvest statistics are provided by Statistical Office of Montenegro[108] (MONSTAT); however, these values underestimate informal yet significant harvest by private persons for, *inter alia*, fuel wood. A national project was thus established to provide annual consumption-based estimates of total harvest and these figures were used for the purpose of the LULUCF Inventory.

For estimating the carbon stock losses, the total harvest was first split between wood from coniferous trees and wood from deciduous trees using a long term split (44 % deciduous, 56 % coniferous) from the 2001-2018 MONSTAT harvest statistics (MONSTAT, 2019), which despite the underestimation are divided between deciduous and coniferous trees (Table 266). The respective coniferous and deciduous harvest values were subsequently multiplied by corresponding type-specific wood densities (Table 263), biomass expansion factors, and carbon fractions (Table 264) to arrive at above-ground biomass carbon stock losses.

Changes in below-ground biomass C stocks due to coniferous and deciduous harvest were calculated from the above-ground biomass carbon stock changes using selected root: shoot ratios (Table 265) 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 above-ground and below ground biomass C losses.

Table 266 Annual harvest from Forest land

Year	Total Harvest [m3]	Total Harvest: Deciduous [m3]	Total Harvest: Coniferous [m3]
1990	1,638,565	713,428	925,137
1991	1,424,918	620,406	804,512
1992	1,637,544	712,983	924,561
1993	1,212,576	527,953	684,623
1994	1,513,324	658,898	854,426
1995	1,575,916	686,150	889,766
1996	1,442,943	628,254	814,689
1997	1,001,979	436,259	565,720
1998	920,411	400,745	519,666
1999	986,905	429,696	557,209
2000	1,172,997	510,720	662,277
2001	1,000,931	435,803	565,128
2002	902,653	393,013	509,640
2003	908,782	395,682	513,100
2004	963,891	419,676	544,215
2005	1,100,403	479,113	621,290
2006	1,284,315	559,188	725,127

[108] http://www.monstat.org/eng/index.php

Year	Total Harvest [m3]	Total Harvest: Deciduous [m3]	Total Harvest: Coniferous [m3]
2007	1,039,552	452,619	586,933
2008	1,108,410	482,599	625,811
2009	853,381	371,560	481,821
2010	1,023,650	445,695	577,955
2011	1,157,569	504,003	653,566
2012	1,222,494	532,271	690,223
2013	1,130,735	492,320	638,415
2014	1,098,581	478,320	620,261
2015	1,131,734	492,755	638,979
2016	1,176,058	512,053	664,005
2017	1,114,401	485,208	629,193
2018	1,096,854	477,568	619,286

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 2018 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

On conversion to Forest land, the biomass C stock of the previous land use category is assumed to be lost in year of the conversion (Table 267). For annual cropland, the IPCC default value of 5 t C ha^{-1} was taken (Table 5.9 Vol 4, Chapter 5). 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 6.392 t C ha^{-1} for Grasslands was derived from the IPCC default biomass stock (above and below ground) for cold temperate-wet grasslands (13.6 t dm ha^{-1}, Table 6.4 Vol 4, Chapter 6) and the default C fraction for herbaceous vegetation (0.47 t C t dm^{-1}). 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 267: 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	5
Perennial Cropland to Forest land	10.32
Grassland to Forest land	6.392
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 263), biomass expansion factors, and carbon fractions (Table 264). Parallel gains in below-ground biomass C stocks were calculated from the above-ground biomass carbon stock changes using conifer- and deciduous-specific root: shoot ratios for LUC to Forest land (Table 265). A final average annual total biomass C stock increment gain 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 268).

Table 268 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 269 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 269 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 270). 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 270 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 270). 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 270). 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.

6.3 Cropland (Category 4.B)

6.3.1 Category description

In 2019, total Cropland area was estimated at 215.66 kha which corresponds to 15.6 % of the total area of Montenegro (Table 271). According to land use changes derived from the CLC change products, Cropland area has been decreasing, but only very marginally. 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 2019 amounted to only 0.64 kt CO_2 eq (Table 272).

Table 271 Areas of Total Cropland and related sub-categories (land use change areas are presented in the 20 years transition period) in 1000 ha (kha)

CRF code	category name	unit	1990	1995	2000	2005	2010	2015	2019
4B	Cropland	kha	215.89	215.89	215.89	215.89	215.88	215.77	215.66
4B1	Cropland remaining cropland	kha	215.46	215.46	215.46	215.46	215.39	215.25	215.16
4B11	Annual cropland remaining annual cropland	kha	NE	NE	NE	NE	NE	NE	NE
4B12	Perennial cropland remaining perennial cropland	kha	NE	NE	NE	NE	NE	NE	NE
4B13	Perennial cropland to annual cropland	kha	NE	NE	NE	NE	NE	NE	NE
4B14	Annual cropland to perennial cropland	kha	NE	NE	NE	NE	NE	NE	NE
4B2	Land converted to cropland	kha	0.43	0.43	0.43	0.43	0.50	0.52	0.51
4B21	Forest land converted to cropland	kha	0.03	0.03	0.03	0.03	0.04	0.06	0.07
4B21a	Forest land converted to annual cropland	kha	0.01	0.01	0.01	0.01	0.02	0.03	0.03
4B21b	Forest land converted to perennial cropland	kha	0.01	0.01	0.01	0.01	0.02	0.03	0.03
4B22	Grassland converted to cropland	kha	0.15	0.15	0.15	0.15	0.26	0.32	0.33
4B22a	Grassland converted to annual cropland	kha	0.07	0.07	0.07	0.07	0.13	0.16	0.16
4B22b	Grassland converted to perennial cropland	kha	0.08	0.08	0.08	0.08	0.13	0.16	0.17
4B23	Wetlands converted to cropland	kha	0.00	0.00	0.00	0.00	0.00	0.01	0.01
4B23a	Wetlands converted to annual cropland	kha	0.00	0.00	0.00	0.00	0.00	0.00	0.01
4B23b	Wetlands converted to perennial cropland	kha	0.00	0.00	0.00	0.00	0.00	0.00	0.01

CRF code	category name	unit	1990	1995	2000	2005	2010	2015	2019
4B24	Settlements converted to cropland	kha	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4B24a	Settlements converted to annual cropland	kha	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4B24b	Settlements converted to perennial cropland	kha	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4B25	Other land converted to cropland	kha	0.25	0.25	0.25	0.25	0.20	0.14	0.10
4B25a	Other land converted to annual cropland	kha	0.12	0.12	0.12	0.12	0.10	0.07	0.05
4B25b	Other land converted to perennial cropland	kha	0.13	0.13	0.13	0.13	0.10	0.07	0.05

Table 272 Net emissions/removals of Cropland in kt CO_2, N_2O, and CO_2eq

CRF code	category name	unit	1990	1995	2000	2005	2010	2015	2019
4B	Total Cropland	kt CO_2	0.00	0.00	0.00	0.00	0.69	0.48	0.55
4B1	Cropland remaining Cropland	kt CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4B2	Land converted to Cropland	kt CO_2	0.00	0.00	0.00	0.00	0.69	0.48	0.55
4B22	Grassland converted to cropland	kt CO_2	0.29	0.29	0.29	0.29	0.81	0.53	0.54
4B23	Wetlands converted to Cropland	kt CO_2	0.00	0.00	0.00	0.00	0.00	-0.03	-0.03
4B24	Settlements converted to Cropland	kt CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4B25	Other Land converted to Cropland	kt CO_2	-0.35	-0.35	-0.35	-0.35	-0.19	-0.13	-0.10
4(III)B21	Forest land converted to cropland	kt N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4(III)B22	Grassland converted to cropland	kt N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4(IV)B21	Forest land converted to cropland	kt N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4(IV)B22	Grassland converted to cropland	kt N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4B	**Total Cropland**	**kt CO_2eq**	**0.04**	**0.04**	**0.04**	**0.04**	**0.76**	**0.57**	**0.64**

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 6.1.3.1, 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 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).

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 6.1.3.1, for the purpose of the LULUCF Inventory national experts assigned specific CLC classes to the IPCC category Cropland (Table 256).

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 practises, 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

On conversion to Cropland, the biomass C stock of the previous land use category is assumed to be lost in year of the conversion (Table 273).

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 262). 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 263), biomass expansion factors, and carbon fractions

(Table 264). The below-ground biomass C stocks for coniferous and deciduous were calculated from the above-ground biomass carbon stocks using corresponding root: shoot ratios (Table 265). 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 262). 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 6.392 t C ha^{-1} was derived from the IPCC default biomass stock (above and below ground) for cold temperate-wet grasslands (13.6 t dm ha^{-1}, Table 6.4 Vol 4, Chapter 6) and the default C fraction for herbaceous vegetation (0.47 t C t dm^{-1}). 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 273 Gross biomass carbon losses following land conversion to Cropland

Conversion	Unit	Biomass C loss in year of conversion to Cropland (i.e. biomass C stock of previous land use)
Forest land to Cropland	t C ha	77.665
Grassland to Cropland	t C ha	6.392
Wetlands to Cropland	t C ha	NE
Settlements to Cropland	t C ha	0
Other land to Cropland	t C ha	0

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 (5 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 267 (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 263) and carbon fractions (Table 264) 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 270.

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 270). 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 IPPC Guidelines (Eq.11.1, Vol 4, Chapter 11):

$$N_2O\text{-}N = F_{SOM} * EF_1 \text{ (Eq.11.1)}$$

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 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 IPPC 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 270. 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):

$$N_2O\text{-}N = F_{SOM} * Frac_{LEACH} * EF_5 \text{ (eq.11.10)}$$

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.

6.4 Grassland (Category 4.C)

6.4.1 Category description

In 2019, total Grassland area was estimated at 142.39 kha which corresponds to 10.3 % of the total area of Montenegro (Table 274). 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 2019, net removals amounted to only -0.90 kt CO_2 eq (Table 275). In terms of trend, the post-2006 increase in Forest land conversion to Grassland led to a small peak in net emissions in 2007 (0.37 kt CO_2eq). Since then, emissions have decreased past zero to net removals due to increased conversion to Grasslands from Settlements and Cropland.

Table 274 Areas of Total Grassland and related sub-categories (land use change areas are presented in the 20 years transition period) in 1000 ha (kha)

CRF code	category name	unit	1990	1995	2000	2005	2010	2015	2019
4C	Grassland	kha	143.12	143.01	142.90	142.78	142.58	142.44	142.39
4C1	Grassland remaining grassland	kha	143.12	143.01	142.90	142.78	142.54	142.35	142.27
4C2	Land converted to grassland	kha	0.00	0.00	0.00	0.00	0.04	0.09	0.12
4C21	Forest Land converted to grassland	kha	0.00	0.00	0.00	0.00	0.00	0.01	0.01
4C22	Cropland converted to grassland	kha	0.00	0.00	0.00	0.00	0.04	0.06	0.06
4C22a	Annual cropland converted to grassland	kha	0.00	0.00	0.00	0.00	0.02	0.03	0.03
4C22b	Perennial cropland converted to grassland	kha	0.00	0.00	0.00	0.00	0.02	0.03	0.03
4C23	Wetlands converted to grassland	kha	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4C24	Settlements converted to grassland	kha	0.00	0.00	0.00	0.00	0.00	0.03	0.06
4C25	Other Land converted to grassland	kha	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 275 Net emissions/removals of Grassland in kt CO_2/CO_2eq

CRF code	category name	unit	1990	1995	2000	2005	2010	2015	2019
4C	Total Grassland	kt CO_2	0.00	0.00	0.00	0.00	0.31	-0.62	-0.90
4C1	Grassland remaining Grassland	kt CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4C2	Land converted to Grassland	kt CO_2	0.00	0.00	0.00	0.00	0.31	-0.62	-0.90
4C21	Forest Land converted to Grassland	kt CO_2	0.00	0.00	0.00	0.00	0.35	0.00	0.00

CRF code	category name	unit	1990	1995	2000	2005	2010	2015	2019
4C22	Cropland converted to Grassland	kt CO_2	0.00	0.00	0.00	0.00	-0.04	-0.12	-0.12
4C23	Wetlands converted to Grassland	kt CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4C24	Settlements converted to Grassland	kt CO_2	0.00	0.00	0.00	0.00	0.00	-0.50	-0.78
4C25	Other Land converted to Grassland	kt CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4C	**Total Grassland**	**kt CO_2eq**	**0.00**	**0.00**	**0.00**	**0.00**	**0.31**	**-0.62**	**-0.90**

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 6.1.3.1, 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 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).

6.4.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

As described in chapter 6.1.3.1, for the purpose of the LULUCF Inventory national experts assigned specific CLC classes to the IPCC category Grassland (Table 256).

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

On conversion to Grassland, the biomass C stock of the previous land use category is assumed to be lost in year of the conversion (Table 276). 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 276: Gross biomass carbon losses following land conversion to Grassland

Conversion	Unit	Biomass C loss in year of conversion to Grassland (i.e. biomass C stock of previous land use)
Forest land to Grassland	t C ha	77.665
Annual Cropland to Grassland	t C ha	5
Perennial Cropland to Grassland	t C ha	10.32
Wetlands to Grassland	t C ha	NO
Settlements to Grassland	t C ha	0
Other land to Grassland	t C ha	NO

After the initial gross biomass C loss following conversion, gross gains in Grassland biomass C (6.392 t C ha^{-1}, derived from the IPCC default biomass stock (above and below ground) for cold temperate-wet grasslands (13.6 t dm ha^{-1}, Table 6.4 Vol 4, Chapter 6) and the default C fraction for herbaceous vegetation (0.47 t C t dm^{-1})) are assumed to take place in the year of the conversion.

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 270.

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 270). 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 270). 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.

6.5 Wetlands (Category 4.D)

6.5.1 Category description

In 2019, total Wetlands area was estimated at 43.01 kha which corresponds to 3.1 % of the total area of Montenegro (Table 277). 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 has decreased slightly (0.1 % decrease compared to 1990).

In contrast to land use change from Wetlands, no land conversion to Wetlands has occurred over the time series. 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 (Table 256). 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.

Table 277 Areas of Total Wetlands and related sub-categories (land use change areas are presented in the 20 years transition period) in 1000 ha (kha)

CRF code	category name	unit	1990	1995	2000	2005	2010	2015	2019
4D	Wetlands	kha	43.05	43.05	43.05	43.05	43.05	43.03	43.01
4D1	Wetlands remaining wetlands	kha	43.05	43.05	43.05	43.05	43.05	43.03	43.01
4D2	Land converted to wetlands	kha	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4D21	Forest Land converted to wetlands	kha	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4D22	Cropland converted to wetlands	kha	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4D22a	Annual cropland converted to wetlands	kha	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4D22b	Perennial cropland converted to wetlands	kha	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4D23	Grassland converted to wetlands	kha	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4D24	Settlements converted to wetlands	kha	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4D25	Other Land converted to wetlands	kha	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 278 Net emissions/removals of Wetlands in kt CO_2/CO_2eq

CRF code	category name	unit	1990	1995	2000	2005	2010	2015	2019
4D	Wetlands	kt CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4D1	Wetlands remaining wetlands	kt CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4D2	Land converted to wetlands	kt CO_2	NO	NO	NO	NO	NO	NO	NO
4D21	Forest Land converted to wetlands	kt CO_2	NO	NO	NO	NO	NO	NO	NO
4D22	Cropland converted to wetlands	kt CO_2	NO	NO	NO	NO	NO	NO	NO

CRF code	category name	unit	1990	1995	2000	2005	2010	2015	2019
4D22a	Annual cropland converted to wetlands	kt CO_2	NO	NO	NO	NO	NO	NO	NO
4D22b	Perennial cropland converted to wetlands	kt CO_2	NO	NO	NO	NO	NO	NO	NO
4D23	Grassland converted to wetlands	kt CO_2	NO	NO	NO	NO	NO	NO	NO
4D24	Settlements converted to wetlands	kt CO_2eq	NO	NO	NO	NO	NO	NO	NO
4D25	Other Land converted to wetlands	kt CO_2	NO	NO	NO	NO	NO	NO	NO

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 6.1.3.1, 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 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).

6.5.3 Land-use definitions and classification systems used and their correspondence to the LULUCF categories

As described in chapter 6.1.3.1, for the purpose of the LULUCF Inventory national experts assigned specific CLC classes to the IPCC category Wetlands (Table 256).

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 (Table 256). 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.

6.6 Settlements (Category 4.E)

6.6.1 Category description

In 2019, total Settlement area was estimated at 29.01 kha which corresponds to 2.1 % of the total area of Montenegro (Table 279). Despite its small area in absolute terms, the Settlement area has undergone a significant relative increase since 1990 (1990-2019 increase of 12.25%). Due to this increase in land conversion to Settlements, emissions from this category have also been increasing (Table 280). Compared to 1990, emissions from the Settlements have increased from 20.84 to 58.71 kt CO_2eq in 2018 (a 182% increase). The most significant driver of emissions from this category has been the conversion of Forest land to Settlements. Of the 58.71kt CO_2eq emissions in 2018, the conversion of Forest land to Settlements contributed 47.95 kt CO_2.

Table 279 Areas of Total Settlements and related sub-categories (land use change areas are presented in the 20 years transition period) in 1000 ha (kha)

CRF code	category name	unit	1990	1995	2000	2005	2010	2015	2019
4E	Settlements	kha	25.84	26.27	26.70	27.13	27.74	28.50	29.01
4E1	Settlements remaining Settlements	kha	24.06	24.49	24.92	25.35	25.79	26.21	26.45
4E2	Land converted to Settlements	kha	1.78	1.78	1.78	1.78	1.94	2.29	2.56
4E21	Forest Land converted to Settlements	kha	0.53	0.53	0.53	0.53	0.71	1.08	1.36
4E22	Cropland converted to Settlements	kha	0.43	0.43	0.43	0.43	0.46	0.52	0.56
4E22a	Annual cropland converted to Settlements	kha	0.21	0.21	0.21	0.21	0.23	0.26	0.27
4E22b	Perennial cropland converted to Settlements	kha	0.22	0.22	0.22	0.22	0.23	0.26	0.28
4E23	Grassland converted to Settlements	kha	0.24	0.24	0.24	0.24	0.28	0.30	0.30
4E24	Wetlands converted to Settlements	kha	0.00	0.00	0.00	0.00	0.00	0.01	0.03
4E25	Other Land converted to Settlements	kha	0.58	0.58	0.58	0.58	0.49	0.39	0.32

Table 280 Net emissions/removals of Settlements in kt CO_2, N_2O and CO_2eq

CRF code	category name	unit	1990	1995	2000	2005	2010	2015	2019
4E	Total Settlements	kt CO_2	19.54	19.54	19.54	19.54	35.53	53.35	56.35
4E1	Settlements remaining Settlements	kt CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4E2	Land converted to Settlements	kt CO_2	19.54	19.54	19.54	19.54	35.53	53.35	56.35
4E21	Forest Land converted to Settlements	kt CO_2	13.05	13.05	13.05	13.05	27.93	45.24	47.95
4E22	Cropland converted to Settlements	kt CO_2	3.84	3.84	3.84	3.84	4.38	4.91	5.19

CRF code	category name	unit	1990	1995	2000	2005	2010	2015	2019
4E23	Grassland converted to Settlements	kt CO_2	2.64	2.64	2.64	2.64	3.22	3.20	3.21
4E24	Wetlands converted to Settlements	kt CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4E25	Other Land converted to Settlements	kt CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4(III)E21	Forest Land converted to Settlements	kt N_2O	0.0015	0.0015	0.0015	0.0015	0.0020	0.0030	0.0038
4(III)E22	Cropland converted to Settlements	kt N_2O	0.0014	0.0014	0.0014	0.0014	0.0015	0.0017	0.0018
4(III)E23	Grassland converted to Settlements	kt N_2O	0.0007	0.0007	0.0007	0.0007	0.0008	0.0008	0.0008
4(IV)E21	Forest Land converted to Settlements	kt N_2O	0.0003	0.0003	0.0003	0.0003	0.0005	0.0007	0.0009
4(IV)E22	Cropland converted to Settlements	kt N_2O	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004
4(IV)E23	Grassland converted to Settlements	kt N_2O	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
4E	**Total Settlements**	**kt CO_2eq**	**20.84**	**20.84**	**20.84**	**20.84**	**37.10**	**55.37**	**58.71**

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 6.1.3.1, 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 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).

6.6.3 Land-use definitions and classification systems used and their correspondence to the LULUCF categories

As described in chapter 6.1.3.1, for the purpose of the LULUCF Inventory national experts assigned specific CLC classes to the IPCC category Settlements (Table 256).

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 281). 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 281: Gross biomass carbon losses following land conversion to Settlements

Conversion	Unit	Biomass C loss in year of conversion to Settlements (i.e. biomass C stock of previous land use)
Forest land to Settlements	t C ha	77.665
Annual Cropland to Settlements	t C ha	5
Perennial Cropland to Settlements	t C ha	10.32
Grassland to Settlements	t C ha	6.392
Wetlands to Settlements	t C ha	NE
Other land to Settlements	t C ha	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 270.

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 270). 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 IPPC 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 IPPC 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 270). 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.

6.7 Other land (Category 4.F)

6.7.1 Category description

In 2018, the total area of Other land was estimated at 124.63 kha which corresponds to 9 % of the total area of Montenegro (Table 282). 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, Table 283). However, since 2006, conversions of Forest land to Other land have ceased. As a result, the subcategory has been GHG-neutral since 2013.

Table 282 Areas of Total Other land and related sub-categories (land use change areas are presented in the 20 years transition period) in 1000 ha (kha)

CRF code	category name	unit	1990	1995	2000	2005	2010	2015	2018
4F	Other land	kha	125.55	125.43	125.32	125.20	125.17	124.90	124.63
4F1	Other land remaining Other land	kha	125.11	124.99	124.88	124.76	124.80	124.62	124.42
4F2	Land converted to Other land	kha	0.44	0.44	0.44	0.44	0.38	0.28	0.21
4F21	Forest Land converted to Other land	kha	0.44	0.44	0.44	0.44	0.38	0.28	0.21
4F22	Cropland converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO
4F22a	Annual cropland converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO
4F22b	Perennial cropland converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO
4F23	Grassland converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO
4F24	Wetlands converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO
4F25	Settlements converted to Other land	kha	NO	NO	NO	NO	NO	NO	NO

Table 283 Net emissions/removals of Other land in kt CO_2/CO_2eq

CRF code	category name	unit	1990	1995	2000	2005	2010	2015	2019
4F	Total Other land	kt CO_2	7.87	7.87	7.87	7.87	1.92	0.00	0.00
4F1	Other land remaining Other land	kt CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4F2	Land converted to Other land	kt CO_2	7.87	7.87	7.87	7.87	1.92	0.00	0.00
4F21	Forest Land converted to Other land	kt CO_2	7.87	7.87	7.87	7.87	1.92	0.00	0.00
4F22	Cropland converted to Other land	kt CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4F23	Grassland converted to	kt CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00

CRF code	category name	unit	1990	1995	2000	2005	2010	2015	2019
	Other land								
4F24	Wetlands converted to Other land	kt CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4F25	Settlements converted to Other land	kt CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4F	**Total Other land**	**kt CO_2eq**	**7.87**	**7.87**	**7.87**	**7.87**	**1.92**	**0.00**	**0.00**

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 6.1.3.1, 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 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).

6.7.3 Land-use definitions and classification systems used and their correspondence to the LULUCF categories

As described in chapter 6.1.3.1, for the purpose of the LULUCF Inventory national experts assigned specific CLC classes to the IPCC category Other land (Table 256).

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 284). 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 284: 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)
Forest land to Other land	t C ha	77.665
Annual Cropland to Other land	t C ha	NO

Perennial Cropland to Other land	t C ha	NO
Grassland to Other land	t C ha	NO
Wetlands to Other land	t C ha	NO
Settlements to Other land	t C ha	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 270). As such, changes in soil C stocks following conversion from Forest land to Other land are not estimated.

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. Although Forest land is the most important category by some distance, the next most important category is the HWPs. In 2018, HWPs contributed net removals of 142.43 kt CO_2eq and since 1990 the removals have increased more than three-fold. It is however important to note that the trend has not been consistent over the time series, due to a post-1990 slump in sawn wood production, which led to small net emissions from the HWPs between 1993 and 2002. Since 2010, production of sawn wood has again increased which in turn has increased the sink strength of this category.

Table 285 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

CRF code	category name	unit	1990	1995	2000	2005	2010	2015	2019
4G	Harvested Wood Products	kt CO_2	-43.31	4.82	9.16	-5.58	23.98	-105.29	-139.64
	HWP - sawn wood: Net emissions/ removals	kt CO_2	-43.36	4.73	9.11	-5.56	24.11	-105.26	-139.63
	HWP – panels: Net emissions/ removals	kt CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	HWP - paper and paper board: Net emissions/ removals	kt CO_2	0.05	0.10	0.06	-0.02	-0.13	-0.02	-0.01
	HWP - sawn wood: Production	m^3	137,708.08	80,094.39	72,640.89	90,615.46	51,836.27	214,948.25	268,959.52
	HWP – panels: Production	m^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	HWP - paper and paper board: Production	t	287.22	114.96	84.86	107.98	226.07	226.95	226.13

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 2018. 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 Table 285. 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 1900 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 1901 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:

$$C_i = e^{-k} * C_{i-1} + \left[\frac{(1 - e^{-k})}{k}\right] * inflow_i$$

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 ($\Delta C_i = C_i - C_{i-1}$).

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 2019. 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.

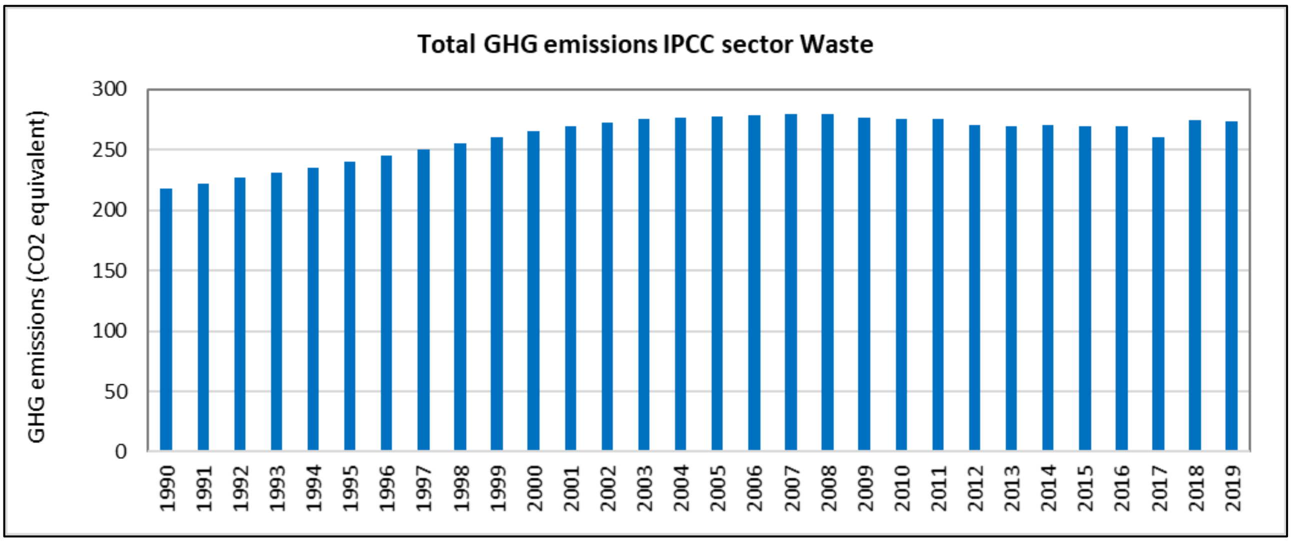


Figure 100 Trend of GHG emissions from 1990 – 2019 for waste

7.1.1 Emission trends

In the period 1990 to 2019 GHG emissions from the Waste Sector increased by 25.3% from 217.97 Gg CO_2 eq in 1990 to 273.08 Gg CO_2 eq in 2019. In the period 2005 to 2019 GHG emissions from the Waste sector decreased by 1.7%. In the period 1990 – 2019 the CH_4 emissions increased by 144% 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. In 2008, methane recovery (R) started in Montenegro. In the period 1990 to 2019 GHG emissions from the category 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 per capita protein consumption.

The most important sources of GHGs in the Waste Sector is *Solid waste Disposal*. Currently only emissions from *Solid waste Disposal* are estimated due to lack of data from sources *Composting*, *Incineration and Open burning of waste*, and *Industrial waste water handling*.

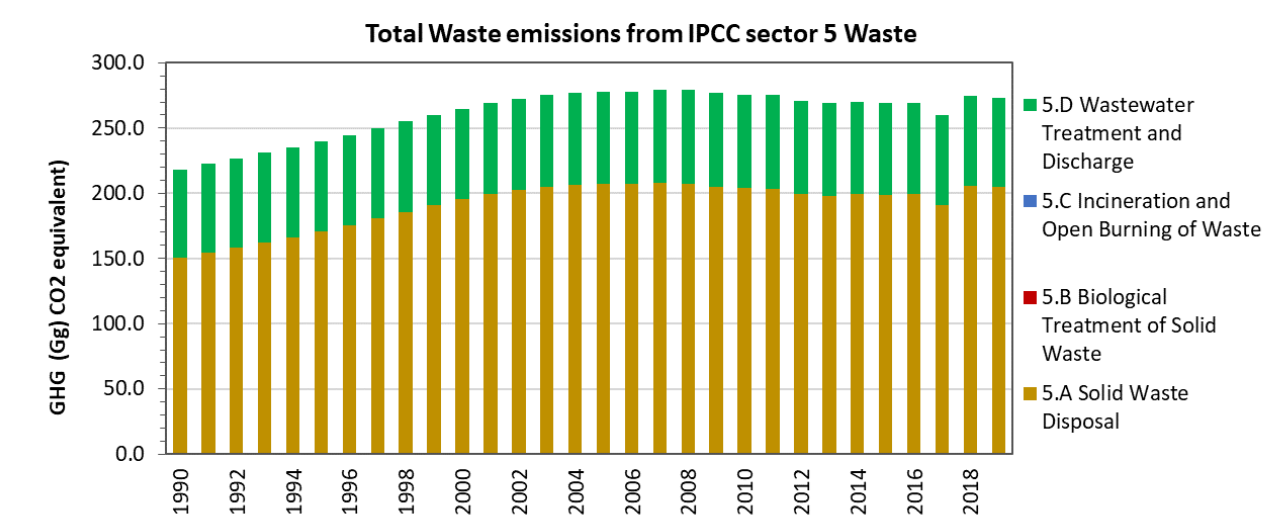


Figure 101 **Total national CH_4 emissions by category of sector Waste (1990-2019)**

Table 286 **Emissions from IPCC sector 5 Waste**

GHG emissions	TOTAL GHG	CO_2	CH_4	N_2O	CH_4	N_2O
	Gg CO_2 equivalent	Gg	Gg CO_2 equivalent	Gg CO_2 equivalent	Gg	Gg
1990	217.97	NE	210.50	7.47	8.42	0.03
1991	222.37	NE	214.71	7.66	8.59	0.03
1992	226.66	NE	218.82	7.84	8.75	0.03
1993	230.89	NE	222.86	8.02	8.91	0.03
1994	235.05	NE	226.84	8.21	9.07	0.03
1995	239.70	NE	231.30	8.40	9.25	0.03
1996	244.78	NE	236.19	8.58	9.45	0.03
1997	250.20	NE	241.42	8.77	9.66	0.03
1998	255.15	NE	246.19	8.96	9.85	0.03
1999	260.06	NE	250.91	9.16	10.04	0.03
2000	264.92	NE	255.57	9.35	10.22	0.03
2001	268.97	NE	259.22	9.75	10.37	0.03
2002	272.54	NE	262.39	10.15	10.50	0.03
2003	275.26	NE	264.71	10.55	10.59	0.04
2004	276.99	NE	266.06	10.93	10.64	0.04
2005	277.85	NE	266.54	11.31	10.66	0.04
2006	278.05	NE	266.37	11.69	10.65	0.04
2007	279.40	NE	267.11	12.29	10.68	0.04
2008	279.25	NE	266.45	12.80	10.66	0.04
2009	276.94	NE	264.17	12.76	10.57	0.04
2010	275.77	NE	262.83	12.94	10.51	0.04
2011	275.34	NE	262.40	12.95	10.50	0.04
2012	270.75	NE	258.32	12.44	10.33	0.04
2013	269.64	NE	256.55	13.09	10.26	0.04
2014	270.24	NE	257.14	13.10	10.29	0.04

GHG emissions	TOTAL GHG	CO_2	CH_4	N_2O	CH_4	N_2O
	Gg $_{CO_2 \text{ equivalent}}$	Gg	Gg $_{CO_2 \text{ equivalent}}$	Gg $_{CO_2 \text{ equivalent}}$	Gg	Gg
2015	269.34	NE	256.23	13.11	10.25	0.04
2016	269.60	NE	256.49	13.11	10.26	0.04
2017	260.33	NE	247.22	13.11	9.89	0.04
2018	274.68	NE	261.57	13.11	10.46	0.04
2019	273.08	NE	259.98	13.10	10.40	0.04
Trend						
1990 - 2019	*25.3%*	*NA*	*23.5%*	75.5%	*23.5%*	*75.5%*
2005 - 2019	*-1.7%*	*NA*	*-2.5%*	15.9%	*-2.5%*	*15.9%*
2017 - 2019	*-0.6%*	*NA*	*-0.6%*	0.0%	*-0.6%*	*0.0%*

7.2 Solid Waste Disposal (IPCC category 5.A)

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 metres.

⇒ 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 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. The 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.

7.2.1 Source category description

GHG emissions/ removals	CO_2	CH_4	N_2O
Estimated			
5.A.1 Managed Waste Disposal Sites	NA	NO	NA
5.A.2 Unmanaged Waste Disposal Sites	NA	NO	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 sub-category 5.A *Solid Waste Disposal* is provided in the following figure and table. The share in total GHG emissions from sector 5.A *Solid Waste Disposal* is 0.7% for the year 1990, 0.6% for the year 2005, and 0.5% for the year 2019. The share in total CH_4 emissions from sector 5.A *Solid Waste Disposal* is 1.4% for the year 1990, 1.1% for the year 2005, and 1.3% for the year 2019.

In the period 1990 – 2019 the CH_4 emissions increased by 144%. In the period 2005 – 2019 the CH_4 emissions increased by 63% 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.

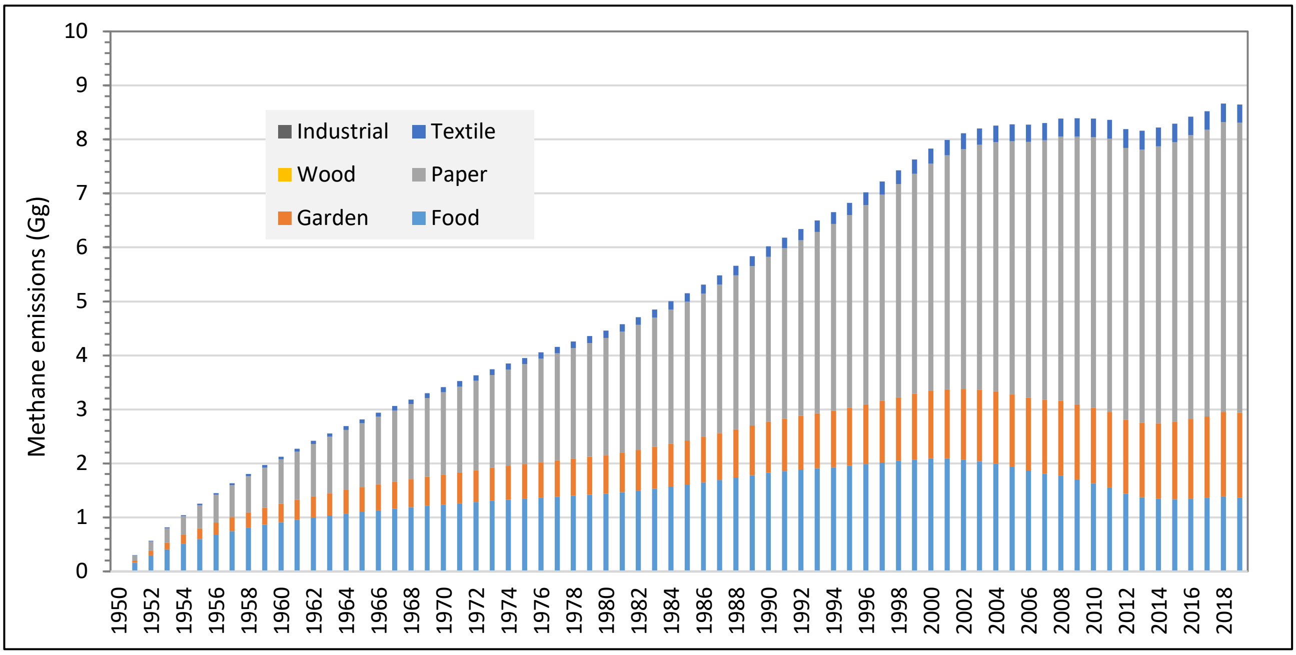


Figure 102 **CH_4 emissions from IPCC sub-category 5.A Solid Waste Disposal 1950 - 2019**

Table 287 **GHG emissions from IPCC sub-category 5.A Solid Waste Disposal 1990 - 2019**

GHG emissions	GHG	CO_2	CH_4 emissions	CH_4 generated	CH_4 recovered	N_2O
	Gg $_{CO_2\ equivalent}$	Gg	Gg	Gg	Gg	Gg
1990	150.493	NA	6.020	6.827	NO	NA
1991	154.520	NA	6.181	7.018	NO	NA
1992	158.511	NA	6.340	7.223	NO	NA

GHG emissions	GHG	CO_2	CH_4 emissions	CH_4 generated	CH_4 recovered	N_2O
	Gg $_{CO_2 \text{ equivalent}}$	Gg	Gg	Gg	Gg	Gg
1993	162.443	NA	6.498	6.020	NO	NA
1994	166.315	NA	6.653	6.181	NO	NA
1995	170.664	NA	6.827	6.340	NO	NA
1996	175.441	NA	7.018	6.498	NO	NA
1997	180.564	NA	7.223	6.653	NO	NA
1998	185.668	NA	7.427	6.827	NO	NA
1999	190.724	NA	7.629	7.018	NO	NA
2000	195.733	NA	7.829	7.223	NO	NA
2001	199.737	NA	7.989	7.427	NO	NA
2002	202.814	NA	8.113	7.629	NO	NA
2003	205.035	NA	8.201	7.829	NO	NA
2004	206.422	NA	8.257	7.989	NO	NA
2005	206.958	NA	8.278	8.113	NO	NA
2006	206.855	NA	8.274	8.201	NO	NA
2007	207.661	NA	8.306	8.257	NO	NA
2008	207.038	NA	8.282	8.278	0.107	NA
2009	204.945	NA	8.198	8.274	0.195	NA
2010	203.802	NA	8.152	8.306	0.238	NA
2011	203.616	NA	8.145	8.389	0.217	NA
2012	199.794	NA	7.992	8.393	0.202	NA
2013	198.279	NA	7.931	8.390	0.229	NA
2014	199.367	NA	7.975	8.362	0.246	NA
2015	198.984	NA	7.959	8.194	0.334	NA
2016	199.778	NA	7.991	8.160	0.428	NA
2017	191.061	NA	7.642	8.220	0.881	NA
2018	205.983	NA	8.239	8.294	0.424	NA
2019	204.564	NA	8.183	8.420	0.463	NA
Trend						
1990 - 2019	*35.9%*	*NA*	*36.9%*	*43.9%*	*NO*	*NA*
2005 - 2019	*-1.2%*	*NA*	*-1.2%*	*4.4%*	*NO*	*NA*
2018 - 2019	*-0.7%*	*NA*	*-0.7%*	*-0.2%*	*9.2%*	*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[109] has been applied:

EQUATION 3.1 CH_4 emission from SWDS (2006 IPCC GL, Vol. 5, Chap.3)

$$CH_4\ Emissions = \left[\sum CH_4\ generated_{x,T} - R_T\right] \times (1 - OX_T)$$

Where:

CH_4 Emissions	= CH_4 emitted in year T (Gg)
T	= inventory year
x	= waste category or type /material
R_T	= recovered CH_4 in year T (Gg)
OX_T	= oxidation factor in year T (fraction)

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 for

[109] Source: 2006 IPCC Guidelines, Volume 5: Waste, Chapter 3: Solid Waste Disposal - 3.2.1.1 FIRST ORDER DECAY (FOD)

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.

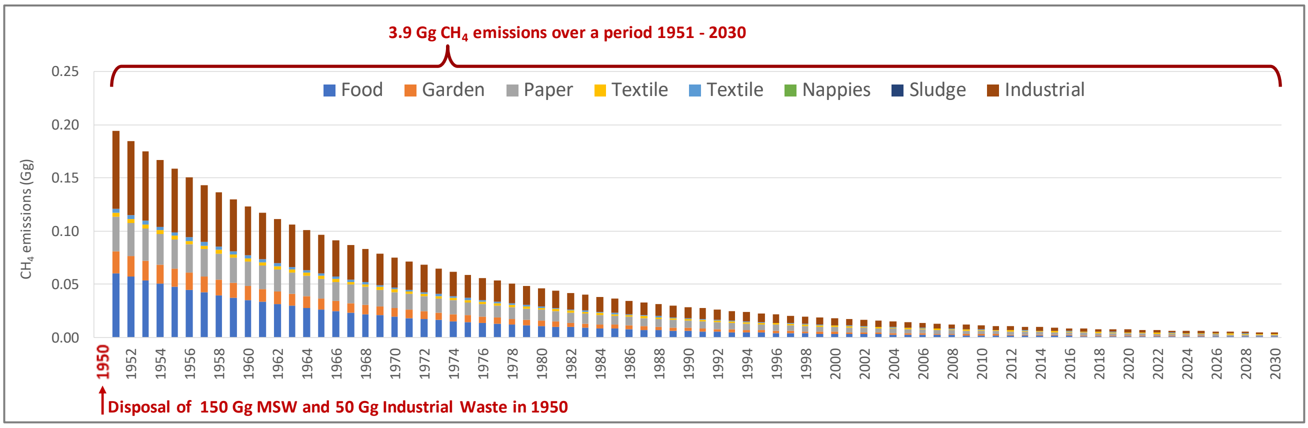


Figure 103 CH_4 emissions from IPCC sub-category 5.A Solid Waste Disposal of the disposal of waste in 1950

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)

$$DDOCma_T = DDOCmd_T + \left(DDOCmd_T \times e^{-k}\right)$$

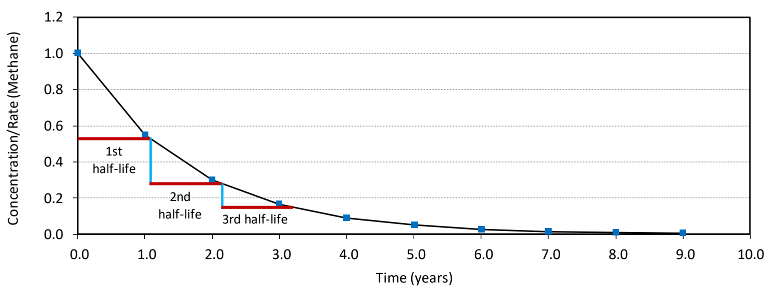
Equation 3.5: DDOCm decomposed in the SWDS at the end of year T (2006 IPCC GL, Vol. 5, Chap.3)

$$DDOCm\ decomp_T = DDOCma_{T-1} \times \left(1 - e^{-k}\right)$$

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, t1/2, 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 104 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 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 288 Municipal solid waste (MSW) landfilled on solid waste disposal sites (SWDS) - 1950 - 2019

	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
			kg/cap/yr		Gg		%		Gg
1948	377,189	Statistics							
1949		inter-polations							
1950	393,213		279.28	extra-polations	109.816		90.0%	Constatn value of 1989	98.835
1951	401,224		284.06		113.972		90.0%		102.575
1952	409,236		288.84		118.204		90.0%		106.383
1953	417,248	Statistics	293.62		122.512		90.0%		110.261
1954	424,079	inter-polations	298.40		126.545		90.0%		113.891
1955	430,910		303.18		130.643		90.0%		117.579
1956	437,740		307.96		134.806		90.0%		121.326
1957	444,571		312.74		139.035		90.0%		125.132
1958	451,402		317.52		143.329		90.0%		128.996
1959	458,232		322.30		147.688		90.0%		132.920
1960	465,063		327.08		152.113		90.0%		136.902
1961	471,894	Statistics	331.86		156.603		90.0%		140.942
1962	477,665	inter-polations	336.64		160.801		90.0%		144.721
1963	483,436		341.42		165.055		90.0%		148.549
1964	489,207		346.20		169.363		90.0%		152.427
1965	494,978		350.98		173.727		90.0%		156.355
1966	500,749		355.76		178.146		90.0%		160.332
1967	506,520		360.54		182.621		90.0%		164.359
1968	512,291		365.32		187.150		90.0%	Constatn value of 1989	168.435
1969	518,062		370.10		191.735		90.0%		172.561
1970	523,833		374.88		196.375		90.0%		176.737
1971	529,604	Statistics	379.66		201.069		90.0%		180.963
1972	535,075	inter-polations	384.44		205.704		90.0%		185.134
1973	540,545		389.22		210.391		90.0%		189.352
1974	546,016		394.00		215.130		90.0%		193.617
1975	551,486		398.78		219.922		90.0%		197.930
1976	556,957		403.56		224.766		90.0%		202.289
1977	562,428		408.34		229.662		90.0%		206.696
1978	567,898		413.12		234.610		90.0%		211.149
1979	573,369		417.90		239.611		90.0%		215.650
1980	578,839		422.68		244.664		90.0%		220.197
1981	584,310	Statistics	427.46		249.769		90.0%		224.792
1982	583,819	inter-	432.24		252.350		90.0%		227.115

	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
			kg/cap/yr		Gg		%		Gg
1983	583,328	polations	437.02		254.926		90.0%	National Statistics: Data on municipal waste, collected by public waste removal scheme including gap filling and correction	229.433
1984	582,837		441.80		257.498		90.0%		231.748
1985	582,346		446.58		260.064		90.0%		234.058
1986	581,856		451.36		262.626		90.0%		236.364
1987	581,365		456.14		265.184		90.0%		238.665
1988	580,874		460.92		267.736		90.0%		240.963
1989	580,383		465.70		270.284		90.0%		243.256
1990	579,892	Statistics	470.60	MONSTAT	272.897	National Statistics Data on municipal waste, collected by public waste removal scheme including gap filling and correction	88.4%		241.325
1991	582,999	MONSTAT	475.10		276.983		88.5%		245.176
1992	585,438		480.00		281.010		88.6%		248.857
1993	587,877		484.90		285.062		88.6%		252.681
1994	590,316		502.50		296.634		88.9%		263.624
1995	592,755		520.40		308.470		89.1%		274.777
1996	595,194		538.40		320.452		89.3%		286.154
1997	597,633		549.90		328.638		89.3%		293.411
1998	600,072		561.60		337.000		89.2%		300.603
1999	602,511		573.50		345.540		89.2%		308.075
2000	604,950		561.80		339.861		89.1%		302.883
2001	607,389		549.60		333.821		89.1%		297.410
2002	609,828		537.00		327.478		89.1%		291.654
2003	612,267		522.80		320.093		89.1%		285.055
2004	613,353		508.00		311.583		88.9%		277.103
2005	614,261		496.10		304.735		88.9%		271.010
2006	615,025		483.90		297.611		88.4%		263.235
2007	615,875		532.60		328.015		88.5%		290.187
2008	616,969		501.60		309.472		88.5%		273.798
2009	618,294		514.70		318.236		88.1%		280.207
2010	619,428	MONSTAT	516.20		319.749		87.5%	Monstat, Waste statitsics (2010: opening of recycling center)	279.925
2011	620,079		524.20		325.045	MONSTAT	71.4%		232.241
2012	620,601		494.40		306.825		75.9%		232.843
2013	621,207		496.70		308.554		83.3%		256.931
2014	621,810		483.70		300.769		85.4%		256.832
2015	622,159		502.60		312.697		85.6%		267.819
2016	622,303		517.90		322.291		85.3%		274.994
2017	622,373		520.80		324.132		82.7%		268.033
2018	622,182		441.50		274.713		83.0%		228.134
2019	622,028		450.93		280.490		85.4%		294.105
Trend									
1990 - 2019	*7.27%*		*-4.18%*		*2.78%*				*21.87%*
2005 - 2019	*1.26%*		*-9.11%*		*-7.96%*				*8.52%*
2018 - 2019	*-0.03%*		*2.14%*		*2.10%*				*28.92%*

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 289 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 [110]

For Montenegro it was possible to collect country specific data on waste composition. In the following table the IPCC default value is also provided. The country specific data on waste composition is in the range of the IPCC default. The IPCC default values of Degradable organic carbon (DOC) were applied and is in the following table presented.

[110] Available (23.01.2020) on https://www.sciencelearn.org.nz/resources/1543-measuring-biodegradability

Table 290 Composition of waste going to solid waste disposal sites

	Food	Garden	Paper	Wood	Textile	Disposable nappies	Plastics, other inert	Source
Waste composition				(share)				
IPCC Default	30.1%	0%	21.8%	7.5%	4.7%	0%	34.5%	TABLE 2.3, Vol. 5, Chapter 2, 2006 IPCC Guidelines
1950	33%	10%	10%	2%	2%	0%	43%	
⋮	extrapolation	extrapolation	extrapolation	constant	constant	constant	extrapolation	
1988	31.7%	13.9%	27.4%	0.0%	2.9%	0.0%	24.1%	Based on MONSTAT's survey OT-KOM 03 including gap filling and
1989	31.2%	13.8%	27.3%	0.0%	2.9%	0.0%	24.8%	
1990	30.2%	13.6%	26.9%	0.0%	2.9%	0.0%	26.5%	
1991	29.2%	13.4%	26.5%	0.0%	2.8%	0.0%	28.2%	
1992	28.2%	13.1%	26.0%	0.0%	2.8%	0.0%	29.9%	
1993	27.1%	12.9%	25.6%	0.0%	2.8%	0.0%	31.6%	
1994	26.1%	12.7%	25.2%	0.0%	2.8%	0.0%	33.3%	
1995	25.1%	12.5%	24.8%	0.0%	2.7%	0.0%	34.9%	
1996	24.1%	12.2%	24.3%	0.0%	2.7%	0.0%	36.6%	
1997	23.1%	12.0%	23.9%	0.0%	2.7%	0.0%	38.3%	
1998	22.1%	11.8%	23.5%	0.0%	2.7%	0.0%	40.0%	
1999	21.0%	11.6%	23.1%	0.0%	2.6%	0.0%	41.7%	
2000	20.0%	11.3%	22.7%	0.0%	2.6%	0.0%	43.4%	
2001	19.0%	11.1%	22.2%	0.0%	2.6%	0.0%	45.1%	
2002	18.0%	10.9%	21.8%	0.0%	2.5%	0.0%	46.8%	
2003	17.0%	10.7%	21.4%	0.0%	2.5%	0.0%	48.5%	
2004	16.0%	10.4%	21.0%	0.0%	2.5%	0.0%	50.2%	
2005	14.9%	10.2%	20.5%	0.0%	2.5%	0.0%	51.9%	
2006	13.9%	10.0%	20.1%	0.0%	2.4%	0.0%	53.5%	
2007	12.9%	9.8%	19.7%	0.0%	2.4%	0.0%	55.2%	
2008	11.9%	9.5%	19.3%	0.0%	2.4%	0.0%	56.9%	
2009	10.9%	9.3%	18.8%	0.0%	2.4%	0.0%	58.6%	
2010	9.9%	9.1%	18.4%	0.0%	2.3%	0.0%	60.3%	
2011	8.9%	8.9%	18.0%	0.0%	2.3%	0.0%	62.0%	
2012	10.7%	10.7%	20.6%	0.0%	1.8%	0.0%	56.3%	
2013	10.5%	10.5%	20.6%	0.0%	1.8%	0.0%	56.6%	
2014	11.3%	11.3%	19.7%	0.0%	1.8%	0.0%	55.9%	
2015	11.8%	11.8%	20.2%	0.0%	1.6%	0.0%	54.6%	
2016	11.5%	11.5%	19.2%	0.0%	1.6%	0.0%	56.3%	
2017	12.9%	12.9%	19.6%	0.0%	1.6%	0.0%	53.1%	
2018	12.0%	12.0%	19.3%	0.0%	1.6%	0.0%	55.1%	
2019	11.0%	11.0%	19.7%	0.0%	1.6%	0.0%	56.8%	

Table 291 Types of waste by LoW included in different waste groups

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 20 01 41, 20 01 99 20 02 03 20 03 01 (60%) 20 03 03 20 03 07 20 03 99	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 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

Table 292 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

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 293 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 and 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

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: Waste Table 3.1, p.6.8).

Table 294 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 SWDS	0.6	

Type of Site	Methane Correction Factor (MCF) Default Values	Source
1 **Anaerobic[111] 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 metres. 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.		

Table 295 Distribution of Waste by Waste Management Typ in Montenegro

	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%	
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%	Based on MONSTAT's survey and interviews of landfill managers
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%	

[111] Anaerobic means "living, active, occurring, or existing in the absence of free oxygen", as opposed to aerobic which means "living, active, or occurring only in the presence of oxygen."

	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
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	0.6%	45.0%	49.8%	0.0%	4.7%	
2014	0.8%	42.6%	52.0%	0.0%	4.6%	
2015	1.0%	43.0%	52.0%	0.0%	4.0%	
2016	1.0%	42.0%	52.0%	0.0%	5.0%	
2017	1.2%	37.5%	56.4%	0.0%	5.0%	
2018	2.0%	31.0%	64.0%	0.0%	3.0%	
2019	2.0%	31.0%	65.0%	0.0%	2.0%	

Furthermore, the following default parameter are 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 Guidelines, 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)

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.

Table 296 Amount of Methane Recovered from SWDS

	Amount of Methane Recovered from SWDS (Gg)	Fraction recovered methane	Source
2008	0.10715	0.01277	NEPA (different years) based on site data
2009	0.19500	0.02323	
2010	0.23758	0.02832	
2011	0.21739	0.02600	
2012	0.20224	0.02468	
2013	0.22870	0.02803	
2014	0.24556	0.02987	
2015	0.33423	0.04030	
2016	0.42839	0.05088	
2017	0.88083	0.10334	
2018	0.42354	0.04889	
2019	0.46251	0.05350	

Table 297 Recommended default methane generation rate (k) values under Tier 1

Type of Waste		Climate Zone*							
		Boreal and Temperate (MAT ≤ 20°C)				Tropical[1] (MAT > 20°C)			
		Dry (MAP/PET < 1)		Wet (MAP/PET > 1)		Dry (MAP < 1000 mm)		Moist and Wet (MAP ≥ 1000 mm)	
		Default	Range[2]	Default	Range[2]	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]	0.045	0.04 – 0.06	0.07	0.06 – 0.085
	Wood/ straw waste	**0.02**	0.01[3,4] – 0.03[6,7]	0.03	0.02 – 0.04	0.025	0.02 – 0.04	0.035	0.03 – 0.05
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]	0.065	0.05 – 0.08	0.17	0.15 – 0.2
Rapidly degrading waste	Food waste/Sewage sludge	**0.06**	0.05 – 0.08	0.185[4]	0.1[3,4] – 0.2[9]	0.085	0.07 – 0.1	0.4	0.17 – 0.7[10]
Bulk Waste		**0.05**	0.04 – 0.06	0.09	0.08[8] – 0.1	0.065	0.05 – 0.08	0.17	0.15[11] – 0.2

Remark: for footnotes see 2006 IPCC Guidelines

Source: Table 3.3, Vol. 5, Chapter 3, 2006 IPCC Guidelines

Table 298 Recommended default half-life (t1/2) values (YR) under Tier 1

Type of Waste		Climate Zone*							
		Boreal and Temperate (MAT ≤ 20°C)				Tropical[1] (MAT > 20°C)			
		Dry (MAP/PET < 1)		Wet (MAP/PET > 1)		Dry (MAP < 1000 mm)		Moist and Wet (MAP ≥ 1000 mm)	
		Default	Range[2]	Default	Range[2]	Default	Range[2]	Default	Range[2]
Slowly degrading waste	Paper/textiles waste	17	14[3,5] – 23[3,4]	12	10 – 14[3,5]	15	12 – 17	10	8 – 12
	Wood/ straw waste	35	23[3,4] – 69[6,7]	23	17 – 35	28	17 – 35	20	14 – 23
Moderately degrading waste	Other (non – food) organic putrescible/ Garden & park waste	14	12 – 17	7	6 – 9[8]	11	9 – 14	4	3 – 5
Rapidly degrading waste	Food waste/Sewage sludge	12	9 – 14	44	3[3,4] – 6[9]	8	6 – 10	2	1[10] – 4
Bulk Waste		14	12 – 17	7	6 – 9[8]	11	9 – 14	4	3 – 5[11]

Remark: for footnotes see 2006 IPCC Guidelines

Source: Table 3.4, Vol. 5, Chapter 3, 2006 IPCC Guidelines

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 299 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 Source-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 Source-specific recalculations

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 300 Recalculations done since NC & BUR in IPCC sub-category 5.A Solid Waste Disposal

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
5.A.	Application of 2006 IPCC Guidelines: FOD model	method	Accuracy, comparability
5.A.	Estimation of waste generation for the time series 1950 - 2018	AD	completeness
5.A.	Estimation of country specific waste composition	AD	Accuracy
5.A.	Application of default values of 2006 IPCC Guidelines	EF	Accuracy, comparability

7.2.6 Source-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 301 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	medium
5	Further investigation on waste generation (rate) • by urban and rural population • by climate zone (see Table 298 & Table 297) • by composition	AD		medium
5	Further investigation on amount and waste management practices regarding clinic waste, sludge, hazardous waste, etc.	AD		medium
5	Further investigation on industrial waste generation and industrial waste management practices	AD		medium
5.A	Further investigation on waste management practices (managed, unmanaged, unspecified) (see Table 294)	AD		high

GHG source & sink category	Planned improvement	Type of improvement		Priority
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	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.

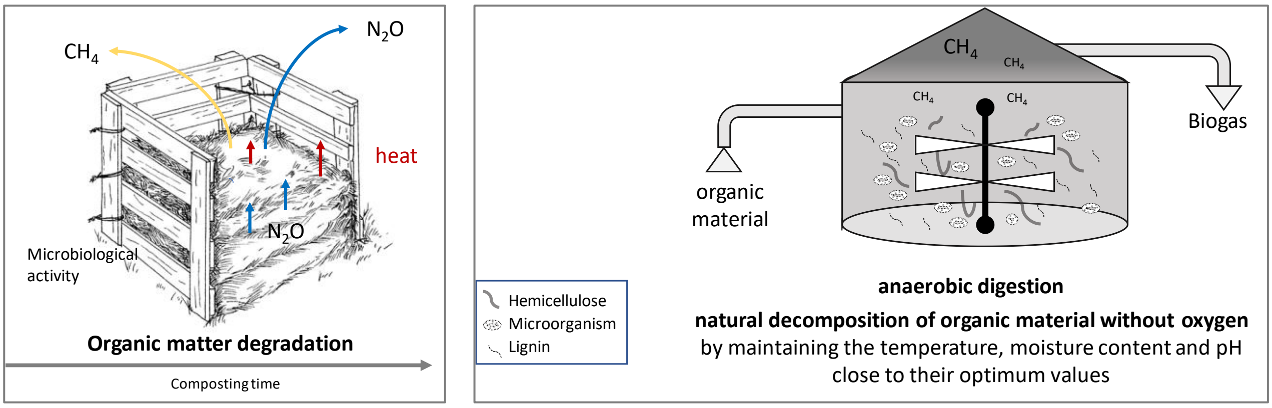


Figure 105 Scheme of composting and anaerobic digestion

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
Estimated			
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 Source-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 302 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	High
5.B	Literature study on GHG emissions from (small-scale) illegal dumping and backyard dumping especially in the period 1990 - 2000	EF		Medium

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 – 2019.

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

GHG emissions/ removals	CO_2	CH_4	N_2O
Sewage Sludge	NO	NO	NO
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 Source-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 303 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		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.

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.

The term “sanitation chain” which refers to the sequence according to which FS is “handled” along the way from production at the level of the households until its disposal is shown in in the following figure.

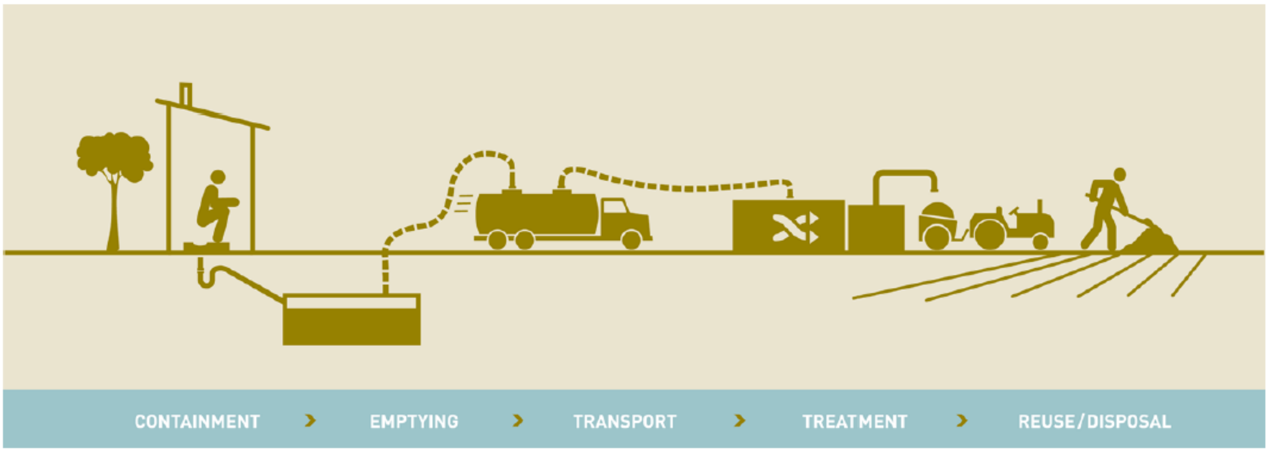


Figure 106 The Sanitation Chain

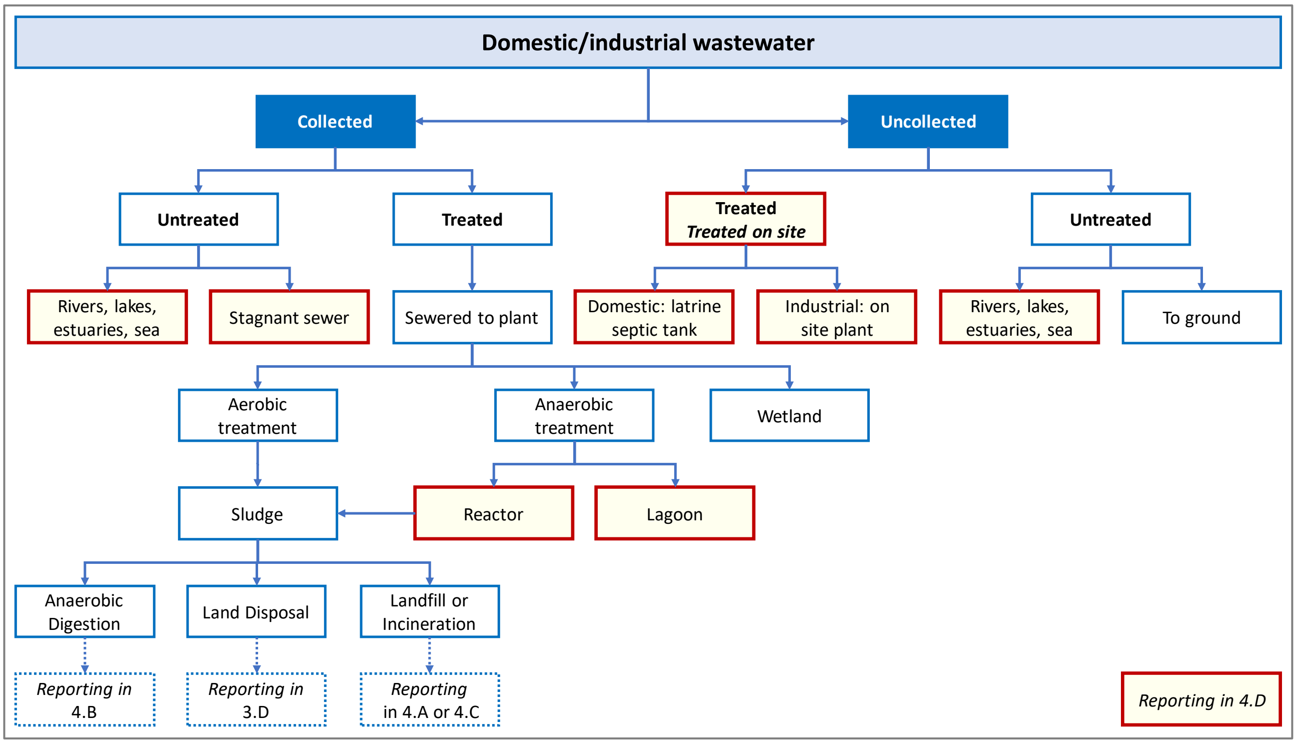


Figure 107 Wastewater treatment systems and discharge pathways[112]

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.

[112] Source: 2006 IPCC Guidelines, Volume 5: Waste, Chapter 6: Wastewater Treatment and Discharge - Figure 6.1

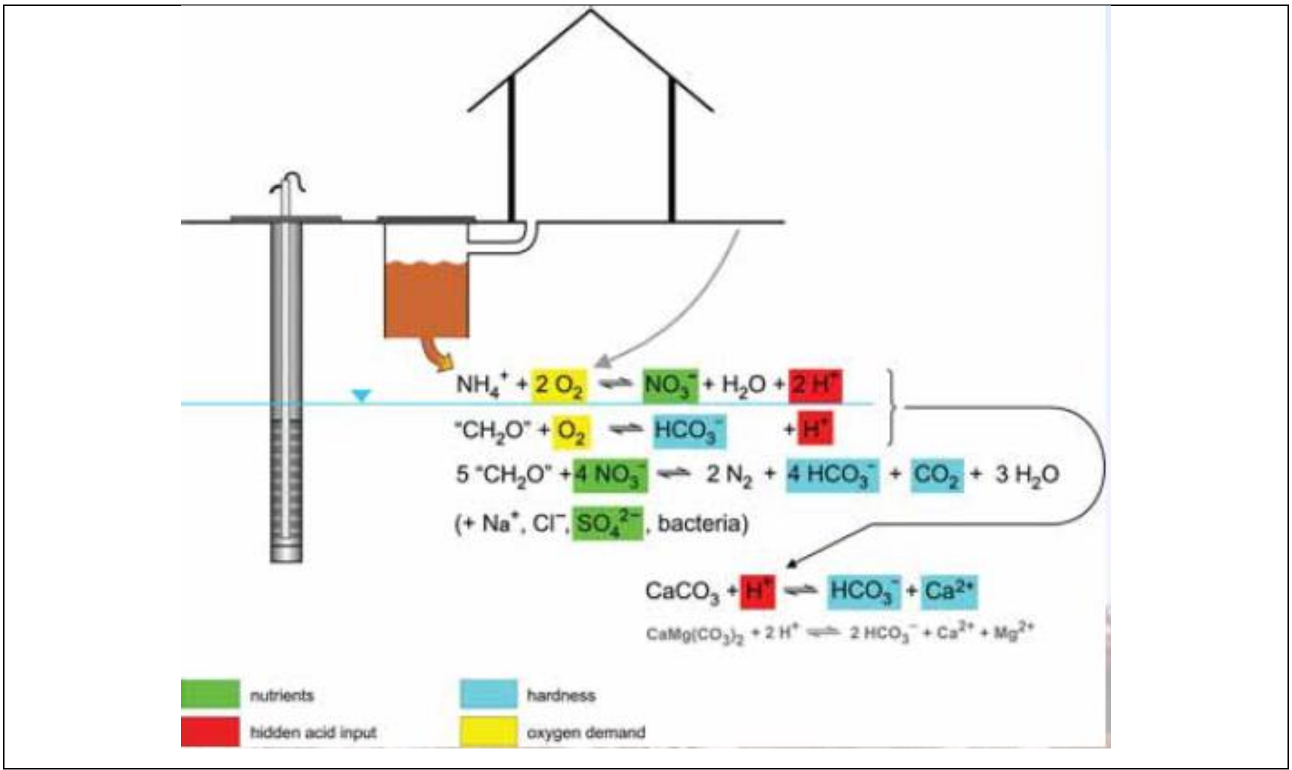


Figure 108 Main process of wastewater influence on shallow groundwater

Source: Federal Institute for Geosciences and Natural Resources (BGR): Groundwater resources at risk. Germany

Further differentiation was done according to the split provided in the 2006 IPCC Guidelines[113].

Type of treatment and discharge pathway or system	Comments
Untreated system	
Open defecation	Rivers with high organics loadings can turn anaerobic.
River and lake discharge	Rivers with high organics loadings can turn anaerobic.
Stagnant sewer	calculated in order to have always 100%
Treated system	
Flowing sewer (open or closed)	Fast moving, clean. (Insignificant amounts of CH_4 from pump stations, etc)
Centralized, aerobic treatment plant	Must be well managed. Some CH_4 can be emitted from settling basins and other pockets.
Centralized, aerobic treatment plant	Not well managed. Overloaded.
Anaerobic digester for sludge	CH_4 recovery is not considered here.
Anaerobic reactor	CH_4 recovery is not considered here.
Anaerobic shallow lagoon	Depth less than 2 metres, use expert judgment.
Anaerobic deep lagoon	Depth more than 2 metres
Septic system	Half of BOD settles in anaerobic tank.

[113] Table 6.3, Chap. 6.2.2.2, Volume 5, 2006 IPCC Guidelines

Type of treatment and discharge pathway or system	Comments
Latrine (family)	Dry climate, ground water table lower than latrine, small family (3-5 persons)
Latrine (many user)	Dry climate, ground water table lower than latrine, communal (many users)
Latrine	Wet climate/flush water use, ground water table higher than latrine
Latrine	Regular sediment removal for fertilizer

In the period 1990 to 2019 GHG emissions from the category wastewater treatment and discharge increased by 1.5% from 67.47 Gg CO_2 eq in 1990 to 68.52 Gg CO_2 eq in 2019. In the period 2005 to 2019 GHG emissions from the Waste sector decreased by 3.3%. The decreasing trend in CH_4 emissions was due to increasing number of population connected to sewage systems and waste water treatment plants (WWTPs). The significant increase of N_2O emissions was due to growing population and higher per capita protein consumption. In the following table are the CH_4 and N_2O emission presented.

Table 304 CH_4 Emissions and N_2O emission

	GHG emissions	Total CH_4 emissions		Total N_2O emissions	
Unit	Gg CO_2 equivalent	Gg	Gg CO_2 equivalent	Gg	Gg CO_2 equivalent
1990	67.47	2.40	60.01	0.025	7.47
1991	67.85	2.41	60.19	0.026	7.66
1992	68.15	2.41	60.30	0.026	7.84
1993	68.44	2.42	60.42	0.027	8.02
1994	68.74	2.42	60.53	0.028	8.21
1995	69.04	2.43	60.64	0.028	8.40
1996	69.33	2.43	60.75	0.029	8.58
1997	69.63	2.43	60.86	0.029	8.77
1998	69.49	2.42	60.52	0.030	8.96
1999	69.34	2.41	60.18	0.031	9.16
2000	69.18	2.39	59.84	0.031	9.35
2001	69.23	2.38	59.49	0.033	9.75
2002	69.73	2.38	59.58	0.034	10.15
2003	70.22	2.39	59.68	0.035	10.55
2004	70.57	2.39	59.64	0.037	10.93
2005	70.89	2.38	59.58	0.038	11.31
2006	71.20	2.38	59.51	0.039	11.69
2007	71.73	2.38	59.45	0.041	12.29
2008	72.21	2.38	59.41	0.043	12.80
2009	71.99	2.37	59.23	0.043	12.76

	GHG emissions	Total CH_4 emissions		Total N_2O emissions	
Unit	Gg CO_2 equivalent	Gg	Gg CO_2 equivalent	Gg	Gg CO_2 equivalent
2010	71.97	2.36	59.03	0.043	12.94
2011	71.73	2.35	58.78	0.043	12.95
2012	70.96	2.34	58.52	0.042	12.44
2013	71.36	2.33	58.27	0.044	13.09
2014	70.87	2.31	57.77	0.044	13.10
2015	70.36	2.29	57.25	0.044	13.11
2016	69.82	2.27	56.71	0.044	13.11
2017	69.27	2.25	56.16	0.044	13.11
2018	68.70	2.22	55.59	0.044	13.11
2019	68.52	2.22	55.41	0.044	13.10
Trend					
1990 - 2019	*1.5%*	*-7.7%*	*-7.7%*	*75.5%*	*75.5%*
2005 - 2019	*-3.3%*	*-6.9%*	*-7.0%*	*15.9%*	*15.9%*
2018 - 2019	*-0.3%*	*-0.3%*	*-0.3%*	*0.05%*	*0.05%*

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 107 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)

Table 305 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, Chapter 6, page 6.12

Table 306 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

Type of treatment and discharge pathway or system	Comments	MCF Default values for domestic wastewater
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 metres, use expert judgment.	0.2
Anaerobic deep lagoon	Depth more than 2 metres	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 = tory year, kg BOD/yr

P = country population in inventory year, (person)

BOD = country-specific per capita BOD in inventory year, g/person/day, See Table 6.4.

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.)

Table 307 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	579,892	5.00	36	55.00	4.00
1991	582,999	*5.00*	36	*54.82*	*3.90*
1992	585,438	*5.00*	37	*54.64*	*3.80*
1993	587,877	*5.00*	37	*54.46*	*3.71*
1994	590,316	*5.00*	37	*54.28*	*3.61*
1995	592,755	*5.00*	37	*54.11*	*3.51*
1996	595,194	*5.00*	38	*53.93*	*3.41*
1997	597,633	5.00	38	*53.75*	*3.31*
1998	600,072	*7.25*	36	*53.57*	*3.21*
1999	602,511	*9.50*	34	*53.39*	*3.12*
2000	604,950	*11.75*	32	*53.21*	*3.02*
2001	607,389	14.00	30	*53.03*	*2.92*
2002	609,828	14.00	30	*52.85*	*2.82*
2003	612,267	14.00	31	*52.67*	*2.72*
2004	613,353	14.00	31	*52.50*	*2.62*
2005	614,261	14.00	31	*52.32*	*2.53*
2006	615,025	14.00	31	*52.14*	*2.43*
2007	615,875	14.00	32	*51.96*	*2.33*
2008	616,969	14.00	32	*51.78*	*2.23*
2009	618,294	*14.80*	31	*51.60*	*2.13*
2010	619,428	*15.60*	31	*51.42*	*2.03*
2011	620,079	*16.40*	30	*51.24*	*1.94*
2012	620,601	*17.20*	30	*51.07*	*1.84*
2013	621,207	18.00	29	*50.89*	*1.74*
2014	621,810	*20.00*	28	*50.71*	*1.64*
2015	622,159	*22.00*	26	50.53	1.54
2016	622,303	*24.00*	24	*50.35*	*1.54*
2017	622,373	*26.00*	22	*50.17*	*1.54*
2018	622,182	28.00	20	*49.99*	*1.54*
2019	621,873	28.00	21	*49.81*	*1.54*
Trend 1990-2019	7.24%	460.00%	-42.66%	-9.43%	-61.42%
Trend 2005-2019	1.11%	100.00%	-34.33%	-4.46%	-36.44%
Trend 2018-2019	-0.05%	0.00%	0.87%	-0.36%	0.00%
Source	*(MONSTAT*	*Monstat, enviorment indicators (kursiv interpolation)*	*calculated*	*2015 WHO sanitation, 1990 assumption, (kursiv interpolation)*	*2015 WHO (kursiv 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

7.5.3 Source-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 308 Planned improvements for IPCC sub-category 5.D Wastewater Treatment and Discharge

GHG source & sink category	Planned improvement	Type of improvement		Priority
5.D	Investigation on wastewater flow: collection – treatment and discharge pathways and systems • Urban population (high / low income) • Rural population	AD	Accuracy Transparency Comparability Completeness	High
5.D	Estimation of amount of wastewater treated • Urban population (high / low income) • Rural population	AD		High
5.D	Use of metadata prepared for and submitted to WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP)	AD		High
5.D	Investigation of flow and amount of industrial wastewater	AD		High
5.D	Sludge separation and annual amount of sludge removal that is • dumped • applied to soil (agriculture) • incinerated	AD		Medium

8 Other

Montenegro does not report any emissions under IPCC sector 6 Other.

9 Recalculations and Improvements

Recalculations of previously submitted inventory data are performed with the only purpose to improve the GHG inventory. This chapter quantifies the changes in emissions for all greenhouse gases compared to the previous submission.

9.1 Explanations and justifications for recalculations

Compiling an emission inventory includes data collecting, data transfer and data processing. Data has to be collected from different sources, for instance national statistics, plant operators, studies, personal information or other publications. The provided data must be transferred from different data formats and units into a unique electronic format to be processed further. The calculation of emissions by applying methodologies on the collected data and the final computing of time series into a predefined reporting format are further steps in the preparation of the final submission.

Finally, the submission must be delivered in due time. Even though a QA/QC system gives assistance so that potential error sources are minimized it is sometimes necessary to make some revisions (called recalculations) under the following circumstances:

- An emission source was not considered in the previous inventory.
- A source/data supplier has delivered new data. The causes might be: Previous data were preliminary data only (by estimation, extrapolation), improvements in methodology.
- Occurrence of errors in data transfer or processing: wrong data, unit-conversion, software errors, etc.
- Methodological changes: a new methodology must be applied to fulfil the reporting obligations caused by one of the following reasons:
  - to decrease uncertainties.
  - an emission source becomes a key source.
  - consistent input data needed for applying the methodology is no longer accessible.
  - input data for more detailed methodology is now available.
  - the methodology is no longer appropriate.

Detailed information on recalculations and their justifications can be found in the following subchapters as well as the corresponding Sector-specific Chapters of the sectors Energy, IPPU, Agriculture, LULUCF and Waste, in which all methodological changes and activity data updates that led to recalculations of emissions with respect to the previous submission are listed.

Table 309 Recalculations

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
1.A.1.a	Use of PS NCV	AD	Accuracy
1.A.1.a	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy
1.A.2.a	use of CS NCV	AD	Accuracy
1.A.2.a	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy
1.A.2.b	use of CS NCV	AD	Accuracy

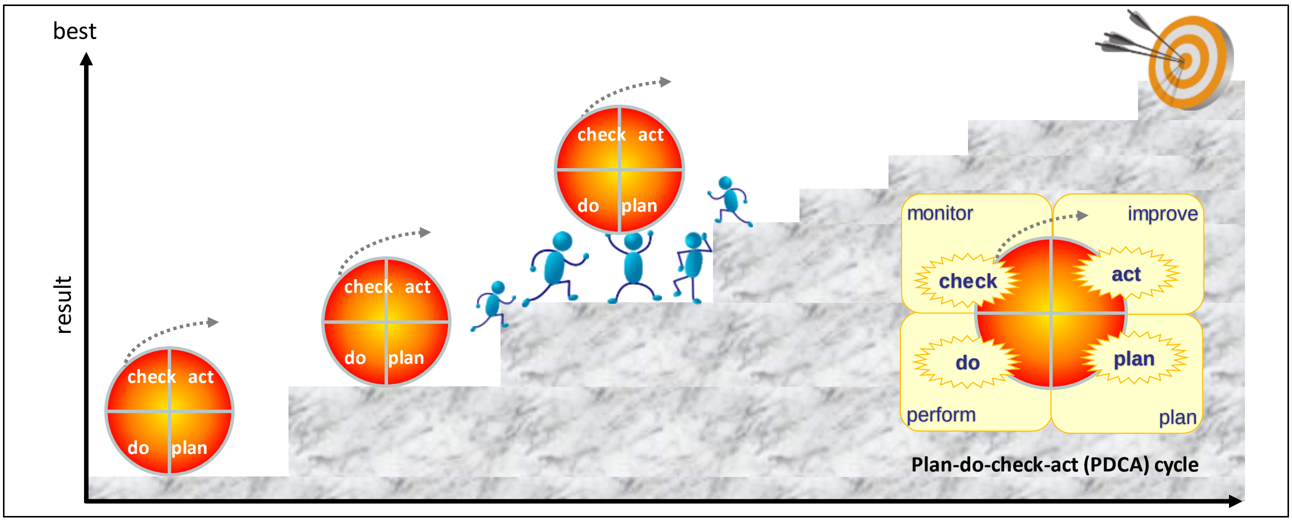
GHG source & sink category	Revisions of data	Type of revision	Type of improvement
1.A.2.b	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy
1.A.2.c	use of CS NCV	AD	Accuracy
1.A.2.c	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy
1.A.2.d	use of CS NCV	AD	Accuracy
1.A.2.d	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy
1.A.2.e	use of CS NCV	AD	Accuracy
1.A.2.e	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy
1.A.2.e	use of CS NCV	AD	Accuracy
1.A.2.e	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy
1.A.2.i	use of CS NCV	AD	Accuracy
1.A.2.i	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy
1.A.2.j	use of CS NCV	AD	Accuracy
1.A.2.j	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy
1.A.2.l	use of CS NCV	AD	Accuracy
1.A.2.l	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy
1.A.2.m	use of CS NCV	AD	Accuracy
1.A.2.m	Fuel consumption data (activity data) was revised due to revised fuel consumption data – plant specific data	AD	Accuracy
1.A.3.a	Application of EMEP/EEA air pollutant emission inventory guidebook 2013	method	Comparability
1.A.3.a	use of default EF of EMEP/EEA air pollutant emission inventory guidebook 2013	EF	Comparability
1.A.3.a	use of CS NCVd	AD	Accuracy
1.A.3.a	Fuel consumption data (activity data) was revised	AD	Accuracy
1.A.3.b	Application of EMEP/EEA air pollutant emission inventory guidebook 2012 and 2006 IPCC Guidelines	method	Comparability
1.A.3.b	use of default EF of EMEP/EEA air pollutant emission inventory guidebook 2013 and 2006 IPCC Guidelines	EF	Comparability
1.A.3.b	use of CS NCV	AD	Accuracy
1.A.3.b	Fuel consumption data (activity data) was revised	AD	Accuracy
1.A.4.a	Fuel consumption data (activity data) was revised due to revised activity data	AD	Accuracy
1.A.4.a	use of CS NCV	AD	Comparability

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
1.A.4.b	Fuel consumption data (activity data) was revised due to revised activity data	AD	Accuracy
1.A.4.b	use of CS NCV	AD	Comparability
1.A.4.c	Fuel consumption data (activity data) was revised due to revised activity data	AD	Accuracy
1.A.4.c	use of CS NCV	AD	Comparability
2.A.2	Application of 2006 IPCC Guidelines	method	Accuracy Comparability
2.A.2	Application of default emission factors of 2006 IPCC Guidelines	EF	Accuracy Transparency
3.A.1	application of 2006 IPCC Guidelines	method	Comparability
3.A.1.a	use of default emission factor of 2006 IPCC Guidelines	EF	Comparability
3.A.1.b-j	use of default emission factor of 2006 IPCC Guidelines	EF	Comparability
3.A.1.a.	split of cattle in dairy, bulls and other non-dairy cattle	AD	Comparability
3.B	application of 2006 IPCC Guidelines	method	Comparability
3.B	use of CH_4 default emission factor of 2006 IPCC Guidelines	EF	Comparability
3.B	use of N_2O default emission factor (direct emission) of 2006 IPCC Guidelines	EF	Comparability
3.B	use of N_2O default emission factor (indirect emission) of 2006 IPCC Guidelines	EF	Comparability
3.D	application of 2006 IPCC Guidelines	method	Comparability
3.D.a	use of N_2O default emission factor (direct emission) of 2006 IPCC Guidelines	EF	Comparability
3.D.b	use of N_2O default emission factor (indirect emission) of 2006 IPCC Guidelines	EF	Comparability
3.F	application of 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
4	For this NIR a completely new LULUCF estimate was carried out by different experts and institutions than in previous GHG inventory submissions of Montenegro. The approaches of estimating the land use and land-use changes, emission factors and emissions/removals were changed to a large extent and estimates for further subcategories were introduced (e.g. for Harvested Wood Products). Consequently, it is no surprise that the LULUCF results differ significantly to previous submissions of Montenegro for this sector (NIR for the period 1990 to 2018, 2nd National Communication and 1st BUR, both in 2015). Particularly, the significant and constant removals for Forest Land of this submission are different to the results of last year's estimates where both net emissions and removals occurred in the time series.	AD EF method	Accuracy Completeness Comparability Consistency Transparency

GHG source & sink category	Revisions of data	Type of revision	Type of improvement
5.A.	Application of 2006 IPCC Guidelines: FOD model	method	Accuracy, comparability
5.A.	Estimation of waste generation for the time series 1950 - 2018	AD	completeness
5.A.	Estimation of country specific waste composition	AD	Accuracy
5.A.	Application of default values of 2006 IPCC Guidelines	EF	Accuracy, comparability

9.2 Planned improvements

In the follow table the planned improvements are listed. Depending on the resources and priorities, the improvements will be implemented within the next inventory cycles.



9.2.1 Planned improvements - General

GHG source & sink category	Planned improvement	Type of improvement		Priority
all	Improve QA/QC activities	all	Accuracy Transparency	high
all	Revision of technical mistakes	all	Accuracy Transparency	high
all	Quantitative unvertainty analaysis	all	Accuracy Transparency Completeness Comparability	High
all	Improve Archiving	all	Accuracy Transparency Completeness Comparability	High
all	Training of national experts regarding excel and word	all	Transparency	High
all	Participation of national experts in international trainings and as inventory reviewers	all	Transparency	High

9.2.2 Planned improvements for IPCC sector Energy

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	high
1.A.1.a	Cross-check of national and international data sources (Eurostat and UNSD)	AD	Consistency Transparency	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
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 (4) Raw materials for carbonization. • Fuelwood & wood fuel: type of wood and wood waste • Agricultural residues • bark waste (5) charcoal making technologies 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
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 timesseries. 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

GHG source & sink 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 timeseries. 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
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 timeseries. 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
1.A.2.d	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.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 timeseries. 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
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

GHG source & sink category	Planned improvement	Type of improvement		Priority
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 timesseries. 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
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 timesseries. 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
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
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 timesseries. 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
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 timesseries. Emissions are allocated in IPCC/NFR subcategory 1.A.2.m Other.	AD	Accuracy Transparency	High

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.A.2.j	Cross-check of national and international data sources (Eurostat and UNSD)	AD	Consistency Transparency	Medium
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 timesseries. 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
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 timesseries. 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
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 timesseries. 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
1.A.3.a	Application of EMEP/EEA air pollutant emission inventory guidebook 2019, TIER 2	meth od	Comparability	high
1.A.3.a	use of default EF of EMEP/EEA air pollutant emission	EF	Comparability	medium

GHG source & sink category	Planned improvement	Type of improvement		Priority
	inventory guidebook 2019, TIER 2			
1.A.3.a	Investigation on Flight movements Investigation on fleet	AD	Comparability	high
1.A.3.b	Application of IPCC 2006 Guidelines, TIER 2/3 **Use of COPERT model**	meth od	Comparability	high
1.A.3.b	Investigation on vehecile movements (milage, age technology of vehicles) Investigation on vehicle fleet	AD	Comparability	High
1.A.3.b	Road vehicle categories and relevant Legislation/ Technology classes • Passenger Cars • Light Commercial Vehicles (LDV) • Heavy-Duty Vehicles (HDV) Mopeds and Motorcycles		Completeness Accuracy Transparency	High
1.A.3.b	Time-series of fuel consumption ⇒ completing time series and gap filling for some years	AD	Consistency Completeness	High
1.A.4	Split of fuel consumption to different sub-categories	EF	Transparency	medium
1.A.4	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.a	Survey on fuel used and relevant characteristics: Waste – biomass fraction / non-biomass fraction	AD	Completeness	high
1.A.4.a	Cross-check of national, Eurostat, FAO and international data sources and feedback to UNSD	AD	Completeness	medium
1.A.4.a	Time-series of fuel consumption	AD	Consistency Completeness	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 Completeness	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
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 &	Survey on Abandoned underground mines and on flaring of	AD	accuracy	medium

GHG source & sink category	Planned improvement	Type of improvement		Priority
1.B.1.a.i.4	drained methane			
1.B.1.b	Uncontrolled combustion and burning coal dumps	AD	accuracy	medium
1.B.2	Estimation of emission from transport, distribution and storage of oil and natural gas	AD EF meth od	Completeness	high

9.2.3 Planned improvements for IPCC sector Industrial Processes and Product Use (IPPU)

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 Limeproduction in 2010.	AD	Accuracy,	Medium
2.C.3	Detailed description of the methods used		Transparency	High
2.D.1	Incorperation of the estimated based on the energy balance	AD	Completness	High
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) ofEUROSTAT and UN statistics of item non-energy use	AD	Accuracy Transparency Consistency	Medium
2.D.3	Analysis of subcategories which are occurring in Montenegro (see Table 191)	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 191)	AD	Accuracy Transparency	High / Medium
2.F.1	In-depth analysis of (a) data on historic and current equipment (b) production, import & export of commodities of • HS code 8415 'Air-condition' • HS code 8418 'Refrigerator and freezer'	AD	Accuracy Transparency Completeness Comparability	High
2.F.1	In-depth analysis of (a) data on historic and current equipment (b) production, import & export of commodities of • Containing fluids / gases • Container size • Life time • usage pattern • maintenance • disposal	AD	Accuracy Transparency Completeness Comparability	High
2.F.1	Analysis of mobile air-conditioning units/equipment	AD	Accuracy Transparency Completeness Comparability	High
2.F.1	Application of methodology of 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 7: Emissions of Fluorinated Substitutes for Ozone Depleting Substances. (7.5 REFRIGERATION AND AIR CONDITIONING) Page 7.43.	AD	Accuracy Transparency Completeness Comparability	High
2.F.2	Analysis of Foam Blowing Agents, e.g.	AD	Accuracy	High

GHG source & sink category	Planned improvement	Type of improvement		Priority
	• the amount of chemical used in foam manufacturing in a country and not subsequently exported the amount of chemical contained in foam imported		Transparency Completeness Comparability	
2.F.2	Investigation on applications • Polyurethane – Integral Skin / Polyurethane – Continuous Panel / Discontinuous Panel / Appliance / Injected / etc. • One Component Foam (OCF) • Extruded Polystyrene (XPS) Phenolic – Discontinuous Block / Discontinuous Laminate	AD	Accuracy Transparency Completeness Comparability	High
2.F.2	Application of methodology of 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 7: Emissions of Fluorinated Substitutes for Ozone Depleting Substances. (7.4 FOAM BLOWING AGENTS) Page 7.32.	AD	Accuracy Transparency Completeness Comparability	High
2.F.3	Investigation of import and use of fire protection products and fire protection equipment	AD	Accuracy Transparency Completeness	High
2.F.3	Application of methodology of 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 7: Emissions of Fluorinated Substitutes for Ozone Depleting Substances. (7.6 FIRE PROTECTION) Page 7.61.	AD	Accuracy Transparency Completeness Comparability	High
2.F.4	Investigation of • Domestic aerosol production • Imported aerosol production	AD	Accuracy Transparency Completeness	High
2.F.4	Investigation of the use and consumption (by chemical composition) of products containing HFC and/or PFC for cleaning: (i) Metered Dose Inhalers (MDIs); (ii) Personal Care Products (e.g., hair care, deodorant, shaving cream); (iii) Household Products (e.g., air-fresheners, oven and fabric cleaners); (iv) Industrial Products (e.g., special cleaning sprays such as those for operating electrical contact, lubricants, pipe-freezers); (v) Other General Products (e.g., silly string, tyre inflators, klaxons).	AD	Accuracy Transparency Completeness	High
2.F.4	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
2.F.5	Investigation of the use and consumption (by chemical	AD	Accuracy	High

GHG source & sink category	Planned improvement	Type of improvement		Priority
	composition) of solvents containing HFC and/or PFC products for (i) Precision Cleaning, (ii) Electronics Cleaning, (iii) Metal Cleaning, (iv) Deposition applications).		Transparency Completeness	
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
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
2.G.1	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 SF_6 if available from their servicing companies will be tried to be obtained.	AD	Accuracy Transparency Completeness Comparability	High
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
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

9.2.4 Planned improvements for IPCC sector Agriculture

GHG source & sink category	Planned improvement	Type of improvement		Priority
3.A.1	Correction of technical mistakes in calculation	AD EF	Completeness	high

GHG source & sink category	Planned improvement	Type of improvement		Priority
3.A. 3.B. 3.D.	Husbandry and Management Practice with consideration • characteristics of Livestock Husbandry for the whole time series: ○ breed, ○ age distribution, ○ weight ○ milk wool yield, ○ wool yield, ○ working hours • characteristics of manure management practice: ○ stall / housed and Housing period ○ pasture/range/paddock (flat/hilly) ○ grazing large areas (flat/hilly) ○ daily spread ○ solid storage ○ dry lot ○ liquid/slurry with/without natural crust cover ○ uncovered anaerobic lagoon ○ pit storage below animal confinements ○ anaerobic digester ○ burned for fuel ○ cattle and swine deep bedding ○ composting ○ aerobic treatment	AD	Accuracy Consistency Comparability Transparency Completeness	high
3.A. 3.B.	Manure management by temperature for sheep, goats, camels, horses, mules, and asses, and poultry	AD	Accuracy Comparability Transparency	medium
3.A.1.c 3.A.1.d 3.A.1.e	Estimation of methane emissions applying TIER 2 approach as these sub-categories are key categories	meth od	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	High
3.A.2	Correction of technical mistakes in calculation	AD, EF	Completeness	high
3.A.2	Estimation of methane emissions applying TIER 2 approach as these sub-categories are key categories	meth od	Transparency Comparability	high
3.B	Survey and/or research on VS excretion rates		Accuracy	medium
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

GHG source & sink category	Planned improvement	Type of improvement		Priority
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)	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	AD	Accuracy Consistency	High
3.E	Analysis of relevant activity data regarding prescribed fires and wildfires and estimation of emissions	AD	Accuracy Consistency Comparability Transparency Completeness	high
3.F	Correction of technical mistakes in calculation	AD	Accuracy	high

GHG source & sink category	Planned improvement	Type of improvement		Priority
3.F	Consideration of cultivated crops and crop residues which are burnt and if possible, by provinces • 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[114] (Emissions – Agriculture) where emissions from crop residues were estimated		Consistency	medium
3.G	Improvement of description of activity data	AD	Transparency	medium
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

[114] Available (03. March 2019) on http://www.fao.org/faostat/en/#data/GA

9.2.5 Planned improvements for IPCC sector Land Use, Land Use Change and Forestry (LULUCF)

GHG source & sink category	Planned improvement	Type of improvement		Priority
4	• First of all, Montenegro intends a re-assessment of its 1st NFI in the next years • A more detailed analysis of the land-use changes between CLC sub-categories and a related adjustment of the emission estimates. • A survey for the availability and derivation of country-specific emission factors for biomass stocks and stock change rates in cropland, grassland, settlement and other land. • A survey for the availability and derivation of country-specific soil C stocks for cropland, grassland and other land. • 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. • An uncertainty analysis of the LULUCF sector will be carried out.	AD EF method	Accuracy Completeness Comparability Consistency Transparency	medium / high

9.2.6 Planned improvements for IPCC sector Waste

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	medium
5	Further investigation on waste generation (rate) • by urban and rural population • by climate zone (see Table 298 & Table 297) • by composition	AD		medium
5	Further investigation on amount and waste management practices regarding clinic waste, sludge, hazardous waste, etc.	AD		medium
5	Further investigation on industrial waste generation and industrial waste management practices	AD		medium
5.A	Further investigation on waste management practices (managed, unmanaged, unspecified) (see Table 294)	AD		medium
5	Further investigation on illegal dumping in districts/ villages - garbage pit, illegal dumping in rivers / lakes, backyard dumping	AD		medium
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
5.B	Investigation on composting activities especially in the rural area and the use of compost in agriculture	AD	Accuracy	High
5.B	Literature study on GHG emissions from (small-scale) illegal dumping and backyard dumping especially in the period 1990 - 2000	EF	Accuracy	Medium
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	High
5.C	Investigation on fraction of waste, which is combustible	AD	Accuracy	High
5.D	Investigation on wastewater flow: collection – treatment and discharge pathways and systems • Urban population (high / low income) Rural population	AD	Accuracy Transparency Comparability Completeness	High
5.D	Estimation of amount of wastewater treated • Urban population (high / low income) Rural population	AD		High
5.D	Use of metadata prepared for and submitted to	AD		High

GHG source & sink category	Planned improvement	Type of improvement		Priority
	WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP)			
5.D	Investigation of flow and amount of industrial wastewater	AD		High
5.D	Sludge separation and annual amount of sludge removal that is • dumped • applied to soil (agriculture) incinerated	AD		Medium

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11 Units and abbreviations

11.1 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

11.2 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

11.3 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

11.4 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

12 Summary Tables

12.1 Summary Tables (without LULUCF) for the years 1990, 1995, 2000, 2005, 2010, 2015 and 2019

Greenhouse gas source and sink categories 2019	CO_2 emissions & removals	CH_4	N_2O	GHG (without LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
1. Energy	**2,578.60**	**3.84**	**0.09**	**2,701.70**	**2,578.60**	**95.95**	**27.15**	**NA**	**NA**	**NA**
A. Fuel combustion (sectoral approach)	2,578.60	1.88	0.09	2,652.76	2,578.60	47.01	27.15	NA	NA	NA
1. Energy industries	1,473.78	0.01	0.02	1,480.67	1,473.78	0.36	6.52	NA	NA	NA
2. Manufacturing industries and construction	192.37	0.02	0.00	193.69	192.37	0.46	0.86	NA	NA	NA
3. Transport	867.61	0.12	0.04	883.29	867.61	2.88	12.80	NA	NA	NA
4. Other sectors	44.84	1.73	0.02	95.11	44.84	43.30	6.97	NA	NA	NA
5. Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
B. Fugitive emissions from fuels	NE	1.96	NE	48.94	NE	48.94	NE	NA	NA	NA
1. Solid fuels	NA	1.96	NA	48.94	NA	48.94	NA	NA	NA	NA
2. Oil and natural gas	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
2. Industrial processes	**91.06**	**0.00**	**NO**	**376.89**	**91.06**	**0.01**	**NO**	**248.35**	**34.03**	**3.44**
A. Mineral products	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
C. Metal production	61.86	0.00	NO	95.90	61.86	0.01	NO	NA	34.03	NA
D. Other production	29.13	NA	NA	29.13	29.13	NA	NA	NA	NA	NA
E. Production of halocarbons and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NE	248.35	NE	NE	NE	248.35	NO	NO
G Other product manufacture and use	NE	NE	NE	3.44	NE	NE	NE	NA	NA	3.44
H. Other	0.08	NA	NA	0.08	0.08	NA	NA	NA	NA	NA
3. Agriculture	**0.35**	**9.99**	**0.07**	**271.57**	**0.35**	**249.84**	**21.37**	**NA**	**NA**	**NA**
A. Enteric fermentation	NA	8.24	NA	205.90	NA	205.90	NA	NA	NA	NA
B. Manure management	NA	1.76	0.03	54.19	NA	43.92	10.27	NA	NA	NA

Greenhouse gas source and sink categories 2019	CO_2 emissions & removals	CH_4	N_2O	GHG (without LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
C. Rice cultivation	NA	NO	NA	NO	NA	NO	NA	NA	NA	NA
D. Agricultural soils	NA	NA	0.04	11.09	NA	NA	11.09	NA	NA	NA
E. Prescribed burning of savannahs	NA	NO	NO	NA	NA	NO	NO	NA	NA	NA
F. Field burning of agricultural residues	NA	0.00	0.00	0.03	NA	0.02	0.01	NA	NA	NA
G. Other (Urea application)	0.35	0.00	0.00	0.35	0.35	0.00	0.00	NA	NA	NA
5. Waste	**NE**	**10.40**	**0.04**	**273.08**	**NE**	**259.98**	**13.10**	**NA**	**NA**	**NA**
A. Solid waste disposal on land	NA	8.18	NA	204.56	NA	204.56	NA	NA	NA	NA
B. Biological Treatment of Solid Waste	NA	NE	NE	NE	NA	NE	NE	NA	NA	NA
C. Waste incineration	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
D. Waste-water handling	NA	2.22	0.04	68.52	NA	55.41	13.10	NA	NA	NA
6. Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
Total national emissions and removals	**159.00**	**24.45**	**0.24**	**3,623.25**	**2,670.01**	**605.78**	**61.63**	**248.35**	**34.03**	**3.44**
Memo items										
International bunkers										
Aviation	**58.02**	**NE**	**0.00**	**59.48**	**58.02**	**NE**	**1.46**	**NA**	**NA**	**NA**
Marine	NO	NO	NO	NE	NO	NO	NO	**NA**	**NA**	**NA**
CO_2 emissions from biomass	**601.67**	**NA**	**NA**	**601.67**	**601.67**	**NA**	**NA**	**NA**	**NA**	**NA**

Greenhouse gas source and sink categories 2015	CO_2 emissions & removals	CH_4	N_2O	GHG (without LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
1. Energy	**2,427.41**	**3.95**	**0.08**	**2,551.11**	**2,427.41**	**98.84**	**24.86**	**NA**	**NA**	**NA**
A. Fuel combustion (sectoral approach)	2,427.41	2.18	0.08	2,506.74	2,427.41	54.48	24.86	NA	NA	NA
1. Energy industries	1,646.38	0.02	0.02	1,654.08	1,646.38	0.41	7.29	NA	NA	NA
2. Manufacturing industries and construction	158.13	0.02	0.00	159.39	158.13	0.45	0.81	NA	NA	NA
3. Transport	580.32	0.10	0.03	591.21	580.32	2.42	8.47	NA	NA	NA
4. Other sectors	42.57	2.05	0.03	102.07	42.57	51.20	8.29	NA	NA	NA
5. Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
B. Fugitive emissions from fuels	NE	1.77	NE	44.36	NE	44.36	NE	NA	NA	NA
1. Solid fuels	NA	1.77	NA	44.36	NA	44.36	NA	NA	NA	NA
2. Oil and natural gas	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
2. Industrial processes	**91.17**	**0.00**	**NO**	**385.96**	**91.17**	**0.01**	**NO**	**220.62**	**71.93**	**2.23**
A. Mineral products	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
C. Metal production	70.93	0.00	NO	142.87	70.93	0.01	NO	NA	71.93	NA
D. Other production	20.16	NA	NA	20.16	20.16	NA	NA	NA	NA	NA
E. Production of halocarbons and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NE	220.62	NE	NE	NE	220.62	NO	NO
G Other product manufacture and use	NE	NE	NE	2.23	NE	NE	NE	NA	NA	2.23
H. Other	0.08	NA	NA	0.08	0.08	NA	NA	NA	NA	NA
3. Agriculture	**0.38**	**11.14**	**0.08**	**301.42**	**0.38**	**278.43**	**22.61**	**NA**	**NA**	**NA**
A. Enteric fermentation	NA	9.19	NA	229.78	NA	229.78	NA	NA	NA	NA
B. Manure management	NA	1.94	0.04	59.93	NA	48.62	11.31	NA	NA	NA
C. Rice cultivation	NA	NO	NA	NO	NA	NO	NA	NA	NA	NA
D. Agricultural soils	NA	NA	0.04	11.29	NA	NA	11.29	NA	NA	NA
E. Prescribed burning of savannahs	NA	NO	NO	NA	NA	NO	NO	NA	NA	NA
F. Field burning of agricultural residues	NA	0.00	0.00	0.03	NA	0.02	0.01	NA	NA	NA

Greenhouse gas source and sink categories **2015**	**CO_2 emissions & removals**	**CH_4**	**N_2O**	**GHG (without LULUCF)**	**CO_2 emissions & removals**	**CH_4**	**N_2O**	**HFC**	**PFC**	**SF6**
	Gg			**Gg CO_2 equivalent**						
G. Other (Urea application)	0.38	0.00	0.00	0.38	0.38	0.00	0.00	NA	NA	NA
5. Waste	**NE**	**10.25**	**0.04**	**269.34**	**NE**	**256.23**	**13.11**	**NA**	**NA**	**NA**
A. Solid waste disposal on land	NA	7.96	NA	198.98	NA	198.98	NA	NA	NA	NA
B. Biological Treatment of Solid Waste	NA	NE	NE	NE	NA	NE	NE	NA	NA	NA
C. Waste incineration	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
D. Waste-water handling	NA	2.29	0.04	70.36	NA	57.25	13.11	NA	NA	NA
6. Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
Total national emissions and removals	**2,518.96**	**25.34**	**0.20**	**3,507.82**	**2,518.96**	**633.50**	**60.58**	**220.62**	**71.93**	**2.23**
Memo items										
International bunkers										
Aviation	**28.49**	**NO**	**0.00**	**29.14**	**28.49**	**NO**	**0.65**	NA	NA	NA
Marine	NO	NO	NO	NE	NO	NO	NO	NA	NA	NA
CO_2 emissions from biomass	**720.88**	**NA**	**NA**	**720.88**	**720.88**	**NA**	**NA**	NA	NA	NA

Greenhouse gas source and sink categories 2010	CO_2 emissions & removals	CH_4	N_2O	GHG (without LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
1. Energy	**2,566.92**	**3.94**	**0.08**	**2,690.59**	**2,566.92**	**98.59**	**25.08**	**NA**	**NA**	**NA**
A. Fuel combustion (sectoral approach)	2,566.92	2.26	0.08	2,648.39	2,566.92	56.39	25.08	NA	NA	NA
1. Energy industries	1,607.66	0.02	0.02	1,615.16	1,607.66	0.40	7.09	NA	NA	NA
2. Manufacturing industries and construction	180.05	0.01	0.00	180.51	180.05	0.14	0.32	NA	NA	NA
3. Transport	623.06	0.12	0.03	635.09	623.06	3.10	8.94	NA	NA	NA
4. Other sectors	156.15	2.11	0.03	217.63	156.15	52.74	8.73	NA	NA	NA
5. Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
B. Fugitive emissions from fuels	NE	1.69	NE	42.20	NE	42.20	NE	NA	NA	NA
1. Solid fuels	NA	1.69	NA	42.20	NA	42.20	NA	NA	NA	NA
2. Oil and natural gas	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
2. Industrial processes	**137.13**	**0.00**	**NO**	**795.64**	**137.13**	**0.01**	**NO**	**159.77**	**497.18**	**1.55**
A. Mineral products	0.63	NO	NO	0.63	0.63	NO	NO	NA	NA	NA
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
C. Metal production	135.96	0.00	NO	633.15	135.96	0.01	NO	NA	497.18	NA
D. Other production	0.45	NA	NA	0.45	0.45	NA	NA	NA	NA	NA
E. Production of halocarbons and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NE	159.77	NE	NE	NE	159.77	NO	NO
G Other product manufacture and use	NE	NE	NE	1.55	NE	NE	NE	NA	NA	1.55
H. Other	0.09	NA	NA	0.09	0.09	NA	NA	NA	NA	NA
3. Agriculture	**0.41**	**11.45**	**0.08**	**309.72**	**0.41**	**286.28**	**23.03**	**NA**	**NA**	**NA**
A. Enteric fermentation	NA	9.48	NA	237.11	NA	237.11	NA	NA	NA	NA
B. Manure management	NA	1.97	0.04	60.55	NA	49.15	11.40	NA	NA	NA
C. Rice cultivation	NA	NO	NA	NO	NA	NO	NA	NA	NA	NA
D. Agricultural soils	NA	NA	0.04	11.62	NA	NA	11.62	NA	NA	NA
E. Prescribed burning of savannahs	NA	NO	NO	NA	NA	NO	NO	NA	NA	NA
F. Field burning of agricultural residues	NA	0.00	0.00	0.02	NA	0.01	0.01	NA	NA	NA

Greenhouse gas source and sink categories 2010	CO_2 emissions & removals	CH_4	N_2O	GHG (without LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
G. Other (Urea application)	0.41	0.00	0.00	0.41	0.41	0.00	0.00	NA	NA	NA
5. Waste	**NE**	**10.51**	**0.04**	**275.77**	**NE**	**262.83**	**12.94**	**NA**	**NA**	**NA**
A. Solid waste disposal on land	NA	8.15	NA	203.80	NA	203.80	NA	NA	NA	NA
B. Biological Treatment of Solid Waste	NA	NE	NE	NE	NA	NE	NE	NA	NA	NA
C. Waste incineration	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
D. Waste-water handling	NA	2.36	0.04	71.97	NA	59.03	12.94	NA	NA	NA
6. Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
Total national emissions and removals	**2,704.46**	**25.91**	**0.20**	**4,071.72**	**2,704.46**	**647.71**	**61.05**	**159.77**	**497.18**	**1.55**
Memo items										
International bunkers										
Aviation	**31.42**	**NO**	**0.00**	**32.07**	**31.42**	**NO**	**0.65**	NA	NA	NA
Marine	NO	NO	NO	NE	NO	NO	NO	NA	NA	NA
CO_2 emissions from biomass	**746.22**	**NA**	**NA**	**746.22**	**746.22**	**NA**	**NA**	NA	NA	NA

Greenhouse gas source and sink categories 2005	CO_2 emissions & removals	CH_4	N_2O	GHG (without LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
1. Energy	**2,172.13**	**3.24**	**0.07**	**2,272.63**	**2,172.13**	**80.90**	**19.60**	**NA**	**NA**	**NA**
A. Fuel combustion (sectoral approach)	2,172.13	1.99	0.07	2,241.49	2,172.13	49.76	19.60	NA	NA	NA
1. Energy industries	1,121.88	0.01	0.02	1,127.11	1,121.88	0.28	4.95	NA	NA	NA
2. Manufacturing industries and construction	547.68	0.02	0.00	549.48	547.68	0.55	1.25	NA	NA	NA
3. Transport	399.53	0.10	0.02	407.64	399.53	2.42	5.69	NA	NA	NA
4. Other sectors	103.04	1.86	0.03	157.26	103.04	46.51	7.71	NA	NA	NA
5. Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
B. Fugitive emissions from fuels	NE	1.25	NE	31.14	NE	31.14	NE	NA	NA	NA
1. Solid fuels	NA	1.25	NA	31.14	NA	31.14	NA	NA	NA	NA
2. Oil and natural gas	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
2. Industrial processes	**205.97**	**0.00**	**NO**	**1,167.11**	**205.97**	**0.03**	**NO**	**90.37**	**869.31**	**1.43**
A. Mineral products	4.51	NO	NO	4.51	4.51	NO	NO	NA	NA	NA
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
C. Metal production	200.79	0.00	NO	1,070.13	200.79	0.03	NO	NA	869.31	NA
D. Other production	0.58	NA	NA	0.58	0.58	NA	NA	NA	NA	NA
E. Production of halocarbons and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NE	90.37	NE	NE	NE	90.37	NO	NO
G Other product manufacture and use	NE	NE	NE	1.43	NE	NE	NE	NA	NA	1.43
H. Other	0.10	NA	NA	0.10	0.10	NA	NA	NA	NA	NA
3. Agriculture	**0.43**	**14.20**	**0.09**	**381.61**	**0.43**	**354.95**	**26.22**	**NA**	**NA**	**NA**
A. Enteric fermentation	NA	11.77	NA	294.33	NA	294.33	NA	NA	NA	NA
B. Manure management	NA	2.42	0.05	74.38	NA	60.56	13.82	NA	NA	NA
C. Rice cultivation	NA	NO	NA	NO	NA	NO	NA	NA	NA	NA
D. Agricultural soils	NA	NA	0.04	12.38	NA	NA	12.38	NA	NA	NA
E. Prescribed burning of savannahs	NA	NO	NO	NA	NA	NO	NO	NA	NA	NA
F. Field burning of agricultural residues	NA	0.00	0.00	0.09	NA	0.06	0.02	NA	NA	NA

Greenhouse gas source and sink categories 2005	CO_2 emissions & removals	CH_4	N_2O	GHG (without LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
G. Other (Urea application)	0.43	0.00	0.00	0.43	0.43	0.00	0.00	NA	NA	NA
5. Waste	**NE**	**10.66**	**0.04**	**277.85**	**NE**	**266.54**	**11.31**	**NA**	**NA**	**NA**
A. Solid waste disposal on land	NA	8.28	NA	206.96	NA	206.96	NA	NA	NA	NA
B. Biological Treatment of Solid Waste	NA	NE	NE	NE	NA	NE	NE	NA	NA	NA
C. Waste incineration	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
D. Waste-water handling	NA	2.38	0.04	70.89	NA	59.58	11.31	NA	NA	NA
6. Other (please specify)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	NA	NA	NA
Total national emissions and removals	**2,378.54**	**28.10**	**0.19**	**4,099.20**	**2,378.54**	**702.41**	**57.13**	**90.37**	**869.31**	**1.43**
Memo items										
International bunkers										
Aviation	**29.17**	**NO**	**0.00**	**29.51**	**29.17**	**NO**	**0.34**	NA	NA	NA
Marine	NO	NO	NO	NE	NO	NO	NO	NA	NA	NA
CO_2 emissions from biomass	**666.92**	**NA**	**NA**	**666.92**	**666.92**	**NA**	**NA**	NA	NA	NA

Greenhouse gas source and sink categories 2000	CO_2 emissions & removals	CH_4	N_2O	GHG (without LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
1. Energy	**2,188.85**	**3.05**	**0.07**	**2,285.04**	**2,188.85**	**76.21**	**19.98**	**NA**	**NA**	**NA**
A. Fuel combustion (sectoral approach)	2,188.85	1.69	0.07	2,250.96	2,188.85	42.13	19.98	NA	NA	NA
1. Energy industries	1,404.88	0.02	0.02	1,411.15	1,404.88	0.50	5.77	NA	NA	NA
2. Manufacturing industries and construction	167.51	0.01	0.00	168.02	167.51	0.15	0.36	NA	NA	NA
3. Transport	513.85	0.13	0.03	524.57	513.85	3.22	7.50	NA	NA	NA
4. Other sectors	102.60	1.53	0.02	147.22	102.60	38.25	6.36	NA	NA	NA
5. Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
B. Fugitive emissions from fuels	NE	1.36	NE	34.08	NE	34.08	NE	NA	NA	NA
1. Solid fuels	NA	1.36	NA	34.08	NA	34.08	NA	NA	NA	NA
2. Oil and natural gas	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
2. Industrial processes	**167.60**	**0.00**	**NO**	**1,579.41**	**167.60**	**0.02**	**NO**	**49.15**	**1,361.71**	**0.92**
A. Mineral products	5.33	NO	NO	5.33	5.33	NO	NO	NA	NA	NA
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
C. Metal production	159.62	0.00	NO	1,521.35	159.62	0.02	NO	NA	1,361.71	NA
D. Other production	2.54	NA	NA	2.54	2.54	NA	NA	NA	NA	NA
E. Production of halocarbons and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NE	49.15	NE	NE	NE	49.15	NO	NO
G Other product manufacture and use	NE	NE	NE	0.92	NE	NE	NE	NA	NA	0.92
H. Other	0.11	NA	NA	0.11	0.11	NA	NA	NA	NA	NA
3. Agriculture	**0.47**	**20.73**	**0.11**	**552.22**	**0.47**	**518.34**	**33.41**	**NA**	**NA**	**NA**
A. Enteric fermentation	NA	17.24	NA	430.92	NA	430.92	NA	NA	NA	NA
B. Manure management	NA	3.50	0.07	108.12	NA	87.38	20.74	NA	NA	NA
C. Rice cultivation	NA	NO	NA	NO	NA	NO	NA	NA	NA	NA
D. Agricultural soils	NA	NA	0.04	12.66	NA	NA	12.66	NA	NA	NA
E. Prescribed burning of savannahs	NA	NO	NO	NA	NA	NO	NO	NA	NA	NA
F. Field burning of agricultural residues	NA	0.00	0.00	0.05	NA	0.04	0.01	NA	NA	NA

Greenhouse gas source and sink categories 2000	CO_2 emissions & removals	CH_4	N_2O	GHG (without LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
G. Other (Urea application)	0.47	0.00	0.00	0.47	0.47	0.00	0.00	NA	NA	NA
5. Waste	**NE**	**10.22**	**0.03**	**264.92**	**NE**	**255.57**	**9.35**	**NA**	**NA**	**NA**
A. Solid waste disposal on land	**NA**	**7.83**	**NA**	195.73	**NA**	**195.73**	**NA**	NA	NA	NA
B. Biological Treatment of Solid Waste	NA	NE	NE	NE	NA	NE	NE	NA	NA	NA
C. Waste incineration	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
D. Waste-water handling	NA	2.39	0.03	69.18	NA	59.84	9.35	NA	NA	NA
6. Other (please specify)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	NA	NA	NA
Total national emissions and removals	**2,356.92**	**34.01**	**0.21**	**4,681.58**	**2,356.92**	**850.13**	**62.75**	**49.15**	**1,361.71**	**0.92**
Memo items										
International bunkers										
Aviation	**30.67**	**NO**	**0.00**	**30.91**	**30.67**	**NO**	**0.24**	NA	NA	NA
Marine	NO	NO	NO	NE	NO	NO	NO	NA	NA	NA
CO_2 emissions from biomass	**540.85**	**NA**	**NA**	**540.85**	**540.85**	**NA**	**NA**	NA	NA	NA

Greenhouse gas source and sink categories 1995	CO_2 emissions & removals	CH_4	N_2O	GHG (without LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
1. Energy	**674.91**	**3.40**	**0.04**	**771.55**	**674.91**	**85.07**	**11.56**	**NA**	**NA**	**NA**
A. Fuel combustion (sectoral approach)	674.91	1.87	0.04	733.13	674.91	46.65	11.56	NA	NA	NA
1. Energy industries	164.99	0.01	0.00	165.59	164.99	0.13	0.47	NA	NA	NA
2. Manufacturing industries and construction	210.28	0.01	0.00	210.96	210.28	0.21	0.48	NA	NA	NA
3. Transport	226.38	0.07	0.01	231.33	226.38	1.70	3.25	NA	NA	NA
4. Other sectors	73.27	1.78	0.02	125.25	73.27	44.61	7.37	NA	NA	NA
5. Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
B. Fugitive emissions from fuels	NE	1.54	NE	38.42	NE	38.42	NE	NA	NA	NA
1. Solid fuels	NA	1.54	NA	38.42	NA	38.42	NA	NA	NA	NA
2. Oil and natural gas	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
2. Industrial processes	**56.20**	**0.00**	**NO**	**418.51**	**56.20**	**0.02**	**NO**	**16.46**	**345.05**	**0.78**
A. Mineral products	5.25	NO	NO	5.25	5.25	NO	NO	NA	NA	NA
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
C. Metal production	48.80	0.00	NO	393.88	48.80	0.02	NO	NA	345.05	NA
D. Other production	2.06	NA	NA	2.06	2.06	NA	NA	NA	NA	NA
E. Production of halocarbons and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NE	16.46	NE	NE	NE	16.46	NO	NO
G Other product manufacture and use	NE	NE	NE	0.78	NE	NE	NE	NA	NA	0.78
H. Other	0.08	NA	NA	0.08	0.08	NA	NA	NA	NA	NA
3. Agriculture	**0.48**	**22.11**	**0.12**	**588.73**	**0.48**	**552.66**	**35.59**	**NA**	**NA**	**NA**
A. Enteric fermentation	NA	18.31	NA	457.87	NA	457.87	NA	NA	NA	NA
B. Manure management	NA	3.79	0.07	116.15	NA	94.73	21.42	NA	NA	NA
C. Rice cultivation	NA	NO	NA	NO	NA	NO	NA	NA	NA	NA
D. Agricultural soils	NA	NA	0.05	14.15	NA	NA	14.15	NA	NA	NA
E. Prescribed burning of savannahs	NA	NO	NO	NA	NA	NO	NO	NA	NA	NA
F. Field burning of agricultural residues	NA	0.00	0.00	0.08	NA	0.06	0.02	NA	NA	NA

Greenhouse gas source and sink categories 1995	CO_2 emissions & removals	CH_4	N_2O	GHG (without LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
G. Other (Urea application)	0.48	0.00	0.00	0.48	0.48	0.00	0.00	NA	NA	NA
5. Waste	**NE**	**9.25**	**0.03**	**239.70**	**NE**	**231.30**	**8.40**	**NA**	**NA**	**NA**
A. Solid waste disposal on land	NA	6.83	NA	170.66	NA	170.66	NA	NA	NA	NA
B. Biological Treatment of Solid Waste	NA	NE	NE	NE	NA	NE	NE	NA	NA	NA
C. Waste incineration	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
D. Waste-water handling	NA	2.43	0.03	69.04	NA	60.64	8.40	NA	NA	NA
6. Other (please specify)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	NA	NA	NA
Total national emissions and removals	**731.59**	**34.76**	**0.19**	**2,018.49**	**731.59**	**869.06**	**55.55**	**16.46**	**345.05**	**0.78**
Memo items										
International bunkers										
Aviation	**2.36**	**NO**	**0.00**	**2.38**	**2.36**	**NO**	**0.02**	NA	NA	NA
Marine	NO	NO	NO	NE	NO	NO	NO	NA	NA	NA
CO_2 emissions from biomass	**639.40**	**3.40**	**0.04**	**639.40**	**639.40**	**NA**	**NA**	NA	NA	NA

Greenhouse gas source and sink categories 1990	CO_2 emissions & removals	CH_4	N_2O	GHG (without LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
1. Energy	**2,620.20**	**4.24**	**0.07**	**2,748.26**	**2,620.20**	**105.99**	**22.07**	**NA**	**NA**	**NA**
A. Fuel combustion (sectoral approach)	2,620.20	2.36	0.07	2,701.34	2,620.20	59.07	22.07	NA	NA	NA
1. Energy industries	1,754.11	0.03	0.02	1,761.87	1,754.11	0.66	7.10	NA	NA	NA
2. Manufacturing industries and construction	386.60	0.01	0.00	387.77	386.60	0.35	0.82	NA	NA	NA
3. Transport	347.86	0.11	0.02	355.53	347.86	2.71	4.96	NA	NA	NA
4. Other sectors	131.62	2.21	0.03	196.17	131.62	55.35	9.20	NA	NA	NA
5. Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
B. Fugitive emissions from fuels	NE	1.88	NE	46.92	NE	46.92	NE	NA	NA	NA
1. Solid fuels	NA	1.88	NA	46.92	NA	46.92	NA	NA	NA	NA
2. Oil and natural gas	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
2. Industrial processes	**213.20**	**0.00**	**NO**	**1,704.68**	**213.20**	**0.05**	**NO**	**NE**	**1,490.64**	**0.78**
A. Mineral products	24.75	NO	NO	24.75	24.75	NO	NO	NA	NA	NA
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
C. Metal production	185.28	0.00	NO	1,675.97	185.28	0.05	NO	NA	1,490.64	NA
D. Other production	3.07	NA	NA	3.07	3.07	NA	NA	NA	NA	NA
E. Production of halocarbons and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NO	NE	NO	NE	NO	NE	NA	NO	NO
G Other product manufacture and use	NE	NE	NE	0.78	NE	NE	NE	NA	NA	0.78
H. Other	0.11	NA	NA	0.11	0.11	NA	NA	NA	NA	NA
3. Agriculture	**0.49**	**23.37**	**0.12**	**621.50**	**0.49**	**584.19**	**36.81**	**NA**	**NA**	**NA**
A. Enteric fermentation	NA	19.36	NA	483.90	NA	483.90	NA	NA	NA	NA
B. Manure management	NA	4.01	0.08	122.91	NA	100.24	22.67	NA	NA	NA
C. Rice cultivation	NA	NO	NA	NO	NA	NO	NA	NA	NA	NA
D. Agricultural soils	NA	NA	0.05	14.13	NA	NA	14.13	NA	NA	NA
E. Prescribed burning of savannahs	NA	NO	NO	NA	NA	NO	NO	NA	NA	NA
F. Field burning of agricultural residues	NA	0.00	0.00	0.07	NA	0.05	0.02	NA	NA	NA

Greenhouse gas source and sink categories 1990	CO_2 emissions & removals	CH_4	N_2O	GHG (without LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
G. Other (Urea application)	0.49	0.00	0.00	0.49	0.49	0.00	0.00	NA	NA	NA
5. Waste	**NE**	**8.42**	**0.03**	**217.97**	**NE**	**210.50**	**7.47**	**NA**	**NA**	**NA**
A. Solid waste disposal on land	**NA**	**6.02**	**NA**	150.49	**NA**	**150.49**	**NA**	NA	NA	NA
B. Biological Treatment of Solid Waste	NA	NE	NE	NE	NA	NE	NE	NA	NA	NA
C. Waste incineration	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
D. Waste-water handling	NA	2.40	0.03	67.47	NA	60.01	7.47	NA	NA	NA
6. Other (please specify)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	NA	NA	NA
Total national emissions and removals	**2,833.89**	**36.03**	**0.22**	**5,292.40**	**2,833.89**	**900.73**	**66.35**	**0.00**	**1,490.64**	**0.78**
Memo items										
International bunkers										
Aviation	**30.67**	**NO**	**0.00**	**30.91**	**30.67**	**NO**	**0.24**	NA	NA	NA
Marine	NO	NO	NO	NE	NO	NO	NO	NA	NA	NA
CO_2 emissions from biomass	**799.54**	**NA**	**NA**	**2,748.26**	**2,620.20**	**NA**	**NA**	NA	NA	NA

12.2 Summary Tables (with LULUCF) for the years 1990, 1995, 2000, 2005, 2010, 2015 and 2019

Greenhouse gas source and sink categories 2019	CO_2 emissions & removals	CH_4	N_2O	GHG (with LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
1. Energy	**2,578.60**	**3.84**	**0.09**	**2,701.70**	**2,578.60**	**95.95**	**27.15**	**NA**	**NA**	**NA**
A. Fuel combustion (sectoral approach)	2,578.60	1.88	0.09	2,652.76	2,578.60	47.01	27.15	NA	NA	NA
1. Energy industries	1,473.78	0.01	0.02	1,480.67	1,473.78	0.36	6.52	NA	NA	NA
2. Manufacturing industries and construction	192.37	0.02	0.00	193.69	192.37	0.46	0.86	NA	NA	NA
3. Transport	867.61	0.12	0.04	883.29	867.61	2.88	12.80	NA	NA	NA
4. Other sectors	44.84	1.73	0.02	95.11	44.84	43.30	6.97	NA	NA	NA
5. Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
B. Fugitive emissions from fuels	NE	1.96	NE	48.94	NE	48.94	NE	NA	NA	NA
1. Solid fuels	NA	1.96	NA	48.94	NA	48.94	NA	NA	NA	NA
2. Oil and natural gas	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
2. Industrial processes	**91.06**	**0.00**	**NO**	**376.89**	**91.06**	**0.01**	**NO**	**248.35**	**34.03**	**3.44**
A. Mineral products	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
C. Metal production	61.86	0.00	NO	95.90	61.86	0.01	NO	NA	34.03	NA
D. Other production	29.13	NA	NA	29.13	29.13	NA	NA	NA	NA	NA
E. Production of halocarbons and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NE	248.35	NE	NE	NE	248.35	NO	NO
G Other product manufacture and use	NE	NE	NE	3.44	NE	NE	NE	NA	NA	3.44
H. Other	0.08	NA	NA	0.08	0.08	NA	NA	NA	NA	NA
3. Agriculture	**0.35**	**9.99**	**0.07**	**271.57**	**0.35**	**249.84**	**21.37**	**NA**	**NA**	**NA**
A. Enteric fermentation	NA	8.24	NA	205.90	NA	205.90	NA	NA	NA	NA
B. Manure management	NA	1.76	0.03	54.19	NA	43.92	10.27	NA	NA	NA
C. Rice cultivation	NA	NO	NA	NO	NA	NO	NA	NA	NA	NA
D. Agricultural soils	NA	NA	0.04	11.09	NA	NA	11.09	NA	NA	NA

Greenhouse gas source and sink categories 2019	CO_2 emissions & removals	CH_4	N_2O	GHG (with LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
E. Prescribed burning of savannahs	NA	NO	NO	NA	NA	NO	NO	NA	NA	NA
F. Field burning of agricultural residues	NA	0.00	0.00	0.03	NA	0.02	0.01	NA	NA	NA
G. Other (Urea application)	0.35	0.00	0.00	0.35	0.35	0.00	0.00	NA	NA	NA
4. Land-use change and forestry	**-2,511.01**	**0.22**	**0.03**	**-2,503.93**	**-2,511.01**	**5.44**	**8.70**	**NA**	**NA**	**NA**
A. Total Forest land	-2,428.30	0.11	0.01	-2,423.78	-2,428.30	2.72	1.79	NA	NA	NA
B. Cropland	0.57	NA	0.00	0.66	0.57	NA	0.09	NA	NA	NA
C. Grassland	-0.99	NA	NA	-0.99	-0.99	NA	NA	NA	NA	NA
D. Wetlands	0.00	NA	NA	0.00	0.00	NA	NA	NA	NA	NA
E. Settlements	57.35	NA	0.01	59.82	57.35	NA	2.47	NA	NA	NA
F. Other land	0.00	NA	0.00	0.00	0.00	NA	0.00	NA	NA	NA
G. Harvested Wood Products	-139.64	NA	NA	-139.64	-139.64	NA	NA	NA	NA	NA
5. Waste	**NE**	**10.40**	**0.04**	**273.08**	**NE**	**259.98**	**13.10**	**NA**	**NA**	**NA**
A. Solid waste disposal on land	NA	8.18	NA	204.56	NA	204.56	NA	NA	NA	NA
B. Biological Treatment of Solid Waste	NA	NE	NE	NE	NA	NE	NE	NA	NA	NA
C. Waste incineration	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
D. Waste-water handling	NA	2.22	0.04	68.52	NA	55.41	13.10	NA	NA	NA
6. Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
Total national emissions and removals	**159.00**	**24.45**	**0.24**	**1,119.31**	**159.00**	**611.23**	**70.33**	**248.35**	**34.03**	**3.44**
Memo items										
International bunkers										
Aviation	**58.02**	**NE**	**0.00**	**59.48**	**58.02**	**NE**	**1.46**	**NA**	**NA**	**NA**
Marine	NO	NO	NO	NE	NO	NO	NO	**NA**	**NA**	**NA**
CO_2 emissions from biomass	**601.67**	**NA**	**NA**	**601.67**	**601.67**	**NA**	**NA**	**NA**	**NA**	**NA**

Greenhouse gas source and sink categories 2015	CO_2 emissions & removals	CH_4	N_2O	GHG (with LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
1. Energy	**2,427.41**	**3.95**	**0.08**	**2,551.11**	**2,427.41**	**98.84**	**24.86**	**NA**	**NA**	**NA**
A. Fuel combustion (sectoral approach)	2,427.41	2.18	0.08	2,506.74	2,427.41	54.48	24.86	NA	NA	NA
1. Energy industries	1,646.38	0.02	0.02	1,654.08	1,646.38	0.41	7.29	NA	NA	NA
2. Manufacturing industries and construction	158.13	0.02	0.00	159.39	158.13	0.45	0.81	NA	NA	NA
3. Transport	580.32	0.10	0.03	591.21	580.32	2.42	8.47	NA	NA	NA
4. Other sectors	42.57	2.05	0.03	102.07	42.57	51.20	8.29	NA	NA	NA
5. Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
B. Fugitive emissions from fuels	NE	1.77	NE	44.36	NE	44.36	NE	NA	NA	NA
1. Solid fuels	NA	1.77	NA	44.36	NA	44.36	NA	NA	NA	NA
2. Oil and natural gas	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
2. Industrial processes	**91.17**	**0.00**	**NO**	**385.96**	**91.17**	**0.01**	**NO**	**220.62**	**71.93**	**2.23**
A. Mineral products	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
C. Metal production	70.93	0.00	NO	142.87	70.93	0.01	NO	NA	71.93	NA
D. Other production	20.16	NA	NA	20.16	20.16	NA	NA	NA	NA	NA
E. Production of halocarbons and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NE	220.62	NE	NE	NE	220.62	NO	NO
G Other product manufacture and use	NE	NE	NE	2.23	NE	NE	NE	NA	NA	2.23
H. Other	0.08	NA	NA	0.08	0.08	NA	NA	NA	NA	NA
3. Agriculture	**0.38**	**11.14**	**0.08**	**301.42**	**0.38**	**278.43**	**22.61**	**NA**	**NA**	**NA**
A. Enteric fermentation	NA	9.19	NA	229.78	NA	229.78	NA	NA	NA	NA
B. Manure management	NA	1.94	0.04	59.93	NA	48.62	11.31	NA	NA	NA
C. Rice cultivation	NA	NO	NA	NO	NA	NO	NA	NA	NA	NA
D. Agricultural soils	NA	NA	0.04	11.29	NA	NA	11.29	NA	NA	NA
E. Prescribed burning of savannahs	NA	NO	NO	NA	NA	NO	NO	NA	NA	NA
F. Field burning of agricultural residues	NA	0.00	0.00	0.03	NA	0.02	0.01	NA	NA	NA

Greenhouse gas source and sink categories 2015	CO_2 emissions & removals	CH_4	N_2O	GHG (with LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
G. Other (Urea application)	0.38	0.00	0.00	0.38	0.38	0.00	0.00	NA	NA	NA
4. Land-use change and forestry	**-2,388.32**	**0.58**	**0.05**	**-2,374.14**	**-2,388.32**	**14.54**	**13.81**	**NA**	**NA**	**NA**
A. Total Forest land	-2,336.23	0.29	0.02	-2,324.17	-2,336.23	7.27	4.79	NA	NA	NA
B. Cropland	0.48	NA	0.00	0.57	0.48	NA	0.09	NA	NA	NA
C. Grassland	-0.62	NA	NA	-0.62	-0.62	NA	NA	NA	NA	NA
D. Wetlands	0.00	NA	NA	0.00	0.00	NA	NA	NA	NA	NA
E. Settlements	53.35	NA	0.01	55.37	53.35	NA	2.03	NA	NA	NA
F. Other land	0.00	NA	0.00	0.00	0.00	NA	0.00	NA	NA	NA
G. Harvested Wood Products	-105.29	NA	NA	-105.29	-105.29	NA	NA	NA	NA	NA
5. Waste	**NE**	**10.25**	**0.04**	**269.34**	**NE**	**256.23**	**13.11**	**NA**	**NA**	**NA**
A. Solid waste disposal on land	NA	7.96	NA	198.98	NA	198.98	NA	NA	NA	NA
B. Biological Treatment of Solid Waste	NA	NE	NE	NE	NA	NE	NE	NA	NA	NA
C. Waste incineration	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
D. Waste-water handling	NA	2.29	0.04	70.36	NA	57.25	13.11	NA	NA	NA
6. Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
Total national emissions and removals	**130.64**	**25.92**	**0.25**	**1,133.68**	**130.64**	**648.04**	**74.39**	**220.62**	**71.93**	**2.23**
Memo items										
International bunkers										
Aviation	**28.49**	**NO**	**0.00**	**29.14**	**28.49**	**NO**	**0.65**	NA	NA	NA
Marine	NO	NO	NO	NE	NO	NO	NO	NA	NA	NA
CO_2 emissions from biomass	**720.88**	**NA**	**NA**	**720.88**	**720.88**	**NA**	**NA**	NA	NA	NA

Greenhouse gas source and sink categories 2010	CO_2 emissions & removals	CH_4	N_2O	GHG (with LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
1. Energy	**2,566.92**	**3.94**	**0.08**	**2,690.59**	**2,566.92**	**98.59**	**25.08**	**NA**	**NA**	**NA**
A. Fuel combustion (sectoral approach)	2,566.92	2.26	0.08	2,648.39	2,566.92	56.39	25.08	NA	NA	NA
1. Energy industries	1,607.66	0.02	0.02	1,615.16	1,607.66	0.40	7.09	NA	NA	NA
2. Manufacturing industries and construction	180.05	0.01	0.00	180.51	180.05	0.14	0.32	NA	NA	NA
3. Transport	623.06	0.12	0.03	635.09	623.06	3.10	8.94	NA	NA	NA
4. Other sectors	156.15	2.11	0.03	217.63	156.15	52.74	8.73	NA	NA	NA
5. Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
B. Fugitive emissions from fuels	NE	1.69	NE	42.20	NE	42.20	NE	NA	NA	NA
1. Solid fuels	NA	1.69	NA	42.20	NA	42.20	NA	NA	NA	NA
2. Oil and natural gas	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
2. Industrial processes	**137.13**	**0.00**	**NO**	**795.64**	**137.13**	**0.01**	**NO**	**159.77**	**497.18**	**1.55**
A. Mineral products	0.63	NO	NO	0.63	0.63	NO	NO	NA	NA	NA
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
C. Metal production	135.96	0.00	NO	633.15	135.96	0.01	NO	NA	497.18	NA
D. Other production	0.45	NA	NA	0.45	0.45	NA	NA	NA	NA	NA
E. Production of halocarbons and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NE	159.77	NE	NE	NE	159.77	NO	NO
G Other product manufacture and use	NE	NE	NE	1.55	NE	NE	NE	NA	NA	1.55
H. Other	0.09	NA	NA	0.09	0.09	NA	NA	NA	NA	NA
3. Agriculture	**0.41**	**11.45**	**0.08**	**309.72**	**0.41**	**286.28**	**23.03**	**NA**	**NA**	**NA**
A. Enteric fermentation	NA	9.48	NA	237.11	NA	237.11	NA	NA	NA	NA
B. Manure management	NA	1.97	0.04	60.55	NA	49.15	11.40	NA	NA	NA
C. Rice cultivation	NA	NO	NA	NO	NA	NO	NA	NA	NA	NA
D. Agricultural soils	NA	NA	0.04	11.62	NA	NA	11.62	NA	NA	NA
E. Prescribed burning of savannahs	NA	NO	NO	NA	NA	NO	NO	NA	NA	NA
F. Field burning of agricultural residues	NA	0.00	0.00	0.02	NA	0.01	0.01	NA	NA	NA

Greenhouse gas source and sink categories 2010	CO_2 emissions & removals	CH_4	N_2O	GHG (with LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
G. Other (Urea application)	0.41	0.00	0.00	0.41	0.41	0.00	0.00	NA	NA	NA
4. Land-use change and forestry	**-2,528.57**	**0.13**	**0.02**	**-2,524.25**	**-2,528.57**	**3.23**	**5.40**	**NA**	**NA**	**NA**
A. Total Forest land	-2,591.01	0.06	0.00	-2,588.33	-2,591.01	1.62	1.07	NA	NA	NA
B. Cropland	0.69	NA	0.00	0.76	0.69	NA	0.07	NA	NA	NA
C. Grassland	0.31	NA	NA	0.31	0.31	NA	NA	NA	NA	NA
D. Wetlands	0.00	NA	NA	0.00	0.00	NA	NA	NA	NA	NA
E. Settlements	35.53	NA	0.01	37.10	35.53	NA	1.57	NA	NA	NA
F. Other land	1.92	NA	0.00	1.92	1.92	NA	0.00	NA	NA	NA
G. Harvested Wood Products	23.98	NA	NA	23.98	23.98	NA	NA	NA	NA	NA
5. Waste	**NE**	**10.51**	**0.04**	**275.77**	**NE**	**262.83**	**12.94**	**NA**	**NA**	**NA**
A. Solid waste disposal on land	NA	8.15	NA	203.80	NA	203.80	NA	NA	NA	NA
B. Biological Treatment of Solid Waste	NA	NE	NE	NE	NA	NE	NE	NA	NA	NA
C. Waste incineration	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
D. Waste-water handling	NA	2.36	0.04	71.97	NA	59.03	12.94	NA	NA	NA
6. Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
Total national emissions and removals	**175.89**	**26.04**	**0.22**	**1,547.47**	**175.89**	**650.94**	**66.45**	**159.77**	**497.18**	**1.55**
Memo items										
International bunkers										
Aviation	**31.42**	**NO**	**0.00**	**32.07**	**31.42**	**NO**	**0.65**	NA	NA	NA
Marine	NO	NO	NO	NE	NO	NO	NO	NA	NA	NA
CO_2 emissions from biomass	**746.22**	**NA**	**NA**	**746.22**	**746.22**	**NA**	**NA**	NA	NA	NA

Greenhouse gas source and sink categories 2005	CO_2 emissions & removals	CH_4	N_2O	GHG (with LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
1. Energy	**2,172.13**	**3.24**	**0.07**	**2,272.63**	**2,172.13**	**80.90**	**19.60**	**NA**	**NA**	**NA**
A. Fuel combustion (sectoral approach)	2,172.13	1.99	0.07	2,241.49	2,172.13	49.76	19.60	NA	NA	NA
1. Energy industries	1,121.88	0.01	0.02	1,127.11	1,121.88	0.28	4.95	NA	NA	NA
2. Manufacturing industries and construction	547.68	0.02	0.00	549.48	547.68	0.55	1.25	NA	NA	NA
3. Transport	399.53	0.10	0.02	407.64	399.53	2.42	5.69	NA	NA	NA
4. Other sectors	103.04	1.86	0.03	157.26	103.04	46.51	7.71	NA	NA	NA
5. Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
B. Fugitive emissions from fuels	NE	1.25	NE	31.14	NE	31.14	NE	NA	NA	NA
1. Solid fuels	NA	1.25	NA	31.14	NA	31.14	NA	NA	NA	NA
2. Oil and natural gas	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
2. Industrial processes	**205.97**	**0.00**	**NO**	**1,167.11**	**205.97**	**0.03**	**NO**	**90.37**	**869.31**	**1.43**
A. Mineral products	4.51	NO	NO	4.51	4.51	NO	NO	NA	NA	NA
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
C. Metal production	200.79	0.00	NO	1,070.13	200.79	0.03	NO	NA	869.31	NA
D. Other production	0.58	NA	NA	0.58	0.58	NA	NA	NA	NA	NA
E. Production of halocarbons and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NE	90.37	NE	NE	NE	90.37	NO	NO
G Other product manufacture and use	NE	NE	NE	1.43	NE	NE	NE	NA	NA	1.43
H. Other	0.10	NA	NA	0.10	0.10	NA	NA	NA	NA	NA
3. Agriculture	**0.43**	**14.20**	**0.09**	**381.61**	**0.43**	**354.95**	**26.22**	**NA**	**NA**	**NA**
A. Enteric fermentation	NA	11.77	NA	294.33	NA	294.33	NA	NA	NA	NA
B. Manure management	NA	2.42	0.05	74.38	NA	60.56	13.82	NA	NA	NA
C. Rice cultivation	NA	NO	NA	NO	NA	NO	NA	NA	NA	NA
D. Agricultural soils	NA	NA	0.04	12.38	NA	NA	12.38	NA	NA	NA
E. Prescribed burning of savannahs	NA	NO	NO	NA	NA	NO	NO	NA	NA	NA
F. Field burning of agricultural residues	NA	0.00	0.00	0.09	NA	0.06	0.02	NA	NA	NA

Greenhouse gas source and sink categories 2005	CO_2 emissions & removals	CH_4	N_2O	GHG (with LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
G. Other (Urea application)	0.43	0.00	0.00	0.43	0.43	0.00	0.00	NA	NA	NA
4. Land-use change and forestry	**-2,462.68**	**0.02**	**0.01**	**-2,460.94**	**-2,462.68**	**0.48**	**3.00**	**NA**	**NA**	**NA**
A. Total Forest land	-2,484.51	0.01	0.00	-2,484.11	-2,484.51	0.24	0.16	NA	NA	NA
B. Cropland	0.00	NA	0.00	0.04	0.00	NA	0.04	NA	NA	NA
C. Grassland	0.00	NA	NA	0.00	0.00	NA	NA	NA	NA	NA
D. Wetlands	0.00	NA	NA	0.00	0.00	NA	NA	NA	NA	NA
E. Settlements	19.54	NA	0.00	20.84	19.54	NA	1.30	NA	NA	NA
F. Other land	7.87	NA	0.00	7.87	7.87	NA	0.00	NA	NA	NA
G. Harvested Wood Products	-5.58	NA	NA	-5.58	-5.58	NA	NA	NA	NA	NA
5. Waste	**NE**	**10.66**	**0.04**	**277.85**	**NE**	**266.54**	**11.31**	**NA**	**NA**	**NA**
A. Solid waste disposal on land	NA	8.28	NA	206.96	NA	206.96	NA	NA	NA	NA
B. Biological Treatment of Solid Waste	NA	NE	NE	NE	NA	NE	NE	NA	NA	NA
C. Waste incineration	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
D. Waste-water handling	NA	2.38	0.04	70.89	NA	59.58	11.31	NA	NA	NA
6. Other (please specify)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	NA	NA	NA
Total national emissions and removals	**-84.14**	**28.12**	**0.20**	**1,638.26**	**-84.14**	**702.89**	**60.13**	**90.37**	**869.31**	**1.43**
Memo items										
International bunkers										
Aviation	**29.17**	**NO**	**0.00**	**29.51**	**29.17**	**NO**	**0.34**	NA	NA	NA
Marine	NO	NO	NO	NE	NO	NO	NO	NA	NA	NA
CO_2 emissions from biomass	**666.92**	**NA**	**NA**	**666.92**	**666.92**	**NA**	**NA**	NA	NA	NA

Greenhouse gas source and sink categories 2000	CO_2 emissions & removals	CH_4	N_2O	GHG (with LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
1. Energy	**2,188.85**	**3.05**	**0.07**	**2,285.04**	**2,188.85**	**76.21**	**19.98**	**NA**	**NA**	**NA**
A. Fuel combustion (sectoral approach)	2,188.85	1.69	0.07	2,250.96	2,188.85	42.13	19.98	NA	NA	NA
1. Energy industries	1,404.88	0.02	0.02	1,411.15	1,404.88	0.50	5.77	NA	NA	NA
2. Manufacturing industries and construction	167.51	0.01	0.00	168.02	167.51	0.15	0.36	NA	NA	NA
3. Transport	513.85	0.13	0.03	524.57	513.85	3.22	7.50	NA	NA	NA
4. Other sectors	102.60	1.53	0.02	147.22	102.60	38.25	6.36	NA	NA	NA
5. Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
B. Fugitive emissions from fuels	NE	1.36	NE	34.08	NE	34.08	NE	NA	NA	NA
1. Solid fuels	NA	1.36	NA	34.08	NA	34.08	NA	NA	NA	NA
2. Oil and natural gas	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
2. Industrial processes	**167.60**	**0.00**	**NO**	**1,579.41**	**167.60**	**0.02**	**NO**	**49.15**	**1,361.71**	**0.92**
A. Mineral products	5.33	NO	NO	5.33	5.33	NO	NO	NA	NA	NA
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
C. Metal production	159.62	0.00	NO	1,521.35	159.62	0.02	NO	NA	1,361.71	NA
D. Other production	2.54	NA	NA	2.54	2.54	NA	NA	NA	NA	NA
E. Production of halocarbons and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NE	49.15	NE	NE	NE	49.15	NO	NO
G Other product manufacture and use	NE	NE	NE	0.92	NE	NE	NE	NA	NA	0.92
H. Other	0.11	NA	NA	0.11	0.11	NA	NA	NA	NA	NA
3. Agriculture	**0.47**	**20.73**	**0.11**	**552.22**	**0.47**	**518.34**	**33.41**	**NA**	**NA**	**NA**
A. Enteric fermentation	NA	17.24	NA	430.92	NA	430.92	NA	NA	NA	NA
B. Manure management	NA	3.50	0.07	108.12	NA	87.38	20.74	NA	NA	NA
C. Rice cultivation	NA	NO	NA	NO	NA	NO	NA	NA	NA	NA
D. Agricultural soils	NA	NA	0.04	12.66	NA	NA	12.66	NA	NA	NA
E. Prescribed burning of savannahs	NA	NO	NO	NA	NA	NO	NO	NA	NA	NA
F. Field burning of agricultural residues	NA	0.00	0.00	0.05	NA	0.04	0.01	NA	NA	NA

Greenhouse gas source and sink categories 2000	CO_2 emissions & removals	CH_4	N_2O	GHG (with LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
G. Other (Urea application)	0.47	0.00	0.00	0.47	0.47	0.00	0.00	NA	NA	NA
4. Land-use change and forestry	**-2,099.01**	**1.40**	**0.09**	**-2,068.71**	**-2,099.01**	**34.91**	**25.70**	**NA**	**NA**	**NA**
A. Total Forest land	-2,135.58	0.70	0.04	-2,106.62	-2,135.58	17.45	11.51	NA	NA	NA
B. Cropland	0.00	NA	0.00	0.04	0.00	NA	0.04	NA	NA	NA
C. Grassland	0.00	NA	NA	0.00	0.00	NA	NA	NA	NA	NA
D. Wetlands	0.00	NA	NA	0.00	0.00	NA	NA	NA	NA	NA
E. Settlements	19.54	NA	0.00	20.84	19.54	NA	1.30	NA	NA	NA
F. Other land	7.87	NA	0.00	7.87	7.87	NA	0.00	NA	NA	NA
G. Harvested Wood Products	9.16	NA	NA	9.16	9.16	NA	NA	NA	NA	NA
5. Waste	**NE**	**10.22**	**0.03**	**264.92**	**NE**	**255.57**	**9.35**	**NA**	**NA**	**NA**
A. Solid waste disposal on land	**NA**	**7.83**	**NA**	195.73	**NA**	**195.73**	**NA**	NA	NA	NA
B. Biological Treatment of Solid Waste	NA	NE	NE	NE	NA	NE	NE	NA	NA	NA
C. Waste incineration	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
D. Waste-water handling	NA	2.39	0.03	69.18	NA	59.84	9.35	NA	NA	NA
6. Other (please specify)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	NA	NA	NA
Total national emissions and removals	**257.91**	**35.40**	**0.30**	**2,612.87**	**257.91**	**885.04**	**88.45**	**49.15**	**1,361.71**	**0.92**
Memo items										
International bunkers										
Aviation	**30.67**	**NO**	**0.00**	**30.91**	**30.67**	**NO**	**0.24**	NA	NA	NA
Marine	NO	NO	NO	NE	NO	NO	NO	NA	NA	NA
CO_2 emissions from biomass	**540.85**	**NA**	**NA**	**540.85**	**540.85**	**NA**	**NA**	NA	NA	NA

Greenhouse gas source and sink categories 1995	CO_2 emissions & removals	CH_4	N_2O	GHG (with LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
1. Energy	**674.91**	**3.40**	**0.04**	**771.55**	**674.91**	**85.07**	**11.56**	**NA**	**NA**	**NA**
A. Fuel combustion (sectoral approach)	674.91	1.87	0.04	733.13	674.91	46.65	11.56	NA	NA	NA
1. Energy industries	164.99	0.01	0.00	165.59	164.99	0.13	0.47	NA	NA	NA
2. Manufacturing industries and construction	210.28	0.01	0.00	210.96	210.28	0.21	0.48	NA	NA	NA
3. Transport	226.38	0.07	0.01	231.33	226.38	1.70	3.25	NA	NA	NA
4. Other sectors	73.27	1.78	0.02	125.25	73.27	44.61	7.37	NA	NA	NA
5. Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
B. Fugitive emissions from fuels	NE	1.54	NE	38.42	NE	38.42	NE	NA	NA	NA
1. Solid fuels	NA	1.54	NA	38.42	NA	38.42	NA	NA	NA	NA
2. Oil and natural gas	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
2. Industrial processes	**56.20**	**0.00**	**NO**	**418.51**	**56.20**	**0.02**	**NO**	**16.46**	**345.05**	**0.78**
A. Mineral products	5.25	NO	NO	5.25	5.25	NO	NO	NA	NA	NA
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
C. Metal production	48.80	0.00	NO	393.88	48.80	0.02	NO	NA	345.05	NA
D. Other production	2.06	NA	NA	2.06	2.06	NA	NA	NA	NA	NA
E. Production of halocarbons and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NE	NE	16.46	NE	NE	NE	16.46	NO	NO
G Other product manufacture and use	NE	NE	NE	0.78	NE	NE	NE	NA	NA	0.78
H. Other	0.08	NA	NA	0.08	0.08	NA	NA	NA	NA	NA
3. Agriculture	**0.48**	**22.11**	**0.12**	**588.73**	**0.48**	**552.66**	**35.59**	**NA**	**NA**	**NA**
A. Enteric fermentation	NA	18.31	NA	457.87	NA	457.87	NA	NA	NA	NA
B. Manure management	NA	3.79	0.07	116.15	NA	94.73	21.42	NA	NA	NA
C. Rice cultivation	NA	NO	NA	NO	NA	NO	NA	NA	NA	NA
D. Agricultural soils	NA	NA	0.05	14.15	NA	NA	14.15	NA	NA	NA
E. Prescribed burning of savannahs	NA	NO	NO	NA	NA	NO	NO	NA	NA	NA
F. Field burning of agricultural residues	NA	0.00	0.00	0.08	NA	0.06	0.02	NA	NA	NA

Greenhouse gas source and sink categories 1995	CO_2 emissions & removals	CH_4	N_2O	GHG (with LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
G. Other (Urea application)	0.48	0.00	0.00	0.48	0.48	0.00	0.00	NA	NA	NA
4. Land-use change and forestry	**-1,631.82**	**0.23**	**0.02**	**-1,625.64**	**-1,631.82**	**5.84**	**6.53**	**NA**	**NA**	**NA**
A. Total Forest land	**-1,664.05**	0.12	0.01	-1,659.21	-1,664.05	2.92	1.93	NA	NA	NA
B. Cropland	0.00	NA	0.00	0.04	0.00	NA	0.04	NA	NA	NA
C. Grassland	0.00	NA	NA	0.00	0.00	NA	NA	NA	NA	NA
D. Wetlands	0.00	NA	NA	0.00	0.00	NA	NA	NA	NA	NA
E. Settlements	19.54	NA	0.00	20.84	19.54	NA	1.30	NA	NA	NA
F. Other land	7.87	NA	0.00	7.87	7.87	NA	0.00	NA	NA	NA
G. Harvested Wood Products	4.82	NA	NA	4.82	4.82	NA	NA	NA	NA	NA
5. Waste	**NE**	**9.25**	**0.03**	**239.70**	**NE**	**231.30**	**8.40**	**NA**	**NA**	**NA**
A. Solid waste disposal on land	NA	6.83	NA	170.66	NA	170.66	NA	NA	NA	NA
B. Biological Treatment of Solid Waste	NA	NE	NE	NE	NA	NE	NE	NA	NA	NA
C. Waste incineration	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
D. Waste-water handling	NA	2.43	0.03	69.04	NA	60.64	8.40	NA	NA	NA
6. Other (please specify)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	NA	NA	NA
Total national emissions and removals	**-900.23**	**35.00**	**0.21**	**392.86**	**-900.23**	**874.90**	**62.08**	**16.46**	**345.05**	**0.78**
Memo items										
International bunkers										
Aviation	**2.36**	**NO**	**0.00**	**2.38**	**2.36**	**NO**	**0.02**	NA	NA	NA
Marine	NO	NO	NO	NE	NO	NO	NO	NA	NA	NA
CO_2 emissions from biomass	**639.40**	**3.40**	**0.04**	**639.40**	**639.40**	**NA**	**NA**	NA	NA	NA

Greenhouse gas source and sink categories 1990	CO_2 emissions & removals	CH_4	N_2O	GHG (with LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
1. Energy	**2,620.20**	**4.24**	**0.07**	**2,748.26**	**2,620.20**	**105.99**	**22.07**	**NA**	**NA**	**NA**
A. Fuel combustion (sectoral approach)	2,620.20	2.36	0.07	2,701.34	2,620.20	59.07	22.07	NA	NA	NA
1. Energy industries	1,754.11	0.03	0.02	1,761.87	1,754.11	0.66	7.10	NA	NA	NA
2. Manufacturing industries and construction	386.60	0.01	0.00	387.77	386.60	0.35	0.82	NA	NA	NA
3. Transport	347.86	0.11	0.02	355.53	347.86	2.71	4.96	NA	NA	NA
4. Other sectors	131.62	2.21	0.03	196.17	131.62	55.35	9.20	NA	NA	NA
5. Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
B. Fugitive emissions from fuels	NE	1.88	NE	46.92	NE	46.92	NE	NA	NA	NA
1. Solid fuels	NA	1.88	NA	46.92	NA	46.92	NA	NA	NA	NA
2. Oil and natural gas	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
2. Industrial processes	**213.20**	**0.00**	**NO**	**1,704.68**	**213.20**	**0.05**	**NO**	**NE**	**1,490.64**	**0.78**
A. Mineral products	24.75	NO	NO	24.75	24.75	NO	NO	NA	NA	NA
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA
C. Metal production	185.28	0.00	NO	1,675.97	185.28	0.05	NO	NA	1,490.64	NA
D. Other production	3.07	NA	NA	3.07	3.07	NA	NA	NA	NA	NA
E. Production of halocarbons and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Consumption of halocarbons and SF6	NE	NO	NE	NO	NE	NO	NE	NA	NO	NO
G Other product manufacture and use	NE	NE	NE	0.78	NE	NE	NE	NA	NA	0.78
H. Other	0.11	NA	NA	0.11	0.11	NA	NA	NA	NA	NA
3. Agriculture	**0.49**	**23.37**	**0.12**	**621.50**	**0.49**	**584.19**	**36.81**	**NA**	**NA**	**NA**
A. Enteric fermentation	NA	19.36	NA	483.90	NA	483.90	NA	NA	NA	NA
B. Manure management	NA	4.01	0.08	122.91	NA	100.24	22.67	NA	NA	NA
C. Rice cultivation	NA	NO	NA	NO	NA	NO	NA	NA	NA	NA
D. Agricultural soils	NA	NA	0.05	14.13	NA	NA	14.13	NA	NA	NA
E. Prescribed burning of savannahs	NA	NO	NO	NA	NA	NO	NO	NA	NA	NA
F. Field burning of agricultural residues	NA	0.00	0.00	0.07	NA	0.05	0.02	NA	NA	NA

Greenhouse gas source and sink categories 1990	CO_2 emissions & removals	CH_4	N_2O	GHG (with LULUCF)	CO_2 emissions & removals	CH_4	N_2O	HFC	PFC	SF6
	Gg			Gg CO_2 equivalent						
G. Other (Urea application)	0.49	0.00	0.00	0.49	0.49	0.00	0.00	NA	NA	NA
4. Land-use change and forestry	**-1,593.96**	**0.07**	**0.01**	**-1,589.84**	**-1,593.96**	**1.68**	**2.45**	**NA**	**NA**	**NA**
A. Total Forest land	**-1,578.07**	**0.07**	**0.00**	**-1,575.29**	**-1,578.07**	**1.68**	**1.10**	**NA**	NA	NA
B. Cropland	**0.00**	**NA**	**0.00**	**0.04**	**0.00**	**NA**	**0.04**	**NA**	NA	NA
C. Grassland	**0.00**	**NA**	**NA**	**0.00**	**0.00**	**NA**	**NA**	**NA**	NA	NA
D. Wetlands	0.00	NA	NA	0.00	0.00	NA	NA	NA	NA	NA
E. Settlements	19.54	NA	0.00	20.84	19.54	NA	1.30	NA	NA	NA
F. Other land	7.87	NA	0.00	7.87	7.87	NA	0.00	NA	NA	NA
G. Harvested Wood Products	-43.31	NA	NA	-43.31	-43.31	NA	NA	NA	NA	NA
5. Waste	**NE**	**8.42**	**0.03**	**217.97**	**NE**	**210.50**	**7.47**	**NA**	**NA**	**NA**
A. Solid waste disposal on land	**NA**	**6.02**	**NA**	150.49	**NA**	**150.49**	**NA**	NA	NA	NA
B. Biological Treatment of Solid Waste	NA	NE	NE	NE	NA	NE	NE	NA	NA	NA
C. Waste incineration	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA
D. Waste-water handling	NA	2.40	0.03	67.47	NA	60.01	7.47	NA	NA	NA
6. Other (please specify)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	NA	NA	NA
Total national emissions and removals	**1,239.93**	**36.10**	**0.23**	**3,702.56**	**1,239.93**	**902.41**	**68.80**	**0.00**	**1,490.64**	**0.78**
Memo items										
International bunkers										
Aviation	**30.67**	**NO**	**0.00**	**30.91**	**30.67**	**NO**	**0.24**	NA	NA	NA
Marine	NO	NO	NO	NE	NO	NO	NO	NA	NA	NA
CO_2 emissions from biomass	**799.54**	**NA**	**NA**	**2,748.26**	**2,620.20**	**NA**	**NA**	NA	NA	NA

12.3 Summary Tables - GHG emissions (without LULUCF) for the period 1990 - 2019

GHG (Gg CO_2 equivalent)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (without LULUCF)		**5,292.40**	**5,673.14**	**4,087.16**	**2,898.37**	**2,328.42**	**2,018.49**	**3,649.67**	**4,061.63**	**4,078.73**	**4,313.01**	**4,681.58**	**4,393.71**	**4,940.36**	**4,656.91**	**4,414.78**	**4,099.20**
1	**Energy**	**2,748.26**	**2,624.50**	**1,859.10**	**1,567.50**	**1,390.88**	**771.55**	**1,818.33**	**1,708.46**	**2,092.57**	**2,264.10**	**2,285.04**	**1,924.95**	**2,503.63**	**2,456.86**	**2,480.59**	**2,272.63**
1.A	Fuel Combustion Activities	2,701.34	2,585.09	1,812.91	1,518.58	1,346.31	733.13	1,776.14	1,673.61	2,057.92	2,228.69	2,250.96	1,895.82	2,446.62	2,421.63	2,444.19	2,241.49
1.A.1	Energy Industries	1,761.87	1,462.53	1,132.27	971.78	807.81	165.59	1,136.67	1,087.34	1,370.31	1,437.80	1,411.15	1,116.26	1,656.63	1,583.00	1,555.70	1,127.11
1.A.2	Manufacturing Industries and Construction	387.77	528.07	305.00	220.45	215.74	210.96	238.35	141.55	111.79	112.00	168.02	191.26	253.88	284.40	267.34	549.48
1.A.3	Transport	355.53	407.83	250.29	193.00	215.34	231.33	285.60	301.40	425.88	528.20	524.57	454.41	358.89	374.91	448.27	407.64
1.A.4	Other Sectors	196.17	186.66	125.35	133.35	107.42	125.25	115.52	143.32	149.94	150.68	147.22	133.90	177.22	179.32	172.88	157.26
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	46.92	39.41	46.19	48.91	44.56	38.42	42.19	34.84	34.64	35.41	34.08	29.13	57.01	35.23	36.40	31.14
1.B.1	Solid Fuels	46.92	39.41	46.19	48.91	44.56	38.42	42.19	34.84	34.64	35.41	34.08	29.13	57.01	35.23	36.40	31.14
1.B.2	Oil and Natural Gas	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2	**IPPU**	**1,704.68**	**2,206.15**	**1,422.12**	**543.76**	**135.53**	**418.51**	**1,002.21**	**1,533.24**	**1,167.70**	**1,222.78**	**1,579.41**	**1,659.46**	**1,612.45**	**1,380.59**	**1,272.88**	**1,167.11**
2.A	Mineral Industry	24.75	23.25	16.50	9.75	3.00	5.25	6.00	6.00	6.00	6.00	5.33	9.74	8.34	6.10	7.94	4.51
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	1,675.97	2,177.20	1,398.96	524.72	118.66	393.88	970.82	1,495.77	1,123.45	1,171.57	1,521.35	1,589.32	1,535.75	1,297.72	1,179.51	1,070.13
2.D	Other Production	3.07	3.48	2.00	1.24	1.53	2.06	2.48	2.42	2.54	2.48	2.54	2.54	2.54	2.54	2.59	0.58
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NO	1.33	3.79	7.22	11.48	16.46	22.06	28.19	34.79	41.79	49.15	56.82	64.78	72.98	81.40	90.37
2.G	Other product manufacture and use	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.84	0.84	0.92	0.92	0.97	1.15	1.33	1.43
2 H	Other	0.11	0.10	0.08	0.06	0.07	0.08	0.08	0.08	0.09	0.10	0.11	0.12	0.07	0.10	0.10	0.10
3	**Agriculture**	**621.50**	**620.12**	**579.28**	**556.23**	**566.97**	**588.73**	**584.35**	**569.73**	**563.31**	**566.06**	**552.22**	**540.33**	**551.74**	**544.20**	**384.32**	**381.61**
3.A	Enteric Fermentation	483.90	482.47	453.10	436.16	444.24	457.87	456.34	443.86	439.22	441.70	430.92	421.42	430.48	423.75	296.32	294.33

GHG (Gg CO_2 equivalent)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (without LULUCF)		**5,292.40**	**5,673.14**	**4,087.16**	**2,898.37**	**2,328.42**	**2,018.49**	**3,649.67**	**4,061.63**	**4,078.73**	**4,313.01**	**4,681.58**	**4,393.71**	**4,940.36**	**4,656.91**	**4,414.78**	**4,099.20**
3.B	Manure Management	122.91	122.60	115.18	110.85	112.85	116.15	115.80	112.55	110.84	111.14	108.12	105.76	108.11	107.34	75.09	74.38
3.C	Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.D	Agricultural soils	14.13	14.50	10.45	8.68	9.31	14.15	11.66	12.76	12.70	12.68	12.66	12.60	12.61	12.60	12.38	12.38
3.E	Prescribed burning of savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.F	Field burning of agricultural residues	0.07	0.07	0.07	0.06	0.07	0.08	0.07	0.09	0.08	0.07	0.05	0.08	0.08	0.06	0.09	0.09
3.G	Other (Urea application)	0.49	0.49	0.48	0.48	0.49	0.48	0.48	0.48	0.47	0.47	0.47	0.46	0.46	0.45	0.44	0.43
5	**Waste**	**217.97**	**222.37**	**226.66**	**230.89**	**235.05**	**239.70**	**244.78**	**250.20**	**255.15**	**260.06**	**264.92**	**268.97**	**272.54**	**275.26**	**276.99**	**277.85**
5.A	Solid Waste Disposal	150.49	154.52	158.51	162.44	166.31	170.66	175.44	180.56	185.67	190.72	195.73	199.74	202.81	205.04	206.42	206.96
5.B	Biological Treatment of Solid Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.C	Incineration and Open Burning of Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.D	Wastewater Treatment and Discharge	67.47	67.85	68.15	68.44	68.74	69.04	69.33	69.63	69.49	69.34	69.18	69.23	69.73	70.22	70.57	70.89
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
	Memo Items																
	International Bunkers	**30.91**	**34.06**	**4.76**	**2.38**	**2.38**	**2.38**	**2.38**	**2.38**	**11.89**	**30.91**	**30.91**	**38.04**	**40.36**	**32.68**	**7.14**	**29.51**
1.A.3.a.i	International Aviation	30.91	34.06	4.76	2.38	2.38	2.38	2.38	2.38	11.89	30.91	30.91	38.04	40.36	32.68	7.14	29.51
1.A.3.d.i	International water-borne navigation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 from Biomass Combustion for Energy Production		**799.54**	**683.66**	**739.74**	**815.40**	**562.92**	**639.40**	**607.10**	**549.14**	**497.73**	**516.46**	**540.85**	**452.69**	**659.56**	**680.93**	**694.25**	**666.92**

GHG (Gg CO_2 equivalent)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (without LULUCF)		**4,099.20**	**4,410.83**	**4,364.29**	**5,094.81**	**3,136.85**	**4,071.72**	**4,131.71**	**3,774.16**	**3,441.41**	**3,314.35**	**3,507.82**	**3,330.64**	**3,462.82**	**3,743.49**	**3,623.25**
1	**Energy**	**87.68**	**81.51**	**91.07**	**76.69**	**98.59**	**100.81**	**101.15**	**91.56**	**88.76**	**98.84**	**99.93**	**102.86**	**101.97**	**95.95**	**87.68**
1.A	Fuel Combustion Activities	51.54	53.06	53.18	55.85	56.39	58.61	58.19	54.71	52.72	54.48	54.13	52.99	48.95	47.01	51.54
1.A.1	Energy Industries	0.32	0.24	0.36	0.19	0.40	0.44	0.43	0.37	0.38	0.41	0.34	0.35	0.41	0.36	0.32
1.A.2	Manufacturing Industries and Construction	0.51	0.59	0.56	0.20	0.14	0.29	0.27	0.29	0.43	0.45	0.44	0.43	0.43	0.46	0.51
1.A.3	Transport	2.67	2.81	2.77	3.43	3.10	2.60	2.44	1.83	2.24	2.42	2.62	2.70	2.80	2.88	2.67
1.A.4	Other Sectors	48.04	49.42	49.48	52.03	52.74	55.29	55.04	52.22	49.67	51.20	50.73	49.50	45.32	43.30	48.04
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	36.14	28.45	37.89	20.84	42.20	42.20	42.96	36.84	36.04	44.36	45.80	49.87	53.02	48.94	36.14
1.B.1	Solid Fuels	36.14	28.45	37.89	20.84	42.20	42.20	42.96	36.84	36.04	44.36	45.80	49.87	53.02	48.94	36.14
1.B.2	Oil and Natural Gas	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2	**IPPU**	**0.04**	**0.04**	**0.05**	**0.03**	**0.01**	**0.02**	**0.01**	**0.00**	**0.00**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.04**
2.A	Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	0.04	0.04	0.05	0.03	0.01	0.02	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.04
2.D	Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other product manufacture and use	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2 H	Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	**Agriculture**	**344.45**	**321.37**	**314.36**	**299.26**	**286.28**	**265.30**	**261.10**	**269.69**	**282.75**	**278.43**	**272.20**	**264.01**	**256.71**	**249.84**	**344.45**
3.A	Enteric Fermentation	285.40	266.70	260.82	247.97	237.11	218.83	215.30	222.77	233.60	229.78	222.08	217.55	211.49	205.90	285.40
3.B	Manure Management	58.99	54.66	53.53	51.28	49.15	46.45	45.78	46.89	49.13	48.62	50.09	46.44	45.19	43.92	58.99

GHG (Gg CO_2 equivalent)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (without LULUCF)		**4,099.20**	**4,410.83**	**4,364.29**	**5,094.81**	**3,136.85**	**4,071.72**	**4,131.71**	**3,774.16**	**3,441.41**	**3,314.35**	**3,507.82**	**3,330.64**	**3,462.82**	**3,743.49**	**3,623.25**
3.C	Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.D	Agricultural soils	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.E	Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.F	Field burning of agricultural residues	0.06	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.06
3.G	Other (Urea application)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	**Waste**	**266.37**	**267.11**	**266.45**	**264.17**	**262.83**	**262.40**	**258.32**	**256.55**	**257.14**	**256.23**	**256.49**	**247.22**	**261.57**	**259.98**	**266.37**
5.A	Solid Waste Disposal	206.86	207.66	207.04	204.94	203.80	203.62	199.79	198.28	199.37	198.98	199.78	191.06	205.98	204.56	206.86
5.B	Biological Treatment of Solid Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.C	Incineration and Open Burning of Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.D	Wastewater Treatment and Discharge	59.51	59.45	59.41	59.23	59.03	58.78	58.52	58.27	57.77	57.25	56.71	56.16	55.59	55.41	59.51
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo Items																
International Bunkers		**29.51**	**32.25**	**10.67**	**18.00**	**13.25**	**32.07**	**17.01**	**3.22**	**6.12**	**27.39**	**29.14**	**28.40**	**26.57**	**34.42**	**59.48**
1.A.3.a.i	International Aviation	29.51	32.25	10.67	18.00	13.25	32.07	17.01	3.22	6.12	27.39	29.14	28.40	26.57	34.42	59.48
1.A.3.d.i	International water-borne navigation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 from Biomass Combustion for Energy Production		**666.92**	**674.85**	**680.28**	**680.33**	**714.65**	**746.22**	**766.02**	**775.74**	**734.57**	**704.75**	**720.88**	**708.51**	**697.42**	**633.30**	**601.67**

12.4 Summary Tables - CO_2 emissions (without LULUCF) for the period 1990 - 2019

CO_2 (Gg)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (without LULUCF)		**2,833.89**	**2,719.27**	**1,914.80**	**1,525.57**	**1,323.88**	**731.59**	**1,813.43**	**1,764.45**	**2,143.17**	**2,312.32**	**2,356.92**	**2,037.75**	**2,580.91**	**2,555.86**	**2,586.88**	**2,378.54**
1	**Energy**	**2,620.20**	**2,512.51**	**1,741.65**	**1,443.85**	**1,291.45**	**674.91**	**1,714.47**	**1,615.92**	**2,000.27**	**2,166.76**	**2,188.85**	**1,843.12**	**2,376.50**	**2,349.60**	**2,370.52**	**2,172.13**
1.A	Fuel Combustion Activities	2,620.20	2,512.51	1,741.65	1,443.85	1,291.45	674.91	1,714.47	1,615.92	2,000.27	2,166.76	2,188.85	1,843.12	2,376.50	2,349.60	2,370.52	2,172.13
1.A.1	Energy Industries	1,754.11	1,456.08	1,127.22	967.42	804.23	164.99	1,131.55	1,082.57	1,364.19	1,431.41	1,404.88	1,111.39	1,649.22	1,575.96	1,548.81	1,121.88
1.A.2	Manufacturing Industries and Construction	386.60	526.44	304.04	219.74	215.04	210.28	237.51	141.01	111.45	111.60	167.51	190.64	253.09	283.57	266.54	547.68
1.A.3	Transport	347.86	399.11	244.82	188.85	210.71	226.38	279.51	294.89	416.75	517.05	513.85	445.18	351.63	367.09	439.27	399.53
1.A.4	Other Sectors	131.62	130.88	65.57	67.84	61.46	73.27	65.89	97.46	107.88	106.71	102.60	95.91	122.56	122.98	115.90	103.04
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B.1	Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2	Oil and Natural Gas	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2	**IPPU**	**213.20**	**206.27**	**172.67**	**81.23**	**31.95**	**56.20**	**98.48**	**148.05**	**142.43**	**145.09**	**167.60**	**194.17**	**203.95**	**205.80**	**215.92**	**205.97**
2.A	Mineral Industry	24.75	23.25	16.50	9.75	3.00	5.25	6.00	6.00	6.00	6.00	5.33	9.74	8.34	6.10	7.94	4.51
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	185.28	179.43	154.08	70.19	27.34	48.80	89.92	139.55	133.81	136.51	159.62	181.78	193.00	197.06	205.29	200.79
2.D	Other Production	3.07	3.48	2.00	1.24	1.53	2.06	2.48	2.42	2.54	2.48	2.54	2.54	2.54	2.54	2.59	0.58
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other product manufacture and use	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2 H	Other	0.11	0.10	0.08	0.06	0.07	0.08	0.08	0.08	0.09	0.10	0.11	0.12	0.07	0.10	0.10	0.10
3	**Agriculture**	**0.49**	**0.49**	**0.48**	**0.48**	**0.49**	**0.48**	**0.48**	**0.48**	**0.47**	**0.47**	**0.47**	**0.46**	**0.46**	**0.45**	**0.44**	**0.43**
3.A	Enteric Fermentation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

CO_2 (Gg)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (without LULUCF)		**2,833.89**	**2,719.27**	**1,914.80**	**1,525.57**	**1,323.88**	**731.59**	**1,813.43**	**1,764.45**	**2,143.17**	**2,312.32**	**2,356.92**	**2,037.75**	**2,580.91**	**2,555.86**	**2,586.88**	**2,378.54**
3.B	Manure Management	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C	Rice Cultivation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D	Agricultural soils	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.E	Prescribed burning of savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.F	Field burning of agricultural residues	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.G	Other (Urea application)	0.49	0.49	0.48	0.48	0.49	0.48	0.48	0.48	0.47	0.47	0.47	0.46	0.46	0.45	0.44	0.43
5	**Waste**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
5.A	Solid Waste Disposal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.B	Biological Treatment of Solid Waste	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.C	Incineration and Open Burning of Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.D	Wastewater Treatment and Discharge	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
	Memo Items																
	International Bunkers	**30.67**	**33.80**	**4.72**	**2.36**	**2.36**	**2.36**	**2.36**	**2.36**	**11.80**	**30.67**	**30.67**	**37.75**	**40.20**	**32.49**	**6.79**	**29.17**
1.A.3.a.i	International Aviation	30.67	33.80	4.72	2.36	2.36	2.36	2.36	2.36	11.80	30.67	30.67	37.75	40.20	32.49	6.79	29.17
1.A.3.d.i	International water-borne navigation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 from Biomass Combustion for Energy Production		**799.54**	**683.66**	**739.74**	**815.40**	**562.92**	**639.40**	**607.10**	**549.14**	**497.73**	**516.46**	**540.85**	**452.69**	**659.56**	**680.93**	**694.25**	**666.92**

CO_2 (Gg)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (without LULUCF)		**2,378.54**	**2,576.58**	**2,440.50**	**2,998.09**	**1,949.08**	**2,704.46**	**2,846.58**	**2,675.46**	**2,440.37**	**2,325.36**	**2,518.96**	**2,352.87**	**2,490.91**	**2,763.37**	**2,670.01**
1	**Energy**	**2,360.94**	**2,221.29**	**2,795.24**	**1,835.00**	**2,566.92**	**2,688.84**	**2,553.36**	**2,360.43**	**2,235.76**	**2,427.41**	**2,264.00**	**2,396.28**	**2,667.29**	**2,578.60**	**2,360.94**
1.A	Fuel Combustion Activities	2,360.94	2,221.29	2,795.24	1,835.00	2,566.92	2,688.84	2,553.36	2,360.43	2,235.76	2,427.41	2,264.00	2,396.28	2,667.29	2,578.60	2,360.94
1.A.1	Energy Industries	1,277.30	924.49	1,441.40	754.84	1,607.66	1,734.14	1,702.31	1,512.85	1,515.06	1,646.38	1,371.71	1,421.43	1,634.76	1,473.78	1,277.30
1.A.2	Manufacturing Industries and Construction	542.83	607.65	583.46	231.12	180.05	146.21	102.48	133.72	159.31	158.13	159.48	185.21	180.96	192.37	542.83
1.A.3	Transport	433.51	532.93	610.01	707.51	623.06	670.33	649.43	627.07	523.15	580.32	684.02	748.01	807.80	867.61	433.51
1.A.4	Other Sectors	107.30	156.23	160.38	141.52	156.15	138.16	99.13	86.79	38.23	42.57	48.78	41.64	43.77	44.84	107.30
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B.1	Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2	Oil and Natural Gas	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2	**IPPU**	**215.22**	**218.78**	**202.43**	**113.67**	**137.13**	**157.34**	**121.78**	**79.56**	**89.22**	**91.17**	**88.50**	**94.26**	**95.72**	**91.06**	**215.22**
2.A	Mineral Industry	6.09	5.32	7.38	3.37	0.63	2.59	NO	NO	NO	NO	NO	NO	NO	NO	6.09
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	207.78	212.68	194.29	109.68	135.96	154.08	121.11	78.90	69.57	70.93	66.90	68.35	67.88	61.86	207.78
2.D	Other Production	1.24	0.68	0.66	0.52	0.45	0.59	0.59	0.59	19.57	20.16	21.52	25.82	27.77	29.13	1.24
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other product manufacture and use	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2 H	Other	0.11	0.11	0.11	0.10	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.11
3	**Agriculture**	**0.42**	**0.42**	**0.42**	**0.42**	**0.41**	**0.40**	**0.32**	**0.38**	**0.38**	**0.38**	**0.38**	**0.37**	**0.35**	**0.35**	**0.42**
3.A	Enteric Fermentation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B	Manure Management	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

CO_2 (Gg)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (without LULUCF)		**2,378.54**	**2,576.58**	**2,440.50**	**2,998.09**	**1,949.08**	**2,704.46**	**2,846.58**	**2,675.46**	**2,440.37**	**2,325.36**	**2,518.96**	**2,352.87**	**2,490.91**	**2,763.37**	**2,670.01**
3.C	Rice Cultivation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D	Agricultural soils	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.E	Prescribed burning of savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.F	Field burning of agricultural residues	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.G	Other (Urea application)	0.42	0.42	0.42	0.42	0.41	0.40	0.32	0.38	0.38	0.38	0.38	0.37	0.35	0.35	0.42
5	**Waste**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
5.A	Solid Waste Disposal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.B	Biological Treatment of Solid Waste	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.C	Incineration and Open Burning of Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.D	Wastewater Treatment and Discharge	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo Items																
International Bunkers		**29.17**	**31.82**	**10.13**	**17.39**	**12.67**	**31.42**	**16.38**	**2.41**	**5.30**	**26.76**	**28.49**	**27.69**	**25.71**	**33.54**	**58.02**
1.A.3.a.i	International Aviation	29.17	31.82	10.13	17.39	12.67	31.42	16.38	2.41	5.30	26.76	28.49	27.69	25.71	33.54	58.02
1.A.3.d.i	International water-borne navigation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 from Biomass Combustion for Energy Production		**666.92**	**674.85**	**680.28**	**680.33**	**714.65**	**746.22**	**766.02**	**775.74**	**734.57**	**704.75**	**720.88**	**708.51**	**697.42**	**633.30**	**601.67**

12.5 Summary Tables – CH_4 emissions (without LULUCF) for the period 1990 - 2019

CH_4 (Gg CO_2 equivalent)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (without LULUCF)		**900.73**	**888.57**	**866.17**	**856.87**	**849.44**	**869.06**	**874.58**	**854.13**	**849.91**	**860.45**	**850.13**	**831.07**	**886.99**	**862.38**	**712.56**	**702.41**
1	**Energy**	**105.99**	**91.31**	**100.25**	**107.28**	**86.15**	**85.07**	**87.56**	**77.09**	**74.46**	**77.57**	**76.21**	**65.09**	**106.94**	**86.98**	**88.78**	**80.90**
1.A	Fuel Combustion Activities	59.07	51.90	54.06	58.37	41.59	46.65	45.37	42.25	39.82	42.16	42.13	35.96	49.93	51.74	52.38	49.76
1.A.1	Energy Industries	0.66	0.55	0.39	0.32	0.29	0.13	0.37	0.41	0.47	0.51	0.50	0.45	0.57	0.56	0.56	0.28
1.A.2	Manufacturing Industries and Construction	0.35	0.48	0.29	0.21	0.21	0.21	0.26	0.17	0.10	0.13	0.15	0.19	0.24	0.25	0.24	0.55
1.A.3	Transport	2.71	3.01	1.98	1.46	1.62	1.70	2.07	2.28	3.13	3.68	3.22	2.74	2.13	2.51	2.60	2.42
1.A.4	Other Sectors	55.35	47.87	51.41	56.37	39.48	44.61	42.68	39.38	36.11	37.84	38.25	32.59	46.99	48.42	48.97	46.51
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	46.92	39.41	46.19	48.91	44.56	38.42	42.19	34.84	34.64	35.41	34.08	29.13	57.01	35.23	36.40	31.14
1.B.1	Solid Fuels	46.92	39.41	46.19	48.91	44.56	38.42	42.19	34.84	34.64	35.41	34.08	29.13	57.01	35.23	36.40	31.14
1.B.2	Oil and Natural Gas	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2	**IPPU**	**0.05**	**0.05**	**0.04**	**0.03**	**0.03**	**0.02**	**0.03**	**0.03**	**0.04**	**0.02**	**0.02**	**0.03**	**0.02**	**0.01**	**0.04**	**0.03**
2.A	Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	0.05	0.05	0.04	0.03	0.03	0.02	0.03	0.03	0.04	0.02	0.02	0.03	0.02	0.01	0.04	0.03
2.D	Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NO	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other product manufacture and use	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2 H	Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	**Agriculture**	**584.19**	**582.49**	**547.06**	**526.70**	**536.41**	**552.66**	**550.80**	**535.59**	**529.23**	**531.95**	**518.34**	**506.73**	**517.63**	**510.68**	**357.68**	**354.95**
3.A	Enteric Fermentation	483.90	482.47	453.10	436.16	444.24	457.87	456.34	443.86	439.22	441.70	430.92	421.42	430.48	423.75	296.32	294.33

CH_4 (Gg CO_2 equivalent)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (without LULUCF)		**900.73**	**888.57**	**866.17**	**856.87**	**849.44**	**869.06**	**874.58**	**854.13**	**849.91**	**860.45**	**850.13**	**831.07**	**886.99**	**862.38**	**712.56**	**702.41**
3.B	Manure Management	100.24	99.98	93.91	90.50	92.12	94.73	94.41	91.66	89.95	90.20	87.38	85.25	87.10	86.89	61.30	60.56
3.C	Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.D	Agricultural soils	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.E	Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.F	Field burning of agricultural residues	0.05	0.05	0.05	0.04	0.05	0.06	0.05	0.06	0.06	0.05	0.04	0.06	0.06	0.04	0.06	0.06
3.G	Other (Urea application)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	**Waste**	**210.50**	**214.71**	**218.82**	**222.86**	**226.84**	**231.30**	**236.19**	**241.42**	**246.19**	**250.91**	**255.57**	**259.22**	**262.39**	**264.71**	**266.06**	**266.54**
5.A	Solid Waste Disposal	150.49	154.52	158.51	162.44	166.31	170.66	175.44	180.56	185.67	190.72	195.73	199.74	202.81	205.04	206.42	206.96
5.B	Biological Treatment of Solid Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.C	Incineration and Open Burning of Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.D	Wastewater Treatment and Discharge	60.01	60.19	60.30	60.42	60.53	60.64	60.75	60.86	60.52	60.18	59.84	59.49	59.58	59.68	59.64	59.58
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
	Memo Items																
	International Bunkers	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.A.3.a.i	International Aviation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.A.3.d.i	International water-borne navigation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 from Biomass Combustion for Energy Production		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

CH_4 (Gg CO_2 equivalent)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (without LULUCF)		**702.41**	**698.53**	**670.03**	**671.93**	**640.15**	**647.71**	**628.53**	**620.57**	**617.80**	**628.65**	**633.50**	**628.63**	**614.10**	**620.25**	**605.78**
1	**Energy**	**80.90**	**87.68**	**81.51**	**91.07**	**76.69**	**98.59**	**100.81**	**101.15**	**91.56**	**88.76**	**98.84**	**99.93**	**102.86**	**101.97**	**95.95**
1.A	Fuel Combustion Activities	49.76	51.54	53.06	53.18	55.85	56.39	58.61	58.19	54.71	52.72	54.48	54.13	52.99	48.95	47.01
1.A.1	Energy Industries	0.28	0.32	0.24	0.36	0.19	0.40	0.44	0.43	0.37	0.38	0.41	0.34	0.35	0.41	0.36
1.A.2	Manufacturing Industries and Construction	0.55	0.51	0.59	0.56	0.20	0.14	0.29	0.27	0.29	0.43	0.45	0.44	0.43	0.43	0.46
1.A.3	Transport	2.42	2.67	2.81	2.77	3.43	3.10	2.60	2.44	1.83	2.24	2.42	2.62	2.70	2.80	2.88
1.A.4	Other Sectors	46.51	48.04	49.42	49.48	52.03	52.74	55.29	55.04	52.22	49.67	51.20	50.73	49.50	45.32	43.30
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	31.14	36.14	28.45	37.89	20.84	42.20	42.20	42.96	36.84	36.04	44.36	45.80	49.87	53.02	48.94
1.B.1	Solid Fuels	31.14	36.14	28.45	37.89	20.84	42.20	42.20	42.96	36.84	36.04	44.36	45.80	49.87	53.02	48.94
1.B.2	Oil and Natural Gas	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2	**IPPU**	**0.03**	**0.04**	**0.04**	**0.05**	**0.03**	**0.01**	**0.02**	**0.01**	**0.00**	**0.00**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
2.A	Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	0.03	0.04	0.04	0.05	0.03	0.01	0.02	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01
2.D	Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other product manufacture and use	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2 H	Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	**Agriculture**	**354.95**	**344.45**	**321.37**	**314.36**	**299.26**	**286.28**	**265.30**	**261.10**	**269.69**	**282.75**	**278.43**	**272.20**	**264.01**	**256.71**	**249.84**
3.A	Enteric Fermentation	294.33	285.40	266.70	260.82	247.97	237.11	218.83	215.30	222.77	233.60	229.78	222.08	217.55	211.49	205.90
3.B	Manure Management	60.56	58.99	54.66	53.53	51.28	49.15	46.45	45.78	46.89	49.13	48.62	50.09	46.44	45.19	43.92

CH_4 (Gg CO_2 equivalent)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (without LULUCF)		**702.41**	**698.53**	**670.03**	**671.93**	**640.15**	**647.71**	**628.53**	**620.57**	**617.80**	**628.65**	**633.50**	**628.63**	**614.10**	**620.25**	**605.78**
3.C	Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.D	Agricultural soils	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.E	Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.F	Field burning of agricultural residues	0.06	0.06	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
3.G	Other (Urea application)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	**Waste**	**266.54**	**266.37**	**267.11**	**266.45**	**264.17**	**262.83**	**262.40**	**258.32**	**256.55**	**257.14**	**256.23**	**256.49**	**247.22**	**261.57**	**259.98**
5.A	Solid Waste Disposal	206.96	206.86	207.66	207.04	204.94	203.80	203.62	199.79	198.28	199.37	198.98	199.78	191.06	205.98	204.56
5.B	Biological Treatment of Solid Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.C	Incineration and Open Burning of Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.D	Wastewater Treatment and Discharge	59.58	59.51	59.45	59.41	59.23	59.03	58.78	58.52	58.27	57.77	57.25	56.71	56.16	55.59	55.41
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo Items																
International Bunkers		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.A.3.a.i	International Aviation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.A.3.d.i	International water-borne navigation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 from Biomass Combustion for Energy Production		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

12.6 Summary Tables – N_2O emissions (without LULUCF) for the period 1990 - 2019

N_2O (Gg CO_2 equivalent)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (without LULUCF)		**66.35**	**65.47**	**56.78**	**53.44**	**51.56**	**55.55**	**57.95**	**57.88**	**60.42**	**62.56**	**62.75**	**59.62**	**63.99**	**63.90**	**58.42**	**57.13**
1	**Energy**	**22.07**	**20.67**	**17.20**	**16.36**	**13.28**	**11.56**	**16.30**	**15.44**	**17.84**	**19.77**	**19.98**	**16.74**	**20.19**	**20.28**	**21.30**	**19.60**
1.A	Fuel Combustion Activities	22.07	20.67	17.20	16.36	13.28	11.56	16.30	15.44	17.84	19.77	19.98	16.74	20.19	20.28	21.30	19.60
1.A.1	Energy Industries	7.10	5.91	4.67	4.04	3.29	0.47	4.75	4.36	5.64	5.89	5.77	4.42	6.84	6.49	6.33	4.95
1.A.2	Manufacturing Industries and Construction	0.82	1.14	0.67	0.50	0.49	0.48	0.58	0.37	0.24	0.28	0.36	0.43	0.55	0.59	0.56	1.25
1.A.3	Transport	4.96	5.71	3.49	2.69	3.01	3.25	4.03	4.23	6.00	7.47	7.50	6.49	5.13	5.30	6.40	5.69
1.A.4	Other Sectors	9.20	7.91	8.38	9.14	6.48	7.37	6.95	6.48	5.95	6.13	6.36	5.40	7.68	7.91	8.01	7.71
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B.1	Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2	Oil and Natural Gas	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2	**IPPU**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
2.A	Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D	Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other product manufacture and use	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2 H	Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	**Agriculture**	**36.81**	**37.14**	**31.74**	**29.05**	**30.07**	**35.59**	**33.07**	**33.67**	**33.61**	**33.64**	**33.41**	**33.14**	**33.65**	**33.06**	**26.19**	**26.22**
3.A	Enteric Fermentation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

N_2O (Gg CO_2 equivalent)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (without LULUCF)		**66.35**	**65.47**	**56.78**	**53.44**	**51.56**	**55.55**	**57.95**	**57.88**	**60.42**	**62.56**	**62.75**	**59.62**	**63.99**	**63.90**	**58.42**	**57.13**
3.B	Manure Management	22.67	22.62	21.27	20.36	20.74	21.42	21.39	20.89	20.89	20.94	20.74	20.52	21.01	20.45	13.79	13.82
3.C	Rice Cultivation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D	Agricultural soils	14.13	14.50	10.45	8.68	9.31	14.15	11.66	12.76	12.70	12.68	12.66	12.60	12.61	12.60	12.38	12.38
3.E	Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.F	Field burning of agricultural residues	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02
3.G	Other (Urea application)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	**Waste**	**7.47**	**7.66**	**7.84**	**8.02**	**8.21**	**8.40**	**8.58**	**8.77**	**8.96**	**9.16**	**9.35**	**9.75**	**10.15**	**10.55**	**10.93**	**11.31**
5.A	Solid Waste Disposal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.B	Biological Treatment of Solid Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.C	Incineration and Open Burning of Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.D	Wastewater Treatment and Discharge	7.47	7.66	7.84	8.02	8.21	8.40	8.58	8.77	8.96	9.16	9.35	9.75	10.15	10.55	10.93	11.31
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
	Memo Items																
	International Bunkers	**0.24**	**0.26**	**0.04**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.09**	**0.24**	**0.24**	**0.29**	**0.16**	**0.19**	**0.35**	**0.34**
1.A.3.a.i	International Aviation	0.24	0.26	0.04	0.02	0.02	0.02	0.02	0.02	0.09	0.24	0.24	0.29	0.16	0.19	0.35	0.34
1.A.3.d.i	International water-borne navigation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 from Biomass Combustion for Energy Production		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

N_2O (Gg CO_2 equivalent)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (without LULUCF)		**57.13**	**59.60**	**58.44**	**61.67**	**57.69**	**61.05**	**61.67**	**60.80**	**61.21**	**54.52**	**60.58**	**61.46**	**60.24**	**62.08**	**61.63**
1	**Energy**	**19.60**	**20.83**	**21.52**	**24.98**	**22.69**	**25.08**	**27.27**	**26.46**	**25.21**	**23.16**	**24.86**	**25.04**	**26.11**	**27.33**	**27.15**
1.A	Fuel Combustion Activities	19.60	20.83	21.52	24.98	22.69	25.08	27.27	26.46	25.21	23.16	24.86	25.04	26.11	27.33	27.15
1.A.1	Energy Industries	4.95	5.64	4.07	6.36	3.33	7.09	7.65	7.51	6.70	6.71	7.29	6.09	6.31	7.26	6.52
1.A.2	Manufacturing Industries and Construction	1.25	1.19	1.35	1.29	0.47	0.32	0.52	0.48	0.52	0.79	0.81	0.80	0.81	0.79	0.86
1.A.3	Transport	5.69	6.11	7.65	8.87	10.28	8.94	9.93	9.56	9.50	7.63	8.47	10.07	11.04	11.97	12.80
1.A.4	Other Sectors	7.71	7.88	8.45	8.46	8.62	8.73	9.16	8.90	8.50	8.04	8.29	8.08	7.95	7.30	6.97
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B.1	Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2	Oil and Natural Gas	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2	**IPPU**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
2.A	Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D	Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other product manufacture and use	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2 H	Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	**Agriculture**	**26.22**	**27.08**	**24.63**	**23.89**	**22.23**	**23.03**	**21.46**	**21.91**	**22.91**	**18.26**	**22.61**	**23.31**	**21.02**	**21.64**	**21.37**
3.A	Enteric Fermentation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B	Manure Management	13.82	13.54	12.79	12.41	11.86	11.40	10.74	10.68	11.03	11.44	11.31	11.82	10.88	10.53	10.27

N_2O (Gg CO_2 equivalent)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (without LULUCF)		**57.13**	**59.60**	**58.44**	**61.67**	**57.69**	**61.05**	**61.67**	**60.80**	**61.21**	**54.52**	**60.58**	**61.46**	**60.24**	**62.08**	**61.63**
3.C	Rice Cultivation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D	Agricultural soils	12.38	13.52	11.83	11.48	10.37	11.62	10.71	11.22	11.87	6.80	11.29	11.48	10.13	11.11	11.09
3.E	Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.F	Field burning of agricultural residues	0.02	0.02	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3.G	Other (Urea application)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	**Waste**	**11.31**	**11.69**	**12.29**	**12.80**	**12.76**	**12.94**	**12.95**	**12.44**	**13.09**	**13.10**	**13.11**	**13.11**	**13.11**	**13.11**	**13.10**
5.A	Solid Waste Disposal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.B	Biological Treatment of Solid Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.C	Incineration and Open Burning of Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.D	Wastewater Treatment and Discharge	11.31	11.69	12.29	12.80	12.76	12.94	12.95	12.44	13.09	13.10	13.11	13.11	13.11	13.11	13.10
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo Items																
International Bunkers		**0.34**	**0.43**	**0.53**	**0.61**	**0.58**	**0.65**	**0.64**	**0.81**	**0.82**	**0.63**	**0.65**	**0.71**	**0.86**	**0.88**	**1.46**
1.A.3.a.i	International Aviation	0.34	0.43	0.53	0.61	0.58	0.65	0.64	0.81	0.82	0.63	0.65	0.71	0.86	0.88	1.46
1.A.3.d.i	International water-borne navigation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 from Biomass Combustion for Energy Production		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

12.7 Summary Tables - GHG emissions (with LULUCF) for the period 1990 - 2019

GHG (Gg CO_2 equivalent)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (with LULUCF)		**3,702.56**	**3,738.05**	**2,554.85**	**673.57**	**580.76**	**392.86**	**1,817.71**	**1,475.73**	**1,399.24**	**1,690.13**	**2,612.87**	**1,804.21**	**2,174.82**	**2,011.73**	**1,750.90**	**1,638.26**
1	**Energy**	**2,748.26**	**2,624.50**	**1,859.10**	**1,567.50**	**1,390.88**	**771.55**	**1,818.33**	**1,708.46**	**2,092.57**	**2,264.10**	**2,285.04**	**1,924.95**	**2,503.63**	**2,456.86**	**2,480.59**	**2,272.63**
1.A	Fuel Combustion Activities	2,701.34	2,585.09	1,812.91	1,518.58	1,346.31	733.13	1,776.14	1,673.61	2,057.92	2,228.69	2,250.96	1,895.82	2,446.62	2,421.63	2,444.19	2,241.49
1.A.1	Energy Industries	1,761.87	1,462.53	1,132.27	971.78	807.81	165.59	1,136.67	1,087.34	1,370.31	1,437.80	1,411.15	1,116.26	1,656.63	1,583.00	1,555.70	1,127.11
1.A.2	Manufacturing Industries and Construction	387.77	528.07	305.00	220.45	215.74	210.96	238.35	141.55	111.79	112.00	168.02	191.26	253.88	284.40	267.34	549.48
1.A.3	Transport	355.53	407.83	250.29	193.00	215.34	231.33	285.60	301.40	425.88	528.20	524.57	454.41	358.89	374.91	448.27	407.64
1.A.4	Other Sectors	196.17	186.66	125.35	133.35	107.42	125.25	115.52	143.32	149.94	150.68	147.22	133.90	177.22	179.32	172.88	157.26
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	46.92	39.41	46.19	48.91	44.56	38.42	42.19	34.84	34.64	35.41	34.08	29.13	57.01	35.23	36.40	31.14
1.B.1	Solid Fuels	46.92	39.41	46.19	48.91	44.56	38.42	42.19	34.84	34.64	35.41	34.08	29.13	57.01	35.23	36.40	31.14
1.B.2	Oil and Natural Gas	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2	**IPPU**	**1,704.68**	**2,206.15**	**1,422.12**	**543.76**	**135.53**	**418.51**	**1,002.21**	**1,533.24**	**1,167.70**	**1,222.78**	**1,579.41**	**1,659.46**	**1,612.45**	**1,380.59**	**1,272.88**	**1,167.11**
2.A	Mineral Industry	24.75	23.25	16.50	9.75	3.00	5.25	6.00	6.00	6.00	6.00	5.33	9.74	8.34	6.10	7.94	4.51
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	1,675.97	2,177.20	1,398.96	524.72	118.66	393.88	970.82	1,495.77	1,123.45	1,171.57	1,521.35	1,589.32	1,535.75	1,297.72	1,179.51	1,070.13
2.D	Other Production	3.07	3.48	2.00	1.24	1.53	2.06	2.48	2.42	2.54	2.48	2.54	2.54	2.54	2.54	2.59	0.58
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NO	1.33	3.79	7.22	11.48	16.46	22.06	28.19	34.79	41.79	49.15	56.82	64.78	72.98	81.40	90.37
2.G	Other product manufacture and use	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.84	0.84	0.92	0.92	0.97	1.15	1.33	1.43
2 H	Other	0.11	0.10	0.08	0.06	0.07	0.08	0.08	0.08	0.09	0.10	0.11	0.12	0.07	0.10	0.10	0.10
3	**Agriculture**	**621.50**	**620.12**	**579.28**	**556.23**	**566.97**	**588.73**	**584.35**	**569.73**	**563.31**	**566.06**	**552.22**	**540.33**	**551.74**	**544.20**	**384.32**	**381.61**
3.A	Enteric Fermentation	483.90	482.47	453.10	436.16	444.24	457.87	456.34	443.86	439.22	441.70	430.92	421.42	430.48	423.75	296.32	294.33

GHG (Gg CO_2 equivalent)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (with LULUCF)		**3,702.56**	**3,738.05**	**2,554.85**	**673.57**	**580.76**	**392.86**	**1,817.71**	**1,475.73**	**1,399.24**	**1,690.13**	**2,612.87**	**1,804.21**	**2,174.82**	**2,011.73**	**1,750.90**	**1,638.26**
3.B	Manure Management	122.91	122.60	115.18	110.85	112.85	116.15	115.80	112.55	110.84	111.14	108.12	105.76	108.11	107.34	75.09	74.38
3.C	Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.D	Agricultural soils	14.13	14.50	10.45	8.68	9.31	14.15	11.66	12.76	12.70	12.68	12.66	12.60	12.61	12.60	12.38	12.38
3.E	Prescribed burning of savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.F	Field burning of agricultural residues	0.07	0.07	0.07	0.06	0.07	0.08	0.07	0.09	0.08	0.07	0.05	0.08	0.08	0.06	0.09	0.09
3.G	Other (Urea application)	0.49	0.49	0.48	0.48	0.49	0.48	0.48	0.48	0.47	0.47	0.47	0.46	0.46	0.45	0.44	0.43
4	**LULUCF**	**-1,589.84**	**-1,935.08**	**-1,532.30**	**-2,224.80**	**-1,747.66**	**-1,625.64**	**-1,831.95**	**-2,585.90**	**-2,679.50**	**-2,622.87**	**-2,068.71**	**-2,589.50**	**-2,765.54**	**-2,645.18**	**-2,663.88**	**-2,460.94**
4.A	Total Forest land	-1,575.29	-1,941.73	-1,555.78	-2,262.12	-1,787.11	-1,659.21	-1,874.22	-2,638.99	-2,732.21	-2,672.35	-2,106.62	-2,636.50	-2,801.59	-2,665.64	-2,665.72	-2,484.11
4.B	Cropland	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
4.C	Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.D	Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.E	Settlements	20.84	20.84	20.84	20.84	20.84	20.84	20.84	20.84	20.84	20.84	20.84	20.84	20.84	20.84	20.84	20.84
4.F	Other land	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87
4.G	Harvested Wood Products	-43.31	-22.10	-5.28	8.57	10.70	4.82	13.52	24.34	23.97	20.73	9.16	18.25	7.30	-8.29	-26.91	-5.58
5	**Waste**	**217.97**	**222.37**	**226.66**	**230.89**	**235.05**	**239.70**	**244.78**	**250.20**	**255.15**	**260.06**	**264.92**	**268.97**	**272.54**	**275.26**	**276.99**	**277.85**
5.A	Solid Waste Disposal	150.49	154.52	158.51	162.44	166.31	170.66	175.44	180.56	185.67	190.72	195.73	199.74	202.81	205.04	206.42	206.96
5.B	Biological Treatment of Solid Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.C	Incineration and Open Burning of Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.D	Wastewater Treatment and Discharge	67.47	67.85	68.15	68.44	68.74	69.04	69.33	69.63	69.49	69.34	69.18	69.23	69.73	70.22	70.57	70.89

GHG (Gg CO_2 equivalent)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (with LULUCF)		**3,702.56**	**3,738.05**	**2,554.85**	**673.57**	**580.76**	**392.86**	**1,817.71**	**1,475.73**	**1,399.24**	**1,690.13**	**2,612.87**	**1,804.21**	**2,174.82**	**2,011.73**	**1,750.90**	**1,638.26**
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
	Memo Items																
	International Bunkers	**30.91**	**34.06**	**4.76**	**2.38**	**2.38**	**2.38**	**2.38**	**2.38**	**11.89**	**30.91**	**30.91**	**38.04**	**40.36**	**32.68**	**7.14**	**29.51**
1.A.3.a.i	International Aviation	30.91	34.06	4.76	2.38	2.38	2.38	2.38	2.38	11.89	30.91	30.91	38.04	40.36	32.68	7.14	29.51
1.A.3.d.i	International water-borne navigation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 from Biomass Combustion for Energy Production		**799.54**	**683.66**	**739.74**	**815.40**	**562.92**	**639.40**	**607.10**	**549.14**	**497.73**	**516.46**	**540.85**	**452.69**	**659.56**	**680.93**	**694.25**	**666.92**

GHG (Gg CO_2 equivalent)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (with LULUCF)		**1,638.26**	**2,298.40**	**2,487.95**	**2,801.34**	**308.91**	**1,547.47**	**3,415.00**	**1,702.48**	**1,022.14**	**807.94**	**1,133.68**	**960.77**	**1,653.58**	**1,287.25**	**1,119.31**
1	**Energy**	**2,272.63**	**2,469.45**	**2,324.32**	**2,911.28**	**1,934.38**	**2,690.59**	**2,816.92**	**2,680.96**	**2,477.19**	**2,347.67**	**2,551.11**	**2,388.97**	**2,525.25**	**2,796.59**	**2,701.70**
1.A	Fuel Combustion Activities	2,241.49	2,433.31	2,295.88	2,873.40	1,913.54	2,648.39	2,774.72	2,638.00	2,440.35	2,311.63	2,506.74	2,343.17	2,475.38	2,743.57	2,652.76
1.A.1	Energy Industries	1,127.11	1,283.27	928.79	1,448.12	758.37	1,615.16	1,742.23	1,710.25	1,519.92	1,522.14	1,654.08	1,378.14	1,428.09	1,642.42	1,480.67
1.A.2	Manufacturing Industries and Construction	549.48	544.53	609.59	585.31	231.79	180.51	147.03	103.23	134.52	160.53	159.39	160.72	186.45	182.18	193.69
1.A.3	Transport	407.64	442.29	543.39	621.64	721.22	635.09	682.85	661.43	638.40	533.02	591.21	696.71	761.76	822.57	883.29
1.A.4	Other Sectors	157.26	163.22	214.10	218.32	202.17	217.63	202.61	163.08	147.51	95.94	102.07	107.59	99.09	96.40	95.11
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	31.14	36.14	28.45	37.89	20.84	42.20	42.20	42.96	36.84	36.04	44.36	45.80	49.87	53.02	48.94
1.B.1	Solid Fuels	31.14	36.14	28.45	37.89	20.84	42.20	42.20	42.96	36.84	36.04	44.36	45.80	49.87	53.02	48.94
1.B.2	Oil and Natural Gas	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2	**IPPU**	**1,167.11**	**1,291.38**	**1,414.15**	**1,565.61**	**603.63**	**795.64**	**752.29**	**539.12**	**401.61**	**395.06**	**385.96**	**376.18**	**391.83**	**393.52**	**376.89**
2.A	Mineral Industry	4.51	6.09	5.32	7.38	3.37	0.63	2.59	NO	NO	NO	NO	NO	NO	NO	NO
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	1,070.13	1,176.24	1,285.04	1,419.49	449.58	633.15	577.15	344.32	194.29	156.18	142.87	112.50	113.50	105.20	95.90
2.D	Other Production	0.58	1.24	0.68	0.66	0.52	0.45	0.59	0.59	0.59	19.57	20.16	21.52	25.82	27.77	29.13
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	90.37	106.22	121.52	136.45	148.53	159.77	170.28	192.12	204.47	217.00	220.62	239.57	249.44	257.02	248.35
2.G	Other product manufacture and use	1.43	1.49	1.49	1.52	1.54	1.55	1.60	2.00	2.19	2.23	2.23	2.52	2.99	3.44	3.44
2 H	Other	0.10	0.11	0.11	0.11	0.10	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
3	**Agriculture**	**381.61**	**371.95**	**346.42**	**338.67**	**321.91**	**309.72**	**287.16**	**283.32**	**292.97**	**301.38**	**301.42**	**295.89**	**285.40**	**278.70**	**271.57**
3.A	Enteric Fermentation	294.33	285.40	266.70	260.82	247.97	237.11	218.83	215.30	222.77	233.60	229.78	222.08	217.55	211.49	205.90
3.B	Manure Management	74.38	72.53	67.46	65.93	63.13	60.55	57.20	56.47	57.92	60.57	59.93	61.91	57.32	55.72	54.19

GHG (Gg CO_2 equivalent)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (with LULUCF)		**1,638.26**	**2,298.40**	**2,487.95**	**2,801.34**	**308.91**	**1,547.47**	**3,415.00**	**1,702.48**	**1,022.14**	**807.94**	**1,133.68**	**960.77**	**1,653.58**	**1,287.25**	**1,119.31**
3.C	Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.D	Agricultural soils	12.38	13.52	11.83	11.48	10.37	11.62	10.71	11.22	11.87	6.80	11.29	11.48	10.13	11.11	11.09
3.E	Prescribed burning of savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.F	Field burning of agricultural residues	0.09	0.08	0.01	0.02	0.02	0.02	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03
3.G	Other (Urea application)	0.43	0.42	0.42	0.42	0.42	0.41	0.40	0.32	0.38	0.38	0.38	0.38	0.37	0.35	0.35
4	**LULUCF**	**-2,460.94**	**-2,112.43**	**-1,876.34**	**-2,293.47**	**-2,827.94**	**-2,524.25**	**-716.71**	**-2,071.68**	**-2,419.27**	**-2,506.41**	**-2,374.14**	**-2,369.87**	**-1,809.24**	**-2,456.24**	**-2,503.93**
4.A	Total Forest land	-2,484.11	-2,175.87	-1,948.28	-2,346.63	-2,891.74	-2,588.33	-678.81	-2,089.16	-2,428.57	-2,485.77	-2,324.17	-2,321.73	-1,721.35	-2,372.25	-2,423.78
4.B	Cropland	0.04	0.04	0.59	0.64	0.70	0.76	0.82	0.88	0.52	0.54	0.57	0.59	0.61	0.64	0.66
4.C	Grassland	0.00	0.00	0.37	0.35	0.33	0.31	0.29	0.27	-0.44	-0.53	-0.62	-0.72	-0.81	-0.90	-0.99
4.D	Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.E	Settlements	20.84	20.84	35.10	35.77	36.43	37.10	37.77	38.44	53.15	54.26	55.37	56.49	57.60	58.71	59.82
4.F	Other land	7.87	7.87	1.92	1.92	1.92	1.92	1.92	1.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.G	Harvested Wood Products	-5.58	34.69	33.97	14.48	24.41	23.98	-78.70	-24.02	-43.94	-74.92	-105.29	-104.50	-145.28	-142.43	-139.64
5	**Waste**	**277.85**	**278.05**	**279.40**	**279.25**	**276.94**	**275.77**	**275.34**	**270.75**	**269.64**	**270.24**	**269.34**	**269.60**	**260.33**	**274.68**	**273.08**
5.A	Solid Waste Disposal	206.96	206.86	207.66	207.04	204.94	203.80	203.62	199.79	198.28	199.37	198.98	199.78	191.06	205.98	204.56
5.B	Biological Treatment of Solid Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.C	Incineration and Open Burning of Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.D	Wastewater Treatment and Discharge	70.89	71.20	71.73	72.21	71.99	71.97	71.73	70.96	71.36	70.87	70.36	69.82	69.27	68.70	68.52

GHG (Gg CO_2 equivalent)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (with LULUCF)		**1,638.26**	**2,298.40**	**2,487.95**	**2,801.34**	**308.91**	**1,547.47**	**3,415.00**	**1,702.48**	**1,022.14**	**807.94**	**1,133.68**	**960.77**	**1,653.58**	**1,287.25**	**1,119.31**
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo Items																
International Bunkers		**29.51**	**32.25**	**10.67**	**18.00**	**13.25**	**32.07**	**17.01**	**3.22**	**6.12**	**27.39**	**29.14**	**28.40**	**26.57**	**34.42**	**59.48**
1.A.3.a.i	International Aviation	29.51	32.25	10.67	18.00	13.25	32.07	17.01	3.22	6.12	27.39	29.14	28.40	26.57	34.42	59.48
1.A.3.d.i	International water-borne navigation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 from Biomass Combustion for Energy Production		**666.92**	**674.85**	**680.28**	**680.33**	**714.65**	**746.22**	**766.02**	**775.74**	**734.57**	**704.75**	**720.88**	**708.51**	**697.42**	**633.30**	**601.67**

12.8 Summary Tables - CO_2 emissions (with LULUCF) for the period 1990 - 2019

CO_2 (Gg)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (with LULUCF)		**1,239.93**	**781.52**	**376.08**	**-705.27**	**-427.30**	**-900.23**	**-25.24**	**-824.26**	**-543.72**	**-312.38**	**257.91**	**-554.92**	**-187.51**	**-106.09**	**-83.66**	**-84.14**
1	**Energy**	**2,620.20**	**2,512.51**	**1,741.65**	**1,443.85**	**1,291.45**	**674.91**	**1,714.47**	**1,615.92**	**2,000.27**	**2,166.76**	**2,188.85**	**1,843.12**	**2,376.50**	**2,349.60**	**2,370.52**	**2,172.13**
1.A	Fuel Combustion Activities	2,620.20	2,512.51	1,741.65	1,443.85	1,291.45	674.91	1,714.47	1,615.92	2,000.27	2,166.76	2,188.85	1,843.12	2,376.50	2,349.60	2,370.52	2,172.13
1.A.1	Energy Industries	1,754.11	1,456.08	1,127.22	967.42	804.23	164.99	1,131.55	1,082.57	1,364.19	1,431.41	1,404.88	1,111.39	1,649.22	1,575.96	1,548.81	1,121.88
1.A.2	Manufacturing Industries and Construction	386.60	526.44	304.04	219.74	215.04	210.28	237.51	141.01	111.45	111.60	167.51	190.64	253.09	283.57	266.54	547.68
1.A.3	Transport	347.86	399.11	244.82	188.85	210.71	226.38	279.51	294.89	416.75	517.05	513.85	445.18	351.63	367.09	439.27	399.53
1.A.4	Other Sectors	131.62	130.88	65.57	67.84	61.46	73.27	65.89	97.46	107.88	106.71	102.60	95.91	122.56	122.98	115.90	103.04
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B.1	Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2	Oil and Natural Gas	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2	**IPPU**	**213.20**	**206.27**	**172.67**	**81.23**	**31.95**	**56.20**	**98.48**	**148.05**	**142.43**	**145.09**	**167.60**	**194.17**	**203.95**	**205.80**	**215.92**	**205.97**
2.A	Mineral Industry	24.75	23.25	16.50	9.75	3.00	5.25	6.00	6.00	6.00	6.00	5.33	9.74	8.34	6.10	7.94	4.51
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	185.28	179.43	154.08	70.19	27.34	48.80	89.92	139.55	133.81	136.51	159.62	181.78	193.00	197.06	205.29	200.79
2.D	Other Production	3.07	3.48	2.00	1.24	1.53	2.06	2.48	2.42	2.54	2.48	2.54	2.54	2.54	2.54	2.59	0.58
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other product manufacture and use	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2 H	Other	0.11	0.10	0.08	0.06	0.07	0.08	0.08	0.08	0.09	0.10	0.11	0.12	0.07	0.10	0.10	0.10
3	**Agriculture**	**0.49**	**0.49**	**0.48**	**0.48**	**0.49**	**0.48**	**0.48**	**0.48**	**0.47**	**0.47**	**0.47**	**0.46**	**0.46**	**0.45**	**0.44**	**0.43**
3.A	Enteric Fermentation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

CO_2 (Gg)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (with LULUCF)		**1,239.93**	**781.52**	**376.08**	**-705.27**	**-427.30**	**-900.23**	**-25.24**	**-824.26**	**-543.72**	**-312.38**	**257.91**	**-554.92**	**-187.51**	**-106.09**	**-83.66**	**-84.14**
3.B	Manure Management	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C	Rice Cultivation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D	Agricultural soils	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.E	Prescribed burning of savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.F	Field burning of agricultural residues	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.G	Other (Urea application)	0.49	0.49	0.48	0.48	0.49	0.48	0.48	0.48	0.47	0.47	0.47	0.46	0.46	0.45	0.44	0.43
4	**LULUCF**	**-1,593.96**	**-1,937.75**	**-1,538.72**	**-2,230.84**	**-1,751.18**	**-1,631.82**	**-1,838.67**	**-2,588.70**	**-2,686.89**	**-2,624.70**	**-2,099.01**	**-2,592.68**	**-2,768.42**	**-2,661.95**	**-2,670.53**	**-2,462.68**
4.A	Total Forest land	-1,578.07	-1,943.06	-1,560.85	-2,266.82	-1,789.29	-1,664.05	-1,879.60	-2,640.46	-2,738.27	-2,672.84	-2,135.58	-2,638.34	-2,803.13	-2,681.06	-2,671.03	-2,484.51
4.B	Cropland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.C	Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.D	Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.E	Settlements	19.54	19.54	19.54	19.54	19.54	19.54	19.54	19.54	19.54	19.54	19.54	19.54	19.54	19.54	19.54	19.54
4.F	Other land	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87
4.G	Harvested Wood Products	-43.31	-22.10	-5.28	8.57	10.70	4.82	13.52	24.34	23.97	20.73	9.16	18.25	7.30	-8.29	-26.91	-5.58
5	**Waste**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
5.A	Solid Waste Disposal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.B	Biological Treatment of Solid Waste	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.C	Incineration and Open Burning of Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.D	Wastewater Treatment and Discharge	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

CO_2 (Gg)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (with LULUCF)		**1,239.93**	**781.52**	**376.08**	**-705.27**	**-427.30**	**-900.23**	**-25.24**	**-824.26**	**-543.72**	**-312.38**	**257.91**	**-554.92**	**-187.51**	**-106.09**	**-83.66**	**-84.14**
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
	Memo Items																
	International Bunkers	**30.67**	**33.80**	**4.72**	**2.36**	**2.36**	**2.36**	**2.36**	**2.36**	**11.80**	**30.67**	**30.67**	**37.75**	**40.20**	**32.49**	**6.79**	**29.17**
1.A.3.a.i	International Aviation	30.67	33.80	4.72	2.36	2.36	2.36	2.36	2.36	11.80	30.67	30.67	37.75	40.20	32.49	6.79	29.17
1.A.3.d.i	International water-borne navigation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 from Biomass Combustion for Energy Production		**799.54**	**683.66**	**739.74**	**815.40**	**562.92**	**639.40**	**607.10**	**549.14**	**497.73**	**516.46**	**540.85**	**452.69**	**659.56**	**680.93**	**694.25**	**666.92**

CO_2 (Gg)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (with LULUCF)		**-84.14**	**462.00**	**492.06**	**689.13**	**-880.76**	**175.89**	**1,938.96**	**580.62**	**18.54**	**-183.30**	**130.64**	**-23.47**	**597.43**	**291.49**	**159.00**
1	**Energy**	**2,360.94**	**2,221.29**	**2,795.24**	**1,835.00**	**2,566.92**	**2,688.84**	**2,553.36**	**2,360.43**	**2,235.76**	**2,427.41**	**2,264.00**	**2,396.28**	**2,667.29**	**2,578.60**	**2,360.94**
1.A	Fuel Combustion Activities	2,360.94	2,221.29	2,795.24	1,835.00	2,566.92	2,688.84	2,553.36	2,360.43	2,235.76	2,427.41	2,264.00	2,396.28	2,667.29	2,578.60	2,360.94
1.A.1	Energy Industries	1,277.30	924.49	1,441.40	754.84	1,607.66	1,734.14	1,702.31	1,512.85	1,515.06	1,646.38	1,371.71	1,421.43	1,634.76	1,473.78	1,277.30
1.A.2	Manufacturing Industries and Construction	542.83	607.65	583.46	231.12	180.05	146.21	102.48	133.72	159.31	158.13	159.48	185.21	180.96	192.37	542.83
1.A.3	Transport	433.51	532.93	610.01	707.51	623.06	670.33	649.43	627.07	523.15	580.32	684.02	748.01	807.80	867.61	433.51
1.A.4	Other Sectors	107.30	156.23	160.38	141.52	156.15	138.16	99.13	86.79	38.23	42.57	48.78	41.64	43.77	44.84	107.30
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B.1	Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2	Oil and Natural Gas	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2	**IPPU**	**215.22**	**218.78**	**202.43**	**113.67**	**137.13**	**157.34**	**121.78**	**79.56**	**89.22**	**91.17**	**88.50**	**94.26**	**95.72**	**91.06**	**215.22**
2.A	Mineral Industry	6.09	5.32	7.38	3.37	0.63	2.59	NO	NO	NO	NO	NO	NO	NO	NO	6.09
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	207.78	212.68	194.29	109.68	135.96	154.08	121.11	78.90	69.57	70.93	66.90	68.35	67.88	61.86	207.78
2.D	Other Production	1.24	0.68	0.66	0.52	0.45	0.59	0.59	0.59	19.57	20.16	21.52	25.82	27.77	29.13	1.24
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other product manufacture and use	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2 H	Other	0.11	0.11	0.11	0.10	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.11
3	**Agriculture**	**0.42**	**0.42**	**0.42**	**0.42**	**0.41**	**0.40**	**0.32**	**0.38**	**0.38**	**0.38**	**0.38**	**0.37**	**0.35**	**0.35**	**0.42**
3.A	Enteric Fermentation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B	Manure Management	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

CO_2 (Gg)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (with LULUCF)		**-84.14**	**462.00**	**492.06**	**689.13**	**-880.76**	**175.89**	**1,938.96**	**580.62**	**18.54**	**-183.30**	**130.64**	**-23.47**	**597.43**	**291.49**	**159.00**
3.C	Rice Cultivation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D	Agricultural soils	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.E	Prescribed burning of savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.F	Field burning of agricultural residues	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.G	Other (Urea application)	0.42	0.42	0.42	0.42	0.41	0.40	0.32	0.38	0.38	0.38	0.38	0.37	0.35	0.35	0.42
4	**LULUCF**	**-2,114.58**	**-1,948.44**	**-2,308.96**	**-2,829.84**	**-2,528.57**	**-907.62**	**-2,094.84**	**-2,421.82**	**-2,508.65**	**-2,388.32**	**-2,376.34**	**-1,893.48**	**-2,471.87**	**-2,511.01**	**-2,114.58**
4.A	Total Forest land	-2,176.68	-2,018.97	-2,360.63	-2,892.07	-2,591.01	-868.01	-2,110.55	-2,429.23	-2,486.01	-2,336.23	-2,325.97	-1,803.26	-2,385.44	-2,428.30	-2,176.68
4.B	Cropland	0.00	0.54	0.59	0.64	0.69	0.75	0.80	0.44	0.46	0.48	0.50	0.52	0.55	0.57	0.00
4.C	Grassland	0.00	0.37	0.35	0.33	0.31	0.29	0.27	-0.44	-0.53	-0.62	-0.72	-0.81	-0.90	-0.99	0.00
4.D	Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.E	Settlements	19.54	33.73	34.33	34.93	35.53	36.14	36.74	51.34	52.35	53.35	54.35	55.35	56.35	57.35	19.54
4.F	Other land	7.87	1.92	1.92	1.92	1.92	1.92	1.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.87
4.G	Harvested Wood Products	34.69	33.97	14.48	24.41	23.98	-78.70	-24.02	-43.94	-74.92	-105.29	-104.50	-145.28	-142.43	-139.64	34.69
5	**Waste**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
5.A	Solid Waste Disposal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.B	Biological Treatment of Solid Waste	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.C	Incineration and Open Burning of Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.D	Wastewater Treatment and Discharge	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

CO_2 (Gg)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (with LULUCF)		**-84.14**	**462.00**	**492.06**	**689.13**	**-880.76**	**175.89**	**1,938.96**	**580.62**	**18.54**	**-183.30**	**130.64**	**-23.47**	**597.43**	**291.49**	**159.00**
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo Items																
International Bunkers		**29.17**	**31.82**	**10.13**	**17.39**	**12.67**	**31.42**	**16.38**	**2.41**	**5.30**	**26.76**	**28.49**	**27.69**	**25.71**	**33.54**	**58.02**
1.A.3.a.i	International Aviation	29.17	31.82	10.13	17.39	12.67	31.42	16.38	2.41	5.30	26.76	28.49	27.69	25.71	33.54	58.02
1.A.3.d.i	International water-borne navigation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 from Biomass Combustion for Energy Production		**666.92**	**674.85**	**680.28**	**680.33**	**714.65**	**746.22**	**766.02**	**775.74**	**734.57**	**704.75**	**720.88**	**708.51**	**697.42**	**633.30**	**601.67**

12.9 Summary Tables – CH_4 emissions (with LULUCF) for the period 1990 - 2019

CH_4 (Gg CO_2 equivalent)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (with LULUCF)		**902.41**	**890.16**	**872.28**	**862.53**	**852.06**	**874.90**	**881.05**	**855.90**	**857.21**	**861.03**	**885.04**	**833.29**	**888.85**	**880.97**	**718.96**	**702.89**
1	**Energy**	**105.99**	**91.31**	**100.25**	**107.28**	**86.15**	**85.07**	**87.56**	**77.09**	**74.46**	**77.57**	**76.21**	**65.09**	**106.94**	**86.98**	**88.78**	**80.90**
1.A	Fuel Combustion Activities	59.07	51.90	54.06	58.37	41.59	46.65	45.37	42.25	39.82	42.16	42.13	35.96	49.93	51.74	52.38	49.76
1.A.1	Energy Industries	0.66	0.55	0.39	0.32	0.29	0.13	0.37	0.41	0.47	0.51	0.50	0.45	0.57	0.56	0.56	0.28
1.A.2	Manufacturing Industries and Construction	0.35	0.48	0.29	0.21	0.21	0.21	0.26	0.17	0.10	0.13	0.15	0.19	0.24	0.25	0.24	0.55
1.A.3	Transport	2.71	3.01	1.98	1.46	1.62	1.70	2.07	2.28	3.13	3.68	3.22	2.74	2.13	2.51	2.60	2.42
1.A.4	Other Sectors	55.35	47.87	51.41	56.37	39.48	44.61	42.68	39.38	36.11	37.84	38.25	32.59	46.99	48.42	48.97	46.51
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	46.92	39.41	46.19	48.91	44.56	38.42	42.19	34.84	34.64	35.41	34.08	29.13	57.01	35.23	36.40	31.14
1.B.1	Solid Fuels	46.92	39.41	46.19	48.91	44.56	38.42	42.19	34.84	34.64	35.41	34.08	29.13	57.01	35.23	36.40	31.14
1.B.2	Oil and Natural Gas	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2	**IPPU**	**0.05**	**0.05**	**0.04**	**0.03**	**0.03**	**0.02**	**0.03**	**0.03**	**0.04**	**0.02**	**0.02**	**0.03**	**0.02**	**0.01**	**0.04**	**0.03**
2.A	Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	0.05	0.05	0.04	0.03	0.03	0.02	0.03	0.03	0.04	0.02	0.02	0.03	0.02	0.01	0.04	0.03
2.D	Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NO	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other product manufacture and use	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2 H	Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	**Agriculture**	**584.19**	**582.49**	**547.06**	**526.70**	**536.41**	**552.66**	**550.80**	**535.59**	**529.23**	**531.95**	**518.34**	**506.73**	**517.63**	**510.68**	**357.68**	**354.95**
3.A	Enteric Fermentation	483.90	482.47	453.10	436.16	444.24	457.87	456.34	443.86	439.22	441.70	430.92	421.42	430.48	423.75	296.32	294.33

CH_4 (Gg CO_2 equivalent)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (with LULUCF)		**902.41**	**890.16**	**872.28**	**862.53**	**852.06**	**874.90**	**881.05**	**855.90**	**857.21**	**861.03**	**885.04**	**833.29**	**888.85**	**880.97**	**718.96**	**702.89**
3.B	Manure Management	100.24	99.98	93.91	90.50	92.12	94.73	94.41	91.66	89.95	90.20	87.38	85.25	87.10	86.89	61.30	60.56
3.C	Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.D	Agricultural soils	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.E	Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.F	Field burning of agricultural residues	0.05	0.05	0.05	0.04	0.05	0.06	0.05	0.06	0.06	0.05	0.04	0.06	0.06	0.04	0.06	0.06
3.G	Other (Urea application)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	**LULUCF**	**1.68**	**1.60**	**6.12**	**5.66**	**2.62**	**5.84**	**6.48**	**1.76**	**7.30**	**0.59**	**34.91**	**2.21**	**1.86**	**18.59**	**6.40**	**0.48**
4.A	Total Forest land	1.68	0.80	3.06	2.83	1.31	2.92	3.24	0.88	3.65	0.29	17.45	1.11	0.93	9.29	3.20	0.24
4.B	Cropland	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4.C	Grassland	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4.D	Wetlands	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4.E	Settlements	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4.F	Other land	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4.G	Harvested Wood Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	**Waste**	**210.50**	**214.71**	**218.82**	**222.86**	**226.84**	**231.30**	**236.19**	**241.42**	**246.19**	**250.91**	**255.57**	**259.22**	**262.39**	**264.71**	**266.06**	**266.54**
5.A	Solid Waste Disposal	150.49	154.52	158.51	162.44	166.31	170.66	175.44	180.56	185.67	190.72	195.73	199.74	202.81	205.04	206.42	206.96
5.B	Biological Treatment of Solid Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.C	Incineration and Open Burning of Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.D	Wastewater Treatment and Discharge	60.01	60.19	60.30	60.42	60.53	60.64	60.75	60.86	60.52	60.18	59.84	59.49	59.58	59.68	59.64	59.58

CH_4 (Gg CO_2 equivalent)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (with LULUCF)		902.41	890.16	872.28	862.53	852.06	874.90	881.05	855.90	857.21	861.03	885.04	833.29	888.85	880.97	718.96	702.89
6	Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Memo Items																
	International Bunkers	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.A.3.a.i	International Aviation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.A.3.d.i	International water-borne navigation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 from Biomass Combustion for Energy Production		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

CH_4 (Gg CO_2 equivalent)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (with LULUCF)		**702.89**	**699.51**	**755.22**	**688.81**	**640.56**	**650.94**	**856.57**	**646.34**	**618.60**	**628.94**	**648.04**	**633.75**	**712.82**	**636.15**	**611.23**
1	**Energy**	**80.90**	**87.68**	**81.51**	**91.07**	**76.69**	**98.59**	**100.81**	**101.15**	**91.56**	**88.76**	**98.84**	**99.93**	**102.86**	**101.97**	**95.95**
1.A	Fuel Combustion Activities	49.76	51.54	53.06	53.18	55.85	56.39	58.61	58.19	54.71	52.72	54.48	54.13	52.99	48.95	47.01
1.A.1	Energy Industries	0.28	0.32	0.24	0.36	0.19	0.40	0.44	0.43	0.37	0.38	0.41	0.34	0.35	0.41	0.36
1.A.2	Manufacturing Industries and Construction	0.55	0.51	0.59	0.56	0.20	0.14	0.29	0.27	0.29	0.43	0.45	0.44	0.43	0.43	0.46
1.A.3	Transport	2.42	2.67	2.81	2.77	3.43	3.10	2.60	2.44	1.83	2.24	2.42	2.62	2.70	2.80	2.88
1.A.4	Other Sectors	46.51	48.04	49.42	49.48	52.03	52.74	55.29	55.04	52.22	49.67	51.20	50.73	49.50	45.32	43.30
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	31.14	36.14	28.45	37.89	20.84	42.20	42.20	42.96	36.84	36.04	44.36	45.80	49.87	53.02	48.94
1.B.1	Solid Fuels	31.14	36.14	28.45	37.89	20.84	42.20	42.20	42.96	36.84	36.04	44.36	45.80	49.87	53.02	48.94
1.B.2	Oil and Natural Gas	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2	**IPPU**	**0.03**	**0.04**	**0.04**	**0.05**	**0.03**	**0.01**	**0.02**	**0.01**	**0.00**	**0.00**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
2.A	Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	0.03	0.04	0.04	0.05	0.03	0.01	0.02	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01
2.D	Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other product manufacture and use	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2 H	Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	**Agriculture**	**354.95**	**344.45**	**321.37**	**314.36**	**299.26**	**286.28**	**265.30**	**261.10**	**269.69**	**282.75**	**278.43**	**272.20**	**264.01**	**256.71**	**249.84**
3.A	Enteric Fermentation	294.33	285.40	266.70	260.82	247.97	237.11	218.83	215.30	222.77	233.60	229.78	222.08	217.55	211.49	205.90
3.B	Manure Management	60.56	58.99	54.66	53.53	51.28	49.15	46.45	45.78	46.89	49.13	48.62	50.09	46.44	45.19	43.92

CH_4 (Gg CO_2 equivalent)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (with LULUCF)		**702.89**	**699.51**	**755.22**	**688.81**	**640.56**	**650.94**	**856.57**	**646.34**	**618.60**	**628.94**	**648.04**	**633.75**	**712.82**	**636.15**	**611.23**
3.C	Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.D	Agricultural soils	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.E	Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.F	Field burning of agricultural residues	0.06	0.06	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
3.G	Other (Urea application)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	**LULUCF**	**0.48**	**0.98**	**85.19**	**16.88**	**0.41**	**3.23**	**228.04**	**25.77**	**0.80**	**0.29**	**14.54**	**5.12**	**98.72**	**15.90**	**5.44**
4.A	Total Forest land	0.24	0.49	42.60	8.44	0.20	1.62	114.02	12.89	0.40	0.14	7.27	2.56	49.36	7.95	2.72
4.B	Cropland	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4.C	Grassland	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4.D	Wetlands	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4.E	Settlements	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4.F	Other land	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4.G	Harvested Wood Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	**Waste**	**266.54**	**266.37**	**267.11**	**266.45**	**264.17**	**262.83**	**262.40**	**258.32**	**256.55**	**257.14**	**256.23**	**256.49**	**247.22**	**261.57**	**259.98**
5.A	Solid Waste Disposal	206.96	206.86	207.66	207.04	204.94	203.80	203.62	199.79	198.28	199.37	198.98	199.78	191.06	205.98	204.56
5.B	Biological Treatment of Solid Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.C	Incineration and Open Burning of Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.D	Wastewater Treatment and Discharge	59.58	59.51	59.45	59.41	59.23	59.03	58.78	58.52	58.27	57.77	57.25	56.71	56.16	55.59	55.41

CH_4 (Gg CO_2 equivalent)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (with LULUCF)		**702.89**	**699.51**	**755.22**	**688.81**	**640.56**	**650.94**	**856.57**	**646.34**	**618.60**	**628.94**	**648.04**	**633.75**	**712.82**	**636.15**	**611.23**
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo Items																
International Bunkers		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.A.3.a.i	International Aviation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.A.3.d.i	International water-borne navigation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 from Biomass Combustion for Energy Production		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

12.10 Summary Tables – N_2O emissions (with LULUCF) for the period 1990 - 2019

N_2O (Gg CO_2 equivalent)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (with LULUCF)		**68.80**	**69.21**	**63.50**	**59.85**	**55.97**	**62.08**	**61.43**	**61.73**	**67.91**	**65.63**	**88.45**	**63.77**	**67.89**	**78.84**	**65.33**	**60.13**
1	**Energy**	**22.07**	**20.67**	**17.20**	**16.36**	**13.28**	**11.56**	**16.30**	**15.44**	**17.84**	**19.77**	**19.98**	**16.74**	**20.19**	**20.28**	**21.30**	**19.60**
1.A	Fuel Combustion Activities	22.07	20.67	17.20	16.36	13.28	11.56	16.30	15.44	17.84	19.77	19.98	16.74	20.19	20.28	21.30	19.60
1.A.1	Energy Industries	7.10	5.91	4.67	4.04	3.29	0.47	4.75	4.36	5.64	5.89	5.77	4.42	6.84	6.49	6.33	4.95
1.A.2	Manufacturing Industries and Construction	0.82	1.14	0.67	0.50	0.49	0.48	0.58	0.37	0.24	0.28	0.36	0.43	0.55	0.59	0.56	1.25
1.A.3	Transport	4.96	5.71	3.49	2.69	3.01	3.25	4.03	4.23	6.00	7.47	7.50	6.49	5.13	5.30	6.40	5.69
1.A.4	Other Sectors	9.20	7.91	8.38	9.14	6.48	7.37	6.95	6.48	5.95	6.13	6.36	5.40	7.68	7.91	8.01	7.71
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B.1	Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2	Oil and Natural Gas	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2	**IPPU**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
2.A	Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D	Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other product manufacture and use	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2 H	Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	**Agriculture**	**36.81**	**37.14**	**31.74**	**29.05**	**30.07**	**35.59**	**33.07**	**33.67**	**33.61**	**33.64**	**33.41**	**33.14**	**33.65**	**33.06**	**26.19**	**26.22**
3.A	Enteric Fermentation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

N_2O (Gg CO_2 equivalent)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (with LULUCF)		**68.80**	**69.21**	**63.50**	**59.85**	**55.97**	**62.08**	**61.43**	**61.73**	**67.91**	**65.63**	**88.45**	**63.77**	**67.89**	**78.84**	**65.33**	**60.13**
3.B	Manure Management	22.67	22.62	21.27	20.36	20.74	21.42	21.39	20.89	20.89	20.94	20.74	20.52	21.01	20.45	13.79	13.82
3.C	Rice Cultivation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D	Agricultural soils	14.13	14.50	10.45	8.68	9.31	14.15	11.66	12.76	12.70	12.68	12.66	12.60	12.61	12.60	12.38	12.38
3.E	Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.F	Field burning of agricultural residues	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02
3.G	Other (Urea application)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	**LULUCF**	**2.45**	**3.74**	**6.72**	**6.42**	**4.41**	**6.53**	**3.48**	**3.85**	**7.49**	**3.07**	**25.70**	**4.14**	**3.91**	**14.94**	**6.91**	**3.00**
4.A	Total Forest land	1.10	0.53	2.02	1.87	0.87	1.93	2.14	0.58	2.41	0.19	11.51	0.73	0.61	6.13	2.11	0.16
4.B	Cropland	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
4.C	Grassland	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4.D	Wetlands	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4.E	Settlements	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
4.F	Other land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.G	Harvested Wood Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	**Waste**	**7.47**	**7.66**	**7.84**	**8.02**	**8.21**	**8.40**	**8.58**	**8.77**	**8.96**	**9.16**	**9.35**	**9.75**	**10.15**	**10.55**	**10.93**	**11.31**
5.A	Solid Waste Disposal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.B	Biological Treatment of Solid Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.C	Incineration and Open Burning of Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.D	Wastewater Treatment and Discharge	7.47	7.66	7.84	8.02	8.21	8.40	8.58	8.77	8.96	9.16	9.35	9.75	10.15	10.55	10.93	11.31

N_2O (Gg CO_2 equivalent)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (with LULUCF)		**68.80**	**69.21**	**63.50**	**59.85**	**55.97**	**62.08**	**61.43**	**61.73**	**67.91**	**65.63**	**88.45**	**63.77**	**67.89**	**78.84**	**65.33**	**60.13**
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
	Memo Items																
	International Bunkers	**0.24**	**0.26**	**0.04**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.09**	**0.24**	**0.24**	**0.29**	**0.16**	**0.19**	**0.35**	**0.34**
1.A.3.a.i	International Aviation	0.24	0.26	0.04	0.02	0.02	0.02	0.02	0.02	0.09	0.24	0.24	0.29	0.16	0.19	0.35	0.34
1.A.3.d.i	International water-borne navigation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 from Biomass Combustion for Energy Production		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

N_2O (Gg CO_2 equivalent)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (with LULUCF)		**60.13**	**62.93**	**117.44**	**75.78**	**61.08**	**66.45**	**215.46**	**81.36**	**65.51**	**58.71**	**74.39**	**69.28**	**130.01**	**77.46**	**70.33**
1	**Energy**	**19.60**	**20.83**	**21.52**	**24.98**	**22.69**	**25.08**	**27.27**	**26.46**	**25.21**	**23.16**	**24.86**	**25.04**	**26.11**	**27.33**	**27.15**
1.A	Fuel Combustion Activities	19.60	20.83	21.52	24.98	22.69	25.08	27.27	26.46	25.21	23.16	24.86	25.04	26.11	27.33	27.15
1.A.1	Energy Industries	4.95	5.64	4.07	6.36	3.33	7.09	7.65	7.51	6.70	6.71	7.29	6.09	6.31	7.26	6.52
1.A.2	Manufacturing Industries and Construction	1.25	1.19	1.35	1.29	0.47	0.32	0.52	0.48	0.52	0.79	0.81	0.80	0.81	0.79	0.86
1.A.3	Transport	5.69	6.11	7.65	8.87	10.28	8.94	9.93	9.56	9.50	7.63	8.47	10.07	11.04	11.97	12.80
1.A.4	Other Sectors	7.71	7.88	8.45	8.46	8.62	8.73	9.16	8.90	8.50	8.04	8.29	8.08	7.95	7.30	6.97
1.A.5	Non-Specified	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B	Fugitive emissions from fuels	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B.1	Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2	Oil and Natural Gas	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2	**IPPU**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
2.A	Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C	Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D	Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G	Other product manufacture and use	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2 H	Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	**Agriculture**	**26.22**	**27.08**	**24.63**	**23.89**	**22.23**	**23.03**	**21.46**	**21.91**	**22.91**	**18.26**	**22.61**	**23.31**	**21.02**	**21.64**	**21.37**
3.A	Enteric Fermentation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B	Manure Management	13.82	13.54	12.79	12.41	11.86	11.40	10.74	10.68	11.03	11.44	11.31	11.82	10.88	10.53	10.27

N_2O (Gg CO_2 equivalent)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (with LULUCF)		**60.13**	**62.93**	**117.44**	**75.78**	**61.08**	**66.45**	**215.46**	**81.36**	**65.51**	**58.71**	**74.39**	**69.28**	**130.01**	**77.46**	**70.33**
3.C	Rice Cultivation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D	Agricultural soils	12.38	13.52	11.83	11.48	10.37	11.62	10.71	11.22	11.87	6.80	11.29	11.48	10.13	11.11	11.09
3.E	Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.F	Field burning of agricultural residues	0.02	0.02	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3.G	Other (Urea application)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	**LULUCF**	**3.00**	**3.33**	**59.01**	**14.11**	**3.39**	**5.40**	**153.79**	**20.56**	**4.31**	**4.20**	**13.81**	**7.82**	**69.77**	**15.38**	**8.70**
4.A	Total Forest land	0.16	0.32	28.09	5.57	0.14	1.07	75.18	8.50	0.26	0.10	4.79	1.69	32.55	5.24	1.79
4.B	Cropland	0.04	0.04	0.05	0.05	0.06	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09
4.C	Grassland	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4.D	Wetlands	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4.E	Settlements	1.30	1.30	1.37	1.43	1.50	1.57	1.63	1.70	1.81	1.92	2.03	2.14	2.25	2.36	2.47
4.F	Other land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.G	Harvested Wood Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	**Waste**	**11.31**	**11.69**	**12.29**	**12.80**	**12.76**	**12.94**	**12.95**	**12.44**	**13.09**	**13.10**	**13.11**	**13.11**	**13.11**	**13.11**	**13.10**
5.A	Solid Waste Disposal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.B	Biological Treatment of Solid Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.C	Incineration and Open Burning of Waste	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.D	Wastewater Treatment and Discharge	11.31	11.69	12.29	12.80	12.76	12.94	12.95	12.44	13.09	13.10	13.11	13.11	13.11	13.11	13.10

N_2O (Gg CO_2 equivalent)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (with LULUCF)		**60.13**	**62.93**	**117.44**	**75.78**	**61.08**	**66.45**	**215.46**	**81.36**	**65.51**	**58.71**	**74.39**	**69.28**	**130.01**	**77.46**	**70.33**
6	**Other**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo Items																
International Bunkers		**0.34**	**0.43**	**0.53**	**0.61**	**0.58**	**0.65**	**0.64**	**0.81**	**0.82**	**0.63**	**0.65**	**0.71**	**0.86**	**0.88**	**1.46**
1.A.3.a.i	International Aviation	0.34	0.43	0.53	0.61	0.58	0.65	0.64	0.81	0.82	0.63	0.65	0.71	0.86	0.88	1.46
1.A.3.d.i	International water-borne navigation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 from Biomass Combustion for Energy Production		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

12.11 Summary Tables - HFC emissions for the period 1990 - 2019

HFC (Gg CO_2 equivalent)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (without LULUCF)		**0.00**	**1.33**	**3.79**	**7.22**	**11.48**	**16.46**	**22.06**	**28.19**	**34.79**	**41.79**	**49.15**	**56.82**	**64.78**	**72.98**	**81.40**	**90.37**
1	**Energy**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
1.A	Fuel Combustion Activities	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B	Fugitive emissions from fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	**IPPU**	**NE**	**1.33**	**3.79**	**7.22**	**11.48**	**16.46**	**22.06**	**28.19**	**34.79**	**41.79**	**49.15**	**56.82**	**64.78**	**72.98**	**81.40**	**90.37**
2.A	Mineral Industry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.B	Chemical Industry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.C	Metal Industry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D	Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NA	1.33	3.79	7.22	11.48	16.46	22.06	28.19	34.79	41.79	49.15	56.82	64.78	72.98	81.40	90.37
2.G	Other product manufacture and use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2 H	Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	**Agriculture**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
4	**LULUCF**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
5	**Waste**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
6	**Other**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
	Memo Items																
	International Bunkers	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
CO_2 from Biomass Combustion for Energy Production		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

HFC (Gg CO_2 equivalent)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (without LULUCF)		**90.37**	**106.22**	**121.52**	**136.45**	**148.53**	**159.77**	**170.28**	**192.12**	**204.47**	**217.00**	**220.62**	**239.57**	**249.44**	**257.02**	**248.35**
1	**Energy**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
1.A	Fuel Combustion Activities	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B	Fugitive emissions from fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	**IPPU**	**90.37**	**106.22**	**121.52**	**136.45**	**148.53**	**159.77**	**170.28**	**192.12**	**204.47**	**217.00**	**220.62**	**239.57**	**249.44**	**257.02**	**248.35**
2.A	Mineral Industry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.B	Chemical Industry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.C	Metal Industry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D	Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	90.37	106.22	121.52	136.45	148.53	159.77	170.28	192.12	204.47	217.00	220.62	239.57	249.44	257.02	248.35
2.G	Other product manufacture and use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2 H	Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	**Agriculture**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
4	**LULUCF**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
5	**Waste**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
6	**Other**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items																
International Bunkers		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
1.A.3.a.i	International Aviation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	58.02
1.A.3.d.i	International water-borne navigation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NE
CO_2 from Biomass Combustion for Energy Production		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

12.12 Summary Tables – PFC emissions for the period 1990 - 2019

PFC (Gg CO_2 equivalent)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (without LULUCF)		**1,490.64**	**1,997.72**	**1,244.84**	**454.50**	**91.29**	**345.05**	**880.87**	**1,356.19**	**989.61**	**1,035.04**	**1,361.71**	**1,407.51**	**1,342.74**	**1,100.65**	**974.19**	**869.31**
1	**Energy**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
1.A	Fuel Combustion Activities	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B	Fugitive emissions from fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	**IPPU**	**1,490.64**	**1,997.72**	**1,244.84**	**454.50**	**91.29**	**345.05**	**880.87**	**1,356.19**	**989.61**	**1,035.04**	**1,361.71**	**1,407.51**	**1,342.74**	**1,100.65**	**974.19**	**869.31**
2.A	Mineral Industry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.B	Chemical Industry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.C	Metal Industry	1,490.64	1,997.72	1,244.84	454.50	91.29	345.05	880.87	1,356.19	989.61	1,035.04	1,361.71	1,407.51	1,342.74	1,100.65	974.19	869.31
2.D	Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.G	Other product manufacture and use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2 H	Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	**Agriculture**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
4	**LULUCF**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
5	**Waste**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
6	**Other**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
	Memo Items																
	International Bunkers	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CO_2 from Biomass Combustion for Energy Production		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

PFC (Gg CO_2 equivalent)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (without LULUCF)		**869.31**	**968.42**	**1,072.31**	**1,225.15**	**339.87**	**497.18**	**423.06**	**223.21**	**115.39**	**86.61**	**71.93**	**45.58**	**45.13**	**37.32**	**34.03**
1	**Energy**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
1.A	Fuel Combustion Activities	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B	Fugitive emissions from fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	**IPPU**	**869.31**	**968.42**	**1,072.31**	**1,225.15**	**339.87**	**497.18**	**423.06**	**223.21**	**115.39**	**86.61**	**71.93**	**45.58**	**45.13**	**37.32**	**34.03**
2.A	Mineral Industry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.B	Chemical Industry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.C	Metal Industry	869.31	968.42	1,072.31	1,225.15	339.87	497.18	423.06	223.21	115.39	86.61	71.93	45.58	45.13	37.32	34.03
2.D	Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.G	Other product manufacture and use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2 H	Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	**Agriculture**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
4	**LULUCF**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
5	**Waste**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
6	**Other**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items																
International Bunkers		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
CO_2 from Biomass Combustion for Energy Production		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

12.13 Summary Tables – SF6 emissions for the period 1990 - 2019

SF6 (Gg CO_2 equivalent)		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total national GHG emissions (without LULUCF)		**0.78**	**0.78**	**0.78**	**0.78**	**0.78**	**0.78**	**0.78**	**0.78**	**0.84**	**0.84**	**0.92**	**0.92**	**0.97**	**1.15**	**1.33**	**1.43**
1	**Energy**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
1.A	Fuel Combustion Activities	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B	Fugitive emissions from fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	**IPPU**	**0.78**	**0.78**	**0.78**	**0.78**	**0.78**	**0.78**	**0.78**	**0.78**	**0.84**	**0.84**	**0.92**	**0.92**	**0.97**	**1.15**	**1.33**	**1.43**
2.A	Mineral Industry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.B	Chemical Industry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.C	Metal Industry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D	Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.G	Other product manufacture and use	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.84	0.84	0.92	0.92	0.97	1.15	1.33	1.43
2 H	Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	**Agriculture**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
4	**LULUCF**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
5	**Waste**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
6	**Other**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
	Memo Items																
	International Bunkers	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CO_2 from Biomass Combustion for Energy Production		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

SF6 (Gg CO_2 equivalent)		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total national GHG emissions (without LULUCF)		**1.43**	**1.49**	**1.49**	**1.52**	**1.54**	**1.55**	**1.60**	**2.00**	**2.19**	**2.23**	**2.23**	**2.52**	**2.99**	**3.44**	**3.44**
1	**Energy**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
1.A	Fuel Combustion Activities	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B	Fugitive emissions from fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	**IPPU**	**1.43**	**1.49**	**1.49**	**1.52**	**1.54**	**1.55**	**1.60**	**2.00**	**2.19**	**2.23**	**2.23**	**2.52**	**2.99**	**3.44**	**3.44**
2.A	Mineral Industry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.B	Chemical Industry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.C	Metal Industry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D	Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.E	Production of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F	Consumption of HFC/PFC and SF6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.G	Other product manufacture and use	1.43	1.49	1.49	1.52	1.54	1.55	1.60	2.00	2.19	2.23	2.23	2.52	2.99	3.44	3.44
2 H	Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	**Agriculture**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
4	**LULUCF**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
5	**Waste**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
6	**Other**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items																
International Bunkers		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CO_2 from Biomass Combustion for Energy Production		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA