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Contents

List of Tables.....	9
List of Figures	16
EXECUTIVE SUMMARY	18
ES.1. Background information on greenhouse gas (GHG) inventories and climate change	18
ES.2. Summary of national emission and removal-related trends.....	19
ES.3. Overview of source and sink category emission estimates and trends	21
ES.4. Other information	22
Chapter 1. Introduction.....	24
1.1. Background information on GHG inventories and climate change.....	24
1.1.1. Background information on climate change	25
1.1.2. Background information on greenhouse gas inventories	27
1.2. A description of the national inventory arrangements.....	28
1.2.1. Institutional, legal and procedural arrangements	28
1.2.2. Overview of inventory planning, preparation and management	32
1.2.3. Quality assurance, quality control and verification plan	35
1.2.4. Changes in the national inventory arrangements since previous annual GHG inventory submission	40
1.3. Brief general description of methodologies and data sources used	40
1.3.1. Global Warming Potential	47
1.4. Brief description of key categories.....	48
1.5. General uncertainty evaluation.....	50
1.6. General assessment of completeness.....	50
Chapter 2. Trends in greenhouse gas emissions	53
2.1. Description and interpretation of emission trends for aggregated GHG emissions.....	53
2.2. Description and interpretation of emission trends by sector	54
2.3. Description and interpretation of emission trends by gas.....	55
Chapter 3. Energy (CRF sector 1)	58
3.1. Overview of sector	58
3.1.1. Trends	60
3.1.2. Methodology.....	61
3.1.3. Completeness.....	63
3.2. Fuel combustion (CRF 1.A).....	63
3.2.1. Source category description	63
3.2.2. Methodological issues.....	64
3.2.3. Energy industries (CRF 1A1)	65
3.2.4. Manufacturing industries and construction (1A2)	69
3.2.5. Transport (1A3)	76
3.2.6. Other sectors (1A4).....	82
3.2.7. Non-Specified (1A5).....	86
3.2.8. Reference approach (1AB)	88
3.2.9. Comparison of the sectoral approach with the reference approach (1AC)	92
3.2.10. Feedstocks and non-energy use of fuels (1AD)	93
3.3. Fugitive emissions from solid fuels and oil and natural gas and other emissions from energy production (1B).....	95
3.3.1. Oil & natural gas and other emissions from energy production.....	95
3.4. CO ₂ transport and storage (CRF 1.C)	97
3.5. Memo items (1.D)	97

3.5.1. International bunkers (1D1).....	97
3.5.2. CO2 emissions from biomass (1.D.3).....	99
Chapter 4. Industrial processes and product use (CRF sector 2)	101
4.1. Overview of sector	101
4.1.1. Emissions trend.....	101
4.1.2. Completeness	104
4.1.3. Methodology	105
4.2. Mineral products (2.A).....	106
4.2.1. Cement production (2.A.1)	107
4.2.2. Lime Production (2.A.2)	109
4.2.3. Glass Production (2.A.3).....	111
4.2.4. Other Process Uses of Carbonates (2.A.4).....	111
4.3. Chemical Industry (2.B).....	115
4.3.1. Carbide production (2.B.5)	115
4.4. Non-Energy Products from Fuels and Solvent Use (2.D)	115
4.4.1. Category description	115
4.4.2. Methodological issues.....	116
4.4.3. Uncertainties and time-series consistency	119
4.4.4. Category-specific QA/QC and verification.....	119
4.4.5. Category-specific recalculations	119
4.4.6. Category-specific planned improvements	120
4.5. Electronic Industry Emissions (2.E).....	120
4.6. Product uses as substitutes for ozone depleting substances (2.F).....	120
4.6.1. Category description	120
4.6.2. Methodological issues.....	121
4.6.3. Uncertainties and time-series consistency	132
4.6.4. Category-specific QA/QC and verification.....	132
4.6.5. Category-specific recalculations	132
4.6.6. Category-specific planned improvements	133
4.7. Other Product Manufacture and Use (2G)	134
4.7.1. Electrical Equipment (2G1)	134
4.7.2. SF6 and PFCs from Other Product Uses (2G2)	137
4.7.3. N2O from Product Uses (2G3)	137
4.7.4. Other product manufacture and use (2G4).....	138
Chapter 5. Agriculture (CRF sector 3)	140
5.1. Overview of sector	140
5.1.1. Emission trends.....	140
5.1.2. Methodology	142
5.2. Enteric Fermentation (3A)	143
5.2.1. Methodological issues.....	144
5.2.2. Uncertainties and time-series consistency	147
5.2.3. Category-specific QA/QC and verification.....	147
5.2.4. Category-specific recalculations	147
5.2.5. Category-specific planned improvements	147
5.3. Manure management (3B).....	147
5.3.1. Category description	148
5.3.2. Methodological issues.....	149
5.3.3. Uncertainties and time-series consistency	154
5.3.4. Category-specific QA/QC and verification.....	154
5.3.5. Category-specific recalculations	154
5.3.6. Category-specific planned improvements	155
5.4. Rice cultivation (CRF source category 3C).....	155
5.5. Agricultural soils (3D)	155
5.5.1. Direct N2O emissions from managed soils (3D1)	156
5.5.2. Indirect N2O emissions from managed soils (3D2).....	166
5.5.3. Prescribed burning of savannas (3E)	169
5.5.4. Field burning of agricultural residues (3F)	169
5.5.5. Liming (3G).....	170

5.5.6. Urea application (3H)	171
5.5.7. Other carbon-containing fertilizers (3I)	172
5.5.8. Other (please specify) (3J)	172
Chapter 6. Land use, land-use change and forestry (CRF sector 4).....	173
6.1. Overview of sector	173
6.1.1. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation	173
6.1.2. Land-use definitions and the classification systems used and their correspondence to the LULUCF categories.....	174
6.1.3. GHG emissions and removals by LULUCF categories	176
6.1.4. Emission Trends	177
6.2. Forest Land (4A).....	178
6.2.1. Description.....	178
6.2.2. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation	178
6.2.3. Land-use definitions and the classification systems used and their correspondence to the LULUCF categories.....	179
6.2.4. Methodological issues.....	180
6.2.5. Uncertainties and time-series consistency	183
6.2.6. Category-specific QA/QC and verification.....	184
6.2.7. Category-specific recalculations	184
6.2.8. Category-specific planned improvements	185
6.3. Cropland (4B)	185
6.3.1. Description.....	185
6.3.2. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation	185
6.3.3. Land-use definitions and the classification systems used and their correspondence to the LULUCF categories.....	185
6.3.4. Methodological issues.....	187
6.3.5. Uncertainties and time-series consistency	189
6.3.6. Category-specific QA/QC and verification.....	190
6.3.7. Category-specific recalculations	190
6.3.8. Category-specific planned improvements	190
6.4. Grassland (4C)	190
6.4.1. Description.....	190
6.4.2. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation	190
6.4.3. Land-use definitions and the classification systems used and their correspondence to the LULUCF categories.....	190
6.4.4. Methodological issues.....	192
6.4.5. Uncertainties and time-series consistency	193
6.4.6. Category-specific QA/QC and verification, if applicable	194
6.4.7. Category-specific recalculations, if applicable, including changes made in response to the review process	194
6.4.8. Category-specific planned improvements, if applicable (e.g., methodologies, activity data, emission factors, etc.), including those in response to the review process	194
6.5. Wetland (4D).....	195
6.5.1. Description.....	195
6.5.2. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation	195
6.5.3. Land-use definitions and the classification systems used and their correspondence to the LULUCF categories.....	195
6.5.4. Methodological issues.....	196
6.5.5. Uncertainties and time-series consistency	196
6.5.6. Category-specific QA/QC and verification.....	197
6.5.7. Category-specific recalculations	197
6.5.8. Category-specific planned improvements	197
6.6. Settlements (4E)	198
6.6.1. Description.....	198

6.6.2. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation	198
6.6.3. Land-use definitions and the classification systems used and their correspondence to the LULUCF categories.....	198
6.6.4. Methodological issues.....	199
6.6.5. Uncertainties and time-series consistency	201
6.6.6. Category-specific QA/QC and verification.....	201
6.6.7. Category-specific recalculations, if applicable, including changes made in response to the review process	201
6.6.8. Category-specific planned improvements, if applicable (e.g., methodologies, activity data, emission factors, etc.), including those in response to the review process	201
6.7. Other Land (4F).....	202
6.7.1. Description.....	202
6.7.2. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation	202
6.7.3. Land-use definitions and the classification systems used and their correspondence to the LULUCF categories.....	202
6.7.4. Methodological issues.....	203
6.7.5. Uncertainties and time-series consistency	204
6.7.6. Category-specific QA/QC and verification.....	205
6.7.7. Category-specific recalculations	205
6.7.8. Category-specific planned improvements	205
6.8. Harvested Wood Products (4G)	205
6.8.1. Description.....	205
6.8.2. Information on approaches used and on databases used for the inventory preparation	206
6.8.3. Category specific definitions and the classification systems used	206
6.8.4. Methodological issues.....	206
6.8.5. Uncertainties and time-series consistency	209
6.8.6. Category-specific QA/QC and verification.....	209
6.8.7. Category-specific recalculations	209
6.8.8. Category-specific planned improvements	209
Chapter 7. Waste (CRF sector 5).....	210
7.1. Overview of sector	210
7.1.1. Emissions trends	210
7.1.2. Methodology.....	211
7.2. Solid Waste Disposal (5A).....	211
7.2.1. Methodological issues.....	214
7.2.2. Uncertainties and time-series consistency	223
7.2.3. Category-specific QA/QC and verification.....	224
7.2.4. Category-specific recalculations	224
7.2.5. Category-specific planned improvements.....	224
7.3. Biological Treatment of Solid Waste (5B).....	224
7.3.1. Methodological issues.....	224
7.3.2. Uncertainties and time-series consistency	225
7.3.3. Category-specific QA/QC and verification.....	225
7.3.4. Category-specific recalculations	225
7.3.5. Category-specific planned improvements.....	225
7.4. Incineration and Open Burning of Waste (5C).....	225
7.5. Wastewater Treatment and Discharge (5D)	226
7.5.1. Domestic Wastewater Treatment and Discharge (4D1).....	227
7.5.2. Industrial wastewater (5D2).....	234
7.6. Other (5E)	241
Chapter 8. Other (CRF sector 6).....	242
Chapter 9. Indirect CO ₂ and N ₂ O emissions.....	243
Chapter 10. Recalculations and improvements.....	244
10.1. Explanations and justifications for recalculations	244

10.2. Implications for emission levels	244
10.3. Implications for emission trends	246
10.4. Planned improvements	247
Chapter 11. KP-LULUCF.....	248
11.1. General information	248
11.1.1. Definition of forest and any other criteria.....	248
11.1.2. Elected activities under Article 3, paragraph 4, of the Kyoto Protocol.....	249
11.1.3. Description of how the definitions of each activity under Article 3.3 and each elected activity under Article 3.4 have been implemented and applied consistently over time	249
11.1.4. Description of precedence conditions and/or hierarchy among Article 3.4 activities, and how they have been consistently applied in determining how land was classified	249
11.2. Land-related information.....	249
11.2.1. Spatial assessment unit used for determining the area of the units of land under Article 3.3	249
11.2.2 Methodology used to develop the land transition matrix	250
11.2.3. Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations.....	251
11.3. Activity-specific information	251
11.3.1. Methods for carbon stock change and GHG emission and removal estimates	251
11.4. Article 3.3.....	256
11.4.1. Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and are direct human-induced.....	256
11.4.2. Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation.....	256
11.4.3. Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested	256
11.5. Article 3.4.....	256
11.5.1. Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced.....	256
11.5.2. Information relating to Cropland Management, Grazing Land Management and Revegetation, if elected, for the base year	257
11.5.3. Information relating to Forest Management	257
11.6. Other information.....	257
11.6.1. Key category analysis for Article 3.3 activities and any elected activities under Article 3.4	257
11.7. Information relating to Article 6	258
11.8. Calculation of an estimate of HWP Contribution under the KP.....	258
11.8.1. Initial steps to estimate the HWP contribution	259
11.8.2. Data for the calculation of an estimate of HWP Contribution under the Kyoto Protocol	259
Chapter 12. Information on accounting of Kyoto units	263
Chapter 13. Information on changes in national system.....	264
Chapter 14. Information on changes in national registry.....	265
Chapter 15. Information on minimising adverse impacts in accordance with article 3, paragraph 14 ..	266
15.1. Introduction	266
15.2. Context.....	266
15.3. Specific Elements.....	266
Annexes to the national inventory report.....	268
Annex 1: Key categories	268
Annex 2: Assessment of uncertainty	284
A2.1: Description of methodology used for identifying uncertainties	284
Annex 3: Detailed methodological descriptions for individual source or sink categories.....	292
A.3.1. Fuel combustion (1A)	292
A.3.2. Solid waste management (5A)	304
Annex 4: The national energy balance for the most recent inventory year (2017).....	307

Annex 5: Indirect greenhouse gases and SO ₂	318
Annex 6: Implementation of recommendations and adjustments.....	328
A6.1. EU review Process	328
A6.2. UNFCCC/KP review Process	329
Annex 7: Key actions of the National Inventory Improvement Plan	336
References	337

List of Tables

Table 1.	GHG emissions trends by gas for the period 1990 – 2017.....	19
Table 2.	GHG emissions by sector for the period 1990 – 2017	21
Table 3.	NO _x , CO, NMVOCs and SO _x emissions 1990-2017 (Gg).....	22
Table 1.1.	QA/QC procedures for the GHG emissions inventory	37
Table 1.2.	Timing and responsibilities	38
Table 1.3.	Methodologies used for the preparation of Cyprus’ GHG inventory	41
Table 1.4.	Data sources and data sets per IPCC sector, source category	44
Table 1.5.	Direct Global Warming Potentials (mass basis) relative to carbon dioxide for the 100-year horizon	48
Table 1.6.	Key categories for Cyprus’ inventory system without LULUCF for 2017	49
Table 1.7.	Key categories for Cyprus’ inventory system with LULUCF for 2017	49
Table 2.1.	Total GHG emissions trend for the period 1990 – 2017	54
Table 2.2.	GHG emissions by sector for the period 1990 – 2017	54
Table 2.3.	GHG emissions trends by gas for the period 1990 - 2017	55
Table 3.1.	Emissions from energy 1990-2017	60
Table 3.2.	Methodology for the estimation of emissions from energy.....	61
Table 3.3.	Emissions from fuel combustion 1990-2017.....	63
Table 3.4.	Emissions from energy industries 1990-2017	65
Table 3.5.	Fuel consumption data obtained from the electricity production company in Cyprus (1990-2004).....	66
Table 3.6.	Data collected through the ETS for electricity production in Cyprus (2005-2015)	66
Table 3.7.	Fuel consumed for petroleum refining in Cyprus (1990-2004).....	67
Table 3.8.	Solid biomass consumed for the production of charcoal.....	68
Table 3.9.	Emissions from manufacturing industries and construction 1990-2017	70
Table 3.10.	Fuel consumption in manufacturing industries and construction 1990-2017.....	72
Table 3.11.	Parameters used for the estimation of emissions.....	75
Table 3.12.	Transport emissions 1990-2017	76
Table 3.13.	International and domestic flights’ fuel consumptions, EUROCONTROL data (2005-2017)	77
Table 3.14.	Share of domestic flights to the total fuel consumption, EUROCONTROL data (2005-2017)	78
Table 3.15.	Share of domestic flights to the total fuel consumption, consumption for domestic and international flights (1990-2004)	78
Table 3.16.	Number of vehicles by type	79
Table 3.17.	Fuel consumed by road transport (kt) during 1990-2017.....	80
Table 3.18.	Diesel consumption by domestic water-borne navigation activities	80
Table 3.19.	Impact of recalculations on Road Transport (1A3b) emissions	81
Table 3.20.	GHG emissions from Other sectors 1990-2017	82
Table 3.21.	Fuel consumption for “Other sectors” for the period 1990-2017	84
Table 3.22.	Parameters used for the estimation of emissions from other sectors.....	86
Table 3.23.	1A4a Commercial / Institutional recalculations (Gg CO ₂ eq.)	86
Table 3.24.	GHG emissions from Other (Not elsewhere specified-Stationary) 1990-2017.....	86
Table 3.25.	Other non-specified fuel consumption 1990-2017	87
Table 3.26.	Parameters used for the estimation of other emissions	87
Table 3.27.	Net calorific value (TJ/kt) and carbon emission factors (t CO ₂ /kt) of fuels consumed in Cyprus used for the reference approach.....	89

Table 3.28.	Apparent consumption (TJ) and CO ₂ emissions (Gg) estimates according to the reference approach 1990-2017.....	91
Table 3.29.	Difference between Reference and Sectoral Approach 1990-2017.....	92
Table 3.30.	Parameters used for the calculation of emissions.....	93
Table 3.31.	Fuel consumption, carbon stored and CO ₂ emissions for Feedstocks and non-energy use of fuels	94
Table 3.32.	Fugitive emissions from oil during 1990-2017, in tons	95
Table 3.33.	Oil refined during 1990-2004, kt	96
Table 3.34.	Fuel density (kg/m ³) used to convert fuel consumption from mass to volume.....	96
Table 3.35.	Volume of fuel transported 1990-2017 (10 ³ m ³).....	96
Table 3.36.	Emissions from memo items (Gg CO ₂ eq.).....	97
Table 3.37.	Emissions from international bunkers 1990-2017.....	97
Table 3.38.	Fuel consumption for international aviation and maritime activities 1990-2017 (kt)	98
Table 3.39.	Parameters used for the calculation of emissions.....	98
Table 3.40.	Activities consuming biomass in Cyprus	99
Table 3.41.	Emissions from CO ₂ from biomass 1990-2017	99
Table 4.1.	Total GHG emissions (in Gg CO ₂ eq) from Industrial Processes, 1990 – 2017	103
Table 4.2.	Industrial Processes – completeness	104
Table 4.3.	Industrial processes – methodologies and emission factors applied	105
Table 4.4.	Emissions from mineral industry 1990-2017 (Gg CO ₂).....	106
Table 4.5.	CO ₂ emissions for Cement production (2.A.1) 1990-2017	107
Table 4.6.	Total clinker production and CO ₂ process emissions from cement production (kt)	108
Table 4.7.	CO ₂ emissions for Lime production (2.A.2) 1990-2017	110
Table 4.8.	Slaked lime production (t).....	110
Table 4.9.	CO ₂ emissions for Other Process Uses of Carbonates (2.A.4) 1990-2017	112
Table 4.10.	Ceramics production (Gg).....	113
Table 4.11.	CO ₂ process emissions of the ETS ceramics installations and estimated annual implied emission factor (2001-2016).....	113
Table 4.12.	Imports of Soda ash in Cyprus (t)	114
Table 4.13.	CO ₂ emissions from non-energy Products from Fuels and Solvent Use	115
Table 4.14.	Lubricant consumption in Cyprus (kt)	117
Table 4.15.	Imports of paraffin wax in Cyprus (kt)	117
Table 4.16.	NMVOCs emissions used for the estimation of CO ₂ emissions from Solvent use.....	118
Table 4.17.	Activity data used for estimation of emissions from Urea-based catalysts	118
Table 4.18.	CO ₂ emissions from Solvent use recalculations	119
Table 4.19.	Emissions from consumption of halocarbons 1990-2017	120
Table 4.20.	Average total population used for the estimation of per capita emissions from 2F activities (EUROSTAT).....	130
Table 4.21.	Per capital emissions by source from 2F activities (kg CO ₂ eq.).....	130
Table 4.22.	Total population used for the estimation of emissions from 2F activities.....	131
Table 4.23.	Contribution of activities to 2F emissions.....	131
Table 4.24.	Total 2F emissions from Stocks estimated for Cyprus (t CO ₂ eq.).....	132
Table 4.25.	2F Recalculations	133
Table 4.26.	Emissions from Other Product Manufacture and Use (2G)	134
Table 4.27.	Annual per capita emissions for 2G1	135
Table 4.28.	SF ₆ emissions for 2G1, as reported in CRFreporter	136
Table 4.29.	N ₂ O emissions (Gg) from Product Uses.....	137
Table 4.30.	NMVOCs emissions used for the estimation of CO ₂ emissions from Other (2G4).....	138
Table 4.31.	CO ₂ emissions from Other (2G4) Recalculations.....	139
Table 5.1.	GHG emissions from Agriculture, for the period 1990 – 2017.....	141
Table 5.2.	Agriculture – methodologies and emission factors applied	142
Table 5.3.	Agriculture – Inventory completeness	143

Table 5.4.	CH ₄ emissions from Enteric Fermentation (3A) 1990-2017	143
Table 5.5.	Animal population for 1990 – 2017 (in 1000s).....	144
Table 5.6.	Information for the application of Tier 2 methodology for dairy cattle	146
Table 5.7.	Daily milk production per dairy cow (kg) and per cent pregnant population of cows in Cyprus.....	146
Table 5.8.	Gross energy (GE) and emissions factor (EF) for dairy cattle for the period 1990 – 2017	146
Table 5.9.	Methane emission factor applied for enteric fermentation, according to animal	147
Table 5.10.	CH ₄ and N ₂ O emissions from manure management for 1990 – 2017.....	148
Table 5.11.	Emission factors used for the estimation of methane emissions from manure management	149
Table 5.12.	Volatile substance excretion (VS) and Bo for T2 methodology (2006 IPCC Guidelines, vol. 4, Annex 10A.2).....	150
Table 5.13.	Waste management per technology contribution	150
Table 5.14.	Default values for Nitrogen excretion rate (IPCC 2006 guidelines, volume 4, table 10.19, pg. 10.59)	152
Table 5.15.	kg N ₂ O-N/kg N ex coefficients per technology used.....	152
Table 5.16.	Default values for volatilisation N losses.....	153
Table 5.17.	Recalculations for indirect N ₂ O emissions	154
Table 5.18.	N ₂ O emissions from agricultural soils for 1990 – 2017	155
Table 5.19.	N input from application of inorganic fertilizers for the period (in kt) 1990-2017	157
Table 5.20.	Default values for nitrogen loss due to volatilisation of NH ₃ and NO _x from manure management	157
Table 5.21.	Volatilisation N-losses (kg N).....	157
Table 5.22.	Dry sludge applied to soils and nitrogen in sewage sludge (kg)	158
Table 5.23.	Activity data used for the calculation of N ₂ O emissions from Other organic fertilizers applied to soils (3D1.2c)	159
Table 5.24.	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	160
Table 5.25.	Default dry matter fraction (DRY), Slope, Intercept, NAGT, RBGT, NBGT per crop .	164
Table 5.26.	Crop residue that is burned (FracBURN).....	164
Table 5.27.	Cf	164
Table 5.28.	3D1.2a. Animal Manure applied to soils recalculations.....	165
Table 5.29.	FON and N ₂ O(ATD) –N (kg N / yr).....	167
Table 5.30.	Atmospheric deposition (3D2.1) recalculations	168
Table 5.31.	Field burning of agricultural residues emissions, 1990-2017	169
Table 5.32.	Urea application emissions, 1990-2017	171
Table 5.33.	Urea consumption in Cyprus (t) and total CO ₂ –C emission (tC/yr)	171
Table 6.1.	The correspondence between the CORINE land cover categories identified in Cyprus and the IPCC 2006 six broad land-use categories as implemented in the Cyprus conditions.	175
Table 6.2.	The IPCC 2006 land-use sub/categories data based on the raw data from the CORINE annual land use data set (k ha). Resolution for detection of individual land uses is 25 ha. The data refer to the areas under the effective control of the Cyprus Government (Managed Lands).	176
Table 6.3.	Emissions and removals (+/-) from Sector 4 LULUCF by sub-categories (k t CO ₂ eq).	177
Table 6.4.	Data on area of land remaining in the same land use subcategory (from Broadleaved Forest to Broadleaved Forest) and areas of land converted to Broadleaved Forest subcategory from other land use sub/categories.....	179

Table 6.5.	Data on area of land remaining in the same land use subcategory (from Coniferous Forest to Coniferous Forest) and areas of land converted to Coniferous Forest subcategory from other land use sub/categories.	180
Table 6.6.	National data on growing stock and annual increment	181
Table 6.7.	Numerical data for BCEF values used in carbon source/sink calculations.	182
Table 6.8.	Data on area of land remaining in the same land use subcategory (from Annual Cropland to Annual Cropland) and areas of land converted to Annual Cropland subcategory from other land use sub/categories. Note that any piece of land after remaining for 20 years in the transitional land use sub/category is transferred to the final land use sub/category.	186
Table 6.9.	Data on area of land remaining in the same land use subcategory (from Woody Cropland to Woody Cropland) and areas of land converted to Woody Cropland subcategory from other land use sub/categories. Note that any piece of land after remaining for 20 years in the transitional land use sub/category is transferred to the final land use sub/category.	187
Table 6.10.	The IPCC default relative soil organic carbon stock change factors.....	189
Table 6.11.	Data on area of land remaining in the same land-use subcategory (Grass Grassland remaining Grass Grassland) and areas of land converted to Grass Grassland subcategory from other land-use sub/categories. Note that there is no conversion of any land to Grass Grassland.....	191
Table 6.12.	Data on area of land remaining in the same land use subcategory (from Woody Grassland to Woody Grassland) and areas of land converted to Woody Grassland subcategory from other land use sub/categories.	192
Table 6.13.	Data on area of land remaining in the same land use category (from Wetland to Wetland) and areas of land converted to Wetland category from other land use sub/categories. Note that any piece of land after remaining for 20 years in the transitional land use category is transferred to the final land use category.	195
Table 6.14.	Data on area of land remaining in the same land use subcategory (from Settlements to Settlements) and areas of land converted to Settlements category from other land use sub/categories. Note that any piece of land after remaining for 20 years in the transitional land use sub/category is transferred to the final land use sub/category.....	198
Table 6.15.	Calculation of the average product of FLU, FMG and FI applicable to Lands to be converted to Settlements	200
Table 6.16.	Calculation of the average product of FLU, FMG and FI applicable to Settlements remaining Settlements.....	200
Table 6.17.	Comparison of land use conversion from/to Other Land category (data in relation to the total converted land during the period 1990 -2017).....	202
Table 6.18.	Data on area of land remaining in the same land use category (from Other Land to Other Land) and areas of land converted to Other Land category from other land use sub/categories. Note that the rule that any piece of land after remaining for 20 years in the transitional land use sub/category is transferred to the final land use sub/category is not implemented for this category due to high dynamics of lands in this category.	203
Table 6.19.	Calculation of the average product of FLU, FMG and FI applicable to Other Land remaining Other Land	204
Table 6.20.	The FAO items and their codes that were the source of numerical data for all calculations relating to the HWP GHG contribution.....	206
Table 6.21.	Wood pulp production in Cyprus 1992 – 2017 (FAO data and estimates calculated based on them)	207
Table 6.22.	The default half-fives and associated decay rates for solid wood products and paper products.....	207
Table 6.23.	Conversion factors used in the calculation of the HWP contribution	208
Table 6.24.	Numerical values of estimated variables 2A and 2B	208
Table 7.1.	Total GHG emissions (in Gg CO ₂ eq) from waste, 1990-2017	210
Table 7.2.	Waste– methodologies and emission factors applied.....	211

Table 7.3.	Waste – completeness	211
Table 7.4.	Total GHG emissions from solid waste disposal sites for the period 1990 – 2017.....	214
Table 7.5.	Total population, annual per capita production (kg/cap), total MSW production (1000t)	215
Table 7.6.	Fraction of MSW disposed at SWDS (MSW_F), mass of MSW disposed to disposal sites (1000t) and other practices.....	216
Table 7.7.	Allocation of waste to types waste disposal sites.....	217
Table 7.8.	Urban and Rural population of Cyprus per district at the end of the year (1000s).....	217
Table 7.9.	Amount of waste generated per district and type of waste disposal site (kt)	219
Table 7.10.	Allocation of population and waste to types waste disposal sites	220
Table 7.11.	Composition of MSW disposed at SWDS	221
Table 7.12.	DOC _i used for the calculation of DOC (weight fraction, wet basis).....	222
Table 7.13.	Methane generation rate constant (k).....	222
Table 7.14.	Waste disposed at (a) managed, (b) deep unmanaged and (c) swallow unmanaged disposal sites	223
Table 7.15.	Other parameters used for methane calculation	223
Table 7.16.	Emissions from biological treatment of solid waste, 1990-2017	224
Table 7.17.	Emissions from Wastewater treatment and discharge (5D) 1990-2017	226
Table 7.18.	Wastewater treatment technologies implemented in Cyprus for the treatment of urban wastewaters	228
Table 7.19.	Utilisation of treated sludge produced by the wastewater treatment plants in Cyprus (t of dry matter/yr)	228
Table 7.20.	Load entering the Urban Waste Water Treatment Plants (UWWTP) (p.e.).....	229
Table 7.21.	Total emissions from Domestic wastewater 1990-2017	229
Table 7.22.	Distribution of wastewater to septic tanks and central treatment stations U _i and estimated TOW	230
Table 7.23.	Parameters used for the estimation of CH ₄ emissions from wastewater treatment.....	231
Table 7.24.	CH ₄ emissions from domestic wastewater treatment 1990-2017	231
Table 7.25.	Annual per capita protein consumption and resulting NEFFLUENT (kg/person/yr)	232
Table 7.26.	N ₂ O emissions from advanced centralised wastewater treatment plants, NWWT and resulting NEFFLUENT	233
Table 7.27.	Total emissions from industrial wastewater 1990-2017.....	234
Table 7.28.	Industrial production 1990-2017 (Gg)	236
Table 7.29.	Wastewater generation coefficient (m ³ /t product) and COD concentration (kg COD/m ³) according to industrial product.....	237
Table 7.30.	Total organically degradable material (Gg), 1990-2017	237
Table 7.31.	Treatment of waste by anaerobic treatment according to industrial production, 1990-2017	238
Table 7.32.	Methane emission factor estimated according to waste stream (kg CH ₄ /kg COD), 1990- 2017	239
Table 7.33.	Total industrial wastewater production (1000 m ³ /year), 1990-2017	240
Table 10.1.	Comparison of NIR2019 to NIR2018, in kt CO ₂ eq.....	244
Table 11.1.	GHG emissions (+) and removals (-) arising from land use, land use change and forestry activities reported under the Kyoto Protocol (incl. HWP) for the period 2013 – 2017..	248
Table 11.2.	Comparison of ARD and FM areas reported under KP and areas of forest land remaining forest land and LUC to/from forests reported under the Convention (k ha).	250
Table 11.3.	The annual land use change matrix for the year 1990/1991 (changes representative for the period 1990 – 2006).	251
Table 11.4.	The annual land use change matrix for the year 2007/2008 (changes representative for the period 2007 – 2017).	251
Table 11.5.	Land-use category conversions occurring under the Convention to be reported as AR under the KP (Non-forest land-use categories converted to forest land-use categories)	253

Table 11.6.	Land-use category conversions occurring under the Convention to be reported as D under the KP (Forest land-use categories converted to non-forest land-use categories).....	254
Table 11.7.	Forest land-use categories remaining Forest land-use categories under the Convention to be reported as FM under the KP	255
Table 11.8.	Afforestation/Reforestation - disaggregation by land-use categories.....	257
Table 11.9.	Deforestation - disaggregation by land-use categories.....	257
Table 11.10.	Forest Management - disaggregation by land-use categories.....	258
Table 11.11.	Key category analysis for the KP LUUCF activities. For the purposes of reporting the signs for removals are always negative (-) and for emissions positive (+).	258
Table 11.12.	Estimation of AR, D and FM area since 1990 (Government Controlled Area)	259
Table 11.13.	Production of HWP by the KP categories in Cyprus.	260
Table 11.14.	Initial stocks, gains and losses of the KP HWP categories for the period 2013 – 2017 (all data in kt C).....	261
Table A1.1.	Key categories analysis without LULUCF – Level assessment for 2017	268
Table A1.2.	Key categories analysis with LULUCF – Level assessment for 2017	270
Table A1.3.	Key categories analysis without LULUCF – Level assessment for 1990	272
Table A1.4.	Key categories analysis with LULUCF – Level assessment for 1990	274
Table A1.5.	Key categories analysis without LULUCF – Trend assessment for 2017	277
Table A1.6.	Key categories analysis with LULUCF – Trend assessment for 2017.....	280
Table A2.1.	Reasoning for activity data and emission factor uncertainty value	285
Table A2.2.	Analytical calculations of uncertainty, without LULUCF 1990	288
Table A2.3.	Analytical calculations of uncertainty, without LULUCF 2017	290
Table A3.1.1.	Contribution of different activities to LPG consumption (2006) used to allocate consumption to different sectors for 1990-2005	292
Table A3.1.2.	International and domestic flights' fuel consumptions, EUROCONTROL data (2005-2016)	292
Table A3.1.3.	Fuel consumption according to the National Energy balance 2017 in kt (1990-2017) ..	293
Table A3.1.4.	Share of domestic flights to the total fuel consumption, EUROCONTROL data (2005-2016)	300
Table A3.1.5.	Share of domestic flights to the total fuel consumption, consumption for domestic and international flights (1990-2004)	300
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	300
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	301
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	301
Table A3.1.9.	Consumption diesel for Water-borne navigation activities	302
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	303
Table A3.2.1.	Data used for fitting and extrapolating GDP and waste activity is tabulated by year. Figures in bold are calculated by the models illustrated in Figures 7.4 and 7.5.....	304
Table A.4.1.	Energy balance 2017 - Liquid Fuels (LPG, Non-biogasoline, Non-bio jet kerosene, Other kerosene, Road diesel, Heating and other gas oil, Total gas/diesel oil, Biodiesel), in kt	308
Table A.4.2.	Energy balance 2017 - Liquid Fuels (Non-bio gas/diesel oil, Total fuel oil, "Fuel oil -high sulphur", Lubricants, Bitumen, Pet-coke), in kt.....	312

Table A.4.3. Energy balance 2017 - Solid Fuels (Bituminous coal), in kt.....	316
Table A.4.4. Energy balance 2017 – Industrial waste (non-renewable), Municipal waste (renewable), Municipal waste (non-renewable), Solid biofuels, Charcoal, Biogases, in TJ	317
Table A5.1. NOx emissions 1990-2017 (as Gg NO ₂)	318
Table A5.2. CO emissions 1990-2017 (Gg).....	320
Table A5.3. NMVOCs emissions 1990-2017 (Gg).....	322
Table A5.4. SOx emissions 1990-2017 (as Gg SO ₂)	325
Table A6.1. Summary of Recommendations from the TERT and status of implementation.....	328
Table A6.2. Summary of Recommendations from the ERT and status of implementation	329
Table A7.1. Key actions of the National Inventory Improvement Plan.....	336

List of Figures

Figure 1.	Overview of the organisational structure of the National Inventory System	19
Figure 2.	GHG emissions by sector for the period 1990 – 2017	22
Figure 1.1.	Overview of the organisational structure of the National Inventory System	29
Figure 1.2.	GHG emissions inventory preparation process in Cyprus	33
Figure 1.3.	Timetable for inventory preparation	34
Figure 1.4.	Flow chart of activities concerning emissions inventory	36
Figure 1.5.	QA/QC process and procedures and inventory related activities	37
Figure 1.6.	Timing and responsibilities of QA/QC tasks	39
Figure 2.1.	Total GHG emissions trend for the period 1990 – 2017	54
Figure 2.2.	GHG emissions by sector for the period 1990 – 2017	55
Figure 3.1.	Emissions from the energy sector 1990-2017	61
Figure 3.2.	Emissions from fuel consumption 1990-2017.....	64
Figure 3.3.	Energy industries emissions (1A1) 1990-2017	65
Figure 3.4.	Emissions from energy use in manufacturing industries and construction (1A2) 1990-2017	70
Figure 3.5.	Transport (1A3) emissions 1990-2017.....	77
Figure 3.6.	Smaller aircrafts LTOs and EUROCONTROL data for domestic flights	78
Figure 3.7.	Trend of vehicles population in the Road transport sector.....	80
Figure 3.8.	Impact of recalculations on Road Transport (1A3b) emissions	82
Figure 3.9.	Other sectors (1A4) emissions 1990-2017	83
Figure 3.10.	GHG emissions from Other (Not elsewhere specified-Stationary) (1A5) 1990-2017	87
Figure 3.11.	CO2 emissions from fuel combustion using sectoral and reference approach.....	93
Figure 3.12.	Emissions from international bunkers 1990-2017.....	98
Figure 3.13.	Emissions from biomass 1990-2017	99
Figure 4.1.	GHG emissions from Industrial Processes (sector 2) for the period 1990 – 2017	104
Figure 4.2.	GHG emissions from Mineral products (2A) for the period 1990 – 2017	107
Figure 4.3.	CO2 emissions for Cement production (2.A.1) 1990-2017	107
Figure 4.4.	CO2 emissions for Lime production (2.A.2) 1990-2017	110
Figure 4.5.	CO2 emissions for Other Process Uses of Carbonates (2.A.4) 1990-2017	112
Figure 4.6.	Emissions from non-energy Products from Fuels and Solvent Use (2D) 1990-2017	116
Figure 4.7.	Lubricant consumption 1990-2017 (kt).....	116
Figure 4.8.	CO2 emissions from Solvent use recalculations	120
Figure 4.9.	Emissions from consumption of halocarbons 1990-2017	121
Figure 4.10.	Average per capita emissions for 2F2 with and without Malta 1998-2015 (t/cap)	129
Figure 4.11.	Average per capita emissions for 2F3 with and without Malta 1990-2015 (t/cap)	129
Figure 4.12.	Average per capita emissions for 2F4 with and without Malta 1993-2015 (t/cap)	129
Figure 4.13.	2F1 recalculations	133
Figure 4.14.	Emissions from Other Product Manufacture and Use (2G)	134
Figure 4.15.	Average per capita emissions for 2G1 with and without Malta 1990-2015 (t/cap).....	135
Figure 4.16.	CO2 emissions from Other (2G4) Recalculations.....	139
Figure 5.1.	Emissions from Agriculture, 1990 – 2017	141
Figure 5.2.	CH4 emissions from Enteric Fermentation (3A) 1990-2017 in Gg CO2 eq.	144
Figure 5.3.	Emissions from manure management, 1990 – 2017	149
Figure 5.4.	Recalculations for indirect N2O emissions	155
Figure 5.5.	N2O emissions from agricultural soils 1990 – 2017 (Gg CO2 eq.)	156
Figure 5.7.	3D1.2a. Animal Manure applied to soils recalculations.....	166

Figure 5.8.	Atmospheric deposition (3D2.1) recalculations	169
Figure 5.9.	Field burning of agricultural residues emissions, 1990-2017 (Gg CO2 eq.).....	170
Figure 5.10.	Urea application emissions, 1990-2017 (Gg CO2 eq.).....	171
Figure 6.1.	Removal (-) trend for the entire LULUCF sector in the period 1990 – 2017.....	178
Figure 6.2.	Forest remaining Forest: Net change in CO2 (blue line) and non-CO2 emissions from forest fires (red line) during the period 1990 – 2017.....	183
Figure 6.3.	Land converted to Forest: Net change in CO2 (blue line) during the period 1990 – 2017	183
Figure 6.4.	Forest remaining Forest and Land converted to Forest: net CO2 emissions/removals during the period 1990 – 2017	184
Figure 6.5.	Woody Cropland remaining Woody Cropland, Land converted to Annual Cropland and Land converted to Woody Cropland: CO2 emissions/removals during the period 1990 – 2017.	189
Figure 6.6.	Woody Grassland remaining Woody Grassland: CO2 removals during the period 1990 – 2017	194
Figure 6.7.	Lands converted to Wetlands: CO2 removals during the period 1990 – 2017.....	197
Figure 6.8.	Lands converted to Settlements: CO2 emissions during the period 1990 – 2017.	201
Figure 6.9.	Lands converted to Other Land: CO2 emissions during the period 1990 – 2017.	205
Figure 6.10.	HWP Contribution to LULUCF emissions/removals. Note: negative numbers denote removals; positive numbers denote emissions.	209
Figure 7.1.	GHG emissions from waste for the period 1990-2017.....	211
Figure 7.2.	Years of activity of active Uncontrolled Waste Disposal Sites.....	212
Figure 7.3.	Starting year of activity for all Uncontrolled Waste Disposal Sites.....	212
Figure 7.4.	Total GHG emissions from solid waste disposal sites for the period 1990 – 2017.....	214
Figure 7.5.	Plot used to estimate the annual per capita production for 1990-1995 (kg/cap)	215
Figure 7.6.	Emissions from Composting 1990-2017.....	224
Figure 7.7.	Wastewater treatment systems and discharge pathways in Cyprus.....	226
Figure 7.8.	Total emissions from Wastewater treatment and discharge (5D) 1990-2017	227
Figure 7.9.	Domestic Wastewater treatment in Cyprus 1990-2017.....	227
Figure 7.10.	Total emissions from Domestic wastewater (5D1) 1990-2017.....	229
Figure 7.12.	Emissions from industrial wastewater 1990-2017	235
Figure 10.1.	Comparison of NIR2019 to NIR2018, in kt CO2 eq.....	246
Figure A.3.2.1.	GDP data 1960-2014 (CYSTAT) extrapolated for the years of 1950-59.....	305
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.....	306
Figure A.3.2.3.	Waste per capita derived from annual GDP data and hind casts.....	306

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, which keeps the overall responsibility, and 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 through their appointed focal persons, ensure the data provision.

International or national associations, along with individual public or private industrial companies

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 DoE.

contribute to data providing and development of methodological issues as appropriate.

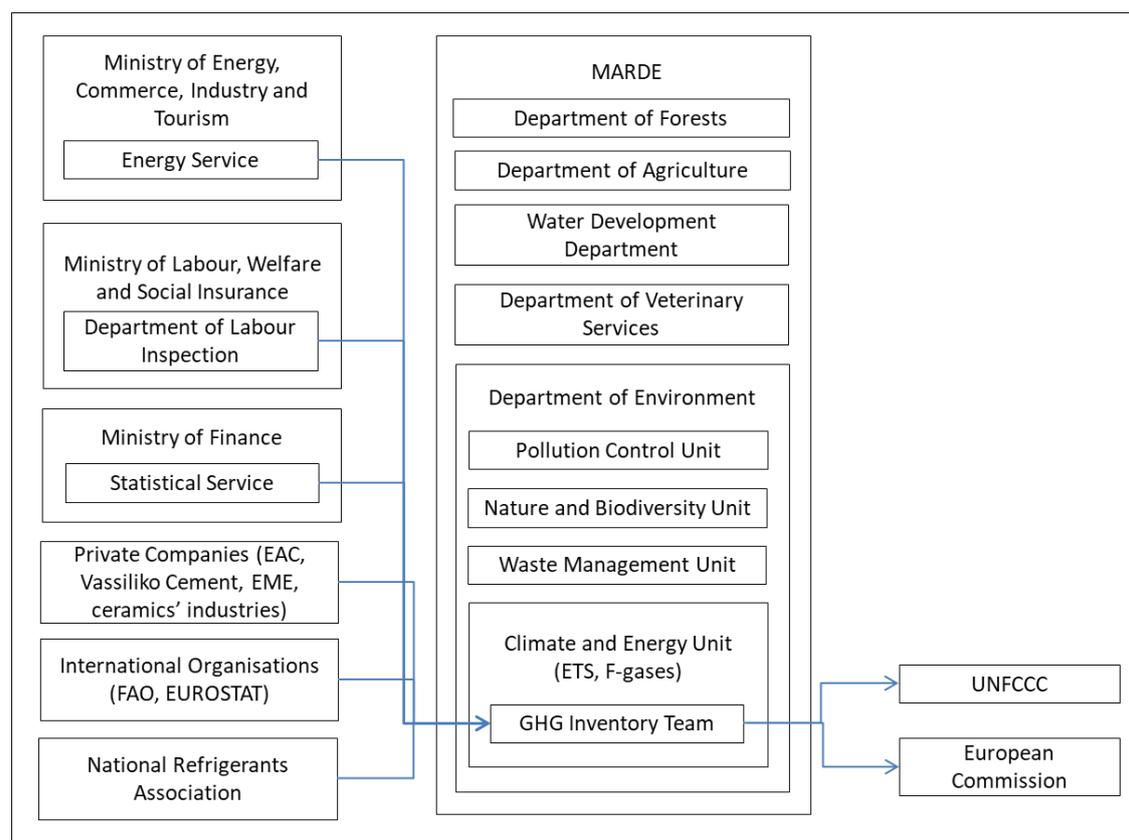


Figure 1. Overview of the organisational structure of the National Inventory System

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 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.

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

GHG emissions trends by gas for the period 1990 - 2017 are presented in Table 1.

Table 1. GHG emissions trends by gas for the period 1990 – 2017

	1990	1991	1992	1993	1994
CO ₂ emissions without LULUCF	4664.61	5154.32	5530.39	5774.41	6018.46
CO ₂ emissions with LULUCF	4413.35	4906.62	5275.25	5502.31	5761.01
CH ₄ emissions without LULUCF	654.58	665.72	683.43	707.40	720.11
CH ₄ emissions with LULUCF	654.63	665.88	683.48	707.81	721.17
N ₂ O emissions without LULUCF	285.75	287.06	317.90	337.57	331.17
N ₂ O emissions with LULUCF	285.77	287.11	317.92	337.72	331.54
HFCs	63.88	76.02	84.42	79.14	82.20
PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF ₆	0.03	0.03	0.03	0.04	0.05
NF ₃	NO	NO	NO	NO	NO
Total (without LULUCF)	5668.85	6183.15	6616.17	6898.56	7151.98

Total (with LULUCF)	5417.66	5935.67	6361.10	6627.01	6895.96
	1995	1996	1997	1998	1999
CO ₂ emissions without LULUCF	5889.45	6240.32	6328.00	6621.50	6890.63
CO ₂ emissions with LULUCF	5611.89	5954.83	6071.88	6436.61	6531.88
CH ₄ emissions without LULUCF	740.83	757.27	760.79	761.73	764.56
CH ₄ emissions with LULUCF	741.24	757.95	761.77	765.09	764.58
N ₂ O emissions without LULUCF	373.29	348.51	343.17	371.03	356.18
N ₂ O emissions with LULUCF	373.44	348.75	343.52	372.21	356.19
HFCs	91.92	95.96	99.69	105.78	116.67
PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF ₆	0.06	0.07	0.07	0.07	0.07
NF ₃	NO	NO	NO	NO	NO
Total (without LULUCF)	7095.55	7442.12	7531.73	7860.11	8128.10
Total (with LULUCF)	6818.55	7157.56	7276.94	7679.76	7769.38
	2000	2001	2002	2003	2004
CO ₂ emissions without LULUCF	7140.26	7015.91	7204.91	7598.82	7833.80
CO ₂ emissions with LULUCF	7199.52	6826.20	6867.36	7246.42	7485.72
CH ₄ emissions without LULUCF	780.52	811.64	835.36	826.86	821.78
CH ₄ emissions with LULUCF	787.72	814.06	835.43	827.16	822.38
N ₂ O emissions without LULUCF	345.44	377.08	381.72	380.37	339.63
N ₂ O emissions with LULUCF	347.96	377.93	381.75	380.48	339.84
HFCs	120.21	121.57	129.79	134.15	146.33
PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF ₆	0.08	0.08	0.08	0.09	0.10
NF ₃	NO	NO	NO	NO	NO
Total (without LULUCF)	8386.50	8326.28	8551.87	8940.29	9141.64
Total (with LULUCF)	8455.49	8139.83	8214.41	8588.30	8794.37
	2005	2006	2007	2008	2009
CO ₂ emissions without LULUCF	8021.49	8212.09	8527.51	8696.16	8443.91
CO ₂ emissions with LULUCF	7644.20	7759.18	8312.69	8183.88	7901.93
CH ₄ emissions without LULUCF	804.37	805.48	808.08	805.78	805.85
CH ₄ emissions with LULUCF	804.57	805.99	812.93	805.96	806.14
N ₂ O emissions without LULUCF	313.36	327.16	320.96	309.02	300.92
N ₂ O emissions with LULUCF	313.43	327.34	322.66	309.08	301.02
HFCs	194.12	197.79	224.54	217.34	224.52
PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF ₆	0.12	0.12	0.14	0.15	0.16
NF ₃	NO	NO	NO	NO	NO
Total (without LULUCF)	9333.44	9542.64	9881.22	10028.45	9775.35
Total (with LULUCF)	8956.44	9090.41	9672.96	9516.40	9233.77
	2010	2011	2012	2013	2014
CO ₂ emissions without LULUCF	8082.33	7760.34	7229.26	6550.83	6931.34
CO ₂ emissions with LULUCF	7592.29	7194.07	6683.14	5970.59	6353.77
CH ₄ emissions without LULUCF	812.57	817.02	805.95	799.52	799.34
CH ₄ emissions with LULUCF	813.69	817.96	807.00	799.89	799.75
N ₂ O emissions without LULUCF	318.08	304.61	303.64	277.70	272.87
N ₂ O emissions with LULUCF	318.47	304.94	304.00	277.82	273.01
HFCs	245.65	219.43	222.13	214.83	213.03
PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF ₆	0.15	0.16	0.16	0.15	0.15

NF ₃	NO	NO	NO	NO	NO
Total (without LULUCF)	9458.77	9101.56	8561.13	7843.03	8216.73
Total (with LULUCF)	8970.25	8536.57	8016.43	7263.29	7639.71
				Change 1990- 2017	
	2015	2016	2017		
CO ₂ emissions without LULUCF	6956.59	7362.10	7538.49	61.61	
CO ₂ emissions with LULUCF	6383.92	7421.65	7003.97	58.70	
CH ₄ emissions without LULUCF	815.52	845.96	863.99	31.99	
CH ₄ emissions with LULUCF	815.66	857.97	864.37	32.04	
N ₂ O emissions without LULUCF	280.48	287.82	293.05	2.56	
N ₂ O emissions with LULUCF	280.53	292.03	293.19	2.60	
HFCs	250.45	245.28	249.56	290.65	
PFCs	NO	NO	NO	0.00	
Unspecified mix of HFCs and PFCs	NO	NO	NO	0.00	
SF ₆	0.16	0.17	0.17	541.56	
NF ₃	NO	NO	NO	0.00	
Total (without LULUCF)	8303.21	8741.33	8945.26	57.80	
Total (with LULUCF)	7730.73	8817.09	8411.26	55.26	

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

Energy, with 6619 Gg CO₂ eq., continues to be the largest contributor to the total national GHG emissions (75% compared to the total without LULUCF). 3299 Gg CO₂ eq. of these emissions is from the production of electricity, while another 2094 Gg CO₂ eq. from transport. Table 2.2 and Figure 2.2 present the emissions for the period 1990-2017 by sector.

Table 2. GHG emissions by sector for the period 1990 – 2017

	Energy	IPPU	Agriculture	LULUCF	Waste	Total (incl. LULUCF)	Total (excl. LULUCF)
1990	3970	841	471	-251	387	5418	5669
1991	4503	814	475	-247	391	5936	6183
1992	4832	875	510	-255	399	6361	6616
1993	5010	940	541	-272	408	6627	6899
1994	5223	980	530	-256	419	6896	7152
1995	5132	957	580	-277	427	6819	7096
1996	5429	1020	562	-285	431	7158	7442
1997	5553	991	549	-255	439	7277	7532
1998	5901	951	563	-180	445	7680	7860
1999	6160	970	546	-359	452	7769	8128
2000	6376	998	552	69	460	8455	8387
2001	6271	985	601	-186	469	8140	8326
2002	6430	1026	621	-337	475	8214	8552
2003	6824	1037	603	-352	476	8588	8940
2004	6958	1121	583	-347	479	8794	9142
2005	7136	1179	533	-377	486	8956	9333
2006	7319	1191	548	-452	484	9090	9543
2007	7641	1215	540	-208	485	9673	9881
2008	7807	1213	516	-512	493	9516	10028
2009	7726	1043	509	-542	497	9234	9775
2010	7495	934	532	-489	498	8970	9459
2011	7202	878	521	-565	501	8537	9102
2012	6716	837	498	-545	511	8016	8561
2013	5794	1064	463	-580	521	7263	7843
2014	5958	1280	448	-577	531	7640	8217
2015	6081	1221	457	-572	544	7731	8303
2016	6480	1225	482	76	554	8817	8741

	Energy	IPPU	Agriculture	LULUCF	Waste	Total (incl. LULUCF)	Total (excl. LULUCF)
2017	6619	1270	495	-534	562	8411	8945
Change 1990-2017	66.7%	50.9%	5.0%	112.6%	45.2%	55.3%	57.8%

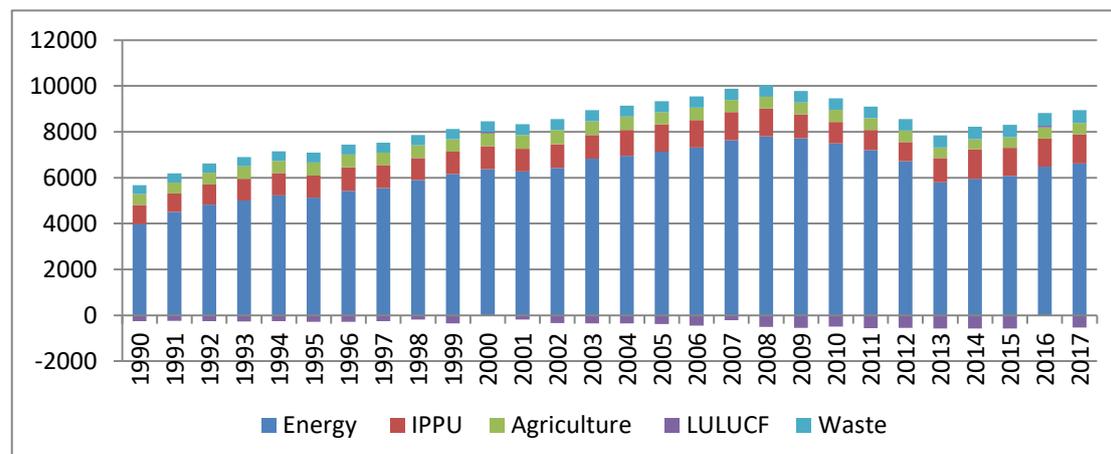


Figure 2. GHG emissions by sector for the period 1990 – 2017

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 that 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 SO_x emissions 1990-2017 (Gg)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NO _x	16.50	16.87	18.75	18.98	20.24	19.06	19.66	19.93	20.29	20.76
CO	43.40	42.62	41.47	39.63	40.31	38.13	36.97	35.48	33.19	31.90
NMVOCs	17.78	17.54	17.68	17.63	18.15	17.66	17.54	17.74	17.33	17.98
SO _x	31.74	33.07	37.90	40.10	42.64	39.64	41.66	43.98	47.29	49.65
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
NO _x	22.06	21.39	21.39	21.68	21.26	21.37	21.21	21.42	20.29	20.12
CO	30.54	29.31	28.61	28.90	27.78	26.68	24.84	23.90	22.01	19.78
NMVOCs	18.55	18.71	18.53	20.23	22.29	22.12	20.76	21.04	21.40	19.24
SO _x	48.37	45.51	45.95	47.40	40.34	37.88	31.49	29.44	22.44	17.77
	2010	2011	2012	2013	2014	2015	2016	2017		
NO _x	18.69	21.54	21.68	16.44	17.44	15.12	14.61	14.52		
CO	18.59	17.15	15.71	14.64	14.64	14.03	14.36	13.84		
NMVOCs	20.71	14.78	15.00	13.97	12.59	12.98	13.04	13.26		
SO _x	21.93	20.94	16.24	13.76	16.91	13.02	16.26	16.47		

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) and sulphur hexafluoride (SF₆) 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 (SO₂).

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 (CO₂) 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 the resulting climate change, 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 an 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 submit to the secretariat national greenhouse gas inventories of anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol. These inventories are subject to an annual technical review process.

By 1995, countries 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 will end 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 Change²

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 Protocol³

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). KP provides a foundation upon which future action can be intensified. It establishes, for the first time, legally binding targets for the reduction of greenhouse gas emissions and it also confirms the capacity of the international community to cooperate in action to deal with a major global environmental problem.

KP calls for legally binding commitments of the developed countries to reduce, individually or jointly, emissions of 6 greenhouse gases (CO₂, CH₄, N₂O, HFC, PFC and SF₆) by more than 5% in the period 2008 to 2012, below their 1990 level. The EU and its Member States at the time agreed to an 8% reduction. For the achievement of these targets, the Protocol provides for 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 CO₂ 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 CO₂ emissions in 1990.

The Doha Amendment⁴

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.

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

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 into force for those Parties having accepted it on the ninetieth day after the date of receipt by the Depository 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 Agreement⁵

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

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

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 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.19⁶, 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 inventories⁷.

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.

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/>

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 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 Kythreoutou, 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, which keeps the overall responsibility, and an active role in the inventory planning, preparation and management, including technical and scientific responsibility for the compilation of the annual inventory.⁸
- 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.

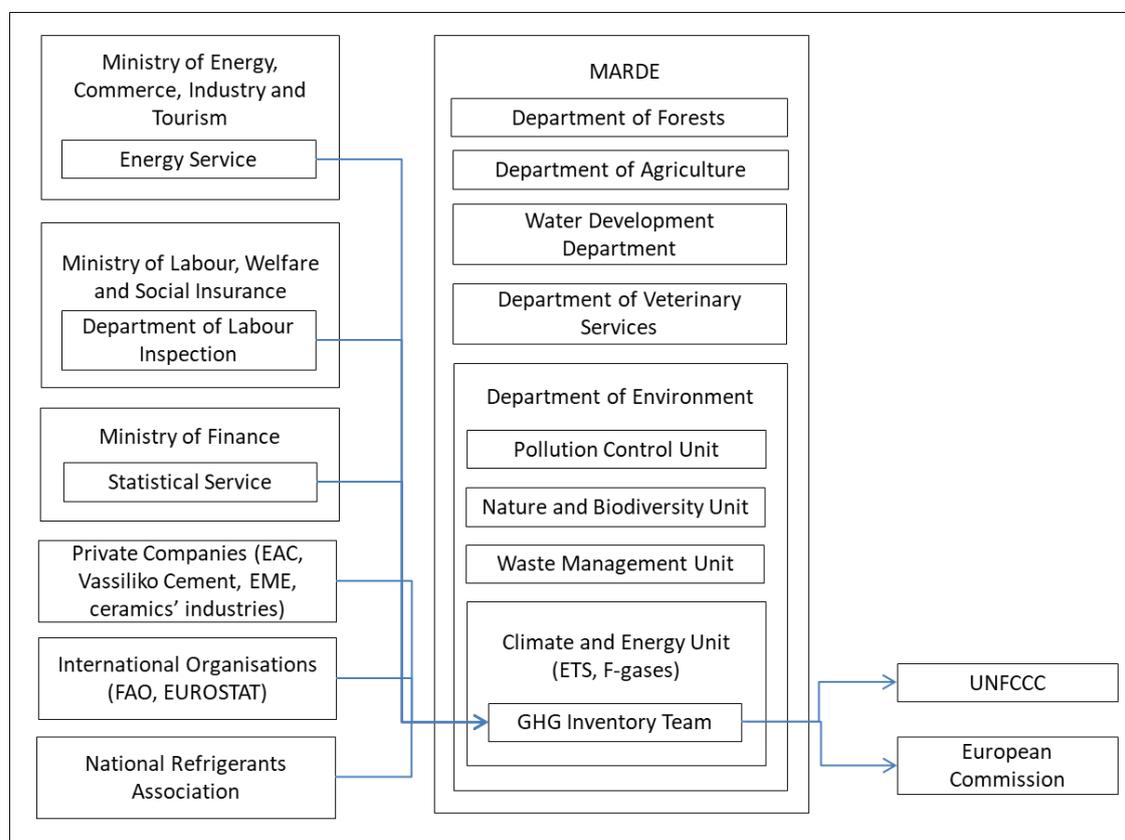


Figure 1.1. Overview of the organisational structure of the National Inventory System

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 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

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 DoE.

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, has the overall responsibility, as the national entity, 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 Protocol⁹,
- The timely submission of the GHG inventory to the European Commission and to the UNFCCC Secretariat.
- 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 implementation of Quality Assurance/Quality Control Plan (QA/QC)¹⁰

In addition, currently, DoE has the technical and scientific responsibility for the planning, preparation and management of the annual national inventory¹¹, 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.

⁹ in co-operation with future technical and scientific consultants

¹⁰ Supervision in future when consultants will be involved

¹¹ As of 2019 a consultant will have these responsibilities.

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) Ms. Melina Menelaou (LULUCF, KP-LULUCF)
Technician, 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 22 408 959, Email. mmenelaou@environment.moa.gov.cy
BA Biological Sciences - emphasis in Ecology, Master's degree in Public Administration
- (c) Mr. Demetris Demetriou (F-gases)
Outsourced expert, Tel. +357 99 452 358, Email. ddemetriou.env@gmail.com
BSc Mechanical Engineer, MSc Environmental Policy and Management

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 in 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 CO₂ 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@environment.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).

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@environment.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 United Nations Food and Agricultural Organization (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 Cyprus' GHG emissions inventory is primarily based on the application of the 2006 IPCC Guidelines.

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).

- **Stage 1:** 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

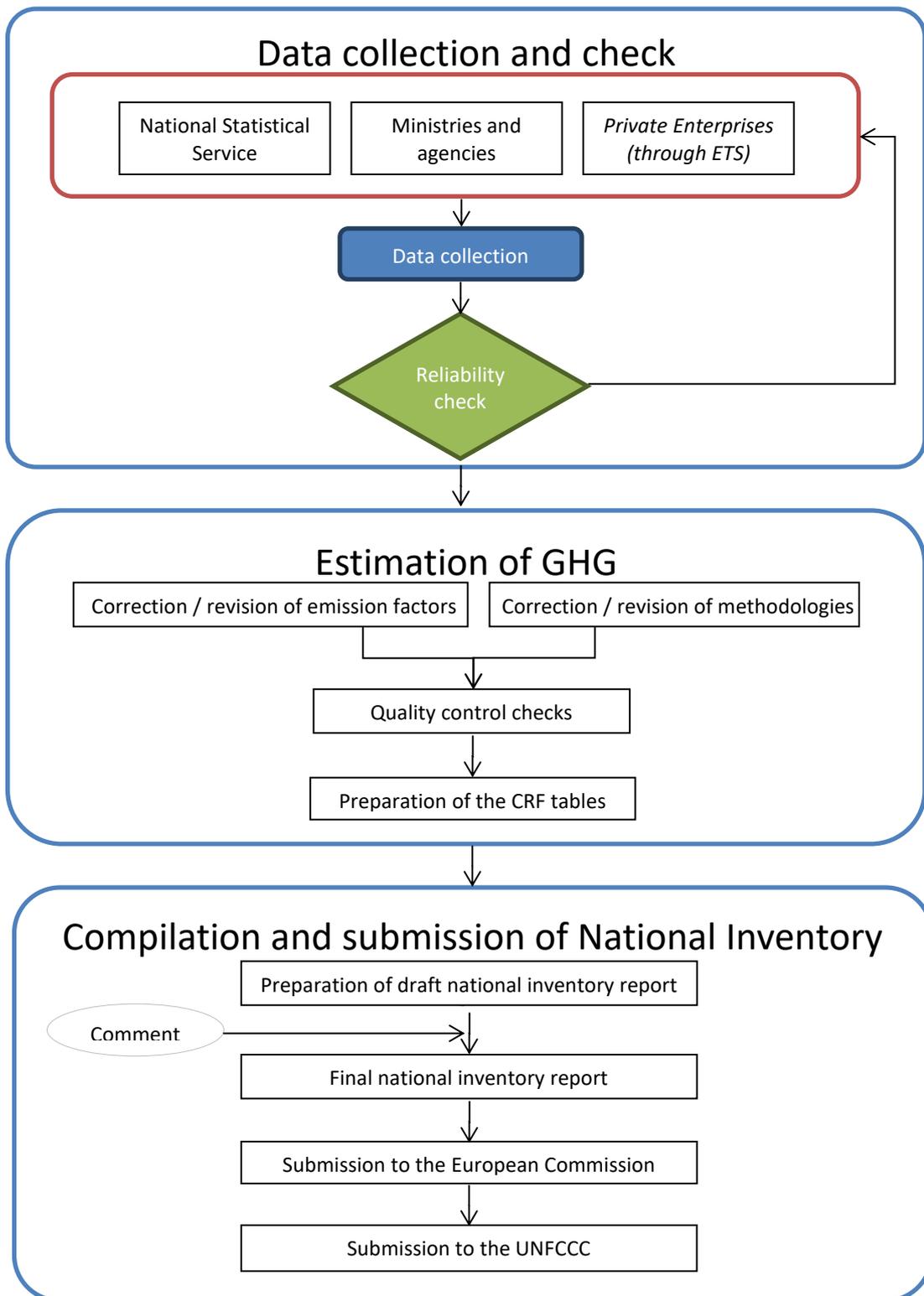


Figure 1.2. GHG emissions inventory preparation process in Cyprus

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.

- **Stage 2:** 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 IPCC Guidelines, the IPCC Good Practice Guidance and the LULUCF Good Practice Guidance. 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.
- **Stage 3:** 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.

DELIVERABLES	Year X-1												Year X				
	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY				

Figure 1.3. Timetable for inventory preparation

As shown in the timetable (Figure 1.3), the government ministries and agencies and the individual private or public industrial companies referred previously should have collected and delivered to the Inventory Team ¹² 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 ¹³.

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.

- 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.

¹² and the technical consultants (in the future)

¹³ http://www.moa.gov.cy/moa/environment/environmentnew.nsf/All/21395032E3B9BB6CC225_7FF0003813DD?OpenDocument

- 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 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, and is revised after 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.

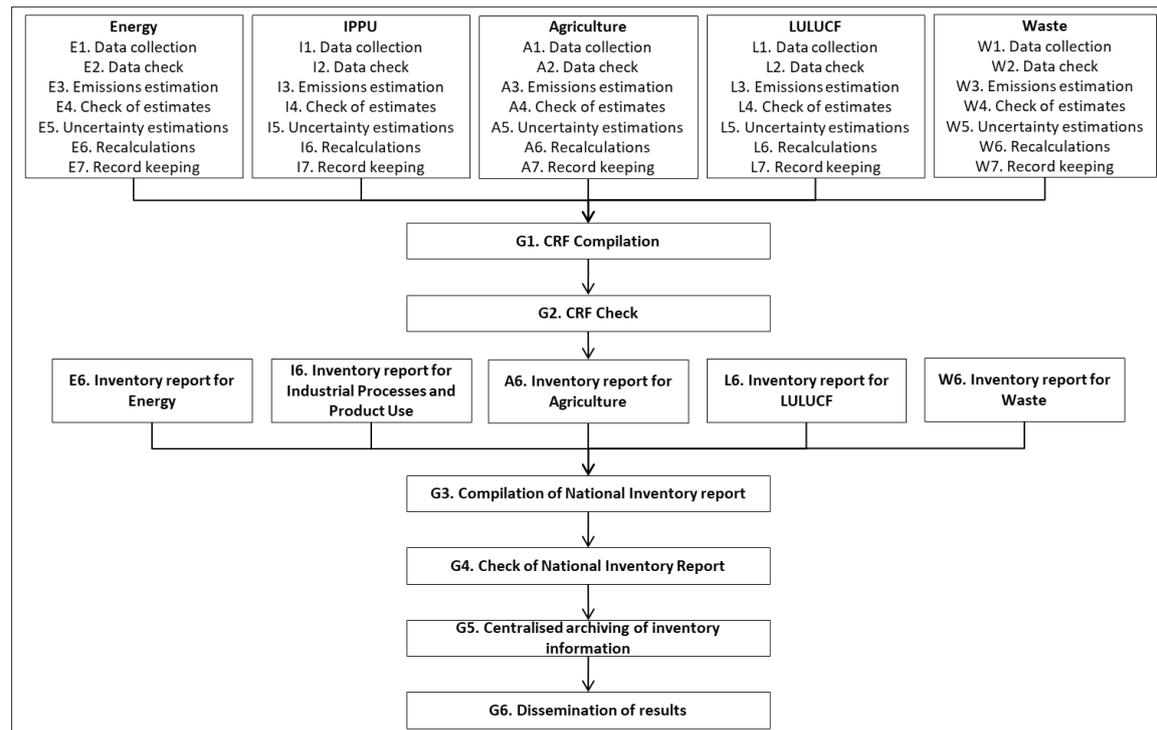


Figure 1.4. Flow chart of activities concerning emissions inventory

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

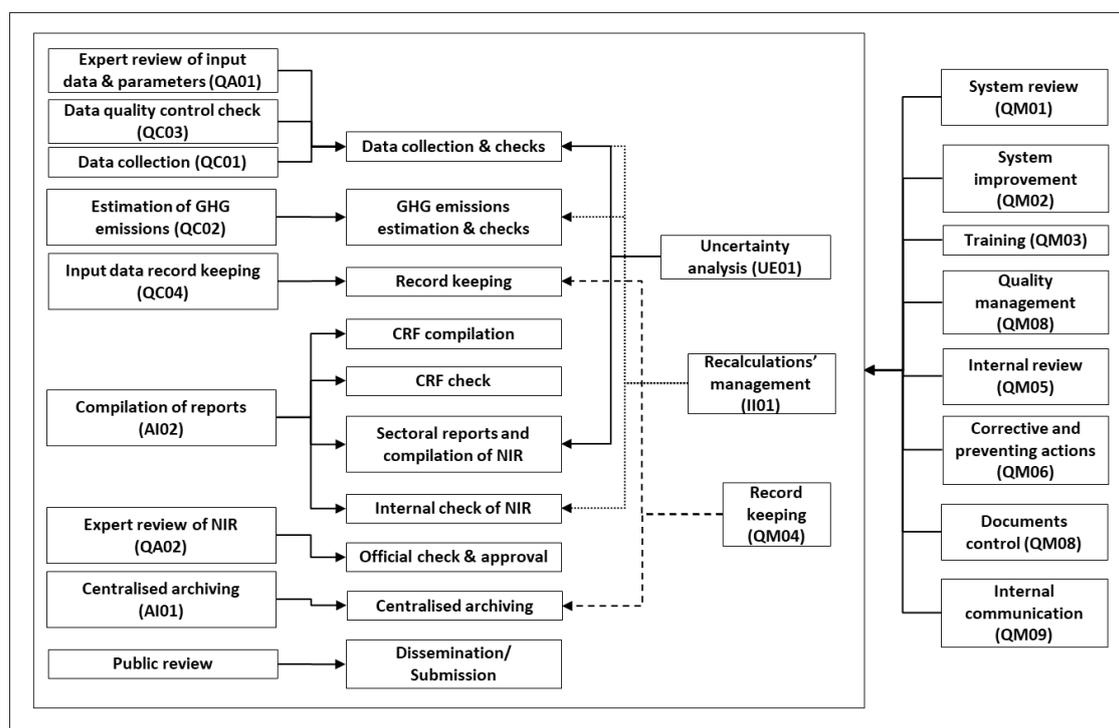


Figure 1.5. QA/QC process and procedures and inventory related activities

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 responsibilities¹⁴

	Responsible	Timing
Data collection	Data providers Nicoletta Kythreotou ¹⁵	by 30/11 of year X-1
Data check	Nicoletta Kythreotou ¹⁶	by 30/11 of year X-1
Emissions estimation	Nicoletta Kythreotou (Energy, IPPU, Agriculture, Waste) Melina Menelaou (LULUCF)	1/10-15/12 of year X-1
Check of estimates	Niki Papaki	1/10-15/12 of year X-1
Uncertainty estimations	Nicoletta Kythreotou (Energy, IPPU, Agriculture, Waste) Melina Menelaou (LULUCF)	1-30/12 of year X-1
Recalculations	Nicoletta Kythreotou (Energy, IPPU, Agriculture, Waste) Melina Menelaou (LULUCF)	1-30/12 of year X-1

¹⁴ Shall be revised upon the recruitment on contract basis the consultants for future submissions according to Council of Ministers’ Decision

¹⁵ 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.

¹⁶ If any discrepancies exist/ noticed, these are discussed with the data providers for explanations/correction

1.2.4. Changes in the national inventory arrangements since previous annual GHG inventory submission

In 2018 for the preparation of the 2019 submission, the estimation of the emissions from the sectors of 2F has been outsourced to a local expert.

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 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 Database¹⁸, 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 N₂O 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

¹⁸ <http://www.ipcc-nggip.iges.or.jp/EFDB/main.php>

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	CO2	CS	CS
1A1a.i	Energy Industries - Public electricity and heat production – Energy generation Liquid fuels	CH4/N2O	D	T1
1A1b	Energy Industries – Petroleum Refining – Liquid fuels	CO2/CH4/N2O	D	T1
1A1c.iv	Manufacture of solid fuels and Other Energy Industries – Charcoal production- biomass	CO2/CH4/N2O	D	T1
1A2b	Manufacturing Industries and Construction – Non-ferrous Metals - Liquid fuels	CO2/CH4/N2O	D	T1
1A2c	Manufacturing Industries and Construction – Chemicals – Liquid fuels	CO2/CH4/N2O	D	T1
1A2c	Manufacturing Industries and Construction – Chemicals – Biomass	CO2/CH4/N2O	D	T1
1A2d	Manufacturing Industries and Construction – Pulp, Paper and Print – Liquid fuels	CO2/CH4/N2O	D	T1
1A2e.	Manufacturing Industries and Construction – Food processing, beverages and tobacco – Liquid fuels	CO2/CH4/N2O	D	T1
1A2e.	Manufacturing Industries and Construction – Food processing, beverages and tobacco – Biomass	CO2/CH4/N2O	D	T1
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – Liquid fuel	CO2	CS	CS
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – Liquid fuel	CH4/N2O	D	T1
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – solid fuel	CO2	CS	CS
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – solid fuel	CH4/N2O	D	T1
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – other fossil fuel	CO2/CH4/N2O	D	T1
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – biomass (2000 and later)	CO2/CH4/N2O	D	T1
1A2g (iii).	Manufacturing Industries and Construction – Other - Mining (excluding fuels) and Quarrying – liquid fuel	CO2/CH4/N2O	D	T1
1A2g (v).	Manufacturing Industries and Construction - Other - Construction – liquid fuel	CO2/CH4/N2O	D	T1
1A2g (viii).	Manufacturing Industries and Construction – Other -Non-specified Industry – liquid fuel	CO2/CH4/N2O	D	T1
1A3a.	Transport - Domestic aviation – Jet kerosene	CO2/CH4/N2O	D	T1
1A3bi.	Transport - Road transportation – Gasoline	CO2/CH4/N2O	M	T2
1A3bi.	Transport - Road transportation - Diesel	CO2/CH4/N2O	M	T2
1A3bi.	Transport - Road transportation - Biomass	CO2/CH4/N2O	M	T2
1A3d	Transport - Domestic Navigation – Gas/Diesel Oil	CO2/CH4/N2O	D	T1
1A4a.	Other Sectors - Commercial/institutional -	CO2/CH4/N2O	D	T1

Category-Classification		Gas	EF	Method
	Liquid fuel			
1A4a.	Other Sectors - Commercial/institutional - Biomass	CO2/CH4/N2O	D	T1
1A4b.	Other Sectors - Residential – Liquid fuel	CO2/CH4/N2O	D	T1
1A4b.	Other Sectors - Residential – Biomass	CO2/CH4/N2O	D	T1
1A4ci.	Agriculture/forestry/fishing - Stationary- Liquid fuel	CO2/CH4/N2O	D	T1
1A4ci.	Agriculture/forestry/fishing – Stationary- Biomass	CO2/CH4/N2O	D	T1
1A4ciii	Agriculture/forestry/fishing – Fishing – Gas/Diesel Oil	CO2/CH4/N2O	D	T1
1A5a	Other - Non-Specified – Stationary – Liquid fuel	CO2/CH4/N2O	D	T1
1A5a	Other - Non-Specified – Stationary – Solid fuel	CO2/CH4/N2O	D	T1
1A5a	Other - Non-Specified – Stationary – Biomass	CO2/CH4/N2O	D	T1
1A5b	Other - Non-Specified – Mobile - Liquid fuel	CO2/CH4/N2O	D	T1
1B2a4	Fugitive Emissions from Fuels- Oil and Natural Gas and Other Emissions from Energy Production- Oil -Refining/Storage	CH4	D	T1
1B2a4	Fugitive Emissions from Fuels- Oil and Natural Gas and Other Emissions from Energy Production- Oil -Refining/Storage	CO2/N2O	NA	NA
2A1.	Industrial Processes and Product Use – Mineral Industry - Cement production	CO2	CS	CS
2A2	Industrial Processes and Product Use – Mineral Industry - Lime Production	CO2	D	T1
2A4a	Industrial Processes and Product Use – Mineral Industry - Other process uses of carbonates - Ceramics	CO2	CS	CS
2A4b	Industrial Processes and Product Use – Mineral Industry - Other process uses of carbonates - Other uses of soda-ash	CO2	D	T1
2A4b	Industrial Processes and Product Use – Mineral Industry - Other process uses of carbonates - Other uses of soda-ash	CH4/N2O	NA	NA
2D1	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use- Lubricant Use	CO2	D	T1
2D1	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use- Lubricant Use	CH4/N2O	NA	NA
2D2	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use - Paraffin Wax Use	CO2	D	T1
2D2	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use - Paraffin Wax Use	CH4/N2O	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)	CO2	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	CH4/N2O	NA	NA

Category-Classification		Gas	EF	Method
	with asphalt, printing)			
2D3	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use – Other - Urea-based catalysts	CO2	D	D
2D3	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use – Other - Urea-based catalysts	CH4/N2O	NA	NA
2F1	Product Uses as Substitutes for ODS - Refrigeration and air conditioning	HFCs	D,CS	T1,CS
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 - N2O from product uses – Medical Applications	N2O	CS	CS
2G3b	Other Product Manufacture and Use - N2O from product uses – Other –Propellant for pressure and aerosol products	N2O	CS	CS
3A	Enteric Fermentation – Dairy Cattle	CH4	CS	T2
3A	Enteric Fermentation - Non-dairy cattle, sheep, goats, horses, mules and asses and swine	CH4	D	T1
3B1.1	Manure Management – Dairy Cattle and Non-dairy cattle	CH4	D	T2
3B1.2	Manure Management – sheep, goats, horses,	CH4	D	T1
3B1.4	mules and asses, poultry			
3B1.3	Manure Management –swine (market & breeding)	CH4	D	T2
3B2.1	Direct N2O emissions – Dairy and non-dairy	N2O	D	T1
3B2.2	cattle, Sheep, swine (market & breeding), goats,			
3B2.3	horses, poultry, mules and asses			
3B2.4				
3B2.5	Indirect N2O emissions	N2O	D	T1
3D1.1	Agricultural soils- Direct N2O Emissions From Managed Soils- Inorganic fertilizers	N2O	D	T1
3D1.2a	Agricultural soils- Direct N2O Emissions From Managed Soils - Organic N fertilizers - Animal manure used as fertilizers	N2O	D	T1
3D1.2b	Agricultural soils- Direct N2O Emissions From Managed Soils - Organic N fertilizers - Sewage sludge applied to soils	N2O	D	T1
3D1.4	Agricultural soils- Direct N2O Emissions From Managed Soils - Crop residues	N2O	D	T1
3D2.1	Indirect N2O emissions from managed soils – Atmospheric Deposition	N2O	D	T1
3D2.2	Indirect N2O emissions from managed soils Nitrogen Leaching and run-off	N2O	D	T1
3F1	Field Burning of Agricultural Residues – Cereals – Wheat, Barley, Oats	N2O/CH4	D	T1
3F2	Field Burning of Agricultural Residues – Pulses – Bean and Pulses	N2O/CH4	D	T1
3F3	Field Burning of Agricultural Residues –Tubers and Roots	N2O/CH4	D	T1
3H	Urea Application	CO2	D	T1
5A1.a	Solid Waste Disposal - Managed waste disposal sites- Anaerobic	CH4	D	T2
5A1.a	Solid Waste Disposal - Managed waste disposal sites- Anaerobic	CO2	NA	NA

Category-Classification		Gas	EF	Method
5A2.	Solid Waste Disposal - Unmanaged waste disposal sites	CH4	D	T2
5A2.	Solid Waste Disposal - Unmanaged waste disposal sites	CO2	NA	NA
5B1a	Biological treatment of solid waste – Composting- municipal solid waste	CH4/N2O	D	T1
5D1.	Wastewater Treatment and Discharge - Domestic wastewater	CH4/N2O	CS	T1
5D2.	Wastewater Treatment and Discharge - Industrial wastewater	CH4	D	T1
5D2.	Wastewater Treatment and Discharge - Industrial wastewater	N2O	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/EC¹⁹) in the framework of the formulation of the National Allocation Plan (NAP) for the period 2005-2007, according to the Directive 2003/87/EC²⁰ (and its transposition to the national Law, 110(I)/2011²¹) 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

¹⁹ Available at <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32004D0156&from=EN> (no longer in force)

²⁰ Available at <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32003L0087&from=EN>

²¹ Available at <http://www.moa.gov.cy/moa/environment/environmentnew.nsf/All/E526DA8D521738B9C2258020002E364D?OpenDocument> (in Greek)

Category-Classification		Data	Sources
			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 Vehicles registration	Statistical Service 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	NMVOCs	DLI

Category-Classification		Data	Sources
	products, asphalt roofing, domestic solvent use including fungicides, road paving with asphalt, printing)		
2D3.	Solvent Use - Urea-based catalysts	Fuel consumption	Statistical Service
2F1.	Refrigeration and air conditioning	Commercial and industrial air-conditioning and refrigeration	Department of Environment – Inventory of equipment containing 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 ₂ O from product uses	Population	Statistical Service
2G3b	N ₂ O from product uses	Population	Statistical Service
3A	Enteric Fermentation – Dairy Cattle	Livestock population milk yield* average weight*	Statistical Service DLI EUROSTAT *Department of Agriculture
3A	Enteric Fermentation - Non-dairy cattle, sheep, goats, horses, mules and asses and swine	Livestock population	Statistical Service DLI EUROSTAT Department of Agriculture
3B1.1	Manure Management – Dairy Cattle and Non-dairy cattle	Livestock population	Statistical Service DLI EUROSTAT Department of Agriculture
3B1.2 3B1.4	Manure Management – sheep, goats, horses, mules and asses, poultry	Livestock population	Statistical Service DLI EUROSTAT Department of Agriculture
3B1.3	Manure Management –swine (market & breeding)	Livestock population	Statistical Service DLI EUROSTAT Department of Agriculture
3B2.1 3B2.2 3B2.3 3B2.4	Direct N ₂ O emissions – Dairy and non-dairy cattle, Sheep, swine (market & breeding), goats, horses, poultry, mules and asses	Livestock population	Statistical Service DLI EUROSTAT Department of Agriculture
3B2.5	Indirect N ₂ O emissions	Livestock population	Statistical Service DLI EUROSTAT Department of Agriculture
3D1.1	Agricultural soils- Inorganic fertilizers	Fertilizers use	Statistical Service Department of Agriculture
3D1.2a	Use of organic N fertilizers - Animal manure used as fertilizers	Fertiliser use Livestock population	Statistical Service Department of Agriculture
3D1.2b	Use of organic N fertilizers - Sewage sludge applied to soils	Fertiliser use Sewage sludge applied to soils	Statistical Service Department of Agriculture
3D1.4	Crop residues	Cultivated areas Crop production	Statistical Service
3D2.1	Indirect N ₂ O emissions from	Fertiliser use	Statistical Service

Category-Classification		Data	Sources
	managed soils – Atmospheric Deposition		Department of Agriculture
3D2.2	Indirect N ₂ O 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
5B1a	Biological treatment of solid waste – Composting- municipal solid waste	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 24/CP.19²² (Annex II).

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.

²² Decision 24/CP.19 Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention

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	25
Nitrous Oxide	N ₂ O	298
HFC-32	CH ₂ F ₂	675
HFC-125	CHF ₂ CF ₂	3500
HFC-134a	CH ₂ FCF ₃	1430
HFC-143a	CF ₃ CH ₃	4470
HFC-227ea	CF ₃ CHF ₂ CF ₃	3220
HFC-245fa	CH ₂ FCF ₂ CHF ₂	1030
HCF-365mfc	CH ₃ CF ₂ CH ₂ CH ₂ CF ₃	794
Sulphur hexafluoride	SF ₆	22800
Nitrogen trifluoride	NF ₃	17200

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 Greek 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) and for the year 2017 are presented in Table 1.6. Twelve key source categories are found in the energy sector, five in the IPPU sector, nine in agriculture and four in waste sector in 2017 (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 2017

IPCC Source category	Direct GHG	Level	Trend
1A1a. Public electricity and heat production	CO2	✓	✓
1A2e. Food processing, beverages and tobacco	CO2	✓	✓
1A2f. Non-metallic minerals	CO2	✓	✓
1A2g. Other (please specify)	CO2	✓	
1A3a. Domestic aviation	CO2		✓
1A3b. Road transportation	CO2	✓	✓
1A3b. Road transportation	CH4		✓
1A3b. Road transportation	N2O		✓
1A4a. Commercial/institutional	CO2	✓	✓
1A4b. Residential	CO2	✓	✓
1A4c. Agriculture/forestry/fishing	CO2	✓	
1A5b. Mobile	CO2		✓
2A1. Cement production	CO2	✓	✓
2A4. Other process uses of carbonates	CO2		✓
2D3. Other	CO2		✓
2F1. Refrigeration and air conditioning	HFCs	✓	✓
2G3. N2O from product uses	N2O	✓	
3A1a. Dairy cattle	CH4	✓	✓
3A1b. Non-dairy cattle	CH4	✓	✓
3A2. Sheep	CH4	✓	✓
3A4a. Goats	CH4		✓
3B3. Swine	CH4		✓
3B3. Swine	N2O		✓
3B4d. Poultry	N2O		✓
3B5. Indirect N2O emissions	N2O		✓
3D. Agricultural soils	N2O	✓	✓
5A1. Managed waste disposal sites	CH4	✓	✓
5A2. Unmanaged waste disposal sites	CH4	✓	✓
5D1. Domestic wastewater	CH4		✓
5D2. Industrial wastewater	CH4		✓

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 2017 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, four from the IPPU sector, seven from agriculture, four from the waste sector and nine from LULUCF have been identified as key.

Table 1.7. Key categories for Cyprus' inventory system with LULUCF for 2017

IPCC Source category	Direct GHG	Level	Trend
1A1a. Public electricity and heat production	CO2	✓	✓
1A2e. Food processing, beverages and tobacco	CO2	✓	✓
1A2f. Non-metallic minerals	CO2	✓	✓
1A2g. Other (please specify)	CO2	✓	
1A3a. Domestic aviation	CO2		✓
1A3b. Road transportation	CO2	✓	
1A3b. Road transportation	CO2	✓	
1A4a. Commercial/institutional	N2O		✓
1A4b. Residential	CO2	✓	✓
1A4c. Agriculture/forestry/fishing	CO2	✓	
2A1. Cement production	CO2	✓	✓
2A4. Other process uses of carbonates	CO2		✓
2F1. Refrigeration and air conditioning	HFCs	✓	✓
2G3. N2O from product uses	N2O	✓	
3A1a. Dairy cattle	CH4	✓	✓

3A1b. Non-dairy cattle	CH4	✓	
3A2. Sheep	CH4	✓	
3B3. Swine	CH4	✓	✓
3D. Agricultural soils	N2O	✓	✓
4A1. Forest land remaining forest land	CO2	✓	✓
4A2. Land converted to forest land	CO2	✓	✓
4B1. Cropland remaining cropland	CO2	✓	✓
4B2. Land converted to cropland	CO2		✓
4C1. Grassland remaining grassland	CO2	✓	✓
4E2. Land converted to settlements	CO2		✓
4F2. Land converted to other land	CO2		✓
4G. Harvested wood products	CO2		✓
5A1. Managed waste disposal sites	CH4	✓	✓
5A2. Unmanaged waste disposal sites	CH4	✓	✓
5D1. Domestic wastewater	CH4	✓	✓

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 CO₂, CH₄, N₂O 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.

The uncertainty analysis was carried out without the LULUCF sector. The total uncertainty without LULUCF in 2017 is 7.24% and the trend uncertainty 2.41% compared to 4.48% and 1.72% 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 CO₂ 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 1990-2017 are presented. All major sources are reported including emissions estimates for indirect greenhouse gases and SO₂ ([Annex 5](#)).

The main deficiency identified, is associated to Transport of oil (1.B.2.a.3) and Distribution of oil products (1.B.2.a.5) for which no data/method is available to estimate the emissions. 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 from its Greek Cypriot inhabitants. By the end of the following year, the majority of the Turkish Cypriots living in the areas left 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, by the name of “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 please refer to the website of the Ministry of Foreign Affairs of the Republic of Cyprus²³.

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

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

Implementation of recommendations and adjustments

The status of implementation of all the recommendations made to the 2018 NIR submission by the EU review team (TERT) during the two review processes are presented in [Annex 6](#). Cyprus' GHG inventory was not reviewed by the UNFCCC in 2018.

²³ http://www.mfa.gov.cy/mfa/mfa2016.nsf/mfa08_en/mfa08_en?OpenDocument

Chapter 2.

Trends in greenhouse gas emissions

*The economy of Cyprus*²⁴

The economy of Cyprus can generally be characterised 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, its economy has undergone significant economic and structural reforms that have transformed the economic landscape.

The tertiary sector (services) is the biggest contributor to GVA, accounting for about for about 86.5% in 2016. 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 latter part of the 1970s and the early part of the 80s, to an international tourist, business and services center during the 1980s, 1990s and the 2000s. The secondary sector (manufacturing) accounted for around 11.4% of GVA in 2016. The primary sector (agriculture and fishing) is continuously shrinking and only reached 2.1% of GVA in 2016.

In terms of the recent economic performance of the economy, positive growth rate of 2.0% was recorded in 2015, after almost four years of recession and despite a challenging external environment. In 2016, the economy grew at a rate of 3.0%, significantly higher than the EU and euro area average (2.0% and 1.8% respectively).

Tourism sector constitutes one of the main drivers of economic growth in Cyprus. In 2016 and 2017, tourism exhibited a record number of tourist arrivals (increase by 19.8% and 14.6% respectively), with very positive signs for 2018 as well. The professional services sector turned out to be remarkably resilient during the economic crisis. This sector was also key in the turnaround of the Cyprus economy and is expected to remain important in the future years. Cyprus' shipping sector is also important for Cyprus. By combining strong geographical, institutional and commercial advantages Cyprus has managed to amass the 10th largest merchant fleet in the world and 3rd largest merchant fleet in the EU.

In the labour market, unemployment fared better than expected as it peaked to around 16.1% in 2014, despite projections of more than 20% of the labour force. In 2016 and 2017, unemployment reduced to 12.9% and 11% respectively and is expected to continue on a downward trend. An issue however of high concern, is the high rate of youth unemployment, as well as the long-term unemployment, even though both are on a declining path.

As regards public finances, targets have been met with considerable margins also in 2015, 2016 and 2017 with positive indications for the following years. This robust fiscal performance has supported debt sustainability, with public debt reaching its peak in 2015 (107.5% of GDP), with a declining trend commencing from 2016 onwards.

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

GHG emissions in 2017 were 8411 Gg CO₂ eq. including LULUCF and 8945 Gg CO₂ eq. excluding LULUCF. Total national emissions excluding LULUCF increased by 58% between 1990 and 2017 and by 2.3% between 2016 and 2017. The total GHG emissions trends for the period 1990 – 2017 are presented in Table 2.1 and Figure 2.1 in kt CO₂ eq.

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The GWP values used for the conversion of emissions estimates into the common unit of carbon dioxide equivalent are those presented in Table 1.4. It is noted that according to the IPCC Guidelines, emissions estimates for international marine and aviation bunkers were not included in the national totals, however they are reported separately as memo items.

Table 2.1. Total GHG emissions trend for the period 1990 – 2017

Total emissions (Gg CO ₂ eq.)	1990	2000	2005	2010	2015	2016	2017
Without LULUCF	5668.85	8386.50	9333.44	9458.77	8303.21	8741.33	8945.26
With LULUCF	5417.66	8455.49	8956.44	8970.25	7730.73	8817.09	8411.26

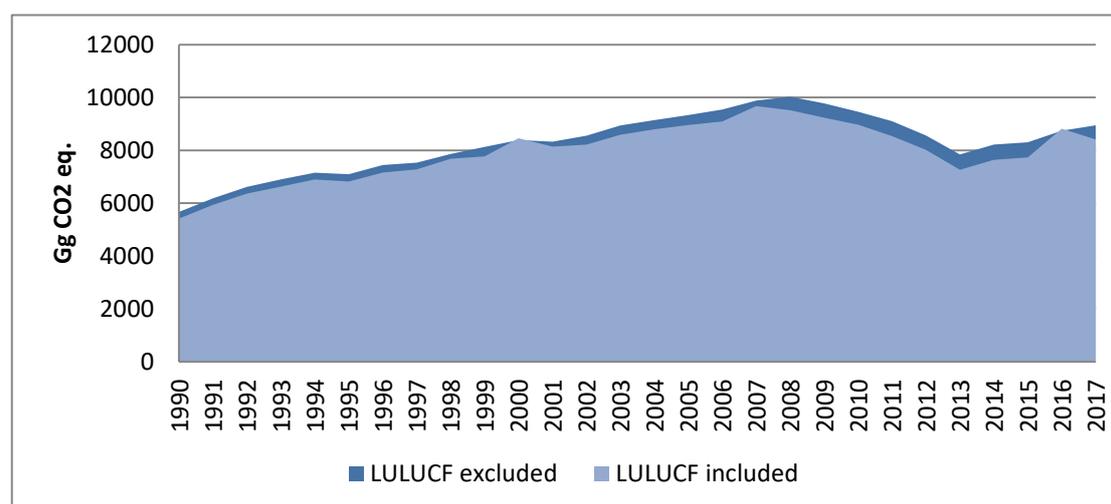


Figure 2.1. Total GHG emissions trend for the period 1990 – 2017

2.2. Description and interpretation of emission trends by sector

Energy, with 6619 Gg CO₂ eq., continues to be the largest contributor to the total national GHG emissions (75% compared to the total without LULUCF). 3299 Gg CO₂ eq. of these emissions is from the production of electricity, while another 2094 Gg CO₂ eq. from transport. Table 2.2 and Figure 2.2 present the emissions for the period 1990-2017 by sector.

Table 2.2. GHG emissions by sector for the period 1990 – 2017

	Energy	IPPU	Agriculture	LULUCF	Waste	Total (incl. LULUCF)	Total (excl. LULUCF)
1990	3970	841	471	-251	387	5418	5669
1991	4503	814	475	-247	391	5936	6183
1992	4832	875	510	-255	399	6361	6616
1993	5010	940	541	-272	408	6627	6899
1994	5223	980	530	-256	419	6896	7152
1995	5132	957	580	-277	427	6819	7096
1996	5429	1020	562	-285	431	7158	7442
1997	5553	991	549	-255	439	7277	7532
1998	5901	951	563	-180	445	7680	7860
1999	6160	970	546	-359	452	7769	8128
2000	6376	998	552	69	460	8455	8387
2001	6271	985	601	-186	469	8140	8326
2002	6430	1026	621	-337	475	8214	8552
2003	6824	1037	603	-352	476	8588	8940
2004	6958	1121	583	-347	479	8794	9142
2005	7136	1179	533	-377	486	8956	9333
2006	7319	1191	548	-452	484	9090	9543
2007	7641	1215	540	-208	485	9673	9881
2008	7807	1213	516	-512	493	9516	10028
2009	7726	1043	509	-542	497	9234	9775

	Energy	IPPU	Agriculture	LULUCF	Waste	Total (incl. LULUCF)	Total (excl. LULUCF)
2010	7495	934	532	-489	498	8970	9459
2011	7202	878	521	-565	501	8537	9102
2012	6716	837	498	-545	511	8016	8561
2013	5794	1064	463	-580	521	7263	7843
2014	5958	1280	448	-577	531	7640	8217
2015	6081	1221	457	-572	544	7731	8303
2016	6480	1225	482	76	554	8817	8741
2017	6619	1270	495	-534	562	8411	8945
Change 1990-2017	66.7%	50.9%	5.0%	112.6%	45.2%	55.3%	57.8%

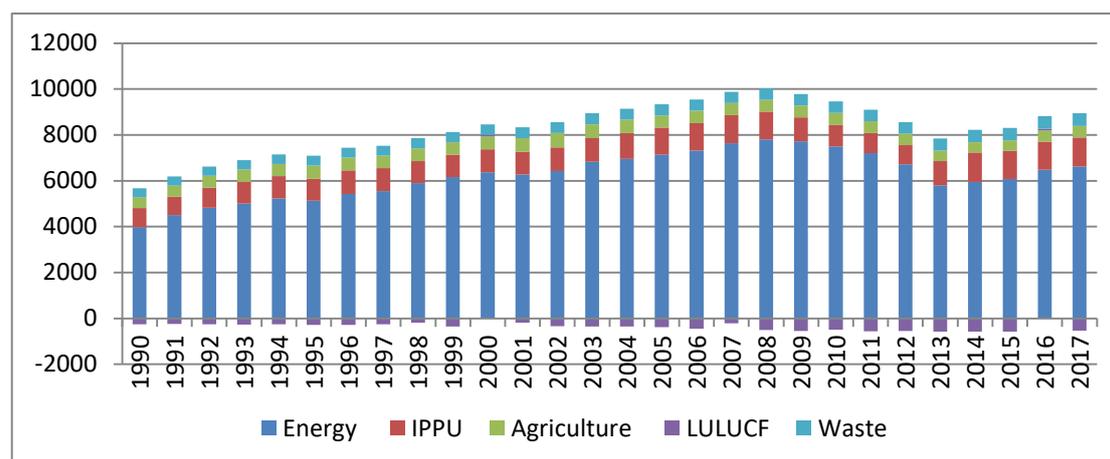


Figure 2.2. GHG emissions by sector for the period 1990 – 2017

2.3. Description and interpretation of emission trends by gas

GHG emissions trends by gas for the period 1990 - 2017 are presented in Table 2.3.

Table 2.3. GHG emissions trends by gas for the period 1990 - 2017

	1990	1991	1992	1993	1994
CO ₂ emissions without LULUCF	4664.61	5154.32	5530.39	5774.41	6018.46
CO ₂ emissions with LULUCF	4413.35	4906.62	5275.25	5502.31	5761.01
CH ₄ emissions without LULUCF	654.58	665.72	683.43	707.40	720.11
CH ₄ emissions with LULUCF	654.63	665.88	683.48	707.81	721.17
N ₂ O emissions without LULUCF	285.75	287.06	317.90	337.57	331.17
N ₂ O emissions with LULUCF	285.77	287.11	317.92	337.72	331.54
HFCs	63.88	76.02	84.42	79.14	82.20
PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF ₆	0.03	0.03	0.03	0.04	0.05
NF ₃	NO	NO	NO	NO	NO
Total (without LULUCF)	5668.85	6183.15	6616.17	6898.56	7151.98
Total (with LULUCF)	5417.66	5935.67	6361.10	6627.01	6895.96
	1995	1996	1997	1998	1999
CO ₂ emissions without LULUCF	5889.45	6240.32	6328.00	6621.50	6890.63
CO ₂ emissions with LULUCF	5611.89	5954.83	6071.88	6436.61	6531.88
CH ₄ emissions without LULUCF	740.83	757.27	760.79	761.73	764.56
CH ₄ emissions with LULUCF	741.24	757.95	761.77	765.09	764.58
N ₂ O emissions without LULUCF	373.29	348.51	343.17	371.03	356.18
N ₂ O emissions with LULUCF	373.44	348.75	343.52	372.21	356.19
HFCs	91.92	95.96	99.69	105.78	116.67

PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF ₆	0.06	0.07	0.07	0.07	0.07
NF ₃	NO	NO	NO	NO	NO
Total (without LULUCF)	7095.55	7442.12	7531.73	7860.11	8128.10
Total (with LULUCF)	6818.55	7157.56	7276.94	7679.76	7769.38
	2000	2001	2002	2003	2004
CO ₂ emissions without LULUCF	7140.26	7015.91	7204.91	7598.82	7833.80
CO ₂ emissions with LULUCF	7199.52	6826.20	6867.36	7246.42	7485.72
CH ₄ emissions without LULUCF	780.52	811.64	835.36	826.86	821.78
CH ₄ emissions with LULUCF	787.72	814.06	835.43	827.16	822.38
N ₂ O emissions without LULUCF	345.44	377.08	381.72	380.37	339.63
N ₂ O emissions with LULUCF	347.96	377.93	381.75	380.48	339.84
HFCs	120.21	121.57	129.79	134.15	146.33
PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF ₆	0.08	0.08	0.08	0.09	0.10
NF ₃	NO	NO	NO	NO	NO
Total (without LULUCF)	8386.50	8326.28	8551.87	8940.29	9141.64
Total (with LULUCF)	8455.49	8139.83	8214.41	8588.30	8794.37
	2005	2006	2007	2008	2009
CO ₂ emissions without LULUCF	8021.49	8212.09	8527.51	8696.16	8443.91
CO ₂ emissions with LULUCF	7644.20	7759.18	8312.69	8183.88	7901.93
CH ₄ emissions without LULUCF	804.37	805.48	808.08	805.78	805.85
CH ₄ emissions with LULUCF	804.57	805.99	812.93	805.96	806.14
N ₂ O emissions without LULUCF	313.36	327.16	320.96	309.02	300.92
N ₂ O emissions with LULUCF	313.43	327.34	322.66	309.08	301.02
HFCs	194.12	197.79	224.54	217.34	224.52
PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF ₆	0.12	0.12	0.14	0.15	0.16
NF ₃	NO	NO	NO	NO	NO
Total (without LULUCF)	9333.44	9542.64	9881.22	10028.45	9775.35
Total (with LULUCF)	8956.44	9090.41	9672.96	9516.40	9233.77
	2010	2011	2012	2013	2014
CO ₂ emissions without LULUCF	8082.33	7760.34	7229.26	6550.83	6931.34
CO ₂ emissions with LULUCF	7592.29	7194.07	6683.14	5970.59	6353.77
CH ₄ emissions without LULUCF	812.57	817.02	805.95	799.52	799.34
CH ₄ emissions with LULUCF	813.69	817.96	807.00	799.89	799.75
N ₂ O emissions without LULUCF	318.08	304.61	303.64	277.70	272.87
N ₂ O emissions with LULUCF	318.47	304.94	304.00	277.82	273.01
HFCs	245.65	219.43	222.13	214.83	213.03
PFCs	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO
SF ₆	0.15	0.16	0.16	0.15	0.15
NF ₃	NO	NO	NO	NO	NO
Total (without LULUCF)	9458.77	9101.56	8561.13	7843.03	8216.73
Total (with LULUCF)	8970.25	8536.57	8016.43	7263.29	7639.71
	2015	2016	2017	Change 1990- 2017	
CO ₂ emissions without LULUCF	6956.59	7362.10	7538.49	61.61	
CO ₂ emissions with LULUCF	6383.92	7421.65	7003.97	58.70	
CH ₄ emissions without LULUCF	815.52	845.96	863.99	31.99	

CH ₄ emissions with LULUCF	815.66	857.97	864.37	32.04	
N ₂ O emissions without LULUCF	280.48	287.82	293.05	2.56	
N ₂ O emissions with LULUCF	280.53	292.03	293.19	2.60	
HFCs	250.45	245.28	249.56	290.65	
PFCs	NO	NO	NO	0.00	
Unspecified mix of HFCs and PFCs	NO	NO	NO	0.00	
SF ₆	0.16	0.17	0.17	541.56	
NF ₃	NO	NO	NO	0.00	
Total (without LULUCF)	8303.21	8741.33	8945.26	57.80	
Total (with LULUCF)	7730.73	8817.09	8411.26	55.26	

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 (CO₂) and water (H₂O), 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 of exploration and exploitation of primary energy sources, conversion of primary energy sources into more useable energy forms in refineries and power plants, 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

A key challenge for Cyprus is its high dependency on fossil fuels for energy – the biggest share within the EU in fact, which makes it crucial for the country to develop both its hydrocarbon and renewable energy sources. Cyprus is reliant on fossil fuel imports for its electricity needs, and spends over 8% of its GDP to cover the costs.

The island also saw the biggest increase in energy demand among the EU28, growing 56% since 1990 from 1.6 million tonnes of oil equivalent (Mtoe) to 2.5 Mtoe in 2017. These figures may be low when compared with its larger EU partners, but a more accurate comparison would be Malta where consumption was only 0.8 Mtoe in 2015. However, Cyprus is determined to find a cleaner solution until it can exploit its own reserves.

The 13% Renewable Energy Sources (RES) goal for 2020²⁵ is set to be generated by wind farms, photovoltaic (PV) systems and biomass and biogas utilisation plants. In the end of 2017, the share of RES in the final energy consumption was 9.27% according to the provisions of the Directive 2009/28/EC. Latest data show that RES accounted for 9.6% of electricity production in 2017. RES power production rose 6% in 2017, compared to 2016, mainly due to an increase 18 % in the electricity production from photovoltaic systems. However wind farms generated almost 47% of electricity from RES in 2017.

In Cyprus, electricity from renewable sources is no more promoted through feed-in-tariff schemes since 2013 where a net metering and self-consumption scheme has been put in place. Moreover in 2016 a new scheme was announced for RES that will participate in the competitive market.

Access of electricity from renewable energy sources to the grid shall be granted according to the principle of non-discrimination.. Grid development is a matter of central planning (Transmission Grid Development Plan 2007-2016 by the Cypriot 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.

The island also was awarded with projects that have won significant funding from ‘NER300’ – a financing instrument managed jointly by the European Commission, European Investment Bank and

²⁵ 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

Member States. The two projects that will be funded are the EOS Green Energy Project and the Green+ Smart-Grid Project that have garnered a combined €71 million to develop innovative renewable ventures and smart grids in Cyprus.

However, the country's national grid system has certain intrinsic and technical limitations affecting RES penetration and reliability of the energy system – such as the lack of interconnections to the trans-European electricity networks, a limitation to the amount of intermittent renewable energy that can be connected to the electricity system, and 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 for 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 up of the energy market and granting consumers the right to choose their own supplier – with expectations of a full liberalisation by June 2019. CERA's proposition is a 'net pool' model, where the operations of the state power company, EAC, are unbundled and the production and supply operations separated. EAC production would then enter into bilateral agreements with suppliers for the sale of energy at regulated prices. However, these plans have experienced some resistance from unions, as they are seen as moves which could put pressure to privatise the state power company.

In respect to the supply of natural gas to Cyprus, the Council of Ministers, at its meeting in June 2016, decided to approve the import of Liquefied Natural Gas (LNG) to Cyprus in a manner leading to the commencement of natural gas supply by the year 2020. For the purpose of implementing the Decision, the Cyprus Natural Gas Company (DEFA) was mandated to carry out a study which concluded that the preferred LNG supply option project is through the use of a floating infrastructure with the development of the necessary mooring facilities and pipeline connection to the natural gas receiving point at Vassilikos.

On the basis of the results of the study the Council of Ministers, at its meeting on May 18th 2017, decided to mandate DEFA to issue, as soon as possible, an invitation for tenders regarding the long-term supply of LNG to Cyprus to satisfy electricity requirements and an invitation for tenders for the construction and operation of the necessary infrastructure. In parallel with the above DEFA was mandated to proceed with the FEED study for the internal pipeline network. The tender for the construction, operation and maintenance of the infrastructure was announced on the 5th October 2018. The tender for the long-term supply of LNG to Cyprus is expected to be announced early Q2 2019, after the infrastructure tender is awarded to the successful tenderer.

The electrical interconnection with Israel and Greece will be the next major challenge in the country energy sector. Cyprus is promoting the «EuroAsia Interconnector» project as aiming at commissioning in 2022-2023. The project will effectively contribute to the security of energy supply and reduction in CO₂ emissions by allowing the countries in the region to use natural gas deposits as well as renewable energy sources for electricity generation.

3.1.1. Trends

The energy sector in Cyprus relies on fossil fuel combustion for meeting the bulk of energy requirements. Final consumption in 2017 amounted to approximately 88 PJ compared to 87 PJ in 2016 (2% increase). 95.9% of the consumption in 2017 was from liquid fuels, 0.1% from solid fuels, 1% from other fossil fuels and 2.9% from biomass. In comparison to 1990, total fuel consumption in 2017 including biomass increased by 69%. Natural gas is currently not available in Cyprus.

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 are acting as a drag on growth until structural changes are in effect. This is greatly affecting the energy sector.

The emissions from the energy sector in Cyprus increased by 67% during the period 1990-2017. The greatest increase in emissions was between 1990 and 2008 (97%), the emissions reached their peak (7807 Gg CO₂ eq.). All the emissions in 2017 are from fuel combustion. The contribution of the emissions from the energy sector to the total without LULUCF in 2017 was 75% compared to 72% in 1990.

Energy is mainly responsible for carbon dioxide emissions, while it contributes also 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 2017 are presented in Table 3.1 and Figure 3.1.

Table 3.1. Emissions from energy 1990-2017

Gg CO ₂ eq.	1990	2000	2005	2010	2015	2016	2017
1. Energy	3970	6376	7136	7495	6081	6480	6619
A. Fuel combustion (sectoral approach)	3970	6376	7136	7495	6081	6480	6619
1. Energy industries	1767	2965	3484	3881	3033	3311	3299
2. Manufacturing industries and construction	515	822	912	700	607	603	660
3. Transport	1242	1837	2111	2325	1891	2022	2094
4. Other sectors	434	731	610	569	528	522	543
5. Other	11.1	21.6	19.2	20.5	22.4	22.4	23.1
B. Fugitive emissions from fuels	0.19	0.31	0.22	0.23	0.19	0.20	0.21
1. Solid fuels	NO						
2. Oil and natural gas and other emissions from energy production	0.19	0.31	0.22	0.23	0.19	0.20	0.21
C. CO ₂ transport and storage	NO						
CO ₂	3927	6310	7088	7453	6045	6442	6579
CH ₄	0.48	0.54	0.59	0.58	0.53	0.56	0.58
N ₂ O	0.10	0.18	0.11	0.09	0.07	0.08	0.09

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

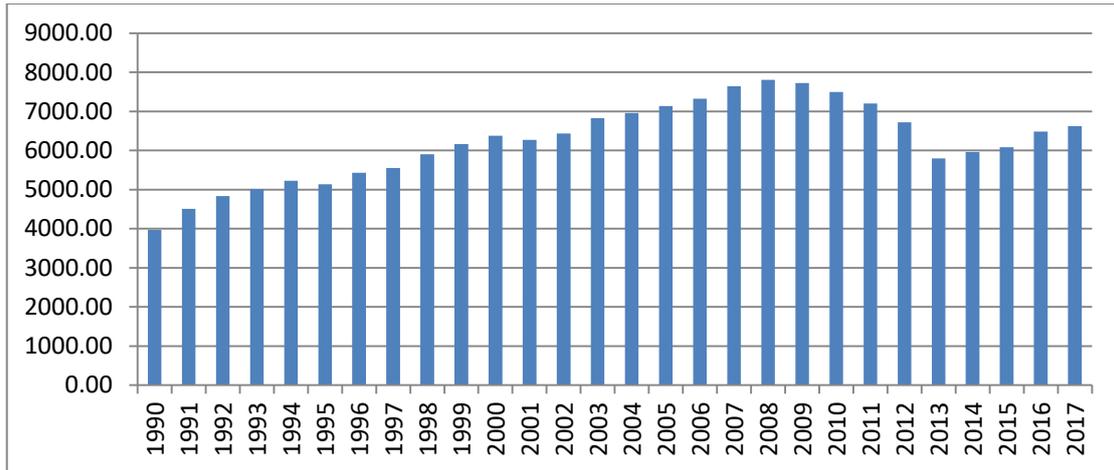


Figure 3.1. Emissions from the energy sector 1990-2017

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 CO₂ is summed across all fuels (excluding biomass) and all sectors. For Tiers 2 and 3, the Detailed Technology-Based Approach, total CO₂ 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 is presented in Table 3.2.

Table 3.2. Methodology for the estimation of emissions from energy

Category-Classification	Gas	EF	Method
1A1a.i	CO ₂	CS	CS
1A1a.i	CH ₄ /N ₂ O	D	T1
1A1b	CO ₂ /CH ₄ /N ₂ O	D	T1
1A1c.iv	CO ₂ /CH ₄ /N ₂ O	D	T1
1A2b	CO ₂ /CH ₄ /N ₂ O	D	T1
1A2c	CO ₂ /CH ₄ /N ₂ O	D	T1
1A2c	CO ₂ /CH ₄ /N ₂ O	D	T1
1A2d	CO ₂ /CH ₄ /N ₂ O	D	T1
1A2e.	CO ₂ /CH ₄ /N ₂ O	D	T1
1A2e.	CO ₂ /CH ₄ /N ₂ O	D	T1

Category-Classification		Gas	EF	Method
	Biomass			
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – Liquid fuel	CO2	CS	CS
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – Liquid fuel	CH4/N2O	D	T1
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – solid fuel	CO2	CS	CS
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – solid fuel	CH4/N2O	D	T1
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – other fossil fuel	CO2/CH4/N2O	D	T1
1A2f.	Manufacturing Industries and Construction – Non-metallic minerals – biomass (2000 και μετά)	CO2/CH4/N2O	D	T1
1A2g (iii).	Manufacturing Industries and Construction – Other - Mining (excluding fuels) and Quarrying – liquid fuel	CO2/CH4/N2O	D	T1
1A2g (v).	Manufacturing Industries and Construction - Other - Construction – liquid fuel	CO2/CH4/N2O	D	T1
1A2g (viii).	Manufacturing Industries and Construction – Other -Non-specified Industry – liquid fuel	CO2/CH4/N2O	D	T1
1A3a.	Transport - Domestic aviation – Jet kerosene	CO2/CH4/N2O	D	T1
1A3bi.	Transport - Road transportation – Gasoline	CO2/CH4/N2O	M	T2
1A3bi.	Transport - Road transportation - Diesel	CO2/CH4/N2O	M	T2
1A3bi.	Transport - Road transportation - Biomass	CO2/CH4/N2O	M	T2
1A3d	Transport - Domestic Navigation – Gas/Diesel Oil	CO2/CH4/N2O	D	T1
1A4a.	Other Sectors - Commercial/institutional - Liquid fuel	CO2/CH4/N2O	D	T1
1A4a.	Other Sectors - Commercial/institutional - Biomass	CO2/CH4/N2O	D	T1
1A4b.	Other Sectors - Residential – Liquid fuel	CO2/CH4/N2O	D	T1
1A4b.	Other Sectors - Residential – Biomass	CO2/CH4/N2O	D	T1
1A4ci.	Agriculture/forestry/fishing - Stationary- Liquid fuel	CO2/CH4/N2O	D	T1
1A4ci.	Agriculture/forestry/fishing – Stationary- Biomass	CO2/CH4/N2O	D	T1
1A4ciii	Agriculture/forestry/fishing – Fishing – Gas/Diesel Oil	CO2/CH4/N2O	D	T1
1A5a	Other - Non-Specified – Stationary – Liquid fuel	CO2/CH4/N2O	D	T1
1A5a	Other - Non-Specified – Stationary – Solid fuel	CO2/CH4/N2O	D	T1
1A5a	Other - Non-Specified – Stationary – Biomass	CO2/CH4/N2O	D	T1
1A5b	Other - Non-Specified – Mobile - Liquid fuel	CO2/CH4/N2O	D	T1
1B2a4	Fugitive Emissions from Fuels- Oil and Natural Gas and Other Emissions from Energy Production- Oil -Refining/Storage	CH4	D	T1
1B2a4	Fugitive Emissions from Fuels- Oil and Natural Gas and Other Emissions from Energy Production- Oil -Refining/Storage	CO2/N2O	NA	NA
1B2c1i	Fugitive Emissions from Fuels- Oil and Natural Gas and Other Emissions from Energy Production- Oil -Venting - tanker trucks	CH4	D	T1

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 74% to the total national emissions excluding LULUCF in 2017 and increased by 67% during the period 1990-2017. The greatest increase in emissions was between 1990 and 2008 (97%), the emissions reached their peak (7807 Gg CO₂ eq.). The majority of energy related GHG emissions in 2017 was derived from energy industries (49.8%), while transport contributed 31.6%, manufacturing industries and construction 10%, other sectors 8.2% and other 0.3% respectively.

The substantial increase of GHG emissions from road transport (69% between 1990 and 2017) is directly linked to the increase of vehicles fleet but also to 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 1990-2017

Gg CO ₂ eq.	1990	2000	2005	2010	2015	2016	2017
A. Fuel combustion activities	3970	6376	7136	7495	6081	6480	6619
1. Energy industries	1767	2965	3484	3881	3033	3311	3299
a. Public electricity and heat production	1681	2860	3483	3881	3033	3311	3299
b. Petroleum refining	86	104	NO	NO	NO	NO	NO
c. Manufacture of solid fuels and other energy industries*	NO						
2. Manufacturing industries and construction	515	822	912	700	607	603	660
a. Iron and steel	NO						
b. Non-ferrous metals	4.9	7.2	6.5	5.1	3.0	6.2	2.2
c. Chemicals	2.2	4.3	3.6	2.1	6.4	6.5	4.5
d. Pulp, paper and print	4.8	9.2	5.2	3.7	3.1	3.1	2.1
e. Food processing, beverages and tobacco	73	132	82	60	56	50	68
f. Non-metallic minerals	382	577	726	556	491	483	513
g. Other	48	93	89	74	48	54	70

3. Transport	1242	1837	2111	2325	1891	2022	2094
a. Domestic aviation	26	18	13	7.7	0.9	0.6	0.8
b. Road transportation	1214	1818	2096	2315	1888	2020	2092
c. Railways	NO						
d. Domestic navigation	2.2	1.7	2.4	3.1	2.0	1.5	1.7
4. Other sectors	NO						
a. Commercial/ institutional	434	731	610	569	528	522	543
b. Residential	76	117	100	120	88	82	93
c. Agriculture/ forestry/ fishing	302	507	421	372	357	360	365
5. Other	56	106	89	77	83	80	85
a. Stationary	11	22	19	20	22	22	23
b. Mobile	11	22	19	17	19	19	18
CO2	3927	6310	7088	7453	6045	6442	6579
CH4	0.48	0.54	0.59	0.58	0.53	0.56	0.58
N2O	0.10	0.18	0.11	0.09	0.07	0.08	0.09

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

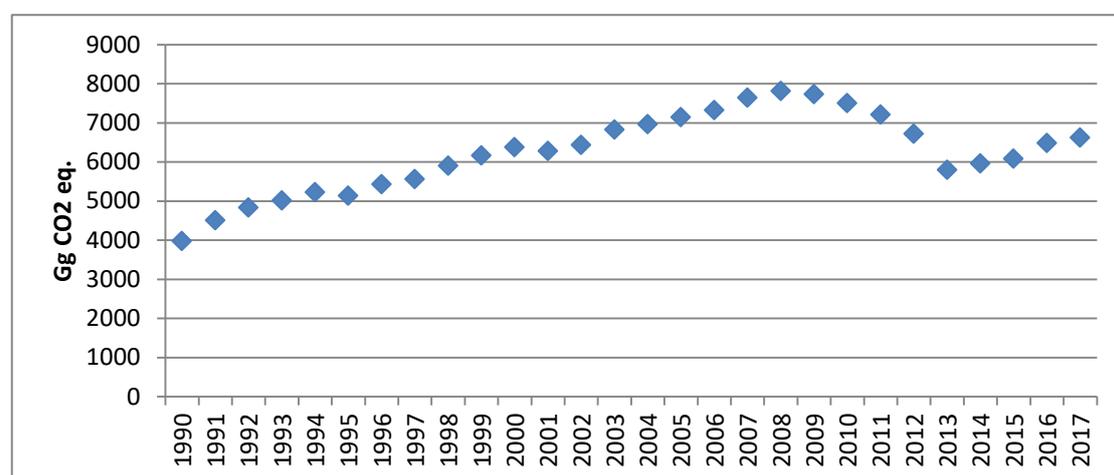


Figure 3.2. Emissions from fuel consumption 1990-2017

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 Service²⁶. Data is available for all sources for the recent years. Therefore 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, EUCONTROL, 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.

²⁶ Ms. Nafsika Apostolou, Statistical Officer, Statistical Service, Ministry of Finance (+357 22602199, napostolou@cystat.mof.gov.cy)

Detailed presentation of the data used is given in the respective section.

3.2.3. Energy industries (CRF 1A1)

Category Energy industries (1A1), comprises of 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 solely 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 (production of charcoal).

The consumption of fossil fuels by energy industries in 2017 (42.7 PJ) increased by 83.1% 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 37.6% of total national emissions without LULUCF for 2017, while in 1990 the contribution was 31.9%. The total GHG emissions from energy industries in 2017 (3.3 Tg CO₂ eq.) increased by 86.7% compared to 1990 (1.8 Tg CO₂ 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 1990-2017 are presented in Figure 3.3.

Table 3.4. Emissions from energy industries 1990-2017

Gg CO ₂ eq.	1990	2000	2005	2010	2015	2016	2017
1. Energy industries	1681	2860	3483	3881	3033	3311	3299
a. Public electricity and heat production	86	104	NO	NO	NO	NO	NO
b. Petroleum refining	NO						
c. Manufacture of solid fuels and other energy industries*	1681	2860	3483	3881	3033	3311	3299
CO ₂ (Gg)	1761	2955	3472	3868	3023	3300	3288
CH ₄ (Gg)	0.07	0.12	0.14	0.15	0.12	0.13	0.13
N ₂ O (Gg)	0.01	0.02	0.03	0.03	0.02	0.03	0.03
Total (Gg CO ₂ eq.)	1681	2860	3483	3881	3033	3311	3299

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

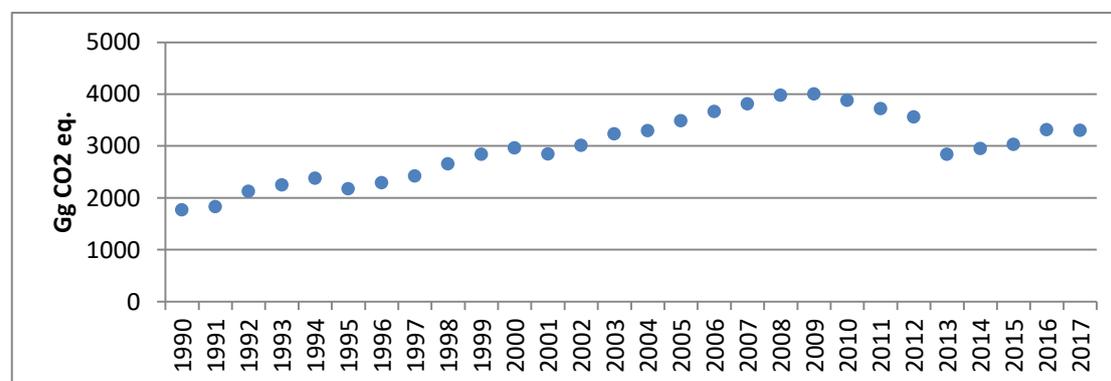


Figure 3.3. Energy industries emissions (1A1) 1990-2017

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 CO₂/TJ HFO and 72.43 t CO₂/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 available²⁷.

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	
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 are submitted annually by the installation since 2005 in compliance to the national Emissions Trading System law (110(I)/2011). The data collected through the ETS for the period 2005-2016 and used for the estimation of the emissions is presented in Table 3.6. For the years 2005-2015, the CO₂ emissions as reported by the installation in compliance with the ETS law have been used.

Table 3.6. Data collected through the ETS for electricity production in Cyprus (2005-2015)

²⁷ 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

	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
CO2 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 CO2/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			
Fuel consumption (kt)								
HFO	649.3	793.3	857.9	882.7	777.9			
Diesel	237.5	123.6	89.4	150.0	255.2			
Net calorific value (TJ/kt)*								
HFO	40.613	40.691	40.880	40.646	40.632			
Diesel	42.580	42.354	42.709	42.717	42.668			
CO2 emissions (Gg)								
HFO	2085.9	2553.1	2742.3	2828.1	2489.3			
Diesel	743.85	387.23	280.73	471.94	798.54			
Implied EF (Gg CO2/TJ)								
HFO	79.098	79.089	78.196	78.827	78.753			
Diesel	73.571	73.980	73.560	73.670	73.330			

* weighted average based on consumption

The overall implied emission factor for CO2 emissions during the period 2005-2016 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-CO2 emissions were estimated using the default EF proposed by the IPCC 2006 guidelines (vol.2, pg. 2.16); i.e. 3 kg CH4 /TJ and 0.6 kg N2O /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). CO2 emission factors are also the defaults proposed by the revised IPCC 2006 guidelines (vol. 2, pg. 2.16); i.e. 77.4 t CO2/TJ RFO, 73.3 t CO2/TJ other oil product and 57.6 t CO2/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-CO2 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 CH₄/TJ and 0.6 kg N₂O/TJ for RFO and other oil products and 1 kg CH₄/TJ and 0.1 kg N₂O/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 CO₂/TJ, 30 kg CH₄/TJ and 4 kg N₂O/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	1997
Solid biomass (TJ)	112	112	112	112	405	388	328	288
Charcoal produced (TJ)	29.5	29.5	29.5	29.5	147.5	118	118	88.5
Conversion efficiency	26.34%	26.34%	26.34%	26.34%	36.42%	30.41%	35.98%	30.73%

	1998	1999	2000	2001	2002	2003	2004	2005
Solid biomass (TJ)	314	281	248	253	235	209	184	174
Charcoal produced (TJ)	118	118	88.5	88.5	88.5	88.5	59.0	59.0
Conversion efficiency	37.58%	41.99%	35.69%	34.98%	37.66%	42.34%	32.07%	33.91%

	2006	2007	2008	2009	2010	2011	2012	2013
Solid biomass (TJ)	135	274	211	47	48	45	82	71
Charcoal produced (TJ)	59.0	118	88.5	29.5	29.5	29.5	29.5	29.5
Conversion efficiency	43.70%	43.07%	41.94%	62.77%	61.46%	65.56%	35.98%	41.55%

	2014	2015	2016	2017				
Solid biomass (TJ)	58	94	163	171.9				
Charcoal produced (TJ)	29.5	29.5	59.0	73.5				
Conversion efficiency	50.86%	31.38%	36.20%	42.75%				

3.2.3.3. Uncertainties and time-series consistency

In general, the uncertainty of emissions of 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 CO₂, less than 5%, since plant and country specific EFs are mainly applied. For the case of CH₄ and N₂O EFs, the uncertainty is higher, about 100 and 300% respectively, since IPCC defaults emission factors per technology / activity are applied. The results of 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. To 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 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. By this way both the national energy balance and the energy consumption used in emission calculations is verified and improved.

2. Emissions comparison: Verified ETS reports were used for the computation of plant specific CO₂ EFs and NCVs. For quality control purposes emissions calculated by applying PS EFs and NCVs are compared with the emissions calculated by using IPCC defaults 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 has been 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: on the one hand, 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 on the other, 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 2017 were 660 Gg CO₂ eq. The total GHG emissions from manufacturing industries and construction in 2017 increased by 28% 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 1990-2017 are presented in Figure 3.4 and Table 3.9.

Table 3.9. Emissions from manufacturing industries and construction 1990-2017

Gg CO2 eq.	1990	2000	2005	2010	2015	2016	2017
2. Manufacturing industries and construction	515	822	912	700	607	603	660
a. Iron and steel	NO						
b. Non-ferrous metals	4.9	7.2	6.5	5.1	3.0	6.2	2.2
c. Chemicals	2.2	4.3	3.6	2.1	6.4	6.5	4.5
d. Pulp, paper and print	4.8	9.2	5.2	3.7	3.1	3.1	2.1
e. Food processing, beverages and tobacco	73	132	82	60	56	50	68
f. Non-metallic minerals	382	577	726	556	491	483	513
g. Other (<i>please specify</i>)	48	93	89	74	48	54	70
CO2 (Gg)	512.2	818.7	908.3	696.6	603.1	599.0	654.7
CH4 (Gg)	0.035	0.040	0.049	0.047	0.049	0.054	0.073
N2O (Gg)	0.006	0.007	0.009	0.008	0.008	0.009	0.011
Total (Gg CO2 eq.)	515	822	912	700	607	603	660

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 1990-2017 is presented in Table 3.10. Consumption for Iron and steel (1A2a) is included in Non-ferrous metals (1A2b). Consumption for Transport equipment (1A2g), Machinery (1A2h) and Autoproducer electricity 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.

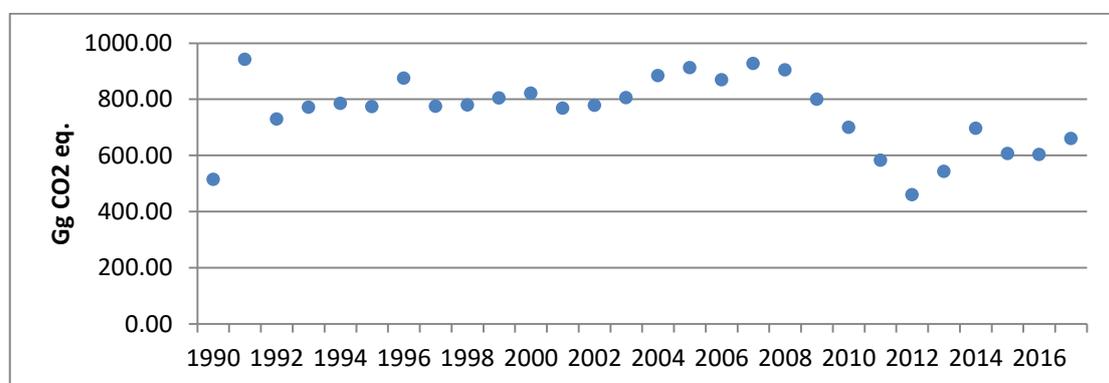


Figure 3.4. Emissions from energy use in manufacturing industries and construction (1A2) 1990-2017

Data for other bituminous coal in source category 1A2f for the years 2005-2017 is from reports submitted for ETS purposes by the cement installations. Waste (non-renewable) in source category 1A2f includes both industrial and municipal waste.

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.

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 CO₂, CH₄ and N₂O emissions were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.18); i.e. 63100 kg CO₂/TJ, 1 kg CH₄/TJ and 0.1 kg N₂O/TJ for LPG and 74100 kg CO₂/TJ, 3 kg CH₄/TJ and 0.6 kg N₂O/TJ for Gas-Diesel oil.

(b) 2004-2017

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1A2b Non-ferrous metals														
LPG	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	0.0	0.0	1.0	1.0	0.487
Diesel/gasoil	1.2	1.1	1.1	1.0	0.9	0.9	0.7	0.8	1.0	0.0	0.0	0.0	1.0	0.224
1A2c Chemical and petrochemical														
LPG														0.184
RFO												1.0	1.0	0.805
Diesel/gasoil	1.2	1.1	1.1	1.0	0.9	0.9	0.7	0.8	1.0	0.0	1.0	1.0	1.0	0.607
Solid biofuels (TJ)											42	52	21	21.6
1A2d Paper, pulp and printing														
RFO	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	0.671
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	4.512
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	12.083
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	5.169
Solid biofuels (TJ)											44	7	36	50.159
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
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
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
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
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
Solid biomass (TJ)	127.0	38.0	61.0	133.0	281.0	304.0	347.0	306.0	117.0	178.0	277.0	420.0	482.0	902.4
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
1A2i Mining and Quarrying														
Diesel (kt)	6	6	6	5	4	4	3	4	5	2	1	3	2	2.546
RFO (kt)														0.488
1A2k Construction														
Diesel (kt)	6	6	6	5	4	4	3	4	5	5	6	6	7	8.845
RFO (kt)									1.0	1.0	3.0	2.0	3	5.55
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	1.611
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	1.416
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
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
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	0.0
LPG (kt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.779

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 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 CO₂, CH₄ and N₂O 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 CO₂/TJ, 3 kg CH₄/TJ and 0.6 kg N₂O/TJ for gas-diesel oil, 63100 kg CO₂/TJ, 1 kg CH₄/TJ and 0.1 kg N₂O/TJ for LPG and 77400 kg CO₂/TJ, 3 kg CH₄/TJ and 0.6 kg N₂O/TJ for RFO. Consumption of solid biomass is reported for the first time in 2014. The CO₂, CH₄ and N₂O 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 CO₂/TJ, 30 kg CH₄/TJ and 4 kg N₂O/TJ.

Pulp, Paper and Print (1A2d)

Fuel consumption for this category has been 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) of the complete period. Consumption of RFO was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 3.11). The CO₂, CH₄ and N₂O 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 CO₂/TJ, 3 kg CH₄/TJ and 0.6 kg N₂O/TJ.

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 oil and RFO (Table 3.10). Fuel consumption was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 3.11). The CO₂, CH₄ and N₂O emissions were estimated using the default emission factors proposed by the IPCC 2006 guidelines (volume 2, pg. 2.18); i.e. 63100 kg CO₂/TJ, 1 kg CH₄/TJ and 0.1 kg N₂O/TJ for LPG, 74100 kg CO₂/TJ, 3 kg CH₄/TJ, 0.6 kg N₂O/TJ for Gas-Diesel oil and 77400 kg CO₂/TJ, 3 kg CH₄/TJ, 0.6 kg N₂O/TJ for RFO. Consumption of solid biomass is reported for the first time in 2014. The CO₂, CH₄ and N₂O 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 CO₂/TJ, 30 kg CH₄/TJ and 4 kg N₂O/TJ.

Non-metallic minerals (1A2f)

According to the energy balance the non-metallic minerals industries consume LPG, gas-diesel oil, RFO, pet-coke, other bituminous coal, solid biomass and industrial waste non-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 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 CO₂ emissions from pet-coke for the period 2005- 2015 were used as reported for the ETS. CO₂ emissions for the period 1990-2004 were estimated using the IEF of 2005, resulting from the division of CO₂ emissions by the TJ fuel consumed (84.51 t CO₂/TJ). CH₄ and N₂O 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 CH₄/TJ and 0.6 kg N₂O/TJ for gas-diesel oil, RFO and pet-coke and 1 kg CH₄/TJ and 0.1 kg N₂O/TJ for LPG.

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 CO₂ emissions from other bituminous coal for the period 2005-2013 were used as reported for the ETS. CO₂ emissions for the period 1990-2004 were estimated using the IEF of 2005, resulting from the division of CO₂ emissions by the TJ fuel consumed (92.60 t CO₂/TJ). CH₄ and N₂O emissions for other bituminous coal were estimated using the default emission factors proposed by the IPCC2006 guidelines (volume 2, pg. 2.18); i.e. 10 kg CH₄/TJ and 1.5 kg N₂O/TJ.

Solid biomass data was available in TJ. Solid biomass is consumed 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 CO₂ emissions from solid biomass for the period 2005-2016 were used as reported for the ETS. CO₂, CH₄ and N₂O 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 CO₂/TJ, 30 kg CH₄/TJ and 4 kg N₂O/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 annual emissions' report according to the requirements of the ETS law 110(I)/2011, since 2005. The CO₂, CH₄ and N₂O emissions for non-renewable industrial waste were estimated using the default emission factors proposed by the IPCC2006 guidelines (volume 2, pg. 2.19); i.e. 143000 kg CO₂/TJ, 30 kg CH₄/TJ and 4 kg N₂O/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 burning the raw material to produce the cement.

Mining (excluding fuels) and Quarrying (1A2i)

According to the energy balance mining and quarrying industries consume diesel and RFO (Table 3.10). Fuel consumption was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 3.11). CO₂, CH₄ and N₂O emissions were estimated using the default emission factors proposed by the IPCC2006 guidelines (volume 2, pg. 2.18); i.e. 74100kg CO₂/TJ, 3 kg CH₄/TJ and 0.6 kg N₂O/TJ for gas – diesel oil and 77400 kg CO₂/TJ, 3 kg CH₄/TJ and 0.6 kg N₂O/TJ for RFO.

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). CO₂, CH₄ and N₂O emissions were estimated using the default emission factors proposed by the IPCC2006 guidelines (volume 2, pg. 2.18); i.e. 74100kg CO₂/TJ, 3 kg CH₄/TJ and 0.6 kg N₂O/TJ for gas – diesel oil.

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 (Table 3.10). Other kerosene has been consumed in 2014 by the gas exploration platforms. RFO consumption for 1990-2014 has been revised due to the addition of Pulp, Paper and Print industries. Fuel consumption was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 3.11). The CO₂, CH₄ and N₂O emissions were estimated using the default emission factors proposed by the IPCC2006 guidelines (volume 2, pg. 2.18); i.e. 74100 kg CO₂/TJ for Gas-Diesel oil, 77400 kg CO₂/TJ for RFO, 71900 kg CO₂/TJ for other kerosene, 73300 kg CO₂/TJ for white spirit and other oil products. The emission factors for CH₄ and N₂O are 3 kg CH₄/TJ, 0.6 kg N₂O/TJ for all fuels.

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

	NCV (TJ/kt)	IEF (tCO ₂ /TJ)*
LPG	47.3	
Other kerosene	43.8	
Other bituminous coal	25.8	92.600

* 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 Department of Labour Inspection, ETS and Statistical Service.

3.2.4.5. Category-specific recalculations

No recalculations have been performed for Manufacturing Industries and Construction.

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 (CO₂), methane (CH₄) and nitrous oxide (N₂O) 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 (SO₂), 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 first year for which emissions are estimated from road transport with COPERT 5 and are therefore distinguished into the appropriate vehicle type. Further details are given in the methodology section.

Between 1990 and 2017 emissions from transport increased by 69% (Table 3.12). During the same period the emissions from domestic aviation decreased by 97%, while emissions from road transport increased by 72%. In 2017 transport contributed 23.8% to the total emissions of the country without LULUCF and 31.2% to the emissions from the energy sector. Transport (1A3) emissions are also presented in Figure 3.5.

Table 3.12. Transport emissions 1990-2017

Gg CO ₂ eq.	1990	2000	2005	2010	2015	2016	2017
3. Transport	1242	1837	2111	2325	1891	2022	2094
a. Domestic aviation	26	18	13	7.7	0.9	0.6	0.8
b. Road transportation	1214	1818	2096	2315	1888	2020	2092
c. Railways	NO						

d. Domestic navigation	2.2	1.7	2.4	3.1	2.0	1.5	1.7
CO2 (Gg)	1212	1790	2085	2305	1875	2005	2077
CH4 (Gg)	0.28	0.24	0.24	0.22	0.16	0.17	0.16
N2O (Gg)	0.08	0.14	0.07	0.05	0.04	0.04	0.04
Total (Gg CO2 eq.)	1242	1837	2111	2325	1891	2022	2094

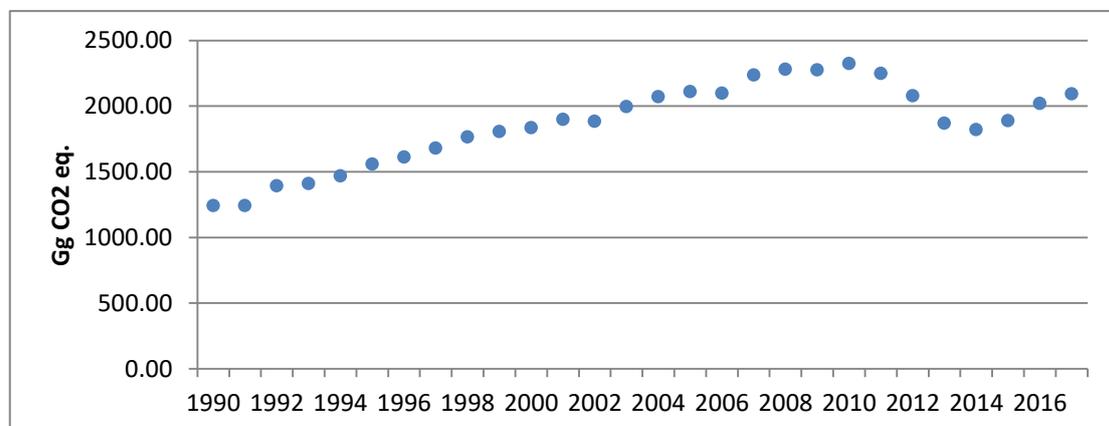


Figure 3.5. Transport (1A3) emissions 1990-2017

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 3.13) for 2005-2017. It is currently not possible to move to higher Tiers; it will be assessed again for future submissions.

Table 3.13. International and domestic flights' fuel consumptions, EUROCONTROL data (2005-2017)

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			
Domestic	0.305	0.191	0.286	0.179	0.260			
International	245.7	246.0	238.1	278.2	316.6			

The share of domestic flights to the total fuel consumption is presented in Table 3.14. 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 3.15), 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 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).

LTOs data was not possible to be used 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 CO₂/TJ, 0.5 kg CH₄/TJ and 2 kg N₂O/TJ.

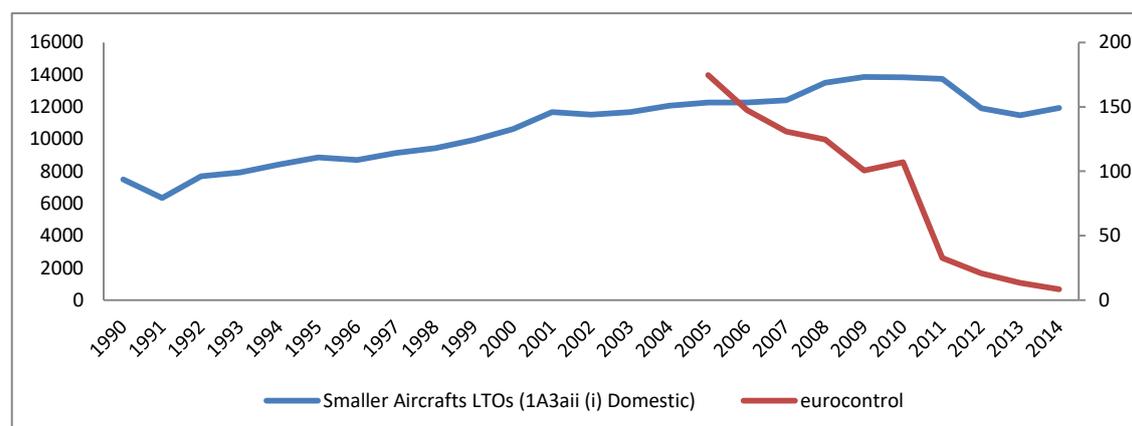


Figure 3.6. Smaller aircrafts LTOs and EUROCONTROL data for domestic flights

Table 3.14. Share of domestic flights to the total fuel consumption, EUROCONTROL data (2005-2017)

	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			
Share of domestic to total	0.12%	0.08%	0.12%	0.06%	0.08%			

Table 3.15. 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 2016²⁸. 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.

²⁸ EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016 – September 2016, EEA Technical Report No. 21/2016

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 – 2017). The total number of road vehicles by type for the period 1990-2017 is shown in Table 3.16 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 3.17. 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.

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).²⁹

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.

Table 3.16. Number of vehicles by type

	1990	2000	2005	2010	2015	2016	2017
Buses	2743	3313	3727	5505	5512	5601	5770
Heavy Duty Trucks	10439	12667	16364	19595	17028	17096	17649
Mopeds & Motorcycles	64457	59403	59924	55001	52168	54267	58303
Light Commercial Vehicles	69708	116672	125586	125507	115597	117341	120153
Passenger Cars	195330	302088	416758	536137	576755	588831	629750

²⁹ Christina Karapitta, Energy Officer A', Energy Service, Ministry of Energy, Commerce and Industry (tel. 22409388, ckarapitta@mcit.gov.cy)

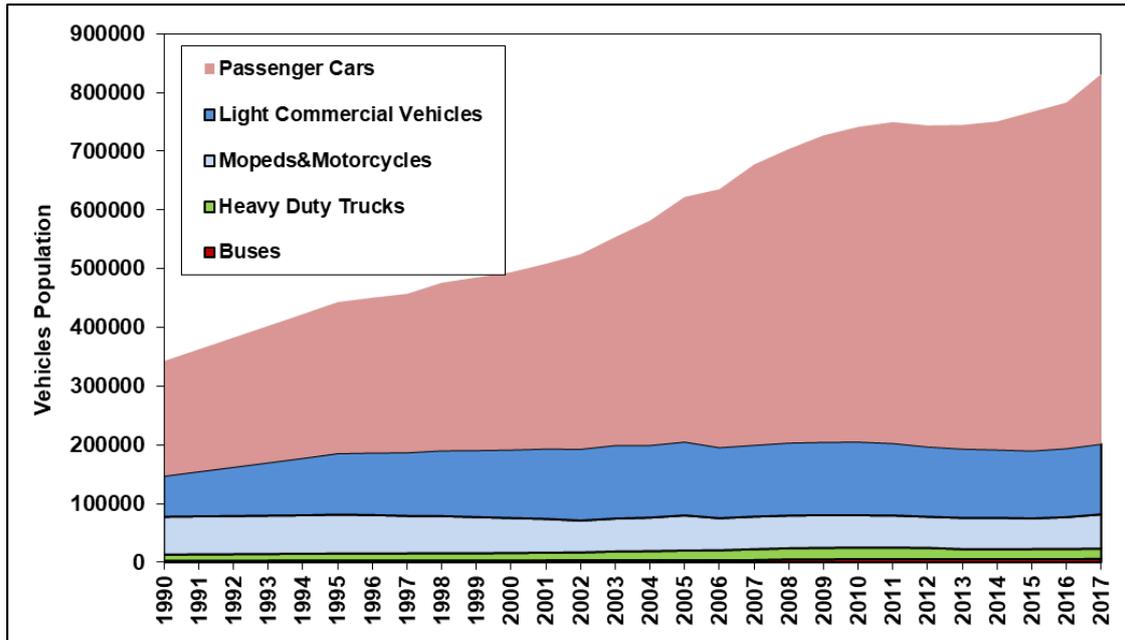


Figure 3.7. Trend of vehicles population in the Road transport sector

Table 3.17. Fuel consumed by road transport (kt) during 1990-2017

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

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

kt	2010	2011	2012	2013	2014	2015	2016	2017		
Gasoline	390	385	372	349	341	345	354	350.858		
Diesel	328	312	271	231	223	241	273	298.6733		
Biodiesel	17	18	18	17	11	11	10	9.697		

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 3.18). 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 the contribution of domestic water-borne navigation activities to road transport was assumed the same as 2016 (0.17%). 2016 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 IPCC2006: NCV 43 TJ/kt (volume 2, pg. 1.18), 74100 kg CO₂/TJ (volume 2, pg. 3.50), 3.9 kg CH₄/TJ and 3.9 kg N₂O/TJ (assumed same as road - default, volume 2, pg. 3.21).

Table 3.18. Diesel consumption by domestic water-borne navigation activities

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Activity (kt)	0.69	0.66	0.81	0.84	0.86	0.94	0.98	1.03	1.10	1.24

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Activity (kt)	0.53	0.43	0.56	0.43	0.60	0.73	0.56	0.63	0.76	1.49

	2010	2011	2012	2013	2014	2015	2016	2017		
Activity (kt)	0.95	0.89	0.63	0.47	0.56	0.63	0.47	0.52		

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 1A3b Road Transport for the whole reporting period and for 1A3d ii Domestic water-borne navigation for the year 2016.

(a) 1A3b Road Transport

In previous submission 2006 IPCC Tier 1 methodology was used, whereas in the current submission the emissions have been obtained from the application of COPERT, which is considered T2 methodology. The impact of the change is presented in Table 3.19 and

Table 3.19. Impact of recalculations on Road Transport (1A3b) emissions

kt CO2 eq.	1990	1991	1992	1993	1994	1995	1996	1997	1998
T1	1200	1197	1346	1365	1420	1507	1558	1626	1703
COPERT	1204	1202	1352	1373	1430	1519	1573	1643	1725
Difference	0.3%	0.4%	0.5%	0.6%	0.8%	0.8%	1.0%	1.1%	1.3%
Impact on total	0.06%	0.08%	0.09%	0.11%	0.16%	0.18%	0.21%	0.23%	0.28%
kt CO2 eq.	1999	2000	2001	2002	2003	2004	2005	2006	2007
T1	1748	1792	1850	1834	1943	2049	2089	2080	2218
COPERT	1766	1818	1879	1864	1979	2056	2096	2087	2228
Difference	1.0%	1.4%	1.5%	1.7%	1.9%	0.3%	0.3%	0.3%	0.5%
Impact on total	0.23%	0.31%	0.35%	0.37%	0.41%	0.08%	0.07%	0.08%	0.10%
kt CO2 eq.	2008	2009	2010	2011	2012	2013	2014	2015	2016
T1	2262	2262	2312	2245	2071	1865	1816	1886	2019
COPERT	2314	2311	2361	2294	2125	1914	1849	1918	2051
Difference	2.3%	2.2%	2.1%	2.2%	2.6%	2.6%	1.8%	1.7%	1.6%
Impact on total	0.53%	0.51%	0.53%	0.56%	0.64%	0.64%	0.40%	0.39%	0.38%

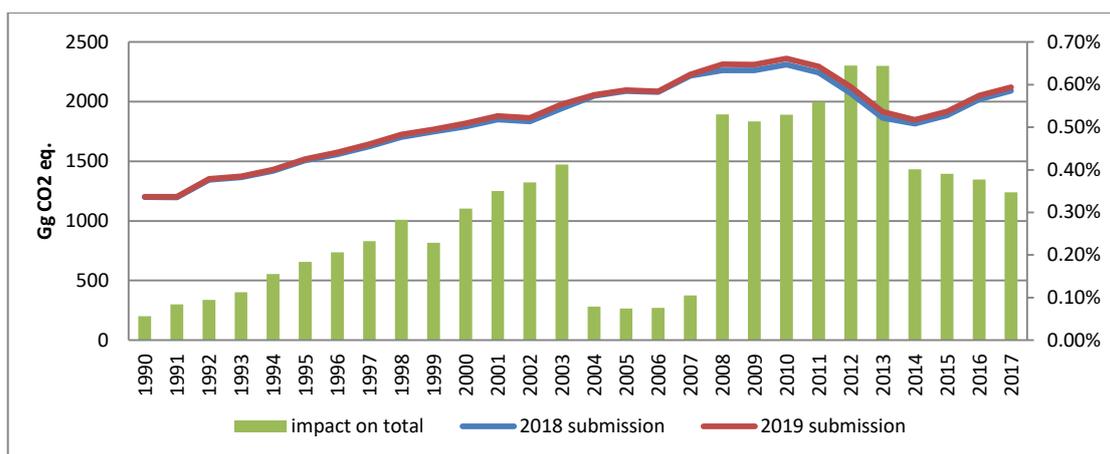


Figure 3.8. Impact of recalculations on Road Transport (1A3b) emissions

(b) 1A3d ii Domestic water-borne navigation

Domestic water-borne navigation (1A3d ii) the recalculations have been caused by availability of new data from the Statistical Service for the year 2016. Therefore calculation for 2016 has been revised to estimate the emissions using the new data.

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 consistence and comparability. Therefore it was decided to complete the period using assumptions.

GHG emissions from other sectors in 2017 increased by 25% compared to 1990 emissions (from 434 Gg CO₂ eq in 1990 to 543 Gg CO₂ eq in 2017). Table 3.20 presents the trend between 1990 and 2017. Other sectors contribute 6.2% to the total emissions of the country in 2017 without LULUCF and 8.2% to the emissions from the energy sector. The emissions from Other sources (1A4) are presented in Figure 3.6.

Table 3.20. GHG emissions from Other sectors 1990-2017

	1990	2000	2005	2010	2015	2016	2017
4. Other sectors	434	731	610	569	528	522	543
a. Commercial/institutional	76	117	100	120	88	82	93
b. Residential	302	507	421	372	357	360	365
c. Agriculture/forestry/fishing	56	106	89	77	83	80	85

CO ₂ (Gg)	430.40	725.39	604.60	563.22	521.74	515.52	536.10
CH ₄ (Gg)	0.10	0.14	0.15	0.16	0.20	0.20	0.21
N ₂ O (Gg)	0.003	0.005	0.005	0.004	0.005	0.004	0.005

Total (Gg CO2 eq.)	434	731	610	569	528	522	543
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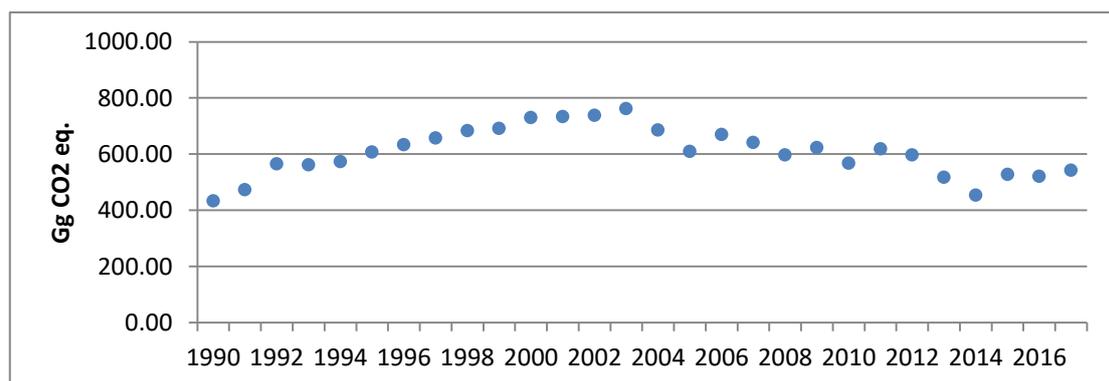


Figure 3.9. Other sectors (1A4) emissions 1990-2017

3.2.6.2. 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. The activity data used for the estimation of GHG emissions of other sectors is presented in Table 3.21.

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 the commercial sector has been revised and Off-road Vehicles and Other Machinery (1A4c ii) consumption is included in road transport (1A3b). Consumption of RFO in 1A4a Commercial / Institutional was revised for the year 2016, due to revision of the energy balance.

Table 3.21. Fuel consumption for “Other sectors” for the period 1990-2017

	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
1A4a Commercial / Institutional										
Gas-diesel oil (kt)	20	19	23	20	16	17	13	13	15	14.325
RFO (kt)	2	2	2	2	4	4	2	3	4	3.14
LPG (kt)	14	13	13	14	14	12	11	12	11	12.122
Solid biofuels (TJ)	15	15	15	13	16	16	16	15	15	17
Biogas (TJ)		11	12	11	11	11	11	11	12	12
Charcoal (kt)	7	6	6	6	6	6	6	7	7	7.071
1A4b Residential										
Other kerosene (kt)	14	19	14	16	17	12	9	14	14	14.381
Gas-diesel oil (kt)	78	83	70	80	76	62	57	65	65	67.105
LPG (kt)	34	36	34	38	37	33	31	34	35	33.941
Solid biofuels (TJ)	123	222	84	123	143	112	71	146	130	163.118
Charcoal (kt)	6	5	5	6	6	6	6	7	8	8.642
1A4c Agriculture / Forestry / Fishing / Fish farms										
1A4c i Stationary										
Gas-diesel oil (kt)	23	20	19	22	21	21	19	22	21	22.109
LPG (kt)	1	1	1	1	1	1	0	2	2	2.424
Biogas (TJ)	78	198	262	437	465	455	464	460	475	487.389
1A4c iii Fishing										
Gas-diesel oil (kt)	3	4	4	3	3	2	2	2	2	2

The GHG emissions from “other sectors” were estimated according to the IPCC2006 guidelines. Fuel consumption was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 3.22). The oxidation factor used is 1, as proposed by the IPCC 2006 guidelines (pg. 1.20). The CO₂, CH₄ and N₂O emissions were estimated using the default emission factors proposed by the IPCC2006 guidelines (IPCC2006, pg. 2.20-2.22, oil) as presented in Table 3.20.

Table 3.22. Parameters used for the estimation of emissions from other sectors

Fuel	NCV (TJ/kt)	kg CO ₂ /TJ	kg CH ₄ /TJ	kg N ₂ O /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
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

Recalculations for 1A4a Commercial / Institutional have been performed due to revision of activity data by the Statistical Service for the year 2016.

Table 3.23. 1A4a Commercial / Institutional recalculations (Gg CO₂ eq.)

	2016
2018 submission	80.96
2019 submission	93.5
% difference	15.5%

3.2.6.6. Category-specific planned improvements

Please refer to [Annex 7](#) for the National Inventory Improvement Plan.

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 1990-2017 are presented in Table 3.24 and Figure 3.10.

Table 3.24. GHG emissions from Other (Not elsewhere specified-Stationary) 1990-2017

	1990	2000	2005	2010	2015	2016	2017
5. Other	11	22	19	20	22	22	23
a. Stationary	11	22	19	17	19	19	18
b. Mobile	NO	NO	NO	3.2	3.2	3.2	5.4
CO ₂ (Gg)	11.00	21.43	19.03	20.29	22.27	22.27	22.97

CH4 (Gg)	0.0015	0.0029	0.0060	0.0062	0.0030	0.0030	0.0031
N2O (Gg)	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Total (Gg CO2 eq.)	11	22	19	20	22	22	23

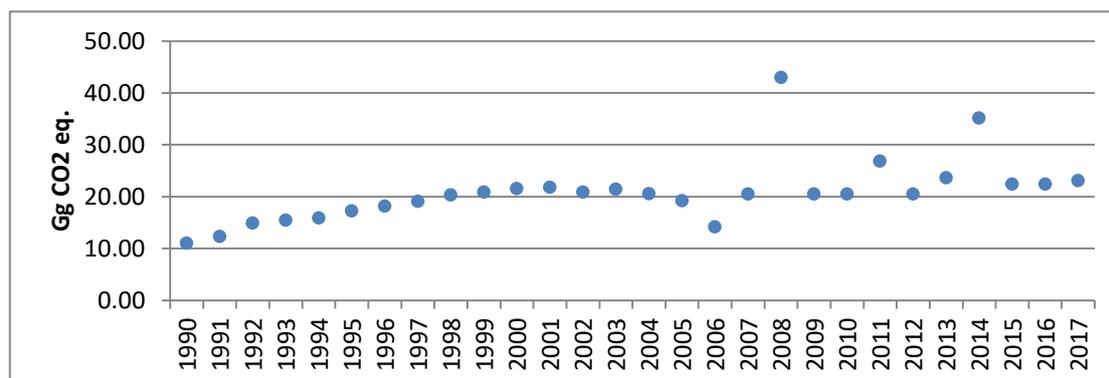


Figure 3.10. GHG emissions from Other (Not elsewhere specified-Stationary) (1A5) 1990-2017

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 3.25. Consumption of Gas-diesel oil and Lignite is allocated to stationary combustion, whereas consumption of jet kerosene to mobile combustion.

Table 3.25. Other non-specified fuel consumption 1990-2017

	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
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
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
Jet kerosene (kt)	0	0	0	1	1	2	1	2
	2014	2015	2016	2017				
Gas-diesel oil (kt)	9	6	6	5.533				
Lignite (kt)	0	0	0	0				
Jet kerosene (kt)	2	1	1	1.683				

Methodology

The GHG emissions were estimated according to the IPCC2006 guidelines. Fuel consumption was converted to TJ using the default NCV proposed by the IPCC 2006 guidelines (Table 1.23). The CO₂, CH₄ and N₂O emissions were estimated using the default emission factors proposed by the IPCC2006 guidelines (volume 2, pg. 2.22) as presented in Table 3.26.

Table 3.26. Parameters used for the estimation of other emissions

Fuel	NCV (TJ/kt)	kg CO ₂ /TJ	kg CH ₄ /TJ	kg N ₂ O /TJ
Diesel	43.0	74100	10	0.6
Jet kerosene	44.1	71500	10	0.6
Lignite	11.9	101000	300	1.5
Solid Biomass	11.6	100000	300	4.0

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

No recalculations to report.

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 CO₂ 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 CO₂ emissions from fuel combustion with limited additional effort and data requirements.

Both sectoral approach and the reference approach are to estimate a country's CO₂ emissions from fuel combustion and to compare the results of 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 CO₂ 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 CO₂ 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 3.27 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 the NCV implied by the annual reports submitted according to national ETS legislation (law no. 110(I)/2011), instead of the default proposed by the IPCC were used, which is 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 3.27) 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 CO₂. The carbon emission factor of 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 the storage of some or all of the carbon contained in the fuel to 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 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 in CO₂ 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 CO₂ emissions

Carbon emissions from all fuels are multiplied by 44/12 to be converted to CO₂ emissions and are summed giving the total amount of CO₂ 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 3.27. Net calorific value (TJ/kt) and carbon emission factors (t CO₂/kt) of fuels consumed in Cyprus used for the reference approach

(a) Net calorific value (TJ/kt) and carbon emission factors (t CO₂/kt) that remain constant for the period 1990-2017

	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
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 CO₂/kt) that are not constant for the period 1990-2017

	1990	1991	1992	1993	1994	1995	1996
NCV (TJ/kt)							
Other bituminous coal	27.650	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	23.047
Other bituminous coal	25.254	25.254	25.254	25.254	25.254	25.254	25.254
C EF (tC/TJ)							
Waste (non-biomass fraction)	NO						
Solid biomass	27.629	27.661	27.664	27.665	28.340	28.264	28.286

	1997	1998	1999	2000	2001	2002	2003
NCV (TJ/kt)							
Other bituminous coal	27.650	27.650	27.650	27.650	26.840	26.400	27.300
Implied CEF (tC/TJ)							
Pet-coke	23.047	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	25.254
C EF (tC/TJ)							
Waste (non-biomass fraction)	NO	NO	NO	NO	39.00	NO	39.00
Solid biomass	28.471	28.530	28.448	28.217	28.157	28.391	28.253

	2004	2005	2006	2007	2008	2009	2010
NCV (TJ/kt)							
Other bituminous coal	28.621	28.621	29.995	28.360	25.950	26.080	26.819
Implied CEF (tC/TJ)							
Pet-coke	23.047	23.047	24.160	24.659	24.486	25.578	25.515
Other bituminous coal	25.254	25.254	25.156	22.815	25.788	25.661	25.794
C EF (tC/TJ)							
Waste (non-biomass fraction)	39.00	39.00	39.00	39.00	39.00	39.00	39.00
Solid biomass	28.542	28.971	28.956	28.664	28.511	28.438	28.569

	2011	2012	2013	2014	2015	2016	2017
NCV (TJ/kt)							
Other bituminous coal	25.517	NO	NO	23.210	25.675	25.675	24.680
Implied CEF (tC/TJ)							
Pet-coke	25.301	24.795	25.238	25.583	25.150	25.313	28.710
Other bituminous coal	25.620	NO	NO	25.890	25.876	25.877	25.563
C EF (tC/TJ)							
Waste (non-biomass fraction)	39.00	25.00	25.00	37.36	30.996	30.996	26.985
Solid biomass	28.647	29.115	29.250	28.918	28.852	28.942	28.772

Table 3.28. Apparent consumption (TJ) and CO2 emissions (Gg) estimates according to the reference approach 1990-2017

	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
CO2	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
CO2	248	248	67	79	69	51	46
Waste (non-biomass fraction)							
Apparent consumption	NO						
CO2	NO						
Biomass							
Apparent consumption	287	262	260	259	726	686	671
CO2	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
CO2	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
CO2	49	67	77	125	132	130	134
Waste (non-biomass fraction)							
Apparent consumption	NO	NO	NO	NO	18	NO	15
CO2	NO	NO	NO	NO	3	NO	2
Biomass							
Apparent consumption	565	614	487	515	551	606	694
CO2	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
CO2	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
CO2	152	139	151	117	99	53	67
Waste (non-biomass fraction)							
Apparent consumption	71	138	73	288	239	276	299
CO2	10	20	10	41	34	39	43
Biomass							
Apparent consumption	608	565	570	915	1,524	1,581	1,552
CO2	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	86,875
CO2	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
CO2	30	1	1	15	15	2	12
Waste (non-biomass fraction)							
Apparent consumption	56	24	45	316	516	663	902
CO2	8	2	4	43	59	66	91
Biomass							
Apparent consumption	1,775	1,667	1,506	1,472	1,558	1,625	1,756
CO2	147	133	120	121	130	138	151

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 3.29.

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 3.29. Difference between Reference and Sectoral Approach 1990-2017

	1990	1991	1992	1993	1994	1995	1996
Fuel consumption (PJ)							
Sectoral approach	52.2	58.9	63.7	66.5	67.9	67.4	71.1
Apparent energy consumption*	56.8	58.4	64.6	69.2	78.9	68.4	75.9
<i>Difference</i>	8.9%	-0.9%	1.5%	4.1%	16.1%	1.5%	6.6%
CO2 (Gg)							
Reference approach	4281	4425	4840	5199	5907	5112	5693
Sectoral approach	3927	4457	4781	4956	5164	5069	5362
<i>Difference</i>	9.0%	-0.7%	1.2%	4.9%	14.4%	0.8%	6.2%

	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
<i>Difference</i>	1.9%	2.2%	-1.9%	2.2%	3.2%	1.4%	5.0%
CO2 (Gg)							
Reference approach	5560	5923	5933	6415	6356	6438	7089
Sectoral approach	5483	5823	6085	6310	6202	6359	6746
<i>Difference</i>	1.4%	1.7%	-2.5%	1.7%	2.5%	1.3%	5.1%

	2004	2005	2006	2007	2008	2009	2010
Fuel consumption (PJ)							
Sectoral approach	91.4	93.5	94.4	98.5	100.8	100.2	97.2
Apparent energy consumption*	87.0	88.4	92.2	97.2	102.6	99.9	95.4
<i>Difference</i>	-4.8%	-5.5%	-2.3%	-1.3%	1.8%	-0.3%	-1.8%
CO2 (Gg)							
Reference approach	6581	6673	7002	7375	7734	7574	7217
Sectoral approach	6910	7088	7271	7591	7756	7682	7453
<i>Difference</i>	-4.8%	-5.9%	-3.7%	-2.8%	-0.3%	-1.4%	-3.2%

	2011	2012	2013	2014	2015	2016	2017
Fuel consumption (PJ)							
Sectoral approach	94.3	88.0	75.7	76.8	79.1	84.4	85.8
Apparent energy consumption*	92.1	86.9	74.7	76.7	77.8	83.2	86.0
<i>Difference</i>	-2.2%	-1.2%	-1.3%	0.0%	-1.7%	-1.4%	0.2%
CO2 (Gg)							
Reference approach	6933	6508	5601	5824	5877	6270	6513
Sectoral approach	7162	6675	5761	5924	6045	6442	6579
<i>Difference</i>	-3.2%	-2.5%	-2.8%	-1.7%	-2.8%	-2.7%	-1.0%

* excluding non-energy use, reductants and feedstocks

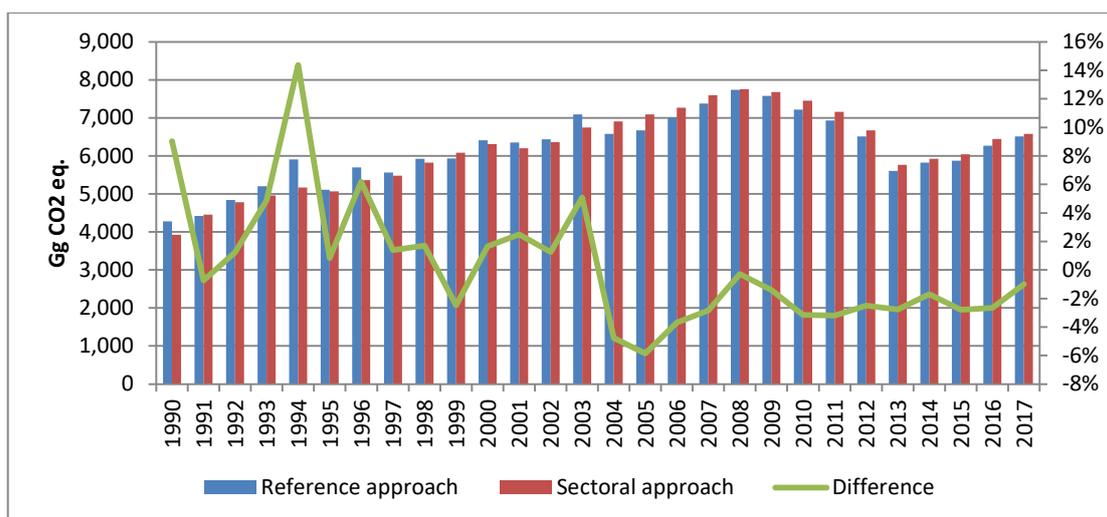


Figure 3.11. CO2 emissions from fuel combustion using sectoral and reference approach

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 as 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

The calculation of carbon dioxide emissions from non-energy use of fuels is according to the methodology proposed by the IPCC2006 guidelines. NCVs, carbon emission factor and fraction of C stored are according to the guidelines (Table 3.30). Non-energy fuel use, carbon dioxide emissions and the amount of carbon stored in the final products are presented in Table 3.31.

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. The years have been completed using backwards extrapolation of activity data for 1993-1996. All the consumption has been assumed imports of the purposes of the reference approach.

Table 3.30. Parameters used for the calculation of emissions

	Lubricants	Bitumen
NCV (TJ/kt)	40.2	40.2
Carbon emission factor (t/TJ)	20.00	22.00
Oxidation factor	1	1

Table 3.31. Fuel consumption, carbon stored and CO2 emissions for Feedstocks and non-energy use of fuels

	1990	1991	1992	1993	1994	1995	1996	1997
Lubricants								
Consumption (kt)	1.9	3.7	5.5	6	11	11	12	11
Carbon excluded (Gg)	1.528	2.975	4.422	4.824	8.844	8.844	9.648	8.844
CO ₂ (Gg)	5.60	10.91	16.21	17.69	32.43	32.43	35.38	32.43
Bitumen								
Consumption (kt)	33	19	50	59	58	51	55	60
Carbon excluded (Gg)	29.19	16.80	44.22	52.18	51.30	45.10	48.64	53.06
CO ₂ (Gg)	107.01	61.61	162.14	191.33	188.08	165.38	178.35	194.57

	1998	1999	2000	2001	2002	2003	2004	2005
Lubricants								
Consumption (kt)	4	5	7	9	8	8	11	10
Carbon excluded (Gg)	3.216	4.02	5.628	7.236	6.432	6.432	8.844	8.04
CO ₂ (Gg)	11.79	14.74	20.64	26.53	23.58	23.58	32.43	29.48
Bitumen								
Consumption (kt)	75	86	85	81	84	69	66	71
Carbon excluded (Gg)	66.33	76.06	75.17	71.64	74.29	61.02	58.37	62.79
CO ₂ (Gg)	243.21	278.88	275.64	262.67	272.40	223.75	214.02	230.24

	2006	2007	2008	2009	2010	2011	2012	2013
Lubricants								
Consumption (kt)	11	10	10	10	11	10	9	7
Carbon excluded (Gg)	8.844	8.04	8.04	8.04	8.844	8.04	7.236	5.628
CO ₂ (Gg)	32.43	29.48	29.48	29.48	32.43	29.48	26.53	20.64
Bitumen								
Consumption (kt)	65	60	69	57	74	64	35	26
Carbon excluded (Gg)	57.49	53.06	61.02	50.41	65.45	56.60	30.95	22.99
CO ₂ (Gg)	210.78	194.57	223.75	184.84	239.97	207.54	113.50	84.31

	2014	2015	2016	2017				
Lubricants								
Consumption (kt)	7	8	8	7.849				
Carbon excluded (Gg)	5.628	6.432	6.432	6.292				
CO ₂ (Gg)	20.64	23.58	23.58	23.07				
Bitumen								
Consumption (kt)	22	21	36	38.95				
Carbon excluded (Gg)	19.46	18.57	31.84	34.45				
CO ₂ (Gg)	71.34	68.10	116.74	126.31				

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

No recalculations to be reported.

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 stop operating (NO). Table 3.32 presents the emissions of the source. Methane emissions from refining activities (1.B.2.A.4) only occur during 1990-2004 when the refinery was operating.

Transport of oil (1.B.2.a.3) according to the definition of the IPCC 2006 Guidelines, took place only during the time the refinery was operating; i.e. 1990-2004, and has not been taking place ever since. 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.

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.

Table 3.32. Fugitive emissions from oil during 1990-2017, in tons

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Refining (t CH ₄)	2.49	2.99	2.85	3.06	3.55	3.24	2.97	4.08	4.23	4.62	4.59
Venting (t CO ₂)	36.5	40.6	44.8	44.2	45.9	46.1	47.7	48.5	51.5	53.4	55.4
Venting (t CH ₄)	3.6	4.1	4.5	4.4	4.6	4.6	4.8	4.8	5.1	5.3	5.5
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Refining (t CH ₄)	4.52	4.25	3.80	1.09	NO						
Venting (t CO ₂)	56.4	56.8	62.9	61.4	62.6	63.6	65.9	67.1	66.9	66.0	65.7
Venting (t CH ₄)	5.6	5.7	6.3	6.1	6.3	6.4	6.6	6.7	6.7	6.6	6.6
	2012	2013	2014	2015	2016	2017					
Refining (t CH ₄)	NO	NO	NO	NO	NO	NO					
Venting (t CO ₂)	61.6	52.6	51.9	53.7	58.2	60.6					
Venting (t CH ₄)	6.2	5.3	5.2	5.4	5.8	6.1					

3.3.1.2. Methodological issues

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

GHG emissions from oil until 2004 when the refinery was operating are estimated according to the Tier 1 methodology described in the IPCC 2006 guidelines. The activity data used is presented in Table 3.33. The activity data is from the energy balance of the National Statistical Service. The emission factor 3.35 kg CH₄ /m³³⁰ for oil refined, is according to the IPCC 2006 guidelines, Table 4.2.4, pg. 4.53.

Table 3.33. 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					

Venting (1.B.2.c.1.i)

Considering that there is no primary production nor processing of fuels in Cyprus and that since 2004 no refinery is operating, it would be possible to use the consumption of all oil products as activity data for this category to calculate emissions (method proposed by the TERT during the EU 2017 review (Observation CY-1B2c-2017-0002)). Therefore the Gross inland deliveries (Observed) from the national energy balance was used for the fuels LPG, Non-biogasoline, Non-bio jet kerosene, Other kerosene, Non-bio gas/diesel oil and Total fuel oil in kt were converted to m³ using the densities shown in Table 3.34. The total volume (Table 3.35) was used to estimate venting emissions using the T1 emission factors presented in Table 4.2.4, pg 4.53, vol.2 of 2006 guidelines (2.3×10^{-5} Gg CO₂/10³ m³ and 2.3×10^{-6} Gg CH₄/10³ m³).

Table 3.34. Fuel density (kg/m³) used to convert fuel consumption from mass to volume³¹

Fuel	ρ (kg/m ³)	Source
LPG	495	http://www.elgas.com.au/blog/453-the-science-a-properties-of-lpg
Gasoline	719.7	https://en.wikipedia.org/wiki/Gasoline
Jet kerosene	804	https://en.wikipedia.org/wiki/Jet_fuel
Other kerosene	820.1	https://www.engineeringtoolbox.com/liquids-densities-d_743.html
Gas/diesel oil	832	https://en.wikipedia.org/wiki/Diesel_fuel
Total fuel oil	991	http://www.viscopedia.com/viscosity-tables/substances/bunker-oil-marine-fuel-oil/

Table 3.35. Volume of fuel transported 1990-2017 (10³m³)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
LPG	99	99	111	103	101	103	103	105	101	99
Gasoline	226	236	239	235	250	254	258	265	271	282
Jet kerosene	294	348	338	287	295	323	310	305	321	328
Other kerosene	15	15	21	20	21	21	22	24	26	24
Gas/diesel oil	370	374	468	475	486	536	559	588	632	656
Total fuel oil	582	691	770	804	845	766	821	820	887	932
TOTAL	1586	1763	1947	1924	1997	2003	2073	2108	2238	2322
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
LPG	107	107	109	117	113	107	109	111	107	111
Gasoline	286	304	317	350	392	421	449	489	518	532
Jet kerosene	333	391	376	402	367	362	373	357	356	331
Other kerosene	29	29	38	38	29	20	20	20	17	23
Gas/diesel oil	673	663	635	656	641	624	605	619	611	675
Total fuel oil	981	960	996	1170	1129	1187	1211	1270	1311	1236
TOTAL	2410	2454	2470	2733	2671	2720	2766	2866	2920	2909
	2010	2011	2012	2013	2014	2015	2016	2017		

³⁰ $(2.6+4.1)/2=3.35$ kg/m³

³¹ Information accessed 28/2/2018

LPG	107	119	119	105	97	109	111	114		
Gasoline	542	535	517	485	474	479	492	488		
Jet kerosene	337	368	330	295	290	291	328	374		
Other kerosene	17	20	21	15	13	17	17	18		
Gas/diesel oil	748	690	757	706	554	548	662	823		
Total fuel oil	1120	1123	935	682	829	891	921	819		
TOTAL	2871	2855	2679	2287	2258	2336	2532	2636		

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.

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

No recalculations to be reported.

3.3.1.6. Category-specific planned improvements

Please refer to [Annex 7](#) for the National Inventory Improvement Plan.

3.4. CO₂ 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 CO₂ from biomass (1D3). The emissions during the period 1990-2017 are presented below.

Table 3.36. Emissions from memo items (Gg CO₂ eq.)

Gg CO ₂ eq.	1990	2000	2005	2010	2015	2016	2017
1D1. International bunkers	910	1448	1768	1431	1534	1802	1822
1D3. CO ₂ from biomass	30	57	63	150	179	196	240

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 1990-2017 are presented in Table 3.37.

Table 3.37. Emissions from international bunkers 1990-2017

Gg CO2 eq.	1990	2000	2005	2010	2015	2016	2017
International bunkers	910	1448	1768	1431	1534	1802	1822
Aviation	724	834	840	835	757	885	1007
Navigation	185	614	928	596	777	917	815
CO2 (Gg)	901	1434	1750	1416	1518	1783	1803
CH4 (Gg)	0.02	0.05	0.08	0.05	0.07	0.08	0.07
N2O (Gg)	0.03	0.04	0.05	0.05	0.05	0.06	0.06
Total (Gg CO2 eq.)	910	1448	1768	1431	1534	1802	1822

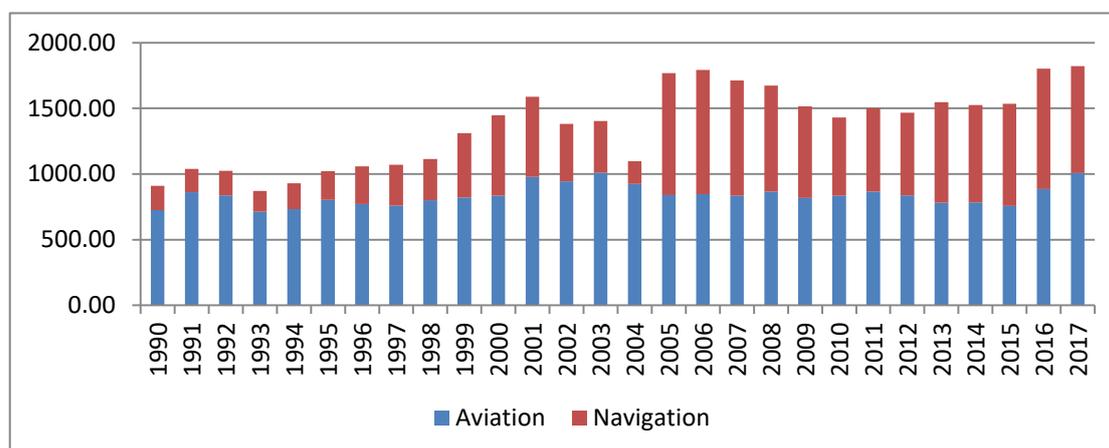


Figure 3.12. Emissions from international bunkers 1990-2017

3.5.1.2. Methodological issues

Activity data used for the estimation of emissions from bunkers is presented in Table 3.38. 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 the consumption of jet-kerosene has been estimated are presented in [section 3.2.5.2](#) and [Annex 3](#). NCV and emission factors (Table 3.39) are the defaults proposed by the IPCC 2006 guidelines; i.e. 44.1 TJ/kt, 71.5 t CO₂/TJ, 0.5 kg CH₄/TJ and 2 kg N₂O/TJ.

Table 3.38. Fuel consumption for international aviation and maritime activities 1990-2017 (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		
Jet Kerosene	263	272	263	246	246	238	278	317		
Gas/Diesel Oil	53	58	69	83	80	75	95	101		
RFO	134	141	128	157	153	169	193	154		

Table 3.39. Parameters used for the calculation of emissions

Fuel	NCV (TJ/kt)	kg CO ₂ /TJ	kg CH ₄ /TJ	kg N ₂ O/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. CO₂ 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 3.40. The resulting emissions from combustion of biomass are presented in Table 3.41.

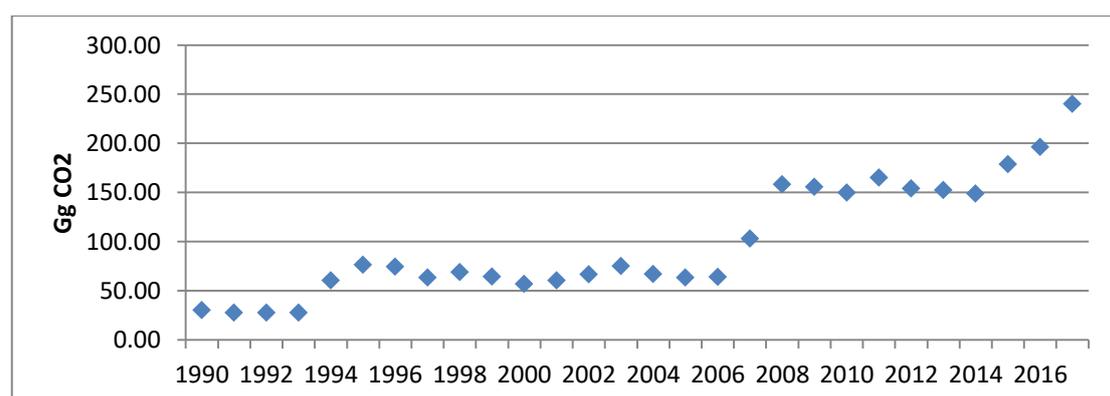


Figure 3.13. Emissions from biomass 1990-2017

Table 3.40. Activities consuming biomass in Cyprus

Source category	Solid biofuels	Charcoal	Liquid biofuels	Gas biofuels
1A1c Manufacture of solid fuels and other energy industries	✓			
1A2c Chemical and petrochemical	✓			
1A2e Food, beverages and tobacco	✓			
1A2f Non-metallic minerals	✓			
1A3b Road transport			✓	
1A4a Commercial and public services	✓	✓		✓
1A4b Residential	✓	✓		
1A4c Agriculture/ Forestry				✓

Table 3.41. Emissions from CO₂ from biomass 1990-2017

	1990	2000	2005	2010	2015	2016	2017
CO ₂ from biomass (Gg)	30	57	64	150	179	196	240

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 CO₂). During these processes, many different greenhouse gases, including carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), 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 (SF₆) and N₂O are used in a number of products used in industry (e.g., SF₆ used in electrical equipment, N₂O used as a propellant in aerosol products primarily in food industry) or by end-consumers (e.g., SF₆ used in running-shoes, N₂O 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 following source categories are 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*³²

Cyprus, after its independence in 1960, 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. From being 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 have been 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 provided for the elimination of 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.

³² Irene Mitsiga, Industry and Technology Service, Ministry of Energy, Commerce, Industry and Tourism, Tel. +357 22 867192, fax. +357 22 375120, e-mail: imitsiga@mcit.gov.cy

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. Following were the subsectors of: 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, wearing apparel, footwear, electricity distribution and control apparatus, kitchen furniture and jewellery and related articles.

2004-2009

On May 1st 2004, Cyprus, together with nine other countries, formally takes its place alongside the 15 member-states of 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 confidence climate, following 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 and investment demand in machinery and transport equipment as well as 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 has been 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 in ICT sector 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 %. With a number of 5,387 enterprises operating in the industrial sector, main exports were pharmaceutical products, food, basic metals, non-metallic mineral products (i.e. cement), machinery and equipment and recycled material.

2015-2017

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. On the basis of provisional estimates, 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. Specifically, according to provisional figures, manufacturing which constitutes the largest industrial sector, recorded an increase of 6.3%, compared to an increase of 5.9% in 2015. 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. Large increases compared to 2015 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 is experiencing positive growth in real terms. According to preliminary estimates of the Cyprus Statistical Office, this rate in the industrial sector as a whole reached 5.7% in 2017. The manufacturing sector, increased by 7.5% in 2017, compared to 6.3% in 2016 and 5.9% in 2015. The contribution of the whole industrial sector to the GDP reached a 7.9% and a 8.8% in total employment.

Competitiveness of the industrial sector is still low. This is 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. The Cyprus New Industrial Strategy Policy framework and action plan will help tackle these challenges and provide solutions aiming at creating the right environment for industry regeneration, increasing production and exports, technological upgrading, creating new jobs, developing innovation and improving infrastructure.

Emissions

In 2017, GHG emissions from Industrial processes accounted for 14.2% of total emissions excluding LULUCF compared to 14.5% in 1990. The emissions have increased by 51% compared to 1990. 79% of the industrial processes emissions are from mineral production, 15% is from consumption of Halocarbons and SF6, 5% is from Other Product Manufacture and Use and the remaining 1% is from non-energy products from fuels and solvent use.

Table 4.1. Total GHG emissions (in Gg CO₂ eq) from Industrial Processes, 1990 – 2017

	1990	2000	2005	2010	2015	2016	2017
2. Industrial Processes	841.14	997.87	1178.66	933.62	1221.35	1225.40	1269.5
A. Mineral industry	717.07	802.75	894.10	589.98	888.12	896.42	934.98
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	18.82	25.61	37.94	38.73	22.90	23.36	23.97
E. Electronic industry	NO	NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes	63.88	120.21	194.12	245.65	250.45	245.28	249.56
G. Other product manufacture and use	41.37	49.30	52.50	59.27	59.87	60.34	61.00

H. Other	NO	NO	NO	NO	NO	NO	NO
CO2 (Gg)	735.93	828.47	932.07	628.73	911.04	919.79	958.97
N2O (Gg)	0.139	0.165	0.176	0.198	0.200	0.202	0.204
HFC (Gg CO2 eq.)	63.88	120.21	194.12	245.65	250.45	245.28	249.56
SF6 (Gg)	0.000001	0.000003	0.000005	0.000007	0.000007	0.000007	0.000007
Total	841.14	997.87	1178.66	933.62	1221.35	1225.40	1269.5

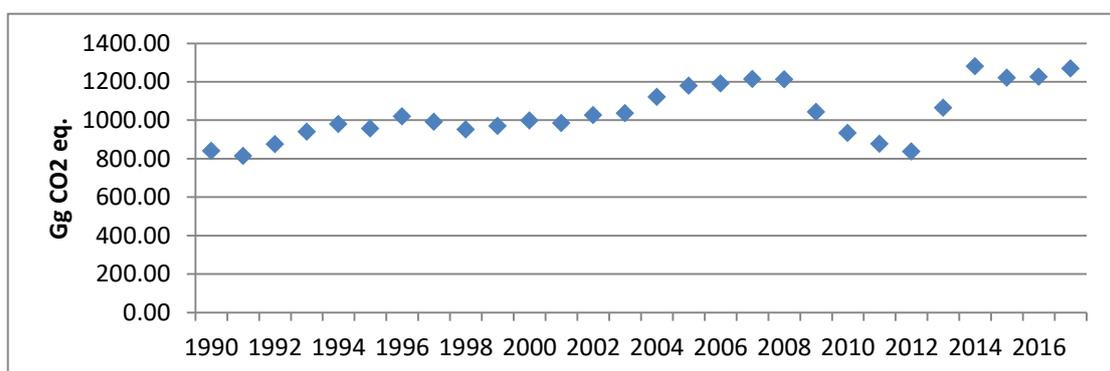


Figure 4.1. GHG emissions from Industrial Processes (sector 2) for the period 1990 – 2017

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	N ₂ O	HFC	PFC	SF ₆
2A1.Cement production	✓				
2A2. Lime production	✓				
2A3. Glass production	NO				
2A4a. Other process Uses of Carbonates - Ceramics	✓				
2A4b. Other uses of soda ash	✓				
2B. Chemical industry	NO				
2C. Metal Industry	NO				
2D1. Non-energy Products from Fuels and Solvent Use – Lubricant Use	✓				
2D2. Paraffin wax Use	✓				
2D3. Lubricant Use	✓				
2E. Electronics Industry			NO	NO	NO
2F1. Refrigeration & air conditioning			✓	NO	NO
2F2. Foam blowing agents			✓	NO	NO
2F3. Fire protection			✓	NO	NO
2F4a. Metered dose inhalers			✓	NO	NO
2F5. Solvents			NO	NO	NO
2G1. Electrical equipment			NO	NO	✓
2G3. N2O from product uses		✓	NO	NO	NO
2G4. Other	✓				

NO: Not occurring

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	CO2	CS	CS
2A2	Industrial Processes and Product Use – Mineral Industry - Lime Production	CO2	D	T1
2A4a	Industrial Processes and Product Use – Mineral Industry - Other process uses of carbonates - Ceramics	CO2	CS	CS
2A4b	Industrial Processes and Product Use – Mineral Industry - Other process uses of carbonates - Other uses of soda-ash	CO2	D	T1
2A4b	Industrial Processes and Product Use – Mineral Industry - Other process uses of carbonates - Other uses of soda-ash	CH4/N2O	NA	NA
2D1	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use- Lubricant Use	CO2	D	T1
2D1	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use- Lubricant Use	CH4/N2O	NA	NA
2D2	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use - Paraffin Wax Use	CO2	D	T1
2D2	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use - Paraffin Wax Use	CH4/N2O	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)	CO2	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)	CH4/N2O	NA	NA
2D3	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use – Other - Urea-based catalysts	CO2	D	D
2D3	Industrial Processes and Product Use – Non Energy Products from Fuels and Solvent Use – Other - Urea-based catalysts	CH4/N2O	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

Category-Classification		Gas	EF	Method
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 - N2O from product uses – Medical Applications	N2O	CS	CS
2G3b	Other Product Manufacture and Use - N2O from product uses – Other –Propellant for pressure and aerosol products	N2O	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 (CO₂) 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 CO₂ from carbonates: calcination and the acid-induced release of CO₂. The primary process resulting in the release of CO₂ 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 2017 increased by 30% compared to 1990. The largest emitter continues to be cement production with 98.3% 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 1990-2017 (Gg CO₂)

Gg CO ₂	1990	2000	2005	2010	2015	2016	2017
A. Mineral industry	717.07	802.75	894.10	589.98	888.12	896.42	934.98
1. Cement production	667.66	762.71	821.81	555.05	877.13	883.25	918.95
2. Lime production	5.33	5.41	12.06	7.20	2.36	2.38	3.18
3. Glass production	NO						
4. Other process uses of carbonates	44.08	34.63	60.23	27.74	8.64	10.78	12.86
CO ₂ (Gg)	717.07	802.75	894.10	589.98	888.12	896.42	934.98
Total (Gg CO ₂)	717.07	802.75	894.10	589.98	888.12	896.42	934.98

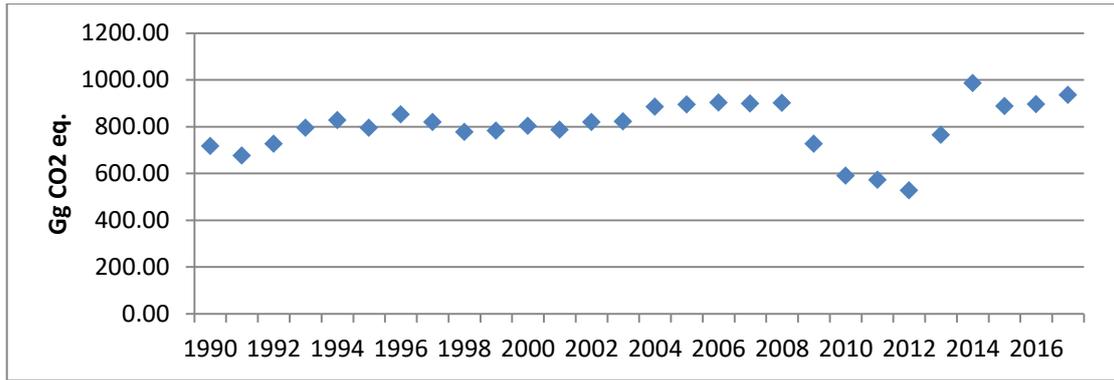


Figure 4.2. GHG emissions from Mineral products (2A) for the period 1990 – 2017

4.2.1. Cement production (2.A.1)

In cement manufacture, CO₂ 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 (CaSO₄·2H₂O) or anhydrite (CaSO₄)], into hydraulic (typically portland) cement. During the production of clinker, limestone, which is mainly calcium carbonate (CaCO₃), is heated, or calcined, to produce lime (CaO) and CO₂ as a by-product. The CaO then reacts with silica (SiO₂), alumina (Al₂O₃), and iron oxide (Fe₂O₃) in the raw materials to make the clinker minerals (chiefly calcium silicates). The proportion in the raw materials of carbonates other than CaCO₃ 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 3 and Figure 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. CO₂ emissions for Cement production (2.A.1) 1990-2017

	1990	2000	2005	2010	2015	2016	2017
Gg CO ₂	668	763	822	555	877	883	919

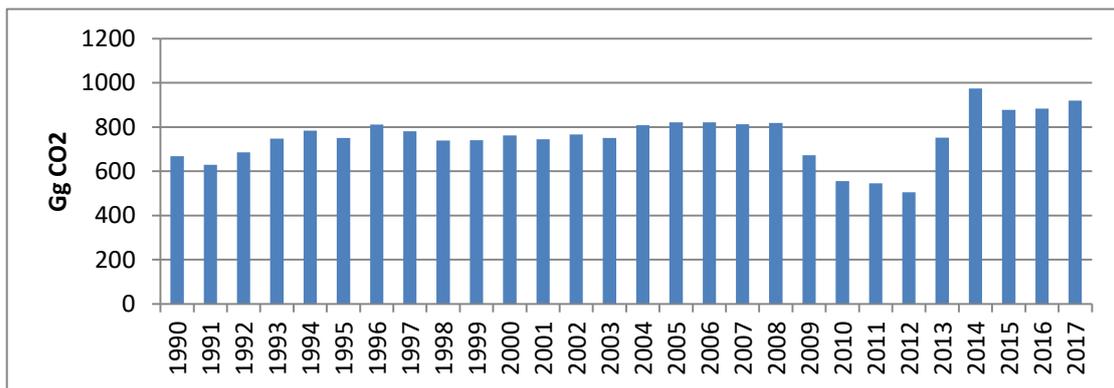


Figure 4.3. CO₂ emissions for Cement production (2.A.1) 1990-2017

In Cyprus, there is one cement producing installation, which provides information regarding CO₂ 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 year³³. 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)³⁴. 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. According to the information provided by the installation, this reduction has been caused by two reasons: (a) there was a reduction in demand for exports; (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 CO₂ emissions is annually submitted from 2005 in accordance to the EU-ETS legislation. Emissions are estimated using tier 3 methodologies. The CO₂ emissions are reported through templates provided by the European Commission for annual emission reports that are based on the Monitoring and Reporting Regulation³⁵. 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 the data submitted by the installations for the preparation of the National Allocation Plan 2005-2007 was used that is also verified by an external verifier, and approved by the European Commission based on the relevant EU legislation.

For 1990-1996, the emission factor of 0.5347 tCO₂/t clinker was used, which is the implied emission factor estimated from the CO₂ 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 and CO₂ process emissions from cement production (kt)

	1990	1991	1992	1993	1994	1995	1996	1997
Clinker production (Gg)								
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
CO₂ process emissions (Gg)								
Installation 1								190
Installation 2								590
Total								780
	1998	1999	2000	2001	2002	2003	2004	2005
Clinker production (kt)								
Installation 1	337	334	362	361	373	363	367	330
Installation 2	1045	1047	1065	1033	1059	1043	1142	1143
Total	1382	1382	1428	1394	1432	1405	1509	1473
CO₂ process emissions (Gg)								
Installation 1	180	180	193	193	200	194	197	195

³³ 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>

³⁴ More information available at https://ec.europa.eu/clima/policies/ets/pre2013/nap_en

³⁵ 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=CELEX:32012R0601>

Installation 2	560	560	569	552	566	557	610	626
Total	740	740	763	745	766	751	808	822
	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
CO2 process emissions (Gg)								
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	1717
Total	1043	1037	953	1418	1822	1641	1648	1717
CO2 process emissions (Gg)								
Installation 1	140	41	0	0	0	0	0	0
Installation 2	415	505	505	752	974	877	883	919
Total	555	546	505	752	974	877	883	919

All the 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 CO₂. Dolomite and dolomitic (high magnesium) limestones may also be processed at high temperature to obtain dolomitic lime (and release CO₂). 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. CO₂ emissions for Lime production (2.A.2) 1990-2017

	1990	2000	2005	2010	2015	2016	2017
Gg CO ₂	5.33	5.41	12.06	7.19	2.36	2.38	3.18

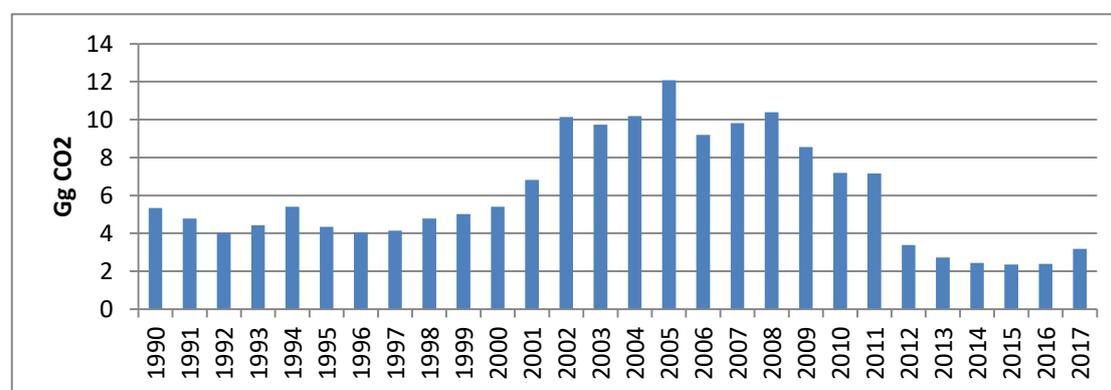


Figure 4.4. CO₂ emissions for Lime production (2.A.2) 1990-2017

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 CO₂/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		
Production (t)	9890	9829	4659	3746	3366	3244	3277	4369		

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 – 2014' (page 159) available on the website of the Statistical Service of Cyprus, in Cyprus presents the manufacture of flat glass, fibre glass and glass articles. 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 ($\text{CaMg}(\text{CO}_3)_2$) 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.

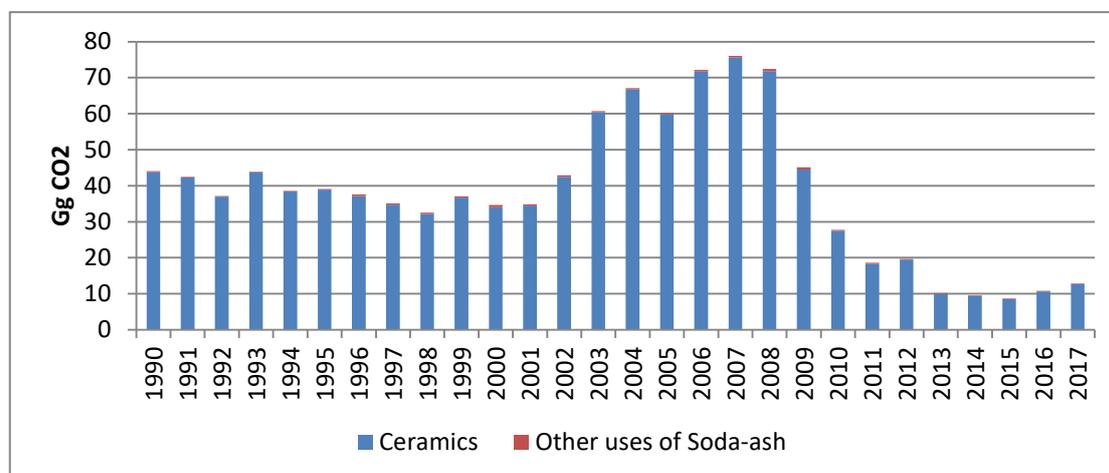
Soda ash production and consumption (including sodium carbonate, Na_2CO_3) results in the release of CO_2 . According to information received by the customs office³⁶ soda ash in Cyprus is imported by a betonite quarry, lab supplies companies, swimming pools companies, building materials companies, and 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. It is currently not clear whether they will recommence operation or go for closure.

³⁶ email 28/9/2016, Solonas Papapolyviou

Table 4.9. CO2 emissions for Other Process Uses of Carbonates (2.A.4) 1990-2017

Gg CO2	1990	2000	2005	2010	2015	2016	2017
Ceramics	43.8	34.1	60.0	27.4	8.5	10.6	12.7
Soda-ash	0.26	0.56	0.28	0.30	0.13	0.19	0.19
TOTAL	44.08	34.63	60.23	27.74	8.64	10.78	12.86

**Figure 4.5. CO2 emissions for Other Process Uses of Carbonates (2.A.4) 1990-2017**

4.2.4.1. Ceramics

4.2.4.1.1. Methodological issues

In Cyprus, there are nine ceramics producing installations, of which eight provide information regarding CO2 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 year³⁷. 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)³⁸. 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 8 installations in operation, 7 in 2016 and 6 in 2017.

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

Information regarding CO2 emissions is annually submitted from 2005 in accordance to the EU-ETS legislation. Emissions are estimated using tier 3 methodologies. The CO2 emissions are reported through templates provided by the European Commission for annual emission reports that are based on the Monitoring and Reporting Regulation³⁹. The emissions for 2005-2016 are used as submitted by the installations for the EU-ETS (Table 4.10) that 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 2005-2007 was used that is also verified by an external verifier, and approved by the European Commission based on the relevant EU legislation.

³⁷ 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>

³⁸ More information available at https://ec.europa.eu/clima/policies/ets/pre2013/nap_en

³⁹ 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=CELEX:32012R0601>

For the period 2001-2012, the emissions of the non-ETS installation were estimated using the emission factor of 0.160 tCO₂/t ceramics was used, which is the implied emission factor estimated from the CO₂ process emissions reported by the eight ceramics producing installations for 2003 (highest available). The highest emission factor was chosen, since being 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 operation therefore there are no additional emissions to those reported under the ETS.

For 1990-2000, the emission factor of 0.123 tCO₂/t ceramics was used, which is the implied emission factor estimated from the CO₂ 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 (Gg)

	1990	1991	1992	1993	1994	1995	1996
Total production (Gg)	355.4	343.0	299.7	354.2	311.2	315.3	301.2
ETS production (Gg)							
Non-ETS production (Gg)							
	1997	1998	1999	2000	2001	2002	2003
Total production (Gg)	281.7	261.3	297.9	276.3	277.8	332.4	377.9
ETS production (Gg)					271.4	314.5	364.2
Non-ETS production (Gg)					6.3	17.9	13.7
	2004	2005	2006	2007	2008	2009	2010
Total production (Gg)	483.9	504.0	491.4	512.4	545.9	356.2	291.5
ETS production (Gg)	470.4	493.2	483.6	500.4	532.9	338.4	282.1
Non-ETS production (Gg)	13.6	10.8	7.8	12.0	13.0	17.8	9.3
	2011	2012	2013	2014	2015	2016	2017
Total production (Gg)	223.0	168.0	90.0	83.7	84.5	111.6	152.6
ETS production (Gg)	211.4	161.7	90.0	83.7	84.5	111.6	152.6
Non-ETS production (Gg)	11.5	6.3	0	0	0	0	0

Table 4.11. CO₂ process emissions of the ETS ceramics installations and estimated annual implied emission factor (2001-2016)

	2001	2002	2003	2004	2005	2006	2007
ETS CO ₂ emissions (Gg)	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)	69.7	41.6	25.9	16.5	18.5	10.0	9.4
IEF (Gg CO ₂ /Gg product)	0.131	0.123	0.092	0.078	0.114	0.111	0.112
	2015	2016	2017				
ETS CO ₂ emissions (Gg)	8.5	10.6	12.7				
IEF (Gg CO ₂ /Gg product)	0.101	0.095	0.083				

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 CO₂ 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. CO₂ Emissions = Mc x EF (where CO₂ Emissions = emissions of CO₂ from other process uses of carbonates, tonnes; Mc = mass of carbonate consumed, tonnes; EF = emission factor for soda ash, tonnes CO₂/tonne carbonate (table 2.1, pg. 2.7, vol.3, 2006 IPCC guidelines) 0.41492 tCO₂/t CO₃ assuming 100% calcination).

Activity data (Table 4.12) was obtained from Statistical Service from imports' statistics. 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) and 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. Since 2010 there was a large decline in the building industry, 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		
Imports of Soda ash (t)	711	771	560	353	401	322	447	449		

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 office⁴⁰ 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 Customs⁴¹, paraffin wax is imported by dental and lab suppliers, importers of agricultural and beauty products and candle makers. The total CO₂ emissions from non-energy products from fuels and solvent use are presented in Table 4.13 and Figure 4.6.

Table 4.13. CO₂ emissions from non-energy Products from Fuels and Solvent Use

Gg CO ₂	1990	2000	2005	2010	2015	2016	2017
D. Non-energy products from fuels and solvent use	18.82	25.61	37.94	38.73	22.90	23.36	23.97
1. Lubricant use	1.12	4.13	5.90	6.49	4.72	4.72	4.61
2. Paraffin wax use	0.06	0.07	0.00	0.03	0.08	0.19	0.06
3. Other	17.63	21.41	32.04	32.21	18.11	18.45	19.30
Dry cleaning	0.44	0.44	0.42	0.13	0.12	0.06	0.12
Coating applications	3.83	3.52	8.39	7.70	3.62	3.83	4.47
Chemical products	0.09	0.11	0.13	0.07	0.02	0.02	0.02
Asphalt roofing	0.07	0.08	0.06	0.12	0.02	0.02	0.02
Domestic solvent use	1.55	1.84	1.96	2.22	2.24	2.26	2.28
Road paving with asphalt	0.02	0.02	0.01	0.03	0.00	0.00	0.00
Printing	0.44	0.74	0.76	0.54	0.56	0.58	0.58
Other	10.21	12.99	18.64	19.84	10.38	10.38	10.38
Urea-based catalysts	1.00	1.67	1.65	1.56	1.15	1.30	1.42

⁴⁰ email 28/9/2016, Solonas Papapolyviou, Department of Customs and Excise, Ministry of Finance (tel. +357 22 601756, spapapolyviou@customs.mof.gov.cy)

⁴¹ email 28/9/2016, Solonas Papapolyviou, Department of Customs and Excise, Ministry of Finance (tel. +357 22 601756, spapapolyviou@customs.mof.gov.cy)

CO2	18.82	25.61	37.94	38.73	22.90	23.36	23.97
Total	18.82	25.61	37.94	38.73	22.90	23.36	23.97

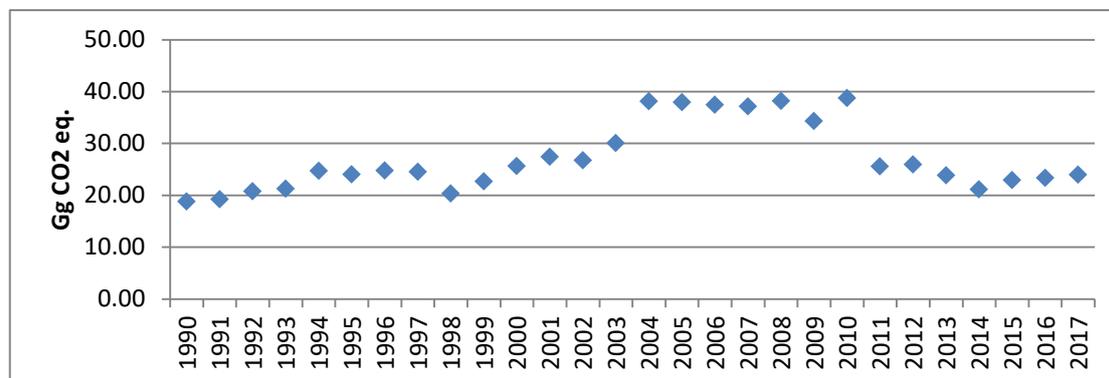


Figure 4.6. Emissions from non-energy Products from Fuels and Solvent Use (2D) 1990-2017

4.4.2. Methodological issues

The methods for calculating carbon dioxide (CO₂) emissions from non-energy product uses 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 applied to oxidation during first use only of lubricants and paraffin waxes and not to subsequent uses (e.g., energy recovery).

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)

Lubricant consumption is obtained in kt from Energy balance by the National Statistical Service (Table 4.14). Consumption data was not available from the energy balance for the years 1990-1992. The activity data for the years after 1993 shows a trend only for the period 1993-1996 (Figure 4.7). The 1993-1996 trend was used to extrapolate backwards to obtain activity data for 1990-1992.

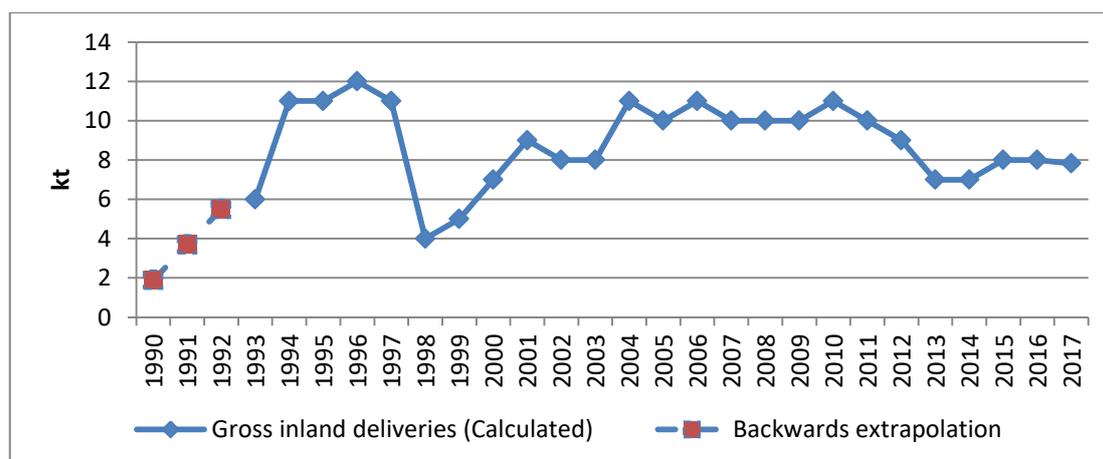


Figure 4.7. Lubricant consumption 1990-2017 (kt)

The calculation of CO₂ emissions from Lubricants was estimated using Tier1 methodology suggested by the IPCC Guidelines (equation 5.2, pg. 5.7, volume 3).

Lubricant consumption is converted to TJ using 40.2 TJ/kt, i.e. the default proposed by the 2006 guidelines, (Table 1.2, pg.1.18, vol.2). Carbon content (*CCLubricant*) is assumed to be 20 while ODU factor is assumed to be 0.2, as proposed by the IPCC 2006 guidelines (table 1.3, pg.1.21, volume 2; table 5.2, pg. 5.9, volume 3 respectively).

Table 4.14. Lubricant consumption in Cyprus (kt)

	1990	1991	1992	1993	1994	1995	1996
Lubricant consumption (kt)	2	4	6	6	11	11	12
	1997	1998	1999	2000	2001	2002	2003
Lubricant consumption (kt)	11	4	5	7	9	8	8
	2004	2005	2006	2007	2008	2009	2010
Lubricant consumption (kt)	11	10	11	10	10	10	11
	2011	2012	2013	2014	2015	2016	2017
Lubricant consumption (kt)	10	9	7	7	8	8	7.829

4.4.2.2. Paraffin Wax Use (2D2)

CO₂ emissions from use of paraffin wax have been estimated using the T1 methodology proposed by the 2006 IPCC guidelines (eqn. 5.4, pg. 5.11, vol.3, IPCC 2006 guidelines):

CO₂ Emissions = PW • CCWax • ODUWax • 44 /12 where CO₂ Emissions = CO₂ emissions from waxes, tonne CO₂; 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 from Statistical Service from imports' statistics in kg. 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 40.2, 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

4.4.2.3. Other (2D3)

Solvent Use

Carbon dioxide emissions from other product use are calculated from NMVOC emissions (Table 4.16), assuming that the carbon content of NMVOC is 60%⁴². NMVOC emissions are obtained from the Department of Labour Inspection that 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. An additional source has been considered for the first time in this submission, "other",

⁴²2006 IPCC Guidelines volume 3, p. 5.17, the default fossil carbon content fraction of NMVOC is 60 per cent by mass

which includes the consumption of glues. Therefore assuming also that oxidation of carbon is 99% the equation applied for the estimation of the CO₂ emissions is the following:

$$CO_2 \text{ emissions (Gg)} = 60\% * NMVOC \text{ emissions (Gg)} * 44/12 * 99\%$$

Table 4.16. NMVOCs emissions used for the estimation of CO₂ emissions from Solvent use

	1990	1991	1992	1993	1994	1995	1996
Dry cleaning	0.2002	0.2003	0.2003	0.2004	0.2005	0.2006	0.2007
Coating applications	1.7387	1.4241	1.5170	1.5202	1.7083	1.4102	1.4097
Chemical products	0.0388	0.0388	0.0388	0.0413	0.0442	0.0471	0.0498
Asphalt roofing	0.0325	0.0325	0.0325	0.0325	0.0325	0.0325	0.0325
Domestic solvent use	0.7045	0.7237	0.7430	0.7595	0.7745	0.7876	0.7996
Road paving with asphalt	0.0075	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	0.2000
Other	4.6390	4.6390	4.6390	4.6390	4.6390	4.6390	4.6390

	1997	1998	1999	2000	2001	2002	2003
Dry cleaning	0.2008	0.2009	0.2012	0.2021	0.2005	0.2004	0.2001
Coating applications	1.5604	1.4476	1.4578	1.6020	1.4785	2.2579	2.8364
Chemical products	0.0474	0.0490	0.0512	0.0500	0.0597	0.0636	0.0625
Asphalt roofing	0.0325	0.0325	0.0325	0.0366	0.0298	0.0324	0.0308
Domestic solvent use	0.8102	0.8195	0.8286	0.8370	0.8466	0.8564	0.8675
Road paving with asphalt	0.0075	0.0075	0.0075	0.0084	0.0069	0.0075	0.0071
Printing	0.2000	0.2000	0.3273	0.3355	0.3801	0.3075	0.2884
Other	4.6390	4.6390	5.2717	5.9043	6.2175	5.5045	6.4112

	2004	2005	2006	2007	2008	2009	2010
Dry cleaning	0.1998	0.1930	0.1100	0.1110	0.0789	0.0602	0.0605
Coating applications	3.5522	3.8150	4.0272	4.3205	3.3507	3.1421	3.4997
Chemical products	0.0674	0.0574	0.0600	0.0580	0.0254	0.0278	0.0302
Asphalt roofing	0.0368	0.0293	0.0265	0.0246	0.0233	0.0396	0.0529
Domestic solvent use	0.8796	0.8928	0.9095	0.9317	0.9563	0.9829	1.0078
Road paving with asphalt	0.0085	0.0068	0.0061	0.0057	0.0054	0.0091	0.0122
Printing	0.3399	0.3446	0.3628	0.3195	0.4469	0.3260	0.2464
Other	8.4924	8.4747	7.8613	7.6870	9.0567	7.5951	9.0202

	2011	2012	2013	2014	2015	2016	2017
Dry cleaning	0.0600	0.0539	0.0265	0.0262	0.0527	0.0261	0.0526
Coating applications	1.5792	1.6311	1.4271	1.2511	1.6473	1.7419	2.0322
Chemical products	0.0137	0.0145	0.0120	0.0099	0.0111	0.0111	0.0111
Asphalt roofing	0.0516	0.0403	0.0213	0.0098	0.0086	0.0086	0.0086
Domestic solvent use	1.0344	1.0391	1.0296	1.0164	1.0180	1.0258	1.0370
Road paving with asphalt	0.0119	0.0093	0.0049	0.0023	0.0020	0.0020	0.0020
Printing	0.3347	0.2658	0.2072	0.2618	0.2526	0.2651	0.2655
Other	5.1600	5.7159	5.7185	4.6354	4.7163	4.7163	4.7163

Urea-based catalysts

The methodology applied is the recommended by the 2006 IPCC guidelines (pg. 3.12, volume 2). More specifically equation 3.2.2 (emission=activity*12/60*purity*44/12) is applied. No national data is available, therefore (a) Activity data is estimated using the recommendation given in the guidelines, i.e. 1-3% of diesel consumption by vehicle; 2% is used.(b) Purity is assumed 32.5%, which is also recommended by the guidelines, i.e. 1-3% of diesel consumption by vehicle; 2% is used. The diesel consumption used is the same as presented in Table 3.17. The resulting activity data used is presented in Table 4.17.

Table 4.17. Activity data used for estimation of emissions from Urea-based catalysts

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
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Activity (kt)	4.19	4.03	4.90	5.08	5.20	5.68	5.94	6.26	6.66	6.78
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Activity (kt)	6.99	7.09	6.81	7.01	7.07	6.91	6.45	6.73	6.58	6.39
	2010	2011	2012	2013	2014	2015	2016	2017		
Activity (kt)	6.56	6.24	5.43	4.61	4.47	4.81	5.46	5.97		

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

CO₂ emissions have been recalculated due to revision of NMVOCs emissions used for the estimation of CO₂ emissions from Solvent use and the inclusion of the new source “other” for the first time. The impact of recalculations on emissions is shown in Table 4.18 and Figure 4.8.

Table 4.18. CO₂ emissions from Solvent use recalculations

	1990	1991	1992	1993	1994	1995	1996
NIR2018 emissions (Gg CO ₂)	11.25	10.60	10.85	10.90	11.35	10.73	10.76
NIR2019 emissions (Gg CO ₂)	16.63	15.98	16.23	16.28	16.73	16.11	16.15
change	47.8%	50.8%	49.7%	49.4%	47.4%	50.2%	50.1%
	1997	1998	1999	2000	2001	2002	2003
NIR2018 emissions (Gg CO ₂)	11.11	10.89	11.87	12.88	13.05	13.93	16.12
NIR2019 emissions (Gg CO ₂)	16.50	16.27	17.99	19.75	20.28	20.31	23.55
change	48.4%	49.5%	51.6%	53.3%	55.4%	45.8%	46.1%
	2004	2005	2006	2007	2008	2009	2010
NIR2018 emissions (Gg CO ₂)	20.01	20.56	20.29	20.71	17.63	15.88	17.66
NIR2019 emissions (Gg CO ₂)	29.87	30.39	29.40	29.61	30.68	26.80	30.65
change	49.3%	47.8%	44.9%	43.0%	74.0%	68.8%	73.6%
	2011	2012	2013	2014	2015	2016	
NIR2018 emissions (Gg CO ₂)	8.70	8.83	8.10	7.38	8.24	8.43	
NIR2019 emissions (Gg CO ₂)	18.14	19.29	18.58	15.87	16.96	17.15	
change	108.6%	118.6%	129.3%	115.0%	105.9%	103.4%	

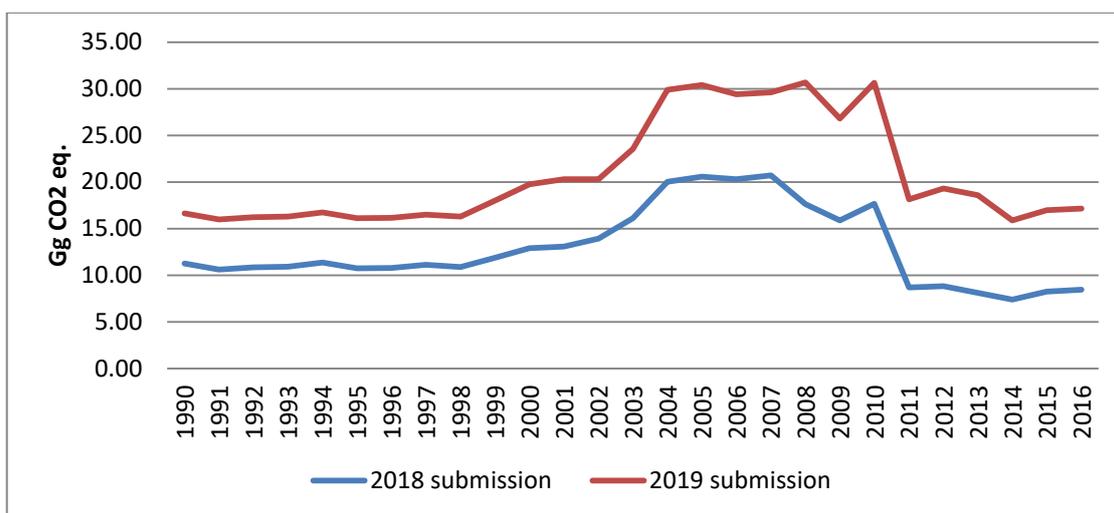


Figure 4.8. CO2 emissions from Solvent use recalculations

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 (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 1990-2017 are presented in Table 4.19 and Figure 4.9.

Table 4.19. Emissions from consumption of halocarbons 1990-2017

	1990	2000	2005	2010	2015	2016	2017
F. Product uses as substitutes for ODS	63.88	120.21	194.12	245.65	250.45	245.28	249.56
1. Refrigeration and air conditioning	63.88	116.20	188.69	236.59	241.47	236.23	240.51

2. Foam blowing agents	NE,NO	0.09	0.54	1.03	1.27	1.28	1.28
3. Fire protection	NE,NO	0.30	1.24	2.93	4.24	4.27	4.27
4. Aerosols	NO	3.63	3.65	5.10	3.47	3.50	3.50
5. Solvents	NO	NO	NO	NO	NO	NO	NO
6. Other applications	NO	NO	NO	NO	NO	NO	NO
HFC-32	10.31	18.51	23.27	29.65	30.67	29.83	31.01
HFC-125	11.73	21.18	26.32	33.11	34.46	33.75	35.12
HFC-134a	6.58	14.71	49.73	63.71	60.76	58.75	57.24
HFC-143a	1.44	2.73	3.07	3.41	3.79	3.95	4.15
HFC-227ea	NO	0.09	0.39	0.91	1.32	1.33	1.33
Unspecified mix of HFCs	NO	0.03	0.19	0.47	1.06	1.06	1.06
Total	63.88	120.21	194.12	245.65	250.45	245.28	249.56

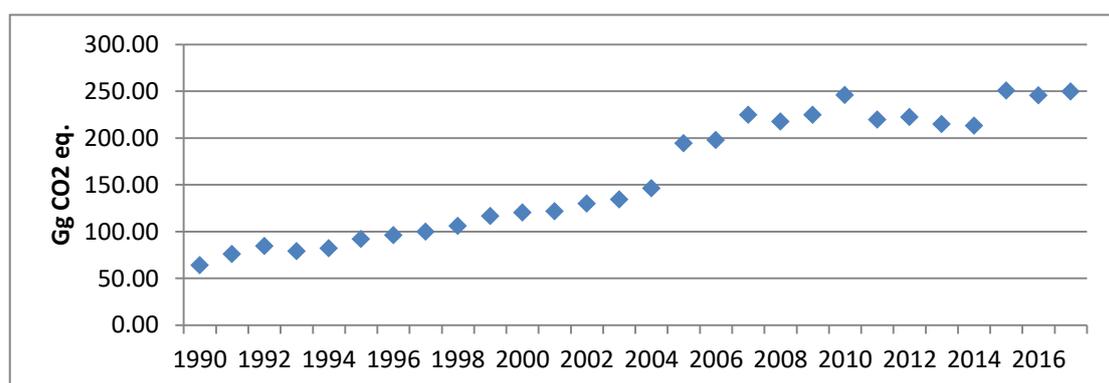


Figure 4.9. Emissions from consumption of halocarbons 1990-2017

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:

- 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;
- Defines the typical refrigerant charge and the equipment lifetime per sub-application;
- 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:

- Domestic refrigeration,
- Commercial refrigeration including different types of equipment, from vending machines to centralised refrigeration systems in supermarkets,
- Industrial refrigeration including food processing and cold storage,
- Transport refrigeration including equipment and systems used in refrigerated trucks, containers, reefers, and wagons,
- 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:

$E_{end-of-life,t}$ = 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
Number of MACs sold each year	Department of Road Transport, Cyprus
Container Heels (c) <ul style="list-style-type: none"> Heels from service containers are recovered, therefore $E_{\text{containers},t} = 0$ 	IPCC guidelines
Nominal charge of each MAC (m_t) <ul style="list-style-type: none"> Average value of $m=0.7$ kg, which is typical of small to medium-sized passenger cars 	IPCC guidelines
Assembly Losses (k) <ul style="list-style-type: none"> MAC systems are imported pre-charged, therefore $E_{\text{charge}, t} = 0$ 	IPCC guidelines
Lifetime (d) <ul style="list-style-type: none"> $d = 12$ years 	IPCC guidelines
Annual Emission Rate (x) <ul style="list-style-type: none"> This factor accounts for both leaks from equipment as well as any emissions during service <ul style="list-style-type: none"> Annual Emissions Rate from leaks = 10% Annual Emission Rate during servicing = 2% $x = 12\%$ 	IPCC guidelines
Residual Charge in MACs Disposed (p) <ul style="list-style-type: none"> $p = 25\%$ 	IPCC guidelines
Recovery Efficiency (n_{rec}) [%] <ul style="list-style-type: none"> $n_{\text{rec}} = 25\%$ 	IPCC guidelines
Other assumptions	
<ul style="list-style-type: none"> All vehicles have air condition systems Refrigerant used for MACs: R134a (100%) MACs are serviced every 5 years 	

Domestic Refrigeration

Activity Data / Emission Factors	Source
Number of households	Statistical Service of Cyprus
Number of refrigerators per households <ul style="list-style-type: none"> 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 <ul style="list-style-type: none"> 0.30 freezers per household 	Demetriou, D., Polatides, H., Haralambopoulos, D, (2010)
Container Heels (c) <ul style="list-style-type: none"> Generally refrigerators and freezers are not serviced during their lifetime, therefore $E_{\text{containers},t} = 0$ 	IPCC guidelines
Nominal charge of each refrigerator and freezer (m_t) <ul style="list-style-type: none"> $m=0.3$ kg 	IPCC guidelines

Assembly Losses (k) • Refrigerators and freezers are imported pre-charged, therefore $E_{\text{charge}, t} = 0$	IPCC guidelines
Lifetime (d) • $d = 15$ years	IPCC guidelines
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}) [%] • $n_{\text{rec}} = 35\%$	IPCC guidelines
Other assumptions	
• Refrigerants used for domestic refrigerators and freezers: R134a (30%), R404A (40%)	

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 $E_{\text{containers}, t} = 0$	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 $E_{\text{charge}, t} = 0$	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}) [%] • $n_{\text{rec}} = 25\%$	IPCC guidelines
Other assumptions	
• Refrigerants used for TRs: R134a (30%), R404A (70%)	
• TRs are serviced each year	

Industrial Refrigeration (IR)

Activity Data / Emission Factors	Source
Bank in Existing Equipment (B_t) for the year 2017 • 9016.15 kg	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 $E_{\text{containers}, t} = 0$	IPCC guidelines
Nominal charge of each IR (m_t)	IPCC guidelines

<ul style="list-style-type: none"> m=100 kg 	
Assembly Losses (k) <ul style="list-style-type: none"> IR systems are imported pre-charged, therefore $E_{\text{charge},t} = 0$ 	IPCC guidelines
Lifetime (d) <ul style="list-style-type: none"> d = 20 years 	IPCC guidelines
Annual Emission Rate (x) <ul style="list-style-type: none"> This factor accounts for both leaks from equipment as well as any emissions during service <ul style="list-style-type: none"> Annual Emissions Rate from leaks = 10% Annual Emission Rate during servicing =5% x = 15% 	IPCC guidelines
Residual Charge in IRs Disposed (p) <ul style="list-style-type: none"> p = 75% 	IPCC guidelines
Recovery Efficiency (n_{rec}) [%] <ul style="list-style-type: none"> $n_{\text{rec}} = 35\%$ 	IPCC guidelines
Other assumptions	
<ul style="list-style-type: none"> Refrigerants used for IRs: R404A (83%), R22 (5%) [Industrial and Commercial RAC Inventory 2017, Cyprus] IRs are serviced each year 	

Commercial Refrigeration (CR)

Activity Data / Emission Factors	Source
Bank in Existing Equipment (B_t) for the year 2017 <ul style="list-style-type: none"> 37861.74 kg for Stand-alone Commercial Applications (R404A) 9645.43 kg for Medium & Large Commercial Refrigeration (R404A) 2851.16 kg for Stand-alone Commercial Applications (R134A) 712.79 kg for Medium & Large Commercial Refrigeration (R134A) 	Industrial and Commercial RAC Inventory 2017, Cyprus
Bank in Existing Equipment (B_t) for previous years <ul style="list-style-type: none"> 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) <ul style="list-style-type: none"> Heels from service containers are recovered, therefore $E_{\text{containers},t} = 0$ 	IPCC guidelines
Nominal charge of each CR (m_t) <ul style="list-style-type: none"> m=5 kg for Stand-alone Commercial Applications m= 100 kg for Medium & Large Commercial Refrigeration 	IPCC guidelines
Assembly Losses (k) <ul style="list-style-type: none"> CR systems are imported pre-charged, therefore $E_{\text{charge},t} = 0$ 	IPCC guidelines
Lifetime (d) <ul style="list-style-type: none"> d = 12 years 	IPCC guidelines
Annual Emission Rate (x) <ul style="list-style-type: none"> This factor accounts for both leaks from equipment as well as any emissions during service Stand-alone Commercial Applications <ul style="list-style-type: none"> Annual Emissions Rate from leaks = 8% Annual Emission Rate during servicing =2% x = 10% Medium & Large Commercial Refrigeration <ul style="list-style-type: none"> Annual Emissions Rate from leaks = 15% Annual Emission Rate during servicing =5% 	IPCC guidelines

○ $x = 20\%$	
Residual Charge in CRs Disposed (p) <ul style="list-style-type: none"> • $p = 40\%$ for Stand-alone Commercial Applications • $p = 75\%$ for Medium & Large Commercial Refrigeration 	IPCC guidelines
Recovery Efficiency (n_{rec}) [%] <ul style="list-style-type: none"> • $n_{rec} = 35\%$ for Stand-alone Commercial Applications • $n_{rec} = 35\%$ for Medium & Large Commercial Refrigeration 	IPCC guidelines
Other assumptions	
<ul style="list-style-type: none"> • Refrigerants used for IRs: R404A (79%), R134A (6%), R22 (4%) [Industrial and Commercial RAC Inventory 2017, Cyprus] • 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 <ul style="list-style-type: none"> • 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 <ul style="list-style-type: none"> • 2.65 A/C units per household 	Demetriou, D., Polatides, H., Haralambopoulos, D. (2010).
Container Heels (c) <ul style="list-style-type: none"> • Heels from service containers are recovered, therefore $E_{containers,t} = 0$ 	IPCC guidelines
Nominal charge of each Residential A/C unit (m_t) <ul style="list-style-type: none"> • $m=3$ kg 	IPCC guidelines
Assembly Losses (k) <ul style="list-style-type: none"> • A/C units are imported pre-charged, therefore $E_{charge,t} = 0$ 	IPCC guidelines
Lifetime (d) <ul style="list-style-type: none"> • $d = 15$ years 	IPCC guidelines
<ul style="list-style-type: none"> • This factor accounts for both leaks from equipment as well as any emissions during service <ul style="list-style-type: none"> ○ Annual Emissions Rate from leaks = 5% ○ Annual Emission Rate during servicing =2% • $x = 7\%$ 	IPCC guidelines
Residual Charge in Residential A/C units Disposed (p) <ul style="list-style-type: none"> • $p = 40\%$ 	IPCC guidelines
Recovery Efficiency (n_{rec}) [%] <ul style="list-style-type: none"> • $n_{rec} = 40\%$ 	IPCC guidelines
Other assumptions	
<ul style="list-style-type: none"> • Refrigerants used for Residential A/C units: R410A (45%), R407C (30%), R22 (25%) [Based on results from Industrial and Commercial RAC Inventory 2017, Cyprus] • 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 2017	Industrial and Commercial RAC

<ul style="list-style-type: none"> • 29762.85 kg (R410A) • 21922.65 kg (R407C) 	Inventory 2017, Cyprus
<p>Bank in Existing Equipment (B_t) for previous years</p> <ul style="list-style-type: none"> • 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
<p>Container Heels (c)</p> <ul style="list-style-type: none"> • Heels from service containers are recovered, therefore $E_{\text{containers},t} = 0$ 	IPCC guidelines
<p>Nominal charge of each Commercial A/C unit (m_t)</p> <ul style="list-style-type: none"> • $m=3$ kg 	IPCC guidelines
<p>Assembly Losses (k)</p> <ul style="list-style-type: none"> • A/C units are imported pre-charged, therefore $E_{\text{charge},t} = 0$ 	IPCC guidelines
<p>Lifetime (d)</p> <ul style="list-style-type: none"> • $d = 15$ years 	IPCC guidelines
<ul style="list-style-type: none"> • This factor accounts for both leaks from equipment as well as any emissions during service <ul style="list-style-type: none"> ○ Annual Emissions Rate from leaks = 5% ○ Annual Emission Rate during servicing =2% • $x = 7\%$ 	IPCC guidelines
<p>Residual Charge in Commercial A/C units Disposed (p)</p> <ul style="list-style-type: none"> • $p = 40\%$ 	IPCC guidelines
<p>Recovery Efficiency (n_{rec}) [%]</p> <ul style="list-style-type: none"> • $n_{\text{rec}} = 40\%$ 	IPCC guidelines
Other assumptions	
<ul style="list-style-type: none"> • Refrigerants used for Commercial A/C units: R410A (45%), R407C (30%), R22 (25%) [Industrial and Commercial RAC Inventory 2017, Cyprus] • Commercial A/C units are serviced every 5 years 	
Chillers	
Activity Data / Emission Factors	Source
<p>Bank in Existing Equipment (B_t) for the year 2017</p> <ul style="list-style-type: none"> • 78313.28 kg (R410A) • 28130.62 kg (R407C) • 29062.62 kg (R134A) 	Industrial and Commercial RAC Inventory 2017, Cyprus
<p>Bank in Existing Equipment (B_t) for previous years</p> <ul style="list-style-type: none"> • 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
<p>Container Heels (c)</p> <ul style="list-style-type: none"> • Heels from service containers are recovered, therefore $E_{\text{containers},t} = 0$ 	IPCC guidelines
<p>Nominal charge of each chiller system (m_t)</p> <ul style="list-style-type: none"> • $m=50$ kg 	IPCC guidelines
<p>Assembly Losses (k)</p> <ul style="list-style-type: none"> • Chiller systems are imported pre-charged, therefore $E_{\text{charge},t} = 0$ 	IPCC guidelines
<p>Lifetime (d)</p> <ul style="list-style-type: none"> • $d = 20$ years 	IPCC guidelines
<ul style="list-style-type: none"> • This factor accounts for both leaks from equipment as well as any emissions during service <ul style="list-style-type: none"> ○ Annual Emissions Rate from leaks = 5% ○ Annual Emission Rate during servicing =5% • $x = 10\%$ 	IPCC guidelines
<p>Residual Charge in Chiller systems Disposed (p)</p>	IPCC guidelines

<ul style="list-style-type: none"> • $p = 90\%$ 	
Recovery Efficiency (n_{rec}) [%] <ul style="list-style-type: none"> • $n_{rec} = 50\%$ 	IPCC guidelines
Other assumptions	
<ul style="list-style-type: none"> • Refrigerants used for Chiller systems: R410A (47.5%), R407C (17%), R22 (25%) [Industrial and Commercial RAC Inventory 2017, Cyprus] • Chiller systems are serviced every year 	

The main deficiencies identified in preparation of inventory are associated with:

- Mobile Air Conditioning (MAC) systems and establishment of the time-series, which could not be completed, because the number of MACs sold from and before 1992 (per year) was unknown.
- Transport Refrigeration category, which no data were delivered on time from the Department of Transportation in order to calculate the emissions for 2017 and establish the time-series.
- 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 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 NIR2017 submissions to the UNFCCC for the years 1990-2015 (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 CO₂ 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 CO₂eq/t).
- (c) The t CO₂ 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 4.20) to provide for the annual per capita emissions (Table 4.21) for the years 1990-2015.
- (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 CO₂ equivalent annual emissions from stocks in Cyprus, based on the population of Cyprus for each corresponding year (Table 4.22). The emissions of 2016 were estimated assuming that the per capita emissions are the same as 2015 and the population of Cyprus for 2016.

Emissions from these sources were kept constant for 2017.

Notes

- 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 and 2009. With Malta excluded, the average per capita emissions is very uniformly increasing through the time series (Figure 4.10).

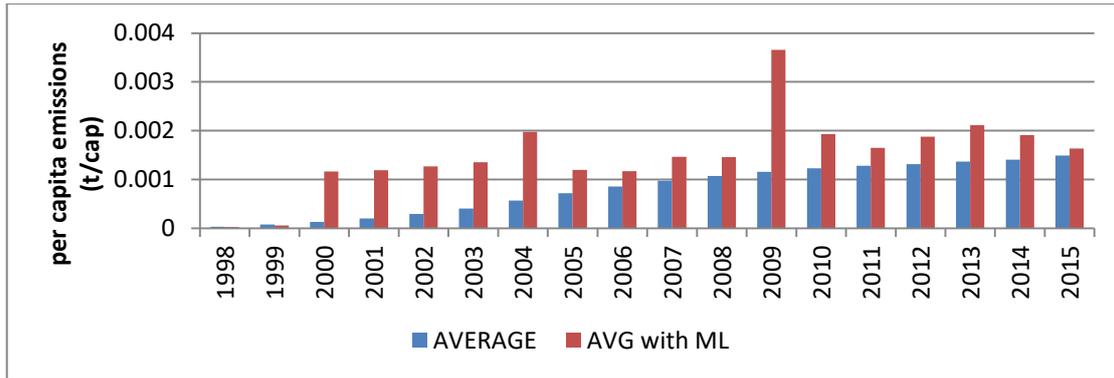


Figure 4.10. Average per capita emissions for 2F2 with and without Malta 1998-2015 (t/cap)

- 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 4.11).

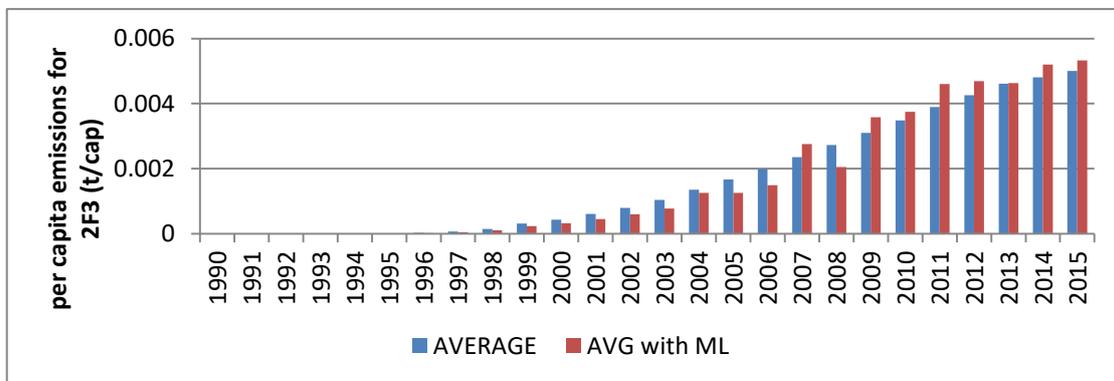


Figure 4.11. Average per capita emissions for 2F3 with and without Malta 1990-2015 (t/cap)

- 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 4.12).

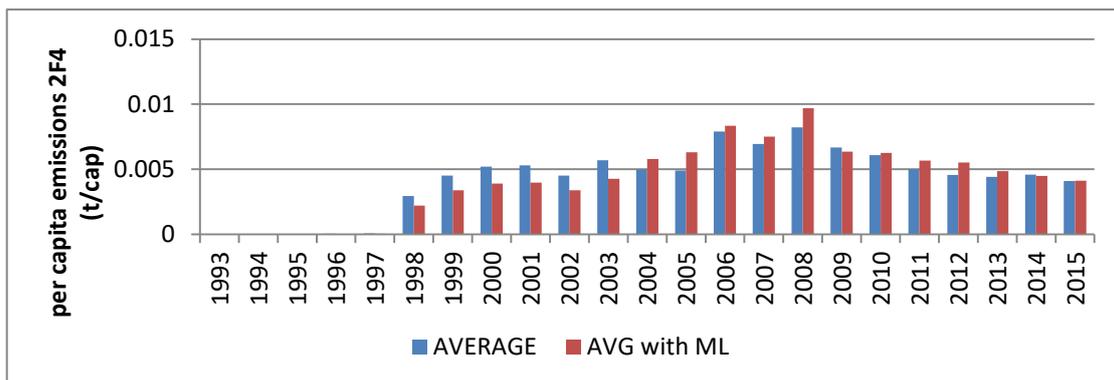


Figure 4.12. Average per capita emissions for 2F4 with and without Malta 1993-2015 (t/cap)

(e) The emissions estimated have been reported in CRFreporter as unspecified mix of hydrofluorocarbons, and divided in each sector (e.g. commercial, industrial refrigeration etc.) by factoring the t CO₂ eq. percent contribution (Table 4.23) to their combined total annual emission estimated for Cyprus (Table 4.24). The emissions for 2016 were estimated assuming the same factors and contribution as 2015. Moreover, 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 4.20. Average total population used for the estimation of per capita emissions from 2F activities (EUROSTAT)

	1990	1991	1992	1993	1994	1995	1996
Greece	10196792	10319927	10399061	10460415	10512922	10562153	10608800
Italy	56719240	56758521	56797087	56831821	56843400	56844303	56860281
Malta	354170	357727	361260	364704	367941	370433	372687
Spain	38850435	38939049	39067745	39189400	39294967	39387017	39478186

	1997	1998	1999	2000	2001	2002	2003
Greece	10661259	10720509	10761698	10805808	10862132	10902022	10928070
Italy	56890372	56906744	56916317	56942108	56974100	57059007	57313203
Malta	375236	377516	379360	381363	393028	395969	398582
Spain	39582413	39721108	39926268	40263216	40756001	41431558	42187645

	2004	2005	2006	2007	2008	2009	2010
Greece	10955141	11020362	11048473	11077841	11107017	11121341	11104899
Italy	57685327	58143979	58438310	58826731	59095365	59277417	59379449
Malta	401268	403834	405308	406724	409379	412477	414508
Spain	42921895	44397319	45226803	45954106	46362946	46576897	46742697

	2011	2012	2013	2014	2015		
Greece	11045011	10965211	10892413	10820883	10770521		
Italy	59539717	60233948	60789140	60730582	60627498		
Malta	416268	419455	423374	427364	431874		
Spain	46773055	46620045	46480882	46444832	46484533		

Table 4.21. Per capital emissions by source from 2F activities (kg CO₂ 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	0.01	0.03	0.06	0.12
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	0.03	0.09
AVERAGE	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.07
2F4								
Spain	0.00	0.00	0.00	0.00	0.00	0.06	0.12	0.20
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	0.02	0.04	0.07

	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	0.10	0.23	0.39	0.60	0.86	1.19	1.62	2.02
Greece	0.00	0.00	0.00	0.01	0.03	0.03	0.03	0.03
AVERAGE	0.03	0.08	0.13	0.20	0.30	0.41	0.57	0.72
2F3								
Spain	0.21	0.34	0.50	0.74	0.97	1.24	1.60	1.92

Italy	0.00	0.29	0.40	0.54	0.69	0.90	1.18	1.48
Greece	0.23	0.30	0.38	0.53	0.73	0.98	1.28	1.62
AVERAGE	0.15	0.31	0.43	0.60	0.80	1.04	1.35	1.67
2F4								
Spain	8.87	12.80	13.55	12.77	10.24	12.98	9.68	9.21
Italy	0.00	0.78	2.04	3.10	3.31	4.08	5.25	5.51
Greece	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AVERAGE	2.96	4.53	5.20	5.29	4.52	5.69	4.98	4.91

	2006	2007	2008	2009	2010	2011	2012	2013
2F2								
Spain	0.16	0.20	0.22	0.23	0.24	0.25	0.26	0.27
Italy	2.38	2.69	2.97	3.22	3.42	3.57	3.65	3.70
Greece	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.12
AVERAGE	0.86	0.97	1.07	1.16	1.23	1.28	1.32	1.36
2F3								
Spain	2.26	2.74	3.26	3.83	4.41	5.08	5.75	6.36
Italy	1.76	2.08	2.38	2.67	2.97	3.30	3.51	3.76
Greece	1.95	2.25	2.53	2.81	3.07	3.31	3.51	3.70
AVERAGE	1.99	2.36	2.73	3.10	3.48	3.90	4.26	4.61
2F4								
Spain	8.37	8.38	8.96	8.51	7.31	6.44	5.64	5.75
Italy	5.70	5.47	5.20	5.08	4.74	4.22	3.67	3.41
Greece	9.59	7.01	10.50	6.42	6.18	4.37	4.37	4.06
AVERAGE	7.89	6.95	8.22	6.67	6.08	5.01	4.56	4.41

	2014	2015						
2F2								
Spain	0.28	0.28						
Italy	3.75	3.92						
Greece	0.20	0.28						
AVERAGE	1.41	1.49						
2F3								
Spain	6.52	6.51						
Italy	3.99	4.36						
Greece	3.92	4.13						
AVERAGE	4.81	5.00						
2F4								
Spain	6.24	5.15						
Italy	3.37	2.94						
Greece	4.19	4.18						
AVERAGE	4.60	4.09						

Table 4.22. Total population used for the estimation of emissions from 2F activities

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Population	587100	603100	619200	632900	645400	656300	666300	675200	682900
	1999	2000	2001	2002	2003	2004	2005	2006	2007
Population	690500	690497	705500	713700	722900	733000	744000	757900	776400
	2008	2009	2010	2011	2012	2013	2014	2015	2016
Population	796900	819100	839800	862000	865900	858000	847000	848300	854800

Table 4.23. Contribution of activities to 2F 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						
2F2								
Closed cells	100%	100%						
2F3								
Fire protection	100%	100%						
2F4								
Metered dose inhalers	100%	100%						

Table 4.24. Total 2F emissions from Stocks estimated for Cyprus (t CO₂ eq.)

	1990	1991	1992	1993	1994	1995	1996	1997	1998
2F2	0	0	0	0	0	0	0	0	23
2F3	0	0	0	1	3	7	19	46	99
2F4	0	0	0	0	0	14	28	46	2019
	1999	2000	2001	2002	2003	2004	2005	2006	2007
2F2	53	91	142	211	296	416	536	649	755
2F3	215	300	426	570	753	992	1245	1507	1830
2F4	3126	3589	3734	3224	4111	3649	3653	5978	5400
	2008	2009	2010	2011	2012	2013	2014	2015	2016
2F2	856	950	1033	1107	1139	1171	1194	1268	1277
2F3	2172	2541	2926	3358	3687	3954	4076	4242	4274
2F4	6550	5464	5102	4320	3950	3783	3896	3472	3498

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

The emissions for the whole period have been recalculated for the 2019 for the category 2F1 due to the

revision of the methodology applied. The impact of the recalculations is presented in the following table and figures.

Table 4.25. 2F Recalculations

2F1 (t CO2 eq.)	1990	1991	1992	1993	1994	1995
2019 submission	63884.5	76024.2	84418.1	79140.6	82192.9	91897.3
2018 submission		0.7	2.0	4.5	275.9	1219.4
<i>change</i>		<i>11037099%</i>	<i>4118858%</i>	<i>1762889%</i>	<i>29691%</i>	<i>7436%</i>
<i>Impact on total</i>		<i>1.2%</i>	<i>1.3%</i>	<i>1.2%</i>	<i>1.2%</i>	<i>1.3%</i>
2F1 (t CO2 eq.)	1996	1997	1998	1999	2000	2001
2019 submission	95913.6	99600.7	103641.8	113278.1	116195.6	117270.3
2018 submission	2653.3	5141.4	10400.7	16208.8	25167.5	35243.9
<i>change</i>	<i>3515%</i>	<i>1837%</i>	<i>896%</i>	<i>599%</i>	<i>362%</i>	<i>233%</i>
<i>Impact on total</i>	<i>1.3%</i>	<i>1.3%</i>	<i>1.2%</i>	<i>1.2%</i>	<i>1.1%</i>	<i>1.0%</i>
2F1 (t CO2 eq.)	2002	2003	2004	2005	2006	2007
2019 submission	125788.8	128993.6	141276.9	188685.6	189653.9	216552.3
2018 submission	45612.4	56042.6	70667.7	86980.1	115349.3	133377.8
<i>change</i>	<i>176%</i>	<i>130%</i>	<i>100%</i>	<i>117%</i>	<i>64%</i>	<i>62%</i>
<i>Impact on total</i>	<i>0.9%</i>	<i>0.8%</i>	<i>0.8%</i>	<i>1.1%</i>	<i>0.8%</i>	<i>0.8%</i>
2F1 (t CO2 eq.)	2008	2009	2010	2011	2012	2013
2019 submission	207762.2	215560.2	236586.8	210647.1	213352.2	205924.0
2018 submission	159168.0	180521.6	202896.1	224718.7	246016.0	248411.6
<i>change</i>	<i>31%</i>	<i>19%</i>	<i>17%</i>	<i>-6%</i>	<i>-13%</i>	<i>-17%</i>
<i>Impact on total</i>	<i>0.5%</i>	<i>0.4%</i>	<i>0.4%</i>	<i>-0.2%</i>	<i>-0.4%</i>	<i>-0.5%</i>
2F1 (t CO2 eq.)	2014	2015	2016			
2019 submission	203865.5	241472.8	236230.3			
2018 submission	260105.5	267628.2	269678.9			
<i>change</i>	<i>-22%</i>	<i>-10%</i>	<i>-12%</i>			
<i>Impact on total</i>	<i>-0.7%</i>	<i>-0.3%</i>	<i>-0.4%</i>			

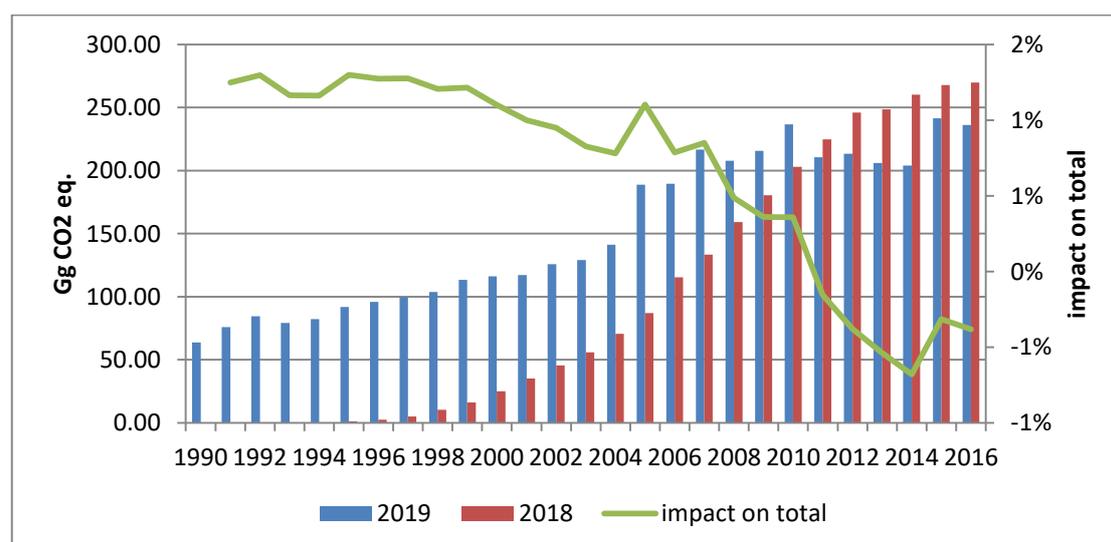


Figure 4.13. 2F1 recalculations

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), SF₆ and PFCs from Other Product Uses (2G2) (Military Applications, Accelerators and other), N₂O 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 N₂O (2G3a) and Propellant for Pressure and Aerosol Products (2G3b). The total emissions by gas and source for the period 1990-2017 are presented in Table 4.26 and Figure 4.14.

Table 4.26. Emissions from Other Product Manufacture and Use (2G)

	1990	2000	2005	2010	2015	2016	2017
G. Other product manufacture and use	41.37	49.30	52.50	59.27	59.87	60.34	61.00
1. Electrical equipment	0.03	0.08	0.12	0.15	0.16	0.17	0.17
2. SF ₆ and PFCs from other product use	NO						
3. N ₂ O from product uses	41.30	49.11	52.36	59.09	59.69	60.17	60.83
4. Other	0.04	0.12	0.03	0.02	0.01	0.01	0.01
CO ₂ (Gg)	0.04	0.12	0.03	0.02	0.01	0.01	0.01
N ₂ O (Gg)	0.14	0.16	0.18	0.20	0.20	0.20	0.20
SF ₆ (kg)	1.13	3.34	5.04	6.59	7.20	7.25	7.25
Total (Gg CO₂ eq.)	41.37	49.30	52.50	59.27	59.87	60.34	61.00

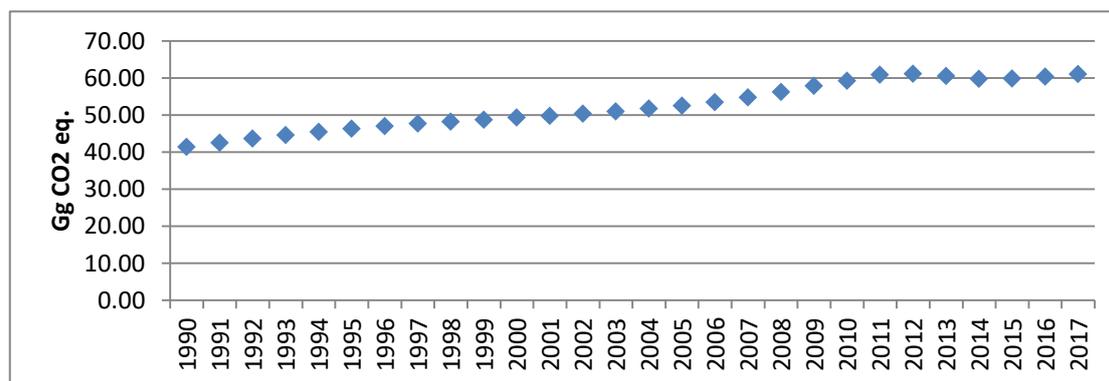


Figure 4.14. Emissions from Other Product Manufacture and Use (2G)

4.7.1. Electrical Equipment (2G1)

Sulphur hexafluoride (SF₆) is used for electrical insulation and current interruption in equipment used in the transmission and distribution of electricity. Emissions occur at each phase of the equipment life cycle, including manufacturing, installation, use, servicing, and disposal. Most of the SF₆ used in electrical equipment is used in gas insulated switchgear and substations (GIS) and in gas circuit breakers (GCB), though some SF₆ is used in high voltage gas-insulated lines (GIL), outdoor gas-insulated instrument transformers and other equipment. The aforementioned applications may be divided into two categories of containment.

Electrical equipment is the largest consumer and most important use of SF₆, globally. It significantly contributes to worldwide SF₆ emissions. However, the importance of this source varies considerably from region to region and from country to country.

4.7.1.1. 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 Electrical Equipment (2G1).

The methodology applied consisted of the following steps:

- The stock emissions from the 2G1 for Greece, Italy, Malta and Spain were obtained from the NIR2017 submissions to the UNFCCC for the years 1990-2015 (CRF – Table 2(II).B-H). The four countries were selected due to their similarity in social and economic conditions to Cyprus.
- The amounts SF₆ used by the four model countries were tabulated in tonnes and modified by their 100-year global warming potential (GWP) to calculate the t CO₂ 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 CO₂eq/t).
- The t CO₂ eq. emissions from each substance are, then, summed per year and divided by the average total population of each country obtained from EUROSTAT (Table 4.16) to provide for the annual per capita emissions (Table 4.27) for the years 1990-2015.
- The annual per capita emissions average of only Spain, Italy and Greece were, in turn, used to calculate the total t CO₂ equivalent annual emissions from stocks in Cyprus, based on the population of Cyprus for each corresponding year (Table 4.17). The emissions of 2016 were estimated assuming that the per capita emissions are the same as 2015 and the population of Cyprus for 2016.

Malta was excluded from the calculation of the average per capita emissions for the source 2G1, because of outstanding high values of per capita HFC emissions in 2011 and 2013. With Malta excluded, the average per capita emissions is more uniform through the time series (Figure 4.15).

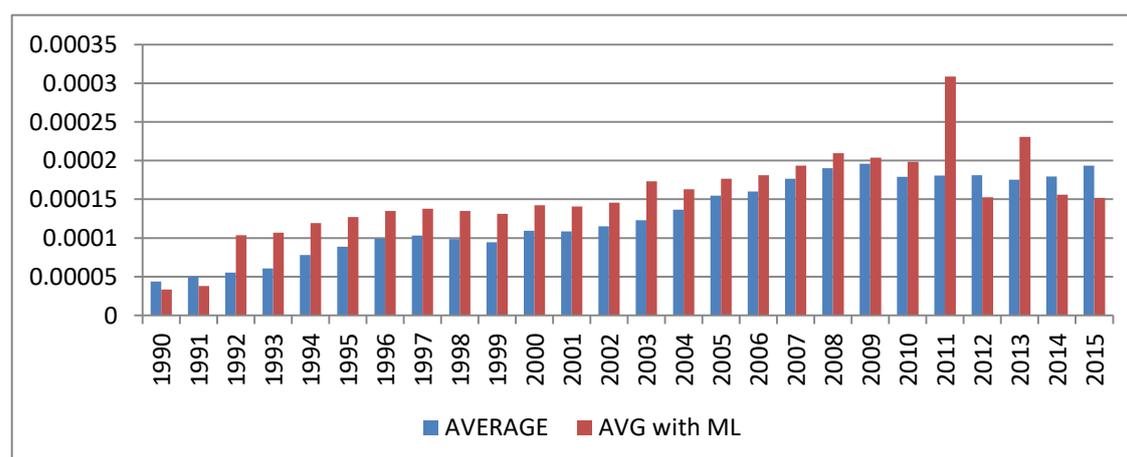


Figure 4.15. Average per capita emissions for 2G1 with and without Malta 1990-2015 (t/cap)

- Consumption of SF₆ for 2G1 was reported in the CRF reporter in tonnes by dividing the total t CO₂ equivalent annual emissions by the GWP of the gas. The reported emissions are presented in Table 4.28.

Table 4.27. Annual per capita emissions for 2G1

	1990	1991	1992	1993	1994	1995	1996	1997
Malta	1.9E-06	1.9E-06	0.00025	0.00025	0.00024	0.00024	0.00024	0.00024
Spain	0.0001	0.00011	0.00011	0.00011	0.00012	0.00012	0.00013	0.00013
Italy	1.8E-05	1.8E-05	1.9E-05	1.9E-05	2E-05	2E-05	2.1E-05	2.1E-05
Greece	1.2E-05	2.5E-05	3.8E-05	5.2E-05	9.9E-05	0.00012	0.00015	0.00016
AVERAGE without Malta	4.4E-05	5E-05	5.5E-05	6.1E-05	7.8E-05	8.9E-05	9.9E-05	0.0001

	1998	1999	2000	2001	2002	2003	2004	2005
Malta	0.00024	0.00024	0.00024	0.00024	0.00024	0.00032	0.00024	0.00024
Spain	0.00014	0.00014	0.00014	0.00015	0.00015	0.00016	0.00018	0.00019
Italy	2.1E-05	2.2E-05	2.2E-05	2.2E-05	2.3E-05	2.3E-05	2.4E-05	3.5E-05

Greece	0.00014	0.00012	0.00016	0.00016	0.00017	0.00019	0.00021	0.00024
AVERAGE without Malta	9.9E-05	9.4E-05	0.00011	0.00011	0.00012	0.00012	0.00014	0.00015

	2006	2007	2008	2009	2010	2011	2012	2013
Malta	0.00024	0.00024	0.00027	0.00023	0.00026	0.00069	6.8E-05	0.0004
Spain	0.00021	0.00023	0.00024	0.00024	0.00026	0.00025	0.00026	0.00026
Italy	4.5E-05	5.4E-05	4.1E-05	2.8E-05	3.3E-05	2.9E-05	2.9E-05	3E-05
Greece	0.00023	0.00025	0.00029	0.00032	0.00025	0.00026	0.00025	0.00024
AVERAGE without Malta	0.00016	0.00018	0.00019	0.0002	0.00018	0.00018	0.00018	0.00018

	2014	2015						
Malta	8.58E-05	2.75E-05						
Spain	0.000263	0.000276						
Italy	2.85E-05	2.95E-05						
Greece	0.000247	0.000275						
AVERAGE without Malta	0.00018	0.000193						

Table 4.28. SF6 emissions for 2G1, as reported in CRFreporter

	1990	1991	1992	1993	1994	1995	1996	1997
SF6 (t)	0.00113	0.00132	0.0015	0.00169	0.00221	0.00255	0.00289	0.00305

	1998	1999	2000	2001	2002	2003	2004	2005
SF6 (t)	0.00295	0.00286	0.00334	0.00336	0.0036	0.0039	0.00439	0.00504

	2006	2007	2008	2009	2010	2011	2012	2013
SF6 (t)	0.00532	0.00601	0.00665	0.00704	0.00659	0.00684	0.00688	0.0066

	2014	2015	2016					
SF6 (t)	0.006673	0.007195	0.007250					

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 be reported.

4.7.1.5. Category-specific planned improvements

Please refer to [Annex 7](#) for the National Inventory Improvement Plan.

4.7.2. SF6 and PFCs from Other Product Uses (2G2)

No information is available to support that SF6 and PFCs from Other Product Uses occurs in Cyprus.

4.7.3. N2O from Product Uses (2G3)

Evaporative emissions of nitrous oxide (N2O) 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 N2O.

4.7.3.1. Methodological issues

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 (Table 4.22) and the emission factor per capita of 0.0222 kg N2O per capita for Medical Applications (2G3a) and 0.214 kg N2O per capita for Propellant for Pressure and Aerosol Products (2G3b) in the equation:

$$N2O \text{ emissions (Gg)} = \text{population} * \text{emission factor per capita (kg N2O/capita)} / 10^6$$

The emission factors have been obtained by the National GHG Inventory Report of Greece for the year 2013. Greece was chosen due to the social, climatic and economic similarities that exist between the two countries.

The results as reported in CRFReporter are presented in Table 4.29.

Table 4.29. N2O emissions (Gg) from Product Uses

	1990	1991	1992	1993	1994	1995	1996
2G3a	0.0130	0.0134	0.0137	0.0141	0.0143	0.0146	0.0148
2G3b	0.1256	0.1291	0.1325	0.1354	0.1381	0.1404	0.1426
TOTAL	0.1387	0.1425	0.1463	0.1495	0.1524	0.1550	0.1574
	1997	1998	1999	2000	2001	2002	2003
2G3a	0.0150	0.0152	0.0153	0.0155	0.0157	0.0158	0.0160
2G3b	0.1445	0.1461	0.1478	0.1493	0.1510	0.1527	0.1547
TOTAL	0.1595	0.1613	0.1631	0.1647	0.1666	0.1686	0.1707
	2004	2005	2006	2007	2008	2009	2010
2G3a	0.0163	0.0165	0.0168	0.0172	0.0177	0.0182	0.0186
2G3b	0.1569	0.1592	0.1622	0.1661	0.1705	0.1753	0.1797
TOTAL	0.1731	0.1757	0.1790	0.1834	0.1882	0.1935	0.1984
	2011	2012	2013	2014	2015	2016	2017
2G3a	0.0191	0.0192	0.0190	0.0188	0.0188	0.0190	0.0192
2G3b	0.1845	0.1853	0.1836	0.1813	0.1815	0.1829	0.1849
TOTAL	0.2036	0.2045	0.2027	0.2001	0.2004	0.2019	0.2041

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. The emissions are estimated from NMVOCs estimates.

4.7.3.1. Methodological issues

Carbon dioxide emissions from other are calculated from NMVOC emissions (Table 4.30; with red the recalculated values), assuming that the carbon content of NMVOC is 60%⁴³. NMVOC emissions are obtained from the Department of Labour Inspection that 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 assuming also that oxidation of carbon is 99% the equation applied for the estimation of the CO₂ emissions is the following:

$$CO_2 \text{ emissions (Gg)} = 60\% * NMVOC \text{ emissions (Gg)} * 44/12 * 99\%$$

Table 4.30. NMVOCs emissions used for the estimation of CO₂ emissions from Other (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	0.01900	0.02065	0.01621
	2014	2015	2016	2017				
Other	0.00643	0.01480	0.01215	0.01302				

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

CO₂ emissions have been recalculated due to revision of NMVOCs emissions used for the estimation of CO₂ emissions for the years 2011-2015. The impact of recalculations on emissions is shown in Table 4.31 and Figure 4.16.

⁴³ 2006 IPCC Guidelines volume 3, p. 5.17, the default fossil carbon content fraction of NMVOC is 60 per cent by mass

Table 4.31. CO2 emissions from Other (2G4) Recalculations

	2011	2012	2013	2014	2015
NIR2018 (Gg CO2)	0.01215	0.01215	0.01215	0.01215	0.01215
NIR2019 (Gg CO2)	0.01900	0.02065	0.01621	0.00643	0.01480
change	56.5%	70.0%	33.5%	-47.1%	21.9%

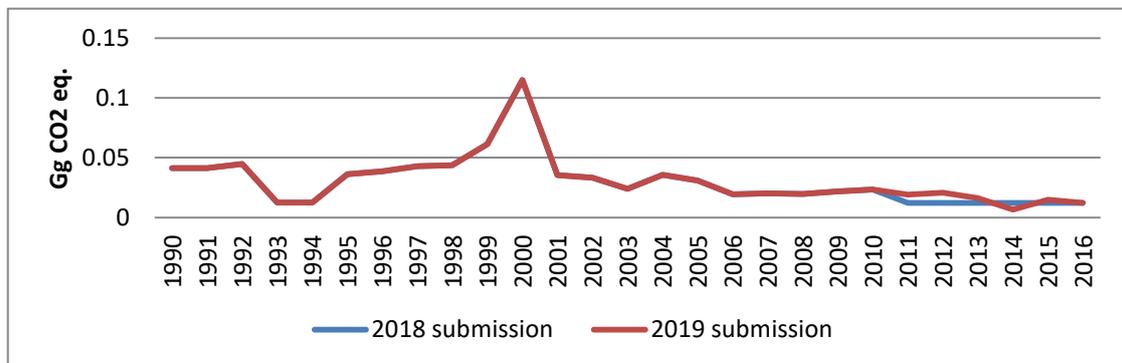


Figure 4.16. CO2 emissions from Other (2G4) Recalculations

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 (CH₄) emissions from enteric fermentation and both CH₄ and nitrous oxide (N₂O) emissions from livestock manure management systems. Cattle are an important source of CH₄ in many countries because of their large population and high CH₄ 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 Cyprus⁴⁴

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

⁴⁴ Cyprus Profile, 2017, Green Growth and Niche Products, available at <http://www.cyprusprofile.com/en/sectors/agriculture-and-food> (accessed 19/12/2017)

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 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 5.9% of total emissions in 2017 (without LULUCF), compared to 8.7% in 1990. Emissions increased by 5.0% compared to 1990. Agriculture is responsible for mainly methane and nitrous oxide emissions. In 2017 agriculture contributed 35% to the total methane emissions and 81% to the total nitrous oxide emissions. The total emissions by gas and source from agricultural activities for the period 1990-2017 in Cyprus are presented in Table 5.1 and Figure 5.1.

Table 5.1. GHG emissions from Agriculture, for the period 1990 – 2017

Gg CO ₂ eq.	1990	2000	2005	2010	2015	2016	2017
3. Agriculture	471.23	552.35	532.98	531.62	457.27	481.54	494.73
A. Enteric fermentation	196.97	224.21	228.47	235.38	224.25	243.59	255.44
B. Manure management	135.41	182.12	170.86	158.80	116.86	119.69	118.37
C. Rice cultivation	NO						
D. Agricultural soils	135.00	143.70	132.01	136.15	115.01	117.75	120.17
E. Prescribed burning of savannas	NO						
F. Field burning of agricultural residues	2.03	0.65	0.68	0.55	0.76	0.12	0.33
G. Liming	NO						
H. Urea application	1.82	1.67	0.97	0.74	0.40	0.39	0.42
I. Other carbon-containing fertilizers	NO						
J. Other	NO						
CO ₂ (Gg)	1.82	1.67	0.97	0.74	0.40	0.39	0.42
CH ₄ (Gg)	10.72	12.85	12.72	12.67	11.11	11.89	12.26
N ₂ O (Gg)	0.68	0.77	0.72	0.72	0.60	0.62	0.63
Total (Gg CO₂ eq.)	471.23	552.35	532.98	531.62	457.27	481.54	494.73

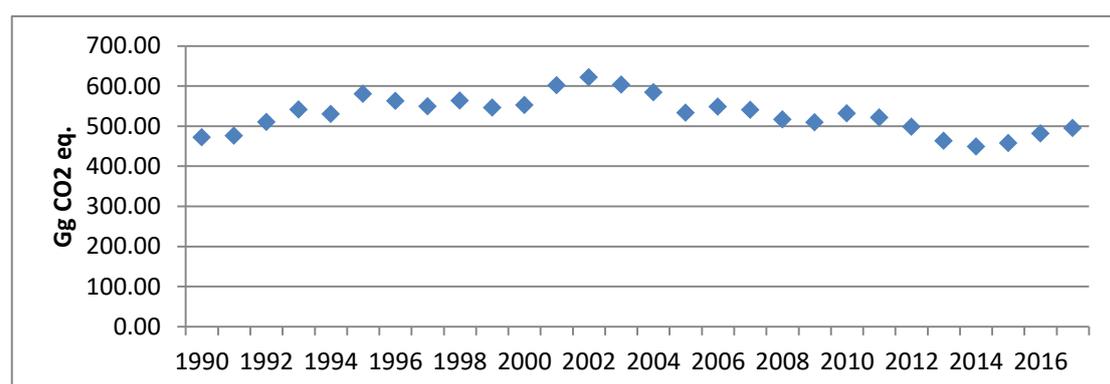


Figure 5.1. Emissions from Agriculture, 1990 – 2017

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 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 5.2.

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, horses, mules and asses and swine	CH ₄	D	T1
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 ₂ O emissions – Dairy and non-dairy cattle, Sheep, swine (market & breeding), goats, horses, poultry, mules and asses	N ₂ O	D	T1
3B2.5	Indirect N ₂ O emissions	N ₂ O	D	T1
3D1.1	Agricultural soils- Direct N ₂ O Emissions From Managed Soils- Inorganic fertilizers	N ₂ O	CS	T1
3D1.2a	Agricultural soils- Direct N ₂ O Emissions From Managed Soils - Organic N fertilizers - Animal manure used as fertilizers	N ₂ O	D	T1
3D1.2b	Agricultural soils- Direct N ₂ O Emissions From Managed Soils - Organic N fertilizers - Sewage sludge applied to soils	N ₂ O	D	T1
3D1.2c	Agricultural soils- Direct N ₂ O Emissions From Managed Soils - Organic N fertilizers – Other organic fertilizers applied to soils	N ₂ O	D	T1
3D1.4	Agricultural soils- Direct N ₂ O Emissions From Managed Soils - Crop residues	N ₂ O	D	T1
3D2.1	Indirect N ₂ O emissions from managed soils – Atmospheric Deposition	N ₂ O	D	T1
3D2.2	Indirect N ₂ O emissions from managed soils Nitrogen Leaching and run-off	N ₂ O	D	T1
3F1	Field Burning of Agricultural Residues – Cereals – Wheat, Barley, Oats	N ₂ O/ CH ₄	D	T1
3F2	Field Burning of Agricultural Residues – Pulses – Bean and Pulses	N ₂ O/ CH ₄	D	T1
3F3	Field Burning of Agricultural Residues –Tubers and Roots	N ₂ O/ 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 ₂ O
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 2017 account for 83% of total GHG emissions from Agriculture and 30% 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. CH₄ emissions from Enteric Fermentation (3A) 1990-2017

Gg CH ₄	1990	2000	2005	2010	2015	2016	2017
A. Enteric fermentation	7.88	8.97	9.14	9.42	8.97	9.74	10.21
1. Cattle	4.05	4.46	4.66	4.53	4.88	5.54	5.82
Dairy cattle	2.21	2.72	2.78	2.75	3.01	3.49	3.74
Non-dairy cattle	1.84	1.75	1.88	1.78	1.86	2.05	2.09
2. Sheep	2.32	1.97	2.15	2.63	2.38	2.43	2.57
3. Swine	0.42	0.61	0.64	0.70	0.54	0.53	0.53
4. Other livestock	1.09	1.92	1.68	1.56	1.18	1.24	1.29
Goats	1.03	1.89	1.65	1.54	1.17	1.23	1.29
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	0.00	0.00	0.00
CH ₄	7.88	8.97	9.14	9.42	8.97	9.74	10.21
Total	7.88	8.97	9.14	9.42	8.97	9.74	10.21

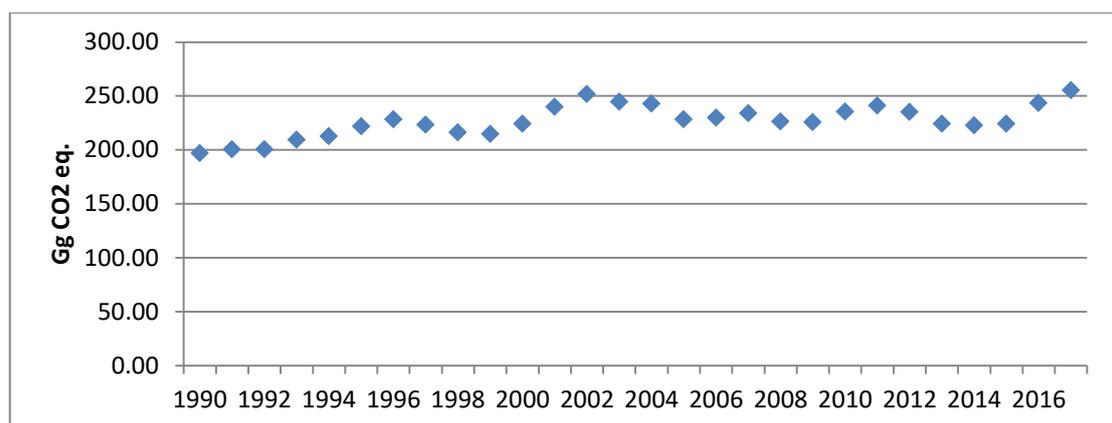


Figure 5.2. CH4 emissions from Enteric Fermentation (3A) 1990-2017 in Gg CO2 eq.

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 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 not available therefore:

- *Horses*: the decreasing trend that exists between 2003 and 2010 is used to extrapolate population for 2011-2017 using equation $y = -58.571x + 1220.6$
- *Mules and asses*: the decreasing trend that is noticed between the populations reported in the available agricultural censuses (for the years 1985, 1994, 2003 and 2010) is best fitted with the exponential equation $y = 8844.5e^{-0.101x}$ with R^2 value of 0.9882. The equation was used to obtain population data for the years 2011-2017.

Table 5.5. Animal population for 1990 – 2017 (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
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

	Dairy cattle	Other cattle	Sheep	Breeding swine ^a	Market swine ^b	Horses	Mules and Asses	Goats	Poultry
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	0.58	290.2	3678
2012	24.1	32.8	346.8	36.3	358.4	0.64	0.52	271.2	3488
2013	24.7	32.5	313.5	35.1	322.8	0.58	0.47	243.1	3091
2014	25.3	34.2	293.0	31.8	326.2	0.52	0.43	232.0	3677
2015	26.2	32.7	296.9	32.1	326.2	0.46	0.39	233.9	3154
2016	28.5	34.5	304.2	32.6	319.6	0.40	0.35	246.6	3261
2017	30.1	36.6	321.5	33.2	317.0	0.34	0.32	257.6	3360

^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 CH₄ emission factor for is based on the following equation (eqn 10.21, pg. 10.30, volume 4):

$$EF = [(GE * (YM/100) * 365 \text{ days/yr}] / 55.65 \text{ MJ/kg CH}_4$$

where EF is the estimated emission factor for CH₄ (kg CH₄/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 CH₄.

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 Agriculture⁴⁵. The remaining parameters have the value of the default proposed by the IPCC GPG. The fat percentage in milk is assumed 3.5% taking into account the suggestion that was made during the volunteered participation of Cyprus in the Effort Sharing Decision review (ESD review) that was took place in 2014. Table 5.6 presents 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 1990-2017 are presented in Table 5.8.

GE estimates have been revised due to the Identification of a mistake in the calculations. More specifically, it was found that GE was calculated with constant milk production of 1990 instead of annual milk production, which was corrected in this submission. The revised GE and the respective EF

⁴⁵ Mr. George Papaioannou, Agricultural Officer, Department of Agriculture, tel. no. +357 22408566

estimated are presented in Table 5.8

Moreover, GE estimates have been affected of the change of DE from 60 to 68.

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 (C _f)	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 (Y _m)	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	2001	2002	2003	2004	2005	2009	2010	2011
Milk production (kg/day/cow)	15.89	14.77	16.71	15.86	16.41	17.95	17.64	17.42
% pregnant population	81.3	81.3	81.3	81.3	80.3	76.3	76.3	72.2

Year	2012	2013	2014	2015	2016	2017		
Milk production (kg/day/cow)	17.29	16.96	17.18	17.08	19.26	19.68		
% pregnant population	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 2017 assumed equal to 2012.

Table 5.8. Gross energy (GE) and emissions factor (EF) for dairy cattle for the period 1990 – 2017

Year	1990	1991	1992	1993	1994	1995	1996
GE (MJ/head/day)	231.8	232.4	232.0	234.9	234.0	237.3	244.8
EF (kg CH ₄ /head/yr)	98.8	99.1	98.9	100.1	99.8	101.2	104.4

Year	1997	1998	1999	2000	2001	2002	2003
GE (MJ/head/day)	248.6	257.4	254.7	270.9	261.4	252.3	268.0
EF (kg CH ₄ /head/yr)	106.0	109.7	108.6	115.5	111.4	107.6	114.3

Year	2004	2005	2006	2007	2008	2009	2010
GE (MJ/head/day)	261.2	265.5	270.4	267.3	275.1	277.3	274.9
EF (kg CH ₄ /head/yr)	111.3	113.2	115.3	114.0	117.3	118.2	117.2

Year	2011	2012	2013	2014	2015	2016	2017
GE (MJ/head/day)	272.6	271.5	268.9	270.7	269.9	287.5	290.8
EF (kg CH ₄ /head/yr)	116.2	115.8	114.6	115.4	115.1	122.5	124.0

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 according to 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

No recalculations to be reported.

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 CH₄. Emissions of CH₄ related to manure handling and storage are reported under ‘Manure Management.’ The main factors affecting CH₄ 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 N₂O emissions occur via combined nitrification and denitrification of nitrogen contained in the

manure. The emission of N₂O 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 N₂O 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 Cyprus⁴⁶

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 or washing the housing areas or 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 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 2017 accounted for 1.3% of the total national emissions without LULUCF. CH₄ and N₂O from manure management in 2017 accounted for 17% and 61% of GHG emissions from Agriculture respectively. Total emissions in 2017 decreased by 13% compared to 1990 levels because of the improvement of waste management practices. CH₄ and N₂O emissions from manure management for the period 1990 – 2017 are presented in Table 5.10 and Figure 5.3.

Table 5.10. CH₄ and N₂O emissions from manure management for 1990 – 2017

Gg CO ₂ eq.	1990	2000	2005	2010	2015	2016	2017
B. Manure management	135.41	182.12	170.86	158.80	116.86	119.69	118.37
1. Cattle	17.80	18.00	18.99	17.96	18.99	20.74	21.66
Dairy cattle	10.99	11.51	12.04	11.40	12.35	13.45	14.23
Non-dairy cattle	6.81	6.48	6.95	6.56	6.64	7.29	7.43
2. Sheep	10.46	8.87	9.69	11.87	10.69	10.98	11.58
3. Swine	62.30	92.00	82.81	74.02	42.31	41.68	37.97
4. Other livestock	20.48	31.71	28.19	24.48	18.92	19.45	19.65
Goats	9.99	18.46	16.07	14.98	11.39	12.02	12.55
Horses	0.07	0.14	0.17	0.12	0.07	0.06	0.05
Mules and Asses	0.44	0.16	0.10	0.06	0.03	0.03	0.03
Poultry	9.97	12.95	11.85	9.33	7.42	7.34	7.01
Other	NO						
5. Indirect N ₂ O emissions	24.38	31.54	31.18	30.47	25.95	26.83	27.51
CH ₄ (Gg)	2.78	3.86	3.56	3.24	2.12	2.14	2.03
N ₂ O (Gg)	0.22	0.29	0.27	0.26	0.21	0.22	0.23
Total (Gg CO₂ eq.)	135.4	182.1	170.9	158.8	116.9	119.7	118.4

⁴⁶ 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

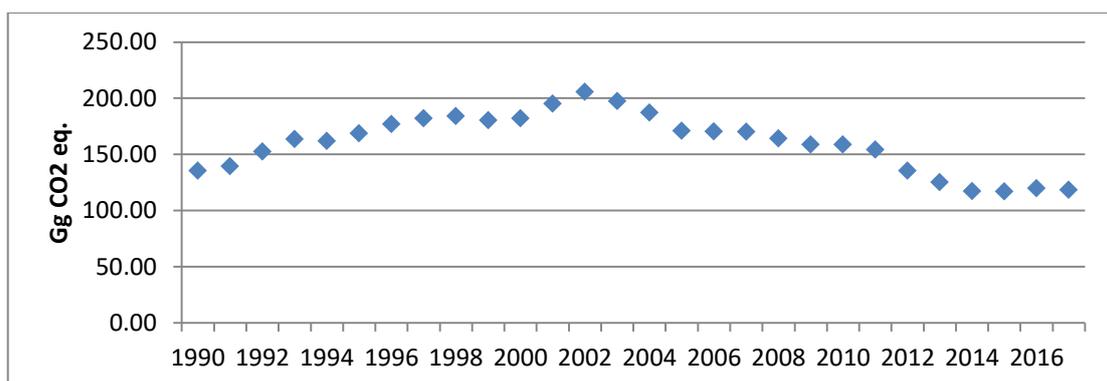


Figure 5.3. Emissions from manure management, 1990 – 2017

5.3.2. Methodological issues

5.3.2.1. CH₄ emissions (3B1)

The best way to determine emission factors is to conduct non-invasive or non-disturbing measurements of missions 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. 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 specie⁴⁷. 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.

⁴⁷ 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).

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). 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 Unit⁴⁸), due to unavailability of any other references on distribution of animal waste to waste management practice. The emissions are estimated by multiplying the EF developed by the animal population (Table 5.5).

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	4.5	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							
Solid storage and dry lot	100%	100%	100%	100%	100%	100%	100%
Anaerobic digestion	0%	0%	0%	0%	0%	0%	0%
Non-Dairy Cattle							
Solid storage and dry lot	100%	100%	100%	100%	100%	100%	100%
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							
Aerobic treatment	100%	97%	94%	91%	88%	85%	82%
Anaerobic digestion	0%	3%	6%	9%	12%	15%	18%
Breeding Swine							
Aerobic treatment	100%	97%	94%	91%	88%	85%	82%
Anaerobic digestion	0%	3%	6%	9%	12%	15%	18%
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							
Solid storage and dry lot	100%	99%	99%	99%	99%	97%	97%
Anaerobic digestion	0%	1%	1%	1%	1%	3%	3%
Non-Dairy Cattle							
Solid storage and dry lot	100%	99%	99%	99%	99%	97%	97%
Anaerobic digestion	0%	1%	1%	1%	1%	3%	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%

⁴⁸ 15/11/2017, Tel. +357 22 408935, email aathanasiades@environment.moa.gov.cy

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							
Aerobic treatment	79%	76%	73%	70%	70%	60%	60%
Anaerobic digestion	21%	24%	27%	30%	30%	40%	40%
Breeding Swine							
Aerobic treatment	79%	76%	73%	70%	70%	60%	60%
Anaerobic digestion	21%	24%	27%	30%	30%	40%	40%
Poultry							
Solid storage and dry lot	96%	94%	92%	90%	90%	90%	90%
Anaerobic digestion	4%	6%	8%	10%	10%	10%	10%
Animal	2014	2015	2016	2017			
Dairy Cattle							
Solid storage and dry lot	95%	95%	95%	95%			
Anaerobic digestion	5%	5%	5%	5%			
Non-Dairy Cattle							
Solid storage and dry lot	95%	95%	95%	95%			
Anaerobic digestion	5%	5%	5%	5%			
Sheep							
Solid storage and dry lot	100%	100%	100%	100%			
Goats							
Solid storage and dry lot	100%	100%	100%	100%			
Horses							
Solid storage and dry lot	100%	100%	100%	100%			
Mules and asses							
Solid storage and dry lot	100%	100%	100%	100%			
Market Swine							
Aerobic treatment	50%	50%	50%	45%			
Anaerobic digestion	50%	50%	50%	55%			
Breeding Swine							
Aerobic treatment	50%	50%	50%	45%			
Anaerobic digestion	50%	50%	50%	55%			
Poultry							
Solid storage and dry lot	90%	85%	80%	80%			
Anaerobic digestion	10%	15%	20%	20%			

5.3.2.2. N₂O emissions (3B2)

The level of detail and methods chosen for estimating N₂O emissions from manure management systems depend upon national circumstances. Tier 2 methodology is applied for calculating direct N₂O emissions from manure management systems as follows:

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 N₂O 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 the IPCC 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 CH₄ for manure management. The reason of different approach is that manure management practises for cattle waste used in Cyprus are more appropriate to be categorised under Eastern Europe. However for the

calculation of the N₂O emissions from manure management, the factor has been changed to Western Europe, due to the high milk production, 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
Breeding 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 kgN₂O-N/kg N ex coefficient, to estimate the N₂O emissions. The kgN₂O-N/kg N ex coefficients used are presented in Table 5.15.

Table 5.15. kg N₂O-N/kg N ex coefficients per technology used

Animal	kgN ₂ O-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	
Anaerobic digestion	0.000	

3B2.5. Indirect N₂O emissions from Manure Management

I. Indirect N₂O emissions from volatilisation of N from Manure Management

To estimate the indirect N₂O emissions from manure management four steps were applied, according to 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 (d) Estimation of N₂O emissions using the totals volatilisation N-losses (kg N/yr). The indirect N₂O emissions were estimated using the equation 10.27 (pg. 10.56, volume 4 2006 IPCC 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.

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 ($N_{\text{volatilisation-MMS}}$) 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 ($\text{Frac}_{\text{GASMS}}$ (%)). The per cent 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 ($N_{\text{volatilization-MMS}}$) is multiplied by the emission factor for N₂O emissions from atmospheric deposition of nitrogen on soils and water surfaces (EF_4) to estimate the N₂O emissions. The emission factor used is 0.01 kg N₂O-N (default value). The equation used to estimate the indirect N₂O emissions from volatilisation

summarised in the equation $N_2O_{G(mm)} = (N_{\text{volatilisation-MMS}} * EF_4) * 44/28$.

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
	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
	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
	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
	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 NH₃. The time of the pre-storage is not too long and the digestate is stored covered.

II. Indirect N₂O emissions from leaching and runoff of nitrogen from manure management

Tier 2 calculation of N volatilisation in forms of NH₃ 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, 2006 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 N₂O 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; (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 proposed by the guidelines is 1-20% (pg. 10.56, vol. 4); i.e. 1%.

The default emission factor for N₂O emissions from nitrogen leaching and runoff, kg N₂O-N/kg N leached and runoff (EF₅) proposed by the IPCC guidelines is used, 0.0075 kg N₂O-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

N₂O emissions from indirect N₂O emissions were recalculated due to changes caused by: (a) introduction of an EF for anaerobic digestion instead of 0, and (b) reduction of leaching losses from solid storage from 10% to 1%. The impact on the emissions is presented below.

Table 5.17. Recalculations for indirect N₂O emissions

Gg N₂O	1990	1991	1992	1993	1994	1995
2018 submission	0.0209	0.0210	0.0219	0.0232	0.0231	0.0240
2019 submission	0.0017	0.0017	0.0017	0.0018	0.0018	0.0019
% change	-91.86%	-91.99%	-92.20%	-92.22%	-92.21%	-92.22%
Gg N₂O	1996	1997	1998	1999	2000	2001
2018 submission	0.0250	0.0261	0.0262	0.0262	0.0272	0.0296
2019 submission	0.0019	0.0020	0.0020	0.0021	0.0021	0.0023
% change	-92.25%	-92.26%	-92.28%	-92.17%	-92.13%	-92.14%
Gg N₂O	2002	2003	2004	2005	2006	2007
2018 submission	0.0313	0.0297	0.0285	0.0264	0.0263	0.0273
2019 submission	0.0024	0.0023	0.0022	0.0020	0.0020	0.0021
% change	-92.18%	-92.27%	-92.27%	-92.27%	-92.42%	-92.37%
Gg N₂O	2008	2009	2010	2011	2012	2013
2018 submission	0.0258	0.0251	0.0262	0.0258	0.0244	0.0225
2019 submission	0.0019	0.0019	0.0019	0.0020	0.0019	0.0017
% change	-92.57%	-92.64%	-92.56%	-92.43%	-92.35%	-92.34%
Gg N₂O	2014	2015	2016			
2018 submission	0.0226	0.0222	0.0231			
2019 submission	0.0017	0.0017	0.0017			
% change	-92.32%	-92.46%	-92.44%			

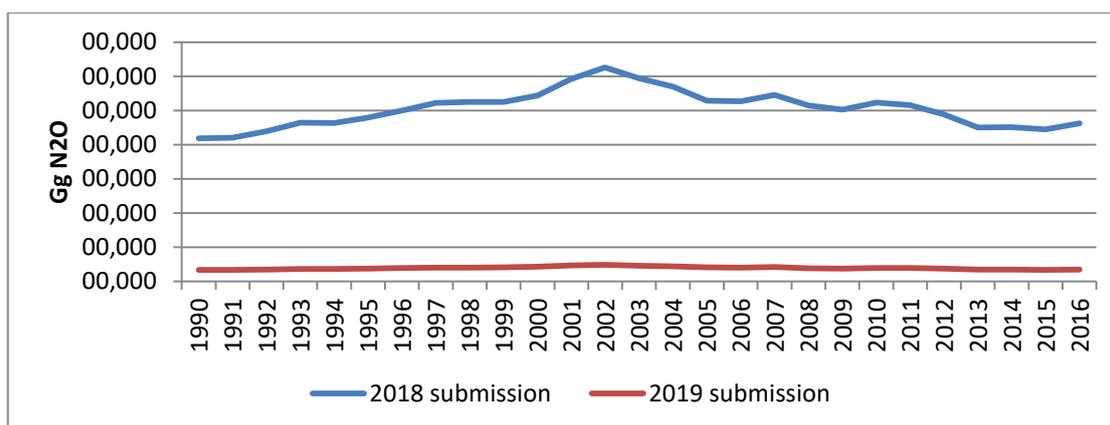


Figure 5.4. Recalculations for indirect N2O emissions

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 (N₂). 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 N₂O emissions using human-induced net N additions to soils (e.g., synthetic or organic fertilizers, deposited manure, crop residues, sewage sludge). Direct emissions of N₂O from managed soils are estimated separately from indirect emissions, though using a common set of activity data.

Total emissions from agricultural soils in 2017 contributed 24% to the emissions from agriculture and 1.3% to the total emissions of the country (excluding LULUCF). Agricultural soils also contributed 41% to the N₂O emissions of the country excluding LULUCF. Total emissions from soils in 2017 reduced by 11% compared to 1990. Emissions from agricultural soils for the period 1990 – 2017 are presented in Table 5.18 and Figure 5.5.

Table 5.18. N₂O emissions from agricultural soils for 1990 – 2017

Gg CO ₂ eq.	1990	2000	2005	2010	2015	2016	2017
3D1. Direct N ₂ O emissions from managed soils	118.10	124.27	113.94	117.64	99.47	101.47	103.56
1. Inorganic N fertilizers	58.19	49.34	40.24	43.87	35.28	37.80	36.72
2. Organic N fertilizers	55.41	72.51	70.24	70.64	60.05	62.50	64.72
a. Animal manure applied to soils	55.33	72.29	69.76	69.73	59.03	61.39	63.75
b. Sewage sludge applied to soils	0.07	0.22	0.48	0.74	0.13	0.23	0.23
c. Other organic fertilizers applied to soils	NO	NO	NO	0.16	0.89	0.89	0.74

3. Urine and dung deposited by grazing animals	NO						
4. Crop residues	4.50	2.41	3.46	3.13	4.14	1.16	2.12
5. Mineralization/immobilization associated with loss/gain of soil organic matter	NO						
6. Cultivation of organic soils	NO						
7. Other	NO						
3D2. Indirect N ₂ O Emissions from managed soils	16.90	19.44	18.07	18.51	15.54	16.28	16.62
1. Atmospheric deposition	16.90	19.44	18.07	18.51	15.54	16.28	16.62
2. Nitrogen leaching and run-off	NO						
N ₂ O (Gg)	0.45	0.48	0.44	0.46	0.39	0.40	0.40
Total (Gg)	0.45	0.48	0.44	0.46	0.39	0.40	0.40

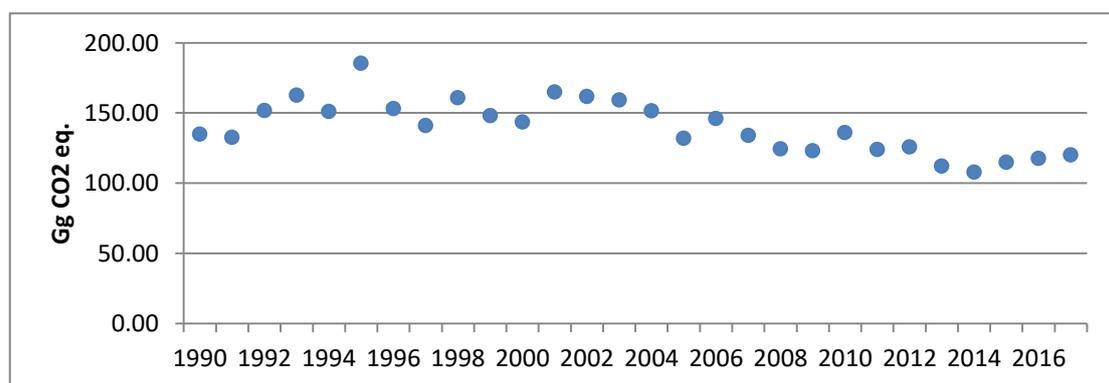


Figure 5.5. N₂O emissions from agricultural soils 1990 – 2017 (Gg CO₂ eq.)

5.5.1. Direct N₂O emissions from managed soils (3D1)

In most soils, an increase in available N enhances nitrification and denitrification rates which then increase the production of N₂O. 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 N₂O 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).

N mineralisation associated with loss of soil organic matter resulting from change of land use or management of mineral soils (FSOM); and drainage/management of organic soils (FOS) are not considered for the GHG inventory of Cyprus as there is no management of mineral soils and organic soils in Cyprus⁴⁹.

5.5.1.1. Methodological issues

In its most basic form, direct N₂O emissions from managed soils are estimated using Equation 11.1 in the 2006 IPCC Guidelines (vol. 4, pg. 11.7) using the following:

Inorganic N fertilizers (3D1.1)

N₂O emissions from the use of inorganic N fertilizers were estimated using Tier 1 methodology suggested by the 2006 IPCC Guidelines. Emission factor EF1 (kg N₂O-N/kg N) is assumed 0.01, as proposed by the 2006 IPCC Guidelines (Table 11.1, pg.11.11, volume 4, 2006 IPCC guidelines).

⁴⁹ personal communication Melina Menelaou, LULUCF expert, Climate Action Unit, Department of Environment (tel. +357 22 408959, mmenelaou@environment.moa.gov.cy)

Activity data is obtained from the Department of Agriculture⁵⁰.

Table 5.19. N input from application of inorganic fertilizers for the period (in kt) 1990-2017

Year	1990	1991	1992	1993	1994	1995	1996
Inorganic fertilizers (kg N)	12.426	12.169	14.760	16.189	14.289	20.526	13.628

Year	1997	1998	1999	2000	2001	2002	2003
Inorganic fertilizers (kg N)	11.126	14.601	11.561	10.537	12.359	10.579	11.198

Year	2004	2005	2006	2007	2008	2009	2010
Inorganic fertilizers (kg N)	10.738	8.593	11.291	8.198	7.499	7.674	9.369

Year	2011	2012	2013	2014	2015	2016	2017
Inorganic fertilizers (kg N)	7.138	8.319	7.051	6.693	7.533	8.073	7.841

Organic N fertilizers - Animal Manure applied to soils (3D1.2a)

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 5.17. 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 5.23. 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 default emission factor for N₂O emissions from N inputs EF1 (0.01 kg N₂O-N/kg N) as recommended by the 2006 IPCC Guidelines (table 11.1, pg.11.11, vol.4) and converted to N₂O by multiplication with 44/28.

Table 5.20. Default values for nitrogen loss due to volatilisation of NH₃ 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%
	Anaerobic digestion	60%
Non-dairy cattle	Solid storage	50%
	Anaerobic digestion	60%
Market swine	Anaerobic digestion	52%
	Aerobic treatment	52%
Breeding swine	Anaerobic digestion	52%
	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 5.21. Volatilisation N-losses (kg N)

	1990	1991	1992	1993	1994	1995	1996
Volatilisation N-losses (kg N)	11816	11887	12206	12701	12684	13097	13657

	1997	1998	1999	2000	2001	2002	2003

⁵⁰ George Theophanous, Agriculture Officer, Department of Agriculture (tel. +357 22464028, gtheophanous@da.moa.gov.cy) – Fertilizer Control Board

Volatilisation N-losses (kg N)	14494	14635	14761	15437	17024	17955	16813
	2004	2005	2006	2007	2008	2009	2010
Volatilisation N-losses (kg N)	16162	14897	14965	15598	14525	14153	14891
	2011	2012	2013	2014	2015	2016	2017
Volatilisation N-losses (kg N)	14735	13989	12844	12701	12605	13109	13614

Organic N fertilizers - Sewage sludge applied to soils (3D1.2b)

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 Environment⁵¹. 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 5.24. Information on population connected to UWWS (%) on which the estimation on 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.

Nitrogen content per kg dry sludge was assumed 3% for all years and was obtained from S. Perikenti⁵². The resulting nitrogen in sewage sludge applied on land is presented in Table 5.24. The fraction of N input converted to N₂O (EF6) is assumed 0.01 kg N₂O-N/kg sewage-N produced, as proposed by the IPCC guidelines.

Table 5.22. Dry sludge applied to soils and nitrogen in sewage sludge (kg)

	1990	1991	1992	1993	1994	1995
Dry sludge (kg)	517390	583589	704000	748000	737000	891000
Nitrogen in sewage sludge (kg)	15522	17508	21120	22440	22110	26730
	1996	1997	1998	1999	2000	2001
Dry sludge (kg)	1232000	1320000	1408000	1463000	1573000	1749000
Nitrogen in sewage sludge (kg)	36960	39600	42240	43890	47190	52470
	2002	2003	2004	2005	2006	2007
Dry sludge (kg)	2013000	2530000	3135000	3427000	3116000	5745000
Nitrogen in sewage sludge (kg)	60390	75900	94050	102810	93480	172350
	2008	2009	2010	2011	2012	2013
Dry sludge (kg)	6515000	7903000	5294000	3912000	2756000	2924000
Nitrogen in sewage sludge (kg)	195450	237090	158820	117360	82680	87720
	2014	2015	2016	2017		
Dry sludge (kg)	1391000	936000	1613100	1613100		
Nitrogen in sewage sludge (kg)	41730	28080	48393	48393		

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 demand for application on land.⁵³ Nevertheless to exclude the possibility of underestimating

⁵¹ 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

⁵² Environment Officer responsible for sewage treatment plants, email dated 18/10/2013

⁵³ 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)

emissions, for the purposes of estimation of emissions from this source, it was assumed that all compost produced from waste management activities is consumed in-country by agriculture. Data on composting in Cyprus has been first collected in 2010 (Table 5.25). 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: 96% dry matter and 1.0187 % N . N₂O emissions are estimated by multiplying the calculated N_{comp} by EF₁ (0.01 default, table 11.1, pg. 11.11, vol.4, 2006 IPCC guidelines) and then by 44/28.

Table 5.23. Activity data used for the calculation of N₂O emissions from Other organic fertilizers applied to soils (3D1.2c)

	2010	2011	2012	2013	2014
TOTAL composting (1000t wet mass)	7.89	14.95	22.98	19.62	29.58
wet compost (kg)	7890000	14950000	22980000	19620000	29580000
Dry compost (kg)	3156000	5980000	9192000	7848000	11832000
N COMP (kg N)	34306	65003	99917	85308	128614
	2015	2016	2017		
TOTAL composting (1000t wet mass)	43.86	43.49	36.52		
wet compost (kg)	43860000	43490000	36520000		
Dry compost (kg)	17544000	17396000	14608000		
N COMP (kg N)	190703	189095	158789		

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 or an assumption on the population grazing⁵⁴.

Crop residues (3D1.4)

The term FCR refers to the amount of N in crop residues (above-ground and below-ground), including N-fixing crops, returned to soils annually. It is estimated from crop yield statistics and default factors for above-/belowground 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 5.24). Crop yield is estimated by dividing the crop production by the area; the results are tabulated in Table 5.24. Harvested annual dry matter yield per crop (Crop(T)) is estimated by multiplying the 2006 IPCC Guidelines default dry matter fraction (DRY) (Table 5.25 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 5.25 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 5.24.

FracBURN (kg N/kg crop-N) shown in Table 5.26, is considered as default for developing countries in 1990 (0.25) linearly declined to default for developed (0.1) in 2008. After that year, this factor has been kept constant. This assumption was based on general knowledge of the sector and in 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 there is illegal burning of agricultural residues taking place, based on observations in the field. There are no statistics on this type of fires. No details are

⁵⁴ Personal communication with Dr. Petros Mavromatis (22/11/2017), head of sheep and goat farming division, Department of Agriculture (tel. +357 22408555, pmavromatis@da.moa.gov.cy)

available to support any deviation from the 10% default.

The resulting estimations of area burnt are presented in Table 5.24. For the calculation of FCR, FracRenewT and FracRemoveT are assumed 1 and 0 respectively according to defaults proposed by 2006 Guidelines (pg.11.14, vol.4).

Due to 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 5.27. 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 Omirou⁵⁵. 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.

N₂O 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.

Table 5.24. 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
Crop production (t/yr)						
Wheat	10400	5600	10500	11700	8000	12297
Barley	98000	59500	171000	193000	154000	133818
Oats	100	80	145	100	150	174
Beans & pulses (legumes)	3505	3000	3629	3607	3157	3992
Potatoes (tubers)	185900	179650	195400	199000	135000	207699
Cultivated area (ha)						
Wheat	5100	4900	5000	5000	3300	3500
Barley	52330	43790	60000	64000	60000	57500
Oats	100	100	110	140	200	220
Beans & pulses (legumes)	1350	1173	1145	1103	810	1039
Potatoes (tubers)	8000	8690	9625	8080	7500	8313
Crop yield (YieldFresh), kg/ha						
Wheat	2039	1143	2100	2340	2424	3514
Barley	1873	1359	2850	3016	2567	2327
Oats	1000	800	1318	714	750	792
Beans & pulses (legumes)	2596	2558	3169	3270	3898	3842
Potatoes (tubers)	23238	20673	20301	24629	18000	24986
CropT (kg dm/ha)						
Wheat	1815	1017	1869	2083	2158	3127
Barley	1667	1209	2537	2684	2284	2071
Oats	890	712	1173	636	668	705
Beans & pulses (legumes)	2363	2327	2884	2976	3547	3496
Potatoes (tubers)	5112	4548	4466	5418	3960	5497
above ground residue dry matter AGDM _T (kg/ha)						
Wheat	2741	1536	2823	3145	3258	4722
Barley	1634	1186	2486	2631	2239	2030
Oats	811	649	1068	579	608	642
Beans & pulses (legumes)	2671	2631	3260	3364	4009	3952
Potatoes (tubers)	512	456	448	543	397	551
Area Burnt (ha/yr)						
Wheat	1275	1184	1167	1125	715	729
Barley	13083	10583	14000	14400	13000	11979
Oats	25	24	26	32	43	46

⁵⁵ personal Communication 16/11/2017 Dr. Michalis Omirou, Agricultural Research Officer, Agricultural Research Institute (Tel. +357-22403146, michalis.omirou@ari.gov.cy)

Beans & pulses (legumes)	338	283	267	248	176	216
Potatoes (tubers)	2000	2100	2246	1818	1625	1732
FCR (kg N/yr)						
Wheat	80498	43770	82845	93187	64317	99783
Barley	674235	413301	1198813	1365700	1099865	964526
Oats	580	468	856	596	903	1058
Beans & pulses (legumes)	30322	26049	31625	31549	27713	35171
Potatoes (tubers)	173144	167960	183362	187395	127630	197017
TOTAL	958778	651547	1497502	1678428	1320428	1297555
	1996	1997	1998	1999	2000	2001
Crop production (t/yr)						
Wheat	13000	11500	11500	14000	10000	10500
Barley	128000	36000	54000	112700	37600	116500
Oats	190	280	320	400	350	380
Beans & pulses (legumes)	3700	3558	3684	3764	3308	3383
Potatoes (tubers)	228000	81500	138092	161500	117000	121000
Cultivated area (ha)						
Wheat	3700	5250	5800	6600	6150	5400
Barley	55000	37500	53000	52000	45000	50200
Oats	240	270	290	340	330	370
Beans & pulses (legumes)	857	890	893	913	832	832
Potatoes (tubers)	9125	7000	7500	6800	6500	5715
Crop yield (YieldFresh), kg/ha						
Wheat	3514	2190	1983	2121	1626	1944
Barley	2327	960	1019	2167	836	2321
Oats	792	1037	1103	1176	1061	1027
Beans & pulses (legumes)	4317	3998	4125	4123	3976	4066
Potatoes (tubers)	24986	11643	18412	23750	18000	21172
CropT (kg dm/ha)						
Wheat	3127	1950	1765	1888	1447	1731
Barley	2071	854	907	1929	744	2065
Oats	705	923	982	1047	944	914
Beans & pulses (legumes)	3929	3638	3754	3752	3618	3700
Potatoes (tubers)	5497	2561	4051	5225	3960	4658
above ground residue dry matter AGDM_T (kg/ha)						
Wheat	4722	2944	2665	2851	2186	2614
Barley	2030	838	889	1891	729	2025
Oats	642	841	895	954	860	833
Beans & pulses (legumes)	4440	4112	4243	4240	4089	4182
Potatoes (tubers)	551	257	406	524	397	467
Area Burnt (ha/yr)						
Wheat	740	1006	1063	1155	1025	855
Barley	11000	7188	9717	9100	7500	7948
Oats	48	52	53	60	55	59
Beans & pulses (legumes)	171	171	164	160	139	132
Potatoes (tubers)	1825	1342	1375	1190	1083	905
FCR (kg N/yr)						
Wheat	106458	95041	95904	117800	84896	89924
Barley	930991	264279	399952	841909	283450	885574
Oats	1165	1731	1996	2517	2222	2434
Beans & pulses (legumes)	32716	31575	32811	33644	29675	30456
Potatoes (tubers)	217061	77940	132456	155429	113035	117298
TOTAL	1288391	470567	663120	1151299	513277	1125686
	2002	2003	2004	2005	2006	2007
Crop production (t/yr)						
Wheat	12900	14280	9930	9249	7520	10712

Barley	128400	150000	100990	60286	58372	52007
Oats	500	410	490	650	943	814
Beans & pulses (legumes)	3358	2410	3280	3291	3348	3318
Potatoes (tubers)	148500	127500	131650	152500	127500	155500
Cultivated area (ha)						
Wheat	5900	7225	7450	5264	5389	5287
Barley	51300	65007	58448	52517	48914	34019
Oats	400	513	808	4368	4919	4250
Beans & pulses (legumes)	847	834	808	796	855	737
Potatoes (tubers)	5700	5511	5380	6190	4290	6290
Crop yield (YieldFresh), kg/ha						
Wheat	2186	1976	1333	1757	1395	2026
Barley	2503	2307	1728	1148	1193	1529
Oats	1250	799	606	149	192	192
Beans & pulses (legumes)	3965	2890	4059	4134	3916	4502
Potatoes (tubers)	26053	23136	24470	24637	29720	24722
CropT (kg dm/ha)						
Wheat	1946	1759	1186	1564	1242	1803
Barley	2228	2054	1538	1022	1062	1361
Oats	1113	711	540	132	171	170
Beans & pulses (legumes)	3608	2630	3694	3762	3563	4097
Potatoes (tubers)	5732	5090	5383	5420	6538	5439
above ground residue dry matter AGDM_T (kg/ha)						
Wheat	2939	2657	1792	2362	1876	2723
Barley	2184	2013	1508	1002	1041	1334
Oats	1013	648	492	121	156	156
Beans & pulses (legumes)	4078	2972	4175	4252	4027	4630
Potatoes (tubers)	574	510	539	543	655	545
Area Burnt (ha/yr)						
Wheat	885	1024	993	658	629	573
Barley	7695	9209	7793	6565	5707	3685
Oats	60	73	108	546	574	460
Beans & pulses (legumes)	127	118	108	100	100	80
Potatoes (tubers)	855	781	717	774	501	681
FCR (kg N/yr)						
Wheat	111442	124436	87280	81983	67223	96553
Barley	984444	1159913	787612	474186	462956	415852
Oats	3230	2672	3221	4328	6323	5503
Beans & pulses (legumes)	30338	21852	29844	30049	30677	30508
Potatoes (tubers)	144444	124469	128969	149919	125765	153941
TOTAL	1273898	1433342	1036926	740465	692944	702357
	2008	2009	2010	2011	2012	2013
Crop production (t/yr)						
Wheat	24720	14690	18890	23740	22923	15180
Barley	34960	40092	46060	45720	48100	36010
Oats	373	2040	780	740	800	740
Beans & pulses (legumes)	3312	3312	4319	3690	4374	4263
Potatoes (tubers)	115000	112500	82000	126080	82200	105480
Cultivated area (ha)						
Wheat	4990	5761	7560	10590	8550	6920
Barley	30680	22444	25970	24954	28853	23530
Oats	3034	2950	510	369	419	310
Beans & pulses (legumes)	554	596	507	548	694	583
Potatoes (tubers)	5110	4970	4260	5070	4550	4640
Crop yield (YieldFresh), kg/ha						
Wheat	4954	2550	2499	2242	2681	2194
Barley	1140	1786	1774	1832	1667	1530

Oats	123	692	1529	2005	1909	2387
Beans & pulses (legumes)	5978	5557	8519	6734	6303	7312
Potatoes (tubers)	22505	22636	19249	24868	18066	22733
CropT (kg dm/ha)						
Wheat	4409	2269	2224	1995	2386	1952
Barley	1014	1590	1578	1631	1484	1362
Oats	109	615	1361	1785	1699	2125
Beans & pulses (legumes)	5440	5057	7752	6128	5735	6654
Potatoes (tubers)	4951	4980	4235	5471	3975	5001
above ground residue dry matter AGDM_T (kg/ha)						
Wheat	6658	3427	3358	3013	3604	2949
Barley	994	1559	1548	1599	1455	1335
Oats	100	561	1240	1625	1547	1934
Beans & pulses (legumes)	6148	5715	8761	6925	6482	7520
Potatoes (tubers)	496	499	425	548	399	501
Area Burnt (ha/yr)						
Wheat	499	576	756	1059	855	692
Barley	3068	2244	2597	2495	2885	2353
Oats	303	295	51	37	42	31
Beans & pulses (legumes)	55	60	51	55	69	58
Potatoes (tubers)	511	497	426	507	455	464
FCR (kg N/yr)						
Wheat	224647	133506	171676	215757	208327	137961
Barley	281867	323196	371307	368563	387759	290302
Oats	2549	13861	5296	5024	5431	5024
Beans & pulses (legumes)	30558	30558	39847	34045	40356	39331
Potatoes (tubers)	114252	111768	81479	125250	81683	104793
TOTAL	653872	612888	669605	748639	723556	577412

	2014	2015	2016	2017		
Crop production (t/yr)						
Wheat	4440	35360	6902	16592		
Barley	2720	52180	2907	18754		
Oats	200	600	352	248		
Beans & pulses (legumes)	4205	4899	4000	4145		
Potatoes (tubers)	117500	95920	122803	111410		
Cultivated area (ha)						
Wheat	6140	11970	8386	8678		
Barley	18940	20560	14536	10953		
Oats	230	320	367	490		
Beans & pulses (legumes)	639	715	498	493		
Potatoes (tubers)	4910	4740	5041	4440		
Crop yield (YieldFresh), kg/ha						
Wheat	723	2954	823	1912		
Barley	144	2538	200	1712		
Oats	870	1875	959	506		
Beans & pulses (legumes)	6581	6852	8032	8408		
Potatoes (tubers)	23931	20236	24361	25092		
CropT (kg dm/ha)						
Wheat	644	2629	733	1702		
Barley	128	2259	178	1524		
Oats	774	1669	854	450		
Beans & pulses (legumes)	5988	6235	7309	7651		
Potatoes (tubers)	5265	4452	5359	5520		
above ground residue dry matter AGDM_T (kg/ha)						
Wheat	972	3970	1107	2570		
Barley	126	2214	175	1494		
Oats	705	1519	778	411		

Beans & pulses (legumes)	6768	7047	8260	8646		
Potatoes (tubers)	528	446	537	553		
Area Burnt (ha/yr)						
Wheat	614	1197	839	868		
Barley	1894	2056	1454	1095		
Oats	23	32	37	49		
Beans & pulses (legumes)	64	72	50	49		
Potatoes (tubers)	491	474	504	444		
FCR (kg N/yr)						
Wheat	40364	321353	62743	150797		
Barley	21992	420609	23483	151184		
Oats	1359	4074	2391	1686		
Beans & pulses (legumes)	38796	45199	36904	38242		
Potatoes (tubers)	116730	95306	121997	110676		
TOTAL	219241	886540	247517	452585		

Table 5.25. 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 5.26. 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 5.27. Cf

Crop	Cf	source
Wheat	0.90	default - table 2.6, pg.2.49, vol.4, IPCC2006
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)

Not occurring

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

(a) 3D1.2a. Animal Manure applied to soils: change of fraction of N-loss according to a mistake identified during the EU 2018 review

Table 5.28. 3D1.2a. Animal Manure applied to soils recalculations

Nex (kg N excreted)	1990	1991	1992	1993	1994
2018 submission	11252091	11299406	11582112	12032117	11978511
2019 submission	11816302	11887345	12206187	12701155	12683570
Gg N2O					
2018 submission	0.1768	0.1776	0.1820	0.1891	0.1882
2019 submission	0.1857	0.1868	0.1918	0.1996	0.1993
change in emissions	5.0%	5.2%	5.4%	5.6%	5.9%
Nex (kg N excreted)	1995	1996	1997	1998	1999
2018 submission	12347945	12940487	13802580	13972845	14103582
2019 submission	13096709	13657459	14493808	14635048	14760648
Gg N2O					
2018 submission	0.1940	0.2034	0.2169	0.2196	0.2216
2019 submission	0.2058	0.2146	0.2278	0.2300	0.2320
change in emissions	6.1%	5.5%	5.0%	4.7%	4.7%
Nex (kg N excreted)	2000	2001	2002	2003	2004
2018 submission	14787418	16339082	17218782	16070691	15440411
2019 submission	15437068	17024258	17955384	16812724	16162320
Gg N2O					
2018 submission	0.2324	0.2568	0.2706	0.2525	0.2426
2019 submission	0.2426	0.2675	0.2822	0.2642	0.2540
change in emissions	4.4%	4.2%	4.3%	4.6%	4.7%
Nex (kg N excreted)	2005	2006	2007	2008	2009
2018 submission	14219691	14290278	14927152	13852194	13490998
2019 submission	14896699	14965260	15597711	14524775	14153265
Gg N2O					
2018 submission	0.2235	0.2246	0.2346	0.2177	0.2120
2019 submission	0.2341	0.2352	0.2451	0.2282	0.2224
change in emissions	4.8%	4.7%	4.5%	4.9%	4.9%
Nex (kg N excreted)	2010	2011	2012	2013	2014
2018 submission	14224695	14070473	13338249	12196538	12041777
2019 submission	14890900	14735248	13989016	12843983	12700642
Gg N2O					
2018 submission	0.2235	0.2211	0.2096	0.1917	0.1892
2019 submission	0.2340	0.2316	0.2198	0.2018	0.1996
change in emissions	4.7%	4.7%	4.9%	5.3%	5.5%
Nex (kg N excreted)	2015	2016			
2018 submission	11925601	12385547			
2019 submission	12604861	13108934			
Gg N2O					
2018 submission	0.1874	0.1946			
2019 submission	0.1981	0.2060			
change in emissions	5.7%	5.8%			

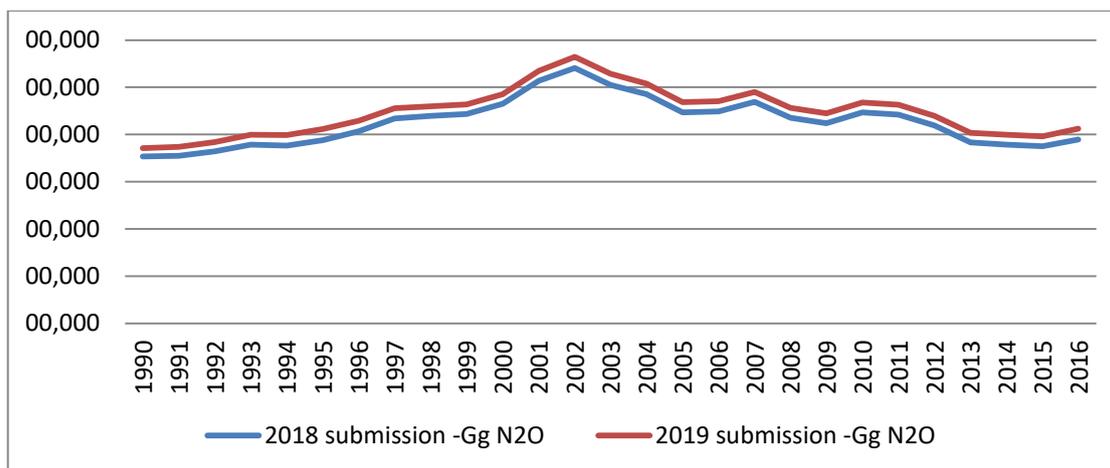


Figure 5.7. 3D1.2a. Animal Manure applied to soils recalculations

(b) 3D1.2b Sewage Sludge applied to soils: new data on sewage applied on land was available in 2018 for the year 2016, which caused the recalculation of the emissions for 2016. The emissions increased from 0.44 t N₂O to 0.76 t N₂O corresponding to an increase of 72%.

5.5.1.5. Category-specific planned improvements

Please refer to [Annex 7](#) for the National Inventory Improvement Plan.

5.5.2. Indirect N₂O emissions from managed soils (3D2)

In addition to the direct emissions of N₂O from managed soils that occur through a direct pathway, emissions of N₂O 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 NH₄⁺ and NO₃⁻ 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 N₂O 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) Tier 1 methodology according to 2006 IPCC Guidelines is applied.

Atmospheric deposition (3D2.1)

The N₂O emissions from atmospheric deposition of N volatilised from managed soil are estimated using 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 NH₃ 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: is 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 5.29.
- 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 grazing⁵⁶
- FracGASM, fraction of applied organic N fertiliser materials (FON) and of urine and dung N deposited by grazing animals (FPRP) that volatilises as NH₃ 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 N₂O emissions from atmospheric deposition of N on soils and water surfaces, kg N–N₂O / kg NH₃–N + NO_x–N volatilized: default of 0.01 as proposed by the 2006 IPCC Guidelines (table 11.3, pg.11.24, vol.4, IPCC2006)

The resulting N₂O(ATD) –N is presented in Table 5.29. N₂O(ATD) –N is converted to N₂O by multiplication with 44/28. Recalculations have been performed for the whole time series caused by the change in Animal manure applied to soils (kgN).

Table 5.29. FON and N₂O(ATD) –N (kg N / yr)

Year	1990	1991	1992	1993	1994	1995
FON	11831824	11904853	12227307	12723595	12705680	13123439
N ₂ O(ATD) –N	36090	35979	39215	41636	39700	46773

Year	1996	1997	1998	1999	2000	2001
FON	13694419	14533408	14677288	14804538	15484258	17076728
N ₂ O(ATD) –N	41017	40193	43956	41170	41506	46512

Year	2002	2003	2004	2005	2006	2007
FON	18015774	16888624	16256370	14999509	15058740	15770061
N ₂ O(ATD) –N	46611	44975	43251	38592	41408	39738

Year	2008	2009	2010	2011	2012	2013
FON	14720225	14390355	15084025	14917611	14171613	13017011
N ₂ O(ATD) –N	36939	36455	39537	36973	36662	33085

Year	2014	2015	2016	2017		
FON	12870986	12823644	13346421	13821529		
N ₂ O(ATD) –N	32435	33180	34766	35484		

Leaching/Runoff (3D2.2)

The N₂O 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: is 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 5.29.
- 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

⁵⁶ 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)

grazing, however no information is available to make an estimation or an assumption on the population grazing⁵⁷

- 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: not occurring in Cyprus therefore 0
- 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. Theophanous⁵⁸) and leaching is unlikely to occur;
- EF5, emission factor for N₂O emissions from N leaching and runoff, kg N₂O–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, IPCC2006)

N₂O_L–N is converted to N₂O 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

Animal manure applied to soils (kgN) has been revised therefore FON and the respective emissions have been recalculated.

Table 5.30. Atmospheric deposition (3D2.1) recalculations

	1990	1991	1992	1993	1994	1995	1996
2018 submission	0.0549	0.0547	0.0597	0.0633	0.0602	0.0711	0.0622
2019 submission	0.0567	0.0565	0.0616	0.0654	0.0624	0.0735	0.0645
change in emissions	3%	3%	3%	3%	4%	3%	4%
	1997	1998	1999	2000	2001	2002	2003
2018 submission	0.0610	0.0670	0.0626	0.0632	0.0709	0.0709	0.0683
2019 submission	0.0632	0.0691	0.0647	0.0652	0.0731	0.0732	0.0707
change in emissions	4%	3%	3%	3%	3%	3%	3%
	2004	2005	2006	2007	2008	2009	2010
2018 submission	0.0657	0.0585	0.0629	0.0603	0.0559	0.0552	0.0600
2019 submission	0.0680	0.0606	0.0651	0.0624	0.0580	0.0573	0.0621
change in emissions	3%	4%	3%	3%	4%	4%	3%
	2011	2012	2013	2014	2015	2016	
2018 submission	0.0560	0.0556	0.0500	0.0489	0.0500	0.0523	
2019 submission	0.0581	0.0576	0.0520	0.0510	0.0521	0.0546	
change in emissions	4%	4%	4%	4%	4%	4%	

⁵⁷ 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)

⁵⁸ 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)

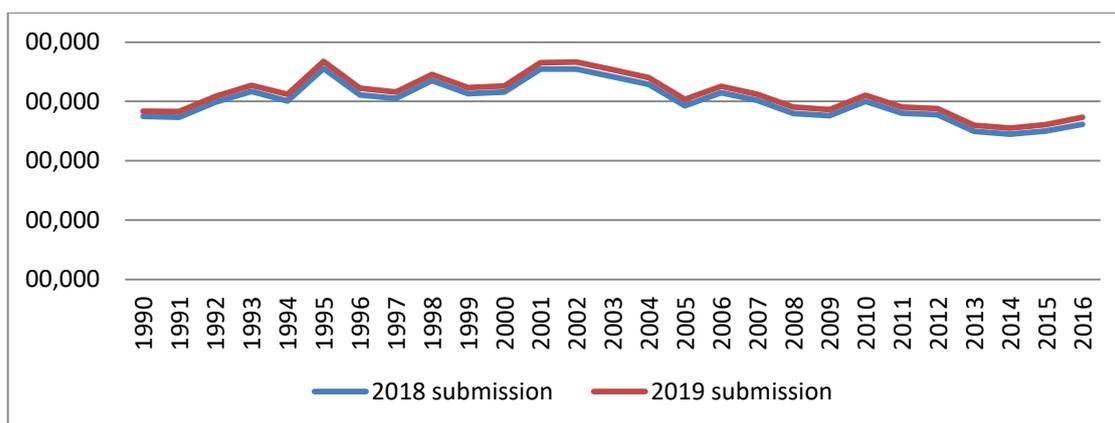


Figure 5.8. Atmospheric deposition (3D2.1) recalculations

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 (CO₂) 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 CH₄, CO, NO_x, and N₂O. This section accounts for emissions of these non-CO₂ 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 1990-2017 are presented in Table 5.31 and Figure 5.9.

Table 5.31. Field burning of agricultural residues emissions, 1990-2017

Gg CO ₂ eq.	1990	2000	2005	2010	2015	2016	2017
3F	2.03	0.65	0.68	0.55	0.76	0.12	0.33
3.F.1 Cereals	1.96	0.61	0.65	0.53	0.74	0.10	0.31
3.F.2 Pulses	0.032	0.020	0.015	0.016	0.018	0.015	0.015
3.F.3 Tubers and Roots	0.036	0.015	0.015	0.006	0.007	0.010	0.09
CH ₄ (t)	62.0	19.7	20.7	16.7	23.3	3.7	10.1
N ₂ O (t)	1.61	0.51	0.54	0.43	0.61	0.09	0.24
Total (Gg CO₂ eq.)	2.03	0.65	0.68	0.55	0.76	0.12	0.33

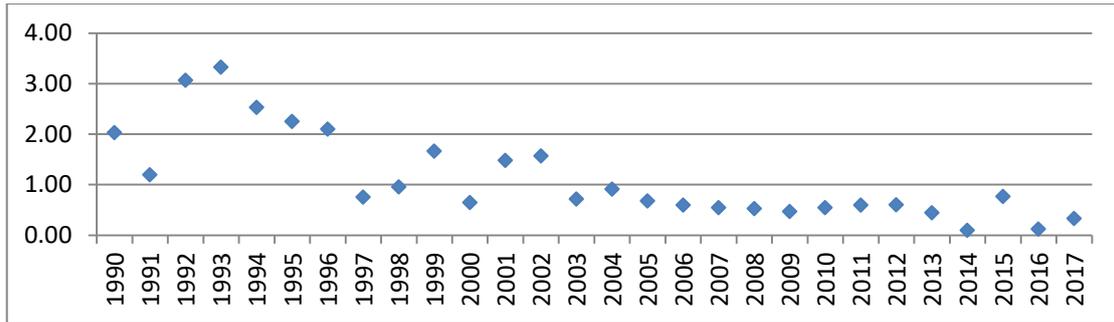


Figure 5.9. Field burning of agricultural residues emissions, 1990-2017 (Gg CO2 eq.)

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 5.24
- M_B , mass of fuel available for combustion, tonnes/ha: data already presented in Table 5.24 (above ground residue dry matter AGDM_T)
- C_f , combustion factor, dimensionless: data already presented in Table 5.27
- G_{ef} , emission factor, g/ kg dry matter burnt: 2.7 g CH4/kg DM burnt, 0.07 g N2O/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, CO2 emissions do not need to be estimated and reported, because it is assumed that annual CO2 removals (through growth) and emissions (whether by decay or fire) by biomass are in balance.

Recalculations have occurred due to revision of the C_f and corrections in the method applied (t dry mass ($M_B \cdot C_f$) in 2017 submission was estimated using the default available dry biomass for combustion recommended by 2006 IPCC Guidelines (vol.4, pg.2.46, table 2.4), whereas in 2018 submission the above ground residue dry matter AGDM_T is used as M_B).

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

No recalculations to be reported.

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 based on the World Reference Base of Food and Agriculture Organization of the United Nations soil classification system⁵⁹, that all have pH of 7 or above. Additionally according to

⁵⁹ 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;

information provided by the Department of Agriculture⁶⁰ 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 CO₂ that was fixed in the industrial production process. Urea (CO(NH₂)₂) is converted into ammonium (NH₄⁺), hydroxyl ion (OH⁻), and bicarbonate (HCO₃⁻), in the presence of water and urease enzymes. Similar to the soil reaction following addition of lime, bicarbonate that is formed evolves into CO₂ and water. This source category is included because the CO₂ 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 Tier 1 approach. Total emissions from urea application for the period 1990-2017 are presented in Table 5.32 and Figure 33.

Table 5.32. Urea application emissions, 1990-2017

	1990	2000	2005	2010	2015	2016	2017
Urea application (Gg CO ₂)	1.82	1.67	0.97	0.74	0.40	0.39	0.42

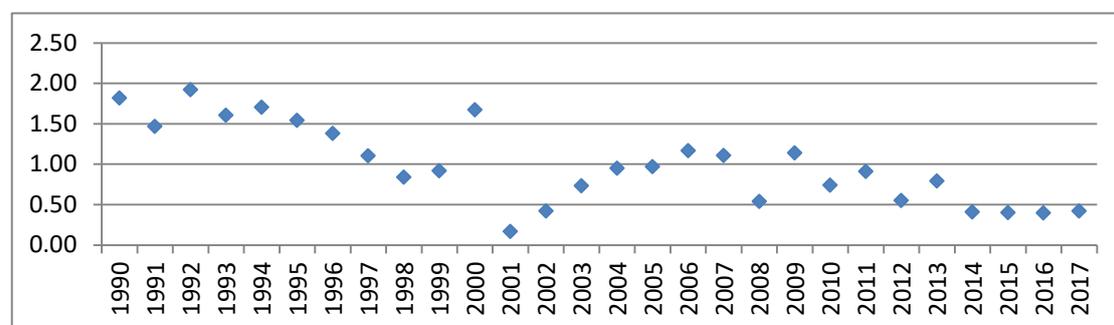


Figure 5.10. Urea application emissions, 1990-2017 (Gg CO₂ eq.)

5.5.6.1. Methodological issues

The steps for estimating CO₂-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 Agriculture⁶¹ (Table 5.33). Activity data is based on the 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(NH₂)₂).

Step 3: Estimate the total CO₂-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 CO₂-C emission estimated in presented in Table 5.33.

Step 4: Multiply by 44/12 to convert CO₂-C emissions into CO₂.

Table 5.33. Urea consumption in Cyprus (t) and total CO₂-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

Deliverable D15, D16. The Cyprus Institute, Nicosia, 15 p.

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⁶¹ George Theophanous, Agriculture Officer, Department of Agriculture (tel. +357 22464028, gtheophanous@da.moa.gov.cy) – Fertilizer Control Board

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				
Urea consumption (t)	555	543	538	570				
CO ₂ -C emission (tC/yr)	111	109	108	114				

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 be reported.

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 U.N. Experts 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 calculations will be included in this report, even though, the activity data is available for the whole of the country.

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., changes both from and to a category) but without spatially-explicit location data. The final result of this Approach is presented as a non-spatially explicit land-use conversion matrixes covering the period 1990 until the currently reported year.

Land use data for Cyprus are sourced from the CORINE land cover (CLC) inventory⁶² data (for details see Chapter 6.2.3). Three CORINE data sets covering the years 2000, 2006 and 2012 were included in the preparation of this NIR. In order to retain consistency among GHG estimates reported for different years the total land area for 2000 and 2006 was adjusted using a proportional approach to the area covered by the 2012 CORINE data set. The adjusted data allowed for establishment of two land use matrixes 2000 – 2006 and 2006 - 2012. Both matrixes were linearly interpolated/ extrapolated to obtain annual land use change data for all individual years within these periods. The 2000 – 2006 annual land use change data were extrapolated backwards to obtain annual land use change data for the period 1990 – 2000 (due to lack of measured data, it was assumed that for all reported lands the pre-1990 land uses were not different from the land use in 1990). The 2006 – 2012 annual land use change data were extrapolated forwards to obtain annual land use change data for the period 2012 to the reported year. The latter extrapolated data will be replaced/ supplemented by the measured data if acquired in the future.

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 the 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.

⁶² <http://land.copernicus.eu/pan-european/corine-land-cover/view>

6.1.2. Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The IPCC 2006 identifies 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 IPCC 2006 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 2015⁶³: 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:

(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 according to the Forest National Law of 2012 (25 (I)/2012) are considered as forest trees.

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.

⁶³ Forest Data Reporting Package for 2015, FAO, page 12, Table 1.2.1 Data sources.

The cropland is further divided into two subcategories: annual cropland and woody 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 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 unchanged among the reported years.

Table 6.1 presents the implementation of the CORINE land cover (CLC) inventory⁶⁴ data to land categorization approach based on the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Table 6.1. The correspondence between the CORINE land cover categories identified in Cyprus and the IPCC 2006 six broad land-use categories as implemented in the Cyprus conditions.

LULUCF Land-Use Categories	CORINE land cover	CLC code
Broadleaved Forest	Broad leaved forest	311
Coniferous Forest	Coniferous forest	312
Coniferous Forest	Mixed forest	313
Coniferous Forest	Transitional woodland/shrub	324
Woody CL	Vineyards	221
Woody CL	Fruit trees and berry plantations	222
Woody CL	Olive groves	223
Woody CL	Complex cultivation	242
Woody CL	Land principally occupied by agriculture, with significant areas of natural vegetation	243
Annual CL	Non-irrigated arable land	211
Annual CL	Permanently irrigated land	212
Annual CL	Annual crops associated with permanent crops	241
Woody GL	Sclerophyllous vegetation	323
Grass GL	Pastures	231
Grass GL	Natural grassland	321
Grass GL	Scarcely vegetated areas	333
SL	Continuous urban fabric	111

⁶⁴ <http://land.copernicus.eu/pan-european/corine-land-cover/view>

LULUCF Land-Use Categories	CORINE land cover	CLC code
SL	Discontinuous urban fabric	112
SL	Industrial or commercial units	121
SL	Road and rail networks and associated land	122
SL	Port areas	123
SL	Airports	124
SL	Mineral extraction sites	131
SL	Dump sites	132
SL	Construction sites	133
SL	Green urban areas	141
SL	Sport and leisure facilities	142
WL	Inland marshes	411
WL	Salt marshes	421
WL	Water courses	511
WL	Water bodies	512
OL	Beaches, dunes and sand plains	331
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 land areas may be classified by these categories in a unique way without duplication.

All lands subject to the effective control of the Republic of Cyprus are considered as managed.

Table 6.2 presents the areas of the IPCC 2006 land-use sub/categories based on the raw data from the CORINE annual land use data set (k ha).

Table 6.2. The IPCC 2006 land-use sub/categories data based on the raw data from the CORINE annual land use data set (k ha). Resolution for detection of individual land uses is 25 ha. The data refer to the areas under the effective control of the Cyprus Government (Managed Lands).

	Year 2000	Year 2006	Year 2012
	k ha	k ha	k ha
Managed Lands			
Broadleaved Forest	0.763	0.608	0.608
Coniferous Forest	154.720	158.204	158.252
Annual Cropland	124.182	121.845	121.507
Woody Cropland	126.103	128.095	127.083
Grass Grassland	26.444	23.725	23.395
Woody Grassland	112.921	107.504	107.453
Wetland	3.382	3.864	3.968
Settlements Land	48.460	54.319	55.898
Other Land	4.821	3.633	3.632
Total Managed Land Area (k ha)	601.796	601.796	601.796
Unmanaged Lands			
All categories	322.348	322.348	322.348
Total Land Area (k ha)	<u>924.144</u>	<u>924.144</u>	<u>924.144</u>

6.1.3. GHG emissions and removals by LULUCF categories

Emissions (-) and removals (+) from Sector 4 LULUCF by sub-categories are presented in Table 6.3. Note that the emission/removal data for harvested wood products (HWP) are included in the estimates

for Forest Land (includes Forest Land remaining Forest Land and Land converted to Forest Land) hence, the column HWP is provided for information only.

Table 6.3. Emissions and removals (+/-) from Sector 4 LULUCF by sub-categories (k t CO₂ eq).

Year	Total	FL	CL	GL	WL	SL	OL	HWP
1990	-251.2	-77.7	-138.9	-134.1	-1.0	1.8	95.5	3.3
1991	-247.5	-82.9	-138.5	-133.1	-1.0	1.8	95.5	10.8
1992	-255.1	-90.0	-141.1	-132.2	-2.0	3.3	95.5	11.4
1993	-271.6	-92.8	-143.7	-131.2	-3.1	4.8	95.5	-1.1
1994	-256.0	-80.1	-146.3	-130.2	-4.1	6.3	95.5	2.9
1995	-277.0	-100.8	-148.9	-129.2	-5.1	7.8	95.5	3.8
1996	-284.6	-105.6	-151.5	-128.2	-6.1	9.3	95.5	2.1
1997	-254.8	-84.2	-154.1	-127.2	-7.2	10.8	95.5	11.6
1998	-180.4	-1.7	-156.7	-126.2	-8.2	12.3	95.5	4.7
1999	-358.7	-176.4	-159.4	-125.2	-9.2	13.8	95.5	2.1
2000	69.0	237.3	-162.0	-124.2	-10.2	15.3	95.5	17.3
2001	-186.4	-24.8	-164.6	-123.2	-11.3	16.8	95.6	25.1
2002	-337.5	-176.0	-167.2	-122.2	-12.3	18.3	95.6	26.4
2003	-352.0	-189.9	-169.8	-121.2	-13.3	19.7	95.6	26.9
2004	-347.3	-184.3	-172.4	-120.2	-14.3	21.2	95.6	27.1
2005	-377.0	-212.8	-175.0	-119.2	-15.4	22.7	95.6	27.1
2006	-452.2	-195.6	-174.0	-123.1	-15.4	23.0	6.4	26.5
2007	-208.3	53.6	-173.8	-123.3	-15.6	23.5	6.4	20.9
2008	-512.0	-249.3	-173.6	-123.4	-15.7	24.0	6.4	19.5
2009	-541.6	-285.6	-173.4	-123.5	-15.9	24.5	6.4	25.9
2010	-488.5	-233.4	-173.2	-123.7	-16.0	25.0	6.5	26.4
2011	-565.0	-312.1	-170.8	-123.8	-15.2	24.0	6.5	26.4
2012	-544.7	-293.7	-168.3	-123.9	-14.3	23.0	6.5	26.1
2013	-579.7	-330.8	-165.9	-124.1	-13.4	22.0	6.5	25.9
2014	-577.0	-329.5	-163.5	-124.2	-12.5	21.1	6.5	25.2
2015	-572.5	-327.1	-161.0	-124.3	-11.6	20.1	6.5	25.0
2016	75.8	318.3	-158.6	-124.5	-10.8	20.1	6.5	24.7
2017	-534.0	-294.3	-156.2	-124.6	-9.9	20.1	6.5	24.3

6.1.4. Emission Trends

The total LULUCF sector represents GHG sink during the entire period 1990 – 2017. The sink has an increasing tendency; however, in years of exceptional extent of forest fires (2000, 2007 and 2016) the tendency is visibly broken (see Figure 6. 1). Overall the sink in the total LULUCF increases from - 251.2 kt CO₂ eq. in 1990 to -534.0 kt CO₂ eq. in 2017 but drops (emissions) due to forest fires to 75.8 kt CO₂ eq. in 2016.

The Cropland remaining Cropland, Land converted to Cropland Forest, Grassland remaining Grassland and Land converted to Grassland categories are all sinks over the entire period 1990 – 2017. National data on these categories are limited to area only hence, all emission/removal factors used in calculations of the GHG sources/sinks estimates are default data of unknown error.

The Forest Land remaining Forest Land and Land converted to Forest Land categories are important contributors to the sink in the LULUCF sector. The categories represent sink for all years except years when forest fires affect significantly great areas.

The Wetlands remaining Wetlands and Lands converted to Wetlands represent minor sink, while Settlements and Lands converted to Settlements represent minor source, during the entire period 1990 – 2017.

The Other Land remaining Other Land and Land converted to Other Land categories represent GHG source during the entire period 1990 – 2017. The source is significant until 2005 and then decreases to a minor value.

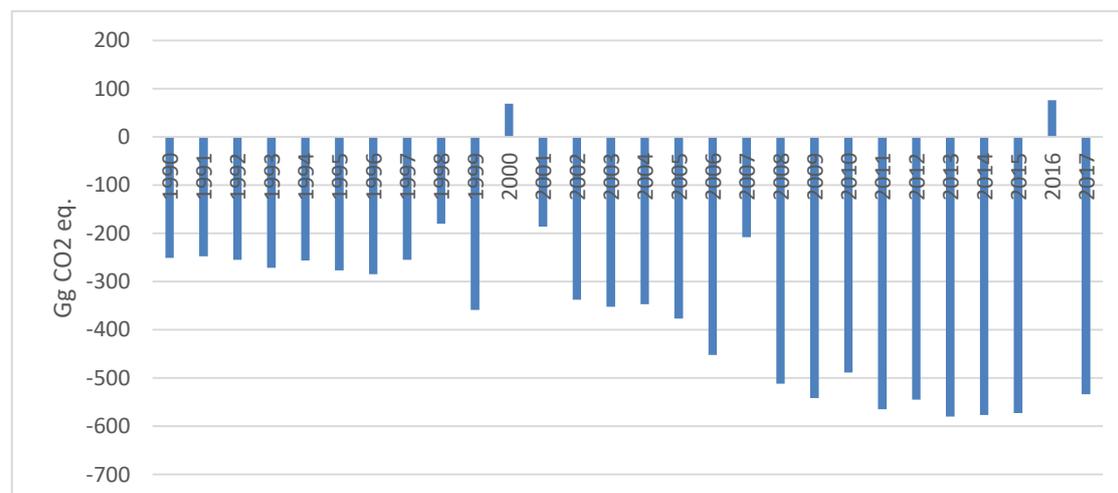


Figure 6.1. Removal (-) trend for the entire LULUCF sector in the period 1990 – 2017

6.2. Forest Land (4A)

6.2.1. Description

Area and ownership of Cyprus forest

The total area of State forests (high forests) is about 172,700 ha and forest occupies the 11,57% of the total area of Cyprus. An area of about 139,053 ha or 80,46% of the total State forest area is situated in the area under the control of the Government whilst the remaining 19,54% is found in the area of Cyprus beyond the control of the Government. According to the 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 (*Cyprinus 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

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 presents data on land converted to/remaining in the Broadleaved Forest subcategory. Note that this subcategory does not contain any land converted to it.

Table 6.4. Data on area of land remaining in the same land use subcategory (from Broadleaved Forest to Broadleaved Forest) and areas of land converted to Broadleaved Forest subcategory from other land use sub/categories.

Year	Land converted to Broadleaved Forest from:								Total area k ha
	Broadl. Forest	Conif. Forest	Annual CL	Woody CL	Grass GL	Woody GL	Settle-ments	Other Land	
	k ha	k ha	k ha	k ha	k ha	k ha	k ha	k ha	
1990	1.022	0	0	0	0	0	0	0	1.022
1991	0.996	0	0	0	0	0	0	0	0.996
1992	0.970	0	0	0	0	0	0	0	0.970
1993	0.944	0	0	0	0	0	0	0	0.944
1994	0.918	0	0	0	0	0	0	0	0.918
1995	0.892	0	0	0	0	0	0	0	0.892
1996	0.866	0	0	0	0	0	0	0	0.866
1997	0.840	0	0	0	0	0	0	0	0.840
1998	0.815	0	0	0	0	0	0	0	0.815
1999	0.789	0	0	0	0	0	0	0	0.789
2000	0.763	0	0	0	0	0	0	0	0.763
2001	0.737	0	0	0	0	0	0	0	0.737
2002	0.711	0	0	0	0	0	0	0	0.711
2003	0.685	0	0	0	0	0	0	0	0.685
2004	0.659	0	0	0	0	0	0	0	0.659
2005	0.633	0	0	0	0	0	0	0	0.633
2006	0.608	0	0	0	0	0	0	0	0.608
2007	0.608	0	0	0	0	0	0	0	0.608
2008	0.608	0	0	0	0	0	0	0	0.608
2009	0.608	0	0	0	0	0	0	0	0.608
2010	0.608	0	0	0	0	0	0	0	0.608
2011	0.608	0	0	0	0	0	0	0	0.608
2012	0.608	0	0	0	0	0	0	0	0.608
2013	0.608	0	0	0	0	0	0	0	0.608
2014	0.608	0	0	0	0	0	0	0	0.608
2015	0.608	0	0	0	0	0	0	0	0.608
2016	0.608	0	0	0	0	0	0	0	0.608
2017	0.608	0	0	0	0	0	0	0	0.608

Table 6.5 presents data on land converted to/remaining in the Coniferous Forest subcategory. Any piece of land converted to this subcategory remains in the relevant sub/category of land converted to Coniferous Forest for 20 years until it is finally transferred to the Coniferous Forest subcategory. Consequently, the area of each sub/category of land converted to Coniferous Forest increases for 20 years (from 1990 to 2010) and then increases or decreases according to the net outcome of balance between land converted to this subcategory since 1990 versus the land converted to this subcategory since 2010. This rule applies to all sub/categories considered in this NIR. Note that Broadleaved Forest, Annual Cropland, Woody Cropland, Woody Grassland and Wetlands (note that Wetlands are not shown in Table 6.5) land-use categories are not converted to the Coniferous Forest land-use category.

Table 6.5. Data on area of land remaining in the same land use subcategory (from Coniferous Forest to Coniferous Forest) and areas of land converted to Coniferous Forest subcategory from other land use sub/categories.

Year	Land converted to Coniferous Forest from:								Total area
	Broadl. Forest	Conif. Forest	Annual CL	Woody CL	Grass GL	Woody GL	Settle-ments	Other Land	
	k ha	k ha	k ha	k ha	k ha	k ha	k ha	k ha	
1990	0.000	148.914	0.000	0.000	0.008	0.000	0.025	0.557	148.914
1991	0.000	148.905	0.000	0.000	0.008	0.000	0.025	0.557	149.494
1992	0.000	148.897	0.000	0.000	0.016	0.000	0.049	1.113	150.075
1993	0.000	148.888	0.000	0.000	0.024	0.000	0.074	1.670	150.656
1994	0.000	148.879	0.000	0.000	0.032	0.000	0.099	2.226	151.236
1995	0.000	148.871	0.000	0.000	0.040	0.000	0.123	2.783	151.817
1996	0.000	148.862	0.000	0.000	0.048	0.000	0.148	3.339	152.398
1997	0.000	148.854	0.000	0.000	0.056	0.000	0.173	3.896	152.978
1998	0.000	148.845	0.000	0.000	0.064	0.000	0.197	4.452	153.559
1999	0.000	148.836	0.000	0.000	0.072	0.000	0.222	5.009	154.139
2000	0.000	148.828	0.000	0.000	0.080	0.000	0.247	5.565	154.720
2001	0.000	148.819	0.000	0.000	0.089	0.000	0.271	6.122	155.301
2002	0.000	148.811	0.000	0.000	0.097	0.000	0.296	6.678	155.881
2003	0.000	148.802	0.000	0.000	0.105	0.000	0.321	7.235	156.462
2004	0.000	148.793	0.000	0.000	0.113	0.000	0.345	7.791	157.043
2005	0.000	148.785	0.000	0.000	0.121	0.000	0.370	8.348	157.623
2006	0.000	148.774	0.000	0.000	0.121	0.000	0.389	8.348	157.631
2007	0.000	148.763	0.000	0.000	0.121	0.000	0.408	8.348	157.639
2008	0.000	148.752	0.000	0.000	0.121	0.000	0.427	8.348	157.647
2009	0.000	148.741	0.000	0.000	0.121	0.000	0.445	8.348	157.655
2010	0.000	148.730	0.000	0.000	0.121	0.000	0.464	8.348	157.663
2011	0.000	149.309	0.000	0.000	0.113	0.000	0.458	7.791	157.671
2012	0.000	149.887	0.000	0.000	0.105	0.000	0.452	7.235	157.679
2013	0.000	150.466	0.000	0.000	0.097	0.000	0.447	6.678	157.687
2014	0.000	151.044	0.000	0.000	0.089	0.000	0.441	6.122	157.695
2015	0.000	151.622	0.000	0.000	0.080	0.000	0.435	5.565	157.703
2016	0.000	152.201	0.000	0.000	0.072	0.000	0.429	5.009	157.711
2017	0.000	152.779	0.000	0.000	0.064	0.000	0.423	4.452	157.719

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 age 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 includes also areas converted to forest in the IPCC 2006 sense. Consequently, all calculations involving biomass growth are performed on the entire forest area basis. 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 follows⁶⁵:

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 7cm. It does not include branches.

⁶⁵ FAO. Forest Data Reporting Package for 2015. Cyprus

Annual increment = Average annual volume of gross increment over the given reference period less that of natural losses on all trees, measured to minimum diameters as defined for “Growing stock”. The annual increment when expressed on the per hectare basis is averaged over the entire net area of forest in 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. Note: annual increment includes volume of trees harvested in that year.

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/year	m ³ /ha/year
1990	45.96	0.5799	n.a.*
2000	45.90	0.5405	n.a.
2003		0.6976	n.a.
2004		0.6976	n.a.
2005	48.50	0.6954	n.a.
2006		0.6954	n.a.
2007		0.6954	n.a.
2008		0.8445	2.0000
2009		0.9431	2.0000
2010	57.39	0.9435	2.0000
2011		1.1687	2.0000
2012	61.06	1.1688	2.0000
2015		1.1691	2.0000
2016		1.1691	2.0000
2017		1.1691	2.0000

*- Data not available

Data provided in Table 6.6 were interpolated and extrapolated to cover the entire period 1990 to the reported year.

National data on the growing stock and volume increment are averaged over the entire net area of forest in 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 when expressed on the per hectare basis is averaged over the entire net area of forest in 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).

In Cyprus, salvage loggings are part of forest harvest however, data on salvage logging are also published separately from data on forest harvest. Salvage logging are included in calculation of emissions from harvest. Consequently, they do not appear in calculation of emissions from wildfires.

The root/shoot ratio for all forest is 0.28 (read from Table 6.4.4 for subtropical dry forest, based on the ERT advice).

The carbon fraction of wood is 0.47 tC/t d.m. (based on the ERT advice).

The biomass conversion factors were read Table 6.4.5 (p. 4.51) for Mediterranean dry tropical, subtropical climatic zone and growing stock level 41 – 100 m³/ha. These factors are presented in Table 6.7.

Table 6.7. Numerical data for BCEF values used in carbon source/sink calculations.

Forest type	BCEF	Value used in calculations
Broadleaved Forest	BCEFS	0.8 t biomass/m ³ wood volume
	BCEF _I	0.55 t biomass/m ³ wood volume
	BCEFR	0.89 t biomass/m ³ wood volume
Coniferous Forest	BCEFS	0.6 t biomass/m ³ wood volume
	BCEF _I	0.45 t biomass/m ³ wood volume
	BCEFR	0.67 t biomass/m ³ wood volume

Forest fires

Combustion factor Cf=0.45 (default all other temperate forests, Table 6.2.6 p.2.48) is used in all calculations relating to forest fires. All forest fires are reported under the land use category Forest remaining Forest.

Land converted to forest land

All emissions/removals relating to change in carbon stocks in above- and below-ground biomass are estimated under the Forest remaining Forest section. This is due to national data specificity as explained earlier. Consequently, the Land converted to Forest Land section covers only changes in carbon stocks in dead organic matter (includes dead wood and litter) and carbon stocks in soils.

A default 20-year transition period is used in calculations regarding changes in biomass and soil organic carbon. It is assumed that all other carbon pools (litter and dead wood) reach equilibrium values in the year of transition. The assumption is based on expert judgement.

It is further assumed that conversion of land to forest land does not lead to non-CO₂ GHG emissions because in the Cyprus situation such conversion does not require fertilization, the use of fire, drying of wetlands, etc.

Change in carbon in dead organic matter

Following the Tier 1 approach it is assumed that dead organic matter pool is zero in all non-forest land-use categories. For Forest Land land-use category, the default values of 28.2 t C/ha and 20.3 t C/ha for broadleaved and coniferous forest types, respectively, are used (Table 6.2.2, p. 2.27, warm temperate dry climate).

Change in carbon stocks in soils

The reference stocks in soil organic carbon are read from Table 6.2.3 of the 2006 IPCC Guidelines (p. 2.31). All non-wetland soils in Cyprus are considered to be high activity clay soils and the default value of 38 t C/ha is used (Table 6.2.3, warm temperate dry climate). For wetland soils, the default value of 88 t C/ha is used (Table 6.2.3, warm temperate dry climate).

Tier 1 approach is implemented hence, the stock change factors for input, management and disturbance regime, are equal to 1. Consequently, the reference default value of 38 t C/ha is used in all calculations relating to changes in soil carbon in mineral soils.

Dead wood carbon stocks are assumed zero before and after conversion (default data are not available).

Default values for carbon stocks in litter in mature forests are read from Table 6.2.2, p. 2.27 for subtropical climate, i.e. 2.8 tC/ha for broadleaved forests and 4.1 tC/ha for coniferous forests.

All calculations are performed using the IPCC generic equations.

6.2.5. Uncertainties and time-series consistency

Uncertainty analysis will be performed when area data of resolution comparable to the area threshold used in the forest definition (0.3 ha) will be available.

Uncertainties are mainly affected by the lack of precise data on area of land converted to/from forest, area and net annual increment in private forests and to a lesser extent by potentially imprecise assessment of net annual increment in deciduous forest managed by the State Forest administration.

Time series for the land-use categories Forest Land remaining Forest Land and Land converted to Forest (for Coniferous and Broadleaved Forest together) are presented in Figure 6.2 and Figure 6.3.

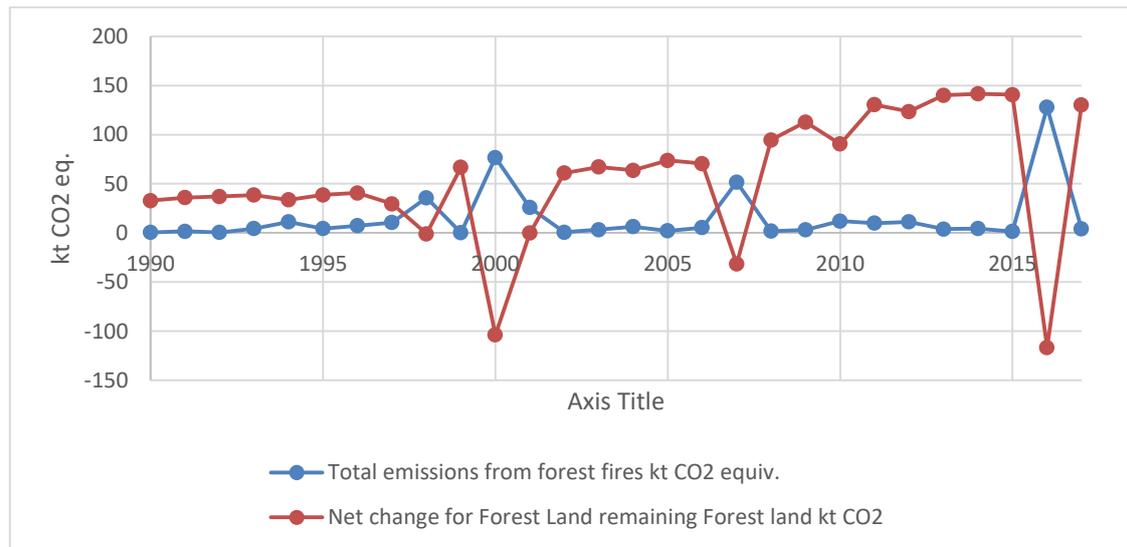


Figure 6.2. Forest remaining Forest: Net change in CO2 (blue line) and non-CO2 emissions from forest fires (red line) during the period 1990 – 2017.

Figure 6.2 presents data that are consistent in time. A trend of increasing sink in Forest remaining Forest is clearly distinguishable. The trend is transiently broken in years of exceptional extent of forest fires.

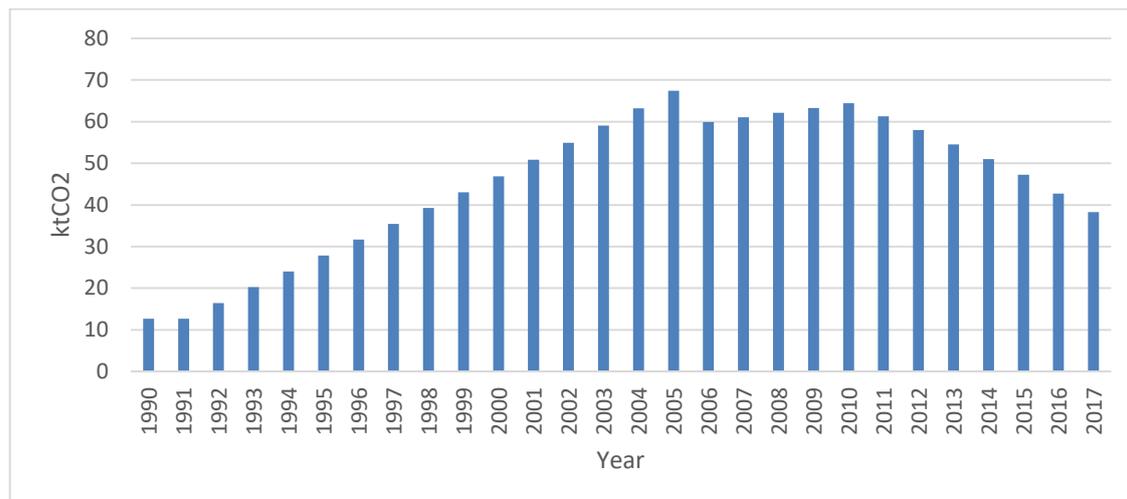


Figure 6.3. Land converted to Forest: Net change in CO2 (blue line) during the period 1990 – 2017

Figure 6.3 presents data that are consistent in time. A trend of increasing sink in land converted to Forest until 2005 is clearly distinguishable. The trend is not retained after 2005 because the annual area of land converted to forest rapidly decreases due to unavailability of land for further forestation.

Figure 6.4 presents the total input from the Forest remaining Forest and Land converted to Forest to the GHG sink/source in the LULUCF sector.

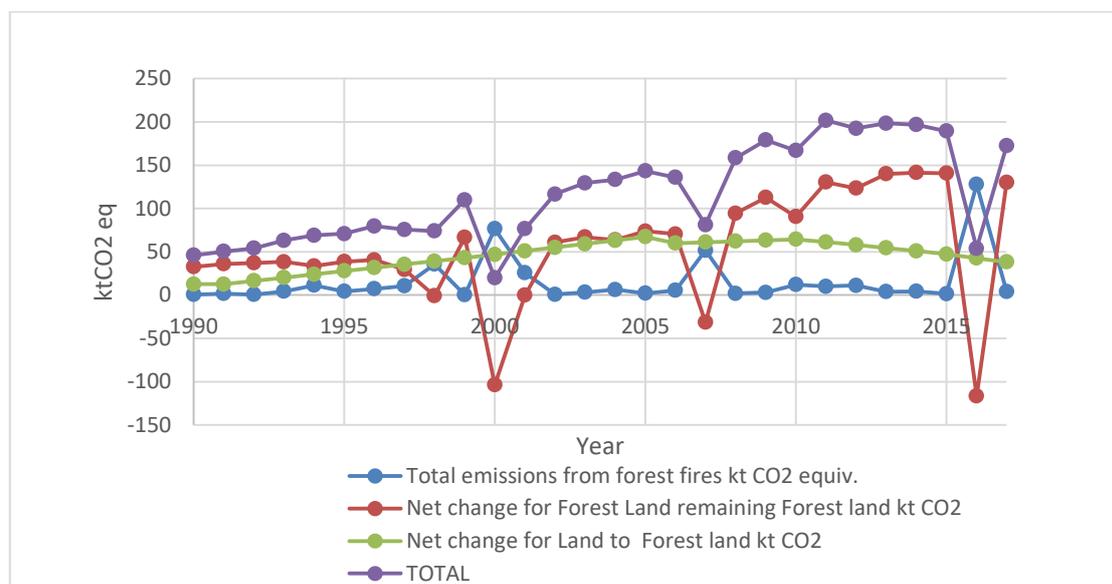


Figure 6.4. Forest remaining Forest and Land converted to Forest: net CO2 emissions/removals during the period 1990 – 2017

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 activity data and emission factors used in calculations and their units;
- Check of plausibility of input data;
- Check of completeness of data;
- Check of plausibility of results;
- Check of references and assumptions applied in processing of the data;
- Check of the correctness of all equations for estimation of the GHG fluxes
- 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.

6.2.7. Category-specific recalculations

Change of BCEFI (biomass conversion and expansion factor for increment) from 0.645 tC/m³ to the default value 0.450 tC/m³ (Table 6.4.5, p. 4.51, value for Mediterranean, dry tropical and subtropical coniferous forest).

Use of interpolated and extrapolated data provided in Table 6.6 to cover the entire period 1990 to the reported year instead of using an average (0.844 m³/ha/yr) for the entire period (coniferous forest).

Use of corrected data for area of land remaining in Forest Land category and converted to Forest Land category. The correction reflects the implementation of the rule of 20-year transition period to Forest Land.

6.2.8. Category-specific planned improvements

1. The interpretation of the satellite images and related the CORINE land cover data used for calculation of LUC matrixes should be further continued until a consistency with the annual land use data is met. Net area changes calculated using the CORINE land use change data (resolution 5 ha) should be equal (within the defined error range) to net area changes calculated from the CORINE annual land use data set (resolution 25 ha).

2. 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.

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 6.8 presents data on lands converted to Annual Cropland. Note that Forest and Woody Grassland land-use categories are not converted to Annual Cropland. Table 6.9 presents data on lands converted to Woody Cropland. Note that Broadleaved Forest land-use category is not converted to Woody Cropland. Wetlands are not converted to both Annual and Woody Cropland (not shown in Table 6.8 and Table 6.9).

Table 6.8. Data on area of land remaining in the same land use subcategory (from Annual Cropland to Annual Cropland) and areas of land converted to Annual Cropland subcategory from other land use sub/categories. Note that any piece of land after remaining for 20 years in the transitional land use sub/category is transferred to the final land use sub/category.

Year	Land converted to Annual Cropland from:								Total area k ha
	Broadl. Forest	Conif. Forest	Annual CL	Woody CL	Grass GL	Woody GL	Settle-ments	Other Land	
	k ha	k ha	k ha	k ha	k ha	k ha	k ha	k ha	
1990	0.000	0.000	128.077	0.001	0.088	0.000	0.000	0.000	128.166
1991	0.000	0.000	127.599	0.001	0.088	0.000	0.000	0.000	127.688
1992	0.000	0.000	127.121	0.002	0.175	0.000	0.000	0.000	127.298
1993	0.000	0.000	126.643	0.003	0.263	0.000	0.000	0.000	126.909
1994	0.000	0.000	126.164	0.005	0.350	0.000	0.000	0.000	126.519
1995	0.000	0.000	125.686	0.006	0.438	0.000	0.000	0.000	126.130
1996	0.000	0.000	125.208	0.007	0.525	0.000	0.000	0.000	125.740
1997	0.000	0.000	124.730	0.008	0.613	0.000	0.000	0.000	125.351
1998	0.000	0.000	124.251	0.009	0.701	0.000	0.000	0.000	124.961
1999	0.000	0.000	123.773	0.010	0.788	0.000	0.000	0.000	124.571
2000	0.000	0.000	123.295	0.012	0.876	0.000	0.000	0.000	124.183
2001	0.000	0.000	122.817	0.013	0.963	0.000	0.000	0.000	123.793
2002	0.000	0.000	122.338	0.014	1.051	0.000	0.000	0.000	123.403
2003	0.000	0.000	121.860	0.015	1.138	0.000	0.000	0.000	123.013
2004	0.000	0.000	121.382	0.016	1.226	0.000	0.000	0.000	122.624
2005	0.000	0.000	120.904	0.017	1.314	0.000	0.000	0.000	122.235
2006	0.000	0.000	120.826	0.029	1.314	0.000	0.001	0.008	122.178
2007	0.000	0.000	120.749	0.041	1.314	0.000	0.002	0.017	122.123
2008	0.000	0.000	120.671	0.052	1.314	0.000	0.003	0.025	122.065
2009	0.000	0.000	120.594	0.064	1.314	0.000	0.004	0.034	122.010
2010	0.000	0.000	120.517	0.075	1.314	0.000	0.005	0.042	121.953
2011	0.000	0.000	120.528	0.086	1.226	0.000	0.007	0.050	121.897
2012	0.000	0.000	120.539	0.096	1.138	0.000	0.008	0.059	121.840
2013	0.000	0.000	120.551	0.107	1.051	0.000	0.009	0.067	121.785
2014	0.000	0.000	120.562	0.117	0.963	0.000	0.010	0.075	121.727
2015	0.000	0.000	120.573	0.128	0.876	0.000	0.011	0.084	121.672
2016	0.000	0.000	120.585	0.138	0.788	0.000	0.012	0.092	121.615
2017	0.000	0.000	120.597	0.167	2.102	0.000	0.013	0.100	122.979

Table 6.9. Data on area of land remaining in the same land use subcategory (from Woody Cropland to Woody Cropland) and areas of land converted to Woody Cropland subcategory from other land use sub/categories. Note that any piece of land after remaining for 20 years in the transitional land use sub/category is transferred to the final land use sub/category.

Year	Land converted to Woody Cropland from:								Total area
	Broadl. Forest	Conif. Forest	Annual CL	Woody CL	Grass GL	Woody GL	Settle-ments	Other Land	
	k ha	k ha	k ha	k ha	k ha	k ha	k ha	k ha	
1990	0.000	0.000	0.092	122.782	0.007	0.066	0.036	0.529	123.512
1991	0.000	0.000	0.092	122.385	0.007	0.066	0.036	0.529	123.115
1992	0.000	0.000	0.183	121.988	0.014	0.131	0.073	1.057	123.446
1993	0.000	0.000	0.275	121.591	0.020	0.197	0.109	1.586	123.778
1994	0.000	0.000	0.366	121.194	0.027	0.263	0.145	2.114	124.109
1995	0.000	0.001	0.458	120.797	0.034	0.328	0.182	2.643	124.443
1996	0.000	0.001	0.549	120.400	0.041	0.394	0.218	3.171	124.774
1997	0.000	0.001	0.641	120.003	0.048	0.460	0.255	3.700	125.108
1998	0.000	0.001	0.732	119.606	0.054	0.525	0.291	4.229	125.438
1999	0.000	0.001	0.824	119.209	0.061	0.591	0.327	4.757	125.770
2000	0.000	0.001	0.915	118.812	0.068	0.657	0.364	5.286	126.103
2001	0.000	0.001	1.007	118.415	0.075	0.722	0.400	5.814	126.434
2002	0.000	0.001	1.098	118.018	0.082	0.788	0.436	6.343	126.766
2003	0.000	0.002	1.190	117.621	0.088	0.854	0.473	6.872	127.100
2004	0.000	0.002	1.281	117.224	0.095	0.919	0.509	7.400	127.430
2005	0.000	0.002	1.373	116.827	0.102	0.985	0.546	7.929	127.764
2006	0.000	0.002	1.377	116.651	0.102	0.988	0.546	7.929	127.595
2007	0.000	0.002	1.380	116.475	0.102	0.992	0.546	7.929	127.426
2008	0.000	0.002	1.384	116.299	0.102	0.995	0.546	7.929	127.257
2009	0.000	0.002	1.388	116.124	0.102	0.999	0.546	7.929	127.090
2010	0.000	0.002	1.392	115.948	0.102	1.002	0.546	7.929	126.921
2011	0.000	0.002	1.304	116.501	0.095	0.940	0.509	7.400	126.751
2012	0.000	0.002	1.216	117.054	0.088	0.877	0.473	6.872	126.582
2013	0.000	0.001	1.129	117.608	0.082	0.815	0.436	6.343	126.414
2014	0.000	0.001	1.041	118.161	0.075	0.753	0.400	5.814	126.245
2015	0.000	0.001	0.953	118.714	0.068	0.691	0.364	5.286	126.077
2016	0.000	0.001	0.865	119.267	0.061	0.628	0.327	4.757	125.906
2017	0.000	0.001	0.777	119.820	0.054	0.565	0.290	4.228	125.735

The decreasing tendency in the area of cropland in Cyprus is consistent with international data provided e.g. by the World Bank⁶⁶.

There is no conversion of Wetlands to Cropland.

6.3.4. Methodological issues

Tier 1 method following the guidance contained in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories was applied due to the lack of national data (except activity data). In particular, all emission factors are default IPCC data read from the 2006 IPCC Guidelines.

⁶⁶ <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 remains 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 soil organic carbon remains unchanged following 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.

Lands converted to Annual Cropland

Lands converted Annual Cropland are subject to changes in woody vegetation, dead wood, litter and soil organic carbon. Tier 1 approach was implemented to calculate GHG sinks and sources resulting from the conversion.

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 differs from the 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 vegetation. Consequently, the default data provided in Table 6.5.1 (2006 IPCC Guidelines, p. 5.9) have been used in the GHG sink/source estimation for this land-use category.

It is further assumed that dead wood, litter and soil organic carbon remain unchanged following the lack of changes in the management of lands reported under this land-use category.

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 what prevents initiation and propagation of fire).

Lands converted to Woody Cropland

Lands converted Woody Cropland are subject to changes in woody vegetation, dead wood, litter and soil organic carbon. Tier 1 approach was implemented to calculate GHG sinks and sources following the conversion.

It is assumed that there is no dead wood in Lands converted to Woody Cropland however, Woody cropland contains litter that amounts to 10% of litter present in forest (based on the default data). These assumptions are based on expert judgement.

Use of fire is not a part of management in lands classified as Lands converted to Woody Cropland.

Organic carbon in soil

The IPCC 2006 default reference value for soil organic C stocks in high activity clay mineral soils (warm temperate dry climate region) SOCREF = 38 t C/ha (Table 6.2.3, pg.2.31, Vol.4, IPCC 2006) is selected for all calculations involving soil carbon in Annual Cropland and Woody Cropland.

Table 6.10 presents the default relative soil organic carbon stock change factors used in calculations.

Table 6.10. The IPCC default relative soil organic carbon stock change factors.

	Relative stock change factor	Error	Remarks on the default values read from Table 6.5.5, p.5.17
Annual CL	Land use FLU= 0.58	+/- 61%	tropical dry moisture regime, long term annual cultivation
Annual CL	Tillage FMG= 1.0	NA	full level tillage
Annual CL	Input FI= 1.0	NA	medium level residue return for tropical dry climate
Woody CL	Land use FLU= 1.0	+/- 50%	all temperature regimes, long term perennial tree crops
Woody CL	Tillage FMG= 1.0	NA	reduced level tillage
Woody CL	Input FI= 1.04	+/- 13%	high level w/o manure residue return for tropical dry climate

6.3.5. Uncertainties and time-series consistency

Uncertainty analysis will be performed when area data of resolution comparable to the area threshold used in the forest definition (0.3 ha) will be available.

Uncertainties are mainly affected by the lack of precise data on area of land converted to/from Annual Cropland and Woody Cropland and area and net annual increment in Woody Cropland. The applicability of default data for woody vegetation stock, growth and harvest (provided in Table 6.5.1 of the 2006 IPCC Guidelines) should be further examined. In particular, the default data result in stock estimates that are greater than similar estimates for forest which may not be true.

All GHG sink/source estimates for Croplands are highly affected by uncertainties in activity data and emission factors (uncertain CORINE data and the use of default data). Greater availability of national data on this land-use category could potentially decrease uncertainties in the estimates.

Time series for the land-use categories Woody Cropland remaining Woody Cropland, Land converted to Annual Cropland and Land converted to Woody Cropland are presented in Figure 6.5.

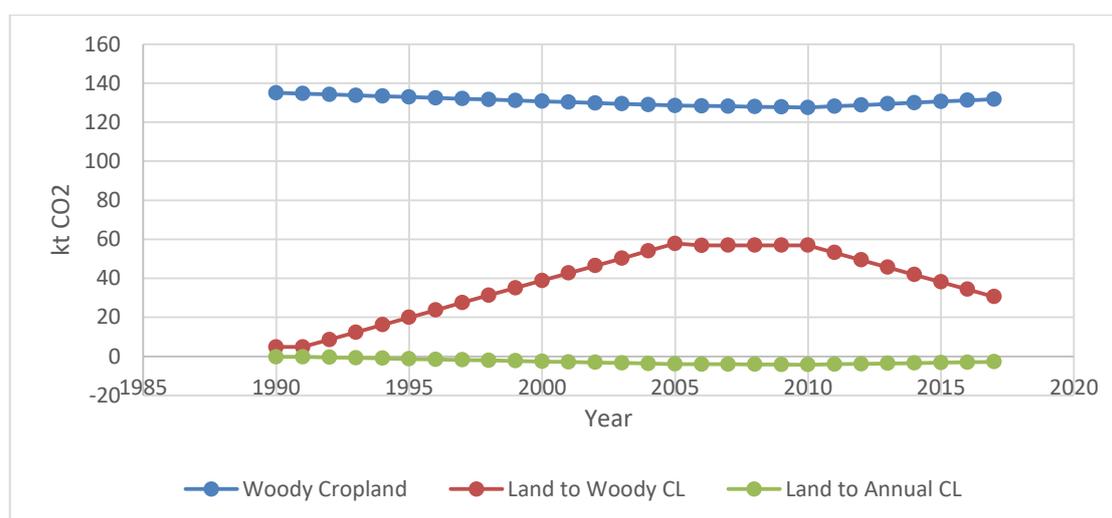


Figure 6.5. Woody Cropland remaining Woody Cropland, Land converted to Annual Cropland and Land converted to Woody Cropland: CO2 emissions/removals during the period 1990 – 2017.

Time series presented in Figure 6.5 are consistent. The changes in 2005 and 2010 reflect changes in data (the CORINE data are available for 2000, 2006 and 2012 only, the remaining data are interpolated

or extrapolated) or the specificity of the 2006 IPCC guidelines (the end of the first 20-year transition period occurs in 2010).

6.3.6. Category-specific QA/QC and verification

See para 6.2.6 above.

6.3.7. Category-specific recalculations

Not applicable (the results of calculations are reported for the first time).

6.3.8. Category-specific planned improvements

See para 6.2.8 above.

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

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”.

6.4.3. 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 6.11 presents numerical data on the area of Grassland remaining Grassland in the period 1990 - 2017.

Table 6.11. Data on area of land remaining in the same land-use subcategory (Grass Grassland remaining Grass Grassland) and areas of land converted to Grass Grassland subcategory from other land-use sub/categories. Note that there is no conversion of any land to Grass Grassland.

Year	Land converted to Grass Grassland from:							
	Broadl. Forest	Conif. Forest	Annual CL	Woody CL	Grass GL	Woody GL	Settle-ments	Other Land
	k ha	k ha	k ha	k ha	k ha	k ha	k ha	k ha
1990	0	0	0	0	30.977	0	0	0
1991	0	0	0	0	30.524	0	0	0
1992	0	0	0	0	30.071	0	0	0
1993	0	0	0	0	29.617	0	0	0
1994	0	0	0	0	29.164	0	0	0
1995	0	0	0	0	28.711	0	0	0
1996	0	0	0	0	28.258	0	0	0
1997	0	0	0	0	27.804	0	0	0
1998	0	0	0	0	27.351	0	0	0
1999	0	0	0	0	26.898	0	0	0
2000	0	0	0	0	26.444	0	0	0
2001	0	0	0	0	25.991	0	0	0
2002	0	0	0	0	25.538	0	0	0
2003	0	0	0	0	25.085	0	0	0
2004	0	0	0	0	24.631	0	0	0
2005	0	0	0	0	24.178	0	0	0
2006	0	0	0	0	24.123	0	0	0
2007	0	0	0	0	24.068	0	0	0
2008	0	0	0	0	24.013	0	0	0
2009	0	0	0	0	23.958	0	0	0
2010	0	0	0	0	23.903	0	0	0
2011	0	0	0	0	23.848	0	0	0
2012	0	0	0	0	23.793	0	0	0
2013	0	0	0	0	23.738	0	0	0
2014	0	0	0	0	23.683	0	0	0
2015	0	0	0	0	23.628	0	0	0
2016	0	0	0	0	23.573	0	0	0
2017	0	0	0	0	23.518	0	0	0

According to the available data there is no conversion of Land to Grass Grassland.

Table 6.12 presents numerical data on the area of Woody Grassland remaining Woody Grassland and area of Lands converted to Woody Grassland in the period 1990 -2017. Note that the conversion of Land to Woody Grassland was detected only since 2006.

Table 6.12. Data on area of land remaining in the same land use subcategory (from Woody Grassland to Woody Grassland) and areas of land converted to Woody Grassland subcategory from other land use sub/categories.

Year	Land converted to Woody Grassland from:							
	Broadl. Forest	Conif. Forest	Annual CL	Woody CL	Grass GL	Woody GL	Settle-ments	Other Land
	k ha	k ha	k ha	k ha	k ha	k ha	k ha	k ha
1990	0	0	0	0	0	121.948	0	0
1991	0	0	0	0	0	121.045	0	0
1992	0	0	0	0	0	120.143	0	0
1993	0	0	0	0	0	119.240	0	0
1994	0	0	0	0	0	118.337	0	0
1995	0	0	0	0	0	117.434	0	0
1996	0	0	0	0	0	116.532	0	0
1997	0	0	0	0	0	115.629	0	0
1998	0	0	0	0	0	114.726	0	0
1999	0	0	0	0	0	113.824	0	0
2000	0	0	0	0	0	112.921	0	0
2001	0	0	0	0	0	112.018	0	0
2002	0	0	0	0	0	111.115	0	0
2003	0	0	0	0	0	110.213	0	0
2004	0	0	0	0	0	109.310	0	0
2005	0	0	0	0	0	108.407	0	0
2006	0	0	0	0	0	108.334	0.006	0.058
2007	0	0	0	0	0	108.261	0.013	0.116
2008	0	0	0	0	0	108.188	0.019	0.174
2009	0	0	0	0	0	108.115	0.025	0.232
2010	0	0	0	0	0	108.042	0.032	0.290
2011	0	0	0	0	0	107.970	0.038	0.348
2012	0	0	0	0	0	107.897	0.044	0.406
2013	0	0	0	0	0	107.824	0.051	0.464
2014	0	0	0	0	0	107.751	0.057	0.522
2015	0	0	0	0	0	107.678	0.063	0.580
2016	0	0	0	0	0	107.605	0.070	0.638
2017	0	0	0	0	0	107.532	0.076	0.696

There is no conversion of Wetlands to Grassland.

6.4.4. Methodological issues

Tier 1 method following the guidance contained in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories was applied due to the lack of national data (except activity data). In particular, all emission factors are default IPCC data read from the 2006 IPCC Guidelines.

Grass Grassland remaining Grass Grassland

By definition this land-use category contains no woody vegetation. Due to the lack of data on changes in management in Grass Grassland, it is assumed that the management remains 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 soil organic carbon remains unchanged following the lack of changes in the management of these lands.

Use of fire is not a part of management in lands classified as Grass Grassland.

Lands converted to Grass Grassland

According to the available data there is no conversion of Land to Grass Grassland.

Woody Grassland remaining Woody Grassland

Woody Grassland differs from the Grass Grassland 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 vegetation. Consequently, the default data provided in Table 6.5.1 (2006 IPCC Guidelines, p. 5.9) have been used to estimate the GHG sink/source for this land-use category.

It is further assumed that dead wood, litter and soil organic carbon remain unchanged following the lack of changes in the management of lands reported under this land-use category.

Use of fire is not a part of management in lands classified as Woody Grassland. Due to the lack of data, it is further assumed that wild fires do not occur in Woody Grassland (this assumption is further justified by the fact that woody vegetation is sparse in this land what prevents initiation and propagation of fire).

Lands converted to Woody Grassland

Lands converted Woody Grassland are subject to changes in woody vegetation, dead wood, litter and soil organic carbon. Tier 1 approach was implemented to calculate GHG sinks and sources following the conversion. However, the conversion of Land to Woody Grassland was detected only since 2006 (see Table 6.12).

It is assumed that there is no dead wood in Lands converted to Woody Grassland however, litter in Woody Grassland amounts to 10% of litter present in forest (based on the default data). These assumptions are based on expert judgement.

Use of fire is not a part of management in lands classified as Lands converted to Woody Grassland.

Organic carbon in soil

The IPCC 2006 default reference value for soil organic C stocks for high activity clay mineral soils (warm temperate dry climate region) SOCREP = 38 t C/ha (Table 6.2.3, pg.2.31, Vol.4, IPCC 2006) is selected for all calculations involving soil carbon in Grass Grassland and Woody Grassland. All relative stock change factors were read from Table 6.5.5, p. 5.17, Vol.4, IPCC 2006. All these factors are equal to 1 for Cyprian conditions.

All IPCC default relative soil carbon stock change factors for Grass Grassland and Woody Grassland are equal to 1 (Table 6.6.2, p. 6.16, vol.4, IPCC 2006).

6.4.5. Uncertainties and time-series consistency

Uncertainty analysis will be performed when area data of resolution comparable to the area threshold used in the forest definition (0.3 ha) will be available. Uncertainties are mainly affected by the lack of precise data on area of land converted to/from Grass Grassland and no data on area of land converted to/from Woody Grassland before 2006. Additionally, there is no national data on the net annual increment in Woody Grassland. The applicability of default data for woody vegetation stock, growth and harvest (provided in Table 6.5.1 of the 2006 IPCC Guidelines) should be further examined. In particular, the default data result in stock estimates that are greater than similar estimates for forest which may not be true.

All GHG sink/source estimates for Grasslands are highly affected by uncertainties in activity data and emission factors (uncertain CORINE data and the use of default data). Greater availability of national data on this land-use category could potentially decrease uncertainties in the estimates. In particular, it seems unlikely that there is no conversion of Land to Grass Grassland since 1990 and no conversion of

Land to Woody Grassland before 2006. The fact that such conversion was detected after 2006 increases probability that similar conversions might have occurred also earlier.

Figure 6.6 presents consistent data series for CO₂ removals in Woody Grassland remaining Woody Grassland during the period 1990 – 2017. The significant decrease in the removals before 2006 and stabilization of them result from changes in the area of this land-use category (compare area data contained in Table 6.11 and Table 6.12).

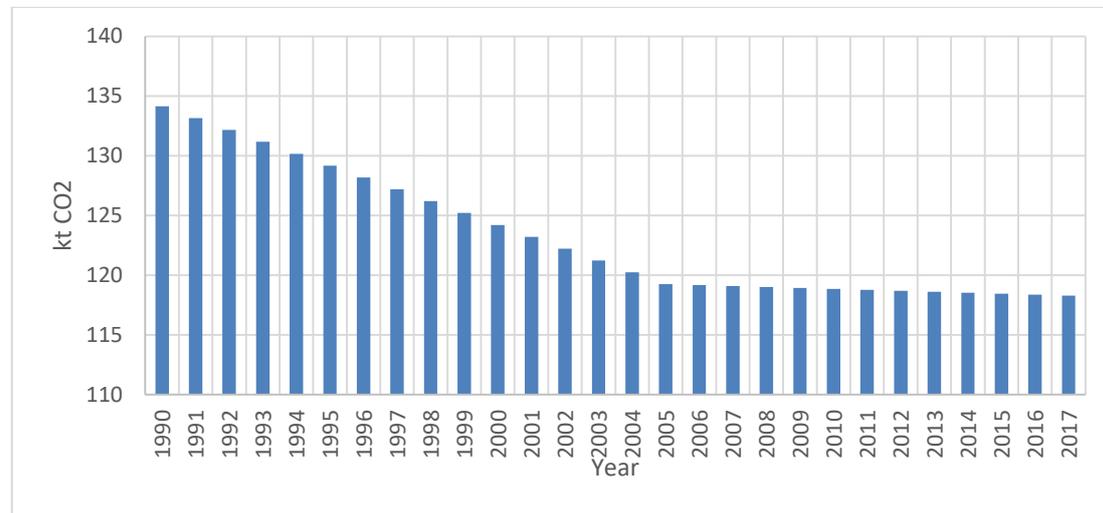


Figure 6.6. Woody Grassland remaining Woody Grassland: CO₂ removals during the period 1990 – 2017

6.4.6. Category-specific QA/QC and verification, if applicable

See para 6.2.6 above.

6.4.7. Category-specific recalculations, if applicable, including changes made in response to the review process

Not applicable (the results of calculations are reported for the first time).

6.4.8. Category-specific planned improvements, if applicable (e.g., methodologies, activity data, emission factors, etc.), including those in response to the review process

See para 6.2.8 above.

6.5. Wetland (4D)

6.5.1. Description

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”.

Table 6.13 provides data on area of Wetlands remaining Wetlands and Lands converted to Wetlands reported annually during the period 1990 – 2017.

Table 6.13. Data on area of land remaining in the same land use category (from Wetland to Wetland) and areas of land converted to Wetland category from other land use sub/categories. Note that any piece of land after remaining for 20 years in the transitional land use category is transferred to the final land use category.

Year	Land converted to Wetlands from:								
	Broadl. Forest	Conif. Forest	Annual CL	Woody CL	Grass GL	Woody GL	Wetlands	Settlements	Other Land
	k ha	k ha	k ha	k ha	k ha	k ha	k ha	k ha	k ha
1990	0	0	0	0	0	0	2.5780	0	0.0804
1991	0	0	0	0	0	0	2.5780	0	0.0804
1992	0	0	0	0	0	0	2.5780	0	0.1608
1993	0	0	0	0	0	0	2.5780	0	0.2412
1994	0	0	0	0	0	0	2.5780	0	0.3215
1995	0	0	0	0	0	0	2.5780	0	0.4019
1996	0	0	0	0	0	0	2.5780	0	0.4823
1997	0	0	0	0	0	0	2.5780	0	0.5627
1998	0	0	0	0	0	0	2.5780	0	0.6431
1999	0	0	0	0	0	0	2.5780	0	0.7235
2000	0	0	0	0	0	0	2.5780	0	0.8038
2001	0	0	0	0	0	0	2.5780	0	0.8842
2002	0	0	0	0	0	0	2.5780	0	0.9646
2003	0	0	0	0	0	0	2.5780	0	1.0450
2004	0	0	0	0	0	0	2.5780	0	1.1254
2005	0	0	0	0	0	0	2.5780	0	1.2058
2006	0	0.0059	0	0	0	0	2.5780	0.0086	1.2086
2007	0	0.0119	0	0	0	0	2.5780	0.0172	1.2114
2008	0	0.0178	0	0	0	0	2.5780	0.0259	1.2141
2009	0	0.0238	0	0	0	0	2.5780	0.0345	1.2169
2010	0	0.0297	0	0	0	0	2.5780	0.0431	1.2197
2011	0	0.0357	0	0	0	0	2.6584	0.0517	1.1422
2012	0	0.0416	0	0	0	0	2.7388	0.0603	1.0646
2013	0	0.0475	0	0	0	0	2.8192	0.0690	0.9870

Year	Land converted to Wetlands from:								
	Broadl. Forest	Conif. Forest	Annual CL	Woody CL	Grass GL	Woody GL	Wetlands	Settlements	Other Land
	k ha	k ha	k ha	k ha	k ha	k ha	k ha	k ha	k ha
2014	0	0.0535	0	0	0	0	2.8996	0.0776	0.9094
2015	0	0.0594	0	0	0	0	2.9800	0.0862	0.8318
2016	0	0.0654	0	0	0	0	3.0603	0.0948	0.7542
2017	0	0.0714	0	0	0	0	3.6833	0.1034	0.6766

Note that Broadleaved Forest, Annual Cropland, Woody Cropland, Grass Grassland and Woody Grassland land-use categories are not converted to Wetlands.

6.5.4. Methodological issues

Tier 1 method following the guidance contained in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories was applied due to the lack of national data (except activity data). In particular, all emission factors are default IPCC data read from the 2006 IPCC Guidelines.

Wetlands remaining Wetlands

In Cypriot conditions this land-use category contains no woody vegetation. According to the available data there is no peatlands and organic soils in Cyprus.

Due to the lack of data on changes in management in Wetlands, it is assumed that the management remains constant since before 1990. Consequently, it is assumed that soil organic carbon remains constant following the lack of changes in the management of these lands. Therefore, the Wetlands remaining Wetlands land-use category does not affect the GHG sinks and sources on annual basis.

Use of fire is not a part of management in lands classified as Wetlands.

Lands converted to Wetlands

Lands converted Wetlands are subject to changes in woody vegetation, dead wood, litter and soil organic carbon. Tier 1 approach was implemented to calculate GHG sinks and sources following the conversion. It is assumed that there is no woody vegetation, dead wood and litter in Lands converted to Woody Grassland. These assumptions are based on expert judgement.

Use of fire is not a part of management in lands classified as Lands converted to Wetlands.

Organic carbon in soil

The reference stock in soil organic C is read from Table 6.2.3 of the 2006 IPCC Guidelines. For wetland soils, the default value of 88 t C/ha is used (Table 6.2.3, warm temperate dry climate).

Tier 1 approach is implemented hence, the stock change factors for input, management and disturbance regime, are equal to 1. Consequently, the default value of 88 t C/ha is used in all calculations relating to soil carbon in Wetland mineral soils. Note that there are no organic soils in Cyprus.

6.5.5. Uncertainties and time-series consistency

Uncertainty analysis will be performed when area data of resolution comparable to the area threshold used in the forest definition (0.3 ha) will be available.

All GHG sink/source estimates for Wetlands are highly affected by uncertainties in activity data and emission factors (uncertain CORINE data and the use of default data). Greater availability of national data on this land-use category could potentially decrease uncertainties in the estimates.

The applicability of default data for organic carbon in soil should be further examined.

In particular, it seems unlikely that there is no conversion of Coniferous Forest and Settlements to Wetlands before 2006. The fact that such conversion was detected after 2006 increases probability that similar conversions might have occurred also earlier. Additionally, the lack of conversion of Broadleaved Forest, Annual Cropland, Woody Cropland, Grass Grassland and Woody Grassland requires further research.

Figure 6.7 presents consistent data series for CO₂ removals in Lands converted to Wetlands during the period 1990 – 2017. The increase in the removals before 2006, stabilization in the period 2006 – 2010 followed by a decrease result from changes in the area of this land-use category (compare area data contained in Table 6.13).

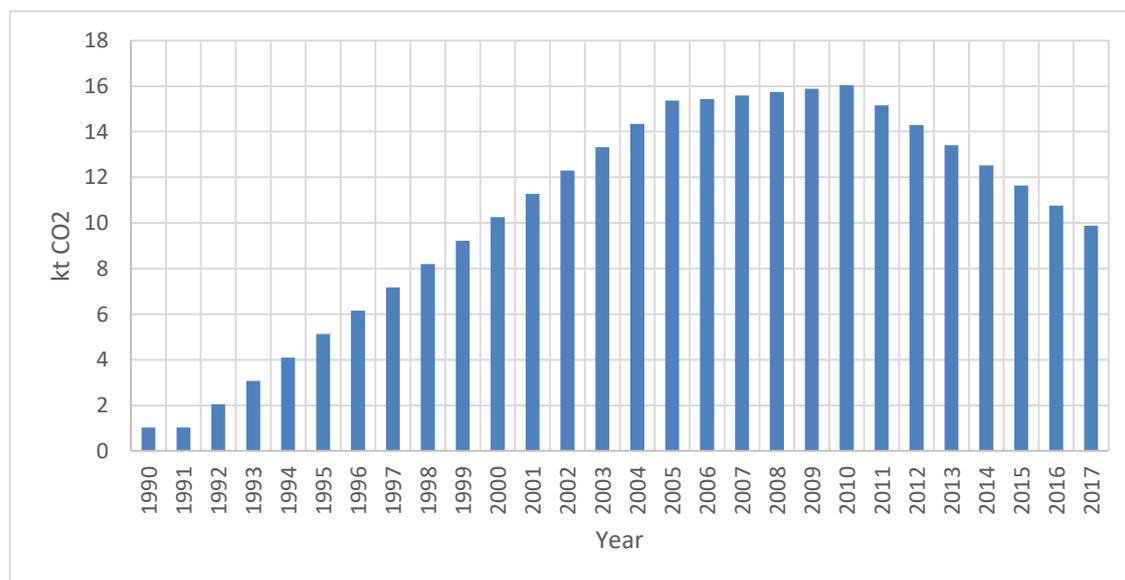


Figure 6.7. Lands converted to Wetlands: CO₂ removals during the period 1990 – 2017.

6.5.6. Category-specific QA/QC and verification

See para 6.2.6 above.

6.5.7. Category-specific recalculations

Not applicable (the results of calculations are reported for the first time).

6.5.8. Category-specific planned improvements

See para 6.2.8 above.

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

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 6.14 provides data on area of Settlements remaining Settlements and Lands converted to Settlements reported annually during the period 1990 – 2017.

Table 6.14. Data on area of land remaining in the same land use subcategory (from Settlements to Settlements) and areas of land converted to Settlements category from other land use sub/categories. Note that any piece of land after remaining for 20 years in the transitional land use sub/category is transferred to the final land use sub/category.

Year	Land converted to Settlements from:							
	Broadl. Forest	Conif. Forest	Annual CL	Woody CL	Grass GL	Woody GL	Settlements	Other Land
	k ha	k ha	k ha	k ha	k ha	k ha	k ha	k ha
1990	0.001	0.009	0.318	0.396	0.117	0.197	386.951	0.000
1991	0.001	0.009	0.318	0.396	0.117	0.197	386.341	0.000
1992	0.003	0.017	0.636	0.792	0.234	0.394	385.730	0.001
1993	0.004	0.025	0.954	11.876	0.350	0.590	385.120	0.001
1994	0.005	0.034	12.721	15.835	0.467	0.787	384.509	0.001
1995	0.006	0.042	15.901	19.793	0.584	0.984	383.899	0.002
1996	0.008	0.051	19.081	23.752	0.701	11.806	383.289	0.002
1997	0.009	0.059	22.262	27.711	0.818	13.774	382.678	0.002
1998	0.010	0.068	25.442	31.669	0.935	15.741	382.068	0.002
1999	0.012	0.076	28.622	35.628	10.513	17.709	381.458	0.003
2000	0.013	0.085	31.802	39.587	11.681	19.677	380.847	0.003
2001	0.014	0.093	34.983	43.546	12.849	21.644	380.237	0.003
2002	0.016	0.102	38.163	47.504	14.017	23.612	379.626	0.004
2003	0.017	0.110	41.343	51.463	15.185	25.580	379.016	0.004
2004	0.018	0.119	44.523	55.422	16.353	27.547	378.406	0.004
2005	0.019	0.127	47.704	59.380	17.521	29.515	377.795	0.005
2006	0.019	0.127	48.440	60.807	17.652	30.210	377.437	0.005
2007	0.019	0.127	49.176	62.234	17.784	30.906	377.079	0.005
2008	0.019	0.127	49.912	63.661	17.915	31.601	376.721	0.005
2009	0.019	0.127	50.648	65.089	18.046	32.297	376.363	0.005
2010	0.019	0.127	51.384	66.516	18.177	32.992	376.005	0.005

2011	0.018	0.119	48.939	63.984	17.141	31.720	386.022	0.004
2012	0.017	0.110	46.495	61.452	16.104	30.448	396.039	0.004
2013	0.016	0.102	44.051	58.921	15.067	29.176	406.057	0.004
2014	0.014	0.093	41.607	56.389	14.030	27.903	416.074	0.003
2015	0.013	0.085	39.160	53.860	12.990	26.630	426.090	0.003
2016	0.012	0.076	36.720	51.330	11.960	25.360	436.110	0.003
2017	0.011	0.067	34.280	48.800	10.930	24.090	446.130	0.003

Note that all land-use categories (except Wetlands) are converted to Settlements. The total area of Settlements continuously increases during the period 1990 – 2017.

6.6.4. Methodological issues

Tier 1 method following the guidance contained in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories was applied due to the lack of national data (except activity data). In particular, all emission factors are default IPCC data read from the 2006 IPCC Guidelines.

In Cypriot conditions 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

Due to the lack of data on changes in management in Settlements remaining Settlements, it is assumed that the management remains constant since before 1990 hence, this land-use category does not affect the GHG sinks and sources on annual basis. It is further assumed that soil organic carbon remains unchanged following the lack of changes in the management of these lands.

Use of fire is not a part of management in lands classified as Settlements.

Lands converted to Settlements

Lands converted Settlements are subject to changes in woody vegetation, dead wood, litter and soil organic carbon. Tier 1 approach was implemented to calculate GHG sinks and sources following the conversion. It is assumed that there is no dead wood and carbon stocks in litter amount to 5% of the stocks in litter found in Forest land-use category. These assumptions are based on expert judgement.

Use of fire is not a part of management in lands classified as Lands converted to Settlements.

Organic carbon in soil

Cyprus does not yet have available data on the magnitude of the change in the soil organic carbon in Settlements hence, a method based on the default approach is applied. The IPCC 2006 default reference value for soil organic C stocks for high activity clay mineral soils (warm temperate dry climate region) SOCREF = 38 t C/ha (Table 6.2.3, pg.2.31, Vol.4, IPCC 2006) is selected for all calculations involving soil carbon in Lands converted to Settlements.

Due to the diverse structure of lands classified as settlements calculation of a product of the relative stock change factors is performed using the following approach:

Step 1: Calculation of the average product of the relative stock change factors FLU, FMG and FI for lands to be converted to Settlements.

Almost all lands converted to Settlements originate from Annual CL (approx. 30%), Woody CL (approx. 39%), Grass GL (approx. 11%) and Woody GL (approx. 19%). The default values of the relative stock change factors FLU, FMG and FI for these land-use categories are available from Table 6.5.5, p. 5.17, Vol.4, IPCC 2006. Table 6.15 presents calculation of the average product of the relative stock change factors FLU, FMG and FI for lands to be converted to Settlements.

Table 6.15. Calculation of the average product of FLU, FMG and FI applicable to Lands to be converted to Settlements

Land converted to Settlements	Share	Land use FLU	Tillage FMG	Input FI	Product
Annual CL	30%	0.58	1	1	0.175
Woody CL	39%	1	1	1.04	0.403
Grass GL	11%	1	1	1	0.108
Woody GL	19%	1	1	1	0.193
Average product FLU, FMG and FI					0.879

Step 2: Calculation of the average product of the relative stock change factors FLU, FMG and FI for Settlements remaining Settlements (or 20 years after the conversion to Settlements).

In order to estimate GHG sink/source in soil organic carbon attributable to the conversion of lands to Settlements a numerical value of the product of the relative stock change factors FLU, FMG and FI that characterizes the soil organic carbon for Settlements remaining Settlements. As the first approximation, it is assumed that the Settlement remaining Settlement area consists in 60% of area that is paved over, 20 % of area that is turfgrass, and 20 % of area that has cultivated soil and is wooded. This approximation is based on expert judgement.

An approach proposed in Chapter 8.3.3.2, p. 8.24, Vol. 4, IPCC 2006 is applied to calculate an average value of the product of FLU, FMG and FI applicable to settlements at equilibrium (20 years after conversion). In particular, it is assumed that in the paved areas 20% of the soil carbon is lost (relative to the pre-conversion state, p. 8.24). For the turfgrass the relative stock change factor FMG= 1.17 (for improved grassland in tropical climate zone – Table 6.6.2, p. 6.16), and for the wooded and cultivated soil the relative stock change factor FMG= 1.17 (no-till FMG value from Table 6.5.5, p. 5.17, with FI equal to 1) were applied. Details of the calculation are presented in Table 6.16.

Table 6.16. Calculation of the average product of FLU, FMG and FI applicable to Settlements remaining Settlements

Land cover within Settlements	Average product FLU, FMG and FI for Lands converted to Settlements (see Error! eference source not found.)	Share	FMG for lands under specific land cover within Settlements	Product
Area that is paved over (and equivalent)	0.879	60%	0.8	0.422
Turfgrass	0.879	20%	1.17	0.206
Wooded and cultivated soil	0.879	20%	1.17	0.206
Average product FLU, FMG and FI for Settlements				0.834

The final value of the product of FLU, FMG and FI applicable to settlements in equilibrium (Settlements remaining Settlements) is 0.834. Consequently, the soil carbon stock in Settlements is $0.834 \times 38 \text{ t C/ha} = 31.692 \text{ t C/ha}$.

6.6.5. Uncertainties and time-series consistency

Uncertainty analysis will be performed when area data of resolution comparable to the area threshold used in the forest definition (0.3 ha) will be available. The character of conversions to/from the Other Land land-use category suggest that it contains more diversified lands than

All GHG sink/source estimates for Settlements are highly affected by uncertainties in activity data and emission factors (uncertain CORINE data and the use of default data). Greater availability of national data on this land-use category could potentially decrease uncertainties in the estimates.

The applicability of default data for organic carbon in soil should be further examined.

In particular, it seems unlikely that there is no conversion of Coniferous Forest and Settlements to Wetlands before 2006. The fact that such conversion was detected after 2006 increases probability that similar conversions might have occurred also earlier. Additionally, the lack of conversion of Broadleaved Forest, Annual Cropland, Woody Cropland, Grass Grassland and Woody Grassland requires further research.

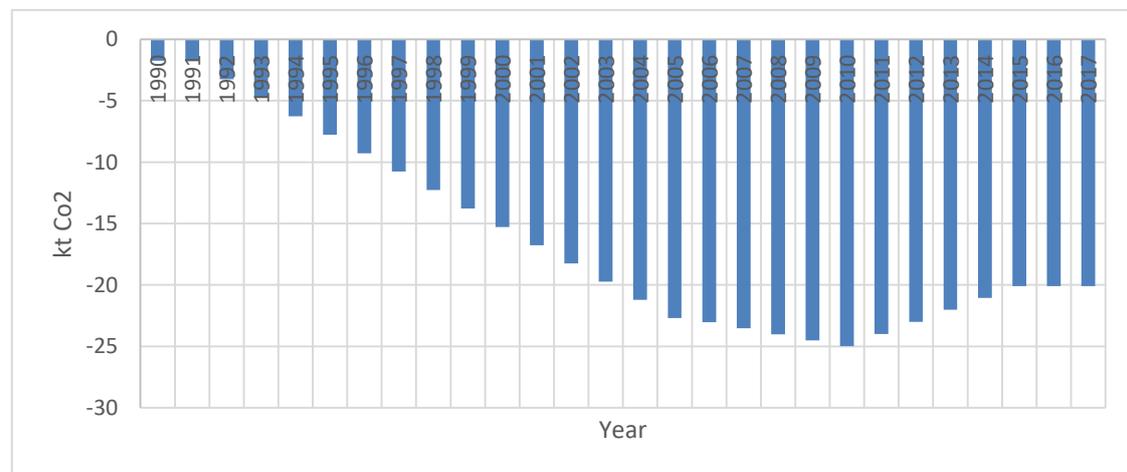


Figure 6.8. Lands converted to Settlements: CO2 emissions during the period 1990 – 2017.

Figure 6.8 presents consistent data series for CO2 emissions in Lands converted to Wetlands during the period 1990 – 2017. The changes in the emissions result from changes in the area of this land-use category (compare area data contained in Table 6.14).

6.6.6. Category-specific QA/QC and verification, if applicable

See para 6.2.6 above.

6.6.7. Category-specific recalculations, if applicable, including changes made in response to the review process

Not applicable (the results of calculations are reported for the first time).

6.6.8. Category-specific planned improvements, if applicable (e.g., methodologies, activity data, emission factors, etc.), including those in response to the review process

See para 6.2.8 above.

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

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".

The Other Land land-use category is characterized by increased dynamics of lands converted to and from the category. In particular, majority of pieces of land converted to this category do not remain in it for a prolonged time (expert judgement, see Table 6.17). However, it may happen that some pieces of land stay longer in the category but the currently available CORINE land cover data do not allow for distinguishing the share of land that stays permanently in this category. Consequently, it was assumed that any piece of land converted to this category is reported under it without any transition period. This assumption may be abandoned when more precise data on land dynamics in this category is available.

Table 6.17. Comparison of land use conversion from/to Other Land category (data in relation to the total converted land during the period 1990 -2017)

Land use sub/category	Conversion	
	from Other Land to:	to Other Land from:
Broadl. Forest		2.42%
Coniferous Forest	45.86%	0.33%
Annual Cropland	0.48%	6.77%
Woody Cropland	43.56%	1.46%
Grass Grassland		25.89%
Woody Grassland	3.29%	63.07%
Wetland	6.78%	
Settlements	0.03%	0.07%

Data presented in Table 6.17 apparently suggest that the Other Land land-use category serves as an intermediate step in conversion from Grass Grassland and Woody Grassland to Wood Cropland and Coniferous Forest. The 1990 area of Other Land is too low to allow for all conversions from the Other Land remaining Other Land to various land-use categories in the period 1990 – 2017 hence, if all these conversions are real, they should occur to a great extent on the expense of lands converted to Other Land during that period.

Table 6.18. Data on area of land remaining in the same land use category (from Other Land to Other Land) and areas of land converted to Other Land category from other land use sub/categories. Note that the rule that any piece of land after remaining for 20 years in the transitional land use sub/category is transferred to the final land use sub/category is not implemented for this category due to high dynamics of lands in this category.

Year	Land converted to Other Land from:							
	Broadl. Forest	Conif. Forest	Annual CL	Woody CL	Grass GL	Woody GL	Settle-ments	Other Land
	k ha	k ha	k ha	k ha	k ha	k ha	k ha	k ha
1990	0.025	0.000	0.069	0.000	0.234	0.640	0.000	5.835
1991	0.025	0.000	0.069	0.000	0.234	0.640	0.000	5.637
1992	0.025	0.000	0.069	0.000	0.234	0.640	0.000	5.439
1993	0.025	0.000	0.069	0.000	0.234	0.640	0.000	5.241
1994	0.025	0.000	0.069	0.000	0.234	0.640	0.000	5.043
1995	0.025	0.000	0.069	0.000	0.234	0.640	0.000	4.844
1996	0.025	0.000	0.069	0.000	0.234	0.640	0.000	4.646
1997	0.025	0.000	0.069	0.000	0.234	0.640	0.000	4.448
1998	0.025	0.000	0.069	0.000	0.234	0.640	0.000	4.250
1999	0.025	0.000	0.069	0.000	0.234	0.640	0.000	4.052
2000	0.025	0.000	0.069	0.000	0.234	0.640	0.000	3.854
2001	0.025	0.000	0.069	0.000	0.234	0.640	0.000	3.656
2002	0.025	0.000	0.069	0.000	0.234	0.640	0.000	3.458
2003	0.025	0.000	0.069	0.000	0.234	0.640	0.000	3.259
2004	0.025	0.000	0.069	0.000	0.234	0.640	0.000	3.061
2005	0.025	0.000	0.069	0.000	0.234	0.640	0.000	2.863
2006	0.000	0.005	0.000	0.022	0.042	0.000	0.001	3.762
2007	0.000	0.005	0.000	0.022	0.042	0.000	0.001	3.761
2008	0.000	0.005	0.000	0.022	0.042	0.000	0.001	3.761
2009	0.000	0.005	0.000	0.022	0.042	0.000	0.001	3.761
2010	0.000	0.005	0.000	0.022	0.042	0.000	0.001	3.761
2011	0.000	0.005	0.000	0.022	0.042	0.000	0.001	3.761
2012	0.000	0.005	0.000	0.022	0.042	0.000	0.001	3.761
2013	0.000	0.005	0.000	0.022	0.042	0.000	0.001	3.761
2014	0.000	0.005	0.000	0.022	0.042	0.000	0.001	3.761
2015	0.000	0.005	0.000	0.022	0.042	0.000	0.001	3.761
2016	0.000	0.005	0.000	0.022	0.042	0.000	0.001	3.761
2017	0.000	0.005	0.000	0.022	0.042	0.000	0.001	3.761

Note that area of land converted to the Other Land land-use category is insignificant (except the land converted from Grass Grassland and Woody Grassland) when compared to the area of Other Land remaining Other Land land-use category.

6.7.4 Methodological issues

Tier 1 method following the guidance contained in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories was applied due to the lack of national data (except activity data). In particular, all emission factors are default IPCC data read from the 2006 IPCC Guidelines (or derived from the IPCC default data).

In Cypriot conditions Other Land land-use category contains a diversified group of lands described in para 6.7.1 above).

Other Land remaining Other land

Due to the lack of data on changes in management in Other Land remaining Other Land, it is assumed that the management remains constant since before 1990 hence, this land-use category does not affect the GHG sinks and sources on annual basis. It is assumed that lands falling into the Other Land land-use category do not contain woody and annual vegetation, dead wood and litter. These assumptions are based on expert judgement. It is further assumed that soil organic carbon remains unchanged following the lack of changes in the management of these lands.

Use of fire is not a part of management in lands classified as Other Land.

Lands converted to Other Land

Lands converted Other Land lose all woody vegetation, dead wood and litter. These lands are also subject to changes in soil organic carbon. Tier 1 approach was implemented to calculate GHG sinks and sources following the conversion.

Use of fire is not a part of management in lands classified as Lands converted to Settlements.

Organic carbon in soil

Cyprus does not yet have available data on soil organic carbon in lands falling into the Other Land land-use category. However, taking into account land-use categories that are converted to and from the Other Land it is clear that assumption that the organic carbon stock is zero for lands belonging to this category does not hold. Note that Other Land in Cyprus includes beaches, dunes, sand plains and bare rock but also a balance area allowing the reported area remain unchanged among the reported years. It is also important to note that lands classified as Other Land are converted to Coniferous Forest and Woody Cropland (see Table 6.17 above). Consequently, an approach developed for the estimation of the average product of FLU, FMG and FI applicable to Settlements remaining Settlements (see Chapter 6.6.4 above) was implemented for the estimation of the average product of FLU, FMG and FI applicable to Other Land remaining Other Land. Table 6.19 presents details of the calculations.

Table 6.19. Calculation of the average product of FLU, FMG and FI applicable to Other Land remaining Other Land

Land converted to Other Land	Share	Land use FLU	Tillage FMG	Input FI	Product
Broadl. F	2.4%	1	1	1	0.024
Coniferous F	0.3%	1	1	1	0.003
Annual CL	6.8%	0.58	1	1	0.039
Woody CL	1.5%	1	1	1.04	0.015
Grass GL	25.9%	1	1	1	0.259
Woody GL	63.1%	1	1	1	0.631
Settlements	0.1%	0.834			0.001
Average product FLU, FMG and FI					0.972

CORINE land cover data did not allow for precise estimation of the share of rock, beaches, dunes and sand plains in the entire area of the Other Land land-use category hence, it was assumed that the share equals 0.5 (expert judgement). Finally, the average product of Land use FLU*Tillage FMG*Input FI =0.972/2=0.486.

6.7.5. Uncertainties and time-series consistency

Uncertainty analysis will be performed when area data of resolution comparable to the area threshold used in the forest definition (0.3 ha) will be available. The character of conversions to/from the Other Land land-use category suggest that it contains more diversified lands than bare soil, rock, beaches, dunes and sand plains. Use of more advanced information on land use may allow for attribution of significant part of the current Other Land land-use category to other categories.

In general, GHG sink/source estimates for Other Land are highly affected by uncertainties in activity data and emission factors (uncertain CORINE data and the use of default data). Greater availability of national data on this land-use category could potentially decrease uncertainties in the estimates.

The applicability of default data for organic carbon in soil should be further examined.

Figure 6.9 presents data series for CO₂ emissions in Lands converted to Other Land during the period 1990 – 2015. The estimates of the CO₂ emission are affected by the assumption that any piece of land converted to this land-use category is reported under it without any transition period. The rapid change in the emission occurring in 2005 is a clear consequence of this assumption. It is likely that the change is an artefact and does not represent the actual transition of CO₂ emissions during the period 1990 – 2015 however, it is entirely consistent with the approach applied for estimation of these emissions.

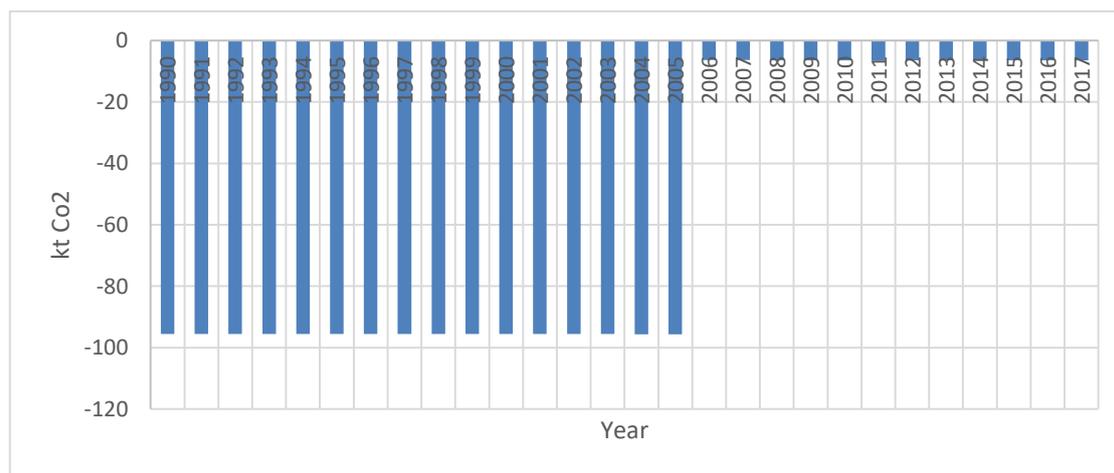


Figure 6.9. Lands converted to Other Land: CO₂ emissions during the period 1990 – 2017.

6.7.6. Category-specific QA/QC and verification

See para 6.2.6 above.

6.7.7. Category-specific recalculations

Not applicable (the results of calculations are reported for the first time).

6.7.8. Category-specific planned improvements

See para 6.2.8 above.

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 land-use category.

6.8.2. Information on approaches used and on databases used for the inventory preparation

All calculations of the HWP contribution under the Convention are performed using the IPCC Harvested Wood Products (HWP) Model as developed by Kim Pingoud and further modified by the authors of Chapter 12 of Volume 4 of the 2006 IPCC Guidelines. The model referred to as “HWP Worksheet (Zipped MS-Excel file)” is available from the IPCC website at <http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html>. All relevant data were collected from the FAO database “Forestry Production and Trade” (Last update: December 14, 2016) available at <http://www.fao.org/faostat/en/#data/FO>.

6.8.3. Category specific definitions and the classification systems used

Definitions contained in “FAO Forest Products Definitions”⁶⁷ are used in this inventory.

6.8.4. Methodological issues

The annual change in HWP carbon stocks in Cyprus are judged to be significant however, due to a limited availability of the country specific data and following the guidance contained in decision tree presented in Figure 6.12.1 (page 12.10 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories) Tier 1 approach was selected to calculate an estimate of HWP Contribution. In particular, the following elements of the IPCC approach are applied (page 12.6):

1. All CO₂ released from HWP is included in the AFOLU Sector;
2. CO₂ released from wood burnt for energy in the Energy Sector is not included in the Energy Sector totals (although CO₂ emissions from biofuels are reported as a memo item for QA/QC purposes). CH₄ and other gases from HWP used for energy is included in the Energy Sector;
3. CO₂ released from HWP in SWDS is not included in the Waste Sector totals although CH₄ emissions from HWP are included.

6.8.4.1. Data for the calculation of an estimate of HWP Contribution under the Convention

All relevant data were collected from the FAO database “Forestry Production and Trade” (Last update: December 14, 2016)⁶⁸. Table 6.20 lists the FAO items and their codes that were the source of numerical data for all calculations in this chapter.

Table 6.20. 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
Roundwood	1861
Sawnwood	1872
Wood-Based Panels	1873
Paper+Paperboard	1876
Wood Pulp plus Rec. Paper (aggregated items)	1875 (wood pulp) 1669 (recycled paper)
Industrial Roundwood	1865
Other Industrial Roundwood	1871
Chips and particles	1619
Wood charcoal	1630
Wood residues	1620

⁶⁷ available at: <http://www.fao.org/forestry/34572-0902b3c041384fd87f2451da2bb9237.pdf>

⁶⁸ available at <http://www.fao.org/faostat/en/#data/FO>

The FAO data for wood pulp production in Cyprus were not complete for the period 1992 – 2015. The missing data (referred to as estimates in Table 6.21) were obtained in the following way: (i) Estimates for 2000 and 2001 were assumed to amount to 10,000 tonnes based on the data from the period 1992 – 1997; (ii) All other estimates were calculated via proportional interpolation/extrapolation however, if data for production are lower than data for export then it is assumed that production is equal to export (to avoid a negative balance of the pulp production and export).

Table 6.21. Wood pulp production in Cyprus 1992 – 2017 (FAO data and estimates calculated based on them)

Year	Data / Estimate	Pulp production	Pulp production adjusted to the export data
		tonne	tonne
1992	Data	10000	10000
1993	Data	10000	10000
1994	Data	10000	10000
1995	Data	10000	10000
1996	Data	10000	10000
1997	Data	10000	10000
1998	Estimate	10000	10000
1999	Estimate	10000	10000
2000	Estimate	10000	11050
2001	Estimate	10000	11410
2002	Data	11000	11380
2003	Estimate	13450	13450
2004	Estimate	14675	14675
2005	Data	15900	15900
2006	Data	16860	16860
2007	Data	23295	23295
2008	Data	25760	25760
2009	Estimate	35461	35461
2010	Data	45162	45166
2011	Estimate	44239	44239
2012	Data	43316	43317
2013	Estimate	42558	44969
2014	Data	41800	41800
2015	Estimate	41042	42243
2016	Data	43627	43627
2017	Data	47255	47255

Estimates for wood pulp production the period 1961 – 1991 were assumed to be zero, unless data for pulp export were provided by the FAO. In such situation, it was assumed that pulp production is equal to pulp export.

Default half-lives for the estimation of “products in use” carbon pools and associated fraction retained each year were read from Table 6.12.7 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (see Table 6.22).

Table 6.22. The default half-lives and associated decay rates for solid wood products and paper products

	Solid wood products	Paper products
Half-life (years)	30 yr	2 yr
Decay rate k ($k = \ln(2)/$ half-life)	0.023 yr^{-1}	0.347 yr^{-1}

Conversion factors used in the calculation of the HWP contribution were read from Table 6.12.4 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The factors are presented in Table 6.23.

Table 6.23. Conversion factors used in the calculation of the HWP contribution

Conversion factor	Value
Sawn wood, other industrial roundwood	0.260 tC/m ³ *
Wood-based panels	0.294 tC/m ³
Paper products	0.450 tC/adt
Charcoal	0.765 tC/adt
Bark	1.12 tC _{overbark} /t C _{underbark}

* Average for temperate species and tropical species

An IPCC default estimated growth rate of HWP consumption prior to 1961 for Europe was used (0.0151 yr⁻¹)

6.8.4.2. Calculation of an estimate of HWP Contribution under the Convention

All calculations of the HWP contribution under the Convention are performed using the IPCC Harvested Wood Products (HWP) Model as developed by Kim Pingoud and further modified by the authors of Chapter 12 of Volume 4 of the 2006 IPCC Guidelines. The model referred to as “HWP Worksheet (Zipped MS-Excel file)” is available from the IPCC website at <http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html>.

Cyprus has selected the Production Approach (described in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, page 12.29 onwards) to be used for the UNFCCC reporting purposes. The Production Approach (PA) estimates changes in carbon stocks in the forest pool (in Cyprus, all domestically produced HWP originate only from harvest occurring in Forest Land land-use category) of the reporting country and the wood products pool containing products made from wood harvested in the reporting country. The wood products pool also includes products made from wood collected at domestic harvest that are exported and stored in uses in other countries.

The Production Approach involves equations: (i) 12.1 (to estimate the first-order decay); (ii) 12.3 (to estimate HWP products produced annually from domestic harvest); and (iii) 12.A.6 (to estimate HWP contribution from the production approach) of volume 4 of the 2006 IPCC Guidelines. The estimation of HWP contribution from the production approach using equation 12.A.6 is explained below:

$$\text{HWP Contribution to AFOLU Net CO}_2 \text{ emissions PA} = -44/12 \bullet (\text{H} - \uparrow\text{CHWP DH})$$

$$\text{and } \uparrow\text{C HWP DH} = \text{H} - \Delta\text{C HWP IU DH} - \Delta\text{C HWP SWDS DH}$$

where:

H = Harvest of wood to be used for HWP (including fuelwood)

$\Delta\text{CHWP IU DH}$ = Annual change in carbon stock in HWP in use (Variable 2A),

$\Delta\text{CHWP SWDS DH}$ = Annual change in carbon stock in HWP in solid waste disposal sites where the wood in the products came from domestic harvest (Variable 2B)

The annual change in carbon stock in HWP in use (Variable 2A) is estimated in this chapter while the annual change in carbon stock in HWP in solid waste disposal sites where the wood in the products came from domestic harvest (Variable 2B) should be estimated under the Waste sector. Numerical values of estimated variables 2A and 2B for the period 2010 – 2017 are presented in Table 6.24.

Table 6.24. Numerical values of estimated variables 2A and 2B

kt C	2010	2011	2012	2013	2014	2015	2016	2017
Variable 2A	-7.201	-7.196	-7.112	-7.067	-6.862	-6.811	-6.740	-6.638
Variable 2B	0.466	0.487	0.646	0.525	0.522	0.463	0.307	0.193

The HWP CRF Table 6 requires calculation of HWP produced and consumed domestically and HWP produced and exported separately for solid wood and paper products. The share of HWP produced and consumed domestically (HWP domestic prod/con) is calculated by means of the following formula:

$$\text{HWP domestic prod/con} = (\text{Sawnwood}_{\text{production}} - \text{Sawnwood}_{\text{export}}) / (\text{Sawnwood}_{\text{production}})$$

Where:

$$\text{Sawnwood} = \text{FAO Item Code 1872 (Sawnwood)}$$

The coefficient HWP domestic prod/con is multiplied by the relevant data for HWP from domestic harvest to obtain numerical values for HWP from domestic harvest consumed domestically. The remaining HWP from domestic harvest (not consumed domestically) are assumed to be exported.

Note: According to the FAO data Cyprus does not produce paper or paper board hence domestic consumption of domestically produced paper is zero.

6.8.5. Uncertainties and time-series consistency

The HWP Contribution to LULUCF emissions/removals reveals trend from 1990 to about 1999 was averaging around 5 kt CO₂ per year and then stabilization of emissions at the level close to 25 kt CO₂ per year. Figure 6.10 presents consistent data series of HWP contribution to LULUCF emissions or removals as appropriate.

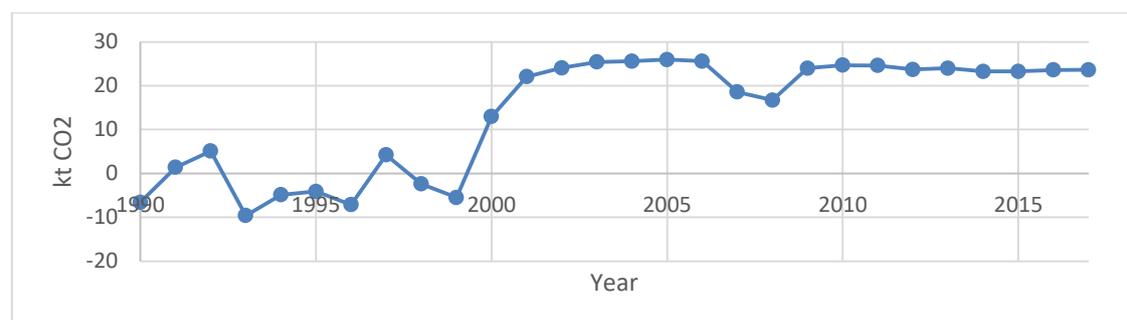


Figure 6.10. HWP Contribution to LULUCF emissions/removals. Note: negative numbers denote removals; positive numbers denote emissions.

6.8.6. Category-specific QA/QC and verification

Not applicable. All data are read from the FAO website.

6.8.7. Category-specific recalculations

Not applicable (the results of calculations are reported for the first time).

6.8.8. Category-specific planned improvements

Not applicable. All data are read from the FAO website. The methodology implements the IPCC proposed approach. No other approaches are available.

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, CH₄ emissions from SWDS are the largest source of greenhouse gas emissions in the Waste Sector. CH₄ 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 CH₄ and N₂O 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 (CH₄). 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 2017 contributed 6.4% of the total emissions without LULUCF, 62.8% to the total methane emissions of the country without LULUCF and 8.8% to the total N₂O emissions without LULUCF. In 2017, 84.8% of the waste sector emissions are from solid waste disposal, 1.0% from biological treatment of solid waste and 14.2% from waste water treatment and discharge. The emissions from waste have changed considerably between 1990 and 2017 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 CO₂ eq) from waste, 1990-2017

Gg CO ₂ eq.	1990	2000	2005	2010	2015	2016	2017
Total waste	386.7	460.0	486.4	498.2	543.8	552.9	561.66
A. Solid waste disposal	258.3	319.4	360.0	406.0	458.2	467.2	476.06
B. Biological treatment of solid waste	0.0	0.0	0.0	1.4	7.5	7.5	5.68
C. Incineration and open burning of waste	NO						
D. Wastewater treatment and discharge	128.4	140.6	126.7	90.8	78.1	78.2	79.92
E. Other	NO						
CH ₄ (Gg)	15.0	17.8	18.9	19.2	21.0	21.3	21.7
N ₂ O (Gg)	0.04	0.05	0.05	0.06	0.07	0.07	0.06
Total (Gg CO₂ eq.)	386.7	460.0	486.4	498.2	543.8	552.9	561.66

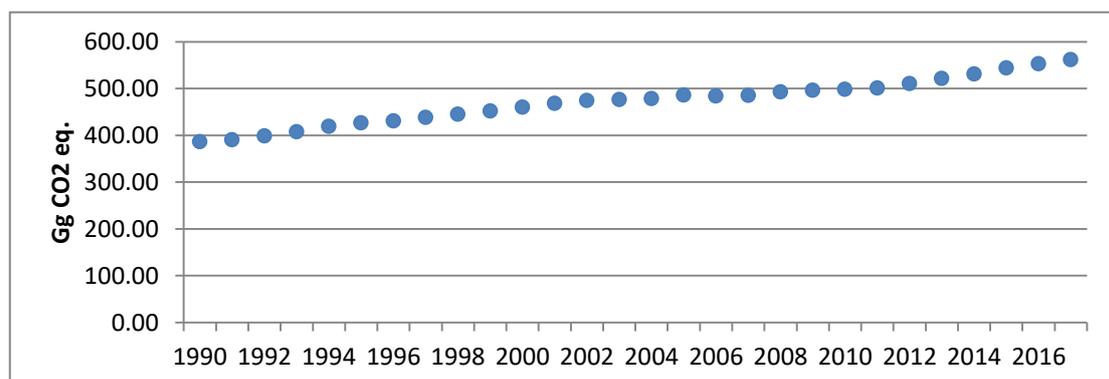


Figure 7.1. GHG emissions from waste for the period 1990-2017

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. Tier 2 method with default IPCC 2006 emission factors and parameters is implemented for Solid Waste Disposal and Tier 1 for Biological Treatment of Solid Waste (5B) and Wastewater Treatment and Discharge (5D). 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	CH4	D	T2
5A1.a	Solid Waste Disposal - Managed waste disposal sites- Anaerobic	CO2	NA	NA
5A2.	Solid Waste Disposal - Unmanaged waste disposal sites	CH4	D	T2
5A2.	Solid Waste Disposal - Unmanaged waste disposal sites	CO2	NA	NA
5B1a	Biological treatment of solid waste – Composting- municipal solid waste	CH4/N2O	D	T1
5D1.	Wastewater Treatment and Discharge - Domestic wastewater	CH4/N2O	CS	T1
5D2.	Wastewater Treatment and Discharge - Industrial wastewater	CH4	D	T1
5D2.	Wastewater Treatment and Discharge - Industrial wastewater	N2O	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 ₂ O
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 (CH₄). In addition to CH₄, solid waste disposal sites (SWDS) also produce biogenic carbon

dioxide (CO₂) and non-methane volatile organic compounds (NMVOCs) as well as smaller amounts of nitrous oxide (N₂O), 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 CO₂ released from waste. These CO₂ 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 collected by local authorities or individuals and disposed of in sites of different characteristics. In 2005⁶⁹ 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.

Until 2010 they were also in operation 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 of which one was closed in mid 1990s while the other is still in operation (Figure 7.3).

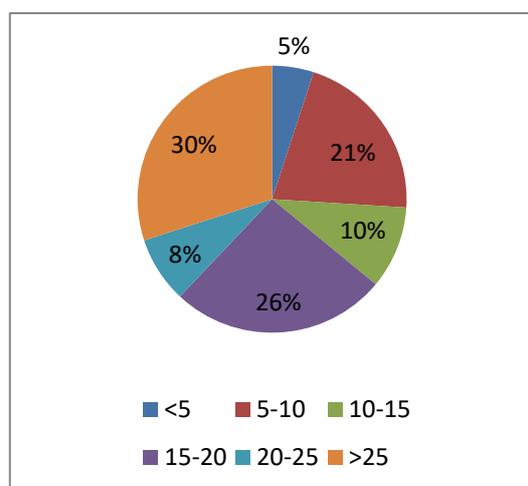


Figure 7.2. Years of activity of active Uncontrolled Waste Disposal Sites

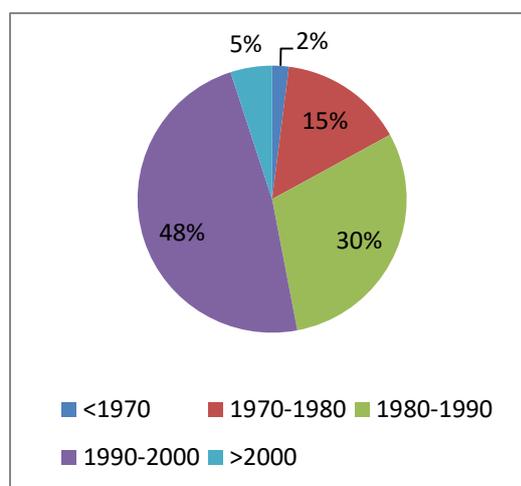


Figure 7.3. Starting year of activity for all Uncontrolled Waste Disposal Sites

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 farcialities are under construction and all the municipal solid wastes produced are transferred to the existing deep unmanaged sites.

⁶⁹ 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")

⁷⁰The national municipal waste Management Plan 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 target is that no more than 95,000 tonnes of biodegradable waste to be disposed in landfills (represents the 35% target of the 1999/31/EC directive). Also 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,
- 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 operated and the rest expected to be operated by 2018.
- Separate collection at source was promoted at households, from the existing collective system for the packing waste servicing also and 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 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, undertake the appropriate environmental studies as well as feasibility studies for the restoration of the prioritized landfills. These studies were a necessary step for the restoration of all landfills recorded.

Two (2) landfills are still active in Cyprus but arrangements are made in order to be closed and restored. According to recent data, these two landfills are feeded with approximately 155.000 ton and 200.000 ton 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 conducted in 2005, these landfills contain approximately 597.269 m³ 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 m³ 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 of the operation of non-compliant landfills by 2009. Also Cyprus has rehabilitated only 46% of its closed landfills.

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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.

CH₄ emissions from solid waste disposal on land in 2017 accounted for 84.7% of total GHG emissions from Waste, 5.4% of total national emissions without LULUCF and 55% of the total CH₄ emissions without LULUCF. Total emissions increased by 84% between 1990 and 2017. 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 – 2017

Gg CH4	1990	2000	2005	2010	2015	2016	2017
A. Solid waste disposal	10.33	12.78	14.40	16.24	18.33	18.69	19.04
1. Managed waste disposal sites	NO	NO	NO	0.53	2.42	2.73	3.04
2. Unmanaged waste disposal sites	10.33	12.78	14.40	15.71	15.91	15.95	16.01
3. Uncategorised waste disposal sites	NO						
A. Solid waste disposal (Gg CO2 eq.)	258.3	319.5	360.0	406.0	458.3	467.3	476.0

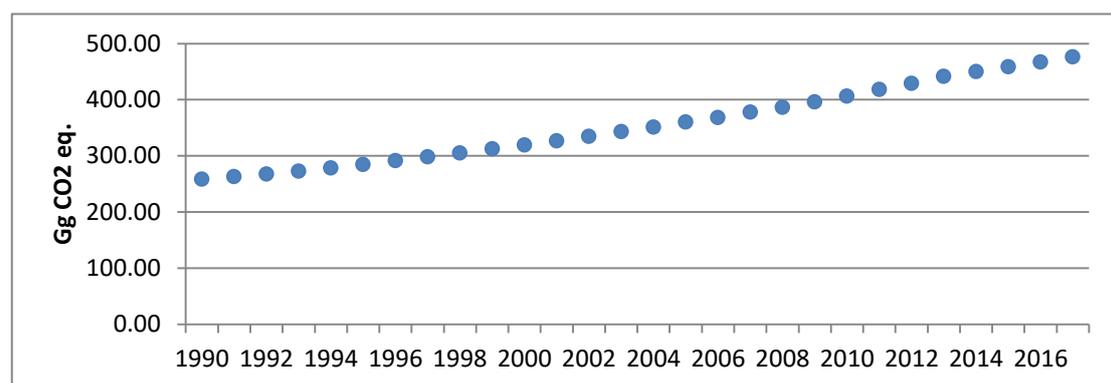


Figure 7.4. Total GHG emissions from solid waste disposal sites for the period 1990 – 2017

7.2.1. Methodological issues

The 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines) outlines three methods to estimate CH₄ 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, is a good practice to use the FOD method in order to account for time dependence of the emissions. 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.

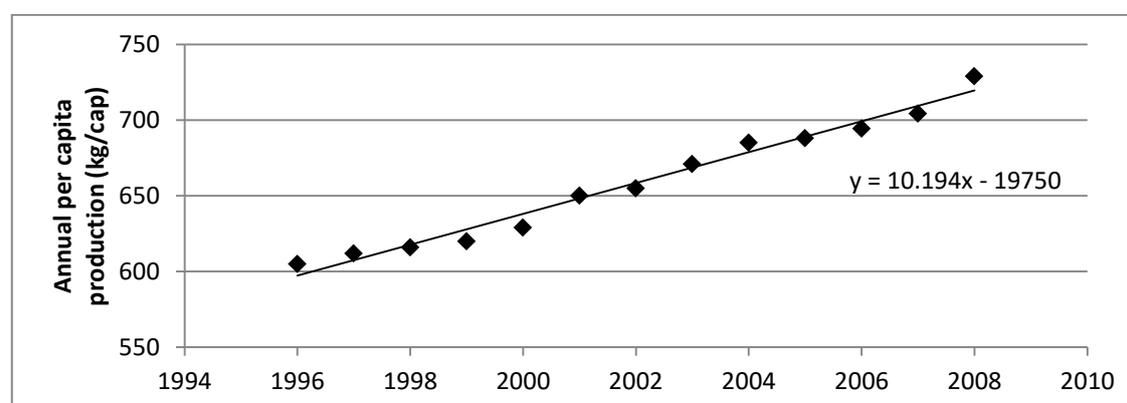


Figure 7.5. Plot used to estimate the annual per capita production for 1990-1995 (kg/cap)

The total population used, the annual per capita production and the resulting total 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 Service⁷¹. Total MSW of 2015 was revised 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 Cyprus⁷². 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
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	694.0	521.0
2007	776400	704.0	539.8

⁷¹ 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](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

⁷² <http://www.mof.gov.cy/mof/cystat/statistics.nsf/All/4756DB2E6CAEB256C22581E200378EA0?OpenDocument&sub=1&sel=1&e=&print>

2008	796900	729.0	572.7
2009	819100	730.0	589.1
2010	839800	690.0	571.4
2011	862000	674.0	571.9
2012	865900	657.0	567.6
2013	858000	618.0	533.0
2014	847000	613.0	523.2
2015	848300	642.0	541.2
2016	854800	642.0	545.4
2017	864200	636	547.4

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 1996-2017 from the National Statistical Service⁷³. 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%
2004		16.48	481.59	96.7%
2005		18.61	489.30	96.3%
2006		21.5	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	7.89	61.09	489.97	85.7%
2011	14.95	72.22	460.96	80.6%
2012	22.98	69.65	451.28	79.5%
2013	19.62	69.78	422.82	79.3%
2014	29.58	70.05	397.85	76.0%
2015	43.86	72.11	403.00	74.5%
2016	43.49	73.25	409.96	75.2%
2017	36.52	78.21	414.33	75.7%

⁷³ 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

* includes Compost for backfilling

Assumptions for allocation have been based on the information provided by the Solid Waste Management Unit of the Department of Environment⁷⁴, 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 is 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	all rural until 2011	
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	all rural until 2011	
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
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

⁷⁴ Mrs. Elena Christodoulidou, Environment Officer, Solid Waste Management Unit, Department of Environment, tel. +357 22866248, email echristodoulidou@environment.moa.gov.cy

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				
Regional Population								
Nicosia	329.5	330	332.2	335.9				
Ammochostos	46.8	46.9	47	47.5				
Larnaca	144	144.2	144.9	146.5				
Limassol	236.6	237	239.4	242.0				
Pafos	90.1	90.2	91.3	92.3				
TOTAL	847	848.3	854.8	864.2				
Urban Population								
Nicosia	241	241.4	244.2	246.9				
Ammochostos	0	0	0	0				
Larnaca	84.8	84.9	85.7	86.6				
Limassol	180	180.3	182.6	184.6				
Pafos	63.5	63.6	64.4	65.1				
TOTAL	569.3	570.2	576.9	583.2				
Rural population								
Nicosia	88.5	88.6	88	89.0				
Ammochostos	46.8	46.9	47	47.5				
Larnaca	59.2	59.3	59.2	59.9				
Limassol	56.6	56.7	56.8	57.4				
Pafos	26.6	26.6	26.9	27.2				
TOTAL	277.7	278.1	277.9	281.0				

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	145.7	149.4	154.7	157.1	142.1	133.6	176.0	163.7
shallow unmanaged	52.8	54.4	56.4	57.3	51.9	48.9	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	27.7	28.5	29.6	30.2	0	0	0	0
managed-anaerobic	0	0	0	0	27.4	25.9	25.0	23.2
Larnaca								
deep unmanaged	51.0	52.4	54.2	55.1	0	0	0	0
shallow unmanaged	33.8	35.0	36.6	37.5	0	0	0	0
managed-anaerobic	0	0	0	0	84.2	79.5	76.9	71.5

Limassol								
deep unmanaged	111.6	114.0	117.6	118.9	107.1	100.3	126.4	117.5
shallow unmanaged	31.0	32.3	34.0	35.0	32.2	30.8	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	50.7	52.6	55.1	56.6	51.9	49.3	48.1	44.7
	2014	2015	2016	2017				
Nicosia								
deep unmanaged	153.6	157.8	160.3	161.7				
shallow unmanaged	0	0	0	0				
managed-anaerobic	0	0	0	0				
Ammochostos								
deep unmanaged	0	0	0	0				
shallow unmanaged	0	0	0	0				
managed-anaerobic	21.8	22.4	22.7	22.9				
Larnaca								
deep unmanaged	0	0	0	0				
shallow unmanaged	0	0	0	0				
managed-anaerobic	67.1	68.9	69.9	70.5				
Limassol								
deep unmanaged	110.3	113.3	115.5	116.5				
shallow unmanaged	0	0	0	0				
managed-anaerobic	0	0	0	0				
Pafos								
deep unmanaged	0	0	0	0				
shallow unmanaged	0	0	0	0				
managed-anaerobic	42.0	43.1	44.1	44.4				

Table 7.10. Allocation of population and waste to types waste disposal sites

	1990	1991	1992	1993	1994	1995	1996	1997
<u>Population (10⁶)</u>								
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
<u>Waste production (Gg)</u>								
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
<u>Population (10⁶)</u>								
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
<u>Waste production (Gg)</u>								
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
<u>Population (10⁶)</u>								

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	308.3	315.8	326.6	331.1	249.3	233.9	302.3	281.2
Un-managed, shallow	145.3	150.2	156.6	160.0	84.1	79.8	0.0	0.0
Managed, anaerobic	50.7	52.6	55.1	56.6	163.5	154.7	150.0	139.5
TOTAL	504.3	518.6	538.2	547.8	496.8	468.3	452.3	420.6
	2014	2015	2016	2017				
Population (10⁶)								
Un-managed, deep	0.566	0.567	0.572	0.578				
Un-managed, shallow	0	0	0	0.000				
Managed, anaerobic	0.281	0.281	0.283	0.286				
TOTAL	0.847	0.848	0.855	0.864				
Waste production (Gg)								
Un-managed, deep	263.9	271.1	275.8	278.2				
Un-managed, shallow	0.0	0.0	0.0	0.0				
Managed, anaerobic	130.9	134.5	136.7	137.8				
TOTAL	394.8	405.5	412.5	416.0				

Composition of MSW disposed at SWDS

Data on the composition of waste to disposal sites is available for the period 1996 to 2017. For the period 1990-1995 it is assumed that the composition is the same as 1996. The breakdown on the organic matter to food waste and non-food/garden waste has been provided from the Statistical Service and is assumed constant for all the years: 86% of organic matter is food waste and the remaining 14% is non-food/garden waste⁷⁵. The resulting composition of MSW disposed at SWDS is presented in Table 7.11. Composition of waste for 1950-1989 is assumed the same as 1990.

Table 7.11. Composition of MSW disposed at SWDS

	Paper	Textiles	Wood	Food waste	Garden	Plastics, other inert
1990	28%	6%	2%	39%	6%	19%
1991	28%	6%	2%	39%	6%	19%
1992	28%	6%	2%	39%	6%	19%
1993	28%	6%	2%	39%	6%	19%
1994	28%	6%	2%	39%	6%	19%
1995	28%	6%	2%	39%	6%	19%
1996	28%	6%	2%	39%	6%	19%
1997	28%	6%	2%	39%	6%	19%
1998	27%	6%	2%	39%	6%	19%
1999	27%	6%	2%	39%	6%	19%
2000	27%	6%	2%	39%	6%	19%
2001	27%	6%	2%	39%	6%	19%
2002	27%	6%	2%	39%	6%	19%
2003	27%	6%	2%	38%	6%	20%
2004	27%	6%	2%	38%	6%	20%
2005	27%	6%	2%	38%	6%	20%
2006	26%	6%	2%	38%	6%	21%
2007	24%	7%	2%	39%	6%	21%
2008	23%	7%	2%	41%	7%	20%
2009	23%	7%	2%	42%	7%	19%
2010	27%	8%	3%	44%	7%	12%
2011	28%	9%	3%	45%	7%	7%
2012	28%	10%	3%	45%	7%	6%

⁷⁵ Mrs. Marilena Kythreotou, +357 22602137, mkythreotou@cystat.mof.gov.cy (tel. communication 25/10/2013)

	Paper	Textiles	Wood	Food waste	Garden	Plastics, other inert
2013	26%	10%	3%	47%	8%	7%
2014	27%	11%	3%	49%	8%	2%
2015	27%	11%	3%	49%	8%	2%
2016	27%	11%	3%	48%	8%	3%
2017	27%	11%	3%	48%	8%	4%

Degradable organic carbon (DOC)

Degradable organic carbon is the organic carbon that is accessible to biochemical decomposition, and should be expressed as Gg C per Gg waste. It is based on the composition of waste and can be calculated from a weighted average of the carbon content of various components of the waste stream. The following equation, as presented in the IPCC Guidelines, estimates DOC using default carbon content values (equation 3.7, volume 5, pg. 3.13):

$$DOC = \sum_i (DOC_i * W_i)$$

where DOC_i is the fraction of degradable organic carbon in waste type and W_i is the fraction of waste type i by waste category. The defaults used by the IPCC waste model for DOC are presented in Table 7.12.

Table 7.12. DOC_i used for the calculation of DOC (weight fraction, wet basis)

Waste stream	Range	Default
Food waste	0.08-0.20	0.15
Garden	0.18-0.22	0.2
Paper	0.36-0.45	0.4
Wood and straw	0.39-0.46	0.43
Textiles	0.20-0.40	0.24

Fraction of degradable organic carbon which decomposes (DOC_F)

DOC_F is an estimate of the fraction of carbon that is ultimately degraded and released from SWDS, and reflects the fact that some organic carbon does not degrade, or degrades very slowly, when deposited in SWDS. The IPCC Guidelines (pg. 3.13, volume 5) provide a default value of 0.5 for DOC_F .

Estimation of CH_4 from waste disposal on land

Landfill gas consists mainly of CH_4 and carbon dioxide (CO_2). The CH_4 fraction F value used is according to the default proposed by the IPCC guidelines, i.e. 0.5. The oxidation factor (OX) reflects the amount of CH_4 from SWDS that is oxidised in the soil or other material covering the waste. The oxidation factor used is according to the defaults proposed by the IPCC guidelines for managed, unmanaged and uncategorised SWDS (Table 3.2, pg. 3.15, vol. 5, 2006 IPCC guidelines); i.e. 0 for deep and shallow unmanaged and 0.1 for managed anaerobic. No methane is recovered from SWDS in Cyprus therefore recovery (R) is assumed 0.

The portion of the waste disposed at disposal sites is presented in Table 7.6. The defaults used by the IPCC waste model for Methane generation rate constant (k) are presented in Table 7.13 and are according to dry temperate climate.

Table 7.13. Methane generation rate constant (k)

Waste stream (per year)	Range	Default
Food waste	0.05–0.08	0.06
Garden	0.04–0.06	0.05
Paper	0.03–0.05	0.04
Wood and straw	0.01–0.03	0.02
Textiles	0.03–0.05	0.04

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 classified as unmanaged disposal sites, and therefore be assumed shallow. The value for the methane correction factor for shallow unmanaged disposal sites is assumed to be 0.4, and is according to the default IPCC2006 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 classified as unmanaged disposal sites, and assumed deep. The value for the methane conversion factor for deep unmanaged disposal sites is assumed to be 0.8, and is according to the default IPCC2006 guidelines (pg. 3.14, volume 5).

The portion of solid waste disposed to managed and unmanaged disposal sites is presented in Table 7.14.

Table 7.14. Waste disposed at (a) managed, (b) deep unmanaged and (c) shallow unmanaged disposal sites

	Un-managed, deep (%)	Un-managed, shallow (%)	Managed, anaerobic (%)
1990	66.5	33.5	0.0
1991	67.1	32.9	0.0
1992	67.7	32.3	0.0
1993	67.8	32.2	0.0
1994	67.9	32.1	0.0
1995	68.1	31.9	0.0
1996	68.2	31.8	0.0
1997	68.4	31.6	0.0
1998	68.5	31.5	0.0
1999	68.7	31.3	0.0
2000	68.8	31.2	0.0
2001	69.0	31.0	0.0
2002	69.1	30.9	0.0
2003	68.7	31.3	0.0
2004	68.5	31.5	0.0
2005	68.3	31.7	0.0
2006	61.1	28.8	10.1
2007	60.9	29.0	10.1
2008	60.7	29.1	10.2
2009	60.4	29.2	10.3
2010	50.2	16.9	32.9
2011	49.9	17.0	33.0
2012	66.8	0.0	33.2
2013	66.8	0.0	33.2
2014	66.8	0.0	33.2
2015	66.8	0.0	33.2
2016	66.9	0.0	33.1
2017	66.9	0.0	33.1

Other parameters used for the calculation of methane emissions by the IPCC waste model are presented in Table 7.15.

Table 7.15. Other parameters used for methane calculation

Delay time (months)	6
Fraction of methane (F) in developed gas	0.5
Conversion factor, C to CH ₄	1.33

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 2015 due to revision of the activity data of solid waste production by the Statistical Service. Emissions decreased for the particular year from 18.333 to 18.329 Gg CH₄, which corresponds to a reduction of emissions by 0.02%.

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. In Cyprus there is no anaerobic digestion of Solid Waste, therefore it is reported as NO. Composting is an aerobic process and a large fraction of the degradable organic carbon (DOC) in the waste material is converted into carbon dioxide (CO₂). CH₄ is formed in anaerobic sections of the compost, but it is oxidised to a large extent in the aerobic sections of the compost.

Emissions from biological treatment of solid waste in 2017 accounted for 10% of total GHG emissions from Waste, 0.06% of total national emissions without LULUCF. 100% of the emissions are from composting; anaerobic treatment is not applied for solid waste in Cyprus. The emissions from biological treatment are presented in Table 7.16 and Figure 7.6.

Table 7.16. Emissions from biological treatment of solid waste, 1990-2017

	1990	2000	2005	2010	2015	2016	2017
CH ₄ (Gg)	NO	NO	NO	0.03	0.18	0.17	0.13
N ₂ O (Gg)	NO	NO	NO	0.0019	0.0105	0.0104	0.0080
Total (Gg CO ₂ eq.)	NO	NO	NO	1.4	7.5	7.5	5.68

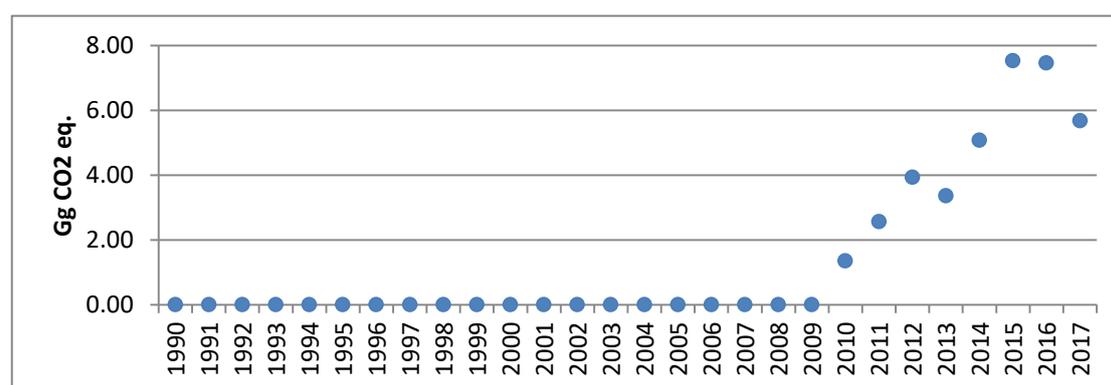


Figure 7.6. Emissions from Composting 1990-2017

7.3.1. Methodological issues

The estimation of CH₄ and N₂O emissions from biological treatment of solid waste according to the 2006 IPCC Guidelines (chapter 4, vol. 5) involves 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 has already been presented in Table 7.6 and is according to the national statistics on production and management of municipal solid waste⁷⁶. Activity data includes the amount of composting material that is used for backfilling.

Step 2. Estimation of emissions

The CH₄ and N₂O emissions of the biological treatment have been estimated using the default method, i.e. equations 4.1 and 4.2 of 2006 IPCC guidelines (volume 5, page 4.5). The emission factor for N₂O emissions is assumed 0.24 g/kg wet waste as proposed in the corrigendum of the 2006 guidelines dated July 2015, while the CH₄ emission factor as 4 g/kg wet waste (IPCC2006, 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 CH₄ generated to estimate net annual CH₄ emissions should be subtracted. No recovery takes place in Cyprus therefore amount of recovered gas is 0.

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](#).

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.

7.3.4. Category-specific recalculations

No recalculations to report

7.3.5. 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 Service⁷⁷ 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.

⁷⁶ 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

⁷⁷ 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](http://www.mof.gov.cy/mof/cystat/statistics.nsf/All/ADFFD39B594E2B42C2256D41001F2DBB/$file/MUNICIPAL_SOLID_WASTE-A93_16-EN-281117.xls?OpenElement)

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 (CH₄) when treated or disposed anaerobically. It can also be a source of nitrous oxide (N₂O) emissions. Wastewater originates from a variety of domestic, commercial and industrial sources and may be treated on site (uncollected), sewer 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 7.7.

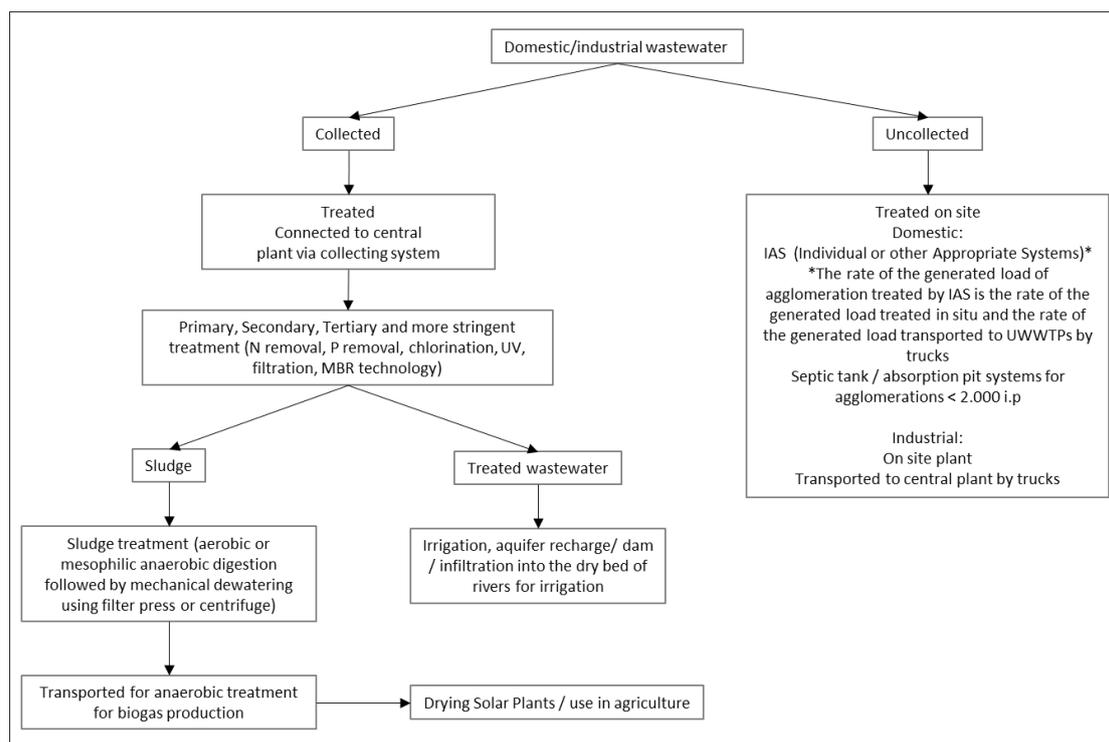


Figure 7.7. Wastewater treatment systems and discharge pathways in Cyprus⁷⁸

Emissions from Wastewater treatment and discharge accounted for 14.2% of the total GHG emissions from Waste in 2017 and 0.9% of total national emissions without LULUCF. The emissions from Wastewater treatment and discharge between 1990 and 2017 decreased by 38% 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 7.17 and Figure 7.8.

Table 7.17. Emissions from Wastewater treatment and discharge (5D) 1990-2017

	1990	2000	2005	2010	2015	2016	2017
D. Wastewater treatment and discharge	128.38	140.62	126.65	90.78	350.16	78.24	79.92
1. Domestic wastewater	103.88	112.39	100.65	63.23	49.33	49.51	49.86
2. Industrial wastewater	24.51	28.23	25.75	27.55	300.83	28.73	30.07
CH ₄ (Gg)	4.64	5.04	4.47	2.98	2.47	2.47	2.53
N ₂ O (Gg)	0.04	0.05	0.05	0.06	0.97	0.06	0.06
Total (Gg CO₂ eq.)	128.38	140.62	126.65	90.78	350.16	78.24	79.92

⁷⁸ Stella Perikenti, Environment Officer, National expert on urban wastewater management, Pollution Control Unit, Department of Environment (+35726804573, sperikenti@environment.moa.gov.cy)

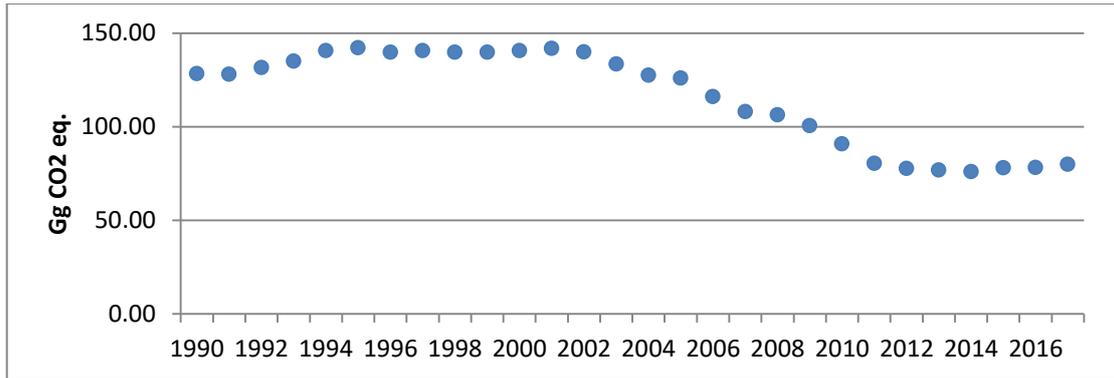


Figure 7.8. Total emissions from Wastewater treatment and discharge (5D) 1990-2017

7.5.1. Domestic Wastewater Treatment and Discharge (4D1)

According to the 2006 IPCC Guidelines, Domestic wastewater is defined as “wastewater from household water use, while industrial wastewater is from industrial practices only”⁷⁹. Sewers in Cyprus are closed and underground, which is believed that is not a significant source of CH₄. The most wastewater treatment methods and pathways in Cyprus are presented in Figure 7.7. 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 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 which gradually reduced due to the construction of the wastewater collection systems and treatment stations (Figure 7.9). 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.

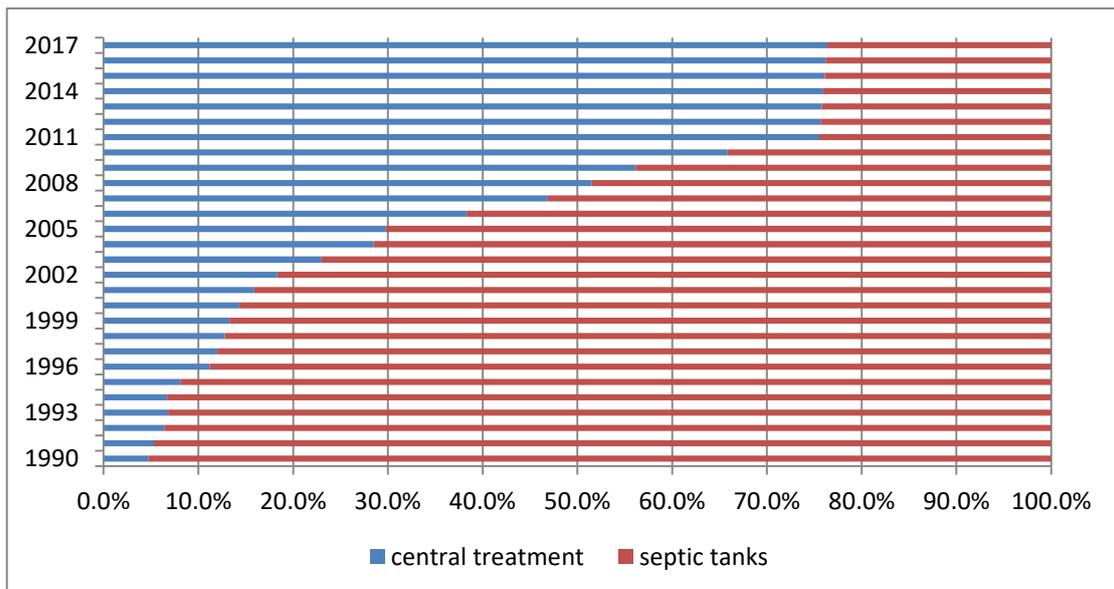


Figure 7.9. Domestic Wastewater treatment in Cyprus 1990-2017

⁷⁹ 2006 IPCC Guidelines, 2015 Corrigendum, Volume 5, pg. 6.6

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 7.18.

Table 7.18. 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	√	√	√	√	√				√

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 majority of treated sludge produced by the wastewater treatment plants in Cyprus is used in agriculture (Table 7.19). Table 7.20 shows the load entering the UWWTPs currently in operation in population equivalent.

CH₄ emissions and N₂O emissions from this source are presented in Table 7.21 and Figure 7.10.

Table 7.19. Utilisation of treated sludge produced by the wastewater treatment plants in Cyprus (t of dry matter/yr)

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Sludge production	8035	7974	9163	7083	6815	6533	6123	6160	6695	7408
Sludge used in agriculture	5745	6515	7903	5294	3912	2756	2924	1391	936	1613
Sludge transported for anaerobic treatment for			620		2478			4061		4505

biogas production									
Sludge stored at the plants				425			621		682
Incineration			640						608

Table 7.20. Load entering the Urban Waste Water Treatment Plants (UWWTP) (p.e.)

UWW Name or IAS	2007	2009	2011	2014
Kakopetria	1200	1200	1200	1200
Paralimni	68487	62700	52665	53500
Ayia Napa			37500	37500
Livadhia Refugee Camp	2000	2000	2000	2000
Larnaca	39090	68000	70000	70000
Kyperounda	2068	2068	2200	2200
Platres	1820	1820	2000	2000
Agros	2400	2400	2500	2500
Limassol	131178	130000	182926	193417
Paphos	50000	85300	123925	119611
Dhali	4710	4710	5000	Not operated
Mia Milia	140000	140000	140000	Not operated
Central Vathia Gonia	9240	13900	20068	1230
Anthoupolis-A	4800	Not operated	Not operated	Not operated
Anthoupolis-B	Not operated	26500	37706	34132
Vathia-Gonia-A	Not operated	Not operated	39781	57252
Pelendri	Not operated	2200	2200	2200
Lythrodontas	Not operated	2100	3500	3500
Mia Milia B	Not operated	Not operated	Not operated	157116
IAS	9240	13900	26328	16219

Table 7.21. Total emissions from Domestic wastewater 1990-2017

	1990	2000	2005	2010	2015	2016	2017
CH ₄ (Gg)	3.68	3.93	3.43	1.88	1.33	1.33	1.34
N ₂ O (Gg)	0.04	0.05	0.05	0.05	0.05	0.05	0.05
Total (Gg CO₂ eq.)	103.88	112.39	100.65	63.23	49.33	49.51	49.86

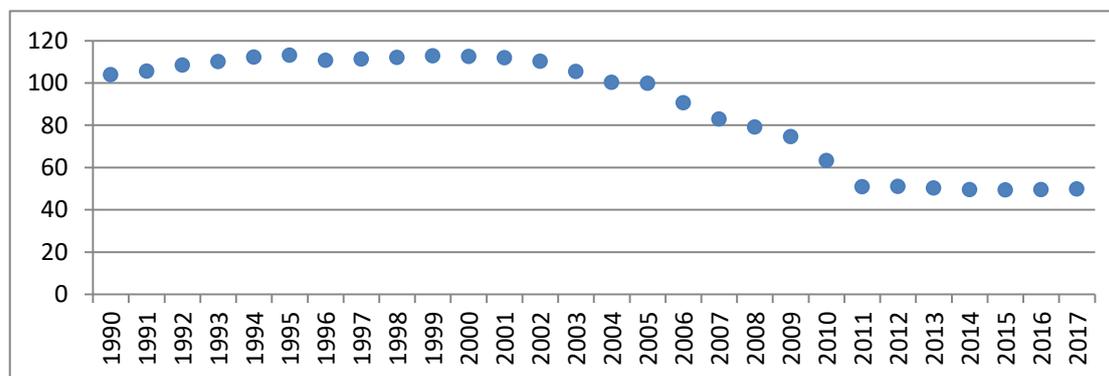


Figure 7.10. Total emissions from Domestic wastewater (5D1) 1990-2017

7.5.1.1. Methodological Issues

Methane emissions from wastewater

Emissions are a function of the amount of organic waste generated and an emission factor that characterises the extent to which this waste generates CH₄. Three tier methods for CH₄ from this category. Tier 2 methodology is applied for estimation of Methane emissions from wastewater in Cyprus.

The steps for inventory preparation for CH₄ 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 used⁸⁰. Country population has already been presented in Table 7.5. I is assumed 1 for waste disposed in septic tanks (assuming default for uncollected; IPCC2006, vol.5, pg. 6.14), eqn.6.3 and 1.25 for wastewater treated in central wastewater treatment stations (assuming default for collected; IPCC2006, vol.5, pg. 6.14). Distribution of wastewater to septic tanks and central treatment stations (Ui) is presented in Table 7.22, 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)⁸¹ 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 Service⁸² and for 2007, 2009, 2011 and 2014 from the Pollution Control Unit of the Department of Environment. 1990-1991 has been estimated from the trend of 1992-2005 ($y=0.0417e^{0.1204x}$, $R^2 = 0.9706$), 2006, 2008, 2010, 2012, 2013 average of the years before and after and 2015-2017 linear trend of 2011-2014 ($y=0.0014x+0.7539$, $R^2 = 1$). The population served by septic tanks has been estimated by subtracting the connected population from 100%.

Table 7.22. 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%	23.9%	23.8%	23.6%
TOW (kt BOD/yr)	4.62	4.61	4.55	4.46	4.44	4.45	4.47

⁸⁰ Stella Perikenti, Environment Officer, National expert on urban wastewater management, Pollution Control Unit, Department of Environment (+35726804573, sperikenti@environment.moa.gov.cy)

⁸¹ Lia Georgiou, Senior Sanitary Engineer, Division of Waste Water and Reuse, Water Development Department (+357 22609186-185, lgeorgiou@wdd.moa.gov.cy)

⁸² 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_TREATMEN T-EN-240707.xls?OpenElement](http://www.mof.gov.cy/mof/cystat/statistics.nsf/All/CB1FB8138D95CBB5C22573210044E253/$file/WASTEWATER_TREATMEN T-EN-240707.xls?OpenElement)

Treatment							
U _i	75.5%	75.7%	75.8%	75.9%	76.1%	76.2%	76.4%
TOW (kt BOD/yr)	17.82	17.94	17.80	17.61	17.67	17.84	18.07

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 kgCH₄/kgBOD (default proposed by IPCC, 2006 guidelines, vol.5, pg. 6.12, table 6.2). MCF_j is 0.5 for septic tanks and 0 for central wastewater treatment units, as recommended by 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 plants⁸³. 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 does comply 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 EF are 0.3 kgCH₄/kgBOD for septic and 0 kgCH₄/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 CH₄ recovery and sum the results for each pathway/system. CH₄ Emissions (Table 7.24) have been estimated using the parameters listed in Table 7.23.

Table 7.23. Parameters used for the estimation of CH₄ emissions from wastewater treatment

Parameter	Value
Total organics in wastewater in inventory year, kg BOD/yr (TOW)	Table 7.22
Fraction of population in income group i in inventory year (U _i)	Table 7.22
Degree of utilisation of treatment/discharge pathway or system, j, for each income group (T _{i,j}) fraction i in inventory year	100%
EF _j = 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 7.24. CH₄ emissions from domestic wastewater treatment 1990-2017

	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
CH ₄ – centralized (t)	0	0	0	0	0	0	0
Total (t)	3904	3912	3933	3927	3898	3831	3657

⁸³ <http://uwwtd.oieau.fr/Cyprus/uwwtps/compliance>

	2004	2005	2006	2007	2008	2009	2010
CH4 – septic (t)	3443	3431	3071	2711	2539	2359	1885
CH4 – 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
CH4 – septic (t)	1386	1384	1364	1339	1333	1335	1341
CH4 – centralized (t)	0	0	0	0	0	0	0
Total (t)	1386	1384	1364	1339	1333	1335	1341

Nitrous oxide emissions from wastewater

The activity data that are needed for estimating N₂O emissions are nitrogen content in the wastewater effluent, country population and average annual per capita protein generation (Table 7.25). Per capita protein generation consists of intake (consumption) which has been obtained from the Food and Agriculture Organization⁸⁴, 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) and also, bath and laundry water can 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) where human population is presented in Table 7.5 and annual per capita protein consumption as presented in Table 7.25. Data is not available after 2007 and therefore considered constant for the remaining years, due to an unclear trend. Default fraction of nitrogen in protein (FNPR) of 0.16, kg N/kg protein, default factor for non-consumed protein added to the wastewater for developed countries (FNON-CON) of 1.4, default factor for industrial and commercial co-discharged protein into the sewer system (FIND-COM) of 1.25 and default nitrogen removed with sludge (NSLUDGE) of 0.

Table 7.25. Annual per capita protein consumption and resulting NEFFLUENT (kg/person/yr)

	1990	1991	1992	1993	1994	1995	1996
Protein consumption (kg/person/yr)	35.4	35.4	35.4	36.1	36.1	36.9	36.9
NEFFLUENT (kg N/yr)	5116938	5010457	5620729	5595673	5672550	5962866	5765676

	1997	1998	1999	2000	2001	2002	2003
Protein consumption (kg/person/yr)	36.9	37.2	37.2	37.6	37.6	37.6	36.3
NEFFLUENT (kg N/yr)	5825439	6038437	6146569	6068449	6147425	6181677	5920774

	2004	2005	2006	2007	2008	2009	2010
Protein consumption (kg/person/yr)	36.3	35.0	35.0	35.0	35.0	35.0	35.0
NEFFLUENT (kg N/yr)	6034959	5971170	5908449	6418466	6660423	6626644	6884229

	2011	2012	2013	2014	2015	2016	2017
Protein	35.0	35.0	35.0	35.0	35.0	35.0	35.0

⁸⁴ FAOSTAT, 2009, Food consumption, Dietary Protein Consumption (g/person/day), available from http://www.fao.org/fileadmin/templates/ess/documents/food_security_statistics/FoodConsumptionNutrients_en.xls

consumption (kg/person/yr)							
NEFFLUENT (kg N/yr)	6952568	6984024	6920305	6831584	6842069	6894495	6970312

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 N₂O emissions from such plants of 3.2 g N₂O/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 7.26. The amount of nitrogen associated with these emissions (N₂O, Table 7.26) have been back calculated and subtracted from the NEFFLUENT. The N₂O is calculated by multiplying N₂OPLANTS by 28/44.

The resulting N₂O emissions from wastewater are also presented in Table 7.26.

Table 7.26. N₂O emissions from advanced centralised wastewater treatment plants, N₂O and resulting NEFFLUENT

	1990	1991	1992	1993	1994	1995	1996
N ₂ OPLANTS (t)	40.20	39.36	44.15	43.96	44.56	46.84	45.29
N ₂ O (kg N/yr)	1228	1261	1289	1314	1336	1357	1228
NEFFLUENT – N ₂ O (kg N/yr)	5009229	5619468	5594384	5671235	5961530	5764320	5009229
N ₂ O emissions (t)	40.20	39.36	44.15	43.96	44.56	46.84	45.29

	1997	1998	1999	2000	2001	2002	2003
N ₂ OPLANTS (t)	45.76	47.43	48.28	47.67	48.29	48.56	46.51
N ₂ O (kg N/yr)	1375	1391	1406	1420	1437	1453	1472
NEFFLUENT – N ₂ O (kg N/yr)	5824064	6037046	6145163	6067029	6145988	6180224	5919302
N ₂ O emissions (t)	45.76	47.43	48.28	47.67	48.29	48.56	46.51

	2004	2005	2006	2007	2008	2009	2010
N ₂ OPLANTS (t)	47.41	46.90	46.41	50.42	52.32	52.05	54.08
N ₂ O (kg N/yr)	1493	1515	1543	1581	1623	1668	1710
NEFFLUENT – N ₂ O (kg N/yr)	6033466	5969655	5906906	6416885	6658800	6624976	6882518
N ₂ O emissions (t)	47.41	46.90	46.41	50.42	52.32	52.05	54.08

	2011	2012	2013	2014	2015	2016	2017
N ₂ OPLANTS (t)	54.61	54.86	54.36	53.66	53.75	54.16	54.75
N ₂ O (kg N/yr)	1755	1763	1747	1725	1727	1741	1760
NEFFLUENT – N ₂ O (kg N/yr)	6950813	6982261	6918558	6829859	6840341	6892755	6968552
N ₂ O emissions (t)	54.61	54.86	54.36	53.66	53.75	54.16	54.75

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

No recalculations to be reported.

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 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 and its wastewater is treated by anaerobic digestion, subsequently by further aerobic treatment and the final effluent is discharged into the local municipal sewerage system.
- Beer - Wastewater derived by two brewery installations, are also treated by anaerobic digestion and subsequently by further aerobic treatment. One is discharging the final effluent into the local municipal sewerage system and the other is using the effluent for irrigation.
- Dairy products - Wastewater derived by one dairy installation are treated by anaerobic digestion and subsequently by further aerobic treatment and the final effluent is discharged into the local municipal sewerage system.
- Meat and Poultry - Wastewater derived by meat and poultry installations are treated by anaerobic digestion plans treating mainly pig slurry and subsequently by further aerobic treatment and 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 plans treating 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 – soft drinks. Cyprus has one installation that is treating wastewater and other waste deriving from vegetables, fruits, juices and soft drinks production by anaerobic digestion.

Emissions from industrial wastewater increased by 23% between 1990 and 2017 (Table 7.27, Figure 7.12). Emission estimates from this source have been revised due to availability of new data for 2015.

Table 7.27. Total emissions from industrial wastewater 1990-2017

	1990	2000	2005	2010	2015	2016	2017
CH4 (t)	967.9	1115.2	1033.8	1091.1	1138.2	1138.2	1191.3
N2O (t)	1.042	1.175	0.958	0.926	0.914	0.914	0.955
Total (Gg CO2 eq.)	24.51	28.23	26.13	27.55	28.73	28.73	30.07

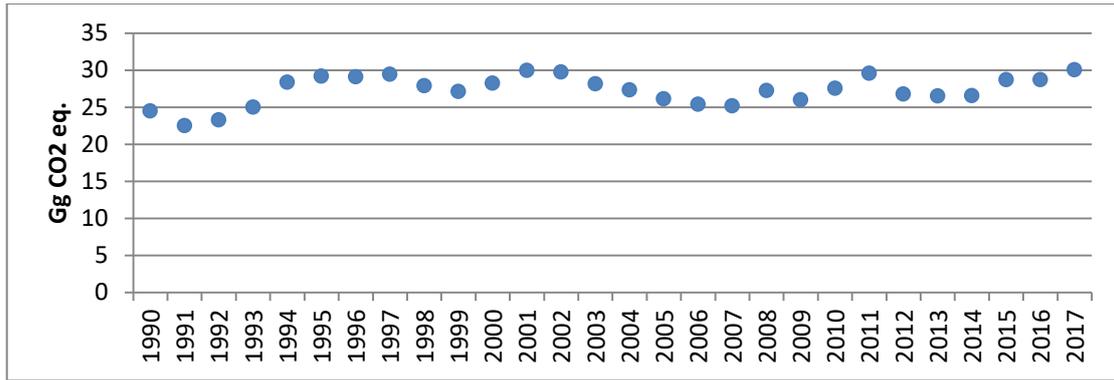


Figure 7.12. Emissions from industrial wastewater 1990-2017

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 CH₄ 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 0. The sum of the emissions for each handling method provides the total CH₄ emissions from industrial wastewater. In equation form, the estimate of total CH₄ emissions from wastewater handling is as follows (equation 6.4, 2006 IPCC guidelines, volume 5 pg. 6.20):

$$CH_4 \text{ Emissions} = \sum [(TOW_i - S_i) * EF_i - R_i]$$

where CH₄ emissions is the total methane emissions from wastewater in kg CH₄, TOW_i is the total organically degradable material in wastewater from industry i in kg COD/yr, S_i is the organic component removed as sludge in inventory year, kg COD/yr, EF_i is the emission factor for industry i in kg CH₄/kg COD and R_i is the total amount of methane recovered in kg CH₄/yr.

To estimate total organic wastewater (TOW) for a particular industry the following equation should be used (equation 6.6, IPCC2006 guidelines, volume 5, pg. 6.22):

$$TOW_i = P_i \times W_i \times COD$$

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 m³/tonne of product, COD is the chemical oxygen demand (industrial degradable organic component in kg COD/m³ wastewater).

To estimate the emission factor for industrial wastewater, the following equation is proposed by the IPCC guidelines (Equation 6.5, IPCC2006 guidelines, volume 5, pg. 6.21):

$$EF_j = B_o \times MCF_j$$

where EF_j is the emission factor (kg CH₄ /kg DC) for each treatment (e.g. aerobic treatment, anaerobic digester for sludge, etc.), B_o is the maximum methane producing capacity (kg CH₄/kg DC), MCF_j is the methane conversion factor. Since no country specific data is available, B_o is considered 0.25 (2006 IPCC guidelines, volume 5, pg. 6.21).

In words, the methodology applied for the estimation of methane emissions from industrial wastewater is the following:

- (a) Collection of data for industrial production (Table 7.28).
- (b) Total industrial organic wastewater was estimated by multiplying the industrial production by the wastewater generation coefficients and by COD in Table 7.29 (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 7.30).
- (d) The wastewater generated was categorised to anaerobic and aerobic treatment according to the assumptions of Table 7.31.
- (e) Methane conversion factor was assumed 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. 0.8 was used for anaerobic treatment, according to the 2006 IPCC guidelines (pg. 6.21, volume 5). Maximum producing capacity was assumed 0.25 kg CH₄ / kg according to the 2006 IPCC guidelines (pg. 6.21, volume 5). The resulting methane emission factor estimated according to waste stream is presented in Table 7.32.
- (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 CH₄ emissions are the sum of the CH₄ 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 2018) are completed and published in the summer after the inventory has to be submitted (which in this case is summer 2019). Therefore, the 2017 "production" is assumed to be equal to the 2016 "production". The industrial production data used is presented in Table 7.28.

Table 7.28. Industrial production 1990-2017 (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	0.61
Beer	32.2	33.0	32.9	32.8	34.18	37.55	37.55
Soft drinks	54.6	35.6	26.0	10.8	11.13	14.46	14.46
Dairy products	109.3	106.2	100.9	99.8	100.12	103.73	103.73
Meat & poultry	103.6	96.0	83.6	79.7	82.43	84.72	84.72
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	8.20
Vegetable oils	15.7	14.3	12.2	12.6	12.06	11.72	11.72
Vegetables, fruits & juices	56.5	48.0	54.5	57.9	68.46	72.93	72.93
Wine	14.2	10.9	11.5	11.0	8.95	8.45	8.45

Industrial organic wastewater

Wastewater production was estimated by multiplying the industrial production by the wastewater generation coefficients in Table 7.29 (volume 5, pg. 6.22, Table 6.8). Information in the 2006 guidelines is not available for soft drinks, soaps & 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 7.29. Wastewater generation coefficient (m³/t product) and COD concentration (kg COD/m³) 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 7.29 (2006 IPCC guidelines, p.6.22). The sum of the TOW of each industrial product divided by 10⁶ is presented in Table 7.30.

Table 7.30. Total organically degradable material (Gg), 1990-2017

	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		
Gg DC	13.68	14.75	13.28	13.14	13.16	14.31	15.02	15.02		

Categorisation of wastewater treatment to aerobic and anaerobic

The wastewater generated was categorised to anaerobic and aerobic treatment according to the

assumptions of Table 7.31. The assumptions were prepared in collaboration with the Pollution Prevention Unit of the Department of Environment.

Methane emission factor

Methane conversion factor was assumed 0 for aerobic treatment and 0.8 for anaerobic treatment, according to the 2006 IPCC guidelines (volume 5, pg. 6.21, Table 6.7). Maximum producing capacity was assumed 0.25 kg CH₄ / kg COD according to the 2006 IPCC guidelines (pg. 6.21, volume 5). The resulting methane emission factor estimated according to waste stream is presented in Table 7.32.

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 7.31. Treatment of waste by anaerobic treatment according to industrial production, 1990-2017

	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%	3.4%
beer	21%	20%	20%	20%	19%	18%	18%
soft drinks	0.85%	1.31%	1.79%	4.31%	4.19%	3.22%	3.22%
dairy products	4.55%	4.69%	4.93%	4.99%	4.97%	4.80%	4.80%
meat & poultry	4.51%	4.86%	5.59%	5.86%	5.67%	5.51%	5.51%

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%	0.8%
veg., fruits & juices	0.8%	1.0%	0.9%	0.8%	0.7%	0.7%	0.7%
wine	0	0	0	0	0	0	0

Table 7.32. Methane emission factor estimated according to waste stream (kg CH₄/kg COD), 1990-2017

	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	0.097
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

Estimation of N₂O emissions

The nitrous oxide emissions were estimated by multiplying the total annual industrial wastewater production (Table 7.33) by the default emission factor of 0.25 g N₂O/m³ wastewater according to EMEP/CORINAIR 2007 methodology⁸⁵.

Table 7.33. Total industrial wastewater production (1000 m³/year), 1990-2017

	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
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				
Alcohol	15	14	15	15				
Beer	206	215	237	237				
Soft drinks	22	22	29	29				
Dairy products	698	701	726	726				
Meat & poultry	1037	1072	1101	1101				
Refinery	0	0	0	0				
Soaps & detergents	22	20	25	25				
Vegetable oils	39	37	36	36				
Veg., fruits & juices	1157	1369	1459	1459				
Wine	253	206	194	194				

7.5.2.2 Uncertainties and time-series consistency

⁸⁵ 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/EMEP/CORINAIR/5/B9101vs1.pdf>, table 2, pg. B9101-2

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 2016 due to revision of the activity data of solid waste production by the Statistical Service. Emissions increased for the particular year from 28.46 to 29.78 Gg CO₂ eq. which corresponds to an increase of emissions by 5%.

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 CO₂ and N₂O emissions

Any indirect CO₂ and N₂O emissions estimated have been reported in the appropriate chapters of the inventory.

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 2018 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. Inconsistencies resolving is also included in this category.
- Updated activity data.

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 excluding LULUCF on a per sector basis is presented.

Table 10.1. Comparison of NIR2019 to NIR2018, in kt CO₂ eq.

NIR2019	1990	1991	1992	1993	1994	1995	1996
1. Energy	3969.8	4503.1	4831.9	5010.1	5222.9	5132.1	5428.9
2. IPPU	841.1	814.0	875.5	940.2	980.1	956.7	1020.2
3. Agriculture	471.2	475.2	509.7	540.5	530.0	580.1	562.2
4. LULUCF	-251.2	-247.5	-255.1	-271.6	-256.0	-277.0	-284.6
5. Waste	386.7	390.8	399.1	407.8	419.0	426.6	430.9
Total (incl. LULUCF)	5417.7	5935.7	6361.1	6627.0	6896.0	6818.5	7157.6
Total (excl. LULUCF)	5668.9	6183.1	6616.2	6898.6	7152.0	7095.6	7442.1
NIR2018							
1. Energy	3956.2	4488.0	4813.5	4989.6	5199.1	5105.2	5399.1
2. IPPU	771.9	732.6	785.7	855.6	892.8	860.6	921.5
3. Agriculture	476.4	480.4	515.7	546.9	536.3	586.8	569.0
4. LULUCF	-267.7	-263.3	-270.0	-285.1	-268.3	-288.2	-294.9
5. Waste	386.7	390.8	399.1	407.8	419.0	426.6	430.9
Total (incl. LULUCF)	5323.5	5828.5	6244.1	6514.8	6778.9	6691.0	7025.7
Total (excl. LULUCF)	5591.2	6091.8	6514.0	6800.0	7047.2	6979.2	7320.5
Difference							
1. Energy	0.34%	0.34%	0.38%	0.41%	0.46%	0.53%	0.55%

2. IPPU	8.97%	11.11%	11.43%	9.88%	9.78%	11.16%	10.70%
3. Agriculture	-1.09%	-1.08%	-1.16%	-1.17%	-1.18%	-1.13%	-1.21%
4. LULUCF	-6.17%	-6.01%	-5.51%	-4.76%	-4.58%	-3.89%	-3.49%
5. Waste	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total (incl. LULUCF)	1.77%	1.84%	1.87%	1.72%	1.73%	1.91%	1.88%
Total (excl. LULUCF)	1.39%	1.50%	1.57%	1.45%	1.49%	1.67%	1.66%

NIR2019	1997	1998	1999	2000	2001	2002	2003
1. Energy	5553.4	5901.3	6160.1	6376.3	6270.8	6430.3	6824.5
2. IPPU	991.1	951.1	970.3	997.9	985.4	1025.9	1036.6
3. Agriculture	548.5	562.8	545.7	552.4	601.5	620.9	602.7
4. LULUCF	-254.8	-180.4	-358.7	69.0	-186.4	-337.5	-352.0
5. Waste	438.7	444.9	452.0	460.0	468.5	474.8	476.4
Total (incl. LULUCF)	7276.9	7679.8	7769.4	8455.5	8139.8	8214.4	8588.3
Total (excl. LULUCF)	7531.7	7860.1	8128.1	8386.5	8326.3	8551.9	8940.3
NIR2018							
1. Energy	5520.6	5863.0	6125.0	6350.9	6242.3	6399.4	6788.4
2. IPPU	891.3	852.5	867.1	900.0	896.2	939.3	956.3
3. Agriculture	555.7	570.0	552.9	559.8	609.7	629.6	611.2
4. LULUCF	-264.4	-189.3	-366.6	62.0	-191.8	-341.0	-353.7
5. Waste	438.7	444.9	452.0	460.0	468.5	474.8	476.4
Total (incl. LULUCF)	7141.9	7541.1	7630.3	8332.8	8024.9	8102.1	8478.6
Total (excl. LULUCF)	7406.3	7730.4	7997.0	8270.7	8216.7	8443.1	8832.3
Difference							
1. Energy	0.59%	0.65%	0.57%	0.40%	0.46%	0.48%	0.53%
2. IPPU	11.20%	11.57%	11.90%	10.88%	9.96%	9.21%	8.41%
3. Agriculture	-1.29%	-1.26%	-1.31%	-1.34%	-1.34%	-1.39%	-1.37%
4. LULUCF	-3.62%	-4.70%	-2.16%	11.23%	-2.80%	-1.04%	-0.48%
5. Waste	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total (incl. LULUCF)	1.89%	1.84%	1.82%	1.47%	1.43%	1.39%	1.29%
Total (excl. LULUCF)	1.69%	1.68%	1.64%	1.40%	1.33%	1.29%	1.22%

NIR2019	2004	2005	2006	2007	2008	2009	2010
1. Energy	6958.1	7136.0	7319.0	7641.0	7807.1	7726.3	7495.4
2. IPPU	1121.2	1178.7	1191.1	1214.8	1212.8	1043.4	933.6
3. Agriculture	583.5	533.0	548.1	539.9	515.8	509.2	531.6
4. LULUCF	-347.3	-377.0	-452.2	-208.3	-512.0	-541.6	-488.5
5. Waste	478.9	485.8	484.4	485.5	492.7	496.5	498.2
Total (incl. LULUCF)	8794.4	8956.4	9090.4	9673.0	9516.4	9233.8	8970.2
Total (excl. LULUCF)	9141.6	9333.4	9542.6	9881.2	10028.5	9775.4	9458.8
NIR2018							
1. Energy	6951.1	7129.2	7312.0	7633.7	7800.1	7725.0	7494.3
2. IPPU	1040.7	1067.1	1107.7	1122.7	1151.1	997.4	887.0
3. Agriculture	591.6	540.6	555.9	548.1	523.7	517.0	539.9
4. LULUCF	-347.8	-376.4	-451.3	-207.0	-507.3	-536.1	-482.4
5. Waste	478.9	485.8	484.4	485.5	492.7	496.5	498.2
Total (incl. LULUCF)	8714.4	8846.3	9008.6	9583.0	9460.4	9199.8	8936.9
Total (excl. LULUCF)	9062.2	9222.7	9459.9	9790.0	9967.7	9735.9	9419.3
Difference							
1. Energy	0.10%	0.10%	0.10%	0.10%	0.09%	0.02%	0.01%
2. IPPU	7.73%	10.45%	7.53%	8.20%	5.35%	4.61%	5.26%
3. Agriculture	-1.37%	-1.40%	-1.39%	-1.49%	-1.50%	-1.52%	-1.54%
4. LULUCF	-0.15%	0.15%	0.20%	0.61%	0.94%	1.02%	1.27%
5. Waste	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total (incl. LULUCF)	0.92%	1.25%	0.91%	0.94%	0.59%	0.37%	0.37%
Total (excl. LULUCF)	0.88%	1.20%	0.87%	0.93%	0.61%	0.41%	0.42%

NIR2019	2011	2012	2013	2014	2015	2016
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1. Energy	7202.0	6716.0	5794.4	5957.5	6080.8	6480.1	
2. IPPU	877.7	836.8	1064.4	1279.7	1221.3	1225.4	
3. Agriculture	520.9	497.6	462.8	448.2	457.3	481.5	
4. LULUCF	-565.0	-544.7	-579.7	-577.0	-572.5	75.8	
5. Waste	501.0	510.7	521.4	531.3	543.8	554.3	
Total (incl. LULUCF)	8536.6	8016.4	7263.3	7639.7	7730.7	8817.1	
Total (excl. LULUCF)	9101.6	8561.1	7843.0	8216.7	8303.2	8741.3	
NIR2018							
1. Energy	7202.2	6711.6	5792.9	5956.2	6080.0	6480.4	
2. IPPU	882.3	859.0	1096.4	1327.5	1238.8	1250.1	
3. Agriculture	529.1	505.5	470.2	456.0	465.0	489.6	
4. LULUCF	-555.3	-536.1	-572.2	-570.6	-566.9	83.1	
5. Waste	501.0	510.7	521.4	531.4	543.8	552.9	
Total (incl. LULUCF)	8559.2	8050.8	7308.7	7700.4	7760.7	8856.2	
Total (excl. LULUCF)	9114.5	8586.9	7880.9	8271.0	8327.6	8773.1	
Difference							
1. Energy	0.00%	0.07%	0.03%	0.02%	0.01%	0.00%	
2. IPPU	-0.52%	-2.58%	-2.92%	-3.60%	-1.41%	-1.98%	
3. Agriculture	-1.55%	-1.57%	-1.56%	-1.72%	-1.66%	-1.64%	
4. LULUCF	1.74%	1.61%	1.31%	1.13%	0.98%	-8.82%	
5. Waste	0.00%	0.00%	0.00%	0.00%	0.00%	0.24%	
Total (incl. LULUCF)	-0.26%	-0.43%	-0.62%	-0.79%	-0.39%	-0.44%	
Total (excl. LULUCF)	-0.14%	-0.30%	-0.48%	-0.66%	-0.29%	-0.36%	

10.3. Implications for emission trends

Total GHG emissions of years 1990-2016 in the current submission are slightly lower than the emissions reported in the 2018 submission. The emission trends in Cyprus for the period 1990 –2016 according to the inventories submitted in 2018 & 2019 are shown in Figure 10.1. Emission trends for the period have not been affected significantly by the recalculations because in most cases the recalculations concerned the whole period.

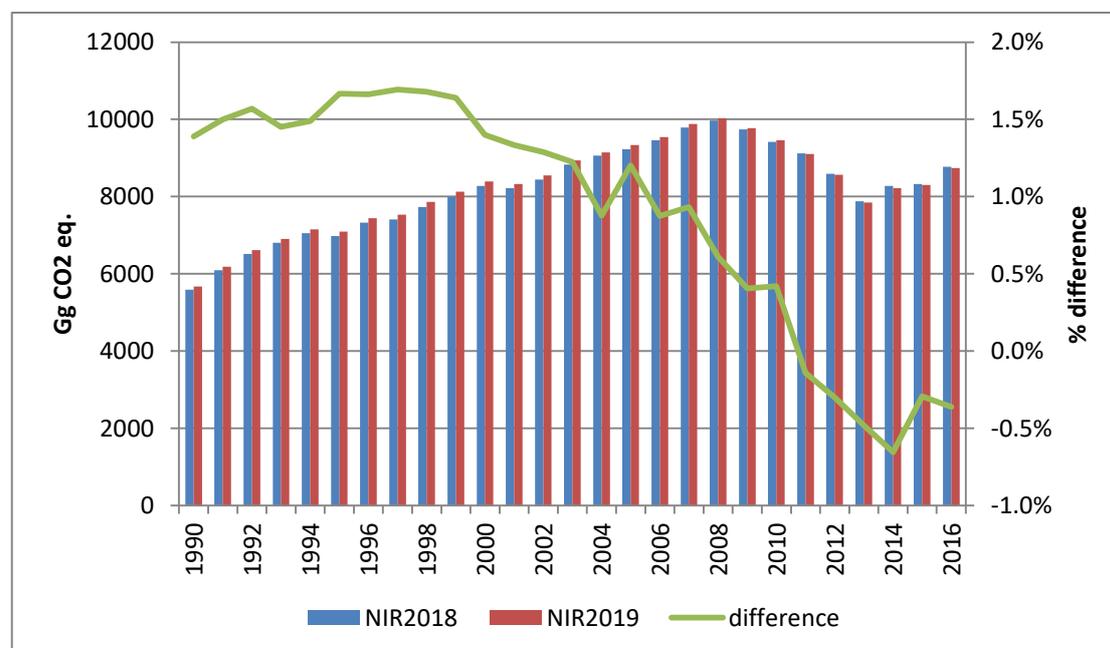


Figure 10.1. Comparison of NIR2019 to NIR2018, in kt CO2 eq.

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,

As a basis to prioritise, plan and materialize future improvements and recalculations. As mentioned above, details on the resulted 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.

The following three major changes in methodological descriptions performed in current NIR compared to previous year NIR have implemented. More details are provided in the relevant section of the report.

- (a) Road transport (1A3b): emissions have been estimated using a Tier 2 methodology for NIR2019 compared to T1 in previous submissions
- (b) Refrigeration and air-conditioning (2F1): methodology has been revised to be in line with the IPCC guidelines – further improvements are progress to revise all 2F and 2G methodologies
- (c) Several improvements have been implemented for the estimation of emissions from Indirect N₂O emissions from animal waste management (3B2.5) and Agricultural Soils (3D) due to (i) identification of mistakes during the EU review process in 2018 and (ii) availability of country specific EFs

Chapter 11.

KP-LULUCF

11.1. General information

GHG emissions and removals arising from land use, land use change and forestry activities reported under the Kyoto Protocol (incl. HWP) for the period 2013 – 2017 are presented in Table 11.1.

Table 11.1. GHG emissions (+) and removals (-) arising from land use, land use change and forestry activities reported under the Kyoto Protocol (incl. HWP) for the period 2013 – 2017

Activity	Greenhouse gas emissions/removals [kt CO ₂ eq]				
	2013	2014	2015	2016	2017
Afforestation/Reforestation	-37.8	-43.0	-41.6	-36.6	-37.1
Deforestation	0.7	0.6	0.5	0.4	0.3
Forest Management	-142.2	-143.4	-139.0	-19.6	-130.0

A weak decreasing trend in GHG emissions from deforestation is distinguishable. GHG removals from A/R and FM are almost stable during the reported period (except for 2016 due to forest wildfires).

It is noticeable that Forest Management Reference Level is lower than the actual removals estimated for the Forest Management Kyoto Protocol activity hence, the accountable input from Forest Management is source (and not sink).

11.1.1. Definition of forest and any other criteria

Cyprus has adopted the following definition of forest: 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 definitions used in the past for reporting to the Food and Agriculture Organization of the United Nations for its Global Forest Resource assessment (FAO FRA 2015). This definition is consistent with the guidance on adopting national definition of forest contained in Decision 16/CMP.1.

Forest Land 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. Note, that forest land contains only areas covered with trees that according to the Forest National Law of 2012 (25 (I)/2012) are considered forest trees.

According to the Forest National Law of 2012 (25 (I)/2012) all forests in Cyprus are managed. Natural forests in the sense of the Decision 2/CMP.7 do not exist in Cyprus. Therefore, there occurs no conversion from natural forests to plantations.

11.1.2. Elected activities under Article 3, paragraph 4, of the Kyoto Protocol

Cyprus has decided not to elect any voluntary activities under Article 3.4 of the KP.

11.1.3. Description of how the definitions of each activity under Article 3.3 and each elected activity under Article 3.4 have been implemented and applied consistently over time

The area of forest land reported for Afforestation/Reforestation, Deforestation and Forest Management under the Kyoto Protocol has the same basis as the area reported for land use changes from and to forests in the greenhouse gas inventory prepared under the Convention however, the time frame is different (under the KP ARD areas start in 1990). Note, that lands classified as ARD under the Kyoto Protocol may be reported under different land-use category under the Convention after the 20-year transition period. All land use changes to/from forests are considered to be direct human induced ARD. Afforestation and Reforestation activities are reported together.

Land-use category definitions and methods for sink/source assessment are implemented in a consistent way for the entire period since 1990.

11.1.4. Description of precedence conditions and/or hierarchy among Article 3.4 activities, and how they have been consistently applied in determining how land was classified

Cyprus has decided not to elect any voluntary activities under Article 3.4 of the KP hence, mandatory FM is the only Art. 3.4 activity reported by Cyprus.

11.2. Land-related information

11.2.1. Spatial assessment unit used for determining the area of the units of land under Article 3.3

Land use data for Cyprus are sourced from the CORINE land cover (CLC) inventory (<http://land.copernicus.eu/pan-european/corine-land-cover/view>) data. More detailed information on the way the CORINE data were analyzed and interpreted is provided in Chapter 7.1.2.2 “The land-use categories for greenhouse gas inventory reporting” above.

Due to its representativeness and coverage the CORINE land cover data allow an unbiased reporting of the complete forest area, forest land remaining forest land and the change of land use from and to forests. At this moment, the CORINE land cover data constitute the only available database covering the entire Cyprus.

Table 11.2. Comparison of ARD and FM areas reported under KP and areas of forest land remaining forest land and LUC to/from forests reported under the Convention (k ha).

Year	Reporting under the Kyoto Protocol					Reporting under the Convention		
	Annual AR area	Total AR since 1990	Annual D area	Total D since 1990	Annual FM area	Forest remaining Forest area (annual)	Land converted to Forest	Land converted from Forest
	k ha	k ha	k ha	k ha	k ha	k ha	20-yr transition period	
	k ha	k ha	k ha	k ha	k ha	k ha	k ha	k ha
1990	0.589	0.589	0.034	0.034	149.381	149.381	0.589	0.034
1991	0.589	1.178	0.034	0.069	149.312	149.312	1.178	0.069
1992	0.589	1.768	0.034	0.103	149.277	149.277	1.768	0.103
1993	0.589	2.357	0.034	0.138	149.243	149.243	2.357	0.138
1994	0.589	2.946	0.034	0.172	149.208	149.208	2.946	0.172
1995	0.589	3.535	0.034	0.207	149.174	149.174	3.535	0.207
1996	0.589	4.125	0.034	0.241	149.139	149.139	4.125	0.241
1997	0.589	4.714	0.034	0.276	149.105	149.105	4.714	0.276
1998	0.589	5.303	0.034	0.310	149.070	149.070	5.303	0.310
1999	0.589	5.892	0.034	0.345	149.036	149.036	5.892	0.345
2000	0.589	6.482	0.034	0.379	149.001	149.001	6.482	0.379
2001	0.589	7.071	0.034	0.414	148.967	148.967	7.071	0.414
2002	0.589	7.660	0.034	0.448	148.932	148.932	7.660	0.448
2003	0.589	8.249	0.034	0.483	148.898	148.898	8.249	0.483
2004	0.589	8.838	0.034	0.517	148.863	148.863	8.838	0.517
2005	0.589	9.428	0.034	0.552	148.829	148.829	9.428	0.552
2006	0.019	9.447	0.011	0.562	148.818	148.818	9.447	0.562
2007	0.019	9.465	0.011	0.573	148.807	148.807	9.465	0.573
2008	0.019	9.484	0.011	0.584	148.796	148.796	9.484	0.584
2009	0.019	9.503	0.011	0.595	148.786	148.786	9.503	0.595
2010	0.019	9.522	0.011	0.606	148.775	149.364	8.933	0.571
2011	0.019	9.541	0.011	0.617	148.764	149.942	8.362	0.548
2012	0.019	9.560	0.011	0.627	148.753	150.521	7.792	0.524
2013	0.019	9.578	0.011	0.638	148.742	151.099	7.221	0.500
2014	0.019	9.597	0.011	0.649	148.731	151.678	6.651	0.477
2015	0.019	9.616	0.011	0.660	148.721	152.256	6.081	0.453
2016	0.019	9.635	0.011	0.671	148.710	152.834	5.510	0.430
2017	0.019	9.654	0.011	0.682	148.700	153.412	4.940	0.407

Lands actually reported under the Kyoto Protocol are marked in bold.

11.2.2 Methodology used to develop the land transition matrix

Land transition matrix was developed using the CORINE land cover change data further processed to obtain consistency with the CORINE land cover data on annual basis. The processing included direct changes in the Other Land category to allow the total area of the lands under control of the Government remain unchanged in all reported years.

The CORINE land cover data are available for the years 2000, 2006 and 2012. It was assumed that annual changes in land use observed during the period 2000 – 2006 approximate the changes occurring in the period 1990 – 2006. It was also assumed that annual changes in land use observed during the period 2006 – 2012 approximate the changes occurring in the period 2007 – 2016. The land use change matrixes for the period 1990 – 2006 and 2007 – 2016 are contained in Table 11.3 and Table 11.4, respectively.

Table 11.3. The annual land use change matrix for the year 1990/1991 (changes representative for the period 1990 – 2006).

From\To	Broadl. F	Conif. F	Annual CL	Woody CL	Grass GL	Woody GL	Wet-land	Settle-ments	Other Land	Total initial area
	k ha	k ha	k ha	k ha	k ha	k ha	k ha	k ha	k ha	k ha
Broadl. F	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	1.02
Conif. F	0.00	148.91	0.00	0.00	0.00	0.00	0.00	0.01	0.00	148.91
Annual CL	0.00	0.00	127.60	0.09	0.00	0.00	0.00	0.32	0.07	128.08
Woody CL	0.00	0.00	0.00	122.39	0.00	0.00	0.00	0.40	0.00	122.78
Grass GL	0.00	0.01	0.09	0.01	30.52	0.00	0.00	0.12	0.23	30.98
Woody GL	0.00	0.00	0.00	0.07	0.00	121.05	0.00	0.20	0.64	121.95
Wetland	0.00	0.00	0.00	0.00	0.00	0.00	2.58	0.00	0.00	2.58
Settlements	0.00	0.02	0.00	0.04	0.00	0.00	0.00	38.63	0.00	38.70
Other Land	0.00	0.56	0.00	0.53	0.00	0.00	0.08	0.00	5.64	6.80
Total final area	1.00	149.49	127.69	123.11	30.52	121.05	2.66	39.67	6.60	601.80

Table 11.4. The annual land use change matrix for the year 2007/2008 (changes representative for the period 2007 – 2017).

From\To	Broadl. F	Conif. F	Annual CL	Woody CL	Grass GL	Woody GL	Wet-land	Settle-ments	Other Land	Total initial area
	k ha	k ha	k ha	k ha	k ha	k ha	k ha	k ha	k ha	k ha
Broadl. F	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61
Conif. F	0.00	158.19	0.00	0.00	0.00	0.00	0.01	0.00	0.00	158.20
Annual CL	0.00	0.00	121.77	0.00	0.00	0.00	0.00	0.07	0.00	121.85
Woody CL	0.00	0.00	0.01	127.92	0.00	0.00	0.00	0.14	0.02	128.09
Grass GL	0.00	0.00	0.00	0.00	23.67	0.00	0.00	0.01	0.04	23.72
Woody GL	0.00	0.00	0.00	0.00	0.00	107.43	0.00	0.07	0.00	107.50
Wetland	0.00	0.00	0.00	0.00	0.00	0.00	3.86	0.00	0.00	3.86
Settlements	0.00	0.02	0.00	0.00	0.00	0.01	0.01	54.28	0.00	54.32
Other Land	0.00	0.00	0.01	0.00	0.00	0.06	0.00	0.00	3.56	3.63
Total final area	0.61	158.21	121.79	127.93	23.67	107.50	3.88	54.58	3.63	601.80

11.2.3. Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations

Maps reflecting the approximate location of land cover changes as detected using the CORINE land cover data base are used for identification of individual land cover change however, reporting is performed on the level of the entire land under the Government control.

11.3. Activity-specific information

11.3.1. Methods for carbon stock change and GHG emission and removal estimates

11.3.1.1. Description of the methodologies and the underlying assumptions used

The methodologies and assumptions used for calculation of the GHG estimates under the Kyoto Protocol Art. 3.3 are identical with those for LUCs from and to forests used for similar calculations under the Convention. However, the areas of the activities under the KP differ from the areas of

subcategories under the Convention as they follow the KP specific rules explained in the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol.

As the first step in estimating carbon stock change and GHG emissions and removals, areas of land subjected to KP activities are calculated by year. In each case, the calculations involve areas of the relevant land-use categories conversions and areas remaining in the same land-use category as reported under the Convention.

Afforestation/Reforestation (AR)

Lands to be reported as AR under the Kyoto Protocol include all lands that were converted from non-forest land-use categories to forest land-use category since 1990 irrespectively of their fate after the conversion with exception to deforestation. All forest lands subjected to deforestation are always reported as D under the KP.

In Cyprus, analysis of land use change matrixes revealed that the following land use categories (reported under the Convention) are converted to forest: Grass Grassland, Settlements and Other Land. Under the Convention lands converted to forest turn into Forest remaining Forest 20 years after the conversion however, under the KP these lands shall be continuously reported under AR.

As discussed in Chapter 7.7.3 (in particular see Table 7.17), lands classified as Other Land reveal increased dynamics and quick turn-over of lands converted to and from the Other Land. The land-use categories that mostly contribute to the Other Land land-use category are Woody Grassland and Grass Grassland. Therefore, conversions of Other Land land-use category to forest was replaced by conversion of Woody Grassland and Grass Grassland to forest in proportion equal to their presence in the Other Land land-use category. This replacement results in closer to reality approximation of carbon stock changes and GHG emission and removal in lands to be reported as AR under the KP.

If initially afforested/reforested land remains in Forest land-use category for at least 20 years then it is reclassified to Forest remaining Forest (referred to as Secondary classification in Table 11.5) for the purpose of reporting under the Convention however, it shall be reported as AR under the Kyoto Protocol. Table 11.5 presents numerical data on area of lands to be reported as AR under the KP.

Deforestation (D)

Lands to be reported as D under the Kyoto Protocol include all lands that were converted from forest land-use category to non-forest land-use categories since 1990 irrespectively of their fate after the conversion.

In Cyprus, analysis of land use change matrixes revealed that lands classified as Broadleaved Forest are converted to Settlements and Other Land while lands classified as Coniferous Forest are converted to Woody Cropland, Wetland, Settlements and Other Land. If initially converted land remains in these land-use categories for at least 20 years then it is reclassified to Woody Cropland remaining Woody Cropland, Wetland remaining Wetland, Settlements remaining Settlements and Other Land remaining Other Land (referred to as Secondary classification in Table 11.6) for the purpose of reporting under the Convention. However, all these lands are reported as Deforestation under the Kyoto Protocol. Table 11.6 presents numerical data on land-use categories to be reported as Deforestation under the Kyoto Protocol.

Forest management (FM)

All land under the forest land-use category is considered as managed. Consequently, lands to be reported as FM under the Kyoto Protocol include Broadleaved Forest remaining Broadleaved Forest and Coniferous Forest remaining Coniferous Forest land-use categories reported under the Convention since 1990 to the reported year of the second commitment period of the KP. It means that lands containing the FM activity shall not contain any lands converted to Forest since 1990. Table 11.7 presents numerical data on area of land-use categories under the Convention to be reported as FM under the KP.

Table 11.5. Land-use category conversions occurring under the Convention to be reported as AR under the KP (Non-forest land-use categories converted to forest land-use categories)

Year	Total AR	Conversion from non-forest land-use categories under the Convention:				Secondary classification
		Grass Grassland	Settlements	Other Land consisting of:		Coniferous F. remaining Coniferous F.
				Woody GL	Grass GL	
		to Coniferous Forest land-use category under the Convention				
ha	ha	ha	ha			
1990	589.2	8.0	24.7	407.5	109.1	
1991	1178.5	16.1	49.3	815.0	218.2	
1992	1767.7	24.1	74.0	1222.6	327.3	
1993	2356.9	32.2	98.7	1630.1	436.4	
1994	2946.2	40.2	123.3	2037.6	545.5	
1995	3535.4	48.3	148.0	2445.1	654.6	
1996	4124.6	56.3	172.7	2852.7	763.7	
1997	4713.9	64.4	197.4	3260.2	872.8	
1998	5303.1	72.4	222.0	3667.7	981.9	
1999	5892.3	80.5	246.7	4075.2	1091.0	
2000	6481.6	88.5	271.4	4482.7	1200.1	
2001	7070.8	96.6	296.0	4890.3	1309.3	
2002	7660.0	104.6	320.7	5297.8	1418.4	
2003	8249.3	112.7	345.4	5705.3	1527.5	
2004	8838.5	120.7	370.0	6112.8	1636.6	
2005	9427.7	128.8	394.7	6520.3	1745.7	
2006	9446.5	128.8	413.5	6520.3	1745.7	
2007	9465.4	128.8	432.4	6520.3	1745.7	
2008	9484.2	128.8	451.2	6520.3	1745.7	
2009	9503.0	128.8	470.0	6520.3	1745.7	
2010	9521.9	128.8	488.9	6520.3	1745.7	
2011	9540.7	120.7	483.0	6112.8	1636.6	589.2
2012	9559.5	112.7	477.2	5705.3	1527.5	1178.5
2013	9578.4	104.6	471.4	5297.8	1418.4	1767.7
2014	9597.2	96.6	465.5	4890.3	1309.3	2356.9
2015	9616.0	88.5	459.7	4482.7	1200.1	2946.2
2016	9634.9	80.5	453.9	4075.2	1091.0	3535.4
2017	9616.1	72.5	448.1	3667.6	981.9	4124.6

Lands actually reported under the Kyoto Protocol are marked in bold.

Table 11.6. Land-use category conversions occurring under the Convention to be reported as D under the KP (Forest land-use categories converted to non-forest land-use categories)

Year	Total D	Conversion from forest land-use categories under the Convention:						Secondary classification:		
		Broadleaved Forest		Coniferous Forest				Woody CL remaining Woody CL	Settlements remaining Settlements	Other Land remaining Other Land
		To non-forest land-use categories under the Convention:								
		Settlements	Other Land	Woody CL	Wetland	Settlements	Other Land	ha	ha	ha
ha	ha	ha	ha	ha	ha	ha	ha	ha		
1990	34.5	1.3	24.6	0.1		8.5				
1991	68.9	2.6	49.2	0.2		17.0				
1992	103.4	3.9	73.7	0.4		25.4				
1993	137.9	5.2	98.3	0.5		33.9				
1994	172.3	6.4	122.9	0.6		42.4				
1995	206.8	7.7	147.5	0.7		50.9				
1996	241.3	9.0	172.1	0.8		59.3				
1997	275.8	10.3	196.7	1.0		67.8				
1998	310.2	11.6	221.2	1.1		76.3				
1999	344.7	12.9	245.8	1.2		84.8				
2000	379.2	14.2	270.4	1.3		93.3				
2001	413.6	15.5	295.0	1.4		101.7				
2002	448.1	16.8	319.6	1.6		110.2				
2003	482.6	18.1	344.2	1.7		118.7				
2004	517.0	19.3	368.7	1.8		127.2				
2005	551.5	20.6	393.3	1.9		135.6				
2006	562.4	20.6	393.3	1.9	5.9	135.6	4.9			
2007	573.2	20.6	393.3	1.9	11.9	135.6	9.8			
2008	584.1	20.6	393.3	1.9	17.8	135.6	14.7			
2009	594.9	20.6	393.3	1.9	23.8	135.6	19.6			
2010	605.8	20.6	393.3	1.9	29.7	135.6	24.5			
2011	616.6	19.3	368.8	1.8	35.7	127.2	29.4	0.1	9.8	24.6
2012	627.5	18.1	344.2	1.7	41.6	118.7	34.3	0.2	19.5	49.2
2013	638.3	16.8	319.6	1.6	47.5	110.2	39.2	0.4	29.3	73.7
2014	649.2	15.5	295.0	1.4	53.5	101.7	44.1	0.5	39.1	98.3
2015	660.0	14.2	270.5	1.3	59.4	93.3	49.0	0.6	48.8	122.9
2016	670.9	12.9	245.9	1.2	65.4	84.8	53.9	0.7	58.6	147.5
2017	681.7	11.6	221.3	1.1	71.3	76.3	58.8	0.9	68.4	172.0

Lands actually reported under the Kyoto Protocol are marked in bold.

Table 11.7. Forest land-use categories remaining Forest land-use categories under the Convention to be reported as FM under the KP

Year	Total FM	Broadleaved F remaining Broadleaved F	Coniferous F remaining Coniferous F
	ha	ha	ha
2011	148174.7	607.6	147567.1
2012	147574.6	607.6	146967.0
2013	146974.5	607.6	146366.9
2014	146374.4	607.6	145766.9
2015	145774.3	607.6	145166.8
2016	145174.3	607.5	144566.7
2017	144574.1	607.5	143966.6

Lands actually reported under the Kyoto Protocol are marked in bold.

Cyprus has decided **not to elect** any among the following approaches allowed by Decision 2/CMP.7 for including in reporting/accounting under the KP⁸⁶:

- Possibility to exclude from the accounting of Afforestation and Reforestation and Forest Management (either annually or at the end of second commitment period) emissions from natural disturbances that in any single year exceed a Forest Management background level.
- Possibility to include in the accounting of Forest Management under Article 3.4 anthropogenic greenhouse gas emissions by sources and removals by sinks resulting from the harvest and conversion of forest plantations, accounted for under Forest Management, to non-forest land.

Consequently, GHG removals/emissions reported under the Convention from lands to be reported under the KP are in fact GHG removals/emissions to be reported under the KP.

11.3.1.2. Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and elected activities under Article 3.4

All carbon pools are included.

No forests are fertilized in Cyprus hence, all GHG emissions relating to fertilization are reported as not occurring “NO”.

11.3.1.3. Information on whether or not indirect and natural GHG emissions and removals have been factored out

Due to unavailability of the UNFCCC approved approaches for factoring out the indirect and natural GHG emissions/removals these have not been implemented in this report.

11.3.1.4 Changes in data and methods since the previous submission (recalculations)

This is the first submission hence no recalculations are reported.

11.3.1.5 Uncertainty estimates

Uncertainty analysis will be performed when area data of resolution comparable to the area threshold used in the forest definition (0.3 ha) will be available. All remarks on uncertainties included in Chapter 7 (LULUCF) are applicable to this chapter as well.

11.3.1.6 Information on other methodological issues

The methodologies used to estimate emissions/removals from ARD activities are identical to methodologies used for reporting under the Convention.

⁸⁶ Details of these approaches are presented in the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol.

11.3.1.7 The year of the onset of an activity, if after 2008

All activities covered by this report are reported since 1 January 2013.

11.4. Article 3.3

11.4.1. Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and are direct human-induced

Land use data for Cyprus leading to identification of the A/R/D activities are sourced from the CORINE land cover (CLC) inventory data⁸⁷ (<http://land.copernicus.eu/pan-european/corine-land-cover/view>) which contains information on the timing of collection of the relevant images. This fact guarantees that activities reported under Article 3.3 approximately began on or after 1 January 1990. However, the earliest data available from the CORINE database cover year 2000 and all numerical data for the preceding years are obtained by extrapolation back the land use changes observed in the period 2000 – 2006.

In Cyprus, all ARD activities are human induced.

11.4.2. Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation

The national definition of forest as contained in the Forest National Law of 2012 (25 (I)/2012) includes under forest all areas that are temporarily un-stocked (e.g. harvested area, disturbances) but expected to revert to forest. Any land use change involving the decrease of forest area requires an administrative permission and lack of such permission ensures that all temporarily un-stocked areas will revert to forest.

11.4.3. Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested

State Forests are legally obliged to reintroduce forest into any area under their control that has lost forest cover. Private forest owners are required to obtain an administrative permission to change land use from forest to non-forest one. Consequently, the annual deforestation rate is about 25 ha/year in the period 1990 – 2016.

11.5. Article 3.4

11.5.1. Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

Land use data for Cyprus leading to identification of the FM activities are sourced from the CORINE land cover (CLC) inventory (<http://land.copernicus.eu/pan-european/corine-land-cover/view>) data which contains information on the timing of collection of the relevant images. This fact guarantees that activities under Article 3.4 have occurred since 1 January 1990. However, the earliest data available

87

from the CORINE database cover year 2000 and all numerical data for the preceding years are obtained by extrapolation back the land use changes observed in the period 2000 – 2006.

In Cyprus, all FM activities are human induced.

11.5.2. Information relating to Cropland Management, Grazing Land Management and Revegetation, if elected, for the base year

Cyprus has decided not to elect any voluntary activities under the KP.

11.5.3. Information relating to Forest Management

Cyprus has a well-established tradition in Forest Management which is characterized by a relevant forest policy that focuses on forest protection and biodiversity conservation in parallel to wood production, resulting e.g. in progressively decreasing volume of harvest. The Forest National Law of 2012 (25 (I)/2012) promotes sustainable management of forests allowing for balancing the relevant ecological, economic and social functions of forests. Therefore, Cyprus decided to use a broad definition of Forest Management under the Kyoto Protocol.

11.6. Other information

11.6.1. Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

A key category is one that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level, the trend, or the uncertainty in emissions and removals. Whenever the term key category is used, it includes both source and sink categories.

Key category analysis requires disaggregation of sinks and sources. Table 11.8, Table 11.9 and Table 11.10 present disaggregation applied for AR, D and FM KP activities, respectively.

Table 11.8. Afforestation/Reforestation - disaggregation by land-use categories

	Initial land-use category	Converted to / remaining	Final land-use category
1	Grass Grassland	converted to:	Coniferous Forest
2	Settlements		Coniferous Forest
3	Other Land		Coniferous Forest
4	Coniferous F.	remaining	Coniferous Forest

Table 11.9. Deforestation - disaggregation by land-use categories

	Initial land-use category	Converted to / remaining	Final land-use category
1	Broadleaved Forest	converted to:	Settlements
2			Other Land
3	Coniferous Forest	converted to:	Woody CL
4			Wetland
5			Settlements
6			Other Land
7	Woody CL	remaining	Woody CL
8	Settlements		Settlements
9	Other Land		Other Land

Table 11.10. Forest Management - disaggregation by land-use categories

	Initial land-use category	Converted to / remaining	Final land-use category
1	Broadleaved Forest	remaining	Broadleaved Forest
2	Coniferous Forest		Coniferous Forest

Table 11.11. Key category analysis for the KP LUUCF activities. For the purposes of reporting the signs for removals are always negative (-) and for emissions positive (+).

IPCC Category Code	IPCC Category	GHG	Latest Year (2017) Estimate (LYE)	Absolute value of LYE	Level Assessment (LA)	Cumulative Total of LA
			kt CO2 eq	kt CO2 eq		
3 B 1 a(1)	Coniferous Forest Land Remaining Coniferous Forest Land	CO2	-129.695	129.695	0.7827	0.7827
3 B 1 b ii (1)(2)	Woody Grassland Converted to Coniferous Forest Land	CO2	-18.639	18.639	0.1125	0.8951
3 B 1 b iv (1)	Settlements Converted to Coniferous Forest Land	CO2	-8.667	8.667	0.0523	0.9474
3 B 6	Grass Grassland to Coniferous Forest	CO2	-5.064	5.064	0.0306	0.9780
3 B 4 b	Coniferous Forest Converted to Wetlands	CO2	-1.124	1.124	0.0068	0.9848
3 B 6 b i (2)	Deciduous Forest Land Converted to Other Land	CO2	0.907	0.907	0.0055	0.9902
3 B 6 b i (1)	Coniferous Forest Land Converted to Other Land	CO2	0.687	0.687	0.0041	0.9944
3 B 1 b ii (1)(1)	Grass Grassland Converted to Coniferous Forest Land	CO2	-0.374	0.374	0.0023	0.9966
3 B 1 a(2)	Deciduous Forest land Remaining Deciduous Forest Land	CO2	-0.327	0.327	0.0020	0.9986
3 B 5 b i (1)	Coniferous Forest Land Converted to Settlements	CO2	-0.212	0.212	0.0013	0.9999
3 B 5 b i (2)	Deciduous Forest Land Converted to Settlements	CO2	0.016	0.016	0.0001	1.0000
3 B 2 b i (1)(2)	Coniferous Forest Land Converted to Woody Cropland	CO2	-0.003	0.003	0.0000	1.0000
	Total			165.712	1.0000	

11.7. Information relating to Article 6

Cyprus does not participate in the implementation of Article 6 of the KP.

11.8. Calculation of an estimate of HWP Contribution under the KP

In Cyprus, transparent and verifiable activity data for the specified categories (paper, wood panels and sawn wood) are available from the FAO Stat data base (for details see para 11.8.2) hence, accounting of Harvested Wood Products shall be on the basis of the change in the Harvested Wood Products pool

during the second commitment period, estimated using the first-order decay function with default half-lives provided in the Decision 2/CMP.7⁸⁸. Therefore, the estimation of the HWP contribution under the KP is calculated following the guidance contained in the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (page 2.109 onwards).

11.8.1. Initial steps to estimate the HWP contribution

The approach for the FMRL construction by Cyprus is a linear extrapolation of historical emissions data (1990–2008) of forest land remaining forest land. Numerical values for the FMRL are: (i) Applying first-order decay function for HWP = -0.157 Mt CO₂ eq/year; (ii) Assuming instantaneous oxidation of HWP = -0.164 Mt CO₂ eq/year.

The approach used to establish the FMRL for Cyprus was assessed by the UNFCCC experts as consistent and transparent methodology in which net emissions are projected from the limited information available (FCCC/TAR/2011/EU).

11.8.2. Data for the calculation of an estimate of HWP Contribution under the Kyoto Protocol

Decision 2/CMP.7 limits the mandatory accounting to HWP originating from domestic forests which are accounted for under Article 3, paragraphs 3 and 4. Imported HWP, irrespective of their origin, are excluded. For Cyprus, Article 3, paragraph 3 activities cover afforestation, reforestation and deforestation (ARD) while Article 3, paragraph 4 covers only forest management as Cyprus decided not to elect any other activities on the voluntary basis.

FAOSTAT provides data on Forestry Production and Trade in Cyprus for the period 1961 – 2015 (available at: <http://www.fao.org/faostat/en/#data/FO> as accessed on 2017.07.26) and these data were used for all calculations presented below. More detailed information about collection and processing of the data are provided in Chapter 7.8.4.1 Data for the calculation of an estimate of HWP Contribution under the Convention.

Country specific data on half-lives on harvested wood products are not available hence, the default half-lives provided in Decision 2/CMP.7, paragraph 29 (two years for paper, 25 years for wood panels and 35 years for sawn-wood) are applied in all calculations relating to HWP.

In Cyprus, all forests are considered as managed. Data on the total forest area and the areas of afforestation/reforestation, deforestation and forest management located in land under the Government control are presented in Table 11.12 (below).

Table 11.12. Estimation of AR, D and FM area since 1990 (Government Controlled Area)

Year	Total area of forest [ha]	Total AR since 1990 [ha]	Total D since 1990 [ha]	Annual FM area [ha]
Data	Data	Data	Data	Estimate
1990	149935	589	34	149381
1991	150490	1178	69	149312
1992	151045	1768	103	149277
1993	151600	2357	138	149243
1994	152154	2946	172	149208
1995	152709	3535	207	149174
1996	153264	4125	241	149139
1997	153819	4714	276	149105
1998	154373	5303	310	149070
1999	154928	5892	345	149036
2000	155483	6482	379	149001

⁸⁸ Table 1, p. 08, 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol.

Year	Total area of forest [ha]	Total AR since 1990 [ha]	Total D since 1990 [ha]	Annual FM area [ha]
2001	156038	7071	414	148967
2002	156592	7660	448	148932
2003	157147	8249	483	148898
2004	157702	8838	517	148863
2005	158257	9428	552	148829
2006	158265	9447	562	148818
2007	158273	9465	573	148807
2008	158281	9484	584	148796
2009	158289	9503	595	148786
2010	158297	9522	606	148775
2011	158305	9541	617	148175
2012	158313	9560	627	147575
2013	158321	9578	638	146975
2014	158329	9597	649	146374
2015	158337	9616	660	145774
2016	158345	9635	671	145174
2017	158353	9654	682	144574

Deforestation in Cyprus is minor in extent (less than 35 ha annually) and occurs predominantly in private forests that are usually degraded before the final removal of tree cover hence, wood stock in areas to be deforested is low and of poor quality. In particular, the wood has no industrial value (according to forest expert judgement). Such wood is usually burned as a part of fire wood. Consequently, it is assumed that wood harvested from deforestation does not enter the HWP pool in Cyprus.

AR lands in Cyprus are not subject to harvest because market value of wood contained in these lands is too low (the oldest AR forest is 25 years old in 2015).

Consequently, all wood suitable for transformation into HWP is harvested from forests subject to FM, hence all HWP categories produced in Cyprus originate from forests that are accounted for by the country. Data on production of HWP by the KP categories are presented in Table 11.13.

Table 11.13. Production of HWP by the KP categories in Cyprus.

Year	Sawn-wood (m3)	Wood-based Panels (m3)	Paper + Paperboard (t)
1990	22000	13800	0
1991	16430	11400	0
1992	14160	12100	0
1993	17160	22000	0
1994	14900	22000	0
1995	14900	21000	0
1996	15600	21000	0
1997	13600	20100	0
1998	11290	19300	0
1999	11750	20500	0
2000	8740	12200	0
2001	8600	4200	0
2002	7460	2600	0
2003	5645	2340	0
2004	4953	1900	0
2005	4255	1718	0
2006	3850	2500	0
2007	8717	2534	0
2008	9657	2312	0
2009	4571	1396	0
2010	3971	1067	0

Year	Sawn-wood (m3)	Wood-based Panels (m3)	Paper + Paperboard (t)
2011	2909	480	0
2012	2628	12	0
2013	2241	8	0
2014	2390	5	0
2015	1865	10	0
2016	1718	6	0
2017	1146	7	0

Data on production export and import of sawn wood, wood-based panels and paper products were collected from the FAOStat data base for the period 1961- 2017 and extended back to the year 1900 using the guidance contained in the IPCC 2006 Guidelines.

Fraction of feedstock originating from domestic production (that is harvested on the FM land) for the period 1961 – 2016 was calculated using the FAOStat database while the fraction of feedstock originating from domestic production for the period 1900 – 1960 is assumed to be equal the respective average for the period 1961 – 2016 for all HWP categories (sawn wood, wood panels and paper).

Default conversion factors were read from Table 11.2.8.1 (sawn wood – 0.229 Mg C/m³; Wood-based panels – 0.269 Mg C/m³; and paper and paperboard – 0.386 Mg C/Mg) and default half-lives of HWP categories were read from Table 11.2.8.2 contained in the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (page 2.122 and 2.123, respectively).

Export of HWP from Cyprus is negligible, hence they do not significantly affect these calculations.

Initial stocks, gains and losses of the KP HWP categories for the period 2013 – 2017 are presented in Table 11.14 (below).

Table 11.14. Initial stocks, gains and losses of the KP HWP categories for the period 2013 – 2017 (all data in kt C)

		Sawn wood		Panels		Paper and paper board	
		Domestically consumed	Exported	Domestically consumed	Exported	Domestically consumed	Exported
2013	Initial stock	242.38	0,00	59.58	0,00	14.86	0,00
	Gains	0.49	0,00	0.02	0,00	0.00	0,00
	Losses	4.76	0,00	1.63	0,00	4.35	0,00
2014	Initial stock	238.12	0,00	57.98	0,00	10.51	0,00
	Gains	0.53	0,00	0.02	0,00	0.00	0,00
	Losses	4.67	0,00	1.59	0,00	3.08	0,00
2015	Initial stock	233.97	0,00	56.41	0,00	7.43	0,00
	Gains	0.39	0,00	0.02	0,00	0.00	0,00
	Losses	4.59	0,00	1.54	0,00	2.18	0,00
2016	Initial stock	229.77	0,00	54.89	0,00	5.29	0,00
	Gains	0.39	0,00	0.02	0,00	0.00	0,00
	Losses	4.51	0,00	1.50	0,00	1.54	0,00
2017	Initial stock	225.65	0.00	53.07	0.00	0.01	0.00
	Gains	0.25	0.00	0.00	0.00	0.00	0.00
	Losses	4.43	0.00	1.45	0.00	0.00	0.00

For the calculations of the Harvested Wood Products the worksheet provided with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories has been used.

Chapter 12.

Information on accounting of Kyoto units

Information regarding Kyoto Protocol units should be included in the NIR in accordance with decision 15/CMP.1, annex, paragraphs 12–17, in conjunction with decision 3/CMP.11, and annex II to decision 3/CMP.11.

The standard electronic format (SEF) for providing information on ERUs, CERs, tCERs, ICERs, AAUs and RMUs for the year 2017 for Cyprus' registry is submitted together with this report. The SEF reporting software has been used for this purpose. Cyprus national registry is still not connected to the ITL. Therefore, until 31.12.2017 no transactions have taken place to and from Cyprus' account.

The joint assigned amount of the EU, its Member States and Iceland for the second commitment period of the Kyoto Protocol is equal to the percentage inscribed for the Union, its Member States and Iceland in the third column of Annex B to the Kyoto Protocol as replaced by the Doha Amendment (80 %) of its base year emissions multiplied by eight. Council Decision (EU) 2015/1339 sets out the terms of the joint fulfilment agreement as well as the respective emission levels of each Party to that agreement. The Agreement between the EU, its Member States and Iceland, concerning Iceland's participation in the joint fulfilment of commitments by the EU, its Member States and Iceland for the second commitment period of the Kyoto Protocol sets out the terms governing Iceland's participation⁸⁹. The emission levels define the Member States' and Iceland's assigned amounts for the second commitment period. These emission levels have been determined on the basis of the existing Union legislation for the period 2013-2020 under the 'Climate and Energy package'⁹⁰. This assigned amount of the EU is determined in line with the terms of the joint fulfilment agreement, as described in the EU's initial report and will be established upon the completion of the initial review, still ongoing at the moment of this submission.

⁸⁹ OJ L 207, 4.8.2015, p. 17

⁹⁰ Directive 2009/29/EC of the European Parliament and of the Council amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community and Decision No 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020, OJ L 140, 5.6. 2009.

Chapter 13.

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 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.

Chapter 14.

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 is still not connected to the ITL.

Chapter 15.

Information on minimising adverse impacts in accordance with article 3, paragraph 14

15.1. 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.

15.2. 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.

15.3. Specific Elements

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

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 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).

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 2017 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 2017

IPCC Source category	Direct GHG	2017 estimate (Gg CO ₂ eq.)	Level assessment	Cumulative total of level assessment
1A1a. Public electricity and heat production	CO ₂	3287.830000	0.3675497755	36.75%
1A3b. Road transportation	CO ₂	2074.952367	0.2319609824	59.95%
2A1. Cement production	CO ₂	918.947700	0.1027300745	70.22%
1A2f. Non-metallic minerals	CO ₂	508.230300	0.0568155691	75.91%
5A2. Unmanaged waste disposal sites	CH ₄	400.1375258	0.0447317707	80.38%
1A4b. Residential	CO ₂	360.407000	0.0402902559	84.41%
2F1. Refrigeration and air conditioning	HFCs	240.5140409	0.0268873031	87.10%
3D. Agricultural soils	N ₂ O	120.1748198	0.0134344623	88.44%
3A1a. Dairy cattle	CH ₄	93.4250000	0.0104440734	89.48%
1A4a. Commercial/institutional	CO ₂	91.642000	0.0102447500	90.51%

IPCC Source category	Direct GHG	2017 estimate (Gg CO ₂ eq.)	Level assessment	Cumulative total of level assessment
1A4c. Agriculture/forestry/fishing	CO ₂	84.054000	0.0093964800	91.45%
5A1. Managed waste disposal sites	CH ₄	75.9175280	0.0084868957	92.30%
1A2g. Other (please specify)	CO ₂	70.192910	0.0078469350	93.08%
1A2e. Food processing, beverages and tobacco	CO ₂	67.587200	0.0075556401	93.84%
3A2. Sheep	CH ₄	64.3000000	0.0071881608	94.56%
2G3. N ₂ O from product uses	N ₂ O	60.8218000	0.0067993293	95.24%
3A1b. Non-dairy cattle	CH ₄	52.1550000	0.0058304592	95.82%
3B3. Swine	CH ₄	33.7975000	0.0037782560	96.20%
5D1. Domestic wastewater	CH ₄	33.5415000	0.0037496375	96.57%
3A4a. Goats	CH ₄	32.2000000	0.0035996699	96.93%
5D2. Industrial wastewater	CH ₄	29.7825000	0.0033294152	97.26%
3B5. Indirect N ₂ O emissions	N ₂ O	27.5132076	0.0030757288	97.57%
2D3. Other	CO ₂	19.299138	0.0021574698	97.79%
1A5a. Stationary	CO ₂	17.630000	0.0019708752	97.99%
5D1. Domestic wastewater	N ₂ O	16.3155000	0.0018239259	98.17%
3A3. Swine	CH ₄	13.1300000	0.0014678157	98.31%
1A3b. Road transportation	N ₂ O	12.9724648	0.0014502047	98.46%
2A4. Other process uses of carbonates	CO ₂	12.858200	0.0014374309	98.60%
3B4a. Goats	N ₂ O	11.2644000	0.0012592584	98.73%
3B2. Sheep	N ₂ O	9.3274000	0.0010427193	98.83%
3B1a. Dairy cattle	CH ₄	7.7600000	0.0008674981	98.92%
1A1a. Public electricity and heat production	N ₂ O	7.5990000	0.0008494997	99.01%
3B1a. Dairy cattle	N ₂ O	6.4666000	0.0007229076	99.08%
1A5b. Mobile	CO ₂	5.335000	0.0005964049	99.14%
3B4d. Poultry	N ₂ O	5.3044000	0.0005929841	99.20%
2D1. Lubricant use	CO ₂	4.614000	0.0005158036	99.25%
1A2c. Chemicals	CO ₂	4.451300	0.0004976152	99.30%
2F3. Fire protection	HFCs	4.2749167	0.0004778972	99.35%
3B3. Swine	N ₂ O	4.1720000	0.0004663920	99.39%
1A3b. Road transportation	CH ₄	4.0524279	0.0004530249	99.44%
3B1b. Non-dairy cattle	CH ₄	4.0050000	0.0004477229	99.48%
1A4b. Residential	CH ₄	3.5775000	0.0003999323	99.52%
2F4. Aerosols	HFCs	3.4982090	0.0003910683	99.56%
3B1b. Non-dairy cattle	N ₂ O	3.4270000	0.0003831077	99.60%
5B1. Composting	CH ₄	3.3125000	0.0003703077	99.64%
1A1a. Public electricity and heat production	CH ₄	3.187500	0.0003563338	99.67%
2A2. Lime production	CO ₂	3.178400	0.0003553165	99.71%
1A2f. Non-metallic minerals	N ₂ O	2.8405360	0.0003175463	99.74%
5B1. Composting	N ₂ O	2.3691000	0.0002648440	99.77%
3B2. Sheep	CH ₄	2.2500000	0.0002515297	99.79%
1A2b. Non-ferrous metals	CO ₂	2.170000	0.0002425865	99.82%
1A2d. Pulp, paper and print	CO ₂	2.098200	0.0002345599	99.84%
3B4d. Poultry	CH ₄	1.7100000	0.0001911626	99.86%
1A3d. Domestic navigation	CO ₂	1.643000	0.0001836726	99.88%
1A2f. Non-metallic minerals	CH ₄	1.6346750	0.0001827419	99.89%
1A4a. Commercial/institutional	CH ₄	1.4295000	0.0001598052	99.91%
3B4a. Goats	CH ₄	1.2875000	0.0001439309	99.93%
2F2. Foam blowing agents	HFCs	1.2773518	0.0001427964	99.94%
1A4b. Residential	N ₂ O	0.9476400	0.0001059376	99.95%
1A3a. Domestic aviation	CO ₂	0.821000	0.0000917804	99.96%
3H. Urea application	CO ₂	0.418000	0.0000467286	99.96%
1A4c. Agriculture/forestry/fishing	CH ₄	0.3345000	0.0000373941	99.97%
5D2. Industrial wastewater	N ₂ O	0.2845900	0.0000318146	99.97%
3F. Field burning of agricultural residues	CH ₄	0.2518350	0.0000281529	99.97%
1A4a. Commercial/institutional	N ₂ O	0.2324400	0.0000259847	99.98%

IPCC Source category	Direct GHG	2017 estimate (Gg CO2 eq.)	Level assessment	Cumulative total of level assessment
1A1c. Manufacture of solid fuels and other energy industries	N2O	0.2050240	0.0000229198	99.98%
1A4c. Agriculture/forestry/fishing	N2O	0.2036830	0.0000227699	99.98%
1A2e. Food processing, beverages and tobacco	N2O	0.1880380	0.0000210210	99.98%
2G1. Electrical equipment	SF6	0.1653081	0.0000184800	99.98%
1A2g. Other (please specify)	N2O	0.1639000	0.0000183225	99.99%
3A4b. Horses	CH4	0.1540000	0.0000172158	99.99%
1B2c. Venting and flaring	CH4	0.1515000	0.0000169363	99.99%
1A1c. Manufacture of solid fuels and other energy industries	CH4	0.129000	0.0000144210	99.99%
1A2e. Food processing, beverages and tobacco	CH4	0.0947500	0.0000105922	99.99%
3A4c. Mules and Asses	CH4	0.0790000	0.0000088315	99.99%
3F. Field burning of agricultural residues	N2O	0.0783651	0.0000087605	99.99%
1A2g. Other (please specify)	CH4	0.0670000	0.0000074900	99.99%
1B2c. Venting and flaring	CO2	0.060640	0.0000067790	100.00%
1A5a. Stationary	CH4	0.0595000	0.0000066516	100.00%
2D2. Paraffin wax use	CO2	0.058943	0.0000065894	100.00%
1A5a. Stationary	N2O	0.0417200	0.0000046639	100.00%
1A2c. Chemicals	N2O	0.0360580	0.0000040310	100.00%
3B4b. Horses	N2O	0.0327800	0.0000036645	100.00%
1A3d. Domestic navigation	N2O	0.0256280	0.0000028650	100.00%
1A2c. Chemicals	CH4	0.0207000	0.0000023141	100.00%
3B4b. Horses	CH4	0.0200000	0.0000022358	100.00%
3B4c. Mules and Asses	N2O	0.0189528	0.0000021188	100.00%
1A5b. Mobile	CH4	0.0187500	0.0000020961	100.00%
1A5b. Mobile	N2O	0.0133504	0.0000014925	100.00%
2G4. Other	CO2	0.013020	0.0000014555	100.00%
3B4c. Mules and Asses	CH4	0.0086900	0.0000009715	100.00%
1A3a. Domestic aviation	N2O	0.0068540	0.0000007662	100.00%
1A2d. Pulp, paper and print	N2O	0.0048574	0.0000005430	100.00%
1A2b. Non-ferrous metals	N2O	0.0024087	0.0000002693	100.00%
1A3d. Domestic navigation	CH4	0.0021500	0.0000002404	100.00%
1A2d. Pulp, paper and print	CH4	0.0020250	0.0000002264	100.00%
1A2b. Non-ferrous metals	CH4	0.0012500	0.0000001397	100.00%
1A3a. Domestic aviation	CH4	0.0001425	0.0000000159	100.00%

Table A1.2. Key categories analysis with LULUCF – Level assessment for 2017

IPCC Source category	Direct GHG	2017 estimate (Gg CO2 eq.)	Level assessment	Cumulative total of level assessment
1A1a. Public electricity and heat production	CO2	3287.830000	0.3431192244	34.31%
1A3b. Road transportation	CO2	2074.952367	0.2165428403	55.97%
2A1. Cement production	CO2	918.947700	0.0959017413	65.56%
1A2f. Non-metallic minerals	CO2	508.230300	0.0530391128	70.86%
5A2. Unmanaged waste disposal sites	CH4	400.1375258	0.0417585086	75.04%
1A4b. Residential	CO2	360.407000	0.0376122154	78.80%
4A1. Forest land remaining forest land	CO2	256.579704	0.0267767582	81.48%
2F1. Refrigeration and air conditioning	HFCs	240.5140409	0.0251001393	83.99%
4B1. Cropland remaining cropland	CO2	131.802000	0.0137549083	85.36%
3D. Agricultural soils	N2O	120.1748198	0.0125414912	86.61%
4C1. Grassland remaining grassland	CO2	118.285046	0.0123442737	87.85%
3A1a. Dairy cattle	CH4	93.4250000	0.0097498695	88.82%
1A4a. Commercial/institutional	CO2	91.642000	0.0095637950	89.78%
1A4c. Agriculture/forestry/fishing	CO2	84.054000	0.0087719083	90.66%
5A1. Managed waste disposal sites	CH4	75.9175280	0.0079227829	91.45%
1A2g. Other (please specify)	CO2	70.192910	0.0073253595	92.18%

IPCC Source category	Direct GHG	2017 estimate (Gg CO ₂ eq.)	Level assessment	Cumulative total of level assessment
1A2e. Food processing, beverages and tobacco	CO₂	67.587200	0.0070534266	92.89%
3A2. Sheep	CH₄	64.3000000	0.0067103731	93.56%
2G3. N₂O from product uses	N₂O	60.8218000	0.0063473868	94.19%
3A1b. Non-dairy cattle	CH₄	52.1550000	0.0054429162	94.74%
4A2. Land converted to forest land	CO₂	38.242714	0.0039910246	95.14%
3B3. Swine	CH₄	33.7975000	0.0035271203	95.49%
5D1. Domestic wastewater	CH₄	33.5415000	0.0035004041	95.84%
3A4a. Goats	CH ₄	32.2000000	0.0033604046	96.18%
5D2. Industrial wastewater	CH ₄	29.7825000	0.0031081133	96.49%
3B5. Indirect N ₂ O emissions	N ₂ O	27.5132076	0.0028712891	96.77%
4B2. Land converted to cropland	CO ₂	24.364016	0.0025426382	97.03%
4G. Harvested wood products	CO ₂	24.339342	0.0025400633	97.28%
4E2. Land converted to settlements	CO ₂	20.086205	0.0020962042	97.49%
2D3. Other	CO ₂	19.299138	0.0020140656	97.69%
1A5a. Stationary	CO ₂	17.630000	0.0018398737	97.88%
5D1. Domestic wastewater	N ₂ O	16.3155000	0.0017026920	98.05%
3A3. Swine	CH ₄	13.1300000	0.0013702519	98.18%
1A3b. Road transportation	N ₂ O	12.9724648	0.0013538115	98.32%
2A4. Other process uses of carbonates	CO ₂	12.858200	0.0013418868	98.45%
3B4a. Goats	N ₂ O	11.2644000	0.0011755572	98.57%
4D2. Land converted to wetlands	CO ₂	9.882116	0.0010313015	98.67%
3B2. Sheep	N ₂ O	9.3274000	0.0009734111	98.77%
3B1a. Dairy cattle	CH ₄	7.7600000	0.0008098366	98.85%
1A1a. Public electricity and heat production	N ₂ O	7.5990000	0.0007930346	98.93%
4F2. Land converted to other land	CO ₂	6.514454	0.0006798510	99.00%
3B1a. Dairy cattle	N ₂ O	6.4666000	0.0006748569	99.07%
4C2. Land converted to grassland	CO ₂	6.304820	0.0006579735	99.13%
1A5b. Mobile	CO ₂	5.335000	0.0005567627	99.19%
3B4d. Poultry	N ₂ O	5.3044000	0.0005535693	99.24%
2D1. Lubricant use	CO ₂	4.614000	0.0004815188	99.29%
1A2c. Chemicals	CO ₂	4.451300	0.0004645394	99.34%
2F3. Fire protection	HFCs	4.2749167	0.0004461320	99.38%
3B3. Swine	N ₂ O	4.1720000	0.0004353916	99.43%
1A3b. Road transportation	CH ₄	4.0524279	0.0004229130	99.47%
3B1b. Non-dairy cattle	CH ₄	4.0050000	0.0004179634	99.51%
1A4b. Residential	CH ₄	3.5775000	0.0003733493	99.55%
2F4. Aerosols	HFCs	3.4982090	0.0003650745	99.59%
3B1b. Non-dairy cattle	N ₂ O	3.4270000	0.0003576431	99.62%
5B1. Composting	CH ₄	3.3125000	0.0003456938	99.66%
1A1a. Public electricity and heat production	CH ₄	3.187500	0.0003326487	99.69%
2A2. Lime production	CO ₂	3.178400	0.0003316991	99.72%
1A2f. Non-metallic minerals	N ₂ O	2.8405360	0.0002964394	99.75%
5B1. Composting	N ₂ O	2.3691000	0.0002472402	99.78%
3B2. Sheep	CH ₄	2.2500000	0.0002348109	99.80%
1A2b. Non-ferrous metals	CO ₂	2.170000	0.0002264620	99.82%
1A2d. Pulp, paper and print	CO ₂	2.098200	0.0002189690	99.84%
3B4d. Poultry	CH ₄	1.7100000	0.0001784563	99.86%
1A3d. Domestic navigation	CO ₂	1.643000	0.0001714641	99.88%
1A2f. Non-metallic minerals	CH ₄	1.6346750	0.0001705953	99.90%
1A4a. Commercial/institutional	CH ₄	1.4295000	0.0001491832	99.91%
3B4a. Goats	CH ₄	1.2875000	0.0001343640	99.92%
2F2. Foam blowing agents	HFCs	1.2773518	0.0001333049	99.94%
1A4b. Residential	N ₂ O	0.9476400	0.0000988961	99.95%
1A3a. Domestic aviation	CO ₂	0.821000	0.0000856799	99.96%
3H. Urea application	CO ₂	0.418000	0.0000436226	99.96%

IPCC Source category	Direct GHG	2017 estimate (Gg CO2 eq.)	Level assessment	Cumulative total of level assessment
4A1. Forest land remaining forest land	CH4	0.3809280	0.0000397538	99.96%
1A4c. Agriculture/forestry/fishing	CH4	0.3345000	0.0000349086	99.97%
5D2. Industrial wastewater	N2O	0.2845900	0.0000296999	99.97%
3F. Field burning of agricultural residues	CH4	0.2518350	0.0000262816	99.97%
1A4a. Commercial/institutional	N2O	0.2324400	0.0000242575	99.98%
1A1c. Manufacture of solid fuels and other energy industries	N2O	0.2050240	0.0000213964	99.98%
1A4c. Agriculture/forestry/fishing	N2O	0.2036830	0.0000212564	99.98%
1A2e. Food processing, beverages and tobacco	N2O	0.1880380	0.0000196237	99.98%
2G1. Electrical equipment	SF6	0.1653081	0.0000172516	99.98%
1A2g. Other (please specify)	N2O	0.1639000	0.0000171047	99.99%
3A4b. Horses	CH4	0.1540000	0.0000160715	99.99%
1B2c. Venting and flaring	CH4	0.1515000	0.0000158106	99.99%
4A1. Forest land remaining forest land	N2O	0.1335489	0.0000139372	99.99%
1A1c. Manufacture of solid fuels and other energy industries	CH4	0.129000	0.0000134625	99.99%
1A2e. Food processing, beverages and tobacco	CH4	0.0947500	0.0000098881	99.99%
3A4c. Mules and Asses	CH4	0.0790000	0.0000082445	99.99%
3F. Field burning of agricultural residues	N2O	0.0783651	0.0000081782	99.99%
1A2g. Other (please specify)	CH4	0.0670000	0.0000069921	100.00%
1B2c. Venting and flaring	CO2	0.060640	0.0000063284	100.00%
1A5a. Stationary	CH4	0.0595000	0.0000062094	100.00%
2D2. Paraffin wax use	CO2	0.058943	0.0000061514	100.00%
1A5a. Stationary	N2O	0.0417200	0.0000043539	100.00%
1A2c. Chemicals	N2O	0.0360580	0.0000037630	100.00%
3B4b. Horses	N2O	0.0327800	0.0000034209	100.00%
1A3d. Domestic navigation	N2O	0.0256280	0.0000026745	100.00%
1A2c. Chemicals	CH4	0.0207000	0.0000021603	100.00%
3B4b. Horses	CH4	0.0200000	0.0000020872	100.00%
3B4c. Mules and Asses	N2O	0.0189528	0.0000019779	100.00%
1A5b. Mobile	CH4	0.0187500	0.0000019568	100.00%
1A5b. Mobile	N2O	0.0133504	0.0000013933	100.00%
2G4. Other	CO2	0.013020	0.0000013588	100.00%
3B4c. Mules and Asses	CH4	0.0086900	0.0000009069	100.00%
1A3a. Domestic aviation	N2O	0.0068540	0.0000007153	100.00%
1A2d. Pulp, paper and print	N2O	0.0048574	0.0000005069	100.00%
1A2b. Non-ferrous metals	N2O	0.0024087	0.0000002514	100.00%
1A3d. Domestic navigation	CH4	0.0021500	0.0000002244	100.00%
1A2d. Pulp, paper and print	CH4	0.0020250	0.0000002113	100.00%
1A2b. Non-ferrous metals	CH4	0.0012500	0.0000001305	100.00%
1A3a. Domestic aviation	CH4	0.0001425	0.0000000149	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	CO2	1675.770000	0.2956100857	29.6%
1A3b. Road transportation	CO2	1183.508424	0.2087738931	50.4%
2A1. Cement production	CO2	667.664000	0.1177776260	62.2%
1A2f. Non-metallic minerals	CO2	379.826700	0.0670023949	68.9%
1A4b. Residential	CO2	299.704000	0.0528685471	74.2%
5A2. Unmanaged waste disposal sites	CH4	258.342510	0.0455722752	78.8%
3D. Agricultural soils	N2O	134.996033	0.0238136432	81.1%
5D1. Domestic wastewater	CH4	91.895500	0.0162105997	82.8%
1A1b. Petroleum refining	CO2	85.718200	0.0151209083	84.3%
1A4a. Commercial/institutional	CO2	75.212000	0.0132675879	85.6%

IPCC Source category	Direct GHG	1990 estimate (Gg CO ₂ eq.)	Level assessment	Cumulative total of level assessment
1A2e. Food processing, beverages and tobacco	CO ₂	72.570570	0.0128016329	86.9%
2F1. Refrigeration and air conditioning	HFCs	63.884515	0.0112693908	88.0%
3A2. Sheep	CH ₄	58.000000	0.0102313474	89.0%
1A4c. Agriculture/forestry/fishing	CO ₂	55.484000	0.0097875186	90.0%
3A1a. Dairy cattle	CH ₄	55.350000	0.0097638806	91.0%
3B3. Swine	CH ₄	54.552500	0.0096231996	91.9%
1A2g. Other (please specify)	CO ₂	47.869907	0.0084443732	92.8%
3A1b. Non-dairy cattle	CH ₄	45.985000	0.0081118708	93.6%
2A4. Other process uses of carbonates	CO ₂	44.076000	0.0077751184	94.4%
2G3. N ₂ O from product uses	N ₂ O	41.302800	0.0072859189	95.1%
1A3a. Domestic aviation	CO ₂	26.045000	0.0045944042	95.6%
3A4a. Goats	CH ₄	25.750000	0.0045423654	96.0%
3B5. Indirect N ₂ O emissions	N ₂ O	24.377503	0.0043002534	96.5%
5D2. Industrial wastewater	CH ₄	24.197500	0.0042685005	96.9%
1A3b. Road transportation	N ₂ O	23.601214	0.0041633141	97.3%
2D3. Other	CO ₂	17.632400	0.0031104002	97.6%
5D1. Domestic wastewater	N ₂ O	11.979600	0.0021132319	97.8%
1A5a. Stationary	CO ₂	10.995000	0.0019395459	98.0%
3A3. Swine	CH ₄	10.422500	0.0018385555	98.2%
3B4a. Goats	N ₂ O	8.969800	0.0015822955	98.4%
3B2. Sheep	N ₂ O	8.433400	0.0014876732	98.5%
3B4d. Poultry	N ₂ O	7.867200	0.0013877941	98.6%
3B3. Swine	N ₂ O	7.748000	0.0013667669	98.8%
1A3b. Road transportation	CH ₄	6.875061	0.0012127782	98.9%
3B1a. Dairy cattle	CH ₄	5.919000	0.0010441266	99.0%
2A2. Lime production	CO ₂	5.332600	0.0009406842	99.1%
3B1a. Dairy cattle	N ₂ O	5.066000	0.0008936553	99.2%
1A2b. Non-ferrous metals	CO ₂	4.910000	0.0008661365	99.3%
1A2d. Pulp, paper and print	CO ₂	4.820700	0.0008503837	99.4%
1A1a. Public electricity and heat production	N ₂ O	3.874000	0.0006833834	99.4%
3B1b. Non-dairy cattle	CH ₄	3.622500	0.0006390182	99.5%
3B1b. Non-dairy cattle	N ₂ O	3.188600	0.0005624771	99.5%
1A2c. Chemicals	CO ₂	2.199000	0.0003879092	99.6%
1A3d. Domestic navigation	CO ₂	2.198000	0.0003877328	99.6%
3B4d. Poultry	CH ₄	2.102500	0.0003708863	99.7%
3B2. Sheep	CH ₄	2.030000	0.0003580972	99.7%
1A4b. Residential	CH ₄	1.904500	0.0003359586	99.7%
3H. Urea application	CO ₂	1.815000	0.0003201706	99.8%
1A1a. Public electricity and heat production	CH ₄	1.650000	0.0002910642	99.8%
3F. Field burning of agricultural residues	CH ₄	1.550718	0.0002735505	99.8%
1A2f. Non-metallic minerals	N ₂ O	1.435168	0.0002531673	99.8%
3A4c. Mules and Asses	CH ₄	1.256500	0.0002216498	99.9%
2D1. Lubricant use	CO ₂	1.120000	0.0001975708	99.9%
3B4a. Goats	CH ₄	1.025000	0.0001808126	99.9%
1A2f. Non-metallic minerals	CH ₄	0.759025	0.0001338939	99.9%
1A4b. Residential	N ₂ O	0.697320	0.0001230090	99.9%
3F. Field burning of agricultural residues	N ₂ O	0.478883	0.0000844762	99.9%
1A4a. Commercial/institutional	CH ₄	0.374750	0.0000661069	99.9%
5D2. Industrial wastewater	N ₂ O	0.310516	0.0000547758	100.0%
3B4c. Mules and Asses	N ₂ O	0.301546	0.0000531935	100.0%
1A3a. Domestic aviation	N ₂ O	0.217093	0.0000382958	100.0%
3A4b. Horses	CH ₄	0.207000	0.0000365153	100.0%
1A4c. Agriculture/forestry/fishing	CH ₄	0.183500	0.0000323699	100.0%
1A2e. Food processing, beverages and tobacco	N ₂ O	0.151980	0.0000268097	100.0%

IPCC Source category	Direct GHG	1990 estimate (Gg CO2 eq.)	Level assessment	Cumulative total of level assessment
1A4a. Commercial/institutional	N2O	0.139524	0.0000246123	100.0%
3B4c. Mules and Asses	CH4	0.138228	0.0000243837	100.0%
1A1c. Manufacture of solid fuels and other energy industries	N2O	0.133504	0.0000235504	100.0%
1A4c. Agriculture/forestry/fishing	N2O	0.128617	0.0000226883	100.0%
1A2g. Other (please specify)	N2O	0.113538	0.0000200284	100.0%
1A1b. Petroleum refining	N2O	0.107280	0.0000189245	100.0%
1B2c. Venting and flaring	CH4	0.091250	0.0000160967	100.0%
1A1c. Manufacture of solid fuels and other energy industries	CH4	0.084000	0.0000148178	100.0%
1A2e. Food processing, beverages and tobacco	CH4	0.066000	0.0000116426	100.0%
2D2. Paraffin wax use	CO2	0.063498	0.0000112011	100.0%
1B2a. Oil	CH4	0.062225	0.0000109766	100.0%
1A1b. Petroleum refining	CH4	0.055500	0.0000097903	100.0%
1A2g. Other (please specify)	CH4	0.047850	0.0000084409	100.0%
3B4b. Horses	N2O	0.044700	0.0000078852	100.0%
2G4. Other	CO2	0.041210	0.0000072695	100.0%
1A5a. Stationary	CH4	0.037000	0.0000065269	100.0%
1B2c. Venting and flaring	CO2	0.036480	0.0000064352	100.0%
1A3d. Domestic navigation	N2O	0.034568	0.0000060979	100.0%
3B4b. Horses	CH4	0.027000	0.0000047629	100.0%
1A5a. Stationary	N2O	0.026522	0.0000046785	100.0%
2G1. Electrical equipment	SF6	0.025767	0.0000045453	100.0%
1A2d. Pulp, paper and print	N2O	0.011145	0.0000019660	100.0%
1A2b. Non-ferrous metals	N2O	0.005960	0.0000010514	100.0%
1A2c. Chemicals	N2O	0.005364	0.0000009462	100.0%
1A2d. Pulp, paper and print	CH4	0.004675	0.0000008247	100.0%
1A3a. Domestic aviation	CH4	0.004550	0.0000008026	100.0%
1A2b. Non-ferrous metals	CH4	0.003250	0.0000005733	100.0%
1A3d. Domestic navigation	CH4	0.002900	0.0000005116	100.0%
1A2c. Chemicals	CH4	0.002250	0.0000003969	100.0%
1A5b. Mobile	CO2	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	CO2	1675.770000	0.2737598779	27.4%
1A3b. Road transportation	CO2	1183.508424	0.1933422377	46.7%
2A1. Cement production	CO2	667.664000	0.1090720177	57.6%
1A2f. Non-metallic minerals	CO2	379.826700	0.0620498702	63.8%
1A4b. Residential	CO2	299.704000	0.0489607347	68.7%
5A2. Unmanaged waste disposal sites	CH4	258.342510	0.0422037714	72.9%
4B1. Cropland remaining cropland	CO2	135.060200	0.0220639252	75.1%
3D. Agricultural soils	N2O	134.996033	0.0220534426	77.4%
4C1. Grassland remaining grassland	CO2	134.142940	0.0219140782	79.5%
4F2. Land converted to other land	CO2	95.534942	0.0156069353	81.1%
5D1. Domestic wastewater	CH4	91.895500	0.0150123829	82.6%
1A1b. Petroleum refining	CO2	85.718200	0.0140032367	84.0%
1A4a. Commercial/institutional	CO2	75.212000	0.0122869057	85.2%
1A2e. Food processing, beverages and tobacco	CO2	72.570570	0.0118553921	86.4%
4A1. Forest land remaining forest land	CO2	65.091031	0.0106335074	87.5%
2F1. Refrigeration and air conditioning	HFCs	63.884515	0.0104364066	88.5%
3A2. Sheep	CH4	58.000000	0.0094750908	89.5%
1A4c. Agriculture/forestry/fishing	CO2	55.484000	0.0090640679	90.4%

IPCC Source category	Direct GHG	1990 estimate (Gg CO ₂ eq.)	Level assessment	Cumulative total of level assessment
3A1a. Dairy cattle	CH4	55.350000	0.0090421772	91.3%
3B3. Swine	CH4	54.552500	0.0089118947	92.2%
1A2g. Other (please specify)	CO ₂	47.869907	0.0078202020	93.0%
3A1b. Non-dairy cattle	CH4	45.985000	0.0075122767	93.7%
2A4. Other process uses of carbonates	CO ₂	44.076000	0.0072004156	94.4%
2G3. N ₂ O from product uses	N ₂ O	41.302800	0.0067473755	95.1%
1A3a. Domestic aviation	CO ₂	26.045000	0.0042548059	95.5%
3A4a. Goats	CH4	25.750000	0.0042066136	95.9%
3B5. Indirect N ₂ O emissions	N ₂ O	24.377503	0.0039823974	96.3%
5D2. Industrial wastewater	CH4	24.197500	0.0039529915	96.7%
1A3b. Road transportation	N ₂ O	23.601214	0.0038555801	97.1%
2D3. Other	CO ₂	17.632400	0.0028804930	97.4%
4A2. Land converted to forest land	CO ₂	12.657145	0.0020677172	97.6%
5D1. Domestic wastewater	N ₂ O	11.979600	0.0019570310	97.8%
1A5a. Stationary	CO ₂	10.995000	0.0017961832	98.0%
3A3. Swine	CH4	10.422500	0.0017026575	98.2%
3B4a. Goats	N ₂ O	8.969800	0.0014653391	98.3%
3B2. Sheep	N ₂ O	8.433400	0.0013777109	98.5%
3B4d. Poultry	N ₂ O	7.867200	0.0012852144	98.6%
3B3. Swine	N ₂ O	7.748000	0.0012657414	98.7%
1A3b. Road transportation	CH4	6.875061	0.0011231349	98.8%
3B1a. Dairy cattle	CH4	5.919000	0.0009669494	98.9%
2A2. Lime production	CO ₂	5.332600	0.0008711529	99.0%
3B1a. Dairy cattle	N ₂ O	5.066000	0.0008276002	99.1%
1A2b. Non-ferrous metals	CO ₂	4.910000	0.0008021154	99.2%
1A2d. Pulp, paper and print	CO ₂	4.820700	0.0007875271	99.2%
1A1a. Public electricity and heat production	N ₂ O	3.874000	0.0006328707	99.3%
4B2. Land converted to cropland	CO ₂	3.851576	0.0006292075	99.4%
3B1b. Non-dairy cattle	CH4	3.622500	0.0005917848	99.4%
4G. Harvested wood products	CO ₂	3.271830	0.0005344980	99.5%
3B1b. Non-dairy cattle	N ₂ O	3.188600	0.0005209013	99.5%
1A2c. Chemicals	CO ₂	2.199000	0.0003592366	99.6%
1A3d. Domestic navigation	CO ₂	2.198000	0.0003590733	99.6%
3B4d. Poultry	CH4	2.102500	0.0003434720	99.6%
3B2. Sheep	CH4	2.030000	0.0003316282	99.7%
1A4b. Residential	CH4	1.904500	0.0003111260	99.7%
3H. Urea application	CO ₂	1.815000	0.0002965050	99.7%
4E2. Land converted to settlements	CO ₂	1.755169	0.0002867309	99.8%
1A1a. Public electricity and heat production	CH4	1.650000	0.0002695500	99.8%
3F. Field burning of agricultural residues	CH4	1.550718	0.0002533308	99.8%
1A2f. Non-metallic minerals	N ₂ O	1.435168	0.0002344543	99.8%
3A4c. Mules and Asses	CH4	1.256500	0.0002052664	99.9%
2D1. Lubricant use	CO ₂	1.120000	0.0001829673	99.9%
3B4a. Goats	CH4	1.025000	0.0001674477	99.9%
4D2. Land converted to wetlands	CO ₂	1.024691	0.0001673972	99.9%
1A2f. Non-metallic minerals	CH4	0.759025	0.0001239971	99.9%
1A4b. Residential	N ₂ O	0.697320	0.0001139167	99.9%
3F. Field burning of agricultural residues	N ₂ O	0.478883	0.0000782321	99.9%
1A4a. Commercial/institutional	CH4	0.374750	0.0000612205	100.0%
5D2. Industrial wastewater	N ₂ O	0.310516	0.0000507270	100.0%
3B4c. Mules and Asses	N ₂ O	0.301546	0.0000492617	100.0%
1A3a. Domestic aviation	N ₂ O	0.217093	0.0000354651	100.0%
3A4b. Horses	CH4	0.207000	0.0000338163	100.0%
1A4c. Agriculture/forestry/fishing	CH4	0.183500	0.0000299772	100.0%

IPCC Source category	Direct GHG	1990 estimate (Gg CO2 eq.)	Level assessment	Cumulative total of level assessment
1A2e. Food processing, beverages and tobacco	N2O	0.151980	0.0000248280	100.0%
1A4a. Commercial/institutional	N2O	0.139524	0.0000227931	100.0%
3B4c. Mules and Asses	CH4	0.138228	0.0000225813	100.0%
1A1c. Manufacture of solid fuels and other energy industries	N2O	0.133504	0.0000218097	100.0%
1A4c. Agriculture/forestry/fishing	N2O	0.128617	0.0000210113	100.0%
1A2g. Other (please specify)	N2O	0.113538	0.0000185480	100.0%
1A1b. Petroleum refining	N2O	0.107280	0.0000175257	100.0%
1B2c. Venting and flaring	CH4	0.091250	0.0000149069	100.0%
1A1c. Manufacture of solid fuels and other energy industries	CH4	0.084000	0.0000137225	100.0%
1A2e. Food processing, beverages and tobacco	CH4	0.066000	0.0000107820	100.0%
2D2. Paraffin wax use	CO2	0.063498	0.0000103732	100.0%
1B2a. Oil	CH4	0.062225	0.0000101653	100.0%
1A1b. Petroleum refining	CH4	0.055500	0.0000090667	100.0%
4A1. Forest land remaining forest land	CH4	0.052758	0.0000086187	100.0%
1A2g. Other (please specify)	CH4	0.047850	0.0000078169	100.0%
3B4b. Horses	N2O	0.044700	0.0000073024	100.0%
2G4. Other	CO2	0.041210	0.0000067322	100.0%
1A5a. Stationary	CH4	0.037000	0.0000060445	100.0%
1B2c. Venting and flaring	CO2	0.036480	0.0000059595	100.0%
1A3d. Domestic navigation	N2O	0.034568	0.0000056472	100.0%
3B4b. Horses	CH4	0.027000	0.0000044108	100.0%
1A5a. Stationary	N2O	0.026522	0.0000043327	100.0%
2G1. Electrical equipment	SF6	0.025767	0.0000042093	100.0%
4A1. Forest land remaining forest land	N2O	0.018496	0.0000030216	100.0%
1A2d. Pulp, paper and print	N2O	0.011145	0.0000018207	100.0%
1A2b. Non-ferrous metals	N2O	0.005960	0.0000009736	100.0%
1A2c. Chemicals	N2O	0.005364	0.0000008763	100.0%
1A2d. Pulp, paper and print	CH4	0.004675	0.0000007637	100.0%
1A3a. Domestic aviation	CH4	0.004550	0.0000007433	100.0%
1A2b. Non-ferrous metals	CH4	0.003250	0.0000005309	100.0%
1A3d. Domestic navigation	CH4	0.002900	0.0000004738	100.0%
1A2c. Chemicals	CH4	0.002250	0.0000003676	100.0%
1A5b. Mobile	CO2	0.000000	0.0000000000	100.0%

Table A1.5. Key categories analysis without LULUCF – Trend assessment for 2017

IPCC Source category	Direct GHG	1990 estimate	2017 estimate	Level assessment 2017	Trend assessment	% contribution to trend	Cumulative total of level assessment
1A1a. Public electricity and heat production	CO2	1675.770000	3287.83	0.367550	0.045590	31.12%	31.12%
1A3b. Road transportation	CO2	1183.508424	2074.952367	0.231961	0.014694	10.03%	41.16%
2F1. Refrigeration and air conditioning	HFCs	63.884515	240.514041	0.026887	0.009897	6.76%	47.91%
5D1. Domestic wastewater	CH4	91.895500	33.5415	0.003750	0.007897	5.39%	53.31%
5A1. Managed waste disposal sites	CH4	0.000000	75.917528	0.008487	0.005378	3.67%	56.98%
3D. Agricultural soils	N2O	134.996033	120.174820	0.013434	0.006578	4.49%	61.47%
1A4b. Residential	CO2	299.704000	360.407	0.040290	0.007971	5.44%	66.91%
2A4. Other process uses of carbonates	CO2	44.076000	12.858200	0.001437	0.004016	2.74%	69.65%
2A1. Cement production	CO2	667.664000	918.947700	0.102730	0.009536	6.51%	76.16%
3B3. Swine	CH4	54.552500	33.797500	0.003778	0.003704	2.53%	78.69%
1A2f. Non-metallic minerals	CO2	379.826700	508.230300	0.056816	0.006456	4.41%	83.10%
1A2e. Food processing, beverages and tobacco	CO2	72.57057	67.5872	0.007556	0.003325	2.27%	85.37%
1A3a. Domestic aviation	CO2	26.045000	0.821000	0.000092	0.002853	1.95%	87.32%
5A2. Unmanaged waste disposal sites	CH4	258.342510	400.137526	0.044732	0.000533	0.36%	87.68%
1A3b. Road transportation	N2O	23.601214	12.972465	0.001450	0.001719	1.17%	88.85%
3A2. Sheep	CH4	58.000000	64.300000	0.007188	0.001929	1.32%	90.17%
1A4a. Commercial/institutional	CO2	75.212000	91.642	0.010245	0.001916	1.31%	91.48%
3A1b. Non-dairy cattle	CH4	45.985000	52.155000	0.005830	0.001446	0.99%	92.46%
3A1a. Dairy cattle	CH4	55.350000	93.425000	0.010444	0.000431	0.29%	92.76%
3B5. Indirect N2O emissions	N2O	24.377503	27.513208	0.003076	0.000776	0.53%	93.29%
3B3. Swine	N2O	7.748000	4.172000	0.000466	0.000571	0.39%	93.68%
2D3. Other	CO2	17.63240032	19.29913823	0.002157	0.000604	0.41%	94.09%
3B4d. Poultry	N2O	7.867200	5.304400	0.000593	0.000504	0.34%	94.43%
1A3b. Road transportation	CH4	6.875061	4.052428	0.000453	0.000481	0.33%	94.76%
1A5b. Mobile	CO2	0.000000	5.335000	0.000596	0.000378	0.26%	95.02%
5D2. Industrial wastewater	CH4	24.197500	29.7825	0.003329	0.000595	0.41%	95.43%
3A4a. Goats	CH4	25.750000	32.200000	0.003600	0.000597	0.41%	95.84%
1A2b. Non-ferrous metals	CO2	4.910000	2.170000	0.000243	0.000395	0.27%	96.11%
1A2d. Pulp, paper and print	CO2	4.8207	2.0982	0.000235	0.000390	0.27%	96.37%
2A2. Lime production	CO2	5.332600	3.178400	0.000355	0.000371	0.25%	96.62%
2F3. Fire protection	HFCs	0.000000	4.274917	0.000478	0.000303	0.21%	96.83%
1A4c. Agriculture/forestry/fishing	CO2	55.484000	84.054000	0.009396	0.000248	0.17%	97.00%
2F4. Aerosols	HFCs	0.000000	3.498209	0.000391	0.000248	0.17%	97.17%
5B1. Composting	CH4	0.000000	3.312500	0.000370	0.000235	0.16%	97.33%
2D1. Lubricant use	CO2	1.120000	4.614000	0.000516	0.000202	0.14%	97.47%

IPCC Source category	Direct GHG	1990 estimate	2017 estimate	Level assessment 2017	Trend assessment	% contribution to trend	Cumulative total of level assessment
3B2. Sheep	N2O	8.433400	9.327400	0.001043	0.000282	0.19%	97.66%
5B1. Composting	N2O	0.000000	2.369100	0.000265	0.000168	0.11%	97.77%
3H. Urea application	CO2	1.815000	0.418	0.000047	0.000173	0.12%	97.89%
3F. Field burning of agricultural residues	CH4	1.550718	0.251835	0.000028	0.000156	0.11%	98.00%
1A1a. Public electricity and heat production	N2O	3.874000	7.599000	0.000849	0.000105	0.07%	98.07%
3A3. Swine	CH4	10.422500	13.130000	0.001468	0.000235	0.16%	98.23%
3A4c. Mules and Asses	CH4	1.256500	0.079000	0.000009	0.000135	0.09%	98.32%
3B4a. Goats	N2O	8.969800	11.264400	0.001259	0.000205	0.14%	98.46%
1A5a. Stationary	CO2	10.995000	17.630000	0.001971	0.000020	0.01%	98.48%
1A3d. Domestic navigation	CO2	2.198000	1.643000	0.000184	0.000129	0.09%	98.57%
3B4d. Poultry	CH4	2.102500	1.710000	0.000191	0.000114	0.08%	98.64%
2F2. Foam blowing agents	HFCs	0.000000	1.277352	0.000143	0.000090	0.06%	98.70%
1A2c. Chemicals	CO2	2.199000	4.4513	0.000498	0.000070	0.05%	98.75%
3B1b. Non-dairy cattle	CH4	3.622500	4.005000	0.000448	0.000121	0.08%	98.84%
3B1b. Non-dairy cattle	N2O	3.188600	3.427000	0.000383	0.000114	0.08%	98.91%
5D1. Domestic wastewater	N2O	11.979600	16.315500	0.001824	0.000183	0.13%	99.04%
2G3. N2O from product uses	N2O	41.302800	60.821800	0.006799	0.000308	0.21%	99.25%
1A4a. Commercial/institutional	CH4	0.374750	1.429500	0.000160	0.000059	0.04%	99.29%
3B1a. Dairy cattle	N2O	5.066000	6.466600	0.000723	0.000108	0.07%	99.36%
1A2g. Other (please specify)	CO2	47.869907	70.192910	0.007847	0.000379	0.26%	99.62%
1A4b. Residential	CH4	1.904500	3.577500	0.000400	0.000041	0.03%	99.65%
3B1a. Dairy cattle	CH4	5.919000	7.760000	0.000867	0.000112	0.08%	99.73%
1A1a. Public electricity and heat production	CH4	1.650000	3.1875	0.000356	0.000041	0.03%	99.75%
1A2f. Non-metallic minerals	N2O	1.435168	2.840536	0.000318	0.000041	0.03%	99.78%
3B2. Sheep	CH4	2.030000	2.250000	0.000252	0.000068	0.05%	99.83%
3F. Field burning of agricultural residues	N2O	0.478883	0.078365	0.000009	0.000048	0.03%	99.86%
1A2f. Non-metallic minerals	CH4	0.759025	1.634675	0.000183	0.000031	0.02%	99.88%
3B4c. Mules and Asses	N2O	0.301546	0.018953	0.000002	0.000032	0.02%	99.90%
1A3a. Domestic aviation	N2O	0.217093	0.006854	0.000001	0.000024	0.02%	99.92%
3B4a. Goats	CH4	1.025000	1.287500	0.000144	0.000023	0.02%	99.94%
3B4c. Mules and Asses	CH4	0.138228	0.008690	0.000001	0.000015	0.01%	99.95%
5D2. Industrial wastewater	N2O	0.310516	0.284590	0.000032	0.000015	0.01%	99.96%
3A4b. Horses	CH4	0.207000	0.154000	0.000017	0.000012	0.01%	99.96%
2G1. Electrical equipment	SF6	0.025767	0.165308	0.000018	0.000009	0.01%	99.97%
1A4c. Agriculture/forestry/fishing	CH4	0.183500	0.334500	0.000037	0.000003	0.00%	99.97%
1A4b. Residential	N2O	0.697320	0.947640	0.000106	0.000011	0.01%	99.98%

IPCC Source category	Direct GHG	1990 estimate	2017 estimate	Level assessment 2017	Trend assessment	% contribution to trend	Cumulative total of level assessment
2G4. Other	CO2	0.041210	0.01302	0.000001	0.000004	0.00%	99.98%
2D2. Paraffin wax use	CO2	0.063498	0.058943	0.000007	0.000003	0.00%	99.98%
1A2e. Food processing, beverages and tobacco	N2O	0.151980	0.188038	0.000021	0.000004	0.00%	99.99%
3B4b. Horses	N2O	0.044700	0.032780	0.000004	0.000003	0.00%	99.99%
1A4a. Commercial/institutional	N2O	0.139524	0.232440	0.000026	0.000001	0.00%	99.99%
1A2c. Chemicals	N2O	0.005364	0.036058	0.000004	0.000002	0.00%	99.99%
1A3d. Domestic navigation	N2O	0.034568	0.025628	0.000003	0.000002	0.00%	99.99%
1B2c. Venting and flaring	CH4	0.091250	0.151500	0.000017	0.000001	0.00%	99.99%
3B4b. Horses	CH4	0.027000	0.020000	0.000002	0.000002	0.00%	99.99%
1A5b. Mobile	CH4	0.000000	0.018750	0.000002	0.000001	0.00%	99.99%
1A2c. Chemicals	CH4	0.002250	0.020700	0.000002	0.000001	0.00%	100.00%
1A4c. Agriculture/forestry/fishing	N2O	0.128617	0.203683	0.000023	0.000000	0.00%	100.00%
1A5b. Mobile	N2O	0.000000	0.013350	0.000001	0.000001	0.00%	100.00%
1A1c. Manufacture of solid fuels and other energy industries	N2O	0.133504	0.205024	0.000023	0.000000	0.00%	100.00%
1A2d. Pulp, paper and print	N2O	0.011145	0.004857	0.000001	0.000001	0.00%	100.00%
1B2c. Venting and flaring	CO2	0.036480	0.060640	0.000007	0.000000	0.00%	100.00%
1A1c. Manufacture of solid fuels and other energy industries	CH4	0.084000	0.129000	0.000014	0.000000	0.00%	100.00%
1A3a. Domestic aviation	CH4	0.004550	0.000143	0.000000	0.000000	0.00%	100.00%
1A2b. Non-ferrous metals	N2O	0.005960	0.002409	0.000000	0.000000	0.00%	100.00%
1A5a. Stationary	CH4	0.037000	0.059500	0.000007	0.000000	0.00%	100.00%
1A2d. Pulp, paper and print	CH4	0.004675	0.002025	0.000000	0.000000	0.00%	100.00%
1A2b. Non-ferrous metals	CH4	0.003250	0.00125	0.000000	0.000000	0.00%	100.00%
1A5a. Stationary	N2O	0.026522	0.041720	0.000005	0.000000	0.00%	100.00%
1A2g. Other (please specify)	CH4	0.047850	0.067000	0.000007	0.000001	0.00%	100.00%
1A3d. Domestic navigation	CH4	0.002900	0.002150	0.000000	0.000000	0.00%	100.00%
1A2e. Food processing, beverages and tobacco	CH4	0.066000	0.094750	0.000011	0.000001	0.00%	100.00%
1A2g. Other (please specify)	N2O	0.113538	0.163900	0.000018	0.000001	0.00%	100.00%
1A1b. Petroleum refining	CO2	85.718200	0.000000	0.000000	0.000000	0.00%	100.00%
1A1b. Petroleum refining	CH4	0.055500	0.000000	0.000000	0.000000	0.00%	100.00%
1A1b. Petroleum refining	N2O	0.107280	0.000000	0.000000	0.000000	0.00%	100.00%
1B2a. Oil	CH4	0.062225	0.000000	0.000000	0.000000	0.00%	100.00%

Table A1.6. Key categories analysis with LULUCF – Trend assessment for 2017

IPCC Source category	Direct GHG	1990 estimate	2017 estimate	Level assessment 2017	Trend assessment	% contribution to trend	Cumulative total of level assessment
1A1a. Public electricity and heat production	CO2	1675.770000	3287.83	0.343119	0.044308	25.27%	25.27%
1A3b. Road transportation	CO2	1183.508424	2074.952367	0.216543	0.014821	8.45%	33.72%
4A1. Forest land remaining forest land	CO2	65.09103108	256.5797035	0.026777	0.010313	5.88%	39.60%
2F1. Refrigeration and air conditioning	HFCs	63.884515	240.514041	0.025100	0.009368	5.34%	44.94%
4F2. Land converted to other land	CO2	95.534942	6.514454	0.000680	0.009536	5.44%	50.38%
5D1. Domestic wastewater	CH4	91.895500	33.5415	0.003500	0.007354	4.19%	54.58%
5A1. Managed waste disposal sites	CH4	0.000000	75.917528	0.007923	0.005061	2.89%	57.46%
5A2. Unmanaged waste disposal sites	CH4	258.342510	400.137526	0.041759	0.000284	0.16%	57.62%
4C1. Grassland remaining grassland	CO2	134.1429398	118.2850464	0.012344	0.006113	3.49%	61.11%
3D. Agricultural soils	N2O	134.996033	120.174820	0.012541	0.006076	3.47%	64.58%
2A1. Cement production	CO2	667.664000	918.947700	0.095902	0.008413	4.80%	69.37%
2A4. Other process uses of carbonates	CO2	44.076000	12.858200	0.001342	0.003743	2.13%	71.51%
4B1. Cropland remaining cropland	CO2	135.060200	131.802	0.013755	0.005308	3.03%	74.54%
3B3. Swine	CH4	54.552500	33.797500	0.003527	0.003440	1.96%	76.50%
1A3a. Domestic aviation	CO2	26.045000	0.821000	0.000086	0.002663	1.52%	78.02%
1A4b. Residential	CO2	299.704000	360.407	0.037612	0.007250	4.13%	82.15%
1A2e. Food processing, beverages and tobacco	CO2	72.57057	67.5872	0.007053	0.003068	1.75%	83.90%
4A2. Land converted to forest land	CO2	12.65714498	38.24271439	0.003991	0.001229	0.70%	84.60%
3A1a. Dairy cattle	CH4	55.350000	93.425000	0.009750	0.000452	0.26%	84.86%
4G. Harvested wood products	CO2	3.271830	24.339342	0.002540	0.001281	0.73%	85.59%
4B2. Land converted to cropland	CO2	3.851576	24.364016	0.002543	0.001222	0.70%	86.29%
1A3b. Road transportation	N2O	23.601214	12.972465	0.001354	0.001598	0.91%	87.20%
4E2. Land converted to settlements	CO2	1.755169	20.086205	0.002096	0.001156	0.66%	87.86%
1A2f. Non-metallic minerals	CO2	379.826700	508.230300	0.053039	0.005756	3.28%	91.14%
1A4c. Agriculture/forestry/fishing	CO2	55.484000	84.054000	0.008772	0.000187	0.11%	91.25%
3A2. Sheep	CH4	58.000000	64.300000	0.006710	0.001766	1.01%	92.25%
4D2. Land converted to wetlands	CO2	1.024691	9.882116	0.001031	0.000552	0.31%	92.57%
3A1b. Non-dairy cattle	CH4	45.985000	52.155000	0.005443	0.001322	0.75%	93.32%
1A2g. Other (please specify)	CO2	47.869907	70.192910	0.007325	0.000316	0.18%	93.50%
2G3. N2O from product uses	N2O	41.302800	60.821800	0.006347	0.000256	0.15%	93.65%
1A4a. Commercial/institutional	CO2	75.212000	91.642	0.009564	0.001740	0.99%	94.64%
4C2. Land converted to grassland	CO2	0.000000	6.304820	0.000658	0.000420	0.24%	94.88%
3B3. Swine	N2O	7.748000	4.172000	0.000435	0.000530	0.30%	95.18%
1A5b. Mobile	CO2	0.000000	5.335000	0.000557	0.000356	0.20%	95.38%
3B4d. Poultry	N2O	7.867200	5.304400	0.000554	0.000467	0.27%	95.65%

IPCC Source category	Direct GHG	1990 estimate	2017 estimate	Level assessment 2017	Trend assessment	% contribution to trend	Cumulative total of level assessment
1A3b. Road transportation	CH4	6.875061	4.052428	0.000423	0.000447	0.26%	95.91%
3B5. Indirect N2O emissions	N2O	24.377503	27.513208	0.002871	0.000710	0.40%	96.31%
2F3. Fire protection	HFCs	0.000000	4.274917	0.000446	0.000285	0.16%	96.47%
1A2b. Non-ferrous metals	CO2	4.910000	2.170000	0.000226	0.000368	0.21%	96.68%
1A2d. Pulp, paper and print	CO2	4.8207	2.0982	0.000219	0.000363	0.21%	96.89%
2A2. Lime production	CO2	5.332600	3.178400	0.000332	0.000345	0.20%	97.09%
2D3. Other	CO2	17.63240032	19.29913823	0.002014	0.000553	0.32%	97.40%
2F4. Aerosols	HFCs	0.000000	3.498209	0.000365	0.000233	0.13%	97.54%
5B1. Composting	CH4	0.000000	3.312500	0.000346	0.000221	0.13%	97.66%
1A5a. Stationary	CO2	10.995000	17.630000	0.001840	0.000028	0.02%	97.68%
2D1. Lubricant use	CO2	1.120000	4.614000	0.000482	0.000191	0.11%	97.79%
1A1a. Public electricity and heat production	N2O	3.874000	7.599000	0.000793	0.000102	0.06%	97.84%
5B1. Composting	N2O	0.000000	2.369100	0.000247	0.000158	0.09%	97.93%
3H. Urea application	CO2	1.815000	0.418	0.000044	0.000162	0.09%	98.03%
5D2. Industrial wastewater	CH4	24.197500	29.7825	0.003108	0.000540	0.31%	98.33%
3F. Field burning of agricultural residues	CH4	1.550718	0.251835	0.000026	0.000145	0.08%	98.42%
3B2. Sheep	N2O	8.433400	9.327400	0.000973	0.000258	0.15%	98.56%
1A2c. Chemicals	CO2	2.199000	4.4513	0.000465	0.000067	0.04%	98.60%
3A4c. Mules and Asses	CH4	1.256500	0.079000	0.000008	0.000126	0.07%	98.67%
3A4a. Goats	CH4	25.750000	32.200000	0.003360	0.000541	0.31%	98.98%
2F2. Foam blowing agents	HFCs	0.000000	1.277352	0.000133	0.000085	0.05%	99.03%
1A3d. Domestic navigation	CO2	2.198000	1.643000	0.000171	0.000120	0.07%	99.10%
1A4b. Residential	CH4	1.904500	3.577500	0.000373	0.000040	0.02%	99.12%
3B4d. Poultry	CH4	2.102500	1.710000	0.000178	0.000105	0.06%	99.18%
1A1a. Public electricity and heat production	CH4	1.650000	3.1875	0.000333	0.000040	0.02%	99.21%
1A2f. Non-metallic minerals	N2O	1.435168	2.840536	0.000296	0.000040	0.02%	99.23%
1A4a. Commercial/institutional	CH4	0.374750	1.429500	0.000149	0.000056	0.03%	99.26%
3B1b. Non-dairy cattle	N2O	3.188600	3.427000	0.000358	0.000104	0.06%	99.32%
3B1b. Non-dairy cattle	CH4	3.622500	4.005000	0.000418	0.000111	0.06%	99.38%
5D1. Domestic wastewater	N2O	11.979600	16.315500	0.001703	0.000162	0.09%	99.48%
1A2f. Non-metallic minerals	CH4	0.759025	1.634675	0.000171	0.000030	0.02%	99.49%
3F. Field burning of agricultural residues	N2O	0.478883	0.078365	0.000008	0.000045	0.03%	99.52%
3A3. Swine	CH4	10.422500	13.130000	0.001370	0.000212	0.12%	99.64%
3B4a. Goats	N2O	8.969800	11.264400	0.001176	0.000185	0.11%	99.74%
3B2. Sheep	CH4	2.030000	2.250000	0.000235	0.000062	0.04%	99.78%
3B4c. Mules and Asses	N2O	0.301546	0.018953	0.000002	0.000030	0.02%	99.80%

IPCC Source category	Direct GHG	1990 estimate	2017 estimate	Level assessment 2017	Trend assessment	% contribution to trend	Cumulative total of level assessment
4A1. Forest land remaining forest land	CH4	0.052758	0.380928	0.000040	0.000020	0.01%	99.81%
1A3a. Domestic aviation	N2O	0.217093	0.006854	0.000001	0.000022	0.01%	99.82%
3B4c. Mules and Asses	CH4	0.138228	0.008690	0.000001	0.000014	0.01%	99.83%
3B1a. Dairy cattle	N2O	5.066000	6.466600	0.000675	0.000098	0.06%	99.88%
2G1. Electrical equipment	SF6	0.025767	0.165308	0.000017	0.000008	0.00%	99.89%
5D2. Industrial wastewater	N2O	0.310516	0.284590	0.000030	0.000013	0.01%	99.90%
3A4b. Horses	CH4	0.207000	0.154000	0.000016	0.000011	0.01%	99.90%
4A1. Forest land remaining forest land	N2O	0.018496	0.133549	0.000014	0.000007	0.00%	99.91%
1A4c. Agriculture/forestry/fishing	CH4	0.183500	0.334500	0.000035	0.000003	0.00%	99.91%
3B4a. Goats	CH4	1.025000	1.287500	0.000134	0.000021	0.01%	99.92%
1A4a. Commercial/institutional	N2O	0.139524	0.232440	0.000024	0.000001	0.00%	99.92%
2G4. Other	CO2	0.041210	0.01302	0.000001	0.000003	0.00%	99.92%
1A4b. Residential	N2O	0.697320	0.947640	0.000099	0.000010	0.01%	99.93%
1A4c. Agriculture/forestry/fishing	N2O	0.128617	0.203683	0.000021	0.000000	0.00%	99.93%
1B2c. Venting and flaring	CH4	0.091250	0.151500	0.000016	0.000001	0.00%	99.93%
1A1c. Manufacture of solid fuels and other energy industries	N2O	0.133504	0.205024	0.000021	0.000000	0.00%	99.93%
1A2c. Chemicals	N2O	0.005364	0.036058	0.000004	0.000002	0.00%	99.93%
3B1a. Dairy cattle	CH4	5.919000	7.760000	0.000810	0.000100	0.06%	99.99%
3B4b. Horses	N2O	0.044700	0.032780	0.000003	0.000002	0.00%	99.99%
2D2. Paraffin wax use	CO2	0.063498	0.058943	0.000006	0.000003	0.00%	99.99%
1A3d. Domestic navigation	N2O	0.034568	0.025628	0.000003	0.000002	0.00%	99.99%
1A1c. Manufacture of solid fuels and other energy industries	CH4	0.084000	0.129000	0.000013	0.000000	0.00%	99.99%
1A5b. Mobile	CH4	0.000000	0.018750	0.000002	0.000001	0.00%	99.99%
1A2c. Chemicals	CH4	0.002250	0.020700	0.000002	0.000001	0.00%	99.99%
1A2g. Other (please specify)	N2O	0.113538	0.163900	0.000017	0.000001	0.00%	99.99%
3B4b. Horses	CH4	0.027000	0.020000	0.000002	0.000001	0.00%	100.00%
1A5b. Mobile	N2O	0.000000	0.013350	0.000001	0.000001	0.00%	100.00%
1B2c. Venting and flaring	CO2	0.036480	0.060640	0.000006	0.000000	0.00%	100.00%
1A5a. Stationary	CH4	0.037000	0.059500	0.000006	0.000000	0.00%	100.00%
1A2e. Food processing, beverages and tobacco	N2O	0.151980	0.188038	0.000020	0.000003	0.00%	100.00%
1A2d. Pulp, paper and print	N2O	0.011145	0.004857	0.000001	0.000001	0.00%	100.00%
1A2e. Food processing, beverages and tobacco	CH4	0.066000	0.094750	0.000010	0.000001	0.00%	100.00%
1A5a. Stationary	N2O	0.026522	0.041720	0.000004	0.000000	0.00%	100.00%
1A3a. Domestic aviation	CH4	0.004550	0.000143	0.000000	0.000000	0.00%	100.00%
1A2b. Non-ferrous metals	N2O	0.005960	0.002409	0.000000	0.000000	0.00%	100.00%
1A2g. Other (please specify)	CH4	0.047850	0.067000	0.000007	0.000001	0.00%	100.00%

IPCC Source category	Direct GHG	1990 estimate	2017 estimate	Level assessment 2017	Trend assessment	% contribution to trend	Cumulative total of level assessment
1A2d. Pulp, paper and print	CH4	0.004675	0.002025	0.000000	0.000000	0.00%	100.00%
1A2b. Non-ferrous metals	CH4	0.003250	0.00125	0.000000	0.000000	0.00%	100.00%
1A3d. Domestic navigation	CH4	0.002900	0.002150	0.000000	0.000000	0.00%	100.00%
1A1b. Petroleum refining	CO2	85.718200	0.000000	0.000000	0.000000	0.00%	100.00%
1A1b. Petroleum refining	CH4	0.055500	0.000000	0.000000	0.000000	0.00%	100.00%
1A1b. Petroleum refining	N2O	0.107280	0.000000	0.000000	0.000000	0.00%	100.00%
1B2a. Oil	CH4	0.062225	0.000000	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, *u_{i,g}* is the combined uncertainty for emissions of *g*-gas and *i*-source, *u_{AD,i}* is the uncertainty of activity data of the *i*-source, *u_{EF,i,g}* is the uncertainty of the emission factor of *g*-gas and *i*-source, *U_{i,g}* is the uncertainty of the calculated emissions of *g*-gas and *i*-source, *E_{i,g}* are the emissions of *g*-gas and *i*-source and *U_{tot}* is the uncertainty of total emissions. Uncertainty estimations on activity data (*u_{AD,i}*) and on the emission factors (*u_{EF,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, $A_{i,g}$ 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, $E_{i,g,t}$ emissions of g-gas and i-source in the inventory year, $E_{i,g,0}$ emissions of g-gas and i-source in the base year, $B_{i,g}$ the difference (%) of emissions of g-gas and i-source in response to a 1% increase of emissions in the inventory year, $TREF_{i,g}$ the contribution of EF uncertainty of g-gas and i-source to the uncertainty in the trend of emissions, $TRAD_i$ 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 CO₂, 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 2017.

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%.	<ul style="list-style-type: none"> • CO₂: 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 EUETS reports are used for the calculation of EFs for the majority of fuels after 2005. We estimate the EF uncertainty to be 3%. • CH₄: In IPCC guidelines is mentioned that the default uncertainty for stationary combustion EF is 50-150%. We select the mean 100%. • N₂O: 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.
Road transport	5% corresponds to the IPCC default	IPCC defaults are used: 5% for CO ₂ ; 40% for

IPCC Source category	Reasoning for activity data uncertainty	Reasoning for emission factor uncertainty
	uncertainty range for AD obtained from national energy balances.	CH4 and 50% for N2O
Navigation	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC defaults are used: 5% for CO2; 100% for CH4 and 300% for N2O
Civil Aviation	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC defaults are used: 5% for CO2; 100% for CH4 and 300% for N2O
Not specified - Mobile	Activity data obtained from national energy balance. 5% corresponds to the IPCC default uncertainty range.	IPCC defaults are used: 5% for CO2; 100% for CH4 and 300% for N2O
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%
SF6 from electrical equipment	Activity data obtained from national statistics (population): 5%	Expert judgement; 500%
N2O 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 CH4 and 100% for N2O
Indirect N2O emissions	Uncertainty given by Statistical Service for the livestock population	Conservative IPCC values: 50% for N2O

IPCC Source category	Reasoning for activity data uncertainty	Reasoning for emission factor uncertainty
	data: 20%	
Agricultural soils – direct emissions	Uncertainty given by Statistical Service for the livestock population data: 20%	Country specific data: 200%
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, without LULUCF 1990

IPCC category/Group	Gas	Base year emissions or removals	1990 emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	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 (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
1A1a. Public electricity and heat production	CH4	1.650	1.650	5%	100%	1.0012	0.0000		0.0001	0.0000	0.0000	1.0593E-10
1A1b. Petroleum refining	CH4	0.056	0.056	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.1985E-13
1A1c. Manufacture of solid fuels and other energy industries	CH4	0.084	0.084	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	2.74542E-13
1A2b. Non-ferrous metals	CH4	0.003	0.003	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	4.10977E-16
1A2c. Chemicals	CH4	0.002	0.002	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.96977E-16
1A2d. Pulp, paper and print	CH4	0.005	0.005	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	8.50381E-16
1A2e. Food processing, beverages and tobacco	CH4	0.066	0.066	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.69488E-13
1A2f. Non-metallic minerals	CH4	0.759	0.759	2%	100%	1.0002	0.0000		0.0001	0.0000	0.0000	3.5866E-12
1A2g. Other (please specify)	CH4	0.048	0.048	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	8.9087E-14
1A3a. Domestic aviation	CH4	0.005	0.005	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	8.05514E-16
1A3b. Road transportation	CH4	6.875	6.875	5%	40%	0.4031	0.0000		0.0006	0.0000	0.0000	1.83909E-09
1A3d. Domestic navigation	CH4	0.003	0.003	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	3.27225E-16
1A4a. Commercial/institutional	CH4	0.375	0.375	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	5.46429E-12
1A4b. Residential	CH4	1.905	1.905	5%	100%	1.0012	0.0000		0.0002	0.0000	0.0000	1.41128E-10
1A4c. Agriculture/forestry/fishing	CH4	0.184	0.184	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.31015E-12
1A5a. Stationary	CH4	0.037	0.037	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	5.32665E-14
1A5b. Mobile	CH4	0.000	0.000	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	0
1B2a. Oil	CH4	0.062	0.062	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	1.50654E-13
1B2c. Venting and flaring	CH4	0.091	0.091	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	3.23978E-13
3A1a. Dairy cattle	CH4	55.350	55.350	5%	50%	0.5025	0.0000		0.0049	0.0000	0.0003	1.19203E-07
3A1b. Non-dairy cattle	CH4	45.985	45.985	5%	50%	0.5025	0.0000		0.0041	0.0000	0.0003	8.22778E-08
3A2. Sheep	CH4	58.000	58.000	5%	50%	0.5025	0.0000		0.0051	0.0000	0.0004	1.3089E-07
3A3. Swine	CH4	10.423	10.423	5%	50%	0.5025	0.0000		0.0009	0.0000	0.0001	4.22663E-09
3A4a. Goats	CH4	25.750	25.750	5%	50%	0.5025	0.0000		0.0023	0.0000	0.0002	2.57991E-08
3A4b. Horses	CH4	0.207	0.207	5%	50%	0.5025	0.0000		0.0000	0.0000	0.0000	1.66721E-12
3A4c. Mules and Asses	CH4	1.257	1.257	5%	50%	0.5025	0.0000		0.0001	0.0000	0.0000	6.14293E-11
3B1a. Dairy cattle	CH4	5.919	5.919	5%	30%	0.3041	0.0000		0.0005	0.0000	0.0000	1.36316E-09
3B1b. Non-dairy cattle	CH4	3.623	3.623	5%	30%	0.3041	0.0000		0.0003	0.0000	0.0000	5.10584E-10
3B2. Sheep	CH4	2.030	2.030	5%	30%	0.3041	0.0000		0.0002	0.0000	0.0000	1.6034E-10
3B3. Swine	CH4	54.553	54.553	5%	30%	0.3041	0.0000		0.0048	0.0000	0.0003	1.15792E-07
3B4a. Goats	CH4	1.025	1.025	5%	30%	0.3041	0.0000		0.0001	0.0000	0.0000	4.08788E-11
3B4b. Horses	CH4	0.027	0.027	5%	30%	0.3041	0.0000		0.0000	0.0000	0.0000	2.83647E-14
3B4c. Mules and Asses	CH4	0.138	0.138	5%	30%	0.3041	0.0000		0.0000	0.0000	0.0000	7.43429E-13
3B4d. Poultry	CH4	2.103	2.103	5%	30%	0.3041	0.0000		0.0002	0.0000	0.0000	1.71998E-10
3F. Field burning of agricultural residues	CH4	1.551	1.551	20%	20%	0.2828	0.0000		0.0001	0.0000	0.0000	1.49705E-09
5A2. Unmanaged waste disposal sites	CH4	258.343	258.343	30%	30%	0.4243	0.0001		0.0228	0.0000	0.0097	9.34856E-05
5D1. Domestic wastewater	CH4	91.896	91.896	30%	30%	0.4243	0.0000		0.0081	0.0000	0.0034	1.18288E-05
5D2. Industrial wastewater	CH4	24.198	24.198	30%	30%	0.4243	0.0000		0.0021	0.0000	0.0009	8.20151E-07
1A1a. Public electricity and heat production	CO2	1675.770	1675.770	5%	5%	0.0707	0.0001		0.1478	0.0000	0.0105	0.000109265
1A1b. Petroleum refining	CO2	85.718	85.718	5%	5%	0.0707	0.0000		0.0076	0.0000	0.0005	2.85888E-07
1A2b. Non-ferrous metals	CO2	4.910	4.910	5%	5%	0.0707	0.0000		0.0004	0.0000	0.0000	9.38023E-10
1A2c. Chemicals	CO2	2.199	2.199	5%	5%	0.0707	0.0000		0.0002	0.0000	0.0000	1.88149E-10
1A2d. Pulp, paper and print	CO2	4.821	4.821	5%	5%	0.0707	0.0000		0.0004	0.0000	0.0000	9.04213E-10
1A2e. Food processing, beverages and tobacco	CO2	72.571	72.571	5%	5%	0.0707	0.0000		0.0064	0.0000	0.0005	2.04914E-07
1A2f. Non-metallic minerals	CO2	379.827	379.827	5%	5%	0.0707	0.0000		0.0335	0.0000	0.0024	5.61334E-06
1A2g. Other (please specify)	CO2	47.870	47.870	5%	5%	0.0707	0.0000		0.0042	0.0000	0.0003	8.91611E-08
1A3a. Domestic aviation	CO2	26.045	26.045	5%	5%	0.0707	0.0000		0.0023	0.0000	0.0002	2.63936E-08
1A3b. Road transportation	CO2	1183.508	1183.508	5%	5%	0.0707	0.0001		0.1044	0.0000	0.0074	5.44996E-05
1A3d. Domestic navigation	CO2	2.198	2.198	5%	5%	0.0707	0.0000		0.0002	0.0000	0.0000	1.87977E-10

1A4a. Commercial/institutional	CO2	75.212	75.212	5%	5%	0.0707	0.0000	0.0066	0.0000	0.0005	2.20102E-07
1A4b. Residential	CO2	299.704	299.704	5%	5%	0.0707	0.0000	0.0264	0.0000	0.0019	3.49491E-06
1A4c. Agriculture/forestry/fishing	CO2	55.484	55.484	5%	5%	0.0707	0.0000	0.0049	0.0000	0.0003	1.1978E-07
1A5a. Stationary	CO2	10.995	10.995	5%	5%	0.0707	0.0000	0.0010	0.0000	0.0001	4.70371E-09
1B2c. Venting and flaring	CO2	0.036	0.036	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	5.17798E-14
2A1. Cement production	CO2	667.664	667.664	2%	2%	0.0283	0.0000	0.0589	0.0000	0.0017	2.77515E-06
2A2. Lime production	CO2	5.333	5.333	2%	5%	0.0539	0.0000	0.0005	0.0000	0.0000	1.77031E-10
2A4. Other process uses of carbonates	CO2	44.076	44.076	5%	5%	0.0707	0.0000	0.0039	0.0000	0.0003	7.55883E-08
2D1. Lubricant use	CO2	1.120	1.120	5%	5%	0.0707	0.0000	0.0001	0.0000	0.0000	4.88075E-11
2D2. Paraffin wax use	CO2	0.063	0.063	5%	5%	0.0707	0.0000	0.0000	0.0000	0.0000	1.56879E-13
2D3. Other	CO2	17.632	17.632	5%	5%	0.0707	0.0000	0.0016	0.0000	0.0001	1.20969E-08
2G4. Other	CO2	0.041	0.041	5%	500%	5.0002	0.0000	0.0000	0.0000	0.0000	6.60778E-14
3H. Urea application	CO2	1.815	1.815	20%	50%	0.5385	0.0000	0.0002	0.0000	0.0000	2.50508E-09
2F1. Refrigeration and air conditioning	HFCs	63.885	63.885	5%	500%	5.0002	0.0008	0.0056	0.0000	0.0004	1.58797E-07
1A1a. Public electricity and heat production	N2O	3.874	3.874	5%	300%	3.0004	0.0000	0.0003	0.0000	0.0000	5.83942E-10
1A1b. Petroleum refining	N2O	0.107	0.107	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	4.47804E-13
1A1c. Manufacture of solid fuels and other energy industries	N2O	0.134	0.134	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	6.93488E-13
1A2b. Non-ferrous metals	N2O	0.006	0.006	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	1.38211E-15
1A2c. Chemicals	N2O	0.005	0.005	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	1.11951E-15
1A2d. Pulp, paper and print	N2O	0.011	0.011	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	4.8331E-15
1A2e. Food processing, beverages and tobacco	N2O	0.152	0.152	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	8.98718E-13
1A2f. Non-metallic minerals	N2O	1.435	1.435	2%	300%	3.0001	0.0000	0.0001	0.0000	0.0000	1.28226E-11
1A2g. Other (please specify)	N2O	0.114	0.114	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	5.01571E-13
1A3a. Domestic aviation	N2O	0.217	0.217	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	1.83376E-12
1A3b. Road transportation	N2O	23.601	23.601	5%	50%	0.5025	0.0000	0.0021	0.0000	0.0001	2.1673E-08
1A3d. Domestic navigation	N2O	0.035	0.035	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	4.64942E-14
1A4a. Commercial/institutional	N2O	0.140	0.140	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	7.57436E-13
1A4b. Residential	N2O	0.697	0.697	5%	300%	3.0004	0.0000	0.0001	0.0000	0.0000	1.89197E-11
1A4c. Agriculture/forestry/fishing	N2O	0.129	0.129	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	6.43644E-13
1A5a. Stationary	N2O	0.027	0.027	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	2.73692E-14
2G3. N2O from product uses	N2O	41.303	41.303	5%	500%	5.0002	0.0003	0.0036	0.0000	0.0003	6.63757E-08
3B1a. Dairy cattle	N2O	5.066	5.066	5%	100%	1.0012	0.0000	0.0004	0.0000	0.0000	9.98575E-10
3B1b. Non-dairy cattle	N2O	3.189	3.189	5%	100%	1.0012	0.0000	0.0003	0.0000	0.0000	3.95595E-10
3B2. Sheep	N2O	8.433	8.433	5%	100%	1.0012	0.0000	0.0007	0.0000	0.0001	2.7673E-09
3B3. Swine	N2O	7.748	7.748	5%	100%	1.0012	0.0000	0.0007	0.0000	0.0000	2.33577E-09
3B4a. Goats	N2O	8.970	8.970	5%	100%	1.0012	0.0000	0.0008	0.0000	0.0001	3.13052E-09
3B4b. Horses	N2O	0.045	0.045	5%	100%	1.0012	0.0000	0.0000	0.0000	0.0000	7.77437E-14
3B4c. Mules and Asses	N2O	0.302	0.302	5%	100%	1.0012	0.0000	0.0000	0.0000	0.0000	3.538E-12
3B4d. Poultry	N2O	7.867	7.867	5%	100%	1.0012	0.0000	0.0007	0.0000	0.0000	2.40819E-09
3B5. Indirect N2O emissions	N2O	24.378	24.378	20%	50%	0.5385	0.0000	0.0022	0.0000	0.0006	3.69955E-07
3D. Agricultural soils(2) (3) (4)	N2O	134.996	134.996	20%	200%	2.0100	0.0006	0.0119	0.0000	0.0034	1.13452E-05
3F. Field burning of agricultural residues	N2O	0.479	0.479	20%	20%	0.2828	0.0000	0.0000	0.0000	0.0000	1.42767E-10
5D1. Domestic wastewater	N2O	11.980	11.980	30%	30%	0.4243	0.0000	0.0011	0.0000	0.0004	2.01019E-07
5D2. Industrial wastewater	N2O	0.311	0.311	100%	30%	1.0440	0.0000	0.0000	0.0000	0.0000	1.50065E-09
2G1. Electrical equipment	SF6	0.026	0.026	5%	500%	5.0002	0.0000	0.0000	0.0000	0.0000	2.58326E-14
Total		5668.853	5668.853				0.0020				0.0003
Total Uncertainties						Uncertainty in total inventory %:	4.48%			Trend uncertainty %:	1.72%

Table A2.3. Analytical calculations of uncertainty, without LULUCF 2017

IPCC category/Group	Gas	Base year emissions or removals	2017 emissions or removals	Activity data uncertainty (1)	Emission factor / estimation parameter uncertainty (1)	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 (2)	Uncertainty in trend in national emissions introduced by activity data uncertainty (3)	Uncertainty introduced into the trend in total national emissions
1A1a. Public electricity and heat production	CH4	1.65000	3.187500	3%	100%	1.0004	0.0000		0.0003	0.0000	0.0000	1.42316E-10
1A1b. Petroleum refining	CH4	0.05550	0.000000	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	0
1A1c. Manufacture of solid fuels and other energy industries	CH4	0.08400	0.129000	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	6.47485E-13
1A2b. Non-ferrous metals	CH4	0.00325	0.001250	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	6.07954E-17
1A2c. Chemicals	CH4	0.00225	0.020700	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.66721E-14
1A2d. Pulp, paper and print	CH4	0.00468	0.002025	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.59551E-16
1A2e. Food processing, beverages and tobacco	CH4	0.06600	0.094750	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	3.49308E-13
1A2f. Non-metallic minerals	CH4	0.75903	1.634675	3%	100%	1.0004	0.0000		0.0001	0.0000	0.0000	3.74296E-11
1A2g. Other (please specify)	CH4	0.04785	0.067000	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.74663E-13
1A3a. Domestic aviation	CH4	0.00455	0.000143	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	7.90096E-19
1A3b. Road transportation	CH4	6.87506	4.052428	5%	40%	0.4031	0.0000		0.0004	0.0000	0.0000	6.38971E-10
1A3d. Domestic navigation	CH4	0.00290	0.002150	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.79857E-16
1A4a. Commercial/institutional	CH4	0.37475	1.429500	5%	100%	1.0012	0.0000		0.0001	0.0000	0.0000	7.95094E-11
1A4b. Residential	CH4	1.90450	3.577500	5%	100%	1.0012	0.0000		0.0003	0.0000	0.0000	4.97977E-10
1A4c. Agriculture/forestry/fishing	CH4	0.18350	0.334500	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	4.35354E-12
1A5a. Stationary	CH4	0.03700	0.059500	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.37748E-13
1A5b. Mobile	CH4	0.00000	0.018750	5%	100%	1.0012	0.0000		0.0000	0.0000	0.0000	1.3679E-14
1B2a. Oil	CH4	0.06223	0.000000	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	0
1B2c. Venting and flaring	CH4	0.09125	0.151500	5%	300%	3.0004	0.0000		0.0000	0.0000	0.0000	8.9305E-13
3A1a. Dairy cattle	CH4	55.35000	93.425000	5%	50%	0.5025	0.0000		0.0082	0.0000	0.0006	3.39607E-07
3A1b. Non-dairy cattle	CH4	45.98500	52.155000	5%	50%	0.5025	0.0000		0.0046	0.0000	0.0003	1.05838E-07
3A2. Sheep	CH4	58.00000	64.300000	5%	50%	0.5025	0.0000		0.0057	0.0000	0.0004	1.60869E-07
3A3. Swine	CH4	10.42250	13.130000	5%	50%	0.5025	0.0000		0.0012	0.0000	0.0001	6.7078E-09
3A4a. Goats	CH4	25.75000	32.200000	5%	50%	0.5025	0.0000		0.0028	0.0000	0.0002	4.03424E-08
3A4b. Horses	CH4	0.20700	0.154000	5%	50%	0.5025	0.0000		0.0000	0.0000	0.0000	9.22766E-13
3A4c. Mules and Asses	CH4	1.25650	0.079000	5%	50%	0.5025	0.0000		0.0000	0.0000	0.0000	2.42831E-13
3B1a. Dairy cattle	CH4	5.91900	7.760000	5%	30%	0.3041	0.0000		0.0007	0.0000	0.0000	2.34301E-09
3B1b. Non-dairy cattle	CH4	3.62250	4.005000	5%	30%	0.3041	0.0000		0.0004	0.0000	0.0000	6.24102E-10
3B2. Sheep	CH4	2.03000	2.250000	5%	30%	0.3041	0.0000		0.0002	0.0000	0.0000	1.96977E-10
3B3. Swine	CH4	54.55250	33.797500	5%	30%	0.3041	0.0000		0.0030	0.0000	0.0002	4.44447E-08
3B4a. Goats	CH4	1.02500	1.287500	5%	30%	0.3041	0.0000		0.0001	0.0000	0.0000	6.44978E-11
3B4b. Horses	CH4	0.02700	0.020000	5%	30%	0.3041	0.0000		0.0000	0.0000	0.0000	1.55636E-14
3B4c. Mules and Asses	CH4	0.13823	0.008690	5%	30%	0.3041	0.0000		0.0000	0.0000	0.0000	2.93826E-15
3B4d. Poultry	CH4	2.10250	1.710000	5%	30%	0.3041	0.0000		0.0002	0.0000	0.0000	1.13774E-10
3F. Field burning of agricultural residues	CH4	1.55072	0.251835	20%	20%	0.2828	0.0000		0.0000	0.0000	0.0000	3.94823E-11
5A1. Managed waste disposal sites	CH4	0.00000	75.917528	30%	30%	0.4243	0.0000		0.0067	0.0000	0.0028	8.07304E-06
5A2. Unmanaged waste disposal sites	CH4	258.34251	400.137526	30%	30%	0.4243	0.0001		0.0353	0.0000	0.0150	0.00022427
5B1. Composting	CH4	0.00000	3.312500	30%	100%	1.0440	0.0000		0.0003	0.0000	0.0001	1.53697E-08
5D1. Domestic wastewater	CH4	91.89550	33.541500	30%	30%	0.4243	0.0000		0.0030	0.0000	0.0013	1.57586E-06
5D2. Industrial wastewater	CH4	24.19750	29.782500	30%	30%	0.4243	0.0000		0.0026	0.0000	0.0011	1.24244E-06
1A1a. Public electricity and heat production	CO2	1675.77000	3287.830000	3%	3%	0.0424	0.0001		0.2900	0.0000	0.0123	0.000151416
1A1b. Petroleum refining	CO2	85.71820	0.000000	5%	5%	0.0707	0.0000		0.0000	0.0000	0.0000	0
1A2b. Non-ferrous metals	CO2	4.91000	2.170000	5%	5%	0.0707	0.0000		0.0002	0.0000	0.0000	1.83219E-10
1A2c. Chemicals	CO2	2.19900	4.451300	5%	5%	0.0707	0.0000		0.0004	0.0000	0.0000	7.70946E-10
1A2d. Pulp, paper and print	CO2	4.82070	2.098200	5%	5%	0.0707	0.0000		0.0002	0.0000	0.0000	1.71295E-10
1A2e. Food processing, beverages and tobacco	CO2	72.57057	67.587200	5%	5%	0.0707	0.0000		0.0060	0.0000	0.0004	1.77738E-07
1A2f. Non-metallic minerals	CO2	379.82670	508.230300	3%	3%	0.0424	0.0000		0.0448	0.0000	0.0019	3.61804E-06
1A2g. Other (please specify)	CO2	47.86991	70.192910	5%	5%	0.0707	0.0000		0.0062	0.0000	0.0004	1.91707E-07
1A3a. Domestic aviation	CO2	26.04500	0.821000	5%	5%	0.0707	0.0000		0.0001	0.0000	0.0000	2.62263E-11
1A3b. Road transportation	CO2	1183.50842	2074.952367	5%	5%	0.0707	0.0001		0.1830	0.0000	0.0129	0.00016752
1A3d. Domestic navigation	CO2	2.19800	1.643000	5%	5%	0.0707	0.0000		0.0001	0.0000	0.0000	1.05033E-10

1A4a. Commercial/institutional	CO2	75.21200	91.642000	5%	5%	0.0707	0.0000	0.0081	0.0000	0.0006	3.26768E-07
1A4b. Residential	CO2	299.70400	360.407000	5%	5%	0.0707	0.0000	0.0318	0.0000	0.0022	5.05402E-06
1A4c. Agriculture/forestry/fishing	CO2	55.48400	84.054000	5%	5%	0.0707	0.0000	0.0074	0.0000	0.0005	2.74895E-07
1A5a. Stationary	CO2	10.99500	17.630000	5%	5%	0.0707	0.0000	0.0016	0.0000	0.0001	1.20936E-08
1A5b. Mobile	CO2	0.00000	5.335000	5%	5%	0.0707	0.0000	0.0005	0.0000	0.0000	1.10744E-09
1B2c. Venting and flaring	CO2	0.03648	0.060640	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	1.43077E-13
2A1. Cement production	CO2	667.66400	918.947700	2%	2%	0.0283	0.0000	0.0811	0.0000	0.0023	5.25717E-06
2A2. Lime production	CO2	5.33260	3.178400	2%	5%	0.0539	0.0000	0.0003	0.0000	0.0000	6.28908E-11
2A4. Other process uses of carbonates	CO2	44.07600	12.858200	5%	5%	0.0707	0.0000	0.0011	0.0000	0.0001	6.43296E-09
2D1. Lubricant use	CO2	1.12000	4.614000	5%	5%	0.0707	0.0000	0.0004	0.0000	0.0000	8.2834E-10
2D2. Paraffin wax use	CO2	0.06350	0.058943	5%	5%	0.0707	0.0000	0.0000	0.0000	0.0000	1.35183E-13
2D3. Other	CO2	17.63240	19.299138	5%	5%	0.0707	0.0000	0.0017	0.0000	0.0001	1.44919E-08
2G4. Other	CO2	0.04121	0.013020	5%	500%	5.0002	0.0000	0.0000	0.0000	0.0000	6.59587E-15
3H. Urea application	CO2	1.81500	0.418000	20%	50%	0.5385	0.0000	0.0000	0.0000	0.0000	1.08773E-10
2F1. Refrigeration and air conditioning	HFCs	63.88452	240.514041	5%	500%	5.0002	0.0045	0.0212	0.0000	0.0015	2.25077E-06
2F2. Foam blowing agents	HFCs	0.00000	1.277352	5%	500%	5.0002	0.0000	0.0001	0.0000	0.0000	6.3485E-11
2F3. Fire protection	HFCs	0.00000	4.274917	5%	500%	5.0002	0.0000	0.0004	0.0000	0.0000	7.11059E-10
2F4. Aerosols	HFCs	0.00000	3.498209	5%	500%	5.0002	0.0000	0.0003	0.0000	0.0000	4.76148E-10
1A1a. Public electricity and heat production	N2O	3.87400	7.599000	3%	300%	3.0001	0.0000	0.0007	0.0000	0.0000	8.08846E-10
1A1b. Petroleum refining	N2O	0.10728	0.000000	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	0
1A1c. Manufacture of solid fuels and other energy industries	N2O	0.13350	0.205024	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	1.63553E-12
1A2b. Non-ferrous metals	N2O	0.00596	0.002409	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	2.2575E-16
1A2c. Chemicals	N2O	0.00536	0.036058	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	5.05887E-14
1A2d. Pulp, paper and print	N2O	0.01115	0.004857	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	9.18033E-16
1A2e. Food processing, beverages and tobacco	N2O	0.15198	0.188038	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	1.37576E-12
1A2f. Non-metallic minerals	N2O	1.43517	2.840536	3%	300%	3.0001	0.0000	0.0003	0.0000	0.0000	1.1302E-10
1A2g. Other (please specify)	N2O	0.11354	0.163900	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	1.04522E-12
1A3a. Domestic aviation	N2O	0.21709	0.006854	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	1.82784E-15
1A3b. Road transportation	N2O	23.60121	12.972465	5%	50%	0.5025	0.0000	0.0011	0.0000	0.0001	6.5478E-09
1A3d. Domestic navigation	N2O	0.03457	0.025628	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	2.55552E-14
1A4a. Commercial/institutional	N2O	0.13952	0.232440	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	2.10219E-12
1A4b. Residential	N2O	0.69732	0.947640	5%	300%	3.0004	0.0000	0.0001	0.0000	0.0000	3.49411E-11
1A4c. Agriculture/forestry/fishing	N2O	0.12862	0.203683	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	1.61421E-12
1A5a. Stationary	N2O	0.02652	0.041720	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	6.77234E-14
1A5b. Mobile	N2O	0.00000	0.013350	5%	300%	3.0004	0.0000	0.0000	0.0000	0.0000	6.93488E-15
2G3. N2O from product uses	N2O	41.30280	60.821800	5%	500%	5.0002	0.0003	0.0054	0.0000	0.0004	1.43936E-07
3B1a. Dairy cattle	N2O	5.06600	6.466600	5%	100%	1.0012	0.0000	0.0006	0.0000	0.0000	1.62706E-09
3B1b. Non-dairy cattle	N2O	3.18860	3.427000	5%	100%	1.0012	0.0000	0.0003	0.0000	0.0000	4.5696E-10
3B2. Sheep	N2O	8.43340	9.327400	5%	100%	1.0012	0.0000	0.0008	0.0000	0.0001	3.3851E-09
3B3. Swine	N2O	7.74800	4.172000	5%	100%	1.0012	0.0000	0.0004	0.0000	0.0000	6.77234E-10
3B4a. Goats	N2O	8.96980	11.264400	5%	100%	1.0012	0.0000	0.0010	0.0000	0.0001	4.93704E-09
3B4b. Horses	N2O	0.04470	0.032780	5%	100%	1.0012	0.0000	0.0000	0.0000	0.0000	4.18089E-14
3B4c. Mules and Asses	N2O	0.30155	0.018953	5%	100%	1.0012	0.0000	0.0000	0.0000	0.0000	1.39765E-14
3B4d. Poultry	N2O	7.86720	5.304400	5%	100%	1.0012	0.0000	0.0005	0.0000	0.0000	1.09477E-09
3B5. Indirect N2O emissions	N2O	24.38	27.513208	20%	50%	0.5385	0.0000	0.0024	0.0000	0.0007	4.71252E-07
3D. Agricultural soils(2) (3) (4)	N2O	135.00	120.174820	20%	200%	2.0100	0.0002	0.0106	0.0000	0.0030	8.99078E-06
3F. Field burning of agricultural residues	N2O	0.48	0.078365	20%	20%	0.2828	0.0000	0.0000	0.0000	0.0000	3.8231E-12
5B1. Composting	N2O	0.00	2.369100	30%	100%	1.0440	0.0000	0.0002	0.0000	0.0001	7.86176E-09
5D1. Domestic wastewater	N2O	11.98	16.315500	30%	30%	0.4243	0.0000	0.0014	0.0000	0.0006	3.72867E-07
5D2. Industrial wastewater	N2O	0.31	0.284590	100%	30%	1.0440	0.0000	0.0000	0.0000	0.0000	1.26052E-09
2G1. Electrical equipment	SF6	0.03	0.165308	5%	500%	5.0002	0.0000	0.0000	0.0000	0.0000	1.06326E-12
Total		5668.85	8945.264612				0.0052				0.0006
Total Uncertainties						Uncertainty in total inventory %:	7.24%			Trend uncertainty %:	2.41%

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 2017 for the period 1990-2017 are presented in Table A3.1.3. In green are sectors/consumers that have been added for the first time in 2017 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 2005-2016.

Table A3.1.2. International and domestic flights' fuel consumptions, EUROCONTROL data (2005-2016)

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				
Domestic	0.305	0.191	0.286	0.179				
International	245.7	246.0	238.1	278.2				

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Road	210	202	246	255	261	285	298	314	334	340	350	355	341	351	354
Chemical and petrochemical															
Non-ferrous metals															
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															

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
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
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

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
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) 2005-2016

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Crude oil												
Refinery intake (Observed)												
Refinery losses												
Refinery gas												
Refinery fuel												
LPG												
Non-ferrous metals		1	1		1	1	1	1			1	1
Non-metallic minerals						1	1	1	1	1	1	1
Food, beverages and tobacco		3	3	3	3	3	4	5	4	4	5	4
Not elsewhere specified (Industry)		1	1	1	1				0	1	0	0
Commercial and public services		13	13	14	13	13	14	14	12	10	11	11
Residential	53	35	36	34	36	34	38	37	33	31	34	35
Agriculture/forestry		1	1	1	1	1	1	1	1		1	2
Not elsewhere specified (Other)									1	1	1	1
Non-biogasoline = GASOLINE												
Road	303	323	352	373	383	390	385	372	349	341	345	354
International aviation	291	300	287	286	265	270	294	264	235	231	233	263
Not elsewhere specified (Other)					1	1	2	1	2	2	1	1
Other kerosene												
Residential	13	16	16	14	19	14	16	17	12	9	14	14
Oil and gas extraction										2		
Not elsewhere specified (Industry)	3											
Residential	16	16	16	14	19	14	16	17	12	9	14	14
Not elsewhere specified (Industry)										2		
Road			1	16	17	17	18	18	17	11	11	10

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Non-bio gas/diesel oil = DIESEL												
International marine bunkers	67	106	104	88	73	53	58	69	83	80	75	95
Main activity producer electricity plants	16	7	16	23	92	158	112	214	236	124	89	150
Autoproducer electricity plants			1				2	2	2	1	2	2
Road	346	323	337	330	321	329	313	272	231	224	241	274
Chemical and petrochemical								1	0	1	1	1
Non-ferrous metals								1				1
Non-metallic minerals								3	1	1	2	2
Mining and Quarrying								5	2	1	3	2
Food, beverages and tobacco								3	2	2	4	3
Construction								5	5	6	6	7
Not elsewhere specified (Industry)	47	24	20	18	18	14	16	3	1	1		
Commercial and public services		19	18	20	19	23	20	16	17	13	13	15
Residential	83	98	89	78	83	70	80	76	62	57	65	65
Agriculture/forestry	27	28	28	23	20	19	22	21	21	19	22	21
Fishing				3	4	4	3	3	2	2	2	2
Not elsewhere specified (Other)		4	6	13	5	5	6	5	5	9	6	6
Total fuel oil												
International marine bunkers	225	190	171	165	146	134	141	128	157	153	169	193
Refinery fuel												
Main activity producer electricity plants	1104	1137	1174	1219	1163	1053	1058	896	649	793	858	883
Autoproducer electricity plants			4	3	2	2	2		2	4		
Autoproducer CHP Plants	6	7	14	12	11	8	2	2	2	0		
Chemical and petrochemical											1	1
Non-metallic minerals	37	35	38	38	30	25	15	13	8	7	8	10
Food, beverages and tobacco								9	8	8	9	9
Paper, pulp and printing										1	1	1
Construction								1	1	3	2	3
Not elsewhere specified (Industry)	28	19	27	25	17	20	34	2	2	3	1	2
Commercial and public services	1	2	2	2	2	2	2	4	4	2	3	
White spirit and SPB												
Not elsewhere specified (Industry)	1	1	1									
Lubricants												

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
International marine bunkers	1	1	1	1								
Non-energy use: Road	2	2	2	2	2	2	2	1	1	1	1	1
Non-energy use: Not elsewhere specified (Industry)	4	4	4	4	4	4	4	4	3	3	3	3
Bitumen												
Construction	69	69	57	66	74	83	64	36	24	21	21	37
Non-energy use: Not elsewhere specified (Industry)												
Pet-coke												
Non-metallic minerals	154	146	143	152	144	116	100	94	135	162	128	123
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
Lignite												
Not elsewhere specified (Other)	1	1	1	1	1	1	1	1	1	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
Municipal waste (non-renewable) TJ												
Non-metallic minerals								24	45	37	295	569
RENEWABLES												
Solid biofuels (TJ)												
Charcoal production plants (Transformation)	174	135	274	211	47	48	45	82	71	58	94	163
Chemical and petrochemical										42	52	21
Non-metallic minerals	38	61	133	281	304	347	306	29	28	116	95	55
Food, beverages and tobacco										44	7	36
Commercial and public services			14	15	15	15	13	16	16	16	15	15
Residential		74	95	123	222	84	123	143	112	71	146	130
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
Residential		5	6	6	5	5	6	6	6	6	6	8

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Not elsewhere specified (Other)	10											
Biogases (TJ)												
Main activity producer CHP plants	0	0	0	0	13	21	92	91	118	116	130	130
Autoproducer CHP plants	0	0	9	78	131	148	180	192	171	176	179	182
Commercial and public services	0	0	0	0	11	12	11	11	11	12	12	16
Agriculture/Forestry	0	0	6	0	54	93	165	182	166	172	151	163
Municipal waste (renewable)												
Non-metallic minerals								88	150	161	325	427

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 (2005-2016)

	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				
Share of domestic to total	0.12%	0.08%	0.12%	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 2016.

(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 1998-2015⁹¹ (Table A3.1.9). The consumption for the period 1990-1997 was estimated assuming that the contribution of

⁹¹ Mr. George Ioannou, Statistical Service, Estimation based on fuel expenses assuming that all fuel is road diesel

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 2012-2016. 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).

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 its 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” (2007-2016) was moved to agriculture.

A.3.2. Solid waste management (5A)

Historical solid waste production

The IPCC Waste Model requires MSW activity data to be reported annually going back to the year 1950. However, 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:

- The 1960-2014 GDP data⁹² was extrapolated backwards, to expand the range to the year 1950.
- 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.
- 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.

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. Figures in bold are calculated by the models illustrated in Figures 7.4 and 7.5

	GDP (€m)	Waste (kg/capita)		GDP (€m)	Waste (kg/capita)
1950	1052.3	457.96		1983	4802.3767
1951	1103	458.65		1984	5227.7582
1952	1156.2	459.37		1985	5478.4979
1953	1211.9	460.13		1986	5675.5858
1954	1270.2	460.92		1987	6078.5212
1955	1331.4	461.76		1988	6583.8328
1956	1395.6	462.64		1989	7117.0653
1957	1462.8	463.56		1990	7650.2977
1958	1533.3	464.52		1991	7703.9494
1959	1607.1	465.54		1992	8428.2477
1960	1468.8528	463.64		1993	8487.3741
1961	1631.9978	465.88		1994	8987.7585
1962	1778.7189	467.91		1995	10190.74
1963	1888.7596	469.44		1996	10355.25
1964	1709.1906	466.95		1997	10602.94
1965	2090.2273	472.24		1998	11138.88
1966	2217.787	474.03		1999	11662.88
1967	2519.4411	478.28		2000	12330.36
1968	2635.504	479.92		2001	12772.74
1969	2880.769	483.42		2002	13185.748
1970	2970.0061	484.69		2003	13556.11
1971	3349.9479	490.17		2004	14179.977
1972	3571.1244	493.39		2005	14730.58
1973	3606.7097	493.91		2006	15396.7
1974	2997.3794	485.09		2007	16156.38
1975	2428.0142	476.98		2008	16746.54
					728.88

⁹² 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

1976	2870.3672	483.27
1977	3323.122	489.78
1978	3577.1465	493.48
1979	3930.2624	498.66
1980	4162.9357	502.11
1981	4289.948	504

2009	16406.76	729.86
2010	16630.61	698
2011	16697.85	684
2012	16289.047	670
2013	15321.63	629
2014	14939.02	626

(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.

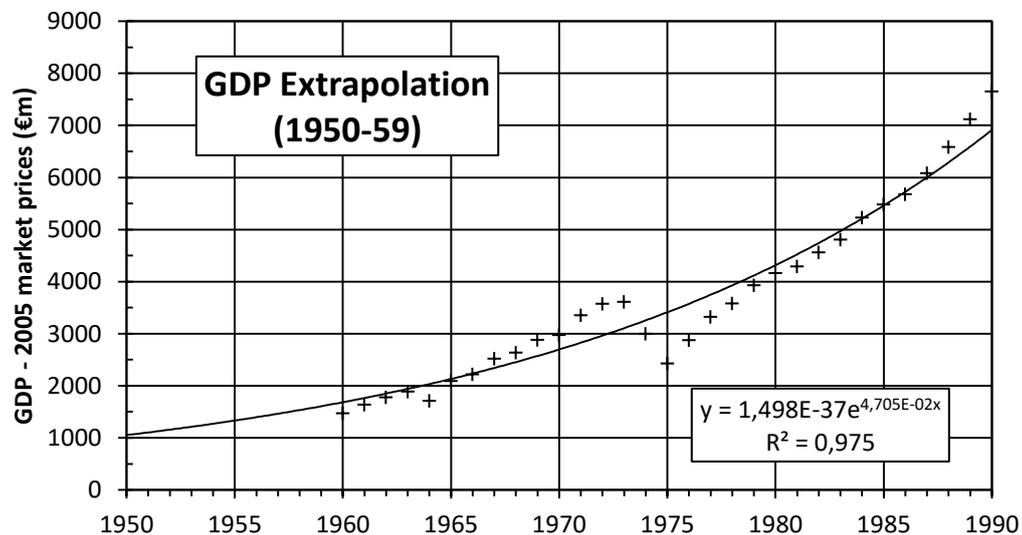


Figure A.3.2.1. GDP data 1960-2014 (CYSTAT) extrapolated for the years of 1950-59.

(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.

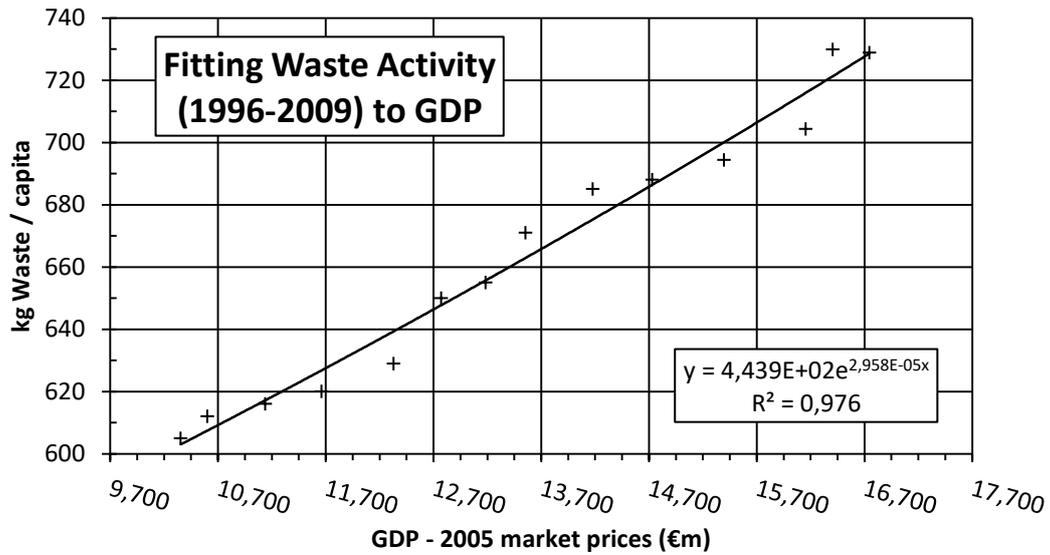


Figure A.3.2.2. Plotting the linear period of waste activity data from 1996-2009 against their corresponding annual GDP, and fitting to an exponential model.

- (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.

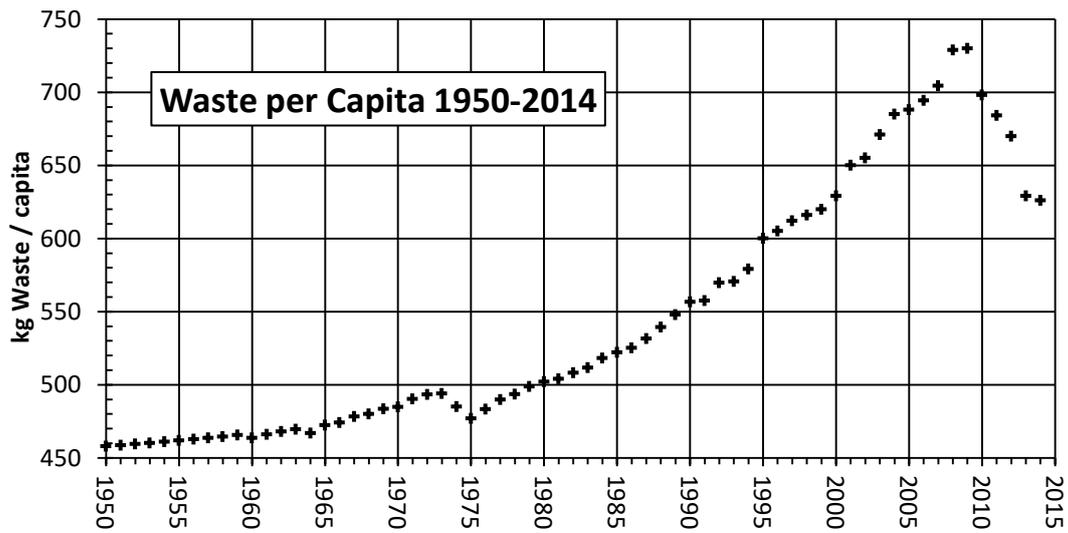


Figure A.3.2.3. Waste per capita derived from annual GDP data and hind casts.

Annex 4: The national energy balance for the most recent inventory year (2017)

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 2017 - Liquid Fuels (LPG, Non-biogasoline, Non-bio jet kerosene, Other kerosene, Road diesel, Heating and other gas oil, Total gas/diesel oil, Biodiesel), in kt

Flow	LPG	Non-biogasoline	Non-bio jet kerosene	Other kerosene	Road diesel	Heating and other gas oil	Total gas/diesel oil	Biodiesel
Indigenous production								
Receipts from other sources								
<i>Solid fuels</i>								
<i>Natural gas</i>								
<i>Renewables</i>								
Backflows							0.000	
Of which: backflows for direct export or sale							0.000	
Primary product receipts					2.499		0.000	2.499
Refinery gross output							253.000	
Recycled products							0.000	
Refinery fuel							0.000	
Imports (Balance)	55.434	349.803	290.195	15.624	373.854	419.033	168.000	7.198
Exports (Balance)							0.000	
International marine bunkers						101.295	14.000	
Interproduct transfers					-8.000	8.000	0.000	
Products transferred							0.000	
Direct use								
Stock changes	-1.037	0.014	7.892	-1.506	-2.157	-7.024	0.000	
Refinery intake (Calculated)								
Gross inland deliveries (Calculated)	54.397	349.817	298.087	14.118	366.196	318.714	407.000	9.697
Statistical difference	-2.249	-1.081	-2.781	-0.263	32.369	-32.357	12.000	0.000
Gross inland deliveries (Observed)	56.646	350.898	300.868	14.381	333.827	351.071	395.000	9.697
Refinery intake (Observed)								
Opening stock level (National territory)	1.927	59.575	44.965	1.101	56.966	122.909	25.000	
Closing stock level (National territory)	2.964	59.561	37.073	2.607	59.123	129.933	25.000	
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	42,800.000	42,759.000	42,779.000	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	

Flow	LPG	Non-biogasoline	Non-bio jet kerosene	Other kerosene	Road diesel	Heating and other gas oil	Total gas/diesel oil	Biodiesel
Net deliveries of Total products								
Net deliveries to the Petrochemical industry								
Gross inland deliveries for energy use	56.646	350.898	300.868	14.381	333.827	351.071	395.000	9.697
Transformation sector	0.000	0.000	0.000	0.000	0.000	256.831	3.000	0.000
Main activity producer electricity						255.220	3.000	
Autoproducer electricity						1.611	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 energy consumption	56.646	350.898	300.868	14.381	333.827	94.240	392.000	9.697
Transport sector	0.000	350.898	299.176	0.000	299.459	0.000	255.000	9.697
International aviation			299.176				0.000	
Domestic aviation							0.000	
Road		350.898			299.459		255.000	9.697
Rail							0.000	
Domestic navigation							0.000	
Pipeline transport							0.000	
Non elsewhere specified (Transport)							0.000	
Industry sector	6.844	0.000	0.000	0.000	2.464	15.072	137.000	0.000
Iron and steel							0.000	
Chemical and petrochemical	0.184					0.607	0.000	
Non-ferrous metals	0.487					0.224	0.000	

Flow	LPG	Non-biogasoline	Non-bio jet kerosene	Other kerosene	Road diesel	Heating and other gas oil	Total gas/diesel oil	Biodiesel
Non-metallic minerals	0.540				0.509	0.293	0.000	
Transport equipment							0.000	
Machinery	0.132						0.000	
Mining and Quarrying					1.955	0.591	0.000	
Food, beverages and tobacco	5.169					4.512	0.000	
Paper, pulp and printing	0.332						0.000	
Wood and wood products							0.000	
Construction						8.845	0.000	
Textiles and leather							0.000	
Not elsewhere specified (Industry)							137.000	
Other sectors	49.802	0.000	1.692	14.381	31.904	79.168	0.000	0.000
Commercial and public services	12.122				2.984	11.341	0.000	
Residential	33.941			14.381		67.105	0.000	
Agriculture/forestry	2.424				22.109		0.000	
Fishing					2.000		0.000	
Not elsewhere specified (Other)	1.315		1.692		4.811	0.722	0.000	
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	

Flow	LPG	Non-biogasoline	Non-bio jet kerosene	Other kerosene	Road diesel	Heating and other gas oil	Total gas/diesel oil	Biodiesel
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 2017 - Liquid Fuels (Non-bio gas/diesel oil, Total fuel oil, "Fuel oil -high sulphur", Lubricants, Bitumen, Pet-coke), in kt

Flow	Non-bio gas/diesel oil	Total fuel oil	Fuel oil - high sulphur	Lubricants	Bitumen	Pet-coke
Indigenous production						
Receipts from other sources						
<i>Solid fuels</i>						
<i>Natural gas</i>						
<i>Renewables</i>						
Backflows		0.000				
Of which: backflows for direct export or sale		0.000				
Primary product receipts		0.000				
Refinery gross output		316.000				
Recycled products		0.000	5.751			
Refinery fuel		16.000				
Imports (Balance)	785.689	599.000	825.111	7.849	35.082	123.689
Exports (Balance)		22.000				
International marine bunkers	101.295	65.000				
Interproduct transfers		0.000				
Products transferred		0.000				
Direct use						
Stock changes	-9.181	52.000	-20.089	-0.023	3.868	-14.991
Refinery intake (Calculated)						
Gross inland deliveries (Calculated)	675.213	864.000	810.773	7.826	38.950	108.698
Statistical difference	0.012	50.000	6.081	4.131	2.286	0.000
Gross inland deliveries (Observed)	675.201	814.000	804.692	3.695	36.664	108.698
Refinery intake (Observed)						
Opening stock level (National territory)	179.875	150.000	85.711	0.786	6.763	29.183
Closing stock level (National territory)	189.056	98.000	105.800	0.809	2.895	44.174
Average net calorific value of Production						
Average net calorific value of Imports						
Average net calorific value of Exports						
Average net calorific value of Average	42,875.000	40,627.000	40,629.000	40,200.000	40,200.000	32,254.000
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		-51.000				
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						

Flow	Non-bio gas/diesel oil	Total fuel oil	Fuel oil - high sulphur	Lubricants	Bitumen	Pet-coke
Gross inland deliveries for energy use	675.201	814.000	804.692	0.000	0.000	108.698
Transformation sector	256.831	703.000	777.929	0.000	0.000	0.000
Main activity producer electricity	255.220	703.000	777.929			
Autoproducer electricity	1.611	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
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	418.370	111.000	26.763	0.000	0.000	108.698
Transport sector	289.762	0.000	0.000	0.000	0.000	0.000
International aviation		0.000				
Domestic aviation		0.000				
Road	289.762	0.000				
Rail		0.000				
Domestic navigation		0.000				
Pipeline transport		0.000				
Non elsewhere specified (Transport)		0.000				
Industry sector	17.536	111.000	25.841	0.000	0.000	108.698
Iron and steel		0.000				
Chemical and petrochemical	0.607	0.000	0.209			
Non-ferrous metals	0.224	0.000				
Non-metallic minerals	0.802	111.000	6.227			108.698
Transport equipment		0.000				
Machinery		0.000				

Flow	Non-bio gas/diesel oil	Total fuel oil	Fuel oil - high sulphur	Lubricants	Bitumen	Pet-coke
Mining and Quarrying	2.546	0.000	0.488			
Food, beverages and tobacco	4.512	0.000	12.083			
Paper, pulp and printing		0.000	0.671			
Wood and wood products		0.000				
Construction	8.845	0.000	5.550			
Textiles and leather		0.000				
Not elsewhere specified (Industry)		0.000	0.613			
Other sectors	111.072	0.000	0.922	0.000	0.000	0.000
Commercial and public services	14.325	0.000	0.922			
Residential	67.105	0.000				
Agriculture/forestry	22.109	0.000				
Fishing	2.000	0.000				
Not elsewhere specified (Other)	5.533	0.000				
Gross inland deliveries for non energy use	0.000	0.000	0.000	3.695	36.664	0.000
Transformation Sector	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
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	3.695	36.664	0.000
Transport sector	0.000	0.000	0.000	1.085	0.000	0.000
International aviation		0.000				

Flow	Non-bio gas/diesel oil	Total fuel oil	Fuel oil - high sulphur	Lubricants	Bitumen	Pet-coke
Domestic aviation		0.000				
Road		0.000		1.085		
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	2.610	36.664	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			36.664	
Textiles and leather		0.000				
Not elsewhere specified (Industry)		0.000		2.610		
Other sectors	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.4.3. Energy balance 2017 - Solid Fuels (Bituminous coal), in kt

Supply, transformation and end-use sectors	2017
Indigenous production	-
Underground production	-
Surface production	-
From other sources	-
From other sources - Oil	-
From other sources - Natural gas	-
From other sources - Renewables	-
Total imports (Balance)	16.500
Total exports (Balance)	-
International marine bunkers	-
Stock changes (National territory)	-11.445
Inland consumption (Calculated)	5.055
Statistical differences	-
Transformation sector	-
Main activity producer electricity	-
Main activity producer CHP	-
Main activity producer heat	-
Autoproducer electricity	-
Autoproducer CHP	-
Autoproducer heat	-
Patent fuel plants (Transformation)	-
Coke ovens (Transformation)	-
BKB/PB plants (Transformation)	-
Gas works (Transformation)	-
Blast furnaces (Transformation)	-
Coal liquefaction plants (Transformation)	-
For blended natural gas	-
Not elsewhere specified (Transformation)	-
Energy sector	-
Own use in electricity, CHP and heat	-
Coal mines	-
Patent fuel plants (Energy)	-
Coke ovens (Energy)	-
BKB/PB plants (Energy)	-
Gas works (Energy)	-
Blast furnaces (Energy)	-
Oil refineries	-
Coal liquefaction plants (Energy)	-
Not elsewhere specified (Energy industry own use)	-
Distribution losses	-
Total final consumption	5.055
Total non-energy use	-
Non-energy use industry/transformation/energy	-
Of which: Non-energy use-Chemical/petrochem	-
Non-energy use in transport	-
Non-energy use in other sectors	-
Final energy consumption	5.055
Industry sector	5.055
Iron and steel	-
Chemical and petrochemical	-
Non-ferrous metals	-
Non-metallic minerals	5.055
Transport equipment	-
Machinery	-
Mining and quarrying	-
Food, beverages and tobacco	-
Paper, pulp and printing	-
Wood and wood products	-
Construction	-
Textiles and leather	-
Not elsewhere specified (Industry)	-
Transport sector	-
Rail	-
Domestic navigation	-
Not elsewhere specified (Transport)	-
Other sectors	-
Commercial and public services	-
Residential	-
Agriculture/forestry	-
Fishing	-
Not elsewhere specified (Other)	-

Table A.4.4. Energy balance 2017 – 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	122.158	21.763	15.328	427.929	2.491	504.345
Total imports (balance)	-	677.498	736.604	98.838	13.222	-
Total exports (balance)	-	-	-	-	-	-
Stock changes (national territory)	-32.063	52.746	60.356	-17.443	-	-
Inland consumption (calculated)	90.095	752.007	812.288	509.324	15.713	504.345
Statistical differences	-	-	-	0.040	-	0.164
Transformation sector	-	-	-	171.900	-	323.270
Main activity producer electricity	-	-	-	-	-	-
Main activity producer CHP	-	-	-	-	-	145.257
Main activity producer heat	-	-	-	-	-	-
Autoproducer electricity	-	-	-	-	-	-
Autoproducer CHP	-	-	-	-	-	178.013
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)	-	-	-	171.900	-	-
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	90.095	752.007	812.288	337.384	15.713	180.911
Final energy consumption	90.095	752.007	812.288	337.384	15.713	180.911
Industry sector	90.095	752.007	812.288	157.266	-	-
Iron and steel	-	-	-	-	-	-
Chemical and petrochemical	-	-	-	21.600	-	-
Non-ferrous metals	-	-	-	-	-	-
Non-metallic minerals	90.095	752.007	812.288	85.507	-	-
Transport equipment	-	-	-	-	-	-
Machinery	-	-	-	-	-	-
Mining and quarrying	-	-	-	-	-	-
Food, beverages and tobacco	-	-	-	50.159	-	-
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	-	-	-	180.118	15.713	180.911
Commercial and public services	-	-	-	17.000	7.071	16.792
Residential	-	-	-	163.118	8.642	-
Agriculture/Forestry	-	-	-	-	-	164.119
Fishing	-	-	-	-	-	-
Not elsewhere specified (Other)	-	-	-	-	-	-

Annex 5: Indirect greenhouse gases and SO₂

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 SO₂ 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 1990-2017 (as Gg NO₂)

	1990	1991	1992	1993	1994	1995	1996	1997
1A1a	3.2129	3.3323	3.8327	4.1307	4.3188	3.9313	4.1767	4.4168
1A1b	0.1300	0.1400	0.1400	0.1400	0.1700	0.1600	0.1500	0.1600
1A2a	0.0024	0.0024	0.0021	0.0021	0.0021	0.0021	0.0021	0.0019
1A2b	0.0816	0.0838	0.0881	0.0891	0.0902	0.0902	0.0902	0.0945
1A2c	0.0279	0.0290	0.0300	0.0301	0.0310	0.0344	0.0365	0.0387
1A2d	0.0140	0.0161	0.0183	0.0193	0.0226	0.0236	0.0247	0.0258
1A2e	0.2320	0.2470	0.2578	0.2685	0.2792	0.2900	0.3007	0.3114
1A2f	1.6213	1.5288	1.6518	1.8062	1.8862	1.8070	1.9436	1.8704
1A2gvii	0.4039	0.4046	0.4046	0.4053	0.4066	0.4072	0.4079	0.4085
1A2gviii	0.4940	0.4979	0.4963	0.4988	0.5037	0.5065	0.5069	0.5091
1A3ai(i)	0.3100	0.3138	0.3177	0.3215	0.3253	0.3291	0.3330	0.3368
1A3aii(i)	0.0069	0.0069	0.0084	0.0087	0.0092	0.0097	0.0095	0.0100
1A3bi	2.9151	2.8217	2.7013	2.5841	2.6913	2.5704	2.5352	2.5081
1A3bii	2.2383	2.4808	2.9910	3.0712	3.5351	3.3351	3.3871	3.4474
1A3biii	3.0304	3.1282	3.6273	3.5664	3.8653	3.5382	3.6675	3.7608
1A3biv	0.0295	0.0292	0.0280	0.0264	0.0270	0.0267	0.0264	0.0277
1A3dii	0.0374	0.0374	0.0374	0.0374	0.0374	0.0374	0.0374	0.0374
1A4bi	0.1591	0.1690	0.2021	0.2069	0.2323	0.2214	0.2315	0.2424
1A4ci	0.1563	0.1681	0.2028	0.2061	0.2343	0.2227	0.2338	0.2453
1A4cii	0.2121	0.2281	0.2751	0.2796	0.3178	0.3022	0.3171	0.3328
1A4ciii	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019
1A5b	0.0081	0.0081	0.0081	0.0081	0.0081	0.0081	0.0081	0.0081
1B2aiv	0.1525	0.1621	0.1694	0.1838	0.1897	0.1987	0.1825	0.2502
1B2c	0.0404	0.0429	0.0448	0.0486	0.0502	0.0526	0.0483	0.0662
2G	0.0069	0.0069	0.0075	0.0021	0.0021	0.0061	0.0064	0.0072
3B1a	0.0028	0.0028	0.0029	0.0032	0.0034	0.0036	0.0034	0.0031
3B1b	0.0012	0.0012	0.0012	0.0014	0.0014	0.0015	0.0016	0.0014
3B2	0.0007	0.0007	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006
3B3	0.0113	0.0121	0.0139	0.0149	0.0147	0.0154	0.0162	0.0170
3B4d	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006	0.0007
3B4e	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3B4f	0.0003	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001
3B4gi	0.0014	0.0013	0.0013	0.0017	0.0016	0.0016	0.0017	0.0016
3B4gii	0.0037	0.0034	0.0039	0.0046	0.0043	0.0045	0.0048	0.0050
3B4giii	0.0003	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003
3B4giv	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001
3Da1	0.8703	0.8789	1.1000	0.9288	0.9061	0.8570	0.9042	0.7231
3Da2b	0.0012	0.0012	0.0012	0.0013	0.0013	0.0013	0.0013	0.0014
3F	0.0794	0.0771	0.0809	0.0811	0.0701	0.0630	0.0569	0.0520
5C1biii	0.0010	0.0010	0.0010	0.0011	0.0011	0.0011	0.0011	0.0011
5C2	0.0015	0.0016	0.0016	0.0016	0.0017	0.0017	0.0017	0.0017
TOTAL	16.5006	16.8694	18.7542	18.9839	20.2447	19.0649	19.6598	19.9287

	1998	1999	2000	2001	2002	2003	2004	2005
1A1a	4.8215	5.0901	5.3539	5.3139	5.5342	5.9476	6.1958	6.5557
1A1b	0.1700	0.1900	0.2100	0.2000	0.1700	0.0800	0.0400	NO
1A2a	0.0017	0.0017	0.0017	0.0009	0.0009	0.0006	0.0004	0.0002

1A2b	0.0945	0.0945	0.0945	0.0967	0.0967	0.0967	0.0967	0.0966
1A2c	0.0408	0.0430	0.0451	0.0473	0.0473	0.0432	0.0430	0.0408
1A2d	0.0279	0.0279	0.0290	0.0290	0.0279	0.0258	0.0258	0.0236
1A2e	0.3179	0.3265	0.3351	0.3394	0.3437	0.3523	0.3566	0.3624
1A2f	1.7690	1.7775	1.8309	1.7914	1.8520	1.8292	1.9781	1.9405
1A2gvii	0.4163	0.4177	0.4242	0.4274	0.4291	0.4307	0.4323	0.4340
1A2gviii	0.5099	0.5101	0.5103	0.5106	0.5107	0.5108	0.5110	0.5131
1A3ai(i)	0.3406	0.3444	0.3483	0.3521	0.3559	0.3597	0.3636	0.3675
1A3aii(i)	0.0103	0.0108	0.0116	0.0127	0.0126	0.0127	0.0132	0.0335
1A3bi	2.3975	2.3504	2.3173	2.2822	2.2575	2.2827	2.1638	2.0261
1A3bii	3.5699	3.6391	4.0438	3.7706	3.6709	3.5734	3.2768	3.1205
1A3biii	3.8294	3.8657	4.4056	4.0741	4.0600	4.2937	4.1562	4.1565
1A3biv	0.0286	0.0313	0.0322	0.0353	0.0370	0.0413	0.0437	0.0445
1A3dii	0.0374	0.0374	0.0374	0.0317	0.0341	0.0390	0.0339	0.0484
1A4bi	0.2549	0.2638	0.2693	0.2726	0.2821	0.2697	0.3054	0.4355
1A4ci	0.2589	0.2683	0.2747	0.2774	0.2881	0.2759	0.2406	0.2499
1A4cii	0.3513	0.3640	0.3727	0.3763	0.3908	0.3743	0.3091	0.3072
1A4ciii	0.0019	0.0019	0.0019	0.0026	0.0025	0.0034	0.0037	0.0028
1A5b	0.0081	0.0081	0.0081	0.0063	0.0060	0.0053	0.0042	0.0053
1B2aiv	0.2599	0.2831	0.2816	0.2774	0.2607	0.2328	0.0669	NO
1B2c	0.0688	0.0749	0.0745	0.0734	0.0690	0.0616	0.0177	NO
2G	0.0073	0.0102	0.0193	0.0059	0.0055	0.0040	0.0059	0.0052
3B1a	0.0029	0.0030	0.0029	0.0030	0.0032	0.0033	0.0032	0.0030
3B1b	0.0012	0.0012	0.0012	0.0011	0.0012	0.0012	0.0013	0.0013
3B2	0.0006	0.0006	0.0006	0.0007	0.0007	0.0006	0.0007	0.0007
3B3	0.0173	0.0165	0.0167	0.0184	0.0197	0.0196	0.0187	0.0173
3B4d	0.0008	0.0008	0.0009	0.0010	0.0011	0.0010	0.0009	0.0008
3B4e	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001
3B4f	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
3B4gi	0.0018	0.0015	0.0012	0.0013	0.0013	0.0013	0.0017	0.0014
3B4gii	0.0049	0.0050	0.0052	0.0052	0.0054	0.0054	0.0045	0.0046
3B4giii	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002	0.0002
3B4giv	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
3Da1	0.6105	0.6514	0.6567	0.7159	0.5732	0.4575	0.5178	0.5498
3Da2b	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0015	0.0015
3F	0.0489	0.0447	0.0355	0.0348	0.0327	0.0351	0.0275	0.0214
5C1biii	0.0012	0.0012	0.0012	0.0012	0.0012	0.0003	NO	NO
5C2	0.0018	0.0018	0.0018	0.0018	0.0018	0.0019	0.0019	0.0019
TOTAL	20.2882	20.7621	22.0588	21.3934	21.3885	21.6755	21.2645	21.3739

	2006	2007	2008	2009	2010	2011	2012	2013
1A1a	6.7618	7.0797	6.3209	7.4322	6.3266	9.7045	10.9561	6.3250
1A1b	NO	NO						
1A2a	NO	NO	0.0086	0.0081	0.0107	0.0098	NO	NO
1A2b	0.0965	0.0967	0.0943	0.0593	0.0602	0.0721	0.0414	0.0676
1A2c	0.0406	0.0309	0.0188	0.0304	0.0407	0.0598	0.0504	0.0337
1A2d	0.0229	0.0196	0.0229	0.0210	0.0205	0.0189	0.0190	0.0206
1A2e	0.3668	0.3728	0.3615	0.3542	0.3463	0.3589	0.3770	0.3427
1A2f	2.0215	1.9912	2.1254	1.8067	1.5821	1.4641	1.3250	1.8911
1A2gvii	0.4356	0.4370	0.3443	0.2941	0.3173	0.2876	0.1714	0.1084
1A2gviii	0.5164	0.5049	0.1336	0.0877	0.0708	0.1141	0.0658	0.0939
1A3ai(i)	0.3649	0.3735	0.3870	0.3772	0.3798	0.3755	0.3661	0.3439
1A3aii(i)	0.0286	0.0256	0.0252	0.0220	0.0191	0.0050	0.0031	0.0010
1A3bi	1.9336	1.9454	1.8959	1.7693	1.7303	1.6091	1.4919	1.3290
1A3bii	2.8603	2.6535	2.5293	2.2974	2.2878	2.0714	1.6314	1.3640
1A3biii	4.0128	4.1488	4.4626	4.1545	4.0924	4.0195	3.7966	3.1313
1A3biv	0.0434	0.0421	0.0440	0.0433	0.0432	0.0428	0.0441	0.0412
1A3dii	0.0470	0.0680	0.0806	0.0950	0.1045	0.1066	0.1273	0.1835
1A4bi	0.4333	0.3966	0.3887	0.3730	0.3204	0.3531	0.3476	0.3001
1A4ci	0.2549	0.2336	0.2258	0.2027	0.1999	0.2066	0.1983	0.1952
1A4cii	0.3049	0.3161	0.3070	0.2750	0.2712	0.2803	0.2690	0.2649
1A4ciii	0.0037	0.0037	0.0032	0.0023	0.0021	0.0034	0.0036	0.0020
1A5b	0.1086	0.1675	0.1009	0.0745	0.0506	0.0580	0.0571	0.0701
1B2aiv	NO	NO						
1B2c	NO	0.0066						
2G	0.0032	0.0034	0.0033	0.0036	0.0039	0.0032	0.0035	0.0027
3B1a	0.0029	0.0029	0.0029	0.0029	0.0029	0.0030	0.0030	0.0030
3B1b	0.0012	0.0012	0.0012	0.0012	0.0012	0.0013	0.0013	0.0012
3B2	0.0007	0.0007	0.0007	0.0007	0.0008	0.0009	0.0008	0.0008
3B3	0.0182	0.0188	0.0183	0.0182	0.0182	0.0170	0.0153	0.0140
3B4d	0.0008	0.0009	0.0008	0.0007	0.0008	0.0007	0.0007	0.0006

3B4e	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3B4f	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3B4gi	0.0014	0.0012	0.0013	0.0013	0.0012	0.0013	0.0014	0.0014
3B4gii	0.0038	0.0042	0.0040	0.0039	0.0040	0.0038	0.0035	0.0030
3B4giii	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000
3B4giv	0.0000	0.0000	0.0000	NO	NO	NO	NO	NO
3Da1	0.4984	0.4695	0.3668	0.3018	0.3764	0.2762	0.2983	0.2888
3Da2b	0.0015	0.0016	0.0016	0.0016	0.0017	0.0017	0.0017	0.0017
3F	0.0163	0.0090	0.0053	0.0043	0.0045	0.0050	0.0052	0.0043
5C1biii	NO							
5C2	0.0019	0.0020	0.0020	0.0021	0.0022	0.0022	0.0022	0.0022
TOTAL	21.2089	21.4228	20.2889	20.1222	18.6942	21.5376	21.6790	16.4398

	2014	2015	2016	2017				
1A1a	6.9664	4.8595	4.0555	3.6551				
1A1b	NO	NO	NO	NO				
1A2a	0.0001	NO	NO	NO				
1A2b	0.0969	0.0401	0.0237	0.0247				
1A2c	0.0435	0.0383	0.0412	0.0429				
1A2d	0.0213	0.0176	0.0181	0.0188				
1A2e	0.4602	0.3776	0.4087	0.4259				
1A2f	2.3626	2.1737	2.1336	2.2300				
1A2gvii	0.1073	0.0910	0.0764	0.0796				
1A2gviii	0.1086	0.0454	0.0672	0.0701				
1A3ai(i)	0.3498	0.3528	0.4068	0.4706				
1A3aii(i)	0.0006	0.0014	0.0011	0.0010				
1A3bi	1.3222	1.3928	1.4671	1.6405				
1A3bii	1.3218	1.3172	1.3717	1.3774				
1A3biii	3.0594	3.1289	3.2269	3.1816				
1A3biv	0.0409	0.0406	0.0437	0.0430				
1A3dii	0.1391	0.1285	0.1055	0.1396				
1A4bi	0.2615	0.3059	0.3179	0.3177				
1A4ci	0.1796	0.1981	0.1931	0.2029				
1A4cii	0.2437	0.2687	0.2619	0.2753				
1A4ciii	0.0016	0.0012	0.0012	0.0005				
1A5b	0.0861	0.0478	0.0554	0.0522				
1B2aiv	NO	NO	NO	NO				
1B2c	NO	NO	NO	NO				
2G	0.0011	0.0025	0.0020	0.0022				
3B1a	0.0031	0.0032	0.0035	0.0037				
3B1b	0.0013	0.0012	0.0013	0.0014				
3B2	0.0007	0.0007	0.0007	0.0008				
3B3	0.0134	0.0138	0.0136	0.0136				
3B4d	0.0006	0.0006	0.0006	0.0006				
3B4e	0.0000	0.0000	0.0000	0.0000				
3B4f	0.0000	0.0000	0.0000	0.0000				
3B4gi	0.0013	0.0012	0.0012	0.0012				
3B4gii	0.0038	0.0032	0.0033	0.0034				
3B4giii	0.0000	0.0000	0.0000	0.0001				
3B4giv	NO	NO	NO	NO				
3Da1	0.2359	0.2549	0.2989	0.2355				
3Da2b	0.0017	0.0017	0.0017	0.0017				
3F	0.0035	0.0046	0.0033	0.0028				
5C1biii	NO	NO	NO	NO				
5C2	0.0022	0.0022	0.0022	0.0022				
TOTAL	17.4419	15.1171	14.6094	14.5188				

Table A5.2. CO emissions 1990-2017 (Gg)

	1990	1991	1992	1993	1994	1995	1996	1997
1A1a	0.3416	0.3543	0.4076	0.4392	0.4593	0.4180	0.4441	0.4697
1A1b	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1A2a	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
1A2b	0.0105	0.0108	0.0113	0.0115	0.0116	0.0116	0.0116	0.0122
1A2c	0.0036	0.0037	0.0039	0.0039	0.0040	0.0044	0.0047	0.0050
1A2d	0.0018	0.0021	0.0023	0.0025	0.0029	0.0030	0.0032	0.0033
1A2e	0.0298	0.0318	0.0332	0.0345	0.0359	0.0373	0.0387	0.0401
1A2f	1.8930	1.7847	1.9300	2.1101	2.2055	2.1117	2.2723	2.1874
1A2gvii	0.1334	0.1336	0.1336	0.1338	0.1342	0.1345	0.1347	0.1349
1A2gviii	0.0636	0.0641	0.0639	0.0642	0.0648	0.0652	0.0652	0.0655
1A3ai(i)	0.1224	0.1039	0.1258	0.1298	0.1377	0.1448	0.1423	0.1494
1A3aii(i)	0.0027	0.0023	0.0028	0.0028	0.0030	0.0032	0.0031	0.0033

1A3bi	27.0702	25.9197	24.1895	22.6553	23.0347	21.6961	20.7556	19.7194
1A3bii	5.8162	6.2000	6.3341	6.0587	6.3873	5.9159	5.6895	5.4773
1A3biii	1.0154	1.0435	1.2094	1.1922	1.2694	1.1416	1.1633	1.1659
1A3biv	3.8031	3.8147	3.7045	3.5390	3.6716	3.6422	3.6199	3.5076
1A4bi	0.3969	0.5040	0.5219	0.6042	0.5422	0.5431	0.5253	0.5282
1A4ci	0.0208	0.0223	0.0269	0.0274	0.0311	0.0296	0.0311	0.0326
1A4cii	0.0706	0.0759	0.0916	0.0931	0.1058	0.1006	0.1056	0.1108
1B2aiv	0.0572	0.0608	0.0635	0.0689	0.0711	0.0745	0.0684	0.0938
1B2c	0.0090	0.0095	0.0100	0.0108	0.0112	0.0117	0.0107	0.0147
2D3c	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024
2G	0.2114	0.2114	0.2299	0.0637	0.0637	0.1860	0.1974	0.2203
3F	2.3012	2.2351	2.3451	2.3506	2.0330	1.8270	1.6511	1.5093
5C1biii	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
5C2	0.0264	0.0272	0.0279	0.0285	0.0291	0.0295	0.0300	0.0304
TOTAL	43.4035	42.6181	41.4715	39.6273	40.3117	38.1341	36.9706	35.4836

	1998	1999	2000	2001	2002	2003	2004	2005
1A1a	0.5127	0.5413	0.5693	0.5651	0.5885	0.6325	0.6589	0.6971
1A1b	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NO
1A2a	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0000
1A2b	0.0122	0.0122	0.0122	0.0124	0.0124	0.0124	0.0124	0.0124
1A2c	0.0053	0.0055	0.0058	0.0061	0.0061	0.0056	0.0055	0.0053
1A2d	0.0036	0.0036	0.0037	0.0037	0.0036	0.0033	0.0033	0.0030
1A2e	0.0409	0.0420	0.0431	0.0437	0.0442	0.0453	0.0459	0.0561
1A2f	2.0685	2.0780	2.1413	2.0954	2.1668	2.1390	2.3103	2.2666
1A2gvii	0.1375	0.1379	0.1401	0.1411	0.1417	0.1422	0.1428	0.1433
1A2gviii	0.0656	0.0656	0.0657	0.0657	0.0657	0.0657	0.0657	0.0803
1A3ai(i)	0.1543	0.1626	0.1736	0.1910	0.1885	0.1909	0.1972	0.1962
1A3aii(i)	0.0034	0.0036	0.0038	0.0042	0.0041	0.0042	0.0043	0.0101
1A3bi	18.1127	17.2074	15.9708	15.8066	15.8309	16.1525	15.7224	15.0006
1A3bii	5.1700	4.9469	4.8662	4.4732	4.0739	3.9833	3.5220	3.3051
1A3biii	1.1613	1.1478	1.2691	1.1409	1.1107	1.1572	1.1141	1.1112
1A3biv	3.2931	3.1074	2.8606	2.7345	2.4522	2.4764	2.3381	2.2969
1A4bi	0.5078	0.5111	0.4823	0.5205	0.4904	0.4479	0.4581	0.5434
1A4ci	0.0344	0.0356	0.0365	0.0369	0.0383	0.0367	0.0320	0.0332
1A4cii	0.1169	0.1211	0.1240	0.1252	0.1301	0.1246	0.1029	0.1023
1B2aiv	0.0975	0.1062	0.1056	0.1040	0.0978	0.0873	0.0251	NO
1B2c	0.0153	0.0166	0.0166	0.0163	0.0153	0.0137	0.0039	NO
2D3c	0.0024	0.0024	0.0027	0.0022	0.0024	0.0022	0.0027	0.0021
2G	0.2242	0.3139	0.5896	0.1817	0.1701	0.1226	0.1822	0.1588
3F	1.4189	1.2973	1.0301	1.0080	0.9477	1.0183	0.7972	0.6213
5C1biii	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	NO	NO
5C2	0.0307	0.0311	0.0314	0.0318	0.0321	0.0325	0.0330	0.0335
TOTAL	33.1893	31.8974	30.5443	29.3103	28.6136	28.8963	27.7801	26.6789

	2006	2007	2008	2009	2010	2011	2012	2013
1A1a	0.7191	0.7431	0.2524	0.4688	0.4596	0.5713	0.5614	0.4279
1A1b	NO	NO	NO	NO	NO	NO	NO	NO
1A2a	NO	NO	0.0011	0.0010	0.0014	0.0013	NO	NO
1A2b	0.0124	0.0124	0.0121	0.0076	0.0077	0.0093	0.0053	0.0087
1A2c	0.0052	0.0040	0.0024	0.0039	0.0052	0.0354	0.0398	0.0479
1A2d	0.0029	0.0025	0.0029	0.0027	0.0026	0.0024	0.0024	0.0027
1A2e	0.0575	0.0589	0.0674	0.0664	0.0678	0.0535	0.0499	0.0486
1A2f	2.3613	2.3250	2.3739	1.9567	1.6389	1.5843	1.4405	2.1005
1A2gvii	0.1438	0.1443	0.1137	0.0971	0.1048	0.0950	0.0566	0.0358
1A2gviii	0.0981	0.1129	0.0176	0.0113	0.0210	0.0147	0.0085	0.0121
1A3ai(i)	0.1910	0.1794	0.1783	0.1560	0.1986	0.2196	0.2189	0.1949
1A3aii(i)	0.0085	0.0076	0.0072	0.0058	0.0064	0.0042	0.0028	0.0013
1A3bi	14.2881	13.3958	12.4499	11.0580	10.2826	9.1365	8.3053	7.3620
1A3bii	2.8457	2.7612	2.5137	2.2406	2.2458	1.9387	1.4844	1.2676
1A3biii	1.0717	1.0660	1.1295	1.0442	1.0291	1.0048	0.9648	0.7915
1A3biv	1.7689	1.9358	1.8726	1.7777	1.6951	1.6364	1.5359	1.4342
1A4bi	0.5184	0.6176	0.5876	0.4882	0.4169	0.4364	0.6135	0.5165
1A4ci	0.0339	0.0310	0.0300	0.0269	0.0266	0.0275	0.0263	0.0259
1A4cii	0.1015	0.1052	0.1022	0.0915	0.0903	0.0933	0.0895	0.0882
1B2aiv	NO	NO	NO	NO	NO	NO	NO	NO
1B2c	NO	NO	NO	NO	NO	NO	NO	0.0295
2D3c	0.0019	0.0018	0.0017	0.0029	0.0039	0.0038	0.0029	0.0016
2G	0.0993	0.1034	0.1006	0.1119	0.1195	0.0974	0.1060	0.0831
3F	0.4738	0.2617	0.1549	0.1249	0.1317	0.1437	0.1513	0.1233
5C1biii	NO	NO	NO	NO	NO	NO	NO	NO

5C2	0.0341	0.0350	0.0359	0.0369	0.0378	0.0388	0.0390	0.0386
TOTAL	24.8374	23.9048	22.0076	19.7808	18.5933	17.1483	15.7052	14.6423

	2014	2015	2016	2017				
1A1a	0.5847	0.4440	0.4478	0.3656				
1A1b	NO	NO	NO	NO				
1A2a	0.0000	NO	NO	NO				
1A2b	0.0125	0.0052	0.0031	0.0032				
1A2c	0.0238	0.0279	0.0148	0.0154				
1A2d	0.0027	0.0023	0.0023	0.0024				
1A2e	0.0725	0.0511	0.0712	0.0742				
1A2f	2.6855	2.4253	2.4338	2.5431				
1A2gvii	0.0354	0.0300	0.0252	0.0263				
1A2gviii	0.0140	0.0058	0.0087	0.0090				
1A3ai(i)	0.2017	0.1865	0.2330	0.2663				
1A3aii(i)	0.0010	0.0013	0.0011	0.0012				
1A3bi	6.9027	6.5278	6.5901	6.2302				
1A3bii	1.2024	1.1710	1.1859	1.1134				
1A3biii	0.7717	0.7838	0.8083	0.7868				
1A3biv	1.4081	1.3993	1.4625	1.3834				
1A4bi	0.4393	0.6090	0.7636	0.7125				
1A4ci	0.0239	0.0263	0.0257	0.0270				
1A4cii	0.0811	0.0894	0.0872	0.0916				
1B2aiv	NO	NO	NO	NO				
1B2c	NO	NO	NO	NO				
2D3c	0.0007	0.0006	0.0006	0.0006				
2G	0.0331	0.0760	0.0624	0.0668				
3F	0.1013	0.1336	0.0952	0.0809				
5C1biii	NO	NO	NO	NO				
5C2	0.0381	0.0382	0.0385	0.0389				
TOTAL	14.6363	14.0346	14.3610	13.8389				

Table A5.3. NMVOCs emissions 1990-2017 (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	2.9439	2.8477	2.7006	2.5444	2.6045	2.4749	2.3902	2.2726
1A3bii	0.5349	0.5711	0.5879	0.5644	0.5978	0.5696	0.5627	0.5583
1A3biii	0.4433	0.4544	0.5270	0.5175	0.5430	0.4813	0.4838	0.4749
1A3biv	1.4400	1.4620	1.4367	1.3884	1.4566	1.4509	1.4475	1.3938
1A3bv	1.5547	1.5202	1.4626	1.4295	1.4479	1.4074	1.3614	1.3276
1A3dii	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027
1A4bi	0.0613	0.0506	0.0481	0.0599	0.0464	0.0483	0.0440	0.0427
1A4ci	0.0066	0.0071	0.0086	0.0088	0.0100	0.0095	0.0099	0.0104
1A4cii	0.0218	0.0234	0.0283	0.0287	0.0327	0.0311	0.0326	0.0342
1A4ciii	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
1A5b	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
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	0.7045	0.7237	0.7430	0.7595	0.7745	0.7876	0.7996	0.8102
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	4.6390	4.6390	4.6390	4.6390	4.6390	4.6390	4.6390	4.6390
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	0.1777	0.1833	0.1895	0.2034	0.2186	0.2338	0.2166	0.2021

3B1b	0.1267	0.1253	0.1253	0.1392	0.1444	0.1517	0.1679	0.1450
3B2	0.0261	0.0266	0.0257	0.0248	0.0230	0.0225	0.0227	0.0221
3B3	0.2205	0.2396	0.2738	0.2896	0.2962	0.3053	0.3180	0.3375
3B4d	0.0139	0.0139	0.0135	0.0134	0.0142	0.0149	0.0162	0.0204
3B4e	0.0015	0.0014	0.0013	0.0012	0.0011	0.0014	0.0017	0.0020
3B4f	0.0072	0.0064	0.0055	0.0047	0.0038	0.0036	0.0034	0.0032
3B4gi	0.0529	0.0513	0.0492	0.0639	0.0624	0.0631	0.0658	0.0612
3B4gii	0.2483	0.2268	0.2641	0.3093	0.2906	0.3006	0.3223	0.3329
3B4giii	0.0151	0.0114	0.0137	0.0105	0.0125	0.0165	0.0158	0.0140
3B4giv	0.0007	0.0008	0.0010	0.0011	0.0011	0.0014	0.0011	0.0013
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	0.5273	0.5429	0.5585	0.5753	0.5944	0.6037	0.6068	0.6209
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	0.0007	0.0007	0.0007
5D1	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
TOTAL	17.7782	17.5351	17.6822	17.6252	18.1509	17.6642	17.5444	17.7426

	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	0.0299
1A3aii(i)	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0009
1A3bi	2.1033	2.0119	1.8853	1.8613	1.8505	1.8804	1.7773	1.6441
1A3bii	0.5506	0.5475	0.5706	0.5282	0.4881	0.4722	0.4171	0.3886
1A3biii	0.4650	0.4523	0.4882	0.4265	0.4010	0.4004	0.3729	0.3613
1A3biv	1.2965	1.2043	1.1044	1.0284	0.8419	0.8435	0.7873	0.7850
1A3bv	1.2846	1.2501	1.2039	1.2022	1.2026	1.2447	1.2439	1.2529
1A3dii	0.0027	0.0027	0.0027	0.0023	0.0025	0.0029	0.0025	0.0035
1A4bi	0.0376	0.0367	0.0314	0.0367	0.0306	0.0261	0.0220	0.0293
1A4ci	0.0110	0.0114	0.0117	0.0118	0.0123	0.0117	0.0102	0.0106
1A4cii	0.0361	0.0374	0.0383	0.0387	0.0545	0.0385	0.0318	0.0316
1A4ciii	0.0001	0.0001	0.0001	0.0002	0.0002	0.0003	0.0003	0.0002
1A5b	0.0005	0.0005	0.0005	0.0004	0.0004	0.0003	0.0003	0.0003
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	0.8195	0.8286	0.8370	0.8466	0.8564	0.8675	0.8796	0.8928
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	4.6390	5.2717	5.9043	6.2175	5.5045	6.4112	8.4924	8.4747
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	0.1889	0.1907	0.1864	0.1932	0.2080	0.2110	0.2068	0.1949
3B1b	0.1257	0.1186	0.1204	0.1141	0.1253	0.1252	0.1344	0.1295
3B2	0.0216	0.0210	0.0222	0.0267	0.0265	0.0239	0.0251	0.0242
3B3	0.3349	0.3132	0.3312	0.3607	0.3804	0.3767	0.3579	0.3365
3B4d	0.0218	0.0234	0.0256	0.0289	0.0311	0.0276	0.0256	0.0223
3B4e	0.0023	0.0026	0.0029	0.0032	0.0035	0.0038	0.0036	0.0034
3B4f	0.0030	0.0028	0.0026	0.0024	0.0022	0.0020	0.0018	0.0017
3B4gi	0.0695	0.0596	0.0454	0.0495	0.0495	0.0495	0.0669	0.0535
3B4gii	0.3306	0.3347	0.3484	0.3484	0.3617	0.3600	0.3054	0.3092
3B4giii	0.0153	0.0144	0.0183	0.0163	0.0171	0.0169	0.0124	0.0092
3B4giv	0.0014	0.0015	0.0016	0.0016	0.0017	0.0016	0.0012	0.0011
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	0.6334	0.6443	0.6599	0.6895	0.7020	0.7279	0.7513	0.7633
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	17.3253	17.9776	18.5489	18.7098	18.5266	20.2319	22.2856	22.1248

	2006	2007	2008	2009	2010	2011	2012	2013
1A1a	0.1095	0.1131	0.1173	0.1101	0.0999	0.1787	0.2842	0.0627
1A1b	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)	0.0251	0.0190	0.0185	0.0152	0.0213	0.0241	0.0251	0.0222
1A3aii(i)	0.0007	0.0005	0.0006	0.0005	0.0004	0.0004	0.0002	0.0001
1A3bi	1.5404	1.4992	1.3871	1.2151	1.1206	0.9770	0.8690	0.7583
1A3bii	0.3318	0.3053	0.2744	0.2397	0.2343	0.2002	0.1426	0.1191
1A3biii	0.3394	0.3159	0.3195	0.2801	0.2571	0.2382	0.2174	0.1732
1A3biv	0.5673	0.6418	0.5893	0.5322	0.4889	0.4589	0.4663	0.4253
1A3bv	1.2429	1.3047	1.2812	1.2410	1.2198	1.2169	1.1598	1.1520
1A3dii	0.0034	0.0049	0.0058	0.0069	0.0076	0.0077	0.0092	0.0133
1A4bi	0.0257	0.0468	0.0427	0.0297	0.0259	0.0251	0.0528	0.0444
1A4ci	0.0108	0.0099	0.0096	0.0086	0.0085	0.0088	0.0084	0.0083
1A4cii	0.0313	0.0325	0.0316	0.0283	0.0279	0.0288	0.0276	0.0272
1A4ciii	0.0003	0.0003	0.0002	0.0002	0.0002	0.0003	0.0003	0.0002
1A5b	0.0071	0.0109	0.0066	0.0048	0.0033	0.0038	0.0037	0.0046
1B2aiv	NO							
1B2av	0.8722	0.9500	1.0874	1.1192	1.1003	1.0844	0.9899	0.8577
1B2c	NO	0.0084						
2C1	NO							
2D3a	0.9095	0.9317	0.9563	0.9829	1.0078	1.0344	1.0391	1.0296
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	1.5792	1.6311	1.4271
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	7.8613	7.6870	9.0567	7.5951	9.0202	5.1600	5.7159	5.7185
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	0.1898	0.1879	0.1874	0.1839	0.1857	0.1909	0.1911	0.1959
3B1b	0.1263	0.1225	0.1258	0.1213	0.1229	0.1290	0.1289	0.1277
3B2	0.0245	0.0263	0.0241	0.0271	0.0296	0.0321	0.0313	0.0283
3B3	0.3535	0.3630	0.3458	0.3414	0.3395	0.3121	0.2803	0.2601
3B4d	0.0233	0.0249	0.0215	0.0190	0.0208	0.0196	0.0183	0.0164
3B4e	0.0032	0.0030	0.0028	0.0026	0.0024	0.0024	0.0024	0.0024
3B4f	0.0015	0.0013	0.0011	0.0009	0.0007	0.0007	0.0007	0.0007
3B4gi	0.0528	0.0479	0.0502	0.0500	0.0458	0.0490	0.0536	0.0529
3B4gii	0.2570	0.2796	0.2706	0.2633	0.2674	0.2550	0.2348	0.2025
3B4giii	0.0090	0.0061	0.0056	0.0042	0.0040	0.0030	0.0024	0.0026
3B4giv	0.0007	0.0006	0.0003	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	0.7792	0.7990	0.8277	0.8419	0.7644	0.7191	0.7040	0.6596
5C1biii	NO							
5C2	0.0008	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009
5D1	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004
TOTAL	20.7615	21.0382	21.3978	19.2420	20.7097	14.7762	14.9979	13.9688

	2014	2015	2016	2017
1A1a	0.0753	0.0814	0.0852	0.0762
1A1b	NO	NO	NO	NO
1A2a	0.0000	NO	NO	NO
1A2b	0.0047	0.0020	0.0012	0.0012
1A2c	0.0118	0.0140	0.0070	0.0073
1A2d	0.0010	0.0009	0.0009	0.0009
1A2e	0.0295	0.0197	0.0298	0.0310
1A2f	0.0410	0.0394	0.0380	0.0408
1A2gvii	0.0111	0.0094	0.0079	0.0082

1A2gviii	0.0053	0.0022	0.0033	0.0034
1A3ai(i)	0.0236	0.0209	0.0273	0.0309
1A3aii(i)	0.0001	0.0001	0.0001	0.0001
1A3bi	0.7041	0.6586	0.6633	0.6165
1A3bii	0.1121	0.1084	0.1094	0.1020
1A3biii	0.1684	0.1661	0.1711	0.1569
1A3biv	0.4075	0.3928	0.4012	0.3740
1A3bv	1.1603	1.1523	1.1657	1.1837
1A3dii	0.0100	0.0093	0.0076	0.0101
1A4bi	0.0380	0.0583	0.0794	0.0720
1A4ci	0.0076	0.0084	0.0082	0.0086
1A4cii	0.0251	0.0276	0.0269	0.0283
1A4ciii	0.0001	0.0001	0.0001	0.0000
1A5b	0.0056	0.0031	0.0036	0.0034
1B2aiv	NO	NO	NO	NO
1B2av	0.7972	0.7822	0.6591	0.5892
1B2c	NO	NO	NO	NO
2C1	NO	NO	NO	NO
2D3a	1.0164	1.0180	1.0258	1.0370
2D3b	0.0023	0.0020	0.0020	0.0020
2D3c	0.0098	0.0086	0.0086	0.0086
2D3d	1.2511	1.6473	1.7419	2.0322
2D3f	0.0262	0.0527	0.0261	0.0526
2D3g	0.0099	0.0111	0.0111	0.0111
2D3h	0.2618	0.2526	0.2651	0.2655
2D3i	4.6354	4.7163	4.7163	4.7163
2G	0.0029	0.0067	0.0055	0.0059
2H2	0.1561	0.1535	0.1535	0.1535
3B1a	0.2008	0.2077	0.2257	0.2400
3B1b	0.1344	0.1283	0.1350	0.1437
3B2	0.0264	0.0268	0.0274	0.0290
3B3	0.2500	0.2509	0.2508	0.2508
3B4d	0.0157	0.0158	0.0167	0.0174
3B4e	0.0024	0.0024	0.0024	0.0024
3B4f	0.0007	0.0007	0.0007	0.0007
3B4gi	0.0490	0.0458	0.0476	0.0471
3B4gii	0.2550	0.2161	0.2220	0.2304
3B4giii	0.0027	0.0027	0.0027	0.0033
3B4giv	NO	NO	NO	NO
3De	0.0218	0.0287	0.0205	0.0174
3F	0.0008	0.0010	0.0007	0.0006
5A	0.6206	0.6287	0.6395	0.6464
5C1biii	NO	NO	NO	NO
5C2	0.0008	0.0008	0.0008	0.0009
5D1	0.0004	0.0005	0.0005	0.0005
TOTAL	12.5928	12.9829	13.0449	13.2601

Table A5.4.SOx emissions 1990-2017 (as Gg SO₂)

	1990	1991	1992	1993	1994	1995	1996	1997
1A1a	21.6153	22.4186	25.8482	27.8109	29.0674	26.4977	28.1351	29.7495
1A1b	0.5900	0.6000	0.6200	0.6200	0.7500	0.7000	0.6600	0.7200
1A2a	0.0055	0.0055	0.0050	0.0050	0.0050	0.0050	0.0050	0.0045
1A2b	0.1900	0.1950	0.2050	0.2075	0.2100	0.2100	0.2100	0.2200
1A2c	0.0650	0.0675	0.0699	0.0700	0.0723	0.0800	0.0850	0.0900
1A2d	0.0325	0.0375	0.0425	0.0450	0.0525	0.0550	0.0575	0.0600
1A2e	0.5400	0.5750	0.6000	0.6250	0.6500	0.6750	0.7000	0.7250
1A2f	0.4825	0.4549	0.4927	0.5382	0.5628	0.5392	0.5805	0.5586
1A2gvii	0.2476	0.2480	0.2480	0.2484	0.2492	0.2496	0.2500	0.2504
1A2gviii	1.1500	1.1590	1.1554	1.1611	1.1726	1.1791	1.1800	1.1850
1A3ai(i)	0.0263	0.0260	0.0257	0.0254	0.0250	0.0247	0.0244	0.0241
1A3aii(i)	0.0004	0.0003	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005
1A3bi	1.0645	1.1143	1.2083	1.2037	1.3212	1.2691	1.3269	1.4058
1A3bii	1.8373	2.0604	2.5947	2.7075	3.1735	3.0888	3.2308	3.3782
1A3biii	1.5692	1.6188	1.8783	1.8433	2.0095	1.8494	1.9267	1.9917
1A3biv	0.0200	0.0200	0.0192	0.0182	0.0187	0.0182	0.0176	0.0168
1A3dii	0.0380	0.0380	0.0380	0.0380	0.0380	0.0380	0.0380	0.0380
1A4bi	1.4168	1.5232	1.8372	1.8673	2.1223	2.0177	2.1177	2.2222
1A4ci	0.2462	0.2648	0.3194	0.3246	0.3690	0.3508	0.3682	0.3863
1A4cii	0.1231	0.1324	0.1597	0.1623	0.1845	0.1754	0.1841	0.1932
1A4ciii	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019
1A5b	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
1B2aiv	0.3940	0.4188	0.4376	0.4748	0.4901	0.5134	0.4714	0.6464

1B2c	0.0575	0.0612	0.0639	0.0693	0.0716	0.0750	0.0688	0.0944
2G	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
3F	0.0173	0.0168	0.0176	0.0176	0.0152	0.0137	0.0124	0.0113
5C1biii	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003
5C2	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
TOTAL	31.7415	33.0683	37.8990	40.0958	42.6432	39.6376	41.6631	43.9843

	1998	1999	2000	2001	2002	2003	2004	2005
1A1a	32.5070	34.3284	32.7969	29.8277	30.3351	32.8993	31.3996	34.0730
1A1b	0.7500	0.8500	0.6600	0.9800	1.0600	0.7200	0.3200	NO
1A2a	0.0040	0.0040	0.0040	0.0020	0.0020	0.0015	0.0010	0.0005
1A2b	0.2200	0.2200	0.2200	0.2250	0.2250	0.2250	0.2250	0.2249
1A2c	0.0950	0.1000	0.1050	0.1100	0.1100	0.1005	0.1000	0.0950
1A2d	0.0650	0.0650	0.0675	0.0675	0.0650	0.0600	0.0600	0.0550
1A2e	0.7400	0.7600	0.7800	0.7900	0.8000	0.8200	0.8300	0.8402
1A2f	0.5286	0.5304	0.5468	0.5347	0.5519	0.5442	0.5873	0.5754
1A2gvii	0.2552	0.2560	0.2600	0.2620	0.2630	0.2640	0.0093	0.0013
1A2gviii	1.1870	1.1875	1.1880	1.1885	1.1888	1.1890	1.1895	1.1893
1A3ai(i)	0.0238	0.0235	0.0231	0.0228	0.0225	0.0222	0.0219	0.0204
1A3aii(i)	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0007	0.0017
1A3bi	1.4560	1.4989	1.5003	1.5175	1.4733	1.3224	0.5060	0.0345
1A3bii	3.6191	3.7841	3.8796	3.7525	3.6199	3.3463	1.1399	0.0185
1A3biii	2.0376	2.0624	2.1057	2.0146	1.9500	1.9783	0.7098	0.0117
1A3biv	0.0154	0.0145	0.0130	0.0123	0.0109	0.0082	0.0038	0.0006
1A3dii	0.0380	0.0380	0.0380	0.0322	0.0347	0.0397	0.0341	0.0486
1A4bi	2.3453	2.4301	2.4880	2.5122	2.6091	2.4988	2.4307	0.5629
1A4ci	0.4078	0.4225	0.5320	0.5200	0.5320	0.4345	0.3789	0.0787
1A4cii	0.2039	0.2113	0.3080	0.3000	0.3080	0.2172	0.1794	0.0357
1A4ciii	0.0019	0.0019	0.0019	0.0026	0.0025	0.0034	0.0037	0.0028
1A5b	0.0100	0.0100	0.0100	0.0077	0.0075	0.0066	0.0052	0.0066
1B2aiv	0.6714	0.7314	0.7274	0.7167	0.6735	0.6015	0.1729	NO
1B2c	0.0980	0.1068	0.1062	0.1046	0.0983	0.0878	0.0252	NO
2G	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
3F	0.0106	0.0097	0.0077	0.0076	0.0071	0.0076	0.0060	0.0047
5C1biii	0.0003	0.0003	0.0003	0.0003	0.0003	0.0001	NO	NO
5C2	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
TOTAL	47.2916	49.6474	48.3704	45.5120	45.9513	47.3989	40.3399	37.8821

	2006	2007	2008	2009	2010	2011	2012	2013
1A1a	27.5192	25.5145	20.5216	16.0816	20.3445	19.3755	14.7525	12.0961
1A1b	NO							
1A2a	NO	NO	0.0080	0.0075	0.0099	0.0091	NO	NO
1A2b	0.2247	0.2250	0.0878	0.0552	0.0560	0.0671	0.0386	0.0630
1A2c	0.0945	0.0720	0.0175	0.0283	0.0379	0.0520	0.0425	0.0257
1A2d	0.0533	0.0457	0.0213	0.0196	0.0191	0.0176	0.0177	0.0192
1A2e	0.8502	0.8639	0.3339	0.3271	0.3194	0.3332	0.3508	0.3185
1A2f	0.6002	0.5908	0.7006	0.6364	0.6065	0.5148	0.4625	0.6377
1A2gvii	0.0013	0.0013	0.0011	0.0002	0.0002	0.0002	0.0001	0.0001
1A2gviii	1.1906	1.1581	0.1244	0.0817	0.0643	0.0634	0.0613	0.0612
1A3ai(i)	0.0202	0.0205	0.0208	0.0199	0.0215	0.0218	0.0213	0.0196
1A3aii(i)	0.0014	0.0013	0.0013	0.0011	0.0010	0.0003	0.0002	0.0001
1A3bi	0.0365	0.0396	0.0422	0.0087	0.0089	0.0088	0.0084	0.0078
1A3bii	0.0173	0.0165	0.0163	0.0031	0.0031	0.0028	0.0024	0.0020
1A3biii	0.0115	0.0124	0.0138	0.0026	0.0027	0.0026	0.0025	0.0021
1A3biv	0.0006	0.0006	0.0006	0.0001	0.0001	0.0001	0.0001	0.0001
1A3dii	0.0477	0.0677	0.0804	0.0950	0.1049	0.1057	0.1260	0.1815
1A4bi	0.5621	0.4869	0.2657	0.2598	0.2154	0.2382	0.2333	0.1910
1A4ci	0.0803	0.0736	0.0356	0.0319	0.0315	0.0325	0.0312	0.0307
1A4cii	0.0354	0.0367	0.0178	0.0160	0.0157	0.0163	0.0156	0.0154
1A4ciii	0.0037	0.0037	0.0032	0.0023	0.0022	0.0034	0.0036	0.0020
1A5b	0.1342	0.2070	0.1247	0.0920	0.0625	0.0717	0.0705	0.0866
1B2aiv	NO							
1B2c	NO	0.0001						
2G	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0000
3F	0.0036	0.0020	0.0012	0.0009	0.0010	0.0011	0.0011	0.0009
5C1biii	NO							
5C2	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
TOTAL	31.4887	29.4399	22.4399	17.7710	21.9286	20.9387	16.2425	13.7615

	2014	2015	2016	2017
1A1a	15.0454	11.3598	14.5972	14.7243

1A1b	NO	NO	NO	NO
1A2a	0.0001	NO	NO	NO
1A2b	0.0902	0.0374	0.0221	0.0230
1A2c	0.0381	0.0326	0.0371	0.0386
1A2d	0.0198	0.0164	0.0168	0.0175
1A2e	0.4268	0.3512	0.3781	0.3940
1A2f	0.7607	0.7270	0.6807	0.7107
1A2gvii	0.0001	0.0001	0.0000	0.0000
1A2gviii	0.0476	0.0423	0.0626	0.0652
1A3ai(i)	0.0199	0.0199	0.0231	0.0266
1A3aii(i)	0.0000	0.0001	0.0001	0.0001
1A3bi	0.0078	0.0081	0.0083	0.0087
1A3bii	0.0020	0.0020	0.0020	0.0020
1A3biii	0.0020	0.0021	0.0022	0.0022
1A3biv	0.0001	0.0001	0.0001	0.0001
1A3dii	0.1370	0.1266	0.1041	0.1382
1A4bi	0.1566	0.1908	0.2069	0.2047
1A4ci	0.0283	0.0312	0.0304	0.0320
1A4cii	0.0141	0.0156	0.0152	0.0160
1A4ciii	0.0016	0.0012	0.0012	0.0005
1A5b	0.1064	0.0591	0.0685	0.0645
1B2aiv	NO	NO	NO	NO
1B2c	NO	NO	NO	NO
2G	0.0001	0.0001	0.0001	0.0000
3F	0.0008	0.0010	0.0007	0.0006
5C1biii	NO	NO	NO	NO
5C2	0.0001	0.0001	0.0001	0.0001
TOTAL	16.9057	13.0247	16.2576	16.4697

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

	Category, gas, year	Summary of recommendation	Status of implementation
1	1.A.2.g Other (manufacturing industries and construction), CO ₂ , 2015	Correction of identified mistake in next submission.	Corrected
2	1.A.3.b Road transportation, N ₂ O, 1990-2015	Development of country-specific EFs	To be assessed again for 2020 submission
3	1.A.3.b Road transportation, CH ₄ , N ₂ O, 1990-2015	Development of country-specific EFs	To be assessed again for 2020 submission
4	2.F Product uses as substitutes for ozone depleting substances, HFCs, 1990-2015	Use methods consistent with the 2006 IPCC Guidelines	Collection of the necessary data is ongoing. It is anticipated that work will be completed for the 2020 submission
5	2.G Other product manufacture and use, SF ₆ , 1990-2015	Use methods consistent with the 2006 IPCC Guidelines	Collection of the necessary data is ongoing. It is anticipated that work will be completed for the 2020 submission
6	2.G Other product manufacture and use, N ₂ O, 1990-2015	Use methods consistent with the 2006 IPCC Guidelines	Collection of the necessary data is ongoing. It is anticipated that work will be completed for the 2020 submission
7	3.B Manure management, N ₂ O, 2015	Correction of identified mistake in next submission.	Corrected
8	3.B Manure management, N ₂ O, 2015	Correction of identified mistake in next submission.	Corrected
9	3.D.1 Direct N ₂ O emissions from managed soils, N ₂ O, 1990-2015	Consider organic N fertilizers as a source of indirect N ₂ O emissions from managed soils in next submission.	Corrected
10	3.D.1 Direct N ₂ O emissions from managed soils, N ₂ O, 1990-2015	Consider compost application as a source of N ₂ O emissions in the sub-category 3.D.1.2.c Agriculture soils "other organic fertilizers applied to soils in next submission.	Estimated and reported
11	3.D.2 Indirect N ₂ O emissions from managed soils, N ₂ O, 2005-2015	Correct the fraction of nitrogen leached and runoff in CRF table 3D in next submission.	Corrected
12	5.A Solid waste disposal, CH ₄ , 2015	Include revised estimate in next submission.	Corrected
13	5.D Wastewater treatment and discharge, CH ₄ , 2015	Include revised estimate in next submission.	Corrected

A6.2. UNFCCC/KP review Process

Table A6.2. Summary of Recommendations from the ERT and status of implementation

	Category, gas, year	Summary of recommendation	Status of implementation
2017 findings			
General			
1	Key category analysis Key category analysis	Correct key category analysis	Corrected
2	National system National system	The national system of Cyprus does not meet the requirements outlined in decision 19/CMP.1, in conjunction with decision 3/CMP.11.	Work in progress
3	National registry National registry	Transparently report any change to its national registry (compared with the information in the previous submission) in its NIR, in accordance with chapter G contained in the annex to decision 15/CMP.1	Cyprus registry still not connected to the ITL
4	Kyoto Protocol units Kyoto Protocol units	Report SEF tables	2018 submission to the UNFCCC
5	Kyoto Protocol units Kyoto Protocol units	Report information in accordance with decision 15/CMP.1, annex, paragraphs 12–18, in conjunction with decision 3/CMP.11.	2018 submission to the UNFCCC
6	Article 3, paragraph 14, of the Kyoto Protocol Article 3, paragraph 14, of the Kyoto Protocol	Report any change(s) in its information provided	2018 submission to the UNFCCC
Energy			
7	1.A.2.c Chemicals 1.A.2.c Chemicals – liquid fuels, CO ₂ , CH ₄ , N ₂ O	Correct the activity data and explain the inter-annual variation in the NIR.	Corrected
8	1.A.1.c Manufacture of solid fuels and other energy industries 1.A.1.c Manufacture of solid fuels and other energy industries – biomass – CO ₂ , CH ₄ , N ₂ O	Report consumption of biomass for charcoal production and the associated emissions in CRF category 1.A.1.c and provide a transparent description in the NIR including the conversion efficiency (kg of biomass input per kg of charcoal produced).	Corrected
9	1.A.2.f Non-metallic minerals 1.A.2.f Non-metallic minerals – other fossil fuels – CO ₂ , CH ₄ , N ₂ O	Include these descriptions of the industrial waste and its use in the NIR.	Corrected
10	1.B.2.a Oil 1.B.2.a Oil – CH ₄	Revise their CH ₄ EF, and report the revised emission estimates in their next submission.	Corrected
11	1.A.2.b Non-ferrous metals 1.A.2.b Non-ferrous metals – liquid fuels, CO ₂ , CH ₄ , N ₂ O	Include this explanation in the NIR along with any supporting information to enhance the transparency of the submission.	Corrected
12	1. General 1. General – liquid fuels, CO ₂ , CH ₄ , N ₂ O	Correct these discrepancies between the NIR and CRF, and enter the correct data covering only international aviation in table 1.D	Corrected
13	1. General 1. General – liquid fuels, CO ₂ , CH ₄ , N ₂ O	Correct errors	Corrected
14	1. General 1. General – liquid fuels, CO ₂ , CH ₄ , N ₂ O	Implement a method of backcasting the trend of the domestic/international aviation split.	Corrected
15	1. General 1. General – liquid fuels, CO ₂ , CH ₄ ,	Complete the cell comments section for all instances of IE so that the information	Cannot find where to report

	Category, gas, year	Summary of recommendation	Status of implementation
	N2O	appears in CRF table 9.	information in the CRF reporter in order to appear in Table 9
	IPPU		
16	2.A Mineral Industry 2.A Mineral Industry – CO ₂	Correct the Table 4.9 in NIR.	Corrected
17	2.A.1 Cement production 2.A.1 Cement production – CO ₂	Include information in NIR to justify the decrease on CO ₂ emissions between 2014 and 2015.	Corrected
18	2.A.2 Lime production 2.A.2 Lime production – CO ₂	Include in NIR a complete description of the methodology used for estimation of the CO ₂ emissions of lime production (2.A.2)	Corrected
19	2.A.4 Other process uses of carbonates 2.A.4 Other process uses of carbonates – ceramics- CO ₂	Update in its NIR the methodology used to calculate CO ₂ emissions from category 2.A.4.a	Corrected
20	2.A.4 Other process uses of carbonates 2.A.4 Other process uses of carbonates – ceramics- CO ₂	Improve the QC procedures to avoid the incorrect reporting on NIR and CRF tables.	Corrected
21	2.A.4 Other process uses of carbonates 2.A.4 Other process uses of carbonates – other uses of soda ash- CO ₂	Include in NIR sufficient information to justify the reason of the decreasing of the imports of soda ash during the period between 2010 and 2015 as was presented during the review week.	Corrected
22	2.F. Product uses as substitutes for ozone depleting substances 2.F. Product uses as substitutes for ozone depleting substances – HFC	Revise the estimations for 2015 of the HFC emissions for category 2.F.1.	Corrected
23	2.G Other product manufacture and use 2.G Other product manufacture and use – N ₂ O, SF ₆	Include this calculation on its NIR and correct all the corresponding CRF tables.	Corrected
	Agriculture		
24	3.A.4 Other livestock 3.A.4 Other livestock – CH ₄ and N ₂ O	Revise population of horses, mules and asses for the 2011-2015 years	Corrected
25	3. General 3. General – CO ₂ and N ₂ O	Crosscheck GHG emissions from agricultural soils reported both in the CRF tables and the textual version of the NIR.	Corrected
26	3.G Liming 3.G Liming – CO ₂	Include in the textual version of the NIR information on the chemical characteristics of the main agricultural soils, including available references, to support the use of the NO notation key in this category.	Corrected
27	3.D.a Direct N ₂ O emissions from managed soils 3.D.a Direct N ₂ O emissions from managed soils – N ₂ O	Implement a Tier 2 methodology to estimate emissions from categories 3.D.1 and 3.D.2, considering desk studies or expert judgement as alternatives given the national circumstances.	Applying higher tier methods is not currently considered – to be assessed again for 2019 submission.
28	3.F Field burning of agricultural residues 3.F	Complete estimation of CH ₄ and N ₂ O emissions by residues burning of barley,	Corrected

	Category, gas, year	Summary of recommendation	Status of implementation
	Field burning of agricultural residues – CO ₂ , CH ₄ , N ₂ O	potatoes, bean and pulses residues' burning in the next NIR submission	
29	3.B.3 Swine3.B.3 Swine – CH ₄	Implement a Tier 2 methodology to estimate CH ₄ emissions from manure management for swine, which could be done by considering desk studies or expert judgement.	Corrected
30	3.D.a.2 Organic N fertilisers3.D.a.2 Organic N fertilisers – N ₂ O	Correct the calculations for the estimation of N excreted applied to soils as organic fertilizer	Corrected
LULUCF			
31	4. General4. General– CO ₂	Make necessary corrections to report the total land area consistently throughout the reporting period.	Corrected
32	4. General4. General – CO ₂	Report emissions and removals in these land categories with appropriate emission factors and reporting tables.	Corrected
33	4. General4. General – N ₂ O, CH ₄	Report estimates for each inventory category for which the 2006 IPCC Guidelines provide methods and default EFs. Alternatively, Cyprus may use the notation key “NO” for any category, pool and/or gas for which the Party has information confirming that the category, pool or gas does not occur, or use the notation key “NE” for categories, pools and/or gases for which the net emissions/removals are negligible, and provide such information in the NIR.	Corrected
34	4.G Harvested wood products4.G Harvested wood products – CO ₂	Reports the emissions and removals from HWP in the next submission.	Corrected
KP-LULUCF			
35	Forest managementForest management – CO ₂	Revise the area of forests included in the land transition matrix in the NIR to be consistent with those reported in CRF tables in future submissions.	Corrected
36	GeneralGeneral – Add gas(es)	Responding the ERT's question, Cyprus indicated that since July 2017, Cyprus has been receiving Technical Support by the European Commission in order to improve LULUCF reporting. The project is entitled "LULUCF inventories- capacity building for Cyprus" and should be finalised by the end of October, 2017. It is anticipated to report all emissions for the 2018 submission. Report emissions and removals from KP-LULUCF activities with appropriate notation keys and reporting tables.	Corrected
Waste			
37	5.A Solid waste disposal on land5.A Solid waste disposal on land – CH ₄	Overall improvement of the quality of its next submission.	Corrected
38	5.A Solid waste disposal on land5.A Solid waste disposal on land – CH ₄	Provide a reference for its population data source	Corrected
39	5.A Solid waste disposal	Enhance section 7.2.4 - Source specific	Corrected

	Category, gas, year	Summary of recommendation	Status of implementation
	on land5.A Solid waste disposal on land – CH4	recalculations	
40	5.D Wastewater treatment and discharge5.D Wastewater treatment and discharge – CH4	Reflect whether any plans are in place to move to higher tier methods as this category is key according to CFR table 7.	Applying higher tier methods is not currently considered – to be assessed again for 2019 submission.
41	5.B.1 Composting5.B.1 Composting – N2O	Enhance the transparency of the NIR	Ongoing – improvement in 2018 submission
42	5.D.1 Domestic wastewater5.D.1 Domestic wastewater – CH4	Enhance data consistency between the NIR and the CFR tables, and in its next submission use a correction factor of 1 instead of 1.25 in line with its NIR	Corrected
43	5. General5. General – CH4; N2O	Ensure that there is proper accounting and alignment of waste streams used as alternative fuel sources in the Energy sector and that these are taken into account and deducted from the waste sector as they may be resulting in an overestimation in waste sector	Ongoing - 2020 submission
44	5.D.1 Domestic wastewater5.D.1 Domestic wastewater – CH4, N2O	Account for the component of organic material and nitrogen removed as sludge in its next inventory submission as it is reported that there are good data sources for sludge in Cyprus.	Corrected
Findings of previous reviews			
General			
1	Inventory planning	Improve the transparency of reporting on all sectors	Work in progress
2	Inventory planning	Include the relevant ministries and agencies in the institutional arrangements for inventory preparation in order to make reporting on LULUCF possible	2018 submission
3	Inventory planning	Report notation keys in the CRF tables instead of leaving cells blank and/or reporting zeros	Corrected
4	Inventory planning	Provide relevant explanations in CRF table 9(a), specifically for all cases of notation key “NE”	Cannot find where to report information in the CRFreporter in order to appear in Table 9
5	Inventory planning	Include in the NIR the description of institutional arrangements for the timely data provision and national greenhouse gas inventory preparation	Corrected
6	Activity data	Give priority to the collection of the necessary AD for the energy and industrial processes and product use sectors in order to complete the inventory	Work in progress
7	Methods	Provide sufficient justification of methods, assumptions and emission parameters used in national inventory preparation, including	Work in progress

	Category, gas, year	Summary of recommendation	Status of implementation
		through the provision of supporting references to literature and other information sources used	
8	Methods	Ensure that appropriate methods are used to estimate emissions from key categories	Work in progress
9	Key category analysis	Present the results of the key category analysis following the format of 2006 IPCC Guidelines	Corrected
10	QA/QC and verification	Provide more detail in the NIR on the QA/QC procedures carried out and review the inventory (sector by sector) using independent national experts after completing the inventory	Corrected
11	QA/QC and verification	Include the updated QA/QC and verification plan in the NIR	Corrected
12	Uncertainty analysis	Include an uncertainty analysis for LULUCF after the LULUCF reporting has been completed	Work in progress
13	Uncertainty analysis	Report the uncertainty assessment with and without the LULUCF sector	Without LULUCF reported – with LULUCF work in progress
14	Uncertainty analysis	Undertake quantitative uncertainty assessment for each category of the national inventory and report the results in the NIR	Work in progress
15	Archiving	Enhance the security and performance of the data archiving and storage system.	Work in progress
16	National system	Report on the progress of implementation of the work plan and explain the on-going activities put in place for continuous and sustainable reporting	Reported
17	Archiving	Enhance the security and performance of the data archiving and storage system.	Work in progress
18	National registry	Include in the NIR information on the national registry 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	2018 submission to the UNFCCC
19	Kyoto Protocol units	Report the SEF tables in accordance with decision 15/CMP.1, annex, paragraphs 12–17, in conjunction with decision 3/CMP.11, and annex II to decision 3/CMP.11	2018 submission to the UNFCCC
20	Article 3, paragraph 14, of the Kyoto Protocol	Provide in the NIR all supplementary information under Article 7, paragraph 1, of the Kyoto Protocol, in particular the information related to Article 3, paragraph 14, in accordance with decision 15/CMP.1	2018 submission to the UNFCCC
	Energy		
21	1. General – all fuels – CO ₂ , CH ₄ and N ₂ O	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	Provided

	Category, gas, year	Summary of recommendation	Status of implementation
		ensured	
22	1.A.1.a Public electricity and heat production – all fuels – CO ₂ , CH ₄ and N ₂ O	Use country- and/or plant-specific EFs for the earlier years in the time series, when available	Assessed – not possible (explained in NIR)
23	1.A.1.a Public electricity and heat production – liquid fuels – CO ₂	Investigate and explain the reasons behind the fluctuation in CO ₂ IEFs after 2005	Explained
24	1.A.3.a Domestic aviation – liquid fuels – CO ₂ , CH ₄ and N ₂ O	Report in the NIR on any progress achieved in applying higher tier methods and improving the consistency of the time series	Reported
25	1.A.3.b Road transportation – liquid fuels – CO ₂ , CH ₄ and N ₂ O	Provide in the NIR a description of the composition of the biofuels used in the category 1.A.3.b, i.e. the composition of the biodiesel being mixed to the diesel (in %), information explaining if all diesel is mixed with biodiesel and if there are other types of biofuels being used in the Country or in road transportation	Reported
26	1.A.3.b.i Cars – liquid fuels – CO ₂ , CH ₄ and N ₂ O	Make efforts to apply higher tier methods to estimate emissions for category 1.A.3.b.i	Applying higher tier methods is not currently considered – to be assessed again for 2019 submission.
27	1.A.3.d Domestic navigation – liquid fuels – CO ₂ , CH ₄ and N ₂ O	Make efforts to collect data to enable the application of higher tier methods and improve the consistency of the time-series	Applying higher tier methods is not currently considered – to be assessed again for 2019 submission.
28	1.A.3.d Domestic navigation – liquid fuels – CO ₂ , CH ₄ and N ₂ O	Report in the NIR on any progress achieved in applying higher tier methods and improving the consistency of the time series	Applying higher tier methods is not currently considered – to be assessed again for 2019 submission.
29	1.A.4.b Residential – biomass –CH ₄ and N ₂ O	Correct the inconsistency between the information on solid biomass consumption for the residential sector for 2011 reported in Table 3.17 of the NIR (2,300.00 TJ) and that in the CRF tables (229.99 TJ)	Corrected
	IPPU		
30	2. General	Conduct the improvement plan to significantly increase the number of categories reported and report emissions for those categories	Work in progress
31	2.A.1 Cement production – CO ₂	Update the description of the methodology used to calculate CO ₂ emissions from category 2.A.1 in the NIR	Updated
32	2.A.4 Other process uses of carbonates – CO ₂	Describe in the NIR the methodology used to calculate CO ₂ emissions from category 2.A.4.a	Described
33	2.A.4 Other process uses of carbonates – CO ₂	Describe in the NIR the methodology used to calculate CO ₂ emissions from category	Described

	Category, gas, year	Summary of recommendation	Status of implementation
		2.A.4.b	
34	2.B.5 Carbide production – CO2	Further investigate if the acetylene production in Cyprus is based on calcium carbide use	Investigated and reported in NIR
35	2.D.1 Lubricant use – CO2	Use one of the splicing techniques available in the 2006 IPCC Guidelines to fill the gap in the AD for 1990–1993 years and report CO2 emission estimates from lubricant use	Implemented
36	2.D.3 Other (non-energy products from fuels and solvent use) – CO2	Report the AD for urea-based catalysts in kt, instead of TJ, in CRF table 2(I).A-Hs2	Corrected
37	2.F. Product uses as substitutes for ozone depleting substances – HFCs	Continue efforts to collect AD and report emissions fully in accordance with the 2006 IPCC Guidelines	Work in progress
38	2.F.1 Refrigeration and air conditioning – HFCs	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	Work in progress
39	2.G.1 Electrical equipment – SF6	Explain in the NIR how SF6 emissions from electrical equipment are estimated	Explained
	Agriculture		
40	3.A Enteric fermentation – CH4	Estimate emissions for all significant livestock categories using an enhanced livestock characterisation and a tier 2 methodology in accordance with the IPCC good practice guidance	Applying higher tier methods is not currently considered – to be assessed again for 2019 submission.
	Waste		
58	5.D Wastewater treatment and discharge – CH4 and N2O	Provide detailed information on the type of handling system used for the treatment of wastewater and sludge as well as the methodology used for the estimation of emissions	Provided
59	5.D Wastewater treatment and discharge – CH4 and N2O	Improve the assessment of the information related to the types of infrastructure, technologies and volume of wastewater treated, considering national circumstances, and that the Party report this information transparently in the NIR	Reported
60	5.D Wastewater treatment and discharge – CH4	Further enhance the use of country-specific data to support the choice of MCF values in order to better represent the types of activities that have been implemented by the industrial sector to process and dispose of all the wastewater generated, including in domestic municipal wastewater treatment plants	Enhanced for domestic – work in progress of industrial
61	5.D Wastewater treatment and discharge – CH4	Describe in the NIR the reasons and the evolution of national circumstances that were considered relevant to support the decision to change the “waste disposal in septic tanks” correction factor from 1.25 to 1	Described

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 2018 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
5	Undertake category specific quantitative uncertainty assessment and report the results in the NIR	To be assessed for 2020 submission
Sector 1. Energy		
1	1.A.3.b Road transportation: Development of country-specific EFs	To be assessed for 2020 submission
Sector 2. IPPU		
1	2.F Product uses as substitutes for ozone depleting substances: Use methods consistent with the 2006 IPCC Guidelines	Collection of the necessary data is ongoing. It is anticipated that work will be completed for the 2020 submission The improvement of the methodologies, has started in 2019 with the correction of the methodology for the majority of the subcategories of 2F1
2	2.G Other product manufacture and use: Use methods consistent with the 2006 IPCC Guidelines	Collection of the necessary data is ongoing. It is anticipated that work will be completed for the 2020 submission
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 2021 submission to explore some modelling approach which could be used to derive DE from other related variables.
2	3D. Improvement of N ₂ O leaching estimates	In view of the information provided by the TERT experts it is considered necessary to examine for 2020 submission all the available information and if found appropriate, to provide N ₂ O estimates.
Sector 4. LULUCF		
1	Report fully uncertainty assessment and recalculations	To be included in the 2020 submission
KP LULUCF		
1	Natural Disturbances	To be included in the 2020 submission

References

All references used in the national inventory report are presented as footnotes to the text.