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The People's Republic of China

Third Biennial Update Report on

Climate Change

December 2023

Foreword

According to decision 1/CP.16 adopted in 2010 at the sixteenth session of the Conference of the Parties (COP 16) to the United Nations Framework Convention on Climate Change (UNFCCC), and decision 2/CP.17 adopted at COP 17 in 2011, non-Annex I Parties, consistent with their capabilities and the level of support received for reporting, are expected to submit biennial update reports starting from 2014. With the support of the grants from the Global Environment Facility (GEF), the government of the People's Republic of China (hereinafter referred to as China) has submitted three national communications (NCs) and two biennial update reports (BURs) on climate change.

Compiled under the support of the GEF grant, The People's Republic of China's Third Biennial Update Report on Climate Change follows the requirements of the UNFCCC biennial update reporting guidelines for non-Annex I Parties, which was approved by the COP 17. At the same time, it takes into account the modalities, procedures and guidelines (MPGs) for the enhanced transparency framework under the Paris Agreement. The national greenhouse gas inventory presented herein is of data in 2018. It aligns as much as possible to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and includes updated calculations corresponding to the reference period of the Nationally Determined Contributions (NDCs), in preparation of the biennial transparency report (BTR) under the Paris Agreement in the future.

The report includes chapters on national greenhouse gas inventory, mitigation actions and their effects, basic information of the Hong Kong Special Administrative Region (SAR) on addressing climate change, basic information of the Macao SAR on addressing climate change, and other information. With regard to national circumstances and institutional arrangements and finance, technology and capacity-building support received and required, please refer to The People's Republic of China's Fourth National Communication on Climate Change, the relevant content will not be repeated in this report.

This report was approved by the State Council after multiple revisions based on broad comments and officially submitted by the Ministry of Ecology and Environment together with The People's Republic of China's Fourth National Communication on Climate Change in fulfillment of the requirement of the Convention. The basic information of Hong Kong SAR and Macao SAR on addressing climate change in this report is provided by the Environmental Protection Department of the Hong Kong SAR Government and the Meteorological and Geophysical Bureau of the Macao SAR Government respectively.

Contents

Part I National Greenhouse Gas Inventory

In accordance with relevant decisions adopted by the UNFCCC and China's national circumstances, the National GHG Inventory of 2018 (NGI2018) covers the emission and absorption of six gases including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) associated with the Energy, Industrial Processes, Agriculture, Land Use, Land-Use Change and Forestry (LULUCF), and Waste. According to the implementation requirements of the Paris Agreement, the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (hereinafter referred to as the 2006 IPCC Guidelines) will be applicable from 2024 in preparing reports and inventories. For better technical and capacity-building preparation of the forthcoming compliance requirements, the methodology adopted for the current round of inventory has gradually been updated in accordance with the 2006 IPCC Guidelines. The Inventory mainly follows the 2006 IPCC Guidelines, the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (hereinafter referred to as the Revised 1996 IPCC Guidelines), the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (hereinafter referred to as GPG 2000), and GPG 2000 for Land Use, Land-Use Change and Forestry (hereinafter referred to as GPG-LULUCF). Activity data are mainly from official statistics, while emission factors are primarily from China's country-specific parameters, followed by the defaulted IPCC emission factor.

Chapter 1 Scope and Methodologies

1.1 Key Category Analysis

In accordance with the 2006 IPCC Guidelines, Approach 1 was used to identify NGI2018 key categories. The results showed that NGI2018 included 51 key categories, including: emission sources from Energy such as public electricity and heat production, iron and steel, non-metallic minerals and road transport; sources from Industrial Processes including CO_2 emissions from cement production, N_2O emissions from adipic acid production, HFCs emissions from fluorochemicals production; sources from Agriculture including CH_4 emissions from enteric fermentation, manure management and rice cultivation, and N_2O emissions from agricultural soils; sources from Waste such as CH_4 emissions from landfill and wastewater treatment; LULUCF such as carbon stock changes from unchanged land by category and land converted to other land-use categories and non-CO_2 emissions. Emissions from these key categories were calculated with higher-tier methods and country-specific emission factors for NGI2018. The methodologies applied for NGI2018 are shown in Table 1-1.

Table 1-1 Methodologies Used for the National GHG Inventory of 2018

Source/Sink Categories	CO_2		CH_4		N_2O	
	Methodology	Emission Factors	Methodology	Emission Factors	Methodology	Emission Factors
Energy industries	T2	D, CS	T1, T2	D, CS	T1, T2	D, CS
Manufacturing industries and construction	T2	D, CS	T1	D	T1	D
Transport	T2	D, CS	T1, T3	D, CS	T1, T3	D, CS
Other sectors	T2	D, CS	T1	D	T1	D
Fugitive emissions from solid fuels			T1, T2, T3	D, CS		
Fugitive emissions from oil and natural gas			T1, T3	D, CS		
Mineral industry	T1, T2	D, CS				
Chemical industry	T1, T2	D, CS	NE	NE	T2	CS
Metal industry	T1, T2	D, CS	T1	D	NO	NO
Non-energy products from fuels and solvent use	T1	D				
Enteric fermentation			T1, T2	D, CS		
Manure management			T1, T2	D, CS	T1, T2	D, CS
Rice cultivation			T3	CS		
Agricultural soils					T1, T2	D, CS
Field burning of agricultural residues			T1	D	T1	D
Forest land	T2	CS	T1	D	T1	D
Cropland	T3	CS	IE	IE	IE	IE
Grassland	T2	CS	T1	D	T1	D
Wetlands	T2	CS	T2	CS	NE	NE
Settlements	T2	CS				
Other land	T2	CS				
Harvested wood products	T2	CS				
Solid waste			T1, T2	D, CS		
Biological treatment			T1, T2	D, CS	T1, T2	D, CS
Wastewater treatment			T1, T2	D, CS	T1, T2	D, CS
Incineration of waste	T2	CS	T1	D, CS	T1	D, CS

Notes: 1. The methodological codes T1, T2 and T3 represent Tier 1, Tier 2 and Tier 3 methods respectively.
2. The emission factor code CS represents the country-specific emission factor in China, D represents the defaulted IPCC emission factor.
3. IE (included elsewhere) stands for sources which have been calculated and reported under other sub-categories. NE (not estimated) stands for existing emissions and removals which have not been estimated. NO (not occurred) stands for sources which do not exist.
4. Their parallel appearance shows that the sub-items use different Tier methods or emission factor data sources.

1.2 Energy

Energy in NGI2018 contains fuel combustion and fugitive emissions. Fuel combustion emissions cover energy industries, manufacturing and construction industries, transport and other sectors, of which, other sectors can be further segmented into service, agriculture and household. Fugitive emissions cover CH_4 emissions from solid fuels, and oil and natural gas systems. CO_2 emissions from fossil fuel combustion were calculated by the Sectoral Approach in the 2006 IPCC Guidelines and were verified with the Reference Approach. CH_4 and N_2O emissions from electricity and heat generation were calculated by Tier 2 method. CH_4 and N_2O emissions from other stationary fuel combustion sources were calculated by Tier 1 method. With regard to mobile combustion emissions, those from road transport were calculated by Tier 3 method, i.e., the COPERT model; those from aviation were calculated by Tier 2 method; those from railways, navigation and other transportation were calculated by Tier 1 method. CH_4 emissions from residential biofuel use and incineration of Waste were calculated by Tier 2 method. CH_4 emissions from other biofuel use were calculated by Tier 1 method. Emissions from mining and post-mining activities were calculated by Tier 2 method; emissions from open-pit coal mining were calculated by Tier 1 method; emissions from abandoned mines were calculated by Tier 3 method. Fugitive CH_4 emissions from the oil and gas systems were calculated using the combination of Tier 1 and Tier 3 methods.

1.3 Industrial Processes

Industrial Processes in NGI2018 include the GHG emissions from Mineral products, chemical industry, metal industry, non-energy products from fuels and solvent use, and consumption of halocarbons and sulfur hexafluoride (SF_6). Comparing with NGI2014, four emission sources were added into the chemical industry category, namely emissions from the production of caprolactam, titanium dioxide, methanol and ethylene; emissions from non-energy uses of lubricants and paraffin waxes were shifted from the Energy to Industrial Processes; emissions from the production of halocarbons and sulfur hexafluoride (SF_6) were included in fluorochemical production processes under the chemical industry category. The preparation of NGI2018 fully adopts the 2006 IPCC Guidelines with most of the sources calculated using Tier 2 method, as shown in Table 1-1.

1.4 Agriculture

Agriculture in NGI2018 includes CH_4 emissions from enteric fermentation, CH_4 and N_2O emissions from manure management, CH_4 emissions from rice cultivation, N_2O emissions from agricultural soils, and CH_4 and N_2O emissions from field burning of agricultural residues. The scope of NGI2018 was similar to that of NGI2014. Key sources of animal enteric fermentation and manure management were calculated by Tier 2 method of the 2006 IPCC Guidelines; CH_4 emissions from rice cultivation were calculated using the domestic CH4MOD model which belongs to Tier 3 method of the 2006 IPCC Guidelines; N_2O emissions from agricultural soils were calculated using the domestic IAP-N model which belongs to Tier 2 method of the 2006 IPCC Guidelines; other sources were calculated by Tier 1 method, as shown in Table 1-1.

1.5 Land Use, Land-Use Change and Forestry

Land Use, Land-Use Change, and Forestry (LULUCF) in NGI2018 covers GHG emissions and carbon sinks from 6 land-use types including forest land, cropland, grassland, wetlands, settlements and other land. For each type of unchanged land by category and land converted to other land-use categories, carbon stock change and non-CO_2 GHG emissions resulting from fires were calculated based on the estimation of 5 carbon pools: aboveground biomass, belowground biomass, litter, dead wood and soil organic matter. Tier 3 method was used for the calculation of the changes of reserves of soil organic carbon. The changes of reserves of forestry products were estimated by the "Production Accounting Approach." The "Stock Change Approach" and Tier 2 method in GPG-LULUCF were used to estimate changes of reserves of aboveground biomass, belowground biomass, litter and dead wood as well as soil organic matters in other carbon pools. Wetland CH_4 emissions were estimated by Tier 2 method. Emissions from forest and grassland fires were calculated by Tier 1 method.

1.6 Waste

Waste in NGI2018 covers GHG emissions from landfill disposal, biological treatment, wastewater treatment and incineration of hazardous waste, medical waste and sludge. Municipal waste incineration was reported under the Energy as the activity produces energy. Emissions from solid waste landfills were calculated using the first order decay (FOD) method (Tier 2). Emissions from incineration, biological treatment and wastewater treatment were calculated by the recommended methods of the 2006 IPCC Guidelines; while CH_4 emissions from urban wastewater treatment adopted a simplified approach, as shown in Table 1-1.

Chapter 2 Data Sources

2.1 Energy

The activity data on fossil fuel combustion in NGI2018 were mainly from the National Bureau of Statistics (NBS) and other relevant departments. Consumption of coal, oil and natural gas in 2018 were 2,784 Mtce, 892 Mtce and 359 Mtce, as shown in Table 1-2.

Table 1-2 Major Activity Data on Energy in 2018

	Activity Data		Activity Data
Coal consumption (Mtce)	2,784	Underground coal mining volume (Mt)	3,113
Oil consumption (Mtce)	892	Natural gas production (Bcm)	160.159
Natural gas consumption (Mtce)	359	Oil production (Mt)	189

The activity data of fugitive emissions from coal mining were mainly from the China Energy Statistical Yearbook 2019 and the Research Report on the Development of Global Coal Industry 2020. The activity data of fugitive emissions from oil and gas systems were mainly sourced from the NBS and underlying data reported by China's leading oil and gas groups, etc.

The carbon content per unit calorific value and carbon oxidation rate of coal combustion in the electricity industry were based on the measured data of power companies in the national carbon market. The carbon content per unit calorific value of natural gas and liquefied natural gas was based on the measured data of major oil and gas fields and imported natural gas and liquefied natural gas. The national average level of emission factors of CH_4 from underground coal mining and post-mining activities were based on the national coal mine gas classification information while other emission factors were the same as those in the NGI2014 or the defaulted value in the 2006 IPCC Guidelines.

2.2 Industrial Processes

The data on production of cement clinker in China in 2018 was quoted from statistical materials released by the NBS. The data on production of synthetic ammonia, nitric acid, iron and steel, aluminum, magnesium, lead and zinc were mainly from the China Industry Statistical Yearbook. The data on production of methanol and ethylene was from the China Chemical Industry Yearbook. The data on production of calcium carbide and lime was from the statistics of China Carbide Industry Association and China Lime Association respectively. The data on production of soda ash and adipic acid came from typical surveys of relevant companies. Activity data of major industry processes is shown in Table 1-3. The emission factors for the production of cement clinker, synthetic ammonia, adipic acid, calcium carbide, methanol, ethylene, fluorochemicals and iron and steel were country-specific data obtained through typical enterprise surveys. The emission factors for the smelting of aluminium, magnesium and lead are the same as those in the NGI2014, other sources were the defaulted factors from the 2006 IPCC Guidelines.

Table 1-3 Activity Data of Major Industrial Processes in 2018

	Activity Data		Activity Data
Cement clinker production (Mt)	1420	Methanol production (Mt)	55.76
Crude steel production (Mt)	929.04	Electrolytic aluminum production (Mt)	36.83
Ammonia production (Mt)	45.87	HCFC-22 production (kt)	683

2.3 Agriculture

Activity data of Agriculture in 2018 were mainly from the China Statistical Yearbook 2019, the China Rural Statistical Yearbook, the China Animal Husbandry and Veterinary Science Yearbook 2019, the Agricultural Information Institute of CAAS, the 2019 statistical data of relevant provinces (autonomous regions, municipalities directly under the central government) and the third agricultural census results. The main activity data are shown in Table 1-4. Country specific CH_4 emission factors for enteric fermentation by dairy cattle, beef cattle, buffalo, sheep and goats, for manure management of swine, beef cattle, dairy cattle, goats and sheep in 2018 were used. The 2018 CH_4 emission factors for rice paddy soil (growing season and fallow season in winter) were estimated using modeling. The 2018 N_2O direct emission factors were generated from multi-year field monitoring data for different agricultural land types in different regions, compiling emission factors by agricultural land type (including non-vegetable dryland, paddy fields with different crop rotations, vegetable fields, orchards and tea gardens, etc.). Other emission factors were the defaulted values of the 2006 IPCC Guidelines.

Table 1-4 Major Activity Data of Agriculture in 2018

	Activity Data		Activity Data
Cattle stock (million)	89.153	Area sown in food crops (Mha)	117.038
Pig stock (million)	428.174	Total rice cultivation (Mha)	30.189
Poultry stock (million)	6,037.387	Nitrogen fertilizer consumption (Mt nitrogen)	20.654
Sheep and goat stock (million)	297.127	Compound fertilizer net consumption (Mt)	22.688
Total cropped area (Mha)	165.902		

2.4 Land Use, Land-Use Changes and Forestry

In the preparation of LULUCF inventory of 2018, the data from the sixth to ninth continuous forest resources inventories and the 2021 nationwide comprehensive ecology monitoring of forest and grassland were used. For provinces (autonomous regions, municipalities directly under the central government), interpolation or aggregation methods according to the actual inventories were used to calculate national activity data in 2018, as shown in Table 1-5. The emission factors of forest land inventory and agricultural soil carbon adopted the country-specific data in the current year.

Table 1-5 Major Activity Data of LULUCF in 2018

	Activity Data		Activity Data
High forest area (Mha)	187.102	Agricultural land area (Mha)	128.614
Bamboo forest area (Mha)	6.653	Grassland area (Mha)	265.946
Shrub land area (Mha)	57.029	Wetlands area (Mha)	54.067
Other forest area (Mha)	21.296	Settlements area (Mha)	44.840

2.5 Waste

The activity data of Waste in 2018 was from the China Urban Construction Statistical Yearbook 2018 and the China Environment Statistical Yearbook 2019. Main activity data of Waste is shown in Table 1-6. Emission factors of landfill, incineration and wastewater treatment were country-specific data. Other emission factors referred to the defaulted values of the 2006 IPCC Guidelines.

Table 1-6 Major Activity Data of Waste in 2018

	Activity Data
Municipal solid waste (MSW) landfill (Mt)	117.0602
MSW incineration (Mt)	101.8492
MSW compost (Mt)	6.7442
COD discharged from wastewater (Mt)	5.5491

Chapter 3 National GHG Inventory in 2018

3.1 Overview

In 2018, China's total GHG emissions (with LULUCF) were approximately 11,779 million ton of carbon dioxide equivalent (Mt CO_2 eq) (Table 1-7), of which CO_2, CH_4, N_2O, HFCs, PFCs and SF_6 accounted for 81.1%, 11.4%, 5.0%, 1.6%, 0.2% and 0.6% respectively (Table 1-8). The GHG sink from LULUCF was 1,257 Mt CO_2 eq, and total GHG emissions were 13,035 Mt CO_2 eq (without LULUCF). The 100-year time-horizon global warming potential (GWP) values were from IPCC SAR (Table 1-9). The detailed information about China's greenhouse gas inventory in 2018 is shown in Table 1-10 and Table 1-11.

Table 1-7 GHG Emissions and Removals of China in 2018 (Mt CO_2 eq)

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Energy	9,426	602	127				10,155
Industrial processes	1,466	0	137	189	22	73	1,887
Agriculture		501	292				793
LULUCF	-1,340	84	0				-1,257
Waste	3	160	37				200
Total (without LULUCF)	10,896	1,263	593	189	22	73	13,035
Total (with LULUCF)	9,555	1,346	594	189	22	73	11,779

Notes: 1. Shaded cells do not require entries;
2. 0 indicates that the value is less than 0.5 Mt CO_2 eq;
3. Due to rounding, the aggregation of various items may be slightly different from the total.

Table 1-8 China's GHG Inventory by Gas in 2018

GHGs	With LULUCF		Without LULUCF	
	Emission/ Sink (Mt CO_2 eq)	Proportion (%)	Emission/ Sink (Mt CO_2 eq)	Proportion (%)
CO_2	9,555	81.1	10,896	83.6
CH_4	1,346	11.4	1,263	9.7
N_2O	594	5.0	593	4.6
Fluorinated gas	284	2.4	284	2.2
Total	11,779	100.0	13,035	100.0

Note: Due to rounding, the aggregation of various items may be slightly different from the total.

Table 1-9 GWP Values Used in the Inventory

GHGs	GWP	GHGs	GWP
CO_2	1	**HFC-152a**	140
CH_4	21	**HFC-227en**	2900
N_2O	310	**HFC-236fa**	6300
HFC-23 (CHF_3)	11700	**HFC-245fa**	1030
HFC-32	650	**HFC-365mfc**	794
HFC-125	2800	**PFC-14 (CF_4)**	6500
HFC-134a	1300	**PFC-116 (C_2F_6)**	9200
HFC-143a	3800	**SF_6**	23900

Note: the 100-year time-horizon GWP values of HFC-245fa and HFC-365mfc are from the IPCC AR4.

Energy is the main source of GHG emissions in China. In 2018, emissions from the Energy accounted for 77.9% of the national total emissions (without LULUCF). GHG emissions of Industrial Processes, Agriculture and Waste accounted for 14.5%, 6.1% and 1.5% respectively, as shown in Figure 1-1.

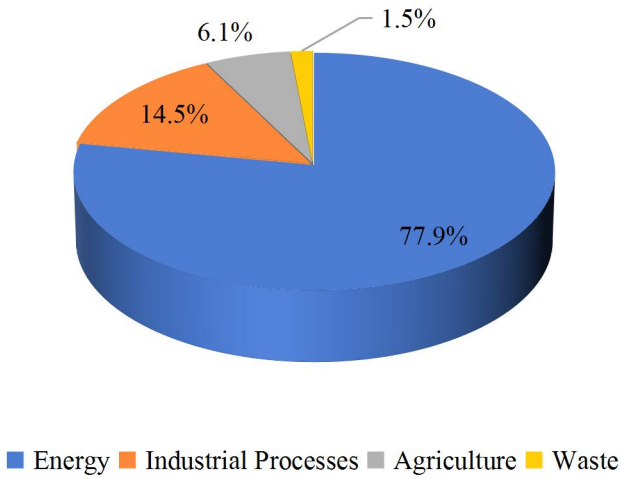

Figure 1-1 GHG emissions of China by sector in 2018 (without LULUCF)

3.1.1 Carbon Dioxide

China's CO_2 emissions in 2018 (with LULUCF) were 9,555 Mt. In 2018, China's CO_2 emissions (without LULUCF) were 10,896 Mt, of which 9,426 Mt were from Energy, accounting for 86.5%; 1,466 Mt were from Industrial Processes, accounting for 13.5%; as shown in Table 1-7. LULUCF, mainly carbon sinks, removed 1,340 Mt CO_2. In 2018, international aviation emitted 47 Mt CO_2, international navigation emitted 33 Mt CO_2, biomass combustion emitted 317 Mt CO_2, which were all reported as memo items, not included in the national total, as shown in Table 1-10.

3.1.2 Methane

China's CH_4 emissions in 2018 were 64.113 Mt, of which 28.658 Mt were from Energy, accounting for 44.7%; 5 kt were from Industrial Processes ; 23.846 Mt were from Agriculture, accounting for 37.2%; 3.981 Mt were from LULUCF, accounting for 6.2%; 7.622 Mt were from Waste, accounting for 11.9%.

3.1.3 Nitrous Oxide

China's N_2O emissions in 2018 were 1.915 Mt, of which 0.411 Mt were from Energy, accounting for 21.5%; 0.441 Mt were from Industrial Processes, accounting for 23.0%; 0.943 Mt were from Agriculture, accounting for 49.2%; 1 kt were from LULUCF, accounting for less than 0.1%; 0.119 Mt were from Waste, accounting for 6.2%.

3.1.4 Fluorinated Gas

In 2018, total emissions of fluorinated gases including HFCs, PFCs and SF_6 were about 284 Mt CO_2 eq, all from Industrial Processes. Among them, emissions from metal production were 20 Mt CO_2 eq, accounting for 7.0%; emissions from chemical production were 30 Mt CO_2 eq, accounting for 10.6%; emissions from consumption of halocarbons and SF_6 were

234 Mt CO_2 eq, accounting for 82.4%, as shown in Table 1-11.

3.2 Energy

In 2018, China's total GHG emissions from Energy were 10,155 Mt CO_2 eq. Among them, emissions from fuel combustion were 9,588 Mt CO_2 eq, accounting for 94.4%; fugitive emissions were 567 Mt CO_2 eq, accounting for 5.6%.

In terms of gas composition, CO_2 emissions were 9,426 Mt, all of which were from fuel combustion. CH_4 emissions were 28.658 Mt, of which 5.8% were from fuel combustion, and 94.2% were from fugitive emissions; and N_2O emissions were 0.411 Mt, all from fuel combustion. Meanwhile, CO_2 emissions from fossil fuel combustion had been estimated by the Reference Approach for verification; the difference between the results of Sectoral and Reference approaches is lower than 5%.

Table 1-10 China's CO_2, CH_4 and N_2O Emissions and Removals in 2018 (kt)

Source and sink categories	CO_2	CH_4	N_2O
Total (without LULUCF)	10,895,866	60,132	1,914
Total (with LULUCF)	9,555,394	64,113	1,915
1. Energy	9,426,194	28,658	411
– Fuel combustion	9,426,194	1,658	411
♦Energy industries	4,403,326	102	291
♦Manufacturing industries and construction	3,344,336	292	75
♦Transport	982,028	129	23
♦Other sectors	696,505	1,135	22
– Fugitive emissions		27,001	
♦Solid fuels		25,122	
♦Oil and natural gas		1,879	
2. Industrial Processes	1,466,252	5	441
– Mineral industry	991,360		
– Chemical industry	290,576		441
– Metal industry	181,670	5	NO
– Non-energy products from fuels and solvent use	2,645		
– Consumption of halocarbons and SF_6			
3. Agriculture		23,846	943
– Enteric fermentation		10,841	
– Manure management		3,461	217
– Rice cultivation		9,329	
– Agricultural soils			720
– Field burning of agricultural residues		216	6
4. LULUCF	-1,340,473	3,981	1
– Forest land	-965,792	1	0
– Cropland	-78,100	IE	IE
– Grassland	-101,752	1	1

Source and sink categories	CO_2	CH_4	N_2O
– Wetlands	-86,417	3,980	NE
– Settlements	-918		
– Other land	1,095		
– Harvested wood products	-108,590		
5. Waste	3,420	7,622	119
– Landfill		4,686	
– Biological treatment		27	2
– Wastewater treatment		2,908	113
– Incineration	3,420	1	4
6. Memo items			
– International aviation	46,834	0	1
– International navigation	33,298	3	1
– CO_2 emissions from biomass	316,584		

Notes: 1. Shaded cells do not require entries;
2. 0 indicates that the value is less than 0.5 kt;
3. NE (not estimated) indicates emissions and removals of existing source are not estimated, IE (included elsewhere) indicates the emission source is estimated and included in other sub-categories, and NO (not occurred) indicates the emission source doesn't exist;
4. Due to rounding, the aggregation of various items may have slight differences with the total;
5. Memo Items are not counted in the total emissions.

3.3 Industrial Processes

The total GHG emissions from China's Industrial Processes in 2018 were 1,887 Mt CO_2 eq, of which 991 Mt were from mineral industry, accounting for 52.5%; 457 Mt were from chemical industry, accounting for 24.2%; 202 Mt were from metal industry, accounting for 10.7%; 3 Mt were from non-energy products from fuels and solvent use, accounting for 0.1%; 234 Mt were from consumption of halocarbons and SF_6, accounting for 12.4%.

In terms of gas composition, CO_2 emissions were 1,466 Mt, of which 67.6% were from mineral industry, 19.8% from chemical industry, and 12.4% from metal industry, 0.2% from non-energy products from fuels and solvent use; CH_4 emissions were 5 kt, all from metal industry; N_2O emissions were 441 kt, all from chemical industry; HFCs emissions were 189 Mt CO_2 eq, of which 84.8% were from consumption of halocarbons and SF_6, and 15.2% from chemical industry; PFCs emissions were 22 Mt CO_2 eq, of which 90.3% were from metal industry, 9.3% from consumption of halocarbons and SF_6 and 0.4% were from chemical industry; SF_6 emissions were 73 Mt CO_2 eq, of which 98.2% were from consumption of halocarbons and SF_6, 1.8% from chemical industry.

Table 1-11 China's Total Emissions of Fluorinated Gases in 2018 (kt)

Sources	HFCs										PFCs		SF_6
	HFC-23	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-152a	HFC-227ea	HFC-236fa	HFC-245fa	HFC-365mfc	CF_4	C_2F_6	
Total emissions	2.0	30.4	25.8	44.6	2.3	0.7	1.8	0.1	0.4	0.0	2.9	0.3	3.0
1. Energy													
2. Industrial Processes	2.0	30.4	25.8	44.6	2.3	0.7	1.8	0.1	0.4	0.0	2.9	0.3	3.0
— Mineral industry													
— Chemical industry	2.0	1.0	0.8	0.9	0.1	0.2	0.1	0.0	0.1		0.0	0.0	0.1
— Metal industry											2.6	0.3	NO
— Non-energy products from fuels and solvent use													
— Consumption of halocarbons and SF_6	0.0	29.4	25.0	43.7	2.2	0.5	1.7	0.1	0.3	0.0	0.3	0.0	3
3. Agriculture													
4. LULUCF													
5. Waste													

Notes: 1. Shaded cells do not require entries;
2. 0.0 indicates that the value is less than 0.5 kt;
3. NO (not occurred) indicates the emission source doesn't exist;
4. Due to rounding, the aggregation of various items may have slight differences with the total.

3.4 Agriculture

In 2018, China's GHG emissions from Agriculture were around 793 Mt CO_2 eq, of which the emissions from enteric fermentation were 228 Mt CO_2 eq, accounting for 28.7%; the emissions from manure management were 140 Mt CO_2 eq, accounting for 17.7%; the emissions from rice cultivation were 196 Mt CO_2 eq, accounting for 24.7%; the emissions from agricultural soils were 223 Mt CO_2 eq, accounting for 28.1%; and the emissions from field burning of agricultural residues were 6 Mt CO_2 eq, accounting for 0.8%.

Regarding the composition of gases, CH_4 emissions were 23.846 Mt, of which 45.5% were from enteric fermentation, 14.5% were from manure management, 39.1% were from rice cultivation, 0.9% were from field burning of agricultural residues. N_2O emissions were 0.943 Mt, of which manure management accounted for 23.0%, agricultural soils emissions for 76.4%, field burning of agricultural residues for 0.6%.

3.5 LULUCF

In 2018, China's LULUCF absorbed 1,340 Mt CO_2, emitted 3.981 Mt CH_4 and 1 kt N_2O, and the net removal of GHG amounted to 1,257 Mt CO_2 eq. Forest land, cropland, grassland, wetlands, settlements and harvested wood products absorbed 966, 78, 102, 3, 1 and 109 Mt CO_2 eq respectively. Other land emitted 1 Mt CO_2.

3.6 Waste

In 2018, the total GHG emissions from Waste were 200 Mt CO_2 eq, of which 98 Mt CO_2 eq were from landfill, accounting for 49.1%; 96 Mt CO_2 eq were from wastewater treatment, accounting for 48%; 5 Mt CO_2 eq were from incineration, accounting for 2.3%; 1 Mt CO_2 eq were from biological treatment, accounting for 0.6%. Besides the aforementioned, municipal waste incineration generated emissions of 31 Mt CO_2 eq which were included under the Energy.

Regarding the composition of gases, CH_4 emissions were 7.622 Mt, accounting for 79.9%, of which 61.5% were from landfill, 38.2% were from wastewater treatment, 0.4% were from biological treatment, less than 0.1% were from incineration; N_2O emissions were 0.119 Mt, accounting for 18.4%, of which 95.1% were from wastewater treatment, 3.2% were from incineration, 1.7% were from biological treatment.

Chapter 4 National GHG Inventory in 2005

4.1 Recalculation of NGI2005

In response to updated estimation methods, expanded scope of calculation and necessary updates of underlying data, we have re-calculated the NGI2005 using the same reporting methods of NGI2018.

The recalculated NGI2005 further segmentized the manufacturing and construction industries, with the number of emission sources increased from 10 to 13. Except for charcoal, other types of biomass combustion were reported under the public electricity and heat production sector and the residential sector. With regard to waste treatment, CH_4 and N_2O emissions from municipal solid waste (MSW) incineration and CO_2 emissions from fossil sources are reported under Energy, and biogenic CO_2 emissions are reported as a memo item. Non-energy emissions were all reported under Industrial Processes.

The metal industry sector of the recalculated 2005 Industrial Processes inventory no longer included CO_2 emission from converter steelmaking, which is already reported in the Energy; N_2O emissions from caprolactam production and CO_2 emissions from titanium dioxide, methanol and ethylene were included under chemistry industry; emissions from lubricant and paraffin waxes of non-energy products from fuels and solvent use were shifted from Energy to Industrial Processes; emissions from production of halocarbons and SF_6 were placed under fluorochemical production of the chemical industry section.

The recalculated 2005 Agriculture inventory newly included indirect N_2O emissions from animal manure management and pasture while indirect N_2O emissions from nitrogen volatilization of livestock excreta were included under manure management.

Adopting the 2006 IPCC Guidelines, GPG-LULUCF and the 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands, the recalculated 2005 LULUCF inventory expanded scope of the report and newly included non-CO_2 emissions from forest land and grassland fires.

The recalculated 2005 Waste inventory only reported CO_2, CH_4 and N_2O emissions from incineration of hazardous waste and medical wastes, as well as CH_4 and N_2O emissions from sludge incineration.

4.2 Recalculated GHG emissions in 2005

4.2.1 Overview

In 2005, total GHG emissions in China (with LULUCF) were about 7,211 Mt CO_2 eq (Table 1-12), of which CO_2, CH_4, N_2O and fluorinated gases accounted for 76.9%, 15.1%, 6.3% and 1.7% respectively. Net removal of LULUCF was 770 Mt CO_2 eq. China's total GHG emissions (without LULUCF) in 2005 were around 7,981 Mt CO_2 eq, of which CO_2, CH_4, N_2O and fluorinated gases accounted for 80.3%, 12.5%, 5.6% and 1.6% respectively.

4.2.2 CO_2 Emissions

Energy and Industrial Processes were the main sources of CO_2 emissions in China. In 2005, total CO_2 emissions in China (without LULUCF) were about 6,407 Mt CO_2, of which emissions from Energy were 5,701 Mt CO_2, accounting for 89.0%; emissions from Industrial Processes were 706 Mt CO_2, accounting for 11.0%; emissions from waste incineration were 1 Mt CO_2, of extremely small percentage. Net removal of LULUCF was 862 Mt CO_2. In 2005, total CO_2 emissions in China (with LULUCF) were about 5,546 Mt CO_2.

Table 1-12 China's Total GHG in 2005 (Mt CO_2 eq)

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Energy	5,701	469	82				6,252
Industrial Processes	706	NE	34	114	4	7	865
Agriculture		450	304				755
LULUCF	-862	88	4				-770
Waste	1	81	29				110
Total (without LULUCF)	6,407	1,000	449	114	4	7	7,981
Total (with LULUCF)	5,546	1,088	453	114	4	7	7,211

Notes: 1. Shaded cells do not require entries;
2. NE (not estimated) indicates emissions and sink removals of existing source are not estimated;
3. Due to rounding, the aggregation of various items may have slight differences with the total;
4. The Table shows recalculated NGI information.

4.2.3 CH_4 Emissions

CH_4 emissions in China mainly originated from Energy and Agricultural. In 2005, total CH_4 emissions in China were about 51.823 Mt, equivalent to 1,088 Mt CO_2 eq, of which emissions from Energy accounted for 43.1%, Agriculture accounted for 41.4%, Waste accounted for 7.4%, and LULUCF accounted for 8.1%.

4.2.4 N_2O Emissions

N_2O emissions in China mainly originated from Agricultural and Energy. In 2005, total N_2O emissions in China were about 1.460 Mt, equivalent to 453 Mt CO_2 eq, of which emissions from Agriculture accounted for 67.2%, Energy accounted for 18.1%, Industrial Processes accounted for 7.4%, Waste accounted for 6.4%, and LULUCF accounted for 0.8%.

4.2.5 Emissions of Fluorinated Gases

In 2005, emissions of fluorinated gases in China came from Industrial Processes , and the total emissions were about 125 Mt CO_2 eq.

Chapter 5 Quality Assurance and Quality Control

5.1 Efforts to Reduce Uncertainties

In preparing NGI2018 and recalculating NGI2005, to improve the quality of inventory and reduce uncertainties, the inventory team paid much attention to quality assurance and quality control.

In terms of methods, the team carried out key category analysis, the results of which were used to choose approaches in the preparation of NGI2018. Emissions from key categories were estimated using as many higher-tier methods and country-specific emission factors as possible, thus improving the accuracy of the inventory.

Regarding the activity data, the NBS established a sector statistical reporting system for addressing climate change, which increased the types of energy statistics in a detailed way to gradually incorporate the activity data required by the preparation of GHG Inventory into the government statistical system. The inventory team also conducted verification using facility-level data from China's national carbon market.

In terms of emission factors, the inventory team and other relevant departments conducted research on carbon content per unit calorific value and carbon oxidation rate of coal combustion in coal-firing power plants, and typical surveys on animal production characteristics and manure management by main livestock and poultry and corresponding percentage to obtain country-specific emission factors and related domestic parameters. In preparing NGI2018, the inventory team gave first priority to country-specific emission factors, and second priority to the defaulted values of the relevant IPCC guidelines.

Regarding inventory management, the inventory team emphasized the management of data files. Materials supporting the preparation were archived in a timely manner. Meanwhile, to ensure high-quality electronic management of inventory-related data, China has established a database system for the national and sector GHG inventories.

The inventory team organized a number of technical seminars for academic exchanges and discussions with other domestic research institutions and experts to fully learn from their research results. In addition, the leading department invited experts who were not involved in the preparation of the inventory to carry out independent analysis and review of the inventory's methodologies and results as a strong support to the quality assurance of the inventory result.

5.2 Uncertainty Analysis

Based on the uncertainty analysis of activity data and emission factors of Energy, Industrial Processes, Agriculture, LULUCF, and Waste, the overall uncertainties were calculated according to the error propagation approach in the 2006 IPCC Guidelines, the overall uncertainty of the NGI2018 was from -4.9% to 5.1%, as shown in Table 1-13.

Table 1-13 Results of Uncertainty Analysis of NGI2018

	Emission/Sink (Mt CO_2 eq)	Uncertainties
Energy	10,155	-5.2%~5.5%
Industrial Processes	1,887	-3.8%~3.8%
Agriculture	793	-14.2%~14.2%
LULUCF	-1,257	-13.6%~13.6%
Waste	200	-23.0%~23.0%
Overall		-4.9%~5.1%

Chapter 6 Information on Inventories in Previous Submissions

In the initial, second, and third national communications, and the first and second biennial update reports, China submitted its national GHG inventories of 1994, 2005, 2010, 2012 and 2014. The following is the summary of the information in previous inventories except for recalculated NGI2005 that has been elaborated in Chapter 4. It should be noted that the inventories of 1994, 2010, 2012 and 2014 haven't been recalculated, so the methods and scope of the four inventories are different from those of 2005 and 2018.

6.1 National GHG Inventory in 1994

In 1994, China's total GHG emissions (with LUCF) were about 3,650 Mt CO_2 eq (Table 1-14), of which CO_2, CH_4 and N_2O accounted for 73.1%, 19.7%, and 7.2% respectively; the net removal of GHG in LUCF was about 407 Mt CO_2 eq. China's total GHG emissions (without LUCF) in 1994 were around 4,057 Mt CO_2 eq, of which CO_2, CH_4 and N_2O accounted for 75.8%, 17.7% and 6.5% respectively.

Table 1-14 GHG Inventory of China in 1994 (Mt CO_2 eq)

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Energy	2,795	197	15				3,008
Industrial Processes	278	NE	5	NE	NE	NE	283
Agriculture		361	244				605
LUCF	-407	NE	NE				-407
Waste	NE	162	NE				162
Total (without LUCF)	3,073	720	264	NE	NE	NE	4,057
Total (with LUCF)	2,666	720	264	NE	NE	NE	3,650

Notes: 1. Shaded cells do not require entries;
2. NE (not estimated) indicates emissions and sink removals of existing source are not estimated;
3. Due to rounding, the aggregation of various items may have slight differences with the total.

6.2 National GHG Inventory in 2010

In 2010, total GHG emissions in China (with LULUCF) were about 9,551 Mt CO_2 eq (Table 1-15), of which CO_2, CH_4, N_2O and fluorinated gases accounted for 80.4%, 12.2%, 5.7% and 1.7% respectively. Net removal of LULUCF was 993 Mt CO_2 eq. China's total GHG emissions (without LULUCF) in 2010 were around 10,544 Mt CO_2 eq, of which CO_2, CH_2, N_2O and fluorinated gases accounted for 82.6%, 10.7%, 5.2% and 1.5% respectively.

Table 1-15 GHG Inventory of China in 2010 (Mt CO_2 eq)

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Energy	7,624	564	96				8,283
Industrial Processes	1,075	0	62	132	10	21	1,301
Agriculture		471	358				828
LULUCF	-1,030	37	0				-993
Waste	8	92	31				132
Total (without LULUCF)	8,707	1,127	547	132	10	21	10,544
Total (with LULUCF)	7,678	1,163	547	132	10	21	9,551

Notes: 1. Shaded cells do not require entries;
2. 0 indicates that the value is less than 0.5 Mt CO_2 eq;
3. Due to rounding, the aggregation of various items may have slight differences with the total.

6.3 National GHG Inventory in 2012

In 2012, total GHG emissions in China (with LUCF) were about 11,320 Mt CO_2 eq (Table 1-16), of which CO_2, CH_4, N_2O and fluorinated gases accounted for 82.3%, 10.4%, 5.6% and 1.7% respectively. Net removal of LUCF was 576 Mt CO_2 eq. China's total GHG emissions (without LUCF) in 2012 were 11,896 Mt CO_2 eq, of which CO_2, CH_4, N_2O and fluorinated gases accounted for 83.1%, 9.9%, 5.4% and 1.6% respectively.

Table 1-16 GHG Inventory of China in 2012 (Mt CO_2 eq)

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Energy	8,688	579	69				9,337
Industrial Processes	1,193	0	79	154	12	24	1,463
Agriculture		481	457				938
LUCF	-576	0	0				-576
Waste	12	114	33				158
Total (without LUCF)	9,893	1,174	638	154	12	24	11,896
Total (with LUCF)	9,317	1,174	638	154	12	24	11,320

Notes: 1. Shaded cells do not require entries;
2. 0 indicates that the value is less than 0.5 Mt CO_2 eq;
3. Due to rounding, the aggregation of various items may have slight differences with the total.

6.4 National GHG Inventory in 2014

In 2014, total GHG emissions in China (with LULUCF) were about 11,186 Mt CO_2 eq (Table 1-17), of which CO_2, CH_4, N_2O and fluorinated gases accounted for 81.6%, 10.4%, 5.4% and 2.6% respectively. Net removal of LULUCF was 1,115 Mt CO_2 eq. China's total GHG emissions (without LULUCF) in 2014 were 12,301 Mt CO_2 eq, of which CO_2, CH_4, N_2O and fluorinated gases accounted for 83.5%, 9.1%, 5.0% and 2.4% respectively.

Table 1-17 GHG Inventory of China in 2014 (Mt CO_2 eq)

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Energy	8,925	520	114				9,559
Industrial Processes	1,330	0	96	214	16	61	1,718
Agriculture		467	363				830
LULUCF	-1,151	36	0				-1,115
Waste	20	138	37				195
Total (without LULUCF)	10,275	1,125	610	214	16	61	12,301
Total (with LULUCF)	9,124	1,161	610	214	16	61	11,186

Notes: 1. Shaded cells do not require entries;
2. 0 indicates that the value is less than 0.5 Mt CO_2 eq;
3. Due to rounding, the aggregation of various items may have slight differences with the total.

Part II Mitigation Actions and Effects

The Chinese government attaches great importance to mitigation policies and actions. Since 2016, through releasing the Work Plan on Greenhouse Gas Emission Control for the 13th Five-Year Plan (hereinafter referred to as GHG Control in the 13th FYP) [1] and other related development schemes, the Chinese government has implemented a series of effective new measures and policies that promote GHG reduction. Meanwhile, China has achieved positive progress in terms of Monitoring, Reporting and Verification (hereinafter referred to as "MRV"), which works as the important groundwork for climate change control.

Chapter 1 Key Mitigation Action Policies and Effects

Guided by the State's low-carbon development strategies and the "top-level design" philosophy, China has managed to significantly reduce CO_2 emission intensity, effectively control non-energy GHG and non-CO_2 GHG emissions, actively increase forest carbon sinks and as a result outperformed its 2020 GHG emission reduction target. Measures adopted in this regard include adjusting industrial structure, optimizing energy structure, promoting energy conservation and higher efficiency, enhancing carbon sink capacity of ecological systems, controlling non-CO_2 GHG emissions and pursuing synergistic effects of reducing pollution and carbon emissions. In 2020, China's carbon emissions per unit of GDP reduced by 48.4% compared to that of 2005, over-fulfilled China's pledge to the international society to reduce 40%-45% by 2020.

1.1 Industrial Structural Adjustments

Climate change brings challenges and new opportunities for the green and low-carbon transformation of China's industries. During the 13th FYP period, the Chinese government spared no efforts in promoting technological innovation and upgrading the countries' industrial structure. The government has implemented a series of pilot programs of comprehensive innovation and reform that support the research and development of core technologies, their subsequent application and integration, and the collaborative innovation of large, medium, and small enterprises. The government continues to advance the development of the real economy, upgrade the industrial base, modernize industrial chains, and keep the share of manufacturing in the economy basically stable. Focus is also placed on transforming and upgrading traditional industries, strengthening strategic emerging industries, and promoting the vigorous development of the service sector. Digitalization and the development of smart technologies have been sped up to create new strengths for the digital economy. Industrial digitalization and digital industrialization have been promoted in a collaborative manner. The Chinese government is committed to developing a digital society, digital government, and sound digital ecosystem as the country pursues the

[1] The 13th FYP period refers to the years from 2016 to 2020.

Digital China initiative. In 2020, the added value of the tertiary industry accounted for 54.5% of China's GDP, which was 16.7 percentage points higher than the added value of the secondary industry in 2020 and increased by 3.7 percentage points from that of 2015. Strategic emerging industries including energy conservation and environmental protection continue to be on a rapid growth track to become China's pillar industries. Added value of the high technology manufacturing industry has taken up a proportion of 15.1% to industries above designated size. During the 13th FYP period, China has effectively curbed the irrational expansion of energy-intensive projects and helped major energy-intensive industries such as steel, petrochemical and chemical production accelerate transformation and upgrading. As a result, the steel industry has eliminated more than 100 Mt outdated production capacity of low-quality steel, achieving its target to resolve excess steel production capacity of 150 Mt two years ahead of the end of the 13th FYP period.

It is estimated that China's CO_2 emission per unit of manufacturing value added (MVA) in 2020 declined by about 22% compared to that of 2015. The resource productivity in 2020 increased by about 26% compared to that of 2015. In 2020, about 260 Mt of steel scrap, 54.9 Mt of waste paper and about 14.5 Mt of non-ferrous scrap were recycled.

1.2 Energy Structure Optimization

The energy activity is the main source of China's GHG emissions. China has adopted a new energy security strategy that features four domestic reforms, i.e., energy consumption, energy supply, technology and energy system reforms, and comprehensive international cooperation. China is stepping up its efforts to improve the energy structure to build a clean, low-carbon, safe and efficient energy system. Giving priority to non-fossil energy, the Chinese government has implemented a full range of measures to enhance the usage of renewable energy. Not only does it promote green hydropower, wind power and solar energy, the Chinese government also develops safe and structured nuclear power, as well as biomass, geothermal and ocean energy in accordance with local conditions. In terms of the coal industry, the Chinese government actively encourages supply-side structural reform that features phasing out of excessive capacity and the transformation to safe, intelligent, green, clean and efficient coal-mining. China supports clean, efficient and high-quality development of coal-fired plants. In terms of final energy consumption, China reduces and finds substitutes for coal consumption, takes comprehensive measures to control the use of bulk coal and encourages the replacement of coal and oil with electricity. All these measures aim to intensify the institutional reform and improve the allocation of resources in the energy sector.

By the end of 2020, China's total installed capacity of renewable energy reached 930 million kW, of which the cumulative installed capacities of hydropower, wind power, and solar photovoltaic (PV) power recorded 370 million kW, 280 million kW, 250 million kW, and 2.952 million kW respectively, each ranking top in the world for 16, 11, 6 and 3 consecutive years. About 40% of China's installed capacity and about

30% of the power generation fall under renewable energy.

Since 2010, China has recorded a cumulative investment of 818 billion USD in power generation from new energy sources, accounting for about 30% of the global investment over the same period.

Through its complete industrial chains of wind power and PV power generating equipment, China has been actively supporting global GHG reduction. Chinese PV products have been exported to more than 200 countries and regions. In 2019, about 67% of the world's polycrystalline silicon, 79% of PV cells and 71% of PV modules were produced in China.

In 2020, the proportion of non-fossil energy consumption increased to 15.9% of the total energy consumption in China, helping to reduce emission equivalent to about 420 Mt of CO_2. The consumption of natural gas increased from 5.9% in 2015 to 8.4% in 2020, achieving emission reduction equivalent to about 75 Mt of CO_2.

1.3 Energy Conservation and Higher Efficiency

A dual control system of total energy consumption and energy intensity is in place. China sets the targets of total energy consumption and energy intensity for different provinces, autonomous regions and municipalities directly under the central government and applies oversight and checks over the performance of local governments at all levels. It breaks down the dual control targets of total energy consumption and energy intensity for key energy consumers, and evaluates their performance accordingly to strengthen energy-saving management. The government continues to improve energy-saving and incentives. Corporate income tax and value-added tax incentives are awarded to energy-saving businesses. China encourages the import of energy-saving technologies and equipment and actively conducts international trade of green and low-carbon products featuring high quality, high technology and high added value. The thermal power industry continues to carry out ultra-low emission and energy-saving upgrades. By the end of 2020, about 950 million kW of coal-fired capacity achieved ultra-low emissions, more than 800 million kW capacity completed energy-saving upgrades. As a result, the national average coal consumption per kWh by coal-fired power plants was reduced to 305.8 grams of coal equivalent (gce). As China improves the green financial system, it has been making use of energy efficiency credits and green bonds to support energy conservation projects. It is exploring new ground in pricing to advance green development. Pricing methods such as differential pricing, time-of-use pricing, and tiered pricing for electricity and natural gas have been adopted. It adopts environment-friendly electricity pricing to arouse the enthusiasm of market entities and the public in energy conservation. Examples include trials of paid use of and trading in energy-using rights in four provinces and cities including Zhejiang Province, and carbon emissions trading in seven provinces and cities including Beijing.

In terms of industrial energy conservation, China has implemented monitoring, law

enforcement and diagnostic mechanisms and carried out energy efficiency benchmarking to meet energy labeling requirements. Energy efficiency leaders have been selected from 12 key industries including steel and electrolytic aluminum production. In strengthening the management of demand-side power use, China selected 153 model enterprises to demonstrate the potential of integrated energy service providers and facilitate the integration of modern energy services and manufacturing. In improving the national energy-saving standards system, China has carried out 100 projects to upgrade energy efficiency standards, enacted more than 340 national energy-saving standards, including almost 200 mandatory standards, covering most high energy-consuming industries and final energy consumption products.

In terms of building energy conservation, China continues to raise the energy-saving standards of new buildings, expand the energy-saving renovation of existing buildings, and improve the structure of energy consumption in construction. While ensuring all new buildings are in compliance with the national energy saving standards, China also promotes pilot projects of ultra-low energy consumption and near-zero energy consumption buildings, renovates existing buildings, enhances energy efficiency of public buildings and encourages the application of renewable energy in buildings. By the end of 2019, about 19.8 billion m^2 of energy-saving building has been completed.

China is developing a highly efficient and comprehensive transport system with lower energy consumption, promoting the use of clean energy in transport, and enhancing energy efficiency of vehicles and transportation means for better energy-saving effect. It is actively improving its public transportation system with various facilitation measures for the development of multi-modal transport, railway electrification, liquid natural gas (LNG)-fueled vehicles and ships, energy-efficient and new-energy vehicles, electric vehicle charging and hydrogen refueling infrastructure, shore power supply for ships and aircrafts, as well as compelled natural gas (CNG) and LNG dispensers. China is working to eliminate outdated and energy-intensive vehicles and ships. The number of new energy vehicles is rising rapidly. In 2019 the total number of new energy vehicles reached 3.8 million, with 1.2 million new energy vehicles going on road that year. Both of these figures represent more than half of the global total. As of the end of 2019, there were 1.2 million electric-vehicle charging stations nationwide, constituting the largest charging network in the world, and effectively improving energy efficiency and optimizing energy consumption in the transport sector.

In order to reduce carbon emissions in the transport sector, China is pushing for bike-sharing schemes as a means for daily or short-distance trips as well as new-energy vehicles including electric vehicles and hydrogen vehicles.

With the support of central and local government finance, China's energy-saving and consumption-reduction actions have achieved positive results, saving more than 750 Mt standard coal in 2020, equivalent to a reduction of about 1.61 billion tons of CO_2 emissions.

1.4 Enhancing Carbon Sink Capacity of Ecological Systems

China has persisted with a systematic approach to conserving and improving mountain, water, forest, farmland, grassland, and desert ecosystems. It continues to launch large-scale land greening programs and spares no effort in implementing key projects such as the northwest-north-northeast China networks of shelterbelts, the forest shelterbelt programs along the Yangtze River, natural forest resources conservation, protection of black soil in Northeast China, construction of high-quality croplands, protection and restoration of wetlands, programs returning marginal farmland to forests and grasslands, the program for ecological restoration of grasslands, Beijing–Tianjin Sandstorm Source Control Project and comprehensive control of desertification, rocky desertification, and soil erosion. China is steadily implementing urban and rural greening programs, carry out forest tending programs to enhance the quality of targeted forests, actively developing biomass energy, intensifying the protection and growth of forest and grassland resources, securing and improving carbon sink capacity of forests, grasslands, wetlands, farmlands, marine and other ecological systems. China has set up a protected area (PA) system with national parks as the mainstay. Having established its first batch of five national parks, China is integrating and advancing the PA system on the national level. China has integrated different plans into a single master plan for territorial space development. A comprehensive system of technological standards is being set up and shaped up. The national territorial space development strategy is being applied at all levels to realize an ecology-oriented, green and low-carbon, secure and resilient development and protection of territorial space. China has brought functional areas of vital importance, exceedingly fragile areas, and areas of potentially vital eco-environmental value within the scope of the ecological conservation redline framework. The framework has also been integrated into the overall master plan for territorial space planning to secure the carbon sink effect of important ecological space. China has implemented and improved a national scheme for ecological conservation and restoration, and enacted a series of plans including the Master Plan on Major Projects for the Conservation and Restoration of National Key Ecosystems (2021-2035). Major ecological conservation and restoration projects are designated in 7 key areas including the Qinghai-Xizang Plateau, the Yellow River and the Yangtze River Basin, with 25 pilot projects for systematic management of mountains, rivers, forests, farmlands, lakes, grasslands, and sandy areas. Examples of major projects include the Blue Bay environment improvement initiative, the coastal belts protection and restoration program, the comprehensive management of the Bohai Sea water environment, and the conservation and restoration of mangrove forests; ecological restoration of abandoned mines in key areas including the main stream and principal tributaries of the Yangtze River, outskirts of Beijing, Tianjin, key cities in Hebei Province, the Fenwei Plain, the Yellow River Basin and the Qinghai-Xizang Plateau. The Chinese government has issued a series of policies to encourage and guide private capital investment in ecological conservation and restoration with an aim to establish a market-oriented and diversified investment scheme. During the 9th

national forest inventory (2014-2018), China achieved growth in both forest coverage ratio (22.96%) and forest stock volume (17.56 billion cubic meters).

1.5 Control of Non-CO_2 GHG Emissions

Attaching great importance to control of non-CO_2 GHG emissions, China has released specific plans and schemes to control non-CO_2 GHG emissions, as contained in the National Plan on Climate Change (2014-2020) and other GHG control plans. During the 13th FYP period, the Chinese government has provided central budgetary investments and financial subsidies to companies that destroyed HFC-23; a total of 70,727 tons of HFC-23 had been destroyed, equivalent to 828 Mt CO_2 eq. In 2020, the ratio of HFC-23 treatment was increased to 95.5% from that of 55% in 2015.

China has officially ratified the Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (hereinafter referred to as the Kigali Amendment) (not applied to Hong Kong for the time being). In compliance with the requirement of the Kigali Amendment, relevant Chinese authorities have released the List of Controlled Ozone Depleting Substances and the List of Ozone Depleting Substances subject to Import and Export Control (hereinafter referred to as the List). Following the implementation of the List, HFCs are now under control and subject to the import and export licensing system. Stringent regulations including the Notice on Control of HFC-23 Emissions as a Byproduct, the Notice on Strict Control of the First Batch of HFC Chemical Production and Construction Projects have been promulgated to intensify the control of HFC emissions including HFC-23 and strictly control relevant chemical production projects with intensive environment management measures. In order to better recycle Coal-bed methane (coal mine gas) and control methane emissions in the oil and gas industry, the Chinese government encouraged major oil and gas companies to found the China Oil and Gas Methane Alliance. The government has also been promoting the incineration of municipal waste to cut CH_4 emissions in the waste treatment sector. The General Office of the State Council released the Opinions on Pushing Forward the Turning of Livestock and Poultry Breeding Waste into Resources for Use, organizing pilot projects in more than 500 counties with significant livestock and poultry production with an aim to control CH_4 and N_2O emissions while turning waste into resources.

1.6 Pursuing Synergistic Effects of Reducing Pollution and Carbon Emissions

GHGs including CO_2 and other ordinary pollutants are often homologous. Controlling the emissions of GHGs including CO_2 will not only drive and accelerate the green economy transition, but also ease the impact of climate change, reduce emissions of various pollutants and improve the environment. Taking a holistic approach in pollution prevention and control and climate governance, China has promoted overall planning, arrangement, advancement, and review of the coordinated effects of reducing pollution and carbon emissions. Balancing environmental, climate and

economic gains, China has found a unique path to reducing GHG emissions that conforms to its actual conditions. China amended the Law on the Prevention and Control of Atmospheric Pollution of the People's Republic of China in 2015 and added specific provisions, which has provided a legal basis for the coordinated control of air pollutants and GHGs and reduction of pollution and carbon emissions. In 2018, China adjusted the functions of relevant government departments, and asked the newly established Ministry of Ecology and Environment (MEE) to lead the work of responding to climate change, thus reinforcing the coordination between addressing climate change and protecting the eco-environment. MEE has released a series of plans and schemes including the Guiding Opinions on Integrating and Strengthening Efforts in Climate Action and Ecological and Environmental Protection and the Implementation Plan for Synergistic Efficiency of Pollution Reduction and Carbon Reduction, which are in line with the Beautiful China Initiative and the national targets of carbon peaking and carbon neutrality.

China has invested major efforts in the landmark campaign to keep the skies blue to drive the overall progress, push for GHG emission reduction and bring notable improvements to the eco-environment. China has been promoting coal reduction and substitution in newly established, rebuilt, and expanded coal-firing projects in the Beijing-Tianjin-Hebei region and neighboring regions (hereinafter referred to as the BTH region), the Yangtze River Delta region, the Fenwei Plain and other key areas for air pollution prevention and control, advancing bulk coal management and usage of natural gas, electricity and renewable energy, etc. as a substitute for coal. By the end of 2020, the rate of clean winter heating in Northern China had been raised to more than 60%, and 25 million households in the BTH region and the Fenwei Plain ceased firing bulk coal, cutting the usage of bulk coal by about 50 Mt, equivalent to reduction of about 92 Mt CO_2 eq.

In addition, as per the estimation of experts, from 1991 to 2020, China has actively implemented the Montreal Protocol on Substances that Deplete the Ozone Layer, and has cumulatively phased out about 504 kt of the production and consumption of six types of ozone-depleting substances, namely Perfluorinated carbons (PFCs), halons, carbon tetrachloride, methyl chloroform, methyl bromide, and hydrochlorofluorocarbons (HCFCs). In addition, China has not only honored its obligations by accomplishing the targets at various stages, at the same time, it has avoided GHG emissions of about 26 billion tons of CO_2 eq[2].

1.7 International Market Mechanism

During the 13th FYP period, China has continued to fulfill its obligations under the *Kyoto Protocol*, supported domestic enterprises in participating in the United Nations Clean Development Mechanism (CDM), promoted domestic work in energy

[2] Source of data: Wu, Jing et al."Banks, emissions, and environmental impacts of China's ozone depletion substances and hydrofluorocarbon substitutes during 1980–2020", *Science of the Total Environment*.

conservation and energy efficiency, and encouraged the development of new and renewable energy sources. However, since 2012, the number of CDM project applications in China has decreased sharply due to a significant decline in the demand for Chinese CDM projects in the EU carbon market. During the 13th FYP period, only one CDM project was registered with the CDM Executive Board. By the end of 2020, a total of 3,764 projects and 43 planning projects had been registered with the CDM Executive Board, including different types of projects covering renewable energy, energy conservation and energy efficiency, CH_4 emission reduction, N_2O emission reduction, HFC destruction and other types of projects, about 1.11 billion tons of CO_2 eq of emission reductions were certified.

Please refer to Table 2-1 below for detailed mitigation actions and their effects.

Table 2-1 Overview of Mitigation Actions and Effects

No.	Action Name	Objectives or Main Contents	Concerned Areas/ GHG	Time - horizon	Nature of Action	Supervision Departments	Status	Progress	Methodologies and Hypotheses	Estimated Emission Reduction Effects	Received Support
1	Nationwide mitigation action	Reduce the CO_2 emissions per unit of GDP by 40%-45% over 2005 by 2020	Energy/ CO_2	2006-2020	Compulsive/ Government	NDRC	Completed	Reduced the CO_2 emissions per unit of GDP by 48.4% over 2005 by 2020, completed the nationwide mitigation action	Calculate the CO_2 emission amount by multiplying the consumption of coal, petroleum and natural gas corresponding to the average emission factor	/	Support from the central finance or the local finance
Energy Structure Optimization											
2	Developing non-fossil energy	Increase the proportion of non-fossil energy consumption in total energy consumption to around 15% by 2020	CO_2 and other gases	2016-2020	Compulsive/ Government	National Energy Administration (NEA), NDRC and other relevant departments	Completed	The 2020 total energy consumption in China was 4.98 billion metric tons of standard coal, of which the proportion	Emission reduction= (current-year non-fossil fuel consumption[3] − non-fossil fuel consumption in 2015) ×implied emission factor of 2014 energy consumption 2.41tCO_2/tce	Compared to 2015, reduced CO_2 emissions by 650 million tons in 2020	Support from the central finance or the local finance

[3] Non-fossil energy consumption does not include biomass.

No.	Action Name	Objectives or Main Contents	Concerned Areas/ GHG	Time - horizon	Nature of Action	Supervision Departments	Status	Progress	Methodologies and Hypotheses	Estimated Emission Reduction Effects	Received Support
								of non-fossil energy was 15.9%, up 3.9 percentage points higher than 2015			
3	Developing natural gas	Increase the share of natural gas consumption in total energy consumption to over 10% by 2020	CO_2 and other gases	2016-2020	Government	NEA, NDRC and other relevant departments	Completed	The 2020 total energy consumption in China was 4.98 billion metric tons of standard coal, of which the proportion of natural gas increased from 5.8% in 2015 to 8.4% in 2020	Emission reduction= (current-year natural gas consumption − natural gas consumption in 2015)×(emission factor of 2014 fossil energy consumption 2.41tCO_2/tce - emission factor of natural gas 1.56tCO_2/tce)	Compared to 2015, reduced CO_2 emissions by 143 million tons in 2020	
4	Control	Reduce the	CO_2 and other	2016-2020	Government	NEA, NDRC	Completed	The 2020	The effect of	The effect	Support

No.	Action Name	Objectives or Main Contents	Concerned Areas/ GHG	Time - horizon	Nature of Action	Supervision Departments	Status	Progress	Methodologies and Hypotheses	Estimated Emission Reduction Effects	Received Support
	over coal consumption	proportion of coal in total energy consumption to less than 58% by 2020	gases			and other relevant departments		total energy consumption in China was 4.98 billion metric tons of standard coal, of which the proportion of coal declined from 63.8% in 2015 to 56.9% in 2020	emission reduction is calculated through the replacement of coal with non-fossil energy and natural gas	of emission reduction results from the replacement with such low carbon energy as non-fossil energy and natural gas (to avoid double counting)	from the central finance or the local finance
5	Developing hydropower	Increase the total installed capacity of hydropower to 3,800 GW and the annual power generation amount to 1,250 Twh by 2020	CO_2 and other gases	2016-2020	Government	NEA, NDRC and other relevant departments	Completed	In 2020, the total electricity output was 7,779.1 TWh, of which hydroelectricity accounted for 17.4%	Emission reductions = (current year hydropower generation – hydropower generation in 2015) × the 2015 thermal electricity emission factor of	Compared to 2015, reduced CO_2 emissions by about 180 million tons in 2020	Support from the central finance or the local finance

No.	Action Name	Objectives or Main Contents	Concerned Areas/ GHG	Time - horizon	Nature of Action	Supervision Departments	Status	Progress	Methodologies and Hypotheses	Estimated Emission Reduction Effects	Received Support
									0.808tCO_2/MWh		
6	Developing wind power	Ensure that the total installed capacity of wind power (grid connected) is over 2,100 GW by 2020	CO_2 and other gases	2016-2020	Government	NEA, NDRC and other relevant departments	Completed	In 2020, total power generation was 7,779.1 TWh, of which wind power generation (with an installed capacity of 281.53 MW) was 466.5 TWh, its proportion increased from 3.2% in 2015 to 6% in 2020	Emission reductions = (current year wind power generation – wind power generation in 2015) × the 2015 thermal electricity emission factor of 0.808tCO_2/MWh	Compared to 2015, reduced CO_2 emissions by about 230 million tons in 2020	CNREC established under the support of Sino-Danish Renewable Energy Development Programme (RED)
7	Developing solar power	Increase the installed capacity of solar power to over 1,100 GW with the installed capacity of	CO_2 and other gases	2016-2020	Government	NEA, NDRC and other relevant departments	Completed	In 2020, total power generation was 7,779.1 TWh, of	Emission reductions = (current year solar power generation – solar power	Compared to 2015, reduced CO_2 emissions by about	Support from the central finance or the local finance

No.	Action Name	Objectives or Main Contents	Concerned Areas/ GHG	Time - horizon	Nature of Action	Supervision Departments	Status	Progress	Methodologies and Hypotheses	Estimated Emission Reduction Effects	Received Support
		photo-voltaic power generation being over 105 GW by 2020						which solar power generation (with an installed capacity of 253.56 MW) was 260.9 TWh, its proportion increased from 0.7% in 2015 to 3.4% in 2020.	generation in 2015) × the 2015 thermal electricity emission factor of 0.808tCO_2/MWh	180 million tons in 2020	
8	Developing nuclear power	Increase the capacity of nuclear power facilities in operation or under construction to 88.00 GW by 2020	CO_2 and other gases	2016-2020	Government	NEA, NDRC and other relevant departments	Completed	In 2020, total power generation was 7,779.1 TWh, of which nuclear power generation (with an installed capacity of 49.88	Emission reductions = (current year nuclear power generation – nuclear power generation in 2015) × the 2015 thermal electricity emission factor of 0.808tCO_2/MWh	Compared to 2015, reduced CO_2 emissions by about 160 million tons in 2020	Support from the central finance or the local finance

No.	Action Name	Objectives or Main Contents	Concerned Areas/ GHG	Time - horizon	Nature of Action	Supervision Departments	Status	Progress	Methodologies and Hypotheses	Estimated Emission Reduction Effects	Received Support
								MW) was 366.2 TWh; capacity under construction was 20.87 MW; the proportion of nuclear power generation increased from 2.9% in 2015 to 4.7% in 2020.			
Energy Conservation and Energy Efficiency Improvement											
9	Nationwide energy conservation action	Reduce the energy consumption per unit of GDP by 15% from 2015 by 2020	All areas/ CO_2	2016-2020	Compulsive/ Government	NDRC and other relevant departments	Completed	Compared to 2015, more than 750 Mt of standard coal was reduced in 2020	Carbon emissions = energy conservation quantity × the 2014 overall energy consumption emission factor of 2.14tCO_2/ tce	Compared to 2015, reduced CO_2 emissions by about 161 million tons in 2020	Support from the central finance or the local finance

No.	Action Name	Objectives or Main Contents	Concerned Areas/ GHG	Time - horizon	Nature of Action	Supervision Departments	Status	Progress	Methodologies and Hypotheses	Estimated Emission Reduction Effects	Received Support
10	Energy conservation in industry sector	Reduce the power consumption per unit of industrial value added by 18% over 2015 by the year 2020	Industry[4]/ CO_2 and other gases	2016-2020	Government	NDRC, MIIT and other relevant departments	Completed	Compared to 2015, more than 380 Mt of standard coal was reduced in 2020	Carbon emissions = energy conservation quantity × the 2014 overall energy consumption emission factor of 2.14tCO_2/ tce	Compared to 2015, reduced CO_2 emissions by about 810 million tons in 2020	Support from the central finance or the local finance

[4] The industries here specifically include three broad categories of industries, namely mining, manufacturing, and electricity, heat, gas and water production and supply industries.

Chapter 2 Domestic MRV

Domestic MRV lays the necessary groundwork for tackling climate change. Ensuring compliance with international climate change agreements and to support the realization of China's goal of controlling GHG emissions, China has carried out a great deal of work at the national, regional, enterprise and project levels since the 12th FYP period, and has achieved positive results. The "dual carbon" goal and the strengthened transparency framework under the Paris Agreement have created a higher demand for domestic MRV, and China has issued the Implementation Plan for Accelerating the Establishment of a Unified and Standardized Carbon Emission Statistical Accounting, which systemically deploys the key work of domestic MRV in the next phase.

2.1 National and Regional Levels

China continues to improve its climate change statistics scheme. During the 12th FYP period, China had gradually established a climate change statistical indicator system and built a fundamental GHG statistics system. During the 13th FYP period, the National Bureau of Statistics and the Ministry of Ecology and Environment further revised relevant policy documents including the Regulations on Statistical Reporting Operations of Departments Involved in Addressing Climate Change and the Climate Change Statistical Data Sheet for Integrated Government Statistics System to guide relevant annual data collection and analysis. Other departments including forestry, architecture and transportation also stepped up their efforts in relevant research on fundamental indicators and statistical work. The central government has been training and guiding all provinces (autonomous regions, municipalities under the central government) on carrying out climate change statistics, with a focus on the assessment of provincial government's carbon intensity target-based accountability. Some provinces have established a dedicated statistical system and institutionalized system for tackling climate change. By 2017, the statistical departments of 27 provinces (autonomous regions, municipalities under the central government) have dedicated statisticians in charge of climate change statistical work.

China timely compiles and updates its GHG inventory. In 2004, 2012, 2017 and 2019 , the Chinese government submitted 5 reports on implementation of the Convention, including the national GHG inventories (NGI) in 1994, 2005, 2010, 2012 and 2014. Through the compilation process, China has established an institutionalized system of NGI compilation, set up an NGI compilation team made up of government authorities in charge of climate change issues and relevant researchers, and completed a database system powered by information technology. During the 12th FYP period, relevant government authorities printed guidelines for provincial GHG inventory compilation and carried out relevant training at provincial level. Four annual provincial GHG inventory compilation and joint quality audit programs had been rolled out. During the 13th FYP period, the Ministry of Ecology and Environment coordinated provincial GHG inventory compilation of 2016 and 2018. Institutionalized systems

for the preparation of GHG inventories had been established in some regions.

China has established appropriate carbon intensity accounting and report systems. Since the 12th FYP period, relevant government authorities have conducted carbon intensity accounting work based on energy consumption and relevant emission factors based on types of energy sources. Such accounting results have provided data for the evaluation, assessment and trend analysis of the progress of carbon intensity targets at national and regional levels. During the 13th FYP period, China gradually increased the frequency of carbon intensity accounting and trend analysis, facilitating relevant government authorities to keep abreast with the latest carbon emission condition. Since 2016, the decline ratios of annual carbon intensity have been included in the Indicator Systems for Green Development for the purpose of comprehensive evaluation of the green development levels of different regions in China. Since 2017, the NBS has included the reduction ratios of carbon intensity into the Statistical Communiqué of the People's Republic of China on the National Economic and Social Development.

China has been conducting annual temperature control assessments at the provincial level. In order to ensure the fulfillment of the obligatory target of reducing CO_2 emissions per unit of GDP by 18% as set out in the 13th FYP, China has broken down the general carbon intensity control target to more specific ones at the provincial level. In order to mobilize and put all regions in China under pressure to realize green and low-carbon development, in 2017, the authorities in charge of addressing climate change introduced provincial-level temperature control assessment methods for the 13th FYP period, focusing on four aspects: target completion, implementation of tasks and measures, basic work and capacity building, and groundbreaking exploration of institutional mechanisms. Annual evaluation and assessment of GHG emission control was conducted at the provincial level in all regions. A mechanism has been established for liaison and data feedback with provincial authorities in charge of climate change for supervision and problem solution. Provincial-level officials of regions that have failed to accomplish the target tasks are scheduled for meetings in person to facilitate correction and improve efficiency, which serves as a great guidance in provincial GHG emission controlling works during the 13th FYP period.

2.2 Corporate and Facility Levels

China has published and improved its national accounting standards and technical specifications for GHG emissions. From 2012 to 2015, the authorities in charge of addressing climate change issued the methodology and reporting guidelines for GHG emissions accounting applicable for enterprises in 24 industries, including electric power, iron and steel, chemical industry, cement, coal, and oil and gas extraction. Subsequently, 11 methodology guidelines were transformed into recommendable national standards. Since 2011, seven carbon trading pilot regions including Beijing and Shanghai have issued methodological guidelines for corporate GHG emission accounting in corresponding regions based on the needs of constructing carbon market. As the national carbon market develops, China has chosen the approach of

management and control by facility (e.g., generating units of thermal power generation enterprises, and cement production lines of cement enterprises). In order to standardize the accounting of carbon emissions at facility level, the authorities concerned issued and revised the accounting guidelines for power generation facilities. In 2018, the Civil Aviation Administration of China issued the Interim Measures for the Administration of Monitoring, Reporting and Verification of Carbon Dioxide Emissions from Civil Aviation Flight Activities, which encourages and standardizes the reporting of GHG emissions by enterprises of the industries involved, and lays an important foundation for relevant enterprises' participation in the market-based emission reduction mechanisms at home and abroad.

China has launched reporting of carbon emission data. During the 13th FYP period, for enterprises in key emitting industries such as electric power, iron and steel, cement, etc. that meet the reporting threshold, the competent authorities organized relevant corporations to conduct GHG emission data reporting on an annual basis, with a gradual transition from offline reporting to reporting via online information platforms. Such corporate emission reports provided an important basis for the formulation of the methodology for the allocation of the national carbon emission allowances as well as corporate compliance. For enterprises in industries outside of the scope of carbon market coverage, China has also been actively encouraging their reporting of GHG emissions. For example, companies in the aviation industry have completed the reporting of CO_2 emissions from flight activities for the 2019 and 2020 fiscal years. The State-owned Assets Supervision and Administration Commission of the State Council (SASAC) has actively guided state-owned enterprises to carry out GHG statistics and accounting. Some state-owned enterprises have set up a carbon asset management information system and are gradually improving their carbon asset management mechanisms, statistical accounting system and GHG emission information disclosure system.

China has strengthened the quality management over emission data. Since 2016, China has exerted great efforts in improving the quality of GHG emission data submitted by enterprises in key industries such as power generation, iron and steel, cement and other key industries. Relevant measures include requesting enterprises to formulate data quality control plans, conduct independent data verification by third-party verification service providers, and the supervision by authorities in charge of addressing climate change. The Ministry of Ecology and Environment has issued the Guidelines for Verification of Corporate Greenhouse Gas Emission Report (Trial), requesting the competent provincial authorities to assess the internal management, impartial management measures, timeliness and quality of work of relevant verification service providers. With the assistance of law enforcement agencies of the ecological environment authorities and industry experts, the Ministry of Ecology and Environment organized special supervision and assistance programs to strengthen the quality of carbon emission reports, and strictly control and investigate irregularities in the management of carbon emission data. Under the organization of Civil Aviation Administration of China (CAAC), the aviation industry completed the verification and

audit of CO_2 emission reports of flight activities for 2019 and 2020.

2.3 Project and Product Levels

China supports the accounting of emission reduction projects under its voluntary emission reduction mechanism. Under the China Certified Emission Reduction (CCER) scheme, a total of 200 emission reduction project accounting methodologies have been filed since 2013, of which the most commonly used ones are renewable energy, fuel/feedstock switching, GHG destruction, energy efficiency, avoided GHG emissions, and carbon sinks. The authorities have supported the registration of 1,315 GHG voluntary emission reduction projects. To improve data quality, the emission reductions in GHG voluntary emission reduction projects were also verified by third-party organizations. The national authorities in charge of addressing climate change issued the Guidelines on Validation and Verification of GHG Voluntary Emission Reduction Projects, clarifying the filing requirements, working procedures and reporting formats for GHG voluntary emission reduction project validation and verification organizations. Through the implementation of the GHG voluntary emission reduction trading scheme, China has cultivated a number of professional carbon accounting consulting organizations for emission reduction projects.

China has been exploring product carbon footprint accounting. Some industry associations and local authorities have issued trade standards and local standards for product carbon footprint evaluation. For example, the China Electronic Energy Conservation Technology Association issued the General Rules for Carbon Footprint Evaluation of Electrical and Electronic Products, the Carbon Footprint Evaluation Specifications for LED Road Lighting Products; and the Beijing Municipal Administration of Market Supervision issued the Carbon Footprint Accounting Guidelines for Electronic Information Products. At the same time, some enterprises have spontaneously attempted to carry out product carbon accounting by referring to and adopting international standards or relevant standards issued by provincial authorities or industry associations.

Part III Other Information

As a non-Annex I Party to the Convention and a responsible major developing country, China attaches great importance to addressing climate change. It stays firmly committed to green development, and promotes international collaboration to create a community of life for humanity and nature. In accordance with decision 2/CP.17 adopted in 2011 at the seventeenth Conference of the Parties to the Convention, non-Annex I Parties are required to report in their biennial update reports, in addition to information on national greenhouse gas (GHG) inventories, mitigation actions and their effects, on national circumstances and institutional arrangements, and on financial resources, technology and capacity-building needed and received. As this report is submitted in tandem with the Fourth National Communication of the People's Republic of China on Climate Change (hereinafter referred to as 4NC), the content of national circumstances and institutional arrangements, financial resources, technology and capacity-building needed and received have already been introduced in the 4NC, hence such content can be referred to in the 4NC and will not be repeated in this report.

Part IV Basic Information of Hong Kong SAR on Addressing Climate Change

Hong Kong SAR (hereinafter referred to as Hong Kong) is a special administrative region of the People's Republic of China. It is a vibrant city featuring mild climate, with limited land and natural resources, high population density and a highly-developed service industries. It is also an eminent international financial, trading and shipping hub [5].

Chapter 1 Hong Kong's GHG Inventory in 2018

In the process of compiling Hong Kong's GHG inventory, references have been made to the GPG 2000 and the 2006 IPCC Guidelines. The reporting year was 2018, and the reporting scope of the report includes Energy, Industrial Processes, Agriculture, Land-Use Change and Forestry (LUCF) as well as Waste, etc. The reported GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6).

1.1 Overview of the 2018 GHG Inventory

In 2018, Hong Kong's net total GHG emissions (with LUCF), amounted to about 39,951.5 kt CO_2 eq, of which the carbon sink from LUCF reached about 463.2 kt CO_2 eq. Without LUCF, Hong Kong's total GHG emissions in 2018 stood at about 40,414.6 kt CO_2 eq, among which CO_2 accounted for about 35,882.6 kt CO_2 eq; CH_4 about 2,857.2 kt CO_2 eq; N_2O about 559.8 kt CO_2 eq; fluorinated gases[6] about 1,114.80 kt CO_2 eq, as shown in Table 4-1. Table 4-2 sets out the emissions inventory of CO_2, CH_4 and N_2O in 2018 by sources. Table 4-3 sets out the major sources and inventory of fluorinated gas emissions in 2018.

Table 4-1 Hong Kong's GHG Emissions in 2018 (kt CO_2 eq)

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Energy	35,296.9	81.5	355.1				35,733.5
Industrial processes	557,8	NO	NO	1,048.1	NO	66.8	1,672.8
Agriculture		11.5	16.5				28.0
LUCF	-463.2	NE	NE				-463.2
Waste	27.8	2,764.3	188.2				2,980.4
Total (without LUCF)	35,882.6	2,857.2	559.8	1,048.1	NO	66.8	40,414.6
Total (with LUCF)	35,419.4	2,857.2	559.8	1,048.1	NO	66.8	39,951.5

Notes: 1. Shaded cells do not require entries. Being rounded to the nearest whole number, the sum of sub-items may slightly differ from the total. The values that are displayed as "0.0" are not actually zero, but are very small numbers that round to zero;
2. NO (Not Occurring) refers to activities or processes that do not occur for a particular gas or source/sink category within Hong Kong;
3. NE (Not Estimated) indicates that existing emissions and removals have not been estimated.

[5] General information and government agencies of Hong Kong SAR were introduced in the People's Republic of China's Fourth National Communication on Climate Change (4NC) and shall not be repeated in this report. Please refer to relevant content in 4NC.
[6] Fluorinated gases include hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride.

Table 4-2 Hong Kong's Emissions of Carbon Dioxide, Methane and Nitrous Oxide in 2018 (kt)

GHG source and sink categories	CO_2	CH_4	N_2O
Total (without LUCF)	35,882.6	13.61	1.8
Total (with LUCF)	35,419.4	13.61	1.8
1. Energy	35,296.9	3.9	1.1
─ Fuel combustion	35,296.9	2.6	1.1
♦Energy industry	26,523.1	0.7	0.6
♦Manufacturing and construction industries	710.9	0.1	0.0
♦Transport	6,797.3	1.8	0.5
♦Other sectors	1,265.7	0.0	0.0
─ Fugitive emission		1.3	
♦Solid fuel		NO	
♦Oil and natural gas system		1.3	
2. Industrial processes	557.8	NO	NO
─ Cement production	557.8		
─ Production of halocarbons and SF_6			
─ Consumption of halocarbons and SF_6			
3. Agriculture		0.5	0.1
─ Enteric fermentation		0.2	
─ Manure management		0.4	0.0
─ Rice cultivation		NO	
─ Agricultural land		NO	NO
─ Agricultural soils		0.0	0.0
─ Prescribed burning of savannas		0.0	0.0
4. Land-use change and forestry (LUCF)	-463.2	NE	NE
─ Changes in forest and other woody biomass stocks	-463.2		
─ Forest conversion	0.0	NE	NE
5. Waste	27.8	131.6	0.6
─ Solid waste disposal	27.8	124.8	0.0
─ Wastewater handling		6.9	0.6
6. Memo Items			
─ Special regional aviation	1,726.0	0.1	0.1
─ Special regional marine	14,192.1	1.3	0.4
─ International aviation	15,101.9	0.1	0.5
─ International marine	20,470.1	1.9	0.5

Notes: 1. Shaded cells do not require entries. Being rounded to the nearest whole number, the sum of all sub-items may slightly differ from the total. The values that are displayed as "0.0" are not actually zero, but are very small numbers that round to zero;
2. NO (Not Occurring) refers to activities or processes that do not occur for a particular gas or source/sink category within Hong Kong;
3. NE (Not Estimated) indicates that existing emissions and removals have not been estimated;
4. Values given in "Memo Items" are not counted in the total emission;
5. Special regional aviation and special regional marine represent aviation and marine between Hong Kong and other parts of China (including Macao SAR and Taiwan area).

Table 4-3 Emissions of Fluorinated Gas in Hong Kong in 2018 (hundred tons)

GHG source and sink categories	HFCs					PFCs	SF_6
	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-227ea		
Total	0.04	0.06	7.40	0.03	0.19	NO	0.03
Energy							
Industrial processes	0.04	0.06	7.40	0.03	0.19	NO	0.03
– Mineral products							
– Chemical industry							
– Metal production						NO	
– Production of halocarbons and SF_6	NO	NO	NO	NO	NO	NO	NO
– Consumption of halocarbons and SF_6	0.04	0.06	7.40	0.03	0.19	NO	0.03
Agriculture							
LUCF							
Waste							

Notes: 1. Shaded cells do not require entries. Being rounded to the nearest whole numbers, the sums of all sub-items may slightly differ from the total. The values that are displayed as "0.00" are not actually zero, but are very small numbers that round to zero;
2. NO (Not Occurring) refers to activities or processes that do not occur for a particular gas or source/sink category within Hong Kong;
3. NE (Not Estimated) indicates that existing emissions and removals have not been estimated;
4. Values given in "Memo Items" are not counted in the total emission;
5. Special regional aviation and special regional marine represent aviation and marine between Hong Kong and other parts of China (including Macao SAR and Taiwan area).

Energy activities are the primary source of GHG emissions in Hong Kong. In 2018, GHG emissions from energy accounted for 88.42% of the total GHG emissions, while GHG emissions from waste, industrial processes and agriculture accounted for 7.37%, 4.14% and 0.07% of the total emissions respectively. Figure 4-1 illustrates Hong Kong's GHG emissions by sources.

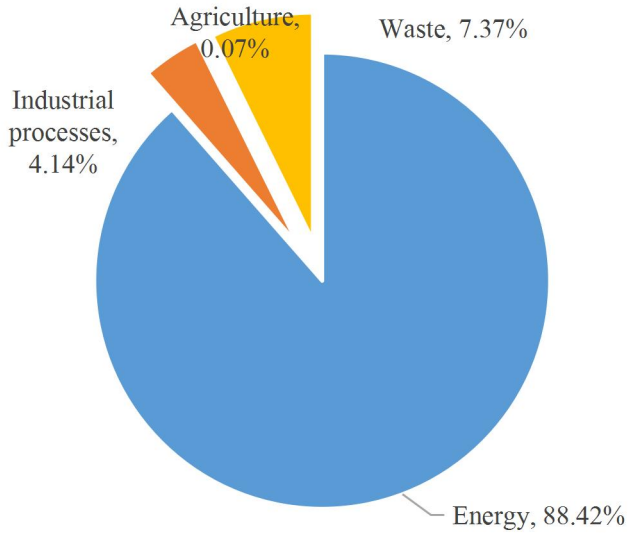

Figure 4-1 Hong Kong's GHG emissions by sources in 2018

The GHG emissions in Hong Kong are primarily CO_2. In 2018, CO_2 accounted for 88.79% of the total emissions, while CH_4, fluorinated gases and N_2O accounted for 7.07%, 2.76% and 1.39% of the total emissions respectively (See Figure 4-2).

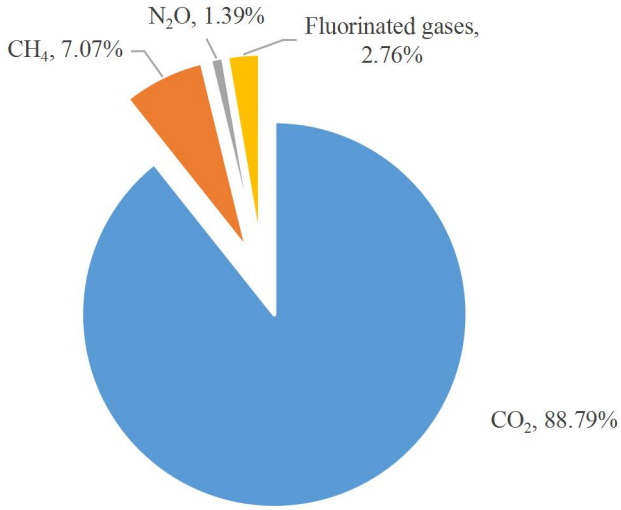

Figure 4-2 Hong Kong's GHG emissions by gas in 2018

In 2018, the GHG emissions from special regional routes and international bunker fuel amounted to about 52.011 Mt CO_2 eq, which included about 16.08 Mt CO_2 eq from special regional marine and aviation emissions, and about 35.931 Mt CO_2 eq from international marine and aviation. The aforesaid emissions were deemed as

memo items and not counted in Hong Kong's total GHG emissions.

1.1.1 Energy

The report on energy mainly covers fuel combustion and fugitive emission. Fuel combustion refers to emissions of CO_2, CH_4 and N_2O from fossil fuel burning in the energy industry, manufacturing industry, construction industry, transportation sector and other sectors, while fugitive emission refers to fugitive CH_4 emissions of oil and gas systems.

The estimation of emissions from energy activities is mainly based on the 2006 IPCC Guidelines. Tier 3 methods were adopted to estimate emissions of CO_2, CH_4 and N_2O emissions from thermal power generation. Tier 2 methods were adopted to estimate CO_2 emissions while Tier 1 methods were adopted to estimate CH_4 and N_2O emissions from towngas production. Tier 2 methods were adopted to estimate CO_2 emissions while Tier 1 methods were adopted to estimate CH_4 and N_2O emissions in utilising landfill gas for energy purposes. As for the manufacturing and construction industries and other sectors, Tier 2 methods were adopted to calculate CO_2 emissions while Tier 1 methods were adopted to calculate CH_4 and N_2O emissions.

Tier 1 and 2 methods were adopted to estimate emissions of CO_2, CH_4 and N_2O from local aviation and marine, rail, non-road transport and road transport sources.

Special regional transport refers to the aviation and marine transport activities departing from Hong Kong with destinations in other parts of the Chinese mainland (including Macao and Taiwan) while international transport denotes aviation and marine transport activities departing from Hong Kong with destinations in places other than the Chinese mainland (including Macao and Taiwan). Tier 3(a) methods were adopted for the estimation of emissions of CO_2, CH_4 and N_2O from special regional and international aviation. Tier 1 methods were adopted to estimate emissions of CO_2, CH_4 and N_2O from special regional and international marine.

Tier 1 methods were adopted to estimate fugitive CH_4 emissions from gas pipelines while Tier 3 methods were adopted to estimate other fugitive CH_4 emissions.

In 2018, 35,733.5 kt CO_2 eq of GHG emissions were generated from the energy sector in Hong Kong, accounting for 88.42% of Hong Kong's total GHG emissions. Of which CO_2 emissions amounted to 35,296.9 kt. CH_4 and N_2O emissions amounted to 81.5 kt CO_2 eq and 355.1 kt CO_2 eq, respectively. CO_2 emissions from energy activities accounted for 98.37% of Hong Kong's total CO_2 emissions.

Among the 2018 GHG emissions from energy activities, 26,738.4 kt CO_2 eq, or 73.83% were from the energy industry (electricity generation and production of towngas); 6,986.1 kt CO_2 eq, or 19.55% were from transportation; 1,267.7 kt CO_2 eq, or 3.55% were from other sectors (including commercial and residential sectors); 714.4 kt CO_2 eq, or 2.00% were from manufacturing and construction industries; 26.8 kt CO_2 eq, or about 0.08% were CH_4 fugitive emissions.

1.1.2 Industrial Processes

The report on industrial processes mainly covers the emissions of CO_2 from the production of cement; the emissions of HFCs and PFCs from refrigerating, air-conditioning and fire-fighting equipment; and the emissions of SF_6 from electrical equipment.

Based on cement clinker production data and related information, Tier 2 methods of the 2006 IPCC Guidelines was adopted to estimate CO_2 emissions from cement production. Tier 2(b) methods of the 2006 IPCC Guidelines were adopted to estimate HFCs emissions from refrigeration and air-conditioning. Tier 1 methods of the 2006 IPCC Guidelines were adopted to estimate PFCs emissions from solvents. Tier 1 methods of the 2006 IPCC Guidelines were adopted to estimate emissions of HFCs and PFCs from fire-fighting equipment. Tier 3 methods of the 2006 IPCC Guidelines were adopted to estimate emissions of SF_6 used in electrical equipment.

In 2018, GHG emissions from industrial processes in Hong Kong were around 1,678.8 kt CO_2 eq, accounting for 4.14% of Hong Kong's total emissions, of which 557.8 kt CO_2 eq were emitted from cement production. HFCs and SF_6 emissions from refrigeration, air-conditioning, fire-fighting and electrical equipment were 1,048.1 kt CO_2 eq and 66.8 kt CO_2 eq respectively.

1.1.3 Agriculture

The report on agriculture mainly covers emissions of CH_4 and N_2O from livestock enteric fermentation and manure management, emissions of N_2O from agricultural soils, and emissions of CO_2, CH_4 and N_2O from savanna burning.

Tier 1 methods of the 2006 IPCC Guidelines were adopted in calculating CH_4 emissions from enteric fermentation. Tier 1 methods of the 2006 IPCC Guidelines were adopted in estimating direct and indirect emissions of N_2O from agricultural soils. Tier 1 methods of the 2006 IPCC Guidelines were adopted in estimating emissions of CH_4 and N_2O from prescribed savanna burning.

In 2018, GHG emissions from agricultural activities in Hong Kong amounted to approximately 28.0 kt CO_2 eq, or 0.07% of Hong Kong's total emissions. CH_4 and N_2O emissions from livestock enteric fermentation and manure management amounted to 15.7 kt CO_2 eq, while N_2O emissions from agricultural soils were approximately 12.2 kt CO_2 eq.

1.1.4 Land-Use Change and Forestry

The report on land-use change and forestry mainly covers the changes in biomass carbon stock caused by the conversion of forestland, cropland and grassland.

Tier 1 methods of the 2006 IPCC Guidelines were adopted and reference was made to relevant emission factors in estimating the CO_2 emissions by the conversion of forestland, cropland and grassland. Tier 1 methods of the 2006 IPCC Guidelines were also adopted to estimate the emissions and removals of CO_2 caused by the changes in the biomass stock of forests and other woody biomass.

In 2018, as carbon sinks, land-use change and forestry had a net removal of

approximately 463.2 kt of CO_2 in total. All of the carbon removals were caused by the changes in the biomass stock of forests and other woody biomass resulting from the conversion of forestland and grassland.

1.1.5 Waste

The report on waste treatment mainly covers CH_4 emissions from solid waste landfills; CH_4 and N_2O emissions from treatment of domestic sewage and industrial wastewater; and CO_2 emissions from waste incineration.

The calculation of emissions from waste treatment was mainly based on the 2006 IPCC Guidelines. Tier 2 methods were adopted to estimate CH_4 emissions from landfilling of solid waste. Tier 1 methods were adopted for estimating emissions of CH_4 and N_2O from wastewater treatment, and Tier 1 methods were also adopted for estimating emissions of CO_2 from waste incineration.

In 2018, GHG emissions from waste treatment in Hong Kong amounted to 2,980.4 kt CO_2 eq, or 7.37% of the total emissions. Most of such emissions were CH_4 which amounted to 2,764.3 kt CO_2 eq, or 96.75% of the total CH_4 emissions in Hong Kong.

1.2 Recalculation of GHG Inventory in 2005

Hong Kong's GHG Inventory is updated as and when appropriate in the light of ongoing improvement in compilation methodologies, appropriate expansion of the scope of compilation and the necessary updating of the underlying data, we have updated. The methodology for compiling the 2018 GHG Inventory has been applied to recalculate GHG Inventory in 2005. The recalculated inventory shows a slight adjustment of the total carbon emissions, by -0.66%. The variation is mainly due to updates of the underlying data in the transport sector.

1.2.1 Overview

The recalculated total GHG emissions (with LUCF) of Hong Kong in 2005 amounted to about 40,882.1 kt CO_2 eq, among which CO_2, CH_4, N_2O and fluorinated gases accounted for 91.66%, 5.33%, 0.91% and 2.10% respectively. The carbon sink from land-use change and forestry accounted for about 412.4 kt CO_2 eq. With the exclusion of land-use change and forestry, Hong Kong's total GHG emissions in 2005 stood at about 41,294.5 kt CO_2 eq, among which CO_2, CH_4, N_2O and fluorinated gases accounted for 91.75%, 5.27%, 0.90% and 2.07% respectively. Table 4-4 sets out the recalculated GHG Inventory in Hong Kong in 2005 by sector.

Table 4-4 Hong Kong's GHG Emissions in 2005 (kt CO_2 eq)

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Energy	37,860.9	88.7	185.6				38,135.2
Industrial processes	NO	NO	NO	732	1.9	122.8	856.7
Agriculture		30.6	40.2				70.8
LUCF	-412.4	NE	NE				-412.4
Waste	25.5	2,058.6	147.7				2,231.8
Total (without LUCF)	37,886.4	2,177.9	373.6	732	1.9	122.8	41,294.5
Total (with LUCF)	37,474	2,177.9	373.6	732	1.9	122.8	40,882.1

Notes: 1. Shaded cells do not require entries. Being rounded to the nearest whole numbers, the sums of all sub-items may slightly differ from the total. The values that are displayed as "0.00" are not actually zero, but are very small numbers that round to zero;
2. NO (Not Occurring) refers to activities or processes that do not occur for a particular gas or source/sink category within Hong Kong;
3. NE (Not Estimated) indicates that existing emissions and removals have not been estimated.

1.2.2 CO_2 Emissions

CO_2 emissions in Hong Kong mainly come from energy activities. In 2005, Hong Kong's total CO_2 emissions (without LUCF) amounted to about 37,886.4 kt CO_2; among which CO_2 emissions from energy activities stood at about 37,860.9 kt CO_2, accounting for 99.93%. About 25.5 kt CO_2 originated from waste treatment. LUCF removed about 412.4 kt CO_2. Hong Kong's total CO_2 emissions in 2005 (with LUCF) were about 37,474.0 kt CO_2.

1.2.3 CH_4 Emissions

In Hong Kong, CH_4 emissions primarily come from waste treatment, followed by energy and agriculture. In 2005, Hong Kong's emissions of CH_4 were about 103.70 kt, equivalent to about 2,177.9 kt CO_2 eq, among which emissions from waste treatment, energy and agriculture accounted for 94.52%, 4.07% and 1.40% respectively.

1.2.4 N_2O Emissions

In Hong Kong, N_2O emissions mainly come from energy, waste treatment and agriculture. In 2005, Hong Kong's emissions of N_2O were about 1.2 kt of N_2O, equivalent to about 373.6 kt CO_2 eq, among which emissions from energy, waste treatment and agriculture accounted for 49.68%, 39.54% and 10.77% respectively.

1.2.5 Emissions of Fluorinated Gases

In 2005, emissions of fluorinated gases in Hong Kong all came from industrial processes, and the total emission was about 856.7 kt CO_2 eq.

1.3 Quality Assurance and Quality Control

1.3.1 Efforts to Reduce Uncertainties

To improve the quality of the inventory, the institutions engaged in inventory preparation were particularly mindful of enhancing the quality assurance and quality control efforts in the process of preparing the inventory, and have taken the following measures :

1) In compiling the guidelines, the guidelines provided by the IPCC were strictly followed to ensure that the inventory compilation was scientific, comparable and transparent;

2) In selecting the methodologies, based on data availability, higher-tiered methods were used as far as practicable to calculate the emissions to ensure the accuracy of the results in the inventory;

3) In the process of collecting and analysing the activity data, the institutions worked closely with the relevant departments to strive to acquire authoritative first-hand official information, which was then managed, verified and examined by specialised personnel, so as to ensure the reliability and rationality of the data used.

4) In determining the emission factors, emission factors suitable to Hong Kong's actual circumstances were adopted as far as practicable. If such emission factors cannot be found, reference would be made to the default emission factors provided by the IPCC Guidelines to ensure the accuracy of the results in the inventory.

1.3.2 Uncertainty Analysis

Based on the uncertainty analysis in accordance with the 2006 IPCC Guidelines, the uncertainty of Hong Kong's GHG inventory in 2018 is around 4.49%. Emissions produced in the process of coal-fired power generation were the major reason for the uncertainty, mainly due to limitations in statistical data such as the type and quantity of coal consumption by power plants.

Chapter 2 Mitigation Measures and Effectiveness

2.1 Analysis on the Effectiveness of Key Mitigation Measures

The government of Hong Kong SAR (hereinafter referred to as the Hong Kong SAR Government) is committed to implementing various policy measures to mitigate GHG emissions. The Hong Kong's Climate Action Plan 2030+ issued in January 2017 put forward the target of reducing the carbon intensity[7] by 65% - 70% before 2030 as compared with the 2005 level, which is equivalent to a reduction of 26% - 36% in total carbon emissions, and a reduction in per capita carbon emissions to 3.3 - 3.8 tonnes . The Hong Kong SAR Government has pledged to achieve carbon neutrality before 2050 and is pursuing the interim target of reducing GHG emissions by 50% before 2035 as compared with the 2005 level. The Hong Kong SAR Government further released the Hong Kong's Climate Action Plan 2050[8] in October 2021. Focusing on the three major GHG emission sources, namely power generation, transport and waste, the Hong Kong SAR Government sets out four major carbon reduction strategies, i.e. "net-zero electricity generation", "energy saving and green buildings", "green transport" and "waste reduction", to lead Hong Kong towards the goal of carbon neutrality.

To achieve the above targets, the Hong Kong SAR Government has implemented various energy conservation and renewable energy measures, promoted the use of electric vehicles, and introduced innovative facilities to turn waste into energy and resources.

In the energy sector, Hong Kong will progressively phase down coal-fired electricity generation and increase the use of natural gas-fired and net-zero-carbon energy for electricity generation units. Furthermore, Hong Kong is vigorously promoting the development of renewable energy (RE), including installing RE systems in government facilities, developing more advanced waste-to-energy facilities, introducing feed-in tariff, facilitating the distributed RE grid connection of distributed RE and encouraging the private sector and the community to invest in distributed RE, etc. The Hong Kong SAR Government's interim targets are to cease the use of coal for daily electricity generation by 2035, and increase the share of RE in the fuel mix for electricity generation to 7.5% - 10% by 2035, and further to 15% in the future; try out the use of new energy and strengthen the cooperation with neighboring regions to increase the share of net-zero-carbon energy to 60% - 70% before 2035 and achieve the long-term target of net-zero electricity generation before 2050.

The Hong Kong SAR Government is continuously enhancing the energy efficiency of buildings through promoting "energy saving and green buildings", including introducing the Buildings Energy Efficiency Ordinance was implemented in 2012; setting energy saving targets for government buildings and conducting energy audits

[7] Carbon intensity: greenhouse gas emissions per unit of GDP.
[8] Official website of Hong Kong's Climate Action Plan 2050: https://cnsd.gov.hk/wp-content/uploads/pdf/CAP2050_booklet_en.pdf.

for major government buildings; enhancing the energy efficiency of electrical appliances through the implementation of the Mandatory Energy Efficiency Labelling Scheme (MEELS); carrying out GHG emission audit for buildings; and publishing carbon audit guidebooks for buildings. At present, buildings account for about 90% of total electricity consumption in Hong Kong. Promoting green buildings, enhancing energy efficiency in buildings and practising low-carbon living will help to reduce electricity consumption and demand for electricity generation, and ease the public's financial burden of switching to clean energy sources for electricity. The Hong Kong SAR Government's target is to reduce the electricity consumption of commercial buildings by 30% to 40% and that of residential buildings by 20% to 30% by 2050 as compared with the 2015 level, and to achieve half of the above targets by 2035. In this regard, the Hong Kong SAR Government will explore the possibility of expanding the regulatory scope of the energy efficiency standards for building services installations; requiring more frequent energy audits and mandatory implementation of the recommended energy management opportunities; and stepping up efforts to promote retro-commissioning; constructing district cooling systems (DCS) in more new development areas and adopting green technologies to enhance the performance of the DCS. The Hong Kong SAR Government will also continue to review the MEELS and study the setting of minimum energy efficiency requirements for various types of prescribed products.

In the transport sector, the railway network continues to serve as the backbone of the public transport system in Hong Kong. The Hong Kong SAR Government is taking forward in an orderly manner the new railway projects recommended in the Railway Development Strategy 2014 in order to respond to the demand for transport services, the need to ensure cost-effectiveness, as well as the need to support the development needs of new development areas and other new development projects, taking into consideration the potential housing supply that may be brought about by railway development. The target is to cover around 75% of the inhabited areas in Hong Kong and around 85% of job opportunities with the railway network. The Hong Kong SAR Government will continue to actively promote the use of electric vehicles via various policy measures, including the concession of the first registration tax on electric vehicles. The development of "green transport" is a major carbon reduction strategy to mitigate climate change and to achieve carbon neutrality before 2050. Through the electrification of vehicles and ferries, the development of new-energy transport and the improvement of traffic management measures, the Hong Kong SAR Government would achieve the long-term target is to reach zero vehicular emissions and zero carbon emissions in the transport sector before 2050. In addition, the Hong Kong SAR Government announced in 2021 ceasing the new registration of fuel-propelled and hybrids private cars in 2035 or earlier; collaborate with franchised bus companies for the trial operation of hydrogen fuel cell electric buses; and the plan to work with other related groups for the trial operation of hydrogen fuel cell electric heavy vehicles.

In the waste management sector, the Hong Kong SAR Government advocated waste

reduction through the encouragement of reduction at source as well as the promotion of recovery and recycling. To turn waste into resources, landfill gas at all operating strategic landfills is used for power generation to support infrastructure facilities at the landfills and the supply of heat for use by leachate treatment plants. Residual landfill gas will be treated and exported to the town gas supply network, or be used for generation of electricity for connection to the public grid. The two operating waste-to-energy facilities turn thermal energy generated from handling food waste and sludge into electricity for the operation of the facilities, while the surplus electricity will be exported to the public power grid. To enhance resource circulation, the study on the planning of future waste management and transfer facilities would be conducted. In order to achieve carbon neutrality in waste management before 2050, the Hong Kong SAR Government has set an interim "waste reduction" targets to strive to develop sufficient waste-to-energy facilities by 2035 in order to move away from reliance on landfills for disposal of municipal waste disposal and support the development of a circular economy; to reduce per capita daily disposal of Municipal Solid Waste (MSW) MSW progressively by 40% to 45% and raise the recovery rate to about 55% through the implementation of various waste reduction measures, including MSW Charging and other waste reduction and recycling measures. The first-phase of the regulation of disposable plastic tableware is also expected to be implemented earlier than 2025 as originally planned.

Please refer to Table 4-5 for the details of the mitigation measures in various sectors and their outcomes.

Through the implementation of the aforementioned measures and actions, Hong Kong has made significant achievements in controlling GHG emissions. The total GHG emissions has been gradually declining. The per capita carbon emissions were reduced from 6.1 tonnes in 2005 to 4.5 tonnes in 2020. The carbon intensity reduced by 43% as compared with 2005 level. To achieve carbon neutrality, the Hong Kong SAR Government will invest about HK$240 billion over the next 15 to 20 years to implement various climate change mitigation and adaptation measures, including promoting renewable energy, energy efficiency and green buildings, green transport and waste management, strengthening coastal defence, and carrying out slope stabilisation and drainage improvement works, etc.

Table 4-5 Overview of Hong Kong's Mitigation Actions and Effects

No.	Name	Targets or major Components	Sectors/ GHG covered	Time frame	Nature of Action (Mandatory/voluntary, Government/ market)	Supervisory department	Status (Under planning/in-progress/completed)	Results achieved thus far	Methodologies and assumptions	Estimated emission reduction effect	Supported by
1	Hong Kong's Climate Action Plan 2030+ and Hong Kong's Climate Action Plan 2050	The Hong Kong SAR Government released the Hong Kong's Climate Action Plan 2030+ in January 2017, wherein a target is set to reduce the carbon intensity by 65% to 70% by 2030 compared with the 2005 level. In October 2021, the HKSAR Government released Hong Kong's Climate Action Plan 2050, setting out four major carbon-reduction strategies: net-zero electricity generation, energy saving and green buildings, green transport, and waste reduction. The HKSAR Government pledges to achieve carbon neutrality by 2050 and reduce carbon emissions by 50% before 2035 compared with the 2005 level. Besides the aforementioned carbon reduction targets, the two Plans include details of the key measures in the areas of	All sectors/CO_2, CH_4, N_2O and fluorinated gases	2017-2050	Mandatory/ Government	Hong Kong Environment and Ecology Bureau (the EEB)[9]	In progress	Carbon emissions per capita was reduced to 4.5 tons in 2020, and carbon intensity from reduced by 42% from that of 2005	The rate of decrease of per capita carbon emissions = (1 - target year per capita carbon emissions/base year per capita carbon emissions) x 100% The rate of decrease of carbon intensity = (1 - target year carbon intensity/ base year carbon intensity) x 100%	By 2035, Hong Kong's GHG emission reduction is expected to be 50% of the level in 2005, and carbon neutrality will be achieved by 2050.	The Hong Kong SAR Government

[9] Formerly the Environment Bureau. The Environment and Ecology Bureau (EEB) was established on 1 July, 2022 under the Hong Kong SAR Government's re-organisation. The newly established EEB is to expand the functions of the former Environment Bureau and is in charge of a more integrated portfolio, including environmental protection, conservation of natural ecology, environmental hygiene, food safety, agriculture, fisheries and animal welfare. The establishment of the EEB achieves synergy in further enhancing Hong Kong's overall environment and maintain environmental hygiene, as well as in taking forward the work on tackling climate change and promoting biodiversity.

No.	Name	Targets or major Components	Sectors/ GHG covered	Time frame	Nature of Action (Mandatory/voluntary, Government/ market)	Supervisory department	Status (Under planning/in-progress/completed)	Results achieved thus far	Methodologies and assumptions	Estimated emission reduction effect	Supported by
		mitigation, adaptation and resilience.									
Energy-Saving Green Buildings											
2	Energy Saving Plan for Hong Kong's Built Environment 2015-2025+	The plan is the first-ever energy saving blueprint for Hong Kong. It analyses energy use in Hong Kong and sets out the policy, strategy, target and key actions that can help Hong Kong achieve the target of energy saving	Energy/CO_2	2015-2025	Mandatory/ voluntary/ Government/ market	The EEB	In progress	Taking 2005 as the base year, the blueprint sets out the target is to achieve a 40% reduction in energy intensity (i.e., energy end-use per unit of GDP) by 2025. Energy intensity has been reduced by more than 30% from 2005 to 2019.	Emission reduction= energy savings×emission factors	Emission reduction is expected to be 140×10^4 t/year by 2025	The Hong Kong SAR Government
3	Buildings Energy Efficiency Ordinance	The Buildings Energy Efficiency Ordinance requires central building services installations in newly completed or substantially renovated	Building/CO_2	2012-present	Mandatory/ Government/ market	The EEB/ Electrical and Mechanical Services Department	In progress	Electricity demand reduction. During the revision of the 2021	Emission reduction= energy savings × emission factors	Emission reduction is expected to be 2.4M t/year	The Hong Kong SAR Government

No.	Name	Targets or major Components	Sectors/ GHG covered	Time frame	Nature of Action (Mandatory/voluntary, Government/ market)	Supervisory department	Status (Under planning/in-progress/completed)	Results achieved thus far	Methodologies and assumptions	Estimated emission reduction effect	Supported by
		buildings to comply with the energy efficiency standards required under the Code of Practice for Energy Efficiency of Building Services Installations. The Ordinance also requires owners of commercial buildings to conduct mandatory energy audits of central building services installations every 10 years in accordance with the Code of Practice for Building Energy Audits. Both codes are regularly reviewed at 3-year intervals.				(the EMSD)		version of the Code of Practice for Energy Efficiency of Building Services Installations and the Code of Practice for Building Energy Audits, the latest technology and internationally accepted energy efficiency standards were reviewed to keep abreast with the latest development.		by 2025. (3Mt/year in 2028)	
4	Mandatory Energy	Under the MEELS, all prescribed products[10]	Energy/CO_2	2009-present	Mandatory/ Government/	The EEB/the EMSD	In progress	Electricity demand	Emission reduction=	Emission reduction is	The Hong Kong SAR

[10] "Prescribed products" means a product specified in the Energy Efficiency (Labelling of Products) Ordinance.

No.	Name	Targets or major Components	Sectors/ GHG covered	Time frame	Nature of Action (Mandatory/voluntary, Government/ market)	Supervisory department	Status (Under planning/in-progress/completed)	Results achieved thus far	Methodologies and assumptions	Estimated emission reduction effect	Supported by
	Efficiency Labelling Scheme (MEELS)	supplied in the market must come with energy labels to inform customers of the products' energy efficiency performance.			market			reduction. The scheme is deployed in stages. As in 2020, the Plan has covered 8 types of prescribed products.	energy savings×emission factors	expected to be 0.72M t/year by 2025.	Government
5	District cooling system (DCS) in the Kai Tak Development (KTD)	The DCS at KTD is a large-scale centralised air-conditioning system. It utilises sea water to produce chilled water at the central plants and distributes the chilled water to consumer buildings in the KTD through the underground water piping network. The DCS project will be completed by 2028.	Energy/CO_2	2011-2028	Voluntary/ Government/ market	The EEB/the EMSD	In progress	Electricity demand reduction. The existing DCS commenced operation in 2013, with additional DCS projects commencing in December 2020 to cater for the increased development density in the	Emission reduction= energy savings×emission factors	The estimated emission reduction is 96.6 kt/year once the DCS is fully implemented in 2028.	The Hong Kong SAR Government

No.	Name	Targets or major Components	Sectors/ GHG covered	Time frame	Nature of Action (Mandatory/voluntary, Government/ market)	Supervisory department	Status (Under planning/in-progress/completed)	Results achieved thus far	Methodologies and assumptions	Estimated emission reduction effect	Supported by
								district.			
6	Wider use of Energy-efficient water-cooled air conditioning system for fresh water cooling towers	As at end-2020, over 2,800 cooling towers were built, and have commenced operation since the launch of the Fresh Water Cooling Tower Scheme in 2000 to the end of 2020. It is estimated that the construction of about 750 cooling towers will be completed from 2021 to 2025. The EMSD will continue to promote a wider use of fresh water cooling towers.	Energy/CO_2	2000-present	Voluntary/ Government/ market	The EEB/the EMSD	In progress	Electricity demand reduction	Emission reduction= energy savings×emission factors	The estimated emission reduction is 500 kt/year once the DCS is fully implemented in 2025	The Hong Kong SAR Government
Green Transport											
7	Hong Kong Roadmap on Popularisation of Electric Vehicles (The Roadmap)	In 2021, the Hong Kong SAR Government released the first Hong Kong Roadmap on Popularisation of Electric Vehicles with a vision of "Zero Carbon Emissions, Clean Air, and Smart City." The Roadmap covers long-term policy targets and plans to promote electric vehicles (EVs) in order to achieve zero vehicle emissions by 2050. Multi-facet measures are raised in the Roadmap, including the goal to cease new registrations of fuel-propelled and hybrid private cars by 2035.	Energy/CO_2	2021-present	Mandatory/ Government	The EEB/ Environmental Protection Department (the EPD)	In progress	The number of EVs in Hong Kong has grown more than 100-fold from about 180 in 2010 to over 18,500 in 2020.	/	/	The Hong Kong SAR Government

No.	Name	Targets or major Components	Sectors/ GHG covered	Time frame	Nature of Action (Mandatory/voluntary, Government/ market)	Supervisory department	Status (Under planning/in-progress/completed)	Results achieved thus far	Methodologies and assumptions	Estimated emission reduction effect	Supported by
Turn Waste to Energy											
8	Sludge Treatment Facility (T·PARK)	The dedicated Sludge Treatment Facility commenced operation in April 2015. It adopts advanced incineration technology to handle sewage sludge generated from the sewage treatment works. Thermal energy generated from incineration is turned into electricity to fully meet the energy needs of the Facility. Surplus electricity from the Facility is exported to the public power grid.	Energy and waste disposal/CO_2 and CH_4	2015-present	Mandatory/ Government	The EPD	In progress	GHG Reduction	Emission reduction= Amount of alternative fossil energy × emission factors + landfill gas reduction	The estimated emission reduction is 240 kt/year	The Hong Kong SAR Government
9	Organic Resources Recovery Centre (ORRC) - Phase 1 (O.Park 1)	The O.Park 1 commenced operation in July 2018. It adopts biological treatment technologies to turn food waste from commercial and industrial sectors into useful resources such as biogas and compost products.	Energy and waste disposal /CO_2, CH_4 and N_2O	2018-present	Construction: Government Use: Voluntary/market/ Government	The EPD	In progress	GHG Reduction	Emission reduction= Amount of alternative fossil energy × emission factors + landfill gas reduction	The estimated emission reduction is 42 kt/year	The Hong Kong SAR Government
10	Organic Resources Recovery Centre (ORRC) - Phase 2 (O.Park 2)	The Hong Kong SAR Government started the design and construction of the O.Park 2 in September 2019. The facility will adopt biological treatment technologies to turn food waste from commercial and industrial sectors into useful resources including biogas and fertiliser.	Energy and waste disposal / CO_2, CH_4 and N_2O	2024-present	Construction: Government Use: Voluntary/market/ government	The EPD	Under construction	GHG Reduction	Emission reduction= Amount of alternative fossil energy × emission factors + landfill gas reduction	67 kt/year	The Hong Kong SAR Government
11	Integrated Waste	The Hong Kong SAR	Energy and	Comme	Mandatory/	The EPD	Under	GHG	Reduction of	440 kt/year	The Hong

No.	Name	Targets or major Components	Sectors/ GHG covered	Time frame	Nature of Action (Mandatory/voluntary, Government/ market)	Supervisory department	Status (Under planning/in-progress/completed)	Results achieved thus far	Methodologies and assumptions	Estimated emission reduction effect	Supported by
	Management Facilities (IWMF) Phase 1 (I·PARK1)	Government started the design and construction of the I·PARK1 in December 2017 and the facility will adopt modern waste-to-energy technology to substantially reduce the volume of waste and turn waste into energy.	waste/CO_2	nce operation in 2025	Government		construction	Reduction	GHG Emission Energy from waste instead of alternative fossil fuels × appropriate emission factors + GHG avoided at landfill gas reduction		Kong SAR Government

2.2 Hong Kong's MRV Work

Regarding Hong Kong's mitigation actions, the Hong Kong SAR Government set up the Steering Committee on Climate Change (SCCC), chaired by the Chief Secretary for Administration, in 2016 to strengthen the steering and co-ordination of the Government's cross-departmental efforts in addressing climate change. To strive for carbon neutrality by 2050, the Hong Kong SAR Government upgraded the SCCC to become the Steering Committee on Climate Change and Carbon Neutrality (SCCCN) in 2021. Chaired by the Chief Executive personally, the SCCCN is responsible for formulating the overall strategy and oversees implementation and coordination. Subsequently, the Office of Climate Change and Carbon Neutrality was set up under the Environment and Ecology Bureau (EEB) to strengthen the co-ordination and promotion of in-depth carbon reduction. The EEB also formed a dedicated advisory committee to encourage active participation of all sectors of the community, including young people, in actions to address climate change.

In December 2012, to facilitate the development of the GHG validation and verification, Hong Kong introduced licensing service for GHG validation and verification bodies, which allows the accredited validation/verification bodies to validate and verify GHG emission reports in accordance with the ISO 14064 standard.

Part V Basic Information of Macao SAR on Addressing Climate Change

Macao SAR (hereinafter referred to as Macao) is a special administrative region of China. It is a vibrant city featuring mild climate, limited natural resources, high population density and a highly-developed gaming industry. It is also a world-renowned destination for tourism and entertainment[11].

Chapter 1 Macao's GHG Inventory in 2018

In the process of compiling Macao's GHG inventory, references had been made to the 2006 IPCC Guidelines and the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, certain calculating parameters and emission factors were referred to the defaulted values of the Revised 1996 IPCC Guidelines. In accordance with the actual situation and the availability of certain data, Macao's GHG Inventory in 2018 covered GHG emissions from energy and urban waste treatment. The reported GHGs cover carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

1.1 Overview

In 2018, Macao's total GHG emissions (see Table 5-1), amounted to about 1,329 kt CO_2 eq, among which emissions from energy accounted for about 94.7%, while emissions from waste accounted for about 5.3% (see Figure 5-1). In 2018, about 1,231 kt of CO_2 was emitted, accounting for about 92.6% of the total GHG emissions; CH_4 emissions were about 14 kt CO_2 eq, accounting for about 1.1%; and N_2O emissions were about 84 kt CO_2 eq, accounting for about 6.3% (see Figure 5-2).

Table 5-1 Macao's Total GHG in 2018 (kt CO_2 eq)

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Energy	1,228	6	23				1,258
Industrial Processes	NE	NE	NE	NE	NE	NE	NE
Agriculture		NO	NO				NO
Land-Use Change and Forestry (LUCF)	NE	NE	NE				NE
Waste	2	8	61				71
Total (without LUCF)	1,231	14	84	NE	NO	NO	1,329
Total (with LUCF)	1,231	14	84	NE	NO	NO	1,329

Notes: 1. Being rounded to the nearest whole number, the sum of sub-items may slightly differ from the total;
2. NO (Not Occurring) refers to activities or processes that do not occur for a particular gas or source/sink category within Macao; NE (Not Estimated) indicates that existing emissions and removals have not been estimated.

[11] General information and government agencies of Macao SAR were introduced in the People's Republic of China's Fourth National Communication on Climate Change (4NC) and shall not be repeated in this report. Please refer to relevant content in 4NC.

Table 5-2 Macao's GHG Inventory in 2018 (hundred ton)

GHG sources and sink categories	CO_2	CH_4	N_2O
Total (without LUCF)	12306.6	6.8	2.7
Energy	12281.9	3.1	0.7
– Fuel combustion	12281.9	3.1	0.7
♦Energy industry	4989.7	1.9	0.4
♦Manufacturing and construction industries	1026.2	0.0	0.0
♦Transport	4213.6	1.1	0.4
♦Other factors	2052.5	0.0	0.0
– Fugitive emissions	NE	NE	
Industrial processes	NE	NE	NE
Agriculture		NO	NO
LUCF	NE	NE	NE
Waste	24.6	3.7	2.0
– Solid waste disposal	24.6	0.0	0.0
– Wastewater handling		3.7	2.0
Memo Items			
– Special regional aviation	4298.2	0.0	0.1
– Special regional marine	2007.4	0.2	0.1
– International aviation	2813.3	0.0	0.1
– International marine	NO	NO	NO
– Biomass combustion	2839.3		

Notes: 1. Being rounded to the nearest whole number, the sum of sub-items may slightly differ from the total;
2. NO (Not Occurring) refers to activities or processes that do not occur for a particular gas or source/sink category within Macao; NE (Not Estimated) indicates that existing emissions and removals have not been estimated;
3. The data of HFCs, PFCS and SF_6 related activities that are not collected and estimated in the industrial processes are presented as NE in total;
4. Fugitive emissions from fuels and LUCF cannot be estimated due to the in-progress statistics system;
5. Values given in 'Memo Items' are not counted in the total emission, and CO_2 emissions from biomass combustion only include those from biogenic waste incineration;
6. Special Regional waterborne-navigation and aviation refer to shipping and airplanes between Macao and other areas in China (including Hong Kong SAR and Taiwan area) ;
7. 0.0 indicates calculation results that is less than 0.05.

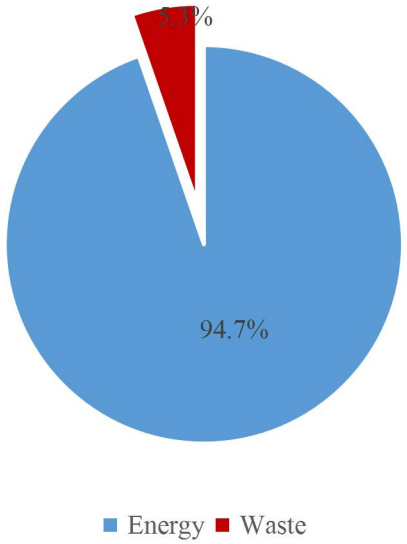

Figure 5-1 2018 GHG emissions in Macao by sector

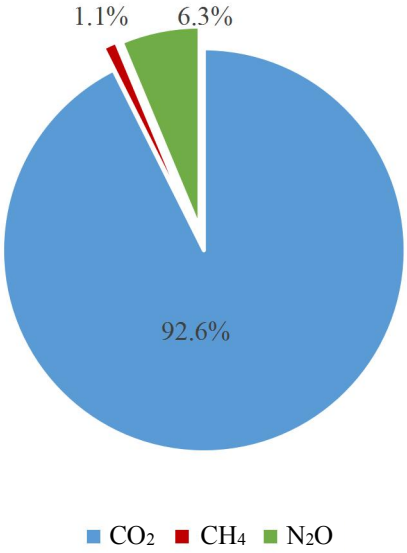

Figure 5-2 2018 GHG emissions in Macao by gas

Macao's GHG emissions from its international aviation and special regional aviation in 2018 were about 718 kt CO_2 eq and those from special regional marine were about 203 kt CO_2 eq. Besides, CO_2 emissions from urban biomass waste burning were about 284 kt. The total GHG emissions from above activities were about 1,205 kt CO_2 eq which were not counted into the total emissions but only listed as a Memo item as required.

1.1.1 Energy

For energy activities, the reporting scope of the Macao's GHG Inventory in 2018 mainly covered CO_2, CH_4 and N_2O emissions from fossil fuel combustion in energy, manufacturing and construction, road transportation and other sectors. Considering the fact that incineration is the primary means of waste handling, and that the power generated in waste incineration is transmitted to Macao's power grid, therefore the GHG emissions from fossil components

(like cloth and plastic) combustion were counted into energy activities, while CO_2 emissions from biomass combustion of urban waste was not counted into the total emissions but only listed as a Memo item.

For the GHG inventory for energy activities, Tier 1 method recommended in the 2006 IPCC Guidelines was applied for CO_2, CH_4 and N_2O emissions caused by fossil fuel combustion from energy processing and transformation, manufacturing, construction, road transport, other sectors, as well as fossil-fuel burning from special region water transportation. For those from international aviation and special region aviation, Tier 2 method recommended in the 2006 IPCC Guidelines was adopted.

The activity level data were the statistical and sectoral data released by the Macao Government. Both sector and fuel categories are basically the same as those given in the 2006 IPCC Guidelines.

The emission factors were mainly from the 2006 IPCC Guidelines and the 2019 Refinement to the 2006 IPCC Guidelines. A small percentage of the emission factors were the defaulted values from the 1996 IPCC Guidelines.

Macao's GHG emissions from energy-related activities in 2018 were about 1,258 kt CO_2 eq (1,228 kt CO_2, 6 kt CH_4 and 23 kt N_2O), accounting for 94.7% of its total emissions. CO_2 emissions from the energy sector accounted for 99.8% of the total emissions.

Among Macao's total GHG emission from energy sector in 2018, 514 kt CO_2 eq were from energy processing and transformation, accounting for 40.9%; 435 kt CO_2 eq were from road transportation, accounting for 34.6%; 206 kt CO_2 eq were from other sectors (including commercial business, restaurants, hotels and residential), accounting for 16.3%; and 103 kt CO_2 eq were from manufacturing and construction, accounting for 8.2%.

1.1.2 Waste

The reporting scope of Macao's GHG inventory for waste treatment mainly covers CH_4 and N_2O emissions from urban sewage treatment, and CO_2, CH_4 and N_2O emissions from solid waste incineration.

Tier 1 method given in the 2006 IPCC Guidelines and the 2019 Refinement to the 2006 IPCC Guidelines was adopted for measuring GHG emissions from waste treatment in Macao.

Activity data of N_2O emissions from wastewater handling were based on the total population provided by the Macao Statistics and Census Service(DSEC). Macao's per capita annual protein consumption in 2018 was provided by the Food and Agriculture Organization of the United Nations. The N_2O emission factors were based on IPCC default values; CO_2, CH_4 and N_2O emissions from waste incineration were estimated using the activity data provided by DSEC and Environmental Protection Bureau of Macao, as well as the IPCC recommended default emission factors.

In 2018, Macao's total GHG emission from waste disposal was 71 kt CO_2 eq, accounting for 5.3% of the total emission of Macao, of which emissions from wastewater handling and waste incineration were 68 kt CO_2 eq and 3 kt CO_2 eq, accounting for 96.4% and 3.6% of the total respectively.

1.2 Recalculation of GHG Inventory in 2005

In response to updated estimation methods, expanded scope of calculation and necessary updates of underlying data, we have updated Macao's GHG Inventory in 2005. The recalculated GHG Inventory 2005 uses the same reporting methods of the 2018 GHG Inventory.

Newly increased content in the recalculated GHG Inventory 2005 include the CO_2 emissions from biomass electricity generation (Biogenic solid waste) and CH_4 emissions due to waste incineration.

The recalculated total GHG emissions of Macao in 2005 amounted to about 1,874 kt CO_2 eq Table 5-3), among which CO_2, CH_4, and N_2O accounted for 96.8%, 0.5% and 2.7% respectively.

Table 5-3 Macao's GHG Emissions in 2005 (kt CO_2 eq)

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	合计
Energy	1,813	4	13				1,831
Industrial processes	NE	NE	NE	NE	NE	NE	NE
Agriculture		NO	NO				NO
LUCF	NE	NE	NE				NE
Waste	1	5	37				43
Total (without LUCF)	1,814	10	51	NE	NO	NO	1,874
Total (with LUCF)	1,814	10	51	NE	NO	NO	1,874

Notes: 1. Being rounded to the nearest whole numbers, the sums of all sub-items may slightly differ from the total.
2. NO (Not Occurring) refers to activities or processes that do not occur for a particular gas or source/sink category within Macao; NE (Not Estimated) indicates that existing emissions and removals have not been estimated.

Energy is the main source of CO_2 emissions in Macao. The total CO_2 emissions of Macao in 2005 amounted to 1,814 kt, of which 1,813 kt were from energy-related activities, 1 kt were from solid waste of fossil origin.

The CH_4 emissions in Macao are mainly from waste treatment. In 2005, total 454 tons of CH_4 were emitted, equivalent to 10 kt CO_2 eq; among which 56.4% were from waste treatment and 43.6% from energy-related activities.

The N_2O emissions in Macao are mainly from waste treatment. In 2005, total 163 tons of N_2O were emitted, equivalent to 51 kt CO_2 eq; among which 73.5% were from waste treatment and 26.5% from energy-related activities.

1.3 Quality Assurance and Quality Control

1.3.1 Efforts to Reduce Uncertainties

To reduce uncertainties of the inventory, methodologies from the 2006 IPCC Guidelines and the 2019 Refinement to the 2006 IPCC Guidelines were adopted to ensure that the methodologies were scientific, comparable and consistent. The institutions who are engaged

in the preparation of the inventory in Macao have selected as many higher-tier methods as reality allows. For example, the Tier 2 methods were adopted for international aviation and special region aviation for being a more detailed approach. As for activity data, the institutions have used the data verified by Macao governmental departments such as the Statistics and Census Service, Civil Aviation Authority, Environmental Protection Bureau, Transport Bureau and other governmental departments as much as possible to ensure the authority of the activity data. The national inventory team was invited as the third-party expert team to review the Macao GHG Inventory during the compilation process.

1.3.2 Uncertainty Analysis

Although great efforts have been made in the reporting scope, methodology and quality by the Macao Inventory Team in the preparation of its 2018 GHG Inventory, some uncertainties still exist.

The Tier 1 method from the 2006 IPCC Guidance was applied by the Macao Inventory Team to calculate uncertainties, taking into account the emission factor uncertainty estimation approach in the 2006 IPCC Guidelines and the 2019 Refinement to the 2006 IPCC Guidelines. The uncertainty of Macao's total GHG emissions in 2018 was about 13.0%. The uncertainty of the fields of energy and waste were 10.3% and 161.3% respectively. See Table 5-4.

Table 5-4 Results of Uncertainty Analysis of GHG Inventory in 2018

	Emissions (kt CO_2 eq)	Uncertainty
Energy	1,258	10.3%
Waste	71	161.3%
Total uncertainty		13.0%

Chapter 2 Mitigation Actions and Their Effects

2.1 Analysis of Key Mitigation Actions and Their Effects

In 2016, the Government of the Macao Special Administrative Region (hereinafter referred to as the Macao Government) formulated the Five-Year Development Plan of the Macao SAR (2016-2020) wherein it is provided that the Macao Government will actively follow the country's green development strategy, and encourage a green, low-carbon, low-emission, modern and healthy lifestyle. In 2021, the Macao Government released the 2nd Five-Year Development Plan for Economic and Social Development of Macao SAR (2021-2025) which further establishes the target of GHG control as follows: GHG emissions per unit of GDP will be cut by 55% by 2025 from the 2005 level, and efforts will be made to achieve peak emissions in or by 2030.

To achieve the goal mentioned above, the Macao Government implemented a series of mitigation actions. In the energy sector, it has been gradually increasing the proportion of natural gas power generation and the proportion of clean electricity from imported electricity; promoting renewable energy including photovoltaic power generation and improving its energy consumption structure. The percentage of power generation by natural gas in Macao increased from 52.9% in 2017 to 57.1% in 2020. The public natural gas pipe network construction within Cotai District has generally been completed. Construction of the Taipa-Macao Peninsula Natural Gas Cross-sea Pipeline was commenced in 2021. Once complete, the natural gas pipeline network will be expanded to southern part of the Macao peninsula, helping residence to reduce the consumption of liquefied petroleum gas.

As for transportation, the Macao Government has been actively reducing energy consumption and carbon emission at airports, implementing the public transportation-first policy, developing a light-rail-centered public transportation network, and promoting the use of environment-friendly and energy-saving vehicles. In 2019, the LRT Taipa Line was put into operation. Covering the main residential areas of Taipa city center, the old town and the tourist area, it carried more than 820,000 passengers during its first month of operation. By 2020, Macao had introduced 543 environment-friendly buses that meet Euro IV or V standards, an increase of 29% than that of 2016; 69 natural-gas-fueled buses, an increase of 53% than that of 2016. Ten range-extended electric buses were also introduced in Macao.

In terms of energy conservation and energy efficiency, the Macao Government has put the energy management mechanism into full implementation. Specific measures include making energy conservation plans for its public departments and organizations, and monitoring and managing the use of energy to improve their energy efficiency. Based on the minimum energy performance standards in neighboring regions, the Macao Government has promulgated its own minimum energy performance standards that suit Macao's conditions and serve as guidance to all sectors in Macao for better energy-conservation targets and improvement of energy management levels. Macao has fully implemented the LED Street Lamps Replacement Plan. By the end of 2021, about 54% of street lamps in Macao were LED lamps.

In terms of the hospitality industry and tourism, since 2007, Macao has held the selection of "Macao Green Hotel Award" winners annually to promote hospitality and related industries in an environment-friendly, low-carbon and clean way. As of 2020, about 50% of the hotels in Macao were green hotels. In 2020, the number of EV charging stations at award-winning "green" hotels increased by 70% compared to that of 2019; the number of "green" hotels that provide electric shuttle buses also increased by more than 30%.

In terms of urban greening, the Macao Government has been planting new trees to actively increase the proportion of green space in Macao and increase its 3D greening space in various regions. During the period of 2017-2020, more than 4,000 new trees were planted in parks, rest areas and sidewalks; more than 10,000 mangrove saplings were planted in the Leisure Area on Taipa Waterfront; and more than 6,000 trees were cultivated to transform the forest region in Coloane.

With Macao's active promotion of the ideas of environment-friendly and energy-saving, low-carbon Macao and green life, and the implementation of a series of emission reduction policies and relevant measures, its GHG emission (CO_2 eq) per capita in 2018 was reduced by about 25.5% over 2017; and GHG emission (expressed in CO_2 eq) per unit of regional GDP was reduced by about 27.7% over 2017. See Table 5-5 for detailed mitigation measures and effects.

Table 5-5 Overview of Macao's Mitigation Actions and Effects

No.	Name	Objectives or Main Contents	Concerned Departments/ GHG	Time Frame	Nature of Action	Supervision Departments	Status	Progress	Methodologies and Assumptions	Estimated Emission Reduction Effects	Support Received
1	Increase the share of natural gas power generation	Macao introduced electricity generated by natural gas in 2008, and gradually increased the share of natural gas power generation.	Energy/CO_2	Since 2008	Government	Environmental Protection Bureau	In Progress		Emission reduction = (natural gas consumption × natural gas CO_2 emission factors) - (heavy oil consumption x heavy oil CO_2 emission factors) Reference Year: 2008	From 2008 to 2020, total GHG reduction was 320 kt CO_2 eq.	Macao Government
2	Participated in Airport Carbon Accreditation Scheme launched by the Airports Council International	Reduced carbon emissions per aircraft taking-off/landing by 20% in 2018 compare to 2012. By increasing energy and fuel efficiency of airports and vehicle groups, Macao strengthened waste management and recycling, and reduced airport carbon emission	Energy, Waste/CO_2, CH_4, N_2O	2012-2018	Voluntary	Civil Aviation Authority	Completed		Carbon reductions per aircraft taking-off/ landing = Carbon emissions per aircraft taking-off/ landing in the current year – Carbon emissions per aircraft taking off/landing in the base year Reference Year: 2012 Boundary of Emission Sources: Based on the requirements for Class II in Airport Carbon Accreditation Scheme, the amounts from direct emission and indirect energy emission shall be computed	Carbon emission per aircraft taking-off/ landing was reduced by 26.7% in 2018 compare to that in 2012	Macau International Airport Company Ltd, Administration of Airports, Ltd and Environmental Protection and Energy Conservation Funds
3	Reduce carbon emissions per aircraft taking-off/ landing	Reduced carbon emissions per aircraft taking-off/landing by 30% in 2028 compare to 2018. Reduce carbon emissions by increasing energy efficiency, replace old lightening system and vehicle groups, control the energy consumption of the airport building and strengthened waste management and recycling.	Energy, Waste/CO_2, CH_4, N_2O	Since 2018	Voluntary	Civil Aviation Authority	In Progress		Carbon reductions per aircraft taking-off/ landing = Carbon emissions per aircraft taking-off/ landing in the current year – Carbon emissions per aircraft taking off/landing in the base year Base Year: 2018 Boundary of Emission Sources: Based on the requirements for Class II in Airport Carbon Accreditation Scheme, the amounts from direct emission and indirect energy emission shall be computed		Macau International Airport Company Ltd and Administration of Airports, Ltd
4	Promoted the use of environment-fri	Provided tax benefits for new motor vehicles complying with standards	Energy/CO_2	Since 2012	Government/Voluntar	Environmental Protection Bureau	In Progress		Emission reduction = fuel savings × CO_2 emission factors caused by gasoline combustion	From 2012 to 2020, total GHG reduction	Macao government

No.	Name	Objectives or Main Contents	Concerned Departments/ GHG	Time Frame	Nature of Action	Supervision Departments	Status	Progress	Methodologies and Assumptions	Estimated Emission Reduction Effects	Support Received
	endly vehicle	for environmental protection and emissions. The main target is to encourage citizens to use environment-friendly vehicles in order to reduce emissions of CO_2 and exhaust pollutants			y				Base Year: 2012	was 94 kt CO_2 eq.	
5	Energy efficient and energy saving plan for public sectors and institutions	By developing their own energy-saving plans, the public sectors/institutions are able to manage daily energy use.	Energy/CO_2	Since 2007	Government / Voluntary	Environmental Protection Bureau	In Progress		Emission reduction = Power savings × power generation emission factor Base Year: 2007	From 2008 to 2020, total GHG reduction was 14 kt CO_2 eq.	Macao Government
6	LED public outdoor Lighting application	Replace and install LED street lights	Energy/CO_2	Since 2010	Government	Environmental Protection Bureau	In Progress		Emission reduction = Power savings × power generation emission factor Base Year: 2010	From 2010 to 2020, total GHG reduction was 3 kt CO_2 eq.	Macao Government
7	LED public local lighting application	Install LED lights at footbridges, parks and public toilets.	Energy/CO_2	Since 2015	Government	Municipal Affairs Bureau	In Progress		Emission reduction = Power savings × power generation emission factor Base Year: 2015	From 2015 to 2020, total GHG reduction was 7 kt CO_2 eq.	Macao Government

2.2 Macao's MRV Work

Macao is still in the initial stage of its MRV work. With regard to Macao's GHG inventory, a preliminary fundamental statistical and accounting system has been established. In 2016, the Macao Government revised its Nomenclature for the External Trade of Macao/Harmonized System, including the statistics of substitutes for ozone-depleting substances (ODS). In the past few years, Macao has been cooperating with the central government in completing and submitting its own GHG inventory for four years in accordance with the IPCC Guidelines, which has been evaluated by domestic and international expert groups. As for corporate inventory, a GHG MRV seminar was organized in 2016 and national experts were invited to share their experiences in order to raise the awareness of Macao's major energy-consuming organizations on MRV of GHG emissions. Thereafter, the Macao Government also conducted research work among large enterprises to prepare for the promotion of carbon audits in the hotel industry.

In the future, the Macao Government will continue to carry forward relevant MRV work. It will continue to improve its fundamental statistics and accounting system to strengthen the statistics in the energy, industry, forestry and waste sectors. It will also actively promote corporate carbon audits, research into and formulate carbon auditing guidelines for different enterprises, and assist them in setting up a comprehensive fundamental statistics system, so as to ensure that Macao's work in combating climate change is up to the standards set by the country and the international community.