

REPUBLIC of CHINA

NATIONAL GREENHOUSE GAS Inventory Report

2021

Report Summary September, 2021





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Executive Summary

ES.1 Background Information on National Greenhouse Gas Inventory

The guidelines in Article 4 and Article 12 of the United Nations Framework Convention on Climate Change (UNFCCC) and Article 5 of the Kyoto Protocol state that each party shall submit information on its progress in response to climate change to the UNFCCC Convention of the Parties for review. In particular, the National Inventory Report (NIR) is a national report in which the UNFCCC¹ requires each Annex 1 country to report on its national greenhouse gas (GHG) inventory describing the procedures for GHG emission inventory preparation, information on emission trends, statistics by sectors, and a national report of re-calculation while submitting its inventory based on Common Reporting Format (CRF). Although Taiwan is not a UNFCCC party, it has long been committed to fulfilling its responsibility as a member of the global community by endeavoring to take initiatives to help slow down global warming. The establishment of a national GHG inventory report and the estimation of GHG emission and sequestration are the fundamental obligation of a country to UNFCCC as well as one of the essential steps in reducing global warming.

Since 1998, Taiwan has taken initiatives to prepare the national GHG inventory. According to Decision 24/CP.17 of the 17th Convention of the Parties (COP17) of the United Nations Framework Convention on Climate Change and the 7th Session of the Conference of the Parties (CMP7) to the Kyoto Protocol held in Durban, requesting developed countries to submit an Annual National Inventory Report starting from 2015 in accordance with the 2006 Intergovernmental Panel on Climate Change Guidelines (2006 IPCC Guidelines) for National Greenhouse Gas Inventories proposed by the Intergovernmental Panel on Climate Change (IPCC) in 2006. The Report also carried out the statistics and compilation in accordance with the 2006 IPCC Guidelines to actively demonstrate the efforts and resolution to abide by the convention. Today, Taiwan has established a greenhouse gas inventory database covering the period from 1990 to

2019. The database provides an overview on greenhouse gas inventory statistics to reflect the GHG trends in Taiwan. It also aims to quantify future greenhouse gas emissions and provide an overview of Taiwan's greenhouse gas statistics, thereby receiving comments from all fields for the continuous improvement on the quality of national greenhouse gas inventories.

ES.2 Summary of National Emission and Absorption Related Trends

Taiwan's total GHG emissions increased from 137,776 kilotons of carbon dioxide equivalents (excluding land use, land use change and forestry, the following report abbreviated as LULUCF) in 1990 to 287,060 kilotons of carbon dioxide equivalents (excluding LULUCF) in 2019, with emissions increased by 108.35% at an average annual growth rate of 2.56%. Among the greenhouse gas emissions in 2019, the proportion of carbon dioxide emissions is 95.28% and that of non-carbon dioxide is 4.72%. Compared with 2005 (Base year) GHG emissions, it decreased slightly by 1.20%. The total emissions in 2019 saw a decrease of 3.41% from the previous year, as shown in Figure ES2.1.

Further comparison of statistics on various greenhouse gas emissions shows that carbon dioxide accounts for the majority of greenhouse gas emissions (excluding LULUCF) in Taiwan in 2005, accounting for 91.71%, followed by methane (3.27%), nitrous oxide (1.48%), and fluorinated greenhouse gas (3.54%); however, carbon dioxide was still the largest of proportion (95.28%) in 2019, followed by nitrous oxide (1.71%), methane (1.67%), and then fluorinated greenhouse gas (1.34%), as shown in Figure ES2.2.

Between 1990 and 2019, carbon dioxide emissions grew by 120.44% with an average annual growth rate of 2.76%; carbon dioxide sequestration decreased by 8.32% with an average annual growth rate of -0.30%; methane emissions decreased by 55.29% with an average annual growth rate of -2.74%, a negative growth; nitrous oxide emissions increased by 63.91% with an annual growth rate of 1.72%. Between 1993 and 2019, fluorinated greenhouse gas emissions grew by 410.63% with an average annual growth rate of 6.47%, as shown in Figure ES2.3 and Table ES2.1.

¹ UNFCCC, FCCC/CP/2002/8, 2002.

1. Carbon Dioxide

The energy sector, industrial process and product use (IPPU) sector, agriculture sector, and waste sector are the main emission sources of carbon dioxide in Taiwan, as shown in Table ES2.2. In 1990, Taiwan's carbon dioxide emissions amounted to 124,078 kilotons of carbon dioxide equivalents. In 2019, that figure was 273,515 kilotons of carbon dioxide equivalents, with an 120.44% increase and an average annual growth rate of 2.76%. In 2019, carbon dioxide emissions

accounted for 95.28% of total GHG emissions. The energy sector accounted for 94.59%, the industrial process and product use (IPPU) sector 5.32%, the waste sector 0.08%, and the agriculture sector 0.01%. Emissions in 2019 increased by 2.65% compared to 2005 (Base year). Compared with 2018, the emissions in 2019 decreased by 3.30% mainly because of the 3.15% decrease in the energy sector, the 6.26% decrease in the IPPU sector, the 1.50% decrease in the agriculture sector, and the 34.40% increase in the waste sector.

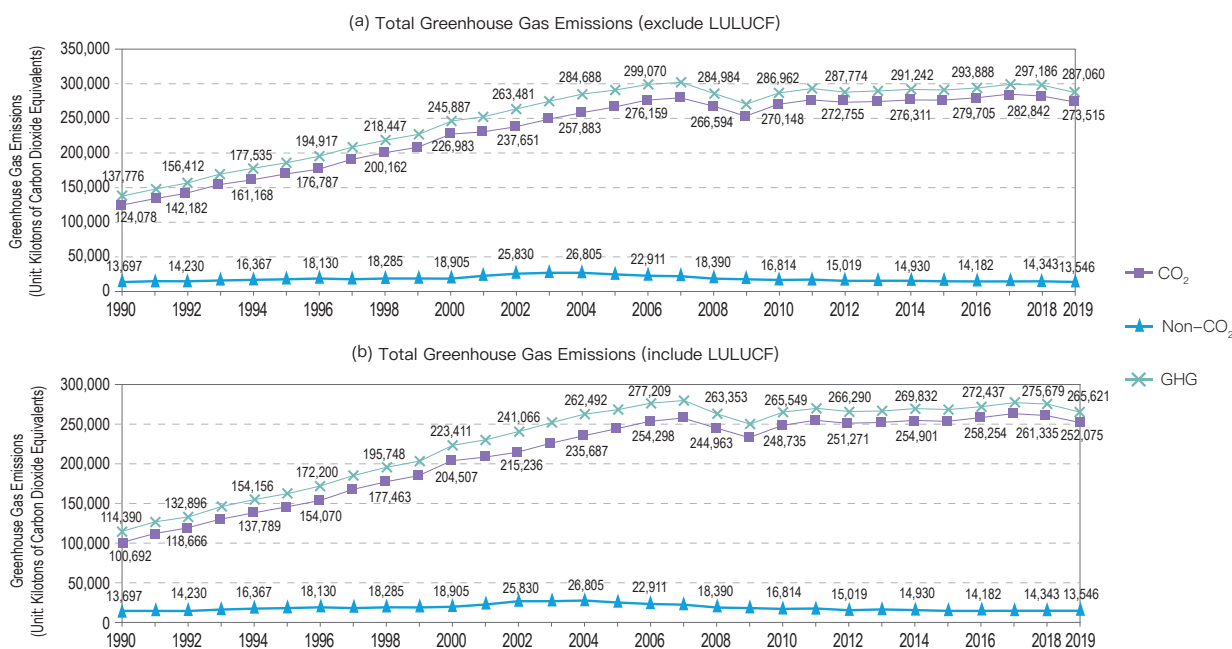


Figure ES2.1 1990-2019 Trends in Total Greenhouse Gas Emissions and Sequestration in Taiwan : (a) Emissions exclude LULUCF ; (b) Emissions include LULUCF

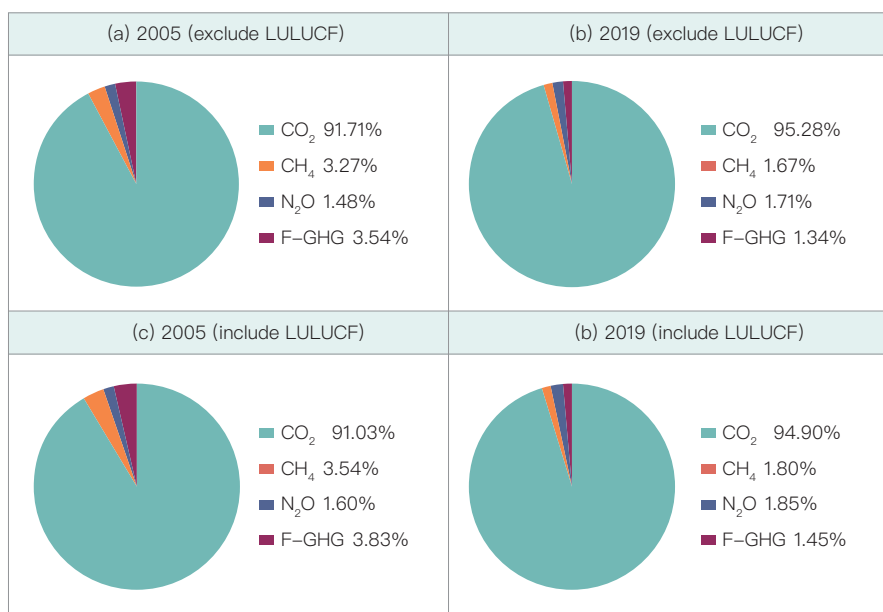


Figure ES2.2 Percentage of Various Types of Greenhouse Gas Emissions in Taiwan : (a) 2005 (exclude LULUCF) ; (b) 2019 (exclude LULUCF) ; (c) 2005 (include LULUCF) ; (d) 2019 (include LULUCF)

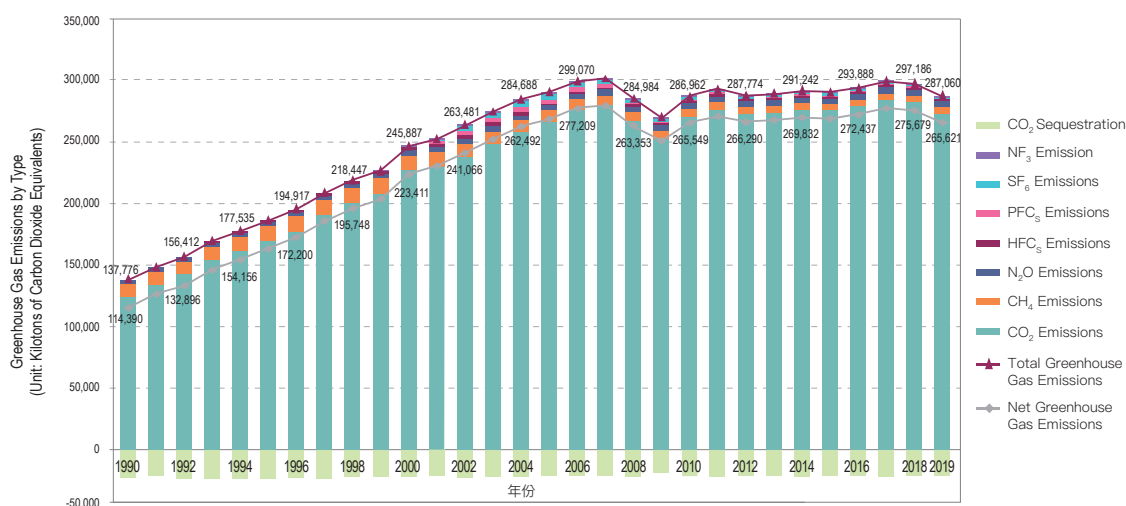


Figure ES2.3 1990-2019 Trends in Total Greenhouse Gas Emissions and Sequestration by Type in Taiwan

Table ES2.1 1990-2019 Greenhouse Gas Emissions and Sequestration in Taiwan by Type

(Unit: Kilotons of Carbon Dioxide Equivalents)

GHG	Global Warming Potential	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO ₂	1	124,078	133,598	142,182	153,801	161,168	168,881	176,787	190,548	200,162	207,800
CH ₄	25	10,705	11,030	10,977	11,383	12,141	12,899	13,291	13,001	12,899	13,188
N ₂ O	298	2,992	3,262	3,253	3,324	3,371	3,448	3,533	3,377	3,304	3,274
HFCs	HFC-134a: 1,430	NE	NE	NE	755	855	801	1,305	1,477	2,083	1,609
PFCs	PFC-14: 7,390	NE	NE	NE	NE	NE	NE	NE	NE	NE	3
SF ₆	22,800	NE	NE	NE	NE	NE	NE	NE	NE	NE	116
NF ₃	17,200	NE	NE	NE	NE	NE	NE	NE	NE	NE	11
CO ₂ Sequestration	1	-23,386	-21,490	-23,516	-23,493	-23,379	-23,233	-22,717	-22,899	-22,699	-22,550
Net GHG Emission (including LULUCF)		114,390	126,400	132,896	145,770	154,156	162,797	172,200	185,504	195,748	203,450
Total GHG Emission (excluding LULUCF)		137,776	147,890	156,412	169,263	177,535	186,030	194,917	208,403	218,447	226,000
GHG	Global Warming Potential	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO ₂	1	226,983	229,927	237,651	248,402	257,883	266,460	276,159	279,800	266,594	252,506
CH ₄	25	12,556	11,734	11,128	10,607	9,969	9,508	8,886	8,318	7,659	7,044
N ₂ O	298	3,887	3,938	4,031	4,048	4,192	4,300	4,800	4,873	4,458	4,622
HFCs	HFC-134a: 1,430	2,319	2,619	2,216	2,397	2,451	1,098	1,015	1,122	1,074	1,018
PFCs	PFC-14: 7,390	13	2,939	4,143	4,198	4,341	3,470	3,664	3,372	2,082	1,560
SF ₆	22,800	120	746	3,914	4,385	5,193	4,951	3,858	3,381	2,912	2,452
NF ₃	17,200	10	235	398	540	659	765	688	798	204	577
CO ₂ Sequestration	1	-22,476	-21,583	-22,415	-22,305	-22,196	-21,918	-21,861	-21,650	-21,631	-18,911
Net GHG Emission (including LULUCF)		223,411	230,555	241,066	252,271	262,492	268,634	277,209	280,015	263,353	250,868
Total GHG Emission (excluding LULUCF)		245,887	252,138	263,481	274,576	284,688	290,552	299,070	301,665	284,984	269,779
GHG	Global Warming Potential	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
CO ₂	1	270,148	276,282	272,755	273,797	276,311	275,835	279,705	284,821	282,842	273,515
CH ₄	25	6,570	6,226	5,890	5,547	5,305	5,093	5,032	4,922	4,891	4,786
N ₂ O	298	5,026	4,927	4,841	4,643	4,624	4,593	4,794	5,003	5,092	4,904
HFCs	HFC-134a: 1,430	971	1,053	907	1,019	1,048	1,020	1,026	1,023	1,013	1,027
PFCs	PFC-14: 7,390	1,770	1,781	1,141	1,345	1,556	1,347	1,441	1,409	1,536	1,420
SF ₆	22,800	2,218	1,918	1,852	1,997	1,730	1,523	1,418	1,416	1,302	935
NF ₃	17,200	258	420	388	773	667	662	472	440	509	473
CO ₂ Sequestration	1	-21,413	-21,470	-21,484	-21,499	-21,410	-21,425	-21,451	-21,486	-21,507	-21,440
Net GHG Emission (including LULUCF)		265,549	271,137	266,290	267,623	269,832	268,648	272,437	277,549	275,679	265,621
Total GHG Emission (excluding LULUCF)		286,962	292,607	287,774	289,121	291,242	290,073	293,888	299,034	297,186	287,060

Note: 1. Global Warming Potential (hereinafter referred to as GWP) is cited from the IPCC *Fourth Assessment Report*.

2. NE (not estimated) refers to the exclusion of estimation on existing emissions and sequestration.

Table ES2.2 1990-2019 Carbon Dioxide Emissions and Sequestration in Taiwan

(Unit: Kilotons of Carbon Dioxide Equivalents)

GHG Emission Source and Sinks	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1. Energy Sector	109,459	118,436	126,052	135,199	143,097	150,803	158,572	170,826	181,509	190,437
1.A.1. Energy Industry	49,123	55,126	58,529	65,962	70,771	76,400	81,254	91,407	100,414	105,782
1.A.2. Manufacturing Industry and Construction	30,117	31,956	33,383	33,611	34,586	35,763	36,785	39,075	39,311	41,305
1.A.3. Transportation	19,646	20,888	24,033	26,103	27,540	28,822	29,801	30,536	31,844	32,772
1.A.4. Other Sectors	10,572	10,466	10,107	9,523	10,200	9,819	10,733	9,808	9,939	10,579
1.A.4.a Service Industry	3,621	3,529	2,989	2,490	3,018	2,445	3,175	2,482	2,946	3,128
1.A.4.b Residential	4,005	4,238	4,446	4,359	4,461	4,597	4,754	4,851	4,952	5,410
1.A.4.c Agriculture, Forestry, Fishery, and Husbandry	2,946	2,700	2,672	2,675	2,721	2,777	2,805	2,475	2,041	2,040
2. Industrial Processes and Product Use Sector	14,458	15,007	15,926	18,408	17,826	17,528	17,677	19,483	18,410	17,179
2.A Mining Industry (Non-Metal Process)	10,584	10,698	11,854	13,879	13,259	12,766	12,645	13,394	11,564	10,746
2.B Chemical Industry	575	551	575	617	770	858	999	1,026	1,007	1,079
2.C Metal Process	3,275	3,735	3,474	3,888	3,774	3,884	4,013	5,045	5,817	5,333
2.H Others	23	23	23	24	23	21	20	19	22	21
3. Agriculture Sector	142	146	139	131	135	151	151	134	127	118
4. Land Use and Forestry Sector	-23,386	-21,490	-23,516	-23,493	-23,379	-23,233	-22,717	-22,899	-22,699	-22,550
5. Waste Sector	20	8	65	63	110	398	387	105	117	65
Net GHG Emission (including LULUCF)	100,692	112,108	118,666	130,308	137,789	145,648	154,070	167,649	177,463	185,250
Total GHG Emission (excluding LULUCF)	124,078	133,598	142,182	153,801	161,168	168,881	176,787	190,548	200,162	207,800
GHG Emission Source and Sinks	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Energy Sector	209,205	213,107	220,870	230,832	239,929	247,956	255,331	259,214	247,537	235,868
1.A.1. Energy Industry	121,143	126,142	130,463	41,730	148,677	156,351	163,615	170,131	164,432	155,166
1.A.2. Manufacturing Industry and Construction	43,934	42,545	44,814	42,788	43,163	42,671	43,994	43,293	39,104	36,698
1.A.3. Transportation	33,207	33,246	34,542	34,509	35,859	36,846	36,771	35,419	33,216	33,541
1.A.4. Other Sectors	10,922	11,174	11,052	11,806	12,230	12,089	10,952	10,370	10,785	10,463
1.A.4.a Service Industry	3,205	3,538	3,487	3,952	4,120	4,227	4,272	4,232	4,226	4,264
1.A.4.b Residential	5,354	5,181	5,107	5,042	5,133	5,235	5,033	5,047	5,017	5,030
1.A.4.c Agriculture, Forestry, Fishery, and Husbandry	2,362	2,455	2,459	2,811	2,977	2,627	1,647	1,091	1,543	1,169
2. Industrial Processes and Product Use Sector	17,388	16,186	16,075	17,070	17,358	18,094	20,299	19,967	18,558	16,428
2.A Mining Industry (Non-Metal Process)	10,486	9,974	10,648	10,270	10,691	11,257	11,014	10,369	9,289	8,467
2.B Chemical Industry	1,148	1,232	1,313	1,384	1,485	1,751	1,721	1,845	1,601	1,623
2.C Metal Process	5,734	4,960	4,096	5,397	5,162	5,066	7,544	7,733	7,648	6,317
2.H Others	20	20	18	18	19	20	21	20	20	21
3. Agriculture Sector	131	94	93	82	84	62	59	57	57	55
4. Land Use and Forestry Sector	-22,476	-21,583	-22,415	-22,305	-22,196	-21,918	-21,861	-21,650	-21,631	-18,911
5. Waste Sector	259	540	612	417	512	348	470	562	443	154
Net GHG Emission (including LULUCF)	204,507	208,344	215,236	226,097	235,687	244,542	254,298	258,150	244,963	233,595
Total GHG Emission (excluding LULUCF)	226,983	229,927	237,651	248,402	257,883	266,460	276,159	279,800	266,594	252,506
GHG Emission Source and Sinks	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1. Energy Sector	251,708	257,096	253,183	254,070	258,481	258,476	262,982	269,462	267,129	258,719
1.A.1. Energy Industry	165,522	169,884	168,333	168,271	175,180	175,198	178,569	187,135	189,212	181,318
1.A.2. Manufacturing Industry and Construction	41,360	42,298	41,000	42,019	38,953	38,074	38,296	36,741	33,401	32,638
1.A.3. Transportation	34,652	35,107	34,284	34,209	34,666	35,506	36,584	36,202	35,207	35,443
1.A.4. Other Sectors	10,174	9,807	9,566	9,571	9,681	9,698	9,533	9,384	9,310	9,320
1.A.4.a Service Industry	4,204	3,898	3,635	3,812	3,928	3,941	3,720	3,779	3,317	3,337
1.A.4.b Residential	4,857	4,786	4,672	4,484	4,411	4,469	4,537	4,402	4,480	4,469
1.A.4.c Agriculture, Forestry, Fishery, and Husbandry	1,113	1,123	1,259	1,274	1,343	1,287	1,276	1,203	1,512	1,514
2. Industrial Processes and Product Use Sector	18,178	18,985	19,369	19,529	17,644	17,219	16,557	15,199	15,525	14,553
2.A Mining Industry (Non-Metal Process)	8,616	9,577	9,333	9,866	8,728	8,345	7,108	6,262	6,403	6,501
2.B Chemical Industry	1,750	1,768	1,714	1,749	1,884	1,854	1,760	1,709	1,684	1,666
2.C Metal Process	7,792	7,620	8,301	7,894	7,013	7,000	7,670	7,208	7,419	6,368
2.H Others	20	20	21	19	19	20	19	20	19	17
3. Agriculture Sector	54	53	55	45	40	38	34	31	30	29
4. Land Use and Forestry Sector	-21,413	-21,470	-21,484	-21,499	-21,410	-21,425	-21,451	-21,486	-21,507	-21,440
5. Waste Sector	208	149	149	153	146	103	132	129	159	214
Net GHG Emission (including LULUCF)	248,735	254,812	251,271	252,298	254,901	254,410	258,254	263,336	261,335	252,075
Total GHG Emission (excluding LULUCF)	270,148	276,282	272,755	273,797	276,311	275,835	279,705	284,821	282,842	273,515

2. Methane Emissions

Methane emissions in Taiwan mainly come from the agriculture sector, waste sector, and energy sector, as shown in Table ES2.3. In 1990, the total methane emission in Taiwan was 10,705 kilotons of carbon dioxide equivalents. In 2019, the total methane emission was 4,786 kilotons of carbon dioxide

equivalents, down by 55.29% with an average growth rate of -2.74%, a negative growth. In 2019, methane emissions accounted for 1.67% of the total GHG emissions. In particular, the waste sector was the largest source of methane emissions in 2019, which accounted for 43.91%, followed by the agriculture sector (40.57%), energy sector (14.98%), and IPPU sector (0.54%).

Table ES2.3 1990-2019 Methane Emissions in Taiwan

(Unit: Kilotons of Carbon Dioxide Equivalents)

GHG Emission Sources and Sinks	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1. Energy Sector	530	506	497	511	526	533	520	514	535	561
2. Industrial Process and Product Use Sector	5	7	6	7	8	10	11	12	10	12
3. Agriculture Sector	2,914	3,100	3,018	3,025	3,012	3,079	3,085	2,672	2,421	2,517
3.A Livestock Gastrointestinal Fermentation	670	731	738	775	789	822	822	732	674	694
3.B Livestock Waste Treatment	1,112	1,304	1,266	1,282	1,312	1,371	1,398	1,062	884	971
3.C Rice Culturing	1,094	1,040	968	946	891	879	858	871	858	845
3.F Field Burning of Agricultural Residues	38	25	48	22	21	7	7	7	6	7
5. Waste Sector	7,257	7,416	7,455	7,839	8,595	9,277	9,675	9,803	9,933	10,098
5.A Garbage Landfill	5,833	5,919	5,930	6,325	7,063	7,721	8,082	8,215	8,376	8,608
5.B Garbage Biological Treatment	11	1	1	0	0	1	0	1	0	2
5.D.1 Domestic Wastewater Treatment and discharge	1,001	1,011	1,020	1,029	1,038	1,046	1,053	1,059	1,051	1,000
5.D.2 Industrial Wastewater Treatment and discharge	411	486	504	485	494	509	541	527	505	488
Total	10,705	11,030	10,977	11,383	12,141	12,899	13,291	13,001	12,899	13,188
GHG Emission Sources and Sinks	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Energy Sector	574	565	585	630	661	631	625	622	604	597
2. Industrial Process and Product Use Sector	14	18	9	22	28	18	22	28	27	21
3. Agriculture Sector	2,511	2,425	2,290	2,188	2,110	2,228	2,197	2,116	2,056	2,006
3.A Livestock Gastrointestinal Fermentation	692	660	636	626	614	623	614	609	584	571
3.B Livestock Waste Treatment	1,003	959	913	909	915	957	945	888	861	825
3.C Rice Culturing	802	792	729	644	574	640	630	616	604	605
3.F Field Burning of Agricultural Residues	14	15	13	9	8	8	8	5	6	5
5. Waste Sector	9,457	8,726	8,235	7,767	7,171	6,631	6,042	5,553	4,972	4,420
5.A Garbage Landfill	8,030	7,311	6,830	6,322	5,777	5,231	4,666	4,144	3,608	3,072
5.B Garbage Biological Treatment	0	0	0	2	7	10	11	14	16	18
5.D.1 Domestic Wastewater Treatment and discharge	957	945	929	920	892	865	838	805	779	755
5.D.2 Industrial Wastewater Treatment and discharge	470	471	475	523	495	526	527	589	569	575
Total	12,556	11,734	11,128	10,607	9,969	9,508	8,886	8,318	7,659	7,044
GHG Emission Sources and Sinks	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1. Energy Sector	631	654	663	676	686	710	730	738	721	717
2. Industrial Process and Product Use Sector	23	15	23	25	26	15	27	24	27	26
3. Agriculture Sector	2,003	2,034	2,010	1,997	1,947	1,927	1,933	1,932	1,932	1,942
3.A Livestock Gastrointestinal Fermentation	578	590	583	579	566	573	561	564	572	575
3.B Livestock Waste Treatment	831	843	807	781	750	744	740	738	743	754
3.C Rice Culturing	589	596	614	634	626	605	629	626	615	611
3.F Field Burning of Agricultural Residues	5	5	5	3	4	5	3	3	2	2
5. Waste Sector	3,913	3,523	3,194	2,849	2,647	2,442	2,342	2,228	2,211	2,102
5.A Garbage Landfill	2,601	2,226	1,890	1,598	1,351	1,141	970	835	723	656
5.B Garbage Biological Treatment	21	26	24	23	20	20	20	20	23	25
5.D.1 Domestic Wastewater Treatment and discharge	740	706	673	651	631	606	583	551	526	480
5.D.2 Industrial Wastewater Treatment and discharge	551	565	607	578	644	674	768	821	940	941
Total	6,570	6,226	5,890	5,547	5,305	5,093	5,032	4,922	4,891	4,786

Emissions of Methane in 2019 decreased by 49.66% compared to 2005(Base year). Compared to 2018, the methane emission in 2018 was down by 2.15%, with the waste sector down by 4.94%, the IPPU sector down by 3.32%, the energy sector down by 0.57%, and the agriculture sector up by 0.48%.

3. Nitrous oxide emissions

Nitrous oxide emissions in Taiwan are mainly from the IPPU sector, the agriculture sector, and energy sector with minor emissions from the waste sector, as shown in Table ES2.4. In 1990, the total nitrous oxide emission in Taiwan was 2,992 kilotons of carbon dioxide equivalents. In 2019, the total nitrous oxide emission was 4,904 kilotons of carbon dioxide equivalents, up by 63.91% with an average growth

rate of 1.72%. In 2019, nitrous oxide emissions accounted for 1.71% of the total GHG emissions. In particular, the IPPU sector accounted for 39.98%, followed by the agriculture sector (27.12%), the energy sector (25.00%), and the waste sector (7.90%).

Emissions of Nitrous oxide in 2019 increased by 14.04% compared to 2005(Base year). Compared to 2018, the nitrous oxide emission in 2019 was down by 3.69%, with the IPPU sector down by 5.15%, the agriculture sector down by 3.97%, the energy sector down by 2.44%, and the waste sector up by 1.08%.

Table ES2.4 1990-2019 Nitrous Oxide Emissions in Taiwan

(Unit: Kilotons of Carbon Dioxide Equivalents)

GHG Emission Sources and Sinks	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1. Energy Sector	537	578	653	703	742	778	825	866	917	968
1.A.1 Energy Industry	138	157	183	207	223	240	271	300	331	361
1.A.2 Manufacturing and Construction Industry	90	95	101	100	103	105	109	114	115	123
1.A.3 Transportation	291	309	353	382	402	418	428	438	456	469
1.A.4 Other Sectors	17	17	15	14	15	14	16	14	14	14
2. Industrial Process and Product Use Sector	166	352	325	301	318	345	343	374	383	312
3. Agriculture Sector	1,994	2,048	1,977	2,008	1,997	1,991	2,028	1,800	1,683	1,665
3.B Livestock Waste Treatment	145	164	162	165	173	180	188	160	145	154
3.D Agricultural Soil	1,837	1,876	1,800	1,837	1,818	1,808	1,838	1,638	1,536	1,509
3.F Field Burning of Agricultural Residues	12	8	15	7	6	2	2	2	2	2
5. Waste Sector	296	285	298	311	313	334	337	337	321	329
Total	2,992	3,262	3,253	3,324	3,371	3,448	3,533	3,377	3,304	3,274
GHG Emission Sources and Sinks	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Energy Sector	1,052	1,083	1,134	1,188	1,228	1,269	1,299	1,303	1,239	1,211
1.A.1 Energy Industry	428	458	480	537	556	584	612	638	616	593
1.A.2 Manufacturing and Construction Industry	134	135	142	138	141	140	145	143	131	124
1.A.3 Transportation	475	475	496	495	513	527	527	508	478	480
1.A.4 Other Sectors	15	16	16	17	18	17	15	13	14	13
2. Industrial Process and Product Use Sector	625	714	744	833	834	1,002	1,474	1,573	1,332	1,500
3. Agriculture Sector	1,879	1,801	1,806	1,674	1,787	1,680	1,709	1,670	1,587	1,616
3.B Livestock Waste Treatment	158	152	147	148	147	153	153	146	145	141
3.D Agricultural Soil	1,717	1,644	1,655	1,524	1,639	1,524	1,554	1,522	1,440	1,474
3.F Field Burning of Agricultural Residues	4	5	4	3	2	2	3	1	2	2
5. Waste Sector	331	340	348	353	343	350	318	328	300	295
Total	3,887	3,938	4,031	4,048	4,192	4,300	4,800	4,873	4,458	4,622
GHG Emission Sources and Sinks	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1. Energy Sector	1,248	1,268	1,247	1,241	1,246	1,242	1,264	1,276	1,257	1,226
1.A.1 Energy Industry	603	607	603	595	599	585	595	621	633	605
1.A.2 Manufacturing and Construction Industry	135	144	137	140	133	131	131	123	103	101
1.A.3 Transportation	497	505	495	494	500	513	526	521	510	508
1.A.4 Other Sectors	13	12	12	12	13	13	12	12	11	11
2. Industrial Process and Product Use Sector	1,877	1,805	1,717	1,582	1,557	1,550	1,744	1,944	2,067	1,961
3. Agriculture Sector	1,598	1,540	1,564	1,497	1,490	1,459	1,456	1,406	1,385	1,330
3.B Livestock Waste Treatment	141	142	139	137	136	136	138	139	141	145
3.D Agricultural Soil	1,456	1,396	1,424	1,359	1,353	1,322	1,318	1,266	1,243	1,184
3.F Field Burning of Agricultural Residues	2	2	2	1	1	1	1	1	1	1
5. Waste Sector	302	314	313	323	332	342	330	377	383	388
Total	5,026	4,927	4,841	4,643	4,624	4,593	4,794	5,003	5,092	4,904

4. Fluoride-Containing Gas Emissions

In Taiwan, the majority of fluorinated greenhouse gases come from industries critical to economic development, namely the semiconductor, optoelectronics, power facilities, and magnesium alloy industries, all of which are emission-heavy industries. The fluorinated greenhouse gas emissions are shown in Table ES2.5. In particular, Taiwan's hydrofluorocarbons (HFCs) emission increased from 755 kilotons of carbon dioxide equivalents in 1993 to 1,027 kilotons of carbon dioxide equivalents in 2019. The perfluorocarbons (PFCs) emission increased from 3 kilotons of carbon dioxide equivalents in 1999 to 1,420 kilotons of carbon dioxide equivalents in 2019, while the sulfur hexafluoride (SF₆) emission increased from 116 kilotons of carbon dioxide equivalents in 1999 to 935 kilotons of carbon dioxide equivalents in 2019. The nitrogen trifluoride (NF₃) emission increased from 11 kilotons of carbon dioxide equivalents in 1999 to 473 kilotons of carbon dioxide equivalents in 2019. For the total emission of fluorinated greenhouse gases, it increased from 1,738 kilotons of carbon dioxide equivalents in 1999 (about 0.77% of the total greenhouse gas emissions in 1999) to 3,855 kilotons of carbon dioxide equivalents in 2019 (about 1.34% of the total greenhouse gas emissions in 2019), with an emissions increase of 121.79% at an average annual growth rate of 4.06%. Emissions of fluoride-containing gas in 2019 decreased by 62.51% compared to 2005(Base year). Compared to 2018, the emission in 2019 decreased by 11.58%.

ES.3 Emission Estimation and Trends Overview for Emission Source and Sinks Classification

Of all the sectors, the energy sector has long been the one accounting for the largest total greenhouse gas emission in Taiwan over the years. In 2005 and 2019, greenhouse gas emissions (exclude LULUCF) from energy sectors were responsible for approximately 85.99% and 90.80% of the total emissions, while the IPPU sector accounted for 10.12% and 7.10%, the agricultural sector accounted for 1.37% and 1.15%, and the waste sector accounted for 2.52 % and 0.94%, as shown in Figure ES3.1.

The GHG emission and trends for Taiwan from 1990 to 2019 by sector are shown in Figure ES3.2 and Table ES3.1. The total greenhouse gas emission in Taiwan in 2019 decreased by 3.41% compared with 2018. In particular, the GHG emission from the energy sector was down by 3.14%, the IPPU sector was down by 7.21%, the agriculture sector was down by 1.38%, and the waste sector was down by 1.83%. Additionally, the carbon dioxide sequestration of the land use, land use change and forestry sector was down by 0.31%.

Compared to 2005(Base year), the emission in 2019 decreased by 1.20%. In particular, the GHG emission from the energy sector was up by 4.33%, the IPPU sector was down by 30.63%, the agriculture sector was down by 16.85%, and the waste sector was down by 63.12%. Additionally, the carbon dioxide sequestration of the land use, land use change and forestry sector was down by 2.18%, as shown in Figure ES3.3.

Table ES2.5 1990-2019 Fluoride-Containing Gas Emissions in Taiwan

(Unit: Kilotons of Carbon Dioxide Equivalents)										
GHG Emission Sources and Sinks	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total HFCs Emissions	NE	NE	NE	755	855	801	1,305	1,477	2,083	1,609
Total PFCs Emissions	NE	NE	NE	NE	NE	NE	NE	NE	NE	3
Total SF ₆ Emissions	NE	NE	NE	NE	NE	NE	NE	NE	NE	116
Total NF ₃ Emissions	NE	NE	NE	NE	NE	NE	NE	NE	NE	11
Total Emissions	NE	NE	NE	755	855	801	1,305	1,477	2,083	1,738
GHG Emission Sources and Sinks	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total HFCs Emissions	2,319	2,619	2,216	2,397	2,451	1,098	1,015	1,122	1,074	1,018
Total PFCs Emissions	13	2,939	4,143	4,198	4,341	3,470	3,664	3,372	2,082	1,560
Total SF ₆ Emissions	120	746	3,914	4,385	5,193	4,951	3,858	3,381	2,912	2,452
Total NF ₃ Emissions	10	235	398	540	659	765	688	798	204	577
Total Emissions	2,462	6,538	10,671	11,520	12,643	10,284	9,225	8,673	6,273	5,607
GHG Emission Sources and Sinks	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total HFCs Emissions	971	1,053	907	1,019	1,048	1,020	1,026	1,023	1,013	1,027
Total PFCs Emissions	1,770	1,781	1,141	1,345	1,556	1,347	1,441	1,409	1,536	1,420
Total SF ₆ Emissions	2,218	1,918	1,852	1,997	1,730	1,523	1,418	1,416	1,302	935
Total NF ₃ Emissions	258	420	388	773	667	662	472	440	509	473
Total Emissions	5,217	5,172	4,288	5,134	5,001	4,552	4,356	4,288	4,360	3,855

Note: NE (not estimated) refers to the exclusion of estimation on existing emissions and sequestration.

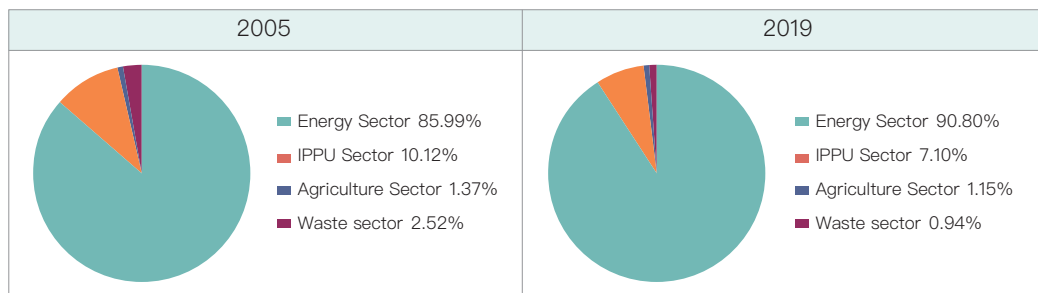


Figure ES3.1 Percentage of Greenhouse Gas Emissions (exclude LULUCF) by Sectors in Taiwan in 2005 (left) and 2019 (right).

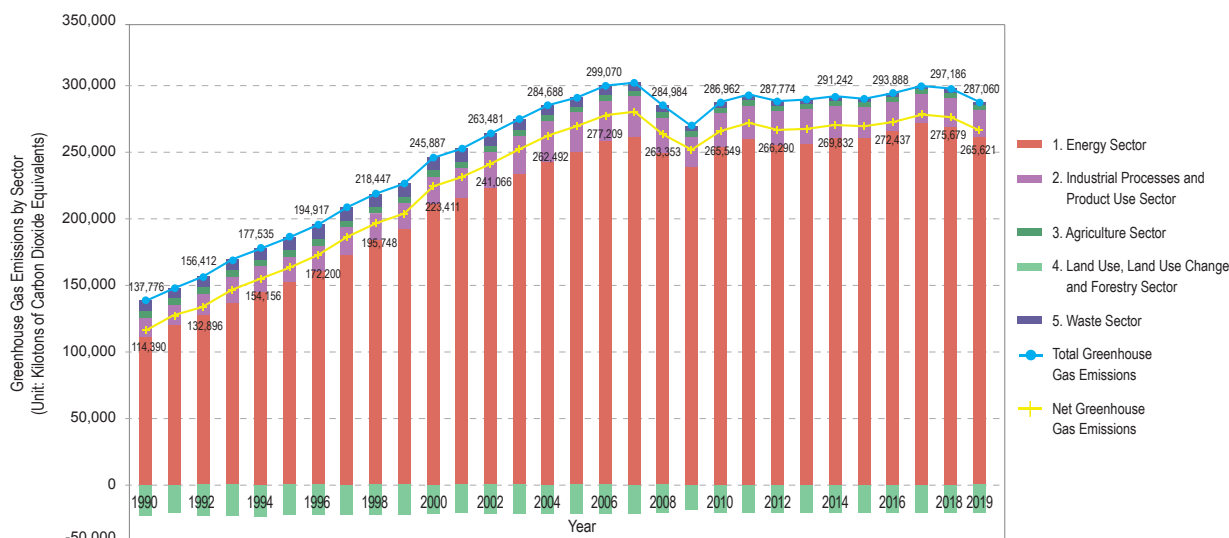


Figure ES3.2 1990-2019 Trends in Greenhouse Gas Emission by Sector in Taiwan

Table ES3.1 1990-2019 Greenhouse Gas Emission in Taiwan by Sector

(Unit: Kilotons of Carbon Dioxide Equivalents)

GHG Emission Sources and Sinks	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1. Energy Sector	110,525	119,521	127,202	136,414	144,365	152,115	159,917	172,206	182,961	191,966
2. Industrial Process and Product Use Sector	14,629	15,366	16,257	19,471	19,007	18,685	19,336	21,346	20,886	19,241
3. Agriculture Sector	5,049	5,294	5,134	5,164	5,145	5,221	5,263	4,606	4,231	4,301
4. Land Use, Land Use Change and Forestry Sector	-23,386	-21,490	-23,516	-23,493	-23,379	-23,233	-22,717	-22,899	-22,699	-22,550
5. Waste Sector	7,573	7,709	7,818	8,214	9,018	10,009	10,399	10,245	10,370	10,493
Net GHG Emission (including LULUCF)	114,390	126,400	132,896	145,770	154,156	162,797	172,200	185,504	195,748	203,450
Total GHG Emission (excluding LULUCF)	137,776	147,890	156,412	169,263	177,535	186,030	194,917	208,403	218,447	226,000
GHG Emission Sources and Sinks	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Energy Sector	210,831	214,756	222,589	232,650	241,818	249,856	257,255	261,138	249,380	237,676
2. Industrial Process and Product Use Sector	20,488	23,456	27,509	29,444	30,864	29,398	31,019	30,241	26,190	23,557
3. Agriculture Sector	4,521	4,320	4,189	3,944	3,981	3,969	3,966	3,844	3,700	3,678
4. Land Use, Land Use Change and Forestry Sector	-22,476	-21,583	-22,415	-22,305	-22,196	-21,918	-21,861	-21,650	-21,631	-18,911
5. Waste Sector	10,047	9,606	9,195	8,538	8,026	7,329	6,830	6,443	5,715	4,868
Net GHG Emission (including LULUCF)	223,411	230,555	241,066	252,271	262,492	268,634	277,209	280,015	263,353	250,868
Total GHG Emission (excluding LULUCF)	245,887	252,138	263,481	274,576	284,688	290,552	299,070	301,665	284,984	269,779
GHG Emission Sources and Sinks	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1. Energy Sector	253,588	259,018	255,093	255,987	260,413	260,428	264,977	271,475	269,107	260,662
2. Industrial Process and Product Use Sector	25,296	25,977	25,397	26,270	24,228	23,336	22,684	21,456	21,979	20,394
3. Agriculture Sector	3,655	3,627	3,630	3,540	3,476	3,423	3,424	3,369	3,347	3,301
4. Land Use, Land Use Change and Forestry Sector	-21,413	-21,470	-21,484	-21,499	-21,410	-21,425	-21,451	-21,486	-21,507	-21,440
5. Waste Sector	4,423	3,986	3,655	3,325	3,125	2,886	2,804	2,734	2,754	2,703
Net GHG Emission (including LULUCF)	265,549	271,137	266,290	267,623	269,832	268,648	272,437	277,549	275,679	265,621
Total GHG Emission (excluding LULUCF)	286,962	292,607	287,774	289,121	291,242	290,073	293,888	299,034	297,186	287,060

1. Energy sector

The total greenhouse gas emission from the energy sector in 1990 was 110,525 kilotons of carbon dioxide equivalents and increased to 260,662 kilotons of carbon dioxide equivalents in 2019 with a growth of 135.84% and an annual average growth of 3.00%, as shown in Table ES3.2. During this period, the greenhouse gas emissions from the energy sector showed a downward trend in 2008 for the first time and declined again in 2009, followed by more reduction in 2012. Emissions produced by energy sector in 2019 increased by 4.33% compared to 2005(Base year). Compared with 2018, the greenhouse gas emissions in 2019 decreased by 3.14%. The total greenhouse gas emission from the energy sector in 2019 accounted for 90.80% of the total greenhouse

gas emission in Taiwan. In particular, 1.A.1 “energy industry” was responsible for 182,014 kilotons of carbon dioxide equivalents, accounting for 69.83% of the total greenhouse gas emission from the energy sector; 1.A.2 “manufacturing and construction industry” was responsible for 32,797 kilotons of carbon dioxide equivalents (accounting for 12.58%); 1.A.3 “transportation” was responsible for 36,238 kilotons of carbon dioxide equivalents (accounting for 13.90%); 1.A.4 “other sectors (including service industry, residential and agriculture, forestry, fishery and husbandry)” was responsible for 9,356 kilotons of carbon dioxide equivalents (accounting for 3.59%); 1.B.2 “oil and gas” was responsible for 258 kilotons of carbon dioxide equivalents (accounting for 0.10%), as shown in Figure ES3.4.

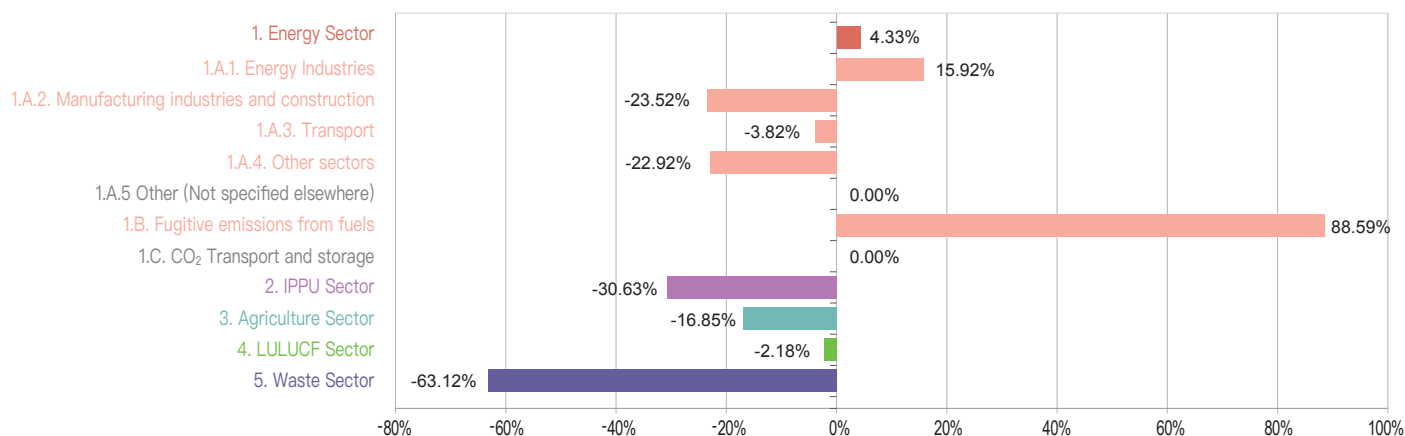


Figure ES3.3 Changes in Greenhouse Gas Emissions and Sequestrations by Sectors in Taiwan from 2005 to 2019.

Table ES3.2 1990–2019 Greenhouse Gas Emissions Produced by Energy Sector in Taiwan

(Unit: Kilotons of Carbon Dioxide Equivalents)

GHG Emission Sources and Sinks	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total CO ₂ Emission	109,459	118,436	126,052	135,199	143,097	150,803	158,572	170,826	181,509	190,437
1.A.1 Energy Industry	49,123	55,126	58,529	65,962	70,771	76,400	81,254	91,407	100,414	105,782
1.A.2 Manufacturing and Construction Industry	30,117	31,956	33,383	33,611	34,586	35,763	36,785	39,075	39,311	41,305
1.A.3 Transportation	19,646	20,888	24,033	26,103	27,540	28,822	29,801	30,536	31,844	32,772
1.A.4 Others Sectors	10,572	10,466	10,107	9,523	10,200	9,819	10,733	9,808	9,939	10,579
Total CH ₄ Emission	530	506	497	511	526	533	520	514	535	561
1.A.1 Energy Industry	26	29	28	32	35	40	41	46	50	58
1.A.2 Manufacturing and Construction Industry	46	48	52	51	52	54	56	58	59	63
1.A.3 Transportation	152	163	187	202	216	228	239	245	257	266
1.A.4 Others Sectors	30	29	28	26	28	27	29	26	27	28
1.B.1 Solid Fuel	162	138	115	113	98	81	51	34	27	31
1.B.2 Oil and Gas	115	98	88	87	97	103	103	104	115	113
Total N ₂ O Emission	537	578	653	703	742	778	825	866	917	968
1.A.1 Energy Industry	138	157	183	207	223	240	271	300	331	361
1.A.2 Manufacturing and Construction Industry	90	95	101	100	103	105	109	114	115	123
1.A.3 Transportation	291	309	353	382	402	418	428	438	456	469
1.A.4 Others Sectors	17	17	15	14	15	14	16	14	14	14
Total Emission from Energy Sector	110,525	119,521	127,202	136,414	144,365	152,115	159,917	172,206	182,961	191,966

Table ES3.2 1990-2019 Greenhouse Gas Emissions Produced by Energy Sector in Taiwan

(Unit: Kilotons of Carbon Dioxide Equivalents)

GHG Emission Sources and Sinks	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total CO ₂ Emission	209,205	213,107	220,870	230,832	239,929	247,956	255,331	259,214	247,537	235,868
1.A.1 Energy Industry	121,143	126,142	130,463	141,730	148,677	156,351	163,615	170,131	164,432	155,166
1.A.2 Manufacturing and Construction Industry	43,934	42,545	44,814	42,788	43,163	42,671	43,994	43,293	39,104	36,698
1.A.3 Transportation	33,207	33,246	34,542	34,509	35,859	36,846	36,771	35,419	33,216	33,541
1.A.4 Others Sectors	10,922	11,174	11,052	11,806	12,230	12,089	10,952	10,370	10,785	10,463
Total CH ₄ Emission	574	565	585	630	661	631	625	622	604	597
1.A.1 Energy Industry	66	70	69	78	81	84	88	90	88	81
1.A.2 Manufacturing and Construction Industry	70	71	75	73	75	75	78	77	71	67
1.A.3 Transportation	270	272	278	287	295	303	298	289	275	281
1.A.4 Others Sectors	29	30	30	32	33	33	29	27	28	27
1.B.1 Solid Fuel	28	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.B.2 Oil and Gas	111	122	132	159	176	137	133	138	142	141
Total N ₂ O Emission	1,052	1,083	1,134	1,188	1,228	1,269	1,299	1,303	1,239	1,211
1.A.1 Energy Industry	428	458	480	537	556	584	612	638	616	593
1.A.2 Manufacturing and Construction Industry	134	135	142	138	141	140	145	143	131	124
1.A.3 Transportation	475	475	496	495	513	527	527	508	478	480
1.A.4 Others Sectors	15	16	16	17	18	17	15	13	14	13
Total Emission from Energy Sector	210,831	214,756	222,589	232,650	241,818	249,856	257,255	261,138	249,380	237,676
GHG Emission Sources and Sinks	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total CO ₂ Emission	251,708	257,096	253,183	254,070	258,481	258,476	262,982	269,462	267,129	258,719
1.A.1 Energy Industry	165,522	169,884	168,333	168,271	175,180	175,198	178,569	187,135	189,212	181,318
1.A.2 Manufacturing and Construction Industry	41,360	42,298	41,000	42,019	38,953	38,074	38,296	36,741	33,401	32,638
1.A.3 Transportation	34,652	35,107	34,284	34,209	34,666	35,506	36,584	36,202	35,207	35,443
1.A.4 Others Sectors	10,174	9,807	9,566	9,571	9,681	9,698	9,533	9,384	9,310	9,320
Total CH ₄ Emission	631	654	663	676	686	710	730	738	721	717
1.A.1 Energy Industry	86	86	86	85	88	91	92	94	94	90
1.A.2 Manufacturing and Construction Industry	74	79	76	78	74	74	74	69	59	58
1.A.3 Transportation	284	287	283	284	285	292	301	295	286	287
1.A.4 Others Sectors	26	25	25	25	25	25	25	24	24	24
1.B.1 Solid Fuel	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.B.2 Oil and Gas	161	176	193	205	214	228	239	255	258	258
Total N ₂ O Emission	1,248	1,268	1,247	1,241	1,246	1,242	1,264	1,276	1,257	1,226
1.A.1 Energy Industry	603	607	603	595	599	585	595	621	633	605
1.A.2 Manufacturing and Construction Industry	135	144	137	140	133	131	131	123	103	101
1.A.3 Transportation	497	505	495	494	500	513	526	521	510	508
1.A.4 Others Sectors	13	12	12	12	13	13	12	12	11	11
Total Emission from Energy Sector	253,588	259,018	255,093	255,987	260,413	260,428	264,977	271,475	269,107	260,662

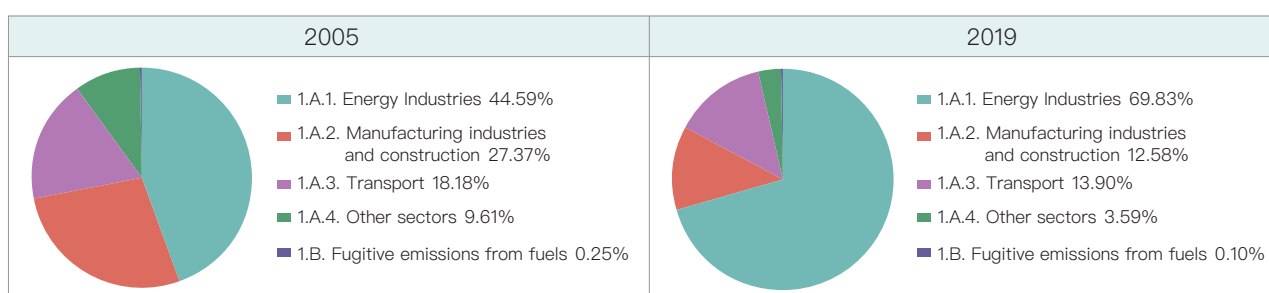


Figure ES3.4 Percentage of Greenhouse Gas Emissions by Energy Sectors in Taiwan in (a)2005 and (b)2019.

2. Industrial Process and Product Use (IPPU) Sector

The greenhouse gas emission from the IPPU sector in 1990 was 14,629 kilotons of carbon dioxide equivalents and increased to 20,394 kilotons in 2019, a growth of 39.41% and

an annual average growth of 1.15%, as shown in Table ES3.3. Emissions produced by IPPU sector in 2019 decreased by 30.63% compared to 2005(Base year). Compared with 2018, the greenhouse gas emissions in 2019 decreased by 7.21%. The

total greenhouse gas emission in 2019 accounted for 7.10% of the total greenhouse gas emission in Taiwan. In particular, 2.A “mining industry (non-metal process)” was responsible for 6,501 kilotons of carbon dioxide equivalents, accounting for 31.88% (the majority) of the greenhouse gases from the IPPU sector, followed by 2.C “metal process”, which was responsible for 6,412 kilotons of carbon dioxide equivalents (accounting for 31.44%), 2.E “electronics industry”, which was responsible for 3,885 kilotons of carbon dioxide equivalents (accounting for

19.05%), 2.B “chemical industry”, which was responsible for 2,623 kilotons of carbon dioxide equivalents (accounting for 12.86%), 2.F “alternatives to ozone-depleting substances”, which was responsible for 846 kilotons of carbon dioxide equivalents (accounting for 4.15%), 2.G. “manufacturing and use of other products”, which was responsible for 110 kilotons of carbon dioxide equivalents (accounting for 0.54%), and 2.H. “others”, which was responsible for 17 kilotons of carbon dioxide equivalents (accounting for 0.08%), as shown in Figure ES3.5.

Table ES3.3 1990–2019 Greenhouse Gas Emissions Produced by Industrial Process and Product Use Sector (IPPU) in Taiwan

(Unit: Kilotons of Carbon Dioxide Equivalents)

GHG Emission Sources and Sinks	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total CO ₂ Emission	14,458	15,007	15,926	18,408	17,826	17,528	17,677	19,483	18,406	17,179
2.A Mining Industry (Non-metal Products)	10,584	10,698	11,854	13,879	13,259	12,766	12,645	13,394	11,564	10,746
2.B Chemical Industry	575	551	575	617	770	858	999	1,026	1,007	1,079
2.C Metal Process	3,275	3,735	3,474	3,888	3,774	3,884	4,013	5,045	5,817	5,333
2.H Others	23	23	23	24	23	21	20	19	22	21
Total CH ₄ Emission	5	7	6	7	8	10	11	12	10	12
Total N ₂ O Emission	166	352	325	301	318	345	343	374	383	312
2.B Chemical Industry	166	352	325	301	318	345	343	374	383	312
2.C Metal Process	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.E Electronics Industry	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total HFCs Emission	NE	NE	NE	755	855	801	1,305	1,477	2,083	1,609
2.B Chemical Industry	NE	NE	NE	755	855	801	1,305	1,477	2,083	1,609
2.E Electronics Industry	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.F Alternatives to Ozone-depleting Substances	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total PFCs Emission (2.E Electronics Industry)	NE	NE	NE	NE	NE	NE	NE	NE	NE	3
Total SF ₆ Emission	NE	NE	NE	NE	NE	NE	NE	NE	NE	116
2.C Metal Process	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.E Electronics Industry	NE	NE	NE	NE	NE	NE	NE	NE	NE	116
2.G Manufacturing and Use of Other Products	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total NF ₃ Emission (2.E Electronics Industry)	NE	NE	NE	NE	NE	NE	NE	NE	NE	11
Total Emission from IPPU Sector	14,629	15,366	16,257	19,471	19,007	18,685	19,336	21,346	20,886	19,241
GHG Emission Sources and Sinks	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total CO ₂ Emission	17,388	16,186	16,075	17,070	17,358	18,094	20,299	19,967	18,558	16,428
2.A Mining Industry (Non-metal Products)	10,486	9,974	10,648	10,270	10,691	11,257	11,014	10,369	9,289	8,467
2.B Chemical Industry	1,148	1,232	1,313	1,384	1,485	1,751	1,721	1,845	1,601	1,623
2.C Metal Process	5,734	4,960	4,096	5,397	5,162	5,066	7,544	7,733	7,648	6,317
2.H Others	20	20	18	18	19	20	21	20	20	21
Total CH ₄ Emission	14	18	19	22	28	18	22	28	27	21
Total N ₂ O Emission	625	714	744	833	834	1,002	1,474	1,573	1,332	1,500
2.B Chemical Industry	625	714	743	831	834	960	969	996	784	1,006
2.C Metal Process	NE	NE	0	2	NE	0	94	95	90	76
2.E Electronics Industry	NE	NE	NE	NE	NE	42	411	481	458	417
Total HFCs Emission	2,319	2,619	2,216	2,397	2,451	1,098	1,015	1,122	1,074	1,018
2.B Chemical Industry	2,319	2,567	2,157	1,937	1,710	NE	NE	NE	NE	NE
2.E Electronics Industry	NE	51	59	59	59	102	119	199	146	206
2.F Alternatives to Ozone-depleting Substances	NE	NE	NE	401	682	996	896	922	928	812
Total PFCs Emission (2.E Electronics Industry)	13	2,939	4,143	4,198	4,341	3,470	3,664	3,372	2,082	1,560
Total SF ₆ Emission	120	746	3,914	4,385	5,193	4,951	3,858	3,381	2,912	2,452
2.C Metal Process	NE	NE	1,027	1,027	1,357	1,063	770	440	144	235
2.E Electronics Industry	120	746	944	1,415	1,783	2,384	2,318	1,988	1,872	1,514
2.G Manufacturing and Use of Other Products	NE	NE	1,943	1,943	2,053	1,503	770	953	895	703
Total NF ₃ Emission (2.E Electronics Industry)	10	235	398	540	659	765	688	798	204	577
Total Emission from IPPU Sector	20,488	23,456	27,509	29,444	30,864	29,398	31,019	30,241	26,190	23,557

Table ES3-3 1990-2019 Greenhouse Gas Emissions Produced by Industrial Process and Product Use Sector (IPPU) in Taiwan

(Unit: Kilotons of Carbon Dioxide Equivalents)

GHG Emission Sources and Sinks	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total CO ₂ Emission	18,178	18,985	19,369	19,529	17,644	17,219	16,557	15,199	15,525	14,553
2.A Mining Industry (Non-metal Products)	8,616	9,577	9,333	9,866	8,728	8,345	7,108	6,262	6,403	6,501
2.B Chemical Industry	1,750	1,768	1,714	1,749	1,884	1,854	1,760	1,709	1,684	1,666
2.C Metal Process	7,792	7,620	8,301	7,894	7,013	7,000	7,670	7,208	7,419	6,368
2.H Others	20	20	21	19	19	20	19	20	19	17
Total CH ₄ Emission	23	15	23	25	26	15	27	24	27	26
Total N ₂ O Emission	1,877	1,805	1,717	1,582	1,557	1,550	1,744	1,944	2,067	1,961
2.B Chemical Industry	1,170	1,195	1,016	780	728	691	961	1,114	1,110	931
2.C Metal Process	119	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.E Electronics Industry	588	611	701	802	829	860	783	830	957	1,030
Total HFCs Emission	971	1,053	907	1,019	1,048	1,020	1,026	1,023	1,013	1,027
2.B Chemical Industry	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.E Electronics Industry	201	172	124	207	220	170	191	202	201	181
2.F Alternatives to Ozone-depleting Substances	770	881	783	812	828	851	835	821	811	846
Total PFCs Emission (2.E Electronics Industry)	1,770	1,781	1,141	1,345	1,556	1,347	1,441	1,409	1,536	1,420
Total SF ₆ Emission	2,218	1,918	1,852	1,997	1,730	1,523	1,418	1,416	1,302	935
2.C Metal Process	57	50	30	38	33	43	41	59	81	43
2.E Electronics Industry	1,923	1,615	1,628	1,800	1,552	1,351	1,295	1,278	1,072	781
2.G Manufacturing and Use of Other Products	238	252	195	160	146	128	82	79	149	110
Total NF ₃ Emission (2.E Electronics Industry)	258	420	388	773	667	662	472	440	509	473
Total Emission from IPPU Sector	25,296	25,977	25,397	26,270	24,228	23,336	22,684	21,456	21,979	20,394

Note: NO (not happened). Taiwanese coal has been discontinued since 2001.

3. Agriculture Sector

In 2019, the greenhouse gas emissions from the agriculture sector totaled 3,301 kilotons of carbon dioxide equivalents, accounting for 1.15% of the total greenhouse gas emission in Taiwan, approximately down by 34.63% compared to 5,049 kilotons of carbon dioxide equivalents in 1990, with an average annual growth rate of -1.46%, as shown in Table ES3.4. Emissions produced by the agriculture sector in 2019 decreased by 16.85% compared to 2005(Base year). Compared to 2018, the greenhouse gas emissions from the agriculture sector in 2019 were down by 1.38%. In particular, greenhouse gas emissions from 3.D “agricultural soil” accounted for 35.88%, greenhouse gas emissions from

3.B “livestock waste treatment” accounted for 27.23%, greenhouse gas emissions from 3.C “rice culturing” accounted for 18.50%, greenhouse gas emissions from 3.A “livestock gastrointestinal fermentation” accounted for 17.41%, greenhouse gas emissions from 3.H “urea use” accounted for 0.89%, and greenhouse gas emissions from 3.F “field burning of agricultural residues” accounted for 0.10%, as shown in Figure ES3.6.

4. Land use, land use change and forestry (LULUCF) sector

The main greenhouse gas sequestered by the land use, land use change and forestry (LULUCF) sector is carbon dioxide, while the change in the annual sequestration does not vary much with the exception of trends in minor fluctuations

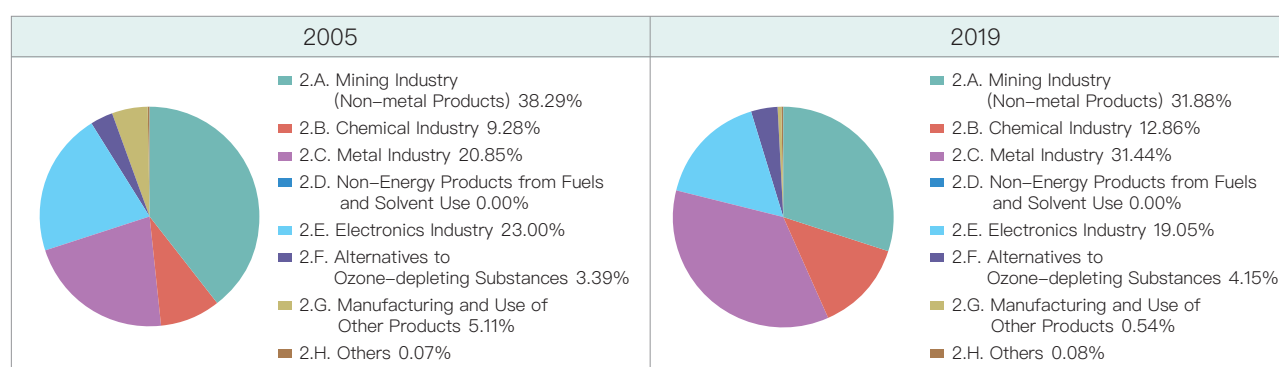


Figure ES3.5 Percentage of Greenhouse Gas Emissions by Industrial Process and Product Use Sectors in Taiwan in 2005 (left) and 2019 (right).

Table ES3.4 1990-2019 Greenhouse Gas Emissions Produced by Agriculture Sector in Taiwan

(Unit: Kilotons of Carbon Dioxide Equivalents)

GHG Emission Sources and Sinks	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total CO ₂ Emission	142	146	139	131	135	151	151	134	127	118
Total CH ₄ Emission	2,914	3,100	3,018	3,025	3,012	3,079	3,085	2,672	2,421	2,517
3.A Livestock Gastrointestinal Fermentation	670	731	738	775	789	822	822	732	674	694
3.B Livestock Waste Treatment	1,112	1,304	1,266	1,282	1,312	1,371	1,398	1,062	884	971
3.C Rice Culturing	1,094	1,040	968	946	891	879	858	871	858	845
3.F Field Burning of Agricultural Residues	38	25	48	22	21	7	7	7	6	7
Total N ₂ O Emission	1,994	2,048	1,977	2,008	1,997	1,991	2,028	1,800	1,683	1,665
3.B Livestock Waste Treatment	145	164	162	165	173	180	188	160	145	154
3.D Agricultural Soil	1,837	1,876	1,800	1,837	1,818	1,808	1,838	1,638	1,536	1,509
3.F Field Burning of Agricultural Residues	12	8	15	7	6	2	2	2	2	2
Total Emission From Agriculture Sector	5,049	5,294	5,134	5,164	5,145	5,221	5,263	4,606	4,231	4,301
GHG Emission Sources and Sinks	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total CO ₂ Emission	131	94	93	82	84	62	59	57	57	55
Total CH ₄ Emission	2,511	2,425	2,290	2,188	2,110	2,228	2,197	2,116	2,056	2,006
3.A Livestock Gastrointestinal Fermentation	692	660	636	626	614	623	614	609	584	571
3.B Livestock Waste Treatment	1,003	959	913	909	915	957	945	888	861	825
3.C Rice Culturing	802	792	729	644	574	640	630	616	604	605
3.F Field Burning of Agricultural Residues	14	15	13	9	8	8	8	5	6	5
Total N ₂ O Emission	1,879	1,801	1,806	1,674	1,787	1,680	1,709	1,670	1,587	1,616
3.B Livestock Waste Treatment	158	152	147	148	147	153	153	146	145	141
3.D Agricultural Soil	1,717	1,644	1,655	1,524	1,639	1,524	1,554	1,522	1,440	1,474
3.F Field Burning of Agricultural Residues	4	5	4	3	2	2	3	1	2	2
Total Emission From Agriculture Sector	4,521	4,320	4,189	3,944	3,981	3,969	3,966	3,844	3,700	3,678
GHG Emission Sources and Sinks	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total CO ₂ Emission	54	53	55	45	40	38	34	31	30	29
Total CH ₄ Emission	2,003	2,034	2,010	1,997	1,947	1,927	1,933	1,932	1,932	1,942
3.A Livestock Gastrointestinal Fermentation	578	590	583	579	566	573	561	564	572	575
3.B Livestock Waste Treatment	831	843	807	781	750	744	740	738	743	754
3.C Rice Culturing	589	596	614	634	626	605	629	626	615	611
3.F Field Burning of Agricultural Residues	5	5	5	3	4	5	3	3	2	2
Total N ₂ O Emission	1,598	1,540	1,564	1,497	1,490	1,459	1,456	1,406	1,385	1,330
3.B Livestock Waste Treatment	141	142	139	137	136	136	138	139	141	145
3.D Agricultural Soil	1,456	1,396	1,424	1,359	1,353	1,322	1,318	1,266	1,243	1,184
3.F Field Burning of Agricultural Residues	2	2	2	1	1	1	1	1	1	1
Total Emission From Agriculture Sector	3,655	3,627	3,630	3,540	3,476	3,423	3,424	3,369	3,347	3,301

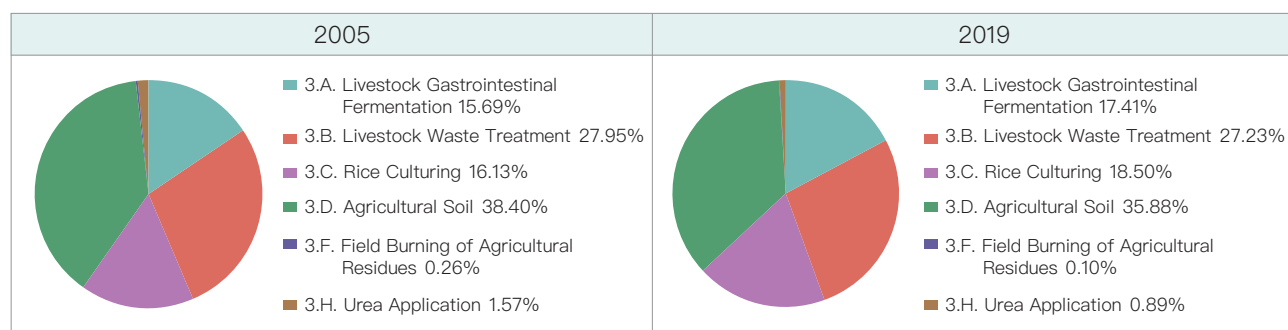


Figure ES3.6 Percentage of Greenhouse Gas Emissions by Agriculture Sectors in Taiwan in 2005 (left) and 2019 (right).

for the sequestration in the past. It is mainly because of the increased sequestration from the annual growth of forest resources while the sequestration reduced from the increased sequestration of forestation and the forest interference is less. The greenhouse gas emission from land use and forestry sector in Taiwan from 1990 to 2019 (mainly consisting of carbon dioxide sequestration by forestry resources) is shown in Table ES3.5. The carbon dioxide sequestration by forestry sector in 1990 was 23,386 kilotons of carbon dioxide equivalents. Compared to 2005(base year), the sequestration in 2019 were down by 2.18%. The sequestration in 2019 was 21,440 kilotons of carbon dioxide equivalents, down by 0.31% compared with 2018. The carbon dioxide sequestration between 1990 and 2019 decreased by 8.32% with an average annual growth rate of -0.30%.

5. Waste sector

In 1990, The greenhouse gas emissions by waste sector was 7,573 kilotons of carbon dioxide equivalents. The emissions from the waste sector in 2019 were 2,703 kilotons of carbon dioxide equivalents, approximately accounting for 0.94% of the total greenhouse gas emission in Taiwan (as shown in Table ES3.6), down by 64.30% compared with 1990, with an average annual growth of -3.49%. Emissions produced by the waste sector in 2019 decreased by 63.12% compared to 2005(Base year). Compared to 2018, the greenhouse gas emissions from the waste sector in 2019 were down by 1.83%. Among the waste sector's emissions in 2019, greenhouse gas emissions from 5.D "wastewater treatment and discharge" accounted for 65.81%, followed by greenhouse gas emissions from 5.A "solid waste disposal", accounting for 24.26%, greenhouse gas emissions from 5.C "waste incineration and opening burning", accounting for 8.21%, greenhouse gas emissions from 5.B "waste biological disposal", accounting for 1.73%, as shown in Figure ES3.7.

Table ES3.5 1990-2019 Changes in Carbon Sequestration by Land Use, Land Use Change and Forestry (LULUCF) Sector in Taiwan

(Unit: Kilotons of Carbon Dioxide Equivalents)

GHG Emission Sources and Sinks		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
4.A.1 Forests Maintaining Forests	Biomass Carbon Sequestration (Δ CO _{2e})	-23,902	-23,902	-23,713	-23,524	-23,335	-23,146	-22,957	-22,768	-22,579	-2,390
	Biomass Carbon Emissions (Δ CO _{2e})	607	2,503 ^a	333	216	190	202	559	266	326	401
4.A.2 Other Lands Turned to Forests	Biomass Carbon Sequestration (Δ CO _{2e})	-91	-91	-136	-185	-233	-288	-319	-397	-446	-561
Total Carbon Sequestration (Δ CO₂)		-23,386	-21,490	-23,516	-23,493	-23,379	-23,233	-22,717	-22,899	-22,699	-22,550
GHG Emission Sources and Sinks		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
4.A.1 Forests Maintaining Forests	Biomass Carbon Sequestration (Δ CO _{2e})	-22,201	-22,012	-21,823	-21,633	-21,444	-21,255	-21,066	-20,877	-20,688	-20,499
	Biomass Carbon Emissions (Δ CO _{2e})	389	1,112 ^b	167	227	243	369	251	308	199	2,753 ^c
4.A.2 Other Lands Turned to Forests	Biomass Carbon Sequestration (Δ CO _{2e})	-665	-683	-759	-899	-995	-1,032	-1,046	-1,080	-1,142	-1,166
Total Carbon Sequestration (Δ CO₂)		-22,476	-21,583	-22,415	-22,305	-22,196	-21,918	-21,861	-21,650	-21,631	-18,911
GHG Emission Sources and Sinks		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
4.A.1 Forests Maintaining Forests	Biomass Carbon Sequestration (Δ CO _{2e})	-20,392	-20,409	-20,435	-20,473	-20,508	-20,546	-20,575	-20,612	-20,656	-20,710
	Biomass Carbon Emissions (Δ CO _{2e})	218	140	145	135	197	189	153	107	83	116
4.A.2 Other Lands Turned to Forests	Biomass Carbon Sequestration (Δ CO _{2e})	-1,240	-1,202	-1,194	-1,161	-1,099	-1,068	-1,029	-980	-934	-845
Total Carbon Sequestration (Δ CO₂)		-21,413	-21,470	-21,484	-21,499	-21,410	-21,425	-21,451	-21,486	-21,507	-21,440

Note:

- In 1991, a total of 7 disasters occurred, including typhoon disasters and forest fires, covering a total area of 295.74 hectares, with a volume of 1,348,998.61 square meters damaged and a volume loss of 1,348,992.06 square meters.
- In addition to the five forest fires that occurred in Takivatan, Lishan Mountain, East Peak of Mt. Shei, and Yangmingshan National Park, there were 59 breaking out of small fire in 2001, and the fire damaged area up to 395 square meters, causing heavy loss of forest resources.
- In 2009, the typhoon Morakot caused severe disasters in central and southern Taiwan, especially in Kaohsiung and parts of Pingtung, dropped more than 2,500 millimeters of rain and produced about 1.25 million tons of driftwood, causing large losses in volume of wood.

Table ES3.6 1990-2019 Greenhouse Gas Emissions in Taiwan by Waste Sector

(Unit: Kilotons of Carbon Dioxide Equivalents)

GHG Emission Sources and Sinks	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total CO ₂ Emission	20	8	65	63	110	398	387	105	117	65
Total CH ₄ Emission	7,257	7,416	7,455	7,839	8,595	9,277	9,675	9,803	9,933	10,098
5.A Solid Waste Disposal	5,833	5,919	5,930	6,325	7,063	7,721	8,082	8,215	8,376	8,608
5.B Solid Waste Biological Disposal	11	1	1	0	0	1	0	1	0	2
5.D Wastewater Treatment and Discharge	1,412	1,497	1,525	1,514	1,532	1,555	1,593	1,587	1,557	1,488
Total N ₂ O Emission	296	285	298	311	313	334	337	337	321	329
5.B Solid Waste Biological Disposal	10	0	1	0	0	1	0	1	0	2
5.C Waste Burn	1	0	4	3	6	18	19	4	6	3
5.D Wastewater Treatment and Discharge	284	284	294	307	307	316	318	332	315	324
Total Emission from Waste Sector	7,573	7,709	7,818	8,214	9,018	10,009	10,399	10,245	10,370	10,493
GHG Emission Sources and Sinks	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total CO ₂ Emission	259	540	612	417	512	348	470	562	443	154
Total CH ₄ Emission	9,457	8,726	8,235	7,767	7,171	6,631	6,042	5,553	4,972	4,420
5.A Solid Waste Disposal	8,030	7,311	6,830	6,322	5,777	5,231	4,666	4,144	3,608	3,072
5.B Solid Waste Biological Disposal	0	0	0	2	7	10	11	14	16	18
5.D Wastewater Treatment and Discharge	1,427	1,416	1,404	1,443	1,387	1,391	1,365	1,395	1,348	1,330
Total N ₂ O Emission	331	340	348	353	343	350	318	328	300	295
5.B Solid Waste Biological Disposal	0	0	0	2	6	9	10	13	15	16
5.C Waste Burn	8	30	26	24	23	27	30	30	21	9
5.D Wastewater Treatment and Discharge	322	310	321	327	314	314	278	285	264	270
Total Emission from Waste Sector	10,047	9,606	9,195	8,538	8,026	7,329	6,830	6,443	5,715	4,868
GHG Emission Sources and Sinks	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total CO ₂ Emission	208	149	149	153	146	103	132	129	159	214
Total CH ₄ Emission	3,913	3,523	3,194	2,849	2,647	2,442	2,342	2,228	2,211	2,102
5.A Solid Waste Disposal	2,601	2,226	1,890	1,598	1,351	1,141	970	835	723	656
5.B Solid Waste Biological Disposal	21	26	24	23	20	20	20	20	23	25
5.D Wastewater Treatment and Discharge	1,290	1,271	1,279	1,228	1,275	1,281	1,352	1,373	1,465	1,421
Total N ₂ O Emission	302	314	313	323	332	342	330	377	383	388
5.B Solid Waste Biological Disposal	19	23	22	20	18	18	18	18	21	22
5.C Waste Burn	11	9	9	9	9	6	7	7	7	8
5.D Wastewater Treatment and Discharge	273	282	282	294	305	318	306	352	356	358
Total Emission from Waste Sector	4,423	3,986	3,655	3,325	3,125	2,886	2,804	2,734	2,754	2,703

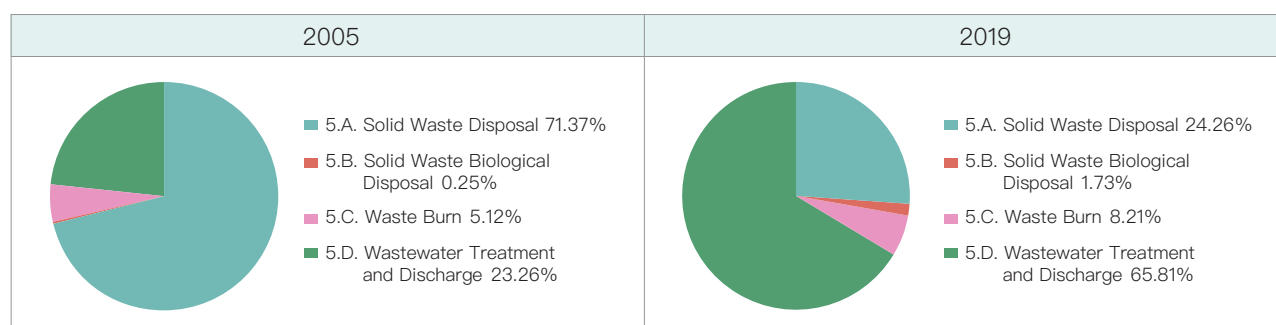


Figure ES3.7 Percentage of Greenhouse Gas Emissions by Waste Sectors in Taiwan in 2005 (left) and 2018 (right).

ES.4 Other Information

According to the Durban Accord, all countries listed under Annex 1 shall submit the National Inventory Report, Biennial Report, and National Communications, while countries not listed under Annex 1 shall submit the Biennial Update Report and National Communications. These national reports all relate to the content of National Greenhouse Gas Inventory. Taiwan is currently taking the initiative in establishing a national system that is feasible to conform to Taiwan's customs, division of labor in sectors, and the hierarchical management of database. In addition to formulating regulations governing national greenhouse gas inventory review, Taiwan also established a review committee, a review on greenhouse gas inventory, and a sound management system to comply with procedures of Measurement Reporting, and Verification (MRV). Moreover, to comply with the UNFCCC, Taiwan shall apply the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (hereinafter referred to as 2006 IPCC Guidelines) starting in 2015. Taiwan has started preparing a national greenhouse gas inventory with 2006 IPCC Guidelines-based statistical foundation and framework in addition to designing and establishing a registration platform for electronics national greenhouse gas inventory starting in 2013. At the same time, the relevant departments will test run this registration platform and submit the national greenhouse gas inventory statistics online. Taiwan has comprehensively adopted the 2006 IPCC Guidelines in step with the UNFCCC starting in 2015.



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