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ETHIOPIA NATIONAL GREENHOUSE GAS INVENTORY FOR THE ENERGY SECTOR: 1990 - 2019

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Prepared by:

Dingane Sithole

Addisu Amare

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Acronyms

AFOLU	Agriculture, Forestry and other Land Uses
AR2	IPCC Second Assessment report
CH_4	Methane
CHP	Combined Heat and Power Generation
CO_2	Carbon Dioxide
CO_2eq	Carbon Dioxide Equivalent
GHG	Greenhouse gas
GWP	Global Warming Potentials
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
ISO	International Standards Organisation
Kt	Kilotonne
LPG	Liquefied Petroleum Gas
LTO	Landing and take Offs
N_2O	Nitrous Oxide
NO	Not Occurring
QA	Quality Assurance
QC	Quality Control
TJ	Tera joule
UNFCCC	United Nations Framework Convention on Climate change
UNSD	United Nations Statistics Division
VKT	Vehicle Kms travelled

1 Overview of Sector

1.1 Sector overview

Ethiopia has been experiencing increased population and industrial growth as well as corresponding increased energy consumption since 1990. The energy mix of Ethiopia is dominated by biofuels, mainly fuelwood (IEA, 2022).The energy supply increased by 152% from 745,593.00TJ in 1990 to 1,878,972.00 TJ in 2019 (Figure *1-1***Error! Reference source not found.**).

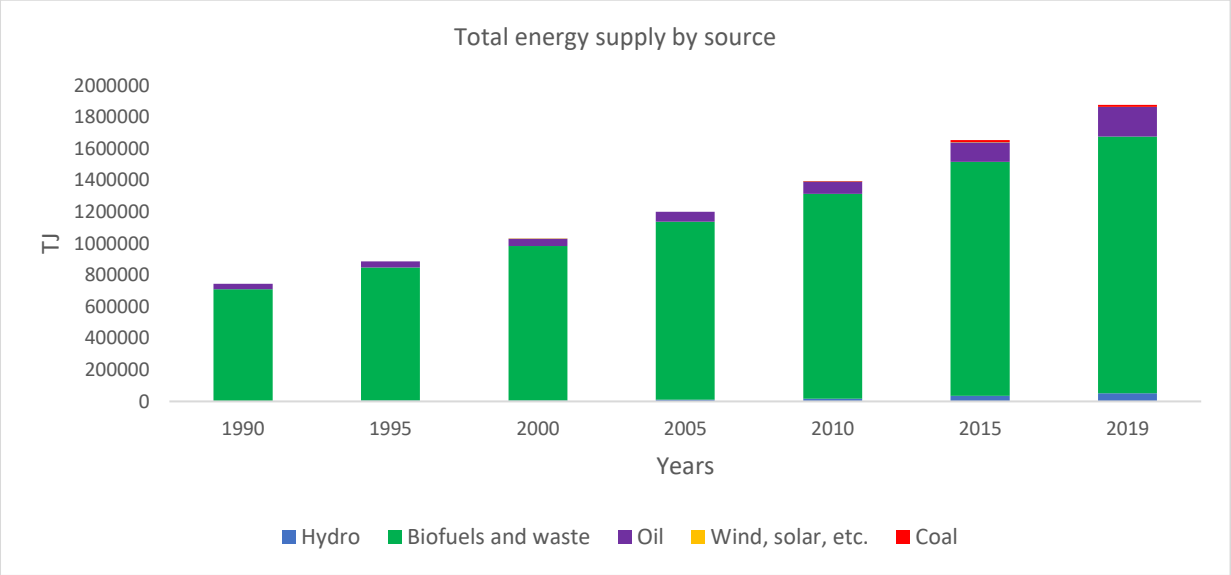

Figure 1-1 Total energy supply

Source: IEA, 2022

Biofuels and waste accounted for 94.92% of the total energy supply in 1990 decreasing gradually to 86.49% by 2019. Over the same period, oil products have been on the rise accounting for 4.57% in 1990 and close to 10% in 2019. Coal and wind have also been on the rise, although they each contribute less than 1% as at 2019 (Table 1-1**Error! Reference source not found.Error! Reference source not found.**)

Table 1-1: Percentage contribution of different energy resources

	Hydro		Biofuels and waste		Oil		Wind, solar		Coal	
Year	TJ	%	TJ	%	TJ	%	TJ	%	TJ	%
1990	3823	0.51%	707680	94.92%	34090	4.57%				
1995	5141	0.58%	843044	95.11%	38172	4.31%				
2000	5926	0.58%	978661	94.99%	45468	4.41%	180	0.02%		
2005	10199	0.85%	1128227	93.96%	62296	5.19%		0.00%		
2010	17752	1.27%	1297947	92.97%	78478	5.62%	648	0.05%	1290	0.09%
2015	34826	2.11%	1482483	89.61%	123721	7.48%	2797	0.17%	10604	0.64%
2019	52429	2.79%	1625032	86.49%	187798	9.99%	1980	0.11%	11733	0.62%

Source: Adapted from (IEA, 2019)

In 2019 the residential sector consumed the highest proportion of 98.5 % of the final consumption, comprising biofuels, with industry demand accounting for a little more than 3 % of 42 million tons of oil equivalent (mtoe) of total energy consumption (FDRE, 2019). The

remaining 1.5% were split evenly between electricity and oil products; with a small bias toward the latter.

1.2 Overview of GHG emissions in 2017.

In 2017 a total of 46,176.91 Gg carbon dioxide equivalent (CO_2eq) of greenhouse gas (GHG) emissions were emitted from the energy sector in Ethiopia. The bulk of these emissions (61.20%) were from methane (CH_4) followed by carbon dioxide (CO_2) contributing 30.62% and nitrous oxide (N_2O) with 8.18%. International bunker emissions from aviation amounted to 2,169.41Gg CO_2eq. Biogenic CO_2 emitted from the combustion of biomass amounted to 628,837.65Gg. The highest emissions (69.65%) came from other sectors (1A4) (encompassing Commercial, Residential as well as Agriculture, forestry and Fishing activities), followed by road transport (1.a.3.b) contributed 14.08% and the Manufacturing industry and construction (MIC) (1A2) weighing in with 9.26%.

A total of 14,138.19Gg of CO_2 were emitted in 2017, while 1,345.76Gg of CH_4 were emitted in the same year. The least emissions by gas were N_2O amounting to 12.19Gg (Table 1-2**Error! Reference source not found.**).

Table 1-2: GHG emissions totals by gas in Gg

	Emissions (Gg)						
Categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1 - Energy	14138.19	1345.76	12.19	209.58	11,428.50	1,729.40	75.00
1.A - Fuel Combustion Activities	14138.19	1345.76	12.19	209.58	11,428.50	1,729.40	75.00
1.A.1 - Energy Industries	3.19	26.06	0.52	5.47	1.56	0.21	23.71
1.A.1.a - Main Activity Electricity and Heat Production	3.19	0.00[1]	0.00[2]	2.74	0.78	0.10	11.86
1.A.1.a.i - Electricity Generation	3.19	0.00	0.00	0.00	0.00	0.00	0.00
1.A.1.a.ii - Combined Heat and Power Generation (CHP)	NO	NO	NO	NO	NO	NO	NO
1.A.1.a.iii - Heat Plants	NO	NO	NO	NO	NO	NO	NO
1.A.1.b - Petroleum Refining	NO	NO	NO	NO	NO	NO	NO
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries		26.05	0.52	2.74	0.78	0.10	11.86
1.A.1.c.i - Manufacture of Solid Fuels		26.05	0.52	2.74	0.78	0.10	11.86
1.A.1.c.ii - Other Energy Industries	NO	NO	NO	NO	NO	NO	NO
1.A.2 - Manufacturing Industries and Construction	4233.60	0.64	0.09	0.00	0.00	0.00	0.00
1.A.3 - Transport	6382.16	0.90	0.33	29.35	22.17	9.01	0.01
1.A.3.a - Civil Aviation	25.23	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.a.i - International Aviation (International Bunkers) (1)							
1.A.3.a.ii - Domestic Aviation	25.23	0.00	0.00	0.03	9.60	0.15	0.01
1.A.3.b - Road Transportation	6356.94	0.90	0.33	29.31	12.57	8.86	-

[1] Very small quantities, becoming 0.00 due to rounding off
[2] Very small quantities, becoming 0.00 due to rounding off

	Emissions (Gg)						
Categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1.A.3.c - Railways	NO	NO	NO	NO	NO	NO	NO
1.A.3.d - Water-borne Navigation	NE	NE	NE	NE	NE	NE	NE
1.A.3.d.i - International water-borne navigation	NO	NO	NO	NO	NO	NO	NO
1.A.3.d.ii - Domestic Water-borne Navigation	NE	NE	NE	NE	NE	NE	NE
1.A.3.e - Other Transportation	NO	NO	NO	NO	NO	NO	NO
1.A.4 - Other Sectors	1015.83	1317.87	11.20	142.34	11,378.05	1,713.46	32.78
1.A.4.a - Commercial/Institutional	226.23	9.37	0.13	3.79	18.14	9.46	0.63
1.A.4.b - Residential	251.11	1308.42	11.07	136.33	11,359.23	1,703.86	31.47
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	538.48	0.07	0.00	0.00	0.00	0.00	0.00
1.A.4.c.i - Stationary	IE	IE	IE	IE	IE	IE	IE
1.A.4.c.ii - Off-road Vehicles and Other Machinery	538.48	0.07	0.00	0.00	2.22	0.68	0.15
1.A.4.c.iii - Fishing (mobile combustion)	IE	IE	IE	IE	IE	IE	IE
1.A.5 - Non-Specified	2503.42	0.29	0.04	0.00	0.00	0.00	0.00
1.A.5.a - Stationary	1961.75	0.26	0.02	0.00	0.00	0.00	0.00
1.A.5.b - Mobile	541.67	0.03	0.03	0.00	0.00	0.00	0.00
1.A.5.b.i - Mobile (aviation component)	NO	NO	NO	NO	NO	NO	NO
1.A.5.b.ii - Mobile (water-borne component)	NO	NO	NO	NO	NO	NO	NO
1.A.5.b.iii - Mobile (Other)	541.67	0.03	0.03	0.00	0.00	0.00	0.00
1.A.5.c - Multilateral Operations (1)(2)							
1.B - Fugitive emissions from fuels	0.00	0.00		0.00	0.00	0.00	0.00
1.B.1 - Solid Fuels	0.00	0.00		0.00	0.00	0.00	0.00
1.B.1.a - Coal mining and handling	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.B.1.a.i - Underground mines	NO	NO	NO	NO	NO	NO	NO
1.B.1.a.i.1 - Mining	NO	NO	NO	NO	NO	NO	NO
1.B.1.a.i.2 - Post-mining seam gas emissions	NO	NO	NO	NO	NO	NO	NO
1.B.1.a.i.3 - Abandoned underground mines	NO	NO	NO	NO	NO	NO	NO
1.B.1.a.i.4 - Flaring of drained methane or conversion of methane to CO2	NO	NO	NO	NO	NO	NO	NO
1.B.1.a.ii - Surface mines	0.00	0.00[3]	0.00	0.00	0.00	0.00	0.00
1.B.1.a.ii.1 - Mining	NE	NE	NE	NE	NE	NE	NE
1.B.1.a.ii.2 - Post-mining seam gas emissions	NE	NE	NE	NE	NE	NE	NE
1.B.1.b - Uncontrolled combustion and burning coal dumps	NE	NE	NE	NE	NE	NE	NE
1.B.1.c - Solid fuel transformation	NO	NO	NO	NO	NO	NO	NO
1.B.2 - Oil and Natural Gas	NE	NE	NE	NE	NE	NE	NE
1.B.2.a - Oil	NO	NO	NO	NO	NO	NO	NO
1.B.2.a.i - Venting	NO	NO	NO	NO	NO	NO	NO

[3] 0.001621 Gg reducing to 0.00Gg due to rounding off

	Emissions (Gg)						
Categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1.B.2.a.ii - Flaring	NO	NO	NO	NO	NO	NO	NO
1.B.2.a.iii - All Other	NE	NE	NE	NE	NE	NE	NE
1.B.2.a.iii.1 - Exploration	NE	NE	NE	NE	NE	NE	NE
1.B.2.a.iii.2 - Production and Upgrading	NO	NO	NO	NO	NO	NO	NO
1.B.2.a.iii.3 - Transport	NO	NO	NO	NO	NO	NO	NO
1.B.2.a.iii.4 - Refining	NO	NO	NO	NO	NO	NO	NO
1.B.2.a.iii.5 - Distribution of oil products	NO	NO	NO	NO	NO	NO	NO
1.B.2.a.iii.6 - Other	NO	NO	NO	NO	NO	NO	NO
1.B.2.b - Natural Gas	NO	NO	NO	NO	NO	NO	NO
1.B.2.b.i - Venting	NO	NO	NO	NO	NO	NO	NO
1.B.2.b.ii - Flaring	NO	NO	NO	NO	NO	NO	NO
1.B.2.b.iii - All Other	NE	NE	NE	NE	NE	NE	NE
1.B.2.b.iii.1 - Exploration	NE	NE	NE	NE	NE	NE	NE
1.B.2.b.iii.2 - Production	NO	NO	NO	NO	NO	NO	NO
1.B.2.b.iii.3 - Processing	NO	NO	NO	NO	NO	NO	NO
1.B.2.b.iii.4 - Transmission and Storage	NO	NO	NO	NO	NO	NO	NO
1.B.2.b.iii.5 - Distribution	NO	NO	NO	NO	NO	NO	NO
1.B.2.b.iii.6 - Other	NO	NO	NO	NO	NO	NO	NO
1.B.3 - Other emissions from Energy Production	NO	NO	NO	NO	NO	NO	NO
1.C - Carbon dioxide Transport and Storage	NO	NO	NO	NO	NO	NO	NO

International bunkers and biogenic CO_2 emissions are reported under memo items (

Table 1-3). Biomass fuel combustion, mainly fuelwood and charcoal, contributed to 628,837.65CO_2 emissions under information items. These emissions were not added to the national totals.

Table 1-3: Memo Items

	Emissions (Gg)						
Categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
International Bunkers	2,150.45	0.02	0.06	2.728	818.4	12.958	0.682
1.A.3.a.i - International Aviation (International Bunkers) (1)	2,150.45	0.02	0.06	2.728	818.4	12.958	0.682
1.A.3.d.i - International water-borne navigation (International bunkers) (1)	NO	NO	NO	NO	NO	NO	NO
1.A.5.c - Multilateral Operations (1)(2)	NO	NO	NO	NO	NO	NO	NO
Information Items							
CO_2 from Biomass Combustion for Energy Production	628,837.65						

1.3 Global Warming Potentials (GWP)

The Global Warming Potentials (GWPs) from the IPCC Second Assessment Report (AR2) were used and are shown in Table 1-4.

Table 1-4*:* Global Warming Potentials from the AR2

Name of gas	Chemical formula	Global warming potential (GWP)
Carbon dioxide	CO_2	1
Methane	CH_4	21
Nitrous oxide	N_2O	310

Source: (IPCC, 1995)

The total GHG emissions in carbon dioxide equivalents (CO_2eq) are presented in Table 1-5.

Table 1-5: GHG emissions in 2017 in CO_2eq

	Emissions (CO_2eq)			
Categories	**CO_2**	**CH_4**	**N_2O**	**Total**
1 - Energy	14,138.19	28260.94	3,777.77	46,176.91
1.A - Fuel Combustion Activities	14,138.19	28260.91	3,777.77	46,176.88
1.A.1 - Energy Industries	3.19	547.16	161.55	711.89
1.A.1.a - Main Activity Electricity and Heat Production	3.19	0.00	0.01	3.20
1.A.1.a.i - Electricity Generation	3.19	0.00	0.01	3.20
1.A.1.a.ii - Combined Heat and Power Generation (CHP)	NO	NO	NO	
1.A.1.a.iii - Heat Plants	NO	NO	NO	
1.A.1.b - Petroleum Refining	NO	NO	NO	
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries	0.00	547.15	161.54	708.70
1.A.1.c.i - Manufacture of Solid Fuels	0.00	547.15	161.54	708.70
1.A.1.c.ii - Other Energy Industries	NO	NO	NO	
1.A.2 - Manufacturing Industries and Construction	4,233.60	13.41	29.40	4,276.40
1.A.3 - Transport	6,382.16	18.94	101.27	6,502.37
1.A.3.a - Civil Aviation	25.23	0.00	0.22	25.45
1.A.3.a.i - International Aviation (International Bunkers) (1)	0.00	0.00	0.00	-
1.A.3.a.ii - Domestic Aviation	25.23	0.00	0.22	25.45
1.A.3.b - Road Transportation	6,356.94	18.94	101.05	6,476.93
1.A.3.c - Railways	NO	NO	NO	
1.A.3.d - Water-borne Navigation	NE	NE	NE	
1.A.3.d.i - International water-borne navigation (International bunkers) (1)	NO	NO	NO	
1.A.3.d.ii - Domestic Water-borne Navigation	NE	NE	NE	
1.A.3.e - Other Transportation	NO	NO	NO	
1.A.4 - Other Sectors	1,015.83	27,675.28	3,471.83	32,162.93
1.A.4.a - Commercial/Institutional	226.23	196.84	38.90	461.96
1.A.4.b - Residential	251.11	27,476.91	3,431.58	31,159.60
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	538.48	1.53	1.35	541.36
1.A.4.c.i - Stationary	IE	IE	IE	
1.A.4.c.ii - Off-road Vehicles and Other Machinery	538.48	1.53	1.35	541.36
1.A.4.c.iii - Fishing (mobile combustion)	IE	IE	IE	
1.A.5 - Non-Specified	2,503.42	6.12	13.73	2,523.28
1.A.5.a - Stationary	1,961.75	5.52	4.89	1,972.17
1.A.5.b - Mobile	541.67	0.60	8.84	551.11
1.A.5.b.i - Mobile (aviation component)	NO	NO	NO	
1.A.5.b.ii - Mobile (water-borne component)	NO	NO	NO	

	Emissions (CO_2eq)			
Categories	**CO_2**	**CH_4**	**N_2O**	**Total**
1.A.5.b.iii - Mobile (Other)	541.67	0.60	8.84	551.11
1.A.5.c - Multilateral Operations (1)(2)	0.00	0.00	NE	-
1.B - Fugitive emissions from fuels	0.00	0.03	NE	0.03
1.B.1 - Solid Fuels	0.00	0.03	NE	0.03
1.B.1.a - Coal mining and handling	0.00	0.03	NE	0.03
1.B.1.a.i - Underground mines	NO	NO	NO	
1.B.1.a.i.1 - Mining	NO	NO	NO	
1.B.1.a.i.2 - Post-mining seam gas emissions	NO	NO	NO	
1.B.1.a.i.3 - Abandoned underground mines	NO	NO	NO	
1.B.1.a.i.4 - Flaring of drained methane or conversion of methane to CO2	NO	NO	NO	
1.B.1.a.ii - Surface mines	NE	0.03	0.00	0.03
1.B.1.a.ii.1 - Mining	NE	0.03	NE	0.03
1.B.1.a.ii.2 - Post-mining seam gas emissions	NE	NE	NE	
1.B.1.b - Uncontrolled combustion and burning coal dumps	NE	NE	NE	
1.B.1.c - Solid fuel transformation	NO	NO	NO	
1.B.2 - Oil and Natural Gas	NE	NE	NE	
1.B.2.a - Oil	NO	NO	NO	
1.B.2.a.i - Venting	NO	NO	NO	
1.B.2.a.ii - Flaring	NO	NO	NO	
1.B.2.a.iii - All Other	NE	NE	NE	
1.B.2.a.iii.1 - Exploration	NE	NE	NE	
1.B.2.a.iii.2 - Production and Upgrading	NO	NO	NO	
1.B.2.a.iii.3 - Transport	NO	NO	NO	
1.B.2.a.iii.4 - Refining	NO	NO	NO	
1.B.2.a.iii.5 - Distribution of oil products	NO	NO	NO	
1.B.2.a.iii.6 - Other	NO	NO	NO	
1.B.2.b - Natural Gas	NO	NO	NO	
1.B.2.b.i - Venting	NO	NO	NO	
1.B.2.b.ii - Flaring	NO	NO	NO	
1.B.2.b.iii - All Other	NE	NE	NE	
1.B.2.b.iii.1 - Exploration	NE	NE	NE	
1.B.2.b.iii.2 - Production	NO	NO	NO	
1.B.2.b.iii.3 - Processing	NO	NO	NO	
1.B.2.b.iii.4 - Transmission and Storage	NO	NO	NO	
1.B.2.b.iii.5 - Distribution	NO	NO	NO	
1.B.2.b.iii.6 - Other	NO	NO	NO	
1.B.3 - Other emissions from Energy Production	NO	NO	NO	
1.C - Carbon dioxide Transport and Storage	NO	NO	NO	
TOTAL	14,138.19	28,260.94	7,292.73	49,691.86

1.4 Overview of methodology and completeness.

The 2006 Intergovernmental Panel on Climate Change (IPCC) guidelines for GHG inventory compilation were used in the estimation of GHGs from the energy sector. Default methodology (Tier 1) was used for all the source categories. Table 1-6 summarizes the

methodologies, activity data source and the categories reported in this inventory. The EMEP/EEA[4] Guidebook for 2019 was used for estimating precursor emissions.

Table 1-6: Summary of methodologies

		Methodology	Emission factors						
	Activity data		CO_2	CH_4	N_2O	NOx	CO	NMVOCs	SO_2
1 - Energy									
1.A - Fuel Combustion Activities	UNSD	T1	D	D	D	EEA	EEA	EEA	EEA
1.A.1 - Energy Industries	-		-	-					
1.A.1.a - Main Activity Electricity and Heat Production	-		-	-					
1.A.1.a.i - Electricity Generation	UNSD	T1	D	D	D	EEA	EEA	EEA	EEA
1.A.1.a.ii - Combined Heat and Power Generation (CHP)	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.1.a.iii - Heat Plants	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.1.b - Petroleum Refining	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.1.c.i - Manufacture of Solid Fuels	UNSD	T1	D	D	D	EEA	EEA	EEA	EEA
1.A.1.c.ii - Other Energy Industries	NO		-	-					
1.A.2 - Manufacturing Industries and Construction	UNSD	T1	D	D	D	EEA	EEA	EEA	EEA
1.A.3 - Transport	UNSD	T1	D	D	D	EEA	EEA	EEA	EEA
1.A.3.a - Civil Aviation	UNSD	T1	D	D	D	EEA	EEA	EEA	EEA
1.A.3.a.i - International Aviation (International Bunkers) (1)	UNSD	T1	D	D	D	EEA	EEA	EEA	EEA
1.A.3.a.ii - Domestic Aviation	UNSD	T1	D	D	D	EEA	EEA	EEA	EEA
1.A.3.b - Road Transportation	UNSD	T1	D	D	D	EEA	EEA	EEA	EEA
1.A.3.c - Railways	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.3.d - Water-borne Navigation	-		-	-					
1.A.3.e - Other Transportation	-		-	-					
1.A.4 - Other Sectors	UNSD	T1	D	D	D	EEA	EEA	EEA	EEA
1.A.4.a - Commercial/Institutional	UNSD	T1	D	D	D	EEA	EEA	EEA	EEA
1.A.4.b - Residential	UNSD	T1	D	D	D	EEA	EEA	EEA	EEA
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	UNSD	T1	D	D	D	EEA	EEA	EEA	EEA
1.A.4.c.i - Stationary	-		-	-					
1.A.4.c.ii - Off-road Vehicles and Other Machinery	UNSD	T1	D	D	D	EEA	EEA	EEA	EEA
1.A.4.c.iii - Fishing (mobile combustion)	-		-	-					
1.A.5 - Non-Specified	UNSD	T1	D	D	D	EEA	EEA	EEA	EEA
1.A.5.a - Stationary	UNSD	T1	D	D	D	EEA	EEA	EEA	EEA
1.A.5.b - Mobile	UNSD	T1	D	D	D	EEA	EEA	EEA	EEA
1.A.5.b.i - Mobile (aviation component)	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.5.b.ii - Mobile (water-borne component)	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.5.b.iii - Mobile (Other)	UNSD	T1	D	D	D	EEA	EEA	EEA	EEA
1.A.5.c - Multilateral Operations	-		-	-					
1.B - Fugitive emissions from fuels	-		-	-					
1.B.1 - Solid Fuels	-		-	-					
1.B.1.a - Coal mining and handling	UNSD	T1	D	D	D	EEA	EEA	EEA	EEA
1.B.1.a.i - Underground mines	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.B.1.a.ii - Surface mines	UNSD	T1	D	D	D	EEA	EEA	EEA	EEA
1.B.1.b - Uncontrolled combustion and burning coal dumps	-		-	-					

[4] https://www.eea.europa.eu/themes/air/air-pollution-sources-1/emep-eea-air-pollutant-emission-inventory-guidebook.

		Methodology	Emission factors						
	Activity data		CO_2	CH_4	N_2O	NOx	CO	NMVOCs	SO_2
1.B.1.c - Solid fuel transformation	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.B.2 - Oil and Natural Gas	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.B.2.a - Oil	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.B.2.b - Natural Gas	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.B.3 - Other emissions from Energy Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.C - Carbon dioxide Transport and Storage	NO	NO	NO	NO	NO	NO	NO	NO	NO

Key: T1-2006 IPCC Tier 1 default methodology; D-IPCC Default emission factor; (EMEP/EEA, 2019)

The collected data were computed into the 2006 IPCC Inventory Software Version 2.69 of 2020.

1.5 Trends in total Energy GHG emissions

There has been a steady rise in GHG emissions from the energy sector in Ethiopia over the years, in line with increase in economic activities. The major sources of the emissions were Residential (1.A.4.b) and Road Transportation (1.A.3.b) (Figure 1-2), with residential dominating throughout the time series.

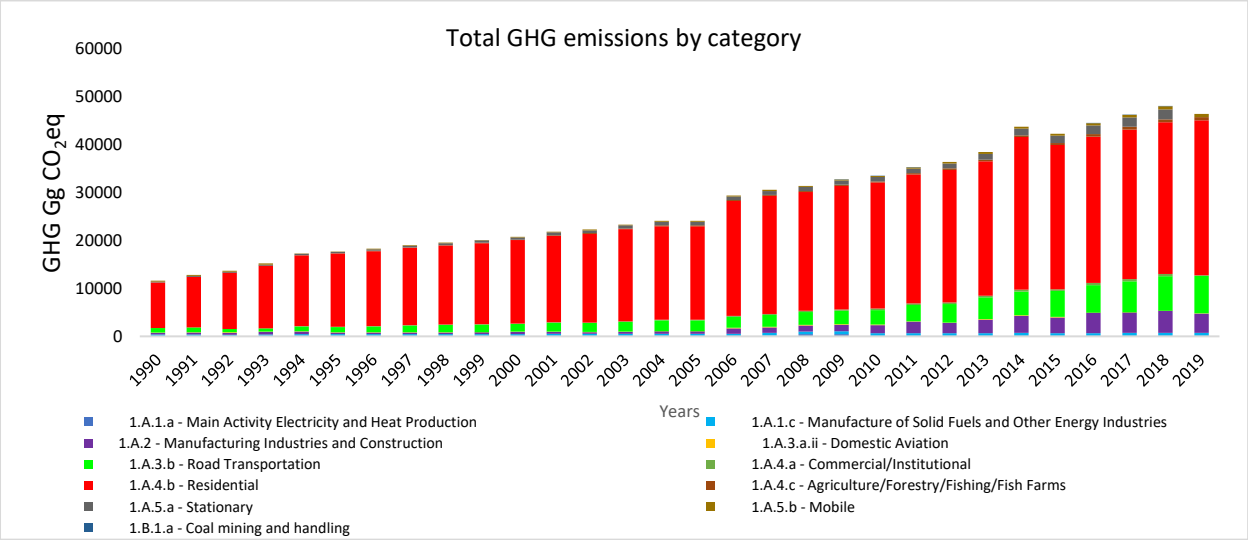

Figure 1-2: Total GHG emissions from the Energy Sector from 1990 to 2019

Total GHG emissions gradually increased from 1990 up to 2014 where there is slight decline in 2014 and the gradual increase continues up to 2018, followed by a slight decline in 2019. The increase in GHG emissions from the 1990 level to 2019 level is about 76%.The trend follows increases in energy consumption driven by rising population and increased industrial activity.

1.6 Uncertainties for Activity Data and Emission Factors

Default activity data and emission factor uncertainty values applied for all categories are summarised in Table 1-7, and were obtained from the IPCC software.

Table 1-7: Summary of uncertainties for activity data and emission factors.

Category	Gas	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)
1.A.1 - Energy Industries - Liquid Fuels	CO_2	5	6.14

Category	Gas	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)
	CH_4, N_2O	5	228.79
1.A.1 - Energy Industries - Solid Fuels	CO_2	7.07	17.55
	CH_4	7.07	282.84
	N_2O	7.07	314.27
1.A.1 - Energy Industries - Biomass	CO_2	5	18.69
	CH_4	5	245.45
	N_2O	5	304.55
1.A.2 - Manufacturing Industries and Construction	CO_2	5	5
	CH_4	5	5
	N_2O	5	5
1.A.3.a - Civil Aviation - Liquid Fuels	CO_2	7.07	5.90
	CH_4	7.07	141.42
	N_2O	7.07	212.13
1.A.3.b - Road Transportation - Liquid Fuels	CO_2	5	3.07
	CH_4	5	244.69
	N_2O	5	209.94
1.A.4 - Other Sectors - Liquid Fuels	CO_2	11.18	13.72
	CH_4	11.18	447.21
	N_2O	11.18	525.18
1.A.4 - Other Sectors - Solid Fuels	CO_2	8.66	21.58
	CH_4	8.66	346.41
	N_2O	8.66	382.35
1.A.4 - Other Sectors - Biomass	CO_2	8.66	32.38
	CH_4	8.66	393.65
	N_2O	8.66	515.68
1.B.1 - Solid Fuels	CO_2	5	0
1.B.1 - Solid Fuels	CH_4	7.07	0

1.7 GHG emissions from combustion activities

1 A Fuel Combustion Activities

In Ethiopia the main driver to the GHG emissions from energy sector is Fuelwood combustion mainly in the Residential Sector.

1.7.1 1 A 1 Energy Industries

Emissions from production of electricity from small diesel thermal power plants and charcoal production are reported in this section. The manufacture of charcoal dominated the emissions over the whole time series. The trend indicates a gradual increase in total GHG emissions from energy industries from 1990 to 2006 followed by a sharp increase from 2007 to 2009. In 2010 there was a sharp decline followed by a gradual increase up to 2019 though marked by slight decline in 2012, 2013 and 2015 with a spike in 2014. The increase from 1990 to 2019 level was around 48% Figure *1-3*).

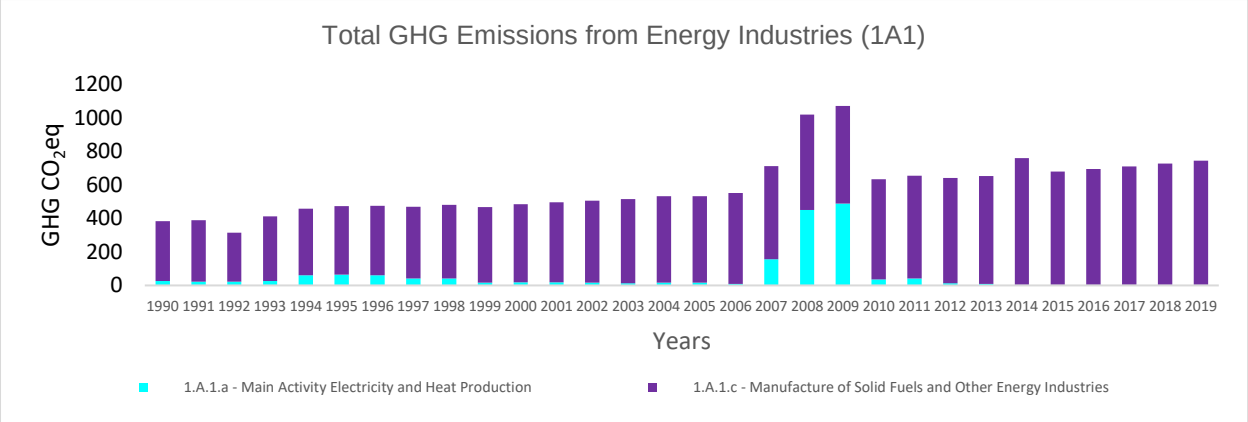

Figure 1-3: GHG emissions from electricity and charcoal production

1.7.1.1 Main Activity Electricity and Heat Production (1 A 1 a)

Ethiopia's electricity is dominated by hydro. Small thermal power plants that exist in regional centres are mainly powered by diesel.

a. Methodological issues

The 2006 IPCC guidelines Tier 1 methodology was used following decision tree in Figure 2.1 in Chapter 2, Volume 2 of the 2006 IPCC guidelines (IPCC, 2006).

b. Activity data

Table 1-8: Activity data for production of electricity from diesel

1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
344	301	301	344	817	860	817	559	559	215	258	258	215	172	215

2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
129	129	2107	6063	6579	473	559	172	129	43	43	43	43	43	54.524

Source; (UNSD, 2021)

c. Emission Factors

Table 1-9: Emission Factors for production of electricity from diesel

Gas	CO_2	CH_4	N_2O	Comment
Emission factor	74100kg/TJ	3kg/TJ	0.6kg/TJ	Default emission factor was applied

d. Category-specific Recalculations

There were no recalculations since these GHG emissions were not reported in the last GHG inventory.

1 A 1 b Petroleum Refining

Ethiopia has no Petroleum Refining Industry; hence source category is Not Occurring.

1.7.1.2 Manufacture of Solid Fuels and Other Energy Industries (1 A 1 c)

This section covers combustion emissions from fuel use during the manufacture of secondary and tertiary products from solid fuels including production of charcoal. Charcoal production is the only source occurring in Ethiopia.

1.7.1.3 Manufacture of Solid Fuels (1 A 1 c i)

Emissions arising from fuel combustion for the production of coke, brown coal briquettes and patent fuel are not occurring in Ethiopia.

1.7.1.4 Other Energy Industries (1 A 1 c ii)

The GHG emissions reported in this section were from own-energy use for the production of charcoal, comprising CH_4 and N_2O. There has been a steady rise in CH_4 and N_2O emissions from fuelwood combustion in charcoal production. The GHG emissions from the manufacture of solid fuels and other energy industries in 1990 up to 2013 were steadily increasing from 350GgCO_2eq to around 600GgCO_2eq. In 2014 there was a slight jump in emissions. The trend then continued on a steady increase to 2019. The change in emissions from the base year (1990) levels to 2019 levels represents about 51% increase (Figure *1-4*).

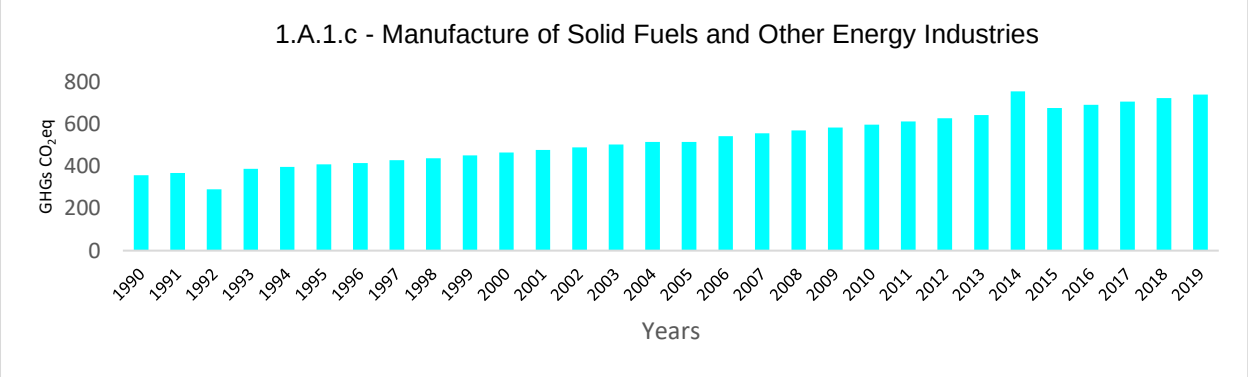

Figure 1-4: GHG emissions from charcoal production

a. Methodological issues

The 2006 IPCC guidelines Tier 1 methodology was used following decision tree Figure 2.1 in Chapter 2, Volume 2 of the 2006 IPCC guidelines.

b. Activity data

Table 1-10: Activity data for Manufacture of charcoal

Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Charcoal (Gg)	2237.024	2296.032	2356.596	2418.758	2482.56	2554.86	2593.35	2677.3	2737.98	2821.94	2908.49	2983.54	3060.54	3139.52	3220.54

Fuel	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Charcoal (Gg)	3304	3386	3470	3555.7	3643.9	3734.3	3826.6	3921.3	4018.3	4717.7	4219.5	4316.6	4416.1	4517.7	4621.7

Source; (UNSD, 2021)

c. Emission Factors

Table 1-11: Emission Factors for Manufacture of charcoal

Emission factor	CO_2	CH_4	N_2O	Source	Comment
Charcoal	11200	200	4	IPCC Default, T1	Default emission factor was applied

1A1 QA/QC and verification

Activity data on charcoal consumed were obtained from the United Nations Statistical Division (UNSD) website (UNSD, 2021). The calculation was done in excel to cross check if data was correctly entered in the software for computation.

1.7.1.5 Manufacturing Industries and Construction (MIC) (1 A 2).

GHG emissions from fuel combustion in MIC (1A2) are reported in this section. Fuel combustion data were obtained from the UNSD website (UNSD, 2021)on energy use in Manufacturing Industry. GHG emissions from this source category were calculated as an aggregate total.

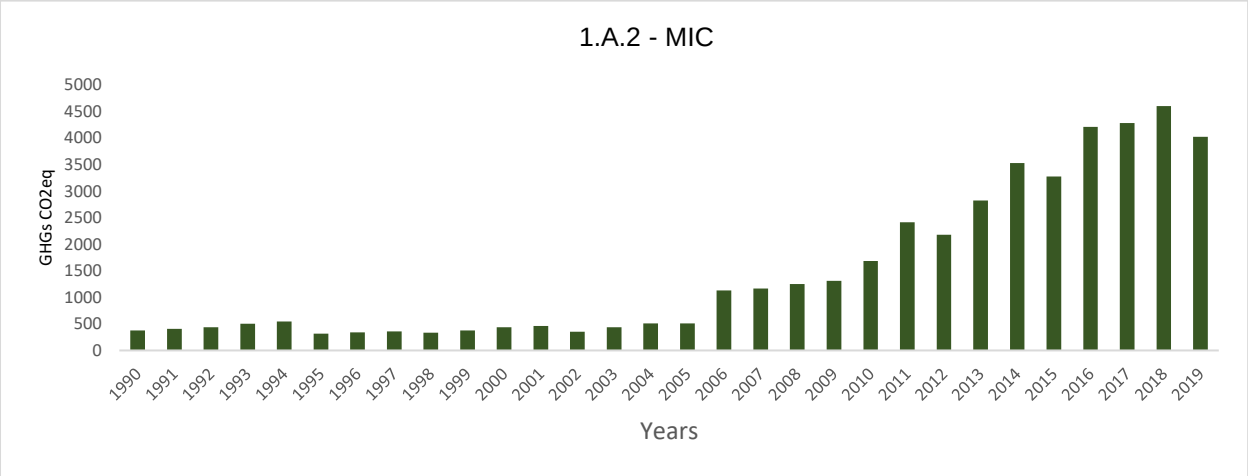

Figure 1-5: Aggregated emissions from MIC

Since 1990 the GHG emissions from the MIC had been gradually increasing up to 2005. In 2006 a slight jump in emissions followed by a slightly sharp increase and decrease in 2019. From 1990 to 2019 the increase in emissions was around 90%. Increased industrial and construction activity was responsible for this increase.

a. Methodological issues

The 2006 IPCC guidelines Tier 1 methodology was used following decision tree Figure 2.1 in Chapter 2, Volume 2 of the 2006 IPCC guidelines.

b. Activity data

Data on fuel consumption could not be obtained locally, hence UNSD (UNSD, 2021)was used as the main data source.

Table 1-12: Manufacturing Industries and Construction Activity Data

Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Gas Oil/Diesel Oil (Gg)	47.8953	53.217	59.13	65.7	73	82	95	104	117	121	136	169	178	191	216
Fuel Oil (Gg)	70	72	75	90	97	98	105	110	103	115	134	140	107	135	162
Bagasse (Gg)	600	525	537	603	310	422	560	561	563	765	712	889	827	850	946

Fuel	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Gas Oil/Diesel Oil (Gg)	201	219	244	251	260	271	289	324	382	422	454	558	631	837	906.321
Fuel Oil (Gg)	169	130	117	107	96	111	124	119	128	67	37	42	55	60.095	0
Petroleum Coke (Gg)				17	17	103	208	62	144	297	211	307	199	212	0
Other Bituminous Coal (Gg)				15	42	50	170	225	291	405	411	526	582	420	454.785

Bagasse(Gg)	1001	1046	924	913	854	818	945	811	1116	1216	1071	1092	1095	1095	0

Source; (UNSD, 2021)

c. Emission Factors

Default emission factors were applied and these were obtained from table 2.2 of Chapter 2, Volume 2 of the 2006 IPCC Guidelines.

Table 1-13: MIC Emission Factors

Emission factor	CO_2	CH_4	N_2O	Source	Comment
Fuel Oil (kg/TJ)	77,400	3	0.6	IPCC Default, T1	Default emission factor was applied
Petroleum Coke (kg/TJ)	97,500	3	0.6		
Bagasse (kg/TJ)	100,000	30	4		

d. Planned Improvements in Energy industries

- Future inventories will include GHG emissions reported by industry type, hence disaggregate data by industry type will be collected.

1.7.1.6 Transport-1 A 3

GHG emissions from Civil Aviation (1A3a) and Road Transport (1A3b) are reported in this section. Road transport is by far the major contributor of GHG emissions in the whole time series. GHG emissions from Road have been growing rapidly from 2009. Total GHG emissions from transport were increasing gradually from 1990 to 2019. The change in emission levels from 1990 to 2019 was about 88% increase. The rapid growth in the road transport activities as a result of increased industrial activity was responsible for this increase.

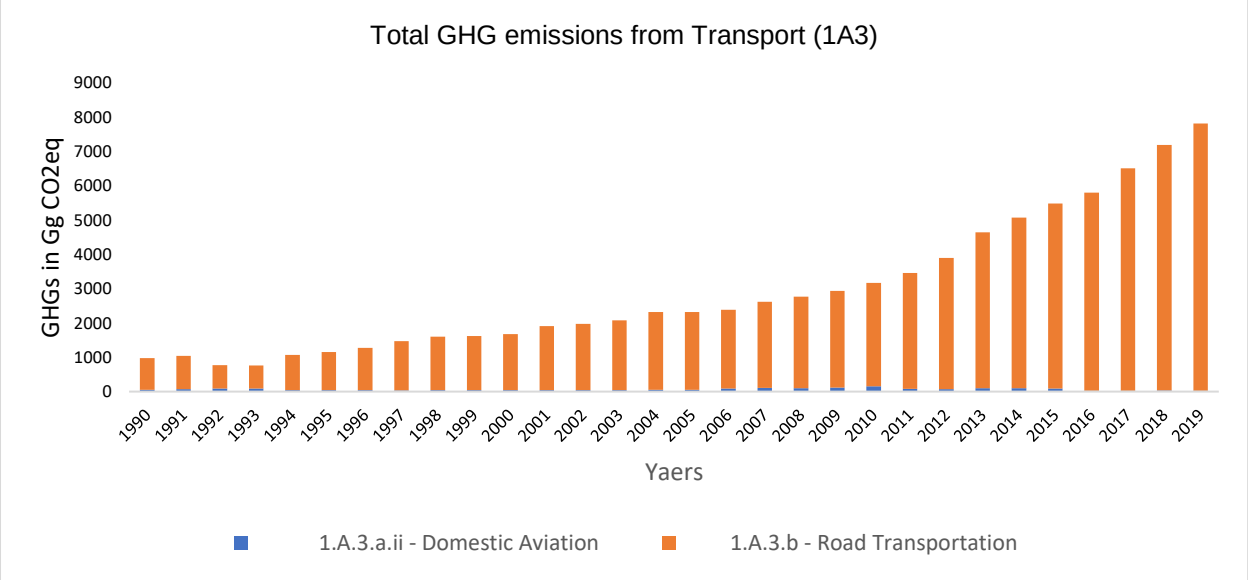

Figure 1-6: Total emissions from transport

1.7.1.7 1 A 3 a Civil Aviation

Emissions from fuel combustion from local aeroplanes were estimated. Emissions from the use of fuel at airports were not reported due to lack of disaggregated data.

a. Methodological issues

Data and emission factors could not be obtained locally. Hence, the 2006 IPCC guidelines Tier 1 methodology was employed following decision tree Figure 3.6.1 and equation number 3.6.1.

b. Activity data

Activity data were obtained from the UNSD (UNSD, 2021)covering the years 1990 to 2019.

c. Emission Factors

Default Emission factors were used as provided in table 3.6.4 Chapter 3, Volume 2 of the 2006 IPCC Guidelines.

1.7.1.8 International (International Bunkers) (1. A.3.a. i) and Domestic Aviation (1.A.3.a.ii)

Emissions from International Aviation were not added to the National total but are only reported as Memo Items. These emissions have been growing in recent years owing to increased activity in the sector. Emissions from international aviation depicts a slight increase from 1990 up to 2005. In 2006 up to 2019 there was a slightly sharp increase in emissions. The change in emissions from the 1990 level to 2019 level represents about 92% increase. There has been a surge in the international aviation activities resulting in the corresponding increase in emissions from the sector. This is shown in (Figure *1-7*)

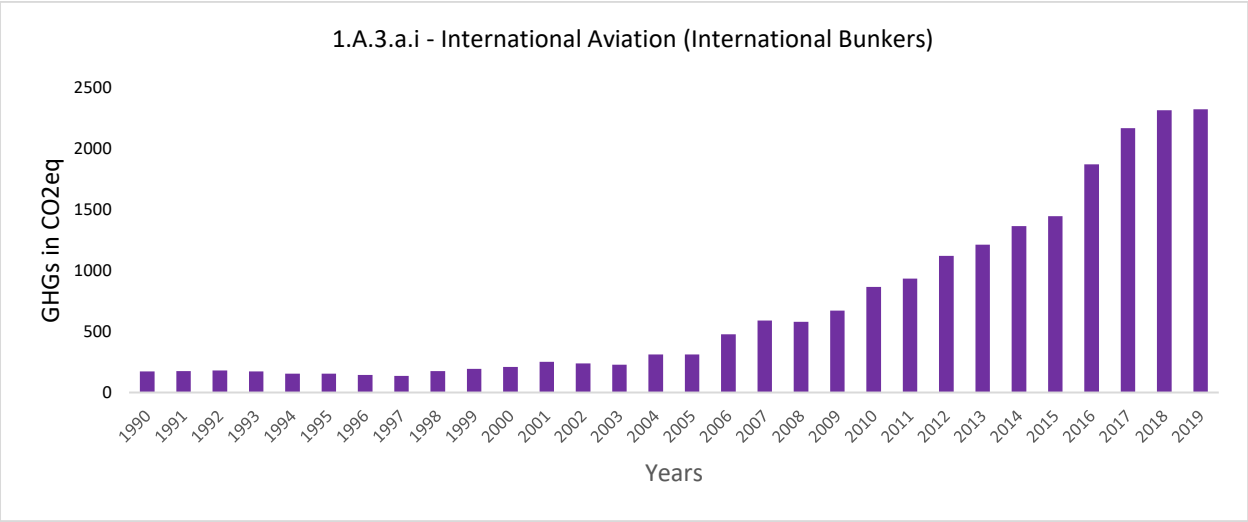

Figure 1-7: GHG emissions from international aviation

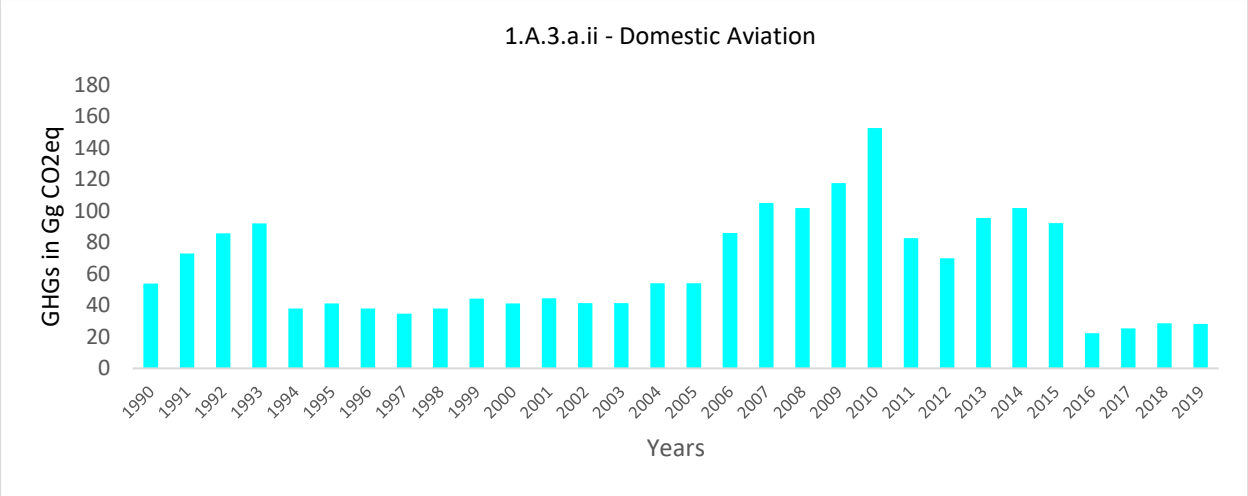

Figure 1-8: GHG emissions from domestic aviation

The trend of GHG emissions from domestic aviation was fluctuating since 1990 up to 2019. The 2019 emissions levels represent a 44% decline in emissions from 1990 levels. There has been a decline in the domestic aviation since 1990 up to 2019 resulting in the corresponding decline in emissions from this sector.

a. Methodological issues

Data and emission factors could not be obtained locally. Hence, the 2006 IPCC guidelines methodology was employed following decision tree Figure 3.6.1 and equation number 3.6.1.

b. Activity data

Activity data were obtained from the UNSD (UNSD, 2021) since it could not be obtained locally.

Table 1-14: International Aviation (International Bunkers) Activity Data

Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Jet Kerosene (kt)	54	55	57	54	48	48	44	42	54	60	65	79	75	72	98
Aviation Gasoline (kt)	0	0	0	0	1	1	1	1	1	1	1	1			

Fuel	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Jet Kerosene (kt)	124	150	186	182	211	272	294	352	381	429	455	588	682	728	0
Aviation Gasoline (kt)															

Table 1-15: Domestic Aviation Activity Data

Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Aviation Gasoline (Gg)	3	3	3	4	4	4	4	4	3	3	2				
Jet Kerosene (Gg)	14	20	24	25	8	9	8	7	9	11	11	14	13	13	17

Fuel	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Aviation Gasoline (Gg)															
Jet Kerosene (Gg)	22	27	33	32	37	48	26	22	30	32	29	7	8	9	8.848

Source: (UNSD, 2021)

c. Emission Factors

The 2006 IPCC guidelines default emission factors obtained from Table 3.6.4 and 3.6.5 in Chapter 3 of Volume 2 were used.

Table 1-16: Civil Aviation Emission factors

Emission factor	CO_2	CH_4	N_2O	Source	Comment
Aviation Gasoline (kg/TJ),	70,000	0.5	2	IPCC Default, T1	Default emission factor was applied
Jet Kerosene (kg/TJ)	71,500	0.5	2		

d. Planned Improvements in Energy industries

- There is need to collect fuel consumption data on International Aviation from Ethiopian Airlines including quantities of fuel, type of aeroplane, number of Landings and take Offs (LTOs)
- Calculate GHG emissions from International Aviation using locally collected data parameters

1.7.1.9 Road Transportation (1 A 3 b)

Road Transportation GHG emissions in Ethiopia arise from the combustion of Gasoline, and Diesel. The GHG emissions cover the time series from 1990 to 2019. There has been a steady rise in the emissions from around 1,000GgCO_2eq in 1990 to over 7,000Gg CO_2eq in 2019.

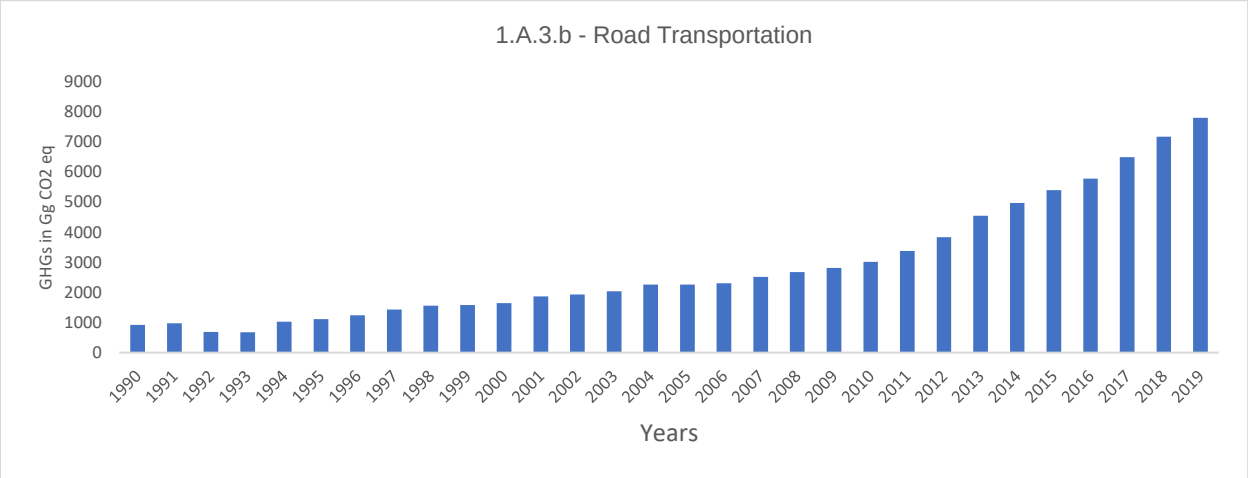

Figure 1-9: GHG emissions from Road Transportation

GHG emissions from transport were increasing gradually from 1990 to 2019. The change in emission levels from the 1990 to 2019 was about 88% increase. The rising activity in the transport sector was the cause of the increase of GHG from 1990 to 2019.

a. Methodological issues

The methodology was limited to the 2006 IPCC guidelines default methodology as provided in section 3.2.1 and equations 3.2.1 for CO_2, as well as 3.2.3 for CH_4 and N_2O. Fuel consumption data could only be obtained as total quantity consumed per type of fuel, and not disaggregated by type of vehicle. CO_2 from Bio gasoline was not added to the national total since it is biogenic, but CH_4 and N_2O emission were added. The CO_2 emissions from Bio gasoline were added to the Memo Items.

b. Activity data

For the times series 1990 to 2019 data for diesel and gasoline covering the whole time series was obtained from UNSD (UNSD, 2021). Bio gasoline use was reported from 2008 to 2019.

Table 1-17: Road Transportation Activity Data

Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Gas/Diesel Oil (Gg)	175	178	83	81	188	211	242	267	300	311	346	431	454	488	552
Biogasoline Gg)															
Motor Gasoline (Gg)	112	125	132	130	134	135	144	180	187	180	164	148	145	143	150

Fuel	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Gas/Diesel Oil (Gg)	514	561	624	643	666	694	740	830	978	1081	1163	1431	1575	1757	1902.179
Biogasoline (Gg)				1	4	5	7	5	7	8	6	5	5	6	
Motor Gasoline (Gg)	162	152	154	185	208	242	310	361	436	465	515.74	361	436	465	515.74

Source: (UNSD, 2021)

c. Emission Factors

Default Emission Factors for Gasoline, Diesel and Bio gasoline use in Road Transportation were obtained from table 3.2.1 (CO_2) while N_2O and CH_4 emission factors were obtained from table 3.3.2 of the 2006 IPCC Guidelines. Decision tree figure 3.2.2 for CO_2 and 3.2.3 for CH_4 and N_2O emissions.

Table 1-18: Road Transportation Emission Factors

Emission factor	CO_2	CH_4	N_2O	Source	Comment
Gas/Diesel Oil (kg/TJ)	74,100	3.9	3.9	IPCC Default, T1	Default emission factor was applied
Biogasoline (kg/TJ)	70,800	3	0.6		
Motor Gasoline (kg/TJ)	69,300	33	3.2		

d. Time series consistency

GHG emissions for the whole times series in the current Inventory were calculated using data obtained from UNSD (UNSD, 2021) and using the IPCC Tier 1 default methodology.

e. Category-specific QA/QC and Verification

The GHG emissions from Road Transportation were calculated for the whole time series from 1990 to 2019 with data obtained from UNSD (UNSD, 2021). In the earlier inventories top-down approaches were being employed. In the current inventory the sectoral approach was used for calculation of GHG emissions with the reference approach being used as a quality control check.

f. Planned Improvements

- Investigate the quantities of Bio gasoline consumed in Road transportation in order to explain the gaps for the period 1990 to 2007 as well as reasons for the gaps recorded.
- There is need to avail complete data suitable for higher tier methodologies in calculating GHG emissions.

1.7.1.10 Evaporative Emissions from Vehicles (1 A 3 b v)

Evaporative emissions from vehicles (e.g. hot soak, running losses) were not estimated due to lack of activity data.

GHG emissions from the following source categories were not reported since they do not occur in Ethiopia

- 1 A 3 c Railways
- 1 A 3 d Water-borne Navigation
- 1 A 3 d i International Water-borne Navigation (International Bunkers)

1.7.1.11 Domestic Water-borne Navigation (1 A 3 d ii)

Emissions from fuels used by vessels in local inland water bodies were not estimated due to lack of data.

a. Planned Improvements in Energy industries

Collect data on fuel used in local water vessels and report GHG emissions for the whole time series.

Emissions from 1 A 3 e Other Transportation, 1 A 3 e i Pipeline Transport and 1 A 3 e ii Off-road do not occur in Ethiopia

1.7.1.12 Other Sectors (1 A 4)

Emissions from commercial institutions, residential, as well agriculture, forestry and fishing are reported in this section. The emissions also include combustion for the generation of electricity and heat for own use in these sectors. The residential sector (1.A.4.b) is, by far, the main contributor owing to the CH_4 emission from combustion of fuelwood and charcoal. This is shown in (Figure *1-10*)

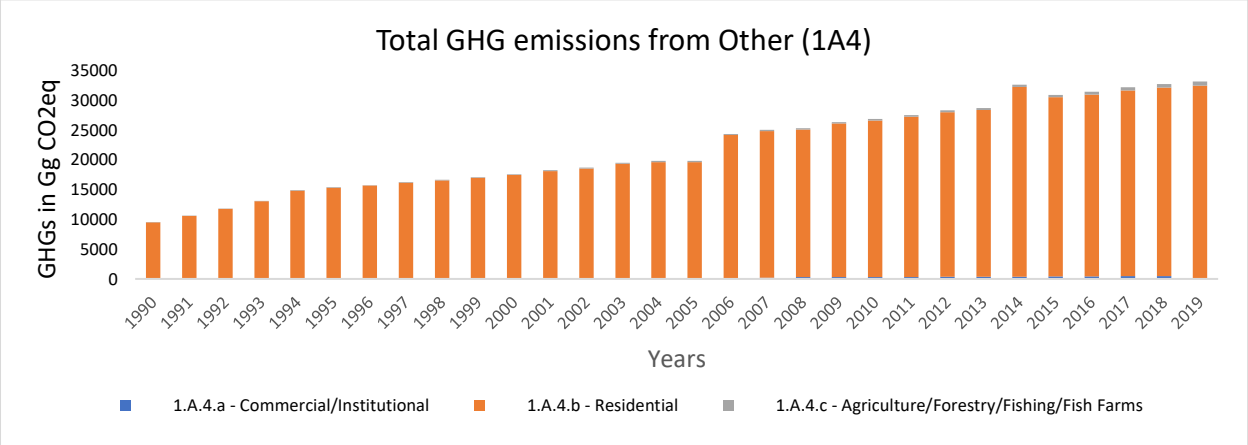

Figure 1-10: Total GHG emissions from other sectors

Total GHG emissions from other sectors were increasing gradually from 1990 to 2019. The change in emission levels from the 1990 level to 2019 level was about 70% increase. The increase in population translate to increase in residential activities thus causing an increase in GHG emissions from this sector.

1.7.1.13 Commercial/Institutional (1 A 4 a)

GHG emissions from fuel combustion in the Commercial and Institutional sectors are reported in this section. The dominant energy source used is Fuelwood followed by charcoal, although Charcoal had been declining steadily since 2015. Use of Diesel has been increasing.

a. Methodological issues

The 2006 IPCC guidelines Tier 1 methodology was used in calculating GHG emissions in Commercial and Institutional sectors following the application of Decision Tree Figure 2.1 and equation 2.1 in Chapter 2 of Volume 2.

b. Activity data

Activity data on mainly three fuels, Fuelwood, Charcoal and Diesel use were obtained from the UNSD website (UNSD, 2021).

Table 1-19: Commercial/Institutional Activity Data

Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Gas/Diesel Oil (Gg)	0	0	0	0	8	9	11	12	13	14	15	19	20	22	25

Fuel	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Gas/Diesel Oil (Gg)	23	25	28	29	30	31	33	37	44	49	53	65	71	76	0
Fuelwood (Gg)		791	808.43	845.98	884.84	925.5	968	1009.3	1050.9	1080.68	1134.54	1176.25	1213.03	1245.21	1150.801
Charcoal (Gg)			69.44	196	87	113	117	121	120	123	27	27	19	19	0
Bagasse (Gg)				10364	10745	11846	11846	11846	11846	11846	11846	11846	11846	11846	0

Source: (UNSD, 2021)

c. Emission Factors

The emission factors were obtained from the IPCC guidelines.

Table 1-20: Commercial/Institutional Emission Factors

Emission factor	CO_2	CH_4	N_2O	Source	Comment
Gas/Diesel Oil (kg/TJ)	74,100	10	0.6	IPCC Default, T1	Default emission factor was applied
Fuelwood (kg/TJ)	112,000	300	4		

1.7.1.14 Residential (1 A 4 b)

The dominant fuel in residential areas in Ethiopia is Fuelwood, followed by Charcoal. There is also use of LPG and other Kerosene in the Residential sector.

a. Methodological issues

The 2006 IPCC Tier 1 default methodology was used following equation 2.1 and Decision tree figure 2.1.

b. Activity data

The National Institutions could not avail data, hence all the data for the source category were obtained from the UNSD (UNSD, 2021) for the whole Time Series.

Table 1-21: Residential Activity data

Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Liquefied Petroleum Gases (Gg)	0	5	5	5	1	2	2	2	2	1
Other Kerosene (Gg)	5	5	4	4	110	130	155	169	159	153
Charcoal (Gg)	47088.8514	52320.94601	58134.38445	64593.7605	71770.845	73860.92	74973.66	77400.625	79154.99	81582.25
Other Primary Solid Biomass (TJ)	426202.56	473558.4	526176	584640	649600	667000	683669.2	699398.8	720696.4	737992

Fuel	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Liquefied Petroleum Gases(Gg)	1	1	1	2	0	0	0	0	6	8
Other Kerosene (kGg)	162	226	232	329	280	230	243	266	272	257

Charcoal (Gg)	84084.44	86254.755	88302.35	90763.535	93105.835	95518.64	97889.26	100314.75	99108.2	104925.6
Other Primary Solid Biomass (TJ)	755705.2	773847.6	792430.8	810573.2	829133.2	848122.4	1350089.2	1380736.4	1417566.4	1455405.6

Fuel	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Liquefied Petroleum Gases (Gg)	8	5	5	7	7	7	8	5	5	
Other Kerosene (Gg)	239	237	269	257	405	261	164	75	77	0
Charcoal (GG)	106825.99	109433.2	112107.965	112641.915	135545.715	123683.765	126571.815	129713.565	132711.65	137095.7053
Other Primary Solid Biomass TJ)	1494265.6	1534169.6	1573377.6	1612759.6	1652304	1694829.6	1737761.2	1810267	1819541.2	1865387.708

Source: (UNSD, 2021)

c. Emission Factors

The IPCC Default Emission factors were used obtained from table 2.2 form Volume 2, since there were no country specific Emission Factors. The selected emission factors are presented in Table 1-22.

Table 1-22: Residential Emission Factors

Emission factor	CO_2	CH_4	N_2O	Source	Comment
Liquefied Petroleum gas (kg/TJ)	63,100	1	0.1	IPCC Default, T1	Default emission factor was applied
Other kerosene (kg/TJ)	71,900	3	0.6		
Fuel wood (kg/TJ)	112,000	30	4		
Charcoal 9kg/TJ)	112,000	200	4		
Other Vegetal Material and Residues (kg/TJ)	100,000	30	4		

d. Time series consistency

Emissions from the whole time series were calculated using data that were obtained from UNSD (UNSD, 2021) and the 2006 Tier 1 default methodology.

1.7.1.15 Agriculture, Forestry and Fishing-1 A 4 c

This section reports GHG emissions from the combustion of Diesel in Agriculture, Forestry, Fishing, fish farms and related activities. In the current Inventory, the fuels recorded to be used in this sector are diesel and motor gasoline.

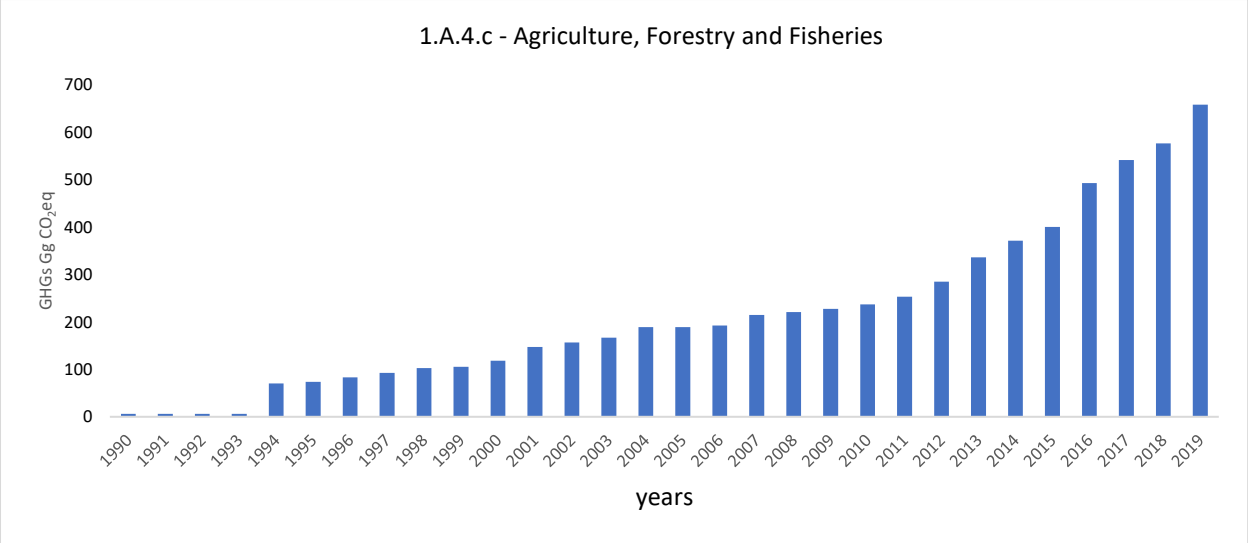

Figure 1-11: Total GHG emissions from Agriculture/Forestry/Fishing/Fish Farms

From 1990 to 1993 there were no significant changes in emissions. In 1994 the emissions started to increase significantly up to 2019. The 2019 emissions level represents about 99% increase from the 1990 emissions level. The rising agriculture/forestry/fishing activities were responsible for the increase in GHG emissions since 1990.

a. Methodological issues

There were no country specific Emission Factors hence the 2006 IPCC Tier 1 default methodology was employed. Decision tree in Figure 2.1 as well as equation 2.1 for Tier 1 approach were used.

b. Activity data

The Activity data for diesel obtained from UNSD (UNSD, 2021) website covered the years 1994 to 2018.

Table 1-23: Agriculture/Forestry/Fishing/Fish Farms Activity Data

Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Gas/Diesel Oil (Gg)					20	23	26	29	32	33	37	46	49	52	59
Motor Gasoline (Gg)	2	2	2	2	2										

Fuel	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Gas/Diesel Oil (Gg)	55	60	67	69	71	74	79	89	105	116	125	154	169	180	
Motor Gasoline (Gg)															

Source: (UNSD, 2021)

c. Emission Factors

Default emission factors were obtained from the 2006 IPCC guidelines Volume 2 table 2.2

Table 1-24: Agriculture Forestry and Fisheries Emission Factors

Emission factor	CO_2	CH_4	N_2O	Source	Comment
Gas/Diesel Oil (kg/TJ)	74,100	10	0.6	IPCC Default, T1	Default emission factor was applied
Liquefied Petroleum Gas (kg/TJ)	63,100	1	0.1		
Charcoal (kg/TJ)	112,000	200	1		

1.7.1.16 Stationary-1.A.4.c.i

Emissions from combustion of charcoal, diesel and LPG were reported.

a. Methodological issues

Default methodology that is Tier 1 in the 2006 IPCC guidelines was used owing to lack of Country specific emission factors.

b. Activity data

Activity data obtained from the UNSD website (UNSD, 2021) had missing charcoal figures for the period 1990 to 1993. These will be investigated. Data on Diesel covered the whole time series.

Table 1-25: Stationary Activity Data

Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Liquefied Petroleum Gases (Gg)	5	5	5	5	1	2	2	2	3	1	1	1	1	2	2.6
Gas/Diesel Oil (Gg)	45.80184	51.46274	57.8233	64.97	73	82	95	104	117	141	136	169	178	191	216
Charcoal (Gg)	-	-	-	-	49.65	51.1	51.87	53.45	54.76	56.44	58.17	59.67	61.21	62.79	64.41

Fuel	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Liquefied Petroleum Gases (Gg)	3.38	4.394	5.7122	6	8	8	5	5	7	7	7	8	5	5	0
Gas/Diesel Oil (Gg)	201	219	244	251	260	271	289	324	382	422	454	558	611	653	0
Charcoal (Gg)	66.08	67.72													

Source: (UNSD, 2021)

1 A 5 Non-Specified

The emissions from unspecified processes were increasing gradually since 1990 up to 2018. In 2019 there was a sudden decline in the emissions. The change represents about 41% increase in emissions, however the emissions from stationery process decreased by almost 100% (Figure *1-12*). Non-specified activities increase was the main cause for the increase in GHG emissions.

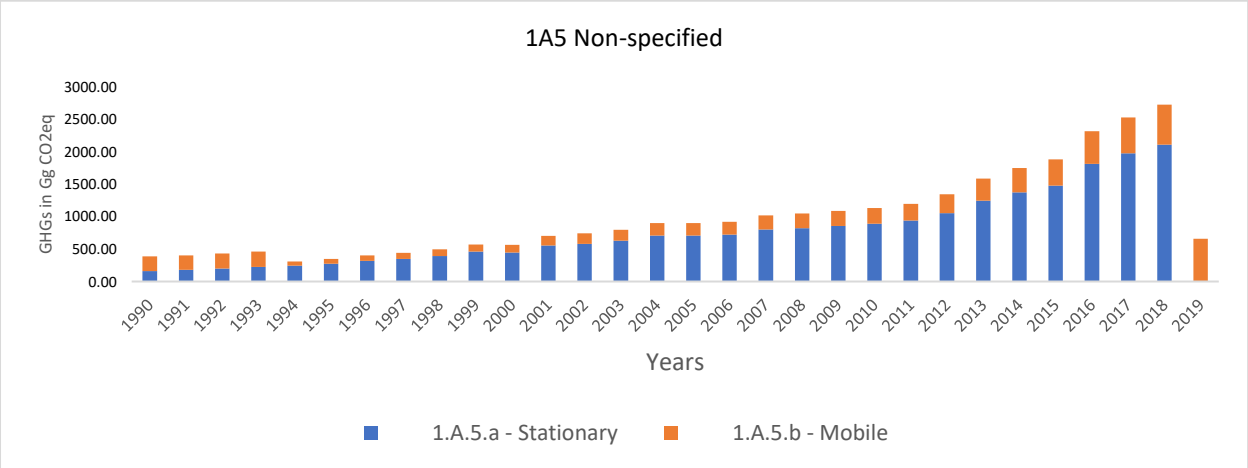

Figure 1-12: Time series from unspecified

1.7.1.17 Mobile1 A 5 b

Emissions from vehicles and other machinery, marine and aviation that could not be allocated not included in 1 A 4 c ii or elsewhere, were reported under this category.

a. Methodological issues

The Default methodology as provided in the 2006 IPCC guidelines was used. Country specific emission factors were not in place.

b. Activity data

Activity data obtained from the UNSD website (UNSD, 2021) had Diesel figures for the period 1990 to 2019.

Table 1-26: Mobile (Other) Activity data

Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Gas/Diesel Oil (Gg)	70	70	72	75	20	23	26	29	32	33	37	46	49	52	59

Fuel	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Gas/Diesel Oil (Gg)	55	60	67	69	71	74	79	89	105	116	125	154	170	190	205

Source: (UNSD, 2021)

c. Emission Factors

The Default emission factors for CO_2, CH_4 and N_2O were obtained from tables 3.2.1 and 3.2.2.

Table 1-27: Mobile (Other) Emission factors

Emission factor	CO_2	CH_4	N_2O	Source	Comment
Gas/Diesel Oil (kg/TJ)	74,100	3.9	3.9	IPCC Default, T1	Default emission factor was applied

d. Time series consistency

Data was obtained from UNSD (UNSD, 2021) and was applied for the whole time series as well as the 2006 IPCC Tier 1 default methodologies.

1.7.2 1 B Fugitive Emissions from Fuels

Includes all intentional and unintentional emissions from the extraction, processing, storage and transport of fuel to the point of final use.

1.7.2.1 Solid Fuels-1 B 1

Includes all intentional and unintentional emissions from the extraction, processing, storage and transport of fuel to the point of final use.

1.7.2.2 Coal Mining and Handling-1 B 1 a

Includes all fugitive emissions from coal.

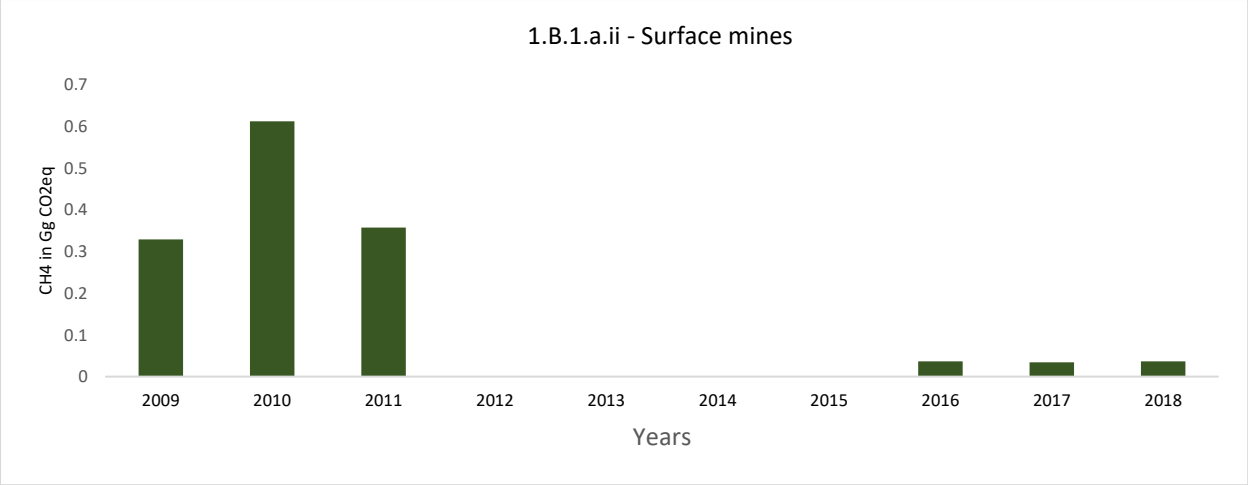

Figure 1-13: Total GHG emissions from Coal Mining and Handling (Surface Mines)

Generally, the GHG emissions declined sharply from 2009 to 2018 despite the 2010 and 2011 spikes. The 2018 levels represent around 88% decrease from the 2009 levels. This trend presents a decline in coal mining and handling activities over the years hence a decline in the GHG emissions from this sector.

a. Methodological issues

Default methodology as provided in the 2006 IPCC guidelines was applied. Country specific emission factors were not in place.

b. Activity data

Activity data were obtained from the UNSD website (UNSD, 2021) for the years 2009 to 2011 and 2016 to 2018.

Table 1-28: Activity Data for Coal Mining and Handling

Fuel	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Other Bituminous Coal (kt)	9	18	10.5	0 0	0		0	1	1	1	

Source; (UNSD, 2021)

c. Emission Factors

Default emission factors were applied obtained from the 2006 IPCC guidelines.

Table 1-29: Emission factors for Coal Mining and Handling

Emission factor	CO2	CH4	N2O	Source	Comment
Other Bituminous Coal		1.2		IPCC Default, T1	Default emission factor was applied

1.7.2.3 Underground Mines-1 B 1 a i

There is no underground coal mining in Ethiopia, the emissions were reported as not occurring.

1.7.2.4 Surface Mines-1 B 1 a ii

This section reports all seam gas emissions arising from surface coal mining. This covers methane emitted during mining from breakage of coal and associated strata and leakage

from the pit floor and high wall, as well as methane emitted after coal has been mined, subsequently processed, stored and transported.

1.7.2.5 Uncontrolled Combustion, and Burning Coal Dumps-1 B 1 b

The GHG includes fugitive emissions of CO_2 from uncontrolled combustion in coal were not reported due to lack of activity data.

1.7.2.6 1 B 2 b Natural Gas

Activity data on natural gas exploration could not be obtained, hence the emissions were not estimated.

1.7.3 1 C Carbon Dioxide Transport and Storage

Carbon Dioxide Transport and Storage does not occur in Ethiopia.

1.8 Comparisons between reporting years

Generally, percentage differences in the energy sector were significant ranging between over 100% to over 2000%, with a few negative differences in 1A1 and 1B and the transport sector giving 65.98% when comparing the TNC with the SNC. For the total emissions, highest emissions were recorded in the TNC. The difference between TNC and INC was 533%. There was, however, a noticeable gradual increase in the emissions from the INC. For 1A1, SNC and TNC comparisons gave a negative % difference of -56. Fugitive emissions (1B) and 1A4- Other Sectors were not reported in the INC (Table 1-30).

Table 1-30: Comparisons between inventory reporting years

Categories	INC 1994	SNC 2013	TNC 2017	INC/SNC % diff	INC/TNC %diff	TNC/SNC % Diff
1 - Energy	7289	21749.435	46176.91	198.39	533.52	112.31
1.A - Fuel Combustion Activities	1778.8	21738.779	46176.88	1122.10	2495.96	112.42
1.A.1 - Energy Industries	234	1650.4692	711.89	605.33	204.23	-56.87
1.A.2 - Manufacturing Industries and Construction	541.7	1492.4008	4276.4	175.50	689.44	186.55
1.A.3 - Transport	1003.1	3917.4783	6502.37	290.54	548.23	65.98
1.A.4 - Other Sectors		14678.431	32162.93			119.12
1.B - Fugitive Emissions from Fuels		10.656339	0.03			-99.72

1.9 Comparison between reference and sectoral approach

The Reference Approach was used to calculate the emissions of CO_2 from fuel combustion, from Source category 1A, Fuel Combustion. This is a key requirement for QA/QC under the energy sector. Calculations were done following Equation 6.1 from Section 6.3, Chapter 6 of Volume 2 of the 2006 IPCC Guidelines. The CO_2 emissions estimated by the reference approach were not included in the national total and used for verification purpose. The reference approach calculation should be based on country supplied data. However, energy supply data was not available and IEA data was used for reference approach. The CO_2 emissions from combustion, using a country's energy supply data.

The apparent energy consumptions *A* are estimated by the following formula:

Apparent Consumption = (Production) + (Imports) – (Exports) - (Stock change)– (International bunkers)

Equation 1-1: Equation for calculating apparent consumption

Source: (IPCC, 2006)

The net calorific values of the fuels, were taken from the 2006 IPCC Guidelines

1.9.1.1 Activity Data

Comparisons were only made for the period 2006 to 2018 owing to data constraints. Data for the Reference Approach was obtained from Ministry of Water, Irrigation and Electricity. Sectoral Approach data for the period 2006 to 2018 was obtained from the UNSD (UNSD, 2021). The UNSD energy database was used as the source for sectoral approach data owing to challenges in obtaining data from the Ministry of Water, Irrigation and Electricity, ministry of transport and other institutions involved in the energy industry.

Table 1-31: Activity Data for reference approach

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Coal	Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	Imports	0.00	0.01	6.03	14.71	24.93	24.79	141.00	224.42	291.39	404.67	411.29	526.22	511.64
0	Stock changes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LPG	Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	Imports	3.54	3.73	6.19	5.91	7.65	84.10	5.45	0.00	7.23	7.28	7.20	8.30	4.74
0	Stock changes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gasoline	Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	Imports	137.23	148.37	138.97	149.95	155.76	143.88	0.13	193.03	211.60	237.77	308.04	366.65	441.54
0	Stock changes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-6.54	-0.72	0.00	0.30	1.26	0.58
Kerosine	Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	Imports	368.67	411.36	482.22	505.70	529.79	320.44	535.30	613.74	700.74	712.75	735.35	820.61	738.11
0	Stock changes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00
Kerosine Other	Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	Imports	0.00	0.00	0.00	0.00	0.00	228.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	Stock changes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	-2.61	-6.46	-6.46	3.62	2.55
Diesel	Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	Imports	811.01	925.39	1072.79	1202.99	1237.08	1182.73	1206.22	1322.55	1558.34	1703.26	1930.54	2235.30	2507.67
0	Stock changes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-34.06	8.96	-18.48	-18.48	4.13	9.24
LFO	Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	Imports	41.39	42.41	49.61	36.37	10.70	35.76	36.49	37.42	37.13	40.64	35.96	41.61	35.79
0	Stock changes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-219.79	0.00	-1.26	-1.26	0.02	0.01
HFO	Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	Imports	116.82	116.44	137.68	116.33	100.87	95.63	107.96	122.88	115.00	127.67	71.08	37.58	47.48
0	Stock changes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pet Coke	Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	Imports	0.00	0.00	5.80	16.50	16.71	102.86	208.30	62.25	143.66	297.10	210.53	306.70	179.88
0	Stock changes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: (Ministry of Water, 2019)

1.9.1.2 Results of the Comparison

The results of the comparisons show significant differences between the Reference and Sectoral approaches from 2006 to 2018 as presented in Table 1-32. Comparisons for 2017, the reporting year, indicated that positive differences were obtained for CO_2 emissions for jet kerosine, residual fuel oil and lignite. Negative differences in 2017 were recorded for motor gasoline, gas/diesel oil, jet kerosene, LPG, other kerosene and petroleum coke. Highest differences ranging from about 1000 to 2000% were obtained from jet kerosene, mainly as a result of aggregated data for domestic and international aviation data in the energy balances. There is, therefore, need to separate domestic and international bunker fuel data in the energy balances. The second highest differences were obtained from residual fuel oil for the years 2006 and 2009 while the least differences were obtained from motor gasoline and diesel. Differences for most fuels, notably LPG and petroleum coke are fluctuating while lignite and jet gasoline remain constant over time. Further details on the causes for the differences in other fuels will be investigated in order to improve inventory quality, and the information reported in the next inventory

Table 1-32: Percentage differences in CO_2 emissions between reference and sectoral approaches

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gas/Diesel Oil	-29.32	-30.09	-26.20	-20.42	-13.29	-22.33	-28.95	-32.17	-29.83	-27.54	-33.31	-30.91	-32.40
Jet Gasoline	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	100.00
Jet Kerosene	1265.44	1146.55	1406.94	-100.00	1003.73	1132.46	2333.18	1945.80	2089.81	2356.72	-100.00	1015 7.63	-100.00
Liquefied Petroleum Gases	-19.48	-34.39	50031.84	-63.08	-52.21	740.56	-45.53	-100.00	-98.91	-48.03	-99.05	-98.25	-52.63
Motor Gasoline	-9.72	-3.66	-24.88	-27.91	-35.64	-53.59	-62.67	-54.23	-54.34	-53.90	-14.75	-16.19	-5.17
Other Kerosene	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.78	-100.00	-97.53	-96.06	-104.82	-103.31
Petroleum Coke	0.00	0.00	-65.87	-2.91	-83.77	-50.53	236.08	-56.76	-51.61	40.85	-31.40	54.17	-15.12
Residual Fuel Oil	-803771.27	99.03	-209.91	-16234.37	0.47	5.91	21.34	196.82	689.11	358.10	157.72	29.34	38.49
Lignite	0.00	100.00	100.00	0.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

1.10 Precursor emissions from Energy sector

The emission factors were obtained from the EMEP/EEA Guidebook for 2019 for the calculation of CO, NO_x, Non-methane Volatile Organic compounds (NMVOCs) and Sulphur Dioxide (SO_2) (

References

EMEP/EEA, 2019. *European Environment Agency EMEP/EEA.* [Online]
Available at: https://www.eea.europa.eu/themes/air/air-pollution-sources-1/emep-eea-air-pollutant-emission-inventory-guidebook
[Accessed 24 April 2022].

FDRE, 2019. *Energy Efficiency Strategy for the Manufcaturing Sector,* Addis Ababa: FDRE.

IEA, 2019. *Country Profile.* [Online]
Available at: https://www.iea.org/countries/ethiopia
[Accessed 24 April 2022].

IEA, 2020. *IEA.* [Online].

IEA, 2022. *Country Profile.* [Online]
Available at: https://www.iea.org/countries/ethiopia
[Accessed 24 April 2022].

IPCC, 1995. *IPCC Second Assement Climate Change 1995,* s.l.: IPCC.

IPCC, 2006. *2006 IPCC Guidelines for Greenhouse Gas Inventories.* Hayama: Institute for Global Environmental Startegies.

Ministry of Water, I. a. E., 2019. *Energy Balance 2017/18,* Addis Ababa: Ministry of Water, Irrigation and Electricity.

UNSD, 2021. [Online].

2 Annexes

Annex *1*).

The precursors were mainly emitted from the combustion of biomass fuel from Residential (1.A.4.b). CO emissions were the highest, ranging from over 7000Gg in 1990 to a peak of over 28000 in 2018(Figure 2-1).

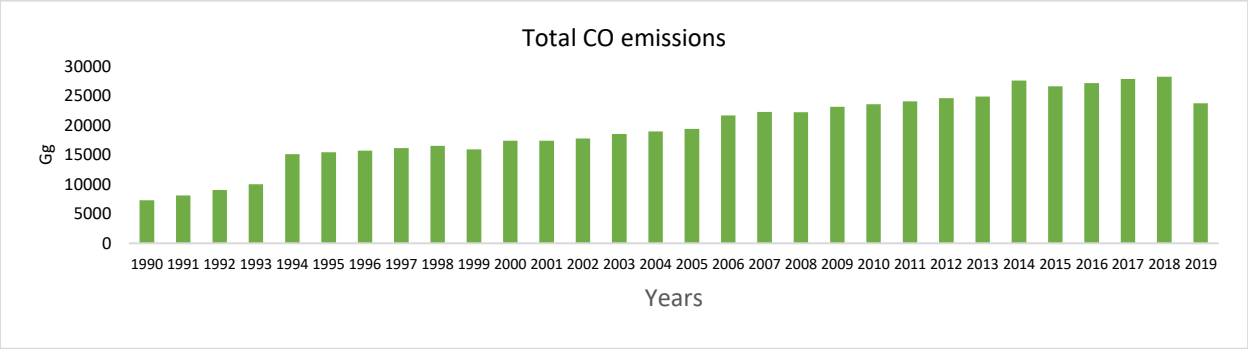

Figure 2-1: Total CO emissions from energy

The CO emissions were increasing gradually since 1990 though characterized by spikes in 2014 and 2018. In 2019 the emissions levels started to decline. The 2019 levels represent a 69% increase from the 1990 levels. This increase was a result of industrial, residential and agricultural activities fueled by rising population.

The NMVOCs were the second in terms of levels of emissions, after CO. The emissions ranged from around 1000Gg in 1990 to a peak of over 4200Gg in 2018 (Figure 2-2)

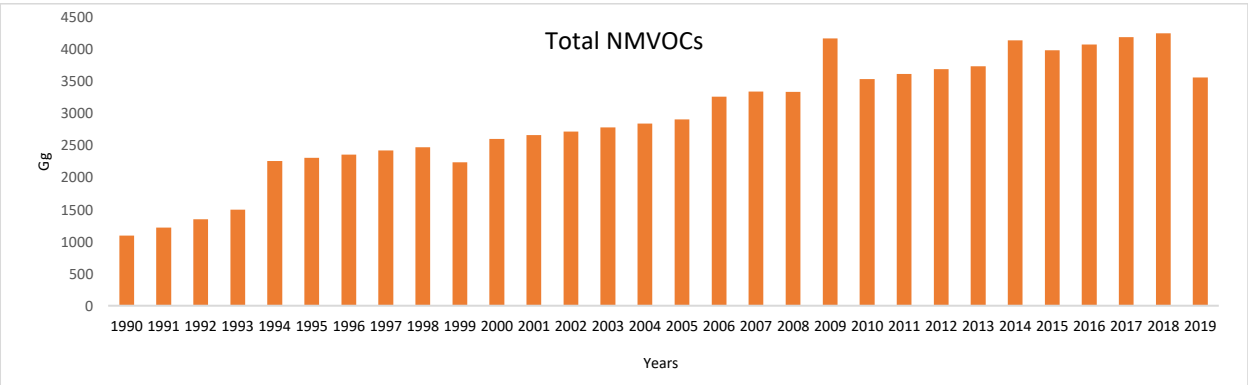

Figure 2-2: Total NMVOCs emissions from energy

The NMVOCs emissions were increasing gradually since 1990 though characterized by spikes in 2009 and 2014. In 2019 the emissions levels started to decline. The 2019 levels represent a 69% increase from the 1990 levels. The increase in energy activities due to rising population demand pushed the NMVOCs up.

The emissions of Sox and NO_x were the least in quantities. These are still in the below 150Gg for SO_x and 300Gg for SO_x.

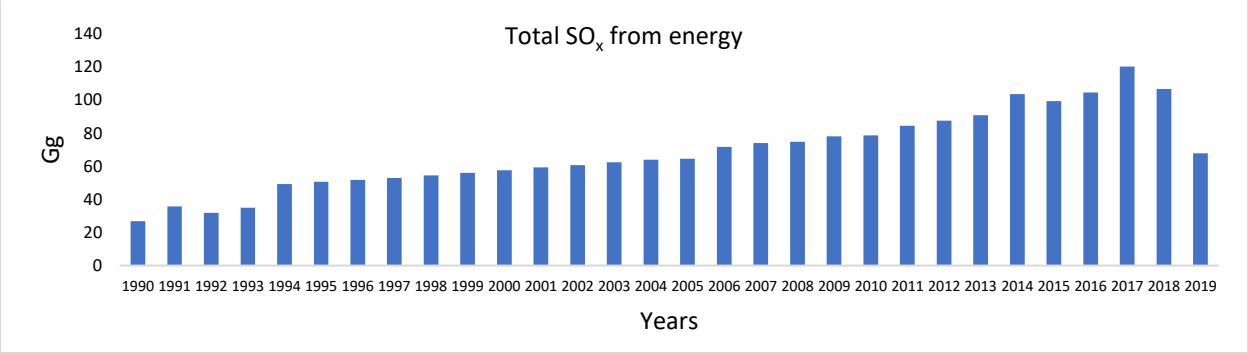

Figure 2-3: Total SO_x emissions from energy

SO_x emissions were increasing gradually since 1990 up to 2017 and in 2018 the emissions started to decline up to 2019. The 2019 levels represent a 61% increase from the 1990 levels. This trend is a result of increased industrial activity since 1990.

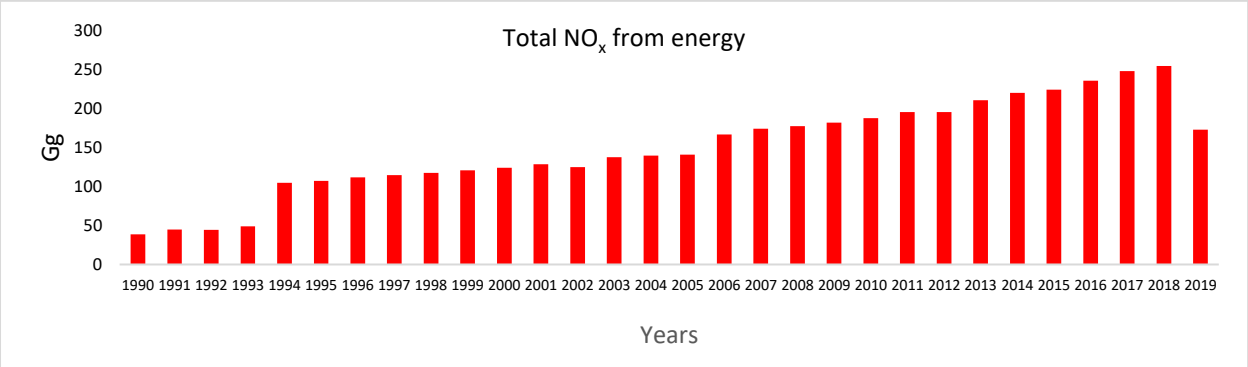

Figure 2-4: Total NO_x emissions from energy

Since 1990 the NOx emissions were increasing gradually up to 1993 followed by a sharp increase in 1994 and thereafter a gradual increase up to 2018. In 2019 the emissions levels declined sharply. The 2019 levels represent a 78% increase from the 1990 levels. This trend is a result of increased industrial activity since 1990.

3 References

EMEP/EEA, 2019. *European Environment Agency EMEP/EEA.* [Online]
Available at: https://www.eea.europa.eu/themes/air/air-pollution-sources-1/emep-eea-air-pollutant-emission-inventory-guidebook
[Accessed 24 April 2022].

FDRE, 2019. *Energy Efficiency Strategy for the Manufcaturing Sector,* Addis Ababa: FDRE.

IEA, 2019. *Country Profile.* [Online]
Available at: https://www.iea.org/countries/ethiopia
[Accessed 24 April 2022].

IEA, 2020. *IEA.* [Online].

IEA, 2022. *Country Profile.* [Online]
Available at: https://www.iea.org/countries/ethiopia
[Accessed 24 April 2022].

IPCC, 1995. *IPCC Second Assement Climate Change 1995,* s.l.: IPCC.

IPCC, 2006. *2006 IPCC Guidelines for Greenhouse Gas Inventories.* Hayama: Institute for Global Environmental Startegies.

Ministry of Water, I. a. E., 2019. *Energy Balance 2017/18,* Addis Ababa: Ministry of Water, Irrigation and Electricity.

UNSD, 2021. [Online].

4 Annexes

Annex 1: Emission factors for precursors

1. A.1.a Public electricity and heat production

Emission factor (g/GJ)	NOx	NMVOC	SOx	CO	Source
Diesel	65	0.8	46.5	16.2	(EMEP/EEA, 2019)
Other Bituminous coal	209	1.0	820	8.7	

1. A.1.c.i Manufacture of solid Fuels

Emission factor (g/GJ)	NOx	NMVOC	SOx	CO	Source
	21	0.8	91	6	(EMEP/EEA, 2019)

EFs for Manufacture of Solid Fuels and Other Energy Industries were obtained from the 2019 EMEP-EEA Air Pollutants Emission Inventory Guidebook (EMEP/EEA, 2019), Table 5-1 Part B: Sectoral Guidance Chapter 1 Energy Industries (1.A.1.c.i- Manufacture of solid fuels).

1. A.2 - Manufacturing Industries and Construction

Emission factor (g/GJ)	NOx	NMVOCs	SOx	CO	Source
Solid Fuels	173	88.8	900	931	(EMEP/EEA, 2019)
Gaseous Fuels	74	23	0.67	29	
Liquid Fuels	513	25	47	66	
Biomass	91	300	11	570	

EFs for Manufacturing Industries and Construction for Solid Fuels, Gaseous Fuels, Liquid Fuels and Biomass were obtained from the 2019 EMEP-EEA Air Pollutants Emission Inventory Guidebook (EMEP/EEA, 2019), Table 3-1, Table3-2, Table 3-3 and Table 3-4 respectively, Part B: Sectoral Guidance Chapter 1 Energy Industries (1.A.2- MIC).

1. A.3.a – Aviation

Emission factor (kg/t fuel)	NOx	NMVOCs	SOx	CO	Source
Jet gasoline and Aviation Gasoline	4	19	1	1200	(EMEP/EEA, 2019)

EFs for Aviation were obtained from the 2019 EMEP-EEA Air Pollutants Emission Inventory Guidebook (EMEP/EEA, 2019), Table 3.3, Part B: Sectoral Guidance Chapter 1 Energy Industries (1.A.3.a – Aviation).

1. A.3.b - Road Transportation

Category	Emission factor (g/kg fuel)	NOx	NMVOCs	SOx	CO	Source
Passenger cars (PC)	Petrol	8.73	10.05			(EMEP/EEA, 2019)
	Diesel	12.96	0.70			
	LPG	15.20	13.64			
Light Commercial Vehicles (LCV)	Petrol	13.22	14.59		152.3	
	Diesel	14.91	1.54		7.40	
Heavy Duty Vehicles (HDV)	Diesel	33.37	1.92			
	CNG (Buses)	13.00	0.26			
L-Category	Petrol	6.64	131.4			

EFs for Road Transportation were obtained from the 2019 EMEP-EEA Air Pollutants Emission Inventory Guidebook (EMEP/EEA, 2019), Table 3-5 for NMVOC and Table 3-6 for NOx, Part B: Sectoral Guidance, Chapter 1 Energy Industries (1.A.3.b- Road Transportation).

1. A.3.c – Railways

Emission factor (kg/t fuel)	NOx	NMVOCs	SOx	CO	Source
Gas Oil/ Diesel	52.4	4.65	NE	10.7	(EMEP/EEA, 2019)

EFs for Railways were obtained from the 2019 EMEP-EEA Air Pollutants Emission Inventory Guidebook (EMEP/EEA, 2019), Table 3.1, Part B: Sectoral Guidance, Chapter 1 Energy Industries (1.A.3.c-Railways).

1. A.4.b – Residential

Emission factor (g/GJ)	NOx	NMVOCs	SOx	CO	Source
Hard Coal and Brown Coal	110	484	900	4600	(EMEP/EEA, 2019)
Gaseous Fuels	51	1.9	0.3	26	
Other Liquid Fuels	51	0.69	70	57	
Solid Biomass	50	600	11	4000	

EFs for Residential were obtained from the 2019 EMEP-EEA Air Pollutants Emission Inventory Guidebook (EMEP/EEA, 2019), Table 3.3 to 3.5, Part B: Sectoral Guidance, Chapter 1 Energy Industries (1.A.4.bi-Residential Plants).

1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms

Emission factor (g/GJ)	NOx	NMVOCs	SOx	CO	Source
Hard Coal and Brown Coal	173	88.8	840	931	(EMEP/EEA, 2019)
Gaseous Fuels	74	23	0.67	29	
Liquid Fuels	306	20	94	93	
Biomass	91	300	11	570	

EFs for Agriculture/Forestry/Fishing/Fish Farms were obtained from the 2019 EMEP-EEA Air Pollutants Emission Inventory Guidebook (EMEP/EEA, 2019). Hard Coal and Brown Coal Table 3.7 (1.a.4.a/c; 1.A.5.a), Gaseous Fuels Table 3.8 (1.a.4.a/c; 1.A.5.a), Liquid fuels Table 3.9 (1.a.4.a/c; 1.A.5.a) and Biomass table 3.10 (1.a.4.a/c; 1.A.5.a) in Part B: Sectoral Guidance, Chapter 1 Energy Industries.

1.B.1.a- Coal Mining and Handling

Emission factor (kg/Mg coal)	NOx	NMVOCs	SOx	CO	Source
	NA	0.8	NA		(EMEP/EEA, 2019)

EFs for Coal Mining and Handling were obtained from the 2019 EMEP-EEA Air Pollutants Emission Inventory Guidebook (EMEP/EEA, 2019), Table 3-1 (1.B.1a- Coal Mining and Handling), Part B: Sectoral Guidance, Chapter 1 Energy Industries.

Energy Sector QC checks

Energy Sector QC Activities

QC Activity	Procedures	Task Completed		
		Name/ Initials	Date	Supporting Documents (List Document Name)
Check that assumptions and criteria for the selection of activity data and emission factors are documented.	• Cross-check descriptions of activity data and emission factors with information on categories and ensure that these are properly recorded and archived.			
Check for transcription errors in data input and reference.	• Confirm that bibliographical data references are properly cited in the internal documentation (MDD template report) • Cross-check a sample of input data from each category (either measurements or parameters used in calculations) for transcription errors. • Utilize electronic data where possible to minimize transcription errors. • Check that spreadsheet features are use d to minimize user/entry error: • Avoid hardwiring factors into formulas. • Create automatic look-up tables for common values used throughout calculations. • Use cell protection so fixed data cannot accidentally be changed. ○ Build in automated checks, such as computational checks for calculations, or range checks for input data.			
Check that emissions/removals are calculated correctly.	• Reproduce a representative sample of emissions/removals calculations. • If models are used, selectively mimic complex model calculations with abbreviated calculations to judge relative accuracy.			
Check that parameter and emission/removal units are correctly recorded and that appropriate conversion factors are used.	• Check that units are properly labeled in calculation sheets and (MDD template report) • Check that units are correctly carried through from beginning to end of calculations. • Check that conversion factors are correct. • Check that temporal and spatial adjustment factors are used correctly.			
Check the integrity of database files.	• Confirm that the appropriate data processing steps are correctly represented in the database.			

QC Activity	Procedures	Task Completed		
		Name/ Initials	Date	Supporting Documents (List Document Name)
	• Confirm that data relationships are correctly represented in the database. • Ensure that data fields are properly labeled and have the correct design specifications. • Ensure that adequate documentation of database and model structure and operation are archived.			
Check for consistency in data between categories.	• Identify parameters (e.g., activity data, constants) that are common to multiple categories and confirm that there is consistency in the values used for these parameters in the emissions/removals calculations.			
Check that the movement of inventory data among processing steps is correct.	• Check that emissions/removals data are correctly aggregated from lower reporting levels to higher reporting levels when preparing summaries. • Check that emissions/removals data are correctly transcribed between different intermediate products.			
Review of internal documentation and archiving.	• Check that there is detailed internal documentation to support the estimates and enable duplication of calculations. • Check that every primary data element has a reference for the source of the data (via cell comments or another system of notation). • Check that inventory data, supporting data, and inventory records are archived and stored to facilitate detailed review. • Check that the archive is closed and retained in secure place following completion of the inventory • Check integrity of any data archiving arrangements of outside organizations involved in inventory preparation.			
Check methodological and data changes resulting in recalculations.	• Check for temporal consistency in time series input data for each category. • Check for consistency in the algorithm/method used for calculations throughout the time series. • Reproduce a representative sample of emission calculations to ensure mathematical correctness.			

QC Activity	Procedures	Task Completed		
		Name/ Initials	Date	Supporting Documents (List Document Name)
Check time series consistency	• Check for temporal consistency in time series input data for each category. • Check for consistency in the algorithm/method used for calculations throughout the time series. • Check methodological and data changes resulting in recalculations. • Check that the effects of mitigation activities have been appropriately reflected in time series calculations.			
Check completeness	• Confirm that estimates are reported for all categories and for all years from the appropriate base year over the period of the current inventory. • For subcategories, confirm that the entire category is being covered. • Proved clear definition of 'Other' type categories. • Check that known data gaps that result in incomplete category emissions/removals estimates are documented, including qualitative evaluation of the importance of the estimate in relation to total net emissions (e.g. subcategories classified as 'not estimated').			
Trend checks	• For each category, compare current inventory estimates to previous estimates, if available. If there are significant changes or departures from expected trends, re-check estimates and explain any difference. Significant changes in emissions or removals from previous years may indicate possible input or calculation errors. • Check value of implied emission factors (aggregate emissions/removals divided by activity data) across time series. Are changes in emissions or removals being captured? • Check if there any unusual or unexplained trends noticed for activity data or other parameters across the time series.			