CYPRUS

National Greenhouse Gas Inventory 2023

2023 submission

under the United Nations Convention on Climate Change and the Paris Agreement

Department of Environment,
Ministry of Agriculture, Rural Development and Environment

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Title of Report	**Cyprus National Greenhouse Gas Inventory 2023**
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EXECUTIVE SUMMARY

ES.1. Background information on greenhouse gas (GHG) inventories and climate change

The Republic of Cyprus ratified the UNFCCC in 1997 with Law No. 19(III) / 1997 as a non-Annex I party. The Kyoto Protocol was ratified by the Republic of Cyprus in 2003 with Law No. 29(III) / 2003. According to decision 10/CP.17 of COP17, as of 9 January 2013, the status of Cyprus changed from a non-Annex I to an Annex I party to the UNFCCC. As part of the EU, Cyprus has taken up commitments for the CP2 of the KP through the Doha amendment. The Republic of Cyprus ratified the Paris Agreement on 4 January 2017 with Law No. 30(III)/2016.

The first national inventory report for Cyprus was prepared in 2001 and covered the period 1990-1998. The inventory was prepared in the framework of the project "Strategic Plan for the Limitation of Greenhouse Gas Emissions in Cyprus".

The first Inventory report submitted by Cyprus to the European Commission for the purposes of Decision no. 280/2004/EC was in 2006 for the period 1990–2004. Cyprus at the time was a non-Annex I party and therefore had no obligation to submit annual inventories to the UNFCCC secretariat.

The first submission of a national inventory report to the UNFCCC secretariat as an Annex I party was made in April 2013.

The Department of Environment of the Ministry of Agriculture, Rural Development and Environment (DoE) is the governmental body responsible for the development and implementation of environmental policy in Cyprus, as well as for the provision of information concerning the state of the environment in Cyprus in compliance with relevant requirements defined in international conventions, protocols and agreements. Moreover, the DoE is responsible for the co-ordination of all involved ministries, as well as any relevant public or private organization, in relation to the implementation of the provisions of the Kyoto Protocol, according to the Law 29(III)/2009 with which Cyprus ratified the Kyoto Protocol.

In this context, the DoE has the overall responsibility for the national GHG inventory, and the official consideration and approval of the inventory prior to its submission. (Contact person: Dr. Nicoletta Kythreotou, Environment Officer, Department of Environment, Ministry of Agriculture, Rural Development and Environment, Offices' address: 20-22 28th Oktovriou Ave., Engomi, 2414, Nicosia, Cyprus, Postal address: Department of Environment, 1498 Nicosia, Cyprus, Tel. +357 22 408 947, Fax. +357 22 774 945, Web. www.moa.gov.cy/environment).

Figure 1 provides an overview of the organisational structure of the National Inventory System. The entities participating in the National Inventory System are:

- The DoE, designated as the national entity responsible for the national inventory, holds the overall responsibility and maintains an active role in the inventory planning, preparation and management, including technical and scientific responsibility for the compilation of the annual inventory.[1]
- Governmental ministries and agencies ensure the data provision through their appointed focal persons.

International or national associations, along with individual public or private industrial companies contribute to data gathering and development of methodological issues as appropriate.

[1] For 2017, there is a contract with an external expert for scientific and technical support to the inventory team of the DoE and the QA of the GHG inventory. As of 2018, according to the Council of Ministers' Decision of 15/11/2017, the technical and scientific responsibility for the compilation of the annual inventory for all sectors will be assigned, on a contract basis, to an independent consultant by the DoE.

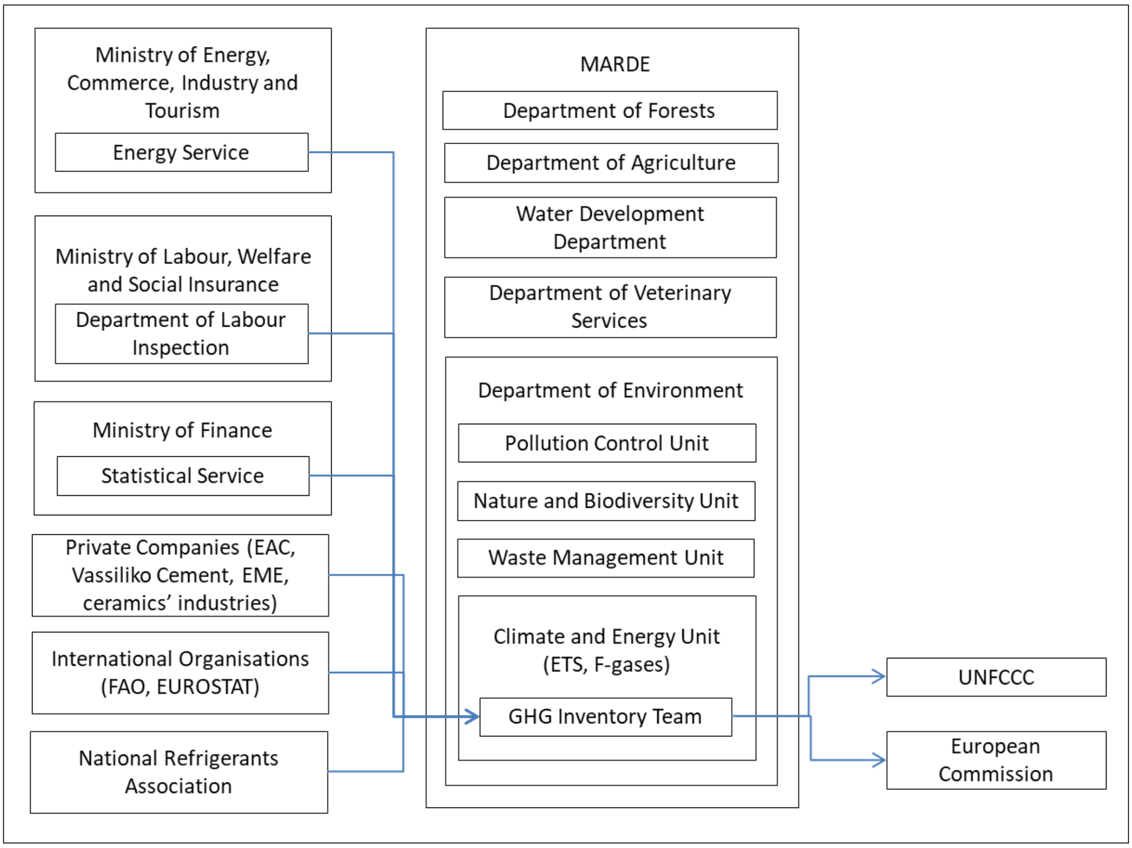

Figure 1. Overview of the organisational structure of the National Inventory System

The legal framework defining the roles, responsibilities, and the co-operation between the DoE Inventory team and the designated contact points of the competent Ministries was formalized by the Council of Ministers' Decision adopted 15 November 2017, entitled "Structure and operation of the National Greenhouse Gases Inventory System- Roles and Responsibilities". The above-mentioned Decision includes a description of each entity's responsibilities concerning the inventory preparation, data providing or other relative information. This formal framework has improved the collaboration between the entities involved, assuring the timely collection and quality of the required activity data and solving data access restriction problems raised due to confidentiality issues.

ES.2. Summary of national emission and removal-related trends

GHG emissions trends by gas for the period 1990–2021 are presented in Table 1.

Table 1. GHG emissions trends by gas for the period 1990–2021

	1990	1991	1992	1993	1994
CO_2 emissions without LULUCF	4644.86	5133.21	5505.66	5749.30	5991.49
CO_2 emissions with LULUCF	4491.73	4966.05	5332.92	5574.06	5807.09
CH_4 emissions without LULUCF	776.45	791.35	816.30	847.17	861.38
CH_4 emissions with LULUCF	776.48	791.45	816.34	847.42	862.04
N_2O emissions without LULUCF	147.69	148.43	164.66	174.85	172.93
N_2O emissions with LULUCF	147.72	148.50	164.71	175.03	173.33
HFCs	NO,NE	NO,NE	23.04	24.62	26.27
PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF_6	2.73	3.37	4.01	4.65	5.29
NF_3	NO	NO	NO	NO	NO
Total (without LULUCF)	5571.73	6076.35	6513.67	6800.58	7057.37
Total (with LULUCF)	5418.66	5909.37	6341.03	6625.78	6874.02

Total (without LULUCF, with indirect)	5576.94	6080.87	6518.41	6805.31	7062.52
Total (with LULUCF, with indirect)	5423.87	5913.89	6345.77	6630.51	6879.17
	1995	**1996**	**1997**	**1998**	**1999**
CO_2 emissions without LULUCF	5861.93	6211.89	6298.29	6592.49	6858.75
CO_2 emissions with LULUCF	5681.44	6025.80	6113.05	6398.72	6660.23
CH_4 emissions without LULUCF	887.56	909.38	914.78	917.45	919.57
CH_4 emissions with LULUCF	887.82	909.81	915.39	919.53	919.58
N_2O emissions without LULUCF	188.27	183.59	180.11	189.73	191.19
N_2O emissions with LULUCF	188.47	183.90	180.52	190.93	191.32
HFCs	28.49	33.60	38.65	47.38	54.29
PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF_6	5.93	6.57	7.21	7.85	8.49
NF_3	NO	NO	NO	NO	NO
Total (without LULUCF)	6972.18	7345.03	7439.03	7754.90	8032.29
Total (with LULUCF)	6792.15	7159.67	7254.82	7564.41	7833.91
Total (without LULUCF, with indirect)	6978.06	7351.01	7444.94	7760.69	8039.93
Total (with LULUCF, with indirect)	6798.02	7165.65	7260.73	7570.20	7841.55
	2000	**2001**	**2002**	**2003**	**2004**
CO_2 emissions without LULUCF	7104.60	6978.50	7169.43	7559.65	7788.73
CO_2 emissions with LULUCF	6955.15	6807.34	6967.01	7344.78	7572.91
CH_4 emissions without LULUCF	938.34	975.92	1003.66	994.65	984.95
CH_4 emissions with LULUCF	942.81	977.43	1003.70	994.84	985.32
N_2O emissions without LULUCF	191.95	212.62	218.49	216.72	185.04
N_2O emissions with LULUCF	194.42	213.68	218.93	217.38	185.93
HFCs	62.44	70.91	80.28	92.00	107.15
PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF_6	9.13	9.80	10.45	11.11	11.76
NF_3	NO	NO	NO	NO	NO
Total (without LULUCF)	8306.44	8247.75	8482.31	8874.12	9077.63
Total (with LULUCF)	8163.94	8079.15	8280.38	8660.11	8863.08
Total (without LULUCF, with indirect)	8314.05	8254.90	8491.53	8885.20	9091.27
Total (with LULUCF, with indirect)	8171.54	8086.31	8289.59	8671.18	8876.72
	2005	**2006**	**2007**	**2008**	**2009**
CO_2 emissions without LULUCF	7957.32	8185.01	8503.49	8715.73	8470.19
CO_2 emissions with LULUCF	7735.46	7961.05	8314.89	8464.66	8191.16
CH_4 emissions without LULUCF	960.06	962.62	964.65	962.36	964.61
CH_4 emissions with LULUCF	960.19	962.94	967.74	962.48	964.80
N_2O emissions without LULUCF	170.84	173.60	170.55	163.11	160.06
N_2O emissions with LULUCF	171.74	174.75	173.19	164.22	161.26
HFCs	121.80	137.79	153.17	172.12	182.72
PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF_6	12.42	11.47	11.78	12.09	12.39
NF_3	NO	NO	NO	NO	NO
Total (without LULUCF)	9222.44	9470.49	9803.65	10025.40	9789.98
Total (with LULUCF)	9001.61	9248.00	9620.76	9775.56	9512.32
Total (without LULUCF, with indirect)	9238.56	9488.17	9821.81	10041.02	9803.61
Total (with LULUCF, with indirect)	9017.73	9265.68	9638.92	9791.18	9525.95

	2010	2011	2012	2013	2014
CO_2 emissions without LULUCF	8101.12	7787.64	7262.77	6582.61	6950.80
CO_2 emissions with LULUCF	7833.85	7484.77	6966.92	6283.78	6650.10
CH_4 emissions without LULUCF	973.73	973.26	963.14	948.40	949.37
CH_4 emissions with LULUCF	974.46	973.87	963.82	948.64	949.64
N_2O emissions without LULUCF	169.33	166.84	162.63	147.97	145.38
N_2O emissions with LULUCF	170.84	168.31	164.17	149.28	146.70
HFCs	198.99	216.37	221.17	225.67	233.18
PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF_6	12.70	14.36	14.97	15.58	16.18
NF_3	NO	NO	NO	NO	NO
Total (without LULUCF)	9455.87	9158.46	8624.68	7920.23	8294.92
Total (with LULUCF)	9190.83	8857.68	8331.06	7622.95	7995.81
Total (without LULUCF, with indirect)	9469.00	9163.34	8629.34	7923.92	8298.26
Total (with LULUCF, with indirect)	9203.97	8862.56	8335.72	7626.63	7999.15
	2015	**2016**	**2017**	**2018**	**2019**
CO_2 emissions without LULUCF	6971.58	7373.67	7503.81	7321.72	7342.34
CO_2 emissions with LULUCF	6674.14	7169.50	7195.21	7017.47	7043.58
CH_4 emissions without LULUCF	957.01	980.39	999.06	1013.25	1034.05
CH_4 emissions with LULUCF	957.11	988.33	999.31	1013.74	1034.40
N_2O emissions without LULUCF	151.24	153.44	159.48	161.28	167.52
N_2O emissions with LULUCF	152.47	158.78	160.80	162.72	168.89
HFCs	246.65	267.02	287.91	308.05	332.27
PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF_6	16.79	15.61	15.80	16.89	15.44
NF_3	NO	NO	NO	NO	NO
Total (without LULUCF)	8343.27	8790.12	8966.07	8821.20	8891.62
Total (with LULUCF)	8047.16	8599.23	8659.04	8518.88	8594.58
Total (without LULUCF, with indirect)	8347.08	8794.05	8971.33	8826.25	8896.59
Total (with LULUCF, with indirect)	8050.97	8603.16	8664.30	8523.93	8599.54
	2020	**2021**	**Change from 1990 to 2021 (%)**		
CO_2 emissions without LULUCF	6910.91	7029.36	51.34		
CO_2 emissions with LULUCF	6610.54	6784.63	51.05		
CH_4 emissions without LULUCF	1064.83	1097.40	41.34		
CH_4 emissions with LULUCF	1065.26	1102.88	42.04		
N_2O emissions without LULUCF	172.70	173.53	17.5		
N_2O emissions with LULUCF	174.10	177.45	20.13		
HFCs	335.68	353.49	100.00		
PFCs	NO	NO	0.00		
Unspecified mix of HFCs and PFCs	NO	NO	0.00		
SF_6	18.74	16.24	494.70		
NF_3	NO	NO	0.00		
Total (without LULUCF)	8502.86	8670.02	55.61		
Total (with LULUCF)	8204.31	8434.69	55.66		
Total (without LULUCF, with indirect)	8508.02	8675.23	55.56		
Total (with LULUCF, with indirect)	8209.47	8439.90	55.61		

ES.3. Overview of source and sink category emission estimates and trends

Energy, with 6172.4 Gg CO_2 eq., continues to be the largest contributor to the total national GHG emissions (70.6% compared to the total without LULUCF). 3088 Gg CO_2 eq. of these emissions is from the production of electricity, while another 2051 Gg CO_2 eq. is from transport. Table 2 and Figure 2 present the emissions for the period 1990–2021 by sector.

Table 2. GHG emissions by sector for the period 1990–2021

	Energy	IPPU	Agriculture	LULUCF	Waste	Total (excl. LULUCF)	Total (incl. LULUCF)
1990	3954.35	727.93	454.27	-153.07	435.18	5418.66	5571.73
1991	4486.96	687.86	460.82	-166.98	440.71	5909.37	6076.35
1992	4811.43	762.12	491.05	-172.65	449.08	6341.03	6513.67
1993	4988.10	833.50	519.19	-174.80	459.80	6625.78	6800.58
1994	5200.67	870.23	513.73	-183.35	472.74	6874.02	7057.37
1995	5107.25	839.73	543.81	-180.03	481.39	6792.15	6972.18
1996	5402.12	904.15	551.12	-185.36	487.64	7159.67	7345.03
1997	5525.00	876.09	540.87	-184.22	497.08	7254.82	7439.03
1998	5866.52	840.75	543.11	-190.49	504.51	7564.41	7754.90
1999	6130.96	853.74	534.53	-198.38	513.07	7833.91	8032.29
2000	6357.63	883.08	542.49	-142.51	523.24	8163.94	8306.44
2001	6252.10	876.25	585.80	-168.60	533.60	8079.15	8247.75
2002	6412.02	919.23	609.53	-201.94	541.54	8280.38	8482.31
2003	6803.06	934.15	592.23	-214.02	544.68	8660.11	8874.12
2004	6942.20	1014.67	572.23	-214.55	548.53	8863.08	9077.63
2005	7136.65	1003.14	525.08	-220.83	557.57	9001.61	9222.44
2006	7321.74	1060.19	530.70	-222.49	557.86	9248.00	9470.49
2007	7642.68	1071.98	529.07	-182.89	559.92	9620.76	9803.65
2008	7853.41	1094.04	507.69	-249.84	570.25	9775.56	10025.40
2009	7781.63	930.88	500.09	-277.65	577.38	9512.32	9789.98
2010	7546.70	810.82	514.43	-265.04	583.92	9190.83	9455.87
2011	7250.42	811.86	506.48	-300.78	589.71	8857.68	9158.46
2012	6769.05	772.54	483.33	-293.62	599.76	8331.06	8624.68
2013	5847.05	1014.55	448.83	-297.29	609.81	7622.95	7920.23
2014	5994.43	1243.21	436.90	-299.11	620.38	7995.81	8294.92
2015	6117.23	1159.72	441.52	-296.11	624.81	8047.16	8343.27
2016	6512.90	1187.42	462.04	-190.89	627.76	8599.23	8790.12
2017	6604.17	1250.85	475.80	-307.03	635.25	8659.04	8966.07
2018	6493.46	1201.49	481.32	-302.31	644.93	8518.88	8821.20
2019	6566.71	1173.02	495.46	-297.04	656.42	8594.58	8891.62
2020	6047.95	1267.49	531.32	-298.54	656.09	8204.31	8502.86
2021	6172.40	1277.81	557.25	-235.33	662.56	8434.69	8670.02
Change 1990–2021	56.09%	75.54%	22.67%	53.74%	52.25%	55.66%	55.61%

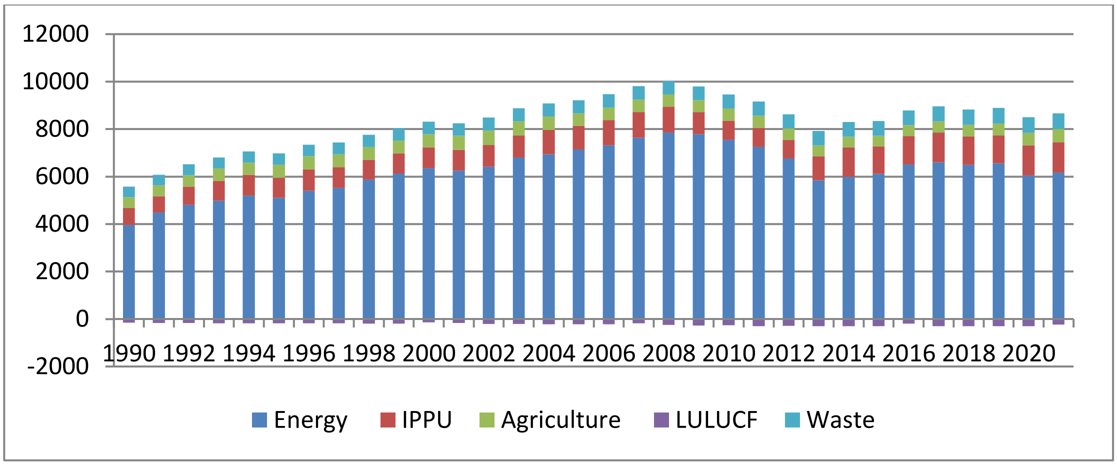

Figure 2. GHG emissions by sector for the period 1990–2021

ES.4. Other information

The role of carbon monoxide (CO), nitrogen oxides (NO_x) and non-methane organic volatile compounds (NMVOC) is important for climate change as these gases act as precursors of tropospheric ozone. In this way, they contribute to ozone formation and alter the atmospheric lifetimes of other greenhouse gases. For example, CO interacts with the hydroxyl radical (OH), the major atmospheric sink for methane, to form carbon dioxide. Therefore, increased atmospheric concentration of CO limits the number of OH compounds available to destroy methane, thus increasing the atmospheric lifetime of methane.

The emissions for these gases have been estimated by the Department of Labour Inspection, which is the competent authority for the preparation of air pollutants inventories under Directive 2001/81/EC. An overview of the period is presented in the following Tables.

Table 3. NO_x, CO, NMVOCs and SOx emissions 1990–2021 (Gg)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
NO_x	17.85	17.64	19.69	20.18	20.77	20.52	21.11	21.42	21.96	22.24
CO	43.39	42.12	40.94	39.16	39.42	37.78	36.60	35.10	32.80	31.43
NMVOCs	12.78	12.42	12.55	12.54	12.97	13.22	13.15	13.11	12.72	13.39
SO_x	31.92	32.78	37.61	39.91	41.85	39.63	41.63	43.98	47.34	49.57
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
NO_x	22.43	22.44	22.26	22.74	22.75	22.60	22.29	21.46	20.06	20.18
CO	29.64	28.69	27.83	27.83	27.20	26.07	24.15	18.44	16.21	14.77
NMVOCs	12.80	13.56	14.54	14.94	15.59	15.32	15.41	13.99	12.77	12.80
SO_x	47.60	45.25	45.42	47.00	40.32	37.84	31.32	29.18	22.24	17.60
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
NO_x	18.83	21.61	21.01	15.44	16.47	14.02	13.88	13.81	13.62	14.34
CO	14.03	13.05	12.45	11.64	12.14	11.66	12.11	11.95	11.30	11.16
NMVOCs	12.38	8.50	8.10	7.05	6.92	6.99	7.09	7.68	7.50	7.53
SO_x	21.77	20.77	16.05	13.50	16.67	12.85	16.08	16.28	16.95	15.87
	2020	**2021**								
NO_x	12.46	12.33								
CO	9.96	10.35								
NMVOCs	7.38	7.51								
SO_x	11.57	9.91								

Chapter 1.
Introduction

1.1. Background information on GHG inventories and climate change

A greenhouse gas (GHG) is a gas in the atmosphere that absorbs and emits radiation within the thermal infrared range. This process is the fundamental cause of the greenhouse effect. The primary natural greenhouse gases in Earth's atmosphere are water vapour, carbon dioxide, methane, nitrous oxide, and ozone. Hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3) are man-made GHG and are mainly used in a number of industrial activities in replacement of CFCs. Other naturally occurring gases, which do not contribute directly to the greenhouse effect are carbon monoxide (CO), oxides of nitrogen (NO_x), non-methane volatile organic compounds (NMVOC) and sulphur dioxide (SO_2).

Human activities since the beginning of the Industrial Revolution have produced an increase in the atmospheric concentration of carbon dioxide. This increase has occurred despite the uptake of a large portion of the emissions by various natural "sinks" involved in the carbon cycle. Anthropogenic carbon dioxide (CO_2) emissions (i.e., emissions produced by human activities) come predominately from combustion of fossil fuels and deforestation.

In 1992, countries joined an international treaty, the United Nations Framework Convention on Climate Change, as a framework for international cooperation to combat climate change by limiting average global temperature increases, and coping with impacts.

The objective of the United Nations Framework Convention on Climate Change (UNFCCC) is to stabilise greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent and reduce dangerous human-induced interference with the climate system. The ability of the international community to achieve this objective is dependent on accurate knowledge of GHG emissions trends, and on our collective ability to alter these trends.

In accordance with Articles 4 and 12 of the Convention and the relevant decisions of the Conference of the Parties (COP), Annex I Parties to the Convention compile national emission inventories of anthropogenic sources and sinks of all greenhouse gases not controlled by the Montreal protocol, and submit them to the Climate Change secretariat. These inventories are subject to an annual technical review process.

By 1995, countries had launched negotiations to strengthen the global response to climate change, and, two years later, adopted the Kyoto Protocol. The Kyoto Protocol legally binds developed country Parties to emission reduction targets. The Protocol’s first commitment period started in 2008 and ended in 2012. The second commitment period began on 1 January 2013 and ended in 2020.

There are now 197 Parties to the Convention and 192 Parties to the Kyoto Protocol.

The 2015 Paris Agreement, adopted in Paris on 12 December 2015, marks the latest step in the evolution of the UN climate change regime and builds on the work undertaken under the Convention. The Paris Agreement charts a new course in the global effort to combat climate change.

1.1.1. Background information on climate change

International framework

United Nations Framework Convention on Climate Change[2]

In response to the emerging evidence that climate change could have a major global impact, the United Nations Framework Convention on Climate Change (henceforth the Convention) was adopted on 9 May 1992 and was opened for signature in Rio de Janeiro in June 1992.

The ultimate objective of the Convention is the stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. The Convention recognises that the developed countries should take the lead in combating climate change and calls these countries to:

- Adopt policies and measures to mitigate climate change.
- Return, individually or jointly, to 1990 levels of carbon dioxide and other greenhouse gas by the year 2000.
- Provide technology transfer and financial resources to help developing countries so as to confront climate change impacts and to develop, ensuring at the same time the environmental protection through the restraint of GHG emissions.

Kyoto Protocol[3]

Recognising early the need for an effective instrument to provide confidence in addressing the climate change challenge, the Parties at the third meeting of the Conference of the Parties (COP) to the Convention, held in Kyoto (1-11 December 1997), finalised negotiations related to the establishment of such a legal instrument, the Kyoto Protocol on Climate Change (KP). The KP established, for the first time, legally binding targets for the reduction of greenhouse gas emissions. The KP provides a foundation upon which future action can be intensified, and also confirms the capacity of the international community to cooperate in action to deal with a major global environmental problem.

The KP called for legally binding commitments of the developed countries to individually or jointly reduce emissions of 6 greenhouse gases (CO_2, CH_4, N_2O, HFC, PFC and SF_6) in the period 2008 to 2012 by more than 5% compared with 1990 levels. The EU and its Member States at the time agreed to an 8% reduction. For the achievement of these targets, the Protocol provided the use of the following:

- Adoption of national policies and measures,
- Establishment of an emissions trading regime,
- Establishment of the joint implementation mechanism,
- Establishment of a clean development mechanism, and
- Protection and promotion of sinks to enhance CO_2 removals.

Detailed rules for the implementation of the Protocol were set out at the 7th Conference of the Parties (in Marrakesh) and are described in the Marrakesh Accords adopted in 2001. The Protocol entered into force on 16 February 2005, after its ratification from 141 Parties (including developed countries with a contribution of more than 55% to global CO_2 emissions in 1990).

The Doha Amendment[4]

At the eighth session of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol held in Doha, Qatar, in December 2012, parties to the Kyoto Protocol adopted an amendment to the Kyoto Protocol by decision 1/CMP.8 in accordance with Articles 20 and 21 of the Kyoto Protocol.

Pursuant to Article 21, paragraph 7 and Article 20, paragraph 4, the amendment is subject to acceptance by Parties to the Kyoto Protocol. In accordance with Article 20, paragraph 4, the amendment will enter

[2] More information available at https://unfccc.int/essential_background/convention/items/6036.php
[3] More information available at https://unfccc.int/essential_background/kyoto_protocol/items/6034.php
[4] More information available at https://unfccc.int/kyoto_protocol/doha_amendment/items/7362.php

into force for those Parties having accepted it on the ninetieth day after the date of receipt by the Depositary of an instrument of acceptance by at least three fourths of the Parties to the Kyoto Protocol. A total of 144 instruments of acceptance are required for the entry into force of the amendment.

The Doha Amendment and the KP Decision set out the rules related to the second commitment period of the Kyoto Protocol (CP2). The key aspects of CP2 are as follows:

- CP2 will be eight years long, running from 1 January 2013 until 31 December 2020;
- Parties taking on commitments in CP2 (CP2 Parties) are required to reduce their aggregate emissions by 18% below 1990 levels in CP2. The commitments of individual Parties range from a 24% reduction (in the case of Ukraine) to a 0.5% reduction (in the case of Australia). The European Union, as a whole, is required to reduce its emissions by 20%;
- CP2 Parties are required to review their commitments by the end of 2014 with a view at increasing the level of their mitigation ambition;
- Notwithstanding the commitments set out in Annex B to the Kyoto Protocol (as amended), each CP2 Party's commitment in CP2 must be at least as ambitious as its actual annual average emissions between 2008 and 2010;
- CP2 Parties may carry over surplus CP1 AAUs into CP2 without limit, but may only use or acquire such AAUs in limited circumstances;
- Access to all of the Kyoto Protocol's market mechanisms remains uninterrupted for CP2 Parties; and
- KP Parties agreed to the implementation of the Doha Amendment pending its formal entry into force, thus ensuring the Kyoto Protocol's operational continuity.

The Paris Agreement[5]

The 2015 Paris Agreement is a historically significant landmark in the global fight against climate change. The Paris Agreement entered into force on 4 November 2016. The Paris Agreement 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.

The key features of the Paris Agreement are as follows:

- It sets out a long term goal to put the world on track to limit global warming to well below 2°C above pre-industrial levels – and pursue efforts to limit the temperature increase to 1.5°C; The aspirational goal of 1.5°C was agreed to drive greater ambition, and to highlight the concerns of the most vulnerable countries that are already experiencing the impacts of climate change.
- It sends a clear signal to all stakeholders, investors, businesses, civil society and policy-makers that the global transition to clean energy is here to stay and that resources have to shift away from fossil fuels; With 189 national climate plans covering some 98% of all emissions, tackling climate change is now become a truly global effort. With Paris, we are moving from action by a few to action by all.
- It provides a dynamic mechanism to take stock and strengthen ambition over time. Starting from 2023, Parties will come together every five years in a "global stocktake" to consider progress in emissions reductions, adaptation and support provided and received in view of the long-term goals of the Agreement.
- Parties have a legally binding obligation to pursue domestic mitigation measures, with the aim of achieving the objectives of their contributions.
- It sets up an enhanced transparency and accountability framework, including the biennial submission by all Parties of greenhouse gas inventories and the information necessary to track their progress, a technical expert review, a facilitative, multilateral consideration of Parties' progress and mechanism to facilitate implementation of and promote compliance.
- It provides an ambitious solidarity package with adequate provisions on climate finance and on addressing needs linked to adaptation and loss and damage associated with adverse effects of climate change. To promote individual and collective action on adaptation, the Paris Agreement establishes for the first time a global goal with the aim to enhance capacity, climate resilience and reduce climate vulnerability. Internationally, it encourages greater cooperation among Parties to share scientific

[5] Available at https://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf

knowledge on adaptation as well as information on practices and policies.

Climate change and Cyprus

The Republic of Cyprus ratified the UNFCCC in 1997 with Law No. 19(III) / 1997 as a non-Annex I party. The Kyoto Protocol was ratified by the Republic of Cyprus in 2003 with Law No. 29(III) / 2003. According to decision 10/CP.17 of COP17, as of 9 January 2013, the status of Cyprus changed from a non-Annex I to an Annex I party to the UNFCCC. As part of the EU, Cyprus has taken up commitments for the CP2 of the KP through the Doha amendment. The Republic of Cyprus ratified the Paris Agreement on 4 January 2017 with Law No. 30(III)/2016.

1.1.2. Background information on greenhouse gas inventories

International framework

Annual inventories of greenhouse and other gas emissions form an essential element of each national environmental policy-making process. They can be used to derive information on emissions trends with reference to a pre-selected base year, and can assist in monitoring the progress of existing abatement measures for the reduction of greenhouse gas emissions and the fulfilment of the KP target.

According to Article 4 of the Convention, Annex I Parties have the obligation to submit national inventories of GHG emissions and removals. At COP2, the annual submission of inventories was decided (Decision 9/CP.2). The Conference of the Parties (COP), by decision 24/CP.19[6], adopted the "Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual greenhouse gas inventories" (UNFCCC Annex I inventory reporting guidelines) and tables of the common reporting format to implement the use of the 2006 IPCC Guidelines for National Greenhouse Gas inventories[7].

The UNFCCC Annex I inventory reporting guidelines also cover the establishment and maintenance of national inventory arrangements for the purpose of the continued preparation of timely, complete, consistent, comparable, accurate and transparent annual GHG inventories.

An annual GHG inventory submission consists of an NIR and the CRF tables, as set out in annexes I and II to decision 24/CP.19. The annual submission also comprises information provided by an Annex I Party in addition to its submitted NIR and CRF tables.

Cyprus

The first national inventory report for Cyprus was prepared in 2001 and covered the period 1990-1998. The inventory was prepared in the framework of the project "Strategic Plan for the Limitation of Greenhouse Gas Emissions in Cyprus".

The first Inventory report submitted by Cyprus to the European Commission for the purposes of Decision no. 280/2004/EC, was in 2006 for the period 1990–2004. Cyprus at the time was a non-Annex I party and therefore had no obligation to submit annual inventories to the UNFCCC secretariat.

The first submission of a national inventory report to the UNFCCC secretariat as an Annex I party was made in April 2013.

1.2. A description of the national inventory arrangements

According to decision 24/CP.19, each Annex I Party should implement and maintain national inventory arrangements for the estimation of anthropogenic GHG emissions by sources and removals by sinks. The national inventory arrangements include all institutional, legal and procedural arrangements made within

[6] Available at http://unfccc.int/resource/docs/2013/cop19/eng/10a03.pdf
[7] Available at https://www.ipcc-nggip.iges.or.jp/public/2006gl/

an Annex I Party for estimating anthropogenic emissions by sources and removals by sinks of all GHGs not controlled by the Montreal Protocol, and for reporting and archiving inventory information.

National inventory arrangements should be designed and operated:

(a) To ensure the transparency, consistency, comparability, completeness and accuracy of inventories;

(b) To ensure the quality of inventories through the planning, preparation and management of inventory activities. Inventory activities include collecting AD, selecting methods and EFs appropriately, estimating anthropogenic GHG emissions by sources and removals by sinks, implementing uncertainty assessment and QA/QC activities, and carrying out procedures for the verification of the inventory data at the national level, as described in the UNFCCC Annex I inventory reporting guidelines.

In the implementation of its national inventory arrangements, each Annex I Party should perform the following general functions:

(a) Establish and maintain the institutional, legal and procedural arrangements necessary to perform the functions defined in decision 24/CP.19, as appropriate, between the government agencies and other entities responsible for the performance of all functions defined in these reporting guidelines;

(b) Ensure sufficient capacity for the timely performance of the functions defined in these reporting guidelines, including data collection for estimating anthropogenic GHG emissions by sources and removals by sinks and arrangements for the technical competence of the staff involved in the inventory development process;

(c) Designate a single national entity with overall responsibility for the national inventory;

(d) Prepare national annual GHG inventories in a timely manner in accordance with these reporting guidelines and relevant decisions of the COP, and provide the information necessary to meet the reporting requirements defined in these reporting guidelines and in relevant decisions of the COP;

(e) Undertake specific functions relating to inventory planning, preparation and management.

1.2.1. Institutional, legal and procedural arrangements

In article 5, paragraph 1 of the Protocol, it is specified that "Each Party included in Annex I shall have in place, no later than one year prior to the start of the first commitment period, a national system for the estimation of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol". A national system includes all institutional, legal and procedural arrangements made within an Annex I Party of the Convention that is also a Party to the Protocol for estimating anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, and for reporting and archiving inventory information.

The Department of Environment of the Ministry of Agriculture, Rural Development and Environment (DoE), is the governmental body responsible for the development and implementation of environmental policy in Cyprus, as well as for the provision of information concerning the state of the environment in Cyprus in compliance with relevant requirements defined in international conventions, protocols and agreements. Moreover, the DoE is responsible for the co-ordination of all involved ministries, as well as any relevant public or private organization, in relation to the implementation of the provisions of the Kyoto Protocol, according to the Law 29(III)/2009 with which Cyprus ratified the Kyoto Protocol.

In this context, the DoE has the overall responsibility for the national GHG inventory, and the official consideration and approval of the inventory prior to its submission. (Contact person: Dr. Nicoletta Kythreotou, Environment Officer, Department of Environment, Ministry of Agriculture, Rural Development and Environment, Offices’ address: 20-22 28th Oktovriou Ave., Engomi, 2414, Nicosia, Cyprus, Postal address: Department of Environment, 1498 Nicosia, Cyprus, Tel. +357 22 408 947, Fax. +357 22 774 945, Web. www.moa.gov.cy/environment).

Figure 1.1 provides an overview of the organisational structure of the National Inventory System. The entities participating in the National Inventory System are:

- The DoE, designated as the national entity responsible for the national inventory, holds the overall responsibility and maintains an active role in the inventory planning, preparation and management, including technical and scientific responsibility for the compilation of the annual inventory.[8]
- The 2020 submission was the first submission for which a team of external experts from the Cyprus Institute[9] worked for the preparation of the emissions and the reporting, under the guidance of the DoE (contractor).
- Governmental ministries and agencies through their appointed focal persons, ensure the data provision.

International or national associations, along with individual public or private industrial companies contribute to data providing and development of methodological issues as appropriate.

The legal framework defining the roles-responsibilities and the co-operation between the DoE Inventory team and the designated contact points of the competent Ministries was formalized by Council of Ministers' Decision adopted 15/11/2017 entitled "Structure and operation of the National Greenhouse Gases Inventory System- Roles and Responsibilities". The above-mentioned Decision includes a description of each entity's responsibilities, concerning the inventory preparation, data providing or other relative information. This formal framework has improved the collaboration between the entities involved, assuring the timely collection and quality of the activity data required and solving data access restriction problems raised due to confidentiality issues.

1.2.1.1. Roles and responsibilities for inventory preparation

Department of Environment

The DoE is the Single National Entity with the overall responsibility for the national GHG inventory. Among its responsibilities are the following:

- The co-ordination of all ministries and other institutions involved, as well as any relevant public or private organization. In this context, it oversees the operation of the National System and decides on the necessary arrangements to ensure compliance with relevant decisions of the COP and the COP/CMP.
- The official consideration and approval of the inventory prior to its submission.
- The response to any issues raised by the inventory review process under Article 8 of the Kyoto Protocol[10].
- The timely submission of the GHG inventory to the European Commission and to the UNFCCC Secretariat.

[8] For 2017, there is a contract with an external expert for scientific and technical support to the inventory team of the DoE and the QA of the GHG inventory. As of 2018, according to the Council of Ministers' Decision of 15/11/2017, the technical and scientific responsibility for the compilation of the annual inventory for all sectors will be assigned, on a contract basis, to an independent consultant by the DoE.

[9] The Cyprus Institute (CyI) is a non-profit research and educational institution with a strong scientific and technological orientation, addressing issues of regional interest but of global significance, with an emphasis on cross-disciplinary research and international collaborations. The team of experts is working at the Energy, Environment and Water Research Center (EEWRC) of the CyI, of which the work and collaborations focus on societally relevant issues related to Energy and Renewables, Environment, Atmosphere and Climate, Water and Natural Resources (www.cyi.ac.cy).

[10] in co-operation with future technical and scientific consultants

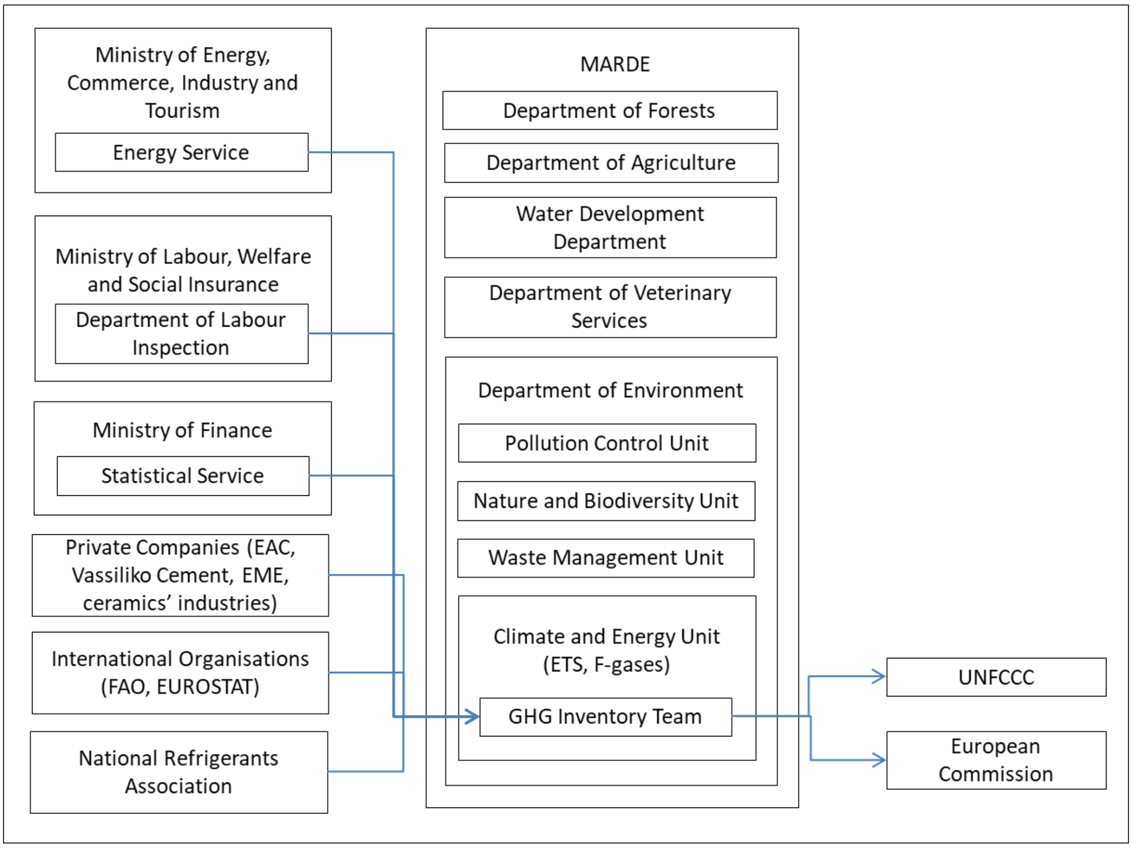

Figure 1.1. Overview of the organisational structure of the National Inventory System

- The keeping of the Centralised Inventory File, which is delivered to the inventory team which has the technical responsibility for the inventory planning, preparation and management at the beginning of each inventory cycle. The Centralised Inventory File is kept at the premises of the DoE.
- The administration of the National Registry. Cyprus cooperates with the Member States of the European Union and with the supplementary transaction log and the registry of the European Community by maintaining the national registries in a consolidated system.
- The supervision and implementation of Quality Assurance/Quality Control Plan (QA/QC)

In addition, DoE, in close collaboration with the contractor, currently has the technical and scientific responsibility for the planning, preparation and management of the annual national inventory, which includes the following tasks:

1. Data collection (activity data and emission factors) for all source categories that are Energy, Industrial Processes, Solvents and Other Product Use, Agriculture, Waste and LULUCF.
2. Reliability check of input data through
   - the comparison of the same or similar data from alternative data sources and
   - time-series assessment in order to identify changes that cannot be explained.
3. Selection of the appropriate methodologies according to the 2006 IPCC guidelines, preparation of GHG emissions estimates by applying the methodologies and models having been selected.
4. Data processing and archiving.
5. Assessment of the consistency of the methodologies applied, inventory improvement – recalculations.
6. Reliability check of results.
7. Key categories analysis.
8. Uncertainty assessment.
9. Preparation of Common Reporting Format (CRF) tables.
10. Preparation of National Inventory Report (NIR).
11. Reporting of the required information according to Regulation 525/2013 of the European Parliament and of the Council and its implementing acts.
12. Preparation and keeping of annual Centralised Inventory File.

13. Development of QA/QC procedures.
14. Implementing the QA/QC procedures.
15. Training the representatives of data providing agencies on inventory issues.

The names and contact details of the DoE inventory team follows:

(a) Dr. Nicoletta Kythreotou
Environment Officer, Department of Environment, Ministry of Agriculture, Rural Development and Environment, Offices' address: 20-22 28th Oktovriou Ave., Engomi, 2414, Nicosia, Cyprus, Postal address: Department of Environment, 1498 Nicosia, Cyprus, Tel. +357 22 408 947, Email. nkythreotou@environment.moa.gov.cy
BSc Environmental Science, MSc Environmental Engineering, PhD Mechanical Engineering

(b) Mr. Iordanis Tzamtzis
Accel – I. Tzamtzis & Co G.P., address: 27, Chrisostomou Smirnis str., 17237, Imittos, Attica, Greece, Tel. +30 6972 730430, Email. i.tzamtzis@accel.gr
BSc Forest Engineer, MSc Environmental Protection and Sustainable Development

(c) Mr. Demetris Demetriou
Technical Research Specialist for Greenhouse Gases and Air Pollutants Inventory, the Cyprus Institute, address. 20, Konstantinou Kavafi Street, 2121, Nicosia, Cyprus, Tel. +357 22 397 559 Email. d.demetriou@cyi.ac.cy
BSc Mechanical Engineering, MSc Environmental Science, Policy and Management, MSc Environmental Dynamics and Climate Change.

(d) Ms. Florence Dubart
Technical Research Specialist for Greenhouse Gases and Air Pollutants Inventory, the Cyprus Institute, address. 20, Konstantinou Kavafi Street, 2121, Nicosia, Cyprus, Tel. +357 22 397 558
Email. f.dubart@cyi.ac.cy
BSc Mathematics, BSc Earth Sciences, MSc Petroleum Geology

Government Ministries/ Government agencies

Data from all the involved parties come in MS Excel spread-sheets and any other additional descriptive information in word documents. The main database maintained by the inventory compiler is also in the form of MS Excel spread-sheets. The collected data is transferred to the main database of the inventory compiler. No special software is used or applied for processing or storage of the data used in the inventory.

The inventory compiler has one MS Excel spread-sheet containing all the data collected and one MS Excel spread-sheet containing the calculations performed for the estimation of the GHG emissions.

Contact points for data collection

Data from the annual ETS submissions from installations participating is the EU-ETS scheme has been obtained since 2006 from the ETS team, which is also part of the Climate Action Unit of the Department of Environment (contact point Ms. Chrystalla Papastavrou, tel. no. +357 22 408962, cpapastavrou@environment.moa.gov.cy). Apart from the fuel consumption data is also obtained for CO_2 emissions (combustion and process emissions) and net calorific value (NCV) of fuels consumed.

The energy balance is obtained from the Energy Service of the Ministry of Commerce, Industry and Tourism. The contact point is Dr. Christina Karapitta–Zachariadou (tel. no. +357 22409388, ckarapitta@mcit.gov.cy).

Information on vehicle registration for the estimation of emissions from road transport is obtained from the Department of Road Transport, Ministry of Transport, Communications and Works (Mr. Renos Venezis, tel. +357 22807002, rvenezis@rtd.mcw.gov.cy).

The contact point for the energy balance prepared by the National Statistical Service (CYstat) for the submission to EUROSTAT is Ms. Nafsika Apostolou (tel. no. +357 22602199, napostolou@cystat.mof.gov.cy). Other contacts at CYstat are: for waste data Mrs. Marilena Kythreotou (tel. no. +357 22602137, mkythreotou@cystat.mof.gov.cy), for population data Ms. Loukia Makri (tel. no.+357 22602150, lmakri@cystat.mof.gov.cy), for industrial production Mr. Charalambos Alkiviadous (tel. 22602189, calkiviadous@cystat.mof.gov.cy) and for agricultural data (cultivated areas and animal population) Mrs. Sofia Pelagia (spelagia@cystat.mof.gov.cy).

Department of Labour Inspection is the competent authority for the preparation of air pollutants inventories under Directive 2001/81/EC. The inventory is communicated to the GHG inventory compiler, Mr. Christos Papadopoulos (tel. no. +357 22405683, cpapadopoulos@dli.mlsi.gov.cy).

The activity data for the estimation of emissions from F-gases (sectors 2F) is obtained by Mr. Pavlos Pavlou, part of the Climate Action Unit, Department of Environment (tel. no. +357 24 202866, ppavlou@environment.moa.gov.cy), Department of Road Transport, Ministry of Transport, Communications and Works (Mr. Renos Venezis, tel. +357 22807002, rvenezis@rtd.mcw.gov.cy).

Other data on municipal solid waste management is obtained from Mrs. Elena Christodoulidou, part of the Waste Management Unit, at the Department of Environment (tel. no. +357 22408951, echristodoulidou@environment.moa.gov.cy).

Municipal liquid waste production and management data is obtained from Mrs. Stella Perikenti part of the Pollution Control Unit, Department of Environment (tel. no. +357 22408942, sperikenti@environm ent.moa.gov.cy) and Ms. Lia Georgiou, Senior Sanitary Engineer at the Water Development Department (tel. no. +357 22409186, lgeorgiou@wdd.moa.gov.cy)

Agricultural waste management information on practices applied is obtained from Mr. Antis Athanasiades part of the Pollution Control Unit, Department of Environment (tel. no. +357 22408935, aathanasiades@environment.moa.gov.cy).

Industrial liquid waste management data is obtained from Dr. Chrystalla Stylianou head of the Pollution Control Unit, Department of Environment (tel. no. +357 22408941, cstylianou@environment.moa.gov. cy).

Livestock population data is provided by Mr. Christodoulos Pipis, Veterinary Services (tel. no. +357 22 80 52 00).

Fertiliser consumption data is provided by Mr. George Theofanous, Department of Agriculture (tel. no. +357 22464028). Details necessary for the implementation of Tier 2 methodology for dairy cattle was obtained from Mr. Georgios Papaioannou, Department of Agriculture (tel. no. +357 22408566).

Land cover data (which includes forest cover data) is obtained from Mr. Andreas Antoniou, part of the Nature & Biodiversity Unit, Department of Environment (tel. no. +357 22408918, aantoniou@envrriron ment.moa.gov.cy).

Forest wildfire data is obtained from Ms. Areti Christodoulou, Department of Forests (tel. no. +357 22459003, archristodoulou@fd.moa.gov.cy).

Data is also obtained from International Organisations as the Food and Agricultural Organization of the United Nations (FAO) and EUROSTAT. This data is supplementary to the data collected from the aforementioned data providers. Furthermore, other government organisations, associations, and individual public and private industrial companies contribute to data providing and development of methodological issues as appropriate (Lime, cement and ceramics (bricks and tiles) production data is obtained directly from the installations).

1.2.2. Overview of inventory planning, preparation and management

1.2.2.1. GHG inventory, data collection, processing and storage

The preparation of the Cyprus' GHG emissions inventory is the responsibility of the Climate Action Unit of the Department of Environment of the Ministry of Agriculture, Rural Development and Environment.

The preparation of the Cyprus' GHG emissions inventory is based on the application of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The compilation of the inventory is completed in three main stages (Figure 1.2).

- <u>Stage 1</u>: The first stage consists of data collection and checks for all source/sink categories. The main data sources used are the National Statistical Service, the national energy balance, the government ministries/agencies involved, along with the verified reports from installations under the EU ETS. Quality control of activity data include the comparison of the same or similar data from alternative data sources (e.g. National Statistical Service, EU ETS reports and energy balance) as well as time-series assessment in order to identify changes that cannot be explained. In cases where problems and/or inconsistencies are identified, the agency's representative, responsible for data providing, is called to explain the inconsistency and/or help solving the problem.
- <u>Stage 2</u>:Once the reliability of input data is checked and certified, emissions/removals per source/sink category are estimated. Emissions estimates are then transformed to the format required by the CRF Reporter. This stage also includes the evaluation of the emission factors used and the assessment of the consistency of the methodologies applied in relation to the provisions of the 2006 IPCC Guidelines. Quality control checks, when at this stage, are related to time-series assessment as well as to the identification and correction of any errors/gaps while estimating emissions/removals and entering the data in the CRF Reporter.
- <u>Stage 3</u>: The last stage involves the compilation of the NIR and its internal check. During this period, the Inventory Team has to revise the report according to the observations and recommendations of the QA. On the basis of this interaction process, the final version of the report is compiled. The Director of the Department of Environment approves the inventory and then the contact points submit the NIR to the European Commission for compliance with Regulation (EU) No 525/2013 and thereafter to the UNFCCC secretariat.

As shown in the timetable (Figure 1.3), the government ministries and agencies and the individual private or public industrial companies referred to previously should have collected and delivered to the Inventory Team [11] the respective activity data needed for the inventory (for year X-2) and any changes in activity data for the period 1990 to year X-2, within the time period of May to November of year X-1 (X is the submission year of CRF tables and NIR referred to X-2 GHG emissions inventory).

The information that is related to the annual GHG emissions inventory (activity data, emission factors, analytic results, compilation in the required analysis level of the CRF tables) is stored in MS Excel spreadsheets. Moreover, the final results (NIR and CRF tables) are available in the DoE website[12].

In addition, and within the context of the Quality Assurance/Quality Control system developed, two master files have been organized aiming at the systematic and safe archiving of inventory information: the Input Data File and the Centralised Inventory File.

[11] and the technical consultants (in the future).

[12] http://www.moa.gov.cy/moa/environment/environmentnew.nsf/All/21395032E3B9BB6CC225 7FF0003813DD?OpenDocument

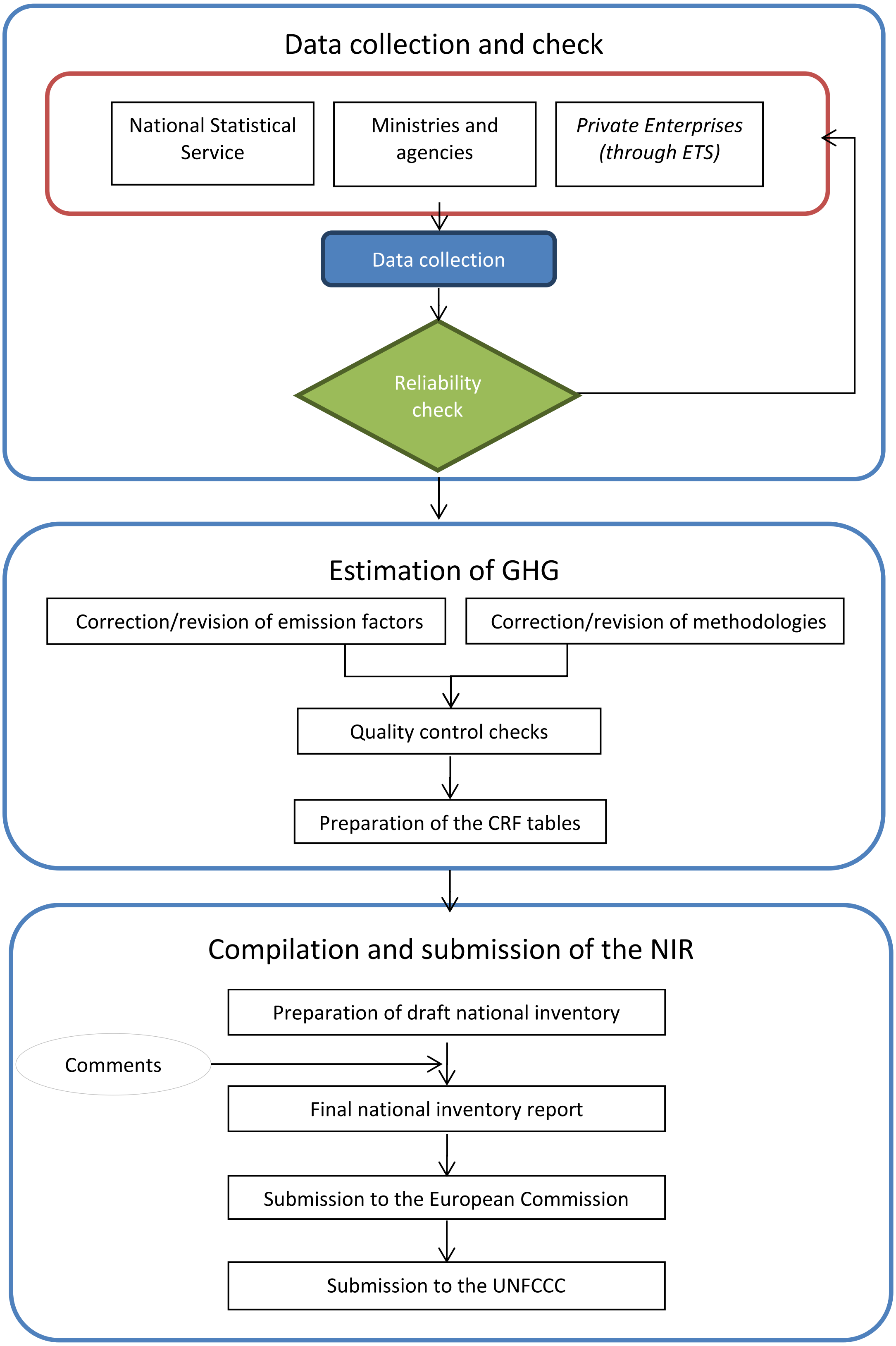

Figure 1.2. GHG emissions inventory preparation process in Cyprus

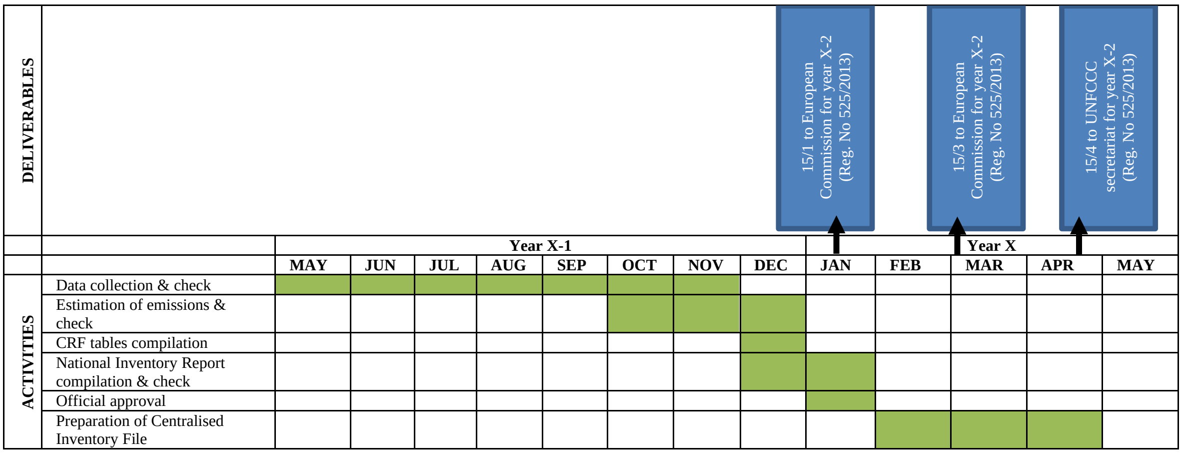

Figure 1.3. Timetable for inventory preparation

- The Input Data File contains (in electronic format and/or hard copy) all input data and parameters that are necessary for the estimation of GHG emissions/removals. Data is stored in sheets by sector and reference year.
- The Centralised Inventory File includes all information relevant to the GHG emissions/removals inventory. At the end of each cycle of the inventory preparation, all inventory related information is handled by the inventory team to the person responsible for keeping the Centralised Inventory File (member of the Climate Team) in the DoE, who in turn provides the latest version of all relevant files (calculation files and NIR) to the Inventory Team at the beginning of the next inventory cycle.

More specifically the information stored in the Centralised Inventory Files includes:

- A list of the reports, the input data files and the calculation/estimation files.
- The members of the Inventory Team.
- Final versions, in electronic format and hard copy, of the NIR.
- CRF tables in electronic format and a hard copy of the CRF tables for the last year covered by each submission.
- XML file and database of CRF reporter.
- Calculation files, including the uncertainty estimation files.
- Expert review reports.
- Any comments from the public review of the inventory.
- Documentation derived from the implementation of the QA/QC procedures.

1.2.3. Quality assurance, quality control and verification plan

A QA/QC plan is an internal document to organise and implement all activities across all of the emissions inventory activities including:

- Stakeholder engagement (stakeholders = e.g. suppliers of data, reviewers, recipients, other inventory compiling institutes (e.g. NFR))
- Data collection
- Data management
- Inventory compilation
- Consolidating the inventory estimates (e.g. into a single national database)
- Reporting

The QA/QC plan is a fundamental element of an inventory management system. The plan needs to clearly identify all important activities used by the inventory compiler and ensure that the minimum data quality objectives required under any relevant reporting obligations are met. The development and the implementation of an inventory QA/QC plan represents a key tool for meeting the objectives of National Systems under Article 5 Paragraph 1 of the Protocol as described in Decision 20/CP.7.

Quality management is essential in order to comply with the requirements of (a) producing transparent, consistent, comparable, complete and accurate emissions estimates, (b) establishing a reliable central archiving system concerning all necessary information for GHG emissions inventories development and (c) compiling national reports according to the provisions of the CMP adopted decisions.

In this framework, a QA/QC system was first prepared in 2012, then revised to reflect 2016 and 2017 ERT recommendations.

Any external experts (through contracts) in close co-operation with the DoE are responsible for the implementation of the QA/QC system. The quality objectives of the system are the following:

1. Compliance with the 2006 IPCC guidelines and the UNFCCC reporting guidelines while estimating and reporting emissions/removals.
2. Continuous improvement of GHG emissions/removals estimates.
3. Timely submission of necessary information in compliance with relevant requirements defined in international conventions, protocols and agreements.

The accomplishment of these objectives can only be ensured by the implementation of the following QA/QC procedures, from all the members of the Inventory Team (see Figure 1.4 for the flow chart of activities concerning emissions inventory):

- Data collection and processing;
- Applying methods consistent with 2006 IPCC Guidelines for calculating/recalculating emissions or removals, and 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol;
- Making quantitative estimates of inventory uncertainty;
- Archiving information and record keeping; and,
- Compiling national inventory reports.

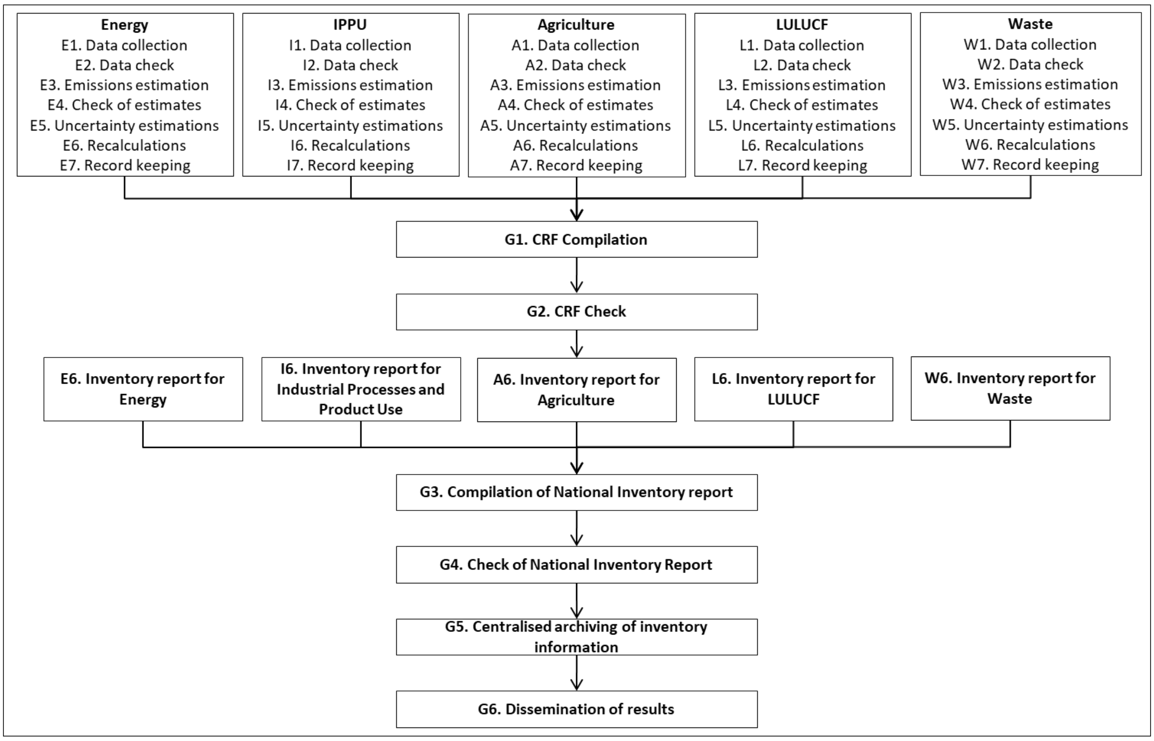

Figure 1.4. Flow chart of activities concerning emissions inventory

The QA/QC system developed covers the following processes:

- *QA/QC system management*, comprising all activities that are necessary for the management and control of the inventory team in order to ensure the accomplishment of the abovementioned quality objectives.

- *Quality control*, which is directly related to the estimation of emissions. The process includes activities related to (a) data inquiry, collection and documentation, (b) methodological choice in accordance with the 2006 IPCC Guidelines, (c) quality control checks for data from secondary sources and (d) record keeping.
- *Archiving inventory information*, comprising activities related to centralised archiving of inventory information and the compilation of the national inventory report.
- *Quality assurance*, comprising activities related to the different levels of review processes including the review of input data from experts, if necessary, and comments from the public
- *Estimation of uncertainties*, defining procedures for estimating and documenting uncertainty estimates per source / sink category and for the whole inventory.
- *Inventory improvement*, that is related to the preparation and the justification of any recalculations made.

Table 1.1 presents the list of procedures within each process and Figure 1.5 the relationship between the processes and the activities of the inventory team.

Table 1.1. QA/QC procedures for the GHG emissions inventory

Process	Procedure code	Procedure
Quality management	QM01	System review
	QM02	System improvement
	QM03	Training
	QM04	Record keeping
	QM05	Internal reviews
	QM06	Non-compliance-corrective and preventing actions
	QM07	Quality management system
	QM08	Documents control
	QM09	Internal communication
Quality control	QC01	Data collection
	QC02	Estimation of emissions/removals
	QC03	Data quality control check
	QC04	Input data record keeping
Archiving of inventory information	AI01	Centralised archiving of inventory information
	AI02	Compilation of reports
Quality assurance	QA01	Expert review of input data and parameters
	QA02	Expert review of GHG emissions/removals inventory
	QA03	Review from public
Uncertainty estimation	UE01	Uncertainty analysis
Inventory improvement	II01	Recalculations management

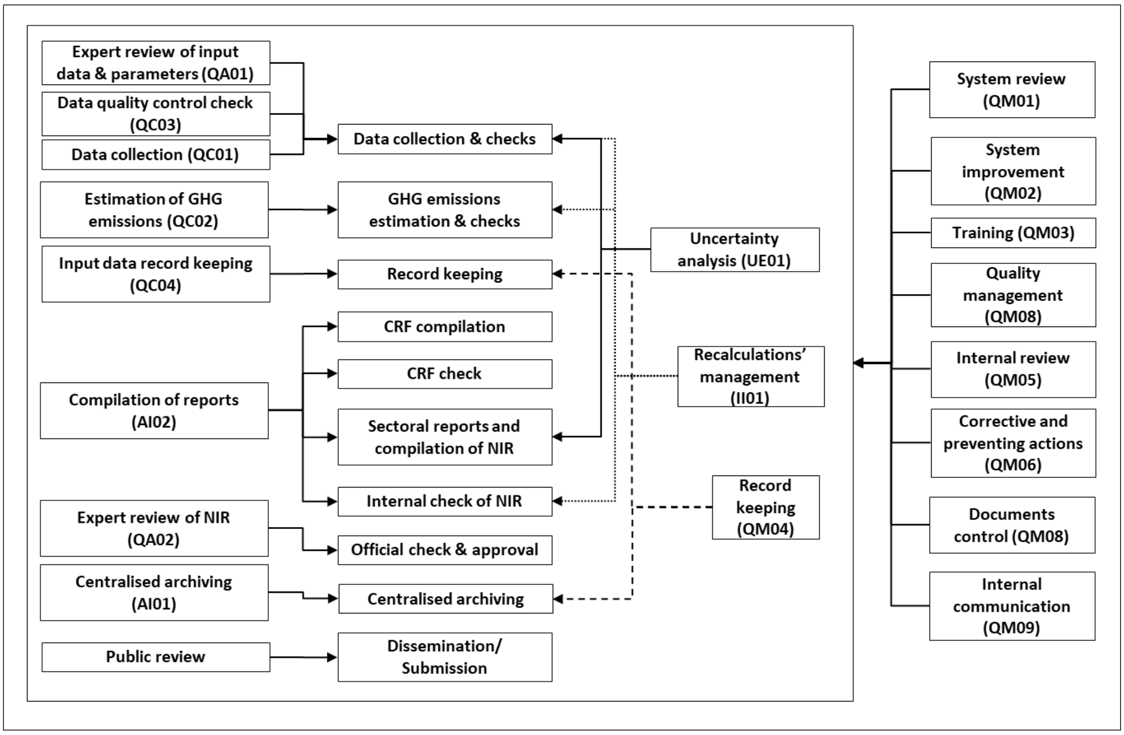

Figure 1.5. QA/QC process and procedures and inventory related activities

All the procedures described in the QA/QC manual are followed by any consultants (where applicable) and the DoE. Audits by independent local experts are planned and implemented at least once every five years.

Each year the EU performs QA/QC checks (called initial checks) to its Member States as a part of EU QA/QC system. These tests are performed annually between 15/1 and 28/2. These checks have been designed to verify the transparency, accuracy, consistency, comparability and completeness of the information submitted and include:

(a) An assessment whether all emission source categories and gases required under Regulation (EU) No 525/2013 are reported;
(b) An assessment whether emissions data time series are consistent;
(c) An assessment whether implied emission factors across Member States are comparable taking the IPCC default emission factors for different national circumstances into account;
(d) An assessment of the use of 'Not Estimated' notation keys where IPCC tier 1 methodologies exist and where the use of the notation key is not justified in accordance with paragraph 37 of the UNFCCC reporting guidelines on annual greenhouse gas inventories as included in Annex I to Decision 24/CP.19;
(e) An analysis of recalculations performed for the inventory submission, in particular if the recalculations are based on methodological changes;
(f) A comparison of the verified emissions reported under the Union's Emissions Trading System with the greenhouse gas emissions reported pursuant to Article 7 of Regulation (EU) No 525/2013 with a view of identifying areas where the emission data and trends as submitted by the Member State under review deviate considerably from those of other Member States;
(g) A comparison of the results of Eurostat's reference approach with the Member States' reference approach;
(h) A comparison of the results of Eurostat's sectoral approach with the Member States' sectoral approach;
(i) An assessment whether recommendations from earlier Union or UNFCCC reviews, not implemented by the Member State could lead to a technical correction;
(j) An assessment whether there are potential overestimations or underestimations relating to a key category in a Member State's inventory.

Moreover, EU carries out comprehensive reviews (similar to centralised UNFCCC reviews) of the national inventory data submitted by Member States. Two comprehensive reviews of Cyprus' inventory, for all sectors except LULUCF, have been performed by the EU in 2012 and 2016.

1.2.3.1. Roles, responsibilities and timing

This section presents the allocation of inventory activities in relation to QA/QC activities to the members of the inventory team and other experts involved in the QA/QC process of Cyprus. The activities are presented schematically in Figure 4 and Figure 5.

Table 1.2 and Figure 1.6 present timing and responsibilities of team members.

Table 1.2. Timing and responsibilities

	Responsible	**Timing**
Data collection	Data providers Nicoletta Kythreotou[13]	by 30/11 of year X-1
Data check	Nicoletta Kythreotou[14] Florence Dubart (Energy, Agriculture) Demetris Demetriou (IPPU, Waste) Iordanis Tzamtzis (LULUCF)	by 30/11 of year X-1
Emissions estimation	Nicoletta Kythreotou Florence Dubart (Energy, Agriculture) Demetris Demetriou (IPPU, Waste) Iordanis Tzamtzis (LULUCF)	1/10-15/12 of year X-1
Check of estimates	Jonilda Kushta Corey McClintock	1/10-15/12 of year X-1
Uncertainty estimations	Nicoletta Kythreotou (Energy, IPPU, Agriculture, Waste) Iordanis Tzamtzis (LULUCF)	1-30/12 of year X-1
Recalculations	Florence Dubart (Energy, Agriculture) Demetris Demetriou (IPPU, Waste) Iordanis Tzamtzis (LULUCF)	1-30/12 of year X-1
Record keeping	Florence Dubart (Energy, Agriculture) Demetris Demetriou (IPPU, Waste) Iordanis Tzamtzis (LULUCF) Angelos Violaris (checks)	1/10-30/12 of year X-1
CRF compilation	Nicoletta Kythreotou (Energy, IPPU, Agriculture, Waste) Iordanis Tzamtzis (LULUCF)	1-27/12 of year X-1
CRF check	Angelos Violaris Corey McClintock	27-30/12 of year X-1
Sectoral reports	Florence Dubart (Energy, Agriculture) Demetris Demetriou (IPPU, Waste) Iordanis Tzamtzis (LULUCF)	1-30/12 of year X-1
Compilation of NIR	Angelos Violaris	20-30/12 of year X-1
Check of NIR		
- internal	Nicoletta Kythreotou	31/12 of year X-1 – 5/1 of year X
→ correction of any errors found	Florence Dubart Demetris Demetriou Iordanis Tzamtzis	5-8/1 of year X
- official (expert review)	Jonilda Kushta	8-11/1 of year X
→ correction of any errors found	Florence Dubart Demetris Demetriou Iordanis Tzamtzis	11-13/1 of year X
- Official check & approval	Theodoulos Mesimeris	13-15/1 of year X

[13] According to the relevant Council of Ministers' Decision, all data shall be sent electronically/via email to the email addresses info@environment.moa.gov.cy, nkythreotou@environment.moa.gov.cy and tmesimeris@environment.moa.gov.cy.
[14] If any discrepancies exist/ noticed, these are discussed with the data providers for explanations/correction.

	Responsible	Timing
Submission to European Commission	Nicoletta Kythreotou	15/1 of year X
Centralised archiving	Angelos Violaris	15/1 of year X
EU QA/QC procedure		15/1-28/2 of year X
Review by stakeholders & public		15/1-28/2 of year X
Corrections to NIR/calculations	Florence Dubart Demetris Demetriou Iordanis Tzamtzis	28/2-15/3 of year X
Final Submission to European Commission	Nicoletta Kythreotou	15/3 of year X
Submission to UNFCCC secretariat	Nicoletta Kythreotou	15/4 of year X

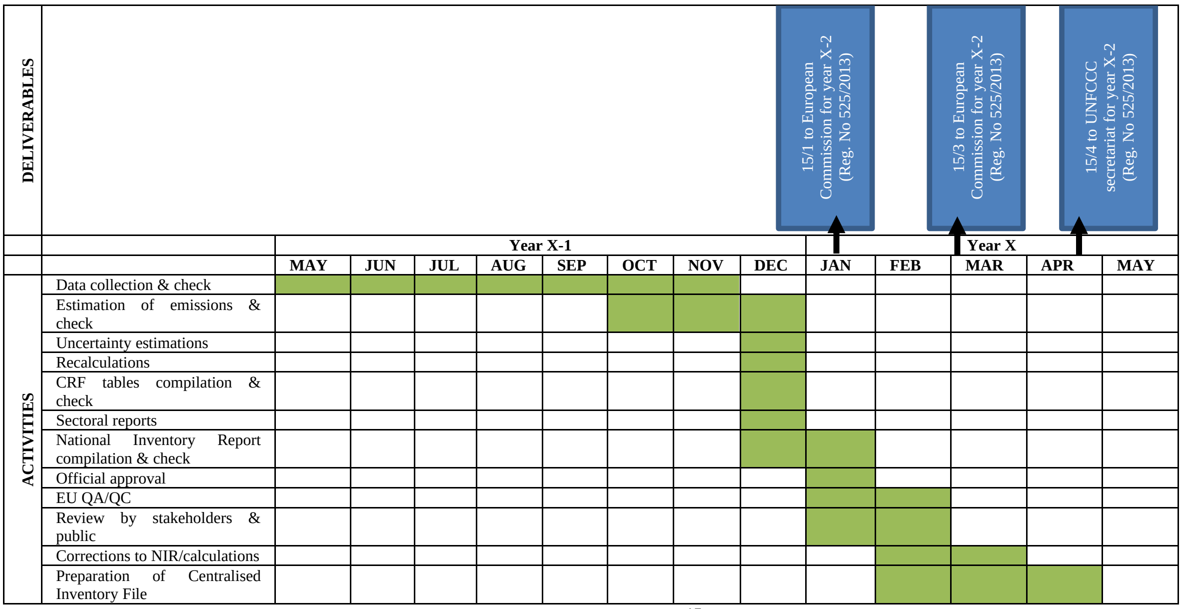

Figure 1.6. Timing and responsibilities of QA/QC tasks[15]

1.3. Brief general description of methodologies and data sources used

According to decision 24/CP.19, Annex I Parties should use the methodologies provided in the 2006 IPCC Guidelines, unless stated otherwise in the UNFCCC Annex I inventory reporting guidelines, and any supplementary methodologies agreed by the COP, and other relevant COP decisions to estimate anthropogenic emissions by sources and removals by sinks of GHGs not controlled by the Montreal Protocol.

Annex I Parties may use different methods (tiers) contained in the 2006 IPCC Guidelines, prioritising these methods in accordance with the 2006 IPCC Guidelines. Annex I Parties may also use national methodologies which they consider better able to reflect their national situation, provided that these methodologies are compatible with the 2006 IPCC Guidelines and are well documented and scientifically based.

For categories that are determined to be key categories, in accordance with the 2006 IPCC Guidelines, and estimated in accordance with the provisions in decision 24/CP.19, Annex I Parties should make every effort to use a recommended method, in accordance with the corresponding decision trees in the 2006 IPCC Guidelines. Annex I Parties should also make every effort to develop and/or select emission factors (EFs), and collect and select activity data (AD), in accordance with IPCC good practice. Where national

[15] Shall be revised upon the recruitment on contract basis of the consultants for future submissions according to Council of Ministers' Decision.

circumstances prohibit the use of a recommended method, then the Annex I Party should explain in its annual GHG inventory submission the reason(s) as to why it was unable to implement a recommended method in accordance with the decision trees in the 2006 IPCC Guidelines.

The 2006 IPCC Guidelines provide default methodologies which include default EFs and in some cases default AD for the categories to be reported. As the assumptions implicit in these default data, factors and methods may not be appropriate for specific national circumstances, Annex I Parties should use their own national EFs and AD, where available, provided that they are developed in a manner consistent with the 2006 IPCC Guidelines and are considered to be more accurate than the defaults. If Annex I Parties lack country-specific information, they could also use EFs or other parameters provided in the IPCC Emission Factor Database[16], where available, provided that they can demonstrate that those parameters are appropriate in the specific national circumstances and are more accurate than the default data provided in the 2006 IPCC Guidelines. Annex I Parties should transparently explain in their annual GHG inventory submissions what data and/or parameters have been used.

Parties are encouraged to refine estimates of anthropogenic emissions and removals in the land use, land-use change and forestry (LULUCF) sector through the application of tier 3 methods, provided that they are developed in a manner consistent with the 2006 IPCC Guidelines, and information for transparency is provided in accordance with decision 24/CP.19.

The estimation of GHG emissions / removals per source / sink category is predominately based on the methods described in the revised 2006 IPCC Guidelines. The emission factors used were derived from the 2006 IPCC Guidelines and special attention was paid in selecting the emission factors that are most representative of practices and conditions in Cyprus. Furthermore, emission factors were obtained from plant specific information contained in EU ETS reports. Due to data unavailability, for the estimation of the emissions of the sectors Refrigeration and Air Conditioning (2F1), Foam Blowing Agents (2F2), Fire Protection (2F3) and Metered Dose Inhalers (2F4a) the implied emission factors per capita from the average of Greece, Italy, Malta and Spain (NIR2015) have been used. For Use of Electrical Equipment (2G1) and N_2O from Product Uses (2G3), the implied emission factor per capita from Greece was used. Details on the methods applied for the calculation of emissions/removals are given the chapters that follow. The methodologies and EF used for the compilation of the 2018 GHG inventory submission are presented in Table 1.3.

The key categories analysis (see Section 1.4) constitutes the basic tool for methodological choice and for the prioritisation of the necessary improvements. In addition, the results of the various review processes (at national, EU and UNFCCC level) represent key input information for the identification of possible improvements. It should be mentioned however, that data availability as well as availability of resources (both human and financial) also have to be considered.

Table 1.3. Methodologies used for the preparation of Cyprus' GHG inventory

Category-Classification		Gas	EF	Method
1A1a.i	Energy Industries - Public electricity and heat production – Energy generation - Liquid fuels	CO_2	CS	CS
1A1a.i	Energy Industries - Public electricity and heat production – Energy generation Liquid fuels	CH_4/N_2O	D	T1
1A1b	Energy Industries – Petroleum Refining – Liquid fuels	$CO_2/CH_4/N_2O$	D	T1
1A1c.iv	Manufacture of solid fuels and Other Energy Industries – Charcoal production- biomass	$CO_2/CH_4/N_2O$	D	T1
1A2b	Manufacturing Industries and Construction – Non-ferrous Metals - Liquid fuels	$CO_2/CH_4/N_2O$	D	T1
1A2c	Manufacturing Industries and Construction – Chemicals – Liquid fuels	$CO_2/CH_4/N_2O$	D	T1
1A2c	Manufacturing Industries and Construction – Chemicals – Biomass	$CO_2/CH_4/N_2O$	D	T1
1A2d	Manufacturing Industries and Construction – Pulp, Paper and Print – Liquid fuels	$CO_2/CH_4/N_2O$	D	T1
1A2e.	Manufacturing Industries and Construction –	$CO_2/CH_4/N_2O$	D	T1

[16] http://www.ipcc-nggip.iges.or.jp/EFDB/main.php

Category-Classification		Gas	EF	Method
	Food processing, beverages and tobacco – Liquid fuels			
1A2e.	Manufacturing Industries and Construction – Food processing, beverages and tobacco – Biomass	$CO_2/CH_4/N_2O$	D	T1
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – Liquid fuel	CO_2	CS	CS
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – Liquid fuel	CH_4/N_2O	D	T1
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – solid fuel	CO_2	CS	CS
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – solid fuel	CH_4/N_2O	D	T1
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – other fossil fuel	$CO_2/CH_4/N_2O$	D	T1
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – biomass (2000 and later)	$CO_2/CH_4/N_2O$	D	T1
1A2g (iii).	Manufacturing Industries and Construction – Other - Mining (excluding fuels) and Quarrying – liquid fuel	$CO_2/CH_4/N_2O$	D	T1
1A2g (v).	Manufacturing Industries and Construction - Other - Construction – liquid fuel	$CO_2/CH_4/N_2O$	D	T1
1A2g (viii).	Manufacturing Industries and Construction – Other -Non-specified Industry – liquid fuel	$CO_2/CH_4/N_2O$	D	T1
1A3a.	Transport - Domestic aviation – Jet kerosene	$CO_2/CH_4/N_2O$	D	T1
1A3bi.	Transport - Road transportation – Gasoline	$CO_2/CH_4/N_2O$	M	T2
1A3bi.	Transport - Road transportation - Diesel	$CO_2/CH_4/N_2O$	M	T2
1A3bi.	Transport - Road transportation - Biomass	$CO_2/CH_4/N_2O$	M	T3
1A3d	Transport - Domestic Navigation – Gas/Diesel Oil	$CO_2/CH_4/N_2O$	D	T1
1A4a.	Other Sectors - Commercial/institutional - Liquid fuel	$CO_2/CH_4/N_2O$	D	T1
1A4a.	Other Sectors - Commercial/institutional - Biomass	$CO_2/CH_4/N_2O$	D	T1
1A4b.	Other Sectors - Residential – Liquid fuel	$CO_2/CH_4/N_2O$	D	T1
1A4b.	Other Sectors - Residential – Biomass	$CO_2/CH_4/N_2O$	D	T1
1A4ci.	Agriculture/forestry/fishing - Stationary- Liquid fuel	$CO_2/CH_4/N_2O$	D	T1
1A4ci.	Agriculture/forestry/fishing – Stationary- Biomass	$CO_2/CH_4/N_2O$	D	T1
1A4ciii	Agriculture/forestry/fishing – Fishing – Gas/Diesel Oil	$CO_2/CH_4/N_2O$	D	T1
1A5a	Other - Non-Specified – Stationary – Liquid fuel	$CO_2/CH_4/N_2O$	D	T1
1A5a	Other - Non-Specified – Stationary – Solid fuel	$CO_2/CH_4/N_2O$	D	T1
1A5a	Other - Non-Specified – Stationary – Biomass	$CO_2/CH_4/N_2O$	D	T1
1A5b	Other - Non-Specified – Mobile - Liquid fuel	$CO_2/CH_4/N_2O$	D	T1
1B2a4	Fugitive Emissions from Fuels- Oil and Natural Gas and Other Emissions from Energy Production- Oil -Refining/Storage	CH_4	D	T1
1B2a4	Fugitive Emissions from Fuels- Oil and Natural Gas and Other Emissions from Energy Production- Oil -Refining/Storage	CO_2/N_2O	NA	NA
2A1.	Industrial Processes and Product Use – Mineral Industry - Cement production	CO_2	CS	CS
2A2	Industrial Processes and Product Use – Mineral Industry - Lime Production	CO_2	D	T1

Category-Classification		Gas	EF	Method
2A4a	Industrial Processes and Product Use – Mineral Industry - Other process uses of carbonates - Ceramics	CO_2	CS	CS
2A4b	Industrial Processes and Product Use – Mineral Industry - Other process uses of carbonates - Other uses of soda-ash	CO_2	D	T1
2A4b	Industrial Processes and Product Use – Mineral Industry - Other process uses of carbonates - Other uses of soda-ash	CH_4/N_2O	NA	NA
2D1	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use- Lubricant Use	CO_2	D	T1
2D1	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use- Lubricant Use	CH_4/N_2O	NA	NA
2D2	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use - Paraffin Wax Use	CO_2	D	T1
2D2	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use - Paraffin Wax Use	CH_4/N_2O	NA	NA
2D3	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use – Other (Dry cleaning, coating applications, chemical products, asphalt roofing, domestic solvent use including fungicides, road paving with asphalt, printing)	CO_2	CS	CS
2D3	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use – Other (Dry cleaning, coating applications, chemical products, asphalt roofing, domestic solvent use including fungicides, road paving with asphalt, printing)	CH_4/N_2O	NA	NA
2D3	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use – Other - Urea-based catalysts	CO_2	D	D
2D3	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use – Other - Urea-based catalysts	CH_4/N_2O	NA	NA
2F1	Product Uses as Substitutes for ODS - Refrigeration and air conditioning	HFCs	D	T2a
2F2	Product Uses as Substitutes for ODS - Foam Blowing Agents	HFCs	CS	CS
2F3	Product Uses as Substitutes for ODS - Fire Protection	HFCs	CS	CS
2F4.	Product Uses as Substitutes for ODS - Aerosols	HFCs	CS	CS
2G1	Electrical equipment	SF_6	D	T1
2G3a	Other Product Manufacture and Use - N_2O from product uses – Medical Applications	N_2O	CS	CS
2G3b	Other Product Manufacture and Use - N_2O from product uses – Other –Propellant for pressure and aerosol products	N_2O	CS	CS
3A	Enteric Fermentation – Dairy Cattle	CH_4	CS	T2
3A	Enteric Fermentation - Non-dairy cattle, sheep, goats, horses, mules and asses and swine	CH_4	D	T1
3B1.1	Manure Management – Dairy Cattle and Non-dairy cattle	CH_4	D	T2
3B1.2	Manure Management – sheep, goats, horses,	CH_4	D	T1

Category-Classification		Gas	EF	Method
3B1.4	mules and asses, poultry			
3B1.3	Manure Management –swine (market & breeding)	CH_4	D	T2
3B2.1 3B2.2 3B2.3 3B2.4	Direct N_2O emissions – Dairy and non-dairy cattle, Sheep, swine (market & breeding), goats, horses, poultry, mules and asses	N_2O	D	T1
3B2.5	Indirect N_2O emissions	N_2O	D	T1
3D1.1	Agricultural soils- Direct N_2O Emissions From Managed Soils- Inorganic fertilizers	N_2O	CS	T2
3D1.2a	Agricultural soils- Direct N_2O Emissions From Managed Soils - Organic N fertilizers - Animal manure used as fertilizers	N_2O	CS	T2
3D1.2b	Agricultural soils- Direct N_2O Emissions From Managed Soils - Organic N fertilizers - Sewage sludge applied to soils	N_2O	CS	T2
3D1.4	Agricultural soils- Direct N_2O Emissions From Managed Soils - Crop residues	N_2O	D	T1
3D2.1	Indirect N_2O emissions from managed soils – Atmospheric Deposition	N_2O	D	T1
3D2.2	Indirect N_2O emissions from managed soils Nitrogen Leaching and run-off	N_2O	D	T1
3F1	Field Burning of Agricultural Residues – Cereals – Wheat, Barley, Oats	N_2O/CH_4	D	T1
3F2	Field Burning of Agricultural Residues – Pulses – Bean and Pulses	N_2O/CH_4	D	T1
3F3	Field Burning of Agricultural Residues –Tubers and Roots	N_2O/CH_4	D	T1
3H	Urea Application	CO_2	D	T1
4A1	Forest land remaining forest land	CO_2	CS,D	T1,T2
4A1	Forest land remaining forest land	N_2O/CH_4	D	T1
4A2	Land converted to forest land	CO_2	CS,D	T1,T2
4B1	Cropland remaining cropland	CO_2	D	T1
4B2	Land converted to cropland	CO_2	CS,D	T1,T2
4B2	Land converted to cropland	N_2O	D	T1
4C1	Grassland remaining grassland	CO_2	CS,D	T1
4C2	Land converted to grassland	CO_2	CS,D	T1,T2
4D2	Land converted to wetlands	CO_2	CS,D	T1
4E1	Settlements remaining settlements	CO_2	NA	T1
4E2	Land converted to settlements	CO_2	CS,D	T1,T2
4E2	Land converted to settlements	N_2O	D	T1
4F2	Land converted to other land	CO_2	CS,D	T1,T2
4F2	Land converted to other land	N_2O	D	T1
4G	Harvested wood products	CO_2	D	T2
5A1.a	Solid Waste Disposal - Managed waste disposal sites- Anaerobic	CH_4	D	T2
5A1.a	Solid Waste Disposal - Managed waste disposal sites- Anaerobic	CO_2	NA	NA
5A2.	Solid Waste Disposal - Unmanaged waste disposal sites	CH_4	D	T2
5A2.	Solid Waste Disposal - Unmanaged waste disposal sites	CO_2	NA	NA
5B1	Biological treatment of solid waste – Composting- municipal solid waste	CH_4/N_2O	D	T1
5B2	Biological treatment of solid waste – Anaerobic digestion at biogas facilities	CH_4	D	T1
5D1.	Wastewater Treatment and Discharge - Domestic wastewater	CH_4/N_2O	CS	T1

Category-Classification		Gas	EF	Method
5D2.	Wastewater Treatment and Discharge - Industrial wastewater	CH_4	D	T1
5D2.	Wastewater Treatment and Discharge - Industrial wastewater	N_2O	OTH	OTH

where: OTH = Other, D = Default, T1 = Tier 1, T2 = Tier 2, CS = Country Specific, NA = Not Applicable, M = COPERT

Data collection, processing and checks constitute the activity with the longest duration in the annual inventory cycle. The duration of this activity is related to the amount of the necessary data and the number of the entities involved. The on-time and successful completion of this activity has a major effect on the timeliness preparation and submission of the inventory as well as on its accuracy, completeness and consistency.

Table 1.4 gives an overview of the main data sets used for the estimation of GHG emissions/removals. Data from international organisations and databases are supplementary to the data collected from the listed data providers. Information and data collected (through questionnaires developed according to the guidelines described in the Commission Decision 2004/156/EC[17]) in the framework of the formulation of the National Allocation Plan (NAP) for the period 2005-2007, according to the Directive 2003/87/EC[18] (and its transposition to the national Law, 110(I)/2011[19]) along with the data from the verified reports from installations under the EU ETS for years 2005-2015 constituted significant source of information and an additional quality control check.

Table 1.4. Data sources and data sets per IPCC sector, source category

Category-Classification		Data	Sources
1A1a.	Public electricity and heat production	Fuel consumption	ETS verified reports Statistical Service Department of Labour Inspection (DLI)
1A1b.	Petroleum Refining	Fuel consumption	Statistical Service
1A2b.	Non-ferrous metals	Fuel consumption	Statistical Service
1A2c.	Chemical and petrochemical	Fuel consumption	Statistical Service
1A2d.	Paper, pulp and printing	Fuel consumption	Statistical Service
1A2e.	Food processing, beverages and tobacco	Fuel consumption	Statistical Service
1A2f.	Non-metallic minerals – Liquid fuel	Fuel consumption	ETS verified reports Statistical Service DLI
1A2f.	Non-metallic minerals – solid fuel	Fuel consumption	ETS verified reports Statistical Service DLI
1A2f.	Non-metallic minerals – other fuel	Fuel consumption	ETS verified reports Statistical Service DLI
1A2f.	Non-metallic minerals – biomass	Fuel consumption	ETS verified reports Statistical Service DLI
1A2g(iii).	Other - Mining (excluding fuels) and Quarrying – liquid fuel	Fuel consumption	Statistical Service
1A2g(v).	Other - Construction – liquid fuel	Fuel consumption	Statistical Service
1A2g(viii).	Other -Non-specified Industry – liquid fuel	Fuel consumption	Statistical Service
1A3a.	Domestic aviation – Jet kerosene	Fuel consumption	Statistical Service /EUROCONTROL
1A3bi.	Road transportation – Gasoline	Fuel consumption	Statistical Service

[17] Available at http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32004D0156&from=EN (no longer in force)
[18] Available at http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32003L0087&from=EN
[19] Available at http://www.moa.gov.cy/moa/environment/environmentnew.nsf/All/E526DA8D521738B9C2258020002E364D?OpenDocument (in Greek)

Category-Classification		Data	Sources
		Vehicles registration	Dep. of Road Transport
1A3bi.	Road transportation - Diesel	Fuel consumption Vehicles registration	Statistical Service Dep. of Road Transport
1A3bi.	Road transportation - Biomass	Fuel consumption Vehicles registration	Statistical Service Dep. of Road Transport
1A3d	Domestic Navigation – Gas/Diesel Oil	Fuel consumption	Statistical Service
1A4a.	Commercial/institutional - Liquid fuel	Fuel consumption	Statistical Service DLI
1A4a.	Commercial/institutional - Biomass	Fuel consumption	Statistical Service DLI
1A4b.	Residential – Liquid fuel	Fuel consumption	Statistical Service DLI
1A4b.	Residential – Biomass	Fuel consumption	Statistical Service DLI
1A4ci.	Agriculture/forestry/fishing - Stationary- Liquid fuel	Fuel consumption	Statistical Service DLI
1A4ci.	Agriculture/forestry/fishing – Stationary- Biomass	Fuel consumption	Statistical Service DLI
1A4ciii	Agriculture/forestry/fishing – Fishing – Gas/Diesel Oil	Fuel consumption	Statistical Service
1A5a.	Other - Non-Specified – Stationary – Liquid fuel	Fuel consumption	Statistical Service
1A5a.	Other - Non-Specified – Stationary – Solid fuel	Fuel consumption	Statistical Service
1A5a.	Other - Non-Specified – Stationary – Biomass	Fuel consumption	Statistical Service
1A5b.	Other - Non-Specified – Liquid fuel	Fuel consumption	Statistical Service
1B2a4.	Fugitive Emissions from Fuels- Oil and Natural Gas and Other Emissions from Energy Production- Refining/Storage	Fuel consumption	Statistical Service
2A1.	Cement production	Clinker production	ETS verified reports Statistical Service DLI
2A2	Lime Production	Lime production	Statistical Service DLI Installation
2A4a.	Other process uses of carbonates - Ceramics	Bricks and Tiles Production	ETS verified reports DLI
2A4b.	Other process uses of carbonates - Other uses of soda-ash	Soda – Ash Imports	Statistical Service
2D1.	Lubricant Use	Lubricants consumption	Statistical Service
2D2.	Paraffin Wax Use	Paraffin Wax Imports	Statistical Service
2D3.	Solvent Use (Dry cleaning, coating applications, chemical products, asphalt roofing, domestic solvent use including fungicides, road paving with asphalt, printing)	NMVOCs	DLI
2D3.	Solvent Use - Urea-based catalysts	Fuel consumption	Statistical Service
2F1.	Refrigeration and air conditioning	Commercial and industrial air-conditioning and	Department of Environment – Inventory of equipment containing

Category-Classification		Data	Sources
		refrigeration	fluorinates and ozone depleting substances*
2F2	Foam Blowing Agents	Emissions Data	National Inventory of Malta, Spain, Italy, Greece
2F3	Fire Protection	Emissions Data	National Inventory of Malta, Spain, Italy, Greece
2F4.	Aerosols	Emissions Data	National Inventory of Malta, Spain, Italy, Greece
2G3a	N_2O from product uses	Population	Statistical Service
2G3b	N_2O from product uses	Population	Statistical Service
3A	Enteric Fermentation – Dairy Cattle	Livestock population milk yield* average weight*	Statistical Service DLI EUROSTAT Veterinary Services *Department of Agriculture
3A	Enteric Fermentation - Non-dairy cattle, sheep, goats, horses, mules and asses and swine	Livestock population	Statistical Service DLI EUROSTAT Veterinary Services Department of Agriculture
3B1.1	Manure Management – Dairy Cattle and Non-dairy cattle	Livestock population	Statistical Service DLI EUROSTAT Veterinary Services Department of Agriculture
3B1.2 3B1.4	Manure Management – sheep, goats, horses, mules and asses, poultry	Livestock population	Statistical Service DLI EUROSTAT Veterinary Services Department of Agriculture
3B1.3	Manure Management –swine (market & breeding)	Livestock population	Statistical Service DLI EUROSTAT Veterinary Services Department of Agriculture
3B2.1 3B2.2 3B2.3 3B2.4	Direct N_2O emissions – Dairy and non-dairy cattle, Sheep, swine (market & breeding), goats, horses, poultry, mules and asses	Livestock population	Statistical Service DLI EUROSTAT Veterinary Services Department of Agriculture
3B2.5	Indirect N_2O emissions	Livestock population	Statistical Service DLI EUROSTAT Veterinary Services Department of Agriculture
3D1.1	Agricultural soils- Inorganic fertilizers	Fertilizers use	Statistical Service Department of Agriculture Agricultural Research Institute
3D1.2a	Use of organic N fertilizers - Animal manure used as fertilizers	Fertiliser use Livestock population	Statistical Service Department of Agriculture Agricultural Research Institute
3D1.2b	Use of organic N fertilizers - Sewage sludge applied to soils	Fertiliser use Sewage sludge applied to soils	Statistical Service Department of Agriculture Agricultural Research Institute
3D1.4	Crop residues	Cultivated areas	Statistical Service

Category-Classification		Data	Sources
		Crop production	
3D2.1	Indirect N_2O emissions from managed soils – Atmospheric Deposition	Fertiliser use	Statistical Service Department of Agriculture
3D2.2	Indirect N_2O emissions from managed soils Nitrogen Leaching and run-off	Fertiliser use Livestock population Sewage sludge applied to soils	Statistical Service Department of Agriculture
3F1	Field Burning of Agricultural Residues – Cereals – Wheat, Barley, Oats	Cultivated areas Crop production	Statistical Service
3F2	Field Burning of Agricultural Residues – Pulses – Bean and Pulses	Cultivated areas Crop production	Statistical Service
3F3	Field Burning of Agricultural Residues –Tubers and Roots	Cultivated areas Crop production	Statistical Service
3H	Urea Application	Urea use	Statistical Service
5A1.a	Managed waste disposal sites	Municipal solid waste production Recycling Population	Statistical Service Department of Environment
5A2.	Unmanaged waste disposal sites	Municipal solid waste production Population	Statistical Service Department of Environment
5B1	Biological treatment of solid waste – Composting- municipal solid waste	Composting	Statistical Service
5B2	Biological treatment of solid waste – Anaerobic digestion at biogas facilities	Composting	Statistical Service
5D1.	Wastewater Treatment and Discharge - Domestic wastewater	Population connected	Statistical Service Water Development Department Department of Environment
5D2.	Wastewater Treatment and Discharge - Industrial wastewater	Industrial production	Statistical Service Department of Environment

*outsourced contract

1.3.1. Global Warming Potential

Emissions from anthropogenic activities affect the concentration and distribution of greenhouse gases in the atmosphere. These changes can potentially produce a radiative forcing of the Earth's surface and lower atmosphere, by changing either the reflection or absorption of solar radiation or the emissions and absorption of long-wave radiation. A simple measure of the relative radiative effects of the emissions of various greenhouse gases is the Global Warming Potential (GWP) index. This index is defined as the cumulative radiative forcing between the present and some chosen time-horizon caused by a unit mass of gas emitted now, expressed relative to that for some reference gas. The values for GWP for the greenhouse gases that are used in this inventory are according to Decision 18/CMA.1[20] (Annex II).

[20] Decision 18/CP.1 Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement.

Corresponding values of GWP for other gases (NO_x, CO, NMVOC) are not given by the IPCC (nor by other sources for this purpose), since at present it is impossible to calculate the indirect results of these gases, as the scientific knowledge on their chemical reactions taking place in the atmosphere is not sufficient.

Table 1.5. Direct Global Warming Potentials (mass basis) relative to carbon dioxide for the 100-year horizon

Gas	Chemical Compound	100-year Global Warming Potential
Carbon dioxide	CO_2	1
Methane	CH_4	28
Nitrous Oxide	N_2O	265
HFC-32	CH_2F_2	677
HFC-125	CHF_2CF_2	3170
HFC-134a	CH_2FCF_3	1300
HFC-143a	CF_3CH_3	4800
HFC-227ea	CF_3CHFCF_3	3350
HFC-245fa	$CH_2FCF_2CHF_2$	858
HCF-365mfc	$CH_3CF_2CH_2CH_2CF_3$	804
Sulphur hexafluoride	SF_6	23500
Nitrogen trifluoride	NF_3	16100

1.4. Brief description of key categories

The 2006 IPCC Guidelines define procedures (in the form of decision trees) for the choice of estimation methods within the context of the IPCC Guidelines. Decision trees formalize the choice of the estimation method most suited to national circumstances considering at the same time the need for accuracy and the available resources (both financial and human). It is considered good practice to identify those source categories (key source categories) that have the greatest contribution to overall inventory uncertainty in order to make the most efficient use of available resources.

In that context, a key source category is one that is prioritised within the national inventory system because its estimate has a significant influence on a country's total inventory of direct greenhouse gases in terms of the absolute level of emissions (level assessment) or/and to the trend of emissions (trend assessment). As far as possible, key source categories should receive special consideration in terms of two important inventory aspects:

1. The use of source category-specific good practice methods is preferable, unless resources are unavailable.

2. The key source categories should receive additional attention with respect to quality assurance (QA) and quality control (QC).

As a result of the adoption of the LULUCF Good Practice Guidance (Decision 13/CP.9) the concept of key sources has been expanded in order to cover LULUCF emissions by sources and removals by sinks. Therefore the term key category is used in order to include both sources and sinks.

The determination of the key categories for the Cyprus' inventory system is based on the application of the Tier 1 methodology (see Annex I for an analytic presentation of calculations) described in the 2006 IPCC Guidelines. Tier 1 methodology for the identification of key categories assesses the impacts of various source categories on the level and the trend of the national emissions inventory. Key categories are those which, when summed together in descending order of magnitude, add up to over 95% of total emissions (level assessment) or the trend of the inventory in absolute terms.

It should be mentioned that source category uncertainty estimates are not taken into consideration and base year estimates were calculated considering 1990 as base year.

The key categories for Cyprus' inventory system (without LULUCF) for the year 2021 are presented in Table 1.6. Nine key source categories are found in the energy sector, five in the IPPU sector, five in agriculture and five in waste sector in 2021 (without LULUCF). Detailed presentation of the key category analysis is presented in Annex 1.

Table 1.6. Key categories for Cyprus' inventory system without LULUCF for 2021

IPCC Source category	Direct GHG	Level	Trend
1A1a. Public electricity and heat production	CO_2	✓	✓
1A2e. Food processing, beverages and tobacco	CO_2	✓	✓
1A2f. Non-metallic minerals	CO_2	✓	✓
1A2g. Other (please specify)	CO_2	✓	
1A3a. Domestic aviation	CO_2		✓
1A3b. Road transportation	CO_2	✓	✓
1A4a. Commercial/institutional	CO_2	✓	✓
1A4b. Residential	CO_2	✓	✓
1A4c. Agriculture/forestry/fishing	CO_2	✓	
2A1. Cement production	CO_2	✓	✓
2A4. Othe process uses of carbonate	CO_2		✓
2F1. Refrigeration and air conditioning	HFCs	✓	✓
2F3. Fire protection	HFCs		✓
2G1. Electrical equipment	SF_6		✓
3A1a. Dairy cattle	CH_4	✓	✓
3A1b. Non-dairy cattle	CH_4	✓	✓
3A2. Sheep	CH_4	✓	✓
3B3. Swine	CH_4		✓
3D. Agricultural soils	N_2O	✓	✓
5A1. Managed waste disposal sites	CH_4	✓	✓
5A2. Unmanaged waste disposal sites	CH_4	✓	✓
5B1. Composting	CH_4		✓
5D1. Domestic wastewater	CH_4		✓
5D2. Industrial wastewater	CH_4		✓

The methodology applied for the determination of the key categories with LULUCF is similar to the one presented above. The key categories identified for the year 2021 are presented in Table 1.7 (see Annex 1 for an analytical presentation of calculations). The comparison of the results of the analysis with and without LULUCF reveals no major differences in the source categories identified, apart from the categories from the LULUCF sector. In the analysis including LULUCF ten categories from the Energy Sector, five from the IPPU sector, five from agriculture, five from the waste sector and five from LULUCF have been identified as key.

Table 1.7. Key categories for Cyprus' inventory system with LULUCF for 2021

IPCC Source category	Direct GHG	Level	Trend
1A1a. Public electricity and heat production	CO_2	✓	✓
1A2e. Food processing, beverages and tobacco	CO_2	✓	✓
1A2f. Non-metallic minerals	CO_2	✓	✓
1A2g. Other (please specify)	CO_2	✓	
1A3a. Domestic aviation	CO_2		✓
1A3b. Road transportation	CO_2	✓	✓
1A3b. Road transportation	CH_4		✓
1A4a. Commercial/institutional	CO_2	✓	✓
1A4b. Residential	CO_2	✓	✓
1A4c. Agriculture/forestry/fishing	CO_2	✓	
2A1. Cement production	CO_2	✓	✓
2A4. Other process uses of carbonates	CO_2		✓
2F1. Refrigeration and air conditioning	HFCs	✓	✓
2F3. Fire protection	HFCs		✓

IPCC Source category	Direct GHG	Level	Trend
2G1. Electrical equipment	SF_6		✓
3A1a. Dairy cattle	CH_4	✓	✓
3A1b. Non-dairy cattle	CH_4	✓	✓
3A2. Sheep	CH_4	✓	✓
3B3. Swine	CH_4	✓	✓
3D. Agricultural soils	N_2O	✓	✓
4A1. Forest land remaining forest land	CO_2	✓	✓
4A2. Land converted to forest land	CO_2		✓
4B1. Cropland remaining cropland	CO_2	✓	✓
4C1. Grassland remaining grassland	CO_2		✓
4G. Harvested wood products	CO_2		✓
5A1. Managed waste disposal sites	CH_4	✓	✓
5A2. Unmanaged waste disposal sites	CH_4	✓	✓
5B1. Composting	CH_4		✓
5D1. Domestic wastewater	CH_4		✓
5D2. Industrial wastewater	CH_4		✓

1.5. General uncertainty evaluation

In order to evaluate the accuracy of an emissions inventory, an uncertainty analysis has to be carried out for both annual estimates of emissions and emissions trends over time. The estimated uncertainty of emissions from individual sources is either a function of instrument characteristics, calibration and sampling frequency of direct measurements, or (more often) a combination of the uncertainties in the emission factors for typical sources and the corresponding activity data.

Emission factors reported in the literature usually derive from measurements at specific installations, the characteristics of which are judged to be typical for a set of similar installations. The validity of this assumption given the national circumstances represents the crucial factor determining uncertainty.

Activity data are more closely linked to economic activity than are emission factors. Therefore, there are often well established incentives requirements for accurate accounting. As a result activity data tend to have lower uncertainties and lower correlation between years. Data availability at the level of analysis required for the estimation of GHG emissions / removals as well as the definitions used by the statistical agencies represent some of the parameters affecting the uncertainty of activity data.

The uncertainty analysis for Cyprus' GHG inventory is based on Tier 1 methodology described in the 2006 IPCC Guidelines, with 1990 as base year for CO_2, CH_4, N_2O and 1995 for F-gases emissions. For the estimation of uncertainties per gas, a combination of the information provided by the IPCC and critical evaluation of information from indigenous sources was applied.

In the current submission, for the first time, the uncertainty analysis was carried out including the LULUCF sector. The total uncertainty with LULUCF in 2021 is 10.1% and the trend uncertainty 2.52% compared to 1.91% and 1.63% respectively in 1990. The uncertainty evaluation is also submitted in xls format. Detailed presentation of the assessment of uncertainty is presented in Annex 2.

1.6. General assessment of completeness

Where methodological or data gaps in inventories exist, information on these gaps should be presented in a transparent manner. Annex I Parties should clearly indicate the sources and sinks which are not considered in their inventories but which are included in the 2006 IPCC Guidelines, and explain the reasons for such exclusion. Similarly, Annex I Parties should indicate the parts of their geographical area, if any, not covered by their inventory and explain the reasons for their exclusion. In addition, Annex I Parties should use the notation keys presented below to fill in the blanks in all the CRF tables. This approach facilitates the assessment of the completeness of an inventory. The notation keys are as follows:

(a) “NO” (not occurring) for categories or processes, including recovery, under a particular source or sink category that do not occur within an Annex I Party.

(b) “NE” (not estimated) for AD and/or emissions by sources and removals by sinks of GHGs which have not been estimated but for which a corresponding activity may occur within a Party.6 Where “NE” is used in an inventory to report emissions or removals, the Annex I Party shall indicate in both the NIR and the CRF completeness table why such emissions or removals have not been estimated. Furthermore, a Party may consider that a disproportionate amount of effort would be required to collect data for a gas from a specific category that would be insignificant in terms of the overall level and trend in national emissions and in such cases use the notation key “NE”. The Party should in the NIR provide justifications for exclusion in terms of the likely level of emissions. An emission should only be considered insignificant if the likely level of emissions is below 0.05 per cent of the national total GHG emissions, and does not exceed 500 kt CO_2 eq. The total national aggregate of estimated emissions for all gases and categories considered insignificant shall remain below 0.1 per cent of the national total GHG emissions. Parties should use approximated AD and default IPCC EFs to derive a likely level of emissions for the respective category. Once emissions from a specific category have been reported in a previous submission, emissions from this specific category shall be reported in subsequent GHG inventory submissions.

(c) “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. If the cells for categories in the CRF tables for which “NA” is applicable are shaded, they do not need to be filled in.

(d) “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. Where “IE” is used in an inventory, the Annex I Party should indicate, in the CRF completeness table, where in the inventory the emissions or removals for the displaced source/sink category have been included, and the Annex I Party should explain such a deviation from the inclusion under the expected category, especially if it is due to confidentiality.

(e) “C” (confidential) for emissions by sources and removals by sinks of GHGs of which the reporting could lead to the disclosure of confidential information, given the provisions of decision 24/CP.19. Annex I Parties are encouraged to estimate and report emissions and removals for source or sink categories for which estimation methods are not included in the 2006 IPCC Guidelines. If Annex I Parties estimate and report emissions and removals for country specific sources or sinks or of gases which are not included in the 2006 IPCC Guidelines, they should explicitly describe what source/sink categories or gases these are, as well as what methodologies, EFs and AD have been used for their estimation, and provide references for these data.

In the present inventory report, estimates of GHG emissions in Cyprus for the years 1990–2021 are presented. All major sources are reported including emissions estimates for indirect greenhouse gases and SO_2 (Annex 5).

The main deficiency identified is the lack of available data/methods to estimate emissions for Transport of oil (1.B.2.a.3) and Distribution of oil products (1.B.2.a.5). Moreover, there are still some empty cells in the xml. Work is in progress to fill all the cells and use the appropriate notation keys. Further details on deficiencies are provided in the appropriate chapter. A national inventory improvement plan is available and implemented.

Information related to the geographical scope

On July 20, 1974, the Turkish armed forces staged a full scale invasion against Cyprus. Turkey proceeded to occupy the northern part of the island and empty it of its Greek Cypriot inhabitants. By the end of the following year, the majority of the Turkish Cypriots living in the areas remaining under the control of the Republic of Cyprus had also made their way to the part of Cyprus occupied by the Turkish army.

On November 15, 1983, the Turkish Cypriot leadership unilaterally declared that area an independent state, and named it the “Turkish Republic of Northern Cyprus”. Despite the fact that this act has been condemned by the UN and that no country other than Turkey has recognised this illegal secessionist entity, the situation continues.

For further information on this situation please refer to the website of the Ministry of Foreign Affairs of the Republic of Cyprus[21].

As the secessionist area is not under the effective control of the Republic of Cyprus, no data from official sources are available for the activities taking place in the particular areas, and no emissions can be estimated for any activities.

This inventory estimates emissions and removals only for areas under the effective control of the Republic of Cyprus.

Implementation of recommendations and adjustments

The implementation status of all the recommendations made to the 2022 NIR submission by the EU review team (TERT) during the two review processes are presented in Annex 6.

[21] http://www.mfa.gov.cy/mfa/mfa2016.nsf/mfa08_en/mfa08_en?OpenDocument

Chapter 2.
Trends in greenhouse gas emissions

The economy of Cyprus[22]

The economic profile of a country has a strong link to greenhouse gas emissions, with the overall level and types of economic activity, strongly correlated to energy use. However, this is also dependent on factors such as energy efficiency and the structure of the economy.

The economy of Cyprus can generally be characterized as small, open and dynamic, with services constituting its engine power. Since the accession of the country to the European Union on 1 May 2004 the subsequent participation to the ERMII in 29 April 2005 and finally membership to the EURO area as of January 1st 2008, its economy has undergone significant economic and structural reforms that have transformed the economic landscape. Interest rates have been liberalized, exchange rates and monetary policy was undertaken by the ECB, while other wide-ranging structural reforms have been promoted, covering the areas of competition, the financial sector and the business sector.

The tertiary sector (services) is the biggest contributor to Gross Value Added (GVA), accounting for about 83.4% in 2021. This development reflects the gradual restructuring of the Cypriot economy from an exporter of minerals and agricultural products in the period 1961-73 and an exporter of manufactured goods in the later part of the 1970s and the early part of the 80s, to an international tourist, business and services centre during the 1980s, 1990s and the 2000s. The secondary sector (manufacturing) accounted for around 14.6% of GVA in 2021. The primary sector (agriculture and fishing) is continuously shrinking and only reached 2.0% of GVA in 2021.

Table 2.1. Main economic indicators

	2016	2017	2018	2019	2020	2021
GDP (in € mln)	18,929	20,245	21,613	23,010	21,618	23,437
Real GDP growth rate	6.5	5.9	5.7	5.3	-5.0	5.5
Per capita GDP in PPS, (EU27_2020=100)	88	90	91	92	88	88
Rate of Inflation HICP	-1.2	0.7	0.8	0.5	-1.1	2.3
Unemployment Rate	12.9	11.1	8.4	7.1	7.6	7.5

The private sector, which is dominated by small and medium-sized enterprises, has a leading role in the production process. On the other hand, the government's role is mainly to support the private sector and regulate the markets in order to maintain conditions of macroeconomic stability and a favourable business environment, via the creation of the necessary legal and institutional framework and secure conditions of fair competition.

The Cyprus economy, following the recession in 2014 had presented a positive growth path of five consecutive years, with an average annual real growth of 5.3% during the period 2015-2019. In 2020 due to the outbreak of the COVID-19 crisis the economy went into recession contracting at a rate of -5.0%. In 2021, the economy rebounded significantly with a growth rate of 5.5%. In the first half of 2022, the economy continued to grow with the growth rate estimated at 5.7% for the whole year. Robust economic activity levels are anticipated to be maintained over the medium-term.

Inflation in 2021 turned back positive to 2.3% after decreasing by -1.1% in 2020. Inflation is mainly driven by developments in international oil prices, with a significant impact on domestic prices of energy products. In the medium-term it will hover around 2%.

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In the labour market, unemployment has declined from its peak of 16.1% of the labour force in 2014 to 7.1% in 2019 following good economic performance. In 2020 it increased only to 7.6% and this was due to the timely and targeted measures taken by the Government to mitigate the repercussions caused by the pandemic. In 2021, following the strong economic recovery it reduced to 7.5%. In the short to medium-term, it is expected to have a downward trend due to improved economic activity.

In 2021, the budget balance recorded a deficit of 1.7% of GDP from a deficit of 5.8% of GDP in 2020. This positive outcome, was attributed to the significant economic recovery in 2021 following the COVID-19 outbreak on the economy in 2020, which recorded a negative rate of growth of 5.0. Consequently, in 2021 the general government gross debt to GDP ratio has marked a significant decrease reaching 103.6% of GDP from 115% in 2020.

In the longer term, the recent explorations for hydrocarbon reserves that have taken place in the Exclusive Economic Zone of Cyprus have revealed positive prospects for the development of the industry, which will have significant implications for the Cyprus economy.

2.1. Description and interpretation of emission trends for aggregated GHG emissions

GHG emissions in 2021 were 8435 Gg CO_2 eq. excluding LULUCF. Total national emissions excluding LULUCF increased by 55.7% between 1990 and 2021 and increased by 1.88% between 2020 and 2021. The total GHG emissions trends for the period 1990–2021 are presented in Table 2.2 and Figure 2.1 in kt CO_2 eq.

The GWP values used for the conversion of emissions estimates into the common unit of carbon dioxide equivalent are presented in Table 1.4. Per the IPCC Guidelines, emissions estimates for international marine and aviation bunkers were not included in the national totals, but rather reported separately as memo items.

Table 2.2. Total GHG emissions trend for the period 1990–2021

Total emissions (Gg CO_2 eq.)	**1990**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**
With LULUCF	5571.73	8306.44	9222.44	9455.87	9158.46	8624.68	7920.23
Without LULUCF	5418.66	8163.94	9001.61	9190.83	8857.68	8331.06	7622.95
Total emissions (Gg CO_2 eq.)	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
With LULUCF	8294.92	8343.27	8790.12	8966.07	8821.20	8891.62	8502.86
Without LULUCF	7995.81	8047.16	8599.23	8659.04	8518.88	8594.58	8204.31
Total emissions (Gg CO_2 eq.)	**2021**						
With LULUCF	8670.02						
Without LULUCF	8434.69						

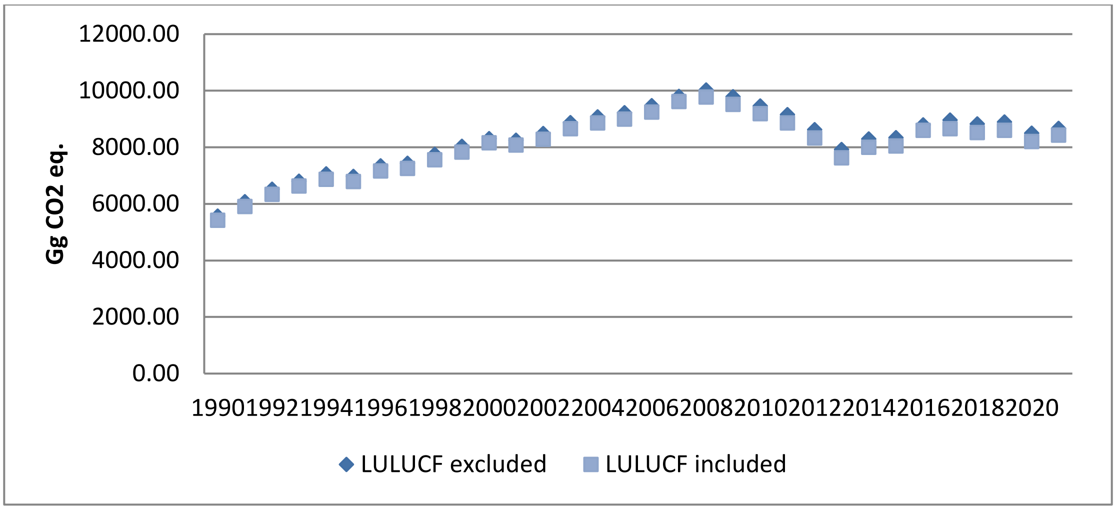

Figure 2.1. Total GHG emissions trend for the period 1990–2021

2.2. Description and interpretation of emission trends by sector

Energy, with 6172.4 Gg CO_2 eq., continues to be the largest contributor to the total national GHG emissions (70.6% compared to the total without LULUCF). 3088 Gg CO_2 eq. of these emissions is from the production of electricity, while another 2051 Gg CO_2 eq. is from transport. Table 2 and Figure 2 present the emissions for the period 1990–2021 by sector.

Table 2.3. GHG emissions by sector for the period 1990–2021

	Energy	IPPU	Agriculture	LULUCF	Waste	Total (excl. LULUCF)	Total (incl. LULUCF)
1990	3954.35	727.93	454.27	-153.07	435.18	5418.66	5571.73
1991	4486.96	687.86	460.82	-166.98	440.71	5909.37	6076.35
1992	4811.43	762.12	491.05	-172.65	449.08	6341.03	6513.67
1993	4988.10	833.50	519.19	-174.80	459.80	6625.78	6800.58
1994	5200.67	870.23	513.73	-183.35	472.74	6874.02	7057.37
1995	5107.25	839.73	543.81	-180.03	481.39	6792.15	6972.18
1996	5402.12	904.15	551.12	-185.36	487.64	7159.67	7345.03
1997	5525.00	876.09	540.87	-184.22	497.08	7254.82	7439.03
1998	5866.52	840.75	543.11	-190.49	504.51	7564.41	7754.90
1999	6130.96	853.74	534.53	-198.38	513.07	7833.91	8032.29
2000	6357.63	883.08	542.49	-142.51	523.24	8163.94	8306.44
2001	6252.10	876.25	585.80	-168.60	533.60	8079.15	8247.75
2002	6412.02	919.23	609.53	-201.94	541.54	8280.38	8482.31
2003	6803.06	934.15	592.23	-214.02	544.68	8660.11	8874.12
2004	6942.20	1014.67	572.23	-214.55	548.53	8863.08	9077.63
2005	7136.65	1003.14	525.08	-220.83	557.57	9001.61	9222.44
2006	7321.74	1060.19	530.70	-222.49	557.86	9248.00	9470.49
2007	7642.68	1071.98	529.07	-182.89	559.92	9620.76	9803.65
2008	7853.41	1094.04	507.69	-249.84	570.25	9775.56	10025.40
2009	7781.63	930.88	500.09	-277.65	577.38	9512.32	9789.98
2010	7546.70	810.82	514.43	-265.04	583.92	9190.83	9455.87
2011	7250.42	811.86	506.48	-300.78	589.71	8857.68	9158.46
2012	6769.05	772.54	483.33	-293.62	599.76	8331.06	8624.68
2013	5847.05	1014.55	448.83	-297.29	609.81	7622.95	7920.23
2014	5994.43	1243.21	436.90	-299.11	620.38	7995.81	8294.92
2015	6117.23	1159.72	441.52	-296.11	624.81	8047.16	8343.27
2016	6512.90	1187.42	462.04	-190.89	627.76	8599.23	8790.12
2017	6604.17	1250.85	475.80	-307.03	635.25	8659.04	8966.07
2018	6493.46	1201.49	481.32	-302.31	644.93	8518.88	8821.20

	Energy	IPPU	Agriculture	LULUCF	Waste	Total (excl. LULUCF)	Total (incl. LULUCF)
2019	6566.71	1173.02	495.46	-297.04	656.42	8594.58	8891.62
2020	6047.95	1267.49	531.32	-298.54	656.09	8204.31	8502.86
2021	6172.40	1277.81	557.25	-235.33	662.56	8434.69	8670.02
Change 1990–2021	56.09	75.54	22.67	53.74	52.25	55.61	55.66

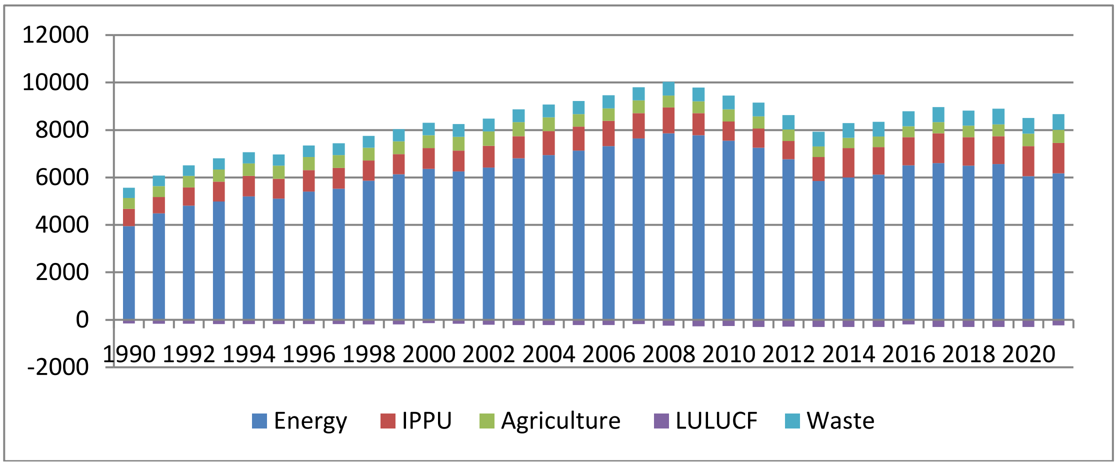

Figure 2.2. GHG emissions by sector for the period 1990–2021

2.3. Description and interpretation of emission trends by gas

GHG emissions trends by gas for the period 1990–2021 are presented in Table 2.4.

	1990	1991	1992	1993	1994
CO_2 emissions without LULUCF	4644.86	5133.21	5505.66	5749.30	5991.49
CO_2 emissions with LULUCF	4491.73	4966.05	5332.92	5574.06	5807.09
CH_4 emissions without LULUCF	776.45	791.35	816.30	847.17	861.38
CH_4 emissions with LULUCF	776.48	791.45	816.34	847.42	862.04
N_2O emissions without LULUCF	147.69	148.43	164.66	174.85	172.93
N_2O emissions with LULUCF	147.72	148.50	164.71	175.03	173.33
HFCs	NO,NE	NO,NE	23.04	24.62	26.27
PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF_6	2.73	3.37	4.01	4.65	5.29
NF_3	NO	NO	NO	NO	NO
Total (without LULUCF)	5571.73	6076.35	6513.67	6800.58	7057.37
Total (with LULUCF)	5418.66	5909.37	6341.03	6625.78	6874.02
Total (without LULUCF, with indirect)	5576.94	6080.87	6518.41	6805.31	7062.52
Total (with LULUCF, with indirect)	5423.87	5913.89	6345.77	6630.51	6879.17
	1995	**1996**	**1997**	**1998**	**1999**
CO_2 emissions without LULUCF	5861.93	6211.89	6298.29	6592.49	6858.75
CO_2 emissions with LULUCF	5681.44	6025.80	6113.05	6398.72	6660.23
CH_4 emissions without LULUCF	887.56	909.38	914.78	917.45	919.57
CH_4 emissions with LULUCF	887.82	909.81	915.39	919.53	919.58
N_2O emissions without LULUCF	188.27	183.59	180.11	189.73	191.19
N_2O emissions with LULUCF	188.47	183.90	180.52	190.93	191.32

HFCs	28.49	33.60	38.65	47.38	54.29
PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF_6	5.93	6.57	7.21	7.85	8.49
NF_3	NO	NO	NO	NO	NO
Total (without LULUCF)	6972.18	7345.03	7439.03	7754.90	8032.29
Total (with LULUCF)	6792.15	7159.67	7254.82	7564.41	7833.91
Total (without LULUCF, with indirect)	6978.06	7351.01	7444.94	7760.69	8039.93
Total (with LULUCF, with indirect)	6798.02	7165.65	7260.73	7570.20	7841.55
	2000	**2001**	**2002**	**2003**	**2004**
CO_2 emissions without LULUCF	7104.60	6978.50	7169.43	7559.65	7788.73
CO_2 emissions with LULUCF	6955.15	6807.34	6967.01	7344.78	7572.91
CH_4 emissions without LULUCF	938.34	975.92	1003.66	994.65	984.95
CH_4 emissions with LULUCF	942.81	977.43	1003.70	994.84	985.32
N_2O emissions without LULUCF	191.95	212.62	218.49	216.72	185.04
N_2O emissions with LULUCF	194.42	213.68	218.93	217.38	185.93
HFCs	62.44	70.91	80.28	92.00	107.15
PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF_6	9.13	9.80	10.45	11.11	11.76
NF_3	NO	NO	NO	NO	NO
Total (without LULUCF)	8306.44	8247.75	8482.31	8874.12	9077.63
Total (with LULUCF)	8163.94	8079.15	8280.38	8660.11	8863.08
Total (without LULUCF, with indirect)	8314.05	8254.90	8491.53	8885.20	9091.27
Total (with LULUCF, with indirect)	8171.54	8086.31	8289.59	8671.18	8876.72
	2005	**2006**	**2007**	**2008**	**2009**
CO_2 emissions without LULUCF	7957.32	8185.01	8503.49	8715.73	8470.19
CO_2 emissions with LULUCF	7735.46	7961.05	8314.89	8464.66	8191.16
CH_4 emissions without LULUCF	960.06	962.62	964.65	962.36	964.61
CH_4 emissions with LULUCF	960.19	962.94	967.74	962.48	964.80
N_2O emissions without LULUCF	170.84	173.60	170.55	163.11	160.06
N_2O emissions with LULUCF	171.74	174.75	173.19	164.22	161.26
HFCs	121.80	137.79	153.17	172.12	182.72
PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF_6	12.42	11.47	11.78	12.09	12.39
NF_3	NO	NO	NO	NO	NO
Total (without LULUCF)	9222.44	9470.49	9803.65	10025.40	9789.98
Total (with LULUCF)	9001.61	9248.00	9620.76	9775.56	9512.32
Total (without LULUCF, with indirect)	9238.56	9488.17	9821.81	10041.02	9803.61
Total (with LULUCF, with indirect)	9017.73	9265.68	9638.92	9791.18	9525.95
	2010	**2011**	**2012**	**2013**	**2014**
CO_2 emissions without LULUCF	8101.12	7787.64	7262.77	6582.61	6950.80
CO_2 emissions with LULUCF	7833.85	7484.77	6966.92	6283.78	6650.10
CH_4 emissions without LULUCF	973.73	973.26	963.14	948.40	949.37
CH_4 emissions with LULUCF	974.46	973.87	963.82	948.64	949.64

N_2O emissions without LULUCF	169.33	166.84	162.63	147.97	145.38
N_2O emissions with LULUCF	170.84	168.31	164.17	149.28	146.70
HFCs	198.99	216.37	221.17	225.67	233.18
PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF_6	12.70	14.36	14.97	15.58	16.18
NF_3	NO	NO	NO	NO	NO
Total (without LULUCF)	9455.87	9158.46	8624.68	7920.23	8294.92
Total (with LULUCF)	9190.83	8857.68	8331.06	7622.95	7995.81
Total (without LULUCF, with indirect)	9469.00	9163.34	8629.34	7923.92	8298.26
Total (with LULUCF, with indirect)	9203.97	8862.56	8335.72	7626.63	7999.15
	2015	**2016**	**2017**	**2018**	**2019**
CO_2 emissions without LULUCF	6971.58	7373.67	7503.81	7321.72	7342.34
CO_2 emissions with LULUCF	6674.14	7169.50	7195.21	7017.47	7043.58
CH_4 emissions without LULUCF	957.01	980.39	999.06	1013.25	1034.05
CH_4 emissions with LULUCF	957.11	988.33	999.31	1013.74	1034.40
N_2O emissions without LULUCF	151.24	153.44	159.48	161.28	167.52
N_2O emissions with LULUCF	152.47	158.78	160.80	162.72	168.89
HFCs	246.65	267.02	287.91	308.05	332.27
PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF_6	16.79	15.61	15.80	16.89	15.44
NF_3	NO	NO	NO	NO	NO
Total (without LULUCF)	8343.27	8790.12	8966.07	8821.20	8891.62
Total (with LULUCF)	8047.16	8599.23	8659.04	8518.88	8594.58
Total (without LULUCF, with indirect)	8347.08	8794.05	8971.33	8826.25	8896.59
Total (with LULUCF, with indirect)	8050.97	8603.16	8664.30	8523.93	8599.54
	2020	**2021**			
CO_2 emissions without LULUCF	6910.91	7029.36			
CO_2 emissions with LULUCF	6610.54	6784.63			
CH_4 emissions without LULUCF	1064.83	1097.40			
CH_4 emissions with LULUCF	1065.26	1102.88			
N_2O emissions without LULUCF	172.70	173.53			
N_2O emissions with LULUCF	174.10	177.45			
HFCs	335.68	353.49			
PFCs	NO	NO			
Unspecified mix of HFCs and PFCs	NO	NO			
SF_6	18.74	16.24			
NF_3	NO	NO			
Total (without LULUCF)	8502.86	8670.02			
Total (with LULUCF)	8204.31	8434.69			
Total (without LULUCF, with indirect)	8508.02	8675.23			
Total (with LULUCF, with indirect)	8209.47	8439.90			

Chapter 3.
Energy (CRF sector 1)

3.1. Overview of sector

Energy systems are for most economies largely driven by the combustion of fossil fuels. During combustion the carbon and hydrogen of the fossil fuels are converted mainly into carbon dioxide (CO_2) and water (H_2O), releasing the chemical energy in the fuel as heat. This heat is generally either used directly or used (with some conversion losses) to produce mechanical energy, often to generate electricity or for transportation. The energy sector is usually the most important sector in greenhouse gas emission inventories. The energy sector mainly comprises exploration and exploitation of primary energy sources, conversion of primary energy sources into more useable energy forms in refineries and power plants, and the transmission and distribution of fuels and use of fuels in stationary and mobile applications. Emissions arise from these activities by combustion and as fugitive emissions, or escape without combustion.

The energy sector in Cyprus [23]

A key challenge for Cyprus is its high dependency on imported fossil fuels for energy, which makes it crucial for the country to develop both its hydrocarbon and renewable energy sources. The energy demand in 2020 was 2,22 million tonnes of oil equivalent (Mtoe).

In 2020 the Renewable Energy Sources (RES) share in gross final consumption of energy in Cyprus (1,64 Mtoe) was 17,04%, exceeding the national mandatory target of 13% RES in 2020, as set in the Directive 2009/28/EC [24]. This share comes from the use of solar water heaters, the installation of PV systems, wind parks, biomass/ biogas units and biofuels for transport sector, in combination with the use of heat pumps and biomass use for heating.

Additionally, RES accounted for 12,62% of electricity production in 2020. RES power production rose 10,56% in 2020, compared to 2019, mainly due to an increase of around 26% in the electricity production from photovoltaic systems. In 2020 the electricity from RES was 51% from photovoltaic systems, 39% from wind parks and 10% from biomass/biogas units.

Since 2015, electricity from renewable sources is no more promoted through feed-in-tariff schemes. Since 2013 is in operation a net metering, net-billing and self-consumption scheme and since 2022 a virtual net-metering scheme. Moreover, in the period 2018-2019 two schemes operated regarding the installation or RES units mainly PV parks that will eventually participate in the competitive electricity market.

Access of electricity from renewable energy sources to the grid is granted according to the principle of non-discrimination. Grid development is a matter of central planning (Transmission Grid Development Plan 2021-2030 by the Cyprus TSO). In addition, renewable heating and cooling (RES H&C) is promoted by support schemes offering subsidies to households for the installation of solar thermal systems.

However, the country's national grid system has certain intrinsic and technical limitations affecting RES penetration, and reliability of the energy system. The lack of electricity interconnections to the trans-

[23] Cyprus Profile, 2017, Energy and Environment, available at http://www.cyprusprofile.com/en/sectors/energy-and-environment (accessed 20/12/2017).

[24] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (Text with EEA relevance), OJ L 140, 5.6.2009, p. 16–62

European electricity networks, limits the amount of intermittent renewable energy that can be connected to the electricity system, and the lack of natural gas interconnections does not allow the supply of Cyprus with electricity produced from natural gas, a fuel that significantly contributes to the reduction of greenhouse gas emissions. In addition, there is a lack of centralised storage capability.

To tackle these problems the country is exploring ways to introduce smart grids in the national network and is on the look-out for projects that could facilitate energy storage, and ventures that have production on a 24-hour basis. Also, the EuroAsia Interconnector could bring more solutions in its wake.

The island is already one of the highest users per capita in the world of solar water heaters in households, with over 90% of households equipped with solar water heaters and over 50% of hotels using large systems of this kind. With almost year-round sunshine, Cyprus certainly has plenty of energy to harness, but competitive energy storing capabilities are crucial in order to fully tap into its solar potential and facilitate better RES penetration.

There continues to be much ground to cover in terms of renewable energy production, but international interest in developing the sector in Cyprus has been on the rise. In this respect, the production of renewable energy is expected to experience considerable growth in coming years, and significant investment is required in order Cyprus to achieve its targets – opening the field for companies with expertise in renewables.

The Cyprus Energy Regulatory Authority (CERA) has worked towards the full opening of the electricity market and enabling the consumers in exercising their right to choose their own supplier – with expectations of a full liberalisation in 2023. CERA has approved the Trade and Settlement Rules which are based on a ‘net pool’ model, i.e. a combination of bilateral agreements with centralized day-ahead, intra-day (at a later stage) and balancing markets. In addition, CERA has issued Regulatory Decisions with respect to the functional and accounting unbundling of the vertically integrated Electricity Authority of Cyprus.

In respect to the supply of natural gas to Cyprus, on 13 of December 2019, the tender for the engineering, construction, operation and maintenance of the LNG Import Terminal, was awarded by ETYFA (DEFA subsidiary) to the joint venture (consortium) China Petroleum Pipeline Engineering, Metron, Hudong-Zhongua Shipbuilding and Wilhelmsen Ship Management. On 28th September 2020 ETYFA approved the revised work program for the project, which is also considered as the official start date of the construction works. Due to the Covid-19 restrictions, which had several effects on the project due to an overall global impact on logistics and availability of materials and equipment, as well the price spike of certain goods, such as steel, the consortium submitted a revised wok program which indicates that project works will be completed by end H2 2023.

With respect to the supply of natural gas, on 4 June 2019, through a pre-qualification - Request for Expressions of Interest (RfEoI) process, DEFA invited prospective LNG suppliers to express an interest in supplying LNG to the LNG Import Terminal in order to be added to DEFA’s list of pre-qualified LNG suppliers. DEFA intends to procure its LNG requirements through a combination of: (a) medium/long-term supply via one or more LNG Sales and Purchase Agreements (SPAs); and (b) supplemental cargos via multiple Master Sales Agreements (MSAs) and a bidding process. The deadline for submission of EoI was the 6 September 2019, and 25 companies submitted their interest. 16. This first stage of the above tender procedure was completed successfully in 21 December 2020. DEFA is expected to proceed to the next stage of the process within 2023 with the negotiation and execution of MSAs and with an RfP for the selection of the medium-term contract supplier of LNG.

Also the first Open Season process for the determination of the allocation of the demand (timely, spatially and quantitatively) of natural gas/LNG by potential buyers within Cyprus (distance of 5km radius from the LNG Import Terminal as per the guidelines set by CERA) was initiated in H1 2022 and is currently ongoing.

Cyprus is promoting the project of common interest «EuroAsia Interconnector», an electricity interconnection which is aiming to start commissioning in in the first half of 2026, and the electricity interconnection between Cyprus, Egypt and Greece, following the trilateral MOU that has been signed in October 2021. In addition, the promotion of the project of common interest «EastMed Pipeline», an offshore/onshore natural gas pipeline connecting East Mediterranean resources to Greece via Cyprus and

Crete is aiming to start commissioning in Q3 2027. These projects will effectively contribute to the internal energy market integration, security of energy supply by enhancing diversification of sources and routes and reduction of GHG emissions by allowing the countries in the region to use natural gas deposits and increase the RES electricity production, in the case of EuroAsia Interconnector.

3.1.1. Trends

The energy sector in Cyprus relies on fossil fuel combustion to meet the bulk of energy requirements. Final consumption in 2021 amounted to approximately 81 PJ, with 95.8% of the consumption coming from liquid fuels,1.3% from solid fuels and 5.2% from biomass. In comparison with 1990, total fuel consumption in 2021 (including biomass) increased by 48%.

After robust growth rates in the 1980s (average annual growth was 6.1%), economic performance in the 1990s was mixed: real GDP growth was 9.7% in 1992, 1.7% in 1993, 6.0% in 1994, 6.0% in 1995, 1.9% in 1996 and 2.3% in 1997. This pattern underlined the economy's vulnerability to swings in tourist arrivals (i.e. to economic and political conditions in Cyprus, Western Europe, and the Middle East) and the need to diversify the economy. Declining competitiveness in tourism and especially in manufacturing acted as a drag on growth prior to actualization of structural changes. This greatly affected the energy sector.

The emissions from the energy sector in Cyprus increased by 56.09% during the period 1990–2021. The greatest increase in emissions was between 1990 and 2008 (97%), when the emissions reached their peak (7853 Gg CO_2 eq.). All the emissions in 2021 are from fuel combustion. The contribution of the emissions from the energy sector to the total without LULUCF in 2021 was 70.6% compared to 74.0% in 1990.

While energy is mainly responsible for carbon dioxide emissions, it also contributes to methane and nitrous oxide emissions. Fugitive emissions from fuels have not been estimated since 2004 when the refining activities stopped in Cyprus. The contribution of each source and gas to the total emissions of the energy sector over the period 1990 to 2021 are presented in Table 3.1 and Figure 3.1.

Table 3.1. Emissions from energy 1990–2021

Gg CO_2 eq.	**1990**	**2000**	**2005**	**2010**	**2011**
1. Energy	3954	6358	7137	7547	7250
A. Fuel combustion (sectoral approach)	3954	6357	7137	7547	7250
1. Energy industries	1767	2964	3483	3880	3722
2. Manufacturing industries and construction	505	802	912	700	575
3. Transport	1237	1838	2112	2375	2305
4. Other sectors	434	731	610	571	622
5. Other	11	22	19	21	27
B. Fugitive emissions from fuels	0	1	NO	NO	NO
1. Solid fuels	NO	NO	NO	NO	NO
2. Oil and natural gas and other emissions from energy production	0	1	NO	NO	NO
C. CO_2 transport and storage	NO	NO	NO	NO	NO
CO_2	3921	6297	7092	7507	7211
CH_4	0.5	0.6	0.6	0.6	0.6
N_2O	0.1	0.2	0.1	0.1	0.1
Gg CO_2 eq.	**2012**	**2013**	**2014**	**2015**	**2016**
1. Energy	6769	5847	5994	6117	6513
A. Fuel combustion (sectoral approach)	6769	5847	5994	6117	6513
1. Energy industries	3557	2839	2950	3033	3311
2. Manufacturing industries and construction	460	540	696	604	5600
3. Transport	2131	1921	1853	1923	2051
4. Other sectors	600	521	457	532	526
5. Other	21	27	38	25	25
B. Fugitive emissions from fuels	NO	NO	NO	NO	NO

1. Solid fuels	NO	NO	NO	NO	NO
2. Oil and natural gas and other emissions from energy production	NO	NO	NO	NO	NO
C. CO_2 transport and storage	NO	NO	NO	NO	NO
CO_2	6732	5814	5962	6081	6474
CH_4	0.6	0.5	0.5	0.6	0.7
N_2O	0.1	0.1	0.1	0.1	0.1

Gg CO_2 eq.	**2017**	**2018**	**2019**	**2020**	**2021**
1. Energy	6604	6493	6567	6060	6172
A. Fuel combustion (sectoral approach)	6604	6493	6567	6060	6172
1. Energy industries	3298	3353	3293	3033	3088
2. Manufacturing industries and construction	621	555	566	574	531
3. Transport	2124	2094	2139	1916	2051
4. Other sectors	536	464	543	511	480
5. Other	26	27	26	27	23
B. Fugitive emissions from fuels	NO	NO	NO	NO	NO
1. Solid fuels	NO	NO	NO	NO	NO
2. Oil and natural gas and other emissions from energy production	NO	NO	NO	NO	NO
C. CO_2 transport and storage	NO	NO	NO	NO	NO
CO_2	6562	6451	6523	6004	6127
CH_4	0.7	0.7	0.8	0.7	0.7
N_2O	0.1	0.1	0.1	0.1	0.1

* Manufacturing of charcoal does take place in Cyprus but does not appear in the table as the fuel consumed is solid biomass.

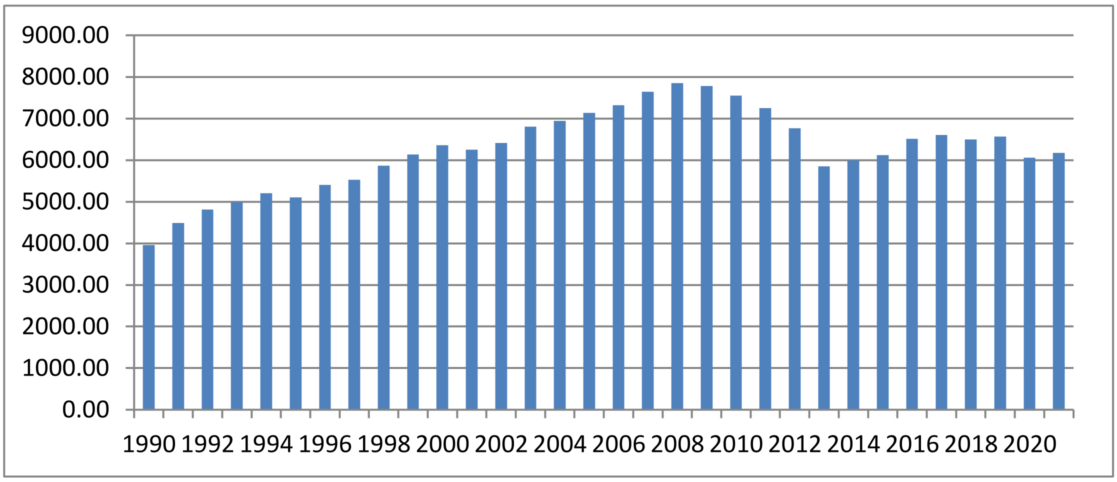

Figure 3.1. Emissions from the energy sector 1990–2021

3.1.2. Methodology

There are three methods provided in the IPCC Guidelines: two Tier 1 approaches (the 'Reference Approach' and the 'Sectoral Approach') and the Tier 2/Tier 3 approach (a detailed technology-based method, also called 'bottom-up' approach). For the Tier 1 Sectoral Approach, total CO_2 is summed across all fuels (excluding biomass) and all sectors. For Tiers 2 and 3, the Detailed Technology-Based Approach, total CO_2 is summed across all fuels and sectors, plus combustion technologies (e.g. stationary and mobile sources). Both approaches provide more disaggregated emission estimates, but also require more data. The sectoral approach is presented in this chapter. The reference approach is presented in details in Section 3.2.8. A comparison of the results of the two approaches is presented in Section 3.2.9.

The calculation of GHG emissions from energy is based on the IPCC 2006 Guidelines. Where data is available for installations included in the Emissions Trading System of the EU, emission factors have been reported as country- or plant-specific. The methodologies applied for the calculation of emissions by source category are presented in Table 3.2.

Table 3.2. Methodology for the estimation of emissions from energy

Category-Classification		Gas	EF	Method
1A1a.i	Energy Industries - Public electricity and heat production – Energy generation - Liquid fuels	CO_2	CS	CS
1A1a.i	Energy Industries - Public electricity and heat production – Energy generation Liquid fuels	CH_4/N_2O	D	T1
1A1b	Energy Industries – Petroleum Refining – Liquid fuels	$CO_2/CH_4/N_2O$	D	T1
1A1c.iv	Manufacture of solid fuels and Other Energy Industries – Charcoal production- biomass	$CO_2/CH_4/N_2O$	D	T1
1A2b	Manufacturing Industries and Construction – Non-ferrous Metals - Liquid fuels	$CO_2/CH_4/N_2O$	D	T1
1A2c	Manufacturing Industries and Construction – Chemicals – Liquid fuels	$CO_2/CH_4/N_2O$	D	T1
1A2c	Manufacturing Industries and Construction – Chemicals – Biomass	$CO_2/CH_4/N_2O$	D	T1
1A2d	Manufacturing Industries and Construction – Pulp, Paper and Print – Liquid fuels	$CO_2/CH_4/N_2O$	D	T1
1A2e.	Manufacturing Industries and Construction – Food processing, beverages and tobacco – Liquid fuels	$CO_2/CH_4/N_2O$	D	T1
1A2e.	Manufacturing Industries and Construction – Food processing, beverages and tobacco – Biomass	$CO_2/CH_4/N_2O$	D	T1
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – Liquid fuel	CO_2	CS	CS
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – Liquid fuel	CH_4/N_2O	D	T1
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – solid fuel	CO_2	CS	CS
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – solid fuel	CH_4/N_2O	D	T1
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – other fossil fuel	$CO_2/CH_4/N_2O$	D	T1
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – biomass	$CO_2/CH_4/N_2O$	D	T1
1A2g (iii).	Manufacturing Industries and Construction – Other - Mining (excluding fuels) and Quarrying – liquid fuel	$CO_2/CH_4/N_2O$	D	T1
1A2g (v).	Manufacturing Industries and Construction - Other - Construction – liquid fuel	$CO_2/CH_4/N_2O$	D	T1
1A2g (viii).	Manufacturing Industries and Construction – Other -Non-specified Industry – liquid fuel	$CO_2/CH_4/N_2O$	D	T1
1A3a.	Transport - Domestic aviation – Jet kerosene	$CO_2/CH_4/N_2O$	D	T1
1A3bi.	Transport - Road transportation – Gasoline	$CO_2/CH_4/N_2O$	M	T2
1A3bi.	Transport - Road transportation - Diesel	$CO_2/CH_4/N_2O$	M	T2
1A3bi.	Transport – Road transportation - LPG	$CO_2/CH_4/N_2O$	D	T1
1A3bi.	Transport - Road transportation - Biomass	$CO_2/CH_4/N_2O$	D	T1
1A3d	Transport - Domestic Navigation – Gas/Diesel Oil	$CO_2/CH_4/N_2O$	D	T1
1A4a.	Other Sectors - Commercial/institutional - Liquid fuel	$CO_2/CH_4/N_2O$	D	T1
1A4a.	Other Sectors - Commercial/institutional - Biomass	$CO_2/CH_4/N_2O$	D	T1

Category-Classification		Gas	EF	Method
1A4b.	Other Sectors - Residential – Liquid fuel	$CO_2/CH_4/N_2O$	D	T1
1A4b.	Other Sectors - Residential – Biomass	$CO_2/CH_4/N_2O$	D	T1
1A4ci.	Agriculture/forestry/fishing - Stationary- Liquid fuel	$CO_2/CH_4/N_2O$	D	T1
1A4ci.	Agriculture/forestry/fishing – Stationary- Biomass	$CO_2/CH_4/N_2O$	D	T1
1A4ciii	Agriculture/forestry/fishing – Fishing – Gas/Diesel Oil	$CO_2/CH_4/N_2O$	D	T1
1A5a	Other - Non-Specified – Stationary – Liquid fuel	$CO_2/CH_4/N_2O$	D	T1
1A5a	Other - Non-Specified – Stationary – Solid fuel	$CO_2/CH_4/N_2O$	D	T1
1A5a	Other - Non-Specified – Stationary – Biomass	$CO_2/CH_4/N_2O$	D	T1
1A5b	Other - Non-Specified – Mobile - Liquid fuel	$CO_2/CH_4/N_2O$	D	T1
1B2a4	Fugitive Emissions from Fuels- Oil and Natural Gas and Other Emissions from Energy Production- Oil -Refining/Storage	CH_4	D	T1
1B2a4	Fugitive Emissions from Fuels- Oil and Natural Gas and Other Emissions from Energy Production- Oil -Refining/Storage	CO_2/N_2O	NA	NA
1B2c1i	Fugitive Emissions from Fuels- Oil and Natural Gas and Other Emissions from Energy Production- Oil -Venting - tanker trucks	CH_4	NA	NA

T1: IPCC methodology Tier 1; D: IPCC default methodology and emission factor; CS: Country specific emission factor; PS: Plant-specific emission factor; OTH: Other; NA: not available, T2: IPCC methodology Tier 2, M: COPERT.

Key categories

The results of the key categories assessment are presented in Section 1.4.

Uncertainty

The uncertainty analysis is presented in Section 1.5.

3.1.3. Completeness

The emissions from energy are complete.

3.2. Fuel combustion (CRF 1.A)

3.2.1. Source category description

The emissions from the fuel combustion in Cyprus contribute 87% to the total national emissions excluding LULUCF in 2021 and increased by 56% during the period 1990–2021. The greatest increase in emissions was between 1990 and 2008 (97%), when the emissions reached their peak (7810 Gg CO_2 eq.). The majority of energy related GHG emissions in 2021 were derived from energy industries (50.2%), while transport contributed 33.2%, manufacturing industries and construction 8.5%, other sectors 7.6% and other 0.4%, respectively.

The substantial increase of GHG emissions from road transport (67.4% between 1990 and 2021) is directly linked to the increase of the vehicle fleet and the increase of transportation activity. The renewal of the passenger car fleet and the implied improvement of energy efficiency limit the increase of GHG emissions. The implemented, adopted and planned measures for the improvement of public transport are expected to moderate the high use of passenger cars. The contribution of each source and gas to the total of the sector is presented in Table 3.3. The trend of the emissions from fuel consumption (1A) is presented in Figure 3.2.

Table 3.3. Emissions from fuel combustion 1990–2021

Gg CO_2 eq.	**1990**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**
A. Fuel combustion activities	3954	6357	7137	7547	7250	6769	5847	5994
1. Energy industries	1767	2964	3483	3880	3722	3557	2839	2950
a. Public electricity and heat production	1681	2859	3483	3880	3722	3557	2839	2950
b. Petroleum refining	86	104	NO	NO	NO	NO	NO	NO
c. Manufacture of solid fuels and other energy industries*	13	28	20	5	0	0	0	0
2. Manufacturing industries and construction	505	802	912	700	575	460	540	696
a. Iron and steel	IE	IE	IE	IE	IE	IE	IE	IE
b. Non-ferrous metals	5	7	7	5	5	6	NO	NO
c. Chemicals	2	4	4	2	2	3	NO	3
d. Pulp, paper and print	5	9	5	4	6	4	3	3
e. Food processing, beverages and tobacco	73	131	82	60	95	53	43	44
f. Non-metallic minerals	382	577	726	556	390	334	443	577
g. Other	38	73	89	74	76	60	51	69
3. Transport	1237	1838	2112	2375	2305	2131	1921	1853
a. Domestic aviation	26	18	13	8	2	1	1	1
b. Road transportation	1208	1818	2097	2365	2300	2127	1918	1851
c. Railways	NO	NO	NO	NO	NO	NO	NO	NO
d. Domestic navigation	2	2	2	3	3	2	2	2
4. Other sectors	434	731	610	571	622	600	521	457
a. Commercial/ institutional	76	117	100	120	113	107	104	82
b. Residential	302	508	421	374	425	413	340	307
c. Agriculture/ forestry/ fishing	56	106	89	77	83	80	77	67
5. Other	11	22	19	21	27	21	27	38
a. Stationary	11	22	19	17	21	17	20	32
b. Mobile	NO	NO	NO	3	6	3	6	6
CO_2	3922	6296	7092	7507	7211	6732	5814	5962
CH_4	0.49	0.54	0.57	0.60	0.61	0.60	0.53	0.51
N_2O	0.07	0.17	0.11	0.09	0.08	0.08	0.07	0.07

Gg CO_2 eq.	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
A. Fuel combustion activities	6117	6513	6604	6493	6567	6048	6172	
1. Energy industries	3033	3311	3298	3353	3293	3033	3088	
a. Public electricity and heat production	3032	3310	3298	3353	3292	3013	3088	
b. Petroleum refining	NO	NO	NO	NO	NO	NO	NO	
c. Manufacture of solid fuels and other energy industries*	11	0	0	0	0	20	10	
2. Manufacturing industries and construction	604	600	621	555	566	561	531	
a. Iron and steel	IE	IE	IE	IE	IE	0	NO	
b. Non-ferrous metals	3	6	2	2	2	3	3	
c. Chemicals	6	6	7	8	8	8	7	
d. Pulp, paper and print	3	3	3	3	3	3	3	
e. Food processing, beverages and tobacco	56	50	71	66	67	62	64	
f. Non-metallic minerals	491	483	478	425	419	426	394	
g. Other	45	51	60	52	67	59	59	
3. Transport	1921	2051	2124	2094	2139	1916	2051	
a. Domestic aviation	3	1	1	1	0	0	0	
b. Road transportation	1921	2049	2121	2091	2136	1915	2048	
c. Railways	NO	NO	NO	NO	NO	NO	NO	
d. Domestic navigation	2	2	2	2	3	1	3	
4. Other sectors	532	526	536	464	543	511	480	
a. Commercial/ institutional	88	82	92	91	119	88	92	
b. Residential	361	364	359	294	338	333	302	
c. Agriculture/ forestry/ fishing	83	80	85	79	85	89	85	
5. Other	25	25	26	27	26	27	23	

a. Stationary	22	22	22	22	22	22	19	
b. Mobile	3	3	4	5	4	5	4	
CO_2	6081	6474	6562	6451	6523	6004	6127	
CH_4	0.63	0.65	0.72	0.72	0.75	0.73	0.74	
N_2O	0.07	0.08	0.08	0.09	0.09	0.09	0.09	

* The fuel consumed for Manufacturing of charcoal is solid biomass.

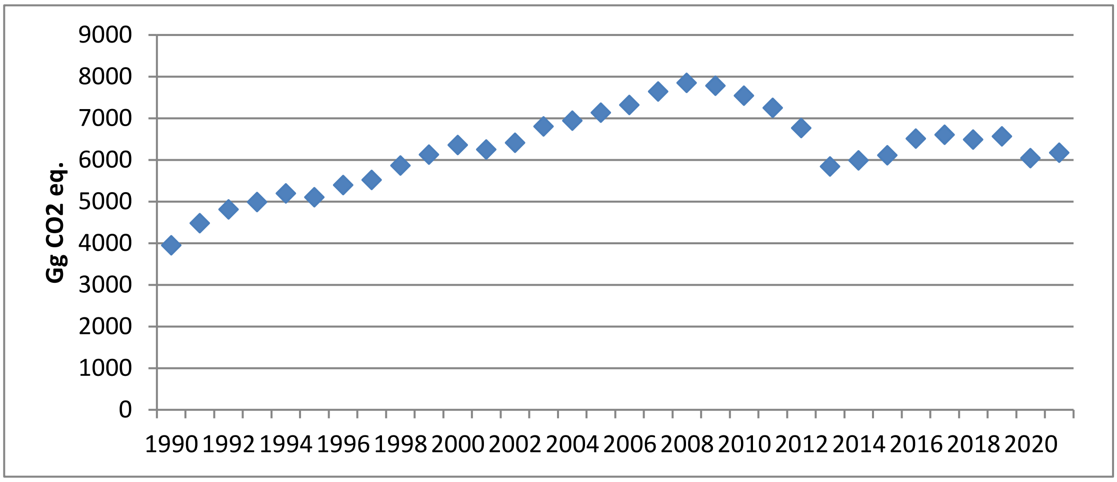

Figure 3.2. Emissions from fuel consumption 1990–2021

3.2.2. Methodological issues

Emission factors

The emission factors used are predominately the defaults proposed by the IPCC guidelines. Further details on the emission factor are provided in the methodological issues Section of each source.

Activity data

The predominant source of the activity data is the national energy balance prepared by the Statistical Service[25]. While data is avaialable for all sources for the recent years, several assumptions have to be made to complete the time-series. Detailed presentation of the methodologies applied to complete the time-series for the years where data is not available is given in Annex 3.1. Other sources of data are the EU-ETS, EUROCONTROL, Department of Road Transport and Department of Labour Inspection. Data sets are compared to national data obtained from the Department of Labour Inspection, the energy balance prepared by the Energy Service, and international sources such as IEE and EUROSTAT. Detailed presentation of the data used is given in the respective section.

[25] Ms. Nafsika Apostolou, Statistical Officer, Statistical Service, Ministry of Finance (+357 22602199, napostolou@cystat.mof.gov.cy)

3.2.3. Energy industries (CRF 1A1)

Category Energy industries (1A1) comprises emissions from fuels combusted by the fuel extraction or energy-producing industries.

3.2.3.1. Category description

The Electricity Authority of Cyprus (EAC) was the sole provider of electrical energy in Cyprus until the introduction of electricity production from renewable energy sources. EAC remains the single electricity producer for the public. Heat production (included in 1A1a) does not occur in Cyprus. Refining activities in the country stopped in 2004 following a government decision not to upgrade it to EU standards, instead turning it into a fuel import and storage terminal. Consequently, emissions from petroleum refinery (1A1b) are reported for the years 1990–2004 only. Emissions from the manufacture of solid fuels and other energy industries (1A1c) are reported for the first time in 2017 (production of charcoal). Gas and Oil Extraction is reported for the first time in 2020 with no activity in 2021.

The consumption of fossil fuels by energy industries in 2021 (40 PJ) increased by 40.1% compared to 1990 (23.3 PJ). Since 2005, when the refinery stopped its operations, the emissions from energy industries are entirely caused by the production of electricity (1A1a). Emissions from energy industries account for 36.3% of total national emissions without LULUCF for 2021, while in 1990 the contribution was 30.3%. The total GHG emissions from energy industries in 2021 (3.0 Tg CO_2 eq.) increased by 42.7% compared to 1990 (1.8 Tg CO_2 eq). The emissions from energy industries are presented in Table 3.4. During the period 2009-2013, a decreasing trend of emissions has been observed, attributed to the penetration of renewable energy technologies to the energy mix, and to the economic recession that the country is facing since 2010. The trend changes in 2014 to an increasing trend with an annual average of 4%. The emissions from energy industries (1A1) for the period 1990–2021 are presented in Figure 3.3.

Table 3.4. Emissions from energy industries 1990–2021

Gg CO_2 eq.	**1990**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**
1. Energy industries	1767	2964	3483	3880	3722	3557	2839	2950
a. Public electricity and heat production	1681	2859	3483	3880	3722	3557	2839	2950
b. Petroleum refining	86	104	NO	NO	NO	NO	NO	NO
c. Manufacture of solid fuels and other energy industries*	13	28	20	5	0	0	0	0
CO2 (Gg)	1761	2955	3472	3868	3710	3546	2830	2940
CH4 (Gg)	0.07	0.12	0.14	0.15	0.15	0.14	0.11	0.11
N2O (Gg)	0.01	0.02	0.03	0.03	0.03	0.03	0.03	0.02
Gg CO_2 eq.	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
1. Energy industries	3033	3311	3298	3353	3293	3033	3088	
a. Public electricity and heat production	3032	3310	3298	3353	3292	3013	3088	
b. Petroleum refining	NO	NO	NO	NO	NO	NO	NO	
c. Manufacture of solid fuels and other energy industries*	11	0	0	0	0	20	10	
CO2 (Gg)	3023	3023	3300	3342	3282	3023	3078	
CH4 (Gg)	0.12	0.12	0.13	0.13	0.13	0.12	0.12	
N2O (Gg)	0.02	0.02	0.03	0.03	0.03	0.02	0.02	

* Manufacturing of charcoal does take place in Cyprus but does not appear in the table as the fuel consumed is solid biomass. Oil and Gas Extraction appears for the first time in 2020.

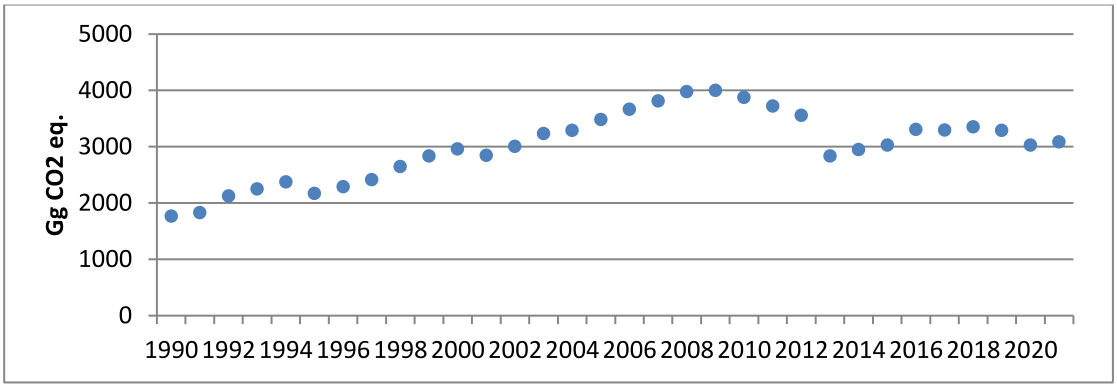

Figure 3.3. Energy industries emissions (1A1) 1990–2021

3.2.3.2. Methodological issues

Main activity electricity and heat production (1A1a)

The IPCC approach to the calculation of emission inventories encourages the use of fuel statistics collected by an officially recognised national body, as this is usually the most appropriate and accessible activity data. As already mentioned, there is only one electricity-producing company in Cyprus, therefore the fuel consumption for public electricity and heat production was obtained from this one company.

The fuel consumption data for all the years was obtained in kt. The fuel consumption data used for the years 1990–2004 is presented in Table 3.5. Fuel consumption for the period 1990–2004 was converted from kt to TJ using the NCV of 2005 (40.446 TJ/kt for HFO and 42.815 TJ/kt for diesel) which is the earliest available country specific NCV. The emissions for 1990–2004 were estimated using the implied emission factors derived from the annual report of the company for 2005 (earliest available) in compliance with the ETS law: 76.67 t CO_2/TJ HFO and 72.43 t CO_2/TJ diesel. The emission factor was multiplied with the fuel consumption of the respective fuel. This method and the EF are considered as country specific method, since it does not follow the methodologies proposed by the IPCC guidelines.

The estimation of country- or plant-specific EF for these years (1990–2004) is not possible since the necessary information is not available[26].

Table 3.5. Fuel consumption data obtained from the electricity production company in Cyprus (1990–2004)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Fuel consumption (kt)								
HFO	540.4	560.5	644.6	694.8	726.4	661.2	702.5	742.9
Diesel	0.0	0.0	10.5	3.5	2.0	8.2	5.9	5.8
Net calorific value (TJ/kt)*								
HFO	40.446	40.446	40.446	40.446	40.446	40.446	40.446	40.446
Diesel	42.815	42.815	42.815	42.815	42.815	42.815	42.815	42.815
CO_2 emissions (Gg)								
HFO	1675.8	1738.0	1999.0	2154.5	2252.6	2050.5	2178.5	2303.7
Diesel	0.0	0.0	32.62	10.79	6.09	25.45	18.39	17.83

	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	
Fuel consumption (kt)								
HFO	810.9	856.1	900.5	893.8	930.8	1000.3	1042.1	
Diesel	11.6	21.0	18.7	3.7	1.6	5.1	8.4	
Net calorific value (TJ/kt)*								
HFO	40.446	40.446	40.446	40.446	40.446	40.446	40.446	

[26] Information provided by Mr. George Platides, Assistant Generation Manager, Generation & Supply Business Unit | Generation Department, Electricity Authority of Cyprus | t: +357 22 201521 | m: +357 99 428064 | f: +357 22 201509 | georgeplatides@eac.com.cy.

Diesel	42.815	42.815	42.815	42.815	42.815	42.815	42.815	
CO_2 emissions (Gg)								
HFO	2514.8	2654.9	2792.5	2771.6	2886.5	3102.2	3231.6	
Diesel	35.91	64.97	57.89	11.48	4.91	15.73	26.14	

* NCV of 2005 data submitted through ETS.

Detailed data on fuel consumption and other parameters have been submitted annually by the installation since 2005, in compliance with the national Emissions Trading System law (110(I)/2011). The data collected through the ETS for the period 2005-2021 and used for the estimation of the emissions is presented in Table 3.6. For the years 2005-2015, the CO_2 emissions used are those reported by the installation in compliance with the ETS law.

Table 3.6. Data collected through the ETS for electricity production in Cyprus (2005-2021)

	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Fuel consumption (kt)								
HFO	1103.2	1137.3	1174.7	1218.5	1163.1	1053.0	1057.8	895.5
Diesel	16.3	6.9	16.0	22.9	91.9	157.5	111.7	213.9
Net calorific value (TJ/kt)*								
HFO	40.446	40.460	40.463	40.690	40.795	40.641	40.741	40.791
Diesel	42.815	42.821	42.806	42.598	42.660	42.938	42.714	42.715
CO_2 emissions (Gg)								
HFO	3421.2	3632.1	3751.9	3896.3	3707.6	3377.5	3373.4	2869.8
Diesel	50.60	21.28	49.72	70.98	284.84	490.53	336.65	676.13
Implied EF (Gg CO_2/TJ)								
HFO	76.672	78.935	78.938	78.582	78.141	78.919	78.274	78.562
Diesel	72.431	72.421	72.444	72.798	72.640	72.532	70.572	74.018

	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Fuel consumption (kt)								
HFO	649.3	793.3	857.9	882.7	777.9	804.3	770.9	602.5
Diesel	237.5	123.6	89.4	150.0	255.2	246.1	258.6	342.3
Net calorific value (TJ/kt)*								
HFO	40.613	40.691	40.880	40.646	40.632	40.559	40.630	40.688
Diesel	42.580	42.354	42.709	42.717	42.668	42.657	42.580	42.603
CO_2 emissions (Gg)								
HFO	2085.9	2553.1	2742.3	2828.1	2489.3	2570.7	2473.1	1935.4
Diesel	743.85	387.23	280.73	471.94	798.54	771.62	808.93	1068.31
Implied EF (Gg CO_2/TJ)								
HFO	79.098	79.089	78.196	78.827	78.753	78.807	78.95	78.95
Diesel	73.571	73.980	73.560	73.670	73.330	73.499	73.47	73.25

	2021							
Fuel consumption (kt)								
HFO	679.6							
Diesel	289.3							
Net calorific value (TJ/kt)*								
HFO	40.58							
Diesel	42.66							
CO_2 emissions (Gg)								
HFO	2176.3							
Diesel	901.37							
Implied EF (Gg CO_2/TJ)								
HFO	78.92							
Diesel	73.04							

* weighted average based on consumption

The overall implied emission factor for CO_2 emissions during the period 2005-2021 shows fluctuations that have been caused by (a) change in the consumption of each fuel; i.e. in years that more diesel is consumed the IEF reduces, while when more HFO consumed the IEF increases; (b) fluctuations in fuel quality and therefore NCV (whereas in previous years it is considered constant); (c) the age and efficiency of the electricity productions used.

Non-CO_2 emissions were estimated using the default EF proposed by the IPCC 2006 guidelines (vol.2, pg. 2.16); i.e. 3 kg CH_4 /TJ and 0.6 kg N_2O /TJ for both fuels.

Petroleum refining (1Ab)

Data for the consumption of fuel for petroleum refining was obtained from the National Statistical Service in kt (Table 3.7). No information is available on the characteristics of the consumption reported as other oil products. The fuel consumption was converted to TJ using the default NCVs of 40.4 TJ/kt RFO, 40.2 TJ/kt other oil product and 49.5 TJ/kt refinery gas which is the default proposed by the 2006 IPCC guidelines (vol.2, pg. 1.18). CO_2 emission factors are also the defaults proposed by the revised IPCC 2006 guidelines (vol. 2, pg. 2.16); i.e. 77.4 t CO_2/TJ RFO, 73.3 t CO_2/TJ other oil product and 57.6 t CO_2/TJ refinery gas.

Table 3.7. Fuel consumed for petroleum refining in Cyprus (1990–2004)

Fuel consumption (kt)	1990	1991	1992	1993	1994	1995	1996	1997
RFO	11	12	13	13	14	17	16	14
Other products	0	0	0	0	0	0	0	0
Refinery gas	18	17	17	13	24	13	12	16

	1998	1999	2000	2001	2002	2003	2004	
RFO	15	16	16	0	0	0	0	
Other products	0	0	0	0	16	16	0	
Refinery gas	16	20	19	19	21	21	9	

Non-CO_2 emissions were estimated using the default emission factors proposed by the IPCC 2006 guidelines for energy industries (vol. 2, pg. 2.16); i.e. 3 kg CH_4/TJ and 0.6 kg N_2O/TJ for RFO and other oil products and 1 kg CH_4/TJ and 0.1 kg N_2O/TJ for Refinery gas.

Manufacture of Solid Fuels and Other energy industries (1A1c)

The solid fuel produced in Cyprus is charcoal. The amount of wood (biomass) consumed for the production of charcoal is obtained by the Statistical Service (national energy balance) in TJ and is presented in Table 3.8. Table 3.8 also presents the amount of charcoal produced (TJ) and the conversion efficiency.

Emissions are estimated using the T1 methodology and the default EF proposed by the IPCC 2006 guidelines for wood (vol.2, pg. 2.17): 112000 kg CO_2/TJ, 30 kg CH_4/TJ and 4 kg N_2O/TJ. This is the first time the emissions from this category are estimated and presented.

Table 3.8. Solid biomass consumed for the production of charcoal

	1990	1991	1992	1993	1994	1995	1996
Solid biomass (TJ)	112	112	112	112	405	388	328
Charcoal produced (TJ)	29.5	29.5	29.5	29.5	147.5	118	118
Conversion efficiency	26.34%	26.34%	26.34%	26.34%	36.42%	30.41%	35.98%

	1997	1998	1999	2000	2001	2002	2003
Solid biomass (TJ)	288	314	281	248	253	235	209
Charcoal produced (TJ)	88.5	118	118	88.5	88.5	88.5	88.5
Conversion efficiency	30.73%	37.58%	41.99%	35.69%	34.98%	37.66%	42.34%

	2004	2005	2006	2007	2008	2009	2010
Solid biomass (TJ)	184	174	135	274	211	47	48
Charcoal produced (TJ)	59.0	59.0	59.0	118	88.5	29.5	29.5
Conversion efficiency	32.07%	33.91%	43.70%	43.07%	41.94%	62.77%	61.46%

	2011	2012	2013	2014	2015	2016	2017
Solid biomass (TJ)	45	82	71	58	94	163	172
Charcoal produced (TJ)	29.5	29.5	29.5	29.5	29.5	59.0	73.5
Conversion efficiency	65.56%	35.98%	41.55%	50.86%	31.38%	36.20%	42.75%
	2018	**2019**	**2020**	**2021**			
Solid biomass (TJ)	112	93	80	91			
Charcoal produced (TJ)	47.7	39.8	34.2	38.7			
Conversion efficiency	42.75%	42.75%	42.7%	42.8%			

Oil and Gas Extraction(1A1cii)

Diesel consumption for Oil and Gas extraction was reported for the first time in 2020. The consumption includes technical support for the extraction. It does not include the extraction itself. The are no emissions related to transmission or pipeline leakage since the transport of the extracted oil and gas did not start yet.

Emissions are estimated using the T1 methodology and the default EF proposed by the IPCC 2006 for guidelines for diesel-oil consumption (vol.2, pg. 2.18): 74100 kg CO_2/TJ, 3 kg CH_4/TJ and 0.6 kg N_2O/TJ. The consumption for 2020 was 261.5 TJ. There was no activity reported for 2021.

3.2.3.3. Uncertainties and time-series consistency

In general, the uncertainty of emissions from the stationary combustion sector is relatively small. The uncertainty associated with activity data (i.e. fuel consumption) is less than 5%, since the AD are obtained from the national energy balance and are cross-checked with data from other sources (e.g. plant specific data). On the other hand, the uncertainty associated with emission factors is also very low for the case of CO_2, less than 5%, since plant and country specific EFs are mainly applied. For the case of CH_4 and N_2O EFs, the uncertainty is higher, about 100 and 300% respectively, since IPCC defaults emission factors per technology/activity are applied. The results of the uncertainty analysis are presented in Table 1.9. The detailed calculations of uncertainty are presented in Annex 2.

The time-series consistency of emissions is controlled by applying consistent methodologies and verified activity data in-line with IPCC guidelines. In case of changes or refinements in methodologies and EFs based on plant-specific data, e.g. from the European Union emissions trading scheme (EU ETS) reports, time-series consistency is ensured by performing recalculations according to the IPCC good practice guidance, if sufficient data is available.

3.2.3.4. Category-specific QA/QC and verification

The following source-specific QC procedures are applied to the stationary combustion sector. These procedures are based on the plant-specific data that become available through the ETS reports. It should be mentioned that ETS reports have been both verified by external verification bodies and reviewed by the competent authorities of the Department of Environment.

1. Activity data comparison: Cross-checking between energy consumption data derived from the national energy balance and plant-specific energy consumption data of major industrial plants derived from verified ETS reports is performed. The findings of the above quality check are communicated to the competent department of Department of Environment. In this way both the national energy balance and the energy consumption used in emission calculations are verified and improved.

2. Emissions comparison: Verified ETS reports were used for the computation of plant-specific CO_2 EFs and NCVs. For quality control purposes emissions calculated by applying plant-specific EFs and NCVs are compared with the emissions calculated by using IPCC default EFs and NCVs.

3.2.3.5. Category-specific recalculations

No recalculations to report.

3.2.3.6. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

3.2.4. Manufacturing industries and construction (1A2)

3.2.4.1. Category description

Emissions from energy consumption for the production of steam and process heat are mainly reported under Manufacturing industry and construction.

Even though the shock inflicted on the manufacturing sector by the Turkish invasion of 1974 was severe, recovery during the period 1975-1983 was remarkable. By 2002 the sector accounted for about 10% of GDP and 12% of employment. However, during the past decade, the manufacturing industry of Cyprus has been going through difficult times, experiencing a fall in the growth of production, exports and employment. This development is the result of erosion in competitiveness, both abroad and in the local market, at a time of increasingly intensified, international competition. At the root of these problems lie the structural weaknesses of the sector, the drastic reduction of tariff protection due to the participation of Cyprus in the World Trade Organization, the rising labour costs and low productivity. As a result the share of the manufacturing sector in the Gross Domestic Product and in employment remained stagnant. International competition is increasingly intensified mainly from two directions: the high-wage producers, who have combined design, quality and new forms of flexible production to cut working and capital costs and improve response times; and the low-wage mass producers of South-East Asia. The main industrial activities that take place in Cyprus are food and beverage processing, cement and gypsum production, light chemicals (predominately pharmaceuticals), metal and wood products.

The GHG emissions caused by energy consumption in manufacturing industries and construction in 2021 were 530.62 Gg CO_2 eq. The total GHG emissions from manufacturing industries and construction in 2021 increased by 5.1% compared to 1990. There is no available information to explain the large change in emissions between 1990 and 1991. The emissions from manufacturing industries and construction 1990–2021 are presented in Figure 3.4 and Table 3.9.

Table 3.9. Emissions from manufacturing industries and construction 1990–2021

Gg CO_2 eq.	**1990**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**
2. Manufacturing industries and construction	505	802	912	700	575	460	540	696
a. Iron and steel	IE	IE	IE	IE	IE	IE	IE	IE
b. Non-ferrous metals	5	7	7	5	5	6	NO	NO
c. Chemicals	2	4	4	2	2	3	NO	3
d. Pulp, paper and print	5	9	5	4	6	4	3	3
e. Food processing, beverages and tobacco	73	131	82	60	95	53	43	44
f. Non-metallic minerals	382	482	577	726	556	390	334	443
g. Other	48	98	93	89	74	76	61	51
CO_2 (Gg)	512	771	819	697	572	459	538	693
CH_4 (Gg)	0.04	0.03	0.04	0.05	0.03	0.02	0.02	0.04
N_2O (Gg)	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
Gg CO_2 eq.	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
2. Manufacturing industries and construction	604	600	621	555	566	561	531	
a. Iron and steel	IE	IE	IE	IE	IE	0	NO	
b. Non-ferrous metals	3	6	2	2	2	3	3	
c. Chemicals	6	6	7	8	8	8	7	
d. Pulp, paper and print	3	3	3	3	3	3	3	
e. Food processing, beverages and tobacco	56	50	71	66	67	62	64	

f. Non-metallic minerals	491	483	478	425	419	426	394	
g. Other	45	51	60	52	67	59	59	
CO_2 (Gg)	600	596	616	550	560	554	522	
CH_4 (Gg)	0.05	0.05	0.07	0.09	0.09	0.11	0.13	
N_2O (Gg)	0.01	0.01	0.01	0.01	0.01	0.01	0.02	

3.2.4.2. Methodological issues

Data

The data used to estimate the emissions for the industrial activities from energy consumption in manufacturing industries and construction 1990–2021 is presented in Table 3.10. Consumption for Iron and steel (1A2a) was included in Non-ferrous metals (1A2b) until last 2019. It has reported separately for the first time for 2020. Biodiesel consumption is included for the first time in 2020 There was no consumption in 2021. Consumption for Autoproducer electricity plants and CHP plants is included in Non-specified Industry (1A2m). Additionally, any revisions in fuel consumption are indicated with red and any new sectors introduced are indicated with green.

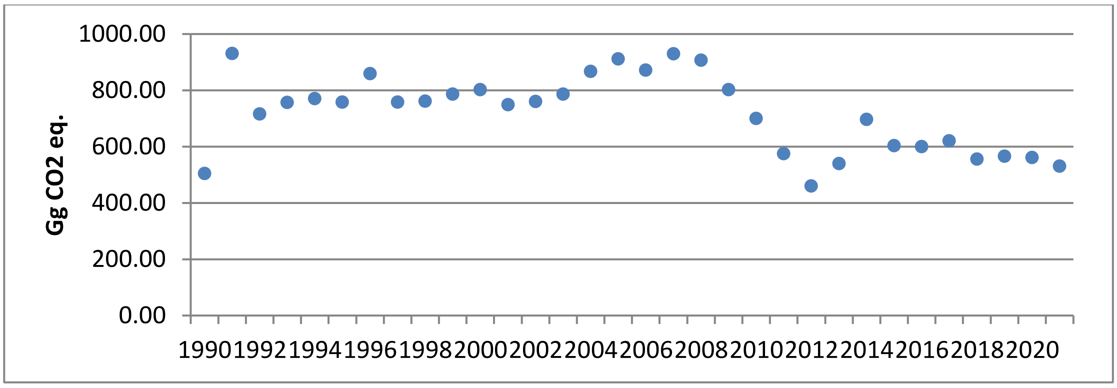

Figure 3.4. Emissions from energy use in manufacturing industries and construction (1A2) 1990–2021

Data for other bituminous coal in source category 1A2f for the years 2005-2020 is from reports submitted for ETS purposes by the cement installations. Waste (non-renewable) in source category 1A2f includes both industrial and municipal waste.

Table 3.10. Fuel consumption in manufacturing industries and construction 1990–2021
(a) 1990-2003

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1A2b Non-ferrous metals														
LPG (kt)	0.9	0.9	1.0	0.9	0.9	0.9	0.9	1.0	0.9	0.9	1.0	1.0	1.0	1.1
Diesel/gasoil (kt)	0.7	0.8	0.9	1.0	1.0	1.1	1.1	1.2	1.3	1.3	1.3	1.4	1.3	1.3
1A2c Chemical and petrochemical														
RFO (kt)														
Diesel/gasoil (kt)	0.7	0.8	0.9	1.0	1.0	1.1	1.1	1.2	1.3	1.3	1.3	1.4	1.3	1.3
Solid biofuels (TJ)														
1A2d Paper, pulp and printing														
RFO (kt)	1.5	5.2	4.9	4.2	4.6	4.0	4.6	2.9	2.8	2.8	2.9	2.3	2.3	2.6
1A2e Food, beverages and tobacco														
Diesel/gasoil (kt)	2.1	2.3	2.8	2.9	3.0	3.2	3.4	3.6	3.8	3.9	4.0	4.1	3.9	4.0
RFO (kt)	18.5	62.0	59.0	50.0	55.0	48.5	55.5	35.0	34.0	34.0	35.0	27.0	27.5	31.0
LPG (kt)	2.7	2.7	3.1	2.8	2.8	2.8	2.8	2.9	2.8	2.7	2.9	2.9	3.0	3.2
Solid biofuels (TJ)														
1A2f Non-Metallic Minerals														
Pet-coke (kt)	40.0	93.0	85.0	114.0	112.0	125.0	147.0	152.0	150.0	154.0	141.0	133.0	139.0	137.0
RFO (kt)	9.3	31.0	29.5	25.0	27.5	24.3	27.8	17.5	17.0	17.0	17.5	13.5	13.8	15.5
diesel (kt)	2.1	2.3	2.8	2.9	3.0	3.2	3.4	3.6	3.8	3.9	4.0	4.1	3.9	4.0
LPG (kt)	0.9	0.9	1.0	0.9	0.9	0.9	0.9	1.0	0.9	0.9	1.0	1.0	1.0	1.1
Other bituminous coal (kt)	97.0	97.0	26.0	31.0	27.0	20.0	18.0	19.0	26.0	30.0	49.0	53.0	53.0	53.0
Solid biomass (TJ)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.0	70.0	90.0	211.0
Waste (non-renewable) (TJ)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.0	0.0	15.0
1A2i Mining and Quarrying														
Diesel (kt)	3	4	5	5	5	5	6	6	6	7	7	7	7	7
1A2k Construction														
Diesel (kt)	3	4	5	5	5	5	6	6	6	7	7	7	7	7
RFO (kt)														
1A2m Non-specified Industry														
Diesel (kt)	2.1	2.3	2.8	2.9	3.0	3.2	3.4	3.6	3.8	3.9	4.0	4.1	3.9	4.0
RFO (kt)	6.2	20.7	19.7	16.7	18.3	16.2	18.5	11.7	11.3	11.3	11.7	9.0	9.2	12.3
Other oil products (kt)	0.0	5.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
White spirit (kt)	0.0	0.0	0.0	1.0	0.0	1.0	1.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0
Other kerosene (kt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LPG (kt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

(b) 2004-2020

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1A2a Iron and Steel																		
Diesel/gasoil(kt)																0.003	0.007	0.0
1A2b Non-ferrous metals																		
LPG (kt)	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	NO	NO	1.0	1.0	0.569	0.594	0.658	0.764	0.758
Diesel/gasoil (kt)	1.2	1.1	1.1	1.0	0.9	0.9	0.7	0.8	1.0	NO	NO	NO	1.0	0.15	0.13	0.059	0.318	0.152
Biodiesel (kt)																	0.001	0.001
1A2c Chemical and petrochemical																		
LPG (kt)														0.21	0.22	0.24	0.29	0.27
RFO (kt)												1.0	1.0	0.775	1.235	0.979	0.95	0.37
Diesel/gasoil (kt)	1.2	1.1	1.1	1.0	0.9	0.9	0.7	0.8	1.0	NO	1.0	1.0	1.0	1.143	1.036	1.377	1.24	1.5
Solid biofuels (TJ)											42	52	21	21.6	18	18	14	11
Biodiesel (kt)																	0.03	0.03
1A2d Paper, pulp and printing																		
LPG (kt)														0.285	0.297	0.329	0.142	0.125
RFO (kt)	2.8	1.6	1.1	1.6	1.5	1.0	1.2	2.0	1.1	1.0	1.0	1.0	1.0	0.57	0.52	0.492	0.674	0.811
Diesel/gasoil (kt)														0.03	0.03	0.172	0.183	0.181
Biodiesel (kt)																	0.001	0.001
1A2e Food, beverages and tobacco																		
Diesel/gasoil	3.6	3.4	3.4	2.9	2.6	2.6	2.0	2.3	3.0	2.0	2.0	4.0	3.0	4.863	4.012	4.278	4.171	5.18
RFO	34.0	19.8	13.4	19.1	17.6	12.0	14.1	24.0	9.0	8.0	8.0	9.0	9.0	12.45	11.34	10.72	10.09	10.13
LPG	3.1	2.9	3.0	3.0	3.0	3.0	3.0	4.0	5.0	4.0	4.0	5.0	4.0	5.515	5.757	6.372	5.716	5.29
Solid biofuels (TJ)											44	7	36	50.15	67.19	99.15	68.94	47.65
Biogases (TJ)														0.03	0.23	0.093	0.012	0.006
Other kerosene														1.314	1.01	4.073	0.525	0.263
Biodiesel (kt)																	0.004	0.006
1A2f Non-Metallic Minerals																		
Pet-coke (kt)	146.0	154.0	146.0	143.0	152.0	144.0	116.0	100.0	94.0	135.0	162.0	128.0	123.0	108.7	74.5	55.6	62.7	12.59
RFO (kt)	17.0	37.0	35.0	38.0	38.0	30.0	25.0	15.0	13.0	8.0	7.0	8.0	10.0	10.0	14.5	15.4	13.4	12.52
diesel (kt)	3.6	3.4	3.4	2.9	2.6	2.6	2.0	2.3	3.0	1.0	1.0	2.0	2.0	0.8	1.4	1.8	2.7	4.86
LPG (kt)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	0.4	0.4	0.7	0.7
other bituminous coal (kt)	57.0	54.7	54.3	49.5	44.6	23.5	27.4	12.3	0.0	0.0	4.2	6.0	0.8	5.1	22.6	27.7	22.4	66.4
Other kerosene (kt)														0.061	0.047	0.018	0.02	0
Solid biomass (TJ)	127.00	38.00	61.00	133.00	281.00	304.00	347.00	306.00	29.00	28.00	116.00	95.00	55.00	85.51	78.36	126.1	204.9	279.3
Waste (non-renewable) (TJ)	71.0	138.0	73.0	288.0	239.0	276.0	299.0	56.2	24.0	45.0	316.0	516.0	663.0	837.5	961.1	1289	1457	1692
Waste (biomass fraction) (TJ)									88.0	150.0	161.0	325.0	427.0	752.0	1156.7	937.8	1377	1481
Biodiesel (kt)																	0.095	0.219
1A2j Wood and wood products																		

LPG (kt)														0.003	0.003	0.003	0.006	0.01
Diesel/gasoil kt)														0.025	0.023	0.025	0.03	0.047
Biodiesel (kt)																	0.001	0.001
1A2i Mining and Quarrying																		
Diesel (kt)	6	6	6	5	4	4	3	4	5	2	1	3	2	3.75	3.66	7.08	4.95	5.64
RFO (kt)														0.12	0.11	0	0	0
Other Kerosene (kt)																	0.111	0
Biodiesel (kt)																	0.298	0.245
1A2g Transport Equipment																		
Diesel (kt)														0.005	0.006	0.001	0.001	0.001
1A2h Machinery																		
LPG (kt)														0.082	0.086	0.095	0.26	0.206
Diesel/Gasoil (kt)														0.257	0.224	0.248	0.278	0.272
RFO (kt)														0.117	0.107	0.101	0	0
Biodiesel (kt)																	0.008	0.001
1A2k Construction																		
Diesel (kt)	6	6	6	5	4	4	3	4	5	5	6	6	7	8.845	7.17	8.334	7.751	8.655
RFO (kt)									1.0	1.0	3.0	2.0	3	2.42	2.2	2.086	1.94	0.507
1A2l Textiles and Leather																		
Diesel (kt)														0.027	0.023	0.018	0.017	0.01
Biodiesel (kt)																	0.001	0
1A2m Non-specified Industry																		
Diesel (kt)	3.6	3.4	3.4	3.9	2.6	2.6	2.0	4.3	5.0	3.0	2.0	2.0	2.0	1.852	2.18	2.24	2.05	2.399
RFO (kt)	16.3	12.6	11.5	24.4	20.9	17.0	14.7	12.0	3.0	5.0	7.0	1.0	2.0	1.287	0.44	0.449	0.987	0.582
Other oil products (kt)	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
White spirit (kt)	0.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other kerosene (kt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2	0.0	0.0	0.007	0.005	0.005	0.002	0.0
LPG (kt)	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.23	0.24	0.26	0.14	0.13
Biodiesel (kt)																	0.003	0.002

Methodology

The emissions from energy use in manufacturing industries and construction were estimated using predominately the IPCC 2006 guidelines. Details for each industrial activity are presented below.

Iron and Steel (1A2a)

The liquid fuels consumed for iron and steel is Gas-Diesel oil. From 1990-2018 it is included in 1A2b and is reported separately for the first time for 2019, 2020 and 2021. Fuel consumption was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 3.11). The CO_2, CH_4 and N_2O emissions were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.18); i.e. 74100 kg CO_2/TJ, 3 kg CH_4/TJ and 0.6 kg N_2O/TJ.

Non-ferrous metals (1A2b)

The liquid fuels consumed by non-ferrous metals are LPG and Gas-Diesel oil (Table 3.10). Fuel consumption was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 3.11). The CO_2, CH_4 and N_2O emissions were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.18); i.e. 63100 kg CO_2/TJ, 1 kg CH_4/TJ and 0.1 kg N_2O/TJ for LPG and 74100 kg CO_2/TJ, 3 kg CH_4/TJ and 0.6 kg N_2O/TJ for Gas-Diesel oil.

Biodiesel consumption was reported for the first time in 2020 for this category.Biofuels in Cyprus are 100% FAME. Emissions from the fossil part of the fuel have been calculated as follows : The default total carbon content has been used 76.5% kgC/kgFAME , as well as 5,4% of carbon content fossil part. The CH_4 and N_2O emissions have been been calculated using the EFs proposed by the 2006 IPCC Guidelines, i.e. 3.8 kg CH_4/TJ and 5.7 kg N_2O/TJ for both fossil and biogenic parts.

Even though activity for Non-ferrous metals has been reported as 'NO' for 2013 and 2014, operation of the installations continued during those years with the use of other energy sources, i.e. electricity from the main supply.

Chemicals (1A2c)

According to the energy balance, gas-diesel oil, LPG, RFO, biodiesel and solid biomass are consumed by chemical industries (Table 3.10). Fuel consumption was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 3.11). The CO_2, CH_4 and N_2O emissions from all fuels were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.18); i.e. 74100 kg CO_2/TJ, 3 kg CH_4/TJ and 0.6 kg N_2O/TJ for gas-diesel oil, 63100 kg CO_2/TJ, 1 kg CH_4/TJ and 0.1 kg N_2O/TJ for LPG and 77400 kg CO_2/TJ, 3 kg CH_4/TJ and 0.6 kg N_2O/TJ for RFO. Consumption of solid biomass is reported for the first time in 2014. The CO_2, CH_4 and N_2O emissions from solid biomass were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.19); i.e. 100000 kg CO_2/TJ, 30 kg CH_4/TJ and 4 kg N_2O/TJ. For 2013, the emissions are reported as "NO". There was some potential consumption of liquid fuels by chemical industries, but due to the number formats and the rounding of the values in the energy balance the consumption appears as 0. Biodiesel consumption was reported for the first time in 2020 for this category.Biofuels in Cyprus are 100% FAME. Emissions from the fossil part of the fuel have been calculated as follows : The default total carbon content has been used 76.5% kgC/kgFAME , as well as 5,4% of carbon content fossil part. The CH_4 and N_2O emissions have been been calculated using the EFs proposed by the 2006 IPCC Guidelines, i.e. 3.8 kg CH_4/TJ and 5.7 kg N_2O/TJ for both fossil and biogenic parts.

Pulp, Paper and Print (1A2d)

Fuel consumption for this category was reported for the first time in the 2014 energy balance. However, the activity did take place in previous years. Therefore, assumptions have been made to estimate the fuel consumption of the category (see previous Section) for the complete period. Consumption of RFO was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 3.11).The CO_2, CH_4 and N_2O emissions from RFO were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.18); i.e. 77400 kg CO_2/TJ, 3 kg CH_4/TJ and 0.6 kg N_2O/TJ.

According to the energy balance LPG and Diesel were also consumed by pulp, paper and print for the first time in 2017. Fuel consumption was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 3.11). The CO_2, CH_4 and N_2O emissions from all fuels were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.18); i.e. 74100 kg CO_2/TJ, 3 kg CH_4/TJ and 0.6 kg N_2O/TJ for gas-diesel oil, 63100 kg CO_2/TJ, 1 kg CH_4/TJ and 0.1 kg N_2O/TJ for LPG.Biodiesel consumption was reported for the first time in 2020 for this category.Biofuels in Cyprus are 100% FAME. Emissions from the fossil part of the fuel have been calculated as follows : The default total carbon content has been used 76.5% kgC/kgFAME , as well as 5,4% of carbon content fossil part. The CH_4 and N_2O emissions have been been calculated using the EFs proposed by the 2006 IPCC Guidelines, i.e. 3.8 kg CH_4/TJ and 5.7 kg N_2O/TJ for both fossil and biogenic parts.

Food processing, beverages and tobacco (1A2e)

According to the energy balance, the fuels consumed by food processing, beverages and tobacco industries are LPG, gas-diesel, RFO and other kerosene (Table 3.10). Fuel consumption was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 3.11). The CO_2, CH_4 and N_2O emissions were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.18); i.e. 63100 kg CO_2/TJ, 1 kg CH_4/TJ and 0.1 kg N_2O/TJ for LPG, 74100 kg CO_2/TJ, 3 kg CH_4/TJ, 0.6 kg N_2O/TJ for Gas-Diesel oil, 77400 kg CO_2/TJ, 3 kg CH_4/TJ, 0.6 kg N_2O/TJ for RFO and 71900 kg CO_2/TJ, 3 kg CH_4/TJ and 0.6 kg N_2O/TJ for other kerosene. Consumption of solid biomass was reported for the first time in 2014.The CO_2, CH_4 and N_2O emissions from solid biomass were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.19); i.e. 100000 kg CO_2/TJ, 30 kg CH_4/TJ and 4 kg N_2O/TJ. Consumption of gas biomass was reported for the first time in 2009.The CO_2, CH_4 and N_2O emissions from gas biomass were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.19) assuming other biogas; i.e. 54600 kg CO_2/TJ, 1 kg CH_4/TJ and 0.1 kg N_2O/TJ. Biodiesel consumption was reported for the first time in 2020:Default total carbon content has been used 76.5% kgC/kgFAME , as well as 5,4% of carbon content fossil part. The CH_4 and N_2O emissions have been been calculated using the EFs proposed by the 2006 IPCC Guidelines, i.e. 3.8 kg CH_4/TJ and 5.7 kg N_2O/TJ for both fossil and biogenic parts.

Non-metallic minerals (1A2f)

According to the energy balance, the non-metallic minerals industries consume LPG, gas-diesel oil, RFO, other kerosene, pet-coke, other bituminous coal, solid biomass, biodiesel and municipal and industrial waste (non-renewable), as well as biomass fraction of waste (renewable) (Table 3.10). RFO consumption for 1990–2004 has been revised due to the addition of Pulp, Paper and Print industries.

All liquid fuel consumption (LPG, gas-diesel oil, RFO, other kerosene and pet-coke) was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 3.11). Pet-coke is consumed only by two cement producing installations during 1990-2011, which merged into one in 2011. These installations have been submitting annual emissions' report according to the requirements of the ETS law 110(I)/2011, since 2005. The CO_2 emissions from pet-coke for the period 2005- 2015 were used as reported for the ETS. CO_2 emissions for the period 1990–2004 were estimated using the IEF of 2005, resulting from the division of CO_2 emissions by the TJ fuel consumed (84.51 t CO_2/TJ). CH_4 and N_2O emissions for fuels were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.18); i.e. 3 kg CH_4/TJ and 0.6 kg N_2O/TJ for gas-diesel oil, RFO and pet-coke and 1 kg CH_4/TJ and 0.1 kg N_2O/TJ for LPG. Most liquid fuel consumption was accounted for by petroleum coke, whose default CO_2 EF of 97.5 t CO_2/TJ in the 2006 IPCC Guidelines (vol. 2, chap. 2) and this explains the high CO_2 IEF (FCCC/ARR/2020/CYP/E.8).

Other bituminous coal was consumed during the period 1990-2011 by only one cement-producing installation, which has been submitting annual emissions' report according to the requirements of the ETS law 110(I)/2011, since 2005. The new installation (after 2011) consumed other bituminous coal in 2014 and 2015. Fuel consumption for the period 2005-2015 was obtained in TJ from the annual ETS reports. Fuel consumption for the period 1990–2004 was converted to TJ with the NCV of the first ETS report submitted (i.e. 2005), which was 29.824 TJ/kt. The CO_2 emissions from other bituminous coal for the period 2005-2013 were used as reported for the ETS. CO_2 emissions for the period 1990–2004 were estimated using the IEF of 2005, resulting from the division of CO_2 emissions by the TJ fuel consumed (92.60 t CO_2/TJ). CH_4 and N_2O emissions for other bituminous coal were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.18); i.e. 10 kg CH_4/TJ and 1.5 kg N_2O/TJ.

Solid biomass data was available in TJ. Solid biomass is consumed by only one cement-producing installation, which has been submitting an annual emissions report since 2005, in accordance with the requirements of the ETS law 110(I)2011. The CO_2 emissions from solid biomass for the period 2005-2016 were used as reported for the ETS. CO_2, CH_4 and N_2O emissions for solid biomass were estimated using the default emission factors proposed by the IPCC 2006 guidelines for "other primary solid biomass" (volume 2, pg. 2.19); i.e. 100000 kg CO_2/TJ, 30 kg CH_4/TJ and 4 kg N_2O/TJ.

Non-renewable waste (industrial waste) data was available in TJ. Non-renewable waste is consumed by only one cement-producing installation, which has been submitting an annual emissions report since 2005, in accordance with the requirements of the ETS law 110(I)2011. The CO_2, CH_4 and N_2O emissions for non-renewable industrial waste were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.19); i.e. 143000 kg CO_2/TJ, 30 kg CH_4/TJ and 4 kg N_2O/TJ. In the industrial waste category we report the non-biomass fraction of biomass incinerated; i.e. sewage sludge, tires, ASF, MBM and compost. The waste is incinerated for production of thermal energy in the furnace which burns the raw material to produce the cement. The non-renewable municipal waste was estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.19); i.e. 91700 kg CO_2/TJ, 30 kg CH_4/TJ and 4 kg N_2O/TJ. The municipal waste (biomass fraction) emissions were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.19); i.e. 100000 kg CO_2/TJ, 30 kg CH_4/TJ and 4 kg N_2O/TJ.

Biodiesel consumption was reported for the first time in 2020:Default total carbon content has been used 76.5% kgC/kgFAME , as well as 5,4% of carbon content fossil part. The CH_4 and N_2O emissions have been been calculated using the EFs proposed by the 2006 IPCC Guidelines, i.e. 3.8 kg CH_4/TJ and 5.7 kg N_2O/TJ for both fossil and biogenic parts.

Transport Equipment (1A2g)

According to the energy balance, transport equipment consume diesel (Table 3.10). Fuel consumption in the energy balance was reported for the first time in 2017 and has been desegregated for the 2020 submission. Fuel consumption was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 3.11.). CO_2, CH_4 and N_2O emissions were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.18); i.e. 74100kg CO_2/TJ, 3 kg CH_4/TJ and 0.6 kg N_2O/TJ.

Machinery (1A2h)

According to the energy balance, machinery consume diesel, LPG and RFO (Table 3.10). Fuel consumption in the energy balance was reported for the first time in 2017 and has been desegregated for the 2020 submission. Fuel consumption was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 3.11.). CO_2, CH_4 and N_2O emissions were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.18); i.e. 74100kg CO_2/TJ, 3 kg CH_4/TJ and 0.6 kg N_2O/TJ for diesel oil, 63100kg CO_2/TJ, 1 kg CH_4/TJ and 0.1 kg N_2O/TJ for LPG and 77400kg CO_2/TJ, 3 kg CH_4/TJ and 0.6 kg N_2O/TJ . Biodiesel consumption was reported for the first time in 2020:Default total carbon content has been used 76.5% kgC/kgFAME , as well as 5,4% of carbon content fossil part. The CH_4 and N_2O emissions have been been calculated using the EFs proposed by the 2006 IPCC Guidelines, i.e. 3.8 kg CH_4/TJ and 5.7 kg N_2O/TJ for both fossil and biogenic parts.

Mining (excluding fuels) and Quarrying (1A2i)

According to the energy balance, mining and quarrying industries consume diesel. RFO and for the first time in 2021 other Kerosene. (Table 3.10). Fuel consumption was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 3.11.). CO_2, CH_4 and N_2O emissions were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.18); i.e. 74100kg CO_2/TJ, 3 kg CH_4/TJ and 0.6 kg N_2O/TJ for gas – diesel oil, 77400 kg CO_2/TJ, 3 kg CH_4/TJ and 0.6 kg N_2O/TJ for RFO and 71900 kg CO_2/TJ, 3 kg CH_4/TJ and 0.6 kg N_2O/TJ for Other Kerosene. Biodiesel consumption was reported for the first time in 2020:Default total carbon content has been used 76.5% kgC/kgFAME , as well as 5,4% of carbon content fossil part. The CH_4 and N_2O emissions have been

been calculated using the EFs proposed by the 2006 IPCC Guidelines, i.e. 3.8 kg CH_4/TJ and 5.7 kg N_2O/TJ for both fossil and biogenic parts.

Wood and wood products (1A2j)

Fuel consumption for this category was reported for the first time in 2017 in the energy balance. Wood and wood products consume diesel oil and LPG and biodiesel. Fuel consumption was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 3.11.). CO_2, CH_4 and N_2O emissions were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.18); i.e. 74100kg CO_2/TJ, 3 kg CH_4/TJ and 0.6 kg N_2O/TJ for diesel oil and 63100kg CO_2/TJ, 1 kg CH_4/TJ and 0.1 kg N_2O/TJ for LPG. Biodiesel consumption was reported for the first time in 2020:Default total carbon content has been used 76.5% kgC/kgFAME , as well as 5,4% of carbon content fossil part. The CH_4 and N_2O emissions have been been calculated using the EFs proposed by the 2006 IPCC Guidelines, i.e. 3.8 kg CH_4/TJ and 5.7 kg N_2O/TJ for both fossil and biogenic parts.

Construction (1A2k)

According to the energy balance, construction industries consume only diesel (Table 3.10). Fuel consumption was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 3.11). CO_2, CH_4 and N_2O emissions were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.18); i.e. 74100kg CO_2/TJ, 3 kg CH_4/TJ and 0.6 kg N_2O/TJ for gas – diesel oil.

Textile and Leather (1A2l)

According to the energy balance, Textile and Leather industries consume biodiesel and diesel oil: Diesel oil was reported for the first time in 2017. (Table 3.10). Fuel consumption was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 3.11). CO_2, CH_4 and N_2O emissions were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.18); i.e. 74100kg CO_2/TJ, 3 kg CH_4/TJ and 0.6 kg N_2O/TJ. Biodiesel consumption was reported for the first time in 2020:Default total carbon content has been used 76.5% kgC/kgFAME , as well as 5,4% of carbon content fossil part. The CH_4 and N_2O emissions have been been calculated using the EFs proposed by the 2006 IPCC Guidelines, i.e. 3.8 kg CH_4/TJ and 5.7 kg N_2O/TJ for both fossil and biogenic parts.

Non-specified Industry (1A2m)

According to the energy balance, the fuels consumed by Non-specified industries are gas-diesel oil, RFO, other oil products and white spirit and biodiesel.(Table 3.10). Other kerosene has been consumed in 2014, 2017 and 2018 by the gas exploration platforms. RFO consumption for 1990-2014 has been revised due to the addition of Pulp, Paper and Print industries. Gas-diesel oil consumption for 2017 has been revised due to the addition of Transport Equipment, Machinery, Wood and wood products, and Textile and leather industries. Fuel consumption was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 3.11). The CO_2, CH_4 and N_2O emissions were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.18); i.e. 74100 kg CO_2/TJ for Gas-Diesel oil, 77400 kg CO_2/TJ for RFO, 71900 kg CO_2/TJ for other kerosene, 73300 kg CO_2/TJ for white spirit and other oil products. The emission factors for CH_4 and N_2O are 3 kg CH_4/TJ, 0.6 kg N_2O/TJ for all fuels. Biodiesel consumption was reported for the first time in 2020:Default total carbon content has been used 76.5% kgC/kgFAME , as well as 5,4% of carbon content fossil part. The CH_4 and N_2O emissions have been been calculated using the EFs proposed by the 2006 IPCC Guidelines, i.e. 3.8 kg CH_4/TJ and 5.7 kg N_2O/TJ for both fossil and biogenic parts.

Table 3.11. Parameters used for the estimation of emissions

	NCV (TJ/kt)	IEF (tCO_2/TJ)*
Gas-diesel oil	43.0	
RFO	40.4	
Other oil products	40.2	
White spirit	40.2	
Pet-coke	32.5	84.505
LPG	47.3	

	NCV (TJ/kt)	IEF (tCO_2/TJ)*
Other kerosene	43.8	
Other bituminous coal	25.8	92.600
Biodiesel	37.0	

* based on the ETS 2005 report; used for the years 1990–2004

3.2.4.3. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

3.2.4.4. Category-specific QA/QC and verification

Fuel consumption data for 1A2f is compared between data from the Department of Labour Inspection, the ETS and the Statistical Service.

3.2.4.5. Category-specific recalculations

Recalculations have been carried out for 2020, as mentioned also by the TERT (CY-1A2-2023-0002) for almost all subcategories due to updated activity data in the energy balance and due to the addition of biodiesel, reported for the first time this year with first consumption in 2020. The recommendation CY-1A2g-2022-0001 has also been implemented. The impacts are presented in the Table 3.12.

Table 3.12. Recalculations 1A2 Manufacturing industries and construction (2020)

Gg CO_2 eq.	1A2b	1A2c	1A2d	1A2e	1A2f	1A2g
NIR 2023	3.30	7.83	3.12	62.24	425.95	59.03
NIR 2022	3.30	7.93	3.13	62.24	438.03	408.19
Change(%)	-0.01	-1.28	-0.09	0.002	-2.83	-591.5

3.2.4.6. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

3.2.5. Transport (1A3)

3.2.5.1. Category description

The activity category of transport should include emissions from the combustion and evaporation of fuel for all transport activity (excluding military transport), regardless of the sector, specified by sub-categories below. Emissions from fuel sold to any air or marine vessel engaged in international transport (1 A 3 a i and 1 A 3 d i) should, as far as possible, be excluded from the totals and subtotals in this category and should be reported separately.

Mobile sources produce direct greenhouse gas emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) from the combustion of various fuel types, as well as several other pollutants such as carbon monoxide (CO), Non-methane Volatile Organic Compounds (NMVOCs), sulphur dioxide (SO_2), particulate matter (PM) and oxides of nitrate (NO_x), which cause or contribute to local or regional air pollution. Greenhouse gas emissions from mobile combustion are most easily estimated by major transport activity, i.e., road, off-road, air, railways, and water-borne navigation. For Cyprus' inventory, emissions of off-road activities are included in road. Railways do not exist in Cyprus.

This is the fifth year for which emissions are estimated from road transport with COPERT 5 and are therefore disaggregated into the appropriate vehicle type. Further details are given in the methodology section.

Between 1990 and 2021 emissions from transport increased by 65.9%, compared to 54.2% between 1990 and 2020. *This must be because of the lockdowns and restrictions to movement due to the COVID-19 pandemic (Table 3.13).*In 2021 transport contributed 24.2% to the total emissions of the country without

LULUCF and 33.2% to the emissions from the energy sector. Transport (1A3) emissions are also presented in Figure 3.5.

Table 3.13. Transport emissions 1990–2021

Gg CO_2 eq.	**1990**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**
3. Transport	1237	1838	2112	2375	2305	2131	1921	1853
a.Domestic aviation	26	18	13	8	2	1	1	1
b.Road transportation	1208	1818	2097	2365	2300	2127	1918	1851
c. Railways	NO	NO	NO	NO	NO	NO	NO	NO
d.Domestic navigation	2	2	2	3	3	2	2	2
CO_2	1218	1520	1797	2359	2289	2116	1907	1841
CH_4	0.28	0.23	0.22	0.18	0.17	0.16	0.15	0.14
N_2O	0.05	0.14	0.07	0.04	0.04	0.04	0.04	0.03
Gg CO_2 eq.	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
3. Transport	1921	2051	2124	2094	2139	1916	2051	
a.Domestic aviation	3	1	1	1	0	0	0	
b.Road transportation	1921	2049	2121	2091	2136	1915	2048	
c. Railways	NO	NO	NO	NO	NO	NO	NO	
d.Domestic navigation	2	2	2	2	3	1	3	
CO_2	1910	2038	2110	2080	2125	1902	2036	
CH_4	0.14	0.14	0.14	0.13	0.13	0.10	0.12	
N_2O	0.03	0.04	0.04	0.04	0.04	0.04	0.04	

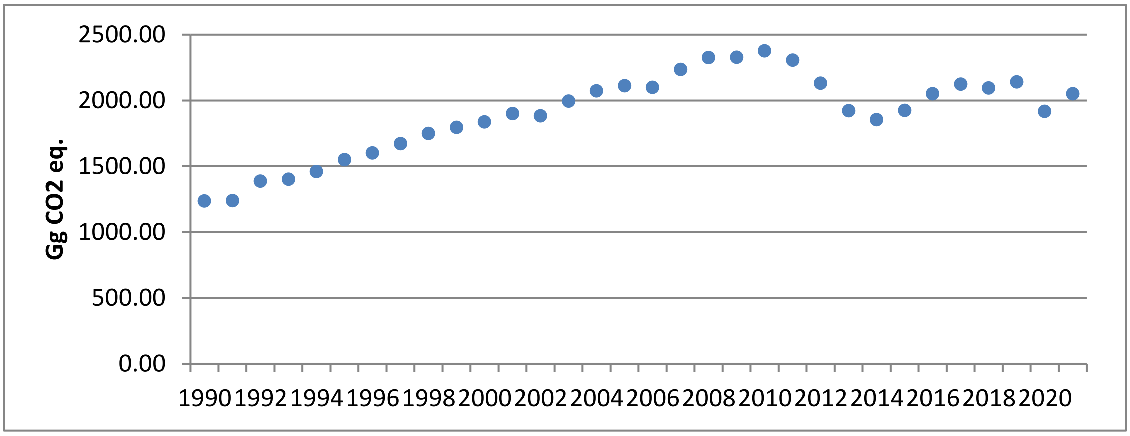

Figure 3.5. Transport (1A3) emissions 1990–2021

3.2.5.2. Methodological issues

Civil aviation (1A3a)

Civil aviation emissions should include emissions from international and domestic civil aviation, including take-offs and landings. Civil aviation comprises civil commercial use of airplanes, including scheduled and charter traffic for passengers and freight, air taxiing, and general aviation. The emissions from civil aviation were estimated using the Tier 1 method proposed by 2006 IPCC guidelines. Information on fuel consumption for domestic flights is not available from national statistics. To estimate the emissions from aviation, the available information on fuel consumption from EUROCONTROL was used (Table 3.14) for 2005-2021. It is currently not possible to move to higher Tiers; it will be assessed again for future submissions.

Table 3.14. International and domestic flights' fuel consumptions, EUROCONTROL data (2005-2021)

Fuel consumption (kt)	2005	2006	2007	2008	2009	2010	2011	2012
Domestic	3.958	3.344	2.967	2.823	2.282	2.429	0.739	0.471
International	264.2	266.4	262.4	272.3	257.4	262.6	272.5	263.4
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Domestic	0.305	0.191	0.286	0.179	0.260	0.282	0.119	0.030
International	245.7	246.0	238.1	278.2	316.6	328.9	325.7	103.6
	2021							
Domestic	0.119							
International	176.1							

The share of domestic flights to the total fuel consumption is presented in Table 3.15. It can be noticed that there is a decreasing trend in the share of domestic flights to the total fuel consumption. The trend for these years can be represented by the equation $y=9E\text{-}05x^2 - 0.0026x + 0.018$. This equation was used to estimate the share of domestic flights to the total for the years 1990–2004 (Table 3.16), the period for which data is not available for domestic flights. The fuel consumption of domestic flights was estimated by multiplying the share of domestic flights by the total fuel consumption reported under all international flights by the Statistical Service for 1990–2004. The international flights consumption for 1990–2004 was revised by subtracting the estimated fuel consumption for domestic flights. The resulting fuel consumption for domestic and international flights for the years 1990–2004 is presented in Table 3.15. Fuel consumption obtained from the Statistical Service is in kt, and converted to TJ using the default NCV proposed by the 2006 IPCC Guidelines, i.e. 44.1 TJ/Gg (Table 1.2, pg.1.18, vol.2).

It was not possible to use LTOs data for the backcasting of the trend of the domestic/international aviation split, since there was no correlation between the available data and the LTOs (Figure 3.6). For the estimation of emissions, the default EF proposed by the IPCC 2006 guidelines are used; i.e. 44.1 TJ/kt, 71.5 t CO_2/TJ, 0.5 kg CH_4/TJ and 2 kg N_2O/TJ.

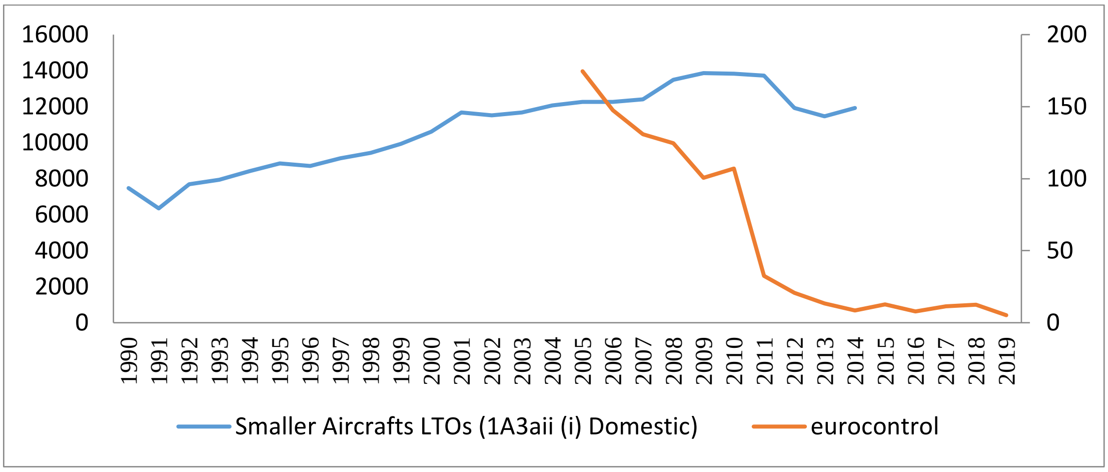

Figure 3.6. Smaller aircrafts LTOs and EUROCONTROL data for domestic flights

Table 3.15. Share of domestic flights to the total fuel consumption, EUROCONTROL data (2005-2021)

	2005	2006	2007	2008	2009	2010	2011	2012
Share of domestic to total	1.48%	1.24%	1.12%	1.03%	0.88%	0.92%	0.27%	0.18%
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Share of domestic to total	0.12%	0.08%	0.12%	0.06%	0.09%	0.08%	0.04%	0.03%
	2021							
Share of domestic to total	0.06%							

Table 3.16. Share of domestic flights to the total fuel consumption, consumption for domestic and international flights (1990–2004)

	1990	1991	1992	1993	1994	1995	1996	1997
Share of domestic to total	3.50%	3.36%	3.22%	3.08%	2.94%	2.80%	2.66%	2.52%
Domestic consumption (TJ)	364	415	386	314	307	321	292	272
International consumption (TJ)	10043	11933	11609	9873	10144	11145	10689	10532
TOTAL (TJ)	10408	12348	11995	10187	10452	11466	10981	10805
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	
Share of domestic to total	2.38%	2.24%	2.10%	1.96%	1.82%	1.68%	1.54%	
Domestic consumption (TJ)	271	261	248	271	242	239	200	
International consumption (TJ)	11107	11382	11571	13576	13076	14005	12809	
TOTAL (TJ)	11378	11642	11819	13847	13318	14244	13010	

Road transport (1A3b)

Road transport emissions should include all combustion and evaporative emissions arising from fuel use in road vehicles, including the use of agricultural vehicles on paved roads. GHG emissions from road transport were estimated using the COPERT 5 software. COPERT 5 is a MS Windows software program. In principle, COPERT 5 has been developed for use by the National Experts in order to estimate emissions from road transport which will be included in official annual national inventories. The use of a software tool to calculate road transport emissions allows for a transparent and standardized, hence consistent and comparable data collecting and emissions reporting procedure, in accordance with the requirements of international conventions and protocols and EU legislation.

The COPERT 5 methodology is part of the EMEP/CORINAIR Emission Inventory Guidebook 2016[27]. The Guidebook, developed by the UNECE Task Force on Emissions Inventories and Projections, is intended to support reporting under the UNECE Convention on Long-Range Transboundary Air Pollution and the EU directive on national emission ceilings.

COPERT 5 estimates emissions of all major air pollutants and GHG produced by different vehicle categories (passenger cars, light duty vehicles, heavy duty vehicles, mopeds and motorcycles). Emissions estimated are distinguished in three sources:

- Emissions produced during thermally stabilized engine operation (hot emissions),
- emissions occurring during engine start from ambient temperature (cold-start and warming-up effects) and
- NMVOC emissions due to fuel evaporation.

Non-exhaust particulate emissions from tyre and brake wear are also included. The total emissions are calculated as a product of activity data provided by the user and speed-dependent emission factors calculated by the software.

In addition, the fuel consumed in this sector is taken into consideration. The COPERT 5 run estimates the fuel consumption (diesel and gasoline). These values are then compared to statistical fuel sold and the annual mileage values are corrected on the basis of the differences between calculated and statistical fuel consumption. A new COPERT run is performed with the adjusted data and all emissions are calculated.

COPERT 5 has been used for the calculations of the whole timeseries (1990 – 2021). The total number of road vehicles by type for the period 1990–2021 is shown in Table 3.17 and the corresponding trend is shown in Figure 3.7. Fuel consumption data was obtained from the energy balance prepared by the Statistical Service and is presented in Table 3.18. The calorific value used to convert mass to energy unit are according to the national energy balance; i.e. Diesel 43.0 TJ/kt, Gasoline 44.3 TJ/kt and Biodiesel 37.0 TJ/kt.

The emissions from vehicles consuming LPG and Biodiesel have not been calculated using COPERT 5.

[27] EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016 – September 2016, EEA Technical Report No. 21/2016

They have been calculated with a Tier 1 method due to the lack of activity data regarding the fleet. Fuel consumption obtained from the Statistical Service is in kt, and converted to TJ using the default NCV proposed by the 2006 IPCC Guidelines, i.e. 47.3 TJ/Gg (Table 1.2, pg.1.18, vol.2). For the estimation of emissions, the default EF proposed by the IPCC 2006 guidelines are used; 63100 kg CO_2/TJ, 62 kg CH_4/TJ and 0.2 kg N_2O/TJ (IPCC 2006, page 3.21, vol.2).

Biofuels have been first introduced to the national energy mix in late 2007. Biofuel is mixed with diesel to a contribution ranging from 3-6.5%. During the first years (2007-2012), biofuels were solely from oil seeds. Since 2013 however, biodiesel used in Cyprus has an increasing contribution of used cooking oils (8.5% in 2013, 61.3% in 2014, 63.2% in 2015 and 97.1% in 2016).[28] According to the certificates of sustainability criteria which accompanied imported biofuels, all biofuels consumed in Cyprus were from biomass. The raw material used was cooking oil or oil crops.

The emissions from vehicles consuming Biofuels have not been calculated using COPERT 5. They have been calculated with a Tier 1 method.After the TERT recommendation, REVIEW 2020 (EU) (CY-1A3-2020-0001), emissions from the fossil part of the fuel have been calculated after Ioannis Sempos note. Biofuels in Cyprus are 100% FAME. The default total carbon content has been used 76.5% kgC/kgFAME , as well as 5,4% of carbon content fossil part. The CH_4 and N_2O emissions have been been calculated using the EFs proposed by the 2006 IPCC Guidelines, i.e. 3.8 kg CH_4/TJ and 5.7 kg N_2O/TJ for both fossil and biogenic parts.

Table 3.17. Number of vehicles by type

	1990	2000	2005	2010	2015	2019	2020	2021
Buses	2308	2949	3217	3403	2712	3151	2646	2770
Heavy Duty Trucks	9633	11174	13605	16265	13142	20258	13372	11473
Mopeds & Motorcycles	50953	43315	40381	40272	39282	39375	41676	41189
Light Commercial Vehicles	64644	103436	104711	104437	90673	101481	104576	104119
Passenger Cars	178602	267589	342146	462562	487692	572182	575907	595771

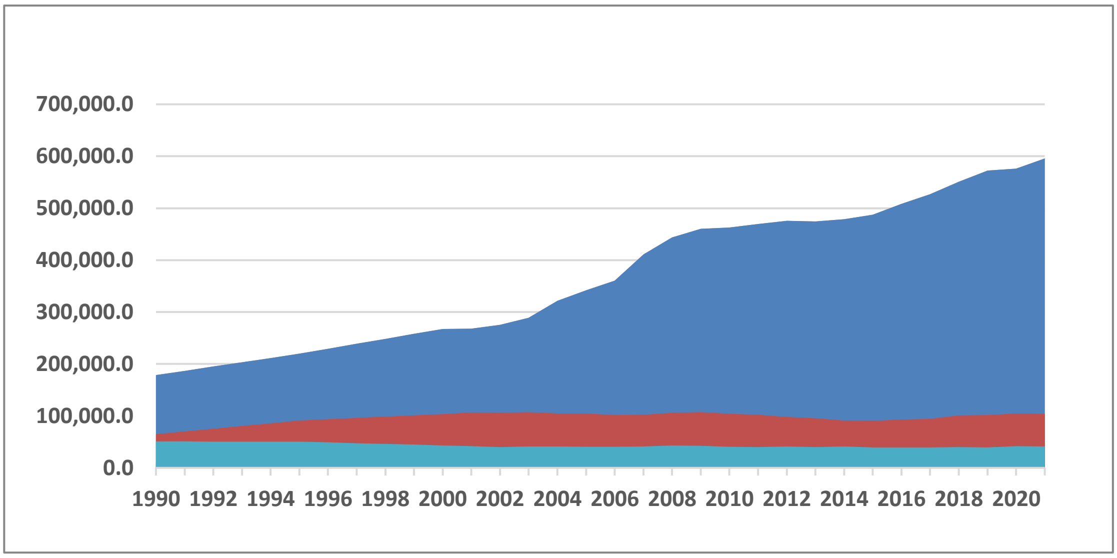

Figure 3.7. Trend of vehicles population in the Road transport sector

[28] Christina Karapitta, Energy Officer A', Energy Service, Ministry of Energy, Commerce and Industry (tel. 22409388, ckarapitta@mcit.gov.cy)

Table 3.18. Fuel consumed by road transport (kt) during 1990–2021

kt	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Gasoline	163	170	172	169	180	183	186	191	195	203
Diesel	209	201	245	254	260	284	297	313	333	339
Biodiesel	0	0	0	0	0	0	0	0	0	0
LPG	0	0	0	0	0	0	0	0	0	0

kt	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Gasoline	206	219	228	252	282	303	323	352	373	383
Diesel	349	355	340	351	353	345	322	336	329	320
Biodiesel	0	0	0	0	0	0	0	1	16	17
LPG	0	0	0	0	0	0	0	0	0	0

kt	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Gasoline	390	385	372	349	341	345	354	351	342	337
Diesel	328	312	271	231	223	241	273	292	304	315
Biodiesel	17	18	18	17	11	11	10	10	10	12
LPG	0	0	0	0	0	0	0	0	0.4	0.5
kt	2020	2021								
Gasoline	284	305								
Diesel	283	304								
Biodiesel	27	28								
LPG	0.4	0.5								

After the TERT recommendation (CY-1A3b-2021-0002), emissions from lubricants combusted in two-stroke engines have been calculated with COPERT 5 and are reported separately for the first year in accordance with the IPCC 2006 Guidelines. The emissions are presented in table 3.19.

Table 3.19. CO2 emissions from lubricant use in two-stroke engines (kt) during 1990-2021

kt	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Lubricants	0.60	0.59	0.61	0.60	0.60	0.60	0.58	0.56	0.54	0.53	0.54
kt	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Lubricants	0.53	0.51	0.46	0.48	0.47	0.44	0.41	0.54	0.53	0.50	0.45
kt	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
Lubricants	0.42	0.41	0.39	0.38	0.32	0.32	0.31	0.30	0.20	0.29	

Domestic water-borne navigation (1A3d(ii))

Domestic water-borne navigation emissions should include emissions from fuels used by vessels of all flags that depart and arrive in the same country (excluding fishing, which should be reported under 1 A 4 c iii, and military, which should be reported under 1 A 5 b).

Estimation of emission from domestic water-borne navigation activities has been made possible due to data obtained from the Statistical Service on fuel consumption for the years 1998-2015 (Table 3.20). The consumption for remaining years has been estimated assuming the following: (a) for the years 1990-1997 the contribution of domestic water-borne navigation activities to road transport was assumed the same as 1998 (0.33%), (b) for 2017 and 2018, activity data has been obtained from the Statistical Service. 2017 activity data has been revised.

Calorific values and emission factors of road diesel for the estimation of emissions from domestic water-borne navigation are according to IPCC 2006: NCV 43 TJ/kt (volume 2, pg. 1.18), 74100 kg CO_2/TJ (volume 2, pg. 3.50), 3.9 kg CH_4/TJ and 3.9 kg N_2O/TJ (assumed same as road - default, volume 2, pg.

3.21). Biodiesel consumption was reported for the first time in 2020:Default total carbon content has been used 76.5% kgC/kgFAME , as well as 5,4% of carbon content fossil part. The CH_4 and N_2O emissions have been been calculated using the EFs proposed by the 2006 IPCC Guidelines, i.e. 3.8 kg CH_4/TJ and 5.7 kg N_2O/TJ for both fossil and biogenic parts.

Table 3.20. Fuel consumption by domestic water-borne navigation activities

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Diesel (kt)	0.69	0.66	0.81	0.84	0.86	0.94	0.98	1.03	1.10	1.24	0.53
Biodiesel(kt)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Diesel (kt)	0.43	0.56	0.43	0.60	0.73	0.56	0.63	0.76	1.49	0.95	0.89
Biodiesel(kt)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
Diesel (kt)	0.63	0.47	0.56	0.63	0.47	0.65	0.67	0.88	0.36	0.83	
Biodiesel(kt)									0.03	0.07	

3.2.5.3. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

3.2.5.4. Category-specific QA/QC and verification

EUROCONTROL has performed detailed, Tier 3, calculations from 2005 which were taken into account for comparison.

3.2.5.5. Category-specific recalculations

Recalculations have been performed for 1A3d ii Domestic water-borne navigation for the years 2017-2020 due to revised values in the energy balance and the addition of biodiesel consumption for 2020. However the difference is very small with no significant change in the emissions.

Recalculations have also been performed for 1A3b Road Transport for the whole time-series due to newer version of COPERT and some added precision in activity data.The impact of the recalculations is presented in the table below.

Table 3.21 Impact of recalculations on CO_2 eq. emissions for Road Trasnport 1990-2019

CO2 eq. (kt)	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
NIR 2022	1211	1209	1358	1377	1432	1521	1572	1640	1717	1763	1807
NIR 2023	1208	1206	1356	1376	1435	1523	1577	1647	1724	1772	1818
Difference (%)	-0.31	-0.22	-0.12	-0.06	0.18	0.16	0.29	0.39	0.41	0.51	0.60
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
NIR 2022	1866	1850	1961	2064	2104	2094	2234	2321	2322	2372	2307
NIR 2023	1879	1864	1977	2057	2097	2087	2223	2310	2311	2361	2296
Difference (%)	0.70	0.78	0.80	-0.36	-0.35	-0.34	-0.47	-0.48	-0.47	-0.49	-0.49
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**		
NIR 2022	2133	1923	1856	1925	2055	2127	2096	2140	1912		
NIR 2023	2123	1914	1848	1918	2047	2119	2087	2132	1908		
Difference (%)	-0.49	-0.49	-0.41	-0.39	-0.41	-0.41	-0.42	-0.37	-0.20		

3.2.5.6. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

3.2.6. Other sectors (1A4)

3.2.6.1. Category description

Other sectors source category (1A4) should include emissions from combustion activities in the sectors Commercial/Institutional (1A4a), Residential (1A4b) and Agriculture/Forestry/Fishing/Fish farms (1A4c), including combustion for the generation of electricity and heat for own use in these sectors. Thermal needs in these sectors are covered mainly by liquid fossil fuels, while the contribution of biomass (fuel wood), especially in the residential sector, is also significant (mainly in mountainous areas).

Due to the unavailability of consumption data for several years and sectors, using the fuel consumption data as published by the Statistical Service would create issues of consistency and comparability. Therefore, it was decided to complete the period using assumptions.

GHG emissions from other sectors in 2021 increased by 10.58% compared to 1990 emissions (from 434 Gg CO_2 eq in 1990 to 480 Gg CO_2 eq in 2021). Table 3.22 presents the trend between 1990 and 2021. Other sectors contributed 5.6% to the total emissions of the country in 2021 without LULUCF and 7.8% to the emissions from the energy sector. The emissions from Other sources (1A4) are presented in Figure 3.8.

Table 3.22. GHG emissions from Other sectors 1990–2021

Gg CO_2 eq.	**1990**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**
4. Other sectors	434	731	610	570	570	621	600	520
a. Commercial/ institutional	76	117	100	120	120	113	107	104
b. Residential	302	507	421	373	373	425	413	339
c. Agriculture/ forestry/ fishing	56	106	89	77	77	83	80	77
CO_2	430	725	605	563	613	591	513	450
CH_4	0.10	0.14	0.15	0.16	0.25	0.27	0.25	0.21
N_2O	0.003	0.005	0.005	0.01	0.01	0.01	0.01	0.00
Gg CO_2 eq.	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
4. Other sectors	532	526	536	464	543	511	480	
a. Commercial/ institutional	88	82	92	91	119	88	92	
b. Residential	361	364	359	294	338	333	302	
c. Agriculture/ forestry/ fishing	83	80	85	79	85	89	85	
CO_2	522	515	523	452	530	498	468	
CH_4	0.32	0.32	0.37	0.36	0.38	0.39	0.36	
N_2O	0.01	0.01	0.01	0.01	0.01	0.01	0.01	

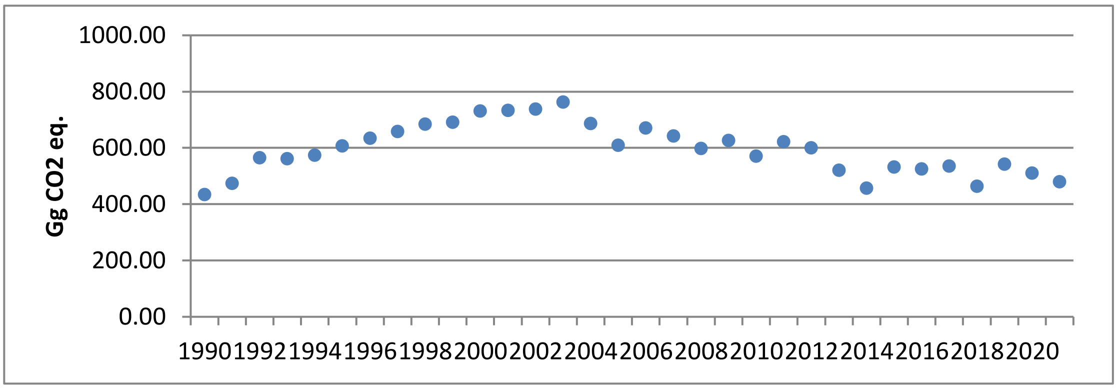

Figure 3.8. Other sectors (1A4) emissions 1990–2021

3.2.6.2. Methodological issues

As mentioned above, the unavailability of consumption data for several years and sectors mandated the use of assumptions to ensure consistency across the period. The activity data used for the estimation of GHG emissions of other sectors is presented in Table 3.23.

Gas biomass consumed by agriculture includes all biogas consumption. Diesel consumption by agriculture was revised to exclude diesel consumed for fishing (in red). Fuel consumption for fishing is added. Moreover RFO consumption by Off-road Vehicles and Other Machinery (1A4c ii) consumption is included in road transport (1A3b). The consumption of biogas by autoproducers is accounted for under category 1.A.4.c.i, as all the production and consumption of biogas occurs at farms with anaerobic digesters.

The GHG emissions from "other sectors" were estimated according to the IPCC 2006 guidelines. Fuel consumption was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 3.24). The oxidation factor used is 1, as proposed by the IPCC 2006 guidelines (pg. 1.20). The CO_2, CH_4 and N_2O emissions were estimated using the default emission factors proposed by the IPCC 2006 guidelines (IPCC 2006, pg. 2.20-2.22, oil) as presented in Table 3.24.

Table 3.23. Parameters used for the estimation of emissions from other sectors

Fuel	NCV (TJ/kt)	kg CO_2 /TJ	kg CH_4 /TJ	kg N_2O /TJ
Diesel	43.0	74100	10	0.6
Other Kerosene	43.8	71900	10	0.6
LPG	47.3	63100	5	0.1
RFO	40.4	77400	10	0.6
Solid Biomass		100000	300	4
Charcoal	29.5	112000	200	1
Biodiesel	37.0		3.8	5.7
Gas biomass		54600	5	0.1

3.2.6.3. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

3.2.6.4. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

3.2.6.5. Category-specific recalculations

Recalculation was performed for the category 1A4a Commercial/Institutional due to revised activity data in the diesel consumption and also, the addition of biodiesel consumption for 2020. However the difference is very small with no significant change in the emissions.

3.2.6.6. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

Table 3.24. Fuel consumption for "Other sectors" for the period 1990-2020

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1A4a Commercial / Institutional																		
Gas-diesel oil (kt)	11	12	15	15	16	17	18	19	20	21	22	22	21	21	19	18	19	18
RFO (kt)	2	5	5	4	5	4	5	3	3	3	3	2	2	3	3	1	2	2
LPG (kt)	12	12	13	12	12	12	12	13	12	12	13	13	13	14	13	13	13	13
Solid biofuels (TJ)	19	15	15	15	11	12	17	9	8	11	10	10	10	9	8	7	5	14
Biogas (TJ)																		
Charcoal (kt)	1	1	1	1	1	4	4	4	4	4	3	3	4	4	4	5	5	7
1A4b Residential																		
Other kerosene (kt)	12	12	17	16	17	17	18	20	21	20	24	24	31	31	24	16	16	16
Gas-diesel oil (kt)	52	58	71	73	75	82	86	90	96	99	102	103	99	102	92	83	98	89
LPG (kt)	32	32	36	33	32	33	33	34	32	32	34	34	35	38	36	34	35	36
Solid biofuels (TJ)	126	105	103	102	74	79	119	61	56	77	68	70	64	58	53	51	74	95
Charcoal (kt)	1	1	1	1	1	4	4	4	4	4	3	3	4	4	4	5	5	6
1A4c Agriculture / Forestry / Fishing / Fish farms																		
1A4c i Stationary																		
Gas-diesel oil (kt)	14	16	20	20	21	23	24	25	27	27	28	29	27	28	25	24	25	25
LPG (kt)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Biogas (TJ)																		15
1A4c iii Fishing																		
Gas-diesel oil (kt)	2	2	3	3	3	3	3	4	4	4	4	4	4	4	4	3	3	3

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1A4a Commercial / Institutional														
Gas-diesel oil (kt)	20	19	23	20	16	17	13	13	15	18.18	16.33	16.4	11.7	14.4
RFO (kt)	2	2	2	2	4	4	2	3	4	4.21	3.2	3.6	2.4	2.6
LPG (kt)	14	13	13	14	14	12	11	12	11	13.17	13.75	15.53	11.12	9.71
Other kerosene (kt)										0.03	1.64	2.21	2.59	2.02
Solid biofuels (TJ)	15	15	15	13	16	16	16	15	15	17	17	17	132	126
Biogas (TJ)		11	12	11	11	11	11	11	12	17	45	54	20	24
Charcoal (kt)	7	6	6	6	6	6	6	7	7	7.07	5.98	5.63	5.46	5.82
Biodiesel (kt)													0.11	0.17
1A4b Residential														
Other kerosene (kt)	14	19	14	16	17	12	9	14	14	14.25	9.30	12.56	12.79	11.46
Gas-diesel oil (kt)	78	83	70	80	76	62	57	65	65	65.04	53.44	60.44	59.7	49.49
LPG (kt)	34	36	34	38	37	33	31	34	35	32.47	28.45	32.15	31.31	33.46
Solid biofuels (TJ)	123	500	260	339	419	353	2491	551	531	691.33	709.2	769	644	610
Charcoal (kt)	6	5	5	6	6	6	6	7	8	8.64	8.51	8.4	10.2	8.7
1A4c Agriculture / Forestry / Fishing / Fish farms														
1A4c i Stationary														
Gas-diesel oil (kt)	23	20	19	22	21	21	19	22	21	22.11	20.57	21.98	23.78	22.69
LPG (kt)	1	1	1	1	1	1	0	2	2	2.42	2.53	2.86	2.58	2.41
Biogas (TJ)	78	198	262	437	465	455	464	460	475	419.39	442.72	463.7	470.9	468.71
1A4c iii Fishing														
Gas-diesel oil (kt)	3	4	4	3	3	2	2	2	2	2	1.79	1.91	1.48	1.62

3.2.7. Non-Specified (1A5)

3.2.7.1. Category description

All remaining emissions from fuel combustion that are not specified elsewhere should be reported under Non-Specified (1A5). 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 should also be included. The emissions during the period 1990–2021 are presented in Table 3.25 and Figure 3.9.

Table 3.25. GHG emissions from Other (Not elsewhere specified-Stationary) 1990–2021

Gg CO_2 eq.	**1990**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**
5. Other	11	22	19	21	27	21	27	38
a. Stationary	11	22	19	17	21	17	20	32
b. Mobile	NO	NO	NO	3	6	3	6	6
CO_2	11	21	19	20	27	20	26	38
CH_4	0.001	0.003	0.01	0.01	0.01	0.01	0.01	0.00
N_2O	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Gg CO_2 eq.	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
5. Other	25	25	26	27	26	27	23	
a. Stationary	22	22	22	22	22	22	19	
b. Mobile	3	3	4	5	4	5	4	
	25	25	26	27	26	27	23	
CO_2	25	25.26	25.41	26.59	25.80	26.48	22.93	
CH_4	0.004	0.003	0.003	0.003	0.004	0.003	0.003	
N_2O	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	

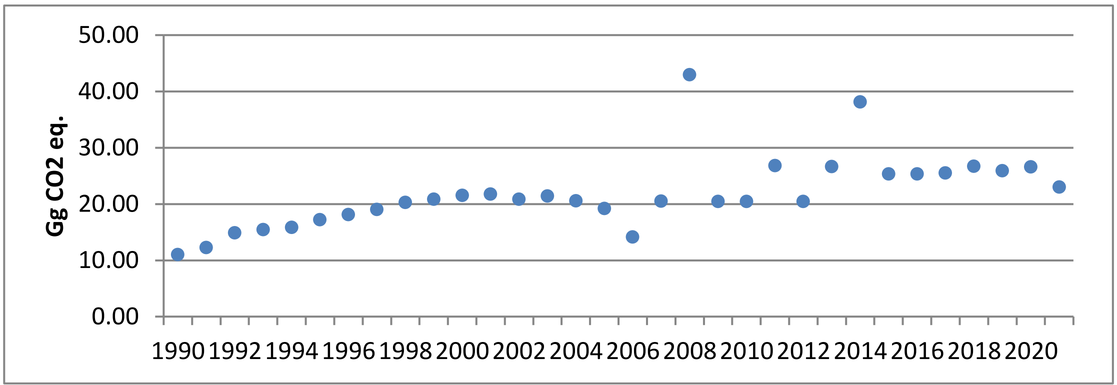

Figure 3.9. GHG emissions from Other (Not elsewhere specified-Stationary) (1A5) 1990–2021

3.2.7.2. Methodological issues

Due to the unavailability of consumption data for several years and sectors, using the fuel consumption data as published by the Statistical Service would create issues of consistence and comparability. Therefore it was decided to complete the period using assumptions. Details on the methodology developed and applied are given in Annex 3. The activity data used for the estimation of GHG emissions of other sectors is presented in Table 3.26. Consumption of Gas-diesel oil, Lignite and LPG and biodiesel since 2020 is allocated to stationary combustion, whereas that of jet kerosene is allocated to mobile combustion.

Table 3.26. Other non-specified fuel consumption 1990–2021

	1990	1991	1992	1993	1994	1995	1996	1997
Gas-diesel oil (kt)	3	4	5	5	5	5	6	6
Lignite (kt)	0	0	0	0	0	0	0	0
LPG (kt)	0	0	0	0	0	0	0	0
Jet kerosene (kt)	0	0	0	0	0	0	0	0
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Gas-diesel oil (kt)	6	7	7	7	7	7	6	6
Lignite (kt)	0	0	0	0	0	0	1	1
LPG (kt)	0	0	0	0	0	0	0	0
Jet kerosene (kt)	0	0	0	0	0	0	0	0
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Gas-diesel oil (kt)	4	6	13	5	5	6	5	5
Lignite (kt)	1	1	1	1	1	1	1	1
LPG (kt)	0	0	0	0	0	0	0	1
Jet kerosene (kt)	0	0	0	1	1	2	1	2
	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Gas-diesel oil (kt)	9	6	6	6	6	6	6	5
Lignite (kt)	0	0	0	0	0	0	0	0
LPG (kt)0	1	1	1	1	1	1	1	1
Jet kerosene (kt)	2	1	1	1	1	1	1	1
Biodiesel (kt)							0.214	0.197

Methodology

The GHG emissions were estimated according to the IPCC 2006 guidelines. Fuel consumption was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 1.23). The CO_2, CH_4 and N_2O emissions were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.22) as presented in Table 3.27.Biodiesel consumption was reported for the first time in 2020:Default total carbon content has been used 76.5% kgC/kgFAME , as well as 5,4% of carbon content fossil part. The CH_4 and N_2O emissions have been been calculated using the EFs proposed by the 2006 IPCC Guidelines, i.e. 3.8 kg CH_4/TJ and 5.7 kg N_2O/TJ for both fossil and biogenic parts.

Table 3.27. Parameters used for the estimation of other emissions

Fuel	NCV (TJ/kt)	kg CO_2 /TJ	kg CH_4 /TJ	kg N_2O /TJ
Diesel	43.0	74100	10	0.6
LPG	47.3	63100	5	0.1
Jet kerosene	44.1	71500	10	0.6
Lignite	11.9	101000	300	1.5
Solid Biomass	11.6	100000	300	4.0
Biodiesel	37.0		3.8	5.7

3.2.7.3. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

3.2.7.4. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

3.2.7.5. Category-specific recalculations

Recalculation was performed for the category 1A5a due to the addition of biodiesel consumption for 2020. However the difference is very small with no significant change in the emissions.

3.2.7.6. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

3.2.8. Reference approach (1AB)

The Reference Approach is a top-down approach, using a country's energy supply data to calculate the emissions of CO_2 from combustion of mainly fossil fuels. The Reference Approach is a straightforward method that can be applied on the basis of relatively easily available energy supply statistics. Excluded carbon has increased the requirements for data to some extent. However, improved comparability between the sectoral and reference approaches continues to allow a country to produce a second independent estimate of CO_2 emissions from fuel combustion with limited additional effort and data requirements.

While the sectoral approach and the reference approach can each be used to estimate a country's CO_2 emissions from fuel combustion, the use of both allows the comparison of results from these two independent estimates. Significant differences may indicate possible problems/mistakes with the activity data, net calorific values, carbon content, excluded carbon calculation, etc.

The Reference Approach is designed to calculate the emissions of CO_2 from fuel combustion, starting from high level energy supply data. The assumption is that carbon is conserved so that, for example, carbon in crude oil is equal to the total carbon content of all the derived products. The Reference Approach does not distinguish between different source categories within the energy sector and only estimates total CO_2 emissions from Source category 1A, Fuel Combustion. Emissions derive both from combustion in the energy sector, where the fuel is used as a heat source in refining or producing power, and from combustion in final consumption of the fuel or its secondary products.

The estimation process is divided in six steps that are described below.

Step 1: Estimation of apparent consumption

This step concerns the estimation of apparent consumption in natural units or in the units commonly used for the recording of the relative fuel amounts. For secondary fuels production data are not included in the apparent consumption calculation, since they are already accounted for in the primary fuel consumption, from which they derive. Therefore, the apparent consumption of primary fuels is estimated by the following equation:

Apparent consumption = Primary production + Imports - Exports - International bunkers + Stock change

The apparent consumption of secondary fuels is estimated by the following equation:

Apparent consumption = Imports - Exports - International bunkers + Stock change

Step 2: Conversion of fuel data to a common energy unit

The values were multiplied by the net calorific values listed in Table 3.29 to provide the energy consumed in TJ. The NCV values used were the defaults proposed by the IPCC 2006 guidelines (volume 2, pg. 1.18) except for pet-coke and other bituminous coal. Pet-coke and other bituminous coal are consumed only from one cement producing installation. Therefore, in place of the default proposed by the IPCC, it was preferred to use the NCV implied by the annual reports submitted in accordance with national ETS legislation (law no. 110(I)/2011), which are available for the years 2000-2014. For the years 1990-1999 the NCV was assumed the same as 2000.

Step 3: Estimation of carbon content

Total carbon included in each fuel is calculated by multiplying energy consumption by an emission factor (Table 3.29) that reflects the amount of carbon per energy unit for each fuel. The result gives the maximum amount of carbon that could be potentially released if all carbon in the fuels were converted to CO_2. The carbon emission factor for fuels used in the reference approach are based predominately on the 2006 IPCC guidelines. The exceptions are pet-coke, other bituminous coal, waste (non-biomass fraction) and solid biomass. Pet-coke and other bituminous coal are consumed only from one cement producing installation. Therefore it was preferred to use the carbon emission factor implied by the annual reports submitted according to national ETS legislation (law no. 110(I)/2011), instead of the default proposed by the IPCC. Waste (non-biomass fraction) and solid biomass show annual variations because of the difference in ratios of the different types of waste and solid biomass consumed to the total.

Step 4: Estimation of carbon stored in products

Depending on the end use, non-energy uses of fuels can result in some or all of the carbon contained in the fuel being stored in the non-energy product. The non-energy consumption of fuels is multiplied by an emission factor that reflects the amount of the carbon content of the fuel stored in the non-energy product. The result is the maximum amount of carbon that could potentially be sequestered if that amount of carbon were stored in the non-energy product. By subtracting this amount from the total carbon calculated in step 3, the amount of carbon that could be theoretically converted to CO_2 is calculated.

Step 5: Estimation of carbon unoxidised during fuel use

The amount of carbon that was previously calculated is reduced by a fraction of 1%, in order to take account of the fact that a small part of the fuel carbon entering combustion escapes oxidation. It is assumed that the carbon that remains unoxidised is stored indefinitely.

Step 6: Estimation of CO_2 emissions

Carbon emissions from all fuels are multiplied by 44/12 to be converted to CO_2 emissions and are summed giving the total amount of CO_2 released in the atmosphere. The emissions estimated with the reference approach are presented in Table 3.28. Detailed presentation of the results is available in Annex 4.

Table 3.28. Net calorific value (TJ/kt) and carbon emission factors (t CO_2/kt) of fuels consumed in Cyprus used for the reference approach

(a) Net calorific value (TJ/kt) and carbon emission factors (t CO_2/kt) that remain constant for the period 1990-2021

	Conversion factor (TJ/kt)	Carbon emission factor (tC/TJ)
Crude oil	42.3	20.0
Gasoline	44.3	18.9
Jet kerosene	44.1	19.5
Other kerosene	43.8	19.6
Gas-diesel oil	43.0	20.2
Residual fuel oil	40.4	21.1
Biodiesel	37.5	7.65
LPG	47.3	17.2
Bitumen	40.2	22.0
Lubricants	40.2	20.0
Pet-coke	32.5	table (b)
Other oil-refinery gas	49.5	15.7
Other oil-White spirit & SBP	40.2	20.0
Other bituminous coal	table (b)	table (b)
Lignite	11.9	27.6
Waste (non-biomass fraction)	NA	table (b)
Solid biomass	NA	table (b)

(b) Net calorific value (TJ/kt) and carbon emission factors (t CO_2/kt) that are not constant for the period 1990-2021

	1990	1991	1992	1993	1994	1995
NCV (TJ/kt)						
Other bituminous coal	27.650	27.650	27.650	27.650	27.650	27.650
Implied CEF (tC/TJ)						
Pet-coke	23.047	23.047	23.047	23.047	23.047	23.047
Other bituminous coal	25.254	25.254	25.254	25.254	25.254	25.254
C EF (tC/TJ)						
Waste (non-biomass fraction)	NO	NO	NO	NO	NO	NO
Solid biomass	27.629	27.661	27.664	27.665	28.340	28.264

	1996	1997	1998	1999	2000	2001
NCV (TJ/kt)						
Other bituminous coal	27.650	27.650	27.650	27.650	27.650	26.840
Implied CEF (tC/TJ)						
Pet-coke	23.047	23.047	23.047	23.047	23.047	23.047
Other bituminous coal	25.254	25.254	25.254	25.254	25.254	25.254
C EF (tC/TJ)						
Waste (non-biomass fraction)	NO	NO	NO	NO	NO	39.00
Solid biomass	28.286	28.471	28.530	28.448	28.217	28.157

	2002	2003	2004	2005	2006	2007
NCV (TJ/kt)						
Other bituminous coal	26.400	27.300	28.621	28.621	29.995	28.360
Implied CEF (tC/TJ)						
Pet-coke	23.047	23.047	23.047	23.047	24.160	24.659
Other bituminous coal	25.254	25.254	25.254	25.254	25.156	22.815
C EF (tC/TJ)						
Waste (non-biomass fraction)	NO	39.00	39.00	39.00	39.00	39.00
Solid biomass	28.391	28.253	28.542	28.971	28.956	28.664

	2008	2009	2010	2011	2012	2013
NCV (TJ/kt)						
Other bituminous coal	25.950	26.080	26.819	25.517	NO	NO
Implied CEF (tC/TJ)						
Pet-coke	24.486	25.578	25.515	25.301	24.795	25.238
Other bituminous coal	25.788	25.661	25.794	25.620	NO	NO
C EF (tC/TJ)						
Waste (non-biomass fraction)	39.00	39.00	39.00	39.00	25.00	25.00
Solid biomass	28.511	28.438	28.569	28.647	29.115	29.250

	2015	2016	2017	2018	2019	2020
NCV (TJ/kt)						
Other bituminous coal	25.675	25.675	24.680	25.8	25.8	26.1
Implied CEF (tC/TJ)						
Pet-coke	25.150	25.313	28.710	24.61	24.68	24.88
Other bituminous coal	25.876	25.877	25.563	25.800	25.98	26.1
C EF (tC/TJ)						
Waste (non-biomass fraction)	30.996	30.996	27.553	27.298	26.66	27.67
Solid biomass	28.852	28.942	28.772	28.239	28.18	28.21

Table 3.29. Apparent consumption (TJ) and CO_2 emissions (Gg) estimates according to the reference approach 1990–2021

	1990	1991	1992	1993	1994	1995	1996
Liquid Fuels							
Apparent consumption	54,217	55,995	65,169	69,671	79,517	68,842	76,855
CO_2	4,029	4,177	4,774	5,119	5,832	5,067	5,647
Solid Fuels							
Apparent consumption	2,682	2,682	719	857	747	553	498
CO_2	248	248	67	79	69	51	46
Waste (non-biomass fraction)							
Apparent consumption	NO	NO	NO	NO	NO	NO	NO
CO_2	NO	NO	NO	NO	NO	NO	NO
Biomass							
Apparent consumption	287	262	260	259	726	686	671
CO_2	29	27	26	26	75	71	70

	1997	1998	1999	2000	2001	2002	2003
Liquid Fuels							
Apparent consumption	75,064	79,987	80,533	86,407	85,371	86,500	94,650
CO_2	5,511	5,856	6,012	6,289	6,222	6,309	6,953
Solid Fuels							
Apparent consumption	525	719	830	1,355	1,423	1,399	1,447
CO_2	49	67	77	125	132	130	134
Waste (non-biomass fraction)							
Apparent consumption	NO	NO	NO	NO	18	NO	15
CO_2	NO	NO	NO	NO	3	NO	2
Biomass							
Apparent consumption	565	614	487	515	551	606	694
CO_2	59	64	51	53	57	63	72

	2004	2005	2006	2007	2008	2009	2010
Liquid Fuels							
Apparent consumption	88,272	89,985	93,586	98,345	104,335	101,715	97,847
CO_2	6,418	6,514	6,841	7,217	7,636	7,482	7,107
Solid Fuels							
Apparent consumption	1,643	1,500	1,632	1,402	1,050	560	709
CO_2	152	139	151	117	99	53	67
Waste (non-biomass fraction)							
Apparent consumption	71	138	73	288	239	276	299
CO_2	10	20	10	41	34	39	43
Biomass							
Apparent consumption	608	565	570	915	1,524	1,581	1,552
CO_2	64	60	61	95	141	139	133

	2011	2012	2013	2014	2015	2016	2017
Liquid Fuels							
Apparent consumption	94,738	88,673	75,925	77,428	78,321	84,258	86,839
CO_2	6,895	6,505	5,596	5,765	5,803	6,202	6,410
Solid Fuels							
Apparent consumption	318	12	12	157	155	21	125
CO_2	30	1	1	15	15	2	12
Waste (non-biomass fraction)							
Apparent consumption	56	24	45	316	516	663	902
CO_2	8	2	4	43	59	66	91
Biomass							
Apparent consumption	1,775	1,667	1,506	1,472	1,558	1,649	1838
CO_2	147	133	120	121	130	140	159

	2018	2019	2020	2021			
Liquid Fuels							
Apparent consumption	85799	84133	77898	77297			
CO_2	6289	6130	5661	5585			
Solid Fuels							
Apparent consumption	582	714	586	1714			
CO_2	55	68	69	159			
Waste (non-biomass fraction)							
Apparent consumption	962	1289	1457	1676			
CO_2	96	126	148	168			
Biomass							
Apparent consumption	2828	2457	4266	4404			
CO_2	153	215	247	250			

3.2.9. Comparison of the sectoral approach with the reference approach (1AC)

The data used in the reference and the sectoral approach and the resulting emissions are presented in Annex 4. The comparison of the fuel consumption and the emissions is summarised in Table 3.30.

The small differences that occur between the two approaches have been caused (a) by the statistical difference that exists in the energy balance, between the Gross inland deliveries (Calculated) and the Gross inland deliveries (Observed) and (b) from differences in the data source used for sectoral approach. The statistical difference of the energy balance is presented in detail in Annex 4.

Table 3.30. Difference between Reference and Sectoral Approach 1990–2020

	1990	1991	1992	1993	1994	1995	1996
Fuel consumption (PJ)							
Sectoral approach	52.2	58.9	63.7	65.8	68.6	67.4	71.1
Apparent energy consumption*	56.8	58.4	64.6	69.2	78.9	68.4	75.9
Difference	8.9%	-0.9%	1.5%	5.3%	14.9%	1.5%	6.6%
CO_2 **(Gg)**							
Reference approach	4281	4425	4840	5199	5907	5112	5693
Sectoral approach	3932	4457	4781	4962	5169	5069	5362
Difference	9.0%	-0.7%	1.2%	4.8%	14.3%	0.8%	6.1%

	1997	1998	1999	2000	2001	2002	2003
Fuel consumption (PJ)							
Sectoral approach	72.8	77.3	80.7	83.7	82.3	84.4	89.5
Apparent energy consumption*	74.2	79.0	79.2	85.5	84.9	85.5	94.0
Difference	1.9%	2.2%	-1.9%	2.2%	3.2%	1.4%	5.0%
CO_2 **(Gg)**							
Reference approach	5560	5923	5933	6415	6356	6438	7089
Sectoral approach	5488	5823	6090	6315	6206	6363	6750
Difference	1.3%	1.7%	-2.6%	1.6%	2.4%	1.2%	5.0%

	2004	2005	2006	2007	2008	2009	2010
Fuel consumption (PJ)							
Sectoral approach	91.4	93.5	94.4	98.5	101.4	100.9	97.8
Apparent energy consumption*	87.0	88.4	92.2	97.2	102.6	99.9	95.4
Difference	-4.8%	-5.5%	-2.3%	-1.3%	1.2%	-1.0%	-2.4%
CO_2 **(Gg)**							
Reference approach	6581	6673	7002	7375	7734	7574	7217
Sectoral approach	6910	7088	7271	7591	7810	7738	7506
Difference	-4.8%	-5.9%	-3.8%	-2.8%	-1.0%	-2.1%	-3.9%

	2011	2012	2013	2014	2015	2016	2017
Fuel consumption (PJ)							
Sectoral approach	94.9	88.7	76.2	77.2	79.5	84.7	86.41
Apparent energy consumption*	92.1	86.9	74.7	76.7	78.3	83.2	85.97
Difference	-2.9%	-1.9%	-2.15%	-0.7%	-1.6%	-1.8%	-0.5%
CO_2 **(Gg)**							
Reference approach	6933	6508	5601	5824	5877	6270	6510
Sectoral approach	7211	6731	5814	5961	6079	6474	6581
Difference	-3.9%	-3.3%	-3.7%	-2.3%	-3.4%	-3.2%	-1.09%

	2018	2019	2020	2021			
Fuel consumption (PJ)							
Sectoral approach	84.95	85.7	77.18	77.6			
Apparent energy consumption*	85.42	84.44	77.84	77.3			
Difference	0.55%	-1.5%	2.35%	-3.24%			
CO_2 **(Gg)**							
Reference approach	6418	6324	5657	5585			
Sectoral approach	6470	6522	5795	5833			
Difference	-0.8%	-3.0%	-2.38%	-4.25%			

* excluding non-energy use, reductants and feedstocks

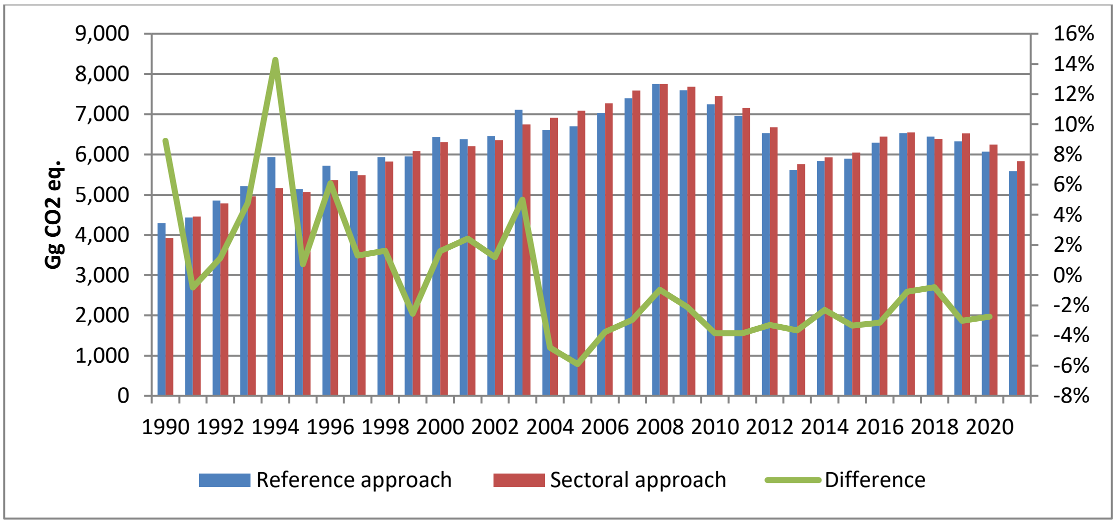

Figure 3.10. CO_2 emissions from fuel combustion using sectoral and reference approach

3.2.10. Feedstocks and non-energy use of fuels (1AD)

3.2.10.1. Category description

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. The main flows of carbon concerned in the calculation of excluded carbon are those used as feedstock, reductant, or non-energy products. In Cyprus fuels that are used for non-energy uses are Lubricants and Bitumen.

Bitumen/asphalt is used for road paving and roof covering, where the carbon it contains remains stored for long periods of time. Consequently, there are no fuel combustion emissions arising from the deliveries of bitumen within the year of the inventory. Lubricating oil statistics usually cover not only use of lubricants in engines but also oils and greases for industrial purposes and heat transfer and cutting oils. All deliveries of lubricating oil should be excluded from the Reference Approach.

Non-energy use of fuels in Cyprus refers to the consumption of lubricants in transport and bitumen in construction. Data on the non-energy consumption of fuels was obtained from the national energy balance (Gross inland deliveries (Calculated)).

3.2.10.2. Methodological Issues

CO_2 emissions from non-energy use of fuels is calculated according to the methodology proposed by the IPCC 2006 guidelines. NCVs, carbon emission factor and fraction of C stored are also taken from the guidelines (Table 3.31) and after the TERT review recommendation (CY-1AB-2020-0001). Non-energy fuel use, carbon dioxide emissions and the amount of carbon stored in the final products are presented in Table 3.32

The emissions are reported under 2D. The large difference that occurs for bitumen between the C stored estimated in Reference and 1AD between 1990–2004 is due to the production of bitumen by the refinery.

Consumption of lubricants is not available from the national energy balance for the years 1990-1992. These years have been completed using backwards extrapolation of activity data for 1993-1996. All the consumption has been assumed as imports of the purposes of the reference approach.

Table 3.31. Parameters used for the calculation of emissions

	Lubricants	Bitumen
NCV (TJ/kt)	40.2	40.2
Carbon emission factor (t/TJ)	20.00	0
Oxidation factor	1	1

Table 3.32. Fuel consumption, carbon stored and CO_2 emissions for Feedstocks and non-energy use of fuels

	1990	1991	1992	1993	1994	1995	1996	1997
Lubricants								
Consumption (kt)	7.00	7.00	7.00	7.81	10.81	10.81	11.81	10.82
Carbon excluded (Gg)	5.63	5.63	5.63	6.28	8.69	8.69	9.50	8.70
CO_2 (Gg)	4.13	4.13	4.13	4.60	6.37	6.37	6.96	6.38
Bitumen								
Consumption (kt)	33	19	50	59	58	51	55	60
Carbon excluded (Gg)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO_2 (Gg)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	1998	1999	2000	2001	2002	2003	2004	2005
Lubricants								
Consumption (kt)	6.82	6.83	6.83	6.84	7.86	7.85	9.85	5.86
Carbon excluded (Gg)	5.49	5.49	5.49	5.50	6.32	6.31	7.92	4.71
CO_2 (Gg)	4.02	4.03	4.03	4.03	4.63	4.63	5.81	3.46
Bitumen								
Consumption (kt)	75	86	85	81	84	69	66	71
Carbon excluded (Gg)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO_2 (Gg)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	2006	2007	2008	2009	2010	2011	2012	2013
Lubricants								
Consumption (kt)	5.87	5.83	5.83	5.84	5.86	5.87	4.87	3.88
Carbon excluded (Gg)	4.72	4.69	4.69	4.70	4.71	4.72	3.92	3.12
CO_2 (Gg)	3.46	3.44	3.44	3.45	3.46	3.46	2.87	2.29
Bitumen								
Consumption (kt)	65	60	69	57	74	64	35	26
Carbon excluded (Gg)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO_2 (Gg)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	2014	2015	2016	2017	2018	2019	2020	2021
Lubricants								
Consumption (kt)	3.88	3.89	3.90	3.60	3.52	7.66	7.34	7.59
Carbon excluded (Gg)	3.12	3.13	3.14	2.89	2.83	6.16	5.90	6.10
CO_2 (Gg)	2.29	2.29	2.30	2.12	2.07	4.52	4.33	4.47
Bitumen								
Consumption (kt)	22	21	36	38.95	40.16	37.12	31.59	42.29
Carbon excluded (Gg)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO_2 (Gg)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

3.2.10.3. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

3.2.10.4. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

3.2.10.5. Category-specific recalculations

Lubricants: After the TERT review 2021 (EU) (CY-1AB-2020-0001), the consumption and emissions from lubricants were corrected in 2022. The emissions from the use of lubricants in two-stroke engines were reported in 1A3b (Table 3.20).The rest of the emissions are reported under the IPPU sector (Table 4.14 and Table 3.33). Due to the use of a newer version of COPERT 5, the emissions in the 2023 submission are slightly different. However the impact of the recalculations is under the threshold of significance (less than 0.15%).

3.2.10.6. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

3.3. Fugitive emissions from solid fuels and oil and natural gas and other emissions from energy production (1B)

Activities related to primary production (extraction), processing, storage and transmission/distribution of fossil fuels should be included in this sector. GHG released in the atmosphere during these operations is the direct result of leaks, disruptions and maintenance procedures. Moreover, the sector should also include emissions resulting from venting and flaring of gases that cannot be controlled by other means.

In Cyprus, there is no primary production of fuels or processing. There was one refinery in the country, which ceased its operation in 2004. Since then all fuels are imported. All transport of liquid fuels in Cyprus takes place by road transport. No central pipeline system is in place.

3.3.1. Oil & natural gas and other emissions from energy production

3.3.1.1. Category description

Based on the above, the fugitive emissions from oil for Cyprus are caused by refining. For refining, no emissions are reported after 2004 when the refinery stopped operating (NO). Table 3.34 presents the emissions of the source. Methane emissions from refining activities (1.B.2.A.4) only occured during 1990–2004 when the refinery was operating.

Transport of oil (1.B.2.a.3), as defined in the IPCC 2006 Guidelines, only took place during the time the refinery was operating; i.e. 1990–2004. As there is no activity data to estimate emissions for the years when the refinery was in operation, NE is used for this period. As no transport operations have taken place since the refinery closed, NO is used for the period after 2004.

Flaring (1.B.2.c.2.i) was taking place at the refinery, which ceased its operation in 2004. For the period the refinery was operating there is no activity data available to estimate emissions, therefore NE is used, while NO is used for the period after 2004.

Venting (1.B.2.c.1.i) occurs due to transport via Tanker Trucks from secondary fuel products. There is no primary production of fuel in Cyprus and the refining activities stopped in 2004. According to the definition of the IPCC 2006 Guidelines and the TERT recommendation CY-1B2C-2020-001, these emissions are included as “NA”.

Table 3.33. Fugitive emissions from oil during 1990–2021, in tons

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Refining (t CH_4)	16.2	19.43	18.51	19.89	23.07	21.09	19.36	26.56	27.56
Venting (t CO_2)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Venting (t CH_4)	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Refining (t CH_4)	30.05	29.87	29.44	27.66	24.73	7.11	NO	NO	NO
Venting (t CO_2)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Venting (t CH_4)	NA	NA	NA	NA	NA	NA	NA	NA	NA
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2015**
Refining (t CH_4)	NO	NO	NO	NO	NO	NO	NO	NO	NO
Venting (t CO_2)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Venting (t CH_4)	NA	NA	NA	NA	NA	NA	NA	NA	NA
	2017	**2018**	**2019**	**2020**	**2021**				
Refining (t CH_4)	NO	NO	NO	NO	NO				
Venting (t CO_2)	NA	NA	NA	NA	NA				
Venting (t CH_4)	NA	NA	NA	NA	NA				

3.3.1.2. Methodological issues

Refining activities (1.B.2.A.4)

GHG emissions from oil when the refinery was operating (through 2004) are estimated according to the Tier 1 methodology described in the IPCC 2006 guidelines. 0.0218 kg CH_4 /m^3 is used as the emission factor,[29] which is the default for oil refined from the IPCC 2006 guidelines (Table 4.2.4, pg. 4.53). The activity data used is from the energy balance of the National Statistical Service, and is presented in Table 3.34.

Table 3.34. Oil refined during 1990–2004, kt

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Oil refined, kt	743	891	849	912	1058	967	888	1218	1264	1379
	2000	**2001**	**2002**	**2003**	**2004**					
Oil refined, kt	1370	1350	1269	1134	326					

3.3.1.3. Uncertainties and time-series consistency

The uncertainty analysis of all sectors is presented in Section 1.5. Time-series consistency is ensured by (a) using the same source of data for all years and (b) using the same methodology for the estimation of emissions for all years.

[29](2.6+4.1)/2=3.35 kg/m^3

3.3.1.4. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

3.3.1.5. Category-specific recalculations

There are no reclaculations to be reported for this category.

3.3.1.6. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

3.4. CO_2 transport and storage (CRF 1.C)

Not occurring

3.5. Memo items (1.D)

All emissions from fuels used for international aviation (bunkers) and multilateral operations pursuant to the Charter of UN are to be excluded from national totals, and reported separately as memo items. Memo items are emissions that have to be estimated and reported but do not count towards the national total. The activities that occur in Cyprus under this category are International bunkers (1D1) and CO_2 from biomass (1D3). The emissions during the period 1990–2021 are presented below.

Table 3.35. Emissions from memo items (Gg CO_2 eq.)

Gg CO_2 eq.	**1990**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**
1D1. International bunkers	910	1447	1767	1430	1498	1464	1545	1523
1D3. CO_2 from biomass	30	57	63	180	188	183	178	169
Gg CO_2 eq.	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
1D1. International bunkers	1533	1800	1820	1913	1914	1214	1369	
1D3. CO_2 from biomass	222	235	288	325	320	413	421	

3.5.1. International bunkers (1D1)

3.5.1.1. Category description

Emissions from flights and vessels of all flags that are engaged in international water-borne navigation that depart in one country and arrive in a different country should be included in international bunkers. Emissions from international bunkers as estimated for the period 1990–2021 are presented in Table 3.36.

Table 3.36. Emissions from international bunkers 1990–2021

Gg CO_2 eq.	**1990**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**
International bunkers	909	1448	1766	1430	1498	1464	1545	1523
Aviation	724	834	839	835	866	837	781	782
Navigation	185	614	927	595	633	627	764	742
CO_2 (Gg)	901	1434	1750	1415	1485	1451	1530	1509
CH_4 (Gg)	0.02	0.05	0.08	0.05	0.06	0.05	0.06	0.06
N_2O (Gg)	0.03	0.04	0.05	0.05	0.05	0.05	0.05	0.05
Gg CO_2 eq.	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
International bunkers	1533	1800	1820	1913	1914	1214	1369	
Aviation	757	884	1006	1045	1035	329	559	
Navigation	777	917	814	867	893	885	810	

CO_2 (Gg)	1518	1783	1803	1894	1910	1201	1355	
CH_4 (Gg)	0.07	0.08	0.07	0.07	0.07	0.07	0.06	
N_2O (Gg)	0.05	0.06	0.06	0.06	0.06	0.04	0.05	

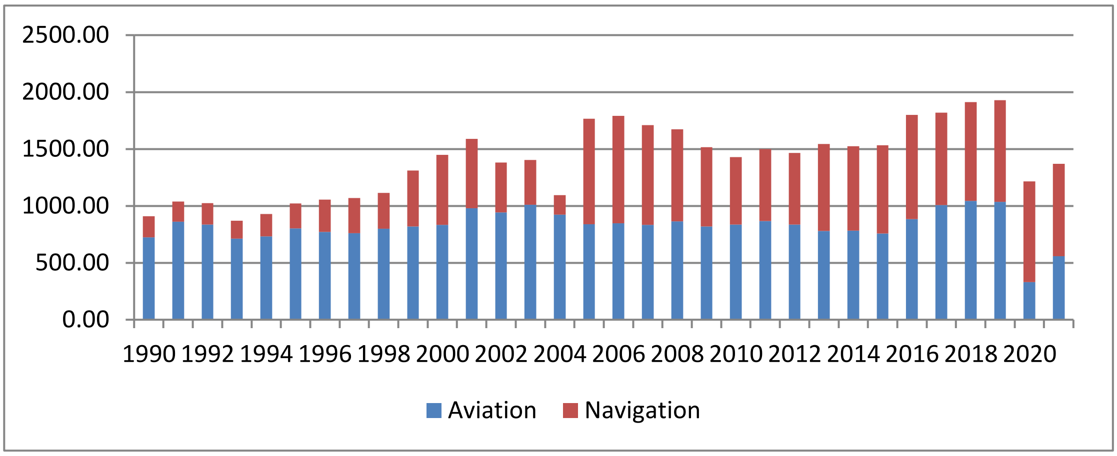

Figure 3.11. Emissions from international bunkers 1990–2021

3.5.1.2. Methodological issues

Activity data used for the estimation of emissions from bunkers is presented in Table 3.37. Data for all fuels except jet-kerosene was obtained from the energy balance of the national statistical service in kt of fuel consumed. Details on the method used to estimate the consumption of jet-kerosene are presented in section 3.2.5.2 and Annex 3. NCV and emission factors (Table 3.38) are the defaults proposed by the IPCC 2006 guidelines; i.e. 44.1 TJ/kt, 71.5 t CO_2/TJ, 0.5 kg CH_4/TJ and 2 kg N_2O/TJ.

Table 3.37. Fuel consumption for international aviation and maritime activities 1990–2021 (kt)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Jet Kerosene	228	271	263	224	230	253	242	239	252	258
Gas/Diesel Oil	24	20	21	14	12	15	25	27	35	46
RFO	34	36	38	36	50	54	65	71	63	108

	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Jet Kerosene	262	308	297	318	290	264	266	262	272	257
Gas/Diesel Oil	50	47	33	36	27	67	106	104	88	73
RFO	143	145	105	88	27	225	190	171	165	146

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Jet Kerosene	263	272	263	246	246	238	278	317	329	295
Gas/Diesel Oil	53	58	69	83	80	75	95	101	117	123
RFO	134	141	128	157	153	169	193	154	154	156

	2020	**2021**								
Jet Kerosene	91	150								
Gas/Diesel Oil	119	113								
RFO	158	141								

Table 3.38. Parameters used for the calculation of emissions

Fuel	**NCV (TJ/kt)**	**kg CO_2/TJ**	**kg CH_4/ TJ**	**kg N_2O/ TJ**
Jet Kerosene	44.10	71500	0.5	2
Gas/Diesel Oil	43	74100	3.9	3.9
RFO	40.4	77400	3	0.6

3.5.1.3. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

3.5.1.4. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

3.5.1.5. Category-specific recalculations

No recalculations to be reported.

3.5.1.6. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

3.5.2. CO_2 emissions from biomass (1.D.3)

3.5.2.1. Category description

Biomass in the energy sector is consumed by the sectors presented in Table 3.39. The resulting emissions from combustion of biomass are presented in Table 3.40 and Figure 3.12.

Table 3.39. Activities consuming biomass in Cyprus

Source category	Solid biofuels	Charcoal	Liquid biofuels	Gas biofuels	Municipal Waste (Biomass Fraction)
1A1c Manufacture of solid fuels and other energy industries	✓				
1A2b Non-ferrous metals			✓		
1A2c Chemical and petrochemical	✓				
1A2d Pupl, paper and print			✓		
1A2e Food, beverages and tobacco	✓				
1A2f Non-metallic minerals	✓				✓
1A2g Other			✓		
1A2m Non-specified Industry			✓		
1A3b Road transport			✓		
1A4a Commercial and public services	✓	✓	✓	✓	
1A4b Residential	✓	✓			
1A4c Agriculture/ Forestry				✓	

Table 3.40. Emissions from CO_2 from biomass 1990–2021

	1990	2000	2005	2010	2011	2012	2013	2014
CO_2 from biomass (Gg)	30	57	63	180	188	183	178	169
	2015	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
CO_2 from biomass (Gg)	222	235	288	325	320	413	421	

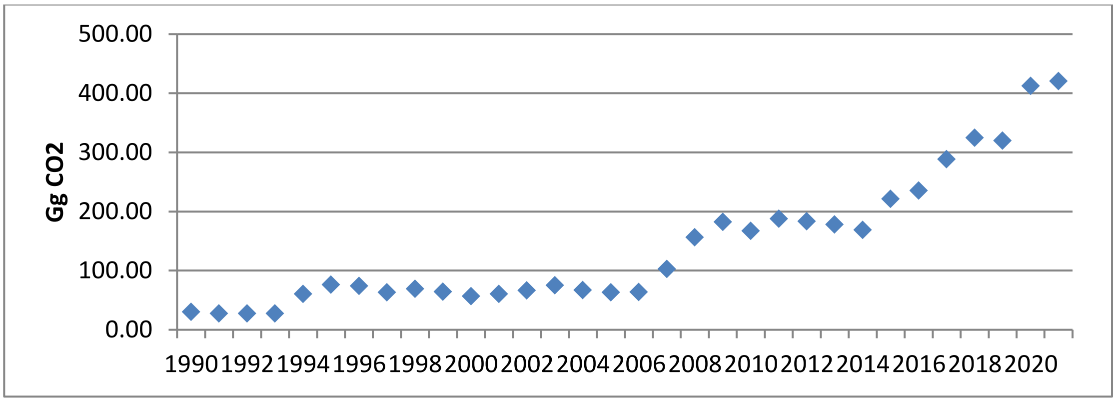

Figure 3.12. Emissions from biomass 1990–2021

3.5.2.2. Methodological issues

Already described in the Sections where the biomass consumption occurs.

3.5.2.3. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

3.5.2.4. Category-specific QA/QC and verification

Already described in the Sections where the biomass consumption occurs.

3.5.2.5. Category-specific recalculations

Already described in the Sections where the biomass consumption occurs.

3.5.2.6. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

Chapter 4.
Industrial processes and product use (CRF sector 2)

4.1. Overview of sector

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

The main emission sources are releases from industrial processes that chemically or physically transform materials (for example, the cement industry is a notable example of industrial processes that release a significant amount of CO_2). 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.

In addition, greenhouse gases often are used in products such as refrigerators, foams or aerosol cans. For example, HFCs are used as alternatives to ozone depleting substances (ODS) in various types of product applications. Similarly, sulphur hexafluoride (SF_6) and N_2O are used in a number of products used in industry (e.g., SF_6 used in electrical equipment, N_2O used as a propellant in aerosol products primarily in food industry) or by end-consumers (e.g., SF_6 used in running-shoes, N_2O used during anaesthesia).

The main industrial activities that take place in Cyprus are food and beverage processing, cement and gypsum production, light chemicals (predominately pharmaceuticals), metal and wood products. Therefore, the source categories applicable for Cyprus in this sector are: Mineral products (2A), Non – energy products from Fuels and Solvent Use (2D), Product Uses as Substitutes for ODS (2F) and Other Product Manufacture and Use (2G).

4.1.1. Emissions trend

Historic evolution of industrial activity in Cyprus[30]

After gaining its independence in 1960, Cyprus demonstrated a successful economic performance in terms of full employment and economic stability, apart from some isolated events. The underdeveloped rural economy inherited from colonialism was transformed into a modern economy with dynamic services, light industry, a very good agricultural sector and advanced physical and social infrastructure. Once traditionally agricultural, Cyprus embraced industrial development in the 1960s and today specializes in the manufacture of medium and high-technology products and semi-customized small-batch products. Industry grew in a sheltered environment with tariffs and quotas which were introduced to protect local production.

Major events that have affected the growth and structure of the economy and specifically of the industrial sector were the Turkish invasion in 1974, accession to the World Trade Organization (WTO), the Customs Union Agreement with the EU in 1988 and eventual membership to the EU in 2004.

The Protocol for the Customs Union and Accession to the EU eliminated all restrictions to trade and increased competition in the local market. This had a major impact on the industrial sector, which had to face fierce competition both from EU markets and third countries.

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1990-2002

In 2002, distribution of Value Added in Manufacturing by Industry, showed Food, beverages and tobacco, as the largest group contributing 38,8% to the manufacturing value added, registered a 1,0% increase in volume of production. This was mainly due to the increase of domestic demand. Other contributing subsectors were as follows: Basic Metals and Metal Products; Machinery and Electrical and Optical Equipment and Manufacture of Transport Equipment; Other Non-Metallic Mineral Products; Refined Petroleum Products; Chemicals and Chemical Products and Rubber and Plastic Products; Manufacturing n.e.c; Pulp, Paper and Paper Products; Publishing and Printing; Wood and Wood Products; Textiles and Textile Products; and Manufacture of Leather and Leather Products. Large increases were recorded in the exports of pharmaceutical products, plastic products, dairy products and perfumes and toilet preparations. Decreases were recorded in the exports of cigarettes, apparel, footwear, electricity distribution and control apparatus, kitchen furniture, and jewellery and related articles.

2004-2009

On 1 May 2004, Cyprus, together with nine other countries, formally took its place alongside the 15 member-states already in the European Union. During 2004, the Cyprus economy exhibited an accelerated rate of growth, in contrast to the conditions of subdued growth observed during the previous two years. The gradual improvement of the overall climate of confidence, which followed the accession of Cyprus to the EU, and the improved external environment of Cyprus, which positively affected the external demand for goods and services, constituted the main contributing factors towards this development. The significant increase of the oil price in international markets constituted a restraining factor towards further growth of the Cyprus economy. In summary, the Cyprus economy exhibited conditions of acceleration of economic activity in 2004, mainly due to the strengthening of domestic demand, and in particular private consumption demand along with investment demand in machinery, transport equipment and construction works.

2009-2014

In 2009, the Cypriot economy began to shrink as the economic crisis in Europe and elsewhere began to bite. The industrial sector was hit the hardest. Local investment was negatively affected by the financial crisis in 2013 where industry found it difficult to secure funding from the local banks.

Cyprus has no heavy industry and the expansion of its light industry is limited by the lack of raw materials and the size of the domestic market. Cyprus is radically restructuring its manufacturing base and actively seeking to attract new high-tech and knowledge-based industries. Main growth industries have been the ICT sector, specifically in manufacturing parts, instruments and electronics, as well as consumer products such as food and cosmetics. Cyprus' key industrial products are pharmaceuticals, food, beverages, chemicals, mineral products, machinery and equipment. Of these, only pharmaceuticals and non-metallic minerals have experienced growth in recent years. Today, manufacturing contributes approximately 5% of GDP and accounts for 9% of people in employment.

The majority of manufacturers are small and medium-sized enterprises (SMEs), which employ less than 10 workers. This makes the sector flexible and open to innovation. The government is seeking to improve SMEs' access to finance and overseas markets, and to maximize the commercial potential of local research and development in order to open up untapped areas of productivity.

In 2014, a stabilization trend began to appear for the industrial sector. Even though there was still a negative growth rate of the industrial sector due to the continuing recession, its value decreased to 0, 3% in 2014, compared to decreases of 6.9% in 2013. Its contribution to the GDP reached 7.1%. A total of 5,387 enterprises were operating in the industrial sector, and main exports were pharmaceutical products, food, basic metals, non-metallic mineral products (i.e. cement), machinery and equipment, and recycled material.

2015-2019

In 2015, the industrial sector registered a positive growth rate in real terms after six years of recession, reaching a rate of 6.1%. Its contribution to the GDP reached 7.0%. This was due to an increase in growth rate in all industrial sectors (NACE Rev.2 Sectors B-E) but especially in the manufacturing sector, where there was an increase in gross output and labour productivity per hour and a small increase in employment.

In 2016, Cyprus reached the end of a three-year economic adjustment program, rebounding significantly from the economic crisis. The industrial sector registered a positive growth rate in real terms for a second year in a row. This rate for the whole of the sector recorded an increase of 6.3% in 2016, compared to an increase of 6.1% in 2015. Manufacturing, which constitutes the largest industrial sector, recorded an increase of 6.3% compared to an increase of 5.9% in 2015 (according to provisional figures). In 2016, domestic industrial output exports grew by 2.6% compared to 2015. The most important categories exported were pharmaceuticals, food, non-metallic mineral products, recycled products, and machinery and equipment. Compared to 2015, large increases were recorded in exports of dairy products and fruit and vegetable products, due to new bilateral agreements (e.g. China) and access to their trading markets, while significant decreases were recorded in exports of cement and base metals.

In 2017, for the third consecutive year, industry experienced positive growth in real terms. In the industrial sector as a whole, production value at current prices increased by 12.8% in 2017 compared to 2016. Employment in the broader industrial sector in 2017 increased by 6.7% compared to 2016. The contribution of the whole industrial sector to the GDP reached 7.9% and 8.8% in total employment.

2018 is the fourth consecutive year that industry experienced positive growth in real terms. According to preliminary estimates from the Cyprus Statistical Office, in the industrial sector as a whole, production value at current prices increased by 8.2% in 2018 compared to 2017. In manufacturing, production value increased by 7.8%, in mines and quarries by 9.3%, in electricity supply by 12.2% and in water supply, sewerage and waste management by 3.4%. Employment in the broader industrial sector in 2018 increased by 3.8% compared to 2017. The contribution of the whole industrial sector to the GDP reached 7.9% and 8.3% in total employment.

According to 2019 statistics, Cyprus Industrial base was mainly operating in light industrial activities. Industry contributed 7.9% to GDP and about 9% of the total employment. The majority of manufacturing units were small- and medium-sized enterprises (SMEs), which occupied less than 10 employees. Main growth sectors were, among others, the ICT sector, the pharmaceutical sector, and the food and drink sector.

Although the Competitiveness of the industrial sector still had a lot of potential, it remained rather low. This was mainly due to low productivity, high production costs and, in general, increased supply chain costs resulting from the small size of the market, the insularity of the economy and its geographic and energy "isolation," its limited resources, its low capacity for innovation (mainly due to a low percent of investment in R&D and to the very small size of businesses), insufficient use and implementation of quality standards, and lack of adequate tangible and intangible infrastructure.

At this point, Cyprus proceeded with the design and implementation of a new Industrial Policy aiming to develop more high-value-added and innovative products and services that will contribute to the overall competitiveness of the Cyprus economy. At the same time Cyprus is aiming to increase productivity by strengthening the industrial ecosystem and promoting investment in digitalisation, sustainability, innovation and circular economy.

Emissions

In 2021, GHG emissions from Industrial processes accounted for 14.6% of total emissions excluding LULUCF compared to 12.9% in 1990. The emissions increased by 75.9% compared to 1990. 70% of the industrial processes emissions were from mineral production, 27.8% from consumption of Halocarbons, 1.7% from Other Product Manufacture and Use and the remaining 0.4% from non-energy products from fuels and solvent use.

Table 4.1. Total GHG emissions (in Gg CO_2 eq) from Industrial Processes, 1990–2021

	1990	2000	2005	2010	2011	2012	2013
2. Industrial Processes	**727.93**	**883.08**	**1003.14**	**810.82**	**811.86**	**772.54**	**1014.55**
A. Mineral industry	717.07	802.75	860.47	589.98	571.83	527.64	765.18
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	NO	NO	NO	NO	NO	NO	NO
D. Non-energy products from fuels and solvent use	4.19	4.10	3.46	3.53	3.53	2.95	2.37
E. Electronic industry	NO	NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes	NO,NE	62.44	121.80	198.99	216.37	221.17	225.67
G. Other product manufacture and use	6.66	13.80	17.40	18.32	20.14	20.77	21.32
H. Other	NO	NO	NO	NO	NO	NO	NO

	2014	2015	2016	2017	2018	2019	2020
2. Industrial Processes	**1243.21**	**1159.72**	**1187.42**	**1250.85**	**1201.49**	**1173.02**	**1269.41**
A. Mineral industry	985.79	888.12	896.42	938.91	868.24	814.39	902.15
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	NO	NO	NO	NO	NO	NO	NO
D. Non-energy products from fuels and solvent use	2.38	2.47	2.66	2.43	2.44	4.98	4.92
E. Electronic industry	NO	NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes	233.18	246.65	267.02	287.91	308.05	332.27	337.60
G. Other product manufacture and use	21.86	22.47	21.33	21.59	22.76	21.39	24.74
H. Other	NO	NO	NO	NO	NO	NO	NO

	2021						
2. Industrial Processes	**1277.81**						
A. Mineral industry	896.99						
B. Chemical industry	NO						
C. Metal industry	NO						
D. Non-energy products from fuels and solvent use	5.03						
E. Electronic industry	NO						
F. Product uses as ODS substitutes	353.49						
G. Other product manufacture and use	22.30						
H. Other	NO						

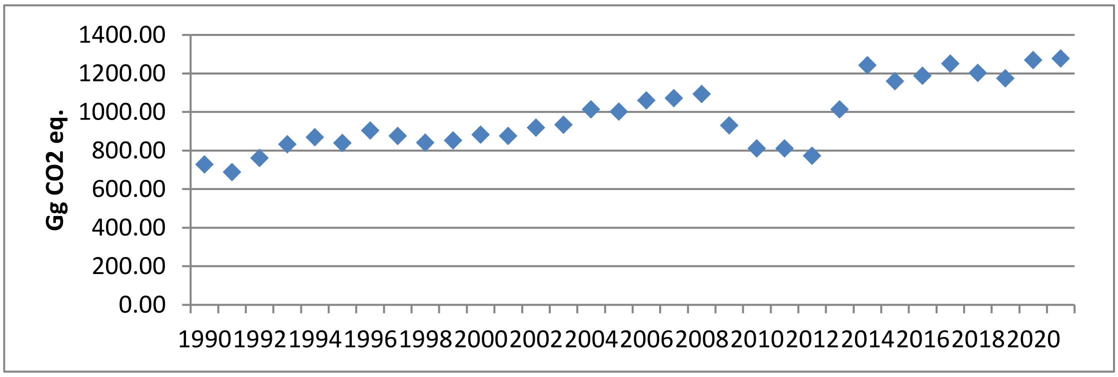

Figure 4.1. GHG emissions from Industrial Processes (sector 2) for the period 1990–2021

4.1.2. Completeness

Table 4.2 gives an overview of the IPCC source categories included in this chapter and presents the status of emissions estimates from all sub-sources in industrial processes.

Table 4.2. Industrial Processes – completeness

	CO_2	CH_4	N_2O	HFC	PFC	SF_6
2A1.Cement production	✓	NE	NE	NE	NE	NE
2A2. Lime production	✓	NE	NE	NE	NE	NE
2A3. Glass production	NO	NE	NE	NE	NE	NE
2A4a. Other process Uses of Carbonates - Ceramics	✓	NE	NE	NE	NE	NE
2A4b. Other uses of soda ash	✓	NE	NE	NE	NE	NE
2B. Chemical industry	NO	NE	NE	NE	NE	NE
2C. Metal Industry	NO	NE	NE	NE	NE	NE
2D1. Non-energy Products from Fuels and Solvent Use – Lubricant Use	✓	NE	NE	NE	NE	NE
2D2. Paraffin wax Use	✓	NE	NE	NE	NE	NE
2D3. Non Energy Products from Fuels and Solvent Use	✓	NE	NE	NE	NE	NE
2E. Electronics Industry	NE	NE	NE	NO	NO	NO
2F1. Refrigeration & air conditioning	NE	NE	NE	✓	NO	NE
2F2. Foam blowing agents	NE	NE	NE	✓	NO	NE
2F3. Fire protection	NE	NE	NE	✓	NO	NE
2F4a. Metered dose inhalers	NE	NE	NE	✓	NO	NE
2F5. Solvents	NE	NE	NE	NO	NO	NE
2G1. Electrical equipment	NE	NE	NE	NE	NO	✓
2G3. N_2O from product uses	NE	NE	✓	NE	NE	NE
2G4. Other	✓	NE	NE	NE	NE	NE

NO: Not Occurring; NE: Not Emitted during the specific industrial process

4.1.3. Methodology

The calculation of GHG emissions is based on the methodologies and emission factors suggested by the IPCC 2006 Guidelines for lime production (2A2), Other uses of soda ash (2A4b), Lubricant Use (2D1) and Urea-based catalysts. The emissions for remaining sectors are estimated using country specific methodologies. The methodologies and emission factors used are summarised in Table 4.3.

Table 4.3. Industrial processes – methodologies and emission factors applied

Category-Classification		Gas	EF	Method
2A1.	Industrial Processes and Product Use – Mineral Industry - Cement production	CO_2	CS	CS
2A2	Industrial Processes and Product Use – Mineral Industry - Lime Production	CO_2	D	T1
2A4a	Industrial Processes and Product Use – Mineral Industry - Other process uses of carbonates - Ceramics	CO_2	CS	CS
2A4b	Industrial Processes and Product Use – Mineral Industry - Other process uses of carbonates - Other uses of soda-ash	CO_2	D	T1
2A4b	Industrial Processes and Product Use – Mineral Industry - Other process uses of carbonates - Other uses of soda-ash	CH_4/N_2O	NA	NA
2D1	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use- Lubricant Use	CO_2	D	T1
2D1	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use- Lubricant Use	CH_4/N_2O	NA	NA
2D2	Industrial Processes and Product Use – Non Energy	CO_2	D	T1

Category-Classification		Gas	EF	Method
	Products from Fuels and Solvent Use - Paraffin Wax Use			
2D2	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use - Paraffin Wax Use	CH_4/N_2O	NA	NA
2D3	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use – Other (Dry cleaning, coating applications, chemical products, asphalt roofing, domestic solvent use including fungicides, road paving with asphalt, printing)	CO_2	CS	CS
2D3	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use – Other (Dry cleaning, coating applications, chemical products, asphalt roofing, domestic solvent use including fungicides, road paving with asphalt, printing)	CH_4/N_2O	NA	NA
2D3	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use – Other - Urea-based catalysts	CO_2	D	D
2D3	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use – Other - Urea-based catalysts	CH_4/N_2O	NA	NA
2F1	Product Uses as Substitutes for ODS - Refrigeration and air conditioning	HFCs	D	T2a
2F2	Product Uses as Substitutes for ODS - - Foam Blowing Agents	HFCs	CS	CS
2F3	Product Uses as Substitutes for ODS - - Fire Protection	HFCs	CS	CS
2F4.	Product Uses as Substitutes for ODS - Aerosols	HFCs	CS	CS
2G3a	Other Product Manufacture and Use - N_2O from product uses – Medical Applications	N_2O	CS	CS
2G3b	Other Product Manufacture and Use - N_2O from product uses – Other –Propellant for pressure and aerosol products	N_2O	CS	CS

T1: IPCC methodology Tier 1; D: IPCC default methodology and emission factor; CS: Country specific; T2a: IPCC methodology Tier 2a

4.2. Mineral products (2.A)

This chapter outlines process-related carbon dioxide (CO_2) emissions resulting from the use of carbonate raw materials in the production and use of a variety of mineral industry products. There are two broad pathways for release of CO_2 from carbonates: calcination and the acid-induced release of CO_2. 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.

The mineral products that are produced in Cyprus are cement, lime and ceramics. Other products that are consumed in Cyprus are limestone (only in cement and lime production - already accounted for in 2A1 and 2A2) and soda ash. According to the information obtained from the Customs, soda ash in Cyprus is imported for consumption by a bentonite quarry, lab supplies, swimming pools, production of building materials and cleaning products. The emissions estimated by product are presented in Table 4.4.

Emissions from mineral products in 2021 increased by 25.1% compared to 1990. A decrease of emissions by 0.6% is observed in relation with the previous year (2020). The largest emitter continues to be cement production with 97.9% of the emissions (compared to 93.1% in 1990). The mineral materials produced in Cyprus are directly associated with the construction industry. Therefore, the economic situation in Cyprus after 2008 that directly affected constructions is also visible in the trend of the emissions of the sector. In 2013 however, even though the economic situation did not improve, emissions increase due to an increase in cement production caused by increase in exports.

Table 4.4. Emissions from mineral industry 1990–2021 (Gg CO_2)

Gg CO_2	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
A. Mineral industry	**717.07**	**802.75**	**860.47**	**589.98**	**571.83**	**527.64**	**765.18**	**985.79**	**888.12**	**896.42**	**938.91**	**868.24**	**814.39**	**902.15**	**896.99**
1. Cement production	667.66	762.71	788.18	555.05	546.04	504.54	752.29	973.76	877.13	883.25	922.88	848.16	789.21	882.32	878.81
2. Lime production	5.33	5.41	12.06	7.20	7.15	3.39	2.73	2.45	2.36	2.38	3.18	5.33	3.93	3.11	3.99
3. Glass production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4. Other process uses of carbonates	44.08	34.63	60.23	27.74	18.63	19.72	10.16	9.58	8.64	10.78	12.86	14.74	21.24	16.72	14.19
CO_2 (Gg)	717.07	802.75	860.47	589.98	571.83	527.64	765.18	985.79	888.12	896.42	938.91	868.24	814.39	902.15	896.99
Total (Gg CO_2)	**717.07**	**802.75**	**860.47**	**589.98**	**571.83**	**527.64**	**765.18**	**985.79**	**888.12**	**896.42**	**938.91**	**868.24**	**814.39**	**902.15**	**896.99**

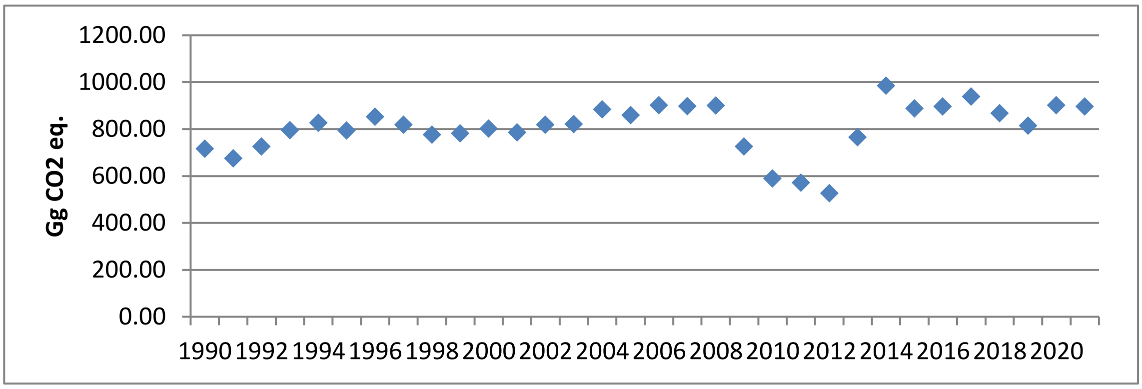

Figure 4.2. GHG emissions from Mineral products (2A) for the period 1990–2021

4.2.1. Cement production (2.A.1)

In cement manufacture, CO_2 is produced during the production of clinker, a nodular intermediate product that is then finely ground, along with a small proportion of calcium sulphate [gypsum ($CaSO_4 \cdot 2H_2O$) or anhydrite ($CaSO_4$)], into hydraulic (typically portland) cement. During the production of clinker, limestone, which is mainly calcium carbonate ($CaCO_3$), is heated, or calcined, to produce lime (CaO) and CO_2 as a by-product. The CaO then reacts with silica (SiO_2), alumina ($A_{l2}O_3$), and iron oxide (Fe_2O_3) in the raw materials to make the clinker minerals (chiefly calcium silicates). The proportion in the raw materials of carbonates other than $CaCO_3$ is generally very small. The other carbonates, if present, exist mainly as impurities in the primary limestone raw material.

The emissions for the source category are presented in Table 4.5 and Figure 4.3. After 2008 there was sharp decrease in activity of the construction industry in Cyprus, which is reflected in the emissions. The sharp increase between 2013 and 2014 is due to an increase of exports, while between 2014 and 2015 there was a reduction in demand for exports, which caused a reduction in production.

Table 4.5. CO_2 emissions for Cement production (2.A.1) 1990–2021

	1990	2000	2005	2010	2011	2012	2013	2014	2015
Gg CO_2	667.7	762.7	788.2	555.1	546.0	504.5	752.3	973.8	877.1

	2016	2017	2018	2019	2020	2021			
Gg CO_2	883.2	922.9	848.1	789.2	882.3	878.8			

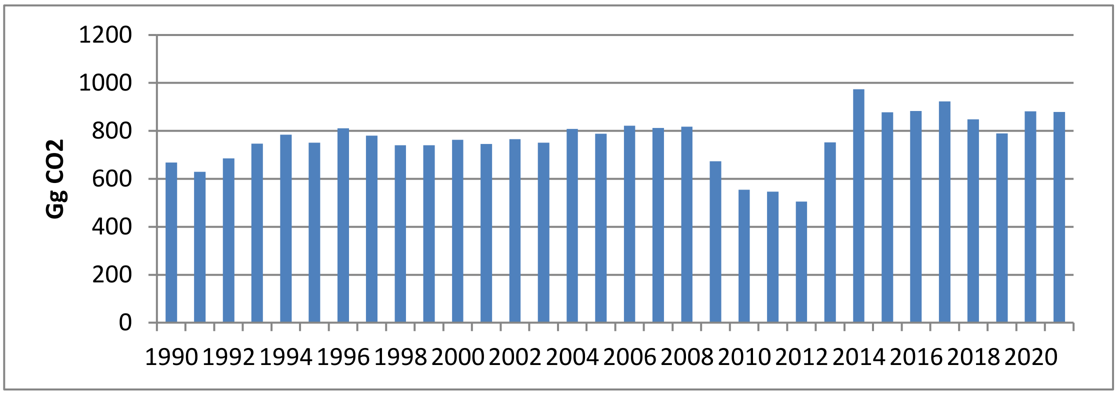

Figure 4.3. CO_2 emissions for Cement production (2.A.1) 1990–2021

In Cyprus, there is one cement producing installation, which provides information regarding CO_2 emissions in accordance to the EU-ETS legislation. Industrial installations covered by the EU ETS are required to have an approved monitoring plan for monitoring and reporting annual emissions. Every year, operators must submit an emissions report. The data for a given year must be verified by an accredited verifier by 31 March of the following year[31]. The EU ETS Directive was adopted in 2003 and the system was launched in 2005. The cap on allowances for the first trading period was set at national level through National Allocation Plans (NAPs)[32]. For the preparation of the NAP for the first trading period (2005-2007) historical data was collected for relevant installations. For the two cement installations that were operating at the time, data was available from 1997.

For the period 2012-2014 the clinker production increased annually due to an increase of exports to Lebanon. However, in 2015, the clinker production decreased 10% below the 2014 production. According to the information provided by the installation, two reasons accounted for this reduction: (a) there was a reduction in demand for exports; and (b) clinker production is regulated by available stocks, storage capacity and demand.

4.2.1.1. Methodological issues

Data for clinker production was obtained from the installations that operate in Cyprus (2 installations 1990-2011, one installation thereafter) (Table 4.6).

The estimation of emissions is based on a country-specific methodology.

Information regarding CO_2 emissions has been submitted annually since 2005, in accordance with the EU-ETS legislation. Emissions are estimated using Tier 3 methodologies. The CO_2 emissions are reported through templates provided by the European Commission for annual emission reports that are

[31] Commission Regulation (EU) No 600/2012 of 21 June 2012 on the verification of greenhouse gas emission reports and tonne-kilometre reports and the accreditation of verifiers pursuant to Directive 2003/87/EC of the European Parliament and of the Council Text with EEA relevance, available at http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012R0600.
[32] More information available at https://ec.europa.eu/clima/policies/ets/pre2013/nap_en

based on the Monitoring and Reporting Regulation[33]. The emissions for 2005-2016 are used as submitted by the installations for the EU-ETS (Table 4.6) that are estimated according to EU legislation and are verified by external verifier accredited by the national authorities. The emissions for the period 1997-2004 are from the data submitted by the installations for the preparation of the National Allocation Plan.

For 1990-1996, the emission factor of 0.5347 tCO_2/t clinker was used, which is the implied emission factor estimated from the CO_2 process emissions reported by the two cement producing installations for 1997. The emissions were estimated by multiplying the IEF by the clinker production (Table 4.6).

Table 4.6. Total clinker production (kt) and CO_2 process emissions ($GgCO_2$) from cement production

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Clinker production (kt)								
Installation 1	353	390	380	382	383	369	359	374
Installation 2	895	786	902	1015	1083	1035	1158	1085
Total	1249	1176	1282	1397	1466	1405	1516	1459
CO_2 **process emissions (Gg**CO_2**)**								
Installation 1								190
Installation 2								590
Total	668	629	686	747	784	751	811	780
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Clinker production (kt)								
Installation 1	337	334	362	361	373	363	367	333
Installation 2	1045	1047	1065	1033	1059	1043	1142	1143
Total	1382	1382	1428	1394	1432	1405	1509	1473
CO_2 **process emissions (Gg**CO_2**)**								
Installation 1	180	180	193	193	200	194	197	181
Installation 2	560	560	569	552	566	557	610	607
Total	740	740	763	745	766	751	808	788
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2008**	**2009**
Clinker production (kt)								
Installation 1	365	350	368	231	260	76	368	231
Installation 2	1177	1166	1158	1033	783	961	1158	1033
Total	1542	1515	1526	1264	1043	1037	1526	1264
CO_2 **process emissions (Gg**CO_2**)**								
Installation 1	198	190	200	125	140	41	200	125
Installation 2	623	622	618	548	415	505	618	548
Total	821	812	818	673	555	546	818	673
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Clinker production (kt)								
Installation 1	260	76	0	0	0	0	0	0
Installation 2	783	961	953	1418	1822	1641	1648	1725
Total	1043	1037	953	1418	1822	1641	1648	1725
CO_2 **process emissions (Gg**CO_2**)**								
Installation 1	140	41	0	0	0	0	0	0
Installation 2	415	505	505	752	974	877	883	923
Total	555	546	505	752	974	877	883	923

[33] Commission Regulation (EU) No 601/2012 of 21 June 2012 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council Text with EEA relevance, available at http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CEL EX:32012R0601.

	2018	**2019**	**2020**	**2021**				
Clinker production (kt)								
Installation 1	0	0	0	0				
Installation 2	1603	1509	1694	1664				
Total	1603	1509	1694	1664				
CO_2 **process emissions (Gg**CO_2**)**								
Installation 1	0	0	0	0				
Installation 2	848	789	882	878				
Total	848	789	882	878				

All the Cement kiln dust (CKD) is bound and recycled into the production process and no CKD is being exported from the system; therefore emissions from CKD are not estimated. According to the ETS inspectors this is the case for the two installations that were operating before 2011 and the one installation that has been operating since. The two installations operating before 2011 have been using the same production technologies and process.

The possibility to use an installation-specific or a country-specific emission factor for the period 1990-1996 was investigated with the installations. However, no data is available.

4.2.1.2. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

4.2.1.3. Category-specific QA/QC and verification

Data for clinker production was compared to the data reported by the statistical service and the data used by the department of Labour Inspection for the preparation of air pollutants inventories under Directive 2001/81/EC.

Moreover, since 2005, all data associated with the calculations is undergoing external verification according to the provisions of the relevant ETS legislation.

4.2.1.4. Category-specific recalculations

No recalculations to be reported.

4.2.1.5. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

4.2.2. Lime Production (2.A.2)

Calcium oxide (CaO or 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. Dolomite and dolomitic (high magnesium) limestones may also be processed at high temperature to obtain dolomitic lime (and release CO_2). The production of lime involves a series of steps, including the quarrying of raw materials, crushing and sizing, calcining the raw materials to produce lime, and (if required) hydrating the lime to calcium hydroxide.

In Cyprus there is one installation producing slaked lime. The final use of the produced lime is predominately in the construction of roads; lime is used as an additive to increase flexibility and reduce cracks.

The emissions for the source category are presented in Table 4.7 and Figure 4.4. After 2008 there was decrease in activity of the construction industry in Cyprus, which is reflected in the amount of lime used (and therefore produced) and the emissions. The sharp decrease between 2011 and 2012 is due to a reduction in production caused by further reduction of activity of the constructions' industry.

Table 4.7. CO_2 emissions for Lime production (2.A.2) 1990–2021

	1990	2000	2005	2010	2011	2012	2013	2014	2015
Gg CO_2	5.33	5.41	12.06	7.19	7.15	3.39	2.73	2.45	2.36

	2016	2017	2018	2019	2020	2021			
Gg CO_2	2.38	3.18	5.33	3.93	3.11	3.99			

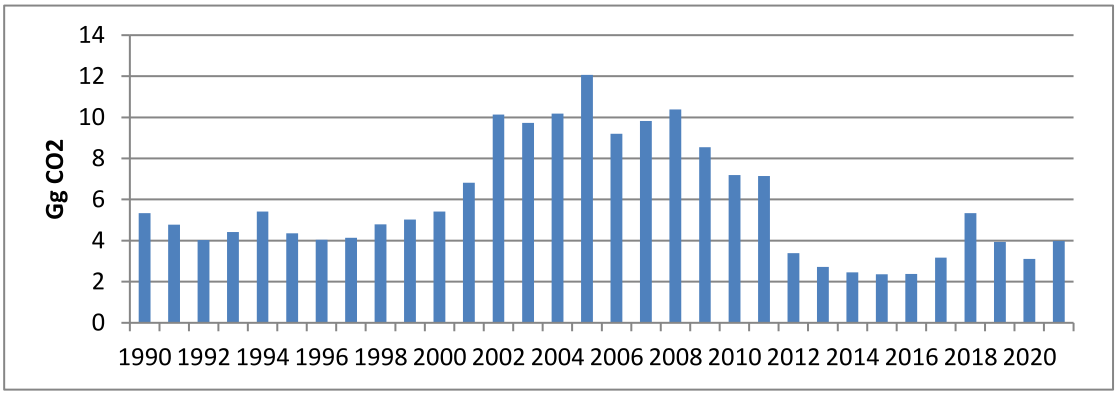

Figure 4.4. CO_2 emissions for Lime production (2.A.2) 1990–2021

4.2.2.1. Methodological issues

The activity data for lime production was obtained from the one installation in Cyprus that produces slaked lime (Table 4.8). The emission factor chosen is the default proposed for high calcium lime according to the 2006 IPCC Guidelines (volume 3, pg. 2.22, table 2.4), 0.75 t CO_2/t lime produced.

Slaked lime is hydrated lime and there is a correction factor for this lime in the 2006 IPCC Guidelines (see vol.3 chapter 2. Mineral Industry, page 2.24). Also, according with 2006 IPCC guidelines: "It is good practice to include a correction for hydrated lime under Tier 2, and where data are available, under Tier 1."

Table 4.8. Slaked lime production (t)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Production (t)	7330	6570	5540	6080	7440	5980	5550	5688	6579	6907

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Production (t)	7439	9372	13934	13367	14004	16583	12640	13494	14285	11753

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Production (t)	9890	9829	4659	3746	3366	3244	3277	4369	7333	5407

	2020	2021								
Production (t)	4274	5489								

4.2.2.2. Uncertainties and time-series consistency

Uncertainty estimates for lime production result predominantly from uncertainties associated with activity data, and to a lesser extent from uncertainty related to the emission factor. The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

4.2.2.3. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

4.2.2.4. Category-specific recalculations

No recalculations to be reported.

4.2.2.5. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

4.2.3. Glass Production (2.A.3)

The publication 'Industrial Statistics – 2016' (page 156), available on the website of the Statistical Service of Cyprus, presents the manufacture of flat glass, fibre glass and glass articles in Cyprus. However, from the information obtained by the Statistical Service it has been revealed that glass production does not take place in Cyprus; only shaping and processing of imported glass. Therefore glass production is not occurring in Cyprus.

4.2.4. Other Process Uses of Carbonates (2.A.4)

Limestone ($CaCO_3$), dolomite ($CaMg(CO_3)_2$) and other carbonates (e.g., $MgCO_3$ and $FeCO_3$) are basic raw materials having commercial applications in a number of industries. In addition to those industries already discussed individually, carbonates also are consumed in metallurgy (e.g., iron and steel), agriculture, construction and environmental pollution control (e.g., flue gas desulphurisation.). The calcination of carbonates at high temperatures yields CO_2.

The two activities that take place in Cyprus are production of ceramics and other uses of soda ash.

Ceramics industries in Cyprus produce bricks and roof tiles. Process-related emissions from ceramics result from the calcination of carbonates in the clay, as well as the addition of additives. Similar to the cement and lime production processes, carbonates are heated to high temperatures in a kiln, producing oxides and CO_2. The raw materials are collected and finely crushed in successive grinding operations. The ground particles are then fired in a kiln to produce a powder. Additives are subsequently added and the ceramic is formed or moulded and 'machined' to smooth rough edges and achieve the desired characteristics of the ceramic. After firing, some ceramics may undergo additional treatment to achieve the final desired quality. CO_2 emissions result from the calcination of the raw material and the use of limestone as a flux.

Soda ash production and consumption (including sodium carbonate, Na_2CO_3) results in the release of CO_2. According to information received by the customs office[34] soda ash in Cyprus is imported by a betonite quarry, lab supplies companies, swimming pools companies, building materials companies, and cleaning products companies.

The emissions for the source category are presented in Table 4.9 and Figure 4.5. After 2008 there was sharp decrease in activity of the construction industry in Cyprus, which is reflected in the amount of bricks and tiles used (and therefore produced) and the respective emissions. Another reason for the reduction of emissions since 2013 is that one ETS installation and the one non-ETS installation have ceased operation.

[34] email 28/9/2016, Solonas Papapolyviou

Table 4.9. CO_2 emissions for Other Process Uses of Carbonates (2.A.4) 1990–2021

Gg CO_2	1990	2000	2005	2010	2011	2012	2013	2014	2015
Ceramics	43.82	34.07	59.95	27.44	18.31	19.49	10.02	9.41	8.51
Soda-ash	0.26	0.56	0.28	0.30	0.32	0.23	0.15	0.17	0.13
TOTAL	**44.08**	**34.63**	**60.23**	**27.74**	**18.63**	**19.72**	**10.16**	**9.58**	**8.64**

Gg CO_2	2016	2017	2018	2019	2020	2021			
Ceramics	10.60	12.67	14.57	21.14	16.66	14.08			
Soda-ash	0.19	0.19	0.17	0.10	0.06	0.10			
TOTAL	**10.78**	**12.86**	**14.74**	**21.24**	**16.72**	**14.19**			

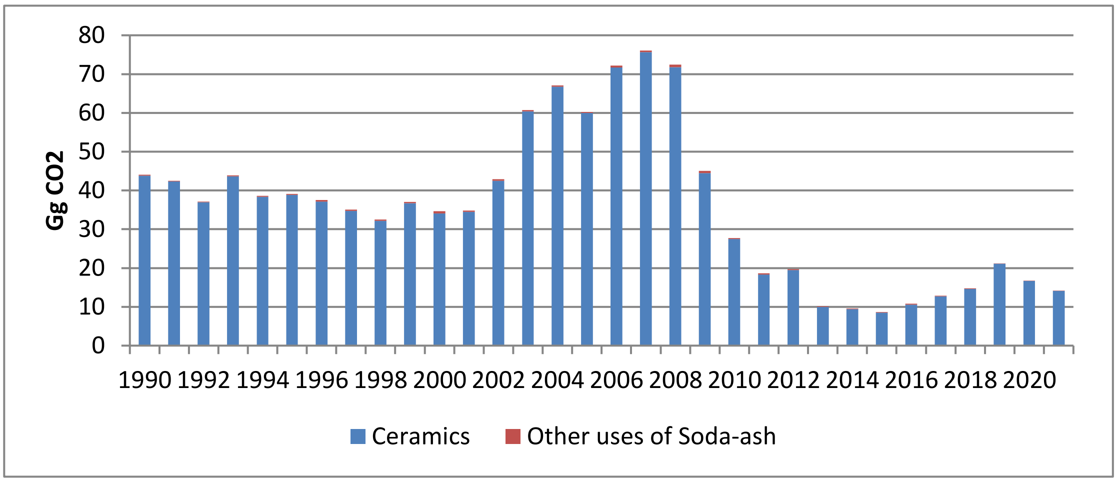

Figure 4.5. CO_2 emissions for Other Process Uses of Carbonates (2.A.4) 1990–2021

4.2.4.1. Ceramics

4.2.4.1.1. Methodological issues

In 2019, there were six ceramics-producing installations (comparing with five ceramics-producing installation in 2018), which provide information regarding CO_2 emissions in accordance to the EU-ETS legislation. Industrial installations covered by the EU ETS are required to have an approved monitoring plan for monitoring and reporting annual emissions. Every year, operators must submit an emissions report. The data for a given year must be verified by an accredited verifier by 31 March of the following year[35]. The EU ETS Directive was adopted in 2003 and the system was launched in 2005. The cap on allowances for the first trading period was set at national level through National Allocation Plans (NAPs)[36]. For the preparation of the NAP for the first trading period (2005-2007) historical data was collected for relevant installations. For the eight ceramics installations that were operating at the time, data was available from 2001.

Production data was obtained from the installations that operate in Cyprus (Table 4.10). For the period 1990-2015 there were eight installations in operation, seven in 2016, six in 2017, five in 2018 and six in 2019.

The estimation of emissions is based on a country-specific methodology.

Information regarding CO_2 emissions is annually submitted from 2005 in accordance with the EU-ETS legislation. Emissions are estimated using tier 3 methodologies. The CO_2 emissions are reported through

[35] Commission Regulation (EU) No 600/2012 of 21 June 2012 on the verification of greenhouse gas emission reports and tonne-kilometre reports and the accreditation of verifiers pursuant to Directive 2003/87/EC of the European Parliament and of the Council Text with EEA relevance, available at http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012R0600
[36] More information available at https://ec.europa.eu/clima/policies/ets/pre2013/nap_en

templates provided by the European Commission for annual emission reports that are based on the Monitoring and Reporting Regulation[37]. The emissions for 2005-2016 are used as submitted by the installations for the EU-ETS (Table 4.10), which are estimated according to EU legislation and are verified by external verifier accredited by the national authorities. The emissions for the period 2001-2004 the data submitted by the installations for the preparation of the National Allocation Plan.

For the period 2001-2012, the emissions of the non-ETS installation were estimated using the emission factor of 0.160 tCO_2/t, which is the implied emission factor estimated from the CO_2 process emissions reported by the eight ceramics producing installations for 2003 (highest available). The highest emission factor was chosen, since as a non-ETS installation it does not have to regulate its emissions and therefore does not take any measures to reduce emissions. The emissions were estimated by multiplying the IEF by the non-ETS ceramics production (Table 4.7). The additional, non-ETS installation ceased its operations, therefore there are no additional emissions to those reported under the ETS.

For 1990-2000, the emission factor of 0.123 tCO_2/t ceramics was used, which is the implied emission factor estimated from the CO_2 process emissions reported by the eight ceramics producing installations for 2001 (earliest available). The emissions were estimated by multiplying the IEF by the TOTAL ceramics production (Table 4.11); i.e. ETS and non-ETS production.

The possibility to use an installation-specific or a country-specific emission factor for the period 1990-2000 was investigated with the installations. However, no data is available.

Table 4.10. Ceramics production (kt)

	1990	1991	1992	1993	1994	1995	1996
Total production (kt)	355.4	343.0	299.7	354.2	311.2	315.3	301.2
ETS production (kt)							
Non-ETS production (kt)							

	1997	1998	1999	2000	2001	2002	2003
Total production (kt)	281.7	261.3	297.9	276.3	277.8	332.4	377.9
ETS production (kt)					271.4	314.5	364.2
Non-ETS production (kt)					6.3	17.9	13.7

	2004	2005	2006	2007	2008	2009	2010
Total production (kt)	483.9	504.0	491.4	512.4	545.9	356.2	291.5
ETS production (kt)	470.4	493.2	483.6	500.4	532.9	338.4	282.1
Non-ETS production (kt)	13.6	10.8	7.8	12.0	13.0	17.8	9.3

	2011	2012	2013	2014	2015	2016	2017
Total production (kt)	223.0	168.0	90.0	83.7	84.5	111.6	152.6
ETS production (kt)	211.4	161.7	90.0	83.7	84.5	111.6	152.6
Non-ETS production (kt)	11.5	6.3	0	0	0	0	0

	2018	2019	2020	2021			
Total production (kt)	151.8	224.8	206.7	231.5			
ETS production (kt)	151.8	224.8	206.7	231.5			
Non-ETS production (kt)	0	0	0	0			

Table 4.11. CO_2 process emissions of the ETS ceramics installations and estimated annual implied emission factor (2001-2021)

	2001	2002	2003	2004	2005	2006	2007
ETS CO_2 emissions ($GgCO_2$)	33.5	39.6	58.2	64.6	58.2	70.4	73.7
IEF (Gg CO_2/Gg product)	0.123	0.126	0.160	0.137	0.118	0.146	0.147

	2008	2009	2010	2011	2012	2013	2014
ETS CO_2 emissions (Gg CO_2)	69.7	41.6	25.9	16.5	18.5	10.0	9.4

[37] Commission Regulation (EU) No 601/2012 of 21 June 2012 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council Text with EEA relevance, available at http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CEL EX:32012R0601

IEF (Gg CO_2/Gg product)	0.131	0.123	0.092	0.078	0.114	0.111	0.112

	2015	2016	2017	2018	2019	2020	2021
ETS CO_2 emissions (Gg CO_2)	8.5	10.6	12.7	14.6	21.1	16.7	14.1
IEF (Gg CO_2/Gg product)	0.101	0.095	0.083	0.096	0.094	0.081	0.061

4.2.4.1.2. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

4.2.4.1.3. Category-specific QA/QC and verification

Data for ceramics production was compared to the data reported by the statistical service and the data used by the department of Labour Inspection for the preparation of air pollutants inventories under Directive 2001/81/EC.

Moreover, since 2005, all data associated with the calculations is undergoing external verification according to the provisions of the relevant ETS legislation.

4.2.4.1.4. Category-specific recalculations

No recalculations to be reported.

4.2.4.1.5. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

4.2.4.2. Other uses of soda ash

4.2.4.2.1. Methodological issues

The CO_2 emissions from other uses of soda-ash have been estimated using the T1 methodology proposed by the 2006 IPCC guidelines. Equation 2.14 (pg. 2.34, vol. 3, IPCC 2006 guidelines) was adopted for soda ash; i.e. CO_2 Emissions = Mc x EF

where:
CO_2 Emissions = emissions of CO_2 from other process uses of carbonates, tonnes;
Mc = mass of carbonate consumed, tonnes;
EF = emission factor for soda ash, tonnes CO_2/tonne carbonate (table 2.1, pg. 2.7, vol.3, 2006 IPCC guidelines), 0.41492 tCO_2/t CO_3 assuming 100% calcination.

Activity data (Table 4.12) was obtained from the imports statistics of the Statistical Service. It was assumed that all imported quantities have been consumed in the year the import has taken place. The imports of soda ash suffered a sharp increase for 2010 (1438 t), 51% above the 2009 value (711 t). For 2015 the imports are the lowest of the entire time series (326 t), which also affected the emissions. According to information obtained from the Customs Department, the main consumers of soda ash in Cyprus (90%) are engaged with the production of building materials. A large decline in the building industry began in 2010, and this is reflected in the consumption of building products and subsequently imports and use of soda ash.

Table 4.12. Imports of Soda ash in Cyprus (t)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Imports of Soda ash (t)	615	499	383	502	504	529	1063	789	808	832

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Imports of Soda ash (t)	1345	823	1003	813	837	664	1179	1132	1479	1438

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Imports of Soda ash (t)	711	771	560	353	401	322	447	449	402	247

	2020	2021								
Imports of Soda ash (t)	154	246								

4.2.4.2.2. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

4.2.4.2.3. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

4.2.4.2.4. Category-specific recalculations

No recalculations to be reported.

4.2.4.2.5. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

4.3. Chemical Industry (2.B)

4.3.1. Carbide production (2.B.5)

According to the imports statistics, there is import of carbides of calcium to Cyprus. According to information received by the customs office[38] carbides products are imported by a company importing raw materials for mattresses. Therefore, carbides of calcium are not used for the production of acetylene.

4.4. Non-Energy Products from Fuels and Solvent Use (2.D)

4.4.1. Category description

According to the 2006 Guidelines, "Non-energy products" are primary or secondary fossil fuels which are used directly for their physical or diluent properties. Examples are: lubricants, paraffin waxes, bitumen, and white spirits. In Cyprus there are imports and consumption of lubricants, paraffin waxes and bitumen. Lubricants in Cyprus are consumed by transport, while according to the information obtained from the Customs[39], paraffin wax is imported by dental and lab suppliers, importers of agricultural and beauty products and candle makers. The total CO_2 emissions from non-energy products from fuels and solvent use are presented in Table 4.13 and Figure 4.6.

Table 4.13. CO_2 emissions from non-energy Products from Fuels and Solvent Use

Gg CO_2	1990	2000	2005	2010	2011	2012	2013
D. Non-energy products from fuels and solvent	**4.19**	**4.10**	**3.46**	**3.53**	**3.53**	**2.95**	**2.37**

[38] email 28/9/2016, Solonas Papapolyviou, Department of Customs and Excise, Ministry of Finance (tel. +357 22 601756, spapapolyviou@customs.mof.gov.cy)
[39] email 28/9/2016, Solonas Papapolyviou, Department of Customs and Excise, Ministry of Finance (tel. +357 22 601756, spapapolyviou@customs.mof.gov.cy)

use							
1. Lubricant use	4.13	4.03	3.45	3.46	3.46	2.87	2.29
2. Paraffin wax use	0.06	0.07	0.003	0.03	0.02	0.04	0.04
3. Other: Urea used as a catalyst	NO	NO	NO	0.04	0.04	0.04	0.03

Gg CO_2	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
D. Non-energy products from fuels and solvent use	**2.38**	**2.47**	**2.66**	**2.43**	**2.44**	**4.98**	**4.92**
1. Lubricant use	2.29	2.29	2.30	2.12	2.07	4.52	4.33
2. Paraffin wax use	0.06	0.08	0.19	0.06	0.06	0.07	0.07
3. Other: Urea used as a catalyst	0.03	0.10	0.17	0.25	0.31	0.39	0.53

Gg CO_2	**2021**						
D. Non-energy products from fuels and solvent use	**5.03**						
1. Lubricant use	4.47						
2. Paraffin wax use	0.05						
3. Other: Urea used as a catalyst	0.51						

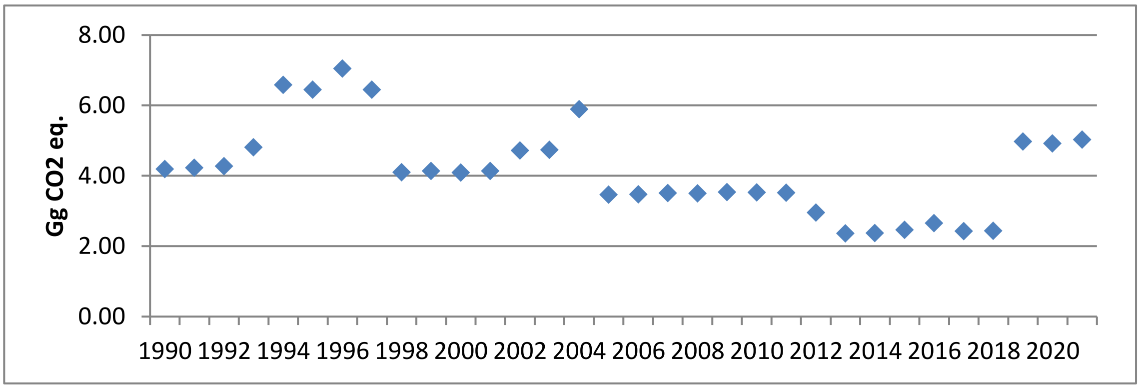

Figure 4.6. Emissions from non-energy Products from Fuels and Solvent Use (2D) 1990–2021

4.4.2. Methodological issues

The methods for calculating carbon dioxide (CO_2) emissions from non-energy product uses (paraffin waxes) follow a basic formula, in which the emission factor is composed of a carbon content factor and a factor that represents the fraction of fossil fuel carbon that is Oxidised During Use (ODU), e.g., actual co-combustion of the fraction of lubricants that slips into the combustion chamber of an engine. This concept is only applied to oxidation during first use of paraffin waxes, and not to subsequent uses (e.g., energy recovery). Emissions from the use of lubricants have been calculated with COPERT5.

The production and use of asphalt for road paving and roofing and the use of solvents derived from petroleum and coal are either not sources or are negligible sources of direct greenhouse gas emissions.

4.4.2.1. Lubricant Use (2D1)

The use of lubricants in engines is primarily for their lubricating properties and associated emissions are therefore considered as non-combustion emissions and are reported under this category. However, in the case of 2-stroke engines, where the lubricant is mixed with another fuel and thus on purpose co-combusted in the engine, the emissions are estimated and reported as part of the combustion emissions in the Energy Sector (1A3b).

Lubricating oil statistics usually cover not only use of lubricants in engines but also oils and greases for industrial purposes and heat transfer and cutting oils. After the TERT recommendation (CY-1A3b-2021-0002), emissions from the use of lubricants in engines have been calculated with COPERT 5. The emissions from the use of lubricants in two-stroke engines were reported under 1A3b (Table 3.20). The rest of the emissions are reported under this category (Table 4.14 and Table 3.33). Figure 4.7 shows the consumption of lubricants for non-energy product uses (COPERT5).

Table 4.14. Emissions from the use of lubricants (2D1)

	1990	1991	1992	1993	1994	1995	1996
Emissions ($GgCO_2$)	4.13	4.13	4.13	4.60	6.37	6.37	6.96

	1997	1998	1999	2000	2001	2002	2003
Emissions ($GgCO_2$)	6.38	4.02	4.03	4.03	4.03	4.63	4.63

	2004	2005	2006	2007	2008	2009	2010
Emissions ($GgCO_2$)	5.81	3.46	3.46	3.44	3.44	3.45	3.46

	2011	2012	2013	2014	2015	2016	2017
Emissions ($GgCO_2$)	3.46	2.87	2.29	2.29	2.29	2.30	2.12

	2018	2019	2020	2021			
Emissions ($GgCO_2$)	2.07	4.52	4.33	4.47			

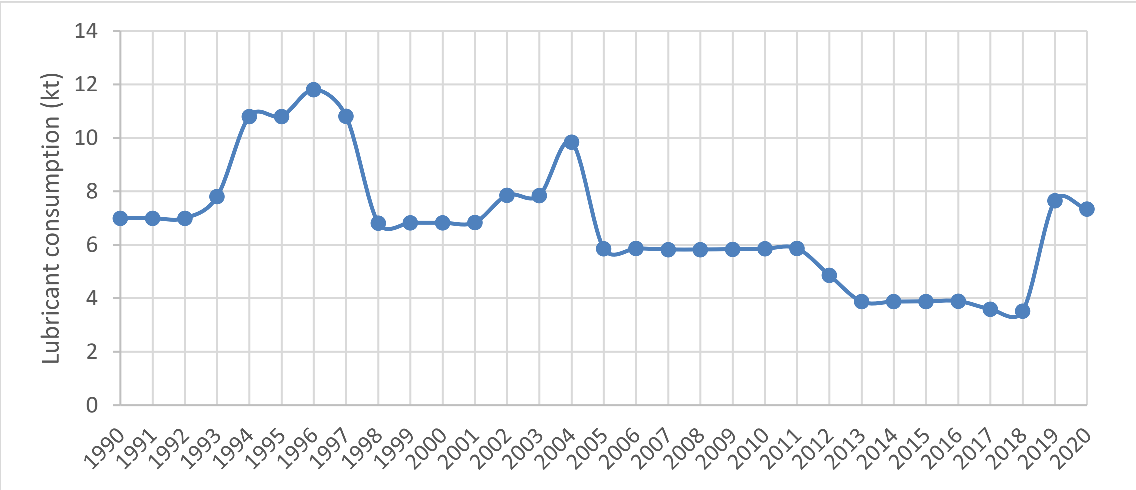

Figure 4.7. Lubricant consumption 1990–2021 (kt)

4.4.2.2. Paraffin Wax Use (2D2)

CO_2 emissions from use of paraffin wax have been estimated using the Tier 1 methodology proposed by the 2006 IPCC guidelines (eqn. 5.4, pg. 5.11, vol.3, IPCC 2006 guidelines):

CO_2 Emissions = PW •CCWax •ODUWax • 44 /12

Where:
CO_2 Emissions = CO_2 emissions from waxes, tonne CO_2;
PW = total wax consumption, TJ;
CCWax = carbon content of paraffin wax (20; default, 2006 IPCC guidelines, vol.2, pg.1.21), tonne C/TJ (= kg C/GJ) and
ODUWax = Oxidised During Use factor for paraffin wax, fraction (0.2; default, 2006 IPCC guidelines, vol.3, pg.5.12).

Activity data (Table 4.15) was obtained in kg from the imports' statistics of the Statistical Service . It was assumed that all imported quantities have been consumed in the year the import has taken place. Imports data was converted to TJ using the default NCV for paraffin wax of 40.2, as proposed by the 2006 IPCC guidelines (vol.2, pg.1.18).

Table 4.15. Imports of paraffin wax in Cyprus (kt)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Imports of paraffin wax (kt)	0.108	0.179	0.252	0.354	0.362	0.134	0.159
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Imports of paraffin wax (kt)	0.117	0.147	0.179	0.111	0.178	0.155	0.185
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Imports of paraffin wax (kt)	0.150	0.005	0.028	0.095	0.060	0.099	0.049
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Imports of paraffin wax (kt)	0.035	0.071	0.074	0.099	0.131	0.320	0.100
	2018	**2019**	**2020**	**2021**			
Imports of paraffin wax (kt)	0.105	0.120	0.113	0.086			

4.4.2.3. Other Non-energy Products from Fuels and Solvent Use (2.D.3)

The use of solvents manufactured using fossil fuels as feedstocks can lead to evaporative emissions of various non-methane volatile organic compounds (NMVOC), which are subsequently further oxidised in the atmosphere.

Emissions of NMVOCs are reported in this category. NMVOCs are indirect greenhouse gases which result from the use of solvents and various other volatile compounds. The indirect CO_2 emissions associated with these NMVOC emissions are reported under this category. Previously, these estimates were reported in the CRF Tables as direct CO_2 and included in Cyprus' national total.

Methodologies for estimating these NMVOC emissions can be found in the EMEP/EEA Emission Inventory Guidebook (EEA, 2016). Further information on emissions of NMVOCs and indirect CO_2 emissions can be found in Chapter 9 of this report.

4.4.2.4. Other: Urea used as a catalyst (2.D.3)

Emissions of CO_2 are estimated from consumption of urea by road vehicles with relevant types of catalytic converters for control of pollutant emissions and are reported under 2D3. Selective catalytic reduction (SCR) technology was introduced in modern vehicles in order to ensure compliance with the EU regulations on air pollution reduction. The SCR technology injects urea solution into the exhaust line as a percentage of fuel use of a vehicle to curb NO_x emissions. The urea solution then releases small amounts of CO_2 and of NH_3 to make a reaction with NO_x to break it down into N_2 and H_2O. However, this small amount of CO_2 from this process causes an additional amount of CO_2 in the exhaust system.

The report considers SCR from Euro IV technologies and thus urea solution as an additive has been estimated for different years according to the penetration of technologies from Euro IV onwards for different categories of vehicles in Cyprus. Euro IV and V Coaches/Buses and HDV penetrated the Cypriot market in 2007 and 2008 respectively. Urea additive for passenger cars and LDVs have been included from 2015 onwards for Euro 6 vehicles.

The 2006 IPCC Guidelines specify two approaches for estimating CO_2 emissions from urea consumption. This is either from statistics on total urea sales or by estimating urea consumption as a proportion of the amount of fuel consumed. There are no statistics on urea sales in Cyprus, so the approach based on fuel consumption is used. Not all diesel vehicles use urea so it is necessary to know the amount of fuel consumed specifically from those vehicles with the relevant exhaust after treatment technology that require urea injection.

Urea is used by HGVs and buses in Cyprus manufactured to Euro IV, V and VI standards. An assumption was made that 75% of Euro IV and V buses and HGVs and 100% of Euro VI vehicles are equipped with SCR. Fuel consumption was calculated using the proportionality of these types of vehicles to the total Cypriot diesel fleet and diesel consumption from road transport data from the Energy Balance. Following the EMEP/EEA Guidebook, urea consumption is assumed to be 4% of fuel consumption for a Euro IV bus or HGV, 6% for Euro V and 3.5% for Euro VI.

Then the recommended equation by the 2006 IPCC guidelines was used:

$$Emissions = Activity * \frac{12}{60} * Purity * \frac{44}{12}$$

Here, Activity means amount of urea-based additive consumed for use in SCR; Purity means the mass fraction of Urea in the urea additive; and the Default value for Purity (if country specific value is not available) is 0.325.

The diesel consumption used is the same as presented in Table 3.18. The resulting activity data used is presented in Table 4.16.

Table 4.16. Activity data used for estimation of emissions from Urea used as a catalyst

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Activity (kt)	0	0	0	0	0	0	0	0	0	0

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Activity (kt)	0	0	0	0	0	0	0	0.078	0.107	0.147

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Activity (kt)	0.173	0.187	0.173	0.133	0.117	0.415	0.716	1.065	1.286	1.630

	2020	2021								
Activity (kt)	2.204	2.145								

4.4.3. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

4.4.4. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

4.4.5. Category-specific recalculations

Emissions for 2D1 Lubricant use category have been recalculated for for the whole time period (1990-2020) due to change in methodology.

The impact of recalculations is presented in the following table.

Table 4.17. 2D1 Lubricant use categoty recalculations

2D1 (Gg CO_2)	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
2022 submission	1.36	1.44	1.39	1.18	1.77	1.36
2023 submission	4.13	4.13	4.13	4.60	6.37	4.13
change	202.69%	186.97%	196.38%	290.09%	260.13%	202.69%

2D1 (Gg CO_2)	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
2022 submission	1.77	1.77	1.77	1.18	1.18	1.18
2023 submission	6.37	6.96	6.38	4.02	4.03	4.03
change	260.13%	293.49%	260.70%	240.91%	241.76%	241.76%
2D1 (Gg CO_2)	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
2022 submission	1.18	1.18	1.77	2.36	2.36	2.36
2023 submission	4.63	4.63	5.81	3.46	3.46	3.44
change	292.64%	292.64%	228.47%	46.71%	46.71%	45.86%
	2008	**2009**	**2010**	**2011**	**2012**	**2013**
2D1 (Gg CO_2)	2.36	2.36	2.36	2.36	2.36	1.77
2022 submission	3.44	3.45	3.46	3.46	2.87	2.29
2023 submission	45.86%	46.29%	46.71%	46.71%	21.69%	29.47%
change	2.36	2.36	2.36	2.36	2.36	1.77
	2014	**2015**	**2016**	**2017**	**2018**	**2019**
2D1 (Gg CO_2)	1.77	1.77	1.77	1.54	1.42	3.14
2022 submission	2.29	2.29	2.30	2.12	2.07	4.52
2023 submission	29.47%	29.47%	30.03%	37.76%	45.80%	43.99%
change	1.77	1.77	1.77	1.54	1.42	3.14
	2020					
2D1 (Gg CO_2)	2.948					
2022 submission	4.33					
2023 submission	46.88%					
change	2.948					

4.4.6. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

4.5. Electronic Industry Emissions (2.E)

This source category is not occurring in Cyprus.

4.6. Product uses as substitutes for ozone depleting substances (2.F)

Hydrofluorocarbons (HFCs) and, to a very limited extent, perfluorocarbons (PFCs), are serving as alternatives to ozone depleting substances (ODS) being phased out under the Montreal Protocol. Current and expected application areas of HFCs and PFCs include: refrigeration and air conditioning, fire suppression and explosion protection, aerosols, solvent cleaning, foam blowing; and other applications. HFCs and PFCs are not controlled by the Montreal Protocol because they do not contribute to depletion of the stratospheric ozone layer. HFCs are chemicals containing only hydrogen, carbon, and fluorine. HFCs and PFCs have high global warming potentials (GWPs) and, in the case of PFCs, long atmospheric residence times.

4.6.1. Category description

Emissions have been estimated for the following source categories of 2.F: 2F1 (Refrigeration and air conditioning), 2F2 (Foam Blowing Agents), 2F3 (Fire Protection), and 2F4 (Aerosols). Due to data unavailability, emissions have been estimated using a country-specific methodology for source categories 2F2, 2F3 and 2F4, while for source category 2F1 the calculation of emissions is based on Tier 2a methodology (see next section). According to the available information, manufacturing of refrigeration and air-conditioning equipment does not occur in Cyprus, therefore the activity is reported NO. Moreover, Solvents (2F5) and Other Applications (2F6) are also not occurring in Cyprus. The total emissions by gas and source for the period 1990–2021 are presented in Table 4.18 and Figure 4.8.

Table 4.18. Emissions from consumption of halocarbons 1990–2021 (Gg CO_2 eq.)

	1990	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**
F. Product uses as substitutes for ODS	**NO**	**62.44**	**121.80**	**198.99**	**216.37**	**221.17**	**225.67**
1. Refrigeration and air conditioning	NO	58.74	114.66	185.48	202.41	206.49	210.55
2. Foam blowing agents	NO	0.08	0.48	0.92	0.98	1.04	1.09
3. Fire protection	NO	0.71	2.92	8.11	8.98	9.84	10.41
4. Aerosols	NO	2.90	3.74	4.48	3.99	3.81	3.62
5. Solvents	NO	NO	NO	NO	NO	NO	NO
6. Other applications	NO	NO	NO	NO	NO	NO	NO
HFC-32	NO	4.43	10.88	18.80	22.21	22.90	23.13
HFC-125	NO	4.98	12.42	21.37	25.09	25.98	26.31
HFC-134a	NO	30.96	49.69	75.25	76.07	75.78	77.50
HFC-143a	NO	0.56	1.57	2.62	2.90	3.12	3.22
HFC-227ea	NO	0.21	0.87	2.42	2.68	2.94	3.11
Total	**NO**	**62.44**	**121.80**	**198.99**	**216.37**	**221.17**	**225.67**

	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
F. Product uses as substitutes for ODS	**233.18**	**246.92**	**267.02**	**287.91**	**308.05**	**332.27**	**337.60**
1. Refrigeration and air conditioning	217.86	231.85	251.93	272.12	291.51	315.17	320.75
2. Foam blowing agents	1.10	1.15	1.15	1.22	1.27	1.32	1.37
3. Fire protection	10.61	10.81	10.82	11.22	11.63	11.80	11.46
4. Aerosols	3.61	3.11	3.12	3.36	3.64	3.98	4.02
5. Solvents	NO	NO	NO	NO	NO	NO	NO
6. Other applications	NO	NO	NO	NO	NO	NO	NO
HFC-32	24.11	26.45	29.88	33.06	36.18	40.26	40.67
HFC-125	27.41	30.03	33.96	37.51	40.86	45.23	45.46
HFC-134a	79.46	81.25	83.49	87.61	92.22	97.02	101.44
HFC-143a	3.34	3.62	4.12	4.48	4.69	4.94	4.71
HFC-227ea	3.17	3.23	3.23	3.35	3.47	3.52	3.42
Total	**233.18**	**246.92**	**267.02**	**287.91**	**308.05**	**332.27**	**337.60**

	2021						
F. Product uses as substitutes for ODS	**353.49**						
1. Refrigeration and air conditioning	336.62						
2. Foam blowing agents	1.37						
3. Fire protection	11.69						
4. Aerosols	3.81						
5. Solvents	NO						
6. Other applications	NO						
HFC-32	44.91						
HFC-125	49.86						
HFC-134a	100.23						

HFC-143a	4.80						
HFC-227ea	3.49						
Total	**353.49**						

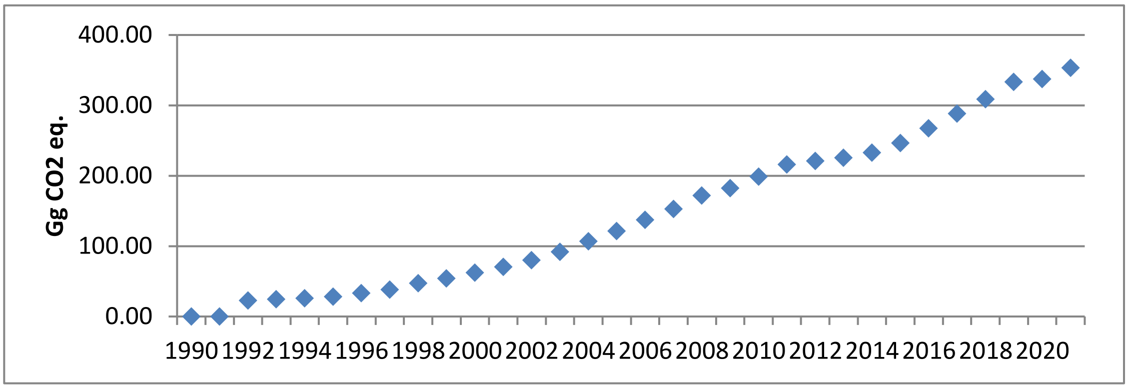

Figure 4.8. Emissions from consumption of halocarbons 1990–2021

4.6.2. Methodological issues

Due to insufficient information for a long period of time, it was decided to use a country-specific methodology for the estimation of the emissions from the sources 2F2, 2F3 and 2F4.

2F1

The calculation of GHG emissions from Refrigeration and Air Condition (RAC) systems is based on Tier 2a methodology suggested by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines). The Tier 2a methodology:

a) Considers the phase out or the phase down of CFCs and HCFCs depending on the Montreal Protocol schedule and possible national or regional regulations, in order to establish the refrigerant choice for all applications;
b) Defines the typical refrigerant charge and the equipment lifetime per sub-application;
c) Defines the emission factors for refrigerant charge, during operation, at servicing and at end-of-life.

RAC systems have been classified into six sub-application categories, listed below:

i. Domestic refrigeration,
ii. Commercial refrigeration including different types of equipment, from vending machines to centralised refrigeration systems in supermarkets,
iii. Industrial refrigeration including food processing and cold storage,
iv. Transport refrigeration including equipment and systems used in refrigerated trucks, containers, reefers, and wagons,
v. Stationary air conditioning including air-to-air systems, heat pumps, and chillers for building and residential applications,
vi. Mobile air-conditioning systems used in passenger cars, truck cabins, buses, and trains.

Refrigerant emissions at a year **t** from each of the six sub-applications of RAC systems were calculated separately. These emissions result from:

$E_{containers,t}$ = emissions related to the management of refrigerant containers
$E_{charge,t}$ = emissions related to the refrigerant charge: connection and disconnection of the refrigerant container and the new equipment to be charged
$E_{lifetime,t}$ = annual emissions from the banks of refrigerants associated with the six sub-applications during operation (fugitive emissions and ruptures) and servicing
$E_{end-of-life,t}$ = emissions at system disposal

Equations for estimating average emission rates for the above-mentioned sectors are outlined below and were calculated on a refrigerant-by-refrigerant basis for all equipment.

Refrigerant management of containers

$$E_{containers,t} = RM_t * \frac{c}{100}$$

Where:
$E_{containers,\,t}$ = emissions from all HFC containers in year t, kg
RM_t = HFC market for new equipment and servicing of all refrigeration application in year t, kg
c = emission factor of HFC container management of the current refrigerant market, percent

Refrigerant charge emissions of new equipment

$$E_{charge,t} = M_t * \frac{k}{100}$$

Where:
$E_{charge,\,t}$ = emissions during system manufacture/assembly in year t, kg
M_t = amount of HFC charged into new equipment in year t (per sub-application), kg
k = emission factor of assembly losses of the HFC charged into new equipment (per sub-application), percent

Emissions during lifetime (operation and servicing)

$$E_{operation,2017} = B_{2017} * \frac{x}{100}$$

Where:
$E_{lifetime,\,t}$ = amount of HFC emitted during system operation in year t, kg
B_t = amount of HFC banked in existing systems in year t (per sub-application), kg
x = annual emission rate (i.e., emission factor) of HFC of each sub-application bank during operation, accounting for average annual leakage and average annual emissions during servicing, percent

Emissions at end-of-life

$$E_{end-of-life,t} = M_{t-d} * \frac{p}{100} * (1 - \frac{n_{rec,d}}{100})$$

Where:
$E_{end\text{-}of\text{-}life,\,t}$ = amount of HFC emitted at system disposal in year t, kg
M_{t-d} = amount of HFC initially charged into new systems installed in year (t-d), kg
p = residual charge of HFC in equipment being disposed of expressed in percentage of full charge, percent
$\eta_{rec,d}$ = recovery efficiency at disposal, which is the ratio of recovered HFC referred to the HFC contained in the system, percent

The emission factors used are predominately the defaults proposed by the IPCC guidelines. These default values reflect the current state of knowledge about the industry and are provided as ranges rather than point estimates.

Other data, assumptions and emission parameters used in preparation of RAC systems emissions inventory for each sub-category are listed below.

Mobile Air Conditioning (MAC) systems

Activity Data / Emission Factors	**Source**
Registration of vehicles at the end of each year	Statistical Service of Cyprus
Container Heels (c)	IPCC guidelines

• Heels from service containers are recovered, therefore $E_{containers,t} = 0$	
Nominal charge of each MAC (m_t) • For passenger cars m_t=0.7 kg, • For trucks m_t=1.0 kg, • For buses m_t=10 kg	IPCC guidelines
Assembly Losses (k) • MAC systems are imported pre-charged, therefore $E_{charge,\ t} = 0$	IPCC guidelines
Lifetime (d) • d = 12 years	IPCC guidelines
Annual Emission Rate (x) • This factor accounts for both leaks from equipment as well as any emissions during service ○ Annual Emissions Rate from leaks = 10% ○ Annual Emission Rate during servicing = 2% ○ x = 12%	IPCC guidelines
Residual Charge in MACs Disposed (p) • p = 25%	IPCC guidelines
Recovery Efficiency (n_{rec}) [%] • n_{rec} = 25%	IPCC guidelines
Other assumptions	
• All new vehicles sold from January 2017 uses R1234yf or R774 as MAC refrigerant (MACs Directive 2006/40/EC[40]) • Introductory year of R134a as MAC refrigerant was 1992 • Vehicles with MAC systems for year 1996-2001 was 60%[41]. The same percentage (60%) was kept for years 1992-1995. For the following years, linear interpolation was used. • MACs are serviced every 5 years	

Domestic Refrigeration (DR)

Activity Data / Emission Factors	Source
Number of households	Statistical Service of Cyprus
Number of refrigerators per households • 1.17 refrigerators per household	Demetriou, D., Polatides, H., Haralambopoulos, D, (2010). Integrated Energy Planning for the Residential Sector: The case-study of Cyprus. Energy Sources, Part B: Economics, Planning and Policy.
Number of freezers per households • 0.30 freezers per household	Demetriou, D., Polatides, H., Haralambopoulos, D, (2010)
Container Heels (c) • Generally refrigerators and freezers are not serviced during their lifetime, therefore $E_{containers,t} = 0$	IPCC guidelines
Nominal charge of each refrigerator and freezer (m_t) • m=0.3 kg	IPCC guidelines
Assembly Losses (k) • Refrigerators and freezers are imported pre-charged, therefore $E_{charge,\ t} = 0$	IPCC guidelines
Lifetime (d) • d = 20 years	IPCC guidelines

[40] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32006L0040

[41] Establishing the Leakage Rates of MACs, 2013, DG Environment (EC)

Annual Emission Rate (x) • x = 0.3%	IPCC guidelines
Residual Charge in Refrigerators and Freezers Disposed (p) • p = 40%	IPCC guidelines
Recovery Efficiency (n_{rec}) [%] • n_{rec} = 35%	IPCC guidelines
Other assumptions	
• Refrigerants used for domestic refrigerators and freezers (with bold the refrigerants used for the calculation of the emissions): **R134a**, R600a, R12 • Introductory year of R134a as DR refrigerant was 1992	

Transport Refrigeration (TR)

Activity Data / Emission Factors	Source
Number of TRs sold each year	Department of Road Transport, Cyprus
Container Heels (c) • Heels from service containers are recovered, therefore $E_{containers,t}$ = 0	IPCC guidelines
Nominal charge of each TR (m_t) • m=4.5 kg	IPCC guidelines
Assembly Losses (k) • TR systems are imported pre-charged, therefore $E_{charge,\ t}$ = 0	IPCC guidelines
Lifetime (d) • d = 15 years	IPCC guidelines

Annual Emission Rate (x)
• This factor accounts for both leaks from equipment as well as any emissions during service
  ○ Annual Emissions Rate from leaks = 15%
  ○ Annual Emission Rate during servicing = 10%
• x = 25%
	IPCC guidelines

Residual Charge in TRs Disposed (p) • p = 75%	IPCC guidelines
Recovery Efficiency (n_{rec}) [%] • n_{rec} = 25%	IPCC guidelines
Other assumptions	
• Refrigerants used for TRs: R134a, R404A • TRs are serviced each year	

Industrial Refrigeration (IR)

Activity Data / Emission Factors	Source
Bank in Existing Equipment (B_t) for the year 2021 (using national GDP) • 10687 kg (R404A) • 186 kg (R134a) • 680 kg (R507A)	Maria Matsi, Economic Officer, Directorate of Economic Research and EU Affairs, Ministry of Finance. Tel. no.: +357 22 60 1231. Email: mmatsi@mof.gov.cy
Bank in Existing Equipment (B_t) for the year 2017 • 9016 kg (R404A) • 341 kg (R134a) • 360 kg (R507A)	Industrial and Commercial RAC Inventory 2017, Cyprus
Bank in Existing Equipment (B_t) for previous years • The national GDP was used to determine the banks for previous years in order to complete the time-series	Maria Matsi, Economic Officer, Directorate of Economic Research and EU Affairs, Ministry of Finance. Tel. no.: +357 22 60 1231. Email: mmatsi@mof.gov.cy

Container Heels (c) • Heels from service containers are recovered, therefore $E_{containers,t} = 0$	IPCC guidelines
Nominal charge of each IR (m_t) • m=100 kg	IPCC guidelines
Assembly Losses (k) • IR systems are imported pre-charged, therefore $E_{charge,\ t} = 0$	IPCC guidelines
Lifetime (d) • d = 20 years	IPCC guidelines

Annual Emission Rate (x)
• This factor accounts for both leaks from equipment as well as any emissions during service
  ○ Annual Emissions Rate from leaks = 10%
  ○ Annual Emission Rate during servicing =5%
• x = 15%
	IPCC guidelines

Residual Charge in IRs Disposed (p) • p = 75%	IPCC guidelines
Recovery Efficiency (n_{rec}) [%] • n_{rec} = 35%	IPCC guidelines
Other assumptions	
• Refrigerants used for IRs (with bold the refrigerants used for the calculation of the emissions): **R404A**, R22, **R134a**, **R507A**, R434A • Introductory year of R404A as IR refrigerant was 1996 • Introductory year of R134a as IR refrigerant was 1992 • Introductory year of R507A as IR refrigerant was 2012 • IRs are serviced each year	

Commercial Refrigeration (CR)

Activity Data / Emission Factors	Source
Bank in Existing Equipment (B_t) for the year 2021 (using national GDP) • 41427 kg for Stand-alone Commercial Applications (R404A) • 10357 kg for Medium & Large Commercial Refrigeration (R404A) • 3242 kg for Stand-alone Commercial Applications (R134A) • 810 kg for Medium & Large Commercial Refrigeration (R134A) • 1424 kg for Stand-alone Commercial Applications (R410A) • 356 kg for Medium & Large Commercial Refrigeration (R410A) • 2193 kg for Stand-alone Commercial Applications (R407C) • 548 kg for Medium & Large Commercial Refrigeration (R407C) • 2127 kg for Stand-alone Commercial Applications (R507A) • 532 kg for Medium & Large Commercial Refrigeration (R507A)	Maria Matsi, Economic Officer, Directorate of Economic Research and EU Affairs, Ministry of Finance. Tel. no.: +357 22 60 1231. Email: mmatsi@mof.gov.cy
Bank in Existing Equipment (B_t) for the year 2017 • 37862 kg for Stand-alone Commercial Applications (R404A) • 9465 kg for Medium & Large Commercial Refrigeration (R404A)	Industrial and Commercial RAC Inventory 2017, Cyprus

• 2851 kg for Stand-alone Commercial Applications (R134A) • 713 kg for Medium & Large Commercial Refrigeration (R134A) • 790 kg for Stand-alone Commercial Applications (R410A) • 198 kg for Medium & Large Commercial Refrigeration (R410A) • 1148 kg for Stand-alone Commercial Applications (R407C) • 287 kg for Medium & Large Commercial Refrigeration (R407C) • 1122 kg for Stand-alone Commercial Applications (R507A) • 280 kg for Medium & Large Commercial Refrigeration (R507A)	
Bank in Existing Equipment (B_t) for previous years • The national GDP was used to determine the banks for previous years in order to complete the time-series	Maria Matsi, Economic Officer, Directorate of Economic Research and EU Affairs, Ministry of Finance. Tel. no.: +357 22 60 1231. Email: mmatsi@mof.gov.cy
Container Heels (c) • Heels from service containers are recovered, therefore $E_{containers,t} = 0$	IPCC guidelines
Nominal charge of each CR (m_t) • m=5 kg for Stand-alone Commercial Applications • m= 100 kg for Medium & Large Commercial Refrigeration	IPCC guidelines
Assembly Losses (k) • Stand-alone Commercial Applications systems are imported pre-charged, therefore $E_{charge,\ t} = 0$ • Medium & Large Commercial Refrigeration systems are charged on-site ○ Assembly Losses = 1.5%	IPCC guidelines
Lifetime (d) • d = 12 years	IPCC guidelines

Annual Emission Rate (x)
• This factor accounts for both leaks from equipment as well as any emissions during service
• Stand-alone Commercial Applications
  ○ Annual Emissions Rate from leaks = 8%
  ○ Annual Emission Rate during servicing =2%
  ○ x = 10%
• Medium & Large Commercial Refrigeration
  ○ Annual Emissions Rate from leaks = 15%
  ○ Annual Emission Rate during servicing =5%
  ○ x = 20%
	IPCC guidelines

Residual Charge in CRs Disposed (p) • p = 40% for Stand-alone Commercial Applications • p = 75% for Medium & Large Commercial Refrigeration	IPCC guidelines
Recovery Efficiency (n_{rec}) [%] • n_{rec} = 35% for Stand-alone Commercial Applications • n_{rec} = 35% for Medium & Large Commercial Refrigeration	IPCC guidelines
Other assumptions	

• Refrigerants used for IRs (with bold the refrigerants used for the calculation of the emissions): **R404A**, **R134A**, R22, **R410A**, **R407C**, **R507A** [Industrial and Commercial RAC Inventory 2017, Cyprus]. • Introductory year of R404A as CR refrigerant was 1996 • Introductory year of R134a as CR refrigerant was 1992 • Introductory year of R410A as CR refrigerant was 2012 • Introductory year of R407A as CR refrigerant was 2012 • Introductory year of R507A as CR refrigerant was 2012 • Stand-alone Commercial Applications accounts approximate 80% of the total CR systems [Industrial and Commercial RAC Inventory 2017, Cyprus] • Medium & Large Commercial Refrigeration accounts approximate 20% of the total CR systems [Industrial and Commercial RAC Inventory 2017, Cyprus] • Stand-alone Commercial Applications systems are serviced every 5 years • Medium & Large Commercial Refrigeration systems are serviced each year

Stationary Air Conditioning systems

Residential A/C	
Activity Data / Emission Factors	**Source**
Number of households	Statistical Service of Cyprus
Percentage of households having split A/C units • 87%	Demetriou, D., Polatides, H., Haralambopoulos, D, (2010). Integrated Energy Planning for the Residential Sector: The case-study of Cyprus. Energy Sources, Part B: Economics, Planning and Policy.
Number of A/C units per households • 2.65 A/C units per household	Demetriou, D., Polatides, H., Haralambopoulos, D, (2010).
Container Heels (c) • Heels from service containers are recovered, therefore $E_{containers,t} = 0$	IPCC guidelines
Nominal charge of each Residential A/C unit (m_t) • m=3 kg	IPCC guidelines
Assembly Losses (k) • A/C units are imported pre-charged, therefore $E_{charge,\ t} = 0$	IPCC guidelines
Lifetime (d) • d = 15 years	IPCC guidelines

• This factor accounts for both leaks from equipment as well as any emissions during service
  o Annual Emissions Rate from leaks = 5%
  o Annual Emission Rate during servicing =2%
• x = 7%
	IPCC guidelines

Residual Charge in Residential A/C units Disposed (p) • p = 40%	IPCC guidelines
Recovery Efficiency (n_{rec}) [%] • n_{rec} = 40%	IPCC guidelines
Other assumptions	
• Refrigerants used for Residential A/C units (with bold the refrigerants used for the calculation of the emissions): **R410A**, **R407C**, R22 [Based on results from Industrial and Commercial RAC Inventory 2017, Cyprus] • Introductory year of R407A as refrigerant was 1996 • Introductory year of R407C as refrigerant was 1996 • Residential A/C units are serviced every 5 years	
Commercial A/C, including heat pumps	
Activity Data / Emission Factors	**Source**

Bank in Existing Equipment (B_t) for the year 2021 (using national GDP) • 33838 kg (R410A) • 24924 kg (R407C)	Maria Matsi, Economic Officer, Directorate of Economic Research and EU Affairs, Ministry of Finance. Tel. no.: +357 22 60 1231. Email: mmatsi@mof.gov.cy
Bank in Existing Equipment (B_t) for the year 2017 • 29763 kg (R410A) • 21923 kg (R407C)	Industrial and Commercial RAC Inventory 2017, Cyprus
Bank in Existing Equipment (B_t) for previous years • The national GDP was used to determine the banks for previous years in order to complete the time-series	Maria Matsi, Economic Officer, Directorate of Economic Research and EU Affairs, Ministry of Finance. Tel. no.: +357 22 60 1231. Email: mmatsi@mof.gov.cy
Container Heels (c) • Heels from service containers are recovered, therefore $E_{containers,t} = 0$	IPCC guidelines
Nominal charge of each Commercial A/C unit (m_t) • m=3 kg	IPCC guidelines
Assembly Losses (k) • A/C units are imported pre-charged, therefore $E_{charge,\ t} = 0$	IPCC guidelines
Lifetime (d) • d = 15 years	IPCC guidelines

• This factor accounts for both leaks from equipment as well as any emissions during service
  ○ Annual Emissions Rate from leaks = 5%
  ○ Annual Emission Rate during servicing =2%
• x = 7%
	IPCC guidelines

Residual Charge in Commercial A/C units Disposed (p) • p = 40%	IPCC guidelines
Recovery Efficiency (n_{rec}) [%] • n_{rec} = 40%	IPCC guidelines
Other assumptions	
• Refrigerants used for Commercial A/C units (with bold the refrigerants used for the calculation of the emissions): **R410A**, **R407C**, R22 [Industrial and Commercial RAC Inventory 2017, Cyprus] • Introductory year of R407A as refrigerant was 1996 • Introductory year of R407C as refrigerant was 1996 • Commercial A/C units are serviced every 5 years	
Chillers	
Activity Data / Emission Factors	**Source**
Bank in Existing Equipment (B_t) for the year 2021 (using national GDP) • 107206 kg (R410A) • 38509 kg (R407C) • 33042 kg (R134A)	Maria Matsi, Economic Officer, Directorate of Economic Research and EU Affairs, Ministry of Finance. Tel. no.: +357 22 60 1231. Email: mmatsi@mof.gov.cy
Bank in Existing Equipment (B_t) for the year 2017 • 78313 kg (R410A) • 28131 kg (R407C) • 29063 kg (R134A)	Industrial and Commercial RAC Inventory 2017, Cyprus
Bank in Existing Equipment (B_t) for previous years • The national GDP was used to determine the banks for previous years in order to complete the time-series	Maria Matsi, Economic Officer, Directorate of Economic Research and EU Affairs, Ministry of Finance. Tel. no.: +357 22 60 1231. Email: mmatsi@mof.gov.cy
Container Heels (c)	IPCC guidelines

• Heels from service containers are recovered, therefore $E_{containers,t} = 0$	
Nominal charge of each chiller system (m_t) • m=50 kg	IPCC guidelines
Assembly Losses (k) • Chiller systems are imported pre-charged, therefore $E_{charge,t} = 0$	IPCC guidelines
Lifetime (d) • d = 20 years	IPCC guidelines

• This factor accounts for both leaks from equipment as well as any emissions during service
  ○ Annual Emissions Rate from leaks = 5%
  ○ Annual Emission Rate during servicing =5%
• x = 10%
	IPCC guidelines

Residual Charge in Chiller systems Disposed (p) • p = 90%	IPCC guidelines
Recovery Efficiency (n_{rec}) [%] • n_{rec} = 50%	IPCC guidelines
Other assumptions	
• Refrigerants used for Chiller systems (with bold the refrigerants used for the calculation of the emissions): **R410A**, **R407C**, **R134a**, R22 [Industrial and Commercial RAC Inventory 2017, Cyprus] • Introductory year of R407A as refrigerant was 1996 • Introductory year of R407C as refrigerant was 1996 • Introductory year or R134a as refrigerant was 1992 • Chiller systems are serviced every year	

The main deficiency identified in preparation of inventory is associated with the lack of reporting obligation for importers of bulk F-gases and F-gas equipment in the early years to establish the time-series for the categories of "Industrial Refrigeration", "Commercial Refrigeration" and "Stationary A/C systems". Data for these categories were established for each year going back to 1950 through a correlation to the annual national GDP.

2F2, 2F3 and 2F4

The methodology applied consisted of the following steps:

(a) The stock emissions from the four sources (2F2, 2F3 and 2F4) for Greece, Italy, Malta and Spain were obtained from the NIR2022 submissions to the UNFCCC for the years 1990-2020 (CRF – Table 2(II).B-H). The four countries were selected due to their similarity in social and economic conditions to Cyprus. Any fluorinated ozone-depleting substances (ODSs) not imported to Cyprus in bulk, as well as emissions other than those from stocks were disregarded in an effort to better historically match and appraise the situation. Therefore, only the following gases have been taken into account: HFC-32, HFC-125, HFC-134a, HFC-143a and HFC-227ea.

(b) The amounts of substitutes of ODSs used by the four model countries were tabulated in tonnes and modified by their 100-year global warming potential (GWP) to calculate the t CO_2 eq. emissions from each source. The substitutes of ODSs applicable to the estimation of emissions from stocks in Cyprus are listed in Table 1.4 (Section 1.4.3). The equivalent emissions are thus calculated as: substitute of ODS amount (t) × GWP (t CO_2eq/t).

(c) The t CO_2 eq. emissions from each substance and subcategories are, then, summed per year and divided by the average total population of each country obtained from EUROSTAT (Table 4.19) to provide for the annual per capita emissions (Table 4.20) for the years 1990-2020.

(d) The annual per capita emissions average of the four countries for 2F1 and only Spain, Italy and Greece for 2F2, 2F3 and 2F4 (see notes) were, in turn, used to calculate the total t CO_2 equivalent annual emissions from stocks in Cyprus, based on the population of Cyprus for each corresponding year (Table 4.21).

<u>Notes</u>

- Malta was excluded from the calculation of the average per capita emissions for the source **2F2**, because of outstanding high values of per capita HFC emissions in 2004, 2009, 2015, 2018, 2019 and 2020. With Malta excluded, the average per capita emissions is very uniformly increasing through the time series (Figure 4.09).

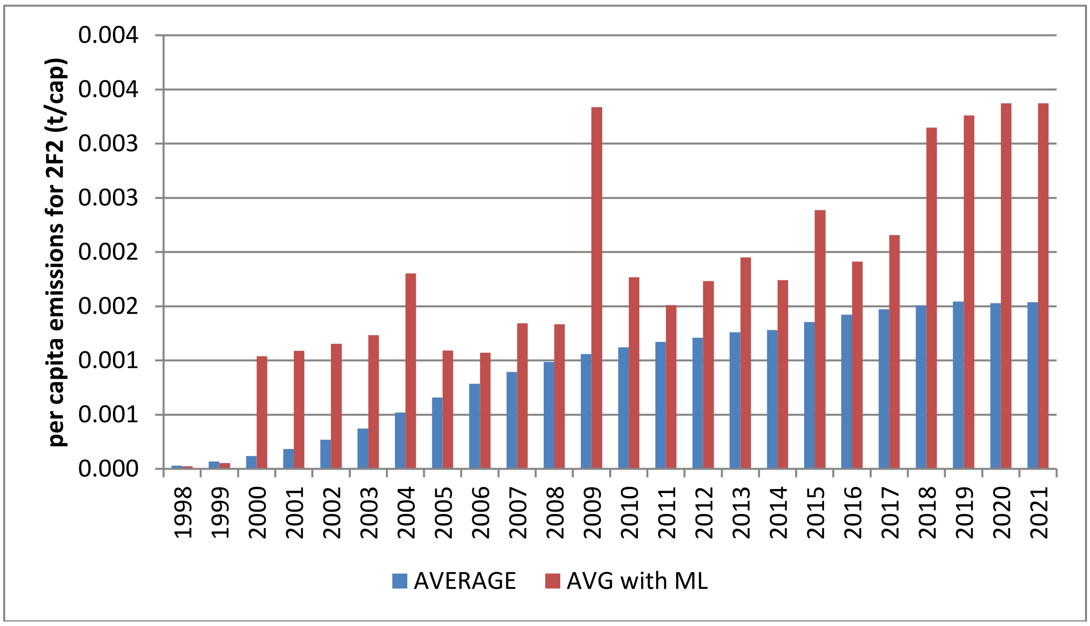

Figure 4.9. Average per capita emissions for 2F2 with and without Malta 1998-2021 (t/cap)

- Malta was excluded from the calculation of the average per capita emissions for the source **2F3**, because of outstanding high (2004) and low (2008) values of per capita HFC. With Malta excluded, the average per capita emissions is very uniformly increasing through the time series (Figure 4.10).

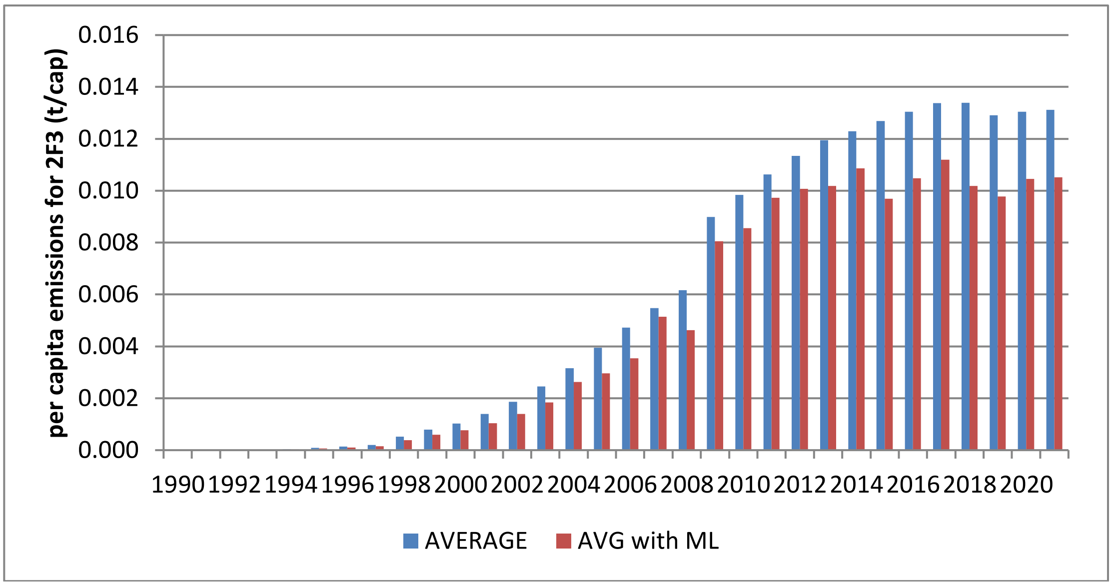

Figure 4.10. Average per capita emissions for 2F3 with and without Malta 1990–2021 (t/cap)

- Malta was excluded from the calculation of the average per capita emissions for the source **2F4**, because of very large fluctuations of the per capita HFC. With Malta excluded, the average per capita emissions show less fluctuation through the time series (Figure 4.11).

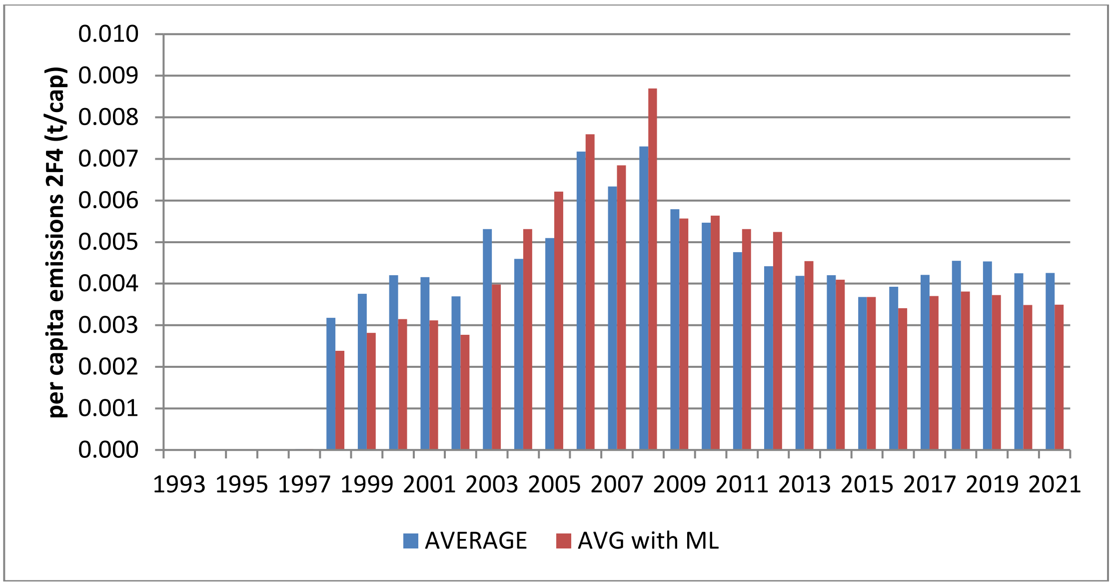

Figure 4.11. Average per capita emissions for 2F4 with and without Malta 1993-2021 (t/cap)

(e) The following have been taken into account during the calculations:

- 2F2: According to the information submitted by the four countries and the imports of bulk gases in Cyprus, all emissions have been assumed to be HCF-134a and from closed cells.
- 2F3: According to the information submitted by the Greece, Italy and Malta, all emissions have been assumed to be HFC-227ea.
- 2F4: For the source MDI-aerosols, only the emissions from Metered Dose Inhalers have been taken into account, since Aerosols do not occur in Cyprus. Moreover, according to the information submitted by the four countries, all emissions have been assumed to be HFC-134a.

Table 4.19. Average total population used for the estimation of per capita emissions from 2F (2F2, 2F3, 2F4) activities (EUROSTAT)

	1990	1991	1992	1993	1994	1995	1996
Malta	352430	361908	365781	369455	373161	376433	378404
Spain	38853227	38881416	39051336	39264034	39458489	39639726	39808374
Italy	56694360	56744119	56772923	56821250	56842392	56844408	56844197
Greece	10120892	10272691	10367163	10430958	10489871	10535973	10588332

	1997	1998	1999	2000	2001	2002	2003
Malta	381405	384176	386397	388759	391415	394641	397296
Spain	39971329	40143449	40303568	40470182	40665545	41035278	41827838
Italy	56876364	56904379	56909109	56923524	56960692	56987507	57130506
Greece	10629267	10693250	10747768	10775627	10835989	10888274	10915770

	2004	2005	2006	2007	2008	2009	2010
Malta	399867	402668	404999	405616	407832	410926	414027
Spain	42547451	43296338	44009971	44784666	45668939	46239273	46486619
Italy	57495900	57874753	58064214	58223744	58652875	59000586	59190143
Greece	10940369	10969912	11004716	11036008	11060937	11094745	11119289

	2011	2012	2013	2014	2015	2016	2017
Malta	414989	417546	422509	429424	439691	450415	460297
Spain	46667174	46818219	46727890	46512199	46449565	46440099	46528024
Italy	59364690	59394207	59685227	60782668	60795612	60665551	60589445
Greece	11123392	11086406	11003615	10926807	10858018	10783748	10768193

	2018	2019	2020	2021			
Malta	475701	493559	514564	516100			
Spain	46658447	46937060	47332614	47398695			

Italy	60483973	59816673	59641488	59236213			
Greece	10741165	10724599	10718565	10678632			

Table 4.20. Per capital emissions by source from 2F (2F2, 2F3, 2F4) activities (kg CO_2 eq.)

	1990	1991	1992	1993	1994	1995	1996	1997
2F2								
Spain	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Italy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Greece	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AVERAGE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2F3								
Spain	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.03
Italy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Greece	0.00	0.00	0.02	0.05	0.13	0.24	0.39	0.57
AVERAGE	0.00	0.00	0.01	0.02	0.04	0.08	0.13	0.20
2F4								
Spain	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Italy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Greece	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AVERAGE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02

	1998	1999	2000	2001	2002	2003	2004	2005
2F2								
Spain	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.11
Italy	0.09	0.21	0.36	0.54	0.78	1.09	1.47	1.84
Greece	0.00	0.00	0.00	0.01	0.03	0.03	0.03	0.03
AVERAGE	0.03	0.07	0.12	0.18	0.27	0.37	0.52	0.66
2F3								
Spain	0.07	0.11	0.12	0.18	0.23	0.29	0.36	0.43
Italy	0.00	0.31	0.42	0.58	0.75	0.96	1.26	1.60
Greece	1.47	1.97	2.53	3.42	4.63	6.12	7.85	9.83
AVERAGE	0.52	0.79	1.03	1.39	1.87	2.45	3.16	3.95
2F4								
Spain	9.53	10.56	10.74	9.63	8.07	12.21	9.01	7.81
Italy	0.00	0.71	1.86	2.82	3.01	3.72	4.79	5.02
Greece	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.46
AVERAGE	3.18	3.76	4.20	4.15	3.70	5.31	4.60	5.10

	2006	2007	2008	2009	2010	2011	2012	2013
2F2								
Spain	0.15	0.18	0.21	0.21	0.22	0.23	0.24	0.24
Italy	2.18	2.47	2.72	2.94	3.12	3.26	3.37	3.43
Greece	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.11
AVERAGE	0.78	0.89	0.98	1.06	1.12	1.17	1.21	1.26
2F3								
Spain	0.50	0.60	0.70	0.80	0.91	1.03	1.16	1.26
Italy	1.95	2.32	2.68	9.52	10.49	11.41	12.21	12.94
Greece	11.71	13.50	15.11	16.64	18.12	19.44	20.66	21.64
AVERAGE	4.72	5.47	6.16	8.99	9.84	10.63	11.34	11.95
2F4								
Spain	7.61	7.65	7.59	6.90	6.47	6.46	5.96	5.75
Italy	5.19	4.99	4.74	4.63	4.32	3.84	3.35	3.13
Greece	8.73	6.38	9.56	5.84	5.62	3.97	3.95	3.68
AVERAGE	7.18	6.34	7.30	5.79	5.47	4.76	4.42	4.19

	2014	2015	2016	2017	2018	2019	2020	2021
2F2								
Spain	0.25	0.26	0.26	0.26	0.26	0.27	0.26	0.26

Italy	3.41	3.55	3.68	3.75	3.79	3.82	3.78	3.80
Greece	0.18	0.25	0.33	0.40	0.47	0.55	0.55	0.55
AVERAGE	1.28	1.35	1.42	1.47	1.51	1.54	1.53	1.54
2F3								
Spain	1.25	1.19	1.12	1.03	0.93	0.86	0.78	0.78
Italy	13.45	13.88	14.29	14.91	14.79	14.67	15.11	15.17
Greece	22.18	22.98	23.72	24.19	24.45	23.19	23.25	23.41
AVERAGE	12.29	12.68	13.04	13.38	13.39	12.91	13.05	13.12
2F4								
Spain	5.76	4.55	5.56	5.79	6.07	5.92	5.62	5.62
Italy	3.07	2.67	2.35	3.01	3.75	3.85	3.31	3.34
Greece	3.79	3.81	3.86	3.83	3.82	3.83	3.81	3.83
AVERAGE	4.21	3.68	3.93	4.21	4.55	4.53	4.25	4.26

Table 4.21. Total population of Cyprus used for the estimation of emissions from 2F (2F2, 2F3, 2F4) activities

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Population	572655	587141	603069	619231	632944	645399	656333	666313	675215

	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Population	682862	690497	697549	705539	713720	722893	733067	744013	757916

	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Population	776333	796930	819140	839751	862011	865878	858000	847008	848319

	2017	**2018**	**2019**	**2020**	**2021**				
Population	854802	864236	875899	888005	896007				

Table 4.22. Contribution of activities to 2F (2F2, 2F3, 2F4) emissions

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
2F2								
Closed cells	100%	100%	100%	100%	100%	100%	100%	100%
2F3								
Fire protection	100%	100%	100%	100%	100%	100%	100%	100%
2F4								
Metered dose inhalers	100%	100%	100%	100%	100%	100%	100%	100%

	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
2F2								
Closed cells	100%	100%	100%	100%	100%	100%	100%	100%
2F3								
Fire protection	100%	100%	100%	100%	100%	100%	100%	100%
2F4								
Metered dose inhalers	100%	100%	100%	100%	100%	100%	100%	100%

	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
2F2								
Closed cells	100%	100%	100%	100%	100%	100%	100%	100%
2F3								
Fire protection	100%	100%	100%	100%	100%	100%	100%	100%
2F4								
Metered dose inhalers	100%	100%	100%	100%	100%	100%	100%	100%

	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
2F2								
Closed cells	100%	100%	100%	100%	100%	100%	100%	100%
2F3								
Fire protection	100%	100%	100%	100%	100%	100%	100%	100%
2F4								
Metered dose inhalers	100%	100%	100%	100%	100%	100%	100%	100%

Table 4.23. Total 2F (2F2, 2F3, 2F4) emissions from Stocks estimated for Cyprus (t CO_2 eq.)

	1990	1991	1992	1993	1994	1995	1996	1997	1998
2F2	0	0	0	0	0	0	0	0	21
2F3	0	0	4	10	27	55	88	133	348
2F4	0	0	0	0	0	1	1	15	2147
	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
2F2	47	82	127	190	266	375	483	583	678
2F3	542	709	971	1318	1752	2283	2897	3510	4146
2F4	2566	2900	2897	2608	3790	3325	3737	5340	4805
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
2F2	764	845	919	983	1044	1091	1098	1147	1149
2F3	4783	7164	8059	8924	9775	10343	10547	10741	10758
2F4	5666	4613	4479	3994	3810	3624	3609	3114	3119
	2017	**2018**	**2019**	**2020**	**2021**				
2F2	1216	1272	1320	1371	1370				
2F3	11151	11560	11727	11461	11690				
2F4	3355	3636	3982	4023	3808				

4.6.3. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

4.6.4. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

4.6.5. Category-specific recalculations

2F1 Refrigeration and air conditioning

Emissions for 2F1 category have been recalculated for:

i. Commercial Refrigeration (2F1a) due to updated GDP values from the Statistical Service,
ii. Domestic Refrigeration (2F1b) due to an error on the number of refrigerators disposed every year, and
iii. Stationary A/C Systems (2F1f) due to updated GDP values from the Statistical Service.

The impact of recalculations is presented in the following table and figure.

Table 4.24. 2F1 Recalculations

2F1 (kt CO_2 eq.)	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
2023 submission	0.00	0.00	23.04	24.62	26.27	28.49
2022 submission	0.00	0.00	25.34	26.93	28.62	30.52
change	0%	0%	-9.07%	-8.58%	-8.20%	-6.64%
2F1 (kt CO_2 eq.)	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
2023 submission	33.60	38.65	47.38	54.29	62.44	70.91
2022 submission	34.53	38.59	44.02	49.44	56.41	64.51
change	-2.70%	0.16%	7.65%	9.81%	10.68%	9.92%

2F1 (kt CO_2 eq.)	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
2023 submission	80.28	92.00	107.15	121.80	137.79	153.17
2022 submission	72.94	84.42	100.49	114.74	130.42	149.00
change	10.07%	8.97%	6.64%	6.15%	5.65%	2.80%
2F1 (kt CO_2 eq.)	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
2023 submission	172.12	182.72	198.99	216.37	221.17	225.67
2022 submission	171.69	182.00	200.47	217.18	223.68	226.55
change	0.25%	0.40%	-0.74%	-0.37%	-1.12%	-0.39%
2F1 (kt CO_2 eq.)	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
2023 submission	233.18	246.65	267.02	287.91	308.05	332.27
2022 submission	232.97	246.54	268.97	290.08	318.28	339.99
change	0.09%	0.05%	-0.73%	-0.75%	-3.21%	-2.27%
2F1 (kt CO_2 eq.)	**2020**					
2023 submission	335.68					
2022 submission	340.49					
change	-1.41%					

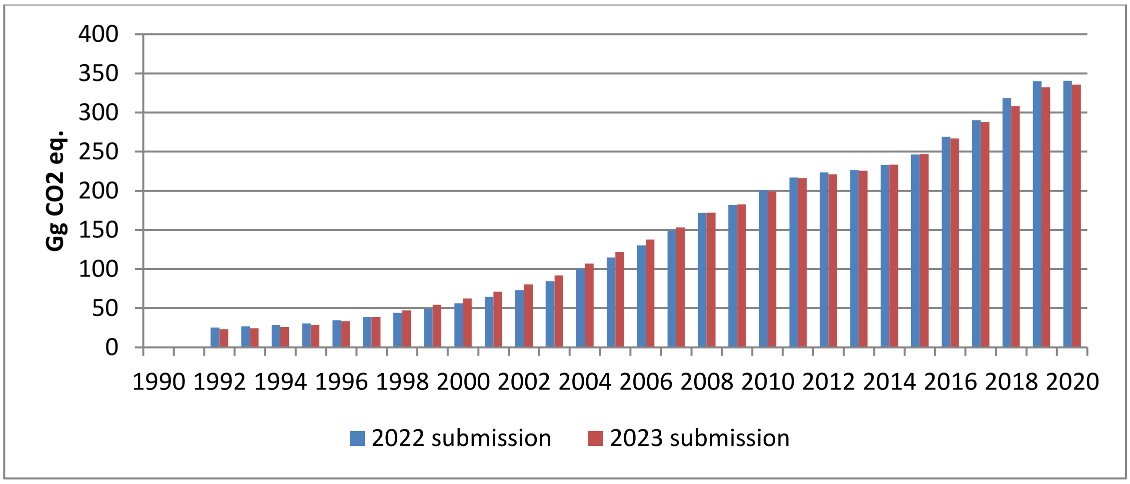

Figure 4.12. 2F1 recalculations

4.6.6. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

4.7. Other Product Manufacture and Use (2G)

According to the 2006 IPCC Guidelines, the source category 2G should include emissions for the activities Electrical Equipment (2G1) (Manufacture, Use and Disposal of Electrical Equipment), SF_6 and PFCs from Other Product Uses (2G2) (Military Applications, Accelerators and other), N_2O from Product Uses (2G3) (Medical Applications, Propellant for Pressure and Aerosol Products and other) and Other (2G4). According to the available information the activities that take place in Cyprus are Use of Electrical Equipment (2G1b), Medical Applications of N_2O (2G3a) and Propellant for Pressure and Aerosol Products (2G3b). The total emissions by gas and source for the period 1990–2019 are presented in Table 4.25 and Figure 4.13.

Table 4.25. Emissions from Other Product Manufacture and Use (2G)

	1990	2000	2005	2010	2011	2012	2013
G. Other product manufacture and use (Gg CO_2 eq.)	**6.66**	**13.80**	**17.40**	**18.32**	**20.14**	**20.77**	**21.32**
1. Electrical equipment	2.73	9.13	12.42	12.70	14.36	14.97	15.58
2. SF_6 and PFCs from other product use	NO	NO	NO	NO	NO	NO	NO
3. N_2O from product uses	3.93	4.67	4.98	5.62	5.77	5.80	5.75
4. Other	NO	NO	NO	NO	NO	NO	NO
N_2O (kt)	14.84	17.63	18.80	21.22	21.78	21.88	21.68
SF_6 (t)	0.12	0.39	0.53	0.54	0.61	0.64	0.66
Total (Gg CO_2 eq.)	**6.66**	**13.80**	**17.40**	**18.32**	**20.14**	**20.77**	**21.32**

	2014	2015	2016	2017	2018	2019	2020
G. Other product manufacture and use (Gg CO_2 eq.)	**21.86**	**22.47**	**21.33**	**21.59**	**22.76**	**21.39**	**24.74**
1. Electrical equipment	16.18	16.79	15.61	15.80	16.89	15.44	18.74
2. SF_6 and PFCs from other product use	NO	NO	NO	NO	NO	NO	NO
3. N_2O from product uses	5.67	5.68	5.72	5.79	5.87	5.95	6.00
4. Other	NO	NO	NO	NO	NO	NO	NO
N_2O (kt)	21.40	21.44	21.60	21.84	22.13	22.44	22.64
SF_6 (t)	0.69	0.71	0.66	0.67	0.72	0.66	0.80
Total (Gg CO_2 eq.)	**21.86**	**22.47**	**21.33**	**21.59**	**22.76**	**21.39**	**24.74**

	2021						
G. Other product manufacture and use (Gg CO_2 eq.)	**22.30**						
1. Electrical equipment	16.24						
2. SF_6 and PFCs from other product use	NO						
3. N_2O from product uses	6.06						
4. Other	NO						
N_2O (kt)	22.86						
SF_6 (t)	0.69						
Total (Gg CO_2 eq.)	**22.30**						

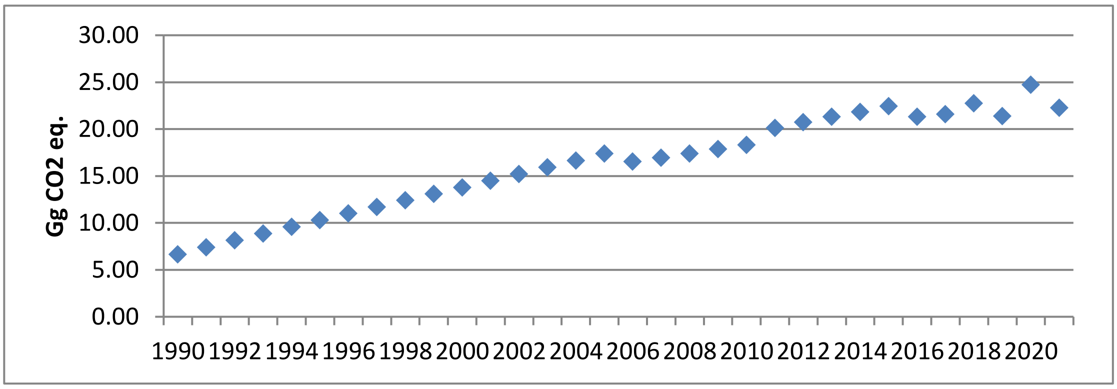

Figure 4.13. Emissions from Other Product Manufacture and Use (2G)

4.7.1. Electrical Equipment (2G1)

SF_6 is used for electrical insulation and for current interruption in equipment used in the transmission and distribution of electricity. The Electricity Authority of Cyprus (EAC) is the owner of both the high and low voltage distribution systems and the owner and operator of the medium and lower voltage distribution systems in Cyprus. SF_6 is used in equipment across all voltage ranges on both the Distribution and Transmission systems owned by EAC Networks.

Electrical equipment containing SF_6 is imported into Cyprus, and at time of purchase is added to the SF_6 installed inventory database. Quantities of SF_6 are needed for servicing and repair of existing equipment. There are no manufacturing emissions.

4.7.1.1. Methodological issues

In the context of the present inventory, emissions are estimated using a Tier 1 method (the default emission-factor approach). In this method, emissions are estimated by multiplying default regional emission factors by the nameplate SF_6 capacity of the equipment at each life cycle stage beyond manufacturing in the country. The following equation was used for the emissions:

$$\begin{aligned} Total\ Emission &= Manufacturing\ Emissions + Equipment\ Installation\ Emissions \\ &+ Equipment\ Use\ Emissions + Equipment\ Disposal\ Emissions \end{aligned}$$

Where:

Manufacturing emissions = Manufacturing Emission Factor * Total SF_6 consumption by equipment manufacturers (there are no manufacturing emissions in Cyprus)

Equipment installation emissions = Installation Emission Factor * Total nameplate capacity of new equipment filled on site (not at the factory).

Equipment use emissions = Use Emission Factor * Total nameplate capacity of installed equipment. The 'use emission factor' includes emissions due to leakage, servicing, and maintenance as well as failures

Equipment disposal emissions = Total nameplate capacity of retiring equipment * Fraction of SF_6 remaining at retirement

Default emissions factors are taken from Table 8.2 to 8.4 (IPCC Guidelines, pgs. 8.15 & 8.16, volume 3, chapter 8).

SF_6 emissions from electrical equipment are presented in Table 4.26.

Table 4.26. SF_6 emissions (in t) from electrical equipment for the period 1990–2021

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
SF_6 (t)	0.12	0.14	0.17	0.20	0.23	0.25	0.28	0.31	0.33	0.36	0.39

	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
SF_6 (t)	0.42	0.44	0.47	0.50	0.53	0.49	0.50	0.51	0.53	0.54	0.61

	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
SF_6 (t)	0.64	0.66	0.69	0.71	0.66	0.67	0.72	0.66	0.80	**0.69**	

4.7.1.2. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

4.7.1.3. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

4.7.1.4. Category-specific recalculations

No recalculations to report.

4.7.1.5. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

4.7.2. SF_6 and PFCs from Other Product Uses (2G2)

No information is available to support that SF_6 and PFCs from Other Product Uses occurs in Cyprus.

4.7.3. N_2O from Product Uses (2G3)

Evaporative emissions of nitrous oxide (N_2O) can arise from various types of product use, including: Medical applications (anaesthetic use, analgesic use and veterinary use), Use as a propellant in aerosol products, primarily in food industry (pressure-packaged whipped cream, etc.), etc. In general, medical applications and use as a propellant in aerosol products are likely to be larger sources than others. In Cyprus these are the two activities identified as consumers of N_2O.

4.7.3.1. Methodological issues

Medical Applications (2G3a)

The necessary activity data is not available to estimate emissions according to the 2006 IPCC guidelines; therefore a country-specific methodology has been developed.

The method uses the total population of Cyprus and the emission factor of 0.00001532 t N_2O per capita in the equation:

$$N_2O \text{ emissions (Gg)} = \text{population} * \text{emission factor per capita (t } N_2O/\text{capita)}$$

The emission factor is based on an average t N_2O/capita value from all EU Member States reporting country-specific data using amount of gas as activity data (0.00001532 t N_2O/capita in 2016).

Propellant for Pressure and Aerosol Products (2G3b)

The necessary activity data is not available to estimate emissions according to the 2006 IPCC guidelines; therefore a country specific methodology has been developed.

The method uses the total population of Cyprus and the emission factor of 0.00000995 t N_2O per capita in the equation:

$$N_2O \text{ emissions (Gg)} = \text{population} * \text{emission factor per capita (t } N_2O/\text{capita)}$$

The emission factor is based on an average t N_2O/capita value from all EU Member States reporting country-specific data using amount of gas as activity data (0.00000995 t N_2O/capita in 2016).

The results as reported in CRFreporter for N_2O emissions from Product Uses are presented in Table 4.27.

Table 4.27. N_2O emissions (Gg) from Product Uses

	1990	1991	1992	1993	1994	1995	1996
2G3a	0.0090	0.0092	0.0095	0.0097	0.0099	0.0101	0.0102
2G3b	0.0058	0.0060	0.0062	0.0063	0.0064	0.0065	0.0066
TOTAL	0.0148	0.0152	0.0156	0.0160	0.0163	0.0166	0.0168
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
2G3a	0.0103	0.0105	0.0106	0.0107	0.0108	0.0109	0.0111
2G3b	0.0067	0.0068	0.0069	0.0069	0.0070	0.0071	0.0072
TOTAL	0.0171	0.0173	0.0174	0.0176	0.0178	0.0180	0.0183
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
2G3a	0.0112	0.0114	0.0116	0.0119	0.0122	0.0125	0.0129
2G3b	0.0073	0.0074	0.0075	0.0077	0.0079	0.0082	0.0084
TOTAL	0.0185	0.0188	0.0192	0.0196	0.0201	0.0207	0.0212
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
2G3a	0.0132	0.0133	0.0131	0.0130	0.0130	0.0131	0.0132
2G3b	0.0086	0.0086	0.0085	0.0084	0.0084	0.0085	0.0086
TOTAL	0.0218	0.0219	0.0217	0.0214	0.0214	0.0216	0.0218
	2018	**2019**	**2020**	**2021**			
2G3a	0.0134	0.0136	0.0137	0.0139			
2G3b	0.0087	0.0088	0.0089	0.0090			
TOTAL	0.0221	0.0224	0.0226	0.0229			

4.7.3.2. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

4.7.3.3. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

4.7.3.4. Category-specific recalculations

No recalculations to report.

4.7.3.5. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

4.7.4. Other product manufacture and use (2G4)

Source category 2G4 in Cyprus includes the emissions associated with Tobacco combustion.

Emissions of NMVOCs are reported in this category. NMVOCs are indirect greenhouse gases which result from the use of tobacco. The indirect CO_2 emissions associated with these NMVOC emissions are reported under this category. Previously, these estimates were reported in the CRF Tables as direct CO_2 and included in Cyprus' national total.

4.7.3.1. Methodological issues

Methodologies for estimating these NMVOC emissions can be found in the EMEP/EEA Emission Inventory Guidebook (EEA, 2016). Further information on emissions of NMVOCs and indirect CO_2

emissions can be found in Chapter 9 of this report.

4.7.4.2. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

4.7.4.3. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

4.7.4.4. Category-specific recalculations

No recalculations to report.

4.7.4.5. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

Chapter 5.
Agriculture (CRF sector 3)

5.1. Overview of sector

In agricultural activities there are many processes leading to emissions and removals of greenhouse gases, which can be widely dispersed in space and highly variable in time. The factors governing emissions and removals can be natural and anthropogenic, direct and indirect, and it can be difficult to clearly distinguish between causal factors.

Livestock production can result in methane (CH_4) emissions from enteric fermentation and both CH_4 and nitrous oxide (N_2O) emissions from livestock manure management systems. Cattle are an important source of CH_4 in many countries because of their large population and high CH_4 emission rate due to their ruminant digestive system. Methane emissions from manure management tend to be smaller than enteric emissions, with the most substantial emissions associated with confined animal management operations where manure is handled in liquid-based systems. Nitrous oxide emissions from manure management vary significantly between the types of management system used and can also result in indirect emissions due to other forms of nitrogen loss from the system.

According to the 2006 IPCC Guidelines, the following source categories are included in this sector: Enteric fermentation (3.A), Manure management (3.B), Rice cultivation (3.C), Agricultural soils (3.D), Prescribed burning of savannas (3.E), Field burning of agricultural residues (3.F), Liming (3.G), Urea Application (3.H), Other Carbon-containing fertilizers (3.I). In Cyprus, rice cultivation (3.C), prescribed burning of savannas (3.E) and Liming (3.G) do not take place and are therefore reported as NO.

5.1.1. Emission trends

***The agricultural sector of Cyprus*[42]**

Although abundant with fresh produce and a sunny climate, farming in Cyprus is faced with droughts and environmental challenges, as well as an ongoing struggle for economic relevance. In the early years of Cyprus' independence, the contribution of the agricultural sector to GDP was about 20%, whereas today it has dropped to around 1.7% and employs 4% of the workforce. However, the sector has tackled these trials and tribulations head-on by adopting new technologies, bringing new products to the market and widening its customer base.

Agriculture has shown remarkable resilience and production has remained at stable levels, despite recent macroeconomic challenges – proving there are positive future prospects for the sector if it continues to develop on a more professional, niche and scientific basis. New structural reforms are also set to increase competitiveness and productivity, allowing Cyprus to become more dynamic, export-oriented and most importantly to adopt a mentality of continuous modernisation.

Cyprus' agricultural share of total domestic exports is around 13.4%, and it is quintessentially Mediterranean with health-promoting foods such as citrus fruit, vegetables, grapes and potatoes. As for processed agricultural goods, Cyprus' key exports are halloumi, fruit and vegetable juices, meats and wines. The island's famous halloumi cheese has become one of the top export products for Cyprus.

The most important crops produced in Cyprus are: cereals (wheat, barley); melons (watermelons, sweet melons); vegetables (potatoes, carrots, tomatoes, cucumbers); and other fruit and tree crops, such as grapes, oranges, lemons, grapefruit, apples, pears, peaches, cherries, bananas, almonds, olives and

[42] Cyprus Profile, 2017, Green Growth and Niche Products, available at http://www.cyprusprofile.com/en/sectors/agriculture-and-food (accessed 19/12/2017)

carobs. An area of success has been the marketing of the Cyprus potato – one of the most important agricultural export products and easily recognisable by its reddish peel and extraordinary taste. Thanks to climatic conditions, fresh new Cyprus potatoes intended for export are available to European markets far before the traditional continental season.

Emissions

Emissions from Agriculture accounted for 6.6% of total emissions in 2021 (without LULUCF), compared to 8.4% in 1990. Emissions increased by 22.7% compared to 1990. Agriculture is responsible for mainly methane and nitrous oxide emissions. In 2021 agriculture contributed 39.7% to the total methane emissions and 69.3% to the total nitrous oxide emissions. The total emissions by gas and source from agricultural activities for the period 1990–2021 in Cyprus are presented in Table 5.1 and Figure 5.1.

Table 5.1. GHG emissions from Agriculture, for the period 1990–2021

Gg CO_2 eq.	**1990**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**
3. Agriculture	**454.27**	**542.49**	**525.08**	**514.43**	**506.48**	**483.33**	**448.83**
A. Enteric fermentation	220.61	251.11	255.88	263.63	270.08	263.38	251.14
B. Manure management	171.99	230.83	211.78	192.95	181.52	165.31	149.00
C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO
D. Agricultural soils	56.90	57.72	55.31	56.35	53.14	53.24	47.27
E. Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	2.96	1.16	1.15	0.76	0.83	0.85	0.64
G. Liming	NO	NO	NO	NO	NO	NO	NO
H. Urea application	1.82	1.67	0.97	0.74	0.91	0.55	0.79
I. Other carbon-containing fertilizers	NO	NO	NO	NO	NO	NO	NO
J. Other	NO	NO	NO	NO	NO	NO	NO
CO_2 (Gg)	1.82	1.67	0.97	0.74	0.91	0.55	0.79
CH_4 (Gg)	12.03	14.70	14.24	13.87	13.70	13.01	12.17
N_2O (Gg)	0.44	0.49	0.47	0.47	0.46	0.45	0.40
Total (Gg CO_2 eq.)	**454.27**	**542.49**	**525.08**	**514.43**	**506.48**	**483.33**	**448.83**
Gg CO_2 eq.	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
3. Agriculture	**436.90**	**441.52**	**462.04**	**475.80**	**481.32**	**495.46**	**531.32**
A. Enteric fermentation	249.45	251.32	273.00	286.37	292.99	303.12	329.61
B. Manure management	142.94	139.78	141.00	139.25	139.14	140.42	148.55
C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO
D. Agricultural soils	43.85	49.03	47.38	49.30	48.59	51.00	52.23
E. Prescribed burning of savannas	NO	NO	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	0.24	0.99	0.26	0.47	0.37	0.69	0.71
G. Liming	NO	NO	NO	NO	NO	NO	NO
H. Urea application	0.41	0.40	0.39	0.42	0.22	0.23	0.22
I. Other carbon-containing fertilizers	NO	NO	NO	NO	NO	NO	NO
J. Other	NO	NO	NO	NO	NO	NO	NO
CO_2 (Gg)	0.41	0.40	0.39	0.42	0.22	0.23	0.22
CH_4 (Gg)	11.87	11.89	12.61	12.95	13.16	13.51	14.65
N_2O (Gg)	0.39	0.41	0.41	0.43	0.43	0.44	0.46
Total (Gg CO_2 eq.)	**436.90**	**441.52**	**462.04**	**475.80**	**481.32**	**495.46**	**531.32**
Gg CO_2 eq.	**2021**						
3. Agriculture	**557.25**						

A. Enteric fermentation	352.15						
B. Manure management	153.77						
C. Rice cultivation	NO						
D. Agricultural soils	50.41						
E. Prescribed burning of savannas	NO						
F. Field burning of agricultural residues	0.62						
G. Liming	NO						
H. Urea application	0.30						
I. Other carbon-containing fertilizers	NO						
J. Other	NO						
CO_2 (Gg)	0.30						
CH_4 (Gg)	15.60						
N_2O (Gg)	0.45						
Total (Gg CO_2 eq.)	**557.25**						

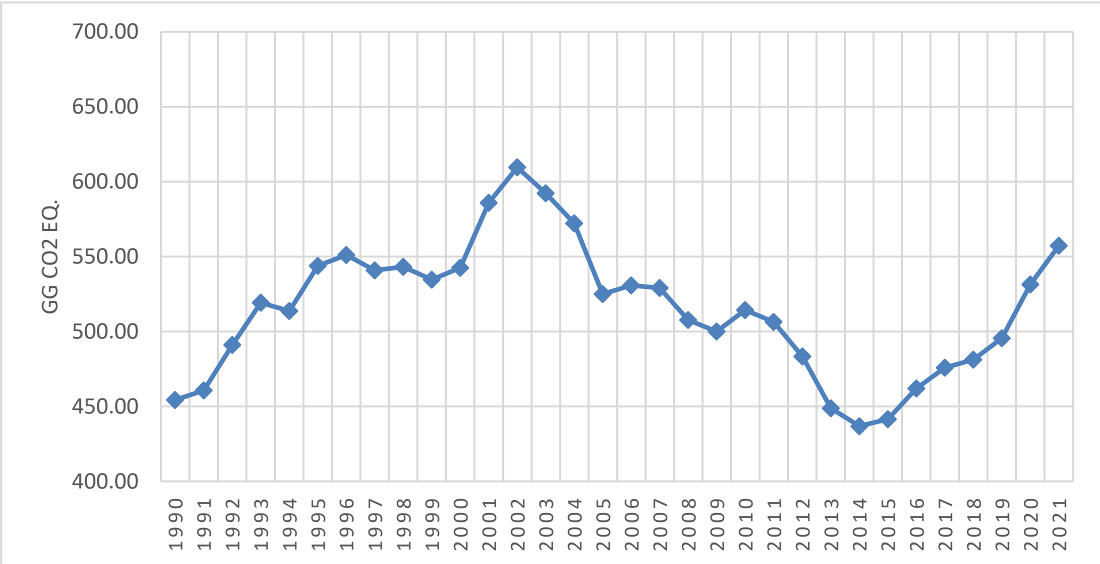

Figure 5.1. Emissions from Agriculture, 1990–2021

5.1.2. Methodology

The calculation of GHG emissions from Agriculture is based on the methodologies and emission factors suggested by the 2006 IPCC Guidelines. Data used for the estimation of the emissions was obtained from the National Statistical Service, the Department of Agriculture, the Veterinary services and other sources. Tier 1 method with default IPCC 2006 emission factors are used for all calculations except enteric fermentation emissions from cattle (3A1a) and manure management of cattle (3B1.1) and swine (3B1.3) that are estimated using Tier 2. The methodologies and emission factors used are summarised in Table 5

Table 5.2. Agriculture – methodologies and emission factors applied

Category-Classification		**Gas**	**EF**	**Method**
3A	Enteric Fermentation – Dairy Cattle	CH_4	CS	T2
3A	Enteric Fermentation - Non-dairy cattle, sheep, goats,	CH_4	D	T1

Category-Classification		Gas	EF	Method
	horses, mules and asses and swine			
3B1.1 3B1.3	Manure Management – Dairy Cattle and Non-dairy cattle, swine (market & breeding)	CH_4	D	T2
3B1.2 3B1.4	Manure Management – sheep, goats, horses, mules and asses, poultry	CH_4	D	T1
3B2.1 3B2.2 3B2.3 3B2.4	Direct N_2O emissions – Dairy and non-dairy cattle, Sheep, swine (market & breeding), goats, horses, poultry, mules and asses	N_2O	D	T1
3B2.5	Indirect N_2O emissions	N_2O	D	T1
3D1.1	Agricultural soils- Direct N_2O Emissions From Managed Soils- Inorganic fertilizers	N_2O	CS	T2
3D1.2a	Agricultural soils- Direct N_2O Emissions From Managed Soils - Organic N fertilizers - Animal manure used as fertilizers	N_2O	CS	T2
3D1.2b	Agricultural soils- Direct N_2O Emissions From Managed Soils - Organic N fertilizers - Sewage sludge applied to soils	N_2O	CS	T2
3D1.2c	Agricultural soils- Direct N_2O Emissions From Managed Soils - Organic N fertilizers – Other organic fertilizers applied to soils	N_2O	CS	T2
3D1.4	Agricultural soils- Direct N_2O Emissions From Managed Soils - Crop residues	N_2O	D	T1
3D2.1	Indirect N_2O emissions from managed soils – Atmospheric Deposition	N_2O	D	T1
3D2.2	Indirect N_2O emissions from managed soils Nitrogen Leaching and run-off	N_2O	D	T1
3F1	Field Burning of Agricultural Residues – Cereals – Wheat, Barley, Oats	N_2O/CH_4	D	T1
3F2	Field Burning of Agricultural Residues – Pulses – Bean and Pulses	N_2O/CH_4	D	T1
3F3	Field Burning of Agricultural Residues –Tubers and Roots	N_2O/CH_4	D	T1
3H	Urea Application	CO_2	D	T1

T1, T2: IPCC methodology Tier 1, 2 respectively; D: IPCC default methodology and emission factor;

Key categories

The results of the key categories assessment are presented in Section 1.4.

Uncertainty

The uncertainty analysis is presented in Section 1.5.

Completeness

Table 5.3 gives an overview of the IPCC source categories included in this chapter and presents the status of emissions estimates from all sub-sources in agriculture. Methane emissions from agricultural soils are not estimated since appropriate methodologies have not been developed yet.

Table 5.3. Agriculture – Inventory completeness

Source category	CO_2	CH_4	N_2O
3A. Enteric fermentation		✓	
3B. Manure management		✓	✓
3C. Rice cultivation		NO	
3D. Agricultural soils		NE	✓
3E. Prescribed burning of savannahs		NO	NO
3F. Field burning of agricultural residues		✓	✓

3G. Liming	NO		
3H. Urea Application	✓		
3I. Other Carbon – containing Fertilizers	NO		

NO: Not occurring; NE: Not estimated due to method unavailability

5.2. Enteric Fermentation (3A)

Methane is produced in herbivores 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 (e.g., cattle, sheep) are major sources of methane with moderate amounts produced from non-ruminant livestock (e.g., pigs, horses). The ruminant gut structure fosters extensive enteric fermentation of their diet.

Methane emissions from enteric fermentation in 2021 account for 63.2% of total GHG emissions from Agriculture and 80.6% of the total methane emissions excluding LULUCF. Methane emissions from enteric fermentation are presented in Table 5.4 and Figure 5.2.

Table 5.4. CH_4 emissions from Enteric Fermentation (3A) 1990–2021

Gg CH_4	**1990**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**
A. Enteric fermentation	**7.88**	**8.97**	**9.14**	**9.42**	**9.65**	**9.41**	**8.97**
1. Cattle	4.05	4.46	4.66	4.53	4.67	4.66	4.69
Dairy cattle	2.21	2.72	2.78	2.75	2.80	2.79	2.83
Non-dairy cattle	1.84	1.75	1.88	1.78	1.87	1.87	1.85
2. Sheep	2.32	1.97	2.15	2.63	2.85	2.78	2.51
3. Swine	0.42	0.61	0.64	0.70	0.66	0.59	0.54
4. Other livestock	1.09	1.92	1.68	1.56	1.47	1.38	1.24
Goats	1.03	1.89	1.65	1.54	1.45	1.36	1.22
Horses	0.01	0.02	0.02	0.01	0.01	0.01	0.01
Mules and Asses	0.05	0.02	0.01	0.01	0.01	0.01	0.01
Total CH4	**7.88**	**8.97**	**9.14**	**9.42**	9.65	9.41	8.97
Gg CH_4	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
A. Enteric fermentation	**8.91**	**8.98**	**9.75**	**10.23**	**10.46**	**10.83**	**11.77**
1. Cattle	4.87	4.88	5.54	5.82	6.16	6.44	7.29
Dairy cattle	2.92	3.01	3.49	3.74	3.94	4.22	4.82
Non-dairy cattle	1.95	1.86	2.05	2.09	2.22	2.21	2.47
2. Sheep	2.34	2.38	2.43	2.57	2.49	2.60	2.62
3. Swine	0.51	0.54	0.53	0.53	0.54	0.52	0.54
4. Other livestock	1.18	1.18	1.25	1.31	1.27	1.28	1.32
Goats	1.16	1.17	1.23	1.29	1.25	1.26	1.30
Horses	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Mules and Asses	0.01	0.00	0.01	0.01	0.01	0.01	0.01
Total CH4	**8.91**	**8.98**	**9.75**	**10.23**	**10.46**	**10.83**	**11.77**
Gg CH_4	**2021**						
A. Enteric fermentation	**12.58**						
1. Cattle	8.20						
Dairy cattle	5.72						
Non-dairy cattle	2.48						
2. Sheep	2.49						
3. Swine	0.54						
4. Other livestock	1.35						
Goats	1.32						

Horses	0.01						
Mules and Asses	0.01						
Total CH4	**12.58**						

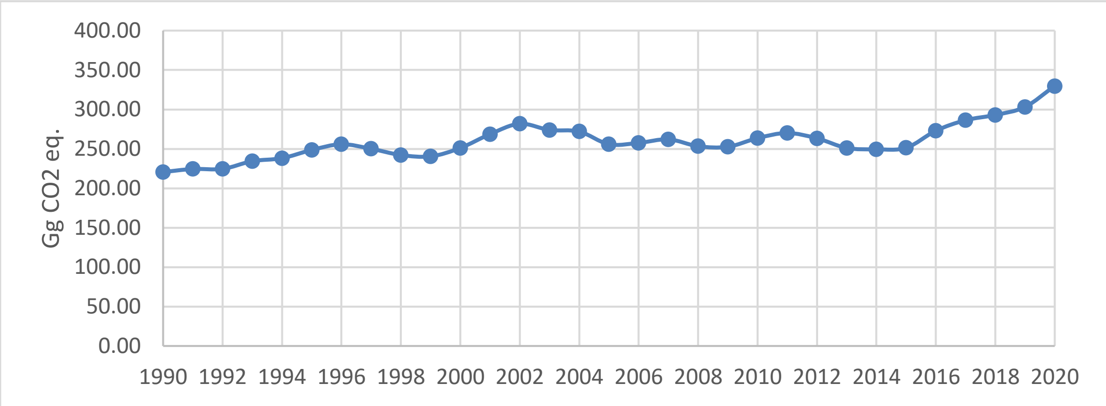

Figure 5.2. CH_4 emissions from Enteric Fermentation (3A) 1990–2021 in Gg CO_2 eq.

5.2.1. Methodological issues

Tier 1 methodology is applied and the default emission factors suggested by the IPCC Guidelines are used for the estimation of methane emissions from enteric fermentation for non-dairy cattle, sheep, goats, horses, mules and asses and swine. The emissions from dairy cattle are estimated using Tier 2 methodology. Poultry emissions were not estimated, since an emission factor is not available in the IPCC guidelines.

5.2.1.1. Activity data

The animal population used for the calculation of methane emissions from enteric fermentation is the annual average and it is presented in Table 5.5. The source of animal population is the Department of Agriculture, except for horses, mules and asses. Following a recommendation of the ERT in the Saturday Paper prepared during the in-country review of the 2016 submission to the UNFCCC, the population for horses, mules and asses was obtained from the Agricultural Censuses of the Statistical Service for the years 1985, 1994, 2002 and 2010 and linearly interpolated to complete the time series. Information after 2010 was available for the mules and asses by the Veterinary Services but was not available for the horses, therefore the decreasing trend that exists between 2003 and 2010 is used to extrapolate population for 2011–2016 using equation $y=-58.571x+1220.6$. Population for the years 2016–2019 was obtained by the veterinary services. Population for 2021 for mules and asses and horses was calculated with linear extrapolation. New data might be available in the next months.

Table 5.5. Animal population for 1990–2021 (in 1000s)

	Dairy cattle	Other cattle	Sheep	Breeding swine[a]	Market swine[b]	Horses	Mules and Asses	Goats	Poultry
1990	22.4	32.3	290.0	33.8	244.2	0.46	5.03	205.0	3694
1991	23.1	31.9	295.0	37.6	258.7	0.43	4.44	205.0	3403
1992	23.9	31.9	285.0	42.4	299.5	0.41	3.85	200.0	3838
1993	25.6	35.5	275.0	43.6	325.8	0.38	3.26	198.0	4551
1994	27.6	36.8	255.0	48.0	308.2	0.35	2.67	210.0	4313
1995	29.5	38.6	250.0	48.4	325.7	0.44	2.53	220.0	4460
1996	27.3	42.8	252.0	48.9	350.7	0.53	2.39	240.0	4749
1997	25.5	36.9	245.0	53.3	361.5	0.62	2.26	302.0	4816
1998	23.8	32.0	240.0	49.8	381.5	0.71	2.12	322.0	4894
1999	24.1	30.2	233.0	44.2	374.3	0.80	1.98	346.0	4823
2000	23.5	30.7	246.0	52.1	356.3	0.89	1.84	378.6	4830

	Dairy cattle	Other cattle	Sheep	Breeding swine[a]	Market swine[b]	Horses	Mules and Asses	Goats	Poultry
2001	24.4	29.1	296.6	55.7	395.6	0.98	1.70	427.1	4873
2002	26.2	31.9	294.0	56.3	435.1	1.07	1.56	459.5	5037
2003	26.6	31.9	264.6	55.6	432.5	1.16	1.42	407.9	5015
2004	26.1	34.2	279.0	51.7	418.8	1.10	1.29	378.0	4547
2005	24.6	33.0	268.9	50.6	379.1	1.04	1.16	329.3	4419
2006	23.9	32.2	272.2	53.0	399.7	0.99	1.03	344.9	3775
2007	23.7	31.2	292.2	54.0	396.3	0.93	0.90	368.1	3978
2008	23.6	32.0	267.3	48.3	416.6	0.87	0.78	318.4	3892
2009	23.2	30.9	300.2	47.0	416.2	0.81	0.65	280.8	3793
2010	23.4	31.3	328.9	46.3	417.4	0.75	0.52	307.4	3793
2011	24.1	32.8	355.9	40.5	398.7	0.69	0.63	290.2	3678
2012	24.1	32.8	346.8	36.3	358.4	0.64	0.70	271.2	3488
2013	24.7	32.5	313.5	35.1	322.8	0.58	0.84	243.1	3091
2014	25.3	34.2	293.0	31.8	326.2	0.52	0.91	232.0	3677
2015	26.2	32.7	296.9	32.1	326.2	0.46	0.96	233.9	3154
2016	28.5	34.5	304.2	32.6	319.6	0.40	1.00	246.6	3261
2017	30.1	36.6	321.5	33.2	317.0	0.40	1.16	257.6	3360
2018	31.9	38.9	311	33.8	328.2	0.43	1.20	250.4	3475
2019	35.0	38.85	324.4	32.7	312.9	0.47	1.25	251.0	3604
2020	39.5	43.4	328.1	32.4	327.0	0.47	1.34	260.8	3588
2021	44.5	43.5	311.7	31.0	329.6	0.51	1.42	264.5	3625

[a] sows; [b] all except sows

5.2.1.2. Methodological issues

Dairy cattle, Tier 2

Methane emissions from the enteric fermentation of dairy cattle are estimated according to the Tier 2 IPCC methodology, as it is described in the IPCC Guidelines (pg. 10.31, volume 4). The calculation of the CH_4 emission factor for is based on the following equation (eqn 10.21, pg. 10.30, volume 4):

$$EF = [[(GE * (YM/100) * 365\ days/yr] / 55.65\ MJ/kg\ CH_4]$$

where EF is the estimated emission factor for CH_4 (kg CH_4/head/yr), GE is the gross energy intake (MJ/head/day) and Ym is the methane conversion rate which is the fraction of the gross energy in feed converted to CH_4.

The calculation of gross energy is based on the following equation (eqn 10.16, pg. 10.21, volume 4):

$$GE = \{[(NE_m + NE_a + NE_l + NE_{work} + NE_p) / REM] + [(NE_g+NE_{wool})/ REG]\} / (DE\% / 100)$$

where NE_m is the net energy required for animal maintenance in MJ/day, NE_a is the net energy for animal activity in MJ/day, NE_l is the net energy for lactation in MJ/day, NE_{work} is the net energy for work, NE_p is the net energy required for pregnancy in MJ/day, REM is the ratio of the net energy available in a diet for maintenance to digestible energy consumed, NE_g is the net energy for growth in MJ/day, NE_{wool} is the net energy required to produce a year of wool, REG is the ratio of net energy available for growth in a diet to digestible energy consumed and DE% is the digestible energy expressed as a percentage of gross energy.

The dairy cattle population used for the calculation of methane emissions from enteric fermentation is presented in Table 5.6. Information for average weight (W), live body weight (BW), mature body weight (MW), milk production and digestibility of feed has been obtained from the Department of Agriculture[43]. The remaining parameters use the default value proposed by the IPCC GPG. The fat percentage in milk is assumed to be 3.5%, based on the suggestion that was made during the volunteer participation of Cyprus in the Effort Sharing Decision review (ESD review) that took place in 2014. Table 5.6 presents

[43] Mr. George Papaioannou, Agricultural Officer, Department of Agriculture, tel. no. +357 22408566

the values used for the calculations, while Table 5.7 presents the daily milk production and the % pregnant population. The resulting Gross energy (GE) and the emissions factors (EFs) for the period 1990–2020 are presented in Table 5.8.

There is an ongoing survey conducted by the department of Agriculture regarding dairy cattle, pregnancy rates, feed and farming. It is expected that once the results available, there will be an upgrade in the methodology.

Table 5.6. Information for the application of Tier 2 methodology for dairy cattle

Parameter	Value	Source
Average weight (W), kg	550	Department of Agriculture
Net energy maintenance coefficient (Cf_i)	0.386	IPCC Guidelines (cattle, Table 10.4, pg. 10.16, vol. 4)
Activity coefficient (C_a)	0.00	IPCC Guidelines (stall, Table 10.5, pg. 10.17, vol. 4)
Live body weight (BW), kg	550	Department of Agriculture
Growth coefficient (C)	0.8	IPCC Guidelines (eqn.10.6, pg. 10.17, vol. 4)
Mature body weight of an adult animal (MW), kg	550	Department of Agriculture
Daily weight gain (WG), kg/day	0	IPCC Guidelines (footnote 1, pg. 10.12,vol.4)
Fat in milk	3.5%	Recommendation which was identified by technical Expert review team during the Review 2014
Hours of work / day	0	Department of Agriculture
$C_{pregnancy}$	0.10	IPCC Guidelines (table 10.7, pg.10.20, vol.4)
Digestibility of feed, DE	68	Recommendation of the review expert of the TERT (comment no. CY-3A-2016-0002)
CH_4 conversion rate (Ym)	0.065	IPCC Guidelines (table 10.12, pg.10.30, vol.4)

Table 5.7. Daily milk production per dairy cow (kg) and per cent pregnant population of cows in Cyprus

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Milk production (kg/day/cow)	12.22	12.30	12.25	12.60	12.49	12.90	13.84	14.30
% pregnant population*	81.3	81.3	81.3	81.3	81.3	81.3	81.3	81.3

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Milk production (kg/day/cow)	15.40	15.07	17.07	15.89	14.77	16.71	15.86	16.41
% pregnant population	81.3	81.3	81.3	81.3	81.3	81.3	81.3	80.3

Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Milk production (kg/day/cow)	15.89	14.77	16.71	17.95	17.64	17.42	17.29	16.96
% pregnant population	81.3	81.3	81.3	76.3	76.3	72.2	72.2	72.2

Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Milk production (kg/day/cow)	17.18	17.08	19.26	19.68	19.60	18.68	19.08	20.99
% pregnant population	72.2	72.2	72.2	72.2	72.2	72.2	72.2	72.2

* No data available for 1990–2003, 2010 and 2011. 1990–2003 assumed that is equal to 2004, 2010 assumed equal to 2009 and 2011, 2013 to 2020 assumed equal to 2012.

Table 5.8. Gross energy (GE) and emissions factor (EF) for dairy cattle for the period 1990–2021

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
GE (MJ/head/day)	231.8	232.4	232.0	234.9	234.0	237.3	244.8	248.6
EF (kg CH_4/head/yr)	98.8	99.1	98.9	100.1	99.8	101.2	104.4	106.0

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
GE (MJ/head/day)	257.4	254.7	270.9	261.4	252.3	268.0	261.2	265.5
EF (kg CH_4/head/yr)	109.7	108.6	115.5	111.4	107.6	114.3	111.3	113.2

Year	2006	2007	2008	2009	2010	2011	2012	2013
GE (MJ/head/day)	270.4	267.3	275.1	277.3	274.9	272.6	271.5	268.9
EF (kg CH_4/head/yr)	115.3	114.0	117.3	118.2	117.2	116.2	115.8	114.6

Year	2014	2015	2016	2017	2018	2019	2020	2021
GE (MJ/head/day)	270.7	269.9	287.5	290.8	290.2	282.8	286.1	301.4
EF (kg CH_4/head/yr)	115.4	115.1	122.5	124.0	123.7	120.5	122.0	128.5

Non-dairy cattle, sheep, goats, horses, mules and asses and swine; Tier 1

The methane emission factors used for enteric fermentation of non-dairy cattle, sheep, goats, horses, mules and asses and swine for the application of the Tier 1 methodology are as defined in the IPCC 2006 guidelines (volume 4, pg. 10.29, Table 10.11) and are presented in Table 5.9. Poultry emissions were not estimated, since an emission factor is not available in the IPCC guidelines (volume 4, pg.10.28, Table 10.10). The animal populations used are presented in Table 5.5.

Table 5.9. Methane emission factor applied for enteric fermentation, according to animal

	Emission factor (kg CH_4/head)	Source
Non-dairy cattle	57	IPCC 2006, pg. 10.29, volume 4, western Europe*
Sheep	8	IPCC 2006, pg. 10.28, volume 4, developed
Swine	1.5	IPCC 2006, pg. 10.28, volume 4, developed
Horses	18	IPCC 2006, pg. 10.28, volume 4, developed
Mules and asses	10	IPCC 2006, pg. 10.28, volume 4, developed
Goats	5	IPCC 2006, pg. 10.28, volume 4, developed

* Milk production closer to North America but production system as Western Europe

5.2.2. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

5.2.3. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. Animal population is compared between four data sources: Statistical Service, DLI, EUROSTAT and Department of Agriculture.

5.2.4. Category-specific recalculations

There are no recalculations for this category.

5.2.5. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

5.3. Manure Management (3B)

The term 'manure' is used here collectively to include both dung and urine (i.e., the solids and the liquids) produced by livestock. The decomposition of manure under anaerobic conditions (i.e., in the absence of oxygen) during storage and treatment, produces CH_4. Emissions of CH_4 related to manure handling and storage are reported under 'Manure Management.' The main factors affecting CH_4 emissions are the amount of manure produced and the portion of the manure that decomposes anaerobically. The former depends on the rate of waste production per animal and the number of animals, and the latter on how the manure is managed.

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. The production and emission of N_2O from managed manures requires the presence of either nitrites or nitrates in an anaerobic environment preceded by aerobic conditions necessary for the formation of these oxidized forms of nitrogen.

5.3.1. Category description

5.3.1.1. Animal waste management in Cyprus[44]

Most small-scale pig farms in Cyprus use mechanical separation for the treatment of their waste. The separated liquid is sent to evaporation lagoons or is used for irrigation, and the solid fraction is used as soil improver. Nine large pig farms have installed a combination of anaerobic/aerobic treatment plants (Anaerobic digestion). The treated liquid fraction is used for irrigation, washing the housing areas or is placed in evaporation lagoons. The produced biogas is combusted onsite by Combined Heat Power generators for the production of heat and electricity. Both heat and electricity are consumed at the farms. Any excess electricity is sold to the electricity provider and directed to the electricity distribution network. Heat is not distributed outside the farm because there is no heat distribution network in Cyprus. The emissions from the electrical energy from the biogas used onsite and offsite has been taken into account in the energy sector according to the national energy balance.

The waste from cattle, sheep, goats, horses, mules and asses are collected and left to dry before being applied on land for soil improver (Solid storage and dry lot). Poultry waste is characterised by high content of solids (almost dry) and it is collected, left to dry and then used as soil improver (Solid storage and dry lot).

Manure management is responsible for methane and nitrous oxide emissions. Methane is produced during the anaerobic decomposition of manure, while nitrous oxide is produced during the storage and treatment of manure before its use as fertilizer.

Emissions from manure management in 2021 accounted for 24.6% of the total agriculture emissions without LULUCF. CH_4 and N_2O from manure management in 2021 accounted for 19.23% and 36.62% of GHG emissions from Agriculture respectively. Total emissions in 2021 decreased by 10.6% compared to 1990 levels because of the improvement of waste management practices. CH_4 and N_2O emissions from manure management for the period 1990–2021 are presented in Table 5.10 and Figure 5.3.

Table 5.10. CH_4 and N_2O emissions from manure management for 1990–2021

Gg CO_2 eq.	**1990**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**
B. Manure management	**172.0**	**230.8**	**211.8**	**192.9**	**181.5**	**165.3**	**149.0**
1. Cattle	26.8	28.9	30.3	28.6	28.78	28.65	28.2
Dairy cattle	16.1	19.0	19.6	18.7	18.67	18.64	18.5
Non-dairy cattle	10.6	9.9	10.7	9.9	10.11	10.01	9.7
2. Sheep	14.5	12.3	13.4	16.4	17.74	17.28	15.6
3. Swine	89.3	131.7	113.7	97.2	85.89	73.34	63.3
4. Other livestock	18.9	29.3	26.0	22.8	21.67	20.26	18.1
Goats	9.1	16.9	14.7	13.7	12.92	12.07	10.8
Horses	0.1	0.2	0.2	0.1	0.12	0.11	0.1
Mules and Asses	0.4	0.1	0.1	0.1	0.05	0.06	0.1
Poultry	9.3	12.1	11.1	8.9	8.58	8.03	7.08
Other	NO	NO	NO	NO	NO	NO	NO
5. Indirect N_2O emissions	22.6	28.7	28.4	28.0	27.4	25.8	23.7

[44] Kythreotou, N., G. Florides, S.A. Tassou, 2010. Production and management of biodegradable waste in Cyprus a paper published in the proceedings of SEEP2010 Conference Proceedings, June 29th– July 2nd 2010, Bari, Italy.

CH_4 (Gg)	4.07	5.69	5.07	3.41	4.03	3.58	3.18
N_2O (Gg)	0.22	0.27	0.26	0.26	0.26	0.25	0.23
Total (Gg CO_2 eq.)	**172.0**	**186.2**	**211.8**	**160.0**	**181.5**	**165.3**	**149.0**
Gg CO_2 eq.	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
B. Manure management	**142.9**	**139.8**	**141.0**	**139.3**	**139.1**	**140.4**	**148.6**
1. Cattle	29.3	28.7	32.4	33.2	35.2	37.0	41.8
Dairy cattle	19.1	19.2	21.9	22.8	24.1	26.0	29.5
Non-dairy cattle	10.2	9.5	10.4	10.4	11.0	11.0	12.3
2. Sheep	14.6	14.8	15.2	16.0	15.5	16.2	16.3
3. Swine	56.1	54.9	50.6	45.9	43.9	41.9	43.4
4. Other livestock	18.7	17.6	18.3	18.9	18.7	19.1	19.4
Goats	10.3	10.4	11.0	11.5	11.2	11.2	11.6
Horses	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Mules and Asses	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Poultry	8.2	7.0	7.1	7.3	7.4	7.7	7.6
Other	NO	NO	NO	NO	NO	NO	NO
5. Indirect N_2O emissions	24.28	23.8	24.58	25.28	25.92	26.32	27.5
CH_4 (Gg)	2.9	2.9	2.9	2.7	2.7	2.7	2.9
N_2O (Gg)	0.2	0.2	0.2	0.2	0.2	0.3	0.3
Total (Gg CO_2 eq.)	**142.9**	**139.8**	**141.0**	**139.3**	**139.1**	**140.4**	**148.6**
Gg CO_2 eq.	**2021**						
B. Manure management	**153.8**						
1. Cattle	47.0						
Dairy cattle	34.6						
Non-dairy cattle	12.4						
2. Sheep	15.5						
3. Swine	43.5						
4. Other livestock	19.7						
Goats	11.8						
Horses	0.1						
Mules and Asses	0.1						
Poultry	7.7						
Other	NO						
5. Indirect N_2O emissions	28.1						
CH_4 (Gg)	3.00						
N_2O (Gg)	0.26						
Total (Gg CO_2 eq.)	**153.8**						

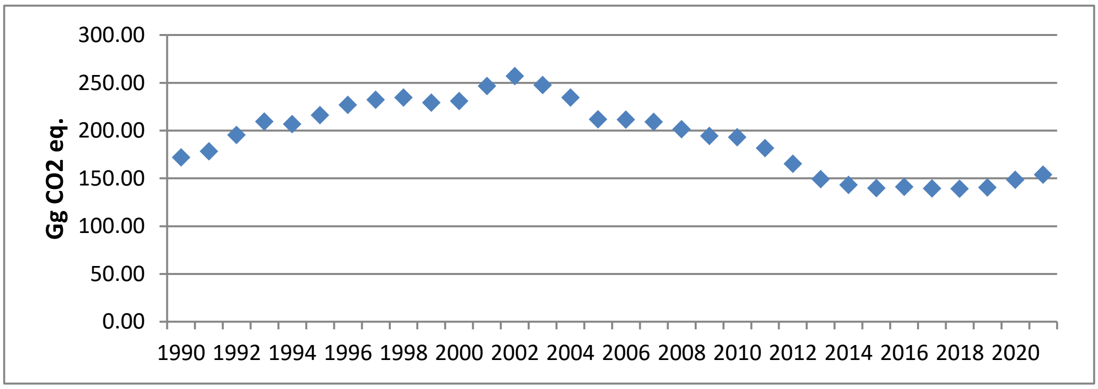

Figure 5.3. Emissions from manure management, 1990–2021

5.3.2. Methodological issues

5.3.2.1. CH_4 emissions (3B1)

The best way to determine emission factors is to conduct non-invasive or non-disturbing measurements of emissions in actual systems representative of those in use in the country. These field results can be used to develop models to estimate emission factors (Tier 3). Such measurements are difficult to conduct, and require significant resources and expertise, and equipment that may not be available.However, attempts will be made in order to carry out such surveys in the following years. There are two alternatives for developing emission factors, with the selection of emission factors depending on the method (i.e., Tier 1 or Tier 2) chosen for estimating emissions. Tier 2 methodology is applied for swine, dairy and other cattle, and Tier 1 applied for sheep, horses, goats, poultry mules and asses.

Tier 1: When using the Tier 1 method, methane emission factors by livestock category or subcategory are used (Table 5.11). The EFs for manure management were chosen according to the manure management practices that are applied in Cyprus for the particular specie[45]. The animal population used is presented in Table 5.5.

Table 5.11. Emission factors used for the estimation of methane emissions from manure management

Animal	kg CH_4/head/yr	Source
Sheep	0.28	Table 10.15, pg.10.40, IPCC 2006 guidelines, volume 4 – developed countries, temperate
Goats	0.20	Table 10.15, pg.10.40, IPCC 2006 guidelines, volume 4– developed countries, temperate
Horses	2.34	Table 10.15, pg.10.40, IPCC 2006 guidelines, volume 4 – developed countries, temperate
Mules and asses	1.10	Table 10.15, pg.10.40, IPCC 2006 guidelines, volume 4 – developed countries, temperate
Laying chicken	0.03	Table 10.15, pg.10.40, IPCC 2006 guidelines, volume 4 – developed countries, temperate/dry
Broiler chicken	0.02	Table 10.15, pg.10.40, IPCC 2006 guidelines, volume 4 – developed countries, temperate
Turkeys	0.09	Table 10.15, pg.10.40, IPCC 2006 guidelines, volume 4 – developed countries, temperate
Other Poultry	0.03	Table 10.15, pg.10.40, IPCC 2006 guidelines, volume 4 – developed countries, temperate/ducks

Tier 2: The Tier 2 method relies on two primary types of inputs that affect the calculation of methane emission factors from manure: Manure characteristics and Manure management system characteristics. Manure characteristics includes the amount of volatile solids (VS) produced in the manure and the maximum amount of methane able to be produced from that manure (Bo). Volatile substance excretion (VS) and Bo are as recommended for Eastern Europe by 2006 IPCC Guidelines in Annex 10A.2 (Table 5.12) except for Dairy cattle where it is calculated after the 2006 IPCC Guidelines, after the TERT recommendation CY_3B_2022_0005. Manure management system characteristics includes the types of systems used to manage manure and a system-specific methane conversion factor (MCF) that reflects the portion of Bo that is achieved. For the development of the EF equation 10.23 (pg. 10.41, vol. 4, 2006 IPCC guidelines) is applied. Waste management practices applied according to animal type is presented in Table 5.13. Information on waste management practices has been obtained from personal communication with Mr. Antis Athanasiades (Environment Officer, Pollution Control Unit[46]), due to the unavailability of any other references on distribution of animal waste to waste management practice. The emissions are estimated by multiplying the developed EF by the animal population (Table 5.5).

[45]The choice for the EFs was based on personal communication with Mr. Antis Athanasiades, the responsible officer for manure management at the Department of Environment (Pollution Prevention Unit, aathanasiades@environment.moa.gov.cy, +35722408935).

[46] 15/11/2017, Tel. +357 22 408935, email aathanasiades@environment.moa.gov.cy

Table 5.12. Volatile substance excretion (VS) and Bo for T2 methodology (2006 IPCC Guidelines, vol. 4, Annex 10A.2)

Animal	VS (kg/hd/day)	Bo (m^3 CH_4/kg VS)	Table
Dairy cows	CS	0.24	10A-4
Other cattle	2.7	0.17	10A-5
Market swine	0.3	0.45	10A-7
Breeding swine	0.5	0.45	10A-8

Table 5.13. Waste management per technology contribution

Animal	1990–2000	2001	2002	2003	2004	2005	2006
Dairy Cattle							
Liquid system	20%	20%	20%	20%	20%	20%	20%
Solid storage and dry lot	80%	80%	80%	80%	80%	80%	80%
Anaerobic digestion	0%	0%	0%	0%	0%	0%	0%
Non-Dairy Cattle							
Liquid system	20%	20%	20%	20%	20%	20%	20%
Solid storage and dry lot	80%	80%	80%	80%	80%	80%	80%
Anaerobic digestion	0%	0%	0%	0%	0%	0%	0%
Sheep							
Solid storage and dry lot	100%	100%	100%	100%	100%	100%	100%
Goats							
Solid storage and dry lot	100%	100%	100%	100%	100%	100%	100%
Horses							
Solid storage and dry lot	100%	100%	100%	100%	100%	100%	100%
Mules and asses							
Solid storage and dry lot	100%	100%	100%	100%	100%	100%	100%
Market Swine							
Solid storage and dry lot	10%	10%	10%	10%	10%	10%	10%
Aerobic treatment	90%	87%	83%	80%	77%	73%	70%
Anaerobic digestion	0%	3%	7%	10%	13%	17%	20%
Breading Swine							
Solid storage and dry lot	10%	10%	10%	10%	10%	10%	10%
Aerobic treatment	90%	87%	83%	80%	77%	73%	70%
Anaerobic digestion	0%	3%	7%	10%	13%	17%	20%
Poultry							
Solid storage and dry lot	100%	100%	100%	100%	100%	100%	98%
Anaerobic digestion	0%	0%	0%	0%	0%	0%	2%
Animal	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Dairy Cattle							
Liquid system	20%	20%	19%	19%	18%	18%	17%
Solid storage and dry lot	80%	80%	80%	80%	80%	80%	80%
Anaerobic digestion	0%	0%	1%	1%	2%	2%	3%
Non-Dairy Cattle							
Liquid system	20%	20%	19%	19%	18%	18%	17%
Solid storage and dry lot	100%	80%	99%	99%	99%	97%	97%
Anaerobic digestion	0%	0%	1%	1%	2%	2%	3%
Sheep							
Solid storage and dry lot	100%	100%	100%	100%	100%	100%	100%
Goats							
Solid storage and dry lot	100%	100%	100%	100%	100%	100%	100%
Horses							
Solid storage and dry lot	100%	100%	100%	100%	100%	100%	100%
Mules and asses							
Solid storage and dry lot	100%	100%	100%	100%	100%	100%	100%
Market Swine							
Solid storage and dry lot	10%	10%	10%	10%	10%	10%	10%
Aerobic treatment	67%	63%	60%	57%	53%	50%	47%

Anaerobic digestion	23%	27%	30%	33%	37%	40%	43%
Breading Swine							
Solid storage and dry lot	10%	10%	10%	10%	10%	10%	10%
Aerobic treatment	67%	63%	60%	57%	53%	50%	47%
Anaerobic digestion	23%	27%	30%	33%	37%	40%	43%
Poultry							
Solid storage and dry lot	97%	95%	94%	92%	91%	89%	88%
Anaerobic digestion	3%	5%	6%	8%	9%	11%	12%
Animal	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Dairy Cattle							
Liquid system	16%	16%	15%	15%	15%	15%	15%
Solid storage and dry lot	80%	80%	80%	80%	80%	80%	80%
Anaerobic digestion	4%	4%	5%	5%	5%	5%	5%
Non-Dairy Cattle							
Liquid system	16%	16%	15%	15%	15%	15%	15%
Solid storage and dry lot	80%	80%	80%	80%	80%	80%	80%
Anaerobic digestion	4%	4%	5%	5%	5%	5%	5%
Sheep							
Solid storage and dry lot	100%	100%	100%	100%	100%	100%	100%
Goats							
Solid storage and dry lot	100%	100%	100%	100%	100%	100%	100%
Horses							
Solid storage and dry lot	100%	100%	100%	100%	100%	100%	100%
Mules and asses							
Solid storage and dry lot	100%	100%	100%	100%	100%	100%	100%
Market Swine							
Solid storage and dry lot	10%	10%	10%	10%	10%	10%	10%
Aerobic treatment	53%	50%	47%	43%	40%	40%	40%
Anaerobic digestion	47%	50%	53%	57%	60%	60%	60%
Breading Swine							
Solid storage and dry lot	10%	10%	10%	10%	10%	10%	10%
Aerobic treatment	53%	50%	47%	43%	40%	40%	40%
Anaerobic digestion	47%	50%	53%	57%	60%	60%	60%
Poultry							
Solid storage and dry lot	86%	85%	83%	82%	80%	80%	80%
Anaerobic digestion	16%	15%	17%	18%	20%	20%	20%
Animal	**2021**						
Dairy Cattle							
Liquid system	15%						
Solid storage and dry lot	80%						
Anaerobic digestion	5%						
Non-Dairy Cattle							
Liquid system	15%						
Solid storage and dry lot	80%						
Anaerobic digestion	5%						
Sheep							
Solid storage and dry lot	100%						
Goats							
Solid storage and dry lot	100%						
Horses							
Solid storage and dry lot	100%						
Mules and asses							
Solid storage and dry lot	100%						
Market Swine							
Solid storage and dry lot	10%						
Aerobic treatment	40%						

Anaerobic digestion	60%						
Breading Swine							
Solid storage and dry lot	10%						
Aerobic treatment	40%						
Anaerobic digestion	60%						
Poultry							
Solid storage and dry lot	80%						
Anaerobic digestion	20%						

5.3.2.2. N_2O emissions (3B2)

The level of detail and methods chosen for estimating N_2O emissions from manure management systems depend upon national circumstances. Tier 2 methodology is applied for calculating direct N_2O emissions from manure management systems, and is described below.

Tier 2 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 (Equation 10.25, pg. 10.54, vol. 4, 2006 IPCC Guidelines). Emissions are then summed over all manure management systems. IPCC default N_2O emission factors and default nitrogen excretion data, whereas manure management system data is country-specific.

The annual nitrogen excretion rate per animal type using the nitrogen excretion rates (kg N ex/animal/year) is shown in Table 5.14. These are the defaults proposed by the IPCC methodologies. The Nitrogen excretion rate has been determined by using the IPPC 2006 Guidelines equation 10.30, pg. 10.57. The animal population used is presented in Table 5.5. It should be noted that Cyprus has used Western Europe default values for N excretion and Eastern Europe default values for CH_4 for manure management. The reason for the different approach is that manure management practices for cattle waste used in Cyprus are more appropriately categorised as Eastern European. However, for the calculation of the N_2O emissions from manure management, the high milk production resulted in the factor being changed to that of Western Europe, based on the comment received by the UNFCCC review team in 2013.

Table 5.14. Default values for Nitrogen excretion rate (IPCC 2006 guidelines, volume 4, table 10.19, pg. 10.59)

Animal	Default values for Nitrogen excretion rate (kg N /animal/day)
Dairy Cattle	0.48
Non-Dairy Cattle	0.33
Market swine	0.51
Breading swine	0.42
Sheep	0.85
Poultry	0.83
Goats	1.28
Horses	0.26
Mules and asses	0.26

The annual nitrogen excretion per waste management system is estimated by multiplying the % of waste allocated to a particular system by the estimated annual nitrogen excretion per animal type. The total annual nitrogen excretion per waste management system (regardless animal type) is then multiplied by the kgN_2O-N/kg Nex coefficient, to estimate the N_2O emissions. The kgN_2O-N/kg N ex coefficients used are presented in Table 5.15. After the TERT CY-3B-2023-0004, aerobic treatment for swine is considered without crust.

Table 5.15. kg N_2O-N/kg N ex coefficients per technology used

Animal	kgN_2O-N/kg N ex	Source
Solid storage and dry lot	0.005	2006 IPCC Guidelines, volume 4, pg. 10.62, table 10.21
Aerobic treatment (forced aeration)	0.005	
Liquid System without crust	0.000	
Anaerobic digestion	0.000	

3B2.5. Indirect N_2O emissions from Manure Management

I. Indirect N_2O emissions from volatilisation of N from Manure Management

To estimate the indirect N_2O emissions from manure management four steps were applied, according to the Tier 1 methodology: (a) Estimation of annual nitrogen excretion per animal type (kg N ex/year), (b) Allocation of waste to waste management system used, (c) Estimation of amount of manure nitrogen that is lost due to volatilisation, and (d) Estimation of N_2O emissions using the totals volatilisation N-losses (kg N/yr). The indirect N_2O emissions were estimated using the equation 10.27 (pg. 10.56, volume 4 2006 IPCC guidelines), as outlined below.

The annual nitrogen excretion per animal type using the nitrogen excretion rates (kg N ex/animal/year) is shown in Table 5.13. These are the defaults proposed by the IPCC methodologies. The animal population used is presented in Table 5.5.

The distribution of waste to the waste management systems has been estimated based on the information presented in Table 5.14.

The annual amount of manure nitrogen that is lost due to volatilisation ($N_{volatilisation\ –MMS}$) is estimated by multiplying the % of waste allocated to a particular waste management system by the annual nitrogen excretion per animal estimated in step (a) and by multiplying the % of managed manure nitrogen for livestock category T in the manure system S ($Frac_{GASMS}$ (%)). The percent of managed manure nitrogen for livestock is presented in Table 5.16.

The total annual amount of manure nitrogen that is lost due to volatilisation ($N_{vol.atilization–MMS}$) is multiplied by the emission factor for N_2O emissions from atmospheric deposition of nitrogen on soils and water surfaces (EF_4) to estimate the N_2O emissions. The emission factor used is 0.01 kg N_2O-N (default value). The equation used to estimate the indirect N_2O emissions from volatilisation are summarised in the equation $N_2O_{G(mm)} = (N_{volatilisation\ –MMS} * EF_4) * 44/28$.

Table 5.16. Default values for volatilisation N losses.

Animal	Manure management system	N volatilisation losses	Source
Dairy cattle	Solid storage	30%	Table 10.22, pg. 10.65, vol. 4, 2006 IPCC guidelines
	Liquid system	40%	Table 10.22, pg. 10.65, vol. 4, 2006 IPCC guidelines
	Anaerobic digestion	40%	Assume same as liquid: based on recommendation from review during EU review 2018, according to a follow-up paper on N-cycle prepared by EU experts in Oct 2018
Non-dairy cattle	Solid storage	45%	Table 10.22, pg. 10.65, vol. 4, 2006 IPCC guidelines
	Liquid system	0%	Table 10.22, pg. 10.65, vol. 4, 2006 IPCC guidelines
	Anaerobic digestion	40%	Assume same as liquid: based on recommendation from review during EU review 2018, according to a follow-up paper on N-cycle prepared by EU experts in Oct 2018
Market swine	Anaerobic digestion	48%	Assume same as liquid: based on recommendation from review during EU review 2018, according to a follow-up paper on N-cycle prepared by EU experts in Oct 2018
	Solid storage	45%	Table 10.22, pg. 10.65, vol. 4, 2006 IPCC guidelines
	Aerobic treatment	48%	Table 10.22, pg. 10.65, vol. 4, 2006

			IPCC guidelines
Breeding swine	Anaerobic digestion	48%	Assume same as liquid: based on recommendation from review during EU review 2018, according to a follow-up paper on N-cycle prepared by EU experts in Oct 2018
	Solid storage	45%	Table 10.22, pg. 10.65, vol. 4, 2006 IPCC guidelines
	Aerobic treatment	48%	Table 10.22, pg. 10.65, vol. 4, 2006 IPCC guidelines
Sheep	Solid storage	12%	No default available for this animal - use other. IPCC guidelines, volume 4, pg. 10.65, table 10.22
Goats	Solid storage	12%	
Horses	Solid storage	12%	
Mules and Asses	Solid storage	12%	
Poultry	Solid storage	40%	Table 10.22, pg. 10.65, vol. 4, 2006 IPCC guidelines: Poultry with litter
	Anaerobic digestion	40%	Assume same as solid storage: based on recommendation from review during EU review 2018*

*anaerobic digestion decreases the N losses from the poultry manure in form of NH_3. The time of the pre-storage is not too long and the digestate is stored covered.

II. Indirect N_2O emissions from leaching and runoff of nitrogen from manure management

The Tier 2 calculation of N volatilisation 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 volatilised nitrogen (see Equation 10.26, pg. 10.54, vol. 4, 200 IPCC Guidelines). N losses are then summed over all manure management systems. The Tier 2 method is applied using default nitrogen excretion data, default fractions of N losses and country-specific manure management system data.

Indirect N_2O emissions from leaching and runoff of nitrogen from manure management have been estimated using eqns. 10.28 and 10.29 (pg. 10.56–10.57, vol. 4) of the IPCC 2006 guidelines. The annual nitrogen excretion per animal type using the nitrogen excretion rates (kg N ex/animal/year) is shown in Table 5.13. These are the defaults proposed by the IPCC methodologies. The animal population used is presented in Table 5.5.

Due to fact that CY has (a) low precipitation during very little time period in a year, and (b) uncovered solid manure storage (therefore some leaching takes place), it was decided to change the Frac(leachMS) from 10% to the lowest recommended from the typical range of 1–20% proposed by the guidelines (pg. 10.56, vol. 4); i.e. 1%.

The default emission factor for N_2O emissions from nitrogen leaching and runoff, kg N_2O-N/kg N leached and runoff (EF5) proposed by the IPCC guidelines is used, 0.0075 kg N_2O-N (kg N leaching/runoff)-1 (vol. 4, Chapter 11, Table 11.3).

5.3.3. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

5.3.4. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. Animal population is compared between four data sources: Statistical Service, DLI, EUROSTAT and Department of Agriculture.

5.3.5. Category-specific recalculations

The manure management systems have been updated for cattle, swine, sheep, horses and mules and asses. After the TERT recommendations CY_3B_2022_0005 and CY_3B_2022_0003, the Volatile Substance Excretion (VS) has been recalculated for Dairy cattle, and liquid systems are considered with crust for cattle but without crust for swine.The impact of these changes for category 3B1 are presented in table 5.17.

N_2O emissions have been also recalculated after the TERT recommendations CY_3B_2002_0001 and CY_3B_2022_004 where the typical animal mass for sheep, horses and mules and asses has changed as well as the kg N_2O-N/kg N ex coefficients per technology used for swine. The impact of the recalculations for category 3B2 is presented in table 5.18.

Table 5.17. Impact from recalculations on CH4 emissions from Manure Management (1990-2020)

CO2 eq.	1990	1991	1992	1993	1994	1995	1996	1997	1998
NIR 2023	113.91	120.20	135.14	145.71	143.73	150.87	159.06	162.55	165.25
NIR 2022	87.37	90.47	100.82	108.68	107.61	112.93	118.21	119.65	120.70
Difference (%)	23.30	24.73	25.39	25.42	25.13	25.15	25.68	26.39	26.96
	1999	2000	2001	2002	2003	2004	2005	2006	2007
NIR 2023	159.93	159.43	168.64	175.26	170.02	159.61	141.92	142.84	137.82
NIR 2022	117.22	116.05	123.22	129.30	125.36	118.92	106.45	107.06	104.04
Difference (%)	26.71	27.21	26.93	26.23	26.27	25.49	25.00	25.05	24.51
	2008	2009	2010	2011	2012	2013	2014	2015	2016
NIR 2023	134.23	128.14	124.07	112.96	100.20	89.10	82.85	80.84	79.74
NIR 2022	101.94	97.76	95.61	88.53	79.70	71.80	67.87	66.82	66.13
Difference (%)	24.06	23.71	22.94	21.63	20.46	19.42	18.08	17.35	17.07
	2017	2018	2019	2020					
NIR 2023	75.79	75.13	74.68	79.89					
NIR 2022	63.75	64.06	64.25	68.67					
Difference (%)	15.90	14.73	13.97	14.04					

Table 5.18. Impact from recalculations on N_2O emissions from Manure Management (1990-2020)

CO2 eq.	1990	1991	1992	1993	1994	1995	1996	1997	1998
NIR 2023	58.08	58.06	60.19	63.67	63.08	65.10	67.70	69.44	69.33
NIR 2022	56.94	56.77	59.98	64.00	63.71	66.01	68.98	71.48	71.72
Difference (%)	1.95	2.22	0.36	-0.51	-0.99	-1.39	-1.89	-2.93	-3.45
	1999	2000	2001	2002	2003	2004	2005	2006	2007
NIR 2023	69.10	71.40	77.83	81.67	77.47	74.73	69.85	68.68	71.28
NIR 2022	71.22	73.45	79.30	83.24	79.18	75.41	69.81	68.63	70.54
Difference (%)	-3.07	-2.88	-1.90	-1.92	-2.21	-0.91	0.05	0.06	1.04
	2008	2009	2010	2011	2012	2013	2014	2015	2016
NIR 2023	67.08	66.13	68.88	68.55	65.11	59.89	60.09	58.93	61.26
NIR 2022	66.39	64.49	66.30	64.66	60.66	55.63	55.73	54.36	56.16
Difference (%)	1.03	2.48	3.74	5.69	6.84	7.13	7.26	7.77	8.31
	2017	2018	2019	2020					
NIR 2023	63.46	64.01	65.74	68.66					
NIR 2022	57.69	58.19	59.48	62.23					
Difference (%)	9.08	9.09	9.52	9.37					

5.3.6. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

5.4. Rice cultivation (CRF source category 3C)

Not occurring.

5.5. Agricultural soils (3D)

Nitrous oxide is produced naturally in soils through the processes of nitrification and denitrification. Nitrification is the aerobic microbial oxidation of ammonium to nitrate, and denitrification is the anaerobic microbial reduction of nitrate to nitrogen gas (N_2). Nitrous oxide is a gaseous intermediate in the reaction sequence of denitrification and a by-product of nitrification that leaks from microbial cells into the soil and ultimately into the atmosphere. One of the main controlling factors in this reaction is the availability of inorganic N in the soil. This methodology, therefore, estimates N_2O emissions using human-induced net N additions to soils (e.g., synthetic or organic fertilizers, deposited manure, crop residues, sewage sludge). Direct emissions of N_2O from managed soils are estimated separately from indirect emissions, though using a common set of activity data.

Total emissions from agricultural soils in 2021 contributed 9.04% to the emissions from agriculture and 0.6% to the total emissions of the country (excluding LULUCF). Agricultural soils also contributed 29.1% to the N_2O emissions of the country excluding LULUCF. Total emissions from soils in 2021 reduced by 11.4% compared to 1990. Emissions from agricultural soils for the period 1990–2021 are presented in Table 5.19 and Figure 5.5.

Table 5.19. N_2O emissions from agricultural soils for 1990–2021

Gg CO_2 eq.	**1990**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**
3D1. Direct N_2O emissions from managed soils	**40.25**	**39.09**	**37.75**	**38.08**	**35.80**	**36.12**	**31.82**
1. Inorganic N fertilizers	15.52	13.16	10.74	11.70	8.92	10.39	8.81
2. Organic N fertilizers	17.21	21.37	20.96	21.55	21.55	20.47	18.75
a. Animal manure applied to soils	17.19	21.31	20.83	21.30	21.32	20.28	18.58
b. Sewage sludge applied to soils	0.02	0.06	0.13	0.20	0.15	0.10	0.11
c. Other organic fertilizers applied to soils	NO	NO	NO	0.04	0.08	0.09	0.06
3. Urine and dung deposited by grazing animals	NO	NO	NO	NO	NO	NO	NO
4. Crop residues	7.52	4.55	6.05	4.81	5.31	5.23	4.23
5. Mineralization/ immobilization associated with loss/gain of soil organic matter	0.00	0.00	0.00	0.02	0.02	0.03	0.04
6. Cultivation of organic soils	NO	NO	NO	NO	NO	NO	NO
7. Other	NO	NO	NO	NO	NO	NO	NO
3D2. Indirect N_2O Emissions from managed soils	**16.7**	**18.6**	**17.6**	**18.3**	**17.3**	**17.1**	**15.4**
1. Atmospheric deposition	16.7	18.6	17.6	18.3	17.3	17.1	15.4
2. Nitrogen leaching and run-off	0.00	0.00	0.00	0.00	0.01	0.01	0.01
N_2O (Gg)	**0.44**	**0.45**	**0.42**	**0.44**	**0.47**	**0.47**	**0.42**
Gg CO_2 eq.	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
3D1. Direct N_2O emissions from managed soils	**28.84**	**33.72**	**31.34**	**32.85**	**32.15**	**34.21**	**34.93**

1. Inorganic N fertilizers	8.36	9.41	10.09	9.80	9.77	9.74	9.74
2. Organic N fertilizers	18.33	18.25	18.99	19.74	19.75	20.28	21.04
a. Animal manure applied to soils	18.23	18.15	18.84	19.61	19.59	20.07	20.85
b. Sewage sludge applied to soils	0.05	0.04	0.06	0.04	0.04	0.05	0.04
c. Other organic fertilizers applied to soils	0.05	0.07	0.09	0.09	0.12	0.16	0.15
3. Urine and dung deposited by grazing animals	NO	NO	NO	NO	NO	NO	NO
4. Crop residues	2.10	6.00	2.20	3.24	2.54	4.09	4.05
5. Mineralization/ immobilization associated with loss/gain of soil organic matter	0.05	0.06	0.07	0.08	0.08	0.09	0.10
6. Cultivation of organic soils	NO	NO	NO	NO	NO	NO	NO
7. Other	NO	NO	NO	NO	NO	NO	NO
3D2. Indirect N_2O Emissions from managed soils	**15.0**	**15.3**	**16.0**	**16.4**	**16.4**	**16.8**	**17.3**
1. Atmospheric deposition	15.01	15.30	16.02	16.43	16.4	16.8	17.3
2. Nitrogen leaching and run-off	0.01	0.01	0.01	0.02	0.02	0.0	0.02
N_2O (Gg)	**0.40**	**0.37**	**0.43**	**0.45**	**0.44**	**0.46**	**0.40**
Gg CO_2 eq.	**2021**						
3D1. Direct N_2O emissions from managed soils	**33.49**						
1. Inorganic N fertilizers	8.41						
2. Organic N fertilizers	21.13						
a. Animal manure applied to soils	20.96						
b. Sewage sludge applied to soils	0.03						
c. Other organic fertilizers applied to soils	0.14						
3. Urine and dung deposited by grazing animals	NO						
4. Crop residues	3.84						
5. Mineralization/ immobilization associated with loss/gain of soil organic matter	0.11						
6. Cultivation of organic soils	NO						
7. Other	NO						
3D2. Indirect N_2O Emissions from managed soils	**16.9**						
1. Atmospheric deposition	16.9						
2. Nitrogen leaching and run-off	0.03						
N_2O (Gg)	**0.39**						

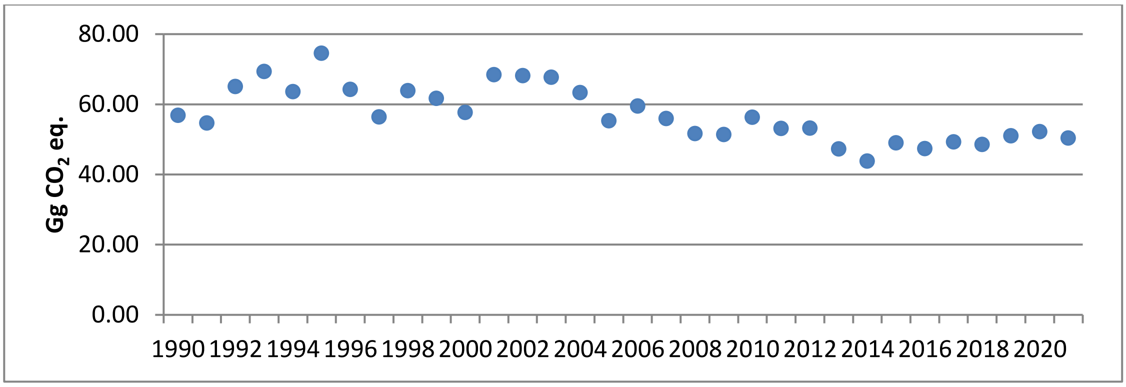

Figure 5.4. N_2O emissions from agricultural soils 1990–2021 (Gg CO_2 eq.)

5.5.1. Direct N_2O emissions from managed soils (3D1)

In most soils, an increase in available N enhances nitrification and denitrification rates which then increase the production of N_2O. Increases in available N can occur through human-induced N additions or change of land-use. The following N sources are included in the methodology for estimating direct N_2O emissions from managed soils: synthetic N fertilizers (FSN); organic N applied as fertiliser (e.g., animal manure, compost, sewage sludge, rendering waste) (FON); urine and dung N deposited on pasture, range and paddock by grazing animals (FPRP); N in crop residues (above-ground and below-ground), including from N-fixing crops and from forages during pasture renewal (FCR); and for the first time in this inventory, N mineralisation associated with loss of soil organic matter resulting from change of land use or management of mineral soils (FSOM).

Drainage/management of organic soils (FOS) is not considered for the GHG inventory of Cyprus, as there is no management of organic soils in Cyprus.

5.5.1.1. Methodological issues

In its most basic form, direct N_2O emissions from managed soils are estimated using Equation 11.1 in the 2006 IPCC Guidelines (vol. 4, pg. 11.7), as described below.

Inorganic N fertilizers (3D1.1)

N_2O emissions from the use of inorganic N fertilizers were estimated using Tier 1 methodology suggested by the 2006 IPCC Guidelines. Country specific emission factor EF1(kg N_2O-N/kg N) is assumed 0.003 after the publication " The effect of chemical and organic N inputs on N2O emission from rain-fed crops in Eastern Mediterranean" in the Elsevier Journal.[47] Activity data is obtained from the Department of Agriculture[48].

Table 5.20. N input from application of inorganic fertilizers for the period (in kt) 1990–2019

Year	1990	1991	1992	1993	1994	1995	1996	1997
Inorganic fertilizers (kg N)	12.426	12.169	14.760	16.189	14.289	20.526	13.628	11.126

Year	1998	1999	2000	2001	2002	2003	2004	2005
Inorganic fertilizers (kg N)	14.601	11.561	10.537	12.359	10.579	11.198	10.738	8.593

Year	2006	2007	2008	2009	2010	2011	2012	2013
Inorganic fertilizers	11.291	8.198	7.499	7.674	9.369	7.138	8.319	7.051

[47] Michalis Omirou, Ioannis Anastopoulos, Dionysia A. Fasoula, Ioannis M. Ioannides,The effect of chemical and organic N inputs on N2O emission from rain-fed crops in Eastern Mediterranean, Journal of Environmental Management, Volume 270, 2020, 110755,ISSN 0301-4797,https://doi.org/10.1016/j.jenvman.2020.110755.

[48] George Theophanous, Agriculture Officer, Department of Agriculture (tel. +357 22464028, gtheophanous@da.moa.gov.cy) – Fertilizer Control Board

(kg N)								

Year	2014	2015	2016	2017	2018	2019	2020	2021
Inorganic fertilizers (kg N)	6.693	7.533	8.073	7.841	7.824	7800	7800	6735

Organic N fertilizers - Animal Manure applied to soils (3D1.2a)

The Tier 1 methodology of the 2006 IPCC Guidelines is applied. The estimate of managed manure nitrogen available for application to managed soils is based on the equation 10.34 in the 2006 IPCC Guidelines (vol. 4, pg. 10.56). Animal population used is as presented in Table 5.5, annual average N excretion per animal of species/ category T in the country is based on defaults proposed by the 2006 IPCC Guidelines (Table 5.15 above), while the fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S in the country is as presented in Table 5.21. The amount of managed manure nitrogen for livestock category T that is lost in the manure management system S $Frac_{LossMS}$ (%) is shown in Table 5.22: Defaults recommended by the 2006 IPCC Guidelines (Table 10.22, pg. 10.65, vol. 4). The amount of estimated volatilisation N-losses is presented in Table 5.22. The values are recalculated for the whole timeseries due to the manure management recalculations described in the previous section. The amount of nitrogen from bedding is not known therefore assumed 0.

Managed manure nitrogen available for application to managed soils is then multiplied by the country-specific emission factor for N_2O emissions from N inputs EF1 (0.003 kg N_2O-N/kg N) after the publication " The effect of chemical and organic N inputs on N2O emission from rain-fed crops in Eastern Mediterranean" in the Elsevier Journal[47], and converted to N_2O by multiplication with 44/28.

Table 5.21. Default values for nitrogen loss due to volatilisation of NH_3 and NO_x from manure management

Animal	Manure management system	N loss due to volatilisation of NH_3 and NO_x from manure management
Dairy cattle	Solid storage	60%
	Liquid system	60%
	Anaerobic digestion	60%
Non-dairy cattle	Solid storage	50%
	Liquid system	60%
	Anaerobic digestion	60%
Market swine	Anaerobic digestion	52%
	Solid Storage	50%
	Aerobic treatment	52%
Breeding swine	Anaerobic digestion	52%
	Solid storage	50%
	Aerobic treatment	52%
Sheep	Solid storage	85%
Goats	Solid storage	85%
Horses	Solid storage	85%
Mules and Asses	Solid storage	85%
Poultry	Solid storage	50%
	Anaerobic digestion	50%

Table 5.22. Volatilisation N-losses (kg N)

	1990	1991	1992	1993	1994	1995	1996	1997
Volatilisation N-losses (kg N)	13761	13869	14125	14552	14398	14779	15366	16126

	1998	1999	2000	2001	2002	2003	2004	2005
Volatilisation N-losses (kg N)	16236	16306	17059	19002	19909	18561	18000	16677

	2006	2007	2008	2009	2010	2011	2012	2013
Volatilisation N-losses (kg N)	16768	17538	16279	16129	17053	17067	16236	14869

	2014	2015	2016	2017	2018	2019	2020	2021
Volatilisation N-losses (kg N)	14593	14528	15079	15698	15680	16067	16686	16776

Organic N fertilizers - Sewage sludge applied to soils (3D1.2b)

The Tier 1 methodology of the 2006 IPCC Guidelines is applied. The treated sewage sludge applied to land data was obtained from the national statistics and the relevant reports from the Department of Environment[49]. Data was available for all wastewater treatment plants for the years 2004 and 2005. Data for the public waste water treatment plants was available for 2004–2012. All data was available in tonnes of dry matter. The sewage sludge used in agriculture during 1990–2003 and 2006–2014 was estimated using (a) the ratio of the public treatment plants compared to all treatment plants for 2004 and 2005, and (b) the percentage of the population served by a sewer system data for 1997 to 2004. The resulting data is presented in Table 5.23. Information on the population connected to UWWS (%), on which the estimation for sludge production is based, is available only until 2015. To estimate emissions for 2016, it was assumed that the population connected is the same as 2015; therefore sludge production used in agriculture is the same.New activity data was available for 2019 and 2020.

Nitrogen content per kg dry sludge was assumed to be 3% for all years and was obtained from S. Perikenti[50]. The resulting nitrogen in sewage sludge applied on land is presented in Table 5.23. The fraction of N input converted to N_2O (EF6) is assumed to be 0.003 kg N_2O-N/kg sewage-N produced, after the publication " The effect of chemical and organic N inputs on N2O emission from rain-fed crops in Eastern Mediterranean" in the Elsevier Journal[47].

Table 5.23. Dry sludge applied to soils and nitrogen in sewage sludge (kg)

	1990	1991	1992	1993	1994	1995	1996
Dry sludge (kg)	517390	583589	704000	748000	737000	891000	1232000
Nitrogen in sewage sludge (kg)	15522	17508	21120	22440	22110	26730	36960

	1997	1998	1999	2000	2001	2002	2003
Dry sludge (kg)	1320000	1408000	1463000	1573000	1749000	2013000	2530000
Nitrogen in sewage sludge (kg)	39600	42240	43890	47190	52470	60390	75900

	2004	2005	2006	2007	2008	2009	2010
Dry sludge (kg)	3135000	3427000	3116000	5745000	6515000	7903000	5294000
Nitrogen in sewage sludge (kg)	94050	102810	93480	172350	195450	237090	158820

	2011	2012	2013	2014	2015	2016	2017
Dry sludge (kg)	3912000	2756000	2924000	1391000	936000	1730100	1130000
Nitrogen in sewage sludge (kg)	117360	82680	87720	41730	28080	51903	33900

	2018	2019	2020	2021			
Dry sludge (kg)	1092000	1213000	1014000	867000			
Nitrogen in sewage sludge (kg)	32760	36390	30420	26010			

Other organic fertilizers applied to soils (3D1.2c)

Even though there is overproduction of compost in Cyprus, all produced compost is stored as there is no

[49] Perikenti, S. 2011&2013. Questionnaire according to Commission Decision 94/741/EC for the report of the Member States on the transposition and implementation of Directive 86/278/EEC on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture, amended by Directive 91/692/EEC. Department of Environment
[50] Environment Officer responsible for sewage treatment plants, email dated 18/10/2013

demand for application on land.[51] Nevertheless, to exclude the possibility of underestimating emissions, it was assumed that all compost produced from waste management activities is consumed in-country by agriculture, for the purposes of estimation of emissions from this source. Data on composting in Cyprus was first collected in 2010 (Table 5.24). Information on other qualitative parameters of the compost applied on land and used for the calculations has been obtained from one of the largest green waste management companies of Cyprus, indicating 96% dry matter and 1.0187% N. N_2O emissions are estimated by multiplying the calculated Ncomp by EF1 (0.003 after the publication " The effect of chemical and organic N inputs on N2O emission from rain-fed crops in Eastern Mediterranean" in the Elsevier Journal[47]) and then by 44/28.

Table 5.24. Activity data used for the calculation of N_2O emissions from Other organic fertilizers applied to soils (3D1.2c)

	2010	**2011**	**2012**	**2013**	**2014**	**2015**
TOTAL composting (1000t wet mass)	7.89	14.95	16.20	11.67	8.72	12.05
wet compost (kg)	7890000	14950000	16200000	11670000	8720000	12050000
Dry compost (kg)	3156000	5980000	6480000	4668000	3488000	4820000
N COMP (kg N)	34306	65003	70438	50741	37915	52393
	2016	**2017**	**2018**	**2019**	**2020**	**2021**
TOTAL composting (1000t wet mass)	16.77	16.62	22.24	30.30	28.40	25.61
wet compost (kg)	16770000	16620000	36520000	30300000	28404000	25610000
Dry compost (kg)	670800	6648000	14608000	12120000	11361600	10244000
N COMP (kg N)	72916	72264	158789	131744	123501	111352

Urine and dung deposited by grazing animals (3D1.3)

Not occurring: A very small percentage of the sheep and goats are grazing; however no information is available to make an estimation of or an assumption for the grazing population[52].

Crop residues (3D1.4)

The term FCR refers to the amount of N in crop residues (above-ground and below-ground) that is returned to soils annually, including N-fixing crops. The FCR is estimated from crop yield statistics, default factors for above-/below-ground residue to yield ratios, and residue N contents. In addition, the method accounts for the effect of residue burning or other removal of residues. Because different crop types vary in residue to yield ratios, renewal time and N contents, separate calculations are performed for major crop types, and then N values from all crop types are summed up. Equation 11.6 in the 2006 IPCC Guidelines (pg. 11.14, vol. 4) provides the equation to estimate N from crop residues and forage/pasture renewal, for a Tier 1 approach.

Crop production (t/yr) and cultivated area (ha) data per crop is obtained from Statistical Service (Table 5.26). Crop yield is estimated by dividing the crop production by the area; the results are tabulated in Table 5.26. Harvested annual dry matter yield per crop (Crop(T)) is estimated by multiplying the 2006 IPCC Guidelines default dry matter fraction (DRY) (Table 5.22 obtained from table 11.2, pg.11.17, vol.4) with the estimated Crop yield (YieldFresh) (eqn 11.7, pg.11.15, vol.4, 2006 IPCC Guidelines). Using the defaults values shown in Table 5.26 for Slope, Intercept, NAGT, RBGT and NBGT (table 11.2, pg.11.17, vol.4) above ground residue dry matter AGDM_T (kg/ha) and ratio of above-ground residues dm to harvested crop RAGT (kg/dm) are estimated. The results are shown in Table 5.26.

FracBURN (kg N/kg crop-N), shown in Table 5.27, is considered as the default for developing countries (0.25) in 1990, then is linearly declined to the default for developed countries (0.1) in 2008. After that

[51] Personal communication with Constantinos Ioannides (10/11/2017), Waste management permitting officer, Pollution Prevention Unit, Department of Environment (tel. +357 22408958, cioannides@environment.moa.gov.cy).
[52] Personal communication with Dr. Petros Mavromatis (22/11/2017), head of sheep and goat farming division, Department of Agriculture (tel. +357 22408555, pmavrommatis@da.moa.gov.cy)

year, this factor has been kept constant. This assumption was based on general knowledge of the sector, and on the fact that a normative banning crop residues burning came into place in 2003. The relevant legislation is the Fire Prevention of Outdoors Law of 1988 (220/1988) as amended by 109(I)2002. 0.1 is used because according to the expert judgement of firefighters and there observations in the field, there is illegal burning of agricultural residues taking place, based. There are no statistics on this type of fires. No details are available to support any deviation from the 10% default.

The resulting estimations of area burnt are presented in Table 5.25. For the calculation of FCR, FracRenewT and FracRemoveT are assumed 1 and 0 respectively, as according to the defaults proposed by 2006 Guidelines (pg.11.14, vol.4).

Due to the unavailability of proposed defaults for Cf for Crops other than wheat in the 2006 IPCC Guidelines, a desk study was performed for the values used by countries with similar climatic conditions with Cyprus; i.e. Greece, Spain, Malta and Italy. Malta and Spain report Cf as NO. Values for Cf used are presented in Table 5.28. The values used by Greece were used for Barley and Oats, while for Beans & pulses (legumes) and Potatoes (tubers) 0.40 was used, based on the expert judgement of Dr. Michalis Omirou[53]. In previous submissions, Cf was considered the same as wheat for all crops. This has resulted in recalculation of FCR for the whole time series for all crops except wheat.

N_2O emissions are estimated by multiplying the calculated FCR by EF1 (0.01 default, table 11.1, pg. 11.11, vol.4, 2006 IPCC guidelines) and then by 44/28.

After the TERT review 2022, the values in red have been recalculated.

Table 5.25. Crop production (t/yr), cultivated area (ha), Crop yield (kg/ha), CropT (kg dm/ha), above ground residue dry matter $AGDM_T$ (kg/ha), ratio of above-ground residues dm to harvested crop RAGT (kg/dm), Area Burnt (ha/yr) and FCR (kg N/yr) per crop

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Crop production (t/yr)							
Wheat	10400	5600	10500	11700	8000	12297	13000
Barley	98000	59500	171000	193000	154000	133818	128000
Oats	100	80	145	100	150	174	190
Beans & pulses (legumes)	3505	3000	3629	3607	3157	3992	3700
Potatoes (tubers)	185900	179650	195400	199000	135000	207699	228000
Cultivated area (ha)							
Wheat	5100	4900	5000	5000	3300	3500	3700
Barley	52330	43790	60000	64000	60000	57500	55000
Oats	100	100	110	140	200	220	240
Beans & pulses (legumes)	1350	1173	1145	1103	810	1039	857
Potatoes (tubers)	8000	8690	9625	8080	7500	8313	9125
Crop yield (YieldFresh), kg/ha							
Wheat	2039	1143	2100	2340	2424	3514	3514
Barley	1873	1359	2850	3016	2567	2327	2327
Oats	1000	800	1318	714	750	792	792
Beans & pulses (legumes)	2596	2558	3169	3270	3898	3842	4317
Potatoes (tubers)	23238	20673	20301	24629	18000	24986	24986
CropT (kg dm/ha)							
Wheat	1815	1017	1869	2083	2158	3127	3127
Barley	1667	1209	2537	2684	2284	2071	2071
Oats	890	712	1173	636	668	705	705
Beans & pulses (legumes)	2363	2327	2884	2976	3547	3496	3929
Potatoes (tubers)	5112	4548	4466	5418	3960	5497	5497
above ground residue dry matter AGDM_T (kg/ha)							

[53] Personal Communication 16/11/2017 Dr. Michalis Omirou, Agricultural Research Officer, Agricultural Research Institute (Tel. +357-22403146, michalis.omirou@ari.gov.cy)

Wheat	3261	2056	3342	3665	3778	5242	5242
Barley	2223	1775	3076	3220	2829	2620	2620
Oats	1700	1538	1958	1469	1497	1531	1531
Beans & pulses (legumes)	3520	3480	4109	4213	4858	4801	5290
Potatoes (tubers)	1571	1515	1507	1602	1456	1610	1610
Area Burnt (ha/yr)							
Wheat	1275	1184	1167	1125	715	729	740
Barley	13083	10583	14000	14400	13000	11979	11000
Oats	25	24	26	32	43	46	48
Beans & pulses (legumes)	338	283	267	248	176	216	171
Potatoes (tubers)	2000	2100	2246	1818	1625	1732	1825
FCR (kg N/yr)							
Wheat	133233	79822	135491	149750	102525	152707	162306
Barley	1260233	829608	2060702	2317592	1903818	1689766	1623779
Oats	1443	1295	1883	1740	2558	2905	3188
Beans & pulses (legumes)	46283	39853	46298	45880	39098	49683	45372
Potatoes (tubers)	364653	373456	410779	382605	303234	398454	438331
TOTAL	1805846	1324033	2655153	2897566	2351234	2293515	2272975

	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Crop production (t/yr)							
Wheat	13000	11500	11500	14000	10000	10500	12900
Barley	128000	36000	54000	112700	37600	116500	128400
Oats	190	280	320	400	350	380	500
Beans & pulses (legumes)	3700	3558	3684	3764	3308	3383	3358
Potatoes (tubers)	228000	81500	138092	161500	117000	121000	148500
Cultivated area (ha)							
Wheat	3700	5250	5800	6600	6150	5400	5900
Barley	55000	37500	53000	52000	45000	50200	51300
Oats	240	270	290	340	330	370	400
Beans & pulses (legumes)	857	890	893	913	832	832	847
Potatoes (tubers)	9125	7000	7500	6800	6500	5715	5700
Crop yield (YieldFresh), kg/ha							
Wheat	3514	2190	1983	2121	1626	1944	2186
Barley	2327	960	1019	2167	836	2321	2503
Oats	792	1037	1103	1176	1061	1027	1250
Beans & pulses (legumes)	4317	3998	4125	4123	3976	4066	3965
Potatoes (tubers)	24986	11643	18412	23750	18000	21172	26053
CropT (kg dm/ha)							
Wheat	3127	1950	1765	1888	1447	1731	1946
Barley	2071	854	907	1929	744	2065	2228
Oats	705	923	982	1047	944	914	1113
Beans & pulses (legumes)	3929	3638	3754	3752	3618	3700	3608
Potatoes (tubers)	5497	2561	4051	5225	3960	4658	5732
above ground residue dry matter AGDM_T (kg/ha)							
Wheat	3464	3185	3371	2705	3133	3458	3464
Barley	1427	1479	2480	1319	2614	2773	1427
Oats	1730	1784	1843	1749	1722	1902	1730
Beans & pulses (legumes)	4961	5092	5089	4938	5031	4927	4961
Potatoes (tubers)	1316	1465	1583	1456	1526	1633	1316
Area Burnt (ha/yr)							
Wheat	740	1006	1063	1155	1025	855	885
Barley	11000	7188	9717	9100	7500	7948	7695
Oats	48	52	53	60	55	59	60
Beans & pulses (legumes)	171	171	164	160	139	132	127

Potatoes (tubers)	1825	1342	1375	1190	1083	905	855
FCR (kg N/yr)							
Wheat	151675	154544	187423	140009	143778	174771	151675
Barley	574295	848472	1468404	639644	1512694	1652986	574295
Oats	4144	4634	5668	5218	5782	7027	4144
Beans & pulses (legumes)	44246	45718	46840	41500	42409	42369	44246
Potatoes (tubers)	237627	309294	319762	266399	254137	283800	237627
TOTAL	1011987	1362662	2028096	1092771	1958800	2160952	1011987
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Crop production (t/yr)							
Wheat	14280	9930	9249	7520	10712	24720	14690
Barley	150000	100990	60286	58372	52007	34960	40092
Oats	410	490	650	943	814	373	2040
Beans & pulses (legumes)	2410	3280	3291	3348	3318	3312	3312
Potatoes (tubers)	127500	131650	152500	127500	155500	115000	112500
Cultivated area (ha)							
Wheat	7225	7450	5264	5389	5287	4990	5761
Barley	65007	58448	52517	48914	34019	30680	22444
Oats	513	808	4368	4919	4250	3034	2950
Beans & pulses (legumes)	834	808	796	855	737	554	596
Potatoes (tubers)	5511	5380	6190	4290	6290	5110	4970
Crop yield (YieldFresh), kg/ha							
Wheat	1976	1333	1757	1395	2026	4954	2550
Barley	2307	1728	1148	1193	1193	1140	1786
Oats	799	606	149	192	192	123	692
Beans & pulses (legumes)	2890	4059	4134	3916	3916	5978	5557
Potatoes (tubers)	23136	24470	24637	29720	29720	22505	22636
CropT (kg dm/ha)							
Wheat	1759	1186	1564	1242	1803	4409	2269
Barley	2054	1538	1022	1062	1361	1014	1590
Oats	711	540	132	171	170	109	615
Beans & pulses (legumes)	2630	3694	3762	3563	4097	5440	5057
Potatoes (tubers)	5090	5383	5420	6538	5439	4951	4980
above ground residue dry matter AGDM_T (kg/ha)							
Wheat	3176	2311	2881	2395	3243	7178	3947
Barley	2603	2097	1591	1631	1923	1584	2148
Oats	1537	1381	1011	1045	1045	990	1450
Beans & pulses (legumes)	3821	5024	5101	4877	5479	6998	6564
Potatoes (tubers)	1569	1598	1602	1714	1604	1555	1558
Area Burnt (ha/yr)							
Wheat	1024	993	658	629	573	499	576
Barley	9209	7793	6565	5707	3685	3068	2244
Oats	73	108	546	574	460	303	295
Beans & pulses (legumes)	118	108	100	100	80	55	60
Potatoes (tubers)	781	717	774	501	681	511	497
FCR (kg N/yr)							
Wheat	197152	147198	131305	111657	150467	320440	201501
Barley	1967237	1410504	942529	906124	757952	555379	565824
Oats	7131	9989	37445	44216	38427	25815	39465
Beans & pulses (legumes)	32230	41452	41586	42768	41635	40246	40575
Potatoes (tubers)	257728	259843	300697	232303	307409	238036	232217
TOTAL	2461477	1868987	1453562	1337068	1295890	1179916	1079582
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**

Crop production (t/yr)							
Wheat	18890	23740	22923	15180	4440	35360	6902
Barley	46060	45720	48100	36010	2720	52180	2907
Oats	780	740	800	740	200	600	352
Beans & pulses (legumes)	4319	3690	4374	4263	4205	4899	4000
Potatoes (tubers)	82000	126080	82200	105480	117500	95920	122803
Cultivated area (ha)							
Wheat	7560	10590	8550	6920	6140	11970	8386
Barley	25970	24954	28853	23530	18940	20560	14536
Oats	510	369	419	310	230	320	367
Beans & pulses (legumes)	507	548	694	583	639	715	498
Potatoes (tubers)	4260	5070	4550	4640	4910	4740	5041
Crop yield (YieldFresh), kg/ha							
Wheat	2499	2242	2681	2194	723	2954	823
Barley	1774	1832	1667	1530	144	2538	200
Oats	1529	2005	1909	2387	870	1875	959
Beans & pulses (legumes)	8519	6734	6303	7312	6581	6852	8032
Potatoes (tubers)	19249	24868	18066	22733	23931	20236	24361
CropT (kg dm/ha)							
Wheat	2224	1995	2386	1952	644	2629	733
Barley	1578	1631	1484	1362	128	2259	178
Oats	1361	1785	1699	2125	774	1669	854
Beans & pulses (legumes)	7752	6128	5735	6654	5988	6235	7309
Potatoes (tubers)	4235	5471	3975	5001	5265	4452	5359
above ground residue dry matter AGDM_T (kg/ha)							
Wheat	3878	3533	4123	3468	1492	4490	1626
Barley	2137	2188	2044	1925	715	2804	764
Oats	2129	2514	2436	2823	1594	2409	1667
Beans & pulses (legumes)	9610	7774	7331	8369	7617	7896	9109
Potatoes (tubers)	1483	1607	1457	1560	1586	1505	1596
Area Burnt (ha/yr)							
Wheat	756	1059	855	692	614	1197	839
Barley	2597	2495	2885	2353	1894	2056	1454
Oats	51	37	42	31	23	32	37
Beans & pulses (legumes)	51	55	69	58	64	72	50
Potatoes (tubers)	426	507	455	464	491	474	504
FCR (kg N/yr)							
Wheat	259713	330709	312689	212053	78332	477511	117177
Barley	651084	641678	689589	527024	135570	688154	113052
Oats	10483	9089	9975	8649	3428	7524	5751
Beans & pulses (legumes)	50798	44298	52857	50785	50594	58714	47269
Potatoes (tubers)	183476	249098	190160	217283	236273	209200	244916
TOTAL	1155554	1274873	1255270	1015794	504197	1441103	528165

	2017	**2018**	**2019**	**2020**	**2021**		
Crop production (t/yr)							
Wheat	16592	15330	29470	32270	24800		
Barley	18754	7920	30400	22503	25000		
Oats	248	400	220	280	300		
Beans & pulses (legumes)	4145	710	200	280	2923		
Potatoes (tubers)	111410	106500	82100	80300	88531		
Cultivated area (ha)							
Wheat	8678	10200	10590	12500	12000		
Barley	10953	12800	11580	18500	13500		
Oats	490	220	220	220	250		

Beans & pulses (legumes)	493	390	170	150	426		
Potatoes (tubers)	4440	4220	3880	3800	3900		
Crop yield (YieldFresh), kg/ha							
Wheat	1912	1503	2783	2582	2067		
Barley	1712	619	2625	1216	1852		
Oats	506	1818	1000	1273	1200		
Beans & pulses (legumes)	8408	1821	1176	1867	6862		
Potatoes (tubers)	25092	25237	21159	21132	22700		
CropT (kg dm/ha)							
Wheat	1702	1338	2477	2298	1839		
Barley	1524	551	2336	1083	1648		
Oats	450	1618	890	1133	1068		
Beans & pulses (legumes)	7651	1657	1071	1698	6244		
Potatoes (tubers)	5520	5552	4655	4649	4994		
above ground residue dry matter AGDM_T (kg/ha)							
Wheat	3089	2540	4260	3989	3297		
Barley	2083	1130	2880	1651	2205		
Oats	1300	2363	1700	1921	1862		
Beans & pulses (legumes)	9496	2722	2060	17851	7906		
Potatoes (tubers)	1612	1615	1526	1525	1559		
Area Burnt (ha/yr)							
Wheat	868	1020	1059	1250	1200		
Barley	1095	1280	1158	1850	1350		
Oats	49	22	22	22	25		
Beans & pulses (legumes)	49	39	17	15	43		
Potatoes (tubers)	444	422	388	380	390		
FCR (kg N/yr)							
Wheat	236193	226874	400403	442027	349189		
Barley	267213	158457	398696	350522	350065		
Oats	5777	5066	3524	4038	4433		
Beans & pulses (legumes)	48802	10749	3498	4209	35027		
Potatoes (tubers)	219221	209017	175109	171383	182494		
TOTAL	777205	610162	981231	972180	921208		

Table 5.26. Default dry matter fraction (DRY), Slope, Intercept, NAGT, RBGT, NBGT per crop

Crop	DRY	Slope	Intercept	NAGT	RBGT	NBGT
Wheat	0.89	1.51	0.52	0.006	0.24	0.009
Barley	0.89	0.98	0.59	0.007	0.22	0.014
Oats	0.89	0.91	0.89	0.007	0.25	0.008
Beans & pulses (legumes)	0.91	1.13	0.85	0.008	0.19	0.008
Potatoes (tubers)	0.22	0.10	1.06	0.019	0.20	0.014

Table 5.27. Crop residue that is burned (FracBURN)

Year	1990	1991	1992	1993	1994	1995	1996	1997
FracBURN	0.25	0.24	0.23	0.23	0.22	0.21	0.20	0.19

Year	1998	1999	2000	2001	2002	2003	2004	2005
FracBURN	0.18	0.18	0.17	0.16	0.15	0.14	0.13	0.13

Year	2006	2007	2008					
FracBURN	0.12	0.11	0.10					

Table 5.28. Cf

Crop	Cf	Source
Wheat	0.90	default - table 2.6, pg.2.49, vol.4, IPCC 2006
Barley	0.89	Greece - NIR2017
Oats	0.89	Greece - NIR2017
Beans & pulses (legumes)	0.40	expert judgement - Michalis Omirou tel. 16/11/2017
Potatoes (tubers)	0.40	expert judgement - Michalis Omirou tel. 16/11/2017

Mineralization/immobilization associated with loss/gain of soil organic matter (3D1.5)

Cyprus reports for the first time in the current submission N2O emissions (direct and indirect) associated with N mineralised in mineral soils resulting from carbon losses in mineral soils in cropland remaining cropland due to management changes. The carbon losses in mineral soils in cropland remaining cropland are reported in the LULUCF sector, however the associated N2O emissions are to be reported in CRF table 3.D. The tier 1 method of the 2006 IPCC guidelines with default parameters were used to estimate direct and indirect N2O emissions. More specifically, for the direct N2O emissions, the C/N ratio equal to 10 and the emission factor of 0.01 kg N2O–N/kg N were used, whereas for the indirect N2O emissions, the emission factor of 0.0075 kg N2O–N/kg N and the fraction of 0.30 for the N mineralised that is lost through leaching/runoff were used.

Cultivation of organic soils (3D1.6)

Not occurring

Other (3D1.7)

Not occurring

5.5.1.2. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

5.5.1.3. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

5.5.1.4. Category-specific recalculations

There have been recalculations in May 2023 after the last TERT review, TERT recommendation CY-3D1-2022-0003,the updated activity data in 3D1.2b sewage sludge,the reporting of emissions in 3D1.5, as well aw use of new country-specific EF for the agricultural soils. The impact is presented in table 5.29 below:

Table 5.29. Impact of recalculations on Direct N2O emissions from managed soils (1990-2020)

CO2 eq.	1990	1991	1992	1993	1994	1995	1996	1997	1998
NIR 2022	135.21	132.86	152.00	162.99	151.38	185.76	153.44	141.28	160.88
NIR April 2023	130.65	149.36	159.05	147.31	177.56	148.87	135.96	153.90	143.11
NIR May 2023	56.90	54.70	65.10	69.38	63.62	74.57	64.24	56.41	63.89
Difference (%)	-56.45	-63.38	-59.07	-52.90	-64.17	-49.91	-52.75	-63.35	-55.36
	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
NIR 2022	148.17	143.69	165.00	161.74	159.28	151.48	132.02	146.04	134.17
NIR April 2023	138.30	159.99	157.25	154.68	147.39	129.27	141.55	131.46	121.60
NIR May 2023	61.75	68.42	68.20	67.71	63.35	55.31	59.49	55.94	57.72

Difference (%)	-55.35	-57.23	-56.63	-56.23	-57.02	-57.21	-57.97	-57.45	-52.53
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
NIR 2022	124.34	123.21	136.09	124.00	125.48	111.74	107.07	114.03	116.91
NIR April 2023	121.45	133.93	124.23	125.26	111.56	106.13	113.56	115.22	118.20
NIR May 2023	51.72	51.37	56.35	53.14	53.24	47.27	43.85	49.03	47.38
Difference (%)	-57.41	-61.64	-54.64	-57.58	-52.28	-55.46	-61.39	-57.45	-59.92
	2017	**2018**	**2019**	**2020**					
NIR 2022	119.40	119.11	122.16	125.54					
NIR April 2023	117.47	121.04	124.13	119.32					
NIR May 2023	49.30	48.59	51.00	52.23					
Difference (%)	-58.03	-59.86	-58.91	-56.23					

5.5.1.5. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

5.5.2. Indirect N_2O emissions from managed soils (3D2)

In addition to the direct emissions of N_2O from managed soils that occur through a direct pathway, emissions of N_2O also take place through two indirect pathways. The first of these pathways is the volatilisation of N as NH3 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. The second pathway is the leaching and runoff from land of N from synthetic and organic fertiliser additions, crop residues, mineralisation 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.

The methodology described in this section addresses the following N sources of indirect N_2O emissions from managed soils arising from agricultural inputs of N: synthetic N fertilizers (FSN); organic N applied as fertiliser (e.g., applied animal manure, compost, sewage sludge, rendering waste and other organic amendments) (FON); urine and dung N deposited on pasture, range and paddock by grazing animals (FPRP); N in crop residues (above- and below-ground), including N-fixing crops and forage/pasture renewal returned to soils (FCR). N mineralisation associated with loss of soil organic matter resulting from change of land use or management on mineral soils (FSOM) because it does not occur in Cyprus.

5.5.2.1. Methodological issues

For both Atmospheric deposition (3D2.1) and Leaching/Runoff (3D2.2) the Tier 1 methodology according to 2006 IPCC Guidelines is applied.

<u>Atmospheric deposition (3D2.1)</u>

The N_2O emissions from atmospheric deposition of N volatilised from managed soil are estimated with Equation 11.9 in the 2006 IPCC Guidelines (pg. 11.21, vol.4), using the following data and parameters:

- FSN, annual amount of synthetic fertiliser N applied to soils (kg N/yr): same as presented in Table 5.19;
- FracGASF, fraction of synthetic fertiliser N that volatilises as NH_3 and NO_x, kg N volatilised/kg of N applied: default of 0.1 as proposed by the 2006 IPCC Guidelines (table 11.3, pg.11.24, vol.4);
- FON, annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N/yr: the total nitrogen input to the soil from the categories animal manure applied to soils and sewage sludge, as estimated for category Organic N fertilizers (3D1.2) – total FON presented in Table 5.28.
- FPRP, annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock (kg N/yr): considered 0 for Cyprus. A very small percentage of the sheep and goats are

grazing, however no information is available to make an estimation or an assumption on the population grazing[54]

- FracGASM, fraction of applied organic N fertiliser materials (FON) and of urine and dung N deposited by grazing animals (FPRP) that volatilises as NH_3 and NO_x, kg N volatilised/kg of N applied or deposited: default of 0.2 as proposed by the 2006 IPCC Guidelines (table 11.3, pg.11.24, vol.4);
- EF4, emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, kg N–N_2O/kg NH_3–N + NO_x–N volatilized: default of 0.01 as proposed by the 2006 IPCC Guidelines (table 11.3, pg.11.24, vol.4, IPCC 2006)

The resulting N_2O(ATD) –N is presented in Table 5.30. N_2O(ATD) –N is converted to N_2O by multiplication with 44/28. Due to the change in Animal manure applied to soils (kgN), recalculations have been performed for the whole time series.

Table 5.30. FON and N_2O(ATD) –N (kg N/yr)

Year	1990	1991	1992	1993	1994	1995
FON	11870609	11946626	12272028	12764740	12741843	13159099
N_2O(ATD) –N	36167	36062	39304	41718	39773	46844

Year	1996	1997	1998	1999	2000	2001
FON	13742386	14549925	14694129	14810866	15481080	17094099
N_2O(ATD) –N	41113	40226	43989	41183	41499	46547

Year	2002	2003	2004	2005	2006	2007
FON	18025139	16886080	16248537	15000636	15061074	15777855
N_2O(ATD) –N	46629	44970	43235	38594	41413	39754

Year	2008	2009	2010	2011	2012	2013
FON	14707075	14381249	15073001	14898038	14098982	12938395
N_2O(ATD) –N	36913	36436	39515	36934	36517	32928

Year	2014	2015	2016	2017	2018	2019
FON	12738243	12649150	13197552	13683323	13758008	14091006
N_2O(ATD) –N	32169	32831	34468	35208	35340	35982
Year	**2020**	**2021**				
FON	14704833					
N_2O(ATD) –N	37217					

Leaching/Runoff (3D2.2)

The N_2O emissions from leaching and runoff in regions where leaching and runoff occurs are estimated using Equation 11.10 in the 2006 IPCC Guidelines (pg. 11.21, vol.4) using the following data and parameters:

- FSN, annual amount of synthetic fertiliser N applied to soils (kg N/yr): same as presented in Table 5.19;
- FON, annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N/yr: the total nitrogen input to the soil from the categories animal manure applied to soils and sewage sludge, as estimated for category Organic N fertilizers (3D1.2) – total FON presented in Table 5.27.
- FPRP, annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock (kg N/yr): considered 0 for Cyprus. A very small percentage of the sheep and goats are grazing, however no information is available to make an estimation or an assumption on the

[54] Personal communication with Dr. Petros Mavromatis (22/11/2017), head of sheep and goat farming division, Department of Agriculture (tel. +357 22408555, pmavrommatis@da.moa.gov.cy).

population grazing[55]

- FCR, 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: as estimated for Crop residues (3D1.4) and presented in Table 5.24
- FSOM, annual amount of N mineralised 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: 0.3 for Cyprus
- FracLEACH, fraction of all N added to/mineralised in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff, kg N/kg of N additions: default of 0 as proposed by the 2006 IPCC Guidelines (table 11.3, pg.11.24, vol.4), since in Cyprus precipitation is lower than evapotranspiration throughout most of the year (G. Theophanous[56]). Excessive irrigation beyond the crop irrigation needs has to be practiced in order for leaching to occur. Irrigation in Cyprus is practiced through advance irrigation systems, like drip and sprinkler irrigation. Therefore, plants are irrigated based on their needs and leaching may rarely occur. In that case, it would concern the surface soil layer (less than a meter deep), not reaching the aquifer in any case. In addition, surface irrigation, which may facilitate leaching, is not practiced anymore in Cyprus.
- EF5, emission factor for N_2O emissions from N leaching and runoff, kg N_2O–N / kg N leached and runoff: default of 0.0075 as proposed by the 2006 IPCC Guidelines (table 11.3, pg.11.24, vol.4, IPCC 2006)

N_2O_L–N is converted to N_2O by multiplication with 44/28. Due to the fact the FracLEACH is zero, the resulting emissions are zero for the whole reporting period.

5.5.2.2. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

5.5.2.3. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

5.5.2.4. Category-specific recalculations

3.D.2: The recalculation for this category is a result of the previous recalculations, i.e. manure management recalculations, as well as the emissions reported in 3.D.2.2 for the first time.. The impact is presented in the table below.

Table 5.31. Recalculation of emissions for 3.D.2.1 for 1990–2019.

Gg CO_2 eq	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
NIR 2022	15.06	15.02	16.37	17.37	16.56	19.51	17.12	16.75	18.32	17.15	17.28
NIR 2023	16.65	16.63	17.93	18.88	17.96	20.88	18.50	18.10	19.64	18.43	18.64
Difference (%)	9.54	9.71	8.71	7.98	7.79	6.57	7.47	7.44	6.71	6.95	7.27
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
NIR 2022	19.38	19.42	18.73	18.00	16.07	17.25	16.55	15.37	15.17	16.46	15.38
NIR 2023	21.02	21.04	20.19	19.54	17.55	18.75	18.17	16.85	16.83	18.27	17.34
Difference (%)	7.76	7.70	7.23	7.87	8.44	8.00	8.87	8.75	9.84	9.92	11.32
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**				
NIR 2022	13.71	13.40	13.67	14.35	14.66	14.72	14.98				
NIR 2023	15.44	15.02	15.32	16.04	16.44	16.44	16.79				
Difference (%)	11.22	10.80	10.74	10.52	10.84	10.51	10.76				

[55] Personal communication with Dr. Petros Mavromatis (22/11/2017), head of sheep and goat farming division, Department of Agriculture (tel. +357 22408555, pmavrommatis@da.moa.gov.cy).
[56] Information to support this statement has been provided by Mr. George Theophanous, Agriculture Officer, Department of Agriculture (tel. +357 22464028, gtheophanous@da.moa.gov.cy).
Article: Panagiotis Dalias et al., 2018, Adjustment of Irrigation Schedules as a Strategy to Mitigate Climate Change Impacts on Agriculture in Cyprus, Agriculture 2019, 9, 4.

5.5.2.5. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

5.5.3. Prescribed burning of savannas (3E)

Not occurring in Cyprus.

5.5.4. Field burning of agricultural residues (3F)

Large quantities of agricultural wastes are produced from farming systems world-wide, in the form of crop residue. Burning of crop residues is not thought to be a net source of carbon dioxide (CO_2) because the carbon released to the atmosphere during burning is reabsorbed during the next growing season. However, crop residue burning is a net source of CH_4, CO, NO_x, and N_2O. This section accounts for emissions of these non-CO_2 gases from field burning of agricultural crop residues. Burning of agricultural wastes in the fields is a common practice in the developing world; it is used primarily to clear remaining straw and stubble after harvest and to prepare the field for the next cropping cycle. In Cyprus, field burning of agricultural residues was a widespread practice until 2003, when a normative banning crop residues burning came into place (Fire Prevention of Outdoors Law of 1988 [220/1988] as amended by 109(I)/2002). Total emissions from field burning of agricultural residues for the period 1990–2021 are presented in Table 5.32 and Figure 5.5.

Table 5.32. Field burning of agricultural residues emissions, 1990–2021

Gg CO_2 eq.	**1990**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**
3F	**2.96**	**1.16**	**1.15**	**0.76**	**0.83**	**0.85**	**0.64**
3.F.1 Cereals	2.15	0.70	0.72	0.59	0.66	0.66	0.47
3.F.2 Pulses	0.03	0.02	0.02	0.02	0.01	0.02	0.02
3.F.3 Tubers and Roots	0.12	0.06	0.05	0.02	0.03	0.02	0.03
CH_4 (t)	84.78	33.18	32.92	21.93	23.77	24.25	18.23
N_2O (t)	2.20	0.86	0.85	0.57	0.62	0.63	0.47
Total (Gg CO_2 eq.)	**2.96**	**1.16**	**1.15**	**0.76**	**0.83**	**0.85**	**0.64**
Gg CO_2 eq.	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
3F	**0.24**	**0.99**	**0.26**	**0.47**	**0.37**	**0.69**	**0.71**
3.F.1 Cereals	0.10	0.84	0.14	0.37	0.28	0.61	0.59
3.F.2 Pulses	0.02	0.02	0.02	0.02	0.00	0.00	0.01
3.F.3 Tubers and Roots	0.03	0.02	0.03	0.03	0.03	0.02	0.01
CH_4 (t)	6.94	28.48	7.49	13.43	10.75	19.74	20.23
N_2O (t)	0.18	0.74	0.19	0.35	0.28	0.51	0.52
Total (Gg CO_2 eq.)	**0.24**	**0.99**	**0.26**	**0.47**	**0.37**	**0.69**	**0.71**
Gg CO_2 eq.	**2021**						
3F	**0.62**						
3.F.1 Cereals	0.59						
3.F.2 Pulses	0.02						
3.F.3 Tubers and Roots	0.02						
CH_4 (t)	17.9						
N_2O (t)	0.46						
Total (Gg CO_2 eq.)	**0.62**						

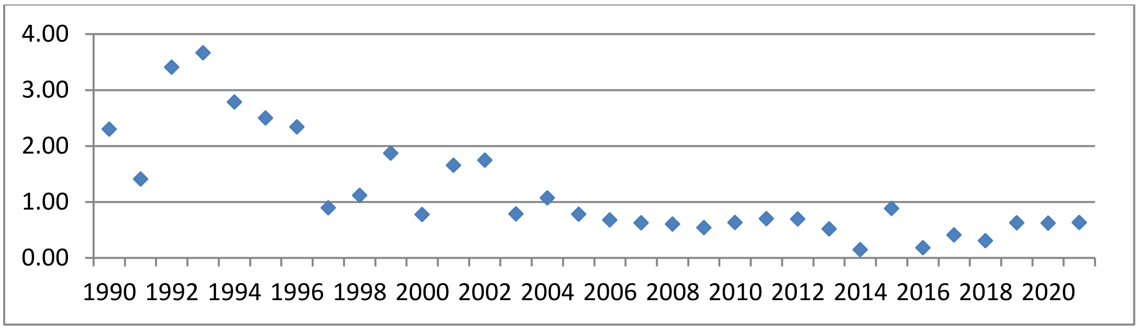

Figure 5.5. Field burning of agricultural residues emissions, 1990–2021 (Gg CO_2 eq.)

5.5.4.1. Methodological issues

A generic methodology to estimate the emissions of individual greenhouse gases for any type of fire is summarised in Equation 2.27 (pg. 2.42, vol. 4, 2006 IPCC Guidelines) using the following:

- A, area burnt, ha: data already presented in Table 5.2
- M_B, mass of fuel available for combustion, tonnes/ha: data already presented in Table 5.25 (above ground residue dry matter AGDM_T)
- C_f, combustion factor, dimensionless: data already presented in Table 5.29
- G_{ef}, emission factor, g/ kg dry matter burnt: 2.7 g CH_4/kg DM burnt, 0.07 g N_2O/kg DM burnt (according to default values in Table 2.5, pg. 2.47, vol. 4, 2006 IPCC Guidelines). According to the 2006 IPCC guidelines for combustion of non-woody biomass in Grassland and Cropland, CO_2 emissions do not need to be estimated and reported, because it is assumed that annual CO_2 removals (through growth) and emissions (whether by decay or fire) by biomass are in balance.

5.5.4.2. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

5.5.4.3. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

5.5.4.4. Category-specific recalculations

Recalculations were done as a result of recalculations in 3.D.1.4. The impact is presented in the table below

Table 5.33. Impact of recalculations for 3.F (1990-2020)

Gg CO_2 eq	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
NIR 2022	2.03	1.19	3.07	3.33	2.53	2.25	2.10	0.75	0.95	1.66	0.65
NIR 2023	2.30	1.41	3.41	3.67	2.79	2.50	2.34	0.90	1.12	1.87	0.78
NIR 2023 May	2.96	1.94	4.11	4.39	3.44	3.10	2.89	1.26	1.61	2.33	1.16
Difference (%)	22.20	27.34	17.06	16.36	18.82	19.45	19.15	28.62	30.26	19.81	32.58
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
NIR 2022	1.48	1.57	0.72	0.91	0.68	0.60	0.54	0.53	0.47	0.55	0.60
NIR 2023	1.65	1.75	0.78	1.07	0.78	0.68	0.63	0.60	0.54	0.63	0.70
NIR 2023 May	2.13	2.36	1.64	1.15	1.01	0.85	0.78	0.68	0.76	0.83	0.85
Difference (%)	22.65	25.73	52.44	6.79	22.64	19.93	19.27	11.29	29.38	24.01	17.65
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**			
NIR 2022	0.44	0.09	0.76	0.12	0.33	0.23	0.53	0.52			
NIR 2023	0.52	0.15	0.89	0.18	0.41	0.31	0.63	0.62			
NIR 2023 May	0.64	0.24	0.99	0.26	0.47	0.37	0.69	0.71			
Difference (%)	18.22	37.98	10.37	31.08	12.45	17.27	8.49	12.11			

5.5.4.5. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

5.5.5. Liming (3G)

Soils on Cyprus vary between lithosols, leptosols, regosols, gypsisols, solonchaks, solonetz, vertisols, and cambisols, as according to the World Reference Base of Food and Agriculture Organization of the United Nations soil classification system[57]. All of these soils have a pH of 7 or above. Additionally, according to information provided by the Department of Agriculture[58], there is no information, data or documents to support that liming does take place in Cyprus. The expert judgement of Mr. Mousouliotis is to report liming activities as NO.

5.5.6. Urea application (3H)

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. This source category is included because the CO_2 removal from the atmosphere during urea manufacturing is estimated in the Industrial Processes and Product Use Sector (IPPU Sector). The GHG inventory is developed using a Tier 1 approach.Total emissions from urea application for the period 1990–2021 are presented in Table 5.34 and Figure 5.6.

Table 5.34. Urea application emissions, 1990–2021

Urea application (Gg CO_2)	**1990**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**
	1.82	1.67	0.97	0.74	0.91	0.55	0.79
Urea application (Gg CO_2)	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
	0.41	0.40	0.39	0.42	0.22	0.23	0.22
Urea application (Gg CO_2)	**2021**						
	0.30						

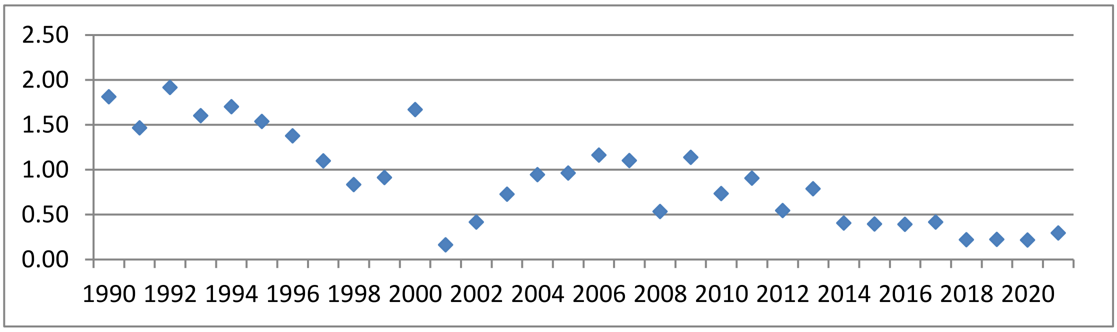

Figure 5.6. Urea application emissions, 1990–2021 (Gg CO_2 eq.)

5.5.6.1. Methodological issues

The steps for estimating CO_2–C emissions from urea applications are:

Step 1: Estimate the total amount of urea applied annually to a soil in the country (M); Data of urea sales in Cyprus is obtained from the Department of Agriculture[59] (Table 5.34). Activity data is based on the

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[57] Zomeni A., Camera C., Bruggeman A., Zissimos A., Christoforou I., Noller J., 2014, Digital soil map of Cyprus (1:25,000); AGWATER - Options for sustainable agricultural production and water use in Cyprus under global change; Scientific Report 6; Deliverable D15, D16. The Cyprus Institute, Nicosia, p.15.

[58] Andreas Mousouliotis, Agriculture Officer, Department of Agriculture (tel. +357 22464016, amousouliotis@da.moa.gov.cy).

[59] George Theophanous, Agriculture Officer, Department of Agriculture (tel. +357 22464028, gtheophanous@da.moa.gov.cy) – Fertilizer Control Board.

assumption that all sold urea in a given year is consumed in the same year.

Step 2: Apply an overall emission factor (EF) of 0.20 for urea, which is equivalent to the carbon content of urea on an atomic weight basis (20% for $CO(NH_2)_2$).

Step 3: Estimate the total CO_2–C emission based on the product of the amount of urea applied, the emission factor, and Equation 11.13 in 2006 IPCC Guidelines (pg. 11.32, vol. 4). Total CO_2–C emission estimated in presented in Table 5.34.

Step 4: Multiply by 44/12 to convert CO_2–C emissions into CO_2.

Table 5.35. Urea consumption in Cyprus (t) and total CO_2–C emission (tC/yr)

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Urea consumption (t)	2475	2000	2615	2185	2323	2101	1879	1502
CO_2–C emission (tC/yr)	495	400	523	437	465	420	376	300

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Urea consumption (t)	1140	1250	2280	227	572	997	1291	1318
CO_2–C emission (tC/yr)	228	250	456	45	114	199	258	264

Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Urea consumption (t)	1590	1508	732	1553	1006	1239	748.4	1078
CO_2–C emission (tC/yr)	318	302	146	311	201	248	150	216

Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Urea consumption (t)	555	543	538	570	305	308	300	408
CO_2–C emission (tC/yr)	111	109	108	114	61	62	60	82

5.5.6.2. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

5.5.6.3. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

5.5.6.4. Category-specific recalculations

No recalculations to report for this category.

5.5.6.5. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

5.5.7. Other carbon-containing fertilizers (3I)

NO

5.5.8. Other (please specify) (3J)

NO

Chapter 6.
Land use, land-use change and forestry (CRF sector 4)

6.1. Overview of sector

Cyprus is an island in the Mediterranean Sea. It measures 240 kilometers long from end to end and 100 kilometers wide at its widest point. It lies between latitudes 34° and 36° N, and longitudes 32° and 35° E. Since 1974 the northern part of Cyprus has been under occupation by Turkey and **beyond the effective control of the Cyprus Government**. For comparability purposes with the rest of the National Inventory sectors of this report, following the recommendations of the UNFCCC Expert Review Team (September 2016 Saturday Paper Report), GHG emissions/removals are reported only for the lands under the effective control of the Government as managed land. The rest of the island is considered to be “unmanaged” and no GHG emissions/removals estimates are included in this report, even though the whole country land area is tracked and reported.

6.1.1. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

Land areas are represented using the IPCC approach 2 (total land-use area, including changes between categories). The essential feature of approach 2 is that it provides an assessment of both the net losses or gains in the area of specific land-use categories and what these conversions represent (i.e., gross changes both from and to a land-use category) but without spatially-explicit location data. The final result of this approach is presented as a non-spatially explicit land-use conversion matrix covering the period 1990 until the latest reported year.

Land use area data for Cyprus are sourced from the CORINE land cover (CLC) inventory[60] data (for details see Chapter 6.2.3). Five CORINE data sets covering the years 1990, 2000, 2006, 2012 and 2018 were considered in the preparation of this inventory. In order to retain consistency among GHG estimates reported for different years the total land area from the 2018 data set was taken as the total country area, and for the previous data sets a proportional approach was used to adjust the areas to the total country area. The complete data sets allowed for the establishment of the respective land use matrices for the periods 1990-2000, 2000–2006, 2006–2012 and 2012-2018. All matrices were linearly interpolated/extrapolated to obtain annual land use change data for all individual years within these periods. Due to the lack of measured data before 1990, it was assumed that for all reported lands the pre-1990 land uses were not different from the land use in 1990. From 2018 onward, the same land-use changes that occurred (type and magnitude) in the period 2012–2018 were assumed in order to complete the land representation up to the latest reported year. Once a new CORINE land cover data set becomes available the land-use matrix from 2018 onward will be revised accordingly.

The surface area of the smallest unit mapped in the CORINE project is 25 hectares. However, the sensitivity for land cover change is 5 ha. As a first approximation, it is assumed that the possible overestimation and underestimation of the individual land use categories and land use changes among these land use categories within the smallest units mapped in the CORINE nullify within the reporting unit. This assumption will be checked against other data of sensitivity comparable to the threshold area used in the definition of forest when the data are available.

It should be noted, that in the current submission several improvements have been implemented, including a complete revision of the land representation in order to correct errors identified as part of the internal QC checks and to resolve issues identified from previous ERTs. In revising the land

[60] http://land.copernicus.eu/pan-european/corine-land-cover/view

representation the same CORINE data sets have been used, by implementing approach 2 for land representation, as explained above.

As a result of the land representation revision, the areas reported in the CRF background tables 4.A-4.F for all land-use categories have changed. More specifically, in the current submission the consistency in land representation and thus in the emissions/removals reported is ensured. This is verified by the fact that:

- The total managed and unmanaged areas remain constant throughout the time series, respectively, and therefore, the total country area remains constant for all inventory years as well.
- For every land-use category X, the final area reported in the year t-1 in CRF table 4.1 equals the initial area reported in the year t in CRF table 4.1 for the same land-use category X;
- For every land-use category X, and for every year Y in the inventory time series, the total area reported in the CRF background tables 4.A-4.F equals the final area reported in CRF table 4.1 for the same land-use category X in year Y.
- The 2006 IPCC guidelines default 20 years conversion and transition period is applied in all land-use categories.

6.1.2. Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The 2006 IPCC guidelines identify six broad land-use categories for the purpose of estimating and reporting greenhouse gas emissions and removals from land use and land-use conversions: (i) forest land; (ii) cropland; (iii) grassland; (iv) wetlands; (v) settlements; and (vi) other land. In the preparation of this inventory the generic definitions of the categories referred to in the 2006 IPCC guidelines were implemented in a country-specific way, described below based on the national definition of forest.

6.1.2.1. Definition of forest

Cyprus adopted the following definition of forest for GHG reporting under the Convention and the Kyoto Protocol:

> ***Forest** comprises of land covered by forest trees which covers at least 0.3 hectares, where the tree crown cover is at least 10 per cent and the minimum tree height is of 5 meters (at maturity).*

The forest definition adopted by Cyprus is in line with the Forest National Law of 2012 (25 (I)/2012) and in accordance with the definition used for its reporting for the Global Forest Resource assessment under the Food and Agriculture Organization of the United Nations (FAO FRA 2015). This definition is also consistent with the guidance of the national definition of forest contained in Decision 16/CMP.1.

It should be noted that the Department of Forests (Department of Forests, CY-1414 Nicosia, Cyprus) applied the following definition of forest in its reporting under the FRA 2015[61]: Forest comprises land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds at maturity in situ. It does not include land that is predominantly under agricultural or urban land use.

It should also be noted that according to the Forest National Law of 2012 (25 (I)/2012), the area threshold of 0.3 hectare is to be implemented in all future reports covering any period since the year 2012.

6.1.2.2. The land-use categories for greenhouse gas inventory reporting

Subsequent to the guidance contained in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, the following national definitions of land-use categories were developed for the purpose of preparation of the GHG inventories:

[61] Forest Data Reporting Package for 2015, FAO, page 12, Table 1.2.1 Data sources.

(i) Forest land

This category contains all lands that meet the definition of forest. It also includes forest roads, cleared tracts, firebreaks and other small open areas within the forest as well as reforested areas or burnt areas or other areas that temporarily have low plant cover due to human intervention or natural causes, but does not include municipal parks and gardens. Forest land contains only areas covered with trees that are considered as forest trees under the Forest National Law of 2012 (25 (I)/2012).

The forest land is further divided into two subcategories: coniferous forest and broadleaved forest, based on the dominant tree species.

(ii) Cropland

This category contains cropped land, including lands with woody vegetation (i.e. fruit trees) where the vegetation does not meet the definition of forest. In particular, this category includes land principally occupied by agriculture, including: arable land, annual and permanent crops as well as vineyards, fruit trees and berry plantations, olive groves and other similar types of cultivation.

The cropland is further divided into two subcategories: annual cropland and woody (perennial) cropland, based on the dominant type of cultivated vegetation.

(iii) Grassland

This category includes rangelands and pasture land that are not considered cropland. It also includes systems with woody vegetation and other non-grass vegetation such as bushes and sclerophyllous vegetation that fall below the threshold values used in the forest land category. The category also includes all pastures, natural grassland and scarcely vegetated areas.

The grassland is further divided into two subcategories: grass and woody (perennial) grassland, based on the dominant type of land cover.

(iv) Wetlands

This category contains areas of land that is covered or saturated by water for all or part of the year and that does not fall into the forest land, cropland, grassland or settlements categories. In particular, it contains: inland and salt marshes, water courses and water bodies.

(v) Settlements

This category contains all developed land, including transportation infrastructure and human settlements of any size. In particular, it contains: industrial and commercial units, urban areas, port areas, airports, construction, mineral extraction and waste dump sites.

(vi) Other land

This category includes bare soil, rock, beaches, dunes and sand plains and all land areas that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area, i.e. to retain the entire Cyprus area constant among the reported years.

Table 6.1 presents the correspondence (mapping) of the CORINE land cover (CLC) data[62] to the land-use categories based on the 2006 IPCC guidelines.

Table 6.1. The correspondence between the CORINE land cover categories identified in Cyprus and the 2006 IPCC land-use categories as implemented in the Cyprus' conditions.

LULUCF Land-Use Categories	CORINE land cover	CLC code
Forest land/Broadleaved forest	Broad leaved forest	311
Forest land/Coniferous forest	Coniferous forest	312

[62] http://land.copernicus.eu/pan-european/corine-land-cover/view

LULUCF Land-Use Categories	CORINE land cover	CLC code
Forest land/Coniferous forest	Mixed forest	313
Forest land/Coniferous forest	Transitional woodland/shrub	324
Cropland/Woody (Woody CL)	Vineyards	221
Cropland/Woody (Woody CL)	Fruit trees and berry plantations	222
Cropland/Woody (Woody CL)	Olive groves	223
Cropland/Woody (Woody CL)	Complex cultivation	242
Cropland/Woody (Woody CL)	Land principally occupied by agriculture, with significant areas of natural vegetation	243
Cropland/Annual (Annual CL)	Non-irrigated arable land	211
Cropland/Annual (Annual CL)	Permanently irrigated land	212
Cropland/Annual (Annual CL)	Annual crops associated with permanent crops	241
Grassland/Woody (Woody GL)	Sclerophyllous vegetation	323
Grassland/Grass (Grass GL)	Pastures	231
Grassland/Grass (Grass GL)	Natural grassland	321
Grassland/Grass (Grass GL)	Scarcely vegetated areas	333
Settlements (SL)	Continuous urban fabric	111
Settlements (SL)	Discontinuous urban fabric	112
Settlements (SL)	Industrial or commercial units	121
Settlements (SL)	Road and rail networks and associated land	122
Settlements (SL)	Port areas	123
Settlements (SL)	Airports	124
Settlements (SL)	Mineral extraction sites	131
Settlements (SL)	Dump sides	132
Settlements (SL)	Construction sites	133
Settlements (SL)	Green urban areas	141
Settlements (SL)	Sport and leisure facilities	142
Wetlands (WL)	Inland marshes	411
Wetlands (WL)	Salt marshes	421
Wetlands (WL)	Water courses	511
Wetlands (WL)	Water bodies	512
Other land (OL)	Beaches, dunes and sand plains	331
Other land (OL)	Bare rock	332
	Burnt areas*	334

*Burned areas were distributed among the remaining land use categories based on the previous land use. In Cyprus, burning of vegetation does not lead to land use change.

The CORINE land cover (CLC) categories listed in Table 6 above exhaust all land uses existing in Cyprus. This ensures that the land categories system implemented in this inventory is complete, hence all country land area is classified into one of these categories in a unique way avoiding duplication.

All lands subject to the effective control of the Republic of Cyprus are considered as managed, whereas the rest of the land area is considered unmanaged. However unmanaged land area is tracked throughout time and reported in CRF Table 4.1 and therefore the total country area is reported annually.

Table 6.2 presents the areas of the 2006 IPCC land-use categories and sub-categories based on the different CORINE data sets.

Table 6.2. Land-use categories and sub-categories area data based on the CORINE data sets. The resolution for detection of individual land use categories is 25 ha. The data cover the areas under the effective control of the Cyprus Government (managed land) and the area which is not under the effective control of the Cyprus Government (unamanaged land).

	Year 1990	Year 2000	Year 2006	Year 2012	Year 2018
	kha				
Land-use categories					
Forest land/broadleaved	0.63	0.63	0.62	0.62	0.62

Forest land/coniferous	157.49	157.58	157.73	157.81	158.17
Cropland/annual	132.62	129.64	127.72	127.33	127.16
Cropland/woody	123.65	124.95	123.77	122.89	122.44
Grassland/grass	24.62	26.35	25.03	24.66	25.72
Grassland/woody	107.00	106.52	104.95	104.81	103.35
Wetlands	3.98	3.98	3.96	4.01	4.06
Settlements	48.90	49.20	55.07	56.72	57.36
Other land	2.92	2.96	2.96	2.96	2.94
Total managed land	**601.82**	**601.82**	**601.82**	**601.82**	**601.82**
Total unmanaged land	**322.35**	**322.35**	**322.35**	**322.35**	**322.35**
Total land	**924.17**	**924.17**	**924.17**	**924.17**	**924.17**

6.1.3. GHG emissions and removals in the LULUCF sector

The emissions and removals from the LULUCF sector by main land-use category for the whole inventory period are presented in Table 6.3.

Table 6.3. Emissions and removals (+/-) from LULUCF categories (kt CO_2 eq).

Year	Total	FL	CL	GL	WL	SL	OL	HWP
1990	-153.07	1.51	-134.23	-23.05	NO,NE	0.46	0.11	2.14
1991	-166.98	-18.24	-134.77	-23.53	NO,NE	0.45	0.14	8.97
1992	-172.65	-23.54	-135.31	-24.01	NO,NE	0.43	0.17	9.60
1993	-174.80	-11.81	-135.85	-24.49	NO,NE	0.41	0.21	-3.28
1994	-183.35	-23.10	-136.39	-24.96	NO,NE	0.39	0.24	0.46
1995	-180.03	-18.77	-136.93	-25.44	NO,NE	0.37	0.27	0.45
1996	-185.36	-22.26	-137.47	-25.92	NO,NE	0.36	0.30	-0.38
1997	-184.22	-29.88	-138.01	-26.40	NO,NE	0.34	0.33	9.38
1998	-190.49	-27.93	-138.55	-26.87	NO,NE	0.32	0.37	2.15
1999	-198.38	-33.17	-139.08	-27.35	NO,NE	0.30	0.40	0.51
2000	-142.51	9.92	-139.62	-27.83	NO,NE	0.28	0.43	14.30
2001	-168.60	-46.21	-139.61	-28.81	NO,NE	23.09	0.35	22.54
2002	-201.94	-81.47	-139.54	-28.75	NO,NE	23.54	0.35	23.86
2003	-214.02	-94.33	-139.47	-28.69	NO,NE	23.99	0.35	24.02
2004	-214.55	-95.72	-139.40	-28.63	NO,NE	24.44	0.35	24.29
2005	-220.83	-102.58	-139.34	-28.57	NO,NE	24.89	0.35	24.27
2006	-222.49	-103.97	-139.27	-28.52	NO,NE	25.32	0.35	23.42
2007	-182.89	-42.13	-140.99	-28.50	0.44	8.94	0.35	18.81
2008	-249.84	-108.26	-140.81	-28.50	0.45	9.08	0.35	17.64
2009	-277.65	-141.28	-140.62	-28.50	0.47	9.22	0.35	22.51
2010	-265.04	-130.19	-140.04	-28.02	0.48	9.38	0.32	22.82
2011	-300.78	-168.10	-139.46	-27.53	0.50	9.53	0.29	23.79
2012	-293.62	-162.14	-138.88	-27.05	0.52	9.68	0.25	23.78
2013	-297.29	-171.08	-132.03	-23.62	0.45	5.06	0.22	23.50
2014	-299.11	-173.38	-131.42	-23.07	0.46	4.98	0.19	22.91
2015	-296.11	-171.27	-130.81	-22.51	0.47	4.91	0.16	22.73
2016	-190.89	-66.95	-130.25	-21.97	0.47	4.89	0.13	22.57
2017	-307.03	-183.98	-129.69	-21.43	0.47	4.87	0.10	22.41
2018	-302.31	-180.14	-129.12	-20.89	0.47	4.85	0.06	22.24
2019	-297.04	-175.66	-128.51	-20.33	0.49	4.76	0.03	21.96
2020	-298.54	-177.58	-127.92	-19.78	0.50	4.70	NO	21.32
2021	-235.33	-112.90	-127.60	-19.73	0.50	4.29	NO	19.92

6.1.4. Emission Trends

The total LULUCF sector represents a GHG sink during the entire period 1990–2021. While the sink generally follows an upward trend, in years of exceptional extent of forest fires (2000, 2007, 2016 and 2021) the trend is visibly broken (see Figure 6.1). Overall the sink in the total LULUCF increases from -153.1 kt CO_2 eq in 1990 to -235.3 kt CO_2 eq in 2021, representing an increase in net removals of 53.7%.

The forest land catetgory is an important contributor to the sink in the LULUCF sector. The land converted to forest land represents a net sink for all inventoried years, while forest land remaining forest land represent sinks for all years, except some specific years in which represents a net source, primarily due to significant forest fire impacts.

The cropland remaining cropland and land converted to grassland categories are sinks over the entire period 1990–2021. For cropland remaining cropland national data are limited to area only, hence all emission/removal factors used in calculations of the GHG sources/sinks estimates are default data.

During the entire period 1990–2021, the wetlands category (land converted to wetlands) represents a minor source as well as the the settlements category (land converted to settlements) does. Finally, the other land category represents a net source of emissions for the whole inventory period, except the last two years (2020, 2021) in which emissions do not occur.

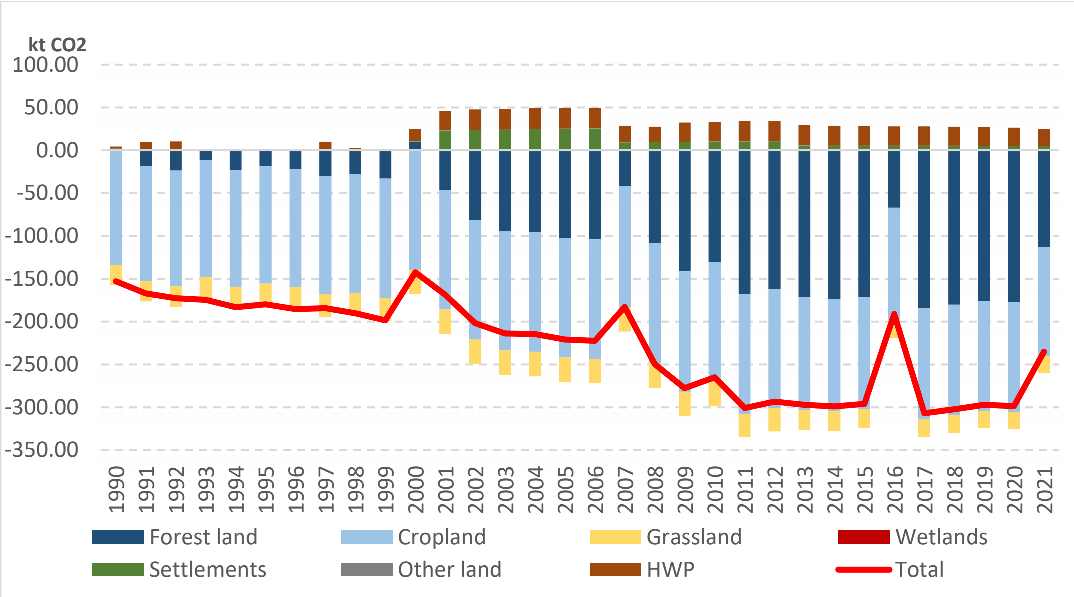


Figure 6.1. Emissions/removals trend in the LULUCF sector in the period 1990–2021

6.2. Forest land (4A)

6.2.1. Description

Area and ownership of Cyprus forest

The total forest land area in 2021 amounts to 158,964 ha covering approximately 26.4% of the total managed land area. Conifers represent the vast majority of the total managed forest land area, namely 99.6% while broadleaf forests are found only on 0.4% of the total managed forest land area in the country. Furthermore, according to a last survey, private forests and other forested State land cover 24.74% of the total area of Cyprus. Private forests are small holdings scattered all over Cyprus and are mainly located in distant mountainous and rural areas.

Floristic composition of Cyprus forests

Nearly half the area of the island is covered by tree vegetation that has been degraded by human activities. Forest is composed mainly of coniferous species like the Calabrian pine (*Pinus brutia*), the black pine (*Pinus nigra*), the Cedar (*Cedrus brevifolia*) and the Cypress (*Cypressus sempervirens*). Maquis vegetation includes species like Lentisk *(Pistacia lentiscus*), Juniper (*Juniperus phoenicea*), Maple (*Acer obtusifolium*) and Strawberry tree (*Arbutus andrachne*), while garigue lands consist of the Rock rose (*Cistus spp.*), Thyme (*Thymus capitatus*), Thorny-broom (*Calycotome villosa*), Thorny gorse (*Genista fasselata*) and Spiny burnet (*Sarcopoterium spinosum*). There are also minor areas consisting of young coniferous plantations (source: Forest Department, Ministry of Agriculture, Rural Development and Environment, Cyprus).

6.2.2. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The approach for representing land areas and land use databases is described in Chapter 6.1.1, "Information on approaches used for representing land areas and on land-use databases used for the inventory preparation".

6.2.3. Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

Land-use definitions are provided in Chapter 6.1.2.2 "The land-use categories for greenhouse gas inventory reporting".

Table 6.4 below presents the area data on land remaining and converted to the broadleaved forest subcategory. Note that there are no conversions to broadleaved within the land converted to forest land category.

Table 6.4. Areas of land remaining in the same land use subcategory (broadleaved remaining broadleaved forests) and of land converted to broadleaved forests from other land-use sub-categories.

Year	Broadleaved remaining broadleaved	Land converted to broadleaved forest from:								Total area
		Conif. FL	Annual CL	Woody CL	Grass GL	Woody GL	WL	SL	OL	
	kha									
1990	0.631	0	0	0	0	0	0	0	0	0.631
1991	0.631	0	0	0	0	0	0	0	0	0.631
1992	0.631	0	0	0	0	0	0	0	0	0.631
1993	0.631	0	0	0	0	0	0	0	0	0.631
1994	0.631	0	0	0	0	0	0	0	0	0.631
1995	0.631	0	0	0	0	0	0	0	0	0.631
1996	0.631	0	0	0	0	0	0	0	0	0.631
1997	0.631	0	0	0	0	0	0	0	0	0.631
1998	0.631	0	0	0	0	0	0	0	0	0.631
1999	0.631	0	0	0	0	0	0	0	0	0.631
2000	0.631	0	0	0	0	0	0	0	0	0.631
2001	0.630	0	0	0	0	0	0	0	0	0.630
2002	0.628	0	0	0	0	0	0	0	0	0.628
2003	0.627	0	0	0	0	0	0	0	0	0.627
2004	0.626	0	0	0	0	0	0	0	0	0.626
2005	0.624	0	0	0	0	0	0	0	0	0.624
2006	0.623	0	0	0	0	0	0	0	0	0.623
2007	0.623	0	0	0	0	0	0	0	0	0.623
2008	0.623	0	0	0	0	0	0	0	0	0.623
2009	0.623	0	0	0	0	0	0	0	0	0.623
2010	0.623	0	0	0	0	0	0	0	0	0.623
2011	0.623	0	0	0	0	0	0	0	0	0.623

2012	0.623	0	0	0	0	0	0	0	0	0.623
2013	0.623	0	0	0	0	0	0	0	0	0.623
2014	0.623	0	0	0	0	0	0	0	0	0.623
2015	0.623	0	0	0	0	0	0	0	0	0.623
2016	0.623	0	0	0	0	0	0	0	0	0.623
2017	0.623	0	0	0	0	0	0	0	0	0.623
2018	0.623	0	0	0	0	0	0	0	0	0.623
2019	0.623	0	0	0	0	0	0	0	0	0.623
2020	0.623	0	0	0	0	0	0	0	0	0.623
2021	0.623	0	0	0	0	0	0	0	0	0.623

FL = forest land, CL = cropland, GL = grassland, WL= wetlands, SL= settlements, OL = other land

Table 6.5 presents the same kind of information for the case of the coniferous forest subcategory. As explained in section 6.1.1, in all land-use categories the 20 years conversion period is applied in the current inventory, namely, any piece of land remains in the ‘conversion’ subcategory for 20 years before transferred to the remaining subcategory.

Table 6.5. Areas of land remaining in the same land use subcategory (coniferous remaining coniferous forests) and of land converted to coniferous forests from other land-use sub-categories.

Year	Coniferous remaining coniferous	Land converted to coniferous forest from:								Total area
		Broad. FL	Annua l CL	Woody CL	Grass GL	Woody GL	WL	SL	OL	
	kha									
1990	157.486	0	0.000	0	0	0.009	0	0	0	157.495
1991	157.486	0	0.001	0	0	0.017	0	0	0	157.504
1992	157.485	0	0.001	0	0	0.026	0	0	0	157.512
1993	157.485	0	0.001	0	0	0.034	0	0	0	157.521
1994	157.485	0	0.002	0	0	0.043	0	0	0	157.530
1995	157.484	0	0.002	0	0	0.052	0	0	0	157.538
1996	157.484	0	0.003	0	0	0.060	0	0	0	157.547
1997	157.484	0	0.003	0	0	0.069	0	0	0	157.556
1998	157.484	0	0.003	0	0	0.078	0	0	0	157.564
1999	157.483	0	0.004	0	0	0.086	0	0	0	157.573
2000	157.483	0	0.004	0	0	0.095	0	0	0	157.582
2001	157.474	0	0.004	0	0.008	0.095	0	0.025	0	157.606
2002	157.466	0	0.004	0	0.016	0.095	0	0.049	0	157.630
2003	157.457	0	0.004	0	0.024	0.095	0	0.074	0	157.654
2004	157.449	0	0.004	0	0.032	0.095	0	0.099	0	157.678
2005	157.440	0	0.004	0	0.040	0.095	0	0.123	0	157.702
2006	157.431	0	0.004	0	0.048	0.095	0	0.148	0	157.726
2007	157.425	0	0.004	0	0.050	0.095	0	0.167	0	157.741
2008	157.419	0	0.004	0	0.052	0.095	0	0.186	0	157.756
2009	157.414	0	0.004	0	0.054	0.095	0	0.205	0	157.770
2010	157.417	0	0.004	0	0.056	0.086	0	0.223	0	157.785
2011	157.420	0	0.003	0	0.057	0.078	0	0.242	0	157.800
2012	157.423	0	0.003	0	0.059	0.069	0	0.261	0	157.815
2013	157.403	0	0.006	0.046	0.059	0.085	0	0.273	0	157.873
2014	157.383	0	0.010	0.092	0.059	0.102	0	0.286	0	157.931
2015	157.363	0	0.013	0.138	0.059	0.118	0	0.298	0	157.990
2016	157.343	0	0.017	0.184	0.059	0.135	0	0.310	0	158.048
2017	157.323	0	0.020	0.230	0.059	0.151	0	0.323	0	158.107
2018	157.303	0	0.023	0.276	0.059	0.168	0	0.335	0	158.165
2019	157.283	0	0.027	0.323	0.059	0.185	0	0.347	0	158.224
2020	157.264	0	0.030	0.369	0.059	0.201	0	0.359	0	158.282
2021	157.267	0	0.034	0.415	0.051	0.226	0	0.347	0	158.341

FL = forest land, CL = cropland, GL = grassland, WL= wetlands, SL= settlements, OL = other land

6.2.4. Methodological issues

Forest area is an area with vegetation cover that meets the national definition of forest. It includes stands of different ages, including areas transiently deprived of vegetation which are expected to revert to forest and lands recently afforested and reforested. All data collected by the Forest Department refer to the entire forest area. It also includes areas converted to forest, as defined by the 2006 IPCC guidelines in the 2006 IPCC sense. Consequently, all calculations involving biomass growth and losses are performed on the basis of the entire forest area. However, estimates relating specifically to the conversion process (e.g. accumulation/release of carbon from soil) are calculated specifically for the relevant conversion areas. The growing stock and annual increment for all subcategories included in this category are defined as follows[63]:

Growing stock = Volume over bark of all living trees more than 12 cm in diameter at breast height. Includes the stem from stump height up to a top diameter of 7 cm. It does not include branches.

Annual increment = Average annual volume of increment over the given reference period net of natural losses on all trees, measured to minimum diameters as defined for "Growing stock". The annual increment is expressed on the per hectare basis.

National data on growing stock and annual increment are presented in Table 6.6.

Table 6.6. National data on growing stock and annual increment

Year	Growing stock	Coniferous forest	Broadleaved forest
	m^3/ha	$m^3/ha/yr$	$m^3/ha/yr$
1990	45.96	0.58	2
1991	45.96	0.58	
1992	45.95	0.57	
1993	45.94	0.57	
1994	45.94	0.56	
1995	45.93	0.56	
1996	45.92	0.56	
1997	45.92	0.55	
1998	45.91	0.55	
1999	45.90	0.54	
2000	45.90	0.54	
2001	46.42	0.59	
2002	46.94	0.65	
2003	47.46	0.70	
2004	47.98	0.70	
2005	48.50	0.70	
2006	50.28	0.70	
2007	52.05	0.70	
2008	53.83	0.84	
2009	55.61	0.94	
2010	57.39	0.94	
2011	59.22	1.17	
2012	61.06	1.17	
2013	62.89	1.17	
2014	64.73	1.17	
2015	66.57	1.17	
2016	66.57	1.17	
2017	66.57	1.17	
2018	66.57	1.17	
2019	68.80	1.17	
2020	69.90	1.17	
2021	69.90	1.20	

[63] FAO. Forest Data Reporting Package for 2015. Cyprus

National data on the growing stock and volume increment are averaged over the entire net area of forest in the current year (that is the area of forest remaining forest plus the areas converted to forest minus areas converted from forest to other uses in that year).

National data on the volume of harvest is expressed as volume under bark. The volume of bark is assumed as 12% of the harvested volume based on forest expert advice. The annual harvest is provided for the total forest land area for each year (that is the area of forest remaining forest plus the areas converted to forest minus areas converted from forest to other uses in that year).

In Cyprus, salvage logging is part of the forest harvest. However, data on salvage logging are also published separately from data on forest harvest, and it is included in calculation of emissions from harvest.

Table 6.7. Annual harvest in forest land

Year	Coniferous forest		Broadleaved forest	
	Roundwood	Fuelwood	Roundwood	Fuelwood
	m^3			
1990	46,305	14,194	1,518	465
1991	35,341	10,831	1,506	462
1992	32,339	10,550	1,511	493
1993	36,529	11,910	1,433	467
1994	31,395	5,397	1,449	249
1995	34,216	8,866	1,505	390
1996	32,366	6,460	1,508	301
1997	26,984	4,683	1,437	249
1998	18,840	-	1,158	-
1999	26,780	7,497	1,590	445
2000	15,859	3,524	1,442	320
2001	11,919	4,723	1,246	494
2002	9,997	3,174	1,290	409
2003	6,981	2,060	1,252	369
2004	5,756	1,004	1,320	230
2005	4,388	725	1,065	176
2006	2,879	-	1,063	-
2007	11,794	5,124	1,132	492
2008	13,585	4,161	1,163	356
2009	4,483	586	1,536	201
2010	5,636	3,007	537	287
2011	5,015	2,802	683	382
2012	4,121	5,571	971	1,313
2013	3,020	4,191	1,159	1,609
2014	3,419	3,644	1,062	1,131
2015	3,050	7,309	820	1,966
2016	1,923	4,955	227	584
2017	579	4,324	72	540
2018	1,727	4,012	248	575
2019	2,401	7,417	74	1,772
2020	2,758	6,503	64	1,407
2021	1,964	5,904	192	575

The root/shoot ratio for all forest types is 0.28 (Table 4.4, of 2006 IPCC guidelines for subtropical dry forest, based on a previous ERT's advice).

The carbon fraction of wood is 0.47 t C/t d.m. for the whole inventory (based on a previous ERT's advice).

The biomass conversion and expansion factors used are the default ones from Table 4.5 of the 2006 IPCC guidelines, for the Mediterranean dry tropical, subtropical climatic zone, and for growing stock level 41–100 m^3/ha. These factors are presented in Table 6.8 below

Table 6.8. BCEF values used in carbon stock changes estimation in living biomass.

Forest type	BCEF	Value used
Broadleaved forest	$BCEF_S$	0.80 t biomass/m^3 wood volume
	$BCEF_I$	0.55 t biomass/m^3 wood volume
	$BCEF_R$	0.89 t biomass/m^3 wood volume
Coniferous forest	$BCEF_S$	0.60 t biomass/m^3 wood volume
	$BCEF_I$	0.45 t biomass/m^3 wood volume
	$BCEF_R$	0.67 t biomass/m^3 wood volume

Forest fires

All emissions from forest fires were attributed to the forest land remaining forest land category. The areas affected by fires are provided annually by the Forest Department of Cyprus. CO_2 emissions from forest fires in living biomass are estimated as part of the living biomass losses (equation 2.14, 2006 IPCC guidelines) and reported in CRF table 4.A (carbon losses), aggregated with the losses from harvestings. In CRF table 4(V) however, non-CO_2 emissions from biomass burning in forest land are reported, applying equation 2.27 of the 2006 IPCC guidelines, with default emission factors (table 2.5 for extra tropical forest) for CH_4 and N_2O. Furthermore, the default combustion factor (Cf=0.45) from 2006 IPCC guidelines is used in all calculations relating to forest fires (Table 2.6 for all other temperate forests).

Land converted to forest land

Due to the lack of country-specific information on annual increment in above-ground biomass for land converted to forest land, the country specific values of growing stock that were presented previously were used to approximate the above-ground biomass growth. The 20 years default conversion and transition period was applied, while the BCEF, root-shoot ratio, and carbon fraction values used are the same as in the case of forest land remaining froest land.

With regard to carbon losses due to forest fires, as explained previously, all emissions from biomass burning are attributed to forest land remaining forest land, thus in CRF table 4(V) the ‘IE’ notation key is used for land converted to forest land and relevant information is reported in CRF table 9.

Change in carbon in dead organic matter

In forest land remaining forest land, the tier 1 assumption from 2006 IPCC guidelines, that carbon stock changes in the dead organic matter (DOM) pool are zero is followed. In land converted to forest land, carbon stock changes in the DOM pool have been estimated and reported. For the whole inventory, carbon stocks in DOM pool in all non-forest land-use categories are taken equal to zero. For the litter carbon stocks in forest land, the default values from the 2006 IPCC guidelines are used for broadleaved and coniferous forests, namely, 2.8 t C/ha and 4.1 t C/ha (Table 2.2, for subtropical climate), respectively. In the current inventory, carbon stock changes in dead wood in land converted to forest land are reported for the first time. In the absence of default values for carbon stocks in dead wood in the 2006 IPCC guidelines, the default values from the 2019 Refinement to the 2006 IPCC Guidelines are used instead. More specifically, a unique value of 64.4 t C/ha (subtropical desert climate) for both broadleaved and coniferous forests is used.

The methodology applied is in accordance with equation 2.23 of the 2006 IPCC guidelines. Furthermore, the assumptions that DOM stocks are entirely lost in the year of conversion in the cases of forest land conversions to the other land-use categories, while DOM gains occur linearly from zero over the 20 years transition period in the cases of DOM buildup (i.e., land conversions to forest land) are applied.

Change in carbon stocks in soils

The reference carbon stock in mineral soils used in all land-use categories is the default one suggested by the 2006 IPCC Guidelines. More specifically, the whole country area in Cyprus is considered to be mineral high activity clay soils with a default reference carbon stock of 38 t C/ha (table 2.3, for tropical, dry climate).

In forest land remaining forest land, the tier 1 assumption from 2006 IPCC guidelines, that carbon stock changes in mineral soil (SOM) pool are zero is followed. In land converted to forest land, carbon stock changes were estimated applying formulation B of equation 2.25 of the 2006 IPCC guidelines with the default 20 years transition period. For forest land, the stock change factors for land use, management and input were taken equal to 1, thus the carbon stocks at equilibrium in forest land equal the reference soil carbon stocks. Similarly, all three stock change factors were taken equal to 1 in the case of woody cropland (F_{LU} for perennial/tree crop, F_{MG} for full tillage, F_I for medium input), grass and woody grassland (F_{LU} for all grassland, F_{MG} for nominal managed grassland, F_I for medium input). In the case of annual cropland, the F_{LU} for long-term cultivated (tropical dry climate) equal to 0.58 is applied, together with the same F_{MG}, F_I used for woody cropland. For settlements, the default 0.8 product of all three stock change factors is applied, and for the other land category the carbon stocks in mineral soils are taken equal to zero.

6.2.5. Uncertainties and time-series consistency

In the current submission for the first time the uncertainty analysis includes the LULUCF sector.

Uncertainties for the whole inventory period (1990-2021) have been assessed following the error propagation (approach 1) and equations 3.1, 3.2 contained in volume 1 of the 2006 IPCC guidelines. Input uncertainties related to activity data and emission factors have been assessed on the basis of information provided in the 2006 IPCC guidelines and country specific information.

The associated uncertainties with the input data for forest land remaining forest land and land converted to forest land are presented in the table below.

Table 6.9. Input data uncertainties.

Input data	%
Area	15
Net annual increment (conifers)	65
Net annual increment (broadleaved)	20
BCEF (coniferous)	38
BCEF (broadleaved)	40
Annual roundwood, fuelwood	20
Area affected by wildfires	10
Litter stocks	20
Dead wood stocks	81
Reference soil carbon stocks	90
Annual & woody cropland biomass carbon stocks & biomass accumulation rate for woody CL	75
FL_U in annual cropland	61
FL_U in woody cropland	50
FL_U*FL_{MG}*FL_I in settlements	61
Average forest growing stock	20
Average above-ground growing stock in woody grassland	50
MB*Cf (biomass burning)	213
Root-shoot ratio (R)	2
Carbon fraction (CF)	2
CH_4 EF for biomass burning	81
N_2O EF for biomass burning	54

The overall uncertainty for forest land remaining forest land is equal to 62%, 230%, 220% for CO_2, CH_4, N_2O emissions respectively, while for land converted to forest land associated uncertainties equal to 43%

for CO_2 emissions. A more detailed description of the results of the uncertainty analysis is reported in Annex 2.

The time series of emissions/removals for the land-use categories forest land remaining forest land and land converted to forest land (for coniferous and broadleaved forest together) is presented in figure 6.2 and figure 6.3.

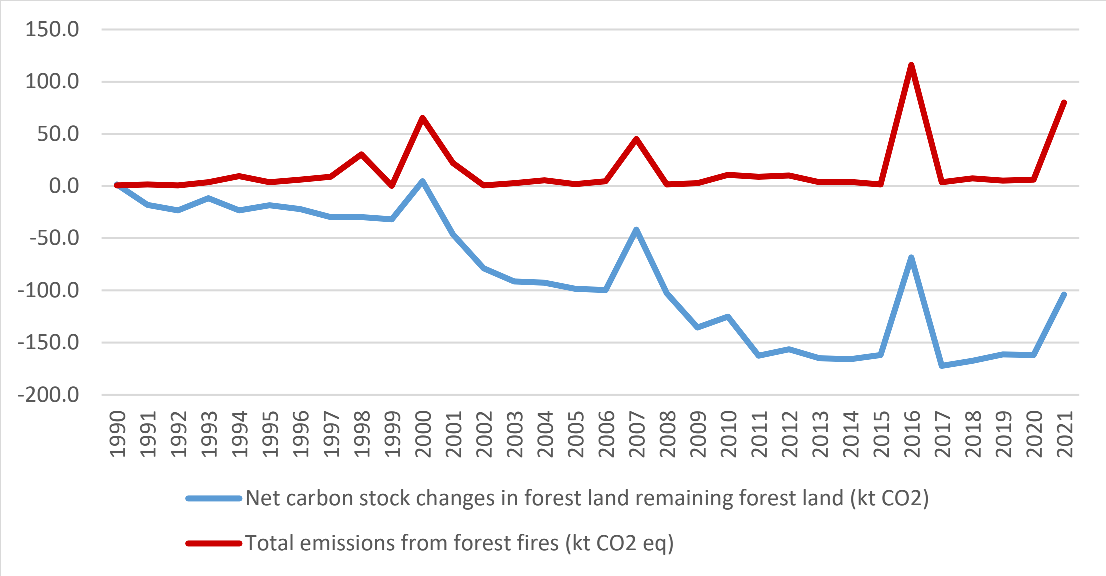


Figure 6.2. Forest land remaining forest land: Net carbon stock changes (blue line) and emissions from forest fires (red line) during the period 1990 – 2021.

In figure 6.2 the trend of an increasing sink in forest land remaining forest land is evident . The trend is transiently broken in years of exceptional forest fire events.

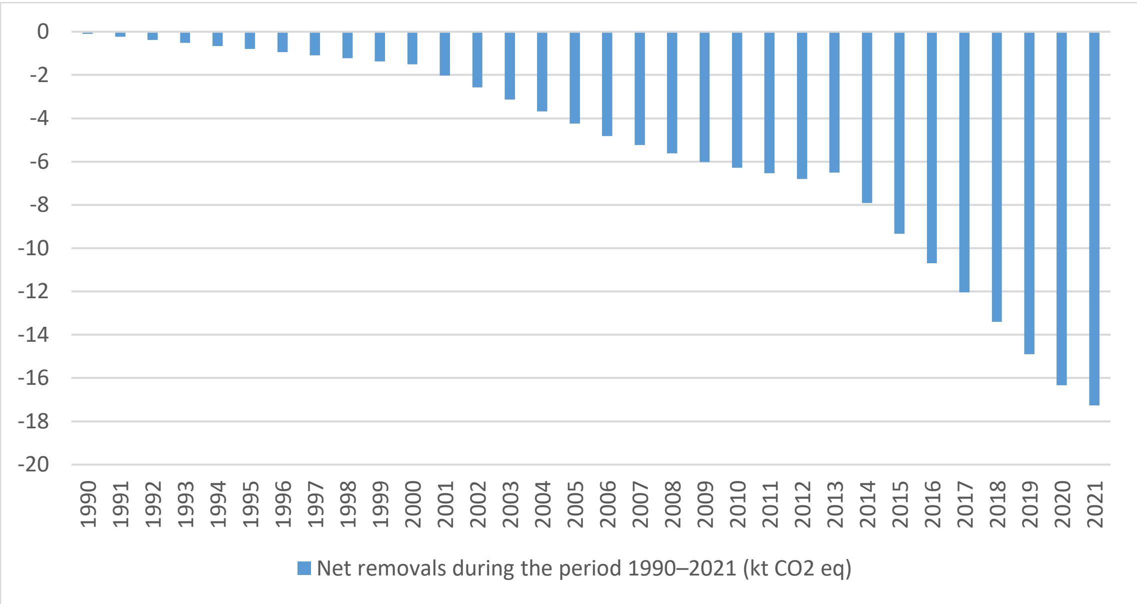


Figure 6.3. Land converted to forest land: Net removals during the period 1990–2021

Figure 6.3 presents the increasing sink trend in land converted to forest land reflecting the increasing trend in areas under land converted to forest land. In land converted to forest land there are not any peaks/valleys due to disturbances, since all emissions from forest firest are included in forest land remaining forest land.

Figure 6.4 presents the total contribution of the forest land remaining forest land and land converted to forest land categories to the GHG emissions/sources in the LULUCF sector.

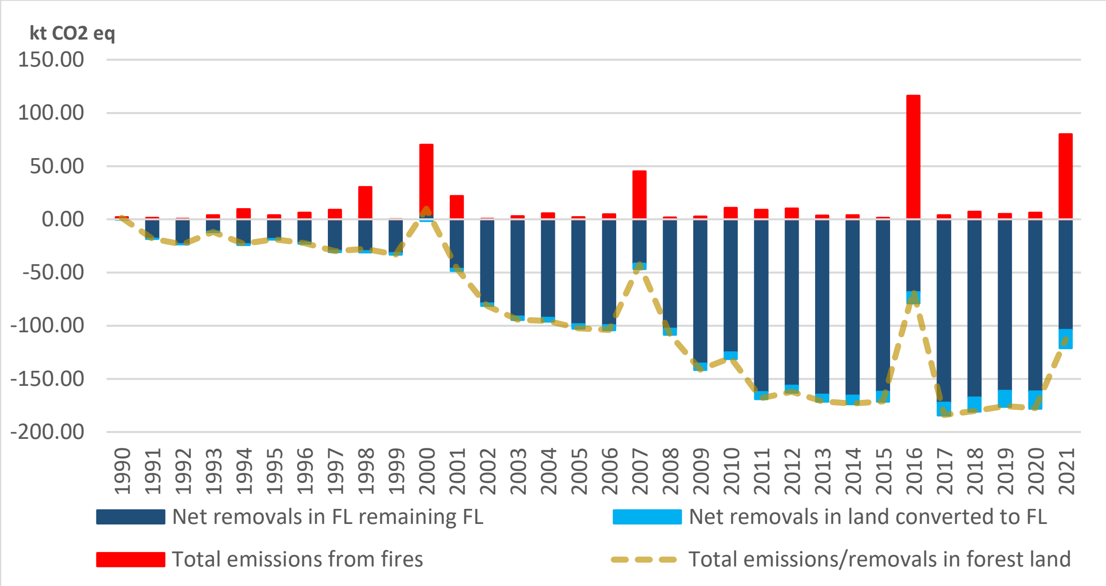


Figure 6.4. Forest land remaining forest land and land converted to forest land contribution: net CO_2 emissions/removals during the period 1990 – 2021

6.2.6. Category-specific QA/QC and verification

The following category specific QA/QC and verification approaches were implemented during preparation of this NIR:

- Check of correctness/plausibility of the land representation, activity data and emission factors used in calculations and their units;
- Check of plausibility of input data;
- Check of completeness of data;
- Check of correctness of the methodologies applied and plausibility of results;
- Check of references and assumptions applied in processing of the data;
- Check of the consistency of the total area of the lands under the effective control of the Republic of Cyprus in all years of the reported period.
- Check of the correct use of notation keys in CRF tables and the complete and correct filling of the CRF tables.

6.2.7. Category-specific recalculations

Several changes were made in this submission that resulted in the recalculated estimates in forest land. These include:

- The complete revision of the land representation as noted in section 6.1.1, which led to revised area estimates in forest land remaining forest land and land converted to forest land.
- Precursor emissions (NOx, CO) associated with forest fires are reported for the first time.
- Previously, carbon flows to the DOM pool as slash from the biomass pool and carbon stock changes in HWP were included in the carbon stock changes in living biomass. In the current submission, biomass carbon stock changes (gains/losses) are estimated for both the above and below-ground biomass without adjusting for any transfers to the DOM pool, and carbon stock changes in HWP pool.

- Previously, carbon losses in the litter pool due to fires were included in total emissions from fires in forest land remaining forest land. In the current submission, litter losses due to fires are not included, since the tier 1 methodology is applied in DOM pool in forest land remaining forest land.
- Corrected an error in the estimation of carbon losses in living biomass. More specifically, previously, losses in biomass from disturbances (wildfires) were included as biomass losses (t dm) without having been converted to carbon losses through the application of carbon fraction.
- Emission factors for non-CO_2 emissions associated with burning (wildfires) changed from those of 'tropical forest' to those of 'extra tropical forest'.
- Carbon stock changes in dead wood are estimated for the first time using default dead wood stocks from the 2019 IPCC Refinement.
- Corrected the methodology in estimating carbon losses in living biomass in cropland converted to forest land. Previously, the below-ground biomass in cropland was not taken equal to zero under tier 1. Currently, the below-ground biomass in cropland is considered equal to zero.
- Corrected the methodology in estimating carbon stock changes in litter in cropland, grassland and settlements converted to forest land. For cropland, grassland and settlements the litter carbon stocks were not considered equal to zero under tier 1. Currently, the DOM carbon stocks in non-forest land uses is considered equal to zero. Furthermore, the 20 years transition period is applied for carbon stock changes in DOM in land converted to forest land instead of the 1 year transition period previously applied.
- The stock change factor for input for carbon stock changes in mineral soils in perennial crops changed from 1.04 (high without manure) to 1 (medium), until updated country information becomes available.
- Previously, a 20 years conversion period was applied to carbon losses in living biomass due to land use change. In the current inventory the methodology changed by attributing the biomass losses due to land-use change in the certain year.
- Country-specific above ground biomass for woody grassland (before conversion) in land converted to forest land is applied in the current inventory, instead of the biomass stocks of perennial cropland that was applied for woody grassland previously.
- The product of F_{LU}, F_{MG}, F_I in mineral soils in settlements in estimating carbon stock changes in settlements converted to forest land changed from 0.834 to the 2006 IPCC guidelines default value of 0.8, until updated information becomes available.
- Corrected an error identified in the reporting of carbon stock changes in living biomass in settlements converted to forest land for years where such land-use change did not occur (e.g., 1990-2000).

6.2.8. Category-specific planned improvements

The improvements considered related to this category include:

- Investigate options for developing more accurate net annual increment values for land conversions to forest land.
- Analyse further the CORINE data sets together with additional country data sources in order to refine equilibrium carbon stocks in mineral soils in cropland, grassland and settlements, to be used in land converted to forest land.
- An approach should be developed to obtain a numerical assessment of land use changes involving individual areas from 0.3 ha to 5 ha and their impact on the numerical estimates of land use changes obtained at the 5 ha resolution. The national definition of forest requires assessment of land use changes at the resolution of 0.3 ha. This may be achieved by means of establishing a correlation between the area of land use changes detected at the resolution of 5 ha and “true” area of land use changes estimated based on the threshold of 0.3 ha.
- Collect further information in order to distinguish forest land areas affected by fires between forest land remaining forest land and land converted to forest land, and between the forest types.

6.3. Cropland (4B)

6.3.1. Description

6.3.2. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

Approach for representing land areas and land use databases are described in Chapter 6.1.1 “Information on approaches used for representing land areas and on land-use databases used for the inventory preparation”.

6.3.3. Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

Land-use definitions are provided in Chapter 6.1.2.2 “The land-use categories for greenhouse gas inventory reporting”. Table 6.10 presents data on lands converted to annual cropland. Note that the only conversions to annual cropland are from coniferous forests, perennial cropland, woody and grass grassland, and settlements. Similarly, table 6.11 presents data on lands converted to woody cropland.

Table 6.10. Areas of land remaining in the same land use subcategory (annual cropland remaining annual cropland) and of land converted to annual cropland from other land-use sub-categories.

Year	Annual cropland remaining annual cropland	Land converted to annual cropland from:								Total area
		Woody CL	Broad. FL	Conif . FL	Grass GL	Woody GL	WL	SL	OL	
	kha									
1990	132.596	0.001	0	0	0	0.025	0	0	0	132.622
1991	132.273	0.001	0	0	0	0.050	0	0	0	132.324
1992	131.950	0.002	0	0	0	0.074	0	0	0	132.026
1993	131.626	0.003	0	0	0	0.099	0	0	0	131.728
1994	131.303	0.004	0	0	0	0.124	0	0	0	131.430
1995	130.979	0.004	0	0	0	0.149	0	0	0	131.132
1996	130.656	0.005	0	0	0	0.174	0	0	0	130.835
1997	130.333	0.006	0	0	0	0.198	0	0	0	130.537
1998	130.009	0.006	0	0	0	0.223	0	0	0	130.239
1999	129.686	0.007	0	0	0	0.248	0	0	0	129.941
2000	129.362	0.008	0	0	0	0.273	0	0	0	129.643
2001	128.953	0.009	0	0	0.088	0.273	0	0	0	129.322
2002	128.543	0.010	0	0	0.175	0.273	0	0	0	129.001
2003	128.134	0.011	0	0	0.263	0.273	0	0	0	128.681
2004	127.724	0.013	0	0	0.350	0.273	0	0	0	128.360
2005	127.315	0.014	0	0	0.438	0.273	0	0	0	128.039
2006	126.905	0.015	0	0	0.525	0.273	0	0	0	127.718
2007	126.828	0.026	0	0	0.525	0.273	0	0.001	0	127.654
2008	126.750	0.038	0	0	0.525	0.273	0	0.002	0	127.589
2009	126.673	0.050	0	0	0.525	0.273	0	0.003	0	127.524
2010	126.621	0.061	0	0	0.525	0.248	0	0.004	0	127.459
2011	126.569	0.071	0	0	0.525	0.223	0	0.005	0	127.395
2012	126.517	0.082	0	0	0.525	0.198	0	0.007	0	127.330
2013	126.471	0.111	0	0.010	0.525	0.177	0	0.007	0	127.301
2014	126.424	0.140	0	0.020	0.525	0.156	0	0.007	0	127.272
2015	126.378	0.169	0	0.029	0.525	0.136	0	0.007	0	127.244
2016	126.332	0.198	0	0.039	0.525	0.115	0	0.007	0	127.215
2017	126.285	0.226	0	0.049	0.525	0.094	0	0.007	0	127.186

2018	126.239	0.255	0	0.059	0.525	0.073	0	0.007	0	127.157
2019	126.192	0.284	0	0.068	0.525	0.052	0	0.007	0	127.129
2020	126.146	0.313	0	0.078	0.525	0.031	0	0.007	0	127.100
2021	126.163	0.341	0	0.088	0.438	0.035	0	0.007	0	127.071

FL = forest land, CL = cropland, GL = grassland, WL= wetlands, SL= settlements, OL = other land

Table 6.11. Areas of land remaining in the same land use subcategory (woody cropland remaining woody cropland) and of land converted to woody cropland from other land-use sub-categories.

Year	Woody cropland remaining woody cropland	Land converted to woody cropland from:								Total area
		Annua l CL	Broad. FL	Conif . FL	Grass GL	Woody GL	WL	SL	OL	
	kha									
1990	123.514	0.137	0	0	0	0.002	0	0	0	123.653
1991	123.504	0.274	0	0	0	0.004	0	0	0	123.782
1992	123.495	0.411	0	0	0	0.006	0	0	0	123.912
1993	123.486	0.548	0	0	0	0.008	0	0	0	124.041
1994	123.477	0.685	0	0	0	0.010	0	0	0	124.171
1995	123.467	0.821	0	0	0	0.012	0	0	0	124.300
1996	123.458	0.958	0	0	0	0.014	0	0	0	124.430
1997	123.449	1.095	0	0	0	0.016	0	0	0	124.560
1998	123.439	1.232	0	0	0	0.018	0	0	0	124.689
1999	123.430	1.369	0	0	0	0.020	0	0	0	124.819
2000	123.421	1.506	0	0	0	0.022	0	0	0	124.948
2001	123.024	1.598	0	0	0.007	0.087	0	0.036	0	124.752
2002	122.627	1.689	0	0	0.014	0.153	0	0.073	0	124.555
2003	122.230	1.781	0	0	0.020	0.219	0	0.109	0	124.359
2004	121.833	1.872	0	0	0.027	0.284	0	0.145	0	124.162
2005	121.436	1.964	0	0.001	0.034	0.350	0	0.182	0	123.965
2006	121.038	2.055	0	0.001	0.041	0.416	0	0.218	0	123.769
2007	120.884	2.059	0	0.001	0.041	0.419	0	0.218	0	123.622
2008	120.730	2.063	0	0.001	0.041	0.422	0	0.218	0	123.475
2009	120.576	2.066	0	0.001	0.041	0.426	0	0.218	0	123.328
2010	120.560	1.933	0	0.001	0.041	0.427	0	0.218	0	123.180
2011	120.545	1.800	0	0.001	0.041	0.429	0	0.218	0	123.033
2012	120.529	1.667	0	0.001	0.041	0.430	0	0.218	0	122.886
2013	120.567	1.534	0	0.010	0.041	0.438	0	0.218	0.003	122.811
2014	120.605	1.402	0	0.018	0.042	0.447	0	0.218	0.005	122.737
2015	120.642	1.269	0	0.027	0.042	0.455	0	0.218	0.008	122.662
2016	120.680	1.136	0	0.036	0.042	0.464	0	0.218	0.011	122.587
2017	120.718	1.003	0	0.045	0.043	0.472	0	0.218	0.014	122.512
2018	120.755	0.870	0	0.054	0.043	0.481	0	0.218	0.016	122.438
2019	120.793	0.738	0	0.062	0.043	0.489	0	0.218	0.019	122.363
2020	120.831	0.605	0	0.071	0.044	0.497	0	0.218	0.022	122.288
2021	120.930	0.518	0	0.080	0.037	0.442	0	0.182	0.024	122.213

The decreasing tendency in the area of cropland in Cyprus is consistent with international data provided, i.e., by the World Bank[64].

6.3.4. Methodological issues

The tier 1 method following the guidance contained in the 2006 IPCC Guidelines was applied due to the lack of national data (except activity data). In particular, all stock change factors are the default provided by the 2006 IPCC Guidelines.

[64] http://www.factfish.com/statistic-country/cyprus/permanent+crops+area+of+total+area

Annual cropland remaining annual cropland

By definition this land-use category contains no woody vegetation. Due to the lack of data on changes in management in annual cropland, it is assumed that the management has remained constant since before 1990, hence the annual vegetation component does not affect the GHG sinks and sources on annual basis. It is further assumed that dead wood, litter and soil organic carbon stocks remain unchanged due to the lack of changes in the management of these lands.

Use of fire is not a part of management in lands classified as annual cropland.

Land converted to annual cropland

Lands converted to annual cropland are subject to changes in woody vegetation, dead wood, litter and soil organic carbon. The tier 2 method was implemented to calculate carbon stock changes in living biomass (equation 2.15 of the 2006 IPCC guidelines) and the tier 1 method for the DOM and SOM mineral pools. It should be noted that in the current inventory, carbon stock changes in mineral soils in cropland remaining cropland associated with woody cropland conversions to annual cropland are reported for the first time.

Use of fire is not a part of management in lands classified as lands converted to annual cropland.

Woody cropland remaining woody cropland

Woody cropland differ from annual cropland due to the presence of the woody vegetation (as detected using the CORINE land cover data). However, there is no national data on stock and net annual increment of this type of vegetation. Consequently, the default data provided in Table 5.1 of the 2006 IPCC Guidelines have been used in the GHG sink/source estimation for this land-use sub-category, namely 9 t C ha^{-1} and 1.8 t C $ha^{-1}yr^{-1}$ for above-ground biomass carbon stock and biomass accumulation rate, respectively.

It is further assumed that dead wood, litter and soil organic carbon stocks remain unchanged due to the lack of changes in the management of these lands .

Use of fire is not a part of management in lands classified as woody cropland. Due to the lack of data it is assumed that wild fires do not occur in woody cropland (this assumption is further justified by the fact that woody vegetation is sparse in this land that prevents initiation and propagation of fire).

Land converted to woody cropland

Lands converted to woody cropland are subject to changes in woody vegetation, dead wood, litter and soil organic carbon. The tier 2 method was implemented to calculate carbon stock changes in living biomass (equation 2.15 of the 2006 IPCC guidelines) and the tier 1 method for the DOM and SOM mineral pools. As explained previously, the DOM pool carbon stocks in all non-forest land-use categories were taken equal to zero. It should be noted that in the current inventory, carbon stock changes in mineral soils in cropland remaining cropland associated with annual cropland conversions to woody cropland are reported for the first time.

Use of fire is not a part of management in lands classified as lands converted to woody cropland.

Organic carbon in soil

For estimating carbon stock changes in both cropland remaining cropland and land converted to cropland, formulation B of equation 2.25 of the 2006 IPCC guidelines with the default 20 years transition period was applied. The 2006 IPCC default reference carbon stock for mineral soils and the stock change factors presented in section 6.2.4 were applied, which are also noted in table 6.12 below.

Table 6.12. The IPCC default relative soil organic carbon stock change factors.

Sub-category	Carbon stock change factor	Description
Annual CL & woody CL	Reference SOC_{REF} = 38 t C/ha	High activity soils in tropical dry climate
Annual CL	Land use F_{LU}= 0.58	tropical dry moisture regime, long term annual cultivation
	Tillage F_{MG}= 1.0	full level tillage
	Input F_I= 1.0	medium level residue return for tropical dry climate
Woody CL	Land use F_{LU}= 1.0	all temperature regimes, perennial tree crops
	Tillage F_{MG}= 1.0	full level tillage
	Input F_I= 1.0	medium level residue return for tropical dry climate

N_2O emissions from N mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils

In the current submission, N_2O emissions from N mineralization associated with mineral soil carbon loss as a result of land-use change to cropland are reported for the first time. These emissions are a consequence of the enhanced mineralisation (conversion to inorganic form) of soil organic matter (SOM) that normally takes place as a result of that conversion.

Both direct and indirect N_2O emissions are reported following the tier 1 method of the 2006 IPCC guidelines with default emission factors. More specifically equations 11.1, 11.8 and 11.10 from chapter 11 were applied. The C/N ratio equal to 15 for forest land, grassland and settlements conversions to cropland, the emission factor (EF1) equal to 0.01 kg N_2O-N/kg N for direct N_2O emissions, and the emission factor (EF5) equal to 0.0075 kg N_2O-N/kg N and the $Frac_{LEACH}$ equal to 0.3 for indirect N_2O emissions are applied. N_2O emissions from N mineralization occur due to land conversions to annual cropland only.

6.3.5. Uncertainties and time-series consistency

Uncertainties for the whole inventory period (1990-2021) have been assessed following the error propagation (approach 1) and equations 3.1, 3.2 contained in volume 1 of the 2006 IPCC guidelines. Input uncertainties related to activity data and emission factors have been assessed on the basis of information provided in the 2006 IPCC guidelines and country specific information.

The associated uncertainties with the input data for cropland remaining cropland and land converted to cropland are presented in table 6.9 above and in table 6.13.

Table 6.13. Input data uncertainties.

Input data	%
EF1 (direct N_2O from N mineralization)	82
EF5 (indirect N_2O from leaching/run off)	96
$Frac_{LEACH}$ (indirect N_2O from leaching/run off)	78

The overall uncertainty for cropland land remaining cropland is equal to 67% for CO_2, while for land converted to cropland associated uncertainties equal to 96% and 176% for CO_2 and N_2O emissions, respectively. A more detailed description of the results of the uncertainty analysis is reported in Annex 2.

The time series of GHG emissions/removals for the land-use categories cropland remaining cropland, land converted to annual cropland and land converted to woody cropland is presented in figure 6.5.

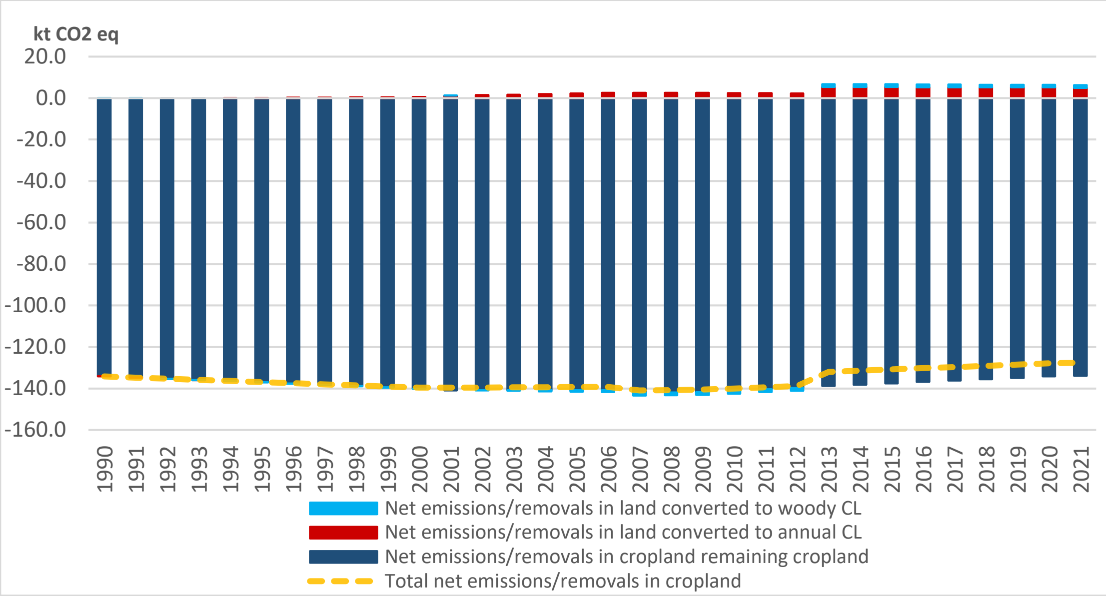


Figure 6.5. Net emissions/removals in cropland category and its subcategories during the period 1990 – 2021 (note: indirect N_2O emissions are included in the net emissions).

6.3.6. Category-specific QA/QC and verification

See paragraph 6.2.6 above.

6.3.7. Category-specific recalculations

Several changes were made in this submission that resulted in the recalculated estimates in cropland. In addition to the relevant changes noted in section 6.2.7, these include:

- The complete revision of the land representation as noted in section 6.1.1, which led to revised area estimates in cropland remaining cropland and land converted to cropland.
- Carbon stock changes in mineral soils in cropland remaining cropland are reported for the first time in this submission.
- Corrected the methodology in estimating carbon losses in living biomass in forest land converted to cropland. Previously, a 20 years conversion period was applied to carbon losses due to land use change. In this inventory the living biomass carbon loss is attributed to the certain year of land-use change.
- In land converted to cropland (annual), the biomass stock after conversion is taken equal to 5 t C ha^{-1} in accordce with the default value of the 2006 IPCC guidelines.
- Carbon stock changes in dead wood in forest land converted to cropland are estimated for the first time using default dead wood stocks from the 2019 IPCC Refinement.

6.3.8. Category-specific planned improvements

The improvements considered related to this category include:

- The applicability of default biomass data for woody cropland (stocks and growth) provided in the 2006 IPCC Guidelines should be further examined. In particular, the default data result in carbon stock changes comparable to those of forest land, which is unlikely for the national circumstances. Therefore, it is needed to either investigate options for developing national data or using regional data that represent more accurately the national circumstances.

- Investigate options for developing data on management and management changes in cropland areas (annual cropland and woody cropland), such as tillage and input application, rotation cycles, etc.
- Analyse further the CORINE data sets together with additional country data sources in order to refine equilibrium carbon stocks in mineral soils in cropland.

6.4. Grassland (4C)

6.4.1. Description

6.4.2. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The approach for representing land areas and land use databases is described in Chapter 6.1.1 “Information on approaches used for representing land areas and on land-use databases used for the inventory preparation”.

6.4.3. Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

Land-use definitions are provided in Chapter 6.1.2.2 “The land-use categories for greenhouse gas inventory reporting”.

Table 6.14 presents numerical data on the area of grass grassland remaining grass grassland and of land converted to grass grassland in the period 1990–2021. Note that no conversions from broadleaved forests, wetlands, settlements and other land to grass grassland occur during the whole inventory period.

Table 6.14. Areas of land remaining in the same land use subcategory (grass grassland remaining grass grassland) and of land converted to grass grassland from other land-use sub-categories.

Year	Grass grassland remaining grass grassland	Land converted to grass grassland from:								Total area
		Woody GL	Broad. FL	Conif. FL	Annual CL	Woody CL	WL	SL	OL	
	kha									
1990	24.451	0.040	0	0	0.132	0.000	0	0	0	24.623
1991	24.451	0.081	0	0	0.264	0.001	0	0	0	24.796
1992	24.451	0.121	0	0	0.395	0.001	0	0	0	24.968
1993	24.451	0.161	0	0	0.527	0.001	0	0	0	25.141
1994	24.451	0.202	0	0	0.659	0.002	0	0	0	25.313
1995	24.451	0.242	0	0	0.791	0.002	0	0	0	25.485
1996	24.451	0.282	0	0	0.923	0.002	0	0	0	25.658
1997	24.451	0.323	0	0	1.054	0.003	0	0	0	25.830
1998	24.451	0.363	0	0	1.186	0.003	0	0	0	26.003
1999	24.451	0.403	0	0	1.318	0.003	0	0	0	26.175
2000	24.451	0.444	0	0	1.450	0.004	0	0	0	26.348
2001	24.232	0.444	0	0	1.450	0.004	0	0	0	26.129
2002	24.012	0.444	0	0	1.450	0.004	0	0	0	25.909
2003	23.793	0.444	0	0	1.450	0.004	0	0	0	25.690
2004	23.574	0.444	0	0	1.450	0.004	0	0	0	25.471
2005	23.355	0.444	0	0	1.450	0.004	0	0	0	25.252
2006	23.135	0.444	0	0	1.450	0.004	0	0	0	25.032
2007	23.073	0.444	0	0	1.450	0.004	0	0	0	24.970
2008	23.011	0.444	0	0	1.450	0.004	0	0	0	24.908
2009	22.949	0.444	0	0	1.450	0.004	0	0	0	24.846

2010	23.059	0.403	0	0	1.318	0.003	0	0	0	24.783
2011	23.169	0.363	0	0	1.186	0.003	0	0	0	24.721
2012	23.279	0.323	0	0	1.054	0.003	0	0	0	24.659
2013	23.431	0.476	0	0.005	0.923	0.002	0	0	0	24.836
2014	23.582	0.629	0	0.010	0.791	0.002	0	0	0	25.014
2015	23.733	0.782	0	0.015	0.659	0.002	0	0	0	25.191
2016	23.884	0.936	0	0.020	0.527	0.001	0	0	0	25.369
2017	24.036	1.089	0	0.025	0.395	0.001	0	0	0	25.546
2018	24.187	1.242	0	0.030	0.264	0.001	0	0	0	25.724
2019	24.338	1.396	0	0.035	0.132	0.000	0	0	0	25.901
2020	24.489	1.549	0	0.040	0.000	0.000	0	0	0	26.078
2021	24.468	1.743	0	0.045	0.000	0.000	0	0	0	26.256

FL = forest land, CL = cropland, GL = grassland, WL= wetlands, SL= settlements, OL = other land

Table 6.15 presents the same information for the case of woody grassland for the period 1990–2021. Note that no conversions from broadleaved forests, wetlands and other land to woody grassland occur during the whole inventory period .

Table 6.15. Areas of land remaining in the same land use subcategory (woody grassland remaining woody grassland) and of land converted to woody grassland from other land-use sub-categories.

Year	Woody grassland remaining woody grassland	Land converted to woody grassland from:								Total area
		Grass GL	Broad. FL	Conif . FL	Annua l CL	Woody CL	W L	SL	OL	
	kha									
1990	106.959	0	0	0.000	0.035	0.003	0	0	0	106.997
1991	106.873	0	0	0.001	0.070	0.007	0	0	0	106.950
1992	106.787	0	0	0.001	0.105	0.010	0	0	0	106.903
1993	106.701	0	0	0.001	0.140	0.014	0	0	0	106.856
1994	106.615	0	0	0.001	0.175	0.017	0	0	0	106.808
1995	106.529	0	0	0.002	0.209	0.021	0	0	0	106.761
1996	106.443	0	0	0.002	0.244	0.024	0	0	0	106.714
1997	106.357	0	0	0.002	0.279	0.028	0	0	0	106.667
1998	106.272	0	0	0.003	0.314	0.031	0	0	0	106.619
1999	106.186	0	0	0.003	0.349	0.034	0	0	0	106.572
2000	106.100	0	0	0.003	0.384	0.038	0	0	0	106.525
2001	105.837	0	0	0.003	0.384	0.038	0	0	0	106.263
2002	105.575	0	0	0.003	0.384	0.038	0	0	0	106.000
2003	105.312	0	0	0.003	0.384	0.038	0	0	0	105.738
2004	105.050	0	0	0.003	0.384	0.038	0	0	0	105.475
2005	104.788	0	0	0.003	0.384	0.038	0	0	0	105.213
2006	104.525	0	0	0.003	0.384	0.038	0	0	0	104.950
2007	104.452	0.043	0	0.003	0.384	0.038	0	0.006	0	104.927
2008	104.379	0.086	0	0.003	0.384	0.038	0	0.013	0	104.903
2009	104.306	0.129	0	0.003	0.384	0.038	0	0.019	0	104.879
2010	104.272	0.171	0	0.003	0.349	0.034	0	0.025	0	104.855
2011	104.238	0.214	0	0.003	0.314	0.031	0	0.032	0	104.832
2012	104.203	0.257	0	0.002	0.279	0.028	0	0.038	0	104.808
2013	103.967	0.278	0	0.002	0.244	0.036	0	0.038	0	104.566
2014	103.731	0.299	0	0.002	0.209	0.044	0	0.038	0	104.323
2015	103.495	0.320	0	0.001	0.175	0.052	0	0.038	0	104.081
2016	103.259	0.340	0	0.001	0.140	0.060	0	0.038	0	103.839
2017	103.023	0.361	0	0.001	0.105	0.069	0	0.038	0	103.596
2018	102.787	0.382	0	0.001	0.070	0.077	0	0.038	0	103.354
2019	102.551	0.403	0	0.000	0.035	0.085	0	0.038	0	103.112
2020	102.315	0.424	0	0.000	0.000	0.093	0	0.038	0	102.870
2021	102.040	0.444	0	0.000	0.000	0.105	0	0.038	0	102.627

FL = forest land, CL = cropland, GL = grassland, WL= wetlands, SL= settlements, OL = other land

6.4.4. Methodological issues

A combination of tier 1 and tier 2 methods with country-specific information and default data following the guidance contained in the 2006 IPCC guidelines is applied in the grassland category.

Grass grassland remaining grass grassland

By definition this land-use category contains no woody vegetation, therefore biomass carbon stocks are taken equal to zero, and following the tier 1 method, carbon stock changes are assumed to be zero. The tier 1 method is applied for the DOM pool, thus carbon stock changes in litter and dead wood pools are considered to be zero. Regarding the SOM mineral pool, grassland areas in Cyprus do not experience significant management changes, consequently, carbon stock changes are assumed to be zero without introducing significant error.

The use of fire is not a part of management in lands classified as grass grassland.

Land converted to grass grassland

Lands converted to grass grassland are subject to changes in biomass when the land before the conversion had woody vegetation, dead wood, litter and soil organic carbon. The tier 2 method is implemented to calculate carbon stock changes in living biomass (equation 2.15 of the 2006 IPCC guidelines) and the tier 1 method for the DOM and SOM mineral pools. The living biomass carbon stocks of grass grassland after the conversion is taken equal to zero, and in the cases where woody vegetation existed in the previous land-use category (e.g., forest land), carbon stock changes are estimated by accounting the loss of total biomass stocks in the year of conversion. The total carbon loss in the year of conversion is applied in the DOM pool as well, where in the previous land-use category the DOM pool was not zero (e.g. forest land). It is noted, that in this submission dead wood carbon stock changes due to forest land conversion to grass grassland are estimated for the first time. Regarding the SOM pool, in the particular case of changes between grass grassland and woody grassland, carbon stock changes are estimated to be equal to zero since both sub-categories are associated with the same carbon stock equilibrium levels (i.e. 38 t C/ha). With regard to carbon stock changes in SOM in land-use conversions to grass grassland other than from woody grassland, these are estimated using the tier 1 method from 2006 IPCC guidelines by applying formulation B of equation 2.25 of the 2006 IPCC guidelines with the default 20 years transition period and the reference carbon stocks and stock change factors that have already been presented in section 6.2.4 and 6.3.4 for the respective land-use categories.

Use of fire is not a part of management in lands classified as lands converted to grass grassland.

Woody grassland remaining woody grassland

Woody grassland differs from the gass grassland due to the presence of the woody vegetation (as detected using the CORINE land cover data). A country-specific net annual increment value is applied in estimating carbon stock changes in living biomass equal to 0.2 $m^3ha^{-1}yr^{-1}$ (for *Quercus alnifolia*) with default $BCEF_I$ (0.5 for hardwoods related to 21-40 growing stock level) and root-shoot ratio (i.e., 0.28) values. The tier 1 method is applied for the DOM pool, thus carbon stock changes in litter and dead wood pools are considered to be zero. Regarding the SOM mineral pools, grassland areas in Cyprus do not experience significant management changes, consequently, carbon stock changes are assumed to be zero.

Use of fire is not a part of management in lands classified as woody grassland. Furthermore, due to the lack of data, it is further assumed that wild fires do not occur on woody grassland (this assumption is further justified by the fact that woody vegetation is sparse in this land that prevents initiation and propagation of fire).

Land converted to woody grassland

Lands converted to woody grassland are subject to changes in biomass when the land before the conversion had woody vegetation, dead wood, litter and soil organic carbon. The tier 2 method is implemented to calculate carbon stock changes in living biomass (equation 2.15 of the 2006 IPCC guidelines) and the tier 1 method for the DOM and SOM mineral pools. In the cases where woody vegetation existed in the previous land-use category (e.g., forest land), carbon stock changes are estimated by accounting the loss of total biomass stocks in the year of conversion. The total carbon loss in the year of conversion is applied in the DOM pool as well, where in the previous land-use category the DOM pool was not zero (e.g. forest land). It is noted, that in this submission dead wood carbon stock changes due to forest land conversion to woody grassland are estimated for the first time. Regarding the SOM pool, in the particular case of changes between grass grassland and woody grassland, carbon stock changes are estimated to be equal to zero since both sub-categories are associated with the same carbon stock equilibrium levels (i.e. 38 t C/ha). With regard to carbon stock changes in SOM in land-use conversions to woody grassland other than from grass grassland, these are estimated using the tier 1 method from 2006 IPCC guidelines by applying formulation B of equation 2.25 of the 2006 IPCC guidelines with the default 20 years transition period and the reference carbon stocks and stock change factors that have already been presented in section 6.2.4 and 6.3.4 for the respective land-use categories

Use of fire is not a part of management in lands classified as lands converted to woody grassland.

6.4.5. Uncertainties and time-series consistency

Uncertainties for the whole inventory period (1990-2021) have been assessed following the error propagation (approach 1) and equations 3.1, 3.2 contained in volume 1 of the 2006 IPCC guidelines. Input uncertainties related to activity data and emission factors have been assessed on the basis of information provided in the 2006 IPCC guidelines and country specific information.

The associated uncertainties with the input data for grassland remaining grassland and land converted to grassland are presented in table 6.9 above.

The overall uncertainty for grassland remaining grassland is equal to 38% for CO_2, while for land converted to grassland associated uncertainties equal to 52% for CO_2. A more detailed description of the results of the uncertainty analysis is reported in Annex 2.

Figure 6.6 presents the emissions/removals time series for the grassland category for the period 1990–2021.

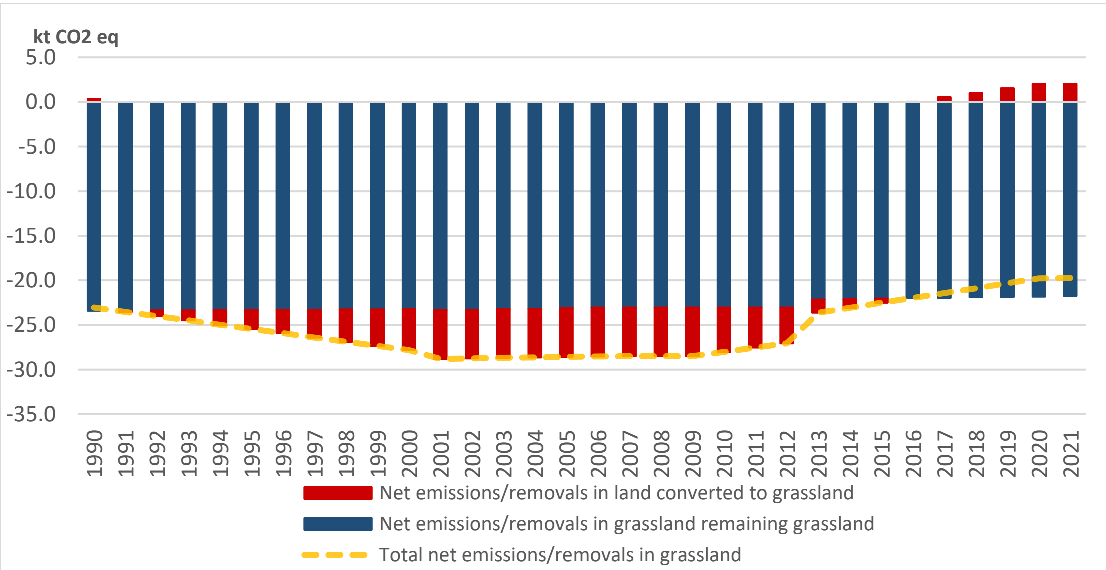


Figure 6.6. Net emissions/removals in grassland remaining grassland and land converted to grassland subcategories during the period 1990 – 2021

6.4.6. Category-specific QA/QC and verification

See paragraph 6.2.6 above.

6.4.7. Category-specific recalculations

Several changes were made in this submission that resulted in the recalculated estimates in grassland. In addition to the relevant changes noted in section 6.2.7, these include:

- The complete revision of the land representation as noted in section 6.1.1, which led to revised area estimates in grassland remaining grassland and land converted to grassland.
- A country-specific net annual increment is applied for woody grassland. Previously, the growth rate and biomass carbon stocks of perennial cropland were applied for the woody grassland subcategory.
- The DOM pool in both grass and woody grassland is considered equal to zero in this inventory while previously the litter pool in woody grassland was assumed 10% of the forest land.
- The methodology has been improved in order to include carbon stock changes in living biomass from changes between grass and woody grassland in the grassland remaing grassland subcategory.
- Corrected the methodology in estimating carbon losses in living biomass in land converted to grassland. Previously, a 20 years conversion period was applied to carbon losses due to land use change. In this inventory living biomass carbon losses due to land-use change are attributed to the certain year of land-use change.
- Carbon stock changes in dead wood in forest land converted to grassland are estimated for the first time using default dead wood stocks from the 2019 IPCC Refinement.

6.4.8. Category-specific planned improvements

The improvements considered related to this category include:

- Continue the land monitoring for detecting fires that may affect areas with woody grassland vegetation.
- Investigate further the net annual increment for woody grassland by exploring additional data sources.

6.5. Wetlands (4D)

6.5.1. Description[65]

Even though many wetlands in Cyprus are known to the public and can be visited, information about their condition and their total number was, until recently, scattered or even non-existent. In order to tackle this lack of knowledge and decentralised information, Terra Cypria, a local environmental NGO[66], conducted a complete Inventory of Cyprus Wetlands[67] using a Rapid Assessment methodology during a two-year period (2014–2015). This effort was funded by the MAVA Fondation pour la Nature. During the course of the project, all wetlands in Cyprus with an area >1.000 m^2 (0.1 ha) were visited and recorded – with the exception of those located within military zones, which were included in the inventory but not visited. The total number of 373 areas have been identified as meeting the qualification criteria set for wetlands outlined in the RAMSAR Convention and MedWet's guidelines; 315 wetlands are artificial and 58 natural (Figure 6.7).
Many of the island's wetlands are in continuous degradation, facing various pressures. The main causes that have been identified leading to degradation according to the team that conducted the research were: i) development pressures from the housing and tourist industry (especially on coastal areas), ii) dam construction halting water supply at downstream wetlands, iii) lack of specific legislation targeting the protection of wetland biodiversity, iv) unsatisfactory implementation of existing legislation which offers

[65] Zotos S., L. Sergides, A. Papatheodoulou; 2019. Conservation of the Island Wetlands of the Mediterranean Basin "Mediterranean Island Wetlands" project; The wetlands of Cyprus technical report; available on https://mava-foundation.org/wp-content/uploads/2020/07/Final-Inventory-Report-final-20.3.20-3-compressed.pdf (accessed 14/2/2021)
[66] https://terracypria.org/
[67] www.cypruswetlands.org

direct or indirect protection at specific wetlands and v) lack of knowledge from some government departments and citizens regarding the presence, importance and value of wetlands.

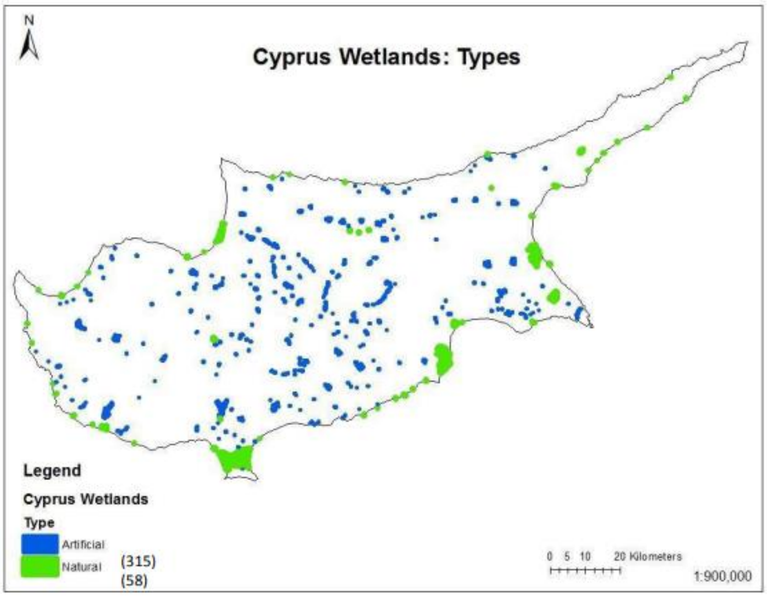


Figure 6.7. Map of Cyprus, indicating the 373 wetlands identified and studied during the "Inventory of Cyprus Wetlands" project.

Most of the natural wetlands are estuaries (68%) followed by marsh/swamps (16%). The rest of the natural wetlands (16%) are divided in four categories including wetlands systems, lakes, salt lakes and lagoons (Figure 6.8).

Almost half of artificial wetlands (48%) are river recharge barriers and reservoirs. One third (28%) are ponds (earth or concrete made). The rest of the artificial wetlands (24%) are divided into seven categories including mine ponds, membrane covered ponds, quarry ponds, tertiary treated waters, off-stream ponds, excavations ponds and wastewater treatment pools (figure 6.9).

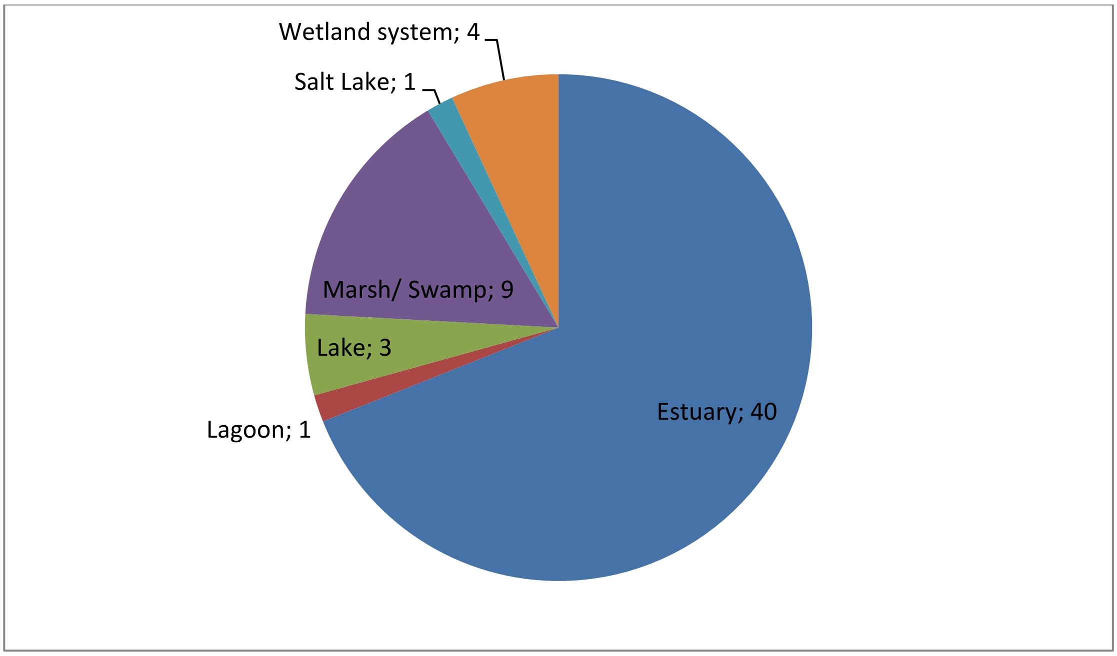


Figure 6.8. Categories of natural wetlands in Cyprus

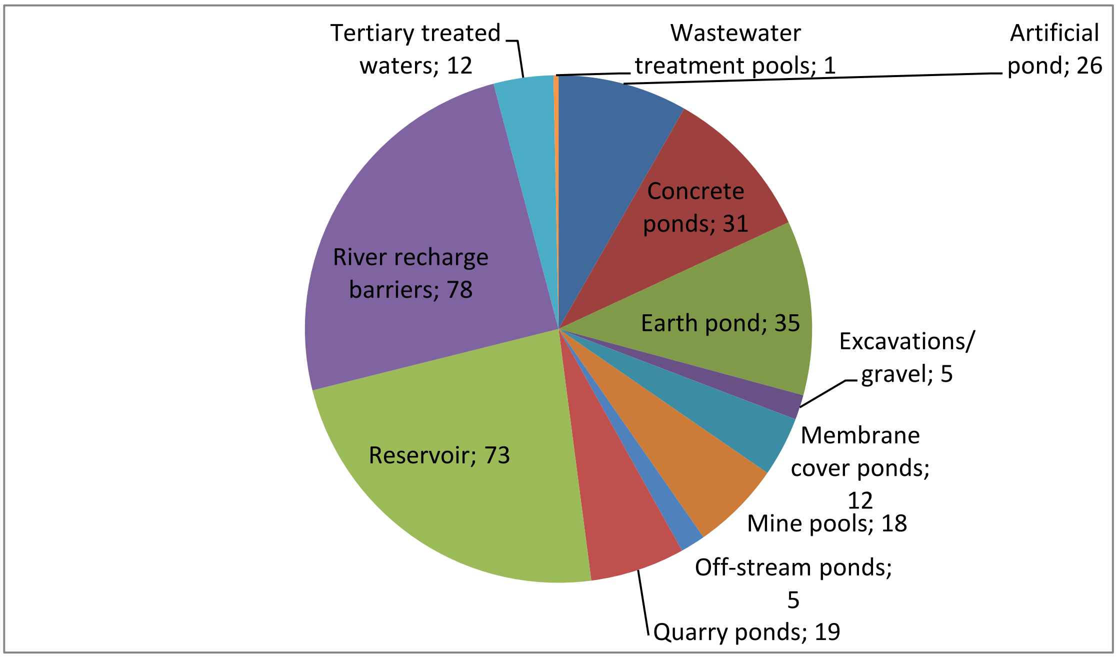


Figure 6.9. Categories of artificial wetlands in Cyprus

6.5.2. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

Approach for representing land areas and land use databases are described in Chapter 6.1.1 "Information on approaches used for representing land areas and on land-use databases used for the inventory preparation".

6.5.3. Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

Land-use definitions are provided in Chapter 6.1.2.2 “The land-use categories for greenhouse gas inventory reporting”.

Error! Reference source not found.6 provides data on area of wetlands remaining wetlands and of lands converted to wetlands during the period 1990–2021.

Table 6.16. Areas of land remaining in the same land use subcategory (wetlands remaining wetlands) and of land converted to wetlands from other land-use sub-categories.

Year	Wetlands remaining wetlands	Land converted to wetlands from:								Total area
		Broad. FL	Conif. FL	Annua l CL	Woody CL	Grass GL	Woody GL	SL	OL	
	kha									
1990	3.977	0	0	0	0	0	0	0	0	3.977
1991	3.977	0	0	0	0	0	0	0	0	3.977
1992	3.977	0	0	0	0	0	0	0	0	3.977
1993	3.977	0	0	0	0	0	0	0	0	3.977
1994	3.977	0	0	0	0	0	0	0	0	3.977
1995	3.977	0	0	0	0	0	0	0	0	3.977
1996	3.977	0	0	0	0	0	0	0	0	3.977
1997	3.977	0	0	0	0	0	0	0	0	3.977
1998	3.977	0	0	0	0	0	0	0	0	3.977
1999	3.977	0	0	0	0	0	0	0	0	3.977
2000	3.977	0	0	0	0	0	0	0	0	3.977
2001	3.975	0	0	0	0	0	0	0	0	3.975
2002	3.972	0	0	0	0	0	0	0	0	3.972
2003	3.970	0	0	0	0	0	0	0	0	3.970
2004	3.968	0	0	0	0	0	0	0	0	3.968
2005	3.966	0	0	0	0	0	0	0	0	3.966
2006	3.963	0	0	0	0	0	0	0	0	3.963
2007	3.957	0	0.006	0	0	0	0	0.009	0	3.972
2008	3.951	0	0.012	0	0	0	0	0.017	0	3.980
2009	3.945	0	0.018	0	0	0	0	0.026	0	3.989
2010	3.939	0	0.024	0	0	0	0	0.034	0	3.997
2011	3.933	0	0.030	0	0	0	0	0.043	0	4.005
2012	3.927	0	0.036	0	0	0	0	0.052	0	4.014
2013	3.927	0	0.041	0	0	0	0.001	0.053	0	4.021
2014	3.927	0	0.046	0	0	0	0.001	0.054	0	4.028
2015	3.927	0	0.051	0	0	0	0.002	0.055	0	4.035
2016	3.927	0	0.057	0	0	0	0.003	0.056	0	4.042
2017	3.927	0	0.062	0	0	0	0.004	0.057	0	4.049
2018	3.927	0	0.067	0	0	0	0.004	0.058	0	4.056
2019	3.927	0	0.073	0	0	0	0.005	0.059	0	4.063
2020	3.927	0	0.078	0	0	0	0.006	0.059	0	4.070
2021	3.927	0	0.083	0	0	0	0.006	0.060	0	4.077

FL = forest land, CL = cropland, GL = grassland, WL= wetlands, SL= settlements, OL = other land

6.5.4. Methodological issues

Wetlands remaining wetlands

In Cyprus, peat extraction does not occur.

2006 IPCC guidelines do not provide methodologies for estimating emissions/removals from wetlands remaining wetlands (other than peat extraction), thus associated emissions and removals have not been estimated and in this context the ‘NE’ notation key is used in CRF table 4.D for all carbon pools and relevant information is reported in CRF table 9.

Land converted to wetlands

For lands converted wetlands, the 2006 IPCC guidelines provide methodology for estimating carbon stock changes only in the living biomass pool, when land is converted to flooded land. The tier 1 method is followed, with the living biomass carbon stocks after the conversion assumed to be zero, and in the cases where woody vegetation existed in the previous land-use category (e.g., forest land), carbon stock changes are estimated by accounting a total loss of biomass stocks in the year of conversion.

For the DOM, and SOM mineral pools, the 2006 IPCC guidelines do not provide methodologies for estimating associated emissions/removals thus the ‘NE’ notation key is used in CRF table 4.D for these carbon pools and relevant information is reported in CRF table 9.

6.5.5. Uncertainties and time-series consistency

Uncertainties for the whole inventory period (1990-2021) have been assessed following the error propagation (approach 1) and equations 3.1, 3.2 contained in volume 1 of the 2006 IPCC guidelines. Input uncertainties related to activity data and emission factors have been assessed on the basis of information provided in the 2006 IPCC guidelines and country specific information.

The associated uncertainties with the input data for land converted to wetlands are presented in table 6.9 above.

The overall uncertainty for land converted to wetlands is equal to 52% for CO_2. A more detailed description of the results of the uncertainty analysis is reported in Annex 2..

Figure 6.10 presents the total net emissions/removals time series for the land converted to wetlands for the period 1990–2021.

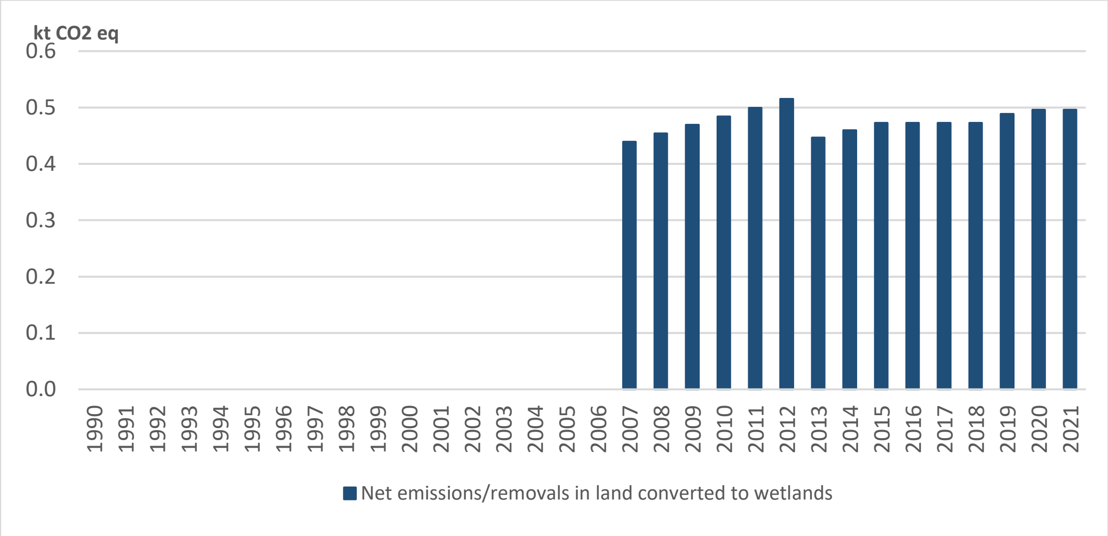


Figure 6.10. Net emissions/removals in land converted to wetlands during the period 1990 – 2021.

6.5.6. Category-specific QA/QC and verification

See para 6.2.6 above.

6.5.7. Category-specific recalculations

Several changes were made in this submission that resulted in the recalculated estimates in wetlands. In addition to the relevant changes noted in section 6.2.7, these include:

- The complete revision of the land representation as noted in section 6.1.1, which led to revised area estimates in wetlands remaining wetlands and land converted to wetlands.
- In the current inventory carbon stock changes are reported only for the carbon pools for which methodologies are provided by the 2006 IPCC guidelines, namely the living biomass in land converted to wetlands (flooded land). With regard to the SOM mineral pool in particular, in previous submissions the wetlands land-use was associated with wetland soils. However, in the current submission all country area regardless the land-use category is considered to be mineral high activity clay soils.

6.5.8. Category-specific planned improvements

There are not any improvements planned for this category.

6.6. Settlements (4E)

6.6.1. Description

6.6.2. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The approach for representing land areas and land use databases are described in Chapter 6.1.1 "Information on approaches used for representing land areas and on land-use databases used for the inventory preparation".

6.6.3. Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

Land-use definitions are provided in Chapter 6.1.2.2 "The land-use categories for greenhouse gas inventory reporting". Table 6.17 provides data on area of settlements remaining settlements and lands converted to settlements during the period 1990–2021.

Table 6.17. Areas of land remaining in the same land use subcategory (settlements remaining settlements) and of land converted to settlements from other land-use sub-categories.

Year	Settlements remaining settlements	Land converted to settlements from:								Total area
		Broad. FL	Conif. FL	Annua l CL	Woody CL	Grass GL	Woody GL	WL	OL	
	kha									
1990	48.871	0	0	0.019	0.003	0	0.008	0	0	48.902
1991	48.871	0	0	0.039	0.005	0	0.016	0	0	48.932
1992	48.871	0	0	0.058	0.008	0	0.024	0	0	48.962
1993	48.871	0	0	0.078	0.011	0	0.033	0	0	48.992
1994	48.871	0	0	0.097	0.014	0	0.041	0	0	49.023
1995	48.871	0	0	0.117	0.016	0	0.049	0	0	49.053
1996	48.871	0	0	0.136	0.019	0	0.057	0	0	49.083
1997	48.871	0	0	0.155	0.022	0	0.065	0	0	49.113
1998	48.871	0	0	0.175	0.024	0	0.073	0	0	49.144
1999	48.871	0	0	0.194	0.027	0	0.081	0	0	49.174

2000	48.871	0	0	0.214	0.030	0	0.089	0	0	49.204
2001	48.810	0.001	0.008	0.532	0.426	0.117	0.286	0.002	0	50.183
2002	48.749	0.003	0.017	0.850	0.821	0.234	0.483	0.005	0	51.161
2003	48.688	0.004	0.025	1.168	1.217	0.350	0.680	0.007	0	52.139
2004	48.627	0.005	0.034	1.486	1.613	0.467	0.877	0.009	0	53.118
2005	48.566	0.006	0.042	1.804	2.009	0.584	1.073	0.011	0	54.096
2006	48.505	0.008	0.051	2.122	2.405	0.701	1.270	0.014	0	55.075
2007	48.470	0.008	0.051	2.195	2.548	0.718	1.340	0.020	0	55.350
2008	48.435	0.008	0.051	2.269	2.690	0.736	1.409	0.026	0	55.624
2009	48.400	0.008	0.051	2.343	2.833	0.754	1.479	0.032	0	55.899
2010	48.396	0.008	0.051	2.397	2.973	0.771	1.540	0.038	0	56.174
2011	48.391	0.008	0.051	2.451	3.113	0.789	1.602	0.044	0	56.448
2012	48.387	0.008	0.051	2.505	3.253	0.806	1.663	0.050	0	56.723
2013	48.404	0.008	0.051	2.550	3.264	0.806	1.696	0.050	0	56.829
2014	48.421	0.008	0.051	2.594	3.275	0.806	1.729	0.050	0	56.934
2015	48.438	0.008	0.051	2.639	3.287	0.806	1.762	0.050	0	57.040
2016	48.455	0.008	0.051	2.684	3.298	0.806	1.795	0.050	0	57.146
2017	48.471	0.008	0.051	2.728	3.309	0.806	1.828	0.050	0	57.252
2018	48.488	0.008	0.051	2.773	3.320	0.806	1.860	0.050	0	57.357
2019	48.505	0.008	0.051	2.817	3.331	0.806	1.893	0.050	0	57.463
2020	48.522	0.008	0.051	2.862	3.343	0.806	1.926	0.050	0	57.569
2021	49.549	0.006	0.042	2.608	2.961	0.689	1.771	0.048	0	57.674

FL = forest land, CL = cropland, GL = grassland, WL= wetlands, SL= settlements, OL = other land

6.6.4. Methodological issues

In Cypriot conditions the settlements land-use category contains all developed land, including transportation infrastructure and human settlements of any size. In particular, it contains: industrial and commercial units, urban areas, port areas, airports, construction, mineral extraction and waste dump sites. Urban areas contain densely and sparsely populated areas (e.g. cities and villages). The category also includes lands covered with woody vegetation typical for inhabited areas that were not classified as forest, woody cropland and woody grassland. It also includes lands containing annual vegetation present in urban areas.

Settlements remaining settlements

The tier 1 assumption of the 2006 IPCC guidelines that carbon stock changes in living biomass, dead wood, litter and SOM mineral pools are zero is applied.

Land converted to settlements

Lands converted to settlements are subject to changes in woody vegetation, dead wood, litter and soil organic carbon. The tier 2 method was implemented to calculate carbon stock changes in living biomass (equation 2.15 of the 2006 IPCC guidelines) and the tier 1 method for the DOM and SOM mineral pools. It should be noted that in the current inventory, carbon stocks in dead wood and litter in settlements after the conversion are taken equal to zero. Furthermore, both the living biomass and DOM stocks that were present before the conversion are assumed to be totally lost in the year of conversion as a result of the land-use change.

For estimating carbon stock changes in SOM mineral, formulation B of equation 2.25 of the 2006 IPCC guidelines with the default 20 years transition period was applied. In the current inventory, the carbon stock equilibrium level of settlements is taken equal to 80% of the reference carbon stocks, following the tier 1 assumption, while in the previous inventories the 83.4% of the reference carbon stocks was applied based on assumptions. However, until further analysis is done on these assumptions, it has been decided to use the tier 1 value instead. The stock change factors that are applied for the respective land-use categories converted to settlements are the ones presented in section 6.2.4.

Use of fire is not a part of management in lands classified as lands converted to settlements.

N_2O emissions from N mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils

In the current submission, N_2O emissions from N mineralization associated with mineral soil carbon loss as a result of land-use change to settlements are reported for the first time. These emissions are a consequence of the enhanced mineralisation (conversion to inorganic form) of soil organic matter (SOM) that normally takes place as a result of that conversion.

Both direct and indirect N_2O emissions are reported following the tier 1 method of the 2006 IPCC guidelines with default emission factors. More specifically equations 11.1, 11.8 and 11.10 from chapter 11 were applied. The C/N ratio equal to 15 for forest land and grassland conversions to settlements, the C/N ratio equal to 10 for cropland conversions to settlements, the emission factor (EF1) equal to 0.01 kg N_2O-N/kg N for direct N_2O emissions, and the emission factor (EF5) equal to 0.0075 kg N_2O-N/kg N and the $Frac_{LEACH}$ equal to 0.3 for indirect N_2O emissions are applied.

6.6.5. Uncertainties and time-series consistency

Uncertainties for the whole inventory period (1990-2021) have been assessed following the error propagation (approach 1) and equations 3.1, 3.2 contained in volume 1 of the 2006 IPCC guidelines. Input uncertainties related to activity data and emission factors have been assessed on the basis of information provided in the 2006 IPCC guidelines and country specific information.

The associated uncertainties with the input data for land converted to settlements are presented in table 6.9 and in table 6.13 above.

The overall uncertainty for land converted to settlements equals to 350% and 380% for CO_2 and N_2O emissions, respectively. A more detailed description of the results of the uncertainty analysis is reported in Annex 2.

The time series of GHG emissions/removals for land converted to settlements is presented in figure 6.11.

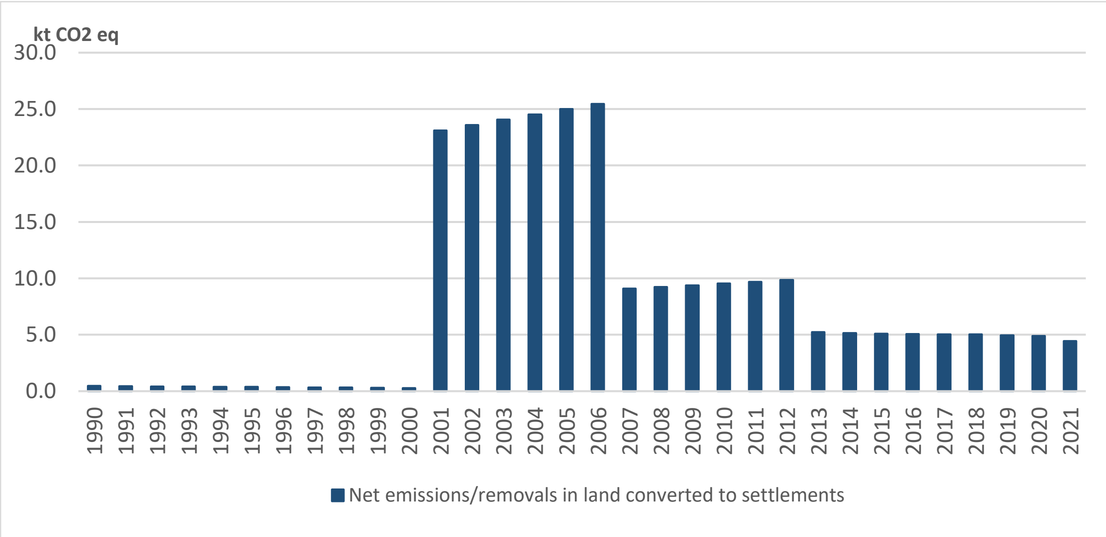


Figure 6.11. Net emissions/removals in land converted to settlements during the period 1990 – 2021 (note: indirect N_2O emissions are included in the net emissions)

Figure 6.11 presents the total net emissions/removals time series for land converted to settlements during the period 1990–2021.

6.6.6. Category-specific QA/QC and verification

See para 6.2.6 above.

6.6.7. Category-specific recalculations

Several changes were made in this submission that resulted in the recalculated estimates in settlements. In addition to the relevant changes noted in section 6.2.7, these include:

- The complete revision of the land representation as noted in section 6.1.1, which led to revised area estimates in settlements remaining settlements and land converted to settlements.
- Carbon stock changes in dead wood in forest land converted to settlements are estimated for the first time using default dead wood stocks from the 2019 IPCC Refinement.
- Corrected the methodology in estimating carbon losses in living biomass in forest land converted to settlements. Previously, a 20 years conversion period was applied to carbon losses due to land use change. In this inventory living biomass carbon losses due to land-use change are attributed to the certain year of land-use change.
- In the previous inventory carbon stock changes in litter and SOM mineral pools in wetlands converted to settlements were reported, while in the current inventory carbon stock changes in these pools in this type of land-use change are not estimated since the 2006 IPCC guidelines do not provide methodology and data for wetlands.
- In the previous inventory the litter stocks after conversion to settlements were not taken equal to zero following the tier 1 assumption. In the current submission, DOM stocks in all non-forest land uses are assumed equal to zero.

6.6.8. Category-specific planned improvements

The improvements considered related to this category include:

- Investigate alternative data sources in order to refine the equilibrium carbon stocks in mineral soils in settlements.
- Investigate options for estimating carbon stock changes in living biomass in settlements remaining settlements and apply tier 2 of the 2006 IPCC guidelines.

6.7. Other land (4F)

6.7.1. Description

This land-use category includes bare soil, rock, beaches, dunes and sand plains and all land areas that couldn’t be classified into any of the other five land-use categories by means of interpretation of the CORINE land cover data. It also allows the total of identified land areas to match the national area, i.e. to retain the entire Cyprus area unchanged among the reported years.

6.7.2. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The approach for representing land areas and land use databases are described in Chapter 6.1.1 “Information on approaches used for representing land areas and on land-use databases used for the inventory preparation”.

6.7.3. Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

Land-use definitions are provided in Chapter 6.1.2.2 “The land-use categories for greenhouse gas inventory reporting”.

Table 6.18 presents numerical data on the area of other land remaining other land and of land converted to other land in the period 1990–2021.

Table 6.18. Areas of land remaining in the same land use subcategory (other land remaining other land) and of land converted to other land from other land-use sub-categories.

Year	Other land remaining other land	Land converted to other land from:								Total area
		Broad. FL	Conif. FL	Annual CL	Woody CL	Grass GL	Woody GL	WL	SL	
	kha									
1990	2.915	0	0	0	0.002	0	0.002	0	0	2.919
1991	2.915	0	0	0	0.004	0	0.004	0	0	2.923
1992	2.915	0	0	0	0.006	0	0.006	0	0	2.927
1993	2.915	0	0	0	0.008	0	0.008	0	0	2.931
1994	2.915	0	0	0	0.011	0	0.010	0	0	2.936
1995	2.915	0	0	0	0.013	0	0.012	0	0	2.940
1996	2.915	0	0	0	0.015	0	0.014	0	0	2.944
1997	2.915	0	0	0	0.017	0	0.017	0	0	2.948
1998	2.915	0	0	0	0.019	0	0.019	0	0	2.952
1999	2.915	0	0	0	0.021	0	0.021	0	0	2.957
2000	2.915	0	0	0	0.023	0	0.023	0	0	2.961
2001	2.915	0	0	0	0.023	0	0.023	0	0	2.961
2002	2.915	0	0	0	0.023	0	0.023	0	0	2.961
2003	2.915	0	0	0	0.023	0	0.023	0	0	2.961
2004	2.915	0	0	0	0.023	0	0.023	0	0	2.961
2005	2.915	0	0	0	0.023	0	0.023	0	0	2.961
2006	2.915	0	0	0	0.023	0	0.023	0	0	2.961
2007	2.915	0	0	0	0.023	0	0.023	0	0	2.961
2008	2.915	0	0	0	0.023	0	0.023	0	0	2.961
2009	2.915	0	0	0	0.023	0	0.023	0	0	2.961
2010	2.919	0	0	0	0.021	0	0.021	0	0	2.961
2011	2.923	0	0	0	0.019	0	0.019	0	0	2.961
2012	2.927	0	0	0	0.017	0	0.017	0	0	2.961
2013	2.929	0	0	0	0.015	0	0.014	0	0	2.958
2014	2.930	0	0	0	0.013	0	0.012	0	0	2.955
2015	2.932	0	0	0	0.011	0	0.010	0	0	2.953
2016	2.933	0	0	0	0.008	0	0.008	0	0	2.950
2017	2.935	0	0	0	0.006	0	0.006	0	0	2.947
2018	2.936	0	0	0	0.004	0	0.004	0	0	2.944
2019	2.938	0	0	0	0.002	0	0.002	0	0	2.942
2020	2.939	0	0	0	0	0	0	0	0	2.939
2021	2.936	0	0	0	0	0	0	0	0	2.936

FL = forest land, CL = cropland, GL = grassland, WL= wetlands, SL= settlements, OL = other land

It is evident from the information in table 6.18 above that the conversions to other land are very limited in Cyprus, and they are associated only with changes from woody cropland and grassland.

6.7.4 Methodological issues

Other Land remaining Other land

No guidance is provided in the 2006 IPCC guidelines for other land remaining other land.

Land converted to other land

Lands converted to other land are subject to changes in woody vegetation, dead wood, litter and soil organic carbon. The tier 2 method was implemented to calculate carbon stock changes in living biomass (equation 2.15 of the 2006 IPCC guidelines) and the tier 1 method for the DOM and SOM mineral pools. It should be noted that carbon stocks in living biomass, dead wood and litter in other land after the conversion are taken equal to zero in accordance with the 2006 IPCC guidelines. Furthermore, both the living biomass and DOM stocks that were present before the conversion are assumed to be totally lost in the year of conversion as a result of the land-use change.

For estimating carbon stock changes in SOM mineral, formulation B of equation 2.25 of the 2006 IPCC guidelines with the default 20 years transition period is applied. In the current inventory, the carbon stock equilibrium level of other land is taken equal to zero, following the tier 1 assumption, while in the previous inventories mineral soil carbon stocks for other land were not taken equal to zero. The stock change factors that are applied for the respective land-use categories converted to other land are the ones presented in section 6.2.4.

N_2O emissions from N mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils

In the current submission, N_2O emissions from N mineralization associated with mineral soil carbon loss as a result of land-use change to other land are reported for the first time. These emissions are a consequence of the enhanced mineralisation (conversion to inorganic form) of soil organic matter (SOM) that normally takes place as a result of that conversion.

Both direct and indirect N_2O emissions are reported following the tier 1 method of the 2006 IPCC guidelines with default emission factors. More specifically equations 11.1, 11.8 and 11.10 from chapter 11 were applied. The C/N ratio equal to 15 (for grassland) and 10 (for cropland) conversions to other land, the emission factor (EF1) equal to 0.01 kg N_2O-N/kg N for direct N_2O emissions, and the emission factor (EF5) equal to 0.0075 kg N_2O-N/kg N and the $Frac_{LEACH}$ equal to 0.3 for indirect N_2O emissions are applied.

6.7.5. Uncertainties and time-series consistency

Uncertainties for the whole inventory period (1990-2021) have been assessed following the error propagation (approach 1) and equations 3.1, 3.2 contained in volume 1 of the 2006 IPCC guidelines. Input uncertainties related to activity data and emission factors have been assessed on the basis of information provided in the 2006 IPCC guidelines and country specific information.

The associated uncertainties with the input data for land converted to other land are presented in table 6.9 and in table 6.13 above.

The overall uncertainty for land converted to other land equals to 34% and 81% for CO_2 and N_2O emissions, respectively. A more detailed description of the results of the uncertainty analysis is reported in Annex 2.

Figure 6.12 presents the total net emissions/removals associated with the land converted to other land during the period 1990–2021.

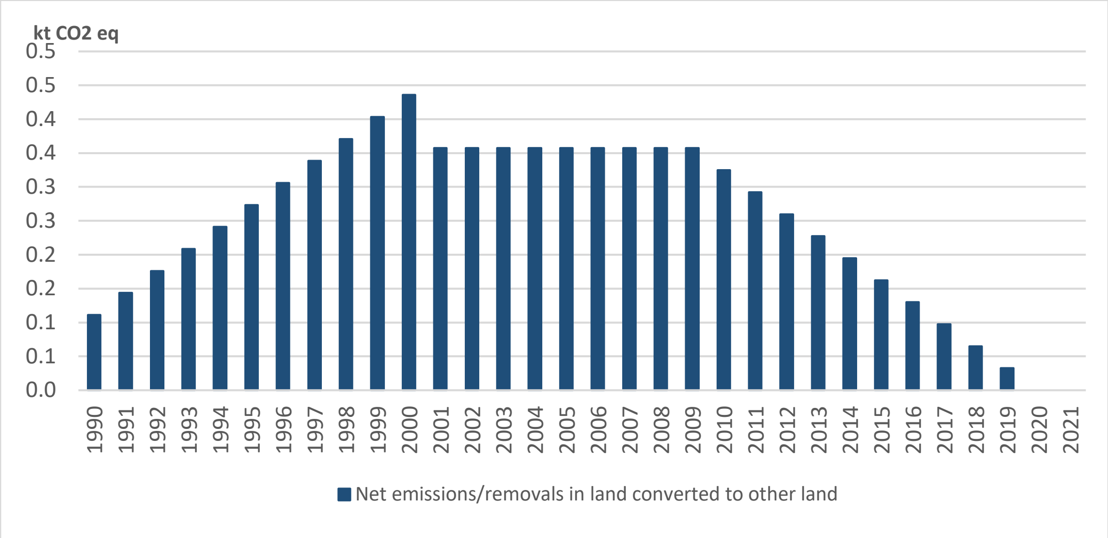


Figure 6.12. Net emissions/removals in land converted to other land during the period 1990 – 2021 (note: indirect N_2O emissions are included in the net emissions).

6.7.6. Category-specific QA/QC and verification

See paragraph 6.2.6 above.

6.7.7. Category-specific recalculations

The changes made in this submission that resulted in the recalculated estimates in other land include, in addition to the relevant changes noted in section 6.2.7:

- The complete revision of the land representation as noted in section 6.1.1, which led to revised area estimates in other land remaining other land and land converted to other land.
- Corrected the methodology in estimating carbon losses in living biomass in land converted to other land. Previously, a 20 years conversion period was applied to carbon losses due to land use change. In this inventory living biomass carbon losses due to land-use change are attributed to the certain year of land-use change.
- In the previous inventory mineral soil carbon stocks were not taken equal to zero for the other land category and the one year transition period was applied for land converted to other land. In this inventory, mineral soil carbon stocks for other land are assumed to be zero and the 20 years transition period is applied in estimating carbon stock changes in the SOM pool.

6.7.8. Category-specific planned improvements

There are not any improvements planned for this category.

6.8. Harvested Wood Products (4G)

6.8.1. Description

Harvested Wood Products (HWP) include all wood material (including bark) that leaves harvest sites. Slash and other material left at harvest sites are regarded as dead organic matter in the associated land-use category.

In Cyprus, all domestically produced HWP originate only from harvest occurring in forest land category.

6.8.2. Information on approaches used and on databases used for the inventory preparation

Annual carbon stock changes in HWP pool are estimated following the production approach as it is described in the 2006 IPCC guidelines in order to estimate CO_2 emissions and removals from HWP originating from the country's land.

Three harvested wood products categories have been considered, namely sawnwood, wood-based panels, and paper and paperboard.

All relevant data were collected from the FAO database "Forestry Production and Trade".

6.8.3. Category specific definitions and the classification systems used

Definitions contained in "FAO Forest Products Definitions"[68] are used in this inventory.

6.8.4. Methodological issues

The tier 2 of the 2006 IPCC guidelines is applied for estimating the HWP contribution in the total net emissions/removals in the LULUCF sector. More specifically, the first order decay function presented in equation 12.6 is used.

Furthermore, the following elements of the 2006 IPCC guidelines are considered:

1. All CO_2 released/removed from HWP is included in the LULUCF sector;

2. CO_2 released from wood burnt for energy in the energy sector is not included in the energy sector totals (although CO_2 emissions from biofuels are reported as a memo item for QA/QC purposes). CH_4 and other gases from HWP used for energy is included in the energy sector;

3. CO_2 released from HWP in SWDS is not included in the waste sector totals although CH_4 emissions from HWP are included.

6.8.4.1. Data for the calculation of an estimate of HWP Contribution under the Convention

The necessary activity data for all three categories, namely data for production, import and export, have been obtained from FAO statistics database "Forestry Production and Trade" (date of data download: 28 December 2022)[69]. Table 6.19 lists the FAO items and their codes that were the source of numerical data for all calculations in this chapter.

Table 6.19. The FAO items and their codes that were the source of numerical data for all calculations relating to the HWP GHG contribution.

Item	Item Code
Sawnwood	1872
Wood-Based Panels	1873
Paper+Paperboard	1876
Wood Pulp	1875
Industrial Roundwood	1865

[68] available at: http://www.fao.org/forestry/34572-0902b3c041384fd87f2451da2bb9237.pdf
[69] available at http://www.fao.org/faostat/en/#data/FO

In the current submission, the activity data used for estimating the HWP contribution are extrapolated back to 1900, in accordance with the 2006 IPCC guidelines. More specifically, equation 12.6 is applied with the estimated continuous rate of change equal to 0.0151 (that of industrial roundwood production increase).The carbon stocks in 1900 are assumed to be equal to zero. It is noted that for wood-based panels a complete time series for production is available only for the period 1982-2022 in FAOSTAT. Thus, the extrapolation back from 1982 to 1900 is approximated by means of equation 12.6.

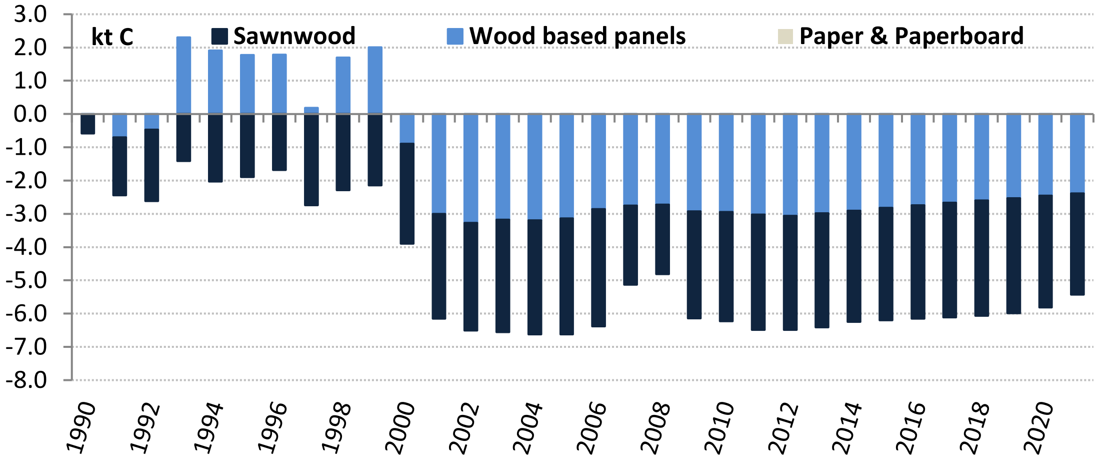
As it has been already indicated, in the current submission the carbon stock changes for solid wood are disaggregated between sawnwood and wood panels compared to previous submission in which aggregated estimates only for solid wood were reported. The default half-lives used for the estimation of "products in use" and associated fraction retained each year are the disaggregated ones for the three HWP categories from the 2013 IPCC KP Supplement presented in table 6.20 below.

Table 6.20. The default half-lives and associated decay rates for solid wood products and paper products

	Sawnwood	Wood-based panesl	Paper products
Half-life (years)	35 yr	25	2 yr
Decay rate k (k = ln(2)/ half-life)	0.020 yr^{-1}	0.028	0.347 yr^{-1}

The conversion factors used in the calculation of the HWP contribution are taken from table 12.4 of the 2006 IPCC and are reported in CRF table 4.Gs2.

Figure 6.13 below presents the annual carbon stock changes in the the period 1990-2021 for each HWP category.



6.8.5. Uncertainties and time-series consistency

The uncertainty associated with this category is based on information provided by the 2006 IPCC guidelines, namely an overall uncertainty equal to 52% for CO_2. A more detailed description of the results of the uncertainty analysis is reported in Annex 2.

6.8.6. Category-specific QA/QC and verification

See paragraph 6.2.6 above.

6.8.7. Category-specific recalculations

The changes made in this submission that resulted in the recalculated estimates HWP pool include:

- Updated activity data based on the latest available information from the FAOSTAT database are used.
- The activity data are extrapolated back to 1900 by means of equation 12.6 of the 2006 IPCC guidelines.
- The HWP contribution is reported for the three HWP categories, namely sawnwood, wood-based panels, paper and paperboard.
- The half-life values used are the ones suggested by the 2013 IPCC KP supplement, separately for the three HWP categories.

Furthermore, as part of the improvements implemented in the current submission, CRF table 4.Gs2 completeness is ensured by reporting HWP activity data for the whole period from 1960 to the latest inventory year and the additional information for the conversion factors used.

6.8.8. Category-specific planned improvements

There are not any improvements planned for this category.

Chapter 7.
Waste (CRF sector 5)

7.1. Overview of sector

Disposal and treatment of industrial and municipal wastes can produce emissions of GHG. Typically, CH_4 emissions from SWDS are the largest source of greenhouse gas emissions in the Waste Sector. CH_4 emissions from wastewater treatment and discharge may also be important.

Solid wastes can be disposed of through landfilling, recycling, incineration or waste-to-energy. Incineration and waste-to-energy technologies are not implemented for the management of municipal solid waste in Cyprus. This chapter will deal with CH_4 and N_2O emissions resulting from solid waste disposal, biological treatment of solid waste and wastewater treatment and discharge. The most important gas produced in this source category is methane (CH_4). Emissions from incineration and open burning of waste are reported as NO as incineration does not take place in Cyprus.

7.1.1. Emissions trends

Emissions from the Waste Sector in 2021 contributed 7.6% of the total emissions without LULUCF, 58.3% to the total methane emissions of the country without LULUCF and 9.3% to the total N_2O emissions without LULUCF. In 2021, 86.3% of the waste sector emissions are from solid waste disposal, 3.2% from biological treatment of solid waste and 10.4% from waste water treatment and discharge. The emissions from waste have changed considerably between 1990 and 2021 due to changes that are taking place in the waste and wastewater management practices of the country. Recycling and composting have been reducing the amount of waste disposal on land since 2010.

Table 7.1. Total GHG emissions (in Gg CO_2 eq) from waste, 1990–2021

Gg CO_2 eq.	**1990**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**
Total waste	**435.18**	**523.24**	**557.57**	**583.92**	**589.71**	**599.76**	**609.81**
A. Solid waste disposal	295.37	369.73	420.35	482.17	495.46	506.81	519.36
B. Biological treatment of solid waste	NO	NO	NO	4.71	8.55	10.35	8.85
C. Incineration and open burning of waste	NO	NO	NO	NO	NO	NO	NO
D. Wastewater treatment and discharge	139.82	153.51	137.22	97.04	85.70	82.60	81.60
E. Other	NO	NO	NO	NO	NO	NO	NO
CH_4 (Gg)	15.19	18.25	19.48	20.30	20.45	20.78	21.17
N_2O (Gg)	0.04	0.05	0.05	0.06	0.06	0.07	0.06
Total (Gg CO_2 eq.)	**435.18**	**523.24**	**557.57**	**583.92**	**589.71**	**599.76**	**609.81**

Gg CO_2 eq.	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Total waste	**620.38**	**624.81**	**627.76**	**635.25**	**644.93**	**656.42**	**656.09**
A. Solid waste disposal	528.51	534.39	541.06	548.31	555.06	561.54	567.87
B. Biological treatment of solid	11.09	12.65	12.65	12.94	16.15	19.67	19.48

waste							
C. Incineration and open burning of waste	NO	NO	NO	NO	NO	NO	NO
D. Wastewater treatment and discharge	80.77	77.76	74.05	74.00	73.72	75.21	68.74
E. Other	NO	NO	NO	NO	NO	NO	NO
CH_4 (Gg)	21.52	21.66	21.76	22.02	22.31	22.67	22.66
N_2O (Gg)	0.07	0.07	0.07	0.07	0.08	0.08	0.08
Total (Gg CO_2 eq.)	**620.38**	**624.81**	**627.76**	**635.25**	**644.93**	**656.42**	**656.09**

Gg CO_2 eq.	**2021**						
Total waste	**662.56**						
A. Solid waste disposal	572.11						
B. Biological treatment of solid waste	21.35						
C. Incineration and open burning of waste	NO						
D. Wastewater treatment and discharge	69.10						
E. Other	NO						
CH_4 (Gg)	22.86						
N_2O (Gg)	0.08						
Total (Gg CO_2 eq.)	**662.56**						

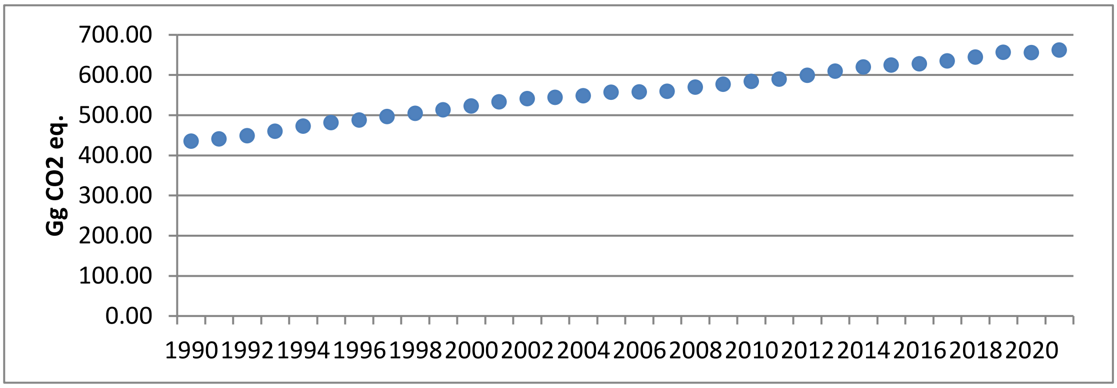


Figure 7.1. GHG emissions from waste for the period 1990–2021

7.1.2. Methodology

The calculation of GHG emissions from Waste is based on the methodologies and emission factors suggested by the IPCC Guidelines. Data used for the estimation of the emissions was obtained from the National Statistical Service. The Tier 2 method with default IPCC 2006 emission factors and parameters is implemented for Solid Waste Disposal (5A) and Tier 1 for Biological Treatment of Solid Waste (5B) and Wastewater Treatment and Discharge (5D). Unfortunately, data for 2018 were unavailable when preparing this report, due to incomplete and insufficient information necessary to properly reflect statistical quantities of waste that were processed from some of the solid waste disposal sides (SWDS). For this reason, the same data as 2017 were used for estimating emissions from Solid Waste Disposal (5A) and Biological Treatment of Solid Waste (5B).

The methodologies and emission factors used are summarised in Table 7.2.

Table 7.2. Waste– methodologies and emission factors applied

Category-Classification		Gas	EF	Method
5A1.a	Solid Waste Disposal - Managed waste disposal sites- Anaerobic	CH_4	D	T2
5A1.a	Solid Waste Disposal - Managed waste disposal sites- Anaerobic	CO_2	NA	NA
5A2.	Solid Waste Disposal - Unmanaged waste disposal sites	CH_4	D	T2
5A2.	Solid Waste Disposal - Unmanaged waste disposal sites	CO_2	NA	NA
5B1a	Biological treatment of solid waste – Composting- municipal solid waste	CH_4/N_2O	D	T1
5D1.	Wastewater Treatment and Discharge - Domestic wastewater	CH_4/N_2O	CS	T1
5D2.	Wastewater Treatment and Discharge - Industrial wastewater	CH_4	D	T1
5D2.	Wastewater Treatment and Discharge - Industrial wastewater	N_2O	OTH	OTH

T1: IPCC methodology Tier 1; D: IPCC default methodology and emission factor; OTH: other methodology – EMEP/CORINAIR 2007

Key categories

The results of the key categories assessment are presented in Section 1.4.

Uncertainty

The uncertainty analysis is presented in Section 1.5.

Completeness

Table 7.3 gives an overview of the IPCC source categories included in this chapter and presents the status of emissions estimates from all sub-sources in the sector of waste.

Table 7.3. Waste – completeness

	CO_2	CH_4	N_2O
5A. Solid Waste Disposal	NA	✓	NA
5B. Biological Treatment of Solid Waste		✓	✓
5D. Wastewater Treatment and Discharge		✓	✓

NA: Not applicable

7.2. Solid Waste Disposal (5A)

Treatment and disposal of municipal, industrial and other solid waste produces significant amounts of methane (CH_4). In addition to CH_4, solid waste disposal sites (SWDS) also produce biogenic carbon dioxide (CO_2) and non-methane volatile organic compounds (NMVOCs) as well as smaller amounts of nitrous oxide (N_2O), nitrogen oxides (NO_x) and carbon monoxide (CO). In Cyprus, as in many other industrialised countries, waste management has changed much over the last decade. Waste minimisation and recycling/reuse policies have been introduced to reduce the amount of waste generated, and increasingly, alternative waste management practices to solid waste disposal on land have been implemented to reduce the environmental impacts of waste management.

Decomposition of organic material derived from biomass sources (e.g., crops, wood) is the primary source of CO_2 released from waste. These CO_2 emissions are not included in national totals, because the carbon is of biogenic origin and net emissions are accounted for under the LULUCF Sector.

Municipal solid waste management in Cyprus

In Cyprus, household waste is collected by local authorities or individuals and disposed of in sites of different characteristics. In 2005[70] five disposal sites were in operation, of which none met the standards for landfills in accordance with the requirements of the relevant EU Directives. The landfills in Nicosia and Limassol operated with controlled drop while the other three sites operate under semi-controlled deposition conditions. These sites have been categorised as deep unmanaged for the purposes of inventory preparation.

Up until 2010, also in operation were 113 sites of uncontrolled disposal of household and other solid waste. These sites have been categorised as shallow unmanaged. Most active UWDS have been active for more than 25 years, while the smallest portion of the active UWDS were active for less than 5 years (Figure 7.2). Approximately half of UWDS (48%) started their operation during 1990-2000, while a significant number became operational during 1980–1990. Before 1970 only two sites operated, one of which was closed in the mid 1990s, while the other is still in operation (Figure 7.3).

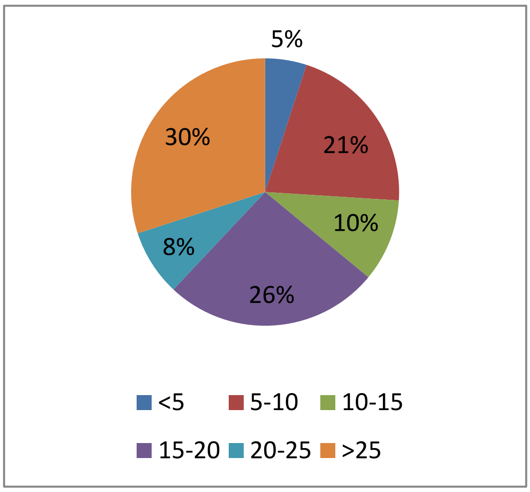


Figure 7.2. Years of activity of active Uncontrolled Waste Disposal Sites

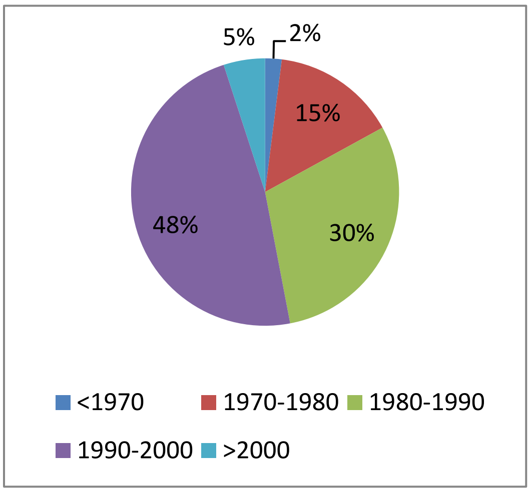


Figure 7.3. Starting year of activity for all Uncontrolled Waste Disposal Sites

The situation started changing in 2006 when the first managed waste disposal site started its operation in Pafos. Then the second managed waste disposal site started its operation in 2010, serving the districts of Larnaca and Ammochostos. For Limassol and Nicosia, the new facilities are under construction and all the municipal solid wastes produced are transferred to the existing deep unmanaged sites[71]. The national municipal waste Management Plant of 2015–2021 (MWMP) contains quantitative and qualitative targets and enumerates specific measures and actions to be taken in order for the EU targets to be reached. One of the quantitative targets is that no more than 95,000 tonnes of biodegradable waste is to be disposed in landfills (represents the 35% target of the 1999/31/EC directive). In addition, the Legal Measures will be focused on the:

- Development of local waste prevention and management schemes
- Mandatory obligation for establishing separate collection systems by local authorities,
- Establishment of extended producer responsibility (EPR) in streams other than packaging waste,
- Establishment of a landfill tax/levy,

[70] In 2005 a census of all the solid waste disposal sites took place in Cyprus through the study “Παροχή συμβουλευτικών υπηρεσιών για την ετοιμασία στρατηγικού σχεδίου, περιβαλλοντικής και τεχνοοικονομικής μελέτης και εγγράφων προσφορών για την αποκατάσταση και μετέπειτα φροντίδα των χώρων ανεξέλεγκτης απόρριψης απορριμμάτων στην Κύπρο" ("Consultancy services for the preparation of the strategic plan, environmental and techno-economic studies and tender documents for the rehabilitation and aftercare of uncontrolled waste disposal sites in Cyprus").

[71] Athena Papanastasiou, Environment Officer, Waste Management Unit, Department of Environment, Tel.: +357 22 866231, E-mail: apapanastasiou@environment.moa.gov.cy

- Banning the disposal of certain waste streams from entering into landfills (e.g. green waste, high calorific value waste, etc.)

The adaptations of the strategy that are envisaged:

- One Sanitary Landfill and one Residual Sanitary Landfill (supplementing MBT unit at Koshi) were constructed and operated (both meet the requirements of directive 99/31/EC). The MBT unit was constructed and operated from 01/04/2010 servicing Larnaca-Ammochostos districts. The Plant was designed in a way that a high separation of recycled and biodegradable material is achieved. Another I.W.M.P (Integrated Waste Management Plant) servicing Limassol district is expected to be operated by the year 2018.
- The construction of the Green Point Network (22 collection points for the depositing of various waste streams out of households – bulky waste, green, textile, furniture, weee, etc.) is completed. The 4 Green Points servicing Paphos district are in operation and the rest are expected to be in operation by 2018.
- Separate collection at source was promoted at households, from the existing collective system for the packing waste servicing and also all types of paper created under the packaging directive, while the competent authority promotes the separate collection from other household streams such as other organic waste, eg. food and green waste.
- The construction works for the rehabilitation/restoration of the old non approved landfills, which are closed at Paphos and Larnaca-Ammochostos districts, were completed. The preparation of studies/documents regarding the rehabilitation/restoration of the 20 non sanitary landfills of Nicosia district and the 44 sanitary landfills of the Limassol district will be completed within 2018, and after that the construction works will begin.

A comprehensive study was undertaken in 2005 for the elaboration of a Strategic Plan, an Environmental study and a Feasibility study for the restoration and management of landfills. The purpose of the study was to record all landfills, assess their status and level of risk, create a restoration priority list based on pollution risk assessments, and undertake the appropriate environmental studies as well as feasibility studies for the restoration of the prioterized landfills. These studies were a necessary step for the restoration of all landfills recorded.

Two (2) landfills are still active in Cyprus but arrangements have been made in order for them to be closed and restored. According to recent data, these two landfills are fed with approximately 155,000 tonnes and 200,000 tonnes of municipality waste each year, respectively (reference year 2012).

Sixty-two (62) non sanitary landfills are planned to be restored appropriately within the following years. According to the preliminary study contacted in 2005, these landfills contain approximately 597,269 m^3 of solid waste, excluding 2 major landfills that have not been closed yet.

Fifty-three (53) landfills have been restored the last five years and are being monitored. During their restoration a total of 4,902,000 m^3 of solid waste were reallocated and properly buried using composite liners and leakage collection systems.

The EU landfill directive is fully harmonized in the national legislation but not fully implemented. Cyprus didn't manage to seize the operation of non-compliant landfills by 2009. Also, Cyprus has rehabilitated only 46% of its closed landfills.

Emission trends

Methane emissions were calculated using the Tier 2 method proposed by the IPCC 2006 guidelines using the IPCCWasteModel excel spreadsheet provided with the 2006 IPCC guidelines.

Carbon dioxide emissions occur during flaring of biogas released from the decomposition of waste. These emissions should not be included in the total GHG emissions of this source as they are of biogenic origin. Nevertheless, recovery and flaring of biogas do not occur in Cyprus and is therefore reported as NO.

CH_4 emissions from solid waste disposal on land in 2021 accounted for 86.3% of total GHG emissions from Waste sector, 6.55% of total national emissions without LULUCF and 52.1% of the total CH_4 emissions without LULUCF. Total emissions increased by 93.7% between 1990 and 2021. Emissions from Solid Waste Disposal Sites are presented in Table 7.4 and Figure 7.4.

Table 7.4. Total GHG emissions from solid waste disposal sites for the period 1990–2021

Gg CH_4	**1990**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**
A. Solid waste disposal	**10.55**	**13.20**	**15.01**	**17.22**	**17.70**	**18.10**	**18.55**
1. Managed waste disposal sites	NO	NO	NO	0.58	1.04	1.47	1.87
2. Unmanaged waste disposal sites	10.55	13.20	15.01	16.64	16.65	16.63	16.67
3. Uncategorised waste disposal sites	NO	NO	NO	NO	NO	NO	NO
A. Solid waste disposal (Gg CO_2 eq.)	**295.37**	**369.73**	**420.35**	**482.17**	**495.46**	**506.81**	**519.36**

Gg CH_4	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
A. Solid waste disposal	**18.88**	**19.09**	**19.32**	**19.58**	**19.82**	**20.06**	**20.28**
1. Managed waste disposal sites	2.21	2.50	2.79	3.07	3.34	3.92	4.87
2. Unmanaged waste disposal sites	16.66	16.58	16.54	16.51	16.48	16.13	15.41
3. Uncategorised waste disposal sites	NO	NO	NO	NO	NO	NO	NO
A. Solid waste disposal (Gg CO_2 eq.)	**528.51**	**534.39**	**541.06**	**548.31**	**555.06**	**561.54**	**567.87**

Gg CH_4	**2021**						
A. Solid waste disposal	**20.43**						
1. Managed waste disposal sites	5.70						
2. Unmanaged waste disposal sites	14.73						
3. Uncategorised waste disposal sites	NO						
A. Solid waste disposal (Gg CO_2 eq.)	**572.11**						

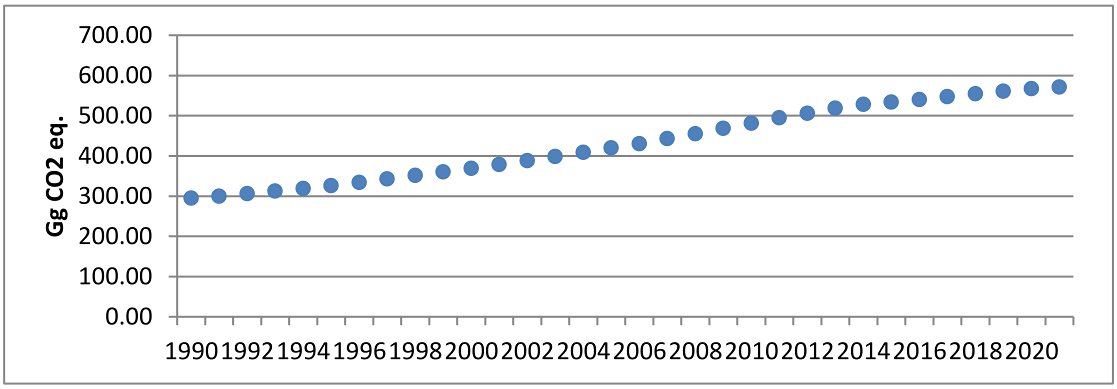


Figure 7.4b. Total GHG emissions from solid waste disposal sites for the period 1990–2021

7.2.1. Methodological issues

The 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines) outlines three methods to estimate CH_4 emissions from solid waste disposal sites: (a) the Tier 1 method based on the IPCC First Order Decay method (FOD), (b) the Tier 2 method using the IPCC FOD method, some default parameters and good quality country specific activity data and (c) the Tier 3 method using good quality country specific activity data and either the FOD IPCC FOD method with country specific key parameters or measurement derived county-specific parameters. According to the 2006 IPCC Guidelines, it is good practice to use the FOD method in order to account for time dependence of the emissions. The Tier 2 methodology was implemented for the estimation of emissions from land disposal of solid waste through the use of the IPCCWasteModel excel spreadsheet. The parameters are set to Southern Europe region, the DOC is calculated based on waste by composition and the methane generation constant is the default for dry temperate.

Total municipal solid waste (MSW_T)

Data on total MSW production and annual per capita production are available for the period 1996–2016 from the National Statistical Service. The data for the period 1990–1995 was obtained using the linear trend equation of 1996–2008 that was obtained from plotting the annual per capita production against time as shown in Figure 7.5. The years 2009 to 2016 were excluded from the trend, because during those years there are considerable changes in (a) the economy of the country and (b) the waste management practices of the country, which resulted in a decrease of the waste production. The total municipal solid waste production (MSW_T) was then estimated by multiplying the annual per capita production by the total population at the end of the year.

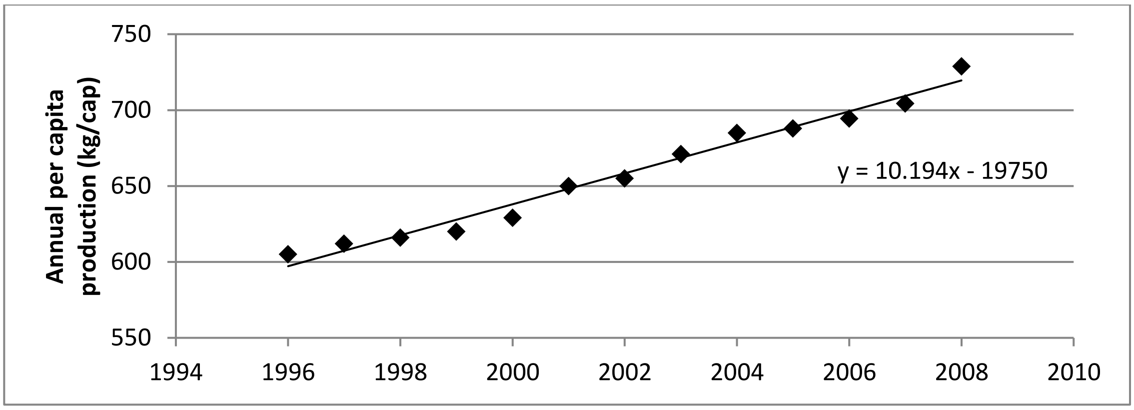


Figure 7.5. Plot used to estimate the annual per capita production for 1990-1995 (kg/cap)

The total population used, the annual per capita production and the resulting municipal solid waste production for the whole reporting period are presented in Table 7.5. Population data is according to national statistics published annually by the Statistical Service[72]. Total MSW production and annual per capita production were revised for the period 2006–2018 according to revised data provided by the Statistical Service.

The population reported by the Statistical Service and used for the purposes of the GHG inventory of Cyprus is the population for the areas under the effective control of the Republic of Cyprus[73]. The reduction in population during the period 2012–2015 has been caused by negative net migration due to the economic crisis experienced during that period.

Table 7.5. Total population, annual per capita production (kg/cap), total MSW production (1000t)

	Total population	Annual per capita production (kg/cap)	Total MSW production (1000t)
1990	587100	536.1	314.7
1991	603100	546.3	329.4
1992	619200	556.4	344.6
1993	632900	566.6	358.6
1994	645400	576.8	372.3
1995	656300	587.0	385.3
1996	666300	605.0	400.1
1997	675200	612.0	410.5

[72] The 2017 publication, which includes data for the years 1996-2016 is available at http://www.mof.gov.cy/mof/cystat/statistics.nsf/All/ACC6EE0E5A63FE79C225703C001EC792/$file/POP-DISTRICT-A96_16-EN-281117.xls?OpenElement; contact person for population statistics at the Statistical Service is Loukia Makri, +357 22602150, lmakri@cystat.mof.gov.cy

[73] http://www.mof.gov.cy/mof/cystat/statistics.nsf/All/4756DB2E6CAEB256C22581E200378EA0?OpenDocument&sub=1&sel=1&e=&print

1998	682900	616.0	418.2
1999	690500	620.0	425.8
2000	697500	629.0	436.1
2001	705500	650.0	456.1
2002	713700	655.0	464.6
2003	722900	671.0	481.4
2004	733000	685.0	498.1
2005	744000	688.0	507.9
2006	757900	694	522.2
2007	776400	704	539.8
2008	796900	729	573.4
2009	819100	730	589.1
2010	839800	696	576.3
2011	862000	677	574.8
2012	865900	664	574.0
2013	858000	618	532.4
2014	847000	601	512.8
2015	848300	623	525.2
2016	854800	634	538.7
2017	864200	625	537.5
2018	875900	645	562.1
2019	888000	649	571.1
2020	896000	609	542.8
2021	904705	613	570.0

Determining Historical Waste per Capita Data

Please refer to Annex 3.2 for the methodology used to estimate Historical Waste per Capita Data.

Fraction of MSW disposed at SWDS (MSW_F)

Data on MSW disposed at SWDS is available for the period 1996–2019 from the National Statistical Service[74]. For the period 1990–1995 it was assumed that the fraction of waste disposed to SWDS is the same as 1996. The MSW_F and the corresponding mass of MSW disposed to disposal sites are presented in Table 7.6. In Table 7.6 data on other waste management practices are also presented for years that data is available. MSW to disposal sites for 1950–1989 is assumed 100%.

Table 7.6. Fraction of MSW disposed at SWDS (MSW_F), mass of MSW disposed to disposal sites (1000t) and other practices

	Composting (1000t)*	Recycling (1000t)	MSW to disposal sites (1000t)	MSW to disposal sites
1990			305.97	97.2%
1991			320.29	97.2%
1992			334.98	97.2%
1993			348.66	97.2%
1994			361.94	97.2%
1995			387.00	97.2%
1996		11.12	389.00	97.2%
1997		12.54	398.00	96.9%
1998		12.17	406.00	97.1%
1999		12.76	413.00	97.0%
2000		13.11	423.00	97.0%
2001		14.1	442.00	96.9%
2002		14.61	450.00	96.9%
2003		14.73	466.63	96.9%

[74] The 2017 publication, which includes data for the years 1996-2016 is available at http://www.cystat.gov.cy/mof/cystat/statistics.nsf/energy_environment_82main_gr/energy_environment_82main_gr?OpenForm&sub=2&sel=2; contact person for population statistics at the Statistical Service is Marilena Kythreotou, +357 22602137, mkythreotou@cystat.mof.gov.cy

	Composting (1000t)*	Recycling (1000t)	MSW to disposal sites (1000t)	MSW to disposal sites
2004		16.48	481.59	96.7%
2005		18.61	489.30	96.3%
2006		21.50	499.49	95.9%
2007		27.59	512.19	94.9%
2008		42.09	530.59	92.7%
2009		49.39	539.67	91.6%
2010	26.31	61.09	497.86	86.4%
2011	47.92	72.22	475.91	82.8%
2012	57.77	69.65	467.48	81.4%
2013	49.10	69.78	434.49	81.6%
2014	61.87	70.05	398.67	77.7%
2015	70.70	72.12	409.99	78.1%
2016	70.65	77.68	424.44	78.8%
2017	64.80	78.21	423.16	78.7%
2018	79.80	79.59	392.86	69.9%
2019	100.90	95.65	379.39	66.4%
2020	99.08	88.52	364.14	67.1%
2021	109.91	91.96	354.30	62.2%

* includes Compost for backfilling

Assumptions for allocation have been based on the information provided by the Solid Waste Management Unit of the Department of Environment[75], presented below (Table 7.7). Managed-semi-aerobic is not used in Cyprus. The categorisation is based on the disposal of the waste according to their origin; i.e. urban or rural. Based on this categorisation, the amount of waste disposed per type of disposal site was estimated using the urban and rural population of each district at the end of the year (Table 7.8) and the waste generation per capita (Table 7.5). The resulting amount of waste generated per district and type of waste disposal site are presented in Table 7.9. The resulting total quantities of municipal solid waste disposed per type of waste disposal site and the population served per technology are presented in Table 7.10. Managed-semi-aerobic is not used in Cyprus and therefore not included in the table.

Table 7.7. Allocation of waste to types waste disposal sites

	Deep unmanaged	Shallow unmanaged	Managed-anaerobic
Nicosia	all urban until 2011; all from 2012 to 2018	all rural until 2011	all from 2019
Ammochostos	all urban until 2009	all rural until 2009	all from 2010
Larnaca	all urban until 2009	all rural until 2009	all from 2010
Limassol	all urban until 2011; all from 2012 to 2017	all rural until 2011	all from 2018
Pafos	all urban until 2005	all rural until 2005	all from 2006

Table 7.8. Urban and Rural population of Cyprus per district at the end of the year (1000s)

	1990	1991	1992	1993	1994	1995	1996	1997
Regional Population								
Nicosia	238.6	244.9	251.3	256.3	260.8	264.6	268	271
Ammochostos	30.3	31.0	31.7	32.7	33.6	34.4	35.1	35.8
Larnaca	98.0	100.8	103.5	105.8	107.8	109.6	111.2	112.6
Limassol	168.7	173.6	178.6	182.4	185.8	188.8	191.5	193.9
Pafos	51.5	52.8	54.1	55.7	57.4	58.9	60.5	61.9
TOTAL	587.1	603.1	619.2	632.9	645.4	656.3	666.3	675.2
Urban Population								
Nicosia	171.6	177.0	182.5	186.4	189.9	193	195.7	198.2
Ammochostos	0.0	0.0	0	0.0	0	0	0	0
Larnaca	58.3	60.5	62.6	64.1	65.4	66.6	67.6	68.6
Limassol	130.6	135.4	140.3	143.6	146.6	149.2	151.7	153.8

[75] Mrs. Elena Christodoulidou, Environment Officer, Solid Waste Management Unit, Department of Environment, tel. +357 22866248, email echristodoulidou@environment.moa.gov.cy

Pafos	30.2	31.8	33.5	35.0	36.6	38.1	39.7	41.2
TOTAL	390.7	404.7	418.9	429.1	438.5	446.9	454.7	461.8
Rural population								
Nicosia	67.0	67.9	68.8	69.9	70.9	71.6	72.3	72.8
Ammochostos	30.3	31.0	31.7	32.7	33.6	34.4	35.1	35.8
Larnaca	39.7	40.3	40.9	41.7	42.4	43.0	43.6	44.0
Limassol	38.1	38.2	38.3	38.8	39.2	39.6	39.8	40.1
Pafos	21.3	21.0	20.6	20.7	20.8	20.8	20.8	20.7
TOTAL	196.4	198.4	200.3	203.8	206.9	209.4	211.6	213.4
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Regional Population								
Nicosia	273.4	275.8	277.9	280.3	283.5	286.2	289.7	293.5
Ammochostos	36.5	37.1	37.8	38.5	39.1	39.6	40.1	40.8
Larnaca	113.9	115.1	116.2	117.5	119.3	120.8	122.8	124.8
Limassol	195.8	197.8	199.5	201.6	204.6	205.7	208.1	210.8
Pafos	63.3	64.7	66.1	67.6	68.6	70.6	72.3	74.1
TOTAL	682.9	690.5	697.5	705.5	715.1	722.9	733.0	744.0
Urban Population								
Nicosia	200.2	202.3	204.1	206.2	208.9	210.3	212.8	215.4
Ammochostos	0	0	0	0.0	0	0	0	0
Larnaca	69.5	70.3	71.1	72.0	73.2	73.5	74.4	75.4
Limassol	155.7	157.5	159.2	161.2	163.9	163.1	164.3	165.7
Pafos	42.7	44.2	45.7	47.3	48.3	49.5	50.7	52
TOTAL	468.1	474.3	480.1	486.7	494.3	496.4	502.2	508.5
Rural population								
Nicosia	73.2	73.5	73.8	74.1	74.6	75.9	76.9	78.1
Ammochostos	36.5	37.1	37.8	38.5	39.1	39.6	40.1	40.8
Larnaca	44.4	44.8	45.1	45.5	46.1	47.3	48.4	49.4
Limassol	40.1	40.3	40.3	40.4	40.7	42.6	43.8	45.1
Pafos	20.6	20.5	20.4	20.3	20.3	21.1	21.6	22.1
TOTAL	214.8	216.2	217.4	218.8	220.8	226.5	230.8	235.5
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Regional Population								
Nicosia	298.4	305.1	312.6	320.6	328	336.0	336.9	333.8
Ammochostos	41.6	42.7	43.8	45.1	46.3	47.6	47.9	47.4
Larnaca	127.4	130.8	134.5	138.5	142.3	146.3	147.2	145.9
Limassol	214.3	219	224.4	230.2	235.5	241.3	241.9	239.7
Pafos	76.2	78.8	81.6	84.7	87.7	90.8	92	91.2
TOTAL	757.9	776.4	796.9	819.1	839.8	862.0	865.9	858
Urban Population								
Nicosia	219	223.7	229.1	234.9	240.2	245.9	246.4	244.1
Ammochostos	0	0	0	0	0	0	0	0
Larnaca	76.6	78.4	80.3	82.4	84.3	86.4	86.7	85.9
Limassol	167.7	170.7	174.1	177.8	181.1	184.6	184.1	182.4
Pafos	53.5	55.3	57.3	59.5	61.6	63.9	64.9	64.3
TOTAL	516.8	528.1	540.8	554.6	567.2	580.8	582.1	576.7
Rural population								
Nicosia	79.4	81.4	83.5	85.7	87.8	90.1	90.5	89.7
Ammochostos	41.6	42.7	43.8	45.1	46.3	47.6	47.9	47.4
Larnaca	50.8	52.4	54.2	56.1	58.0	59.9	60.5	60
Limassol	46.6	48.3	50.3	52.4	54.4	56.7	57.8	57.3
Pafos	22.7	23.5	24.3	25.2	26.1	26.9	27.1	26.9
TOTAL	241.1	248.3	256.1	264.5	272.6	281.2	283.8	281.3
	2014	**2015**	**2016**	**2017**	**2018**	**2019**		

Regional Population								
Nicosia	329.5	330	332.2	335.9	341.7	346.4		
Ammochostos	46.8	46.9	47	47.5	48.2	48.9		
Larnaca	144	144.2	144.9	146.5	147.0	149.0		
Limassol	236.6	237	239.4	242.0	244.9	248.3		
Pafos	90.1	90.2	91.3	92.3	94.1	95.4		
TOTAL	847	848.3	854.8	864.2	875.9	888.0		
Urban Population								
Nicosia	241	241.4	244.2	246.9	252.9	256.4		
Ammochostos	0	0	0	0	0	0.0		
Larnaca	84.8	84.9	85.7	86.6	87.0	88.2		
Limassol	180	180.3	182.6	184.6	187.0	189.6		
Pafos	63.5	63.6	64.4	65.1	66.9	67.8		
TOTAL	569.3	570.2	576.9	583.2	593.8	602.0		
Rural population								
Nicosia	88.5	88.6	88	89.0	88.8	90.0		
Ammochostos	46.8	46.9	47	47.5	48.2	48.9		
Larnaca	59.2	59.3	59.2	59.9	60.0	60.8		
Limassol	56.6	56.7	56.8	57.4	57.9	58.7		
Pafos	26.6	26.6	26.9	27.2	27.2	27.6		
TOTAL	277.7	278.1	277.9	281.0	282.1	286.0		

Table 7.9. Amount of waste generated per district and type of waste disposal site (kt)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Nicosia								
deep unmanaged	89.4	94.0	98.7	102.7	106.5	110.1	115.1	117.6
shallow unmanaged	34.9	36.1	37.2	38.5	39.8	40.9	42.5	43.2
managed-anaerobic	0	0	0	0	0	0	0	0
Ammochostos								
deep unmanaged	0	0	0	0	0	0	0	0
shallow unmanaged	15.8	16.5	17.1	18.0	18.8	19.6	20.6	21.2
managed-anaerobic	0	0	0	0	0	0	0	0
Larnaca								
deep unmanaged	30.4	32.1	33.9	35.3	36.7	38.0	39.8	40.7
shallow unmanaged	20.7	21.4	22.1	23.0	23.8	24.5	25.6	26.1
managed-anaerobic	0	0	0	0	0	0	0	0
Limassol								
deep unmanaged	68.1	71.9	75.9	79.1	82.2	85.2	89.2	91.3
shallow unmanaged	19.9	20.3	20.7	21.4	22.0	22.6	23.4	23.8
managed-anaerobic	0	0	0	0	0	0	0	0
Pafos								
deep unmanaged	15.7	16.9	18.1	19.3	20.5	21.7	23.4	24.4
shallow unmanaged	11.1	11.2	11.1	11.4	11.7	11.9	12.2	12.3
managed-anaerobic	0	0	0	0	0	0	0	0
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Nicosia								
deep unmanaged	119.7	121.7	124.5	129.9	132.5	136.8	140.9	142.8
shallow unmanaged	43.8	44.2	45.0	46.7	47.3	49.4	50.9	51.8
managed-anaerobic	0	0	0	0	0	0	0	0
Ammochostos								
deep unmanaged	0	0	0	0	0	0	0	0
shallow unmanaged	21.8	22.3	23.1	24.3	24.8	25.8	26.6	27.0
managed-anaerobic	0	0	0	0	0	0	0	0
Larnaca								
deep unmanaged	41.6	42.3	43.4	45.4	46.4	47.8	49.3	50.0
shallow unmanaged	26.6	26.9	27.5	28.7	29.2	30.8	32.1	32.7
managed-anaerobic	0	0	0	0	0	0	0	0

Limassol								
deep unmanaged	93.1	94.7	97.1	101.5	104.0	106.1	108.8	109.8
shallow unmanaged	24.0	24.2	24.6	25.4	25.8	27.7	29.0	29.9
managed-anaerobic	0	0	0	0	0	0	0	0
Pafos								
deep unmanaged	25.5	26.6	27.9	29.8	30.6	32.2	33.6	34.5
shallow unmanaged	12.3	12.3	12.4	12.8	12.9	13.7	14.3	14.6
managed-anaerobic	0	0	0	0	0	0	0	0
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Nicosia								
deep unmanaged	145.4	149.4	154.5	157.1	144.4	137.8	182.2	168.3
shallow unmanaged	52.7	54.4	56.3	57.3	52.8	50.5	0	0
managed-anaerobic	0	0	0	0	0	0	0	0
Ammochostos								
deep unmanaged	0	0	0	0	0	0	0	0
shallow unmanaged	27.6	28.5	29.5	30.2	0	0	0	0
managed-anaerobic	0	0	0	0	27.8	26.7	25.9	23.9
Larnaca								
deep unmanaged	50.8	52.4	54.2	55.1	0	0	0	0
shallow unmanaged	33.7	35.0	36.6	37.5	0	0	0	0
managed-anaerobic	0	0	0	0	85.6	82.0	79.6	73.6
Limassol								
deep unmanaged	111.3	114.0	117.4	118.9	108.9	103.5	130.8	120.9
shallow unmanaged	30.9	32.3	33.9	35.0	32.7	31.8	0	0
managed-anaerobic	0	0	0	0	0	0	0	0
Pafos								
deep unmanaged	0	0	0	0	0	0	0	0
shallow unmanaged	0	0	0	0	0	0	0	0
managed-anaerobic	50.6	52.6	55.0	56.6	52.7	50.9	49.8	46.0
	2014	**2015**	**2016**	**2017**	**2018**	**2019**		
Nicosia								
deep unmanaged	153.9	160.5	165.9	165.3	154.0	0		
shallow unmanaged	0	0	0	0	0	0		
managed-anaerobic	0	0	0	0	0	149.2		
Ammochostos								
deep unmanaged	0	0	0	0	0			
shallow unmanaged	0	0	0	0	0			
managed-anaerobic	21.9	22.8	23.5	23.4	21.7	21.1		
Larnaca								
deep unmanaged	0	0	0	0	0			
shallow unmanaged	0	0	0	0	0			
managed-anaerobic	67.3	70.1	72.4	72.1	66.3	64.2		
Limassol								
deep unmanaged	110.5	115.3	119.6	119.1	0			
shallow unmanaged	0	0	0	0	0			
managed-anaerobic	0	0	0	0	110.4	107.0		
Pafos								
deep unmanaged	0	0	0	0	0			
shallow unmanaged	0	0	0	0	0			
managed-anaerobic	42.1	43.9	45.6	45.4	42.4	41.1		

Table 7.10. Allocation of population and waste to types waste disposal sites

	1990	1991	1992	1993	1994	1995	1996	1997
Population (10^6)								
Un-managed, deep	0.391	0.405	0.419	0.429	0.439	0.447	0.455	0.462
Un-managed, shallow	0.196	0.198	0.200	0.204	0.207	0.209	0.212	0.213
Managed, anaerobic	0	0	0	0	0	0	0	0
TOTAL	0.587	0.603	0.619	0.633	0.645	0.656	0.666	0.675
Waste production (Gg)								
Un-managed, deep	203.6	214.9	226.6	236.4	245.9	255.1	267.4	274.0
Un-managed, shallow	102.4	105.4	108.4	112.3	116.0	119.5	124.5	126.6
Managed, anaerobic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	306.0	320.3	335.0	348.7	361.9	374.6	391.9	400.6
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Population (10^6)								
Un-managed, deep	0.468	0.474	0.480	0.487	0.494	0.496	0.502	0.509
Un-managed, shallow	0.215	0.216	0.217	0.219	0.221	0.227	0.231	0.236
Managed, anaerobic	0	0	0	0	0	0	0	0
TOTAL	0.683	0.691	0.698	0.706	0.715	0.723	0.733	0.744
Waste production (Gg)								
Un-managed, deep	280.0	285.3	292.9	306.6	313.6	322.9	332.6	337.0
Un-managed, shallow	128.5	130.0	132.6	137.8	140.1	147.3	152.9	156.1
Managed, anaerobic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	408.4	415.3	425.5	444.4	453.7	470.2	485.5	493.1
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Population (10^6)								
Un-managed, deep	0.463	0.473	0.484	0.495	0.421	0.431	0.579	0.574
Un-managed, shallow	0.218	0.225	0.232	0.239	0.142	0.147	0	0
Managed, anaerobic	0.076	0.079	0.082	0.085	0.276	0.285	0.287	0.285
TOTAL	0.758	0.776	0.797	0.819	0.840	0.862	0.866	0.858
Waste production (Gg)								
Un-managed, deep	307.6	315.8	326.1	331.1	253.3	241.3	313.0	289.2
Un-managed, shallow	145.0	150.2	156.4	160.0	85.5	82.3	0.0	0.0
Managed, anaerobic	50.6	52.6	55.0	56.6	166.1	159.6	155.3	143.5
TOTAL	503.1	518.6	537.5	547.8	504.9	483.1	468.3	432.7
	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Population (10^6)								
Un-managed, deep	0.566	0.567	0.572	0.578	0.342	0	0	0
Un-managed, shallow	0	0	0	0	0	0	0	0
Managed, anaerobic	0.281	0.281	0.283	0.286	0.534	0.888	0.896	0.905
TOTAL	0.847	0.848	0.855	0.864	0.876	0.888	0.896	0.905
Waste production (Gg)								
Un-managed, deep	264.5	275.7	285.5	284.4	154.0	0.0	0.0	0.0
Un-managed, shallow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Managed, anaerobic	131.2	136.8	141.5	140.9	240.8	381.1	364.2	344.7
TOTAL	395.7	412.5	427.0	425.2	394.9	382.9	364.2	344.7

Composition of MSW disposed at SWDS

In previous inventories, the breakdown on composition of MSW to disposal sites was based on evaluations that took place years ago, hence not reflecting the implementation of the latest years' waste policy in Cyprus. In this report, an assumption of constant waste composition for the years 2005–2021 was reported based on the 2020 review. A new study is expected to take place this year to reflect on the implementation of waste policy in Cyprus and to provide more accurate results on composition of MSW to disposal sites.

Table 7.11. Composition of MSW disposed at SWDS

	Paper	Textiles	Wood	Food waste	Garden	Plastics, other inert
1990	38.58%	6.28%	27.58%	2.31%	6.39%	18.86%
1991	38.58%	6.28%	27.58%	2.31%	6.39%	18.86%
1992	38.58%	6.28%	27.58%	2.31%	6.39%	18.86%
1993	38.58%	6.28%	27.58%	2.31%	6.39%	18.86%
1994	38.58%	6.28%	27.58%	2.31%	6.39%	18.86%
1995	38.58%	6.28%	27.58%	2.31%	6.39%	18.86%
1996	38.58%	6.28%	27.58%	2.31%	6.39%	18.86%
1997	38.80%	6.32%	27.62%	2.32%	6.43%	18.52%
1998	38.68%	6.30%	27.41%	2.31%	6.41%	18.89%
1999	38.75%	6.31%	27.43%	2.32%	6.42%	18.77%
2000	38.76%	6.31%	27.34%	2.32%	6.42%	18.85%
2001	38.82%	6.32%	27.42%	2.32%	6.43%	18.68%
2002	38.81%	6.32%	27.42%	2.32%	6.43%	18.70%
2003	38.79%	6.31%	27.43%	2.33%	6.43%	18.71%
2004	38.77%	6.31%	27.43%	2.33%	6.42%	18.73%
2005	38.75%	6.31%	27.44%	2.33%	6.42%	18.75%
2006	38.75%	6.31%	27.44%	2.33%	6.42%	18.75%
2007	38.75%	6.31%	27.44%	2.33%	6.42%	18.75%
2008	38.75%	6.31%	27.44%	2.33%	6.42%	18.75%
2009	38.75%	6.31%	27.44%	2.33%	6.42%	18.75%
2010	38.75%	6.31%	27.44%	2.33%	6.42%	18.75%
2011	38.75%	6.31%	27.44%	2.33%	6.42%	18.75%
2012	38.75%	6.31%	27.44%	2.33%	6.42%	18.75%
2013	38.75%	6.31%	27.44%	2.33%	6.42%	18.75%
2014	38.75%	6.31%	27.44%	2.33%	6.42%	18.75%
2015	38.75%	6.31%	27.44%	2.33%	6.42%	18.75%
2016	38.75%	6.31%	27.44%	2.33%	6.42%	18.75%
2017	38.75%	6.31%	27.44%	2.33%	6.42%	18.75%
2018	38.75%	6.31%	27.44%	2.33%	6.42%	18.75%
2019	38.75%	6.31%	27.44%	2.33%	6.42%	18.75%
2020	38.75%	6.31%	27.44%	2.33%	6.42%	18.75%
2021	38.75%	6.31%	27.44%	2.33%	6.42%	18.75%

Total non-municipal solid waste

In addition to the municipal solid waste production data presented above, data has been obtained for the following additional solid waste categories: Animal and vegetal wastes, Paper and cardboard wastes, Wood wastes, Textile wastes and Industrial effluent sludges. Data was obtained from the National Statistical Service[76]. The Statistical Service has collected the data for the purposes of compliance with Regulation (EC) No 2150/2002 of 25 November 2002 on waste statistics, by the application of the methodologies presented in the relevant manuals published by EUROSTAT[77].

The available data for the pre-mentioned categories is presented in Table 7.12.

Table 7.12. Total waste disposal – landfilled for non-municipal solid waste (in tonnes)

Category	2010	2012	2014	2016	2018	2020
Industrial effluent sludges	299	177	539	672	211	0
Wood wastes	17481	10589	8769	5415	4426	0
Textile wastes	:	14	13	13	12	0
Animal and vegetal wastes	201439	17941	11913	10434	9613	5476

[76] Ms. Marilena Kythreotou, Statistical Officer A', tel. +357 22 602317, mkythreotou@cystat.mof.gov.cy

[77] Manual on waste statistics, available at http://ec.europa.eu/eurostat/product?code=KS-RA-13-015&language=en; Waste generation and treatment (ESMS metadata file — env_wasgt_esms), available at http://ec.europa.eu/eurostat/cache/metadata/en/env_wasgt_esms.htm

The first reference year for which data for Generation and Treatment of Waste is available is 2004, in accordance with the provisions of the Waste Statistics Regulation (EC) No 2150/2002. No data are available for Cyprus before 2004. The methodology applied may differ between years, due to the amendment of the Regulation (data 2010 and onwards), and moreover due to improved methods of reporting waste following Eurostat's recommendations. Data revisions were applied from 2012 onwards.

An estimation of the activity data for the years 2013, 2015, 2017 and 2019 was made by obtaining the average of the years before and after; i.e. 2012 and 2014; 2014 and 2016; 2016 and 2018; 2018 and 2020 respectively.

The annual change of the Gross Domestic Product at Constant market prices of 2005 to estimate activity data for 2021.

To estimate the activity data for the years prior to 2012, going back to the year 1950 (see Annex 3.2), the annual change of the Gross Domestic Product at Constant market prices of 2005 was used, as published by the Statistical Service in the Statistical Abstract[78] (Table 7.13 for the period 1990–2011).

Table 7.13. Gross Domestic Product (GDP) at Constant market prices of 2005 (1990–2011)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
GDP (€mn)	7650	7704	8428	8487	8988	10191	10355	10603
Annual change		0.7%	9.4%	0.7%	5.9%	13.4%	1.6%	2.4%
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
GDP (€mn)	11139	11663	12330	12773	13186	13556	14180	14731
Annual change	5.1%	4.7%	5.7%	3.6%	3.2%	2.8%	4.6%	3.9%
	2006	**2007**	**2008**	**2009**	**2010**	**2011**		
GDP (€mn)	15397	16156	16747	16407	16631	16698		
Annual change	4.5%	4.9%	3.7%	-2.0%	1.4%	0.4%		

The resulting waste production per waste stream obtained from the application of the assumptions and methods presented above is presented in Table 7.14 for the complete time series.

Table 7.14. Solid waste production per waste stream 1990–2021 (in tonnes)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Industrial effluent sludges	64	64	71	72	76	104	105	108
Wood wastes	3831	3858	4259	4289	4558	6217	6296	6466
Textile wastes	5	5	6	6	6	8	8	9
Animal and vegetal wastes	6491	6537	7216	7267	7722	10534	10667	10956
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Industrial effluent sludges	115	121	129	134	139	143	151	158
Wood wastes	6887	7250	7710	8027	8337	8562	9015	9475
Textile wastes	9	10	10	11	11	11	12	13
Animal and vegetal wastes	11669	12283	13062	13600	14126	14506	15274	16053
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Industrial effluent sludges	166	175	182	178	182	183	177	358
Wood wastes	9943	10478	10874	10659	10908	10954	10589	9679
Textile wastes	13	14	14	14	14	14	14	14
Animal and vegetal wastes	16847	17752	18424	18060	18482	18559	17941	14927
	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Industrial effluent sludges	539	605.5	672	442	211	106	0	0
Wood wastes	8769	7092	5415	4921	4426	2213	0	0
Textile wastes	13	13	13	13	12	6	0	0
Animal and vegetal wastes	11913	11173.5	10434	10024	9613	7545	5476	4525

[78] Available at http://www.cystat.gov.cy/mof/cystat/statistics.nsf/All/9707F78B64756B8AC225809700377869/$file/ABSTRACT-2014-EN-281215.pdf?OpenElement

Reservations and reflections on the methodology applied

(a) The backcasting of the waste production using a purely economic indicator shows the weakness that it does not represent the changes in the waste management practices that have been occurring after 2004, when Cyprus joined the European Union.

(b) During the period 1990–2000 Cyprus had considerably higher industrial activity than today, which started decreasing during the late 1990s. During the start of 2000s and especially after Cyprus joined the European Union, the economy of Cyprus focused more on services. These conditions cannot be represented in the backcasting with the GDP applied.

However, given the information available, this is the only methodology that can be applied to complete the series. Attempts will be made to improve the estimation of waste production through the examination of other available data and methods for future submission.

Allocation of waste to types of waste disposal sites

For the allocation of solid waste estimated to different types of waste disposal sites, it was decided to use the Number of Establishments by Economic Activity NACE (Rev. 2) and District for the year 2017, published by the Statistical Service in 2018[79] (Table 7.15).

[79] Available at https://www.mof.gov.cy/mof/cystat/statistics.nsf/All/8E65F57AC6EB3259C22583590036DE1F/$file/ESTABLISMENTS_NACE2_DISTRICT-2017-041218.pdf?OpenElement

Table 7.15. Number of Establishments by Economic Activity NACE (Rev. 2) and District for the year 2017 associated with the production Industrial effluent sludges, Wood wastes, Textile wastes and Animal and vegetal wastes

Number of Establishments by Economic Activity NACE (Rev. 2) and District (2017)	Nicosia	Ammochostos	Larnaca	Limassol	Pafos	TOTAL
WOOD WASTES						
16 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	264	51	164	297	85	
31091 Manufacture of wooden furniture	80	5	25	29	10	
43321 Installation of non self-manufactured doors, windows, kitchens, frames and the like of wood or other materials	25	6	9	29	9	
46731 Wholesale of wood	28	4	8	16	5	
47524 Retail sale of wood	10	2	4	7	2	
TOTAL wood	**407**	**68**	**210**	**378**	**111**	**1174**
contribution of district to total	**35%**	**6%**	**18%**	**32%**	**9%**	
TEXTILE WASTES						
13 Manufacture of textiles	52	4	23	22	7	
46161 Agents involved in the sale of textiles, clothing, fur, footwear and leather goods	8	0	4	8	0	
4641 Wholesale of textiles	32	1	7	18	0	
4751 Retail sale of textiles in specialized stores	43	6	19	48	13	
46411 Wholesale of textiles (e.g fabrics, yarn, household linen, sewing thread, etc.)	32	1	7	18	0	
47511 Retail sale of fabrics	13	1	3	15	4	
TOTAL textile	**180**	**13**	**63**	**129**	**24**	**409**
contribution of district to total	**44%**	**3%**	**15%**	**32%**	**6%**	
ANIMAL AND VEGETAL WASTES						
014 Animal production	343	70	363	190	110	
0162 Support activities for animal production	2	0	0	2	0	
104 Manufacture of vegetable and animal oils and fats	13	3	10	3	6	
103 Processing and preserving of fruit and vegetables	14	1	8	18	4	
104 Manufacture of vegetable and animal oils and fats	13	3	10	3	6	
105 Manufacture of dairy products	30	7	25	33	9	
10611 Production of flour from cereals and vegetables	4	1	1	2	0	
4631 Wholesale of fruit and vegetables	57	18	39	46	18	
4721 Retail sale of fruit and vegetables in specialized stores	58	8	36	35	10	
0113 Growing of vegetables and melons, roots and tubers	155	387	321	134	117	
TOTAL Animal and vegetal products	**689**	**498**	**813**	**466**	**280**	**2746**
contribution of district to total	**25%**	**18%**	**30%**	**17%**	**10%**	
INDUSTRIAL EFFLUENT SLUDGES						
total establishments	**39966**	**6865**	**16308**	**30444**	**11436**	**105019**
contribution of district to total	**38%**	**7%**	**16%**	**29%**	**11%**	

Assumptions for allocation have been based on the information provided by the Solid Waste Management Unit of the Department of Environment, which is the same as for municipal solid waste (see Table 7.7). The categorization is based on the disposal of the waste according to their origin; i.e. urban or rural. All waste generated by industrial activities are assumed as urban waste that is transferred to either deep unmanaged of managed-anaerobic sites.

The resulting amount of waste generated per district is presented in Table 7.16, while the total quantities of solid waste disposed per type of waste and waste disposal site are presented in Table 7.17.

Table 7.16. Amount of non-municipal solid waste generated per district (tonnes)

	1990	1991	1992	1993	1994	1995	1996	1997
Nicosia								
Industrial effluent sludges	24.4	24.5	27.1	27.3	29.0	39.5	40.0	41.1
Wood wastes	1328.2	1337.6	1476.4	1486.9	1580.0	2155.3	2182.6	2241.8
Textile wastes	2.2	2.2	2.5	2.5	2.7	3.6	3.7	3.8
Animal and vegetal wastes	1628.8	1640.3	1810.5	1823.3	1937.5	2643.0	2676.4	2749.0
Ammochostos								
Industrial effluent sludges	4.2	4.2	4.7	4.7	5.0	6.8	6.9	7.1
Wood wastes	221.9	223.5	246.7	248.4	264.0	360.1	364.7	374.5
Textile wastes	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
Animal and vegetal wastes	1177.3	1185.6	1308.6	1317.9	1400.4	1910.3	1934.5	1986.9
Larnaca								
Industrial effluent sludges	9.9	10.0	11.1	11.1	11.8	16.1	16.3	16.8
Wood wastes	685.3	690.2	761.8	767.2	815.2	1112.1	1126.1	1156.7
Textile wastes	0.8	0.8	0.9	0.9	0.9	1.3	1.3	1.3
Animal and vegetal wastes	1921.9	1935.5	2136.3	2151.4	2286.2	3118.6	3158.1	3243.7
Limassol								
Industrial effluent sludges	18.6	18.7	20.6	20.8	22.1	30.1	30.5	31.3
Wood wastes	1233.6	1242.3	1371.2	1380.9	1467.4	2001.7	2027.0	2082.0
Textile wastes	1.6	1.6	1.8	1.8	1.9	2.6	2.6	2.7
Animal and vegetal wastes	1101.6	1109.4	1224.5	1233.2	1310.4	1787.6	1810.2	1859.3
Pafos								
Industrial effluent sludges	7.0	7.0	7.8	7.8	8.3	11.3	11.5	11.8
Wood wastes	362.2	364.8	402.7	405.5	430.9	587.8	595.2	611.4
Textile wastes	0.3	0.3	0.3	0.3	0.4	0.5	0.5	0.5
Animal and vegetal wastes	661.9	666.6	735.8	741.0	787.4	1074.1	1087.6	1117.2

	1998	1999	2000	2001	2002	2003	2004	2005
Nicosia								
Industrial effluent sludges	43.8	46.1	49.0	51.1	53.0	54.5	57.3	60.3
Wood wastes	2387.7	2513.3	2672.7	2782.7	2890.3	2968.2	3125.3	3284.7
Textile wastes	4.0	4.2	4.5	4.7	4.9	5.0	5.2	5.5
Animal and vegetal wastes	2927.9	3081.9	3277.5	3412.3	3544.3	3639.8	3832.4	4027.9
Ammochostos								
Industrial effluent sludges	7.5	7.9	8.4	8.8	9.1	9.4	9.9	10.4
Wood wastes	398.9	419.9	446.5	464.9	482.9	495.9	522.2	548.8
Textile wastes	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4
Animal and vegetal wastes	2116.3	2227.6	2368.9	2466.4	2561.8	2630.8	2770.0	2911.3

Larnaca								
Industrial effluent sludges	17.9	18.8	20.0	20.8	21.6	22.2	23.4	24.6
Wood wastes	1232.0	1296.8	1379.0	1435.8	1491.3	1531.5	1612.5	1694.8
Textile wastes	1.4	1.5	1.6	1.6	1.7	1.7	1.8	1.9
Animal and vegetal wastes	3454.8	3636.6	3867.3	4026.5	4182.1	4294.8	4522.1	4752.8
Limassol								
Industrial effluent sludges	33.4	35.1	37.4	38.9	40.4	41.5	43.7	45.9
Wood wastes	2217.5	2334.2	2482.3	2584.4	2684.4	2756.7	2902.6	3050.6
Textile wastes	2.9	3.0	3.2	3.3	3.5	3.6	3.8	4.0
Animal and vegetal wastes	1980.3	2084.5	2216.7	2307.9	2397.1	2461.7	2592.0	2724.2
Pafos								
Industrial effluent sludges	12.5	13.2	14.0	14.6	15.2	15.6	16.4	17.2
Wood wastes	651.2	685.4	728.9	758.9	788.3	809.5	852.3	895.8
Textile wastes	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7
Animal and vegetal wastes	1189.9	1252.5	1331.9	1386.7	1440.3	1479.2	1557.4	1636.9

	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Nicosia								
Industrial effluent sludges	63.3	66.6	69.2	67.8	69.4	69.7	67.4	136.2
Wood wastes	3447.2	3632.3	3769.8	3695.3	3781.7	3797.5	3671.0	3355.5
Textile wastes	5.8	6.1	6.3	6.2	6.3	6.4	6.2	5.9
Animal and vegetal wastes	4227.1	4454.2	4622.8	4531.5	4637.4	4656.8	4501.6	3745.3
Ammochostos								
Industrial effluent sludges	10.9	11.4	11.9	11.6	11.9	12.0	11.6	23.4
Wood wastes	575.9	606.9	629.8	617.4	631.8	634.5	613.3	560.6
Textile wastes	0.4	0.4	0.5	0.4	0.5	0.5	0.4	0.4
Animal and vegetal wastes	3055.3	3219.4	3341.3	3275.3	3351.8	3365.9	3253.7	2707.1
Larnaca								
Industrial effluent sludges	25.8	27.2	28.2	27.7	28.3	28.4	27.5	55.6
Wood wastes	1778.6	1874.2	1945.1	1906.7	1951.2	1959.4	1894.1	1731.3
Textile wastes	2.0	2.1	2.2	2.2	2.2	2.2	2.2	2.1
Animal and vegetal wastes	4987.9	5255.8	5454.8	5347.0	5472.0	5494.9	5311.7	4419.4
Limassol								
Industrial effluent sludges	48.2	50.8	52.7	51.7	52.9	53.1	51.3	103.8
Wood wastes	3201.5	3373.5	3501.2	3432.0	3512.2	3526.9	3409.4	3116.4
Textile wastes	4.1	4.4	4.5	4.4	4.5	4.6	4.4	4.3
Animal and vegetal wastes	2859.0	3012.6	3126.6	3064.8	3136.4	3149.6	3044.6	2533.1
Pafos								
Industrial effluent sludges	18.1	19.1	19.8	19.4	19.9	19.9	19.3	39.0
Wood wastes	940.1	990.6	1028.1	1007.8	1031.4	1035.7	1001.2	915.1
Textile wastes	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Animal and vegetal wastes	1717.8	1810.1	1878.6	1841.5	1884.6	1892.4	1829.4	1522.1

	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Nicosia								
Industrial effluent sludges	205.1	230.4	255.7	168.0	80.3	40.1	0.0	0.0
Wood wastes	3040.0	2458.6	1877.3	1705.8	1534.4	767.2	0.0	0.0
Textile wastes	5.7	5.7	5.7	5.5	5.3	2.6	0.0	0.0
Animal and vegetal wastes	2989.1	2803.5	2618.0	2515.0	2412.0	1893.0	1374.0	1135.4

Ammochostos								
Industrial effluent sludges	35.2	39.6	43.9	28.9	13.8	6.9	0.0	0.0
Wood wastes	507.9	410.8	313.6	285.0	256.4	128.2	0.0	0.0
Textile wastes	0.4	0.4	0.4	0.4	0.4	0.2	0.0	0.0
Animal and vegetal wastes	2160.5	2026.4	1892.3	1817.8	1743.4	1368.2	993.1	820.7
Larnaca								
Industrial effluent sludges	83.7	94.0	104.4	68.6	32.8	16.4	0.0	0.0
Wood wastes	1568.6	1268.6	968.6	880.2	791.7	395.9	0.0	0.0
Textile wastes	2.0	2.0	2.0	1.9	1.8	0.9	0.0	0.0
Animal and vegetal wastes	3527.0	3308.1	3089.2	2967.6	2846.1	2233.7	1621.3	1339.8
Limassol								
Industrial effluent sludges	156.3	175.5	194.8	128.0	61.2	30.6	0.0	0.0
Wood wastes	2823.4	2283.5	1743.5	1584.3	1425.1	712.5	0.0	0.0
Textile wastes	4.1	4.1	4.1	3.9	3.8	1.9	0.0	0.0
Animal and vegetal wastes	2021.7	1896.2	1770.7	1701.0	1631.3	1280.3	929.3	767.9
Pafos								
Industrial effluent sludges	58.7	65.9	73.2	48.1	23.0	11.5	0.0	0.0
Wood wastes	829.1	670.5	512.0	465.2	418.5	209.2	0.0	0.0
Textile wastes	0.8	0.8	0.8	0.7	0.7	0.4	0.0	0.0
Animal and vegetal wastes	1214.7	1139.3	1063.9	1022.1	980.2	769.3	558.4	461.4

Table 7.17. Total quantities of solid waste disposed per type of waste and waste disposal site (tonnes)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Deep unmanaged								
Industrial effluent sludges	64.0	64.5	71.2	71.7	76.2	103.9	105.2	108.1
Wood wastes	3831.3	3858.4	4258.8	4288.9	4557.6	6217.1	6295.6	6466.4
Textile wastes	5.1	5.1	5.6	5.7	6.0	8.2	8.3	8.5
Animal and vegetal wastes	6491.5	6537.3	7215.7	7266.7	7722.0	10533.6	10666.7	10956.1
Managed anaerobic								
Industrial effluent sludges	NO	NO	NO	NO	NO	NO	NO	NO
Wood wastes	NO	NO	NO	NO	NO	NO	NO	NO
Textile wastes	NO	NO	NO	NO	NO	NO	NO	NO
Animal and vegetal wastes	NO	NO	NO	NO	NO	NO	NO	NO

	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Deep unmanaged								
Industrial effluent sludges	115.1	121.2	128.9	134.2	139.4	143.1	150.7	158.4
Wood wastes	6887.3	7249.6	7709.5	8026.8	8337.1	8561.8	9014.9	9474.7
Textile wastes	9.1	9.6	10.2	10.6	11.0	11.3	11.9	12.5
Animal and vegetal wastes	11669.1	12283.1	13062.3	13599.8	14125.7	14506.2	15274.0	16053.0
Managed anaerobic								
Industrial effluent sludges	NO	NO	NO	NO	NO	NO	NO	NO
Wood wastes	NO	NO	NO	NO	NO	NO	NO	NO
Textile wastes	NO	NO	NO	NO	NO	NO	NO	NO
Animal and vegetal wastes	NO	NO	NO	NO	NO	NO	NO	NO

	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Deep unmanaged								
Industrial effluent sludges	148.1	156.1	162.0	158.8	122.2	122.8	118.7	240.0
Wood wastes	9003.3	9486.9	9846.0	9651.5	7293.9	7324.5	7080.4	6471.9
Textile wastes	12.4	13.0	13.5	13.3	10.9	10.9	10.6	10.2

Animal and vegetal wastes	15129.3	15942.0	16545.5	16218.5	7773.8	7806.3	7546.2	6278.5
Managed anaerobic								
Industrial effluent sludges	18.1	19.1	19.8	19.4	60.1	60.3	58.3	118.0
Wood wastes	940.1	990.6	1028.1	1007.8	3614.5	3629.6	3508.6	3207.1
Textile wastes	0.8	0.8	0.8	0.8	3.5	3.5	3.4	3.3
Animal and vegetal wastes	1717.8	1810.1	1878.6	1841.5	10708.3	10753.2	10394.8	8648.5

	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Deep unmanaged								
Industrial effluent sludges	361.4	406.0	450.5	296.0	141.5	0	0	0
Wood wastes	5863.4	4742.1	3620.8	3290.1	1534.4	0	0	0
Textile wastes	9.8	9.8	9.8	9.4	5.3	0	0	0
Animal and vegetal wastes	5010.7	4699.7	4388.7	4216.0	2412.0	0	0	0
Managed anaerobic								
Industrial effluent sludges	177.6	199.5	221.5	145.5	130.7	105.5	0.0	0.0
Wood wastes	2905.6	2349.9	1794.2	1630.4	2891.6	2213.0	0.0	0.0
Textile wastes	3.2	3.2	3.2	3.1	6.7	6.0	0.0	0.0
Animal and vegetal wastes	6902.3	6473.8	6045.3	5807.5	7201.0	7544.5	5476.0	4525.3

Estimation of CH_4 from waste disposal on land

For the purpose of estimation of emissions, the default IPCC parameters have been used, assuming that waste streams have the same characteristics as the MSW component and the IPCC waste model excel template. Therefore, the quantities presented in Table 7.17 have been added to the quantities of the MSW in the model.

Degradable organic carbon (DOC) has been estimated using the following equation (equation 3.7, volume 5, pg. 3.13 of IPCC 2006 guidelines using default carbon content values (0.15 for food waste, 0.43 for wood, 0.24 for textiles and 0.05 for Sewage sludge)).

$$DOC = \Sigma_i (DOC_i * W_i)$$

Fraction of degradable organic carbon which decomposes (DOC_F) is assumed as 0.5, which is the default value proposed by the 2006 IPCC guidelines (pg. 3.13, volume 5).

The CH_4 fraction F value used is the default proposed by the IPCC guidelines, i.e. 0.5. The oxidation factors (OX) used are the defaults proposed by the IPCC guidelines (Table 3.2, pg. 3.15, vol. 5, 2006 IPCC guidelines); i.e. 0 for deep unmanaged and 0.1 for managed anaerobic. No methane is recovered from SWDS in Cyprus, therefore recovery (R) is assumed 0.

The defaults used by the IPCC waste model for Methane generation rate constant (k) are according to dry temperate climate; i.e. 0.06 for food waste, 0.02 for wood and straw and 0.04 for textiles.

According to the consultations with the Waste Management Unit of the Department of Environment, and according to the 2006 IPCC Guidelines, all SWDS not meeting the criteria of managed SWDS and which have depth smaller than 5m are classified as unmanaged disposal sites, and are therefore assumed to be shallow. The value for the methane correction factor for shallow unmanaged disposal sites is assumed to be 0.4, per the default from the IPCC 2006 guidelines (pg. 3.14, volume 5). Moreover, all SWDS not meeting the criteria of managed SWDS and which have depth greater than or equal to 5m are classified as unmanaged disposal sites, and assumed to be deep. The value for the methane conversion factor for deep unmanaged disposal sites is assumed to be 0.8, per the default from the IPCC 2006 guidelines (pg. 3.14, volume 5).

Other parameters used for the calculation of methane emissions by the IPCC waste model are Delay time of 6 months; Fraction of methane (F) in developed gas of 0.5; and Conversion factor, for C to CH, of 1.33.

The resulting CH_4 emissions for the <u>total solid waste,</u> including both municipal and non-municipal solid wastes as estimated by the IPCC Waste Model, are presented in Table 7.18.

7.2.2. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

7.2.3. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

7.2.4. Category-specific recalculations

Emissions from solid waste management (5A) were recalculated for the time series 1990–2020, due to:

a. Technical correction from the 2022 TERT review;
b. Revised activity data from the Statistical Service of Cyprus regarding the Annual per capita production (kg/cap) for 2019 and 2020, and
c. Revised GDP data from the Statistical Service of Cyprus that affects the waste historical data feeding the waste model.

The resulting CH_4 emissions for the total solid waste, including both municipal and non-municipal solid wastes as estimated by the IPCC Waste Model, are presented in Table 7.18.

Table 7.18. Revised total solid waste CH_4 emissions (Gg) – recalculation in red

	1990	1991	1992	1993	1994	1995	1996	1997
Un-managed, deep	8.47	8.63	8.80	8.99	9.19	9.41	9.65	9.91
Un-managed, shallow	2.08	2.11	2.15	2.18	2.22	2.26	2.31	2.36
Un-managed, total	10.55	10.74	10.94	11.18	11.41	11.67	11.97	12.27
Managed, anaerobic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Managed, anaerobic from disposal of residues	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Managed, anaerobic total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	10.55	10.74	10.94	11.18	11.41	11.67	11.97	12.27

	1998	1999	2000	2001	2002	2003	2004	2005
Un-managed, deep	10.17	10.44	10.70	10.98	11.28	11.59	11.91	12.24
Un-managed, shallow	2.41	2.45	2.50	2.55	2.60	2.65	2.71	2.78
Un-managed, total	12.58	12.89	13.20	13.53	13.88	14.24	14.62	15.01
Managed, anaerobic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Managed, anaerobic from disposal of residues	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Managed, anaerobic total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	12.58	12.89	13.20	13.53	13.88	14.24	14.62	15.01

	2006	2007	2008	2009	2010	2011	2012	2013
Un-managed, deep	12.56	12.80	13.05	13.32	13.59	13.63	13.64	13.82
Un-managed, shallow	2.84	2.89	2.94	3.00	3.06	3.02	2.99	2.85
Un-managed, total	15.40	15.69	15.99	16.32	16.64	16.65	16.63	16.67
Managed, anaerobic	0.00	0.15	0.29	0.43	0.58	1.04	1.47	1.86
Managed, anaerobic from disposal of residues	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02
Managed, anaerobic total	0.00	0.15	0.29	0.43	0.58	1.04	1.47	1.87
TOTAL	15.40	15.84	16.28	16.75	17.22	17.70	18.10	18.55

	2014	2015	2016	2017	2018	2019	2020	
Un-managed, deep	13.94	13.98	14.05	14.13	14.21	13.96	13.34	
Un-managed, shallow	2.72	2.60	2.49	2.38	2.27	2.17	2.07	
Un-managed, total	16.66	16.58	16.54	16.51	16.48	16.13	15.41	
Managed, anaerobic	2.19	2.48	2.76	3.04	3.30	3.83	4.72	
Managed, anaerobic from disposal of residues	0.02	0.03	0.03	0.04	0.04	0.09	0.15	
Managed, anaerobic total	2.21	2.50	2.79	3.07	3.34	3.92	4.87	
TOTAL	18.88	19.09	19.32	19.58	19.82	20.06	20.28	

The impact of recalculations is presented in the following table and figure.

Table 7.19. Impact of recalculation of total solid waste CH_4 emissions

	1990	1991	1992	1993	1994	1995	1996	1997
2022 submission ($GgCH_4$)	10.76	10.96	11.18	11.43	11.68	11.95	12.28	12.60
2023 submission ($GgCH_4$)	10.55	10.74	10.94	11.18	11.41	11.67	11.97	12.27
change in $GgCH_4$	-0.21	-0.22	-0.24	-0.25	-0.27	-0.28	-0.31	-0.34
change in %	-1.9%	-2.0%	-2.1%	-2.2%	-2.3%	-2.4%	-2.5%	-2.7%
change in $GgCO_2$ eq.	-5.842	-6.251	-6.639	-7.085	-7.507	-7.958	-8.720	-9.449
impact to solid waste	-1.9%	-2.0%	-2.1%	-2.2%	-2.3%	-2.4%	-2.5%	-2.7%
impact to waste sector	-1.4%	-1.5%	-1.5%	-1.6%	-1.6%	-1.7%	-1.8%	-1.9%
impact to total excl. LULUCF	-0.10%	-0.10%	-0.10%	-0.10%	-0.11%	-0.11%	-0.12%	-0.13%

	1998	1999	2000	2001	2002	2003	2004	2005
2022 submission ($GgCH_4$)	12.94	13.28	13.62	13.98	14.36	14.75	15.16	15.58
2023 submission ($GgCH_4$)	12.58	12.89	13.20	13.53	13.88	14.24	14.62	15.01
change in $GgCH_4$	-0.36	-0.39	-0.42	-0.45	-0.48	-0.51	-0.54	-0.57
change in %	-2.8%	-2.9%	-3.1%	-3.2%	-3.3%	-3.4%	-3.5%	-3.7%
change in $GgCO_2$ eq.	-10.167	-10.924	-11.708	-12.535	-13.373	-14.221	-15.060	-15.938
impact to solid waste	-2.8%	-2.9%	-3.1%	-3.2%	-3.3%	-3.4%	-3.5%	-3.7%
impact to waste sector	-2.1%	-2.2%	-2.3%	-2.4%	-2.5%	-2.7%	-2.8%	-2.9%
impact to total excl. LULUCF	-0.13%	-0.13%	-0.14%	-0.15%	-0.16%	-0.16%	-0.16%	-0.17%

	2006	2007	2008	2009	2010	2011	2012	2013
2022 submission ($GgCH_4$)	16.01	16.47	16.96	17.46	17.96	18.47	18.91	19.38
2023 submission ($GgCH_4$)	15.40	15.84	16.28	16.75	17.22	17.70	18.10	18.55
change in $GgCH_4$	-0.60	-0.64	-0.67	-0.71	-0.74	-0.78	-0.81	-0.83
change in %	-3.8%	-3.9%	-4.0%	-4.1%	-4.1%	-4.2%	-4.3%	-4.3%
change in $GgCO_2$ eq.	-16.853	-17.830	-18.855	-19.895	-20.823	-21.769	-22.580	-23.242
impact to solid waste	-3.8%	-3.9%	-4.0%	-4.1%	-4.1%	-4.2%	-4.3%	-4.3%
impact to waste sector	-3.1%	-3.3%	-3.4%	-3.5%	-3.7%	-3.8%	-3.9%	-3.9%
impact to total excl. LULUCF	-0.18%	-0.18%	-0.19%	-0.20%	-0.22%	-0.24%	-0.26%	-0.29%

	2014	2015	2016	2017	2018	2019	2020	
2022 submission ($GgCH_4$)	19.75	20.04	20.36	20.71	21.05	21.35	21.66	
2023 submission ($GgCH_4$)	18.88	19.09	19.32	19.58	19.82	20.06	20.28	
change in $GgCH_4$	-0.88	-0.95	-1.03	-1.12	-1.22	-1.29	-1.38	
change in %	-4.5%	-4.7%	-5.1%	-5.4%	-5.8%	-6.1%	-6.4%	
change in $GgCO_2$ eq.	-24.625	-26.642	-28.920	-31.453	-34.271	-36.207	-38.566	
impact to solid waste	-4.5%	-4.7%	-5.1%	-5.4%	-5.8%	-6.1%	-6.4%	
impact to waste sector	-4.1%	-4.4%	-4.7%	-5.1%	-5.5%	-5.7%	-6.1%	
impact to total excl. LULUCF	-0.29%	-0.32%	-0.33%	-0.35%	-0.39%	-0.40%	-0.45%	

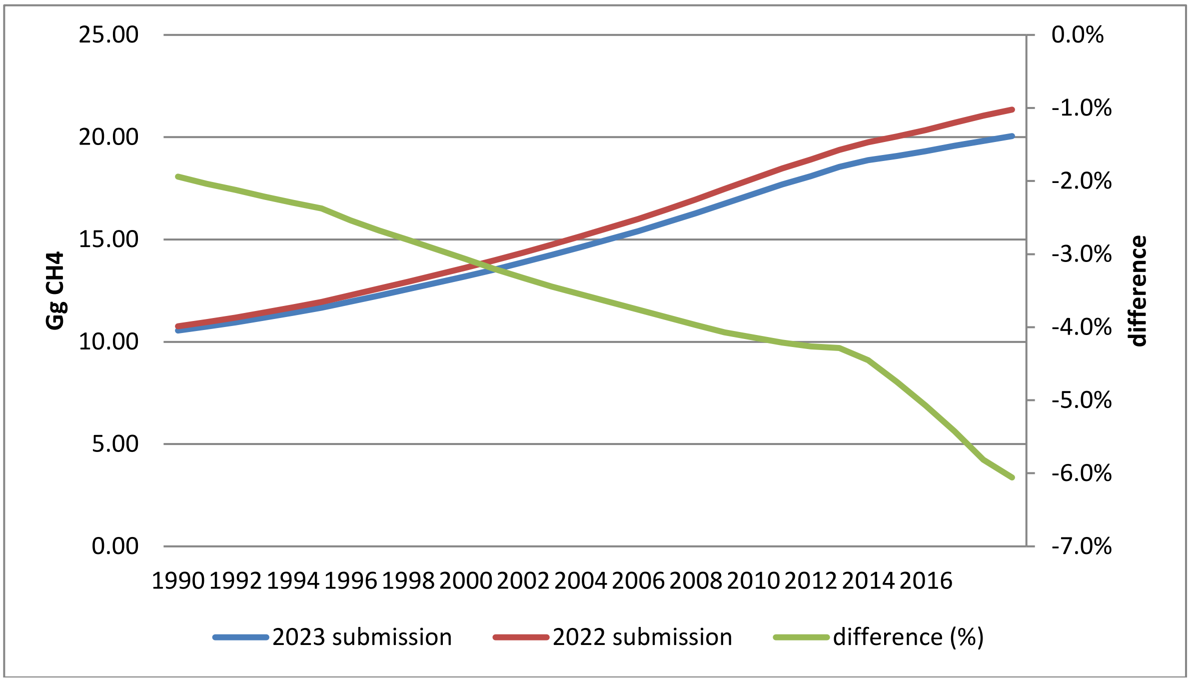


Figure 7.6. **Impact of recalculations to the total CH_4 emissions from solid waste management ranges**

7.2.5. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

7.3. Biological Treatment of Solid Waste (5B)

Composting and anaerobic digestion of organic waste, such as food waste, garden (yard) and park waste and sludge, is common both in developed and developing countries. Advantages of the biological treatment include: reduced volume in the waste material, stabilisation 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 fertiliser and soil amendment, or be disposed in SWDS.

Emissions from biological treatment of solid waste in 2021 accounted for 3.2% of total GHG emissions from Waste sector, and 0.24% of total national emissions without LULUCF. 99.6% of the emissions are from composting (5B1) and 1.4% from anaerobic digestion at biogas facilities (5B2). The emissions from biological treatment of solid waste (5B) are presented in Table 7.20 and Figure 7.7.

Table 7.20. **Emissions from biological treatment of solid waste, 1990–2021**

	1990	2000	2005	2010	2011	2012	2013
CH_4 (Gg)	NO	NO	NO	0.108	0.197	0.238	0.205
N_2O (Gg)	NO	NO	NO	0.0063	0.0115	0.0139	0.0118
Total (Gg CO_2 eq.)	NO	NO	NO	4.71	8.55	10.35	8.85

	2014	2015	2016	2017	2018	2019	2020
CH_4 (Gg)	0.256	0.291	0.291	0.296	0.369	0.449	0.444
N_2O (Gg)	0.0148	0.0170	0.0170	0.0176	0.0220	0.0268	0.0266
Total (Gg CO_2 eq.)	11.09	12.65	12.65	12.94	16.15	19.67	19.48

	2021						
CH_4 (Gg)	0.487						
N_2O (Gg)	0.0291						
Total (Gg CO_2 eq.)	21.35						

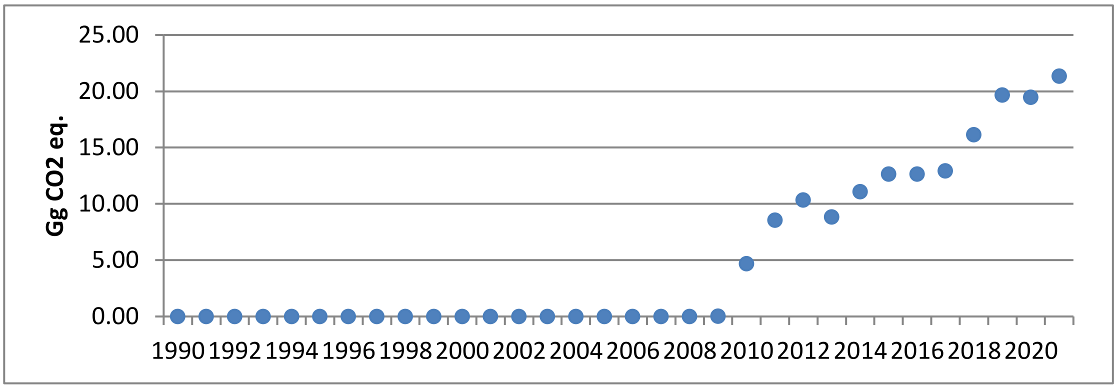


Figure 7.7. Emissions from biological treatment of solid waste 1990–2021

7.3.1. Composting (5B1)

Composting is an aerobic process and a large fraction of the degradable organic carbon (DOC) in the waste material is converted into carbon dioxide (CO_2). CH_4 is formed in anaerobic sections of the compost, but it is oxidised to a large extent in the aerobic sections of the compost. Composting can also produce emissions of N_2O.

7.3.1.1. Methodological issues

The estimation of CH_4 and N_2O emissions from biological treatment of solid waste according to the 2006 IPCC Guidelines (chapter 4, vol. 5) involves the following steps:

Step 1. Activity data

Collect data on the amount and type of solid waste which is treated biologically. The amount of solid waste composted is presented in Table 7.21 and is according to the national statistics on production and management of municipal solid waste[80]. Activity data includes the amount of composting material that is used for backfilling and sludge transported for composting.

Table 7.21. The amount of solid waste composted for the period 2010–2021

	2010	2011	2012	2013	2014	2015
Composting (1000t on a wet weight basis)	0.00	0.00	6.78	7.95	19.11	24.54
Compost from MTB Koshi (1000t on a wet weight basis)	26.31	47.92	50.99	41.15	42.76	46.16
Sludge transported for composting (1000t on a dry weight basis)						

	2016	2017	2018	2019	2020	2021
Composting (1000t on a wet weight basis)	22.02	13.61	15.21	17.92	18.44	26.56
Compost from MTB Koshi (1000t on a wet weight basis)	48.63	51.19	64.59	82.98	80.64	83.35
Sludge transported for composting (1000t on a dry weight basis)		3.43	4.71	4.29	4.68	4.55

[80] The 2017 publication, which includes data for the years 1996-2016 is available at http://www.cystat.gov.cy/mof/cystat/statistics.nsf/energy_environment_82main_gr/energy_environment_82main_gr?OpenForm&sub=2&sel=2; contact person for population statistics at the Statistical Service is Marilena Kythreotou, +357 22602137, mkythreotou@cystat.mof.gov.cy.

Step 2. Estimation of emissions

The CH_4 and N_2O emissions of composting have been estimated using the default method, i.e. equations 4.1 and 4.2 of the 2006 IPCC guidelines (volume 5, page 4.5). The emission factor for N_2O emissions is assumed to be 0.24 g/kg for wet waste and 0.6 g/kg for dry waste, while the CH_4 emission factor as 4 g/kg wet waste and 10 g/kg for dry waste (IPCC 2006, vol.5, pg. 4.6, table 4.1).

Step 3. Subtraction of recovered gas

According to the guidelines, the amount of recovered gas from the amount of CH_4 generated to estimate net annual CH_4 emissions should be subtracted. No recovery takes place in Cyprus therefore amount of recovered gas is 0.

7.3.1.2. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

7.3.1.3. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

7.3.1.4. Category-specific recalculations

Emissions from composting (5B1) were recalculated for the time series 2010–2020, based on 2022 TERT review and includes the activity data from the composting stage of two MBT-plants.

The impact of recalculations is presented in the following table.

Table 7.22. Composting (5B1) recalculations

5B1 (Gg CH_4)	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
2022 submission	0.0316	0.0598	0.0919	0.0785	0.1113	0.1464
2023 submission	0.1052	0.1917	0.2311	0.1964	0.2475	0.2828
change	233.5%	220.5%	151.4%	150.3%	122.3%	93.2%

5B1 (Gg CH_4)	**2016**	**2017**	**2018**	**2019**	**2020**	
2022 submission	0.1552	0.1552	0.1969	0.2399	0.2344	
2021 submission	0.2826	0.2935	0.3662	0.4465	0.4432	
change	82.1%	89.1%	86.0%	86.1%	89.0%	

5B1 (Gg N_2O)	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
2022 submission	0.0019	0.0036	0.0055	0.0047	0.0067	0.0088
2023 submission	0.0063	0.0115	0.0139	0.0118	0.0148	0.0170
change	233.5%	220.5%	151.4%	150.3%	122.3%	93.2%

5B1 (Gg N_2O)	**2016**	**2017**	**2018**	**2019**	**2020**	
2022 submission	0.0093	0.0093	0.0118	0.0144	0.0141	
2021 submission	0.0170	0.0176	0.0220	0.0268	0.0266	
change	82.1%	89.1%	86.0%	86.1%	89.0%	

7.3.1.5. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

7.3.2 Anaerobic Digestion at Biogas Facilities (5B2)

Anaerobic digestion of organic waste expedites the natural decomposition of organic material without oxygen by maintaining the temperature, moisture content and pH close to their optimum values. Emissions of CH_4 from such facilities due to unintentional leakages during process disturbances or other unexpected events will generally be between 0 and 10 percent of the amount of CH_4 generated. In the absence of further information, use 5 percent as a default value for the CH_4 emissions. N_2O emissions from the process are assumed to be negligible.

7.3.2.1. Methodological issues

The estimation of CH_4 emissions from biological treatment of solid waste as according to the 2006 IPCC Guidelines (chapter 4, vol. 5) involves the following steps:

Step 1. Activity data

Collect data on the amount of sludge transported for anaerobic treatment for biogas production. The amount of sludge transported for anaerobic treatment for biogas production is presented in Table 7.23 and is according to data provided by the Pollution Control Unit of Department of Environment under the provisions of the Urban Waste Water Treatment Directive 91/271/EEC.

Table 7.23. The amount of sludge transported for anaerobic treatment for biogas production for the period 2009-2021

	2009	2010	2011	2012	2013	2014
Sludge transported for for anaerobic treatment for biogas production (1000t on a dry weight basis)	620	1549	2478	3682	4117	4061

	2015	2016	2017	2018	2019	2020
Sludge transported for for anaerobic treatment for biogas production (1000t on a dry weight basis)	4221	4380	1044	1281	1192	508

	2021					
Sludge transported for for anaerobic treatment for biogas production (1000t on a dry weight basis)	866					

Step 2. Estimation of emissions

The CH_4 emissions of anaerobic digestion at biogas facilities have been estimated using the default method, i.e. equations 4.1 and 4.2 of the 2006 IPCC guidelines (volume 5, page 4.5). The emission factor for CH_4 is assumed to be 2 g/kg dry waste (IPCC 2006, vol.5, pg. 4.6, table 4.1). The N_2O emission factor for anaerobic digestion at biogas facilities is assumed as negligible.

7.3.2.2. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

7.3.2.3. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

7.3.2.4. Category-specific recalculations

Emissions from Anaerobic Digestion at Biogas Facilities (5B2) were recalculated for the year 2019 and 2020 due to updated activity data. Emissions decreased by 6.9% for 2019 and 60.3% for the year 2020.

7.3.2.5. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

7.4. Incineration and Open Burning of Waste (5C)

Incineration and Open Burning of Waste do not take place in Cyprus and are therefore reported as NO. Fire Prevention of Outdoors Law of 1988 (220/1988) as amended by 109(I)2002 prohibits any open burning of waste or any other material by the population, including waste.

However, according to the Statistical Service[81] in 2014, 4.45 kt of partly stabilised biodegradable waste that has been generated during sorting have been incinerated for energy recovery in the cement kiln. The emissions of this activity have been considered in the energy sector, source category 1A2f, Non-Metallic Minerals.

7.5. Wastewater Treatment and Discharge (5D)

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. Wastewater originates from a variety of domestic, commercial and industrial sources and may be treated on site (uncollected), sewered to a centralized plant (collected) or disposed untreated nearby or via an outfall. In Cyprus there is no disposal of untreated wastewater nearby or via an outfall. Wastewater treatment systems and discharge pathways in Cyprus are presented in Figure 7.8.

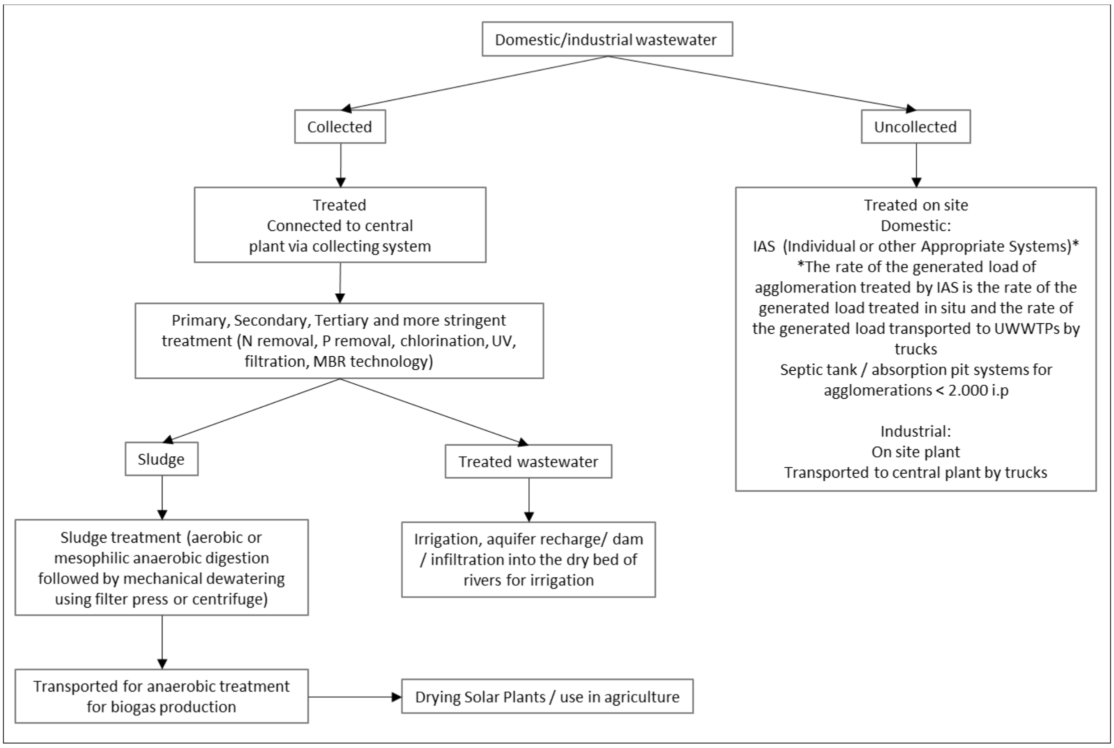


Figure 7.8. Wastewater treatment systems and discharge pathways in Cyprus[82]

Emissions from Wastewater treatment and discharge accounted for 10.4% of the total GHG emissions from the Waste sector in 2021 and 0.79% of total national emissions without LULUCF. The emissions

[81] Statistical Service, 2017, Generation and treatment of municipal solid waste, available at http://www.mof.gov.cy/mof/cystat/statistics.nsf/All/ADFFD39B594E2B42C2256D41001F2DBB/$file/MUNICIPAL_SOLID_WASTE-A93_16-EN-281117.xls?OpenElement

[82] Stella Perikenti, Environment Officer, National expert on urban wastewater management, Pollution Control Unit, Department of Environment (+35726804573, sperikenti@environment.moa.gov.cy)

from Wastewater treatment and discharge between 1990 and 2021 decreased by 50.6%, mainly due to the shift from septic tanks to centralised aerobic treatment systems for the treatment of domestic wastewater. The emissions from these sources are presented in Table 7.24 and Figure 7.9.

Table 7.24. Emissions from Wastewater treatment and discharge (5D) 1990–2021

	1990	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**
D. Wastewater treatment and discharge	**139.82**	**153.51**	**137.22**	**97.04**	**85.70**	**82.60**	**81.60**
1. Domestic wastewater	112.44	121.97	108.02	66.24	52.64	52.66	51.96
2. Industrial wastewater	27.10	31.23	28.95	30.55	32.79	29.70	29.41
CH_4 (Gg)	4.64	5.04	4.47	2.98	2.56	2.45	2.41
N_2O (Gg)	0.04	0.05	0.05	0.05	0.05	0.05	0.05
Total (Gg CO_2 eq.)	**139.82**	**153.51**	**137.22**	**97.04**	**85.70**	**82.60**	**81.60**

	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
D. Wastewater treatment and discharge	**80.77**	**77.76**	**74.05**	**74.00**	**73.72**	**75.21**	**68.74**
1. Domestic wastewater	51.08	45.65	40.45	39.30	39.03	39.57	37.45
2. Industrial wastewater	29.46	31.87	33.36	34.43	34.42	35.37	31.04
CH_4 (Gg)	2.39	2.28	2.15	2.14	2.12	2.17	1.93
N_2O (Gg)	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Total (Gg CO_2 eq.)	**80.77**	**77.76**	**74.05**	**74.00**	**73.72**	**75.21**	**68.74**

	2021						
D. Wastewater treatment and discharge	**69.10**						
1. Domestic wastewater	37.82						
2. Industrial wastewater	31.04						
CH_4 (Gg)	1.94						
N_2O (Gg)	0.05						
Total (Gg CO_2 eq.)	**69.10**						

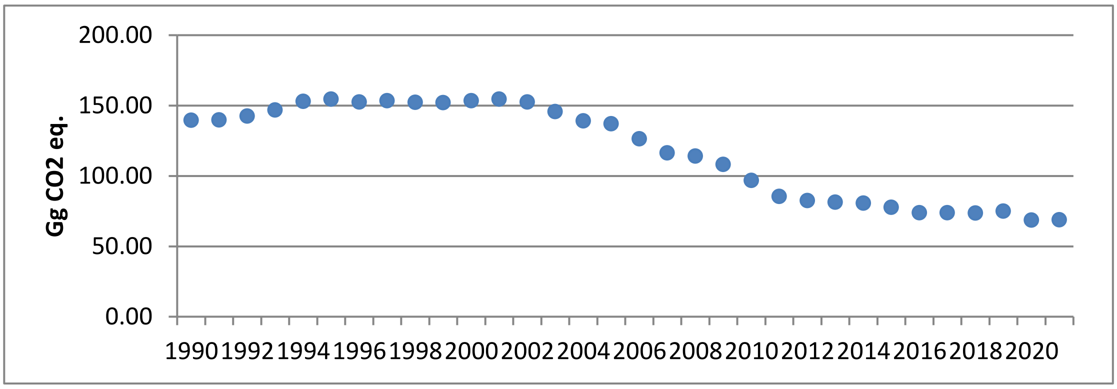


Figure 7.9. Total emissions from Wastewater treatment and discharge (5D) 1990–2021

7.5.1. Domestic Wastewater Treatment and Discharge (5D1)

According to the 2006 IPCC Guidelines, Domestic wastewater is defined as "wastewater from household water use, while industrial wastewater is from industrial practices only"[83]. Sewers in Cyprus are closed and underground, which is not believed to be a significant source of CH_4. An overview of most wastewater treatment methods and pathways in Cyprus is presented in Figure 7.8. All information presented regarding urban wastewater has been obtained from Ms. Stella Perikenti (Pollution Control Unit, Department of Environment) and Ms. Lia Georgiou (Division of Waste Water and Reuse, Water

[83] 2006 IPCC Guidelines, 2015 Corrigendum, Volume 5, pg. 6.6

Development Department).

To meet regulatory standards, many large industrial facilities pre-treat their wastewater before releasing it into the sewage system. Domestic wastewater is also treated in on-site septic systems. These are advanced systems that may treat wastewater from one household. They consist of an anaerobic underground tank and a drainage field for the treatment of effluent from the tank. This used to be a common practice in the 1990s, but gradually decreased due to the construction of the wastewater collection systems and treatment stations (Figure 7.10). 10% of wastewater disposed in septic tanks is collected by authorised wastewater collectors and transported to aerobic wastewater treatment plants. Some industrial wastewater may be discharged into municipal sewer lines, where it combines with domestic wastewater, provided that the organic load of the wastewater is reduced to the limits set in the wastewater disposal permit issued by the Department of Environment.

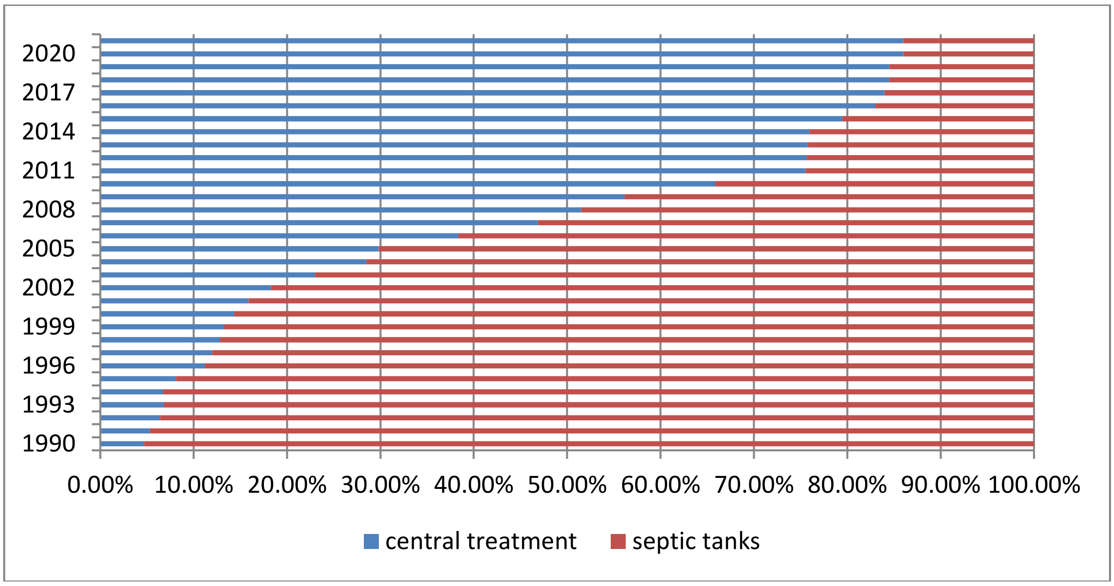


Figure 7.10. Domestic Wastewater treatment in Cyprus 1990–2021

Centralised wastewater treatment methods can be classified as primary, secondary, and tertiary treatment. In primary treatment, physical barriers remove larger solids from the wastewater. Remaining particulates are then allowed to settle. Secondary treatment consists of a combination of biological processes that promote biodegradation by micro-organisms. Tertiary treatment processes are used to further purify the wastewater of pathogens, contaminants, and remaining nutrients such as nitrogen and phosphorus compounds. This is achieved using one or a combination of processes that can include biological processes, advanced filtration, carbon adsorption, UV and disinfection. Details on the technologies used in Cyprus are presented in Table 7.25.

Table 7.25. Wastewater treatment technologies implemented in Cyprus for the treatment of urban wastewaters

Wastewater treatment plant	**Capacity**	**Primary**	**Secondary**	**Tertiary**	**N Removal**	**P Removal**	**UV**	**Chlorination**	**Sand Filtration**	**MBR Technology**
Kakopetria	2200	√	√							
Paralimni	68750	√	√	√	√	√		√	√	
Ayia Napa	56250	√	√	√	√	√		√	√	
Livadhia Refugee Camp	2000	√	√	√				√	√	
Larnaca	70000	√	√	√	√			√	√	√
Kyperounda	3500	√	√	√				√	√	
Platres	3500	√	√	√				√	√	

Agros	5250	√	√	√				√	√	
Limassol	272000	√	√	√	√	√		√	√	
Paphos	162500	√	√	√	√	√		√	√	
Dhali	5000	√	√	√				√	√	
Mia Milia	160000	√	√							
Central Vathia Gonia	45765	√	√	√				√	√	
Anthoupolis-A	7200	√	√	√				√		
Anthoupolis-B	130000	√	√	√	√	√				√
Vathia-Gonia-A	201667	√	√	√	√	√	√			√
Pelendri	3000	√	√	√				√	√	
Lythrodontas	3500	√	√	√				√	√	
Mia Milia B	269117	√	√	√	√	√				√
Astromeritis	14767	√	√	√				√	√	

Sludge is produced in all of the primary, secondary and tertiary stages of treatment. Sludge that is produced in primary treatment consists of solids that are removed from the wastewater and is not accounted for in this category. Sludge produced in secondary and tertiary treatment results from biological growth in the biomass, as well as the collection of small particles. This sludge is treated further before it can be safely disposed of. Methods of sludge treatment include aerobic and anaerobic stabilisation (digestion), centrifugation, composting, and drying. The utilization of sludge produced by the wastewater treatment plants in Cyprus is shown in Table 7.26. Table 7.27 shows the load entering the UWWTPs currently in operation in population equivalent.

CH_4 emissions and N_2O emissions from this source are presented in Table 7.28 and Figure 7.11.

Table 7.26. Utilisation of sludge produced by the wastewater treatment plants in Cyprus (t of dry matter/yr)

Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Sludge production	8035	7974	9163	7083	6815	6533	6123	6160	6695
Sludge used in agriculture	5745	6515	7903	5294	3912	2756	2924	1391	936
Sludge transported for anaerobic treatment for biogas production			620		2478			4061	
Sludge stored at the plants					425			621	
Incineration			640						
Sludge transported for composting									
Others (green areas)									
Year	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**			
Sludge production	6850	7166	8406	8681	8216	8832			
Sludge used in agriculture	1436	1075	937	1015	1014	867			
Sludge transported for anaerobic treatment for biogas production	4380	1044	1281	1192	508	866			
Sludge stored at the plants	309	781	1062	1504	1728	2083			
Incineration	608	788	266	479	284	464			
Sludge transported for composting		3425	4705	4293	4682	4552			
Others (green areas)	117	53	155	198	0	0			

Table 7.27. Load entering the Urban Waste Water Treatment Plants (UWWTP) (p.e.)

UWW Name or IAS	**2007**	**2009**	**2011**	**2014**	**2016**	**2020**
Kakopetria	1200	1200	1200	1200	1200	1200
Paralimni	68487	62700	52665	53500	68750	68750
Ayia Napa			37500	37500	56250	56250
Livadhia Refugee Camp	2000	2000	2000	2000	2000	2000
Larnaca	39090	68000	70000	70000	70000	80800
Kyperounda	2068	2068	2200	2200	2200	2200
Platres	1820	1820	2000	2000	2000	2000

Agros	2400	2400	2500	2500	2500	2500
Limassol	131178	130000	182926	193417	225989	240800
Paphos	50000	85300	123925	119611	120100	120100
Dhali	4710	4710	5000	N/O	N/O	N/O
Mia Milia	140000	140000	140000	N/O	N/O	N/O
Central Vathia Gonia	9240	13900	20068	1230	14857	7391
Anthoupolis-A	4800	N/O	N/O	N/O	N/O	N/O
Anthoupolis-B	N/O	26500	37706	34132	35983	44476
Vathia-Gonia-A	N/O	N/O	39781	57252	63187	63202
Pelendri	N/O	2200	2200	2200	2200	2200
Lythrodontas	N/O	2100	3500	3500	3500	3500
Mia Milia B	N/O	N/O	N/O	157116	156330	156322
IAS	9240	13900	26328	16219	34117	24865
Astromeritis	N/O	N/O	N/O	N/O	N/O	7700

N/O – not operated

Table 7.28. Total emissions from Domestic wastewater 1990–2021

	1990	2000	2005	2010	2011	2012	2013
CH_4 (Gg)	3.68	3.93	3.43	1.88	1.39	1.38	1.36
N_2O (Gg)	0.04	0.04	0.04	0.05	0.05	0.05	0.05
Total (Gg CO_2 eq.)	**112.44**	**121.97**	**108.02**	**66.24**	**52.64**	**52.66**	**51.96**

	2014	2015	2016	2017	2018	2019	2020
CH_4 (Gg)	1.34	1.14	0.95	0.91	0.89	0.90	0.82
N_2O (Gg)	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Total (Gg CO_2 eq.)	**51.08**	**45.65**	**40.45**	**39.30**	**39.03**	**39.57**	**37.45**

	2021						
CH_4 (Gg)	0.83						
N_2O (Gg)	0.05						
Total (Gg CO_2 eq.)	**37.82**						

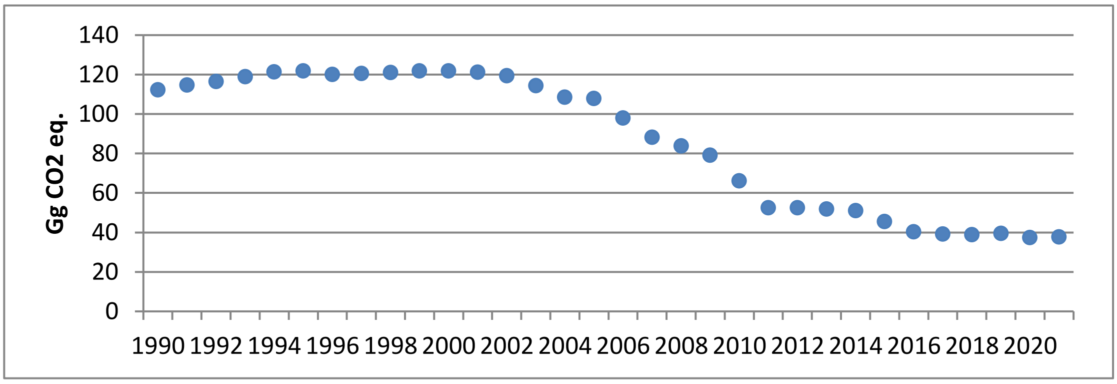


Figure 7.11. Total emissions from Domestic wastewater (5D1) 1990–2021

7.5.1.1. Methodological Issues

<u>Methane emissions from wastewater</u>

Emissions are a function of the amount of organic waste generated and an emission factor that characterises the extent to which this waste generates CH_4. Three tier methods for CH_4 from this category. Tier 2 methodology is applied for estimation of Methane emissions from wastewater in Cyprus.

The steps for inventory preparation for CH_4 from domestic wastewater are as follows:

Step 1: Use Equation 6.3 (2006 IPCC Guidelines, vol. 5, pg. 6.13) to estimate total organically degradable carbon in wastewater (TOW).

BOD is country-specific, and according to Ms. Stella Perikenti 60 g/person/day should be used[84]. Country population has already been presented in Table 7.5. It is assumed as 1.00 for waste disposed in septic tanks (assuming default for uncollected; IPCC 2006, vol.5, pg. 6.14), eqn.6.3; and 1.25 for wastewater treated in central wastewater treatment stations (assuming default for collected; IPCC 2006, vol.5, pg. 6.14). Distribution of wastewater to septic tanks and central treatment stations (Ui) is presented in Table 7.29, along with the estimated TOW for the whole period.

Ui has been recalculated after meetings with representatives of the Water Development Department (responsible department for the construction and management of the Urban Wastewater Treatment Units)[85] and the Pollution Prevention Unit of the Department of Environment on completion of the time series. Data on population equivalents served by wastewater treatment plants (on the basis of the actual BOD loads) was available for the years 1992-2005 from the Statistical Service[86] and for 2007, 2009, 2011, 2014 and 2016 from the Pollution Control Unit of the Department of Environment. 1990-1991 has been estimated from the trend of 1992-2005 ($y=0.0417e^{0.1204x}$, $R^2 = 0.9706$), years 2006, 2008, 2010, 2012, 2013 and 2015 from the average of the years before and after. For the period 2017-2019 an exponential smoothing forecast based on 1990-2016 values was used (function forecast.ets in excel). The population served by septic tanks has been estimated by subtracting the connected population from 100%.

Table 7.29. Distribution of wastewater to septic tanks and central treatment stations Ui and estimated TOW

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Septic							
Ui	95.3%	94.7%	93.6%	93.2%	93.3%	91.9%	88.8%
TOW (kt BOD/yr)	12.25	12.51	12.69	12.92	13.19	13.21	12.96
Treatment							
Ui	4.7%	5.3%	6.4%	6.8%	6.7%	8.1%	11.2%
TOW (kt BOD/yr)	0.76	0.88	1.08	1.18	1.18	1.46	2.04

	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Septic							
Ui	88.0%	87.2%	86.7%	85.7%	84.1%	81.7%	77.0%
TOW (kt BOD/yr)	13.01	13.04	13.11	13.09	12.99	12.77	12.19
Treatment							
Ui	12.0%	12.8%	13.3%	14.3%	15.9%	18.3%	23.0%
TOW (kt BOD/yr)	2.22	2.39	2.51	2.73	3.07	3.58	4.55

	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Septic							
Ui	71.5%	70.2%	61.7%	53.1%	48.5%	43.8%	34.2%
TOW (kt BOD/yr)	11.48	11.44	10.24	9.04	8.46	7.86	6.28
Treatment							
Ui	28.5%	29.8%	38.3%	46.9%	51.5%	56.2%	65.8%
TOW (kt BOD/yr)	5.72	6.07	7.95	9.96	11.24	12.59	15.14

	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Septic							
Ui	24.5%	24.3%	24.2%	24.1%	20.5%	17%	16%
TOW (kt BOD/yr)	4.62	4.61	4.55	4.46	3.81	3.18	3.03
Treatment							
Ui	75.5%	75.7%	75.8%	75.9%	79.5%	83%	84%
TOW (kt BOD/yr)	17.82	17.94	17.80	17.61	18.45	19.42	19.87

[84] Stella Perikenti, Environment Officer, National expert on urban wastewater management, Pollution Control Unit, Department of Environment (+35726804573, sperikenti@environment.moa.gov.cy)
[85] Lia Georgiou, Senior Sanitary Engineer, Division of Waste Water and Reuse, Water Development Department (+357 22609186-185, lgeorgiou@wdd.moa.gov.cy)
[86] resident population connected to wastewater collecting system and wastewater treatment plants, 2007, available at http://www.mof.gov.cy/mof/cystat/statistics.nsf/All/CB1FB8138D95CBB5C22573210044E253/$file/WASTEWATER_TREATMENT-EN-240707.xls?OpenElement

	2018	2019	2020	2021			
Septic							
Ui	15.5%	15.5%	15.5%	15.5%			
TOW (kt BOD/yr)	2.97	3.01	3.04	3.07			
Treatment							
Ui	84.5%	84.5%	84.5%	84.5%			
TOW (kt BOD/yr)	20.26	20.54	20.73	20.93			

Step 2: Select the pathway and systems according to country activity data. Use Equation 6.2 (2006 IPCC Guidelines, vol. 5, pg. 6.12) to obtain the emission factor for each domestic wastewater treatment/discharge pathway or system.

Bo is considered as 0.6 $kgCH_4$/kgBOD (default proposed by IPCC, 2006 guidelines, vol.5, pg. 6.12, table 6.2). MCFj is 0.5 for septic tanks and 0 for central wastewater treatment units, as recommended by the IPCC (2006 guidelines, vol.5, pg. 6.13, table 6.3). 0 was chosen for MCF for WWTP, since the information available indicated that they are well managed.

According to further investigation from TERT during the 2017 annual review of the issue it was found that the European Commission published a database on all waste water treatment plants, which shows the status of compliance of those plants with EU legislation. This source also contains information on the Cypriot plants[87]. According to this website, all but one of the Cypriot waste water treatment plants are fully compliant with UWWTD (Urban Waste Water Treatment Directive) standards. Most important is the compliance on DOC5. DOC5 is the biodegradable part of the organic load into the waste water treatment plant. All experts in the TERT agree that when a plant is overloaded or not well managed, an increase in DOC5 is expected before an increased methane emissions becomes apparent. The single plant that is not compliant with legislation in Cyprus still complies with the DOC5-criterion. For the TERT the information provided on this website seems to prove that all Cypriot waste water treatment plants are well-managed, and therefore a MCF=0 for collected waste water is justified. This is independent EU information demonstrating compliance of wastewater treatment plants in Cyprus, justifying an MCF of 0.

The resulting EFs are 0.3 $kgCH_4$/kgBOD for septic and 0 $kgCH_4$/kgBOD for centralised treatment.

Step 3: Use Equation 6.1 (2006 IPCC Guidelines, vol. 5, pg. 6.11) to estimate emissions, adjust for possible sludge removal and/or CH_4 recovery and sum the results for each pathway/system. CH_4 Emissions (Table 7.31) have been estimated using the parameters listed in Table 7.30.

Table 7.30. Parameters used for the estimation of CH_4 emissions from wastewater treatment

Parameter	Value
Total organics in wastewater in inventory year, kg BOD/yr (TOW)	Table 7.29
Fraction of population in income group i in inventory year (Ui)	Table 7.29
Degree of utilisation of treatment/discharge pathway or system, j, for each income group (Ti,j) fraction i in inventory year	100%
EFj = emission factor, kg CH_4 / kg BOD	Septic: 0.3 $kgCH_4$/kgBOD Centralised treatment: 0 $kgCH_4$/kgBOD
R = amount of CH_4 recovered in inventory year, kg CH_4/yr	0

Table 7.31. CH_4 emissions from domestic wastewater treatment 1990–2021

	1990	1991	1992	1993	1994	1995	1996
CH_4 – septic (t)	3676	3752	3808	3875	3956	3963	3887
CH_4 – centralized (t)	0	0	0	0	0	0	0
Total (t)	3676	3752	3808	3875	3956	3963	3887

	1997	1998	1999	2000	2001	2002	2003
CH_4 – septic (t)	3904	3912	3933	3927	3898	3831	3657

[87] http://uwwtd.oieau.fr/Cyprus/uwwtps/compliance

CH_4 – centralized (t)	0	0	0	0	0	0	0
Total (t)	3904	3912	3933	3927	3898	3831	3657

	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
CH_4 – septic (t)	3443	3431	3071	2711	2539	2359	1885
CH_4 – centralized (t)	0	0	0	0	0	0	0
Total (t)	3443	3431	3071	2711	2539	2359	1885

	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
CH_4 – septic (t)	1386	1384	1364	1339	1144	955	908
CH_4 – centralized (t)	0	0	0	0	0	0	0
Total (t)	1386	1384	1364	1339	1144	955	908

	2018	**2019**	**2020**	**2021**			
CH_4 – septic (t)	892	904	912	921			
CH_4 – centralized (t)	0	0	0	0			
Total (t)	892	904	912	921			

Nitrous oxide emissions from wastewater

The activity data that are needed for estimating N_2O emissions are nitrogen content in the wastewater effluent, country population and average annual per capita protein generation (Table 7.28). Per capita protein generation consists of intake (consumption) which has been obtained from the Food and Agriculture Organization[88], multiplied by factors to account for additional 'non-consumed' protein and for industrial protein discharged into the sewer system. Food (waste) that is not consumed may be washed down the drain (e.g., as result of the use of garbage disposals in some developed countries), bath and laundry water can also be expected to contribute to nitrogen loadings. Wastewater from industrial or commercial sources that is discharged into the sewer may contain protein (e.g., from grocery stores and butchers).

The total nitrogen in the effluent is estimated using equation 6.8 (pg. 6.25, vol. 5, 2006 IPCC guidelines), with human population as presented in Table 7.5 and annual per capita protein consumption as presented in Table 7.32. Data is not available after 2007 and therefore considered constant for the remaining years, due to an unclear trend. The following defaults are used: fraction of nitrogen in protein (FNPR), 0.16 kg N/kg protein; factor for non-consumed protein added to the wastewater (FNON-CON), 1.1; default factor for industrial and commercial co-discharged protein into the sewer system (FIND-COM), 1.25; and default nitrogen removed with sludge (NSLUDGE), 0 kg N/yr.

Table 7.32. Annual per capita protein consumption and resulting NEFFLUENT (kg/person/yr)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**
Protein consumption (kg/person/yr)	35.4	35.4	35.4	36.1	36.1	36.9
NEFFLUENT (kg N/yr)	4572981	4697606	4823011	5031365	5130736	5322790

	1996	**1997**	**1998**	**1999**	**2000**	**2001**
Protein consumption (kg/person/yr)	36.9	36.9	37.2	37.2	37.6	37.6
NEFFLUENT (kg N/yr)	5403893	5476075	5593361	5655609	5768953	5835120

	2002	**2003**	**2004**	**2005**	**2006**	**2007**
Protein consumption (kg/person/yr)	37.6	36.3	36.3	35.0	35.0	35.0
NEFFLUENT (kg N/yr)	5902941	5775863	5856560	5735347	5842500	5985112

	2008	**2009**	**2010**	**2011**	**2012**	**2013**
Protein consumption	35.0	35.0	35.0	35.0	35.0	35.0

[88] FAOSTAT, 2009, Food consumption, Dietary Protein Consumption (g/person/day), available from http://www.fao.org/filead min/templates/ess/documents/food_security_statistics/FoodConsumptionNutrients_en.xls

(kg/person/yr)						
NEFFLUENT (kg N/yr)	6143143	6314278	6473850	6644986	6675050	6614150

	2014	2015	2016	2017	2018	2019
Protein consumption (kg/person/yr)	35.0	35.0	35.0	35.0	35.0	35.0
NEFFLUENT (kg N/yr)	6529354	6539375	6589482	6661945	6752138	6845414

	2020	2021				
Protein consumption (kg/person/yr)	35.0	35.0				
NEFFLUENT (kg N/yr)	6907085	6974190				

After the collection of the information presented above regarding wastewater treatment, it appeared that emissions from advanced centralised wastewater treatment plants should also be estimated and subtracted from the overall emissions. Thus, the emissions have been estimated using the overall emission factor to estimate N_2O emissions from such plants as 3.2 g N_2O/person/year, recommended in the 2006 IPCC Guidelines (Box 6.1, pg. 6.26, vol. 5). The population used is the population presented in Table 7.5. The resulting emissions are presented in Table 7.32. The amount of nitrogen associated with these emissions (NWWT, Table 7.32) have been back calculated and subtracted from the NEFFLUENT. The NWWT is calculated by multiplying N_2OPLANTS by 28/44.

The resulting N_2O emissions from wastewater are also presented in Table 7.33.

Table 7.33. N_2O emissions from advanced centralised wastewater treatment plants, NWWT and resulting NEFFLUENT

	1990	1991	1992	1993	1994	1995	1996
N_2OPLANTS (t)	35.92	36.90	37.89	39.52	40.30	41.81	42.45
NWWT (kg N/yr)	1196	1228	1261	1289	1314	1336	1357
NEFFLUENT – NWWT (kg N/yr)	4571785	4696378	4821750	5030076	5129422	5321453	5402536
N_2O emissions (t)	35.92	36.90	37.89	39.52	40.30	41.81	42.45

	1997	1998	1999	2000	2001	2002	2003
N_2OPLANTS (t)	43.02	43.94	44.43	45.32	45.84	46.37	45.37
NWWT (kg N/yr)	1375	1391	1406	1420	1437	1453	1472
NEFFLUENT – NWWT (kg N/yr)	5474700	5591970	5654203	5767532	5833683	5901488	5774390
N_2O emissions (t)	43.02	43.94	44.43	45.32	45.84	46.37	45.37

	2004	2005	2006	2007	2008	2009	2010
N_2OPLANTS (t)	46.00	45.05	45.89	47.01	48.25	49.60	50.85
NWWT (kg N/yr)	1493	1515	1543	1581	1623	1668	1710
NEFFLUENT – NWWT (kg N/yr)	5855067	5733832	5840956	5983531	6141520	6312610	6472140
N_2O emissions (t)	46.00	45.05	45.89	47.01	48.25	49.60	50.85

	2011	2012	2013	2014	2015	2016	2017
N_2OPLANTS (t)	52.20	52.43	51.95	51.29	51.37	51.76	52.33

NWWT (kg N/yr)	1755	1763	1747	1725	1727	1741	1760
NEFFLUENT – NWWT (kg N/yr)	5855067	5733832	5840956	5983531	6141520	6312610	6472140
N_2O emissions (t)	52.20	52.43	51.95	51.29	51.37	51.76	52.33

	2018	**2019**	**2020**	**2021**			
$N_2OPLANTS$ (t)	53.04	53.77	54.26	54.78			
NWWT (kg N/yr)	1784	1808	1825	1842			
NEFFLUENT – NWWT (kg N/yr)	6750354	6843606	6905260	6972348			
N_2O emissions (t)	53.04	53.77	54.26	54.78			

7.5.1.2 Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

7.5.1.3. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

7.5.1.4. Category-specific recalculations

CH_4 emissions from domestic wastewater treatment and discharge (5D1) were recalculated for the time series 2017-2020, due to updated data regarding the percentage of distribution of wastewater to septic tanks and central treatment stations from the Water Pollution Control Permit & Inspections Unit of the Department of Environment. The impact of recalculations is presented in the following table.

Table 7.34. 5D1 Recalculations (N_2O emissions)

N_2O emissions (kt)	**2017**	**2018**	**2019**	**2020**		
2022 submission	0.88094	0.73900	0.59321	0.59855		
2023 submission	0.90845	0.89197	0.90429	0.82414		
change	3.12%	20.70%	52.44%	37.69%		

7.5.1.5. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

7.5.2. Industrial wastewater (5D2)

The principal factor that determines methane generation potential of wastewater is the amount of organic material in the wastewater stream. For industrial wastewater, this is indicated by the Chemical Oxygen Demand (COD). COD indicates the total amount of carbon, biodegradable and non-biodegradable, that is available for oxidation. According to the IPCC guidelines, industrial production should be grouped according to their methane production potential. The main groups are paper and pulp manufacture, slaughterhouses, alcohol, beer, starch, organic chemicals and others (vegetable oil production, textiles, rubber, petroleum refineries, fruits and vegetables). The industrial activities taking place in Cyprus are predominately food and drink industries.

Regarding the treatment of wastewaters produced by the manufacturing processes implemented, the following apply:

- Alcohol - Cyprus has one installation producing alcohol. Its wastewater is treated by anaerobic digestion, followed by further aerobic treatment before the final effluent is discharged into the local municipal sewerage system.
- Beer - Wastewater derived from two brewery installations are also treated by anaerobic digestion and subsequently by further aerobic treatment. One brewery discharges the final effluent into the local municipal sewerage system, while the other uses the effluent for irrigation.
- Dairy products - Wastewater derived from one dairy installation is treated by anaerobic digestion and subsequently by further aerobic treatment before the final effluent is discharged into the local municipal sewerage system.
- Meat and Poultry - Wastewater derived from meat and poultry installations are treated by anaerobic digestion plants that treat mainly pig slurry, and subsequently treated by further aerobic treatment before their final disposal to evaporation lagoons.
- Vegetable oils - Cyprus has several olive oil mills. A portion of the produced wastewater is treated by anaerobic digestion plants that treat mainly pig slurry. In addition, during the process of producing biodiesel from used cooking oils, glycerol is produced and it is mainly treated by anaerobic digestion.
- Veg., fruits and juices, and soft drinks. - Cyprus has one installation that is treating wastewater and other waste derived from the production of vegetables, fruits, juices and soft drinks. The treatment uses anaerobic digestion.

Emissions from industrial wastewater increased by 12.4% between 1990 and 2021 (Table 7.35, Figure 7.13). Emission estimates from this source have been revised due to the availability of new data for 2020.

Table 7.35. Total emissions from industrial wastewater 1990–2021

	1990	2000	2005	2010	2011	2012	2013
CH_4 (t)	967.9	1115.2	1033.8	1091.1	1171.2	1060.7	1050.3
N_2O (t)	0.001042	0.001175	0.000958	0.000926	0.000991	0.000890	0.000870
Total (Gg CO_2 eq.)	**27.10**	**31.23**	**28.95**	**30.55**	**32.79**	**29.70**	**29.41**

	2014	2015	2016	2017	2018	2019	2020
CH_4 (t)	1052.2	1138.2	1191.3	1229.6	1229.3	1263.1	1108.7
N_2O (t)	0.000862	0.000914	0.000955	0.000991	0.001003	0.001038	0.000918
Total (Gg CO_2 eq.)	**29.46**	**31.87**	**33.36**	**34.43**	**34.42**	**35.37**	**31.04**

	2021						
CH_4 (t)	1108.7						
N_2O (t)	0.000918						
Total (Gg CO_2 eq.)	**31.04**						

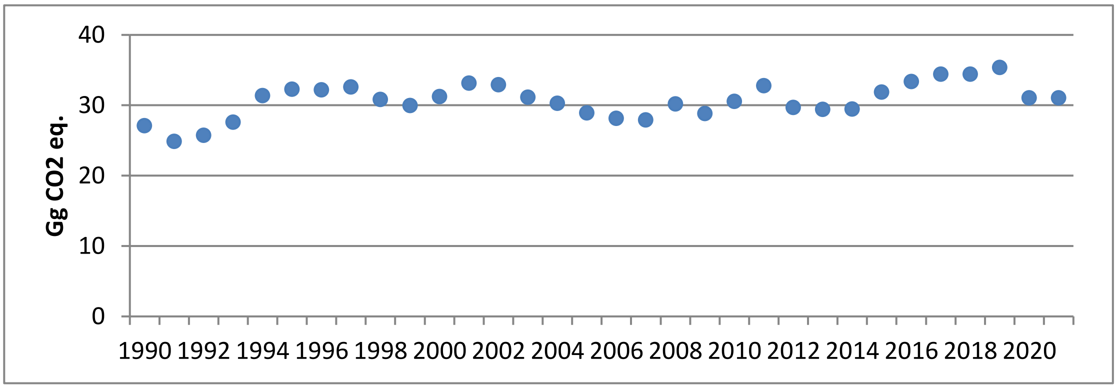


Figure 7.13. Emissions from industrial wastewater 1990–2021 (AR5)

7.5.2.1. Methodological Issues

Methane emissions

According to the IPCC guidelines, to estimate total emissions from wastewater the selected emissions factors are multiplied by the associated organic wastewater production and summed. The amount of CH_4 recovered and thus not emitted into the atmosphere for each handling method should be subtracted: no methane recovery takes place in Cyprus, therefore recovery is assumed to be 0. The sum of the emissions for each handling method provides the total CH_4 emissions from industrial wastewater. In equation form, the estimate of total CH_4 emissions from wastewater handling is as follows (equation 6.4, 2006 IPCC guidelines, volume 5 pg. 6.20):

$$CH_4\ Emissions=\Sigma[(TOW_i-S_i)*EF_i-R_i]$$

where CH_4 emissions is the total methane emissions from wastewater in kg CH_4, TOWi is the total organically degradable material in wastewater from industry i in kg COD/yr, Si is the organic component removed as sludge in inventory year in kg COD/yr, EFi is the emission factor for industry i in kg CH_4/kg COD, and Ri is the total amount of methane recovered in kg CH_4/yr.

To estimate total organic wastewater (TOW) for a particular industry the following equation should be used (equation 6.6, IPCC 2006 guidelines, volume 5, pg. 6.22):

$$TOWi = Pi \times Wi \times COD$$

where TOW is the total industrial organically material in wastewater for industry in kg COD/yr, P is the total industrial product for industrial sector W is the wastewater generated in m^3/tonne of product, and COD is the chemical oxygen demand (industrial degradable organic component in kg COD/m^3 wastewater).

To estimate the emission factor for industrial wastewater, the following equation is proposed by the IPCC guidelines (Equation 6.5, IPCC 2006 guidelines, volume 5,pg. 6.21):

$$EF_j = B_o \times MCF_j$$

where EF_j is the emission factor (kg CH_4/kg DC) for each treatment (e.g. aerobic treatment, anaerobic digester for sludge, etc.), Bo is the maximum methane producing capacity (kg CH_4/kg DC), and MCF_j is the methane correction factor. Since no country specific data is available, Bo is considered to be 0.25 (2006 IPCC guidelines, volume 5, pg. 6.21).

A verbal description of the methodology applied for the estimation of methane emissions from industrial wastewater is as follows:
(a) Collection of data for industrial production (Table 7.34).
(b) Total industrial organic wastewater was estimated by multiplying the industrial production by the wastewater generation coefficients and by COD in Table 7.35 (2006 IPCC guidelines, volume 5, pg. 6.22, Table 6.8).
(c) Organically Degradable material (TOW) in Gg is the sum of the TOW of each industrial product divided by 1,000,000 (Table 7.36).
(d) The wastewater generated was categorised as either anaerobic or aerobic treatment according to the assumptions of Table 7.37.
(e) The methane correction factor (MCF) was assumed to be 0.3 for aerobic treatment, following a recommendation of the ERT during the in-country review of the 2016 submission. In the initial submission, the MCF used was 0, which is the default for centralised. 0.3, which is currently used, is the default for not well managed, centralised, overloaded aerobic treatment (table 6.3, pg. 6.13, volume 5, 2006 IPCC guidelines). This change has been made until sufficient information is available for the wastewater treatment plants in Cyprus to justify the use of 0. Per the defaults provided in the 2006 IPCC guidelines, a MCF of 0.8 was used for anaerobic treatment, while maximum producing capacity was assumed to be 0.25 kg CH_4/kg COD (pg. 6.21, volume 5). The resulting methane emission factor estimated according to the waste stream is presented in Table 7.35.
(f) The emission factor for each waste streams was multiplied by the TOW (kg COD/ year) of the respective waste stream to estimate the annual emissions of methane per waste stream. The total CH_4

emissions are the sum of the CH_4 emitted per waste stream.

Data for industrial production

Detailed statistics on industrial production in Cyprus do not exist. Therefore data on industrial consumption is used instead. Another issue associated with the national statistics on industrial activity is that the sales of industrial products for the year x-2 (which in this case is 2021) are completed and published in the summer after the inventory has to be submitted (which in this case is summer 2023). Therefore, the 2021 “production" is assumed to be equal to the 2020 “production”. The industrial production data used is presented in Table 7.36.

Table 7.36. Industrial production 1990–2021 (Gg)

Gg product	1990	1991	1992	1993	1994	1995	1996
Alcohol	1.0	1.0	1.0	1.0	1.0	1.1	0.9
Beer	33.1	34.8	36.6	36.1	35.6	35.2	33.1
Soft drinks	46.6	50.5	54.7	55.4	56.2	56.9	57.5
Dairy products	60.7	64.6	68.8	71.2	73.9	76.7	81.1
Meat & poultry	64.4	63.1	67.7	76.0	80.9	81.0	88.0
Refinery	635.3	763.2	727.1	781.2	896.8	827.9	760.0
Soaps & detergents	12.1	12.9	13.8	10.9	9.8	9.5	9.0
Vegetable oils	21.7	24.9	28.6	27.5	26.5	25.7	28.1
Vegetables, fruits & juices	47.9	34.9	34.0	38.0	52.1	56.3	53.0
Wine	49.4	52.8	56.5	56.3	56.0	55.8	54.3

Gg product	1997	1998	1999	2000	2001	2002	2003
Alcohol	1.0	1.0	2.1	2.6	3.9	3.8	2.5
Beer	33.3	36.5	40.5	40.9	40.4	38.3	36.7
Soft drinks	58.3	59.3	60.0	60.9	62.7	62.3	62.1
Dairy products	81.4	86.3	84.1	83.3	89.5	92.4	93.2
Meat & poultry	97.0	93.7	69.5	80.5	87.8	90.0	92.4
Refinery	1042.7	1082.6	1140.4	1134.8	1115.1	1045.5	931.9
Soaps & detergents	7.1	7.2	7.2	7.0	7.8	8.1	6.2
Vegetable oils	26.3	22.7	23.2	21.8	20.1	21.3	19.4
Vegetables, fruits & juices	52.5	48.0	49.0	49.9	51.6	48.7	44.2
Wine	42.0	30.9	43.2	37.4	34.5	37.5	35.5

Gg product	2004	2005	2006	2007	2008	2009	2010
Alcohol	1.9	1.3	1.2	1.0	0.9	0.7	0.7
Beer	37.1	37.7	37.4	39.8	42.7	35.7	34.3
Soft drinks	60.5	66.6	58.3	62.5	62.9	59.4	57.9
Dairy products	93.9	96.3	99.5	97.8	112.1	104.1	106.0
Meat & poultry	93.4	95.5	94.0	94.5	102.1	99.1	105.6
Refinery	269.2	0.0	0.0	0.0	0.0	0.0	0.0
Soaps & detergents	7.4	6.1	6.2	6.3	6.8	6.9	7.1
Vegetable oils	19.6	19.3	19.1	18.1	18.2	16.3	16.9
Vegetables, fruits & juices	42.1	37.6	34.4	35.4	40.6	40.4	45.5
Wine	31.7	29.8	26.5	20.2	15.9	12.4	11.1

Gg product	2011	2012	2013	2014	2015	2016	2017
Alcohol	0.6	0.7	0.7	0.6	0.57	0.61	0.65
Beer	32.2	33.0	32.9	32.8	34.18	37.55	39.43
Soft drinks	54.6	35.6	26.0	10.8	11.13	14.46	14.57
Dairy products	109.3	106.2	100.9	99.8	100.12	103.73	108.45
Meat & poultry	103.6	96.0	83.6	79.7	82.43	84.72	87.47
Refinery	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Soaps & detergents	6.7	7.1	6.5	7.3	6.79	8.20	7.30
Vegetable oils	15.7	14.3	12.2	12.6	12.06	11.72	13.97
Vegetables, fruits & juices	56.5	48.0	54.5	57.9	68.46	72.93	74.90

Wine	14.2	10.9	11.5	11.0	8.95	8.45	9.27

Gg product	**2018**	**2019**	**2020**	**2021**			
Alcohol	0.55	0.55	0.48	0.48			
Beer	41.07	40.41	31.06	31.06			
Soft drinks	13.76	13.17	8.05	8.05			
Dairy products	117.81	123.70	126.00	126.00			
Meat & poultry	87.59	92.12	87.53	87.53			
Refinery	0.00	0.00	0.00	0.00			
Soaps & detergents	8.23	9.13	9.37	9.37			
Vegetable oils	13.74	15.67	14.66	14.66			
Vegetables, fruits & juices	72.75	73.52	57.82	57.82			
Wine	9.95	10.75	8.59	8.59			

Industrial organic wastewater

Wastewater production was estimated by multiplying the industrial production by the wastewater generation coefficients in Table 7.37 (volume 5, pg. 6.22, Table 6.8). Information in the 2006 guidelines is not available for soft drinks, soaps and detergents, and COD of vegetable oils. For these categories, the values recommended in the 2000 IPCC Good Practice Guide (pg.5.22) are used.

Table 7.37. Wastewater generation coefficient (m^3 /t product) and COD concentration (kg COD/m^3) according to industrial product

	Wastewater generation (m^3/t)	**COD (kg/m^3)**
Alcohol	24	11
Beer	6.3	2.9
Soft drinks	2 [a]	2 [a]
Dairy products	7	2.7
Meat& poultry	13	4.1
Refinery	0.6	1.0
Soaps& detergents	3.0 [a]	0.9 [a]
Vegetable oils	3.1	0.9 [a]
Vegetables, fruits & juices	20.0	5.0
Wine	23.0	1.5

[a] 2000 IPCC Good Practice Guide, pg. 5.22

Total organic wastewater

Total organically degradable material in wastewater in kg COD/year per industrial product was then estimated by multiplying the industrial production by the wastewater generated and by the COD coefficient of each industrial product in Table 7.35 (2006 IPCC guidelines, p.6.22). The sum of the TOW of each industrial product divided by 10^6 is presented in Table 7.38.

Table 7.38. Total organically degradable material (Gg), 1990–2021

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Gg DC	12.61	11.55	11.96	12.85	14.64	15.07	15.04	15.22	14.40	13.98

	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Gg DC	14.58	15.49	15.38	14.53	13.72	13.08	12.53	12.42	13.51	12.86

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Gg DC	13.68	14.75	13.28	13.14	13.16	14.31	15.02	15.53	15.52	15.98

	2020	**2021**								
Gg DC	13.92	13.92								

Categorisation of wastewater treatment to aerobic and anaerobic

The wastewater generated was categorised as either anaerobic or aerobic treatment according to the assumptions of Table 7.39. The assumptions were prepared in collaboration with the Pollution Prevention Unit of the Department of Environment.

Methane emission factor

The methane conversion factor was assumed to be 0 for aerobic treatment and 0.8 for anaerobic treatment, as according to the 2006 IPCC guidelines (volume 5, pg. 6.21, Table 6.7). Maximum producing capacity was assumed to be 0.25 kg CH_4/kg COD, also as according to the 2006 IPCC guidelines (pg. 6.21, volume 5). The resulting methane emission factor estimated according to the waste stream is presented in Table 7.40.

The aggregate MCF for all waste streams was multiplied by the total annual organic wastewater generation (kg COD/year) to estimate the annual emissions of methane.

Table 7.39. Treatment of waste by anaerobic treatment according to industrial production, 1990–2021

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
alcohol	2.0%	2.1%	2.1%	2.0%	1.9%	1.9%	2.2%
beer	20%	19%	18%	18%	19%	19%	20%
soft drinks	1.00%	0.92%	0.85%	0.84%	0.83%	0.82%	0.81%
dairy products	0	0	0	0	0	0	0
meat & poultry	0	0	0	0	0	0	0
refinery	0	0	0	0	0	0	0
soaps & detergents	0	0	0	0	0	0	0
vegetable oils	0	0	0	0	0	0	0
veg., fruits & juices	1.0%	1.4%	1.4%	1.3%	0.9%	0.9%	0.9%
wine	0	0	0	0	0	0	0

	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
alcohol	2.1%	2.0%	1.0%	0.8%	0.5%	0.5%	0.8%
beer	20%	18%	16%	16%	16%	17%	18%
soft drinks	0.80%	0.79%	0.78%	0.76%	0.74%	0.75%	0.75%
dairy products	0	0	0	0	0	0	0
meat & poultry	0	0	0	0	0	0	0
refinery	0	0	0	0	0	0	0
soaps & detergents	0	0	0	0	0	0	0
vegetable oils	0	0	0	0	0	0	0
veg., fruits & juices	0.9%	1.0%	1.0%	1.0%	0.9%	1.0%	1.1%
wine	0	0	0	0	0	0	0

	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
alcohol	1.1%	1.5%	1.8%	2.1%	2.3%	2.8%	2.8%
beer	18%	18%	18%	17%	15%	19%	19%
soft drinks	0.77%	0.70%	0.80%	0.75%	0.74%	0.78%	0.80%
dairy products	0	0	5.00%	5.09%	4.44%	4.78%	4.69%
meat & poultry	5.00%	4.89%	4.97%	4.95%	4.57%	4.71%	4.42%
refinery	0	0	0	0	0	0	0
soaps & detergents	0	0	0	0	0	0	0
vegetable oils	0	0	0.5%	0.5%	0.5%	0.6%	0.5%
veg., fruits & juices	1.1%	1.3%	1.4%	1.4%	1.2%	1.2%	1.1%
wine	0	0	0	0	0	0	0

	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
alcohol	3.5%	3.1%	3.1%	3.2%	3.6%	3.4%	3.1%

beer	21%	20%	20%	20%	19%	18%	17%
soft drinks	0.85%	1.31%	1.79%	4.31%	4.19%	3.22%	3.20%
dairy products	4.55%	4.69%	4.93%	4.99%	4.97%	4.80%	4.59%
meat & poultry	4.51%	4.86%	5.59%	5.86%	5.67%	5.51%	5.34%
refinery	0	0	0	0	0	0	0
soaps & detergents	0	0	0	0	0	0	0
vegetable oils	0.6%	0.6%	0.7%	0.7%	0.7%	0.8%	0.6%
veg., fruits & juices	0.8%	1.0%	0.9%	0.8%	0.7%	0.7%	0.6%
wine	0	0	0	0	0	0	0

	2018	**2019**	**2020**	**2021**			
alcohol	3.7%	3.7%	4.3%	4.3%			
beer	16%	16%	21%	21%			
soft drinks	3.39%	3.54%	5.79%	5.79%			
dairy products	4.22%	4.02%	3.95%	3.95%			
meat & poultry	5.33%	5.07%	5.34%	5.34%			
refinery	0	0	0	0			
soaps & detergents	0	0	0	0			
vegetable oils	0.7%	0.6%	0.6%	0.6%			
veg., fruits & juices	0.7%	0.7%	0.8%	0.8%			
wine	0	0	0	0			

Table 7.40. Methane emission factor estimated according to waste stream (kg CH_4/kg COD), 1990–2021

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
alcohol	0.078	0.078	0.078	0.078	0.077	0.077	0.078
beer	0.100	0.099	0.098	0.098	0.098	0.099	0.100
soft drinks	0.076	0.076	0.076	0.076	0.076	0.076	0.076
dairy products	0.075	0.075	0.075	0.075	0.075	0.075	0.075
meat & poultry	0.075	0.075	0.075	0.075	0.075	0.075	0.075
refinery	0.075	0.075	0.075	0.075	0.075	0.075	0.075
soaps & detergents	0.075	0.075	0.075	0.075	0.075	0.075	0.075
vegetable oils	0.075	0.075	0.075	0.075	0.075	0.075	0.075
veg., fruits & juices	0.076	0.077	0.077	0.077	0.076	0.076	0.076
wine	0.075	0.075	0.075	0.075	0.075	0.075	0.075

	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
alcohol	0.078	0.078	0.076	0.076	0.076	0.076	0.076
beer	0.100	0.098	0.095	0.095	0.095	0.097	0.098
soft drinks	0.076	0.076	0.076	0.076	0.076	0.076	0.076
dairy products	0.075	0.075	0.075	0.075	0.075	0.075	0.075
meat & poultry	0.075	0.075	0.075	0.075	0.075	0.075	0.075
refinery	0.075	0.075	0.075	0.075	0.075	0.075	0.075
soaps & detergents	0.075	0.075	0.075	0.075	0.075	0.075	0.075
vegetable oils	0.075	0.075	0.075	0.075	0.075	0.075	0.075
veg., fruits & juices	0.076	0.076	0.076	0.076	0.076	0.076	0.076
wine	0.075	0.075	0.075	0.075	0.075	0.075	0.075

	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
alcohol	0.076	0.077	0.077	0.078	0.078	0.079	0.078
beer	0.097	0.097	0.097	0.096	0.094	0.098	0.099
soft drinks	0.076	0.076	0.076	0.076	0.076	0.076	0.076
dairy products	0.075	0.075	0.081	0.081	0.081	0.081	0.081
meat & poultry	0.081	0.081	0.081	0.081	0.081	0.081	0.081
refinery	0.075	0.075	0.075	0.075	0.075	0.075	0.075
soaps & detergents	0.075	0.075	0.075	0.075	0.075	0.075	0.075
vegetable oils	0.075	0.075	0.076	0.076	0.076	0.076	0.076
veg., fruits & juices	0.076	0.077	0.077	0.077	0.076	0.076	0.076

wine	0.075	0.075	0.075	0.075	0.075	0.075	0.075

	2011	2012	2013	2014	2015	2016	2017
alcohol	0.079	0.079	0.079	0.079	0.080	0.079	0.079
beer	0.101	0.100	0.100	0.100	0.099	0.097	0.096
soft drinks	0.076	0.077	0.077	0.080	0.080	0.079	0.079
dairy products	0.081	0.081	0.081	0.081	0.081	0.081	0.081
meat & poultry	0.081	0.081	0.082	0.082	0.082	0.082	0.082
refinery	0.075	0.075	0.075	0.075	0.075	0.075	0.075
soaps & detergents	0.075	0.075	0.075	0.075	0.075	0.075	0.075
vegetable oils	0.076	0.076	0.076	0.076	0.076	0.076	0.076
veg., fruits & juices	0.076	0.076	0.076	0.076	0.076	0.076	0.076
wine	0.075	0.075	0.075	0.075	0.075	0.075	0.075

	2018	2019	2020	2021			
alcohol	0.080	0.080	0.080	0.080			
beer	0.095	0.095	0.102	0.102			
soft drinks	0.079	0.079	0.082	0.082			
dairy products	0.080	0.080	0.080	0.080			
meat & poultry	0.082	0.081	0.082	0.082			
refinery	0.075	0.075	0.075	0.075			
soaps & detergents	0.075	0.075	0.075	0.075			
vegetable oils	0.076	0.076	0.076	0.076			
veg., fruits & juices	0.076	0.076	0.076	0.076			
wine	0.075	0.075	0.075	0.075			

Estimation of N_2O emissions

The nitrous oxide emissions were estimated by multiplying the total annual industrial wastewater production (Table 7.41) by the default emission factor of 0.25 g N_2O/m^3 wastewater, as according to the EMEP/CORINAIR 2007 methodology[89].

Table 7.41. Total industrial wastewater production (1000 m^3/year), 1990–2021

	1990	1991	1992	1993	1994	1995	1996	1997
Alcohol	24	24	23	24	25	26	22	23
Beer	208	219	231	227	225	222	208	210
Soft drinks	93	101	109	111	112	114	115	117
Dairy products	425	452	481	499	517	537	568	570
Meat & poultry	837	820	880	987	1052	1052	1145	1261
Refinery	381	458	436	469	538	497	456	626
Soaps &detergents	36	39	41	33	29	29	27	21
Vegetable oils	67	77	89	85	82	80	87	82
Veg., fruits & juices	959	698	680	759	1041	1127	1060	1050
Wine	1136	1215	1300	1295	1289	1283	1250	965

	1998	1999	2000	2001	2002	2003	2004	2005
Alcohol	24	50	61	94	92	59	46	32
Beer	230	255	257	255	242	231	234	238
Soft drinks	119	120	122	125	125	124	121	133
Dairy products	604	589	583	626	647	652	657	674
Meat & poultry	1218	903	1047	1142	1170	1202	1214	1242
Refinery	650	684	681	669	627	559	161	0
Soaps &detergents	22	22	21	23	24	19	22	18
Vegetable oils	70	72	68	62	66	60	61	60

[89] EMEP/CORINAIR Emission Inventory Guidebook – 2007, Group 9: Waste treatment and disposal; 091001 - Waste water treatment in industry, EEA Technical report No 16/2007, available at https://www.eea.europa.eu/publications/EMEPCORINAIR5/B9101vs1.pdf, table 2, pg. B9101-2.

Veg., fruits & juices	961	980	999	1031	974	884	842	751
Wine	711	993	860	793	863	817	730	685

	2006	2007	2008	2009	2010	2011	2012	2013
Alcohol	28	24	21	17	18	14	16	16
Beer	236	251	269	225	216	203	208	207
Soft drinks	117	125	126	119	116	109	71	52
Dairy products	696	684	785	729	742	765	743	706
Meat & poultry	1222	1228	1327	1289	1373	1347	1248	1086
Refinery	0	0	0	0	0	0	0	0
Soaps &detergents	19	19	21	21	21	20	21	20
Vegetable oils	59	56	56	50	52	49	44	38
Veg., fruits & juices	687	708	812	808	911	1129	960	1090
Wine	609	465	366	285	254	327	250	265

	2014	2015	2016	2017	2018	2019	2020	2021
Alcohol	15	14	15	16	13	13	11	11
Beer	206	215	237	248	259	255	196	196
Soft drinks	22	22	29	29	28	26	16	16
Dairy products	698	701	726	759	825	866	882	882
Meat & poultry	1037	1072	1101	1137	1139	1197	1138	1138
Refinery	0	0	0	0	0	0	0	0
Soaps &detergents	22	20	25	22	25	27	28	28
Vegetable oils	39	37	36	43	43	49	45	45
Veg., fruits & juices	1157	1369	1459	1498	1455	1470	1156	1156
Wine	253	206	194	213	229	247	197	197

7.5.2.2 Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

7.5.2.3. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

7.5.2.4. Category-specific recalculations

Emissions from Industrial Wastewater Treatment and Discharge (5D2) were recalculated for the year 2020 due to revision of the activity data of solid waste production by the Statistical Service. Emissions decreased for the particular year from 35.37 to 31.04 Gg CO_2 eq., which corresponds to a decrease of emissions by 12.22%.

7.5.2.5. Category-specific planned improvements

Please refer to Annex 7 for the National Inventory Improvement Plan.

7.6. Other (5E)

Not occurring.

Chapter 8.
Other (CRF sector 6)

Not applicable

Chapter 9.
Indirect CO_2 and N_2O emissions

9.1 Description of Sources of Indirect Emissions in GHG Inventory

The use of solvents manufactured using fossil fuels as feedstocks can lead to evaporative emissions of various non-methane volatile organic compounds (NMVOC), which are subsequently further oxidised in the atmosphere. The IPCC source sector 2.D.3, Solvent and Other Produce Use, is important in relation to the emissions of NMVOC. NMVOC are indirect greenhouse gases which result from the use of solvents and various other volatile compounds, and are therefore reported as CO_2 equivalent emissions included in national totals.

Categories present in 2.D.3 include:

- Dry cleaning
- Coating Applications
- Chemical products
- Asphalt roofing
- Domestic solvent use including fungicides
- Road paving with asphalt
- Printing
- Other solvent use (glue consumption).

Also included are emissions from sector 2.G.4 Other product use (Use of tobacco).

Indirect CO_2 emissions from NMVOC accounted for 0.09% (5.209 kt of CO_2 equivalent) and 0.06% (5.215 kt of CO_2 equivalent) of total national emissions in 1990 and 2021, respectively. The total CO_2 emissions from solvent use are presented in Table 9.1 and Figure 9.1.

Table 9.1. CO_2 emissions from Solvent and Other Product Use (2.D.3. and 2.G.4.)

Gg CO_2 eq.	**1990**	**2000**	**2005**	**2010**	**2015**	**2020**	**2021**
2.D.3. Solvent and Other Product Use	**5.168**	**7.487**	**16.083**	**13.113**	**3.797**	**5.152**	**5.205**
Dry cleaning	0.4403	0.4446	0.4246	0.1331	0.1159	0.0583	0.0591
Coating applications	3.8252	3.5243	8.3930	7.6994	2.3586	3.1656	3.3255
Chemical products	0.0854	0.1099	0.1262	0.0664	0.0244	0.0250	0.0231
Asphalt roofing	0.0953	0.1074	0.0859	0.1551	0.0251	0.0301	0.0301
Domestic solvent use	0.2678	0.3229	0.3428	0.3830	0.3572	0.7130	0.5613
Road paving with asphalt	0.0138	0.0155	0.0124	0.0224	0.0036	0.0043	0.0043
Printing	0.4400	0.7381	0.7580	0.5420	0.5558	0.3432	0.3529
Other (glue consumption)	NO	2.2245	5.9395	4.1113	0.3561	0.8121	0.8486
2.G.4 Other product use (Use of tobacco)	0.04121	0.11503	0.03094	0.02326	0.01198	0.00970	0.01044
Total Indirect Emissions	**5.209**	**7.602**	**16.114**	**13.136**	**3.809**	**5.161**	**5.215**

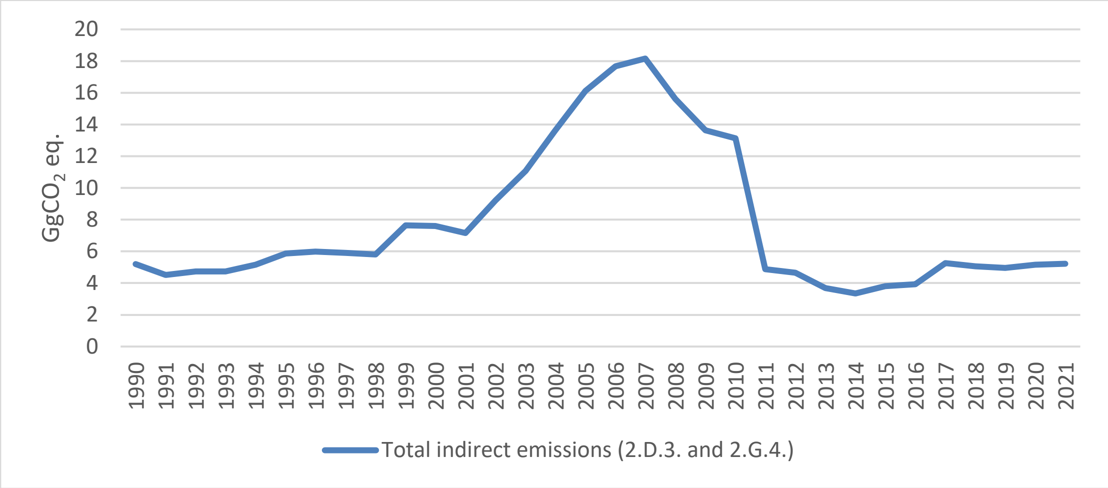


Figure 9.1. Emissions from Solvent and Other Product Use (2.D.3. and 2.G.4.) 1990–2021

9.1.1 Methodological Issues

2.D.3. Solvent and Other Product Use

Carbon dioxide emissions from other product use are calculated from NMVOC emissions (Table 9.2), assuming that the carbon content of NMVOC (C) is 60% (carbon content fractions for NMVOCs from road paving with asphalt is 50% and from asphalt roofing is 80%[90]). NMVOC emissions are obtained from the Department of Labour Inspection, which is responsible for the preparation of the air pollutants inventory for Directive 2001/81/EC. The estimation of NMVOC emissions is based on the CONINAIR methodology. Therefore the equation applied for the estimation of the CO_2 emissions is the following:

$$CO_2 \text{ emissions (Gg)} = C * \text{NMVOC emissions (Gg)} * 44/12$$

Table 9.2. NMVOCs emissions used for the estimation of CO_2 emissions from Solvent use (2D3)

	1990	1991	1992	1993	1994	1995
Dry cleaning	0.2002	0.2003	0.2003	0.2004	0.2005	0.2006
Coating applications	1.7387	1.4241	1.5170	1.5202	1.7083	1.4102
Chemical products	0.0388	0.0388	0.0388	0.0413	0.0442	0.0471
Asphalt roofing	0.0325	0.0325	0.0325	0.0325	0.0325	0.0325
Domestic solvent use	0.1217	0.1248	0.1282	0.1316	0.1345	0.1372
Road paving with asphalt	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075
Printing	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
Other (glue consumption)	0	0	0	0	0	0.60810

	1996	1997	1998	1999	2000	2001
Dry cleaning	0.2007	0.2008	0.2009	0.2012	0.2021	0.2005
Coating applications	1.4097	1.5604	1.4476	1.4578	1.6020	1.4785
Chemical products	0.0498	0.0474	0.0490	0.0512	0.0500	0.0597
Asphalt roofing	0.0325	0.0325	0.0325	0.0325	0.0366	0.0298
Domestic solvent use	0.1395	0.1416	0.1435	0.1451	0.1468	0.1483
Road paving with asphalt	0.0075	0.0075	0.0075	0.0075	0.0084	0.0069
Printing	0.2000	0.2000	0.2000	0.3273	0.3355	0.3801
Other (glue consumption)	0.65140	0.46794	0.52517	1.21299	1.01102	0.92295

[90] 2006 IPCC Guidelines volume 3, p. 5.16.

	2002	2003	2004	2005	2006	2007
Dry cleaning	0.2004	0.2001	0.1998	0.1930	0.1100	0.1110
Coating applications	2.2579	2.8364	3.5522	3.8150	4.0272	4.3205
Chemical products	0.0636	0.0625	0.0674	0.0574	0.0600	0.0580
Asphalt roofing	0.0324	0.0308	0.0368	0.0293	0.0265	0.0246
Domestic solvent use	0.1500	0.1517	0.1537	0.1558	0.1581	0.1611
Road paving with asphalt	0.0075	0.0071	0.0085	0.0068	0.0061	0.0057
Printing	0.3075	0.2884	0.3399	0.3446	0.3628	0.3195
Other (glue consumption)	1.14428	1.43649	1.81574	2.70004	3.26949	3.23798

	2008	2009	2010	2011	2012	2013
Dry cleaning	0.0789	0.0602	0.0605	0.0600	0.0539	0.0265
Coating applications	3.3507	3.1421	3.4997	1.1160	1.1342	0.9821
Chemical products	0.0254	0.0278	0.0302	0.0137	0.0145	0.0120
Asphalt roofing	0.0233	0.0396	0.0529	0.0516	0.0403	0.0213
Domestic solvent use	0.1650	0.1694	0.1741	0.1785	0.1832	0.1840
Road paving with asphalt	0.0054	0.0091	0.0122	0.0119	0.0093	0.0049
Printing	0.4469	0.3260	0.2464	0.3347	0.2658	0.2072
Other (glue consumption)	2.98838	2.39945	1.86897	0.42663	0.39428	0.22134

	2014	2015	2016	2017	2018	2019
Dry cleaning	0.0262	0.0527	0.0261	0.0526	0.0262	0.0267
Coating applications	0.8677	1.0721	1.1182	1.2681	1.4052	1.4971
Chemical products	0.0099	0.0111	0.0110	0.0107	0.0118	0.0114
Asphalt roofing	0.0098	0.0086	0.0089	0.0111	0.0145	0.0112
Domestic solvent use	0.1824	0.1624	0.1621	0.1460	0.2884	0.2594
Road paving with asphalt	0.0023	0.0020	0.0020	0.0026	0.0033	0.0026
Printing	0.2618	0.2526	0.2651	0.2655	0.2273	0.2458
Other (glue consumption)	0.15577	0.16187	0.18500	0.62638	0.30966	0.19517

	2020	2021				
Dry cleaning	0.0265	0.0269				
Coating applications	1.4389	1.5116				
Chemical products	0.0114	0.0105				
Asphalt roofing	0.0103	0.0103				
Domestic solvent use	0.3241	0.2551				
Road paving with asphalt	0.0024	0.0024				
Printing	0.1560	0.1604				
Other (glue consumption)	0.36912	0.38571				

2.G.4. Other Product Use

Carbon dioxide emissions from Other product use are calculated from NMVOC emissions (Table 9.3), assuming that the carbon content of NMVOC is 60%[91]. NMVOC emissions are obtained from the Department of Labour Inspection, which is responsible for the preparation of the air pollutants inventory for Directive 2001/81/EC. The estimation of NMVOC emissions is based on the CONINAIR methodology. Therefore, the equation applied for the estimation of the CO_2 emissions is the following:

[91] 2006 IPCC Guidelines volume 3, p. 5.17, the default fossil carbon content fraction of NMVOC is 60 per cent by mass

CO_2 *emissions (Gg) = 60% * NMVOC emissions (Gg) * 44/12*

Table 9.3. NMVOCs emissions used for the estimation of CO_2 emissions from Other Product Use (2G4)

Gg	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Other	0.0185	0.0185	0.0202	0.0056	0.0056	0.0163	0.0173	0.0193

	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Other	0.0197	0.0275	0.0518	0.0159	0.0149	0.0107	0.0160	0.0139

	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Other	0.0087	0.0091	0.0088	0.0098	0.0105	0.0086	0.0093	0.0073

	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Other	0.0029	0.0054	0.0051	0.0056	0.0049	0.0051	0.0044	0.047

9.1.2. Uncertainties and time-series consistency

The results of the uncertainty analysis undertaken for the GHG emissions inventory of Cyprus are presented in Section 1.5, while the detailed calculations are presented in Annex 2.

9.1.3. Category-specific QA/QC and verification

QA/QC and verification activities are presented in Section 1.2.3. No sector-specific QA/QC and verification activities are applied for this sector.

9.1.4. Category-specific recalculations

2.D.3. Solvent and Other Product Use

CO_2 emissions have been recalculated mainly with reference to 2.D.3. (Domestic Solvent Use). The values of NMVOCS are taken from the Cyprus Informative Inventory Report. The impact of recalculations on emissions is shown in Table 9.4 and Figure 9.2.

Table 9.4. CO_2 emissions from Solvent use (2.D.3.) recalculations (Gg CO_2 eq.)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
NIR2022	6.45	5.80	6.05	6.10	6.55	7.27	7.39
NIR2023	5.17	4.48	4.69	4.71	5.14	5.84	5.94
Change	-19.9%	-22.7%	-22.4%	-22.7%	-21.5%	-19.7%	-19.6%
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
NIR2022	7.34	7.24	9.08	9.01	8.65	10.74	12.62
NIR2023	5.87	5.75	7.58	7.49	7.12	9.18	11.05
Change	-20.0%	-20.5%	-16.6%	-16.9%	-17.8%	-14.5%	-12.5%
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
NIR2022	15.20	17.70	19.32	19.84	17.34	15.40	14.95
NIR2023	13.61	16.08	17.66	18.14	15.60	13.61	13.11
Change	-10.5%	-9.2%	-8.6%	-8.5%	-10.0%	-11.6%	-12.3%
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
NIR2022	6.74	6.52	5.52	5.18	5.68	5.82	7.21
NIR2023	4.86	4.64	3.66	3.34	3.80	3.92	5.25
Change	-27.9%	-28.9%	-33.7%	-35.5%	-33.1%	-32.7%	-27.2%

	2018	2019	2020				
NIR2022	6.72	6.73	6.86				
NIR2023	5.04	4.96	5.15				
Change	-25.0%	-26.4%	-24.8%				

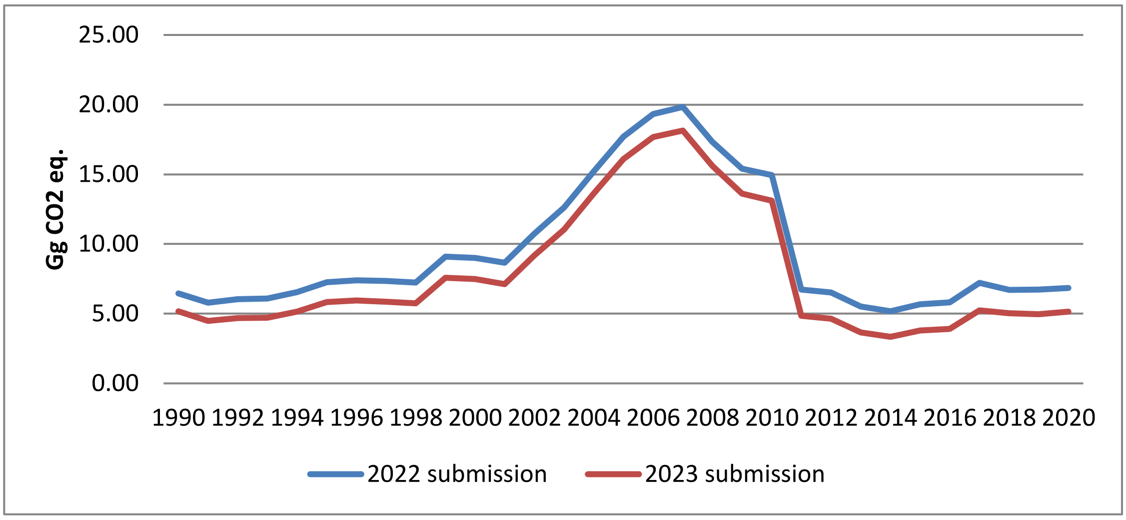


Figure 9.2. CO_2 emissions from Solvent use (2.D.3.) recalculations

Chapter 10.
Recalculations and improvements

10.1. Explanations and justifications for recalculations

The recalculations made are driven by the results of the various review processes, QC checks and internal audits, and the ERT reviews of the annual submissions of Cyprus by the nominated experts from the UNFCCC. In the 2023 submission, several recalculations were implemented as a result of the following:

- Changes or refinements in methods: A methodological change occurs when an inventory agency uses a different tier to estimate emissions from a source category (e.g. for key source categories) or when it moves from a tier described in the IPCC Guidelines to a national method. Methodological changes are often driven by the development of new and different data sets. A methodological refinement occurs when an inventory agency uses the same tier to estimate emissions but applies it using a different data source or a different level of aggregation.
- Inclusion of new sources: A new source is defined as a source for which estimates (all or some gases) did not exist in previous inventories either due to lack of data or because it has just been identified.
- Allocation: Changes in allocation of emissions to different sectors or sources/sub-sources.
- Correction of errors: This case concerns errors during calculating emissions (e.g. transcript errors) or while filling in the required information in the CRF tables. Resolving inconsistencies is also included in this category.
- Updated activity data.
- Change of GWP values of gases according to the new Assessment Report (AR5)

10.2. Implications for emission levels

The justification of the recalculations made in the present submission as far as the preparation of GHG inventory is concerned has been presented in details in Chapters 3 – 7. In Table 10.1 the effect of the recalculations made on the total GHG emissions in Cyprus on a per sector basis is presented.

Table 10.1. Comparison of NIR2022 to NIR2023, in kt CO_2 eq.

NIR2022	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
1. Energy	3976.80	4510.45	4837.10	5013.81	5224.55	5133.22
2. IPPU	725.57	685.57	762.08	832.79	868.39	837.58
3. Agriculture	478.07	480.55	514.97	546.23	535.96	586.59
4. LULUCF	-304.97	-298.23	-298.62	-307.71	-290.95	-300.93
5. Waste	396.04	401.40	409.28	419.35	431.34	439.56
Total (incl. LULUCF)	5576.49	6077.96	6523.43	6812.18	7060.23	6996.94
Total (excl. LULUCF)	5271.52	5779.74	6224.81	6504.47	6769.29	6696.02
NIR2023	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
1. Energy	3954.35	4486.96	4811.43	4988.10	5200.67	5107.25
2. IPPU	727.93	687.86	762.12	833.50	870.23	839.73
3. Agriculture	529.99	536.24	574.61	608.14	596.77	646.20
4. LULUCF	-153.07	-166.98	-172.65	-174.80	-183.35	-180.03
5. Waste	435.18	440.71	449.08	459.80	472.74	481.39
Total (incl. LULUCF)	5647.45	6151.77	6597.23	6889.54	7140.40	7074.57
Total (excl. LULUCF)	5494.38	5984.78	6424.58	6714.73	6957.05	6894.54
Difference						
1. Energy	-0.56%	-0.52%	-0.53%	-0.51%	-0.46%	-0.51%
2. IPPU	0.32%	0.33%	0.00%	0.09%	0.21%	0.26%
3. Agriculture	10.86%	11.59%	11.58%	11.33%	11.35%	10.16%
4. LULUCF	-49.81%	-44.01%	-42.18%	-43.19%	-36.98%	-40.17%

5. Waste	9.88%	9.79%	9.72%	9.64%	9.60%	9.52%
Total (incl. LULUCF)	1.27%	1.21%	1.13%	1.14%	1.14%	1.11%
Total (excl. LULUCF)	4.23%	3.55%	3.21%	3.23%	2.77%	2.96%
NIR2022	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
1. Energy	5427.31	5549.59	5891.73	6155.36	6381.29	6274.28
2. IPPU	900.34	871.91	837.60	849.76	878.48	871.56
3. Agriculture	568.48	553.65	567.34	550.23	556.42	605.76
4. LULUCF	-300.54	-275.72	-225.79	-318.70	-67.19	-208.36
5. Waste	445.86	454.97	462.30	470.65	480.49	490.51
Total (incl. LULUCF)	7341.99	7430.13	7758.97	8026.00	8296.68	8242.10
Total (excl. LULUCF)	7041.44	7154.40	7533.18	7707.30	8229.48	8033.75
NIR2023	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
1. Energy	5402.12	5525.00	5866.52	6130.96	6357.63	6252.10
2. IPPU	904.15	876.09	840.75	853.74	883.08	876.25
3. Agriculture	635.20	620.06	632.64	615.42	622.69	676.97
4. LULUCF	-185.36	-184.22	-190.49	-198.38	-142.51	-168.60
5. Waste	487.64	497.08	504.51	513.07	523.24	533.60
Total (incl. LULUCF)	7429.10	7518.22	7844.42	8113.19	8386.64	8338.92
Total (excl. LULUCF)	7243.74	7334.01	7653.93	7914.81	8244.14	8170.32
Difference						
1. Energy	-0.46%	-0.44%	-0.43%	-0.40%	-0.37%	-0.35%
2. IPPU	0.42%	0.48%	0.38%	0.47%	0.52%	0.54%
3. Agriculture	11.74%	12.00%	11.51%	11.85%	11.91%	11.76%
4. LULUCF	-38.33%	-33.19%	-15.63%	-37.75%	112.08%	-19.08%
5. Waste	9.37%	9.25%	9.13%	9.01%	8.90%	8.79%
Total (incl. LULUCF)	1.19%	1.19%	1.10%	1.09%	1.08%	1.17%
Total (excl. LULUCF)	2.87%	2.51%	1.60%	2.69%	0.18%	1.70%
NIR2022	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
1. Energy	6432.19	6823.53	6981.88	7157.94	7342.06	7664.32
2. IPPU	913.08	929.56	1010.50	1002.68	1061.92	1077.08
3. Agriculture	624.42	606.28	587.13	535.68	550.50	542.03
4. LULUCF	-290.19	-290.34	-280.69	-291.97	-284.01	-140.76
5. Waste	498.38	501.87	506.09	514.88	516.01	518.79
Total (incl. LULUCF)	8468.07	8861.24	9085.60	9211.18	9470.49	9802.22
Total (excl. LULUCF)	8177.88	8570.90	8804.91	8919.21	9186.48	9661.46
NIR2023	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
1. Energy	6412.02	6803.06	6942.20	7136.65	7321.74	7642.68
2. IPPU	919.23	934.15	1014.67	1003.14	1060.19	1071.98
3. Agriculture	698.19	677.63	655.71	598.68	612.44	604.37
4. LULUCF	-201.94	-214.02	-214.55	-220.83	-222.49	-182.89
5. Waste	541.54	544.68	548.53	557.57	557.86	559.92
Total (incl. LULUCF)	8570.97	8959.52	9161.11	9296.03	9552.22	9878.95
Total (excl. LULUCF)	8369.04	8745.50	8946.56	9075.21	9329.74	9696.06
Difference						
1. Energy	-0.31%	-0.30%	-0.57%	-0.30%	-0.28%	-0.28%
2. IPPU	0.67%	0.49%	0.41%	0.05%	-0.16%	-0.47%
3. Agriculture	11.81%	11.77%	11.68%	11.76%	11.25%	11.50%
4. LULUCF	-30.41%	-26.29%	-23.56%	-24.37%	-21.66%	29.93%
5. Waste	8.66%	8.53%	8.39%	8.29%	8.11%	7.93%
Total (incl. LULUCF)	1.22%	1.11%	0.83%	0.92%	0.86%	0.78%
Total (excl. LULUCF)	2.34%	2.04%	1.61%	1.75%	1.56%	0.36%
NIR2022	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
1. Energy	7874.86	7800.03	7565.75	7268.77	6785.24	5861.46
2. IPPU	1104.55	942.31	825.25	825.96	789.62	1030.37
3. Agriculture	517.27	510.18	532.68	518.40	501.17	463.86

4. LULUCF	-317.83	-327.64	-295.32	-336.59	-328.30	-353.13
5. Waste	529.01	536.38	540.36	544.28	553.82	564.14
Total (incl. LULUCF)	10025.69	9788.90	9464.04	9157.42	8629.84	7919.82
Total (excl. LULUCF)	9707.86	9461.26	9168.73	8820.83	8301.54	7566.69
NIR2023	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
1. Energy	7853.41	7781.63	7546.70	7250.42	6769.05	5847.05
2. IPPU	1094.04	930.88	810.82	811.86	772.54	1014.55
3. Agriculture	577.40	570.03	591.88	577.44	555.21	513.01
4. LULUCF	-249.84	-277.65	-265.04	-300.78	-293.62	-297.29
5. Waste	570.25	577.38	583.92	589.71	599.76	609.81
Total (incl. LULUCF)	10095.11	9859.92	9533.32	9229.42	8696.56	7984.42
Total (excl. LULUCF)	9845.27	9582.27	9268.28	8928.64	8402.94	7687.13
Difference						
1. Energy	-0.27%	-0.24%	-0.25%	-0.25%	-0.24%	-0.25%
2. IPPU	-0.95%	-1.21%	-1.75%	-1.71%	-2.16%	-1.54%
3. Agriculture	11.62%	11.73%	11.11%	11.39%	10.78%	10.60%
4. LULUCF	-21.39%	-15.26%	-10.25%	-10.64%	-10.56%	-15.82%
5. Waste	7.80%	7.64%	8.06%	8.35%	8.30%	8.10%
Total (incl. LULUCF)	0.69%	0.73%	0.73%	0.79%	0.77%	0.82%
Total (excl. LULUCF)	1.42%	1.28%	1.09%	1.22%	1.22%	1.59%
NIR2022	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
1. Energy	6006.82	6129.30	6526.60	6637.69	6526.12	6578.59
2. IPPU	1258.09	1174.37	1204.20	1268.50	1227.88	1196.90
3. Agriculture	453.57	460.36	483.38	497.63	503.79	517.82
4. LULUCF	-354.93	-357.39	16.80	-360.50	-348.65	-348.82
5. Waste	574.17	580.05	585.13	593.01	600.01	606.80
Total (incl. LULUCF)	8292.64	8344.08	8799.32	8996.82	8857.80	8900.12
Total (excl. LULUCF)	7937.72	7986.70	8816.12	8636.32	8509.15	8551.29
NIR2023	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
1. Energy	5994.43	6117.23	6512.90	6604.17	6493.46	6566.71
2. IPPU	1243.21	1159.72	1187.42	1250.85	1201.49	1173.02
3. Agriculture	499.08	505.95	529.82	544.67	550.14	565.46
4. LULUCF	-299.11	-296.11	-190.89	-307.03	-302.31	-297.04
5. Waste	620.38	624.81	627.76	635.25	644.93	656.42
Total (incl. LULUCF)	8357.10	8407.71	8857.90	9034.93	8890.02	8961.62
Total (excl. LULUCF)	8057.99	8111.60	8667.01	8727.90	8587.71	8664.58
Difference						
1. Energy	-0.21%	-0.20%	-0.21%	-0.51%	-0.50%	-0.18%
2. IPPU	-1.18%	-1.25%	-1.39%	-1.39%	-2.15%	-1.99%
3. Agriculture	10.03%	9.90%	9.61%	9.45%	9.20%	9.20%
4. LULUCF	-15.73%	-17.15%	-1236.1%	-14.83%	-13.29%	-14.84%
5. Waste	8.05%	7.72%	7.29%	7.12%	7.49%	8.18%
Total (incl. LULUCF)	0.78%	0.76%	0.67%	0.42%	0.36%	0.69%
Total (excl. LULUCF)	1.52%	1.56%	-1.69%	1.06%	0.92%	1.32%
NIR2022	**2020**					
1. Energy	6416.76					
2. IPPU	1288.35					
3. Agriculture	551.87					
4. LULUCF	-348.81					
5. Waste	614.59					
Total (incl. LULUCF)	8871.57					
Total (excl. LULUCF)	8522.77					
NIR2023	**2020**					
1. Energy	6047.95					
2. IPPU	1267.49					
3. Agriculture	603.16					
4. LULUCF	-298.54					

5. Waste	656.09					
Total (incl. LULUCF)	8574.70					
Total (excl. LULUCF)	8276.15					
Difference						
1. Energy	-5.75%					
2. IPPU	-1.62%					
3. Agriculture	9.29%					
4. LULUCF	-14.41%					
5. Waste	6.75%					
Total (incl. LULUCF)	-3.35%					
Total (excl. LULUCF)	-2.89%					

10.3. Implications for emission trends

Total GHG emissions for years 1990-2019 in the current submission are slightly higher in most of the years than the emissions reported in the 2021 submission. The emission trends for the period 1990 –2019 according to the inventories submitted in 202 and 2022 are shown in Figure 10.1 (LULUCF excluded). Emission trends for the period have not been affected significantly by the recalculations because in most cases the recalculations concerned the whole period.

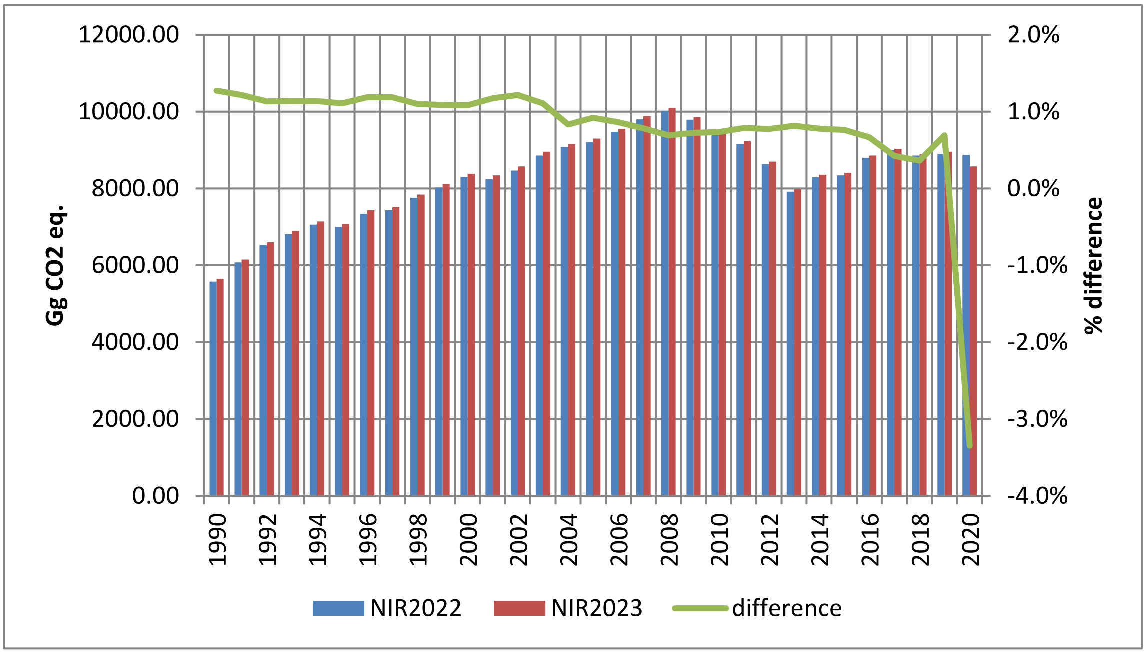


Figure 10.1. Comparison of NIR2022 to NIR2023, LULUCF excluded [kt CO_2 eq.]

10.4. Planned improvements

An inventory improvement procedure is in place, which utilises:

- the recommendations from UNFCCC ERT reports,
- the annual QA/QC checks of the inventory by EU under the Monitoring Mechanism Regulation (MMR),
- the recommendations of 2017 comprehensive review of national greenhouse gas inventory data pursuant to Article 19(1) of Regulation (EU) No 525 (MMR),
- the findings of independent audits carried out by local experts at the end of each year,
- the output of key category analysis, uncertainty analysis and QA/QC procedures.

These serve as a basis to prioritise, plan and materialize future improvements and recalculations. As mentioned above, details on the resultant recalculations and improvements planned per source/sink category have been presented in the respective chapters (Chapters 3 – 7).

Finally, it should be mentioned that the results and the proposals that will arise from the review of the present inventory, within the technical review process defined in relevant decisions of the Conference of the Parties, will be integrated in the plan for the improvement of the GHG emissions inventory.

Chapter 11.
Information on changes in national system

The national inventory arrangements and the QA/QC procedures have been restructured in 2017, to meet the requirements of CMP and COP Decisions relevant to national systems and QA/QC. The most important change is that the legal framework defining the roles-responsibilities and the co-operation between the DoE Inventory team and the designated contact points of the competent Ministries was formalized by the Council of Ministers' Decision adopted 15/11/2017 and entitled "Structure and operation of the National Greenhouse Gases Inventory System- Roles and Responsibilities". The above-mentioned Decision includes a description of each entity's responsibilities concerning the inventory preparation, data providing or other relative information. This formal framework has improved the collaboration between the entities involved, assuring the timely collection and quality of the activity data required and solving data access restriction problems raised due to confidentiality issues.

Chapter 12.
Information on changes in national registry

The information regarding the National Registry that should be included in the NIR in accordance decision 5/CMP.1 and the annex to decision 13/CMP.1 in conjunction with decision 3/CMP.11 and other relevant provisions and standards are presented in the following table.

Cyprus national registry has been fully connected to the ITL.

Also, about the national registry:

- No discrepancies have been identified by the transaction log pursuant to paragraph 43 of the annex to decision 13/CMP.1 and paragraph 54 of the annex to decision 5/CMP.1.
- No notification has been received from the Executive Board of the clean development mechanism (CDM) directing the Party to replace lCERs in accordance with paragraph 49 of the annex to decision 5/CMP.1.
- No notification has been received from the Executive Board of the clean development mechanism (CDM) directing the Party to replace lCERs in accordance with paragraph 50 of the annex to decision 5/CMP.1.
- No record to report of non-replacement identified by the transaction log in accordance with paragraph 56 of the annex to decision 5/CMP.1.
- All ERUs, CERs, tCERs, lCERs, AAUs and RMUs held in the national registry at the end of 2021 are valid for use towards compliance with commitments under Article 3, paragraph 1, pursuant to paragraph 43 (b) of the annex to decision 13/CMP.1.
- The SEF tables have been completed and submitted as part of the national 2023 GHG NIR submission,
- Publicly accessible registry information is available on the following website: http://www.moa.gov.cy/moa/environment/environmentnew.nsf/All/121CAE00B02167ACC22588B1004174FB?OpenDocument .

Cyprus commitment period reserve (CPR) is 42 705 115 t CO2 eq. which corresponds to 90% of Cyprus' assigned amount calculated pursuant to Article 3, paragraphs 7 and 8, of the Kyoto Protocol. The CPR was calculated in accordance with the annex to decision 18/CP.7, the annex to decision 11/CMP.1 and decision 1/CMP.8, paragraph 18, and can be found in table 4 of Annex I of the review of the report to facilitate the calculation of the assigned amount for the second commitment period of the Kyoto Protocol of Cyprus.

The CPR of Cyprus has not changed since the previous submission, and initial report, as 100 % of eight times Cyprus' most recently reviewed inventory emains higher than 90 % of the assigned amount.

Ref:	Category	Subject	Question	Response
1	Registry	Organization & system	Country or organization?	Cyprus
1.1			By what name is your organization known?	Department of Environment Ministry of Agriculture, Rural Development and Environment
1.2			By what name is your Registry system known?	CY Union Registry
1.3		Location	Where / in which nation is your Registry located? (Please provide your full address for correspondence)	Postal Address: Department of Environment 1498, Nicosia, Cyprus Offices: 20-22 28th Oktovriou Ave., Engomi, 2414, Nicosia, Cyprus
1.4		Time zone:	Please state GMT +/- hours.	Standard Time is 2 hours ahead of Greenwich Mean Time (GMT+2).
1.5		Days/hours of operation	Please indicate periods when the system will be operational, including uptime / downtime.	
1.6		Calendar constraints	Please identify critical dates/periods (e.g. service deadlines, holidays/reduced service, etc.)	
2.1	Personnel	Primary (Business) contact:	Please provide the following details for your business Registry System Administrator. This is the person responsible for day-to-day operation of the Registry: • Name • Role / Job title • Telephone number • Email address • Level of training / expertise in registry system (e.g. developer, administrator, user) • Competence level in English (e.g. native, fluent, proficient, etc.)	• Name: Dr. Theodoulos MESIMERIS • Role / Job title: Senior Environment Officer /Head of Climate Action Unit/ National Administrator • Telephone number: +357 22408948 • Email address tmesimeris@environment.moa.gov.cy • Level of training / expertise in registry system (e.g. developer, administrator, user): National Administrator • Competence level in English (e.g. native, fluent, proficient, etc.): Proficient user
2.2		Secondary (Technical) contact:	Please provide the following details for your technical support. This is the person responsible for technical support of your infrastructure and networking operation of the Registry: • Name	

			• Role / Job title • Telephone number • Email address • Level of training / expertise in registry system (e.g. developer, administrator, user) • Competence level in English (e.g. native, fluent, proficient, etc.)	
2.3		Other possible contacts?	How many other members of staff are regularly involved on a frequent basis?	Two other members of staff are regularly involved on a frequent basis. Person 1: • Name: Nicoletta Kythreotou • Role / Job title: Environment Officer • Telephone number: +357 22408947 • Email address: nkythreotou@environment.moa.gov.cy • Level of training / expertise in registry system (e.g. developer, administrator, user): National Administrator (2) • Competence level in English (e.g. native, fluent, proficient, etc.): Proficient user Person 2: • Name: Niki Papaki • Role / Job title: Environment Technician • Telephone number: +357 22408946 • Email address: npapaki@environment.moa.gov.cy • Level of training / expertise in registry system (e.g. developer, administrator, user): National Administrator (3) • Competence level in English (e.g. native, fluent, proficient, etc.): Independent user

Chapter 13.
Information on minimising adverse impacts in accordance with article 3, paragraph 14

13.1. Introduction

Article 3, paragraph 14, of the Kyoto Protocol requires that Annex I Parties shall strive to meet their commitments under Article 3, paragraph 1 of the Kyoto Protocol in such a way as to minimize adverse social environmental and economic impacts on developing country Parties, particularly those Parties identified in Article 4, paragraphs 8 and 9, of the Convention. Information on how commitments under Article 3, paragraph 14, are being implemented is to be prioritised under a number of actions as set down in section H of the annex to guidelines for the preparation of supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol (Decision 15/CMP.1). These requirements are addressed in this chapter.

13.2. Context

As a Member State of the European Union, Cyprus commitments under the Kyoto Protocol are being implemented under Decision 2005/166/EC, governing joint fulfilment under Article 4, and Decision 280/2004/EC, which covers specific emissions monitoring and reporting requirements. In this context, the minimization of adverse impacts on developing countries is also largely dictated by the European Commission’s policy on climate change and by its policies and programmes affecting developing countries. Regulation at the European level also controls or influences market conditions, fiscal incentives, tax and duty exemptions and subsidies in all economic sectors in Member States.

The impact assessment of new policy initiatives has been established in the European Union, which allows their potential adverse social, environmental and economic impacts on various stakeholders, including developing country Parties, to be identified and limited at an early stage within the legislative process. Impact Assessment Guidelines specifically address impacts on third countries and also issues related to international relations. This provides a framework in which Member States like Cyprus can also ensure a high level of protection of the environment and contribute to the integration of environmental considerations into the preparation and adoption of specified plans and programmes with a view to promoting sustainable development.

13.3. Specific Elements

<u>a) The progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse-gas-emitting sectors, taking into account the need for energy price reforms to reflect market prices and externalities</u>

The current paragraph includes information on the means used by the country in order to enhance the progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies that run counter to the objectives of the Convention and on the application of market instruments.

Cyprus, as a Member of the EU, supports and makes the necessary steps to implement the EU Common Agricultural Policy. In the specific policy environmental concerns have been gradually incorporated. Such examples are the including "decoupled" direct payments which have replaced price support; environmental cross compliance; a substantial increase in budget for rural development. As part of 2008

Common Agriculture Policy Health Check, additional part of direct aid has been shifted to climate change, renewable energy, water management, biodiversity, innovation; - transparency of agricultural subsidies has improved. It is important to note that in the other areas most subsidies are within the competence of the country.

The energy market liberalisation (National Laws 122(I)/2003 and 183(I)/2004) has been an important step to create an original internal energy market and can be considered as a mean to address market imperfections and to reflect externalities. The existence of a competitive internal energy market is a strategic instrument both in terms of giving local consumers a choice between different companies supplying gas and electricity at reasonable prices, but also in terms of making the market accessible for all suppliers, especially the smallest and those investing in renewable forms of energy.

At the same time, Cyprus participates in the EU Emissions Trading Scheme, which constitutes an important market instrument to implement the objectives of the Convention and Article 3, paragraph 1 of the Kyoto Protocol which aims at creating the right incentives for forward looking low carbon investment decisions by reinforcing a clear, undistorted and long-term carbon price signal.

Finally, the taxation on energy products and electricity, as defined by the Directive 2003/96/EC, contribute to establishment of rules for the taxation of energy products used as motor or heating fuel, taxes on energy consumption, and common minimum levels of taxation. The Directive has been transposed into Cyprus legislation with Law 91(I)/2004.

(b) Cooperating in the development, diffusion, and transfer of less-greenhouse-gas emitting advanced fossil-fuel technologies, and/or technologies, relating to fossil fuels, that capture and store greenhouse gases, and encouraging their wider use; and facilitating the participation of the least developed countries and other non-Annex I Parties in this effort

Cyprus considers important that EU remains committed to the climate change mitigation, through the international funding. Therefore, Cyprus has already contributed through the direct funding of the EU, with the amount of 1.2 million € for two projects in Nepal and eastern Caribbean. In the fulfilment of the requirements of Article 16 of Regulation (EU) No 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC, Cyprus submits reports including information regarding funding provided by the Republic of Cyprus to developing countries. No private funding, technology and capacity building have been provided to developing countries since 2013 due to the fact that Cyprus is implementing a macroeconomic adjustment program in order to improve key sectors of the economy as well as its public finances, pursuant to the provisions of the Memorandum of Understanding.

Annexes
to the national inventory report

Annex 1: Key categories

The 2006 IPCC Guidelines defines procedures (in the form of decision trees) for the choice of estimation methods within the context of the IPCC Guidelines. Decision trees formalize the choice of the estimation method most suited to national circumstances while simultaneously considering the need for accuracy and the available resources (both financial and human). It is considered good practice to identify those source categories (key source categories) that have the greatest contribution to overall inventory uncertainty in order to make the most efficient use of available resources.

In that context, a “key source category” is one that is prioritised within the national inventory system because its estimate has a significant influence on a country’s total inventory of direct greenhouse gases in terms of the absolute level of emissions (level assessment) and/or to the trend of emissions (trend assessment).

As far as possible, key source categories should receive special consideration in terms of two important inventory aspects.

1. The use of source category-specific good practice methods is preferable, unless resources are unavailable.

2. The key source categories should receive additional attention with respect to quality assurance (QA) and quality control (QC).

The determination of the key categories without LULUCF for the Greek inventory system is based on the application of the Tier 1 methodology described in the 2006 IPCC Guidelines, adopting the categorization of sources that is presented in the GLs. Key categories are those which, when summed together in descending order of magnitude, add up to over 95% of total emissions (level assessment) or the trend of the inventory in absolute terms. It should be noted that according to the 2006 IPCC GLs, the trend is estimated on the basis of the base year (1990). The methodology for the determination of key categories with LULUCF is the same as for the one for key sources without LULUCF.

The key categories analysis has been performed for the years 1990 and 2021 on both level and trend analysis basis. Any differences between the key categories in the time-series are due to the fluctuation of the trend in specific categories and refer to trend analysis.

Table A1.1.Key categories analysis without LULUCF – Level assessment for 2021

IPCC Source category	Direct GHG	2021 estimate (Gg CO2 eq.)	Level assessment	Cumulative total of level assessment
1A1a. Public electricity and heat production	**CO_2**	**3077.688200**	**0.3521876077**	**35.22%**
1A3b. Road transportation	**CO_2**	**2033.266639**	**0.2326718195**	**58.49%**
2A1. Cement production	**CO_2**	**878.8070000**	**0.1005640971**	**68.54%**
5A2. Unmanaged waste disposal sites	**CH_4**	**412.4601850**	**0.0471988572**	**73.26%**
1A2f. Non-metallic minerals	**CO_2**	**386.444814**	**0.0442218528**	**77.68%**
2F1. Refrigeration and air conditioning	**HFCs(1)**	**336.6178764**	**0.0385200309**	**81.54%**
1A4b. Residential	**CO_2**	**293.632603**	**0.0336011179**	**84.90%**
3A1a. Dairy cattle	**CH_4**	**160.1252241**	**0.0183235325**	**86.73%**
5A1. Managed waste disposal sites	**CH_4**	**159.6479744**	**0.0182689196**	**88.56%**
3D. Agricultural soils(2) (3) (4)	**N_2O**	**119.2078690**	**0.0136412565**	**89.92%**
1A4a. Commercial/institutional	**CO_2**	**89.809011**	**0.0102770712**	**90.95%**
1A4c. Agriculture/forestry/fishing	**CO_2**	**84.6548959**	**0.0096872728**	**91.92%**
3A2. Sheep	**CH_4**	**69.8212480**	**0.0079898212**	**92.72%**
3A1b. Non-dairy cattle	**CH_4**	**69.3780274**	**0.0079391023**	**93.51%**
1A2e. Food processing, beverages and tobacco	**CO_2**	**63.965813**	**0.0073197690**	**94.24%**
1A2g. Other (*please specify*)	**CO_2**	**58.694681**	**0.0067165801**	**94.91%**
3B3. Swine	CH_4	42.6451727	0.0048799945	95.40%
3A4a. Goats	CH_4	37.0269177	0.0042370834	95.82%
5D2. Industrial wastewater	CH_4	31.0439323	0.0035524353	96.18%
3B5. Indirect N_2O emissions	N_2O	28.0987296	0.0032154084	96.50%
3B1a. Dairy cattle	CH_4	26.1177343	0.0029887181	96.80%
5D1. Domestic wastewater	CH_4	23.3001345	0.0026662930	97.07%
1A5a. Stationary	CO_2	18.8459391	0.0021565883	97.28%
2G1. Electrical equipment	SF_6	16.2405210	0.0018584437	97.47%
3A3. Swine	CH_4	15.1446120	0.0017330361	97.64%
5D1. Domestic wastewater	N_2O	14.5174237	0.0016612653	97.81%
2A4. Other process uses of carbonates	CO_2	14.1868139	0.0016234328	97.97%
5B1. Composting	CH_4	13.5841440	0.0015544678	98.13%
3B2. Sheep	N_2O	13.0880595	0.0014976996	98.28%
2F3. Fire protection	HFCs(1)	11.6912987	0.0013378647	98.41%
1A3b. Road transportation	N_2O	11.605327	0.0013280267	98.54%

3B4a. Goats	N_2O	10.2911255	0.0011776394	98.66%
3B1b. Non-dairy cattle	CH_4	9.0171933	0.0010318601	98.76%
5B1. Composting	N_2O	7.7138532	0.0008827156	98.85%
1A4b. Residential	CH_4	7.5235168	0.0008609350	98.94%
3B1a. Dairy cattle	N_2O	7.1437681	0.0008174794	99.02%
1A2c. Chemicals	CO_2	6.731460	0.0007702979	99.10%
1A1a. Public electricity and heat production	N_2O	6.346672	0.0007262657	99.17%
2G3. N2O from product uses	N_2O	6.0584023	0.0006932782	99.24%
3B4d. Poultry	N_2O	5.4877387	0.0006279758	99.30%
1A2f. Non-metallic minerals	N_2O	4.536763	0.0005191532	99.35%
2D1. Lubricant use	CO_2	4.4700000	0.0005115134	99.40%
1A5b. Mobile	CO_2	4.0801761	0.0004669048	99.45%
2A2. Lime production	CO_2	3.9932475	0.0004569574	99.50%
2F4. Aerosols	HFCs(1)	3.8082262	0.0004357849	99.54%
1A2d. Pulp, paper and print	CO_2	3.486067	0.0003989194	99.58%
1A2f. Non-metallic minerals	CH_4	3.478479	0.0003980511	99.62%
1A1a. Public electricity and heat production	CH_4	3.352959	0.0003836875	99.66%
1A3b. Road transportation	CH_4	3.248340	0.0003717157	99.70%
3B1b. Non-dairy cattle	N_2O	2.8170782	0.0003223653	99.73%
1A2b. Non-ferrous metals	CO_2	2.746970	0.0003143427	99.76%
3B3. Swine	N_2O	2.7080809	0.0003098925	99.79%
1A3d. Domestic navigation	CO_2	2.639698	0.0003020672	99.82%
3B2. Sheep	CH_4	2.4437437	0.0002796437	99.85%
1A4a. Commercial/institutional	CH_4	2.319730	0.0002654525	99.87%
3B4d. Poultry	CH_4	2.2290416	0.0002550748	99.90%
3B4a. Goats	CH_4	1.4810767	0.0001694833	99.92%
2F2. Foam blowing agents	HFCs(1)	1.3702454	0.0001568006	99.93%
1A4b. Residential	N_2O	1.1748668	0.0001344430	99.95%
2D3. Other	CO_2	0.5112974	0.0000585091	99.95%
3F. Field burning of agricultural residues	CH_4	0.5099816	0.0000583585	99.96%
3A4c. Mules and Asses	CH_4	0.3971946	0.0000454520	99.96%
1A4c. Agriculture/forestry/fishing	CH_4	0.3742769	0.0000428294	99.97%
1A3a. Domestic aviation	CO_2	0.352940	0.0000403878	99.97%
1A4a. Commercial/institutional	N_2O	0.322948	0.0000369558	99.97%
3H. Urea application	CO_2	0.2988333	0.0000341963	99.98%
3A4b. Horses	CH_4	0.2585504	0.0000295866	99.98%

5D2. Industrial wastewater	N_2O	0.2431769	0.0000278273	99.98%
1A4c. Agriculture/forestry/fishing	N_2O	0.1816502	0.0000207867	99.99%
1A2e. Food processing, beverages and tobacco	N_2O	0.159764	0.0000182821	99.99%
1A2g. Other (*please specify*)	N_2O	0.148909	0.0000170400	99.99%
3F. Field burning of agricultural residues	N_2O	0.1251344	0.0000143194	99.99%
1A2e. Food processing, beverages and tobacco	CH_4	0.102028	0.0000116753	99.99%
1A1c. Manufacture of solid fuels and other energy industries	N_2O	0.096035	0.0000109895	99.99%
1A1c. Manufacture of solid fuels and other energy industries	CH_4	0.076103	0.0000087087	99.99%
3B4c. Mules and Asses	N_2O	0.0686733	0.0000078585	99.99%
1A2g. Other (*please specify*)	CH_4	0.067313	0.0000077028	100.00%
1A5a. Stationary	CH_4	0.0665566	0.0000076162	100.00%
3B4b. Horses	N_2O	0.0557512	0.0000063797	100.00%
2D2. Paraffin wax use	CO_2	0.0504591	0.0000057742	100.00%
1A5a. Stationary	N_2O	0.0440192	0.0000050372	100.00%
3B4c. Mules and Asses	CH_4	0.0436914	0.0000049997	100.00%
1A3d. Domestic navigation	N_2O	0.040629	0.0000046492	100.00%
3B4b. Horses	CH_4	0.0336116	0.0000038463	100.00%
1A2c. Chemicals	N_2O	0.026023	0.0000029779	100.00%
1A2c. Chemicals	CH_4	0.016207	0.0000018546	100.00%
1A5b. Mobile	CH_4	0.0159783	0.0000018284	100.00%
1A5b. Mobile	N_2O	0.0090734	0.0000010383	100.00%
1A2d. Pulp, paper and print	N_2O	0.006663	0.0000007624	100.00%
1A3d. Domestic navigation	CH_4	0.004153	0.0000004753	100.00%
1A2d. Pulp, paper and print	CH_4	0.003572	0.0000004088	100.00%
1A3a. Domestic aviation	N_2O	0.002616	0.0000002994	100.00%
1A2b. Non-ferrous metals	N_2O	0.002048	0.0000002344	100.00%
1A2b. Non-ferrous metals	CH_4	0.001557	0.0000001782	100.00%
1A3a. Domestic aviation	CH_4	0.000069	0.0000000079	100.00%
2G4. Other	CO_2	0.0000000	0.0000000000	100.00%

Table A1.2.Key categories analysis with LULUCF – Level assessment for 2020

IPCC Source category	Direct GHG	2020 estimate (Gg CO2 eq.)	Level assessment	Cumulative total of level assessment
1A1a. Public electricity and heat production	**CO_2**	**3077.688200**	**0.3398447463**	**33.98%**
1A3b. Road transportation	**CO_2**	**2033.266639**	**0.2245175405**	**56.44%**
2A1. Cement production	**CO_2**	**878.8070000**	**0.0970397008**	**66.14%**
5A2. Unmanaged waste disposal sites	**CH_4**	**412.4601850**	**0.0455447134**	**70.69%**
1A2f. Non-metallic minerals	**CO_2**	**386.444814**	**0.0426720419**	**74.96%**
2F1. Refrigeration and air conditioning	**HFCs[(1)]**	**336.6178764**	**0.0371700476**	**78.68%**
1A4b. Residential	**CO_2**	**293.632603**	**0.0324235241**	**81.92%**
3A1a. Dairy cattle	**CH_4**	**160.1252241**	**0.0176813610**	**83.69%**
5A1. Managed waste disposal sites	**CH_4**	**159.6479744**	**0.0176286621**	**85.45%**
4B1. Cropland remaining cropland	**CO_2**	**133.8833939**	**0.0147836834**	**86.93%**
3D. Agricultural soils(2) (3) (4)	**N_2O**	**119.2078690**	**0.0131631814**	**88.25%**
4A1. Forest land remaining forest land	**CO_2**	**103.9788211**	**0.0114815582**	**89.40%**
1A4a. Commercial/institutional	**CO_2**	**89.809011**	**0.0099168982**	**90.39%**
1A4c. Agriculture/forestry/fishing	**CO_2**	**84.6548959**	**0.0093477701**	**91.32%**
3A2. Sheep	**CH_4**	**69.8212480**	**0.0077098077**	**92.09%**
3A1b. Non-dairy cattle	**CH_4**	**69.3780274**	**0.0076608664**	**92.86%**
1A2e. Food processing, beverages and tobacco	**CO_2**	**63.965813**	**0.0070632385**	**93.56%**
1A2g. Other (*please specify*)	**CO_2**	**58.694681**	**0.0064811890**	**94.21%**
3B3. Swine	**CH_4**	**42.6451727**	**0.0047089689**	**94.68%**
3A4a. Goats	CH_4	37.0269177	0.0040885894	95.09%
5D2. Industrial wastewater	CH_4	31.0439323	0.0034279357	95.44%
3B5. Indirect N_2O emissions	N_2O	28.0987296	0.0031027203	95.75%
3B1a. Dairy cattle	CH_4	26.1177343	0.0028839747	96.03%
5D1. Domestic wastewater	CH_4	23.3001345	0.0025728494	96.29%
4C1. Grassland remaining grassland	CO_2	21.7525342	0.0024019602	96.53%
4G. Harvested wood products [(5)]	CO_2	19.9235005	0.0021999945	96.75%
1A5a. Stationary	CO_2	18.8459391	0.0020810079	96.96%
4A2. Land converted to forest land	CO_2	17.2662821	0.0019065789	97.15%
2G1. Electrical equipment	SF_6	16.2405210	0.0017933122	97.33%
3A3. Swine	CH_4	15.1446120	0.0016722996	97.50%
5D1. Domestic wastewater	N_2O	14.5174237	0.0016030442	97.66%

2A4. Other process uses of carbonates	CO_2	14.1868139	0.0015665376	97.81%
5B1. Composting	CH_4	13.5841440	0.0014999895	97.96%
3B2. Sheep	N_2O	13.0880595	0.0014452108	98.11%
2F3. Fire protection	HFCs(1)	11.6912987	0.0012909776	98.24%
1A3b. Road transportation	N_2O	11.605327	0.0012814844	98.37%
3B4a. Goats	N_2O	10.2911255	0.0011363675	98.48%
3B1b. Non-dairy cattle	CH_4	9.0171933	0.0009956973	98.58%
5B1. Composting	N_2O	7.7138532	0.0008517797	98.66%
1A4b. Residential	CH_4	7.5235168	0.0008307624	98.75%
3B1a. Dairy cattle	N_2O	7.1437681	0.0007888298	98.83%
1A2c. Chemicals	CO_2	6.731460	0.0007433019	98.90%
1A1a. Public electricity and heat production	N_2O	6.346672	0.0007008128	98.97%
4B2. Land converted to cropland	CO_2	6.1582448	0.0006800062	99.04%
2G3. N2O from product uses	N_2O	6.0584023	0.0006689814	99.11%
3B4d. Poultry	N_2O	5.4877387	0.0006059675	99.17%
4A1. Forest land remaining forest land	CH_4	5.4776222	0.0006048505	99.23%
1A2f. Non-metallic minerals	N_2O	4.536763	0.0005009588	99.28%
2D1. Lubricant use	CO_2	4.4700000	0.0004935867	99.33%
1A5b. Mobile	CO_2	4.0801761	0.0004505415	99.37%
2A2. Lime production	CO_2	3.9932475	0.0004409427	99.42%
2F4. Aerosols	HFCs(1)	3.8082262	0.0004205123	99.46%
4E2. Land converted to settlements	CO_2	3.5580739	0.0003928899	99.50%
1A2d. Pulp, paper and print	CO_2	3.486067	0.0003849387	99.53%
1A2f. Non-metallic minerals	CH_4	3.478479	0.0003841009	99.57%
1A1a. Public electricity and heat production	CH_4	3.352959	0.0003702407	99.61%
1A3b. Road transportation	CH_4	3.248340	0.0003586885	99.65%
4A1. Forest land remaining forest land	N_2O	2.8678432	0.0003166732	99.68%
3B1b. Non-dairy cattle	N_2O	2.8170782	0.0003110676	99.71%
1A2b. Non-ferrous metals	CO_2	2.746970	0.0003033262	99.74%
3B3. Swine	N_2O	2.7080809	0.0002990319	99.77%
1A3d. Domestic navigation	CO_2	2.639698	0.0002914809	99.80%
3B2. Sheep	CH_4	2.4437437	0.0002698433	99.83%
1A4a. Commercial/institutional	CH_4	2.319730	0.0002561494	99.85%
3B4d. Poultry	CH_4	2.2290416	0.0002461354	99.88%
4C2. Land converted to grassland	CO_2	2.0221548	0.0002232906	99.90%
3B4a. Goats	CH_4	1.4810767	0.0001635436	99.91%

2F2. Foam blowing agents	HFCs[1]	1.3702454	0.0001513053	99.93%
1A4b. Residential	N_2O	1.1748668	0.0001297312	99.94%
2D3. Other	CO_2	0.5112974	0.0000564585	99.95%
3F. Field burning of agricultural residues	CH_4	0.5099816	0.0000563132	99.95%
4D2. Land converted to wetlands	CO_2	0.4961218	0.0000547828	99.96%
3A4c. Mules and Asses	CH_4	0.3971946	0.0000438591	99.96%
1A4c. Agriculture/forestry/fishing	CH_4	0.3742769	0.0000413284	99.97%
1A3a. Domestic aviation	CO_2	0.352940	0.0000389723	99.97%
1A4a. Commercial/institutional	N_2O	0.322948	0.0000356606	99.98%
3H. Urea application	CO_2	0.2988333	0.0000329978	99.98%
3A4b. Horses	CH_4	0.2585504	0.0000285497	99.98%
5D2. Industrial wastewater	N_2O	0.2431769	0.0000268521	99.98%
1A4c. Agriculture/forestry/fishing	N_2O	0.1816502	0.0000200582	99.99%
1A2e. Food processing, beverages and tobacco	N_2O	0.159764	0.0000176414	99.99%
1A2g. Other (*please specify*)	N_2O	0.148909	0.0000164428	99.99%
3F. Field burning of agricultural residues	N_2O	0.1251344	0.0000138176	99.99%
1A2e. Food processing, beverages and tobacco	CH_4	0.102028	0.0000112661	99.99%
1A1c. Manufacture of solid fuels and other energy industries	N_2O	0.096035	0.0000106044	99.99%
1A1c. Manufacture of solid fuels and other energy industries	CH_4	0.076103	0.0000084035	99.99%
3B4c. Mules and Asses	N_2O	0.0686733	0.0000075831	99.99%
1A2g. Other (*please specify*)	CH_4	0.067313	0.0000074329	100.00%
1A5a. Stationary	CH_4	0.0665566	0.0000073493	100.00%
3B4b. Horses	N_2O	0.0557512	0.0000061562	100.00%
2D2. Paraffin wax use	CO_2	0.0504591	0.0000055718	100.00%
1A5a. Stationary	N_2O	0.0440192	0.0000048607	100.00%
3B4c. Mules and Asses	CH_4	0.0436914	0.0000048245	100.00%
1A3d. Domestic navigation	N_2O	0.040629	0.0000044863	100.00%
3B4b. Horses	CH_4	0.0336116	0.0000037115	100.00%
1A2c. Chemicals	N_2O	0.026023	0.0000028735	100.00%
1A2c. Chemicals	CH_4	0.016207	0.0000017896	100.00%
1A5b. Mobile	CH_4	0.0159783	0.0000017644	100.00%
1A5b. Mobile	N_2O	0.0090734	0.0000010019	100.00%
1A2d. Pulp, paper and print	N_2O	0.006663	0.0000007357	100.00%
1A3d. Domestic navigation	CH_4	0.004153	0.0000004586	100.00%
1A2d. Pulp, paper and print	CH_4	0.003572	0.0000003944	100.00%
1A3a. Domestic aviation	N_2O	0.002616	0.0000002889	100.00%

1A2b. Non-ferrous metals	N_2O	0.002048	0.0000002262	100.00%
1A2b. Non-ferrous metals	CH_4	0.001557	0.0000001719	100.00%
1A3a. Domestic aviation	CH_4	0.000069	0.0000000076	100.00%
2G4. Other	CO_2	0.0000000	0.0000000000	100.00%
4F2. Land converted to other land	CO_2	0.0000000	0.0000000000	100.00%

Table A1.3. Key categories analysis without LULUCF – Level assessment for 1990

IPCC Source category	Direct GHG	1990 estimate (Gg CO2 eq.)	Level assessment	Cumulative total of level assessment
1A1a. Public electricity and heat production	**CO_2**	**1675.770000**	**0.2964910048**	**29.6%**
1A3b. Road transportation	**CO_2**	**1188.320532**	**0.2102474377**	**50.7%**
2A1. Cement production	**CO_2**	**667.664000**	**0.1181286037**	**62.5%**
1A2f. Non-metallic minerals	**CO_2**	**379.826741**	**0.0672020695**	**69.2%**
1A4b. Residential	**CO_2**	**299.703957**	**0.0530260879**	**74.5%**
5A2. Unmanaged waste disposal sites	**CH_4**	**295.365426**	**0.0522584793**	**79.7%**
3D. Agricultural soils	**N_2O**	**133.281845**	**0.0235813197**	**82.1%**
5D1. Domestic wastewater	**CH_4**	**102.922960**	**0.0182099762**	**83.9%**
3B3. Swine	**CH_4**	**88.595028**	**0.0156749607**	**85.5%**
1A1b. Petroleum refining	**CO_2**	**85.718200**	**0.0151659686**	**87.0%**
1A4a. Commercial/institutional	**CO_2**	**75.212242**	**0.0133071682**	**88.3%**
1A2e. Food processing, beverages and tobacco	**CO_2**	**72.570573**	**0.0128397825**	**89.6%**
3A2. Sheep	**CH_4**	**64.960000**	**0.0114932572**	**90.8%**
3A1a. Dairy cattle	**CH_4**	**61.992000**	**0.0109681343**	**91.9%**
1A4c. Agriculture/forestry/fishing	**CO_2**	**55.484174**	**0.0098167162**	**92.8%**
3A1b. Non-dairy cattle	**CH_4**	**51.503200**	**0.0091123695**	**93.8%**
2A4. Other process uses of carbonates	**CO_2**	**44.076000**	**0.0077982883**	**94.5%**
1A2g. Other	CO_2	38.008328	0.0067247459	95.2%
3A4a. Goats	CH_4	28.840000	0.0051026099	95.7%
5D2. Industrial wastewater	CH_4	27.101200	0.0047949671	96.2%
1A3a. Domestic aviation	CO_2	26.045000	0.0046080955	96.7%
3B5. Indirect N_2O emissions	N_2O	22.550517	0.0039898228	97.1%
3B2. Sheep	N_2O	12.176814	0.0021544220	97.3%
1A3b. Road transportation	N_2O	12.121616	0.0021446559	97.5%

3A3. Swine	CH_4	11.673200	0.0020653185	97.7%
3B1a. Dairy cattle	CH_4	11.645470	0.0020604123	97.9%
1A5a. Stationary	CO_2	10.994979	0.0019453221	98.1%
5D1. Domestic wastewater	N_2O	9.519110	0.0016841991	98.3%
3B4a. Goats	N_2O	7.976773	0.0014113162	98.4%
1A3b. Road transportation	CH_4	7.874346	0.0013931940	98.5%
3B1b. Non-dairy cattle	CH_4	7.708403	0.0013638340	98.7%
3B4d. Poultry	N_2O	6.990740	0.0012368592	98.8%
3B3. Swine	N_2O	6.887049	0.0012185133	98.9%
2A2. Lime production	CO_2	5.332600	0.0009434874	99.0%
1A2b. Non-ferrous metals	CO_2	4.910000	0.0008687176	99.1%
1A2d. Pulp, paper and print	CO_2	4.820730	0.0008529232	99.2%
2D1. Lubricant use	CO_2	4.127200	0.0007302182	99.3%
2G3. N2O from product uses	N_2O	3.931545	0.0006956012	99.3%
3B1a. Dairy cattle	N_2O	3.597150	0.0006364373	99.4%
1A1a. Public electricity and heat production	N_2O	3.445000	0.0006095177	99.5%
2G1. Electrical equipment	SF_6	2.730860	0.0004831662	99.5%
3B4d. Poultry	CH_4	2.355332	0.0004167247	99.5%
3B1b. Non-dairy cattle	N_2O	2.324418	0.0004112551	99.6%
3B2. Sheep	CH_4	2.273600	0.0004022640	99.6%
1A2c. Chemicals	CO_2	2.198996	0.0003890644	99.7%
1A3d. Domestic navigation	CO_2	2.197794	0.0003888517	99.7%
1A4b. Residential	CH_4	2.133144	0.0003774134	99.7%
1A1a. Public electricity and heat production	CH_4	1.848000	0.0003269634	99.8%
3F. Field burning of agricultural residues	CH_4	1.845687	0.0003265541	99.8%
3H. Urea application	CO_2	1.815000	0.0003211247	99.8%
3A4c. Mules and Asses	CH_4	1.407280	0.0002489875	99.9%
1A2f. Non-metallic minerals	N_2O	1.276195	0.0002257949	99.9%
3B4a. Goats	CH_4	1.148000	0.0002031136	99.9%
1A2f. Non-metallic minerals	CH_4	0.849999	0.0001503888	99.9%
1A4b. Residential	N_2O	0.619852	0.0001096693	99.9%
1A4a. Commercial/institutional	CH_4	0.467544	0.0000827216	99.9%
1B2a. Oil	CH_4	0.453521	0.0000802408	100.0%
3F. Field burning of agricultural residues	N_2O	0.452670	0.0000800901	100.0%
5D2. Industrial wastewater	N_2O	0.276130	0.0000488552	100.0%
3B4c. Mules and Asses	N_2O	0.243335	0.0000430527	100.0%

3A4b. Horses	CH_4	0.231840	0.0000410190	100.0%
1A4c. Agriculture/forestry/fishing	CH_4	0.205432	0.0000363467	100.0%
1A3a. Domestic aviation	N_2O	0.193053	0.0000341564	100.0%
3B4c. Mules and Asses	CH_4	0.154814	0.0000273911	100.0%
1A2e. Food processing, beverages and tobacco	N_2O	0.136404	0.0000241338	100.0%
1A4a. Commercial/institutional	N_2O	0.123835	0.0000219099	100.0%
1A1c. Manufacture of solid fuels and other energy industries	N_2O	0.118720	0.0000210049	100.0%
1A4c. Agriculture/forestry/fishing	N_2O	0.114381	0.0000202373	100.0%
1A1c. Manufacture of solid fuels and other energy industries	CH_4	0.094080	0.0000166454	100.0%
1A2g. Other	N_2O	0.079785	0.0000141162	100.0%
1A2e. Food processing, beverages and tobacco	CH_4	0.073865	0.0000130689	100.0%
2D2. Paraffin wax use	CO_2	0.063498	0.0000112345	100.0%
3B4b. Horses	N_2O	0.050016	0.0000088492	100.0%
1A2g. Other	CH_4	0.042290	0.0000074824	100.0%
1A5a. Stationary	CH_4	0.041546	0.0000073507	100.0%
1A3d. Domestic navigation	N_2O	0.030653	0.0000054235	100.0%
3B4b. Horses	CH_4	0.030154	0.0000053351	100.0%
1A5a. Stationary	N_2O	0.023592	0.0000041742	100.0%
1A2d. Pulp, paper and print	N_2O	0.009903	0.0000017521	100.0%
1A2b. Non-ferrous metals	N_2O	0.005300	0.0000009377	100.0%
1A2d. Pulp, paper and print	CH_4	0.005232	0.0000009257	100.0%
1A3a. Domestic aviation	CH_4	0.005096	0.0000009016	100.0%
1A2c. Chemicals	N_2O	0.004718	0.0000008348	100.0%
1A2b. Non-ferrous metals	CH_4	0.003640	0.0000006440	100.0%
1A3d. Domestic navigation	CH_4	0.003239	0.0000005730	100.0%
1A2c. Chemicals	CH_4	0.002493	0.0000004410	100.0%
1A1b. Petroleum refining	CH_4	0.000000	0.0000000000	100.0%
1B2c. Venting and flaring	CH_4	0.000000	0.0000000000	100.0%
2D3. Other	CO_2	0.000000	0.0000000000	100.0%
2G4. Other	CO_2	0.000000	0.0000000000	100.0%
2F1. Refrigeration and air conditioning	HFCs	0.000000	0.0000000000	100.0%
1A1b. Petroleum refining	N_2O	0.000000	0.0000000000	100.0%

Table A1.4. Key categories analysis with LULUCF – Level assessment for 1990

IPCC Source category	Direct GHG	1990 estimate (Gg CO2 eq.)	Level assessment	Cumulative total of level assessment
1A1a. Public electricity and heat production	**CO_2**	**1675.770000**	**0.2882089517**	**28.8%**
1A3b. Road transportation	**CO_2**	**1188.320532**	**0.2043744755**	**49.3%**
2A1. Cement production	**CO_2**	**667.664000**	**0.1148288497**	**60.7%**
1A2f. Non-metallic minerals	**CO_2**	**379.826741**	**0.0653248756**	**67.3%**
1A4b. Residential	**CO_2**	**299.703957**	**0.0515448798**	**72.4%**
5A2. Unmanaged waste disposal sites	**CH_4**	**295.365426**	**0.0507987133**	**77.5%**
4B1. Cropland remaining cropland	**CO_2**	**133.968962**	**0.0230407837**	**79.8%**
3D. Agricultural soils	**N_2O**	**133.281845**	**0.0229226092**	**82.1%**
5D1. Domestic wastewater	**CH_4**	**102.922960**	**0.0177013065**	**83.9%**
3B3. Swine	**CH_4**	**88.595028**	**0.0152371030**	**85.4%**
1A1b. Petroleum refining	**CO_2**	**85.718200**	**0.0147423289**	**86.9%**
1A4a. Commercial/institutional	**CO_2**	**75.212242**	**0.0129354515**	**88.2%**
1A2e. Food processing, beverages and tobacco	**CO_2**	**72.570573**	**0.0124811215**	**89.4%**
3A2. Sheep	**CH_4**	**64.960000**	**0.0111722095**	**90.5%**
3A1a. Dairy cattle	**CH_4**	**61.992000**	**0.0106617551**	**91.6%**
1A4c. Agriculture/forestry/fishing	**CO_2**	**55.484174**	**0.0095425002**	**92.6%**
3A1b. Non-dairy cattle	**CH_4**	**51.503200**	**0.0088578285**	**93.4%**
2A4. Other process uses of carbonates	**CO_2**	**44.076000**	**0.0075804542**	**94.2%**
1A2g. Other	**CO_2**	**38.008328**	**0.0065368997**	**94.8%**
3A4a. Goats	CH_4	28.840000	0.0049600758	95.3%
5D2. Industrial wastewater	CH_4	27.101200	0.0046610265	95.8%
1A3a. Domestic aviation	CO_2	26.045000	0.0044793749	96.3%
4C1. Grassland remaining grassland	CO_2	23.415771	0.0040271844	96.7%
3B5. Indirect N_2O emissions	N_2O	22.550517	0.0038783728	97.0%
3B2. Sheep	N_2O	12.176814	0.0020942413	97.3%
1A3b. Road transportation	N_2O	12.121616	0.0020847480	97.5%
3A3. Swine	CH_4	11.673200	0.0020076268	97.7%
3B1a. Dairy cattle	CH_4	11.645470	0.0020028576	97.9%
1A5a. Stationary	CO_2	10.994979	0.0018909823	98.1%

5D1. Domestic wastewater	N_2O	9.519110	0.0016371534	98.2%
3B4a. Goats	N_2O	7.976773	0.0013718931	98.4%
1A3b. Road transportation	CH_4	7.874346	0.0013542772	98.5%
3B1b. Non-dairy cattle	CH_4	7.708403	0.0013257372	98.6%
3B4d. Poultry	N_2O	6.990740	0.0012023093	98.7%
3B3. Swine	N_2O	6.887049	0.0011844759	98.9%
2A2. Lime production	CO_2	5.332600	0.0009171325	99.0%
1A2b. Non-ferrous metals	CO_2	4.910000	0.0008444512	99.0%
1A2d. Pulp, paper and print	CO_2	4.820730	0.0008290980	99.1%
2D1. Lubricant use	CO_2	4.127200	0.0007098206	99.2%
2G3. N2O from product uses	N_2O	3.931545	0.0006761705	99.3%
3B1a. Dairy cattle	N_2O	3.597150	0.0006186594	99.3%
1A1a. Public electricity and heat production	N_2O	3.445000	0.0005924917	99.4%
2G1. Electrical equipment	SF_6	2.730860	0.0004696697	99.4%
3B4d. Poultry	CH_4	2.355332	0.0004050841	99.5%
3B1b. Non-dairy cattle	N_2O	2.324418	0.0003997673	99.5%
3B2. Sheep	CH_4	2.273600	0.0003910273	99.6%
1A2c. Chemicals	CO_2	2.198996	0.0003781965	99.6%
1A3d. Domestic navigation	CO_2	2.197794	0.0003779897	99.6%
4G. Harvested wood products	CO_2	2.136998	0.0003675338	99.7%
1A4b. Residential	CH_4	2.133144	0.0003668709	99.7%
1A1a. Public electricity and heat production	CH_4	1.848000	0.0003178301	99.7%
3F. Field burning of agricultural residues	CH_4	1.845687	0.0003174323	99.8%
3H. Urea application	CO_2	1.815000	0.0003121546	99.8%
4A1. Forest land remaining forest land	CO_2	1.551913	0.0002669072	99.8%
3A4c. Mules and Asses	CH_4	1.407280	0.0002420324	99.8%
1A2f. Non-metallic minerals	N_2O	1.276195	0.0002194876	99.9%
3B4a. Goats	CH_4	1.148000	0.0001974399	99.9%
1A2f. Non-metallic minerals	CH_4	0.849999	0.0001461879	99.9%
1A4b. Residential	N_2O	0.619852	0.0001066059	99.9%
1A4a. Commercial/institutional	CH_4	0.467544	0.0000804109	99.9%
4E2. Land converted to settlements	CO_2	0.461793	0.0000794220	99.9%
1B2a. Oil	CH_4	0.453521	0.0000779993	99.9%
3F. Field burning of agricultural residues	N_2O	0.452670	0.0000778529	99.9%
4C2. Land converted to grassland	CO_2	0.361126	0.0000621087	100.0%
5D2. Industrial wastewater	N_2O	0.276130	0.0000474905	100.0%

4B2. Land converted to cropland	CO_2	0.267118	0.0000459406	100.0%
3B4c. Mules and Asses	N_2O	0.243335	0.0000418501	100.0%
3A4b. Horses	CH_4	0.231840	0.0000398732	100.0%
1A4c. Agriculture/forestry/fishing	CH_4	0.205432	0.0000353314	100.0%
1A3a. Domestic aviation	N_2O	0.193053	0.0000332023	100.0%
3B4c. Mules and Asses	CH_4	0.154814	0.0000266259	100.0%
1A2e. Food processing, beverages and tobacco	N_2O	0.136404	0.0000234596	100.0%
1A4a. Commercial/institutional	N_2O	0.123835	0.0000212979	100.0%
1A1c. Manufacture of solid fuels and other energy industries	N_2O	0.118720	0.0000204182	100.0%
1A4c. Agriculture/forestry/fishing	N_2O	0.114381	0.0000196720	100.0%
4F2. Land converted to other land	CO_2	0.107723	0.0000185269	100.0%
4A2. Land converted to forest land	CO_2	0.096432	0.0000165849	100.0%
1A1c. Manufacture of solid fuels and other energy industries	CH_4	0.094080	0.0000161804	100.0%
1A2g. Other	N_2O	0.079785	0.0000137219	100.0%
1A2e. Food processing, beverages and tobacco	CH_4	0.073865	0.0000127038	100.0%
2D2. Paraffin wax use	CO_2	0.063498	0.0000109207	100.0%
3B4b. Horses	N_2O	0.050016	0.0000086020	100.0%
1A2g. Other	CH_4	0.042290	0.0000072734	100.0%
1A5a. Stationary	CH_4	0.041546	0.0000071454	100.0%
4A1. Forest land remaining forest land	CH_4	0.032747	0.0000056321	100.0%
1A3d. Domestic navigation	N_2O	0.030653	0.0000052720	100.0%
3B4b. Horses	CH_4	0.030154	0.0000051860	100.0%
1A5a. Stationary	N_2O	0.023592	0.0000040576	100.0%
4A1. Forest land remaining forest land	N_2O	0.017145	0.0000029487	100.0%
1A2d. Pulp, paper and print	N_2O	0.009903	0.0000017032	100.0%
1A2b. Non-ferrous metals	N_2O	0.005300	0.0000009115	100.0%
1A2d. Pulp, paper and print	CH_4	0.005232	0.0000008998	100.0%
1A3a. Domestic aviation	CH_4	0.005096	0.0000008764	100.0%
1A2c. Chemicals	N_2O	0.004718	0.0000008115	100.0%
1A2b. Non-ferrous metals	CH_4	0.003640	0.0000006260	100.0%
1A3d. Domestic navigation	CH_4	0.003239	0.0000005570	100.0%
1A2c. Chemicals	CH_4	0.002493	0.0000004287	100.0%
1A1b. Petroleum refining	CH_4	0.000000	0.0000000000	100.0%
1B2c. Venting and flaring	CH_4	0.000000	0.0000000000	100.0%
2D3. Other	CO_2	0.000000	0.0000000000	100.0%
2G4. Other	CO_2	0.000000	0.0000000000	100.0%

4D2. Land converted to wetlands	CO_2	0.000000	0.0000000000	100.0%
2F1. Refrigeration and air conditioning	HFCs	0.000000	0.0000000000	100.0%
1A1b. Petroleum refining	N_2O	0.000000	0.0000000000	100.0%

Table A1.5. Key categories analysis without LULUCF – Trend assessment for 2021

IPCC Source category	Direct GHG	1990 estimate	2021 estimate	Level assessment 2021	Trend assessment	% contribution to trend	Cumulative total of level assessment
1A1a. Public electricity and heat production	**CO_2**	**1675.770000**	**3077.688200**	**0.352188**	**0.036023**	**19.33%**	**19.33%**
2F1. Refrigeration and air conditioning	**HFCs(1)**	**0.000000**	**336.6178764**	**0.038520**	**0.024914**	**13.37%**	**32.70%**
1A2f. Non-metallic minerals	**CO_2**	**379.826741**	**386.444814**	**0.044222**	**0.014863**	**7.98%**	**40.68%**
1A3b. Road transportation	**CO_2**	**1188.320532**	**2033.266639**	**0.232672**	**0.014504**	**7.78%**	**48.46%**
1A4b. Residential	**CO_2**	**299.703957**	**293.632603**	**0.033601**	**0.012564**	**6.74%**	**55.20%**
5A1. Managed waste disposal sites	**CH_4**	**0.000000**	**159.6479744**	**0.018269**	**0.011816**	**6.34%**	**61.55%**
2A1. Cement production	**CO_2**	**667.664000**	**878.8070000**	**0.100564**	**0.011360**	**6.10%**	**67.64%**
5D1. Domestic wastewater	**CH_4**	**102.922960**	**23.3001345**	**0.002666**	**0.010053**	**5.40%**	**73.04%**
3B3. Swine	**CH_4**	**88.595028**	**42.6451727**	**0.004880**	**0.006982**	**3.75%**	**76.78%**
3D. Agricultural soils(2) (3) (4)	**N_2O**	**133.281845**	**119.2078690**	**0.013641**	**0.006429**	**3.45%**	**80.24%**
3A1a. Dairy cattle	**CH_4**	**61.992000**	**160.1252241**	**0.018324**	**0.004757**	**2.55%**	**82.79%**
2A4. Other process uses of carbonates	**CO_2**	**44.076000**	**14.1868139**	**0.001623**	**0.003994**	**2.14%**	**84.93%**
1A2e. Food processing, beverages and tobacco	**CO_2**	**72.570573**	**63.965813**	**0.007320**	**0.003570**	**1.92%**	**86.85%**
5A2. Unmanaged waste disposal sites	**CH_4**	**295.365426**	**412.4601850**	**0.047199**	**0.003272**	**1.76%**	**88.60%**
1A3a. Domestic aviation	**CO_2**	**26.045000**	**0.352940**	**0.000040**	**0.002954**	**1.59%**	**90.19%**
3A2. Sheep	**CH_4**	**64.960000**	**69.8212480**	**0.007990**	**0.002266**	**1.22%**	**91.41%**
1A4a. Commercial/institutional	**CO_2**	**75.212242**	**89.809011**	**0.010277**	**0.001960**	**1.05%**	**92.46%**
5B1. Composting	**CH_4**	**0.000000**	**13.5841440**	**0.001554**	**0.001005**	**0.54%**	**93.00%**
2G1. Electrical equipment	**SF_6**	**2.730860**	**16.2405210**	**0.001858**	**0.000889**	**0.48%**	**93.47%**
2F3. Fire protection	**HFCs(1)**	**0.000000**	**11.6912987**	**0.001338**	**0.000865**	**0.46%**	**93.94%**
5D2. Industrial wastewater	**CH_4**	**27.101200**	**31.0439323**	**0.003552**	**0.000804**	**0.43%**	**94.37%**
3A1b. Non-dairy cattle	**CH_4**	**51.503200**	**69.3780274**	**0.007939**	**0.000759**	**0.41%**	**94.78%**
1A3b. Road transportation	CH_4	7.874346	3.248340	0.000372	0.000661	0.35%	95.13%
3B1a. Dairy cattle	CH_4	11.645470	26.1177343	0.002989	0.000600	0.32%	95.45%
3B3. Swine	N_2O	6.887049	2.708080925	0.000310	0.000588	0.32%	95.77%
5B1. Composting	N_2O	0.000000	7.7138532	0.000883	0.000571	0.31%	96.08%

3A4a. Goats	CH_4	28.840000	37.0269177	0.004237	0.000560	0.30%	96.38%
1A3b. Road transportation	N_2O	12.121616	11.605327	0.001328	0.000528	0.28%	96.66%
3B5. Indirect N_2O emissions	N_2O	22.550517	28.0987296	0.003215	0.000501	0.27%	96.93%
3B2. Sheep	N_2O	12.176814	13.08805945	0.001498	0.000425	0.23%	97.16%
3B4d. Poultry	N_2O	6.990740	5.4877387	0.000628	0.000394	0.21%	97.37%
1A2b. Non-ferrous metals	CO_2	4.910000	2.746970	0.000314	0.000359	0.19%	97.56%
2A2. Lime production	CO_2	5.332600	3.9932475	0.000457	0.000315	0.17%	97.73%
1A4b. Residential	CH_4	2.133144	7.5235168	0.000861	0.000313	0.17%	97.90%
1A5b. Mobile	CO_2	0.000000	4.0801761	0.000467	0.000302	0.16%	98.06%
1A2d. Pulp, paper and print	CO_2	4.820730	3.486067	0.000399	0.000294	0.16%	98.22%
2F4. Aerosols	HFCs(1)	0.000000	3.8082262	0.000436	0.000282	0.15%	98.37%
1A2c. Chemicals	CO_2	2.198996	6.731460	0.000770	0.000247	0.13%	98.50%
3A3. Swine	CH_4	11.673200	15.1446120	0.001733	0.000215	0.12%	98.61%
3B1b. Non-dairy cattle	CH_4	7.708403	9.0171933	0.001032	0.000215	0.12%	98.73%
1A2f. Non-metallic minerals	N_2O	1.276195	4.536763	0.000519	0.000190	0.10%	98.83%
3H. Urea application	CO_2	1.815000	0.2988333	0.000034	0.000186	0.10%	98.93%
3F. Field burning of agricultural residues	CH_4	1.845687	0.5099816	0.000058	0.000173	0.09%	99.02%
1A2f. Non-metallic minerals	CH_4	0.849999	3.478479	0.000398	0.000160	0.09%	99.11%
3B4a. Goats	N_2O	7.976773	10.2911255	0.001178	0.000151	0.08%	99.19%
2D1. Lubricant use	CO_2	4.127200	4.4700000	0.000512	0.000141	0.08%	99.27%
1A5a. Stationary	CO_2	10.994979	18.8459391	0.002157	0.000137	0.07%	99.34%
3A4c. Mules and Asses	CH_4	1.407280	0.3971946	0.000045	0.000132	0.07%	99.41%
1A4a. Commercial/institutional	CH_4	0.467544	2.319730	0.000265	0.000118	0.06%	99.47%
3B1a. Dairy cattle	N_2O	3.597150	7.1437681	0.000817	0.000117	0.06%	99.54%
3B4d. Poultry	CH_4	2.355332	2.2290416	0.000255	0.000105	0.06%	99.59%
2F2. Foam blowing agents	HFCs(1)	0.000000	1.3702454	0.000157	0.000101	0.05%	99.65%
1A4c. Agriculture/forestry/fishing	CO_2	55.484174	84.6548959	0.009687	0.000084	0.04%	99.69%
3B2. Sheep	CH_4	2.273600	2.4437437	0.000280	0.000079	0.04%	99.74%
1A1a. Public electricity and heat production	N_2O	3.445000	6.346672	0.000726	0.000076	0.04%	99.78%
3B1b. Non-dairy cattle	N_2O	2.324418	2.8170782	0.000322	0.000057	0.03%	99.81%
1A3d. Domestic navigation	CO_2	2.197794	2.639698	0.000302	0.000056	0.03%	99.84%
3F. Field burning of agricultural residues	N_2O	0.452670	0.1251344	0.000014	0.000043	0.02%	99.86%
2D3. Other	CO_2	0.000000	0.5112974	0.000059	0.000038	0.02%	99.88%
1A1a. Public electricity and heat production	CH_4	1.848000	3.352959	0.000384	0.000037	0.02%	99.90%
3B4c. Mules and Asses	N_2O	0.243335	0.0686733	0.000008	0.000023	0.01%	99.91%
1A3a. Domestic aviation	N_2O	0.193053	0.002616	0.000000	0.000022	0.01%	99.92%

3B4a. Goats	CH_4	1.148000	1.4810767	0.000169	0.000022	0.01%	99.94%
1A4b. Residential	N_2O	0.619852	1.1748668	0.000134	0.000016	0.01%	99.94%
5D1. Domestic wastewater	N_2O	9.519110	14.5174237	0.001661	0.000015	0.01%	99.95%
3B4c. Mules and Asses	CH_4	0.154814	0.0436914	0.000005	0.000014	0.01%	99.96%
5D2. Industrial wastewater	N_2O	0.276130	0.2431769	0.000028	0.000014	0.01%	99.97%
1A4a. Commercial/institutional	N_2O	0.123835	0.322948	0.000037	0.000010	0.01%	99.97%
3A4b. Horses	CH_4	0.231840	0.2585504	0.000030	0.000007	0.00%	99.98%
1A1c. Manufacture of solid fuels and other energy industries	N_2O	0.118720	0.096035	0.000011	0.000006	0.00%	99.98%
1A2g. Other (*please specify*)	CO_2	38.008328	58.694681	0.006717	0.000005	0.00%	99.98%
1A1c. Manufacture of solid fuels and other energy industries	CH_4	0.094080	0.076103	0.000009	0.000005	0.00%	99.99%
1A4c. Agriculture/forestry/fishing	CH_4	0.205432	0.3742769	0.000043	0.000004	0.00%	99.99%
1A2e. Food processing, beverages and tobacco	N_2O	0.136404	0.159764	0.000018	0.000004	0.00%	99.99%
2D2. Paraffin wax use	CO_2	0.063498	0.0504591	0.000006	0.000004	0.00%	99.99%
1A2g. Other (*please specify*)	N_2O	0.079785	0.148909	0.000017	0.000002	0.00%	99.99%
3B4b. Horses	N_2O	0.050016	0.0557512	0.000006	0.000002	0.00%	99.99%
2G3. N2O from product uses	N_2O	3.931545	6.0584023	0.000693	0.000002	0.00%	99.99%
1A2c. Chemicals	N_2O	0.004718	0.026023	0.000003	0.000001	0.00%	100.00%
1A5b. Mobile	CH_4	0.000000	0.0159783	0.000002	0.000001	0.00%	100.00%
3B4b. Horses	CH_4	0.030154	0.0336116	0.000004	0.000001	0.00%	100.00%
1A2c. Chemicals	CH_4	0.002493	0.016207	0.000002	0.000001	0.00%	100.00%
1A2e. Food processing, beverages and tobacco	CH_4	0.073865	0.102028	0.000012	0.000001	0.00%	100.00%
1A5b. Mobile	N_2O	0.000000	0.0090734	0.000001	0.000001	0.00%	100.00%
1A2d. Pulp, paper and print	N_2O	0.009903	0.006663	0.000001	0.000001	0.00%	100.00%
1A3a. Domestic aviation	CH_4	0.005096	0.000069	0.000000	0.000001	0.00%	100.00%
1A5a. Stationary	N_2O	0.023592	0.0440192	0.000005	0.000001	0.00%	100.00%
1A3d. Domestic navigation	N_2O	0.030653	0.040629	0.000005	0.000001	0.00%	100.00%
1A2b. Non-ferrous metals	N_2O	0.005300	0.002048	0.000000	0.000000	0.00%	100.00%
1A4c. Agriculture/forestry/fishing	N_2O	0.114381	0.1816502	0.000021	0.000000	0.00%	100.00%
1A2d. Pulp, paper and print	CH_4	0.005232	0.003572	0.000000	0.000000	0.00%	100.00%
1A2b. Non-ferrous metals	CH_4	0.003640	0.001557	0.000000	0.000000	0.00%	100.00%
1A5a. Stationary	CH_4	0.041546	0.0665566	0.000008	0.000000	0.00%	100.00%
1A2g. Other (*please specify*)	CH_4	0.042290	0.067313	0.000008	0.000000	0.00%	100.00%
1A3d. Domestic navigation	CH_4	0.003239	0.004153	0.000000	0.000000	0.00%	100.00%
1A1b. Petroleum refining	CH_4	0.000000	0	0.000000	0.000000	0.00%	100.00%
1B2a. Oil	CH_4	0.453521	0	0.000000	0.000000	0.00%	100.00%
1A1b. Petroleum refining	CO_2	85.718200	0	0.000000	0.000000	0.00%	100.00%

2G4. Other	CO_2	0.000000	0	0.000000	0.000000	0.00%	100.00%
1A1b. Petroleum refining	N_2O	0.000000	0	0.000000	0.000000	0.00%	100.00%

Table A1.6. Key categories analysis with LULUCF – Trend assessment for 2021

IPCC Source category	Direct GHG	1990 estimate	2021 estimate	Level assessment 2021	Trend assessment	% contribution to trend	Cumulative total of level assessment
1A1a. Public electricity and heat production	CO_2	1675.770000	3077.688200	0.339845	0.033152	16.96%	16.96%
2F1. Refrigeration and air conditioning	HFCs(1)	0.000000	336.6178764	0.037170	0.023865	12.21%	29.17%
1A2f. Non-metallic minerals	CO_2	379.826741	386.444814	0.042672	0.014544	7.44%	36.61%
1A3b. Road transportation	CO_2	1188.320532	2033.266639	0.224518	0.012933	6.62%	43.23%
1A4b. Residential	CO_2	299.703957	293.632603	0.032424	0.012277	6.28%	49.51%
2A1. Cement production	CO_2	667.664000	878.8070000	0.097040	0.011421	5.84%	55.35%
5A1. Managed waste disposal sites	CH_4	0.000000	159.6479744	0.017629	0.011318	5.79%	61.14%
5D1. Domestic wastewater	CH_4	102.922960	23.3001345	0.002573	0.009713	4.97%	66.11%
4A1. Forest land remaining forest land	CO_2	1.551913	103.9788211	0.011482	0.007200	3.68%	69.80%
3B3. Swine	CH_4	88.595028	42.6451727	0.004709	0.006759	3.46%	73.25%
3D. Agricultural soils(2) (3) (4)	N_2O	133.281845	119.2078690	0.013163	0.006266	3.21%	76.46%
4B1. Cropland remaining cropland	CO_2	133.968962	133.8833939	0.014784	0.005301	2.71%	79.17%
3A1a. Dairy cattle	CH_4	61.992000	160.1252241	0.017681	0.004507	2.31%	81.48%
2A4. Other process uses of carbonates	CO_2	44.076000	14.1868139	0.001567	0.003861	1.98%	83.45%
1A2e. Food processing, beverages and tobacco	CO_2	72.570573	63.965813	0.007063	0.003479	1.78%	85.23%
5A2. Unmanaged waste disposal sites	CH_4	295.365426	412.4601850	0.045545	0.003373	1.73%	86.96%
1A3a. Domestic aviation	CO_2	26.045000	0.352940	0.000039	0.002851	1.46%	88.42%
3A2. Sheep	CH_4	64.960000	69.8212480	0.007710	0.002223	1.14%	89.56%
1A4a. Commercial/institutional	CO_2	75.212242	89.809011	0.009917	0.001938	0.99%	90.55%
4A2. Land converted to forest land	CO_2	0.096432	17.2662821	0.001907	0.001213	0.62%	91.17%

4G. Harvested wood products [5]	**CO_2**	**2.136998**	**19.9235005**	**0.002200**	**0.001177**	**0.60%**	**91.77%**
4C1. Grassland remaining grassland	**CO_2**	**23.415771**	**21.7525342**	**0.002402**	**0.001043**	**0.53%**	**92.30%**
5B1. Composting	**CH_4**	**0.000000**	**13.5841440**	**0.001500**	**0.000963**	**0.49%**	**92.80%**
2G1. Electrical equipment	**SF_6**	**2.730860**	**16.2405210**	**0.001793**	**0.000850**	**0.43%**	**93.23%**
2F3. Fire protection	**HFCs[1]**	**0.000000**	**11.6912987**	**0.001291**	**0.000829**	**0.42%**	**93.66%**
5D2. Industrial wastewater	**CH_4**	**27.101200**	**31.0439323**	**0.003428**	**0.000792**	**0.41%**	**94.06%**
3A1b. Non-dairy cattle	**CH_4**	**51.503200**	**69.3780274**	**0.007661**	**0.000768**	**0.39%**	**94.45%**
1A3b. Road transportation	**CH_4**	**7.874346**	**3.248340**	**0.000359**	**0.000639**	**0.33%**	**94.78%**
3B3. Swine	N_2O	6.887049	2.7080809	0.000299	0.000568	0.29%	95.07%
3B1a. Dairy cattle	CH_4	11.645470	26.1177343	0.002884	0.000566	0.29%	95.36%
3A4a. Goats	CH_4	28.840000	37.0269177	0.004089	0.000560	0.29%	95.65%
5B1. Composting	N_2O	0.000000	7.7138532	0.000852	0.000547	0.28%	95.93%
1A3b. Road transportation	N_2O	12.121616	11.605327	0.001281	0.000516	0.26%	96.19%
3B5. Indirect N_2O emissions	N_2O	22.550517	28.0987296	0.003103	0.000498	0.25%	96.45%
3B2. Sheep	N_2O	12.176814	13.0880595	0.001445	0.000417	0.21%	96.66%
4B2. Land converted to cropland	CO_2	0.267118	6.1582448	0.000680	0.000407	0.21%	96.87%
4A1. Forest land remaining forest land	CH_4	0.032747	5.4776222	0.000605	0.000385	0.20%	97.06%
3B4d. Poultry	N_2O	6.990740	5.4877387	0.000606	0.000383	0.20%	97.26%
1A2b. Non-ferrous metals	CO_2	4.910000	2.746970	0.000303	0.000347	0.18%	97.44%
2A2. Lime production	CO_2	5.332600	3.9932475	0.000441	0.000306	0.16%	97.59%
1A4b. Residential	CH_4	2.133144	7.5235168	0.000831	0.000298	0.15%	97.75%
1A5b. Mobile	CO_2	0.000000	4.0801761	0.000451	0.000289	0.15%	97.89%
1A2d. Pulp, paper and print	CO_2	4.820730	3.486067	0.000385	0.000285	0.15%	98.04%
2F4. Aerosols	HFCs[1]	0.000000	3.8082262	0.000421	0.000270	0.14%	98.18%
1A2c. Chemicals	CO_2	2.198996	6.731460	0.000743	0.000234	0.12%	98.30%
3A3. Swine	CH_4	11.673200	15.1446120	0.001672	0.000215	0.11%	98.41%

3B1b. Non-dairy cattle	CH_4	7.708403	9.0171933	0.000996	0.000212	0.11%	98.52%
4A1. Forest land remaining forest land	N_2O	0.017145	2.8678432	0.000317	0.000201	0.10%	98.62%
4E2. Land converted to settlements	CO_2	0.461793	3.5580739	0.000393	0.000201	0.10%	98.72%
1A2f. Non-metallic minerals	N_2O	1.276195	4.536763	0.000501	0.000181	0.09%	98.82%
3H. Urea application	CO_2	1.815000	0.2988333	0.000033	0.000179	0.09%	98.91%
3F. Field burning of agricultural residues	CH_4	1.845687	0.5099816	0.000056	0.000168	0.09%	98.99%
1A2f. Non-metallic minerals	CH_4	0.849999	3.478479	0.000384	0.000153	0.08%	99.07%
3B4a. Goats	N_2O	7.976773	10.2911255	0.001136	0.000151	0.08%	99.15%
2D1. Lubricant use	CO_2	4.127200	4.4700000	0.000494	0.000139	0.07%	99.22%
3A4c. Mules and Asses	CH_4	1.407280	0.3971946	0.000044	0.000127	0.07%	99.28%
1A4c. Agriculture/forestry/fishing	CO_2	55.484174	84.6548959	0.009348	0.000125	0.06%	99.35%
1A5a. Stationary	CO_2	10.994979	18.8459391	0.002081	0.000122	0.06%	99.41%
1A4a. Commercial/institutional	CH_4	0.467544	2.319730	0.000256	0.000113	0.06%	99.47%
3B1a. Dairy cattle	N_2O	3.597150	7.1437681	0.000789	0.000109	0.06%	99.52%
4C2. Land converted to grassland	CO_2	0.361126	2.0221548	0.000223	0.000103	0.05%	99.58%
3B4d. Poultry	CH_4	2.355332	2.2290416	0.000246	0.000102	0.05%	99.63%
2F2. Foam blowing agents	HFCs[(1)]	0.000000	1.3702454	0.000151	0.000097	0.05%	99.68%
3B2. Sheep	CH_4	2.273600	2.4437437	0.000270	0.000078	0.04%	99.72%
1A1a. Public electricity and heat production	N_2O	3.445000	6.346672	0.000701	0.000070	0.04%	99.75%
3B1b. Non-dairy cattle	N_2O	2.324418	2.8170782	0.000311	0.000057	0.03%	99.78%
1A3d. Domestic navigation	CO_2	2.197794	2.639698	0.000291	0.000056	0.03%	99.81%
3F. Field burning of agricultural residues	N_2O	0.452670	0.1251344	0.000014	0.000041	0.02%	99.83%
2D3. Other	CO_2	0.000000	0.5112974	0.000056	0.000036	0.02%	99.85%
1A2g. Other (*please specify*)	CO_2	38.008328	58.694681	0.006481	0.000036	0.02%	99.87%
4D2. Land converted to wetlands	CO_2	0.000000	0.4961218	0.000055	0.000035	0.02%	99.89%
1A1a. Public electricity and heat production	CH_4	1.848000	3.352959	0.000370	0.000034	0.02%	99.91%

3B4c. Mules and Asses	N_2O	0.243335	0.0686733	0.000008	0.000022	0.01%	99.92%
5D1. Domestic wastewater	N_2O	9.519110	14.5174237	0.001603	0.000022	0.01%	99.93%
3B4a. Goats	CH_4	1.148000	1.4810767	0.000164	0.000022	0.01%	99.94%
1A3a. Domestic aviation	N_2O	0.193053	0.002616	0.000000	0.000021	0.01%	99.95%
1A4b. Residential	N_2O	0.619852	1.1748668	0.000130	0.000015	0.01%	99.96%
3B4c. Mules and Asses	CH_4	0.154814	0.0436914	0.000005	0.000014	0.01%	99.96%
5D2. Industrial wastewater	N_2O	0.276130	0.2431769	0.000027	0.000013	0.01%	99.97%
1A4a. Commercial/institutional	N_2O	0.123835	0.322948	0.000036	0.000009	0.00%	99.98%
3A4b. Horses	CH_4	0.231840	0.2585504	0.000029	0.000007	0.00%	99.98%
1A1c. Manufacture of solid fuels and other energy industries	N_2O	0.118720	0.096035	0.000011	0.000006	0.00%	99.98%
1A1c. Manufacture of solid fuels and other energy industries	CH_4	0.094080	0.076103	0.000008	0.000005	0.00%	99.99%
2G3. N2O from product uses	N_2O	3.931545	6.0584023	0.000669	0.000005	0.00%	99.99%
1A4c. Agriculture/forestry/fishing	CH_4	0.205432	0.3742769	0.000041	0.000004	0.00%	99.99%
1A2e. Food processing, beverages and tobacco	N_2O	0.136404	0.159764	0.000018	0.000004	0.00%	99.99%
2D2. Paraffin wax use	CO_2	0.063498	0.0504591	0.000006	0.000003	0.00%	99.99%
1A2g. Other (*please specify*)	N_2O	0.079785	0.148909	0.000016	0.000002	0.00%	99.99%
3B4b. Horses	N_2O	0.050016	0.0557512	0.000006	0.000002	0.00%	100.00%
1A2c. Chemicals	N_2O	0.004718	0.026023	0.000003	0.000001	0.00%	100.00%
1A5b. Mobile	CH_4	0.000000	0.0159783	0.000002	0.000001	0.00%	100.00%
3B4b. Horses	CH_4	0.030154	0.0336116	0.000004	0.000001	0.00%	100.00%
1A2e. Food processing, beverages and tobacco	CH_4	0.073865	0.102028	0.000011	0.000001	0.00%	100.00%
1A2c. Chemicals	CH_4	0.002493	0.016207	0.000002	0.000001	0.00%	100.00%
1A5b. Mobile	N_2O	0.000000	0.0090734	0.000001	0.000001	0.00%	100.00%
1A2d. Pulp, paper and print	N_2O	0.009903	0.006663	0.000001	0.000001	0.00%	100.00%
1A3a. Domestic aviation	CH_4	0.005096	0.000069	0.000000	0.000001	0.00%	100.00%
1A5a. Stationary	N_2O	0.023592	0.0440192	0.000005	0.000001	0.00%	100.00%

1A3d. Domestic navigation	N_2O	0.030653	0.040629	0.000004	0.000001	0.00%	100.00%
1A2b. Non-ferrous metals	N_2O	0.005300	0.002048	0.000000	0.000000	0.00%	100.00%
1A2d. Pulp, paper and print	CH_4	0.005232	0.003572	0.000000	0.000000	0.00%	100.00%
1A2b. Non-ferrous metals	CH_4	0.003640	0.001557	0.000000	0.000000	0.00%	100.00%
1A4c. Agriculture/forestry/fishing	N_2O	0.114381	0.1816502	0.000020	0.000000	0.00%	100.00%
1A5a. Stationary	CH_4	0.041546	0.0665566	0.000007	0.000000	0.00%	100.00%
1A2g. Other (*please specify*)	CH_4	0.042290	0.067313	0.000007	0.000000	0.00%	100.00%
1A3d. Domestic navigation	CH_4	0.003239	0.004153	0.000000	0.000000	0.00%	100.00%
1A1b. Petroleum refining	CH_4	0.000000	0	0.000000	0.000000	0.00%	100.00%
1B2a. Oil	CH_4	0.453521	0	0.000000	0.000000	0.00%	100.00%
1A1b. Petroleum refining	CO_2	85.718200	0	0.000000	0.000000	0.00%	100.00%
2G4. Other	CO_2	0.000000	0.0000000	0.000000	0.000000	0.00%	100.00%
4F2. Land converted to other land	CO_2	0.107723	0.0000000	0.000000	0.000000	0.00%	100.00%
1A1b. Petroleum refining	N_2O	0.000000	0	0.000000	0.000000	0.00%	100.00%

Annex 2: Assessment of uncertainty

A2.1: Description of methodology used for identifying uncertainties

Uncertainty analysis constitutes a key activity in the annual inventory cycle. The realisation of such an analysis is foreseen in the reporting guidelines under the Convention and represents a specific function to be performed by a National System (Decision 24/CP.19).

Uncertainty information is not intended to dispute the validity of the inventory estimates, but to help prioritize efforts to improve the accuracy of inventories and guide decisions on methodological choice. This will be achieved with the correct application of the analytic calculating methods at least for the key categories.

There are two methods for the uncertainty estimation suggested by the 2006 IPCC Guidelines; a basic method (Tier 1) which is mandatory and an analytic one (Tier 2).

The Tier 2 methodology is based on Monte Carlo analysis. The principle of Monte Carlo analysis is to select random values of emission factor and activity data from within their individual probability density functions, and to calculate the corresponding emission values. This procedure is repeated many times, and the results of each calculation run build up the overall emission probability density function. Monte Carlo analysis can be performed at the source category level, for aggregations of source categories or for the inventory as a whole. This analysis is suitable for a composite system such as the calculation of GHG emissions in national level. but its application requires significant resources and time.

The application of the Tier 1 methodology for uncertainty analysis is based on the following equations.

A. Uncertainty of total emissions

$$u_{i,g} = \sqrt{u_{AD,i}^2 + u_{EF,i,g}^2}$$

$$U_{i,g} = \frac{u_{i,g} \cdot E_{i,g}}{\sum_{i,g} E_{i,g}}$$

$$U_{tot} = \sqrt{\sum_{i,g} U_{i,g}^2}$$

where. i is the index referring to emission sources, g is the index referring to GHG, ui.g is the combined uncertainty for emissions of g-gas and i-source, uAD.i is the uncertainty of activity data of the i-source, uEF.i.g is the uncertainty of the emission factor of g-gas and i-source, Ui.g is the uncertainty of the calculated emissions of g-gas and i-source, Ei.g are the emissions of g-gas and i-source and Utot is the uncertainty of total emissions. Uncertainty estimations on activity data (uAD.i) and on the emission factors (uEF.i.g) are based on IPCC defaults using expert judgement and reasoning details and detailed explanation regarding their choice for each sector is presented in reasoning details and detailed explanation regarding their choice for each sector is presented in Table A2.1.

B. Uncertainty in trend in emissions

$$A_{i,g} = \frac{0{,}01 \cdot E_{i,g,t} + \sum_{i,g} E_{i,g,t} - \left(0{,}01 \cdot E_{i,g,0} + \sum_{i,g} E_{i,g,0}\right)}{0{,}01 \cdot E_{i,g,0} + \sum_{i,g} E_{i,g,0}} \cdot 100 - \frac{\sum_{i,g} E_{i,g,t} - \sum_{i,g} E_{i,g,0}}{\sum_{i,g} E_{i,g,0}} \cdot 100$$

$$B_{i,g} = \frac{E_{i,g,t}}{\sum_{i,g} E_{i,g,0}}$$

$$TREF_{i,g} = A_{i,g} \cdot u_{EF,i,g}$$

$$TRAD_i = B_{i,g} \cdot u_{AD,i} \cdot \sqrt{2}$$

$$U_{TR} = \sqrt{\sum_{i,g} TREF_{i,g}^2 + TRAD_{i,g}^2}$$

where, t is the index referring to the inventory year, 0 is the index referring to the base year, Ai,g is the difference (%) of emissions of g-gas and i-source in response to a 1% increase of emissions in the base year and inventory year, Ei,g,t emissions of g-gas and i-source in the inventory year, Ei,g, 0 emissions of g-gas and i-source in the base year, Bi,g the difference (%) of emissions of g-gas and i-source in response to a 1% increase of emissions in the inventory year, TREFi,g the contribution of EF uncertainty of g-gas and i-source to the uncertainty in the trend of emissions, TRADi the contribution of AD uncertainty i-source to the uncertainty in the trend of emissions and UTR is the uncertainty in the trend of emissions.

The uncertainty analysis for the Cyprus' GHG inventory is based on Tier 1 methodology with 1990 as base year for CO_2, CH4, N2O and 1995 for F-gases emissions.

Moreover:

- For the estimation of uncertainties per gas, a combination of the information provided by the IPCC and critical evaluation of information from indigenous sources was applied.
- 100% of emissions are used for the uncertainty analysis.
- The uncertainty analysis was carried out both without and with the LULUCF sector.

In Tables A2.2 and A2.3, the analytical calculations of the emissions estimates uncertainty are presented, without the sector of LULUCF for 1990 and 2021.

Table A2.1.Reasoning for activity data and emission factor uncertainty value

IPCC Source category	Reasoning for activity data uncertainty	Reasoning for emission factor uncertainty
Stationary Combustion	5% corresponds to the IPCC default uncertainty range for AD obtained from national energy balances. After 2005 that AD are cross-checked with PS AD from verified EUETS reports (source specific QA/QC), the uncertainty of AD is reduced to 3%.	• CO_2: According to IPCC guidelines the use of default carbon content per fuel corresponds to 95% confidence intervals and the % uncertainty is estimated < 5%. 1990–2004 5%; PS data from verified EU-ETS reports are used for the calculation of EFs for the majority of fuels after 2005. We estimate the EF uncertainty to be 3%. • CH_4: In IPCC guidelines is mentioned that the default uncertainty for stationary combustion EF is 50-150%. We select the mean 100%. • N_2O: Although in IPCC GPG is mentioned that EF from Table 2.16 may be expected to limit uncertainties to within an order of magnitude. In order to be conservative we select 300% as uncertainty.

IPCC Source category	**Reasoning for activity data uncertainty**	**Reasoning for emission factor uncertainty**
Road transport	5% corresponds to the IPCC default uncertainty range for AD obtained from national energy balances.	IPCC defaults are used: 5% for CO_2; 40% for CH_4 and 50% for N_2O
Navigation	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC defaults are used: 5% for CO_2; 100% for CH_4 and 300% for N_2O
Civil Aviation	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC defaults are used: 5% for CO_2; 100% for CH_4 and 300% for N_2O
Not specified - Mobile	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC defaults are used: 5% for CO_2; 100% for CH_4 and 300% for N_2O
Oil and Natural gas	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	In IPCC guidelines is mentioned that the EF used may be expected to limit uncertainties to within an order of magnitude. However, in order to be conservative the value 300% is selected for all gases
Cement Production	Plant level production data (2%).	Plant level production data (2%)
Lime Production	Plant level production data (2%).	In IPCC guidelines is mentioned that the EF used may be expected to range between 1-5%. In order to be conservative the value 5% is selected.
Other process uses of carbonates	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	In IPCC guidelines is mentioned that the EF used may be expected to range between 1-5%. In order to be conservative the value 5% is selected.
Non-Energy Products from Fuels and Solvent Use	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	In IPCC guidelines is mentioned that the EF used may be expected to range between 1-5%. In order to be conservative the value 5% is selected.
Refrigeration and Air Conditioning Equipment	Activity data obtained from national statistics (population, inventory of fluorinated and ozone depleting containing equipment): 5%	Expert judgement; 500%
Foam Blowing	Activity data obtained from national statistics (population): 5%	Expert judgement; 500%
Fire Extinguishers	Activity data obtained from national statistics (population): 5%	Expert judgement; 500%
Aerosols/MDIs	Activity data obtained from national statistics (population): 5%	Expert judgement; 500%
SF_6 from electrical equipment	Activity data obtained from national statistics (population): 5%	Expert judgement; 500%
N_2O from product uses	Uncertainty given by Statistical Service for the population data: 5%	Expert judgement; 500%
Enteric fermentation	Uncertainty given by Statistical Service for the livestock population data: 5%	30-50% proposed by 2006 IPCC guidelines; However, in order to be conservative the value 50% is selected.
Manure management	Uncertainty given by Statistical Service for the livestock population data: 5%	Conservative IPCC values: 30% for CH_4 and 100% for N_2O
Indirect N_2O	Uncertainty given by Statistical	Conservative IPCC values: 50% for N_2O

IPCC Source category	Reasoning for activity data uncertainty	Reasoning for emission factor uncertainty
emissions	Service for the livestock population data: 20%	
Agricultural soils – direct emissions	Uncertainty given by Statistical Service for the livestock population data: 20%	In IPCC guidelines is mentioned that the EF used may be expected to range between 3-30%. In order to be conservative the value 30% is selected.
Agricultural soils – indirect emissions	Uncertainty given by Statistical Service for the livestock population data: 20%	50% (According to Good Practice Guidance. Page 4.75)
Field burning of agricultural Residues	Uncertainty given by Statistical Service for the livestock population data: 20%	20% (According to Good Practice Guidance. Page 4.82. Table 4.20)
Urea application	Uncertainty given by Statistical Service for the livestock population data: 20%	50% (According to Good Practice Guidance)
Solid waste disposal	IPCC proposes 10-30%. 30% chosen as Cyprus is a country collecting data on regular basis	Estimated based on information from 2006 IPCC guidelines (vol. 5, pg. 3.27, table 3.5) using highest values to be conservative: 30%
Composting	IPCC proposes 10-30%. 30% chosen as Cyprus is a country collecting data on regular basis	Estimated based on information from 2006 IPCC guidelines using highest values to be conservative: 100%
Wastewater handling	Domestic: 30% Industrial: 100%	Estimated 30% based on information in 2006 IPCC guidelines

Table A2.2.Analytical calculations of uncertainty, with LULUCF 1990

IPCC category	Gas	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor/estimation parameter uncertainty	Combined uncertainty	Contribution to Variance by Category in Year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data Note A	Input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\left\|\frac{D}{\sum C}\right\|$	$I*F$ Note C	$J*E*\sqrt{2}$ Note D	K^2+L^2
		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
1A1a. Public electricity and heat production	CH4	1.85	1.85	3%	100%	1.0004	0.0000		0.0002	0.0000	0.0000	5.084E-11
1A1b. Petroleum refining	CH4	0.00	0.00	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	0
1A1c. Manufacture of solid fuels and other energy industries	CH4	0.09	0.09	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	3.6601E-13
1A2b. Non-ferrous metals	CH4	0.00	0.00	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	5.479E-16
1A2c. Chemicals	CH4	0.00	0.00	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	2.5696E-16
1A2d. Pulp, paper and print	CH4	0.01	0.01	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.1319E-15
1A2e. Food processing, beverages and tobacco	CH4	0.07	0.07	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	2.2562E-13
1A2f. Non-metallic minerals	CH4	0.85	0.85	3%	100%	1.0004	0.0000		0.0001	0.0000	0.0000	1.0756E-11
1A2g. Other	CH4	0.04	0.04	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	7.3957E-14
1A3a. Domestic aviation	CH4	0.01	0.01	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.0739E-15
1A3b. Road transportation	CH4	7.87	7.87	5%	40%	0.4031	0.0000		0.0007	0.0000	0.0001	2.5641E-09
1A3d. Domestic navigation	CH4	0.00	0.00	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	4.3379E-16
1A4a. Commercial/institutional	CH4	0.47	0.47	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	9.0395E-12

1A4b. Residential	CH4	2.13	2.13	5%	100%	1.0012	0.0000		0.0002	0.0000	0.0000	1.8816E-10
1A4c. Agriculture/forestry/fishing	CH4	0.21	0.21	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.7452E-12
1A5a. Stationary	CH4	0.04	0.04	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	7.1378E-14
1A5b. Mobile	CH4	0.00	0.00	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	0
1B2a. Oil	CH4	0.45	0.45	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	8.5054E-12
3A1a. Dairy cattle	CH4	61.99	61.99	5%	50%	0.5025	0.0000		0.0056	0.0000	0.0004	1.5892E-07
3A1b. Non-dairy cattle	CH4	51.50	51.50	5%	50%	0.5025	0.0000		0.0047	0.0000	0.0003	1.0969E-07
3A2. Sheep	CH4	64.96	64.96	5%	50%	0.5025	0.0000		0.0059	0.0000	0.0004	1.745E-07
3A3. Swine	CH4	11.67	11.67	5%	50%	0.5025	0.0000		0.0011	0.0000	0.0001	5.6348E-09
3A4a. Goats	CH4	28.84	28.84	5%	50%	0.5025	0.0000		0.0026	0.0000	0.0002	3.4394E-08
3A4b. Horses	CH4	0.23	0.23	5%	50%	0.5025	0.0000		0.0000	0.0000	0.0000	2.2227E-12
3A4c. Mules and Asses	CH4	1.41	1.41	5%	50%	0.5025	0.0000		0.0001	0.0000	0.0000	8.1895E-11
3B1a. Dairy cattle	CH4	11.65	11.65	5%	30%	0.3041	0.0000		0.0011	0.0000	0.0001	5.6081E-09
3B1b. Non-dairy cattle	CH4	7.71	7.71	5%	30%	0.3041	0.0000		0.0007	0.0000	0.0000	2.4571E-09
3B2. Sheep	CH4	2.27	2.27	5%	30%	0.3041	0.0000		0.0002	0.0000	0.0000	2.1376E-10
3B3. Swine	CH4	88.60	88.60	5%	30%	0.3041	0.0000		0.0081	0.0000	0.0006	3.2458E-07
3B4a. Goats	CH4	1.15	1.15	5%	30%	0.3041	0.0000		0.0001	0.0000	0.0000	5.4498E-11
3B4b. Horses	CH4	0.03	0.03	5%	30%	0.3041	0.0000		0.0000	0.0000	0.0000	3.7599E-14
3B4c. Mules and Asses	CH4	0.15	0.15	5%	30%	0.3041	0.0000		0.0000	0.0000	0.0000	9.9111E-13
3B4d. Poultry	CH4	2.36	2.36	5%	30%	0.3041	0.0000		0.0002	0.0000	0.0000	2.294E-10
3F. Field burning of agricultural residues	CH4	1.85	1.85	20%	20%	0.2828	0.0000		0.0002	0.0000	0.0000	2.2539E-09
4.A.1 Forest Land remaining Forest Land	CH4	0.03	0.03	10%	230%	2.3022	0.0000		0.0000	0.0000	0.0000	1.7738E-13
5A1. Managed waste disposal sites	CH4	0.00	0.00	30%	30%	0.4243	0.0000		0.0000	0.0000	0.0000	0
5A2. Unmanaged waste disposal sites	CH4	295.37	295.37	30%	30%	0.4243	0.0001		0.0269	0.0000	0.0114	0.00012987
5B1. Composting	CH4	0.00	0.00	30%	100%	1.0440	0.0000		0.0000	0.0000	0.0000	0
5D1. Domestic wastewater	CH4	102.92	102.92	30%	30%	0.4243	0.0000		0.0094	0.0000	0.0040	1.577E-05
5D2. Industrial wastewater	CH4	27.10	27.10	30%	30%	0.4243	0.0000		0.0025	0.0000	0.0010	1.0934E-06
1A1a. Public electricity and heat production	CO2	1675.77	1675.77	3%	3%	0.0424	0.0000		0.1524	0.0000	0.0065	4.1805E-05

1A1b. Petroleum refining	CO2	85.72	85.72	5%	5%	0.0707	0.0000		0.0163	0.0000	0.0012	1.3249E-06
1A2b. Non-ferrous metals	CO2	4.91	4.91	5%	5%	0.0707	0.0000		0.0004	0.0000	0.0000	9.9692E-10
1A2c. Chemicals	CO2	2.20	2.20	5%	5%	0.0707	0.0000		0.0002	0.0000	0.0000	1.9996E-10
1A2d. Pulp, paper and print	CO2	4.82	4.82	5%	5%	0.0707	0.0000		0.0004	0.0000	0.0000	9.61E-10
1A2e. Food processing, beverages and tobacco	CO2	72.57	72.57	5%	5%	0.0707	0.0000		0.0066	0.0000	0.0005	2.1778E-07
1A2f. Non-metallic minerals	CO2	379.83	379.83	3%	3%	0.0424	0.0000		0.0345	0.0000	0.0015	2.1477E-06
1A2g. Other	CO2	38.01	38.01	5%	5%	0.0707	0.0000		0.0035	0.0000	0.0002	5.9739E-08
1A3a. Domestic aviation	CO2	26.05	26.05	5%	5%	0.0707	0.0000		0.0024	0.0000	0.0002	2.8051E-08
1A3b. Road transportation	CO2	1188.32	1188.32	5%	5%	0.0707	0.0001		0.1081	0.0000	0.0076	5.8394E-05
1A3d. Domestic navigation	CO2	2.20	2.20	5%	5%	0.0707	0.0000		0.0002	0.0000	0.0000	1.9974E-10
1A4a. Commercial/institutional	CO2	75.21	75.21	5%	5%	0.0707	0.0000		0.0068	0.0000	0.0005	2.3392E-07
1A4b. Residential	CO2	299.70	299.70	5%	5%	0.0707	0.0000		0.0273	0.0000	0.0019	3.7144E-06
1A4c. Agriculture/forestry/fishing	CO2	55.48	55.48	5%	5%	0.0707	0.0000		0.0050	0.0000	0.0004	1.273E-07
1A5a. Stationary	CO2	10.99	10.99	5%	5%	0.0707	0.0000		0.0010	0.0000	0.0001	4.999E-09
1A5b. Mobile	CO2	0.00	0.00	5%	5%	0.0707	0.0000		0.0000	0.0000	0.0000	0
2A1. Cement production	CO2	667.66	667.66	2%	2%	0.0283	0.0000		0.0607	0.0000	0.0017	2.9494E-06
2A2. Lime production	CO2	5.33	5.33	2%	5%	0.0539	0.0000		0.0005	0.0000	0.0000	1.8815E-10
2A4. Other process uses of carbonates	CO2	44.08	44.08	5%	5%	0.0707	0.0000		0.0040	0.0000	0.0003	8.0335E-08
2D1. Lubricant use	CO2	4.13	4.13	5%	5%	0.0707	0.0000		0.0004	0.0000	0.0000	7.0438E-10
2D2. Paraffin wax use	CO2	0.06	0.06	5%	5%	0.0707	0.0000		0.0000	0.0000	0.0000	1.6673E-13
2D3. Other	CO2	0.00	0.00	5%	5%	0.0707	0.0000		0.0000	0.0000	0.0000	0
3H. Urea application	CO2	1.82	1.82	20%	50%	0.5385	0.0000		0.0002	0.0000	0.0000	2.1796E-09
4.A.1 Forest Land remaining Forest Land	CO2	1.55	1.55	15%	60%	0.6185	0.0000		0.0001	0.0000	0.0000	8.9634E-10
4.A.2 Land converted to Forest Land	CO2	-0.10	-0.10	15%	40%	0.4272	0.0000		0.0000	0.0000	0.0000	3.4608E-12
4.B.1 Cropland remaining Cropland	CO2	-133.97	-133.97	15%	65%	0.6671	0.0001		0.0122	0.0000	0.0026	6.6796E-06
4.B.2 Land converted to Cropland	CO2	-0.27	-0.27	15%	95%	0.9618	0.0000		0.0000	0.0000	0.0000	2.6555E-11
4.C.1 Grassland remaining Grassland	CO2	-23.42	-23.42	15%	35%	0.3808	0.0000		0.0021	0.0000	0.0005	2.0406E-07

4.C.2 Land converted to Grassland	CO2	0.36	0.36	15%	50%	0.5220	0.0000		0.0000	0.0000	0.0000	4.8535E-11
4.D.2 Land converted to Wetlands	CO2	0.00	0.00	15%	50%	0.5220	0.0000		0.0000	0.0000	0.0000	0
4.E.2 Land converted to Settlements	CO2	0.46	0.46	15%	350%	3.5032	0.0000		0.0000	0.0000	0.0000	7.9366E-11
4.F.2 Land converted to Other Land	CO2	0.11	0.11	15%	30%	0.3354	0.0000		0.0000	0.0000	0.0000	4.3188E-12
4.G Harvested Wood Products	CO2	2.14	2.14	15%	50%	0.5220	0.0000		0.0002	0.0000	0.0000	1.6996E-09
2F1. Refrigeration and air conditioning	HFCs(1)	0.00	0.00	5%	500%	5.0002	0.0000		0.0000	0.0000	0.0000	0
2F2. Foam blowing agents	HFCs(1)	0.00	0.00	5%	500%	5.0002	0.0000		0.0000	0.0000	0.0000	0
2F3. Fire protection	HFCs(1)	0.00	0.00	5%	500%	5.0002	0.0000		0.0000	0.0000	0.0000	0
2F4. Aerosols	HFCs(1)	0.00	0.00	5%	500%	5.0002	0.0000		0.0000	0.0000	0.0000	0
1A1a. Public electricity and heat production	N2O	3.45	3.45	3%	300%	3.0001	0.0000		0.0003	0.0000	0.0000	1.7668E-10
1A1b. Petroleum refining	N2O	0.00	0.00	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	0
1A1c. Manufacture of solid fuels and other energy industries	N2O	0.12	0.12	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	5.8284E-13
1A2b. Non-ferrous metals	N2O	0.01	0.01	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	1.1616E-15
1A2c. Chemicals	N2O	0.00	0.00	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	9.2067E-16
1A2d. Pulp, paper and print	N2O	0.01	0.01	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	4.0554E-15
1A2e. Food processing, beverages and tobacco	N2O	0.14	0.14	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	7.694E-13
1A2f. Non-metallic minerals	N2O	1.28	1.28	3%	300%	3.0001	0.0000		0.0001	0.0000	0.0000	2.4246E-11
1A2g. Other	N2O	0.08	0.08	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	2.6323E-13
1A3a. Domestic aviation	N2O	0.19	0.19	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	1.5412E-12
1A3b. Road transportation	N2O	12.12	12.12	5%	50%	0.5025	0.0000		0.0011	0.0000	0.0001	6.076E-09
1A3d. Domestic navigation	N2O	0.03	0.03	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	3.8856E-14
1A4a. Commercial/institutional	N2O	0.12	0.12	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	6.3414E-13
1A4b. Residential	N2O	0.62	0.62	5%	300%	3.0004	0.0000		0.0001	0.0000	0.0000	1.5888E-11
1A4c. Agriculture/forestry/fishing	N2O	0.11	0.11	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	5.4101E-13
1A5a. Stationary	N2O	0.02	0.02	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	2.3017E-14
1A5b. Mobile	N2O	0.00	0.00	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	0

2G3. N2O from product uses	N2O	3.93	3.93	5%	500%	5.0002	0.0000		0.0004	0.0000	0.0000	6.3918E-10
3B1a. Dairy cattle	N2O	3.60	3.60	5%	100%	1.0012	0.0000		0.0003	0.0000	0.0000	5.3508E-10
3B1b. Non-dairy cattle	N2O	2.32	2.32	5%	100%	1.0012	0.0000		0.0002	0.0000	0.0000	2.2342E-10
3B2. Sheep	N2O	12.18	12.18	5%	100%	1.0012	0.0000		0.0011	0.0000	0.0001	6.1315E-09
3B3. Swine	N2O	6.89	6.89	5%	100%	1.0012	0.0000		0.0006	0.0000	0.0000	1.9614E-09
3B4a. Goats	N2O	7.98	7.98	5%	100%	1.0012	0.0000		0.0007	0.0000	0.0001	2.6312E-09
3B4b. Horses	N2O	0.05	0.05	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.0345E-13
3B4c. Mules and Asses	N2O	0.24	0.24	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	2.4485E-12
3B4d. Poultry	N2O	6.99	6.99	5%	100%	1.0012	0.0000		0.0006	0.0000	0.0000	2.0209E-09
3B5. Indirect N2O emissions	N2O	22.55	22.55	20%	50%	0.5385	0.0000		0.0021	0.0000	0.0006	3.3646E-07
3D. Agricultural soils	N2O	133.28	133.28	5%	3%	0.0583	0.0000		0.0121	0.0000	0.0009	7.3458E-07
3F. Field burning of agricultural residues	N2O	0.45	0.45	20%	20%	0.2828	0.0000		0.0000	0.0000	0.0000	1.3558E-10
4.A.1 Forest Land remaining Forest Land	N2O	0.02	0.02	10%	220%	2.2023	0.0000		0.0000	0.0000	0.0000	4.8622E-14
4.B.2 Land converted to Cropland	N2O	0.01	0.01	15%	175%	1.7564	0.0000		0.0000	0.0000	0.0000	1.1222E-14
4.E.2 Land converted to Settlements	N2O	0.00	0.00	15%	380%	3.8030	0.0000		0.0000	0.0000	0.0000	6.1508E-16
4.F.2 Land converted to Other Land	N2O	0.00	0.00	15%	80%	0.8139	0.0000		0.0000	0.0000	0.0000	2.8313E-15
5B1. Composting	N2O	0.00	0.00	30%	100%	1.0440	0.0000		0.0000	0.0000	0.0000	0
5D1. Domestic wastewater	N2O	9.52	9.52	30%	30%	0.4243	0.0000		0.0009	0.0000	0.0004	1.3489E-07
5D2. Industrial wastewater	N2O	0.28	0.28	100%	30%	1.0440	0.0000		0.0000	0.0000	0.0000	1.2612E-09
2G1. Electrical equipment	SF6	2.73	2.73	5%	500%	5.0002	0.0000		0.0002	0.0000	0.0000	3.0839E-10
Total		5498.94	5498.94				0.00036595					0.00026676
		ΣC	ΣD		Percentage uncertainty in total inventory:		0.01912981				Trend uncertainty:	0.01633294

Table A2.3.Analytical calculations of uncertainty, with LULUCF 2021

IPCC category	Gas	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor/estimation parameter uncertainty	Combined uncertainty	Contribution to Variance by Category in Year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data Note A	Input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	$I*F$ Note C	$J*E*\sqrt{2}$ Note D	K^2+L^2
		Gg CO_2 equivalent	Gg CO_2 equivalent	%	%	%		%	%	%	%	%
1A1a. Public electricity and heat production	CH4	1.85	3.35	3%	100%	1.0004	0.0000		0.0003	0.0000	0.0000	1.6736E-10
1A1b. Petroleum refining	CH4	0.00	0.00	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	0
1A1c. Manufacture of solid fuels and other energy industries	CH4	0.09	0.08	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	2.395E-13
1A2b. Non-ferrous metals	CH4	0.00	0.00	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.0026E-16
1A2c. Chemicals	CH4	0.00	0.02	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.0861E-14
1A2d. Pulp, paper and print	CH4	0.01	0.00	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	5.2767E-16
1A2e. Food processing, beverages and tobacco	CH4	0.07	0.10	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	4.3046E-13
1A2f. Non-metallic minerals	CH4	0.85	3.48	3%	100%	1.0004	0.0000		0.0003	0.0000	0.0000	1.8013E-10
1A2g. Other	CH4	0.04	0.07	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.8737E-13
1A3a. Domestic aviation	CH4	0.01	0.00	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.9749E-19
1A3b. Road transportation	CH4	7.87	3.25	5%	40%	0.4031	0.0000		0.0003	0.0000	0.0000	4.3634E-10
1A3d. Domestic navigation	CH4	0.00	0.00	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	7.1328E-16
1A4a. Commercial/institutional	CH4	0.47	2.32	5%	100%	1.0012	0.0000		0.0002	0.0000	0.0000	2.2252E-10

1A4b. Residential	CH4	2.13	7.52	5%	100%	1.0012	0.0000		0.0007	0.0000	0.0000	2.3407E-09
1A4c. Agriculture/forestry/fishing	CH4	0.21	0.37	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	5.7927E-12
1A5a. Stationary	CH4	0.04	0.07	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.8318E-13
1A5b. Mobile	CH4	0.00	0.02	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.0557E-14
1B2a. Oil	CH4	0.45	0.00	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	0
3A1a. Dairy cattle	CH4	61.99	160.13	5%	50%	0.5025	0.0000		0.0146	0.0000	0.0010	1.0603E-06
3A1b. Non-dairy cattle	CH4	51.50	69.38	5%	50%	0.5025	0.0000		0.0063	0.0000	0.0004	1.9904E-07
3A2. Sheep	CH4	64.96	69.82	5%	50%	0.5025	0.0000		0.0063	0.0000	0.0004	2.0159E-07
3A3. Swine	CH4	11.67	15.14	5%	50%	0.5025	0.0000		0.0014	0.0000	0.0001	9.4845E-09
3A4a. Goats	CH4	28.84	37.03	5%	50%	0.5025	0.0000		0.0034	0.0000	0.0002	5.6693E-08
3A4b. Horses	CH4	0.23	0.26	5%	50%	0.5025	0.0000		0.0000	0.0000	0.0000	2.7643E-12
3A4c. Mules and Asses	CH4	1.41	0.40	5%	50%	0.5025	0.0000		0.0000	0.0000	0.0000	6.5239E-12
3B1a. Dairy cattle	CH4	11.65	26.12	5%	30%	0.3041	0.0000		0.0024	0.0000	0.0002	2.8208E-08
3B1b. Non-dairy cattle	CH4	7.71	9.02	5%	30%	0.3041	0.0000		0.0008	0.0000	0.0001	3.3623E-09
3B2. Sheep	CH4	2.27	2.44	5%	30%	0.3041	0.0000		0.0002	0.0000	0.0000	2.4695E-10
3B3. Swine	CH4	88.60	42.65	5%	30%	0.3041	0.0000		0.0039	0.0000	0.0003	7.5203E-08
3B4a. Goats	CH4	1.15	1.48	5%	30%	0.3041	0.0000		0.0001	0.0000	0.0000	9.071E-11
3B4b. Horses	CH4	0.03	0.03	5%	30%	0.3041	0.0000		0.0000	0.0000	0.0000	4.6717E-14
3B4c. Mules and Asses	CH4	0.15	0.04	5%	30%	0.3041	0.0000		0.0000	0.0000	0.0000	7.8939E-14
3B4d. Poultry	CH4	2.36	2.23	5%	30%	0.3041	0.0000		0.0002	0.0000	0.0000	2.0546E-10
3F. Field burning of agricultural residues	CH4	1.85	0.51	20%	20%	0.2828	0.0000		0.0000	0.0000	0.0000	1.7208E-10
4.A.1 Forest Land remaining Forest Land	CH4	0.03	5.48	10%	230%	2.3022	0.0000		0.0005	0.0000	0.0001	4.963E-09
5A1. Managed waste disposal sites	CH4	0.00	159.65	30%	30%	0.4243	0.0000		0.0145	0.0000	0.0062	3.7943E-05
5A2. Unmanaged waste disposal sites	CH4	295.37	412.46	30%	30%	0.4243	0.0001		0.0375	0.0000	0.0159	0.00025326
5B1. Composting	CH4	0.00	13.58	30%	100%	1.0440	0.0000		0.0012	0.0000	0.0005	2.747E-07
5D1. Domestic wastewater	CH4	102.92	23.30	30%	30%	0.4243	0.0000		0.0021	0.0000	0.0009	8.082E-07
5D2. Industrial wastewater	CH4	27.10	31.04	30%	30%	0.4243	0.0000		0.0028	0.0000	0.0012	1.4347E-06
1A1a. Public electricity and heat production	CO2	1675.77	3077.69	3%	3%	0.0424	0.0001		0.2799	0.0000	0.0119	0.00014101

1A1b. Petroleum refining	CO2	85.72	0.00	5%	5%	0.0707	0.0000		0.0000	0.0000	0.0000	0
1A2b. Non-ferrous metals	CO2	4.91	2.75	5%	5%	0.0707	0.0000		0.0002	0.0000	0.0000	3.1204E-10
1A2c. Chemicals	CO2	2.20	6.73	5%	5%	0.0707	0.0000		0.0006	0.0000	0.0000	1.8738E-09
1A2d. Pulp, paper and print	CO2	4.82	3.49	5%	5%	0.0707	0.0000		0.0003	0.0000	0.0000	5.0254E-10
1A2e. Food processing, beverages and tobacco	CO2	72.57	63.97	5%	5%	0.0707	0.0000		0.0058	0.0000	0.0004	1.692E-07
1A2f. Non-metallic minerals	CO2	379.83	386.44	3%	3%	0.0424	0.0000		0.0351	0.0000	0.0015	2.2232E-06
1A2g. Other	CO2	38.01	58.69	5%	5%	0.0707	0.0000		0.0053	0.0000	0.0004	1.4246E-07
1A3a. Domestic aviation	CO2	26.05	0.35	5%	5%	0.0707	0.0000		0.0000	0.0000	0.0000	5.1511E-12
1A3b. Road transportation	CO2	1188.32	2033.27	5%	5%	0.0707	0.0001		0.1849	0.0000	0.0131	0.00017096
1A3d. Domestic navigation	CO2	2.20	2.64	5%	5%	0.0707	0.0000		0.0002	0.0000	0.0000	2.8814E-10
1A4a. Commercial/institutional	CO2	75.21	89.81	5%	5%	0.0707	0.0000		0.0082	0.0000	0.0006	3.3353E-07
1A4b. Residential	CO2	299.70	293.63	5%	5%	0.0707	0.0000		0.0267	0.0000	0.0019	3.5654E-06
1A4c. Agriculture/forestry/fishing	CO2	55.48	84.65	5%	5%	0.0707	0.0000		0.0077	0.0000	0.0005	2.9635E-07
1A5a. Stationary	CO2	10.99	18.85	5%	5%	0.0707	0.0000		0.0017	0.0000	0.0001	1.4687E-08
1A5b. Mobile	CO2	0.00	4.08	5%	5%	0.0707	0.0000		0.0004	0.0000	0.0000	6.8842E-10
2A1. Cement production	CO2	667.66	878.81	2%	2%	0.0283	0.0000		0.0799	0.0000	0.0023	5.1098E-06
2A2. Lime production	CO2	5.33	3.99	2%	5%	0.0539	0.0000		0.0004	0.0000	0.0000	1.055E-10
2A4. Other process uses of carbonates	CO2	44.08	14.19	5%	5%	0.0707	0.0000		0.0013	0.0000	0.0001	8.3228E-09
2D1. Lubricant use	CO2	4.13	4.47	5%	5%	0.0707	0.0000		0.0004	0.0000	0.0000	8.2625E-10
2D2. Paraffin wax use	CO2	0.06	0.05	5%	5%	0.0707	0.0000		0.0000	0.0000	0.0000	1.0529E-13
2D3. Other	CO2	0.00	0.51	5%	5%	0.0707	0.0000		0.0000	0.0000	0.0000	1.081E-11
3H. Urea application	CO2	1.82	0.30	20%	50%	0.5385	0.0000		0.0000	0.0000	0.0000	5.9085E-11
4.A.1 Forest Land remaining Forest Land	CO2	1.55	-103.98	15%	60%	0.6185	0.0000		0.0095	0.0000	0.0020	4.0237E-06
4.A.2 Land converted to Forest Land	CO2	-0.10	-17.27	15%	40%	0.4272	0.0000		0.0016	0.0000	0.0003	1.1095E-07
4.B.1 Cropland remaining Cropland	CO2	-133.97	-133.88	15%	65%	0.6671	0.0000		0.0122	0.0000	0.0026	6.671E-06
4.B.2 Land converted to Cropland	CO2	-0.27	6.16	15%	95%	0.9618	0.0000		0.0006	0.0000	0.0001	1.4114E-08
4.C.1 Grassland remaining Grassland	CO2	-23.42	-21.75	15%	35%	0.3808	0.0000		0.0020	0.0000	0.0004	1.761E-07

4.C.2 Land converted to Grassland	CO2	0.36	2.02	15%	50%	0.5220	0.0000		0.0002	0.0000	0.0000	1.5218E-09
4.D.2 Land converted to Wetlands	CO2	0.00	0.50	15%	50%	0.5220	0.0000		0.0000	0.0000	0.0000	9.1605E-11
4.E.2 Land converted to Settlements	CO2	0.46	3.56	15%	350%	3.5032	0.0000		0.0003	0.0000	0.0001	4.7116E-09
4.F.2 Land converted to Other Land	CO2	0.11	0.00	15%	30%	0.3354	0.0000		0.0000	0.0000	0.0000	0
4.G Harvested Wood Products	CO2	2.14	19.92	15%	50%	0.5220	0.0000		0.0018	0.0000	0.0004	1.4773E-07
2F1. Refrigeration and air conditioning	HFCs(1)	0.00	336.62	5%	500%	5.0002	0.0098		0.0306	0.0000	0.0022	4.6857E-06
2F2. Foam blowing agents	HFCs(1)	0.00	1.37	5%	500%	5.0002	0.0000		0.0001	0.0000	0.0000	7.7642E-11
2F3. Fire protection	HFCs(1)	0.00	11.69	5%	500%	5.0002	0.0000		0.0011	0.0000	0.0001	5.6523E-09
2F4. Aerosols	HFCs(1)	0.00	3.81	5%	500%	5.0002	0.0000		0.0003	0.0000	0.0000	5.9971E-10
1A1a. Public electricity and heat production	N2O	3.45	6.35	3%	300%	3.0001	0.0000		0.0006	0.0000	0.0000	5.9964E-10
1A1b. Petroleum refining	N2O	0.00	0.00	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	0
1A1c. Manufacture of solid fuels and other energy industries	N2O	0.12	0.10	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	3.8138E-13
1A2b. Non-ferrous metals	N2O	0.01	0.00	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	1.7349E-16
1A2c. Chemicals	N2O	0.00	0.03	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	2.8003E-14
1A2d. Pulp, paper and print	N2O	0.01	0.01	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	1.8356E-15
1A2e. Food processing, beverages and tobacco	N2O	0.14	0.16	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	1.0555E-12
1A2f. Non-metallic minerals	N2O	1.28	4.54	3%	300%	3.0001	0.0000		0.0004	0.0000	0.0000	3.064E-10
1A2g. Other	N2O	0.08	0.15	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	9.1694E-13
1A3a. Domestic aviation	N2O	0.19	0.00	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	2.8303E-16
1A3b. Road transportation	N2O	12.12	11.61	5%	50%	0.5025	0.0000		0.0011	0.0000	0.0001	5.5695E-09
1A3d. Domestic navigation	N2O	0.03	0.04	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	6.826E-14
1A4a. Commercial/institutional	N2O	0.12	0.32	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	4.3128E-12
1A4b. Residential	N2O	0.62	1.17	5%	300%	3.0004	0.0000		0.0001	0.0000	0.0000	5.7079E-11
1A4c. Agriculture/forestry/fishing	N2O	0.11	0.18	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	1.3645E-12
1A5a. Stationary	N2O	0.02	0.04	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	8.0128E-14
1A5b. Mobile	N2O	0.00	0.01	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	3.4044E-15

2G3. N2O from product uses	N2O	3.93	6.06	5%	500%	5.0002	0.0000		0.0006	0.0000	0.0000	1.5178E-09
3B1a. Dairy cattle	N2O	3.60	7.14	5%	100%	1.0012	0.0000		0.0006	0.0000	0.0000	2.1103E-09
3B1b. Non-dairy cattle	N2O	2.32	2.82	5%	100%	1.0012	0.0000		0.0003	0.0000	0.0000	3.2817E-10
3B2. Sheep	N2O	12.18	13.09	5%	100%	1.0012	0.0000		0.0012	0.0000	0.0001	7.0835E-09
3B3. Swine	N2O	6.89	2.71	5%	100%	1.0012	0.0000		0.0002	0.0000	0.0000	3.0326E-10
3B4a. Goats	N2O	7.98	10.29	5%	100%	1.0012	0.0000		0.0009	0.0000	0.0001	4.3795E-09
3B4b. Horses	N2O	0.05	0.06	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.2853E-13
3B4c. Mules and Asses	N2O	0.24	0.07	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.9502E-13
3B4d. Poultry	N2O	6.99	5.49	5%	100%	1.0012	0.0000		0.0005	0.0000	0.0000	1.2453E-09
3B5. Indirect N2O emissions	N2O	22.55	28.10	20%	50%	0.5385	0.0000		0.0026	0.0000	0.0007	5.2239E-07
3D. Agricultural soils	N2O	133.28	119.21	5%	3%	0.0583	0.0000		0.0108	0.0000	0.0008	5.8764E-07
3F. Field burning of agricultural residues	N2O	0.45	0.13	20%	20%	0.2828	0.0000		0.0000	0.0000	0.0000	1.036E-11
4.A.1 Forest Land remaining Forest Land	N2O	0.02	2.87	10%	220%	2.2023	0.0000		0.0003	0.0000	0.0000	1.3604E-09
4.B.2 Land converted to Cropland	N2O	0.01	0.12	15%	175%	1.7564	0.0000		0.0000	0.0000	0.0000	5.8098E-12
4.E.2 Land converted to Settlements	N2O	0.00	0.73	15%	380%	3.8030	0.0000		0.0001	0.0000	0.0000	2.0006E-10
4.F.2 Land converted to Other Land	N2O	0.00	0.00	15%	80%	0.8139	0.0000		0.0000	0.0000	0.0000	0
5B1. Composting	N2O	0.00	7.71	30%	100%	1.0440	0.0000		0.0007	0.0000	0.0003	8.8582E-08
5D1. Domestic wastewater	N2O	9.52	14.52	30%	30%	0.4243	0.0000		0.0013	0.0000	0.0006	3.1375E-07
5D2. Industrial wastewater	N2O	0.28	0.24	100%	30%	1.0440	0.0000		0.0000	0.0000	0.0000	9.7814E-10
2G1. Electrical equipment	SF6	2.73	16.24	5%	500%	5.0002	0.0000		0.0015	0.0000	0.0001	1.0907E-08
Total		5498.94	8503.26				0.01017959					0.00063659
		ΣC	ΣD		Percentage uncertainty in total inventory:		0.10089396				Trend uncertainty:	0.02523069

Annex 3: Detailed methodological descriptions for individual source or sink categories

A.3.1. Fuel combustion (1A)

The fuel consumption data published by the National Statistical Service in 2019 for the period 1990–2019 are presented in Table A3.1.3. In green are sectors/consumers that have been added for the first time in 2019 and in red are the revisions.

Due to the unavailability of consumption data for several years, using the data as is would create issues of inconsistency and incomparability. Therefore, it was decided to complete the period using the following assumptions. The resulting data used for the estimation of the emissions will be presented at the methodological issues Section of the appropriate sector in Chapter 3. The following pages present the assumptions made to allocate consumption to activities where data was not available.

LPG

(a) 2006-2009 consumption from Not elsewhere specified (Industry) has been moved to Non-metallic minerals.

(b) There is available data for all the consumers of LPG during the period 2006-2015. Since there is no particular trend during this period, it was decided to use the same ratio as 2006 to distribute the consumption that was allocated to residential to all sectors for the period 1990-2005 (Table A3.1.1).

Table A3.1.1. Contribution of different activities to LPG consumption (2006) used to allocate consumption to different sectors for 1990-2005

Activity	Consumption
Non-ferrous metals	1.9%
Non-metallic minerals	1.9%
Food, beverages and tobacco	5.6%
Commercial and public services	24.1%
Residential	64.8%
Agriculture/forestry	1.9%

Jet kerosene

Information on fuel consumption for domestic flights is not available from national statistics. To estimate the emissions from aviation, the available information on fuel consumption from EUROCONTROL was used (Table A3.1.2) for 2005-2020.

Table A3.1.2. International and domestic flights' fuel consumptions, EUROCONTROL data (2005-2020)

Fuel consumption (kt)	2005	2006	2007	2008	2009	2010	2011	2012
Domestic	3.958	3.344	2.967	2.823	2.282	2.429	0.739	0.471
International	264.2	266.4	262.4	272.3	257.4	262.6	272.5	263.4
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Domestic	0.305	0.191	0.286	0.179	0.3	0.3	0.1	0.0
International	246	246	238	278	317	329	326	104

Table A3.1.3. Fuel consumption according to the National Energy balance 2021 in kt (1990–2021)

(a) 1990–2004

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Crude oil															
Refinery intake (Observed)	636	763	727	781	906	828	760	1043	1082	1180	1173	1156	1086	971	279
Refinery losses	10	16	3	3	4	2	2	5	6	4	1	5	4	3	
Refinery gas															
Refinery fuel	18	17	17	13	24	13	12	16	16	20	19	19	21	21	9
LPG															
Non-ferrous metals															
Non-metallic minerals															
Food, beverages and tobacco															
Not elsewhere specified (Industry)															
Commercial and public services															
Residential	49	49	55	51	50	51	51	52	50	49	53	53	54	58	56
Agriculture/forestry															
Not elsewhere specified (Other)															
Non-biogasoline = GASOLINE															
Road	163	170	172	169	180	183	186	191	195	203	206	219	228	252	282
International aviation	236	280	272	231	237	260	249	245	258	264	268	314	302	323	295
Not elsewhere specified (Other)															
Other kerosene															
Residential	12	12	17	16	17	17	18	20	21	20	24	24	31	31	24
Oil and gas extraction															
Not elsewhere specified (Industry)															
Residential	12	12	17	16	17	17	18	20	21	20	24	24	31	31	24
Not elsewhere specified (Industry)															
Road															
Non-bio gas/diesel oil = DIESEL															
International marine bunkers	24	20	21	14	12	15	25	27	35	46	50	47	33	36	27
Main activity producer electricity plants			11	3	2	8	6	6	12	21	19	4	2	5	8
Autoproducer electricity plants															
Road	210	202	246	255	261	285	298	314	334	340	350	355	341	351	354
Chemical and petrochemical															
Non-ferrous metals															

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Non-metallic minerals															
Mining and Quarrying															
Food, beverages and tobacco															
Construction															
Not elsewhere specified (Industry)	98	109	132	137	141	153	161	169	180	185	191	193	185	190	171
Commercial and public services															
Residential															
Agriculture/forestry															
Fishing															
Not elsewhere specified (Other)															
Total fuel oil															
International marine bunkers	34	36	38	36	50	54	65	71	63	108	143	145	105	88	27
Refinery fuel	11	12	13	13	14	17	16	14	15	16	16				
Main activity producer electricity plants	540	561	645	697	727	662	703	743	811	856	902	897	932	1095	1046
Autoproducer electricity plants															
Autoproducer CHP Plants														2	5
Chemical and petrochemical															
Non-metallic minerals	37	124	118	100	110	97	111	70	68	68	70	54	55	62	68
Food, beverages and tobacco															
Paper, pulp and printing															
Construction															
Not elsewhere specified (Industry)															
Commercial and public services															
White spirit and SPB															
Not elsewhere specified (Industry)				1		1	1	1		1		1			
Lubricants															
International marine bunkers							1	1	1	1	1	1	1	1	1
Non-energy use: Road				6	8	8	9	8	5	5	5	5	6	6	7
Non-energy use: Not elsewhere specified (Industry)				2	3	3	3	3	2	2	2	2	2	2	3
Bitumen															
Construction															
Non-energy use: Not elsewhere specified (Industry)	33	23	50	59	57	54	57	62	75	86	83	81	84	70	65
Pet-coke															
Non-metallic minerals		93	85	114	112	125	147	152	150	154	141	133	139	137	146
Other products (liquid)															
Refinery fuel													16	16	
Not elsewhere specified (Industry)	40	5						1							6

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Bituminous Coal															
Non-metallic minerals	97	97	26	31	27	20	18	19	26	30	49	53	53	53	57
Lignite															
Not elsewhere specified (Other)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Waste (non-biomass fraction)															
Industrial waste (non-renewable) (TJ)															
Non-metallic minerals	0	0	0	0	0	0	0	0	0	0	0	18	0	15	71
Municipal waste (non-renewable) TJ															
Non-metallic minerals															
RENEWABLES															
Solid biofuels (TJ)															
Charcoal production plants (Transformation)	112	112	112	112	405	388	328	288	314	281	248	253	235	209	184
Chemical and petrochemical															
Non-metallic minerals											41	70	90	211	127
Food, beverages and tobacco															
Commercial and public services															
Residential															
Agriculture/Forestry															
Not elsewhere specified (Other)	145	120	118	117	85	91	136	70	64	88	78	80	74	67	61
Charcoal (kt)															
Commercial and public services															
Residential															
Not elsewhere specified (Other)	1	1	1	1	2	7	7	7	8	7	5	5	7	7	8
Biogases (TJ)															
Main activity producer CHP plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Autoproducer CHP plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commercial and public services	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture/Forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Municipal waste (renewable)															
Non-metallic minerals															

(b) 2005-2021

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Crude oil																	
Refinery intake (Observed)																	
Refinery losses																	
Refinery gas																	
Refinery fuel																	
LPG																	
Non-ferrous metals		1	1		1	1	1	1			1	1	0.57	0.59	0.66	0.76	0.76
Chemical and Petrochemical													0.21	0.22	0.24	0.29	0.27
Non-metallic minerals						1	1	1	1	1	1	1	0.38	0.39	0.43	0.71	0.65
Food, beverages and tobacco		3	3	3	3	3	4	5	4	4	5	4	5.52	5.76	6.38	5.72	5.29
Paper, pulp and printing													0.29	0.30	0.33	0.14	0.13
Wood and wood products													0.003	0.003	0.003	0.006	0.01
Not elsewhere specified (Industry)		1	1	1	1				0	1	0	0	2.424	0.237	0.263	0.137	0.129
Commercial and public services		13	13	14	13	13	14	14	12	10	11	11	13.17	13.8	15.5	11.1	9.7
Residential	53	35	36	34	36	34	38	37	33	31	34	35	32.467	28.45	32.15	31.31	33.46
Agriculture/forestry		1	1	1	1	1	1	1	1		1	2	2.424	2.53	2.86	2.58	2.41
Not elsewhere specified (Other)									1	1	1	1	1.315	0.912	1.25	1.27	1.13
Road												0.441	0.477	0.399	0.458	0.399	0.458
Non-biogasoline = GASOLINE																	
Road	303	323	352	373	383	390	385	372	349	341	345	354	351	342	337	284	305
Jet Kerosene																	
International aviation	291	300	287	286	265	270	294	264	235	231	233	263	298	308	295	90.4	149.7
Domestic aviation													2	1.77	1.31	1.38	1.52
Not elsewhere specified (Other)					1	1	2	1	2	2	1	1	1	1	1	1.5	1.3
Other kerosene																	
Residential	13	16	16	14	19	14	16	17	12	9	14	14	14	9	13	13	11
Oil and gas extraction										2							
Not elsewhere specified (Other)	3														0.02	0.04	0.00

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
															6	5	9
Non-metallic minerals													0.06	0.05	0.02	0.02	0
Food, beverages and tobacco													0.03	0.02	0.1	0.01	0.001
Not elsewhere specified (Industry)										2				0.005	0.005	0.002	0
Commercial and Public Services													0.03	1.64	2.22	2.26	2.02
Biodiesel																	
Road																27.2	27.50
Water-borne navigation			1	16	17	17	18	18	17	11	11	10	9.697	10.1	12.15	0.034	0.075
Chemical and petrochemical																0.034	0.029
Non-ferrous metals																0.001	0.001
Non-metallic minerals																0.095	0.219
Mining and Quarrying																0.298	0.245
Food, beverages and tobacco																0.004	0.006
Paper, pulp and printing																0.001	0.001
Machinery																0.008	0.011
Textiles and Leather																0.001	0.000
Wood and wood products																0.001	0.001
Commercial and public services																0.105	0.169
Not elsewhere specified (Industry)																0.003	0.002
Not elsewhere specified (Other)																0.214	0.197
Non-bio gas/diesel oil = DIESEL																	

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
International marine bunkers	67	106	104	88	73	53	58	69	83	80	75	95	101				
Main activity producer electricity plants	16	7	16	23	92	158	112	214	236	124	89	150	255	246	259	342	289
Autoproducer electricity plants			1				2	2	2	1	2	2	2	1.75	1.91	1.5	1.6
Road	346	323	337	330	321	329	313	272	231	224	241	274	292	304	315	283	304
Chemical and petrochemical								1	0	1	1	1	0.15	1.036	1.377	1.24	1.5
Non-ferrous metals								1				1	1	0.130	0.059	0.317	0.152
Non-metallic minerals								3	1	1	2	2	2	1	2	2.17	4.86
Transport Equipment													0.005	0.006	0.001	0.001	0.001
Machinery													0.257	0.224	0.248	0.278	0.272
Mining and Quarrying								5	2	1	3	2	4	4	7	5	5.39
Food, beverages and tobacco								3	2	2	4	3	5	4	4	4.65	5.39
Textiles and Leather													0.027	0.023	0.018	0.017	0.01
Construction								5	5	6	6	7	9	7	8	8	9
Not elsewhere specified (Industry)	47	24	20	18	18	14	16	3	1	1	2	2	2	2.18	2.245	2.05	2.399
Commercial and public services		19	18	20	19	23	20	16	17	13	13	15	18	10	16	12	14
Residential	83	98	89	78	83	70	80	76	62	57	65	65	65	53	60	60	49
Agriculture/forestry	27	28	28	23	20	19	22	21	21	19	22	21	22	21	22	24	23
Fishing				3	4	4	3	3	2	2	2	2	2	2	2	1	1.7
Not elsewhere specified (Other)		4	6	13	5	5	6	5	5	9	6	6	6	6	6	5.4	4.8
Total fuel oil																	
International marine bunkers	225	190	171	165	146	134	141	128	157	153	169	193	154				
Refinery fuel																	
Main activity producer electricity plants	1104	1137	1174	1219	1163	1053	1058	896	649	793	858	883	778	804	771	603	680
Autoproducer electricity plants			4	3	2	2	2		2	4							
Autoproducer CHP Plants	6	7	14	12	11	8	2	2	2	0			1		0.032	0.125	0.036
Chemical and petrochemical											1	1	1	1	1	1	0.36
Non-metallic minerals	37	35	38	38	30	25	15	13	8	7	8	10	13	15	15	13	13
Mining													0.2	0.1	0.1	0	0

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Food, beverages and tobacco								9	8	8	9	9	12	11	11	10	10
Paper, pulp and printing										1	1	1	1	1	0.5	0.7	0.81
Construction								1	1	3	2	3	2	2	2	2	3
Not elsewhere specified (Industry)	28	19	27	25	17	20	34	2	2	3	1	2	1	0.4	0.4	1	0.6
Commercial and public services	1	2	2	2	2	2	2	4	4	2	3	4	4	3	4	2	3
White spirit and SPB																	
Not elsewhere specified (Industry)	1	1	1														
Lubricants																	
International marine bunkers	1	1	1	1													
Non-energy use: Road	2	2	2	2	2	2	2	1	1	1	1	1	1	1	2	2	3
Non-energy use: Not elsewhere specified (Industry)	4	4	4	4	4	4	4	4	3	3	3	3	2	2	5	5	5
Bitumen																	
Construction	69	69	57	66	74	83	64	36	24	21	21	37	36	37	34	31	42
Non-energy use: Not elsewhere specified (Industry)																	
Pet-coke																	
Non-metallic minerals	154	146	143	152	144	116	100	94	135	162	128	123	109	74	56	63	13
Other products (liquid)																	
Refinery fuel																	
Not elsewhere specified (Industry)																	
Bituminous Coal																	
Non-metallic minerals	52	54	49	40	21	26	12	0	0	4	6	0	5	23	28	22	66
Lignite																	
Not elsewhere specified (Other)	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Waste (non-biomass fraction)																	
Industrial waste (non-renewable) (TJ)																	
Non-metallic minerals	138	73	288	239	276	299	4	0	0	279	221	94	90	157	165	289	266
Municipal waste (non-renewable) TJ																	
Non-metallic minerals								24	45	37	295	569	812	805	1123	1168	1426
RENEWABLES																	
Solid biofuels (TJ)																	
Charcoal production plants (Transformation)	174	135	274	211	47	48	45	82	71	58	94	163	172	112	93	80	91
Chemical and petrochemical										42	52	21	22	18	18	14	11
Non-metallic minerals	38	61	133	281	304	347	306	29	28	116	95	55	86	78	126	205	279
Food, beverages and tobacco										44	7	36	51	67	99	69	48

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Commercial and public services			14	15	15	15	13	16	16	16	15	15	17	17	17	132	126
Residential		74	95	123	500	260	339	419	353	249	551	531	691	709	766	644	610
Agriculture/Forestry		5															
Not elsewhere specified (Other)	58																
Charcoal (kt)																	
Commercial and public services		5	7	7	6	6	6	6	6	6	7	7	7	6	6	5	6
Residential		5	6	6	5	5	6	6	6	6	6	8	9	9	8	10	9
Not elsewhere specified (Other)	10																
Biogases (TJ)																	
Main activity producer CHP plants	0	0	0	0	13	21	92	91	118	116	130	130	145	143	136	131	127
Autoproducer CHP plants	0	0	9	78	131	148	180	192	171	176	179	182	178	204	208	206	208
Commercial and public services	0	0	0	0	11	12	11	11	11	12	12	16	17	44	56	20	24
Agriculture/Forestry	0	0	6	0	54	93	165	182	166	172	151	163	96	442	464	471	469
Municipal waste (renewable)																	
Non-metallic minerals								88	150	161	325	427	419	442	463	1378	1482

The share of domestic flights to the total fuel consumption is presented in Table A3.1.4. It can be noticed that there is a decreasing trend in the share of domestic flights to the total fuel consumption. The trend for these years can be represented by the equation y=-0.0014x+0.0154. This equation was used to estimate the share of domestic flights to the total for the years 1990–2004 (Table A3.1.5), years for which data is not available for domestic flights. By multiplying the share by the total fuel consumption reported all under international flights by the Statistical Service for 1990–2004, the fuel consumption of domestic flights was estimated. The international flights consumption for 1990–2004 was revised by subtracting the estimated fuel consumption for domestic flights. The resulting fuel consumption for domestic and international flights for the years 1990–2004 is presented in Table A3.1.5. Fuel consumption obtained from the Statistical Service is in kt, and converted to TJ using the default NCV proposed by the 2006 IPCC Guidelines, i.e. 44.1 TJ/Gg (Table 1.2, pg.1.18, vol.2).

Table A3.1.4. Share of domestic flights to the total fuel consumption, EUROCONTROL data (2005–2021)

	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Share of domestic to total	1.48%	1.24%	1.12%	1.03%	0.88%	0.92%	0.27%	0.18%	0.12%
	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
Share of domestic to total	0.08%	0.12%	0.06%	0.08%	0.09%	0.04%	0.03%	0.06%	

Table A3.1.5. Share of domestic flights to the total fuel consumption, consumption for domestic and international flights (1990–2004)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Share of domestic to total	3.50%	3.36%	3.22%	3.08%	2.94%	2.80%	2.66%	2.52%
Domestic consumption (TJ)	364	415	386	314	307	321	292	272
International consumption (TJ)	10043	11933	11609	9873	10144	11145	10689	10532
TOTAL (TJ)	10408	12348	11995	10187	10452	11466	10981	10805
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	
Share of domestic to total	2.38%	2.24%	2.10%	1.96%	1.82%	1.68%	1.54%	
Domestic consumption (TJ)	271	261	248	271	242	239	200	
International consumption (TJ)	11107	11382	11571	13576	13076	14005	12809	
TOTAL (TJ)	11378	11642	11819	13847	13318	14244	13010	

Other kerosene

(a) Other kerosene consumption was recorded for non-elsewhere specified (industry) only for 2005. For the same year the consumption of residential sector was much lower than other years. The consumption from non-elsewhere specified (industry) of 2005 was moved to residential.

(b) Oil and gas extraction consumption reported only for 2014 was moved to Not elsewhere specified (Industry).

Diesel

According to the energy balance, the consumers of gas-diesel oil are Main activity producer electricity plants, Road, Chemical and petrochemical, Non-ferrous metals, Non-metallic minerals, Mining and Quarrying, Food, beverages and tobacco, Construction, Not elsewhere specified (Industry), Commercial and public services, Residential, Agriculture/Forestry and Not elsewhere specified (Other). Consumption data for Chemical and petrochemical, Non-ferrous metals, Non-metallic minerals, Mining and Quarrying, Food, beverages and tobacco, Construction is only available for 2012 to 2017.

(a) For the years 2006–2011 all consumption from industrial activities (incl. autoproducers) was included in Not elsewhere specified (Industry). The consumption was allocated to the industrial sectors according to the ratio of 2012 (Table A3.1.6).

Table A3.1.6. Contribution of different activities to gas-diesel oil consumption (2012) used to allocate consumption to Chemical and petrochemical, Non-ferrous metals, Non-metallic minerals, Mining and Quarrying, Food, beverages and tobacco, Construction, Not elsewhere specified (Industry) for 2006–2011

Activity	Consumption
Chemical and petrochemical	5%
Non-ferrous metals	5%
Non-metallic minerals	14%
Mining and Quarrying	24%
Food, beverages and tobacco	14%
Construction	24%
Not elsewhere specified (Industry)	14%

(b) The contribution of fishing consumption to the total for the years 2005–2007 is assumed the same as 2008.

(c) For 2005, consumption is available for Main activity producer electricity plants, road, Residential and Agriculture/forestry. Due to the large increase of the Not elsewhere specified (Industry) compare to 2006–2011, it is assumed that consumption by Commercial and public services, and Not elsewhere specified (Other) is included in the Not elsewhere specified (Industry). The assumed contribution of each sector to the consumption allocated to Not elsewhere specified (Industry) is based on the 2012 consumption ratio for these sectors (Table A3.1.7).

Table A3.1.7. Contribution of different activities to gas-diesel oil consumption (2012) used to allocate consumption to Chemical and petrochemical, Non-ferrous metals, Non-metallic minerals, Mining and Quarrying, Food, beverages and tobacco, Construction, Not elsewhere specified (Industry), Commercial and public services, Not elsewhere specified (Other) from Not elsewhere specified (Industry) for 2005

Activity	Consumption
Chemical and petrochemical	2%
Non-ferrous metals	2%
Non-metallic minerals	7%
Mining and Quarrying	12%
Food, beverages and tobacco	7%
Construction	12%
Not elsewhere specified (Industry)	7%
Commercial and public services	38%
Not elsewhere specified (Other)	12%

(d) To estimate the consumption for the years 1990–2004, the consumption ratio compared to Not elsewhere specified (Industry) is assumed to be the same as 2012 (Table A3.1.8).

Table A3.1.8. Contribution of different activities to gas-diesel oil consumption (2012) used to allocate consumption to from Not elsewhere specified (Industry) for 1990–2004

Activity	Consumption
Chemical and petrochemical	0.7%
Non-ferrous metals	0.7%
Non-metallic minerals	2.11%
Mining and Quarrying	3.52%
Food, beverages and tobacco	2.11%
Construction	3.52%
Not elsewhere specified (Industry)	2.11%
Commercial and public services	11.27%
Residential	53.52%
Agriculture/ forestry	14.79%
Fishing	2.11%
Not elsewhere specified (Other)	3.52%

(e) Consumption for Water-borne navigation activities is available for the years 1998–2015[92] (Table A3.1.9). The consumption for the period 1990–1997 was estimated assuming that the contribution of the activity to road transport consumption is the same as 1998; the consumption for 2016 was estimated assuming that the contribution of the activity to road transport consumption is the same as 2015.

(f) The consumption for Water-borne navigation activities was subtracted from Road transport. Therefore road transport consumption was revised for the whole reporting period.

Table A3.1.9. Consumption diesel for Water-borne navigation activities

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006
t	1097.05	1236.84	531.915	430.208	561.862	430.478	596.723	730.847	558.887
kt	1.10	1.24	0.53	0.43	0.56	0.43	0.60	0.73	0.56
% of road	0.33%	0.36%	0.15%	0.12%	0.16%	0.12%	0.17%	0.21%	0.17%

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015
t	626.709	757.997	1491.21	946.597	886.776	625.631	472.399	558.96	558.96
kt	0.63	0.76	1.49	0.95	0.89	0.63	0.47	0.56	0.56
% of road	0.19%	0.23%	0.46%	0.29%	0.28%	0.23%	0.20%	0.25%	0.23%

RFO

(a) All consumption allocated to Autoproducer electricity and Autoproducer CHP Plants was moved to Not elsewhere specified (Industry).

(b) The consumption for food, beverages and tobacco, is only available for 2012–2021. For 2005–2012 consumption is also reported for non – metallic minerals and commercial and public services.

(c) All consumption during 1990–2004 except Refinery fuel and Main activity producer electricity plants was allocated to non-metallic minerals, food, beverages and tobacco, not elsewhere specified (industry) and commercial and public services.

Bitumen

All bitumen consumption allocated to Non-energy use: Not elsewhere specified (Industry) during 1990–2004 has been moved to construction.

Pet-coke

Pet-coke in Cyprus is consumed only for cement production. According to the information received from the cement installations, pet-coke was consumed in 1990. The energy balance shows that pet-coke was not imported in 1990. To reduce the inconsistency and the impact on the times series, it was decided to move the "other liquid fuels" consumption of 1990 to cement as pet-coke.

Solid biofuels

(a) All consumption of solid biofuels for the period 1990–1999 is reported as non-elsewhere specified (other).

(b) For 2001–2005 consumption is reported as non-elsewhere specified (other) and non-metallic minerals.

(c) Consumption in agriculture is reported only for 2006.

The consumption of agriculture of 2006 was moved to commercial and public services for which consumption is reported for 2007–2015. All the consumption reported as non-elsewhere specified (other) for 1990–2005 was distributed to commercial and public services, and residential sector according to the consumption ratio the two sectors had in 2007 (Table A3.1.10).

[92] Mr. George Ioannou, Statistical Service, Estimation based on fuel expenses assuming that all fuel is road diesel

Table A3.1.10. Contribution of different activities to solid biofuels consumption (2007) used to allocate consumption to commercial and public services, and residential for 1990–2005

Activity	**Consumption**
Commercial and public services	12.8%
Residential	87.2%

Charcoal

All charcoal consumption for the period 1990-2005 was reported as non-elsewhere specified (other). For the period 2006-2016, the charcoal consumption is allocated to commercial and public services, and residential sectors using the ratio of 50:50. This ratio was used to allocate charcoal consumption to the two sectors for the period 1990-2005.

Biogases

Biogas consumption is available in Cyprus after 2006, when the first anaerobic digester of the country started it operation. The biogas in Cyprus is consumed onsite to produce electricity and heat through a combined heat power (CHP) generator. Therefore, the biogas consumed by "Main activity producer CHP plants" (2009-2012) and "Autoproducer CHP plants" (2007-2021) was moved to agriculture.

A.3.2. Solid waste management (5A)

Historical solid waste production

The IPCC Waste Model requires MSW and non-MSW activity data to be reported annually going back to the year 1950.

MSW activity data in Cyprus were only recorded between the years of 1996-2016, while the previously reported period of 1990-1995 was linearly extrapolated from the trend observable in years 1996-2009.

In an attempt to determine the historical waste per capita data going back to the year 1950, as recommended during the TERT review, a linear extrapolation from the small sample size of recorded data would not have sufficed, or otherwise been applicable. Therefore, a more pertinent indicator of waste activity was required, and, as such, the national GDP was used to correlate the annual waste activity against the corresponding years.

The methodology used to determine the historical waste per capita data was applied as follows:
(a) The 1960-2014 GDP data[93] was extrapolated backwards, to expand the range to the year 1950.
(b) Waste activity data from 1996-2009 was fitted exponentially to the respective GDP value of each year to provide for a correlation between waste per capita and GDP.
(c) Hence, a hind cast of the annual waste activity was calculated going back to 1950 using the derived relation of waste per capita to GDP.

Regarding non-MSW, the first reference year which data are available is 2014 in accordance with the provisions of the Waste Statistics Regulation (EC) No 2150/2002. No data are available for Cyprus before 2004. The methodology applied is may differ between years, due to the amendment of the Regulation (data 2010 and onwards) and moreover due to improved methods of reporting waste following Eurostat's recommendations. Data revisions were applied from 2012 onwards.

An estimation of the activity data for the years 2013 and 2015 was made by obtaining the average of the years before and after; i.e. 2012 and 2014, 2014 and 2016 respectively.

An extrapolation of the trend available from the years 2012-2016 was used to estimate activity data for 2017, 2018 and 2019.

To estimate the activity data for the years prior to 2012, the annual change of the Gross Domestic Product at Constant market prices of 2005 was used, as published by the Statistical Service in the Statistical Abstract.

GDP data alongside the calculated waste activity derived from the methodology of the model is summarized annually in Table A3.2.1. The aforementioned methodology is described analytically below in conjunction with the relevant data.

Table A3.2.1. Data used for fitting and extrapolating GDP and waste activity is tabulated by year.

	GDP (€m)	Waste (kg/capita)	Food (Gg)	Wood (Gg)	Textile (Gg)	Sludge (Gg)
1950	1052.30	457.96	0.626018	0.369484	0.000489	0.006176
1951	1103.00	458.65	0.657707	0.388187	0.000513	0.006489
1952	1156.20	459.37	0.691037	0.407859	0.000539	0.006818
1953	1211.90	460.13	0.726013	0.428502	0.000567	0.007163
1954	1270.20	460.92	0.762704	0.450157	0.000595	0.007525
1955	1331.40	461.76	0.801312	0.472944	0.000625	0.007905
1956	1395.60	462.64	0.841909	0.496905	0.000657	0.008306
1957	1462.80	463.56	0.884498	0.522042	0.000690	0.008726
1958	1533.30	464.52	0.929286	0.548476	0.000725	0.009168

[93] Maria Matsi, Economic Officer, Directorate of Economic Research and EU Affairs, Ministry of Finance. Tel. no.: +357 22 60 1231. Email: mmatsi@mof.gov.cy

1959	1607.10	465.54	0.976275	0.576210	0.000762	0.009632
1960	1468.85	463.64	0.898945	0.530569	0.000701	0.008869
1961	1632.00	465.88	1.011266	0.596862	0.000789	0.009977
1962	1778.72	467.91	1.111163	0.655822	0.000867	0.010962
1963	1888.76	469.44	1.184439	0.699070	0.000924	0.011685
1964	1709.19	466.95	1.081607	0.638378	0.000844	0.010671
1965	2090.23	472.24	1.391912	0.821524	0.001086	0.013732
1966	2217.79	474.03	1.482377	0.874917	0.001157	0.014625
1967	2519.44	478.28	1.715745	1.012654	0.001339	0.016927
1968	2635.50	479.92	1.798601	1.061557	0.001404	0.017744
1969	2880.77	483.42	1.983157	1.170484	0.001548	0.019565
1970	2970.01	484.69	2.046553	1.207901	0.001597	0.020191
1971	3349.95	490.17	2.346766	1.385090	0.001831	0.023152
1972	3571.12	493.39	2.512662	1.483004	0.001961	0.024789
1973	3606.71	493.91	2.537952	1.497931	0.001980	0.025039
1974	2997.38	485.09	2.171150	1.281440	0.001694	0.021420
1975	2428.01	476.98	1.824566	1.076881	0.001424	0.018001
1976	2870.37	483.27	2.231031	1.316782	0.001741	0.022011
1977	3323.12	489.78	2.648844	1.563381	0.002067	0.026133
1978	3577.15	493.48	2.868085	1.692779	0.002238	0.028296
1979	3930.26	498.66	3.182215	1.878183	0.002483	0.031395
1980	4162.94	502.11	3.382458	1.996369	0.002639	0.033370
1981	4289.95	504	3.488906	2.059195	0.002723	0.034420
1982	4546.16	508.04	3.710514	2.189991	0.002895	0.036607
1983	4802.38	511.7	3.932122	2.320787	0.003068	0.038793
1984	5227.76	518.18	4.314268	2.546334	0.003367	0.042563
1985	5478.50	522.03	4.531619	2.674617	0.003536	0.044707
1986	5675.59	525.09	4.700727	2.774427	0.003668	0.046376
1987	6078.52	531.38	5.059956	2.986448	0.003948	0.049920
1988	6583.83	539.39	5.518732	3.257224	0.004306	0.054446
1989	7117.07	547.96	6.005091	3.544279	0.004686	0.059244
1990	7650.30	556.68	6.491450	3.831334	0.005066	0.064043
1991	7703.95	557.56	6.537297	3.858393	0.005101	0.064495
1992	8428.25	569.64	7.215691	4.258790	0.005631	0.071188
1993	8487.37	570.64	7.266668	4.288877	0.005670	0.071691
1994	8987.76	579.15	7.721924	4.557575	0.006026	0.076182
1995	11386.80	600.13	10.533582	6.217050	0.008220	0.103921
1996	11528.90	605	10.666696	6.295616	0.008324	0.105234
1997	11833.40	612	10.956066	6.466406	0.008549	0.108089
1998	12556.50	616	11.669128	6.887264	0.009106	0.115124
1999	13184.10	620	12.283061	7.249614	0.009585	0.121181
2000	13970.60	629	13.062295	7.709528	0.010193	0.128868
2001	14522.80	650	13.599840	8.026794	0.010612	0.134172
2002	15063.40	655	14.125657	8.337137	0.011023	0.139359
2003	15458.60	671	14.506239	8.561762	0.011320	0.143114
2004	16235.60	685	15.273959	9.014879	0.011919	0.150688
2005	17023.50	688	16.052997	9.474677	0.012527	0.158374
2006	17826.00	694	16.847185	9.943417	0.013146	0.166209
2007	18734.70	704	17.752119	10.477520	0.013853	0.175137
2008	19418.00	729	18.424091	10.874126	0.014377	0.181766
2009	19026.60	730	18.060062	10.659272	0.014093	0.178175
2010	19461.13	696	18.482155	10.908396	0.014422	0.182339
2011	19542.22	677	18.559495	10.954043	0.014483	0.183102
2012	18868.53	664	17.941000	10.589000	0.014000	0.177000
2013	17625.57	618	14.927000	9.679000	0.013500	0.358000
2014	17312.53	601	11.913000	8.769000	0.013000	0.539000
2015	17904.43	623	11.173500	7.092000	0.013000	0.605500
2016	19081.39	634	10.434000	5.415000	0.013000	0.672000

2017	20175.42	625	10.023500	4.920500	0.012500	0.441500
2018	21314.90	645	9.613000	4.426000	0.012000	0.211000
2019	22493.49	649	7.544500	2.213000	0.006000	0.105500
2020	21509.97	609	5.476000	0.000000	0.000000	0.000000
2021	22938.00	613	4.525264	0.00	0.000000	0.000000

(a) Reliable national GDP data is available, courtesy of the Statistical Service of Cyprus (CYSTAT), starting from 1960 – marked by the establishment of the Republic of Cyprus, and using constant market prices of 2005.

GDP data between the years of 1950-59 was extrapolated exponentially to allow for the waste activity to be fitted to that period as well, as shown in Figure; not much growth was to be expected during those years due to the British rule and Cyprus Emergency, and the fitted model is shown to be in accord. The GDP data appear to effectively gauge the socio-political economics of the time period, as they factor in any fluctuations in the market that may economically influence waste activity, as well as by modelling the situation in the aftermath of a war, such as the Turkish invasion of 1974.

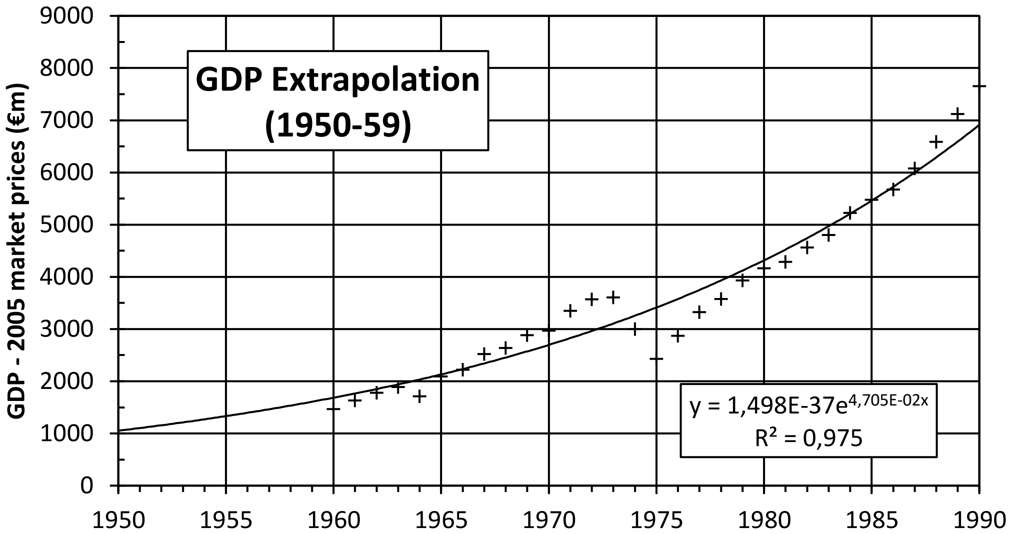


Figure A.3.2.1. GDP data 1960-2014 (CYSTAT) extrapolated for the years of 1950-59.

(b) As illustrated in Figure, the waste activity data showing a linear trend between the years 1996-2009 was used to fit waste per capita to GDP exponentially, and, by association, correlate waste activity with each corresponding year.

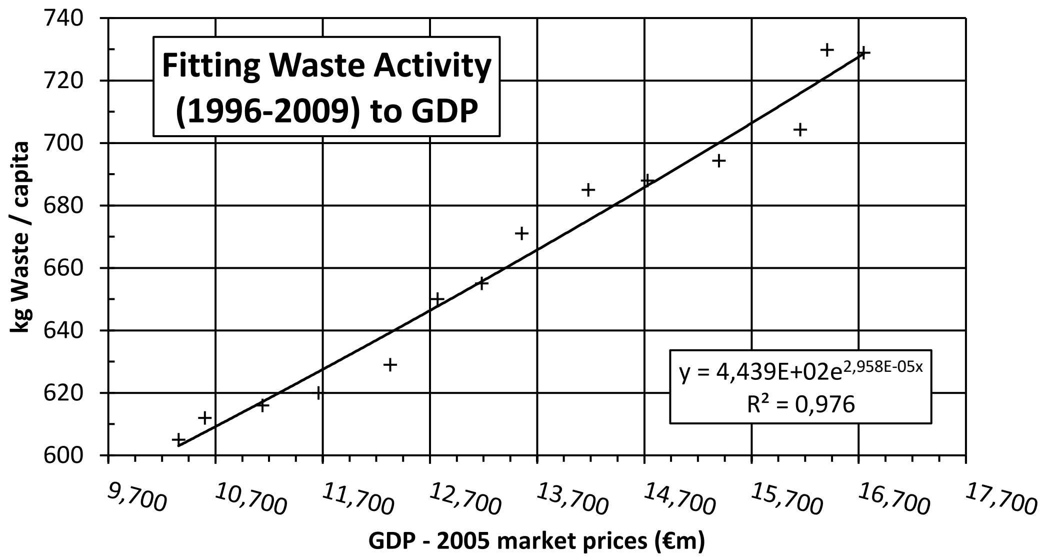


Figure A.3.2.2. Plotting the linear period of waste activity data from 1996-2009 against their corresponding annual GDP, and fitting to an exponential model.

(c) The GDP data from 1950-2014 could now be normalized to waste activity data by relation to the exponential fit determined from plotting waste activity to GDP for 1996-2009 in Figure. Hence, the waste activity data can be hind cast for each year going back to 1950 through a correlation to the annual GDP, as in Figure A.3.2.3.

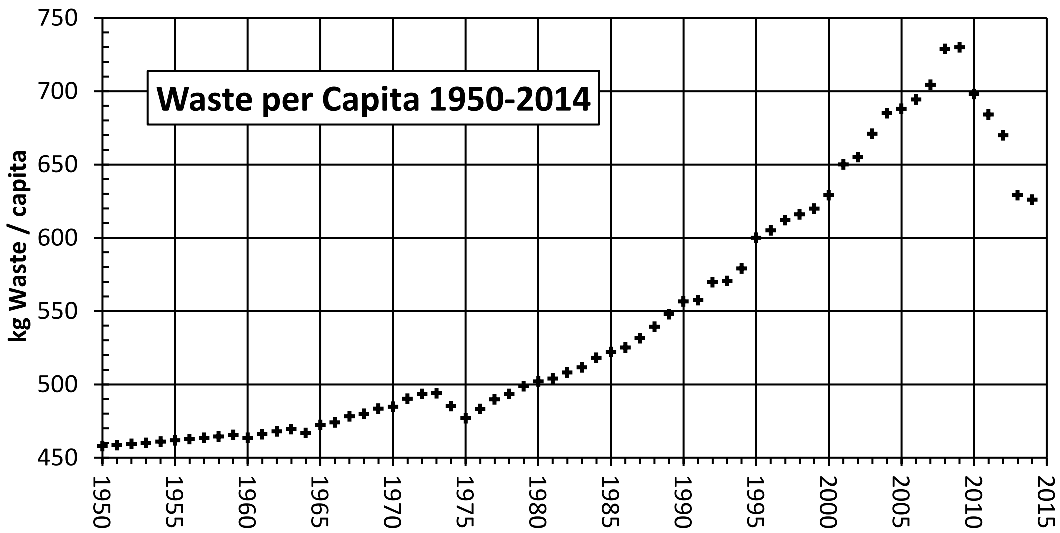


Figure A.3.2.3. Waste per capita derived from annual GDP data and hind casts.

Annex 4: The national energy balance for the most recent inventory year (2021)

The national energy balance prepared by the Statistical Service of Cyprus according to the requirements of Regulation (EC) No 1099/2008 of the European Parliament and of the Council of 22 October 2008 on energy statistics (OJ L 304, 14.11.2008, p. 1–62) is presented in the tables that follow.

Table A.4.1. Energy balance 2021 - Liquid Fuels (LPG, Non-bio gasoline, Non-bio jet kerosene, Other kerosene, Road diesel, Heating and other gas oil, Total gas/diesel oil, Biodiesel), in kt

Flow	LPG	Non-bio gasoline	Non-bio jet kerosene	Other kerosene	Road Diesel	Heating and other gas oil	Total gas/diesel oil	Biodiesel
Indigenous production								
Receipts from other sources								
Solid fuels								
Natural gas								
Renewables								
Backflows	-	-	-	-	-	-	0.000	-
Of which: backflows for direct export or sale	-	-	-	-	-	-	0.000	-
Primary product receipts	-	-	-	-	12.750	-	12.750	12.750
Refinery gross output	-	-	-	-	-	-	0.000	-
Recycled products	-	-	-	-	-	-	0.000	-
Refinery fuel	-	-	-	-	-	-	0.000	-
Imports (Balance)	52.790	294.683	151.761	12.476	443.192	404.901	848.093	15.706
Exports (Balance)	-	-	-	-	-	32.983	32.983	-
International marine bunkers	-	-	-	-	-	113.321	113.321	-
Interproduct transfers	-	-	-	-	-37.047	37.047	0.000	-
Products transferred	-	-	-	-	-	-	0.000	-
Direct use								
Stock changes	3.101	4.977	-0.818	1.002	-23.020	51.267	28.247	-0.579
Refinery intake (Calculated)								
Gross inland deliveries (Calculated)	**55.891**	**299.660**	**150.943**	**13.478**	**395.875**	**346.911**	**742.786**	**27.877**
Statistical difference	*1.272*	*-5.711*	*-1.567*	*-0.014*	*26.501*	*-27.606*	*-1.105*	*-0.579*
Gross inland deliveries (Observed)	**54.619**	**305.371**	**152.510**	**13.492**	**369.374**	**374.517**	**743.891**	**28.456**
Refinery intake (Observed)								

Opening stock level (National territory)	3.494	77.317	37.095	5.056	91.698	111.427	203.125	-
Closing stock level (National territory)	0.393	72.340	37.913	4.054	114.718	60.160	174.878	0.579
Average net calorific value of Production								
Average net calorific value of Imports								
Average net calorific value of Exports								
Average net calorific value of Average	47,300.000	44,300.000	44,100.000	43,800.000	42,537.771	42,734.730	42,637.072	37,000.000
Refinery fuel used for Electricity generation	-	-	-	-	-	-	*0.000*	-
Refinery fuel used CHP production	-	-	-	-	-	-	*0.000*	-
Refinery fuel used Heat production	-	-	-	-	-	-	*0.000*	-
Stock changes at Main activity plants	-	-	-	-	-	-	0.000	-
Refinery losses								
Gross deliveries to Petrochemical industry	-	-	-	-	-	-	0.000	-
Energy use in Petrochemical industry	-	-	-	-	-	-	0.000	-
Non-energy use in Petrochemical industry	-	-	-	-	-	-	0.000	-
Net deliveries of Total products								
Net deliveries to the Petrochemical industry								
Gross inland deliveries for energy use	**54.619**	**305.371**	**152.510**	**13.492**	**369.374**	**374.517**	**743.891**	**28.456**
Transformation sector	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**291.466**	**291.466**	**0.000**
Main activity producer electricity	-	-	-	-	-	289.119	289.119	-
Autoproducer electricity	-	-	-	-	-	2.347	2.347	-
Main activity producer CHP	-	-	-	-	-	-	0.000	-
Autoproducer CHP Plants	-	-	-	-	-	-	0.000	-
Main activity producer heat	-	-	-	-	-	-	0.000	-
Autoproducer heat	-	-	-	-	-	-	0.000	-
Gas works (and other conversion to gases)	-	-	-	-	-	-	0.000	-
Natural gas blending plants	-	-	-	-	-	-	0.000	-
Coke ovens (Transformation)	-	-	-	-	-	-	0.000	-

Blast furnaces (Transformation)	-	-	-	-	-	-	0.000	-
Petrochemical industry	-	-	-	-	-	-	0.000	-
Patent fuel plants (Transformation)	-	-	-	-	-	-	0.000	-
Not elsewhere specified (Transformation)	-	-	-	-	-	-	0.000	-
Energy sector	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Coal mines	-	-	-	-	-	-	0.000	-
Oil and gas extraction	-	-	-	-	-	-	0.000	-
Coke ovens (Energy)	-	-	-	-	-	-	0.000	-
Blast furnaces (Energy)	-	-	-	-	-	-	0.000	-
Gas works (Energy)	-	-	-	-	-	-	0.000	-
Electricity, CHP and Heat	-	-	-	-	-	-	0.000	-
Non elsewhere specified (Energy)	-	-	-	-	-	-	0.000	-
Distribution losses	-	-	-	-	-	-	0.000	-
Total final energy consumption	**54.705**	**305.371**	**152.510**	**13.492**	**369.374**	**83.051**	**452.425**	**28.456**
Transport sector	**0.399**	**305.371**	**151.216**	**0.000**	**332.357**	**0.000**	**332.357**	**27.575**
International aviation	-	-	149.699	-	-	-	0.000	-
Domestic aviation	-	-	1.517	-	-	-	0.000	
Road	0.399	305.371	-	-	331.457	-	331.457	27.500
Rail	-	-	-	-		-	0.000	
Domestic navigation	-		-	-	0.900	-	0.900	0.075
Pipeline transport	-		-	-	-	-	0.000	
Non elsewhere specified (Transport)	-		-	-	-	-	0.000	
Industry sector	**8.026**		**0.000**	**0.006**	**6.211**	**20.602**	**26.813**	**0.515**
Iron and steel	-		-	-	-	-	0.000	-
Chemical and petrochemical	0.287	-	-	-	0.354	1.175	1.529	0.029
Non-ferrous metals	0.764	-	-	-	0.008	0.145	0.153	0.001
Non-metallic minerals	0.714	-	-	-	2.641	2.433	5.074	0.219

Transport equipment	-	-	-	-	0.001	-	0.001	-
Machinery	0.260	-	-		0.136	0.147	0.283	0.011
Mining and Quarrying	-	-	-	-	2.950	2.688	5.638	0.245
Food, beverages and tobacco	5.716		-	0.006	0.073	5.113	5.186	0.006
Paper, pulp and printing	0.142	-	-	-	0.011	0.171	0.182	0.001
Wood and wood products	0.006	-	-	-	0.010	0.038	0.048	0.001
Construction	-	-	-	-		8.655	8.655	-
Textiles and leather	-	-	-	-	0.004	0.006	0.010	-
Not elsewhere specified (Industry)	0.137		-	-	0.023	0.031	0.054	0.002
Other sectors	**46.280**		**1.294**	**13.486**	**30.806**	**62.449**	**93.255**	**0.366**
Commercial and public services	11.123		-	2.022	2.039	12.372	14.411	0.169
Residential	31.307		-	11.455		49.488	49.488	
Agriculture/forestry	2.578		-		22.691		22.691	
Fishing	-		-		1.619		1.619	
Not elsewhere specified (Other)	1.272		1.294	0.009	4.457	0.589	5.046	0.197
Gross inland deliveries for non energy use	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Transformation Sector	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Main activity producer electricity	-	-	-	-	-	-	0.000	-
Autoproducer electricity	-	-	-	-	-	-	0.000	-
Main activity producer CHP	-	-	-	-	-	-	0.000	-
Autoproducer CHP Plants	-	-	-	-	-	-	0.000	-
Main activity producer heat	-	-	-	-	-	-	0.000	-
Autoproducer heat	-	-	-	-	-	-	0.000	-
Gas works (and other conversion to gases)	-	-	-	-	-	-	0.000	-
Natural gas blending plants	-	-	-	-	-	-	0.000	-
Coke ovens (Transformation)	-	-	-	-	-	-	0.000	-
Blast furnaces (Transformation)	-	-	-	-	-	-	0.000	-

Petrochemical industry	-	-	-	-	-	-	0.000	-
Patent fuel plants (Transformation)	-	-	-	-	-	-	0.000	-
Not elsewhere specified (Transformation)	-	-	-	-	-	-	0.000	-
Energy sector	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Coal mines	-	-	-	-	-	-	0.000	-
Oil and gas extraction	-	-	-	-	-	-	0.000	-
Coke ovens (Energy)	-	-	-	-	-	-	0.000	-
Blast furnaces (Energy)	-	-	-	-	-	-	0.000	-
Gas works (Energy)	-	-	-	-	-	-	0.000	-
Electricity, CHP and Heat	-	-	-	-	-	-	0.000	-
Non elsewhere specified (Energy)	-	-	-	-	-	-	0.000	-
Distribution losses	-	-	-	-	-	-	0.000	-
Total final non energy use consumption	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Transport sector	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
International aviation	-	-	-	-	-	-	0.000	-
Domestic aviation	-	-	-	-	-	-	0.000	-
Road	-	-	-	-	-	-	0.000	-
Rail	-	-	-	-	-	-	0.000	-
Domestic navigation	-	-	-	-	-	-	0.000	-
Pipeline transport	-	-	-	-	-	-	0.000	-
Non elsewhere specified (Transport)	-	-	-	-	-	-	0.000	-
Industry sector	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Iron and steel	-	-	-	-	-	-	0.000	-
Chemical and petrochemical	-	-	-	-	-	-	0.000	-
Non-ferrous metals	-	-	-	-	-	-	0.000	-
Non-metallic minerals	-	-	-	-	-	-	0.000	-
Transport equipment	-	-	-	-	-	-	0.000	-

Machinery	-	-	-	-	-	-	0.000	-
Mining and Quarrying	-	-	-	-	-	-	0.000	-
Food, beverages and tobacco	-	-	-	-	-	-	0.000	-
Paper, pulp and printing	-	-	-	-	-	-	0.000	-
Wood and wood products	-	-	-	-	-	-	0.000	-
Construction	-	-	-	-	-	-	0.000	-
Textiles and leather	-	-	-	-	-	-	0.000	-
Not elsewhere specified (Industry)	-	-	-	-	-	-	0.000	-
Other sectors	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Commercial and public services	-	-	-	-	-	-	0.000	-
Residential	-	-	-	-	-	-	0.000	-
Agriculture/forestry	-	-	-	-	-	-	0.000	-
Fishing	-	-	-	-	-	-	0.000	-
Not elsewhere specified (Other)	-	-	-	-	-	-	0.000	-

Table A.4.2. Energy balance 2021 - Liquid Fuels (Non-bio gas/diesel oil, Total fuel oil, Lubricants, Bitumen, Pet-coke), in kt

Flow	Non bio-gas Diesel Oil	Total fuel oil	Lubricants	Bitumen	Pet-Coke
Indigenous production					
Receipts from other sources					
Solid fuels					
Natural gas					
Renewables					
Backflows	-	0.000	-	-	-
Of which: backflows for direct export or sale	-	0.000	-	-	-
Primary product receipts	-	0.000	-	-	-
Refinery gross output	-	0.000	-	-	-
Recycled products	-	4.324	-	-	-
Refinery fuel	-	0.000	-	-	-
Imports (Balance)	832.387	849.611	7.592	36.503	17.101
Exports (Balance)	32.983	0.000	-	-	-
International marine bunkers	113.321	140.508	-	-	-
Interproduct transfers	-	0.000	-	-	-
Products transferred	-	0.000	-	-	-
Direct use					
Stock changes	28.826	-5.940	0.083	-4.914	-3.503
Refinery intake (Calculated)					
Gross inland deliveries (Calculated)	**714.909**	**707.487**	**7.675**	**31.589**	**13.598**
Statistical difference	*-0.526*	*0.375*	*0.001*	*0.706*	*0.999*
Gross inland deliveries (Observed)	**715.435**	**707.112**	**7.674**	**30.883**	**12.599**
Refinery intake (Observed)					
Opening stock level (National territory)	203.125	119.468	0.562	1.128	10.165

Closing stock level (National territory)	174.299	125.408	0.479	6.042	13.668
Average net calorific value of Production					
Average net calorific value of Imports					
Average net calorific value of Exports					
Average net calorific value of Average	42,860.947	40,698.873	40,200.000	40,200.000	32,301.000
Refinery fuel used for Electricity generation	-	*0.000*	-	-	-
Refinery fuel used CHP production	-	*0.000*	-	-	-
Refinery fuel used Heat production	-	*0.000*	-	-	-
Stock changes at Main activity plants	-	0.000	-	-	-
Refinery losses					
Gross deliveries to Petrochemical industry	-	0.000	-	-	-
Energy use in Petrochemical industry	-	0.000	-	-	-
Non-energy use in Petrochemical industry	-	0.000	-	-	-
Net deliveries of Total products					
Net deliveries to the Petrochemical industry					
Gross inland deliveries for energy use	**715.435**	**707.112**	**0.000**	**0.000**	**12.599**
Transformation sector	**291.466**	**679.631**	**0.000**	**0.000**	**0.000**
Main activity producer electricity	289.119	679.631	-	-	-
Autoproducer electricity	2.347	0.000	-	-	-
Main activity producer CHP	-	0.000	-	-	-
Autoproducer CHP Plants	-	0.000	-	-	-
Main activity producer heat	-	0.000	-	-	-
Autoproducer heat	-	0.000	-	-	-
Gas works (and other conversion to gases)	-	0.000	-	-	-
Natural gas blending plants	-	0.000	-	-	-
Coke ovens (Transformation)	-	0.000	-	-	-
Blast furnaces (Transformation)	-	0.000	-	-	-

Petrochemical industry	-	0.000	-	-	-
Patent fuel plants (Transformation)	-	0.000	-	-	-
Not elsewhere specified (Transformation)	-	0.000	-	-	-
Energy sector	**0.000**	**0.036**	**0.000**	**0.000**	**0.000**
Coal mines	-	0.000	-	-	-
Oil and gas extraction	-	0.000	-	-	-
Coke ovens (Energy)	-	0.000	-	-	-
Blast furnaces (Energy)	-	0.000	-	-	-
Gas works (Energy)	-	0.000	-	-	-
Electricity, CHP and Heat	-	0.036	-	-	-
Non elsewhere specified (Energy)	-	0.000	-	-	-
Distribution losses	-	0.000	-	-	-
Total final energy consumption	**423.969**	**27.445**	**0.000**	**0.000**	**12.599**
Transport sector	**304.782**	**0.000**	**0.000**	**0.000**	**0.000**
International aviation	-	0.000	-	-	-
Domestic aviation	-	0.000	-	-	-
Road	303.957	0.000	-	-	-
Rail	-	0.000	-	-	-
Domestic navigation	0.825	0.000	-	-	-
Pipeline transport	-	0.000	-	-	-
Non elsewhere specified (Transport)	-	0.000	-	-	-
Industry sector	**26.298**	**24.885**	**0.000**	**0.000**	**12.599**
Iron and steel	-	0.000	-	-	-
Chemical and petrochemical	1.500	0.368	-	-	-
Non-ferrous metals	0.152	0.000	-	-	-
Non-metallic minerals	4.855	12.529	-	-	12.599
Transport equipment	0.001	0.000	-	-	-

Machinery	0.272	0.000	-	-	-
Mining and Quarrying	5.393	0.000	-	-	-
Food, beverages and tobacco	5.180	10.124	-	-	-
Paper, pulp and printing	0.181	0.811	-	-	-
Wood and wood products	0.047	0.000	-	-	-
Construction	8.655	0.507	-	-	-
Textiles and leather	0.010	0.000	-	-	-
Not elsewhere specified (Industry)	0.052	0.546	-	-	-
Other sectors	**92.889**	**2.560**	**0.000**	**0.000**	**0.000**
Commercial and public services	14.242	2.560	-	-	-
Residential	49.488	0.000	-	-	-
Agriculture/forestry	22.691	0.000	-	-	-
Fishing	1.619	0.000	-	-	-
Not elsewhere specified (Other)	4.849	0.000	-	-	-
Gross inland deliveries for non energy use	**0.000**	**0.000**	**7.674**	**30.883**	**0.000**
Transformation Sector	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Main activity producer electricity	-	-	-	-	-
Autoproducer electricity	-	-	-	-	-
Main activity producer CHP	-	-	-	-	-
Autoproducer CHP Plants	-	-	-	-	-
Main activity producer heat	-	-	-	-	-
Autoproducer heat	-	-	-	-	-
Gas works (and other conversion to gases)	-	-	-	-	-
Natural gas blending plants	-	-	-	-	-
Coke ovens (Transformation)	-	-	-	-	-
Blast furnaces (Transformation)	-	-	-	-	-
Petrochemical industry	-	-	-	-	-

Patent fuel plants (Transformation)	-	-	-	-	-
Not elsewhere specified (Transformation)	-	-	-	-	-
Energy sector	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Coal mines	-	-	-	-	-
Oil and gas extraction	-	-	-	-	-
Coke ovens (Energy)	-	-	-	-	-
Blast furnaces (Energy)	-	-	-	-	-
Gas works (Energy)	-	-	-	-	-
Electricity, CHP and Heat	-	-	-	-	-
Non elsewhere specified (Energy)	-	-	-	-	-
Distribution losses	-	-	-	-	-
Total final non energy use consumption	**0.000**	**0.000**	**7.403**	**30.883**	**0.000**
Transport sector	**0.000**	**0.000**	**2.392**	**0.000**	**0.000**
International aviation	-	-	-	-	-
Domestic aviation	-	-	-	-	-
Road	-	-	2.392	-	-
Rail	-	-	-	-	-
Domestic navigation	-	-	-	-	-
Pipeline transport	-	-	-	-	-
Non elsewhere specified (Transport)	-	-	-	-	-
Industry sector	**0.000**	**0.000**	**5.011**	**30.883**	**0.000**
Iron and steel	-	-	-	-	-
Chemical and petrochemical	-	-	-	-	-
Non-ferrous metals	-	-	-	-	-
Non-metallic minerals	-	-	-	-	-
Transport equipment	-	-	-	-	-
Machinery	-	-	-	-	-

Mining and Quarrying	-	-	-	-	-
Food, beverages and tobacco	-	-	-	-	-
Paper, pulp and printing	-	-	-	-	-
Wood and wood products	-	-	-	-	-
Construction	-	-	-	30.883	-
Textiles and leather	-	-	-	-	-
Not elsewhere specified (Industry)	-	-	5.011	-	-
Other sectors	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Commercial and public services	-	-	-	-	-
Residential	-	-	-	-	-
Agriculture/forestry	-	-	-	-	-
Fishing	-	-	-	-	-
Not elsewhere specified (Other)	-	-	-	-	-

Table A.4.3. Energy balance 2020 – Industrial waste (non-renewable), Municipal waste (renewable), Municipal waste (non-renewable), Solid biofuels, Charcoal, Biogases, in TJ

	Industrial Waste (non-renewable)	Municipal Waste (renewable)	Municipal Waste (non-renewable)	Solid Biofuels	Charcoal	Biogases
Indigenous production	**250.756**	**157.283**	**158.425**	**1,004.592**	**1.313**	**559.040**
Total imports (balance)	16.371	1,258.035	1,197.243	166.224	13.233	-
Total exports (balance)	-	-	-	-	-	-
Stock changes (national territory)	-0.838	66.296	70.403	-4.829	-	-
Inland consumption (calculated)	**266.289**	**1,481.614**	**1,426.071**	**1,165.987**	**14.546**	**559.040**
Statistical differences	-	-	-	-0.097	-	-0.645
Transformation sector	**-**	**-**	**-**	**90.599**	**-**	**335.667**
Main activity producer electricity	-	-	-	-	-	-
Main activity producer CHP	-	-	-	-	-	127.297
Main activity producer heat	-	-	-	-	-	-
Autoproducer electricity	-	-	-	-	-	-
Autoproducer CHP	-	-	-	-	-	208.370
Autoproducer heat	-	-	-	-	-	-
Patent fuel plants (Transformation)	-	-	-	-	-	-
BKB plants (Transformation)	-	-	-	-	-	-
Gas works (Transformation)	-	-	-	-	-	-
Blast furnaces (Transformation)	-	-	-	-	-	-
Natural gas blending plants	-	-	-	-	-	-
For blending with Motor gasoline/Diesel/Kerosene	-	-	-	-	-	-
Charcoal production plants (Transformation)	-	-	-	90.599	-	-
Not elsewhere specified (Transformation)	-	-	-	-	-	-
Energy sector	**-**	**-**	**-**	**-**	**-**	**-**
Gasification plants for Biogas	-	-	-	-	-	-
Own use in electricity, CHP and heat	-	-	-	-	-	-
Coal mines	-	-	-	-	-	-
Patent fuel plants (Energy)	-	-	-	-	-	-
Coke ovens (Energy)	-	-	-	-	-	-
Oil refineries	-	-	-	-	-	-
BKB plants (Energy)	-	-	-	-	-	-
Gas works (Energy)	-	-	-	-	-	-
Blast furnaces (Energy)	-	-	-	-	-	-
Charcoal production plants (energy)	-	-	-	-	-	-
Not elsewhere specified (Energy)	-	-	-	-	-	-
Distribution losses	-	-	-	-	-	-
Total final consumption	**266.289**	**1,481.614**	**1,426.071**	**1,075.485**	**14.546**	**224.018**
Final energy consumption	**266.289**	**1,481.614**	**1,426.071**	**1,075.485**	**14.546**	**224.018**

Industry sector	**266.289**	**1,481.614**	**1,426.071**	**337.726**	**-**	**67.359**
Iron and steel	-	-	-	-	-	-
Chemical and petrochemical	-	-	-	10.800	-	-
Non-ferrous metals	-	-	-	-	-	-
Non-metallic minerals	266.289	1,481.614	1,426.071	279.278	-	-
Transport equipment	-	-	-	-	-	-
Machinery	-	-	-	-	-	-
Mining and quarrying	-	-	-	-	-	-
Food, beverages and tobacco	-	-	-	47.648	-	67.359
Paper, pulp and printing	-	-	-	-	-	-
Wood and wood products	-	-	-	-	-	-
Construction	-	-	-	-	-	-
Textiles and leather	-	-	-	-	-	-
Not elsewhere specified (Industry)	-	-	-	-	-	-
Transport sector	**-**	**-**	**-**	**-**	**-**	**-**
Rail	-	-	-	-	-	-
Road	-	-	-	-	-	-
Domestic navigation	-	-	-	-	-	-
Not elsewhere specified (Transport)	-	-	-	-	-	-
Other sectors	**-**	**-**	**-**	**737.759**	**14.546**	**156.659**
Commercial and public services	-	-	-	126.389	5.818	23.620
Residential	-	-	-	609.969	8.728	-
Agriculture/Forestry	-	-	-	1.401	-	133.039
Fishing	-	-	-	-	-	-
Not elsewhere specified (Other)	-	-	-	-	-	-

Annex 5: Indirect greenhouse gases and SO_2

The role of carbon monoxide (CO), nitrogen oxides (NO_x) and non-methane organic volatile compounds (NMVOC) is important for climate change as these gases act as precursors of tropospheric ozone. In this way, they contribute to ozone formation and alter the atmospheric lifetimes of other greenhouse gases. For example, CO interacts with the hydroxyl radical (OH), the major atmospheric sink for methane, to form carbon dioxide. Therefore, increased atmospheric concentration of CO limits the number of OH compounds available to destroy methane, thus increasing the atmospheric lifetime of methane.

These gases are generated through a variety of anthropogenic activities. Emissions for indirect greenhouse gases and SO_2 are presented in the tables that follow. The emissions have been estimated by the Department of Labour Inspection that is the competent authority for the preparation of air pollutants inventories under Directive 2001/81/EC.

Sectors which are not presented in the tables are reported NO or IE or NA.

Table A5.1.NO_x emissions 1990-2021 (as Gg NO_2)

	1990	1991	1992	1993	1994	1995	1996	1997
1A1a	18.0001	18.8942	19.4686	20.4713	20.7966	19.1539	19.7882	20.6170
1A1b	0.7283	0.7938	0.7112	0.6938	0.8186	0.7796	0.7107	0.7469
1A2a	0.0132	0.0134	0.0109	0.0106	0.0103	0.0105	0.0102	0.0090
1A2b	0.4573	0.4750	0.4473	0.4418	0.4344	0.4395	0.4274	0.4412
1A2c	0.1564	0.1644	0.1525	0.1490	0.1495	0.1674	0.1730	0.1805
1A2d	0.0782	0.0913	0.0927	0.0958	0.1086	0.1151	0.1170	0.1203
1A2e	1.2996	1.4006	1.3093	1.3306	1.3446	1.4128	1.4247	1.4538
1A2f	9.0836	8.6684	8.3906	8.9514	9.0826	8.8042	9.2086	8.7308
1A2gvii	2.2631	2.2941	2.0552	2.0084	1.9577	1.9840	1.9324	1.9069
1A2gviii	2.7678	2.8231	2.5213	2.4720	2.4257	2.4679	2.4016	2.3762
1A3ai(i)	1.7368	1.7795	1.6136	1.5933	1.5665	1.6036	1.5775	1.5721
1A3aii(i)	0.0385	0.0393	0.0426	0.0429	0.0442	0.0471	0.0450	0.0465
1A3bi	16.3165	15.8038	13.5434	12.6586	12.6067	12.4174	11.8904	11.5789
1A3bii	15.6622	16.0155	17.5256	17.9169	18.2613	19.4342	18.9246	18.8936
1A3biii	17.2634	16.1287	16.8976	16.4838	15.6335	16.6287	16.7341	16.9304
1A3biv	0.1648	0.1650	0.1416	0.1302	0.1296	0.1294	0.1245	0.1285
1A3dii	0.1484	0.1445	0.1576	0.1594	0.1585	0.1751	0.1781	0.1849
1A4bi	1.2274	1.3203	1.4152	1.4130	1.5421	1.4870	1.5121	1.5604
1A4ci	0.8837	0.9617	1.0393	1.0305	1.1381	1.0948	1.1174	1.1553
1A4cii	1.1883	1.2932	1.3975	1.3856	1.5305	1.4722	1.5026	1.5535
1A4ciii	0.7456	0.8393	0.9106	0.9220	0.9220	1.0123	1.0359	1.0713
1B2aiv	0.8546	0.9192	0.8605	0.9109	0.9136	0.9683	0.8646	1.1680
1B2c	0.2261	0.2432	0.2276	0.2410	0.2417	0.2562	0.2287	0.3090
2G	0.0386	0.0391	0.0381	0.0103	0.0100	0.0296	0.0305	0.0336
3B1a	0.0918	0.0959	0.0888	0.0930	0.0971	0.1051	0.0947	0.0870
3B1b	0.0732	0.0739	0.0668	0.0712	0.0708	0.0750	0.0817	0.0665
3B2	0.0189	0.0194	0.0168	0.0158	0.0143	0.0142	0.0139	0.0133
3B3	0.0270	0.0294	0.0303	0.0316	0.0305	0.0321	0.0329	0.0340
3B4d	0.0232	0.0235	0.0205	0.0198	0.0204	0.0217	0.0230	0.0285
3B4e	0.0007	0.0007	0.0006	0.0005	0.0005	0.0006	0.0007	0.0008
3B4f	0.0038	0.0035	0.0028	0.0025	0.0022	0.0020	0.0018	0.0016
3B4gi	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3B4gii	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3B4giii	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3B4giv	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3Da1	4.3296	4.2775	4.9848	4.4075	4.2530	3.8549	3.9810	3.0634
3Da2a	1.7115	1.7579	1.6930	1.7979	1.7627	1.8664	1.8687	1.8161
3Da2b	0.0064	0.0067	0.0061	0.0061	0.0061	0.0063	0.0062	0.0062
3Da3	1.9127	1.9496	1.6949	1.6161	1.5648	1.6109	1.6526	1.8578
3F	0.4446	0.4370	0.4108	0.4017	0.3376	0.3070	0.2698	0.2429
5C1biii	0.0055	0.0057	0.0052	0.0052	0.0052	0.0054	0.0053	0.0053
5C2	0.0086	0.0088	0.0080	0.0080	0.0079	0.0082	0.0081	0.0081
TOTAL	100	100	100	100	100	100	100	100

	1998	1999	2000	2001	2002	2003	2004	2005
1A1a	21.9559	22.8905	23.8652	23.6779	24.8651	26.1530	27.2321	29.0020
1A1b	0.7741	0.8544	0.9361	0.8912	0.7638	0.3518	0.1758	NO
1A2a	0.0078	0.0077	0.0077	0.0038	0.0039	0.0028	0.0019	0.0010

1A2b	0.4304	0.4250	0.4213	0.4307	0.4343	0.4250	0.4248	0.4273
1A2c	0.1858	0.1932	0.2011	0.2106	0.2123	0.1898	0.1888	0.1805
1A2d	0.1272	0.1256	0.1293	0.1292	0.1255	0.1133	0.1133	0.1045
1A2e	1.4476	1.4682	1.4936	1.5122	1.5441	1.5490	1.5671	1.6033
1A2f	8.0556	7.9934	8.1614	7.9820	8.3211	8.0436	8.6943	8.5845
1A2gvii	1.8960	1.8782	1.8908	1.9046	1.9278	1.8939	1.9002	1.9198
1A2gviii	2.3221	2.2941	2.2749	2.2750	2.2944	2.2460	2.2459	2.2699
1A3ai(i)	1.5511	1.5490	1.5524	1.5689	1.5991	1.5819	1.5979	1.6563
1A3aii(i)	0.0469	0.0488	0.0516	0.0568	0.0565	0.0560	0.0578	0.1550
1A3bi	10.7951	10.3901	9.8413	9.8863	9.7376	9.5627	9.3153	8.7605
1A3bii	19.0130	18.6268	18.3987	18.4131	17.2327	16.6944	16.1925	15.4616
1A3biii	16.9427	16.5865	16.9083	16.8115	16.1371	17.0653	17.5463	17.6436
1A3biv	0.1295	0.1398	0.1421	0.1559	0.1644	0.1763	0.1893	0.1935
1A3dii	0.1918	0.2136	0.0910	0.0736	0.0969	0.0727	0.1007	0.1242
1A4bi	1.6007	1.6361	1.6556	1.6750	1.7482	1.6361	1.8555	2.3501
1A4ci	1.1896	1.2172	1.2353	1.2469	1.3058	1.2239	1.0668	1.1156
1A4cii	1.5996	1.6368	1.6611	1.6766	1.7559	1.6458	1.3588	1.3591
1A4ciii	1.1131	1.1298	1.1562	1.1599	1.1211	1.1269	1.0137	0.8656
1B2aiv	1.1835	1.2732	1.2552	1.2361	1.1714	1.0239	0.2942	NO
1B2c	0.3131	0.3368	0.3321	0.3270	0.3099	0.2709	0.0778	NO
2G	0.0333	0.0461	0.0858	0.0264	0.0249	0.0176	0.0261	0.0229
3B1a	0.0794	0.0791	0.0767	0.0794	0.0862	0.0856	0.0838	0.0796
3B1b	0.0568	0.0517	0.0508	0.0509	0.0551	0.0524	0.0554	0.0548
3B2	0.0127	0.0122	0.0127	0.0154	0.0153	0.0135	0.0142	0.0138
3B3	0.0337	0.0317	0.0320	0.0349	0.0376	0.0363	0.0346	0.0321
3B4d	0.0296	0.0314	0.0341	0.0384	0.0417	0.0362	0.0336	0.0294
3B4e	0.0009	0.0010	0.0011	0.0012	0.0014	0.0015	0.0014	0.0013
3B4f	0.0014	0.0012	0.0011	0.0010	0.0009	0.0008	0.0007	0.0007
3B4gi	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3B4gii	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3B4giii	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3B4giv	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3Da1	3.0164	3.0064	2.1325	2.1317	2.2321	2.4542	2.5070	2.2792
3Da2a	1.7439	1.6748	1.6646	1.7622	1.8914	1.8292	1.7782	1.6763
3Da2b	0.0061	0.0061	0.0062	0.0062	0.0063	0.0063	0.0064	0.0065
3Da3	1.8775	1.9289	2.0688	2.3791	2.5172	2.1968	2.1178	1.9213
3F	0.2228	0.2012	0.1583	0.1549	0.1468	0.1544	0.1208	0.0948
5C1biii	0.0052	0.0052	0.0052	0.0053	0.0054	0.0013	NO	NO
5C2	0.0080	0.0080	0.0080	0.0081	0.0083	0.0082	0.0083	0.0084
TOTAL	100	100	100	100	100	100	100	100

	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
1A1a	30.3395	32.5395	31.5133	36.8210	33.6065	44.9174	52.1435	40.9526
1A1b	NO	NO	NO	NO	NO	NO	NO	NO
1A2a	NO	NO	0.0428	0.0400	0.0566	0.0454	NO	NO
1A2b	0.4330	0.4503	0.4701	0.2936	0.3196	0.3337	0.1971	0.4379
1A2c	0.1822	0.1440	0.0936	0.1507	0.2161	0.2769	0.2399	0.2185
1A2d	0.1026	0.0915	0.1140	0.1042	0.1089	0.0876	0.0903	0.1336
1A2e	1.6459	1.7368	1.8023	1.7549	1.8396	1.6613	1.7941	2.2190
1A2f	9.0704	9.2770	10.5961	8.9510	8.4042	6.7766	3.2094	5.9756
1A2gvii	1.9545	2.0358	1.7164	1.4568	1.6857	1.3310	0.8160	0.7018
1A2gviii	2.3169	2.3524	0.6662	0.4346	0.3760	0.5281	0.3133	0.6078
1A3ai(i)	1.6663	1.7673	1.9560	1.8903	2.0216	1.7149	1.7051	2.2071
1A3aii(i)	0.1325	0.1232	0.1285	0.1084	0.0958	0.0211	0.0122	0.0026
1A3bi	8.4126	5.7591	5.7165	5.5594	5.8685	4.8736	4.9131	5.6844
1A3bii	14.0518	12.2995	12.7600	11.7054	12.7135	10.3391	9.1552	10.7453
1A3biii	16.9107	18.6694	19.3911	18.3098	20.2959	16.4434	14.8543	16.5972
1A3biv	0.1928	0.2855	0.2976	0.2776	0.2624	0.2244	0.1763	0.2585
1A3dii	0.0963	0.1121	0.1447	0.2813	0.1893	0.1527	0.1093	0.1110
1A4bi	2.3733	2.2256	2.3432	2.2280	2.0346	1.9513	1.9775	2.2957
1A4ci	1.1541	1.0981	1.1359	1.0130	1.0712	0.9649	0.9519	1.2754
1A4cii	1.3683	1.4729	1.5305	1.3623	1.4405	1.2976	1.2801	1.7150
1A4ciii	0.8509	0.9046	0.9553	1.2668	1.3570	0.8876	0.9146	0.8323
1B2aiv	NO	NO	NO	NO	NO	NO	NO	NO
1B2c	NO	NO	NO	NO	NO	NO	NO	0.0425
2G	0.0145	0.0157	0.0163	0.0181	0.0207	0.0147	0.0165	0.0176
3B1a	0.0785	0.0808	0.0862	0.0840	0.0910	0.0815	0.0839	0.1169
3B1b	0.0545	0.0556	0.0583	0.0564	0.0609	0.0544	0.0526	0.0698
3B2	0.0142	0.0140	0.0155	0.0173	0.0203	0.0191	0.0192	0.0236
3B3	0.0342	0.0364	0.0377	0.0371	0.0395	0.0320	0.0294	0.0366
3B4d	0.0313	0.0346	0.0321	0.0281	0.0330	0.0271	0.0261	0.0318

3B4e	0.0013	0.0012	0.0012	0.0011	0.0011	0.0009	0.0009	0.0011
3B4f	0.0006	0.0006	0.0006	0.0005	0.0005	0.0004	0.0005	0.0008
3B4gi	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3B4gii	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3B4giii	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3B4giv	0.0000	0.0000	0.0000	NO	NO	NO	NO	NO
3Da1	2.7245	2.4288	2.3545	1.8535	1.3684	1.1355	1.1968	2.0253
3Da2a	1.6855	1.7750	1.8644	1.8227	1.9719	1.6848	1.6405	2.1147
3Da2b	0.0067	0.0071	0.0077	0.0079	0.0087	0.0078	0.0082	0.0112
3Da3	2.0165	2.1526	2.1124	2.0299	2.3820	2.0769	2.0335	2.4903
3F	0.0733	0.0420	0.0266	0.0213	0.0241	0.0229	0.0248	0.0275
5C1biii	NO	NO	NO	NO	NO	NO	NO	NO
5C2	0.0087	0.0092	0.0101	0.0103	0.0113	0.0101	0.0107	0.0146
TOTAL	100	100	100	100	100	100	100	100

	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
1A1a	42.2969	34.6650	29.2232	26.4668	26.6275	27.2382	23.4831	23.8181
1A1b	NO	NO	NO	NO	NO	NO	NO	NO
1A2a	0.0007	NO	0.0008	0.0005	0.0008	0.0007	0.0008	0.0008
1A2b	0.5881	0.2863	0.1708	0.3014	0.2010	0.2235	0.2084	0.2221
1A2c	0.2639	0.2732	0.2967	0.2832	0.2906	0.3317	0.4077	0.4345
1A2d	0.1293	0.1254	0.1303	0.1106	0.1285	0.1076	0.1535	0.1636
1A2e	2.7942	2.6935	2.9452	3.0221	2.8240	3.1888	3.5523	3.7859
1A2f	6.7901	7.5172	7.2677	7.7252	7.2831	6.6709	8.0611	8.1269
1A2gvii	0.6514	0.6489	0.7359	0.8817	1.0200	1.1419	1.6073	1.7130
1A2gviii	0.6592	0.3238	0.3625	0.5021	1.4735	1.6408	0.5635	0.6005
1A3ai(i)	2.1076	2.4961	2.9229	3.3968	3.5666	3.3043	1.2335	2.1489
1A3aii(i)	0.0011	0.0067	0.0058	0.0028	0.0023	0.0014	0.0009	0.0061
1A3bi	5.1872	6.5737	7.3649	8.3480	8.7893	8.9382	9.1420	11.0342
1A3bii	8.8238	11.6539	13.1097	13.4911	12.8355	12.6207	12.3189	15.2847
1A3biii	17.2212	17.8086	19.6745	19.7855	19.0611	18.2885	20.7832	14.3758
1A3biv	0.2311	0.2636	0.2726	0.2584	0.2371	0.2119	0.1760	0.1436
1A3dii	0.1210	0.1580	0.1175	0.1674	0.1644	0.2049	0.1070	0.2195
1A4bi	1.8471	2.5652	2.7331	2.7302	2.6305	2.7638	2.9118	2.5319
1A4ci	1.1003	1.4256	1.4037	1.4824	1.3975	1.4161	1.6627	1.5719
1A4cii	1.4796	1.9170	1.8875	1.9934	1.8792	1.9042	2.2358	2.1138
1A4ciii	0.7788	0.9120	0.9217	0.8586	0.8407	0.8534	0.7609	0.8383
1B2aiv	NO	NO	NO	NO	NO	NO	NO	NO
1B2c	NO	NO	NO	NO	NO	NO	NO	NO
2G	0.0065	0.0143	0.0135	0.0152	0.0135	0.0133	0.0130	0.0142
3B1a	0.1124	0.1366	0.1501	0.1595	0.1711	0.1785	0.2317	0.2638
3B1b	0.0696	0.0785	0.0842	0.0883	0.0976	0.0908	0.1179	0.1205
3B2	0.0227	0.0246	0.0255	0.0270	0.0265	0.0263	0.0306	0.0294
3B3	0.0327	0.0393	0.0392	0.0391	0.0407	0.0370	0.0439	0.0441
3B4d	0.0285	0.0337	0.0359	0.0377	0.0371	0.0354	0.0423	0.0433
3B4e	0.0009	0.0009	0.0008	0.0008	0.0009	0.0009	0.0011	0.0012
3B4f	0.0008	0.0010	0.0010	0.0012	0.0013	0.0012	0.0015	0.0016
3B4gi	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3B4gii	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3B4giii	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3B4giv	NO	NO	NO	NO	NO	NO	NO	NO
3Da1	2.2716	2.3188	2.8285	2.3094	2.7474	3.1226	3.5947	3.6313
3Da2a	2.0242	2.3516	2.4606	2.5499	2.6884	2.6113	3.2048	3.3816
3Da2b	0.0104	0.0121	0.0122	0.0124	0.0127	0.0122	0.0143	0.0145
3Da3	2.3076	2.6208	2.7553	2.9080	2.8608	2.7734	3.2771	3.2627
3F	0.0212	0.0329	0.0237	0.0202	0.0243	0.0222	0.0294	0.0296
5C1biii	NO	NO	NO	NO	NO	NO	NO	NO
5C2	0.0136	0.0157	0.0159	0.0161	0.0165	0.0159	0.0186	0.0189
TOTAL	100	100	100	100	100	100	100	100

Table A5.2. CO emissions 1990–2021 (Gg)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
1A1a	0.79	0.84	1.00	1.12	1.16	1.11	1.21	1.34
1A2a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1A2b	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03
1A2c	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1A2d	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
1A2e	0.07	0.08	0.08	0.09	0.09	0.10	0.11	0.11
1A2f	4.36	4.24	4.71	5.39	5.59	5.59	6.21	6.23
1A2gvii	0.31	0.32	0.33	0.34	0.34	0.36	0.37	0.38
1A2gviii	0.15	0.15	0.16	0.16	0.16	0.17	0.18	0.19

1A3ai(i)	0.28	0.25	0.31	0.33	0.35	0.38	0.39	0.43
1A3aii(i)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1A3bi	62.16	61.20	58.74	57.53	57.98	57.13	56.40	55.82
1A3bii	13.59	14.53	15.28	15.36	15.50	15.70	15.56	15.64
1A3biii	2.27	2.15	2.59	2.71	2.59	2.80	2.95	3.09
1A3biv	8.73	9.02	9.01	9.00	9.27	9.59	9.84	9.93
1A3dii	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.06
1A4bi	0.90	0.76	0.75	0.97	0.75	0.81	0.76	0.77
1A4ci	0.11	0.12	0.15	0.16	0.18	0.18	0.20	0.21
1A4cii	0.16	0.18	0.22	0.24	0.27	0.27	0.29	0.32
1A4ciii	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.08
1B2aiv	0.13	0.14	0.16	0.18	0.18	0.20	0.19	0.27
1B2c	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04
2G	0.49	0.50	0.56	0.16	0.16	0.49	0.54	0.63
3F	5.30	5.31	5.73	6.00	5.16	4.84	4.51	4.30
5C1biii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5C2	0.06	0.06	0.07	0.07	0.07	0.08	0.08	0.09
TOTAL	100	100	100	100	100	100	100	100

	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
1A1a	1.72	1.92	1.97	2.11	2.27	2.42	2.67	1.72
1A2a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1A2b	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.04
1A2c	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
1A2d	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1A2e	0.13	0.15	0.15	0.16	0.16	0.17	0.22	0.13
1A2f	6.61	7.23	7.30	7.78	7.69	8.49	8.70	6.61
1A2gvii	0.44	0.47	0.49	0.51	0.51	0.52	0.55	0.44
1A2gviii	0.21	0.22	0.23	0.24	0.24	0.24	0.31	0.21
1A3ai(i)	0.52	0.59	0.67	0.68	0.69	0.72	0.77	0.52
1A3aii(i)	0.01	0.01	0.01	0.01	0.02	0.02	0.04	0.01
1A3bi	54.25	53.15	54.41	56.06	56.22	56.93	56.58	54.25
1A3bii	15.68	15.55	15.30	14.03	13.74	12.92	12.62	15.68
1A3biii	3.38	3.58	3.59	3.45	3.69	3.87	4.04	3.38
1A3biv	9.81	9.56	9.43	8.71	8.64	8.47	8.67	9.81
1A3dii	0.08	0.04	0.03	0.04	0.03	0.04	0.06	0.08
1A4bi	0.74	0.67	0.81	0.69	0.59	0.50	0.80	0.74
1A4ci	0.26	0.28	0.30	0.32	0.30	0.27	0.29	0.26
1A4cii	0.39	0.42	0.44	0.47	0.45	0.38	0.39	0.39
1A4ciii	0.09	0.10	0.11	0.10	0.11	0.10	0.09	0.09
1B2aiv	0.34	0.36	0.36	0.35	0.31	0.09	NO	0.34
1B2c	0.05	0.06	0.06	0.06	0.05	0.01	NO	0.05
2G	1.00	1.99	0.63	0.61	0.44	0.67	0.61	1.00
3F	4.13	3.48	3.51	3.40	3.66	2.93	2.38	4.13
5C1biii	0.00	0.00	0.00	0.00	0.00	NO	NO	0.00
5C2	0.10	0.11	0.11	0.12	0.12	0.12	0.13	0.10
TOTAL	100	100	100	100	100	100	100	100

	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
1A1a	2.98	4.03	1.56	3.17	3.28	4.38	4.51	3.68
1A2a	NO	NO	0.01	0.01	0.01	0.01	NO	NO
1A2b	0.05	0.07	0.07	0.05	0.06	0.07	0.04	0.07
1A2c	0.02	0.02	0.01	0.03	0.04	0.27	0.32	0.41
1A2d	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
1A2e	0.24	0.32	0.42	0.45	0.48	0.41	0.40	0.42
1A2f	9.78	12.61	14.65	13.25	11.68	12.14	11.57	18.04
1A2gvii	0.60	0.78	0.70	0.66	0.75	0.73	0.45	0.31
1A2gviii	0.41	0.61	0.11	0.08	0.15	0.11	0.07	0.10
1A3ai(i)	0.81	1.00	1.13	1.09	1.45	1.69	1.76	1.68
1A3aii(i)	0.04	0.05	0.05	0.04	0.04	0.03	0.02	0.00
1A3bi	58.03	45.31	44.92	45.50	46.73	45.13	49.20	42.99
1A3bii	11.58	11.09	11.44	11.11	11.16	10.34	8.73	8.64
1A3biii	4.12	5.39	5.93	6.25	6.84	6.89	6.33	5.56
1A3biv	7.18	13.65	14.08	13.57	12.68	12.93	10.34	12.09
1A3dii	0.05	0.07	0.09	0.20	0.13	0.13	0.10	0.08
1A4bi	0.76	1.74	1.81	1.42	1.11	1.19	2.34	2.12
1A4ci	0.32	0.39	0.43	0.42	0.44	0.49	0.49	0.51
1A4cii	0.42	0.57	0.63	0.62	0.64	0.72	0.72	0.76
1A4ciii	0.09	0.12	0.14	0.20	0.21	0.17	0.18	0.13
1B2aiv	NO	NO	NO	NO	NO	NO	NO	NO
1B2c	NO	NO	NO	NO	NO	NO	NO	0.25

2G	0.41	0.56	0.62	0.76	0.85	0.75	0.85	0.71
3F	1.96	1.42	0.96	0.85	0.94	1.10	1.22	1.06
5C1biii	NO	NO	NO	NO	NO	NO	NO	NO
5C2	0.14	0.19	0.22	0.25	0.27	0.29	0.32	0.34
TOTAL	100	100	100	100	100	100	100	100

	2014	2015	2016	2017	2018	2019	2020	2021
1A1a	4.82	3.81	3.70	3.06	2.81	3.39	3.62	3.88
1A2a	0.00	NO	0.00	0.00	0.00	0.00	0.00	0.00
1A2b	0.10	0.04	0.03	0.04	0.03	0.04	0.03	0.03
1A2c	0.20	0.24	0.12	0.11	0.12	0.11	0.11	0.12
1A2d	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
1A2e	0.60	0.44	0.59	0.68	0.59	0.65	0.66	0.67
1A2f	22.13	20.80	20.09	21.30	20.96	20.10	24.89	23.76
1A2gvii	0.29	0.26	0.28	0.34	0.41	0.48	0.66	0.67
1A2gviii	0.12	0.05	0.05	0.10	0.27	0.30	0.11	0.11
1A3ai(i)	1.66	1.60	1.91	2.22	2.52	2.49	0.91	1.36
1A3aii(i)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
1A3bi	41.10	42.00	42.17	42.06	43.41	43.95	41.48	44.88
1A3bii	7.36	8.06	8.27	8.08	7.81	7.73	7.32	7.87
1A3biii	6.23	5.35	5.64	5.60	5.58	5.69	6.31	4.17
1A3biv	10.84	11.07	10.67	10.12	9.90	9.50	8.01	6.67
1A3dii	0.09	0.10	0.07	0.11	0.11	0.15	0.08	0.15
1A4bi	1.76	2.72	3.47	3.22	2.38	2.18	2.13	2.18
1A4ci	0.45	0.52	0.49	0.52	0.51	0.55	0.63	0.57
1A4cii	0.67	0.77	0.72	0.77	0.75	0.81	0.93	0.84
1A4ciii	0.12	0.13	0.12	0.12	0.12	0.13	0.11	0.12
1B2aiv	NO	NO	NO	NO	NO	NO	NO	NO
1B2c	NO	NO	NO	NO	NO	NO	NO	NO
2G	0.27	0.53	0.48	0.54	0.50	0.53	0.50	0.52
3F	0.83	1.15	0.79	0.68	0.85	0.83	1.07	1.02
5C1biii	NO	NO	NO	NO	NO	NO	NO	NO
5C2	0.32	0.33	0.32	0.33	0.35	0.36	0.41	0.40
TOTAL	100	100	100	100	100	100	100	100

Table A5.3.NMVOCs emissions 1990-2021 (Gg)

	1990	1991	1992	1993	1994	1995	1996	1997
1A1a	0.0520	0.0540	0.0621	0.0669	0.0700	0.0637	0.0677	0.0715
1A1b	0.4100	0.4900	0.4600	0.5000	0.5700	0.5300	0.4900	0.6700
1A2a	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
1A2b	0.0040	0.0041	0.0043	0.0043	0.0044	0.0044	0.0044	0.0046
1A2c	0.0014	0.0014	0.0015	0.0015	0.0015	0.0017	0.0018	0.0019
1A2d	0.0007	0.0008	0.0009	0.0009	0.0011	0.0012	0.0012	0.0013
1A2e	0.0113	0.0120	0.0126	0.0131	0.0136	0.0141	0.0147	0.0152
1A2f	0.0398	0.0378	0.0377	0.0425	0.0419	0.0406	0.0419	0.0402
1A2gvii	0.0418	0.0419	0.0419	0.0419	0.0421	0.0421	0.0422	0.0423
1A2gviii	0.0241	0.0243	0.0242	0.0243	0.0245	0.0247	0.0247	0.0248
1A3ai(i)	0.0126	0.0107	0.0130	0.0134	0.0142	0.0149	0.0147	0.0154
1A3aii(i)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003
1A3bi	2.9353	2.8278	2.6806	2.5275	2.5767	2.4611	2.3762	2.2569
1A3bii	0.5508	0.5709	0.5896	0.5704	0.5806	0.5841	0.5769	0.5745
1A3biii	0.4128	0.3790	0.4434	0.4432	0.4209	0.4301	0.4336	0.4281
1A3biv	1.4343	1.4559	1.4304	1.3822	1.4500	1.4441	1.4406	1.3854
1A3bv	1.5477	1.5109	1.4492	1.4107	1.4229	1.3743	1.3216	1.2779
1A3dii	0.0051	0.0049	0.0060	0.0062	0.0064	0.0070	0.0073	0.0077
1A4bi	0.0485	0.0397	0.0375	0.0471	0.0359	0.0375	0.0339	0.0328
1A4ci	0.0103	0.0111	0.0134	0.0136	0.0154	0.0147	0.0154	0.0162
1A4cii	0.0218	0.0234	0.0283	0.0287	0.0327	0.0311	0.0326	0.0342
1A4ciii	0.0066	0.0073	0.0089	0.0092	0.0095	0.0103	0.0108	0.0113
1B2aiv	0.1271	0.1351	0.1412	0.1532	0.1581	0.1656	0.1521	0.2085
1B2av	0.7159	0.7083	0.7588	0.7662	0.7843	0.8057	0.8188	0.8397
1B2c	0.0015	0.0016	0.0017	0.0018	0.0019	0.0019	0.0018	0.0025
2C1	0.0003	0.0002	0.0003	0.0003	0.0003	0.0003	0.0002	0.0002
2D3a	0.1217	0.1248	0.1282	0.1316	0.1345	0.1372	0.1395	0.1416
2D3b	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075
2D3c	0.0325	0.0325	0.0325	0.0325	0.0325	0.0325	0.0325	0.0325
2D3d	1.7387	1.4241	1.5170	1.5202	1.7083	1.4102	1.4097	1.5604
2D3f	0.2002	0.2003	0.2003	0.2004	0.2005	0.2006	0.2007	0.2008
2D3g	0.0388	0.0388	0.0388	0.0413	0.0442	0.0471	0.0498	0.0474
2D3h	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
2D3i	0.0000	0.0000	0.0000	0.0000	0.0000	0.6081	0.6514	0.4679

2G	0.0185	0.0185	0.0202	0.0056	0.0056	0.0163	0.0173	0.0193
2H2	0.2599	0.2902	0.3244	0.3288	0.3350	0.3498	0.3534	0.3439
3B1a	0.4020	0.4147	0.4286	0.4600	0.4946	0.5288	0.4900	0.4572
3B1b	0.2873	0.2841	0.2841	0.3156	0.3275	0.3440	0.3807	0.3288
3B2	0.0490	0.0499	0.0482	0.0465	0.0431	0.0423	0.0426	0.0414
3B3	0.1921	0.2065	0.2373	0.2538	0.2517	0.2619	0.2765	0.2900
3B4d	0.1111	0.1111	0.1084	0.1073	0.1138	0.1192	0.1301	0.1637
3B4e	0.0020	0.0018	0.0017	0.0016	0.0015	0.0019	0.0023	0.0027
3B4f	0.0071	0.0064	0.0058	0.0052	0.0047	0.0043	0.0039	0.0035
3B4gi	0.1057	0.1025	0.0983	0.1277	0.1246	0.1261	0.1316	0.1224
3B4gii	0.3232	0.2953	0.3438	0.4027	0.3783	0.3913	0.4196	0.4334
3B4giii	0.0263	0.0198	0.0238	0.0183	0.0217	0.0287	0.0275	0.0244
3B4giv	0.0033	0.0035	0.0048	0.0050	0.0049	0.0065	0.0051	0.0060
3De	0.0495	0.0506	0.0560	0.0594	0.0546	0.0523	0.0507	0.0499
3F	0.0173	0.0168	0.0176	0.0176	0.0152	0.0137	0.0124	0.0113
5A	0.1669	0.1699	0.1731	0.1768	0.1806	0.1846	0.1893	0.1941
5C1biii	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
5C2	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0007	0.0007
5D1	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
TOTAL	12.778	12.424	12.549	12.536	12.965	13.222	13.151	13.115

	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
1A1a	0.0781	0.0824	0.0867	0.0861	0.0896	0.0963	0.1004	0.1062
1A1b	0.6900	0.7500	0.6900	0.7300	0.6800	0.7300	0.2500	NO
1A2a	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
1A2b	0.0046	0.0046	0.0046	0.0047	0.0047	0.0047	0.0047	0.0047
1A2c	0.0020	0.0021	0.0022	0.0023	0.0023	0.0021	0.0021	0.0020
1A2d	0.0014	0.0014	0.0014	0.0014	0.0014	0.0013	0.0013	0.0012
1A2e	0.0155	0.0159	0.0163	0.0165	0.0167	0.0172	0.0174	0.0227
1A2f	0.0376	0.0396	0.0405	0.0386	0.0423	0.0448	0.0516	0.0489
1A2gvii	0.0431	0.0432	0.0439	0.0442	0.0444	0.0446	0.0447	0.0449
1A2gviii	0.0248	0.0249	0.0249	0.0249	0.0249	0.0249	0.0249	0.0326
1A3ai(i)	0.0159	0.0168	0.0179	0.0197	0.0195	0.0197	0.0204	0.0305
1A3aii(i)	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0012
1A3bi	2.0864	1.9922	1.8551	1.8363	1.8204	1.8190	1.7502	1.6160
1A3bii	0.5701	0.5620	0.5502	0.5340	0.4866	0.4771	0.4467	0.4190
1A3biii	0.4233	0.4056	0.3970	0.3755	0.3397	0.3491	0.3471	0.3377
1A3biv	1.2870	1.1943	1.0943	1.0178	0.8327	0.8188	0.7760	0.7724
1A3bv	1.2252	1.1757	1.1157	1.0959	1.0801	1.0932	1.0801	1.0746
1A3dii	0.0082	0.0092	0.0040	0.0032	0.0042	0.0032	0.0044	0.0054
1A4bi	0.0286	0.0278	0.0234	0.0278	0.0227	0.0191	0.0156	0.0221
1A4ci	0.0171	0.0177	0.0181	0.0183	0.0190	0.0182	0.0159	0.0165
1A4cii	0.0361	0.0374	0.0383	0.0387	0.0545	0.0385	0.0318	0.0316
1A4ciii	0.0121	0.0124	0.0128	0.0129	0.0124	0.0127	0.0115	0.0097
1B2aiv	0.2166	0.2359	0.2347	0.2312	0.2173	0.1940	0.0558	NO
1B2av	0.8621	0.8918	0.9084	0.9627	1.0075	1.1418	1.2437	1.3311
1B2c	0.0025	0.0028	0.0028	0.0027	0.0026	0.0023	0.0007	NO
2C1	0.0003	0.0003	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
2D3a	0.1435	0.1451	0.1468	0.1483	0.1500	0.1517	0.1537	0.1558
2D3b	0.0075	0.0075	0.0084	0.0069	0.0075	0.0071	0.0085	0.0068
2D3c	0.0325	0.0325	0.0366	0.0298	0.0324	0.0308	0.0368	0.0293
2D3d	1.4476	1.4578	1.6020	1.4785	2.2579	2.8364	3.5522	3.8150
2D3f	0.2009	0.2012	0.2021	0.2005	0.2004	0.2001	0.1998	0.1930
2D3g	0.0490	0.0512	0.0500	0.0597	0.0636	0.0625	0.0674	0.0574
2D3h	0.2000	0.3273	0.3355	0.3801	0.3075	0.2884	0.3399	0.3446
2D3i	0.5252	1.2130	1.0110	0.9230	1.1443	1.4365	1.8157	2.7000
2G	0.0197	0.0275	0.0518	0.0159	0.0149	0.0107	0.0160	0.0139
2H2	0.3154	0.3168	0.2911	0.2805	0.2746	0.2747	0.2529	0.2569
3B1a	0.4273	0.4314	0.4217	0.4370	0.4705	0.4773	0.4678	0.4410
3B1b	0.2850	0.2688	0.2730	0.2588	0.2842	0.2840	0.3047	0.2937
3B2	0.0406	0.0394	0.0416	0.0501	0.0497	0.0447	0.0471	0.0454
3B3	0.2951	0.2815	0.2851	0.3129	0.3357	0.3330	0.3189	0.2951
3B4d	0.1745	0.1875	0.2052	0.2315	0.2490	0.2211	0.2049	0.1785
3B4e	0.0030	0.0034	0.0038	0.0042	0.0046	0.0050	0.0047	0.0045
3B4f	0.0032	0.0029	0.0026	0.0023	0.0021	0.0019	0.0017	0.0016
3B4gi	0.1389	0.1191	0.0908	0.0990	0.0990	0.0990	0.1337	0.1070
3B4gii	0.4304	0.4358	0.4536	0.4536	0.4709	0.4687	0.3977	0.4025
3B4giii	0.0266	0.0251	0.0318	0.0284	0.0298	0.0293	0.0215	0.0161
3B4giv	0.0065	0.0069	0.0073	0.0071	0.0078	0.0073	0.0054	0.0050
3De	0.0508	0.0507	0.0443	0.0481	0.0509	0.0625	0.0571	0.0534
3F	0.0106	0.0097	0.0077	0.0076	0.0071	0.0076	0.0060	0.0047

5A	0.1990	0.2039	0.2089	0.2140	0.2196	0.2253	0.2313	0.2375
5C1biii	0.0004	0.0004	0.0004	0.0004	0.0004	0.0001	NO	NO
5C2	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007
5D1	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
TOTAL	12.723	13.394	12.998	12.805	13.562	14.540	14.944	15.591

	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
1A1a	0.1095	0.1132	0.1176	0.1108	0.1009	0.1800	0.2855	0.0640
1A1b	NO	NO	NO	NO	NO	NO	NO	NO
1A2a	NO	NO	0.0004	0.0004	0.0005	0.0005	NO	NO
1A2b	0.0047	0.0047	0.0046	0.0029	0.0029	0.0035	0.0020	0.0033
1A2c	0.0020	0.0015	0.0009	0.0015	0.0020	0.0176	0.0201	0.0247
1A2d	0.0011	0.0010	0.0011	0.0010	0.0010	0.0009	0.0009	0.0010
1A2e	0.0233	0.0240	0.0287	0.0283	0.0292	0.0214	0.0191	0.0191
1A2f	0.0488	0.0489	0.0620	0.0533	0.0517	0.0355	0.0301	0.0351
1A2gvii	0.0451	0.0452	0.0356	0.0304	0.0328	0.0298	0.0177	0.0112
1A2gviii	0.0420	0.0500	0.0067	0.0043	0.0097	0.0056	0.0032	0.0046
1A3ai(i)	0.0256	0.0193	0.0193	0.0164	0.0225	0.0242	0.0249	0.0222
1A3aii(i)	0.0010	0.0008	0.0008	0.0005	0.0004	0.0004	0.0002	0.0000
1A3bi	1.5100	0.8088	0.6761	0.6315	0.6060	0.5455	0.5775	0.4611
1A3bii	0.3582	0.3154	0.2836	0.2461	0.2389	0.1968	0.1603	0.1380
1A3biii	0.3112	0.2487	0.2292	0.2067	0.2058	0.1826	0.1534	0.1275
1A3biv	0.5545	1.0267	0.9529	0.8446	0.7516	0.7118	0.5397	0.5807
1A3bv	1.0394	1.1335	1.0567	1.0387	1.0025	0.9931	0.9624	0.9309
1A3dii	0.0042	0.0047	0.0056	0.0110	0.0069	0.0064	0.0044	0.0033
1A4bi	0.0191	0.0365	0.0332	0.0228	0.0165	0.0160	0.0334	0.0283
1A4ci	0.0168	0.0154	0.0149	0.0134	0.0132	0.0136	0.0131	0.0129
1A4cii	0.0313	0.0325	0.0316	0.0283	0.0279	0.0288	0.0276	0.0272
1A4ciii	0.0094	0.0097	0.0095	0.0127	0.0127	0.0095	0.0096	0.0064
1B2aiv	NO	NO	NO	NO	NO	NO	NO	NO
1B2av	0.8722	0.9500	1.0874	1.1192	1.1003	1.0844	0.9899	0.8577
1B2c	NO	NO	NO	NO	NO	NO	NO	0.0084
2C1	NO	NO	NO	NO	NO	NO	NO	NO
2D3a	0.1581	0.1611	0.1650	0.1694	0.1741	0.1785	0.1832	0.1840
2D3b	0.0061	0.0057	0.0054	0.0091	0.0122	0.0119	0.0093	0.0049
2D3c	0.0265	0.0246	0.0233	0.0396	0.0529	0.0516	0.0403	0.0213
2D3d	4.0272	4.3205	3.3507	3.1421	3.4997	1.1160	1.1342	0.9821
2D3f	0.1100	0.1110	0.0789	0.0602	0.0605	0.0600	0.0539	0.0265
2D3g	0.0600	0.0580	0.0254	0.0278	0.0302	0.0137	0.0145	0.0120
2D3h	0.3628	0.3195	0.4469	0.3260	0.2464	0.3347	0.2658	0.2072
2D3i	3.2695	3.2380	2.9884	2.3994	1.8690	0.4266	0.3943	0.2213
2G	0.0087	0.0091	0.0088	0.0098	0.0105	0.0086	0.0093	0.0073
2H2	0.2380	0.2385	0.2351	0.2116	0.2099	0.2082	0.1862	0.1607
3B1a	0.4293	0.4251	0.4240	0.4160	0.4201	0.4317	0.4323	0.4430
3B1b	0.2864	0.2776	0.2853	0.2751	0.2786	0.2924	0.2922	0.2896
3B2	0.0460	0.0438	0.0452	0.0507	0.0556	0.0602	0.0586	0.0530
3B3	0.3105	0.3196	0.3119	0.3095	0.3089	0.2887	0.2594	0.2376
3B4d	0.1870	0.1995	0.1726	0.1522	0.1666	0.1573	0.1470	0.1318
3B4e	0.0042	0.0040	0.0037	0.0035	0.0032	0.0030	0.0027	0.0025
3B4f	0.0014	0.0013	0.0012	0.0010	0.0009	0.0009	0.0010	0.0012
3B4gi	0.1054	0.0957	0.1003	0.0998	0.0916	0.0980	0.1072	0.1058
3B4gii	0.3346	0.3640	0.3523	0.3428	0.3482	0.3320	0.3056	0.2636
3B4giii	0.0157	0.0107	0.0097	0.0072	0.0069	0.0052	0.0042	0.0045
3B4giv	0.0031	0.0026	0.0012	NO	NO	NO	NO	NO
3De	0.0509	0.0375	0.0333	0.0268	0.0283	0.0309	0.0325	0.0265
3F	0.0036	0.0020	0.0012	0.0009	0.0010	0.0011	0.0011	0.0009
5A	0.2437	0.2505	0.2576	0.2650	0.2724	0.2799	0.2863	0.2934
5C1biii	NO	NO	NO	NO	NO	NO	NO	NO
5C2	0.0007	0.0008	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009
5D1	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004
TOTAL	15.319	15.411	13.987	12.771	12.385	8.500	8.098	7.050

	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
1A1a	0.0766	0.0828	0.0852	0.0762	0.0784	0.0757	0.0608	0.0677
1A1b	NO	NO	NO	NO	NO	NO	NO	NO
1A2a	0.0000	NO	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1A2b	0.0047	0.0020	0.0012	0.0020	0.0013	0.0016	0.0013	0.0013
1A2c	0.0118	0.0140	0.0070	0.0061	0.0061	0.0057	0.0050	0.0053
1A2d	0.0010	0.0009	0.0009	0.0007	0.0009	0.0008	0.0009	0.0010
1A2e	0.0295	0.0197	0.0298	0.0349	0.0277	0.0295	0.0261	0.0275
1A2f	0.0410	0.0394	0.0380	0.0412	0.0383	0.0388	0.0393	0.0398

1A2gvii	0.0111	0.0094	0.0106	0.0126	0.0144	0.0169	0.0207	0.0219
1A2gviii	0.0053	0.0022	0.0025	0.0051	0.0120	0.0130	0.0042	0.0044
1A3ai(i)	0.0237	0.0212	0.0278	0.0313	0.0324	0.0288	0.0093	0.0163
1A3aii(i)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0001
1A3bi	0.4635	0.4511	0.5407	0.5707	0.5941	0.6313	0.5636	0.7111
1A3bii	0.1186	0.1275	0.1378	0.1316	0.1190	0.1168	0.1002	0.1182
1A3biii	0.1704	0.1193	0.1324	0.1191	0.1092	0.1078	0.1059	0.0732
1A3biv	0.5329	0.5268	0.5111	0.4797	0.4396	0.4110	0.3016	0.2584
1A3bv	0.9575	0.9314	0.9068	0.9395	0.9468	0.9544	0.9041	0.7774
1A3dii	0.0038	0.0042	0.0031	0.0044	0.0042	0.0056	0.0025	0.0051
1A4bi	0.0243	0.0371	0.0502	0.0456	0.0310	0.0273	0.0237	0.0258
1A4ci	0.0118	0.0131	0.0127	0.0134	0.0124	0.0133	0.0135	0.0127
1A4cii	0.0251	0.0276	0.0269	0.0283	0.0263	0.0281	0.0286	0.0268
1A4ciii	0.0064	0.0064	0.0064	0.0059	0.0057	0.0061	0.0047	0.0051
1B2aiv	NO	NO	NO	NO	NO	NO	NO	NO
1B2av	0.7972	0.7822	0.6591	0.5892	0.4478	0.4193	0.3559	0.3821
1B2c	NO	NO	NO	NO	NO	NO	NO	NO
2C1	NO	NO	NO	NO	NO	NO	NO	NO
2D3a	0.1824	0.1624	0.1621	0.1460	0.2884	0.2594	0.3241	0.2551
2D3b	0.0023	0.0020	0.0020	0.0026	0.0033	0.0026	0.0024	0.0024
2D3c	0.0098	0.0086	0.0089	0.0111	0.0145	0.0112	0.0103	0.0103
2D3d	0.8677	1.0721	1.1182	1.2681	1.4052	1.4971	1.4389	1.5116
2D3f	0.0262	0.0527	0.0261	0.0132	0.0262	0.0267	0.0265	0.0269
2D3g	0.0099	0.0111	0.0110	0.0107	0.0118	0.0114	0.0105	0.0105
2D3h	0.2618	0.2526	0.2650	0.2655	0.2273	0.2458	0.1560	0.1604
2D3i	0.1558	0.1619	0.1850	0.6264	0.3097	0.1952	0.3691	0.3857
2G	0.0029	0.0054	0.0051	0.0056	0.0049	0.0051	0.0044	0.0047
2H2	0.1561	0.1535	0.1572	0.1668	0.1655	0.1769	0.1609	0.1609
3B1a	0.4543	0.4698	0.5112	0.5406	0.5718	0.6281	0.7084	0.7983
3B1b	0.3046	0.2908	0.3075	0.3258	0.3462	0.3459	0.3864	0.3870
3B2	0.0545	0.0502	0.0514	0.0543	0.0526	0.0548	0.0555	0.0527
3B3	0.2277	0.2344	0.2319	0.2312	0.2385	0.2282	0.2352	0.2344
3B4d	0.1258	0.1268	0.1337	0.1396	0.1357	0.1361	0.1413	0.1433
3B4e	0.0022	0.0020	0.0017	0.0017	0.0018	0.0020	0.0020	0.0022
3B4f	0.0013	0.0014	0.0015	0.0017	0.0018	0.0018	0.0020	0.0021
3B4gi	0.0980	0.0915	0.0950	0.0941	0.0926	0.1019	0.0990	0.1063
3B4gii	0.3320	0.2813	0.2890	0.3000	0.3136	0.3225	0.3207	0.3209
3B4giii	0.0047	0.0048	0.0047	0.0058	0.0049	0.0059	0.0043	0.0046
3B4giv	NO	NO	NO	NO	NO	NO	NO	NO
3De	0.0218	0.0287	0.0205	0.0174	0.0206	0.0198	0.0228	0.0227
3F	0.0008	0.0010	0.0007	0.0006	0.0007	0.0007	0.0008	0.0008
5A	0.2986	0.3019	0.3057	0.3098	0.3136	0.3173	0.3208	0.3232
5C1biii	NO	NO	NO	NO	NO	NO	NO	NO
5C2	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009
5D1	0.0004	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006
TOTAL	6.919	6.986	7.086	7.678	7.501	7.530	7.376	7.510

Table A5.4.SO$_x$ emissions 1990–2021 (as Gg SO_2)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
1A1a	67.7215	68.3835	68.7223	69.6905	69.4509	66.8693	67.5827	67.6458
1A1b	1.8485	1.8302	1.6484	1.5536	1.7920	1.7665	1.5854	1.6372
1A2a	0.0172	0.0168	0.0133	0.0125	0.0119	0.0126	0.0120	0.0102
1A2b	0.5953	0.5948	0.5450	0.5200	0.5018	0.5300	0.5044	0.5002
1A2c	0.2036	0.2059	0.1858	0.1754	0.1726	0.2019	0.2042	0.2046
1A2d	0.1018	0.1144	0.1130	0.1128	0.1254	0.1388	0.1381	0.1364
1A2e	1.6918	1.7539	1.5952	1.5662	1.5530	1.7034	1.6815	1.6485
1A2f	1.5118	1.3875	1.3098	1.3486	1.3447	1.3606	1.3945	1.2703
1A2gvii	0.7757	0.7565	0.6594	0.6225	0.5954	0.6299	0.6005	0.5694
1A2gviii	3.6030	3.5353	3.0718	2.9096	2.8017	2.9756	2.8345	2.6945
1A3ai(i)	0.0824	0.0793	0.0683	0.0635	0.0598	0.0624	0.0586	0.0548
1A3aii(i)	0.0013	0.0011	0.0011	0.0011	0.0011	0.0012	0.0011	0.0011
1A3bi	3.3948	3.2340	3.0635	2.9120	2.8506	3.1500	3.1223	3.1413
1A3bii	6.2811	6.1398	6.7897	6.8106	6.8488	8.0604	7.9856	7.9479
1A3biii	5.0049	4.4944	4.5836	4.3089	4.0353	4.5082	4.4675	4.3750
1A3biv	0.0623	0.0608	0.0507	0.0453	0.0445	0.0456	0.0420	0.0379
1A3dii	0.0086	0.0081	0.0086	0.0084	0.0082	0.0094	0.0094	0.0094
1A4bi	4.4410	4.6478	4.8859	4.6808	5.0718	5.0932	5.0880	5.0539
1A4ci	0.7714	0.8076	0.8491	0.8133	0.8815	0.8852	0.8844	0.8785
1A4cii	0.3857	0.4038	0.4246	0.4067	0.4408	0.4426	0.4422	0.4392
1A4ciii	0.0259	0.0281	0.0297	0.0290	0.0285	0.0326	0.0327	0.0325
1B2aiv	1.2346	1.2775	1.1634	1.1898	1.1711	1.2956	1.1324	1.4698
1B2c	0.1803	0.1865	0.1699	0.1737	0.1710	0.1892	0.1654	0.2146

2G	0.0004	0.0004	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003
3F	0.0540	0.0511	0.0467	0.0442	0.0364	0.0346	0.0297	0.0257
5C1biii	0.0007	0.0007	0.0006	0.0006	0.0006	0.0007	0.0006	0.0006
5C2	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
TOTAL	100	100	100	100	100	100	100	100

	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
1A1a	68.6673	69.2456	68.9036	65.9164	66.7839	70.0041	77.8741	90.0384
1A1b	1.5843	1.7146	1.3866	2.1657	2.3336	1.5320	0.7936	NO
1A2a	0.0084	0.0081	0.0084	0.0044	0.0044	0.0032	0.0025	0.0013
1A2b	0.4647	0.4438	0.4622	0.4972	0.4953	0.4788	0.5580	0.5942
1A2c	0.2007	0.2017	0.2206	0.2431	0.2422	0.2138	0.2480	0.2510
1A2d	0.1373	0.1311	0.1418	0.1492	0.1431	0.1277	0.1488	0.1453
1A2e	1.5632	1.5330	1.6387	1.7458	1.7612	1.7448	2.0585	2.2202
1A2f	1.1165	1.0698	1.1488	1.1817	1.2151	1.1580	1.4566	1.5204
1A2gvii	0.5391	0.5164	0.5462	0.5790	0.5790	0.5617	0.0230	0.0035
1A2gviii	2.5074	2.3954	2.4959	2.6265	2.6171	2.5300	2.9501	3.1427
1A3ai(i)	0.0502	0.0473	0.0486	0.0504	0.0495	0.0472	0.0542	0.0544
1A3aii(i)	0.0011	0.0011	0.0012	0.0014	0.0014	0.0014	0.0016	0.0045
1A3bi	3.0342	2.9429	2.8477	3.1951	2.9990	2.6157	1.2290	0.0907
1A3bii	7.9660	7.8086	7.5051	8.2443	7.5916	6.9180	2.9201	0.0504
1A3biii	4.1899	3.9778	3.8179	4.1356	3.8105	3.8211	1.6989	0.0298
1A3biv	0.0324	0.0289	0.0271	0.0268	0.0237	0.0169	0.0092	0.0016
1A3dii	0.0093	0.0100	0.0045	0.0038	0.0049	0.0037	0.0059	0.0077
1A4bi	4.9550	4.9026	5.2277	5.5526	5.7447	5.3174	6.0405	1.4963
1A4ci	0.8614	0.8523	1.1177	1.1491	1.1712	0.9245	0.9397	0.2080
1A4cii	0.4307	0.4261	0.6471	0.6630	0.6781	0.4623	0.4450	0.0942
1A4ciii	0.0321	0.0315	0.0339	0.0360	0.0344	0.0342	0.0358	0.0324
1B2aiv	1.4182	1.4753	1.5283	1.5837	1.4827	1.2799	0.4288	NO
1B2c	0.2071	0.2154	0.2232	0.2313	0.2165	0.1869	0.0626	NO
2G	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
3F	0.0225	0.0196	0.0162	0.0167	0.0156	0.0162	0.0148	0.0123
5C1biii	0.0006	0.0006	0.0006	0.0006	0.0006	0.0001	NO	NO
5C2	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002
TOTAL	100	100	100	100	100	100	100	100

	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
1A1a	87.8653	87.4380	92.2729	91.3914	93.4449	93.2913	91.8980	89.6095
1A1b	NO	NO	NO	NO	NO	NO	NO	NO
1A2a	NO	NO	0.0360	0.0427	0.0456	0.0440	NO	NO
1A2b	0.7173	0.7711	0.3948	0.3136	0.2573	0.3233	0.2402	0.4665
1A2c	0.3017	0.2466	0.0786	0.1610	0.1740	0.2506	0.2650	0.1901
1A2d	0.1700	0.1566	0.0958	0.1113	0.0877	0.0848	0.1101	0.1424
1A2e	2.7146	2.9605	1.5011	1.8587	1.4670	1.6045	2.1854	2.3596
1A2f	1.9164	2.0247	3.1502	3.6164	2.7858	2.4788	2.8814	4.7243
1A2gvii	0.0043	0.0046	0.0047	0.0010	0.0009	0.0008	0.0007	0.0005
1A2gviii	3.8015	3.9690	0.5592	0.4642	0.2955	0.3052	0.3818	0.4537
1A3ai(i)	0.0651	0.0708	0.0947	0.1142	0.1000	0.1060	0.1335	0.1459
1A3aii(i)	0.0045	0.0044	0.0056	0.0060	0.0045	0.0015	0.0011	0.0002
1A3bi	0.1156	0.1267	0.1763	0.0460	0.0381	0.0395	0.0495	0.0547
1A3bii	0.0556	0.0633	0.0812	0.0196	0.0159	0.0157	0.0173	0.0179
1A3biii	0.0346	0.0446	0.0565	0.0139	0.0117	0.0116	0.0131	0.0128
1A3biv	0.0018	0.0031	0.0042	0.0010	0.0008	0.0008	0.0008	0.0011
1A3dii	0.0071	0.0086	0.0068	0.0170	0.0087	0.0086	0.0078	0.0070
1A4bi	1.8053	1.6806	1.2083	1.4979	1.0026	1.1634	1.4770	1.4343
1A4ci	0.2564	0.2522	0.1599	0.1814	0.1446	0.1567	0.1945	0.2278
1A4cii	0.1130	0.1258	0.0801	0.0907	0.0723	0.0783	0.0972	0.1139
1A4ciii	0.0379	0.0417	0.0270	0.0455	0.0368	0.0289	0.0375	0.0298
1B2aiv	NO	NO	NO	NO	NO	NO	NO	NO
1B2c	NO	NO	NO	NO	NO	NO	NO	0.0004
2G	0.0004	0.0005	0.0006	0.0007	0.0006	0.0001	0.0006	0.0000
3F	0.0113	0.0067	0.0052	0.0053	0.0045	0.0052	0.0071	0.0068
5C1biii	NO	NO	NO	NO	NO	NO	NO	NO
5C2	0.0002	0.0002	0.0003	0.0004	0.0003	0.0004	0.0005	0.0006
TOTAL	100	100	100	100	100	100	100	100

	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
1A1a	90.2690	88.4333	90.7969	90.4299	90.7196	89.4190	87.0255	84.8443
1A1b	NO	NO	NO	NO	NO	NO	NO	NO
1A2a	0.0006	NO	0.0007	0.0004	0.0006	0.0005	0.0008	0.0010
1A2b	0.5412	0.2909	0.1373	0.2380	0.1504	0.1879	0.2088	0.2572

1A2c	0.2283	0.2539	0.2307	0.2173	0.2112	0.2737	0.4032	0.4967
1A2d	0.1190	0.1275	0.1047	0.0873	0.0961	0.0905	0.1539	0.1895
1A2e	2.5604	2.7343	2.3519	2.3644	2.0999	2.6705	3.5507	4.3734
1A2f	4.5642	5.6594	4.2339	4.4145	3.9251	4.0090	5.7101	6.6273
1A2gvii	0.0004	0.0004	0.0004	0.0005	0.0005	0.0006	0.0011	0.0013
1A2gviii	0.2858	0.3290	0.2914	0.3940	1.0992	1.3776	0.5631	0.6936
1A3ai(i)	0.1203	0.1562	0.1448	0.1646	0.1657	0.1734	0.0778	0.1465
1A3aii(i)	0.0001	0.0004	0.0003	0.0002	0.0002	0.0001	0.0001	0.0005
1A3bi	0.0433	0.0580	0.0485	0.0494	0.0473	0.0509	0.0599	0.0782
1A3bii	0.0130	0.0190	0.0167	0.0172	0.0158	0.0175	0.0198	0.0287
1A3biii	0.0111	0.0139	0.0123	0.0128	0.0121	0.0134	0.0183	0.0160
1A3biv	0.0009	0.0011	0.0010	0.0010	0.0009	0.0009	0.0010	0.0010
1A3dii	0.0067	0.0099	0.0059	0.0083	0.0078	0.0111	0.0070	0.0166
1A4bi	0.9516	1.5086	1.3087	1.2786	1.1569	1.3730	1.7456	1.7284
1A4ci	0.1697	0.2429	0.1891	0.1963	0.1753	0.1997	0.2794	0.3053
1A4cii	0.0849	0.1214	0.0946	0.0981	0.0877	0.0998	0.1397	0.1526
1A4ciii	0.0241	0.0312	0.0249	0.0228	0.0212	0.0241	0.0257	0.0327
1B2aiv	NO	NO	NO	NO	NO	NO	NO	NO
1B2c	NO	NO	NO	NO	NO	NO	NO	NO
2G	0.0005	0.0005	0.0005	0.0002	0.0017	0.0016	0.0009	0.0003
3F	0.0046	0.0078	0.0044	0.0037	0.0043	0.0044	0.0069	0.0080
5C1biii	NO	NO	NO	NO	NO	NO	NO	NO
5C2	0.0005	0.0006	0.0005	0.0005	0.0005	0.0005	0.0007	0.0008
TOTAL	100	100	100	100	100	100	100	100

Annex 6: Implementation of recommendations and adjustments

A6.1. EU review Process

Table A6.1.Summary of Recommendations from the TERT and status of implementation

CRF category / issue	Review recommendation	Status of implementation
1A2g Other (Manufacturing Industries and Construction), 2020, CO_2	For category 1A2giii Other (Mining (Excluding Fuels) and Quarrying) and gas CO2 for year 2020, the TERT noted that the CO2 emission factor in CRF Table1.A(a)s2 is very high. In response to a question raised during the review, Cyprus explained that there was a mistake in the CO2 emissions from Other Kerosene and that the emission was a factor 1000 too high. Cyprus provided a revised estimate for the year 2020 and stated that it will be included in the next submission. The TERT agreed with the revised estimate provided by Cyprus and attached to the annex of the review report. The TERT recommends that Cyprus include the revised estimate in its next submission.	Resolved.
3B Manure Management, 1990-2020, CH_4, N_2O	For category 3B Manure Management, CH_4, all years, the TERT noted that in the NIR (page 156) Tier 2 is used for swine, but some values are not clearly referenced, and it appeared that some calculations for swine were incorrect. (1) A mistake was done in the calculation of methane from market swine due to a wrong link in the calculation file on solid manure (MCF used =22 % instead of 4 %). (2) A mistake was done in the calculation of breeding swine due to a wrong link in the calculation file. (3) Cyprus reported a large part of its swine manure as aerobic treatment without any liquid manure, but the TERT considers that there was no sufficient information in the NIR to justify the reporting of aerobic treatment (forced) as defined by the 2006 IPCC Guidelines, this manure should be considered as liquid. In response to a question raised during the review, Cyprus provided a revised estimate for 2020 and stated that it will be included in the next submission. The TERT agreed with the revised estimate provided by Cyprus and attached to the annex of the review report. The TERT recommends that Cyprus include the revised estimate in its next submission.	Resolved.
3B Manure Management, 1990-2020, N_2O	For category 3B Manure Management for all years, the TERT noted in the NIR, page 159, that nitrogen excretion rates are estimated by a Tier 1 method but the application of Tier 1 for N_2O from livestock presents a few mistakes. (1) The	Resolved. Technical correction accepted

	weights used in the calculation of nitrogen rates are different from default values of the 2006 IPCC Guidelines for some animals (sheep, horses, mules) and not referenced. (2) N_2O emission factors from liquid manure were irrelevant regarding crust (liquid without crust for cattle and with crust for swine). In response to a question raised during the review, Cyprus provided a revised estimate for 2020 and stated that it will be included in the next submission. The TERT disagreed with the revised estimate provided by Cyprus. The revised estimate proposed by Cyprus did not include impact on indirect emissions from 3B Manure Management and 3D Direct and Indirect N_2O Emissions from Agricultural Soils. It also did not correct N_2O emission factors on liquid manure. The TERT decided to calculate a technical correction for the year 2020 which was accepted by Cyprus. The estimates demonstrate that the issue is above the threshold of significance. The TERT recommends that Cyprus include a revised estimate in its next submission.	
4 Land use, land-use change and forestry - CH_4, CO_2, N_2O / Adherence to the UNFCCC Annex I inventory reporting guidelines	The sum of areas reported under the land use categories is not constant over years.	
4 Land use, land-use change and forestry - CH_4, CO_2, N_2O / Adherence to the UNFCCC Annex I inventory reporting guidelines	Cyprus reports in 1990 the same area of land use conversions in table 4.1 as in table 4.A to 4.C and 4.E for cropland converted to forest land, grassland converted to forest land, cropland converted to grassland and grassland converted to cropland, cropland converted to settlements and grassland converted to settlements. Table 4.A to 4.F should include 20 years of conversions. If there was no conversions prior to 1990, then the net carbon stock change in litter per ha in table 4.A seems very high considering the tress are only one year old.	Resolved.
4A Forest land - CO_2 / Compliance with regulation (EU) 2018/841	Cyprus reports NA for dead wood for forest land remaining forest land in table 4.A.	Currently there are no available data in the country that would allow estimating carbon stock changes in dead wood in forest land remaining forest land. There is an internal consultation on this matter in order to report on this

		carbon pool in future inventories.
4B1 Cropland remaining cropland - CO_2 / Compliance with regulation (EU) 2018/841	Cropland remaining cropland and grassland remaining grassland are both key categories according to table 7 in the CRF and living biomass contribute with more than 25% for both land use categories. According to the NIR2022 living biomass for both categories are estimated using a tier 1 method	Developing data that would allow increasing the tier method in significant subcategories in key categories is included in our GHGI improvement plan. Taking into account the resources available in the country, we will prioritize our future actions accordingly
4 Land use, land-use change and forestry - N_2O / Completeness	Cyprus reports NE for lands converted to forestland, cropland, grassland and settlements in table 4(III). However, in table 4.A, 4.B, 4.C and 4.E Cyprus reports a loss of soil carbon from mineral soils for conversions to forests land, cropland, grassland and settlements, respectively.	Resolved
4C2 Land converted to grassland - CO_2 / Accuracy	Same value for emissions from cropland converted to grassland for 2020 and 2021 in table 4C, despite the area has decreased.	Resolved
5A Solid Waste Disposal, 1990-2020, CH_4	For 5A Solid Waste Disposal, CH_4 and the year 2020 the TERT noted that in response to a question raised during the review Cyprus provided a revised estimate that the TERT disagreed with. The TERT decided to calculate a technical correction for the year 2020 which was accepted by Cyprus. The estimates demonstrate that the issue is above the threshold of significance. The TERT recommends that Cyprus include a revised estimate in its next submission.	Resolved. Technical correction accepted
5B Biological Treatment of Solid Waste, 2010-2020, CH_4, N_2O	For category 5B Biological Treatment of Solid Waste, CH_4 and N_2O and 2020 the TERT noted that Cyprus operates two plants for mechanical separation and/or mechanical biological treatment of waste. Such a plant often includes a biological treatment step, of which emissions need to be included in the emission inventory. In response to a question raised during the review, Cyprus explained that IWMF Koshie does include a composting step and IWMF	Resolved.

	Pentakomo does not. Cyprus provided a revised estimate for year 2020. The TERT agreed with the revised estimate provided by Cyprus and attached to the annex of the review report. The TERT recommends that Cyprus include the revised estimate in its next submission.	
5D Wastewater Treatment and Discharge, 1990-2020, CH_4	For category 5D Wastewater Treatment and Discharge, CH_4 and 2020 the TERT noted that part of the generated waste water might be discharged without treatment. In response to a question raised during the review, Cyprus requested additional expert judgement of the Water Pollution Control Permit & Inspections Unit of the Cypriot Department of Environment. Based on this expert judgement Cyprus provided a revised estimate for the year 2020 and stated that it will be included in the next submission. The TERT agreed with the revised estimate provided by Cyprus and attached to the annex of the review report. The TERT recommends that Cyprus include the revised estimate in its next submission.	Resolved.

A6.2. UNFCCC/KP review Process

Table A6.2.Summary of Recommendations from the ERT and status of implementation

CRF category / issue	Review recommendation	Status of implementation
CRF tables (G.2, 2020) (G.8, 2019) (G.5, 2017) (G.8, 2016) (G.8, 2015) (table 4, 2013) Convention reporting adherence	Provide relevant explanations in CRF table 9, specifically for all cases of the notation key "NE" being reported and for sources reported as "IE" (e.g. indirect emissions from agricultural soils).	In progress, will be implemented for the March 2023 submission
Methods (G.4, 2020) (G.11, 2019) (G.10, 2017) (G.15, 2016) (G.15, 2015) Accuracy	Ensure that appropriate methods are used to estimate emissions for key categories: The Party reported in the CRF Summary 3 tables and table 1.3 of the NIR the use of CS and T2 methods for most key categories. Also, in its reply to the Assessment report, Party explained that appropriate methods were used where AD were available. The ERT believes that given the limited capacity, Cyprus improved its estimation methods. Sector specific issues are included under corresponding sections.	In progress.

National system (G.5 2020) (G.4, 2020) (G.11, 2019) (G.10, 2017) (G.15, 2016) (G.15, 2015) KP reporting adherence	Report on the progress of implementation of the workplan that includes the description of legal, institutional and procedural arrangements for performing the functions of the national system, and explain the activities in place for continuous and sustainable reporting, including enhancing the capacity to report supplementary information under the Kyoto Protocol, in particular on the LULUCF sector.	Resolved.
National system (G.6 2020) (G.16, 2019) (G.22, 2017) KP reporting adherence	Implement the workplan in accordance with the listed tasks and deadlines and update the text in the NIR accordingly to describe any changes to the national system: Chapter 1 of the NIR describes legal, institutional and procedural arrangements for performing the functions of the national system. Chapter 13 of the NIR reports changes that were introduced in 2017. During the review, Cyprus provided additional information on the proposals to improve the GHG inventory preparation process. Given the limited capacity of the Party, the ERT considers the issue resolved.	Resolved. Will be improved in future submissions.
Notation keys (G.7 2020) (G.23, 2019) Completeness	Assess the significance of emissions and removals when reporting them as “NE” and indicate in both the NIR and the CRF completeness table (CRF table 9) why such emissions or removals have not been estimated, in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guideline: The issue is related to G.1 above. The Party did not report any insignificant categories as “NE” in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines. In its reply to the Assessment report, Party explained that it is not always possible to estimate the significance of emissions and removals where information is not available. In this respect, the ERT considers that issue is resolved.	Resolved. Will be improved in future submissions.
Uncertainty analysis (G.8 2020) (G.20, 2019) (G.14, 2017) (G.6, 2016) (G.6, 2015) Convention reporting adherence	Conduct an uncertainty analysis for LULUCF after the LULUCF reporting has been completed.	Will be adressed in future submission.
Uncertainty analysis (G.9 2020) (G.24, 2019) Transparency	Provide the sources of expert judgment used to quantitatively assess the uncertainty of source or sink categories for AD or EFs in annex 2 to the	In progress and will be adressed in future submissions.

	NIR, consistently with the 2006 IPCC Guidelines (vol. 1, section 3.5).	
National registry (G.10 2020) (G.13, 2019) (G.18, 2017) (G.19, 2016) (G.19, 2015) KP reporting adherence	Include in the NIR information on the national registry in accordance with decision 5/CMP.1 and the annex to decision 13/CMP.1 in conjunction with decision 3/CMP.11 and other relevant provisions and standards (including contact information for the designated organization and registry administrator, and a description of the standardized electronic database applied for registry performance and publicly accessible information).	Resolved.
National registry (G.11 2020) (G.14, 2019) (G.23, 2017) KP reporting adherence	Report any change to the national registry (since the previous annual submission) in the NIR in accordance with decision 15/CMP.1, annex, paragraph 22.	In progress, will be implemented for the March 2023 submission
Kyoto Protocol units (G.12 2020) (G.12, 2019) (G.24, 2017)	Report in the NIR information in accordance with decision 15/CMP.1, annex, paragraphs 12–18, in conjunction with decision 3/CMP.11, including on information reported in the SEF tables; discrepancies and notification; publicly accessible registry information; and the calculation of the CPR.	In progress.
Article 3.14 (G.14 2020) KP reporting adherence	Report any changes to the information provided under Article 3, paragraph 14, of the Kyoto Protocol in accordance with decision 15/CMP.1 in conjunction with decision 3/CMP.11.	Resolved.
CRF tables (G.15 2020) Comparability	Complete the blank cells in the CRF tables for the IPPU, agriculture and LULUCF sectors and CRF summary tables 2 (2.B and 2.G for fluorinated gases) and 3 (1.B, 2.B, 2.C, 4.B–4.F and 5.C).	Resolved.
Uncertainty analysis (G.16 2020) Convention reporting adherence	Include information in the NIR on how the uncertainty estimates help it to prioritize its efforts to improve the accuracy of the national inventory and to guide its methodological decisions.	In progress.
1. General (energy sector) – All fuels – CO2, CH4 and N2O (E.1, 2020) (E.1, 2019) (E.1, 2017) (E.1, 2016) (E.1, 2015) (18, 2013 Transparency	Provide information on how emissions are estimated by including information on efforts to reconcile energy balance and EU ETS data, as well as additional information on the use of EU ETS data and an explanation of how the time-series consistency of the emission estimates is ensured.	Resolved.

1.A.2.c Chemicals liquid fuels – CO_2, CH_4 and N_2O (E.5, 2021) (E.9, 2019) (E.18, 2017) Transparency	Correct the AD for 2013 (i.e., report liquid fuel consumption as “NO”) and explain the inter-annual variation in the AD and CO2, CH4 and N2O emissions in the NIR.	Resolved.
1.A.2.g Other (manufacturing industries and construction) – liquid fuels – liquid fuels – CO2, CH4 and N2O. (E.9, 2020) (E.23, 2019) Comparability	Correct the reporting by allocating the LPG consumption reported in the energy balance under other sector – not specified elsewhere and the corresponding emissions to the category other stationary (1.A.5a) in both the NIR (tables 3.24–3.25) and CRF table 1.A(a).	Resolved.
1.A.3.b Road transportation – liquid fuels – CO2, CH4 and N2O (E.11, 2020) (E.24, 2019) Transparency	Document in the NIR how the COPERT V model and the EFs applied are appropriate to the national circumstances.	This will be adressed in NIR 2023 for the March 2023 submission
1.A.3.b Road transportation – liquid fuels – CO2 (E.12, 2020) (E.25, 2019 Accuracy	Correct the CO2 EF used to estimate emissions from gasoline consumption in road transportation for 1993 and 1994 and ensure the time-series consistency of the applied EFs.	Resolved.
1.A.3.b Road transportation – liquid fuels – CO2, CH4 add gas(es) E13, 2020) (E.26,2019) Accuracy	Correct the N2O EF used to estimate emissions from diesel consumption in road transportation for 1999 and 2000 and ensure the time-series consistency of the applied EFs.	Resolved.
1.A.3.b.ii Light-duty trucks – Oil – N2O (E.14, 2020) (E.27, 2019) Completeness	Correct the estimates of N2O emissions from diesel consumption by light-duty trucks for 1990–1999.	Resolved.
1.A.3.d Domestic navigation – liquid fuels – CO2, CH4 and N2O (E.15, 2020) (E.17, 2019) (E.10, 2017) (E.21, 2016) (E.21, 2015) Transparency	Report in the NIR on any progress achieved in improving the consistency of the time series.	Resolved.
1.A Fuel combustion – sectoral approach – solid biomass – CO2, CH4 and	Revise its estimates of CO_2, CH_4 and N_2O emissions from solid biomass in 2017 on the basis of the correct AD and report the impact of the correction in the NIR.	Resolved.

N2O (E.19, 2020) Accuracy		
1.A Fuel combustion – sectoral approach – other biomass – CO2, CH4 and N2O (E.20, 2020) Accuracy	Include the estimates of CO2, CH4 and N2O emissions from biogenic waste consumption on the basis of the correct AD and report the impact of the correction in the NIR.	Resolved.
1.B.2.a Oil – secondary liquid fuels CO2 and CH4.	The Party did not report CO2 and CH4 emissions from distribution of secondary oil products in its NIR. The category 1.B.2.a.iii.5 in the CRF table 1.B.2 is reported as "NE" for the entire time series. During the review the Party indicated that evaporation losses from storage, filling and unloading activities and fugitive equipment leaks are the primary sources of these emissions in Cyprus, however there is no activity data available to calculate these emissions, hence the use of the notation key NE in the CRF tables. The ERT recommends the party to report the total amount of liquid fuels distributed in Cyprus directly derived from national statistics if available; otherwise, it could be set equal to total liquid fuel production by refineries plus imports minus exports, according to the 2006 IPCC Guidelines Volume 2 Chapter 4: Fugitive emissions (Table 4.2.7). Furthermore, the ERT recommends the use of notation key NA instead of NE for EF considering that the emission factors for distribution of oil (1.B.2) are not available in the 2006 IPCC Guidelines.	Resolved.
1.A.2.g Other (manufacturing industries and construction) – all fuels – CO_2	The ERT noted that the Party reported in its CRF table 1. A(a)s2 that the CO_2 IEF implied emission factor for 1.A.2.g.iii Mining (excluding fuels) and quarrying - Liquid Fuels for 2020 was 1678.70 t/TJ and is by far outside of the range of the IPCC default values. During the review the Party indicated that there was a mistake in the activity data that has been corrected. The correct CO_2eq emissions for 2020 are 16.2 kt and the liquid fuels consumption 217.63 TJ. The ERT recommends the party to correct the emissions from liquid fuel in the CRF Table 1.A(a)s2 and NIR in the next submission.	Resolved.
2.F Product uses as substitutes for ozone-depleting substances – PFCs and NF3 (I.3, 2020) (I.15, 2019) (I.11, 2017) (I.19, 2016) (I.19, 2015) Convention reporting adherence	Further examine whether PFC and NF3 emissions from product uses as substitutes for ozone-depleting substances occur in the country and, as appropriate, report estimates or report an appropriate notation key (i.e. “NO”) in the corresponding CRF tables.	Resolved. Emissions of PFC and NF3 from ozone-depleting substances do not occur in Cyprus

2.F.1 Refrigeration and air conditioning – HFCs (I.4, 2020) (I.18, 2019) (I.12, 2017) (I.4, 2016) (I.4, 2015) (46, 2013) Transparency	Further examine whether emissions from manufacturing of refrigeration and air-conditioning equipment occur in the country and, as appropriate, report values or revise the use of the notation keys reported.	Resolved. Available information indicates there is no manufacturing of refrigeration and air-conditioning equipment in the country and therefore this activity does not occur in Cyprus.
2.F.1 Refrigeration and air conditioning – HFCs (I.5, 2020) (I.22, 2019) Comparability	Estimate emissions from mobile air conditioning (2.F.1.e) using the methods provided in the 2006 IPCC Guidelines (vol. 3, chap. 7) for 1990–2004. If national circumstances prevent the use of those methods, use surrogate data to estimate the emissions in accordance with the 2006 IPCC Guidelines (vol. 1, section 2.2.1).	Resolved. Emissions for category (2.F.1) has been estimated using Tier 2a methodology in the 2006 IPCC Guidelines for the entire time series in accordance with the recommendation.
2.G Other product manufacture and use – N2O and SF6 (I.7, 2020) (I.20, 2019) (I.23, 2017) Accuracy	Recalculate SF6 emissions from electrical equipment, N2O emissions from medical applications and N2O emissions from other – propellant for pressure and aerosol products, and include up-to-date values for population and average per capita emissions and update the values reported in CRF tables 2(I).A-Hs2 and 2(II)B-Hs2.	Resolved
2.G.1 Electrical equipment – N2O and SF6 (I.8, 2020) (I.24, 2019) Issue type	Estimate SF6 emissions from electrical equipment (2.G.1) by using the methods provided in the 2006 IPCC Guidelines (vol. 3, chap. 8). If national circumstances prevent the use of those methods, use surrogate data to estimate the emissions, in accordance with the 2006 IPCC Guidelines (vol. 1, section 2.2.1), including the use, for example, of power grid installed capacity, as SF6 emissions are normally correlated with this parameter.	Resolved. SF6 emissions from electrical equipment (2.G.1) are estimated using the tier 1 methodology provided in the 2006 IPCC guidelines (the default emission-factor approach) where emissions are estimated by multiplying default regional emission factors by the nameplate SF6 capacity of the equipment at each life cycle stage of

		the equipment, and that there is no manufacturing in the country.
2. General (IPPU) – HFCs, SF6 and N2O (I.10, 2020) Transparency	Include in its NIR justification, and a description of the criteria used, for selecting countries for surrogate data for estimating HFC emissions for categories 2.F.2, 2.F.3, 2.F.4, 2.G.1 and 2.G.3.b.	This will be adressed in NIR 2023 for the March 2023 submission
2. General (IPPU) – all gases (I.11, 2020) Transparency	Include in the NIR an assessment of the completeness of categories and emissions estimated for the IPPU sector, with an explanation for each category and gas for which no emissions are estimated, for example by reporting relevant notation keys in NIR table 4.2.	This will be adressed in NIR 2023 for the March 2023 submission
2. General (IPPU) – CO2 (I.12, 2020) Accuracy	Ensure that indirect emissions are not included in national total direct emissions. It also recommends that the Party report the national totals in the relevant CRF tables including and excluding indirect CO2, as required by paragraph 29 of the UNFCCC Annex I inventory reporting guidelines.	Resolved. Indirect emissions of NMVOCs from category 2.D.3 previously reported in the CRF Tables as direct CO2 and included in Cyprus' national total is now reported as indirect CO2 emissions associated with NMVOC emissions. This is currently reported as IE in table CRF 2(I)-Hs2 and included in the indirect CO2 emission in summary table 1.A.s3.
2.A.1 Cement production – CO2 (I.13, 2020) Transparency	Include in the NIR emission estimates for cement production (category 2.A.1) for the entire inventory time series.	This will be adressed in NIR 2023 for the March 2023 submission
2.B.5 Carbide production – CO2 (I.14, 2020) Completeness	Explain in the NIR how imported calcium carbide is used in the country and through which processes CO2 emissions are generated (e.g. acetylene production). It also recommends that the Party estimate any CO2 emissions from calcium carbide use by applying the	Resolved. According to further information received from the customs' office and the Statistical

	corresponding EF from the 2006 IPCC Guidelines (vol. 3, chap. 3) and report these emissions in the NIR and CRF tables.	service, the imports are very small quantities of calcium carbide imported for used for metal cutting.
2.D.1 Lubricant use – CO_2 (I.15, 2020) Accuracy	Revise its estimated CO_2 emissions from lubricant use by allocating lubricants used in two-stroke engines to the energy sector and all other lubricants to the IPPU sector in order to avoid double counting.	This will be adressed in NIR 2023 for the March 2023 submission
2.D.1 Lubricant use – CO_2 (I.16, 2020) Comparability	Report in CRF table 2(I).A-H (sheet 2) AD for lubricant use (category 2.D.1) in kt instead of TJ to ensure comparability among Parties included in Annex I to the Convention.	Resolved. Reported in the NIR and in CRF table 2(I).A-Hs2 AD in kt instead of TJ.
2.D.3 Other (non-energy products from fuels and solvent use) – CO_2 (I.17, 2020) Accuracy	Revise its estimates of CO_2 emissions from use of urea-based catalysts in vehicles on the basis of the applicable inventory years and taking into consideration vehicle class (e.g. EURO IV, V, VI) and type (e.g. bus, truck, car).	Resolved. Reported in the NIR information on vehicle class and types for the inventory years 2007 - 2020 urea based additive technologies according to the penetration and recalculated emissions for urea used as a catalyst (2D3 other) category for the whole time period (2007-2019) due to recomposition of new information on vehicle fleet.
2.G Other product manufacture and use – N_2O and SF_6 (I.18, 2020) Transparency	Include in NIR tables 4.26–4.28 N_2O and SF_6 emission estimates and AD for the latest years of the time series.	This will be adressed in NIR 2023 for the March 2023 submission
2.G.3 N_2O from product uses – N_2O (I.19, 2020) Transparency	Use in NIR table 4.30 and figure 4.16 the appropriate units (i.e. kt N_2O) for reporting N_2O emissions from medical applications (category 2.G.3.a).	Resolved. Provided N_2O emissions in kt N_2O in table 4.25 in the NIR

3.B.3 Swine – CH4 and N2O (A.2, 2020) (A.10, 2019) Transparency	Correct the digester allocations under manure management systems in CRF table 3.B(a)s.2 for market swine for 2017.	Resolved
3.B.3 Swine – CH4 (A.5, 2020) Transparency	Provide a clear explanation in its NIR for the change in allocation of market swine manure between aerobic treatment and anaerobic digestion from 2011 onward.	Resolved
4. General (LULUCF) / Accuracy	Report the areas converted to a different land use under the relevant land-use conversion category for 20 consecutive years before reporting them under the corresponding land remaining category	Resolved. See NIR, section 6.1.1, sections justifying recalculations, CRF table 4.1 and CRF tables 4.A-F
4. General (LULUCF) – CO_2 / Accuracy	Explore the use of, where relevant, the carbon stock change factors and assumptions used for the estimation of the carbon stock changes in biomass, dead wood and litter, and ensure comparability between the land-use changes both to and from a category.	Resolved. The correct notation key together with comments are used for reporting under the tier 1 assumption that carbon stock changes assumed to be zero; correct notation key together with comments are used to report when carbon stock changes are zero; carbon stock changes in all mandatory carbon pools are reported if occur; the correct notation key is used for sources/sinks that do not occur in the country.
4. General (LULUCF) – CO_2, CH_4 and N_2O / Comparability	Report "NO" for any category, pool and/or gas for which there is information confirming that it does not occur, and provide such information in the NIR, and report "NE" for categories, pools and/or gases for which there is no information on emissions/removals or for which net emissions/removals are negligible.	Resolved. The correct notation key is used for sources/sinks that do not occur in the country. The 'NE' is used for source/sinks that are not estimated in the inventory, together with

		relevant information in CRF table 9
4. General (LULUCF) – CO_2, CH_4 and N_2O / Completeness	Report all mandatory carbon pools.	Resolved. Carbon stock changes from all mandatory carbon pools are reported. Relevant information is provided in the relevant sections of LULUCF chapter 6 and in the respective CRF tables
4.A Forest land - CO_2 / Convention reporting adherence	Revise the reporting of the area of settlements converted to forest land and ensure consistency between the areas reported in the NIR, CRF table 4.1 and CRF table 4.A.	Resolved. See NIR (table 6.4, 6.5), CRF table 4.1 and CRF table 4.A
4.D Wetlands - CO_2 / Convention reporting adherence	Revise the reporting of land areas converted to wetlands and ensure consistency between the information reported in CRF tables 4.1 and 4.D.	Resolved. See CRF table 4.1 and CRF table 4.D
4.E Settlements - CO_2 / Convention reporting adherence	Revise the area of settlements reported in NIR table 6.14 and ensure consistency with the total area of settlements reported in CRF table 4.E.	Resolved. See NIR table 6.17 and CRF table 4.E
4(V) Biomass burning – CO_2, CH_4 and N_2O / Completeness	Provide the missing estimates of emissions from forest fires for land converted to forest land for 2011.	Resolved. Emissions from forest fires in 2011 are reported altogether under forest land remaining forest land. The 'IE' notation key is used in land converted to forest land and the necessary information is provided in CRF table 9
Land representation – CO_2, CH_4 and N_2O / Accuracy	Use the 2018 CORINE land-cover map for its next submission to ensure consistency of the AD used for land representation for the whole time series	Resolved. See NIR section 6.1.1 and table 6.2

4.A Forest land - CO_2, CH_4 and N_2O / Transparency	Include in its next submission AD for forest fires and any other coefficients and parameters used in calculating forest fire emissions	Resolved. AD are reported in CRF table 4(V). All relevant coefficient and parameters used are reported in the NIR 6.2.4
4.B.1 Cropland remaining cropland – CO_2 / Accuracy	Assume that the growth and harvest of orchards in the country cancel each other out and therefore carbon stocks for living biomass are in equilibrium, and report "NA" in CRF table 4.B.	Not resolved. The ERT's recommendation is under assessment for its appropriateness for Cyprus' circumstances
4.B.1 Cropland remaining cropland – CO_2 / Convention reporting adherence	Correct the errors in NIR table 6.9 (p.193) for its next submission	Resolved. See NIR table 6.11
4.C.1 Grassland remaining grassland – CO_2 / Accuracy	Assume that the growth and harvest of woody grassland in the country cancel each other out and therefore carbon stocks for living biomass are in equilibrium, and report "NA" in CRF table 4.C.	Resolved. See NIR section 6.4.4. Country-specific annual increment is used.
4.D.2.2 Land converted to flooded land – CO_2 /	Report only emissions for newly constructed dams and flooded mines and construction sites, attributable to instantaneous oxidation of biomass for the year of conversion	Resolved. See NIR section 6.5.4 and CRF table 4.D. Only carbon stock changes in living biomass are reported in land converted to wetlands accounting for a total loss of biomass in the year of conversion.
5.B.2 Anaerobic digestion at biogas facilities – CH4 (W.4, 2020) (W.13, 2019) Completeness	Report CH4 emissions from sludge transported for anaerobic treatment for biogas production under the category anaerobic digestion at biogas facilities (5.B.2) and include an explanation in the energy sector chapter of the NIR concerning the consumption of biogas on farms with anaerobic digesters for solid waste.	Resolved. CH_4 emissions from sludge transported for anaerobic treatment for biogas production were reported under the category anaerobic digestion at biogas facilities (5.B.2)

		and an explanation concerning the consumption of biogas on farms with anaerobic digesters for solid waste were included on page 93 of the NIR under the energy sector chapter.
5.C.1 Waste incineration – CO2, CH4 and N2O (W.5, 2020) (W.14, 2019) Completeness	Estimate and report emissions from waste incineration without energy recovery.	This will be addressed in future submission
5.D Wastewater treatment and discharge – CH4 (W.6, 2020) (W.10, 2019) (W.9, 2017) Accuracy	Provide information in the NIR, under category-specific planned improvements, on whether any plans are in place to move to higher-tier methods as this category has been identified as key.	This will be addressed in future submission
5.D.1 Domestic wastewater – CH4 and N2O (W.7, 2020) (W.11, 2019) (W.10, 2017) Accuracy	Account for the component of organic material and nitrogen removed as sludge, because it is reported that there are good data sources for sludge in Cyprus and explain any recalculations for categories 5.D.1 and 3.D.1.a.2.b resulting from this change.	This will be adressed in NIR 2023 for the March 2023 submission

Annex 7: Key actions of the National Inventory Improvement Plan

Table A7.1 presents the key actions identified for the improvement of the national inventory, after the preparation of the 2021 submission.

Table A7.1.Key actions of the National Inventory Improvement Plan

	Description	Planned Implementation
General		
1	Improve QA/QC plan	Continuous
2	Improve implementation of QA/QC procedures	Continuous
3	Improve descriptive information in NIR (e.g. inter-annual variations) to improve transparency	Continuous
4	Implement Tier 2 methodologies for key categories	Continuous
Sector 1. Energy		
1	1.A.3.b Road transportation: Development of country-specific EFs	To be assessed for 2023 submission
Sector 2. IPPU		
1	2.F Product uses as substitutes for ozone depleting substances: Continue efforts to collect AD and report emissions fully in accordance with the 2006 IPCC Guidelines - Emissions from blowing agents (2.F.2), fire protection (2.F.3) and aerosols (2.F.4)	Collection of the necessary data is ongoing. Further improvements in future submissions
Sector 3. Agriculture		
1	3A. Improvement of DE time series for the improvement of estimation of CH_4 emissions from enteric fermentation dairy cattle.	In view of the difficulty to find reasonably good data on time series for feeding plans and in the absence of historical data, we plan by the 2023 submission to explore some modelling approach which could be used to derive DE from other related variables.
2	3D. Improvement of N_2O leaching estimates	Reference provided
3.	3D. Implement a tier 2 methodology to estimate emissions for categories 3.D.a.1 and 3.D.A.2 considering desk studies or expert judgment as alternatives given in the national circumstances.	In progress.
Sector 4. LULUCF		
1	Report fully uncertainty assessment and recalculations	To be included in the 2022 submission
Sector 5. Waste		
1	5.D Wastewater treatment and discharge: Move to higher-tier methods	Further improvements in future submissions
2	5.D.1 Domestic wastewater: Account for the component of organic material and N removed as sludge and explain any recalculations for categories 5.D.1 and 3.D.1.a.2.b as a result of this change.	Further improvements in future submissions

References

All references used in the national inventory report are presented as footnotes to the text.