Unofficial Translation

For Reference Use Only

The People's Republic of China
Second Biennial Update Report on Climate Change

December 2018

Foreword

Recalling Articles 4 and 12 of the United Nations Framework Convention on Climate Change (hereinafter referred to as the Convention), each Party shall submit its national communication. As a non-Annex I party to the Convention, the People's Republic of China (hereinafter referred to as China) has actively fulfilled its international obligations. China submitted *The People's Republic of China Initial National Communication on Climate Change*, *The People's Republic of China Second National Communication on Climate Change* and *The People's Republic of China First Biennial Update Report on Climate Change* in 2004, 2012 and 2017 respectively, in which policies and actions for addressing climate change and related information were comprehensively stated, and the 1994, 2005 and 2012 national greenhouse gas inventories were reported.

According to decisions 1/CP.16 adopted at COP 16 in 2010 and 2/CP.17 at COP 17 in 2011, non-Annex I Parties, consistent with their capabilities and the level of support received for reporting, should submit their biennial update reports, containing updates of national greenhouse gas inventories, mitigation actions, and needs and support received. The biennial update report should be subject to international consultation and analysis. Upon receiving the grants from the Global Environment Facility in 2015, the Chinese government launched the preparation of its first and second biennial update report and third national communication by organizing the departments and research institutions concerned and by following *UNFCCC biennial update reporting guidelines for Parties not included in Annex I to the Convention*, which was approved by COP 17. After over three years' efforts, *The People's Republic of China Second Biennial Update Report on Climate Change* was completed. In 2018, in accordance with the arrangements for the institutional reform of Chinese government, the functions of addressing climate change were allocated from National Development and Reform Commission to the newly established Ministry of Ecology and Environment. This report was approved by the State Council after multiple revisions based on broad comments and submitted by the Ministry of Ecology and Environment together with *The People's Republic of China Third National Communication on Climate Change (TNC)*.

The People's Republic of China Second Biennial Update Report on Climate Change approved by the Chinese government, is divided into six Parts: National Circumstances and Institutional Arrangements, National Greenhouse Gas Inventories, Mitigation Actions and

Their Effects, Funds, Technology and Capacity-Building Needs and Support Received, 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, presenting a full picture of China's national efforts on addressing climate change. The national greenhouse gas inventory presented herein is of 2014, while the relevant data and information in other parts are generally updated to 2016. In accordance with the relevant principles set down in the *Basic Law of the Hong Kong Special Administrative Region* and the *Basic Law of the Macao Special Administrative Region*, the basic information of these two SARs 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.

Addressing climate change is a shared mission of mankind. Considering its basic national circumstances and the characteristics of its development stage, China is vigorously promoting eco-civilization, and executing a national strategy for actively addressing climate change by integrating climate change into its medium- and long-term national socio-economic development planning. China is trying to accelerate green low-carbon development and actively controlling greenhouse gas emission by resorting to legal, administrative, technical and market means. The Chinese government will continue, as always, to fulfill its own obligations under UNFCCC on the basis of equity and in accordance with common but differentiated responsibilities and respective capabilities, and to fulfill the international commitments actively. China will implement its Nationally Appropriate Mitigation Actions and Nationally Determined Contributions comprehensively, participate in negotiations on global climate change actively, promote the establishment of an equitable, rational, cooperative and win-win global climate governance, deepen bilateral dialogues and pragmatic cooperation on climate change, support other developing countries to enhance their capacity building in response to climate change, and promote to build a community with a shared future for mankind.

Contents

Part I National Circumstances and Institutional Arrangements

China is a country with a huge population, complex climate and vulnerable eco-environment, and one of the most vulnerable countries to the adverse impacts of climate change. The Chinese government has pursued with firmness the vision of innovative, coordinated, green, open and shared development, promoted economic, political, cultural, social, and ecological advancement in a coordinative way, and made every effort to build a moderately prosperous society in all respects. As a responsible developing country, China has attached great importance to the issue of global climate change, set up national, local or relevant departmental (industrial) organizations and institutions to address climate change, created stable technical support institutions, and organized core expert teams as an important assurance for the preparation and submission of the national communication on climate change and the biennial update report on climate change.

Chapter 1 National Circumstances

1.1 Natural Conditions

1.1.1 Topography

China's terrains vary significantly, including all five basic terrains, namely plateaus, hills, mountains, basins and plains. The land descends like a terrace from west to east. The Tibetan Plateau with an average altitude of 4,000-5,000 meters constitutes the highest step. Such plateaus as the Yunnan-Guizhou Plateau, the Loess Plateau, and the Inner Mongolian Plateau, and such basins as the Sichuan Basin, the Tarim Basin and the Junggar basin, which are all at an altitude of 1,000-2,000 meters, constitute the second step. The areas to the east of the Greater Khingan Range, the Taihang Mountain, the Wu Mountains and the Xuefeng Mountains, and to the west of the ocean, most of which are at an altitude up to 500-1,000 meters, constitute the third step. To the east of China's land, there are the Bohai Sea, the Yellow Sea, the East China Sea and the South China Sea, with their depths increasing from north to south. The vast continental shelf extends along the long coastline.

1.1.2 Climate and Climatic Disasters

China's climate features complexity and diversity. The Eastern China has a monsoon climate, the northwestern region is of a temperate continental climate, and the Tibetan Plateau falls into an alpine climate category. China is subject to frequent disastrous weather, with droughts, floods, cold waves and typhoons having considerable influence. Northern China is mainly subject to droughts, while both floods and droughts affect Southern China. In summer and fall, the southeast coastal region of China is often stricken by tropical storms, between June and September in particular. In fall and winter, the cold air from Mongolia and Siberia moves southward, resulting in cold waves and causing such disasters as low temperatures, gales, sandstorms, and frosts. In the wake of global warming, such meteorological disasters as rainstorms, floods, typhoons and severe convection stroke frequently in 2016. Waterlogging occurred in 26 provinces (autonomous regions, municipalities); typhoons hit China frequently and heavily; there was a high frequency of severe convection weather; over 2,000 counties (or cities) were stricken by hail or tornadoes.

1.2 Natural Resources

1.2.1 Land Resources

China's land resources are characterized by complexity and diversity in types, arable lands, forest lands, grasslands, deserts and beach land are distributed extensively in the country, but the per capita arable cropland is small. Land resources feature uneven distribution. The Northeast China Plain, the North China Plain, the Middle- and Lower-reach Yangtze Plain, the Pearl River Delta and the Sichuan Basin are the areas where croplands are mostly concentrated, while grasslands are mainly distributed in the northern and western China, and forests mainly gather in the Northeast, Southwest and South China. China arable land was 134.921 million hectares (ha), parkland 14.2663 million ha, forest land 252.9081 million ha and rangeland 219.3592 million ha in 2016.

1.2.2 Water Resources

Water resources are unevenly distributed in China in either temporal or spatial sense. The water resources are rich in summer and fall, fewer in winter and spring, and significantly vary on an annual basis. They are rich in the eastern and southern regions, and fewer in the western and northern regions. China's per capita water resources are only a quarter of the global average. China water resources was 3,246.64 billion cubic meters (m^3) in

2016, including 3,127.39 billion m^3 of surface water resources and 885.48 billion m^3 of ground water resources (there was an overlap of 766.23 billion m^3).

1.2.3 Forest Resources

China's forest resources rank high in the world in terms of area and stock, but China's per capita values are lower than the global average. China's forest resources are uneven in regional distribution, with most forests concentrated in the northeastern region and the southwestern region. Due to the great variance in regional climates, China's forests feature the diversity of tree species. In 2016, China's forest area was 214 million hectares, forest coverage as 22.3% and forest stock volume as 16,372 million m^3.

1.2.4 Marine resources

China administers wide sea areas, covering more than 11,000 islands in total. China's vast seas are rich in marine organisms, marine minerals, ocean space, ocean water, marine renewable energy, etc. Most of China's marine development projects have been conducted at the coastal or offshore area, while the open sea lacks further development. In 2016, China maintained a stable marine ecological environment. Most sea areas under China's jurisdiction complied with the Class 1 Seawater Quality Standards (SQS) in spring and summer. By the end of 2016, China has established over 250 marine protection areas (marine parks) of different levels, with a total area of about 124,000 square kilometers. In 2016, 16 national marine parks were newly approved of construction.

1.2.5 Biodiversity

China has attached great importance to the protection of biological diversity, including the diversity of ecosystems and species. Up to the end of 2016, China has created 2,750 nature reserves of different levels and in different types, and their total area was 147.33 million ha, with the nature reserves' land area being 142.88 million ha and accounting for 14.88% of China's land area. China had 446 state-level nature reserves, and their total area was 96.95 million ha, with land area accounting for 9.97% of China's land area.

1.3 Social and Economic Development

The Chinese government has been proactively adapting to the new situations, transforming development modes, improving development quality in pursuit of better outcomes, and keeping the steady growth of economy. In 2016, GDP increased by 6.7% to 74 trillion RMB yuan (yuan). It has made notable progress in promoting employment, eliminating poverty, improving living standards and protecting the environment. See Figure 1-1, Table 1-1, Table 1-2, Table 1-3, and Table 1-4 for details.

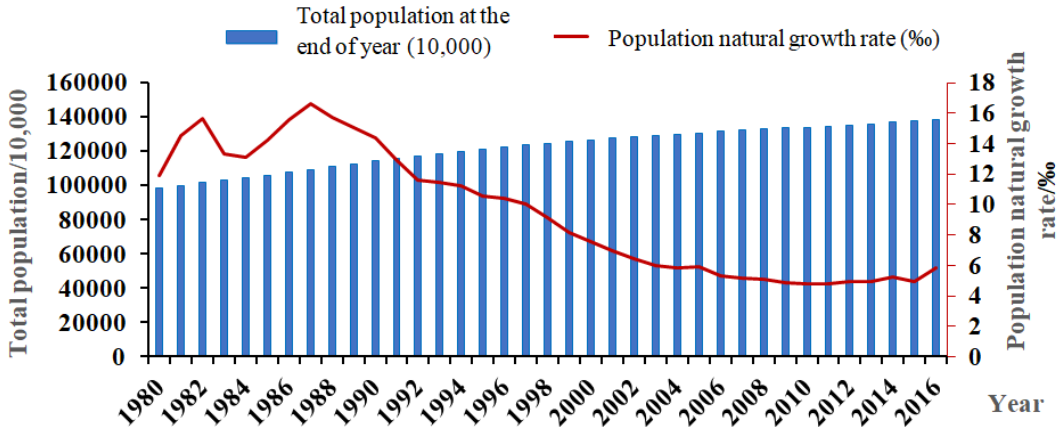

Figure 1-1 Changes in China's Total Population and Natural Growth Rate 1980-2016

Table 1-1 Population Indicators of China and the World in 2016

Population Indicators	China	World
Population natural growth rate (‰)	5.86	11.24
Birth rate (‰)	12.95	18.89
Mortality rate (‰)	7.09	7.65
Average life expectancy (years)	76.5	71.9

Source: *China Health Statistical Yearbook 2018*, *China Statistical Yearbook 2018*, and the statistical database from the World Bank.

Table 1-2 China's Employment Structure (by the end of the year)

Employment Structure	2005	2010	2016
Proportion of employees in the primary industry (%)	44.8	36.7	27.7
Proportion of employees in the secondary industry (%)	23.8	28.7	28.8
Proportion of employees in the tertiary industry (%)	31.4	34.6	43.5

Source: *China Statistical Yearbook 2018*.

Table 1-3 Lengths of Transportation Lines in China (2005-2016) (10,000 km)

	2005	2010	2016
Railway	7.5	9.1	12.4
Including: high speed railway	-	0.5	2.30
Highway	334.5	400.8	469.6
Including: freeway	4.1	7.4	13.1
Inland waterway	12.3	12.4	12.7
Regular flight route	199.9	276.5	634.8
Oil (gas) pipeline	4.4	7.9	11.3

Source: *China Statistical Yearbook 2006, China Statistical Yearbook 2011, China Statistical Yearbook 2018.*

Table 1-4 Number of durable consumer goods owned per 100 urban households in China

	2005	2010	2016
Refrigerator (set)	90.7	96.6	96.4
Color TV (set)	134.8	137.4	122.3
Air conditioner (set)	80.7	112.1	123.7
Home computer (set)	41.5	71.2	80.0
Mobile phone (set)	137.0	188.9	231.4
Private car (set)	3.4	13.1	35.5

Source: *China Statistical Yearbook 2006*, *China Statistical Yearbook 2011*, and *China Statistical Yearbook 2018*.

Chapter 2 National Institutional Arrangements for Addressing Climate Change

The Chinese government has attached great importance to the establishment of institutions for addressing climate change. With persistent efforts, China has established national, regional and departmental (industrial) institutions for addressing climate change, which have been continuously improved based on needs from daily work. In regard of the national communication, biennial update reports and national greenhouse gas (GHG) inventories, China has built relatively stable institutions for technical support and organized core teams of experts, which have provided institutional guarantees for the preparation and submission of national communications and biennial update reports.

2.1 National Institutions

The National Leading Group on Climate Change, Energy Conservation and Emission Reduction (hereinafter referred to as the Climate Change Leading Group) is responsible for comprehensive coordination of addressing climate change of China. In 2014, the Chinese government set up a Climate Change Statistics Leadership Group comprised of the National Development and Reform Commission, the National Bureau of Statistics (NBS) and the Ministry of Science and Technology (MOST) and the industry association which further strengthened the organization and administration of statistical work in addressing climate change. In 2015, the Climate Change Leading Group convened the meeting which discussed and approved China's Nationally Determined Contributions. According to the requirements of organizational structuring and personnel changes as well as needs from daily work, the State Council has adjusted the units or personnel of

the Climate Change Leading Group[1] (Figure 1-2).

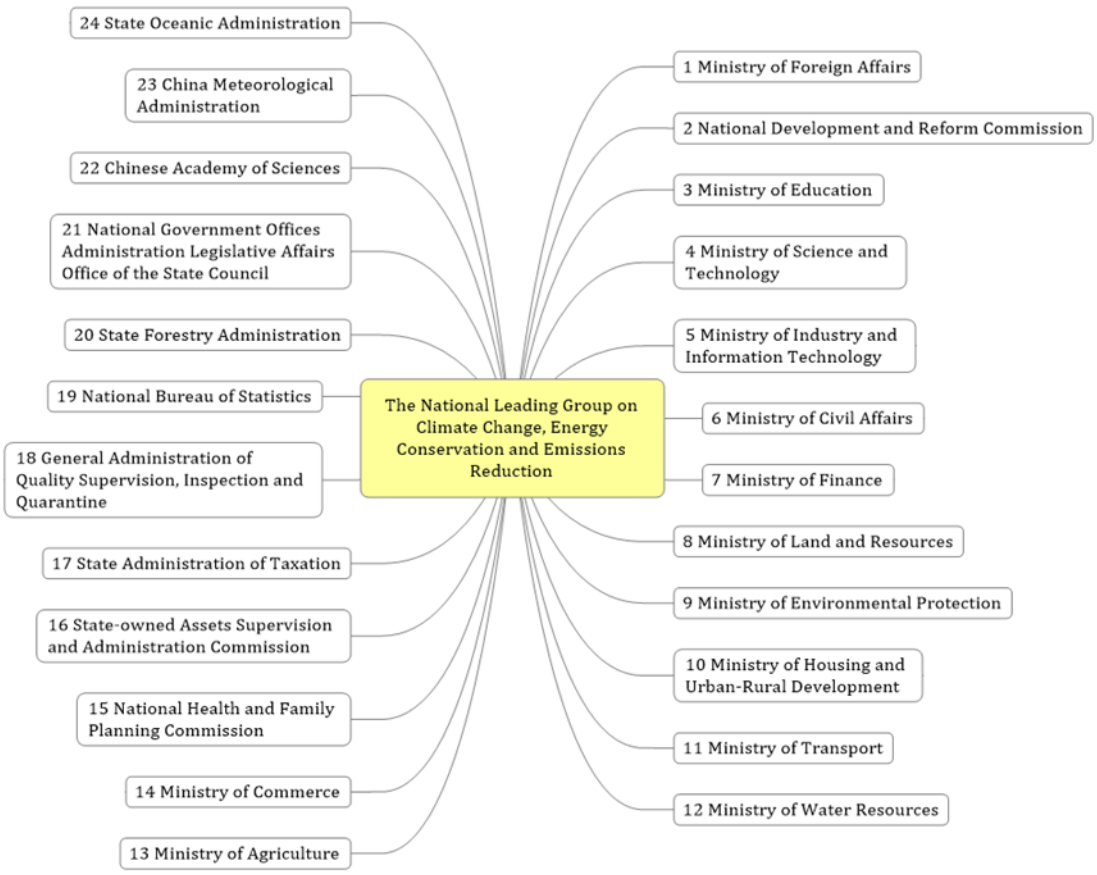

Figure 1-2 Members of the Climate Change Leading Group

2.2 Regional and Departmental (Industrial) Level Institutions

The Chinese government has further strengthened institutions at regional and departmental (industrial) levels to address climate change. In 2008 the National Development and Reform Commission (NDRC) set up the Department of Climate Change. In 2012, National Center for Climate Change Strategy and International Cooperation (NCSC) was established.

All units of the Climate Change Leading Group, as governmental authorities in respective industries, have appointed leaders and major responsible units for addressing climate change, meanwhile strengthened the guidance to respective industry associations.

According to the requirements of the central government, each provincial (autonomous

[1] Source: *Notice of the General Office of the State Council on Personnel Adjustments of the National Climate Change, Energy Conservation and Emission Reduction Leadership Group* (State Council [2013] No. 72).

region, municipal) governments have established their respective Leading Groups on Climate Change, which are chaired by their top leaders and participated in by relevant departments and are to lead and coordinate the efforts to address climate change.

Following the establishment of the Department of Climate Change under the NDRC, provincial governments have successively established standing institutions for addressing climate change at provincial levels. By the end of 2016, 11 provincial climate change administration authorities have set up Divisions of Climate Change. In the meantime, the establishment of scientific research institutions for addressing climate change at regional level have also be strengthened, which has continuously provided scientific support for local governments' decision-making in addressing climate change.

2.3 National Communications and Biennial Update Reports

Preparation and submission of national communications and biennial update reports, including national GHG inventory, is an obligation of all parties of the Convention. Since the compilation and submission of its Initial National Communication on Climate Change, the Chinese government has established a national system for GHG inventory development and a relatively stable team for national GHG inventories (NGI), national communications (NC) and biennial update reports (BUR) (Table 1-5). According to the ministerial responsibility assigned by the Chinese government on climate change issue, national authority addressing climate change is responsible for the preparations with the support from other relevant departments, including providing basic statistical data, coordinating of industry associations and typical businesses to provide related data, and establishing of the National GHG Inventory Database, etc. Upon completion, national communications on climate change and biennial update reports are approved by national authority addressing climate change and officially submitted to the secretariat of the Convention.

Table 1-5 Main Organizations Involved in Preparation of NC, BUR and NGI

Tasks	Organizations
In charge of the NC, BUR and NGI	National authority addressing climate change
GHG inventory for energy	NCSC, Energy Research Institute of National Development and Reform Commission(ERI), Fudan University, China Special Equipment Inspection and Research Institute (CSEI)
GHG inventory for industrial processes	Tsinghua University, Foreign Economic Cooperation Office, Ministry of Ecology and Environment
GHG inventory for agriculture (livestock)	Institute of Environment and Sustainable Development in Agriculture, Chinese Academy of Agricultural Sciences
GHG inventory for agriculture (croplands)	Institute of Atmospheric Physics, Chinese Academy of Sciences
GHG inventory for LULUCF	Institute of Forest Ecology, Environment and Protection of the Chinese Academy of Forestry; Research, Planning and Design institute of the National Forestry and Grassland Administration; Research Institute of Forestry New Technology of the Chinese Academy of Forestry; Institute of Environment and Sustainable Development in Agriculture, Chinese Academy of Agricultural Sciences; Institute of Atmospheric Physics of Chinese Academy of Sciences
GHG inventory for waste	Chinese Research Academy of Environmental Sciences
National GHG inventory database	NCSC

Part II National Greenhouse Gas Inventory

According to relevant decisions of UNFCCC and China's national circumstances, the National GHG Inventory of 2014 (NGI2014) covers six gases including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6) from energy, industrial processes, agriculture, land use, land-use change and forestry, and waste. The Inventory mainly follows *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (hereinafter referred to as *Revised 1996 IPCC Guidelines*), *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (hereinafter referred to as *IPCC Good Practice Guidance*), and *IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry* (hereinafter referred to as *IPCC Good Practice Guidance for Forestry)*, and adopted reference to *2006 IPCC Guidelines for National GHG Inventories* (hereinafter referred to as *2006 IPCC Guidelines*). Activity data are mainly from official statistics, while emission factors are primarily from the 2014 China's country-specific parameters, followed by relevant data from 2010 National GHG Inventories in *TNC* (NGI2010). Compared with 2012 Inventory reported in the *China First Biennial Update Report on Climate Change* (1BUR), NGI2014 has included instructions on activity data information and transparency is enhanced.

Chapter 1 Scope and Methodologies

1.1 Key Category Analysis

According to *IPCC Good Practice Guidance* and *IPCC Good Practice Guidance for Forestry*, quantitative and qualitative key category analysis were carried out for NGI2010. The results showed that NGI2010 included 40 key categories, including: 19 CO_2 emission sources from energy activities such as public electricity and heat production, steel and iron industries and ferroalloy production, construction material production and road transport; 6 sources from industrial production processes including CO_2 emissions from cement production and iron and steel production, N_2O emissions from adipic acid production, HFC-23 emissions from HCFC-22 production; 6 sources from agricultural activities including livestock enteric fermentation, CH_4 emissions from rice cultivation,

direct and indirect emissions of N_2O from agricultural soils; 2 CH_4 emission sources from solid wastes and waste water treatment; and 7 sinks of forestry biomass, forestry dead biomass, agricultural land soil carbon and grassland soil carbon. Emissions from these key categories were calculated with higher-tier methods and country-specific emission factors for NGI2014. The methodologies applied for NGI2014 are shown in Table 2-1.

1.2 Energy

Energy in NGI2014 contains fuel combustion and fugitive emissions. Fuel combustion emissions cover energy industries, manufacturing industries and construction, transport, other sectors and other categories, of which, other sectors can be further segmented into service, agriculture and household, and "other" report CH_4 and N_2O emissions from biomass fuels burning and CO_2 emissions from non-energy use. Fugitive emissions cover CH_4 emissions from solid fuels, and oil and natural gas systems.

CO_2, CH_4 and N_2O emissions from fossil fuel combustion were calculated by the sectoral approach. CO_2 emissions were calculated by Tier 2 method and China's domestic emission factor parameters and were verified with the reference approach. CH_4 and N_2O emissions from road transport were calculated using the Tier 3 method, i.e. COPERT model. CH_4 and N_2O emissions from public electricity and heat and aviation were calculated using the Tier 2 method, the other sectors were calculated using the Tier 1 method. The fugitive CH_4 emissions from coal mining and post-mining activities were calculated using the combination of Tier 1 and Tier 2 methods, while the fugitive CH_4 emissions from the oil and gas systems were calculated using the combination of Tier 1 and Tier 3 methods (Table 2-1).

1.3 Industrial Processes

Industrial processes in NGI2014 includes the GHG emissions from mineral products, chemical industry, metal production, and production and consumption of halocarbons and sulfur hexafluoride (SF_6). GHG emissions from glass, ammonia, soda, ferroalloy, magnesium, aluminum, lead and zinc production were calculated using *2006 IPCC Guidelines*. Other sources were calculated using *Revised 1996 IPCC Guidelines* and *IPCC Good Practice Guidance*, mostly based on Tier 2 method, as shown in Table 2-1.

Table 2-1 Methodologies Used for the National GHG Inventory of 2014

Source/ Sink Categories	CO_2		CH_4		N_2O	
	Method	Emission Factors	Method	Emission Factors	Method	Emission Factors
Energy industry	T2	CS	T1,T2	D,CS	T1,T2	D,CS
Manufacturing industries and construction	T2	CS	T1	D	T1	D
Transportation	T2	CS	T1,T3	D,CS	T1,T3	D,CS
Other sectors	T2	CS	T1	D	T1	D
Other	T2	CS	T1,T2	D,CS	T1,T2	D,CS
Fugitive emissions from solid fuels			T1,T2	D,CS		
Fugitive emissions from oil and natural gas			T1,T3	D,CS		
Mineral products	T1,T2	D,CS				
Chemical industry	T1,T2	D,CS	NE	NE	T3	CS
Metal production	T1,T2	D,CS	T1	D	NE	NE
Enteric fermentation			T1,T2	D,CS		
Manure management			T1,T2	D,CS	T2	D,CS
Rice cultivation			T3	CS		
Agricultural soils			NE	NE	T1,T2	D,CS
Field burning of agricultural residues			T1	D,CS	T1	D,CS
Forest land	T2	CS				
Cropland	T3	CS	IE	IE	IE	IE
Grassland	T2	CS	IE	IE	IE	IE
Wetlands	T2	CS	T2	CS	NE	NE
Settlements	T2	CS				
Other land	T1	D				
Harvested wood products	T2	CS				
Solid waste	T1,T2	CS	T1,T2	D,CS	T1	D,CS
Wastewater treatment			T1,T2	D,CS	T1,T2	D,CS

Note: 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.
4. Their parallel appearance shows that the sub-items use different Tier methods or emission factor data sources.

1.4 Agriculture

Agriculture in NGI2014 includes CH_4 emissions from livestock 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 2014 Inventory was similar to that of 2012 Inventory. Key sources of animal enteric fermentation and manure management were calculated by Tier 2 method of *Revised 1996 IPCC Guidelines*, while other sources by Tier 1 method. CH_4 emissions from rice fields and N_2O emissions from agricultural soils were calculated by China's domestic models, and CH_4 and N_2O emissions from field burnings of agricultural residues by Tier 1 method in *Revised 1996 IPCC Guidelines*, as shown in Table 2-1.

1.5 Land Use, Land-Use Change and Forestry

Land use, land-use changes, and forestry (LULUCF) in NGI2014 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 land-use and land-use change, carbon stock change is calculated based on the estimation of the 5 carbon pools: aboveground biomass, belowground biomass, litter, dead wood and soil organic matter. A Tier 3 methodology is used for the calculation of the changes of reserves of soil organic carbon. The changes of reserves of forestry products were estimated by "production accounting approach". Tier 2 method in *IPCC Good Practice Guidance for Forest* is used to estimate changes of reserves of aboveground biomass, underground biomass, litter and dead wood as well as soil organic matters in other carbon pools. Wetland CH_4 emissions were estimated using Tier 1 method, as shown in Table 2-1.

1.6 Waste

Waste in NGI2014 covers GHG emissions from municipal solid waste disposal, wastewater treatment and waste incineration. The scope of NGI2014 is similar to that of 2012 Inventory. Greenhouse gas emissions from solid waste landfills were calculated using Tier 2 method in *Revised 1996 IPCC Guidelines*, waste water treatment by recommended methods of *Revised 1996 IPCC Guidelines* and *IPCC Good Practice Guidance*, and waste incineration by using Tier 1 method in *2006 IPCC Guidelines*, as shown in Table 2-1.

Chapter 2 Data Sources

2.1 Energy

The activity data on fossil fuel combustion in NGI2014 were mainly from NBS and other relevant departments. Consumption of coal, oil and natural gas in 2014 were 2,793 Mtce, 741 Mtce and 243 Mtce, as shown in Table 2-2.

Table 2-2 Major Activity Data on Energy in 2014

Activity Level	Values	Activity Level	Values
Coal consumption (Mtce)	2,793	Underground coal mining volume (Mt)	3,292
Oil consumption (Mtce)	741	Natural gas exploitation and gathering system (thousand)	9.3
Natural gas consumption (Mtce)	243	Straw consumption (Mtce)	132

The activity data sources of biomass fuel combustion included *China Agriculture Yearbook 2015* etc. The activity data of fugitive emissions from coal mining were mainly from *China Coal Industry Yearbook 2015*. The activity data of fugitive emissions from oil and gas systems were mainly sourced from *Sinopec Group Statistical Yearbook 2015* etc. The emission factors of CO_2 from solid fuel combustion and those of CH_4 and N_2O from road transportation were updated based on the 2014 data, while emission factors from other emission sources were the same with those in the NGI2010.

2.2 Industrial Processes

The data on production of cement clinker, crude steel and primary aluminum of China in 2014 were quoted from statistical materials released by the NBS. The production of synthetic ammonia was mainly from *China Chemical Industry Yearbook 2015*. The production of lime was from the estimated data of China Lime Association. The production of nitric acid was from research data of National Chemical Industrial Nitric Acid and Nitrate Technological Coordination Network. The data on production of adipic acid, ferrosilicon and chlorodifluoromethane (HCFC-22) were from company surveys. Activity data on major processes were shown in Table 2-3. The emission factors for the production of cement clinker, ammonia, adipic acid and HCFC-22 were country-specific data obtained through typical enterprise surveys. The emission factors for other sources were the default factors from NGI2010 or *2006 IPCC Guidelines*.

Table 2-3 Activity Data of Major Industrial Processes in 2014

Activity Data	Production	Activity Data	Production
Cement clinker(Mt)	1,408.65	Ferrosilicon(Mt)	6.15
Crude steel(Mt)	822.31	Primary aluminum(Mt)	28.86
Ammonia(Mt)	57.00	HCFC-22(kt)	624

2.3 Agriculture

Activity data of agriculture in 2014 were mainly from *China Agriculture Yearbook 2015*, *China Statistical Yearbook 2015*, *China Animal Industry Yearbook 2015* and the 3rd agricultural census results. The main activity data are shown in Table 2-4. Country-specific N_2O direct emission factor and 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 and other main animals and for rice cultivation in 2014 were used. Emission factors of other sources were adopted from NGI2010.

Table 2-4 Major Activity Data of Agriculture in 2014

	Activity Data		Activity Data
Dairy herd stock (million)	11.28	Sheep stock (million)	162.24
Beef cattle stock (million)	60.33	Pig stock (million)	471.60
Buffalo stock (million)	18.47	Nitrogen fertilizer consumption (Mt nitrogen)	23.93
Goat stock (million)	141.68	Compound fertilizer net consumption (Mt)	21.16

2.4 Land Use, Land-Use Changes and Forestry

In the preparation of the LULUCF inventory of 2014, the data from the sixth to ninth continuous forest resources inventories were used. For provinces (autonomous regions, municipalities), interpolation or extrapolation methods according to the actual inventories year were used to calculate activity data in 2014. National data were calculated by aggregating data of provinces as shown in Table 2-5. The emission factors of forest land inventory and agricultural soil carbon adopted the country-specific data in the current year.

Table 2-5 Major Activity Data of LULUCF in 2014

	Area (Mha)		Area (Mha)
High forest	170.15	Agricultural land	135.06
Bamboo forest	6.32	Grassland	286.56
Open forest	3.57	Wetlands	39.73
Shrub land	73.63	Settlements	37.23

2.5 Waste

The activity data of waste were from *China Urban Construction Statistical Yearbook 2014* and *China Environment Statistical Yearbook 2014*. Activity data of waste is shown in Table 2-6. Emission factors of solid waste disposal were country-specific data in 2014. Other emission factors were adopted from NGI2010, *IPCC Good Practice Guidance* and *2006 IPCC Guidelines*.

Table 2-6 Activity Data of Waste in 2014

	Activity Data (Mt)
Municipal solid waste (MSW) landfill	107.44
Waste incineration	53.30
COD discharged from wastewater	22.95

Chapter 3 National GHG Inventory in 2014

3.1 Overview

In 2014, China's total GHG emissions (with LULUCF) were approximately 11,186 million ton of carbon dioxide equivalent (Mt CO_2 eq) (Table 2-7), of which CO_2, CH_4, N_2O, HFCs, PFCs and SF_6 accounted for 81.6%, 10.4%, 5.4%, 1.9%, 0.1% and 0.6% respectively (Table 2-8). The GHG sink from LULUCF were 1,115 Mt CO_2 eq, and total GHG emission were 12,301 Mt CO_2 eq (without LULUCF). The 100-year time-horizon global warming potential (GWP) values are from IPCC SAR (Table 2-9). The detailed information about China's greenhouse gas emissions in 2014 is shown in Table 2-10 and Table 2-11.

Table 2-7 GHG Emissions and Removals of China in 2014（Mt CO_2 eq）

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
1. Energy	8,925	520	114				9,559
2. Industrial processes	1,330	0	96	214	16	61	1,718
3. Agriculture		467	363				830
4. Waste	20	138	37				195
5. LULUCF	-1,151	36	0				-1,115
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

Note: 1. Shaded cells do not require entries;

2. 0 indicates that the calculation result 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 2-8 China's GHG Emissions by Gas in 2014

GHGs	With LULUCF		Without LULUCF	
	Emission/ Sink (Mt CO_2 eq)	Proportion (%)	Emission/ Sink (Mt CO_2 eq)	Proportion (%)
CO_2	9,124	81.6	10,275	83.5
CH_4	1,161	10.4	1,125	9.1
N_2O	610	5.4	610	5.0
Fluorinated gas	291	2.6	291	2.4
Total	11,186	100.0	12,301	100.0

Table 2-9 GWP Values Used in the Inventory

GHGs	GWP	GHGs	GWP
CO_2	1	HFC-152a	140
CH_4	21	HFC-227ea	2,900
N_2O	310	HFC-236fa	6,300
HFC-23 (CHF_3)	11,700	HFC-245fa	1,030
HFC-32	650	PFC-14 (CF_4)	6,500
HFC-125	2,800	PFC-116 (C_2F_6)	9,200
HFC-134a	1,300	SF_6	23,900
HFC-143a	3,800		

Note: the 100-year time-horizon GWP value of HFC-245fa is from the IPCC AR4.

Energy is the main source of GHG emissions in China. In 2014, emissions from energy sector accounted for 77.7% of the national total emissions (without LULUCF). GHG emissions of industrial processes, agriculture and waste sectors accounted for 14.0%, 6.7% and 1.6% respectively, as shown in Figure 2-1.

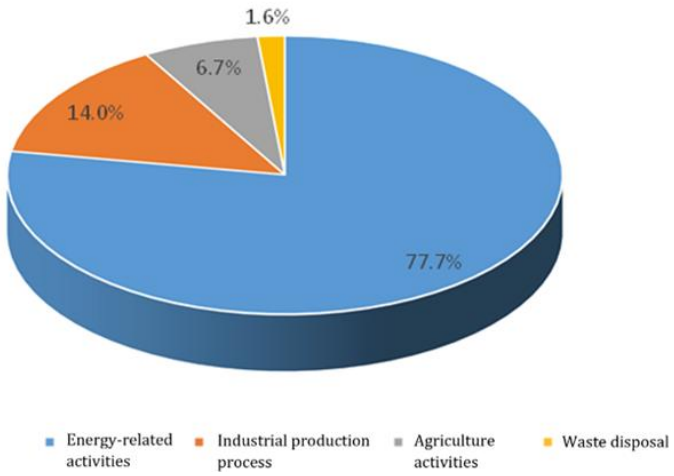

Figure 2-1 GHG Emissions of China by Sector in 2014 (without LULUCF)

3.1.1 Carbon Dioxide

China's CO_2 emissions in 2014 (with LULUCF) were 9,124 Mt. In 2014, China's CO_2 emissions (without LULUCF) were 10,275 Mt, of which 8,925 Mt were from energy, accounting for 86.9%; 1,330 Mt were from industrial processes, accounting for 12.9%; 20 Mt were from waste, accounting for 0.2%. LULUCF, mainly carbon sinks, which removed 1,151 Mt CO_2. In 2014, international aviation emitted 29 Mt CO_2, international marine emitted 22 Mt CO_2, biomass combustion emitted 776 Mt CO_2, which were all reported as memo items, not included in the national total, as shown in Table 2-10.

3.1.2 Methane

China's CH_4 emissions in 2014 were 55.292 Mt, of which 24.757 Mt were from energy, accounting for 44.8%; 6 kt were from industrial processes; 22.245 Mt were from agriculture, accounting for 40.2%; 1.72 Mt were from LULUCF, accounting about 3.1%; 6.564 Mt were from waste, accounting for 11.9%.

3.1.3 Nitrous Oxide

N_2O emissions in China in 2014 were 1.967 Mt, of which 0.367 Mt were from energy, accounting for 18.6%; 0.311 Mt were from industrial processes, accounting for 15.8%; 1.170 Mt were from agriculture, accounting for 59.5%; 0.12 Mt were from waste, accounting for 6.1%.

3.1.4 Fluorinated Gas

In 2014, total emissions of fluorinated gases including HFCs, PFCs and SF_6 were about 291 Mt CO_2 eq, all of them were from industrial processes. Among them, emissions from metal production were 15 Mt CO_2 eq, accounting for 5.3%; emissions from production of halocarbons and SF_6 were 150 Mt CO_2 eq, accounting for 51.4%; emissions from consumption of halocarbons and SF_6 were 126 Mt CO_2 eq, accounting for 43.3%, as shown in Table 2-11.

3.2 Energy

In 2014, China's total GHG emissions from energy were 9,559 Mt CO_2 eq. Among them, emissions from fuel combustion were 9,094 Mt CO_2 eq, accounting for 95.1%; fugitive emissions were 465 Mt CO_2 eq, accounting for 4.9%.

In terms of gas composition, CO_2 emissions were 8,925 Mt, all of which were from fossil fuel combustion. CH_4 emissions were 24.757 Mt, of which 10.6% were from fossil fuel combustion, and 89.4% were from fugitive emissions; and N_2O emissions were 0.367 Mt, all from fossil 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%.

3.3 Industrial Processes

The total GHG emissions from China's industrial processes in 2014 were 1,718 Mt CO_2 eq, of which 915 Mt were from mineral products, accounting for 53.3%; 238 Mt were from chemical industry, accounting for 13.9%; 288 Mt were from metal production, accounting for 16.8; 150 Mt were from production of halocarbons and SF_6, accounting for 8.7%; and 126 Mt were from consumption of halocarbons and SF_6, accounting for 7.3%.

In terms of gas composition, CO_2 emissions were 1,330 Mt, of which 68.8% emissions were from mineral products, 10.7% from chemical industry, and 20.5% from metal production; CH_4 emissions were 6 kt, all from metal production; N_2O emissions were 311 kt, all from chemical industry; HFCs emissions were 214 Mt CO_2 eq, of which 70.1% were from production of halocarbons and SF_6, and 29.9% from consumption; PFCs emissions were 16 Mt CO_2 eq, of which 95.6% were from metal production, 0.3% and 4.1% respectively from production and consumption of halocarbons and SF_6; SF_6 emissions were 61 Mt CO_2 eq, all from consumption of halocarbons and SF_6.

Table 2-10 China's CO_2, CH_4 and N_2O Emissions and Removals in 2014 (kt)

Source and sink categories	CO_2	CH_4	N_2O
Total (with LULUCF)	9,123,940	55,292	1,967
1. Energy	8,924,929	24,757	367
—Fossil fuel combustion	8,924,929	2,614	367
♦Energy industry	3,995,344	50	223
♦Manufacturing industries and construction	3,423,506	324	65
♦Transport	819,740	79	21
♦Other sectors	623,178	777	7
♦Other	63,161	1,384	51
—Fugitive emissions		22,142	
♦Solid fuels		21,015	
♦Oil and gas systems		1,127	
2. Industrial processes	1,329,866	6	311
—Mineral products	915,202		
—Chemical industry	141,963	NA	311
—Metal production	272,702	6	NA
—Production of halocarbons and SF_6			
—Consumption of halocarbons and SF_6			
3. Agriculture		22,245	1170
—Enteric fermentation		9,856	
—Manure management		3,155	233
—Rice cultivation		8,911	
—Agricultural soils		NA	930
—Prescribed burning of savannahs		NO	NO
—Field burning of agricultural residues		323	7
4. LULUCF	-1,150,910	1,720	IE,NE
—Forest land	-839,730		
—Cropland	-49,460	IE	IE
—Grassland	-109,160	IE	IE
—Wetlands	-44,540	1,720	NE
—Settlements	2,530		
— Other land	0		
— Harvested wood products	-110,550		
5. Waste	20,055	6,564	120
—Solid waste	20,055	3,842	9
—Wastewater treatment		2,721	110
Memo items			
—International aviation	29,336	0	1

Source and sink categories	CO_2	CH_4	N_2O
—International marine	21,912	2	1
—CO_2 emissions from biomass	775,817		

Note: 1. Shaded cells do not require entries;

2. 0 indicates that the value is less than 500t;

3. NE (not estimated) indicates emissions and sink removals of existing source are not estimated, IE (included elsewhere) indicates the emission source is estimated and included in other sub-field, and NO (not occurred) indicates the emission source doesn't exist;

4. Due to rounding, the aggregation of various items may have slight difference with the total.

5. Memo Items are not counted in the total emissions.

3.4 Agriculture

In 2014, China's GHG emissions from agriculture were around 830 Mt CO_2 eq, of which the emissions from livestock enteric fermentation were 207 Mt CO_2 eq, accounting for 24.9%; the emissions from livestock manure management were 138 Mt CO_2 eq, accounting for 16.7%; the emissions from rice cultivation were 187 Mt CO_2 eq, accounting for 22.6%; the emissions from agricultural soils were 288 Mt CO_2 eq, accounting for 34.7%; and the emissions from field burning of agricultural residues were 9 Mt CO_2 eq, accounting for 1.1%.

Regarding the composition of gases, CH_4 emissions were 22.245 Mt, of which 44.3% were from enteric fermentation emissions, 14.2% were from manure management, 40.1% were from rice cultivation, 1.4% were from field burning of agricultural residues. N_2O emissions were 1.170 Mt, of which manure management emissions accounted for 19.9%, agricultural soils emissions for 79.5%, field burning of agricultural residues for 0.6%.

3.5 LULUCF

In 2014, China's LULUCF absorbed 1,151 Mt CO_2, emitted 1.72 Mt CH_4, and the net removal of GHG amounted to 1,115 Mt CO_2 eq. The forest land, agricultural soils, grassland and wetland respectively absorbed 840, 49, 109 and 45 Mt CO_2 respectively; the settlements emitted 2.53 Mt of CO_2; harvested wood products absorbed 111 Mt CO_2. The CH_4 emissions from the wetland were 1.72 Mt.

Table 2-11 China's Emissions of HFCs, PFCs and SF_6 in 2014(kt)

Emission source types	HFCs									PFCs		SF_6
	HFC-23	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-152a	HFC-227ea	HFC-236fa	HFC-245fa	CF_4	C_2F_6	
Total	12.5	3.1	3.2	41.9	0.2	0.2	0.1	0.0	0.2	2.1	0.3	2.6
1. Energy												
2. Industrial processes	12.5	3.1	3.2	41.9	0.2	0.2	0.1	0.0	0.2	2.1	0.3	2.6
—Mineral products												
—Chemical industry												
—Metal production										2.0	0.2	
—Production of halocarbons and SF_6	12.5	0.4	0.4	0.7	0.1	0.2	0.1	0.0	0.0	0.0	0.0	NO
—Consumption of halocarbons and SF_6	NO	2.7	2.8	41.2	0.1	NO	NO	NO	0.2	0.1	0.0	2.6
3. Agriculture												
4. LULUCF												
5. Waste												

Note: 1. Shaded cells do not require entries;

2. 0.0 indicates that the value is less than 50t;

3. NO (not occurred) indicates the emission source doesn't exit;

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

3.6 Waste

In 2014, the total GHG emissions from waste were 195 Mt CO_2 eq, of which 104 Mt were from municipal solid waste disposal, accounting for 53.2%; 91 Mt were from wastewater treatment and discharge, accounting for 46.8%.

Regarding the composition of gases, CO_2 emissions were 20 Mt, all of which were from waste incineration. CH_4 emissions were 6.564 Mt, of which 58.5% were from solid waste disposal and 41.5% were from wastewater treatment. N_2O emissions were 0.12 Mt, of which 7.9% were from solid waste disposal and 92.1% were from wastewater treatment.

Chapter 4 Quality Assurance and Quality Control

4.1 Efforts to Reduce Uncertainties

In preparing the National Greenhouse Gas Inventory of 2014, to reduce uncertainties and improve the quality of inventory, 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 approach. Emissions from key categories were estimated using as many higher-tier methods and country-specific emission factors as possible in 2014 inventory, thus improving the accuracy of the inventory.

Regarding the activity data, 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. In terms of the estimation of CO_2 emissions from coal combustion, further investigation was made on the net calorific value (NCV) of coals consumed in key sectors by type and purpose.

In terms of emission factors, NBS initially established a relevant parameter statistical survey system. The inventory team and other relevant departments conducted researches on the rate of carbon storage in the coal chemical industry, and on-site measurement of nitrogen excretion by main livestock and poultry as well as direct emission factors of N_2O from agricultural soils, to obtain country-specific emission factors and related parameters. In preparing the Inventory of

2014, the inventory team gave first priority to country-specific emission factors of 2014, and second priority to country-specific emission factors of 2010. The default values of relevant IPCC guidelines were used when national data were not available.

Regarding inventory management, the inventory team emphasized the management of data file. The 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.

4.2 Uncertainty Analysis

Based on the uncertainties analysis of activity data and emission factors of energy, industrial processes, agriculture, LULUCF, and waste sectors, the overall uncertainties are calculated according to the error propagation approach in *IPCC Good Practice Guidance*, the overall uncertainty of the National GHG Inventory of 2014 was from -5.2% to 5.3%, see table 2-12 for details.

Table 2-12 Results of Uncertainty Analysis of 2014 National GHG Inventory

	Emission/ Sink (Mt CO_2 eq)	**Uncertainties**
Energy	9,559	-5.2%~5.3%
Industrial processes	1,718	-3.9%~3.9%
Agriculture	830	-19.2%~20.4%
LULUCF	-1,115	-21.1%~21.2%
Waste	195	-23.2%~23.2%
Overall		-5.2%~5.3%

Chapter 5 Information on Inventories in Previous Submissions

In the initial, the second, the third national communications and the first biennial

update report, China submitted its National GHG Inventories of 1994, 2005, 2010 and 2012. The following is the summary of the information on the previous inventories. It should be noted that the inventories of 1994 and 2012 haven't been recalculated, so the methods and scopes of the two inventories are different from those of other years.

5.1 National GHG Inventory in 1994

In 1994, China's total GHG emissions (with LUCF) were 3,650 Mt CO_2 eq (Table 2-13), 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 is 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 2-13 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
Waste	NE	162	NE				162
LUCF	-407	NE	NE				-407
Total (without LUCF)	3,073	720	264	NE	NE	NE	4,057
Total (with LUCF)	2,666	720	264	NE	NE	NE	3,650

Note: 1. Shaded cells do not require entries;

2. NE (Not Estimated) for existing emissions and removals which have not been estimated;

3. Due to rounding, the aggregation of various items may have slight difference with the total.

5.2 National GHG Inventory in 2005

According to the recalculated information in the Third National Communication on Climate Change, in 2005, China's total GHG emissions (with LULUCF) were 7,249 Mt CO_2 eq (Table 2-14), of which CO_2, CH_4, N_2O and fluorinated gas accounted for 77.0%, 14.4%, 6.9% and 1.7% respectively; net removal of LULUCF was 766 Mt CO_2 eq. China's total GHG emissions (without LULUCF) in 2005 were around 8,015 Mt CO_2 eq, of which CO_2, CH_4, N_2O and fluorinated gases accounted for 79.6%, 12.6%, 6.2% and 1.6% respectively.

Table 2-14 GHG Inventory of China in 2005 (Mt CO_2 eq.)

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Energy	5,665	497	81				6,243
Industrial processes	713	NE	33	109	6	10	871
Agriculture		431	357				788
Waste	3	81	29				113
LULUCF	-803	37	NE, IE				-766
Total (w/o LULUCF)	6,381	1,009	500	109	6	10	8,015
Total (w/ LULUCF)	5,578	1,046	500	109	6	10	7,249

Note: 1. Shaded cells do not require entries;

2. 0 indicates that the value is less than 0.5 Mt CO_2 eq;

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. w/o stands for without. w/ stand for with.

4. Due to rounding, the aggregation of various items may have slight difference with the total.

5. The table shows the information on inventory data after backtracking calculation is performed.

5.3 National GHG Inventory in 2010

In 2010, total GHG emissions in China (with LULUCF) were about 9,551 Mt CO_2 eq (Table 2-15), 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 2-15 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
Waste	8	92	31				132
LULUCF	-1,030	37	0				-993
Total (w/o LULUCF)	8,707	1127	547	132	10	21	10,544
Total (w/ LULUCF)	7,678	1163	547	132	10	21	9,551

Note: 1. Shaded cells do not require entries

2. 0 indicates that the calculation result 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.

5.4 National GHG Inventory in 2012

In 2012, total GHG emissions in China (with LULUCF) were about 11,320 Mt CO_2

eq (Table 2-16), 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 LULUCF was 576 Mt CO_2 eq. China's total GHG emissions (without LULUCF) 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 2-16 GHG Inventory of China in 2012（Mt CO2 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
Waste	12	114	33				158
LULUCF	-576	0	0				-576
Total (w/o LULUCF)	9,893	1,174	638	154	12	24	11,896
Total (w/ LULUCF)	9,317	1,174	638	154	12	24	11,320

Note: 1. Shaded cells do not require entries;

2. 0 indicates that the calculation result is less than 0.5Mt;

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

Part III Mitigation Actions and Their Effects

The Chinese government released *the Work Plan on Greenhouse Gas Emission Control for the 13th FYP* (hereinafter referred to as *GHG Control in 13th FYP*), and other related development schemes for every aspects of the energy field, with a view to increase the guiding force by strategic goals and policies for low-carbon development, promote industrial structure and energy structure optimization, continuously boost energy conservation and increase energy efficiency, control greenhouse gas emissions from non-energy-related activities, actively increase forest carbon sinks, and promote the implementation and innovation of systems and mechanisms for mitigation actions, and continue to explore new models for low-carbon development fit in with national circumstances.

Chapter 1 Policies and Targets for GHG Emission Control

China has set indicators for 2020 in the nationally appropriate mitigation actions (NAMAs): to lower its CO_2 emissions per unit of GDP (hereinafter referred to as carbon intensity) by 40%-45% compared with the 2005 level, to increase the share of non-fossil energy in primary energy consumption to around 15%, and to increase forest area by 40 million ha and forest stock volume by 1.3 billion m^3 compared with the 2005 level. Besides, the *Work Plan on Greenhouse Gas Emission Control for the 12th FYP*, proposed in 2011, clearly pointed out that the targets were to reduce carbon intensity dramatically, like a fall of 17% in 2015 compared with 2010; to achieve progress on the control of CO_2 emissions from non-energy-related activities and other greenhouse gas emissions including CH_4, N_2O, HFC, PFC and SF_6.

In *GHG Control in 13th FYP* issued in 2016, it is further stressed out China's determined mitigation actions, and clearly pointed out that to exert effective control on carbon emissions, and by 2020 carbon intensity is 18% lower than that of 2015; to put more efforts to control the emission of greenhouse gas other than CO_2, including HFCs, CH_4, N_2O, PFCs and SF_6; and to increase significantly carbon sink capability.

Chapter 2 Mitigation Actions and Progress

2.1 Intensify Guidance and Target Control

Organize Implementation of Plans and Schemes Addressing Climate Change. In the *Outline of the 13th Five-Year Plan for National Economic and Social Development (hereinafter referred to as Outline of the 13th FYP)*, it is clearly stated that China would strive to increase green and low carbon in production and consumption, exert active control on carbon emission and include the target of decreasing carbon intensity by 18% as a binding indicator in the indicator system of economic and social development during the 13th FYP period; in *GHG Control in 13th FYP*, it is clearly set out that China would make efforts to improve guidance on low carbon development, promote energy and industry revolution, boost supply-side structural reform and consumption transformation, promote balanced regional development, determine provincial carbon emission control target based on factors of development stage, resource and advantage, strategic positioning of each province (autonomous region, municipality), and require each province (autonomous region, municipality) to include large drop of carbon emission intensity into their economic and social development plans, annual plans and government work reports. Up to June. 2017, 18 provinces (autonomous regions, municipalities) had issued provincial-level work plan or relevant planning on GHG emission control for the 13th FYP period. Besides, the Ministry of Industry and Information Technology (MIIT), the Ministry of Transport, the MOST, and The State Forestry Administration have released action plans and other related documents, providing support in the implementation of greenhouse gas control targets.

Strengthen Reviews on Task Fulfillment and Responsibility Taking. In 2013, NDRC together with relevant departments, formulated the *Implementation Programme for the CO_2 Emission per Unit of GDP Control Target Assessment System in the 12th FYP Period.* Proposed in this document was an accountability assessment system consisting of 12 basic indicators plus 1 reference indicator of the provincial governments' fulfillment of the GHG emission control targets. They are used to check target fulfillment, task and measure implementation, fundamental work and capacity building, and institutional innovations. Provincial government GHG control evaluation and review work duiring 12th FYP period was

accomplished in 2016. Since 2016, the condition on target fulfillment and responsibility taking have been further improved, through persistent efforts in improving the system of estimation, assessment and accountability.

2.2 Economic and Industrial Structural Adjustment

The proportion of value added to the tertiary industry in 2016 was 51.6%[1], 1.4 percentage points (pps) higher than that of 2015. The contribution of the service industry to the national growth in economy in 2016 was 57.5%, an increase of 4.6 pps year on year (YoY)[2].

Accelerate Development of Modern Service Industry. China has been working on to broaden market access, promote a quality and efficient development for the service industry, promote the extension of production-oriented sectors of service industry into the higher part of value chain with more professionalism, as well as promote the transformation of consumer-oriented service companies toward refinement and high quality, and, in the area of manufacturing industry, promote the shift in the manufacturing industry from production orientation to production and service orientation.

Promote Industry Transformation and Upgrading, Boost Low Carbon Industries' Sustainable Development. In 2016, China clearly pointed out, it would made a major reduction in production capacity for three to five years[3], and an elimination of outdated industry capacity in compliance with regulations and laws[4]; It would formulate rigid standards for additional production in industries with excessive production capacity, including steel, electrolytic aluminum, cement, flat glass and ship[5]. In 2016, China slashed total of over 65 million tons in steel capacity (crude steel), shut down approximately 1,500 small coal mines with capacity less than 0.3 million tons[6], and eliminated a large deal of outdated capacity (Table 3-1). The expansion rate of energy intensive industries was effectively controlled. China's large-scale industry saw an increase of 6.0% in value

[1] Source: *China Statistical Yearbook-2017*.
[2] Source: NBS.
[3] *Opinion on Tackling Overcapacity in Steel Industry and Addressing Development Challenges* and *Opinion on Tackling Overcapacity in Coal Industry and Addressing Development Challenges* by the State Council (February 2016).
[4] Guiding Opinions of the MIIT and other relevant ministries on *Promoting the Elimination of Outdated Industry Capacity in Compliance with Laws and Regulations through Comprehensive Standards* (February 2017).
[5] *List of Investment Projects Approved by the Government*, issued by the State Council in December 2016.
[6] Source: *Stable Growth in Industrial Economy and Optimized adjustment in Growth Driver Structure - Part Eight of the Achievements in Social and Economic Development following the 18th National Congress of the CPC*, by NBS.

added in 2016[1], 0.8 pps higher than the value added in the six energy intensive industries[2].

Table 3-1 Fulfillment of Phasing Out Outdated Production Capacity[3]

Industries	Unit	Fulfillment in 2015	Fulfillment in 2016
Iron making	Mt	13.78	6.77
Steel production	Mt	17.06	10.96
Electrolytic aluminum	Mt	0.362	0.32
Cement clinker	Mt	49.74	5.59
Flat glass	M weight box	14.29	33.40

Continued the efforts in promoting the development of emerging industries of strategic importance, and deployed a series of systematic projects in multiple frontier areas of strategic importance. In 2016, the large-scale emerging industry of industrial strategic importance saw an increase of 10.5% in value added, 4.5 pps higher than the growth rate of industrial value added in 2015. The large-scale emerging sectors of strategic importance in service industry saw a YoY increase in revenue of 15.1% in 2016, achieving a better result than previous years[4].

2.3 Energy Structure Optimization

China has adopted forceful policies and measures to further its optimization in energy structure (Figure 3-1) since 2016. Between 2015 and 2016, China saw a reduction from 63.7% to 62.0% in the proportion of coal consumption among total energy consumption, a rise from 5.9% to 6.2% in the proportion of natural gas consumption, and an increase from 12.1% to 13.3% in the proportion of non-fossil energy consumption.

[1] The six energy intensive industries contain petroleum processing, coking and nuclear fuel processing industry, chemical raw materials and chemical products manufacturing industry, non-metallic mineral products industry, ferrous metal smelting and rolling processing industry, non-ferrous metal smelting and rolling processing industry, and electricity and heat production and supply industry.
Source: Statistical Bulletin on National Economic and Social Development of China in 2016.
[3] Source: MIIT.
[4] Source: *Statistical Bulletin on National Economic and Social Development of China in 2016* etc.

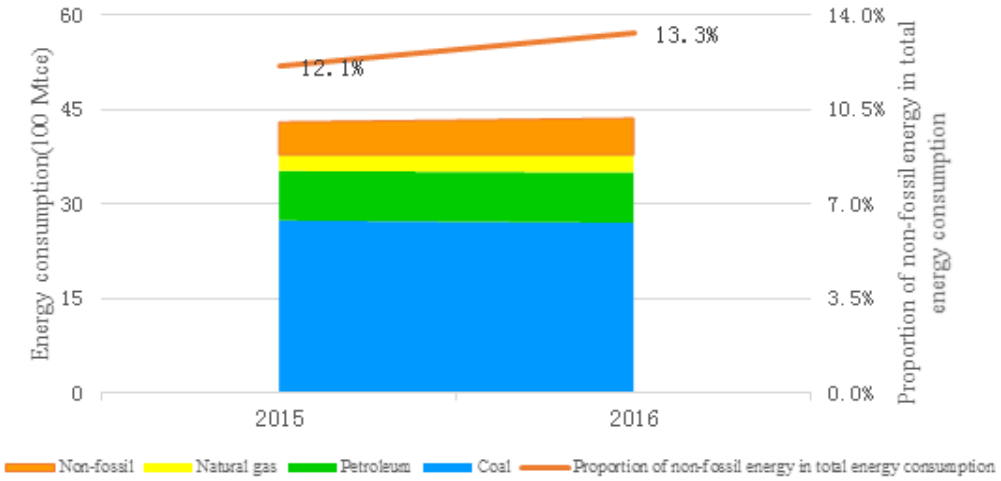

Figure 3-1 Energy Consumption Structure of China in 2015-2016[1]

Actively Develop Non-fossil Energy. To promote an active development of renewable energy and a steady development of nuclear power generation, China has printed and distributed a series of plans during the 13th FYP period on the development of renewable energy, hydropower, wind power, solar power, and biomass, geothermal energy and nuclear industry, with specific development goals, schemes and arrangements, and construction highlights for non-fossil energy during the 13th FYP period. Compared with 2015, China's installed non-fossil energy power capacity went up by 13.4% in 2016. Power generation by non-fossil energy went up by 12.3% (Table 3-2).

Increase Share of Natural Gas Consumption in Total Energy Consumption in a Steady Manner. China's energy development plan during the 13th FYP period set out goals to accelerate the development of low-carbon fossil energy, to promote the revolution of natural gas pricing[2, 3, 4, 5], and provide a sound price mechanism to support the development of natural gas. According to statistic information, China produced 136.9 billion m^3 of natural gas in 2016, with natural gas consumption accounting for 6.2%[6] of the total energy consumption and kept a growing momentum.

---

[1] Source: China Statistical Yearbook 2017.

[2] *Notice of the National Development and Reform Commission on Lowering the Gate Station Price of Natural Gas for Non-residential Users and Further Promoting the Transformation for Marketization of Price* (November 2015).

[3] *Notice on Tightening Regulation on Regional Natural Gas Distribution Price and Lowering Gas Cost for Enterprises* by NDRC(August 2016).

[4] *Administrative Measures for Natural Gas Pipeline Transportation Price* issued by NDRC (Pilot Version) (October 2016).

[5] *Measures for Monitoring and Reviewing Cost Pricing of Pipeline Transportation of Natural Gas*, printed and distributed by the NDRC (Pilot Version) (October 2016).

[6] Source: *China Energy Statistical Yearbook 2017*.

Table 3-2 Non Fossil-Fuel Installed Capacity and Power Generation of China[1]

	Unit	2015	2016
Installed Capacity (IC)			
Hydropower	GW	319.54	332.07
Wind power	GW	130.75	147.47
Solar power	GW	42.18	76.31
Nuclear power	GW	27.17	33.64
Others	GW	0.09	0.07
Power Generation (PG)			
Hydropower	TWh	1,112.7	1,174.8
Wind power	TWh	185.6	240.9
Solar power	TWh	39.5	66.5
Nuclear power	TWh	171.4	213.2
Others	TWh	0.1	0.1

Put More Efforts in Total Coal Consumption Control. China made it clear that it would continue its efforts to put in place a strict control on total coal consumption[2], and to implement alternative measures to reduce coal consumption in places such as Beijing, Tianjin, Hebei, Shandong, Yangtze River Delta region, Pearl River Delta region and Fenhe-Weihe Plain, as well as alternative measures equal to coal consumption in other major areas. In 2016, China's total coal consumption was about 2,700 Mt standard coal, representing 62% of total energy consumption, 1.7 pps lower than 2015. Meanwhile, the shares of China's install thermal power capacity and thermal power generation were respectively 64.3% and 71.8%, both dropped[3]. The work on alternative measures to reduce coal consumption has achieved significant progress in many places, take Beijing-Tianjin-Hebei region, by 2016, Beijing and Tianjin completed their 2017 targets ahead of schedule, and Hebei completed 81% of its 2017 target, reducing 12 Mt CO_2 emission compared with 2015.

2.4 Energy Conservation and Higher Efficiency

The Chinese Government brought forward 2016 targets for improving energy efficiency, which required energy consumption per ten thousand yuan of GDP in 2016, comparing with 2015, to be reduced by more than 3.4%; and coal

[1] Data Source: *2016 Quick Statistics on Electric Power* and *2017 Quick Statistics on Electric Power* by China Electricity Council.
[2] *13th FYP for Energy Development*, printed and distributed by the National Development and Reform Commission and the National Energy Administration in December 2016.
[3] Source: *2017 Quick Statistics on Electric Power*.

consumption per kWh by coal-fired power plants to be reduced by 1 gram of coal equalvant (gce) to 314 gce.[1]

China made significant achievements in energy conservation and efficiency improvement, with energy consumption of main energy-intensive products steadily reduced (Figure 3-2) and the total energy saved by the whole society equaling more than 200 Mtce. As for the industrial department, energy consumption per unit of industrial value added in 2016 decreased by 6.4% over 2015, saving about 190 Mtce.[2]

Strengthening Performance Assessment of Energy Conservation Targets. China has assigned the targets of total energy consumption amount and energy consumption intensity, also referred to as "double control" targets, during the 13th FYP period to each province (autonomous region, municipality)[3] and carried out on-site evaluations and reviews of each provincial (autonomous regional, municipal) government's performance in meeting their respective targets. According to *2016 Review Results of All Provinces (Autonomous Regions, Municipalities) on Meeting the "Double Control" Targets*, 30 provinces (autonomous regions, municipalities) met their respective 2016 targets of total energy consumption amount and energy consumption intensity, of which 7 provinces (autonomous regions, municipalities) including Beijing and Tianjin outperformed their respective annual "double control" targets.

Increased Investment to Key Energy Conservation Programs. With positive influences of promoting energy performance contracting (EPC), China's energy conservation service industry experienced rapid development. Investments to EPC programs continuously increased, which has generated substantial energy conservation potentials and CO_2 emission reduction results (Figure 3-3).

Improving Energy Conservation Standards and Labeling. China initiated the "Project on Promoting a Hundred Energy Efficiency Standards", which improved energy conservation labeling management system and expanded the application of energy labeling[4]. By the end of 2016, China issued 64 mandatory standards for implementing energy efficiency, 104 mandatory standards for energy

[1] *The Notice on Printing and Issuing Guidance and Advices for Energy Work in 2016* by National Energy Administration, March 2016.
[2] Source: *China Statistical Yearbook-2017*, *China Energy Statistical Yearbook 2017*.
[3] *Comprehensive Work Plan on Energy Conservation and Mitigation for 13th FY*P period by the State Council, December 2016.
[4] *Energy Efficiency Labeling Management Methods* by NDRC and General Administration of Quality Supervision, Inspection and Quarantine (GAQSIQ), February 2016.

consumption limits, more than 150 recommended nationals standards for energy conservation, and 13 batches, 35 categories of products which require energy labeling, including domestic refrigerator, domestic washing machine, electric storage water heater and flat-screen TV[1].

Figure 3-2 Energy Consumption of Energy-Intensive Products in China in 2015-2016[2]

Promoting Energy Conservation Technologies and Products. In 2016, China released the *Catalogue for the Promotion of National Key Energy Conservation Low-Carbon Technologies (Energy Conservation)*. To encourage companies to benchmark and meet energy labeling requirements, China released the first edition of *Catalogue of "Energy Efficiency Leader" Products*[3], the *Catalogue of Recommended Energy Conservation Mechanical and Electrical Equipment (Products)*

[1] Source: www.energylabel.gov.cn, Fast Facts of Products Requiring Energy Labels in China.
[2] Source: *China Energy Statistical Yearbook 2017*.
[3] *Catalogue of "Energy Efficiency Leader" Products* by NDRC, GQASIQ and China National Institute of Standardization (NIS), June 2016.

(the 7th batch), and the *Catalogue of "Energy-Efficiency Star" Products (2016)*[1]. China also initiated an Action Program of Multiplying High Efficiency and Energy Conservation Products to encourage the public to participate in the energy conservation endeavor[2].

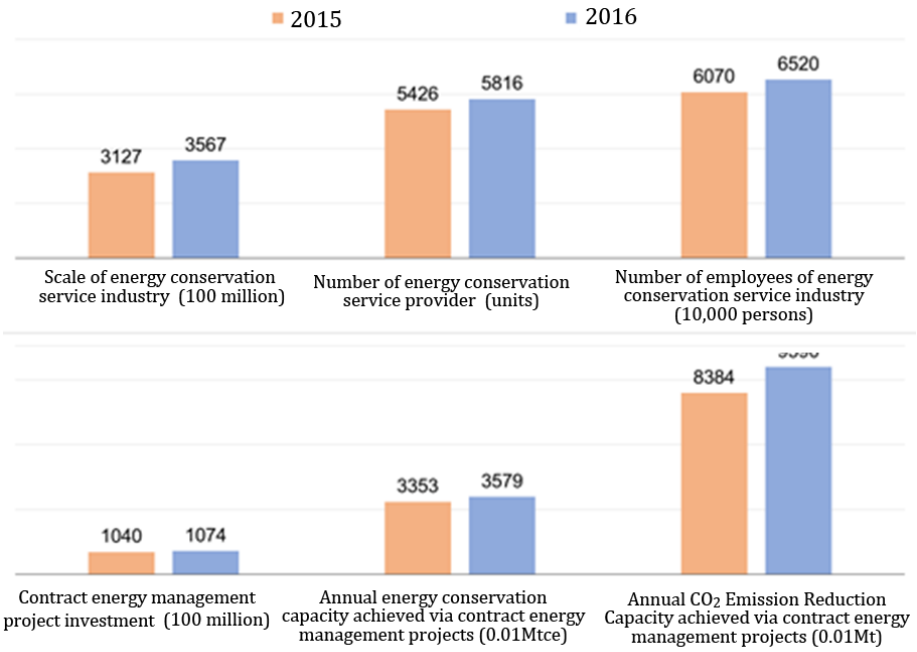

Figure 3-3 Development of Energy Conservation Service Industry and Energy Management Contracting in China in 2015-2016[3]

Enhancing Energy Conservation of Buildings. China guided the development of green buildings. In 2016, new green buildings in urban areas exceeded 500 million square meters, accounting for more than 29% of newly built civil buildings in urban areas. China pushed forward energy renovations of existing buildings. Energy renovations of 87.89 million square meters of existing buildings were completed in 2016 (Table 3-3). China also strengthened energy conservation management of public buildings. In 2016, China's provinces (autonomous regions, municipalities) completed energy auditing of 2,718 public buildings, published energy consumption results of 6,810 buildings, monitored and inspected energy consumption of 2,373 buildings, and conducted energy renovation of 27.6 million square meters of public buildings.

[1] MIIT, *Catalogue of Recommended Energy Conservation Mechanical and Electrical Equipment (Products) (the 7th batch)* and *Catalogue of "Energy-efficiency Star" Products (2016)*, September 2016.
[2] *Nationwide Energy Conservation Action Plan during the 13th FYP* period by NDRC, December 2016.
[3] Source: *Energy Conservation Service Industry Development Report 2017*, by ESCO Committee of China Energy Conservation Association (EMAC).

Table 3-3 Fulfillment of the 2016 Targets of Energy Conservation Renovations on Existing Residential Buildings

Category	Area of Renovated Space (10,000 square meters)
Provinces (autonomous regions, municipalities) in extremely cold and cold areas	7,262
Provinces (autonomous regions, municipalities) in areas with hot summers and cold winters	1,527
Total	8,789

Promoting Transportation Energy Conservation. China set up green transportation development systems and frameworks which strongly implemented strategies to give priorities to public transportation, greatly promoted green travel and achieved improvements on energy consumption indexes of most travel modes (Table 3-4).

2.5 Control of Non-CO_2 GHG Emissions

Since 2016, China has carried out relevant actions in industrial production processes, agriculture-related activities, waste disposal and other sectors to enhance control of non-CO_2 GHG emissions.

Control of GHG Emissions from Industrial Processes. China comprehensively pushed forward green manufacturing, actively promoted cleaner production techniques and crafts, greatly pushed forward integrated utilization of industrial resources and achieved continuous improvements of energy efficiency in key industries. It also controlled N_2O emissions from nitric acid production by phasing out backward production capacities in cement and iron and steel productions, and adopting secondary and tertiary treatment methods. China continued inspections of HFCs treatment and provided subsidies to companies that destroyed HFC-23 during waste treatment. In 2016, the 13 companies which received central budgetary investments and financial subsidies destroyed about 13,300 tons of HFC-23 in total.

Table 3-4 Major Energy Consumption Indicators of Transportation in China in 2016[1]

Category	Unit	2016	2016 Compared to 2015 (%)
Unit energy consumption of public transport company	kgce/100 vehicle-km	48.5	-0.9
Unit energy consumption of passenger transport company for public road commute	kgce/100 vehicle-km	29.7	-1.5
Unit energy consumption of public road specialized freight transport company	kgce/100 ton-km	1.8	-4.0
unit energy consumption of ocean freight and coastal freight company	kgce/1,000 ton-sea mile	5.0	-4.9
Unit energy consumption of port enterprise	tce/Ten thousand tons	2.5	-3.0
Comprehensive energy consumption per unit of railway transport amount	tce/ million converted ton-km	4.71	Same Level
Unit oil consumption of civil aviation	kg/ ton-km	0.293	-0.3

Control of GHG Emissions from Agriculture. China continued the implementation of "Zero Usage Increase of Chemical Fertilizer by 2020 Action" and "Zero Usage Increase of Pesticides by 2020 Action", strongly promoted technologies of formula fertilization by soil testing and for reducing amount and elevating efficiency of chemical fertilizers and pesticides. It promoted transformation and upgradings of rural biogas systems, elevated comprehensive utilization of stalk and actively controlled greenhouse gas emissions from raising livestocks and poultries. In 2016, China's chemical fertilizer usage for the first time came near to zero increase. 40,577,100 households countrywide adopted domestic biogas systems and 109,819 biogas projects of diverse types were constructed. Annul production of biogas nationwide reached 12.5 billion m^3, which accounted for about 4% of national natural gas consumption and substituted fossil energy of 8.7 Mtce. In 2016, biogas systems in rural areas treated about 1,600 Mt of animal manure from raising livestocks and poultries, stalks and organic domestic waste, and reduced greenhouse gas emission equaling more than

[1] Source: *Statistical Bulletin on Transportation Industry Development on China in 2016*, Statistical Bulletins on Civil Aviation Industry Development in 2015 and 2016.

50 Mt CO_2 eq.

Control of GHG Emissions from Waste Disposal. The Chinese government attaches great importance to the development of circular economy, actively pushing reducing, reusing and recycling of the resources to curb GHG emissions from the source and production processes. Ministry of Housing and Urban-Rural Development (MoHURD) improved the existing municipal waste standards, implemented the system of charged municipal waste disposal services, promoted the use of advanced waste incineration technologies, and formulated incentive policies to advance the recycling and reuse of the landfill gases. In 2016, pollution-free treatment in both cities and towns reached 94%. 249 waste incineration factories and 657 sanitary landfills were built in cities, and 50 waste incineration factories and 1,183 sanitary landfills were built in towns[1]. By the end of 2016, national municipal daily waste water disposal capacity reached 149.10 million m^3, annual amount of waste water treatment reached 44.88 billion m^3, and waste water treatment rate reached 93.44%[2].

2.6 Increasing Carbon Sinks

Forestry Carbon Sinks Functionality Steadily Strengthened. China continued to implement a number of major forestry ecology protection and restoration projects (Table 3-5), including protecting natural forest resources, restoring arable land to nature, building forest shelterbelt systems, wetland protection and restoration, comprehensive treatment of stony desertification and sandstorm source control in Beijing and Tianjin, and accelerating afforestation. In 2016 China completed afforestation of 6.788 million hectares[3], over-fulfilling the planned target of that year. China comprehensively strengthened forest tending management. In 2016, 8.5004 million ha of forests were tended. Forest area and forest stock volume continued to grow[4].

[1] Source: China City Environmental Health Association, China Urban Construction Design & Research Institute Co. Ltd., *2017 China Domestic Waste Disposal Industry Development Report -- Opportunities and Challenges of the New Era*.
[2] Source: *China Urban and Rural Construction Statistical Yearbook 2016*.
[3] Source: *China Land Greening Bulletin 2016* and *China Land Greening Bulletin 2017*.
[4] Source: *China Forestry Development Report 2017*.

Table 3-5 Progress of Five Major Forestry Protection and Restoration Projects[1]

Project	Sub-project	Unit	2015	2016
Natural forest resources conservation	Afforestation	Area (10,000 hectares)	49.9	25.6
	Cultivation of young and middle-aged forests	Area (10,000 hectares)	167.8	175.3
	Forest management and conservation	100 million hectares	1.15	1.15
Grain to green project	Incremental target for grain to green project	Area (10,000 hectares)	66.7	100.7
	Total target for grain to green project in the new round	Area (10,000 hectares)	100	200.7
	Afforestation	Area (10,000 hectares)	53.3	79.6
Beijing and Tianjin sandstorm source control project	Afforestation	Area (10,000 hectares)	24.7	25.1
	Sand fixation	Area (10,000 hectares)	0.79	0.98
Northwest-North-Northeast China (Sanbei) forest shelterbelt program	Afforestation	Area (10,000 hectares)	74.55	66.7
	Initiated shelterbelt base of millions Mu construction	Piece	2	2
Forest shelterbelt program along the Yangtze river, in the Pearl river basin, along the coastal line, in the Taihang Mountains and in plain areas	Afforestation	Area (10,000 hectares)	68	50.6

Proactively Increase Grassland Carbon Sinks. In 2016, China increased grassland fences of 2.993 million ha, completed improvements of degraded

[1] Source: *China Land Greening Bulletin 2015, 2016 and 2017*.

grassland of 3.127 million ha, planted artificial grasslands of 13.079 million ha, implemented grazing prohibitions on grasslands of 105 million ha, and achieved balance between forage and animal on 170 million ha. The total production of fresh grass from natural grasslands reached 1.04 billion tons, a YoY growth of 1%. Comprehensive vegetation coverage reached 54.6%, 0.6 pps higher than last year[1]. The nationwide tendency towards environmental deterioration of grassland was effectively restrained with vegetation condition of major ecological engineering program areas prominently improved.

Development of Marine Blue Carbon Sinks. China carried out the "South Mangrove and North Willow" wetland restoration program, "Eco-Island and Reef" project and "Blue Gulf" renovation program, gradually pushed forward blue carbon pilot program and strengthened management of marine carbon sinks.

2.7 Promoting Mechanism Construction of Implementing and Strengthening Mitigation Actions

Implement Controls on Carbon Intensity Under Classification Guidance. In 2016, based on overall consideration on development stage, resource endowment, strategic positioning, eco-environmental protection and other relative factors of various provinces (autonomous regions, municipalities), China determined the carbon intensity control goal of each province (autonomous region, municipality) in the 13th FYP period, established appropriate accounting and report methods, and carried out assessments on the implementation of target tasks of each province (autonomous region, municipality). In 2016, a total of 27 provinces (autonomous region, municipality) finished their annual carbon intensity reduction goals. See *The People's Republic of China First Biennial Update Report on Climate Change* for other details of domestic measurement, reporting and verification (MRV).

S**upport and Encourage Peaking Carbon Emissions in Advance in Regions.** China supported preferential development areas to take the lead to reach the peak carbon emissions. China encouraged other places to propose peak goals and define the routes of reaching the goals, and conducted a pilot test on control of total carbon emissions in some developed provinces and cities. It encouraged the regions that lead reaching the carbon emission peak and others with appropriate

[1] Source: *China Land Greening Bulletin 2016*.

conditions to increase efforts to reduce emissions, improve policy measures and try to finish the peak goals ahead of schedule. Currently, 23 pilot provinces and cities in China have promised to reach the peak CO_2 emissions before 2030.

Strengthen Construction of Regional and National Emission Trading Mechanism. In 2016, nearly 64 Mt of spot carbon allowance transactions were made in pilot carbon markets of seven provinces and cities and the secondary market in Fujian, with the total trade volume about 1.045 billion yuan[1]. Efforts will be made to develop a unified national carbon emission trading scheme, and to implement the carbon emission reporting, measuring, verification and allowance systems for key emitters, under the requirements in the *Outline for the 13th FYP*. On December 18, 2017, relevant departments issued *Scheme for the Construction of the National Carbon Emission Trading Market (for the Power Generation Industry)*, and made mobilization and deployment on fully implementing the tasks and requirements of the Scheme and pushing the construction of national carbon emission trading market, marking the official establishment of a national carbon emission trading system.

Promoting In-depth Development of Low-Carbon Pilot and Demonstrative Projects. China further advanced the special pilot low-carbon projects and related work, and launched the third group of 45 pilot low-carbon cities in 2017[2]. Since then, the number of pilot low-carbon provinces and cities had reached 87; the implementing schemes of 51 national pilot low-carbon industrial parks and eight pilot low-carbon cities (townships) had been approved; the number of provincial pilot low-carbon communities had surpassed 400. In addition, provincial near-zero emission demonstration projects were initiated in Shaanxi, Guangdong and Zhejiang. The pilot projects for climate investment and financing were promoted step by step, and carbon capture, utilization and storage (CCUS) testing and pilot projects were pushed forward steadily.

International Market Mechanism. According to the Project Management Database of the website of Clean Development Mechanism (CDM) of China[3], till the end of 2016, a total of 5,074 CDM projects had been approved by the NDRC, contributing the annual emission reductions of about 782 Mt CO_2 eq. To August 23, 2016, a total of 1,557 projects had been granted the CDM certificate issued by CERs,

[1] Source: *Annual Report of Beijing Carbon Market 2016*, and *Annual Report of Beijing Carbon Market 2017*.
[2] *Notice on Carrying out the National Third Batch of Pilot Low-carbon Cities* by NDRC, 2017.
[3] Database address: http://cdm.ccchina.org.cn/NewItemTable.aspx.

with the annual emission reductions at about 358 Mt CO_2 eq.

Chapter 3 Analysis on the Results of Major Mitigation Actions

China resorted to legal, administrative, technical and market means to experiment on and explore into low-carbon new development patterns better suited to the national conditions. With the close attention of Chinese government, the policy action of climate change mitigation achieved substantial progress in energy structure adjustment and energy conservation, significantly reduced the carbon emission intensity and effectively controlled the total amount of GHG emissions. As calculated, the CO_2 emissions of unit GDP in 2016 was 6.1% lower YoY.

Avoided Carbon Emission from Energy Conservation. Under the support of central and local finance, the energy-saving and consumption-reduction action achieved positive results. In 2016, the energy consumption per ten thousand yuan of GDP decreased by 5.0% YoY, with the annual energy reduction over 200 Mtce, which, through preliminary calculation, was equivalent to emission reductions of 490 Mt of CO_2.

Avoided Carbon Emission from Energy Structure Improvement. Under the guide of specific goals, the proportion of China's non-fossil energy in the total energy consumption rose to 13.3% in 2016, and the installed power-generating capacity of non-fossil energy was 590 GW, accounting to 35.7% of the total installed capacity, with 1.6 pps higher than the last year; the power generation amount of non-fossil energy was 1,700 TWh, with an increase of 190 TWh than 2015; the proportion of consumed natural gas in the total energy consumption increased from 5.9% in 2015 to 6.2%. Through preliminary calculation, 112 Mt and 8 Mt of CO_2 emissions were saved respectively.

See Table 3-6 for mitigation actions and effect analysis in details. Details of specific policies are included in TNC submitted in the meantime.

Table 3-6 Mitigation Actions and Effects

No.	Action Name	Objectives or Main Contents	Concerned Departments/ GHG	Time - horizon	Nature of Action	Supervision Departments	Status	Progress	Methodologies and Hypotheses	Estimated Emission Reduction Effects[1]	Receive Support
1	Nationwide mitigation action	Reduce the CO_2 emissions per unit of GDP by 40%-45% over 2005 by 2020	Various Departments/ CO_2	2006 -2020	Compulsive/ Government	NDRC	In Progress	Reduce the CO_2 emissions per unit of GDP by 6.1% over 2015 by 2016	Calculate the CO_2 emission amount by multiplying the consumption of coal, petroleum and natural gas corresponding 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 to around 13% by 2016; Increase the proportion of non-fossil energy consumption in total energy consumption to around 15% by 2020	CO_2 etc.	2016 -2020	Compulsive/ Government	National Energy Administration (NEA), NDRC and other relevant departments	In Progress	The proportion of non-fossil energy in energy consumption was 13.3% in 2016, up 1.2 pps high than 2015	Emission reduction=(current-year non-fossil fuel consumption –current-year energy consumption×2015 share of non-fossil energy in total energy consumption) ×implied emission factor of 2014 energy consumption2.14tCO_2/tce	Reduce CO_2 emissions by 110 million tons in 2016	Support from the central finance or the local finance
3	Developing natural gas	Increase the share of natural gas consumption to around 6.3% by 2016; Increase the share of natural gas consumption in total energy consumption to over 10% by 2020	CO_2 etc.	2016 -2020	Government	NEA, NDRC and other relevant departments	In Progress	The proportion of natural gas in total energy consumption increased from 5.9% in 2015 to 6.2% in 2016	Emission reductions = (consumption of natural gas in the year – total energy consumption in the year ×share of natural gas in 2015) × (the 2014 overall energy consumption emission factor of 2.14tCO_2/tce – the natural gas emission factor of 1.56tCO_2/tce)	Reduce CO_2 emissions by 8 million tons in 2016	

[1]"Emission reductions" may have overlaps, should not be accumulated

No.	Action Name	Objectives or Main Contents	Concerned Departments/ GHG	Time - horizon	Nature of Action	Supervision Departments	Status	Progress	Methodologies and Hypotheses	Estimated Emission Reduction Effects	Receive Support
4	Control over coal consumption	Reduce the proportion of coal consumption to less than 63% by 2016; reduce the proportion of coal in total energy consumption to less than 58% by 2020	CO_2 etc.	2016 -2020	Government	NEA, NDRC and other relevant departments	In Progress	The proportion of coal in total energy consumption decreased from 63.7% in 2015 to 62% in 2016	The effect of emission reduction is calculated through the replacement of coal with non-fossil energy and natural gas	The effect of emission reduction results from the replacement with such low carbon energy as non-fossil energy and natural gas (to avoid double counting)	Support from the central finance or the local finance
5	Developing hydropower	Increase the total installed capacity of hydropower to 380 MW and the annual power generation amount to 1.25 Tkwh by 2020	CO_2 etc.	2016 -2020	Compulsive/ Government	NEA, NDRC and other relevant departments	In Progress	In 2016, the installed capacity of hydroelectricity (incl. pumped-storage) was 332.07 GW and its power generation amount was 1,174.8 TWh	Emission reductions = (hydropower generation of the year – total power generation of the year × proportion of hydropower in 2015) × the 2015 electricity emission factor of 0.6101tCO_2/ MWh	Reduce CO_2 emissions by 4 million tons in 2016	Support from the central finance or the local finance

No.	Action Name	Objectives or Main Contents	Concerned Departments/ GHG	Time - horizon	Nature of Action	Supervision Departments	Status	Progress	Methodologies and Hypotheses	Estimated Emission Reduction Effects	Receive Support
6	Developing wind power	Increase the total wind power capacity in China to 30.83 GW by 2016; ensure that the total installed capacity of wind power connected to the grid is over 2,100 GW by 2020	CO_2 etc.	2016 -2020	Compulsive/ Government	NEA, NDRC and other relevant departments	In progress	In 2016, the installed capacity of wind power (grid connected) was 147.47 GW and its power generation amount was 240.9 Tkwh	Emission reductions = (wind power generation of the year – total power generation of the year × proportion of wind power in 2015) × the 2015 electricity emission factor of 0.6101tCO_2/ MWh	Reduce CO_2 emissions by 28 million tons in 2016.	CNREC established under the support of Sino-Danish Renewable Energy Development Programme (RED)
7	Developing solar power	Construct photo-voltaic power stations of 18.10 GW in 2016; Increase the installed capacity of solar power to over 1,100 GW with the installed capacity of photo-voltaic power generation being over 105 GW by 2020	CO_2 etc.	2016 -2020	Compulsive/ Government	NEA, NDRC and other relevant departments	In progress	In 2016, the installed capacity of solar power generation (grid connected) was 76.31 GW and its power generation amount was 66.5 TWh	Emission reduction=(current-year solar power generation – current-year total power generation× 2015 share of solar power)×electricity emission factor0.6101tCO_2/ MWh	Reduce CO_2 emissions by 15 million tons in 2016.	Support from the central finance or the local finance.

No.	Action Name	Objectives or Main Contents	Concerned Departments/ GHG	Time - horizon	Nature of Action	Supervision Departments	Status	Progress	Methodologies and Hypotheses	Estimated Emission Reduction Effects	Receive Support
8	Developing nuclear power	Increase the capacity of nuclear power facilities in operation or under construction to 88.00 GW by 2020	CO_2 etc.	2016 -2020	Government	NEA, NDRC and other relevant departments	In progress	In 2016, the installed capacity of nuclear power (grid connected) was 33.64 GW and its power generation amount was 213.2 TWh	Emission reductions =(nuclear power generation of the year - total power generation of the year × proportion of nuclear power in 2015) × the 2015 electricity emission factor of 0.6101tCO_2/ MWh	Reduce CO_2 emissions by 20 million tons in 2016	Support from the central finance or the local finance
Energy Conservation and Improving Energy Efficiency											
9	Nationwide energy conservation action	Reduce the energy consumption per unit of GDP by more than 3.4% from 2015 by 2016; Reduce the energy consumption per unit of GDP by 15% from 2015 by 2020	Various Departments/ CO_2	2016 -2020	Compulsive/ Government	NDRC and other relevant departments	Completed	The energy consumption per unit of GDP decreased by 5.0% in 2016 than that in 2015; In 2016, more than 200 Mtce were saved	Carbon emissions = energy conservation quantity × the 2014 overall energy consumption emission factor of 2.14tCO_2/ tce	Reduce CO_2 emissions by 490 million tons in 2016	Support from the central finance or the local finance
10	Energy management contracting (EMC) extension Project	Promote contract energy management, develop the energy conservation service industry, and the capacity for saving 80 million tons of standard coal in the period of the 13th FYP	Energy Conservation on Service/ CO_2 etc.	Since 2010	Government	NDRC and other relevant departments	In progress	Annual energy conservation of about 35.79 Mtce was achieved in 2016	/	The CO_2 emission reduction reached 95.90 Mt in 2016[1]	Support from the central finance or the local finance

[1] Data Source: *2016 Energy Conservation Service Industry Report* by ESCO Committee of EMAC. The emission reduction data were directly quoted from source calculation.

No.	Action Name	Objectives or Main Contents	Concerned Departments/ GHG	Time - horizon	Nature of Action	Supervision Departments	Status	Progress	Methodologies and Hypotheses	Estimated Emission Reduction Effects	Receive Support
11	Energy conservation in industry sector	Reduce the power consumption per unit of industrial value added by 18% over 2015 by the year 2020	Industry/ CO_2 etc.	2016 - 2020	Government	NDRC, MIIT and other relevant departments	In progress	2016 energy consumption per unit of industrial value added (above designated size) dropped by 190about 6.4% against 2015; an accumulated energy conservation of about 190 Mtce	Carbon emissions = energy conservation quantity × the 2014 overall energy consumption emission factor of 2.14tCO_2/ tce	Reduce CO_2 emissions by 410 million tons in 2016	Support from the central finance or the local finance

Part IV Finance, Technology and Capacity-Building Needs and Support Received

As a developing country, China always focuses on improving the quality of social and economic development and actively promoting ecological civilization construction and green and low-carbon transformation, and has made strenuous efforts to address climate change in the aspects of financial input, technology R&D and promotion, and capacity building. But the country still demands great supports in finance, technology and capacity building to comprehensively implement the strategic goals of addressing climate change and national determined contributions (NDCs), while the supports from developed country are very limited no matter in coverage, in strength or in scale. Therefore, it is necessary to strengthen subsequent actions for these aspects.

Chapter 1 Finance Needs and Support Received

1.1 Finance Needs for Addressing Climate Change

To effectively fulfill the liabilities under the Convention, and positively implement the target tasks of NAMAs and NDCs, China needs to further increase funding for climate change mitigation and adaptation under the support of developed countries.

1.1.1 China's Finance Needs for Climate Change Mitigation

According to the estimation of NCSC, from 2016 to 2030, China will cumulatively need to spend about 32 trillion yuan (at 2015 constant price) in achieving the goals and tasks of climate change mitigation, with an average annual cost of about 2.1 trillion yuan, in which the newly increased energy-saving investment demand will be approximate 13 trillion yuan, the low-carbon energy investment demand be 17.6 trillion yuan, and the forest carbon sink investment demand be 1.3 trillion yuan.

1.1.2 China's Finance Needs for Climate Change Adaptation

According to the estimation of NCSC, from 2016 to 2030, China will spend about 24 trillion yuan, averaged to 1.6 trillion yuan annually, to finish the goals of climate change adaptation in NDCs.

1.1.3 China's Total Finance Needs for Fulfilling Goals

Comprehensively, till 2030, China's total finance needs for fulfilling its goals will reach about 56 trillion yuan, averaged to 3.7 trillion yuan annually, which is equivalent to 6.3% of the national total fixed asset investment in 2016.At the same time, as more efforts will be made to address climate change and more risks of climate change will appear, the yearly average finance needs for addressing climate change will show a growing tendency.

1.2 International Climate Finance Received by China

1.2.1 Financial Support Received by China within the Financial Mechanism under the Convention

From the years of 2010-2016, China received 19 national climate change projects from Global Environment Facility (GEF) grant commitments that worth about USD 132 million, mainly covering such fields as energy efficiency improvement, low-carbon transportation, energy-efficient buildings, low-carbon city demonstration projects. See Table 4-1 for finance support.

Moreover, China has yet to receive any funding from Green Climate Fund (GCF).

Table 4-1 Financial Support Received by China within the Financial Mechanism under the Convention (10,000 dollars)

	Project Name	Finance Source	Project Amount	Sub-project Cycle
1	Joint demonstration project of fuel cell vehicles of China	GEF	823	2016-2020
2	Project on advancing transformation of semiconductor lighting market and promoting energy-saving and environment-friendly new light sources	GEF	624	2016-2020
3	Demonstration project on cooperation of green logistics platforms of Zhejiang	GEF	291	2016-2020
4	Promote the project to develop clean, green and low-carbon city of China through international cooperation	GEF	200	2016-2017
5	China efficient electric motors promotion project	GEF	350	2015-2020
6	Project on sustainable management of forest and improving adaptability of forest to climate change of China	GEF	715	2015-2021
7	Production of climate-intelligent staple food crops	GEF	510	2014-2019
8	Third national communication on climate change	GEF	728	2014-2018
9	China urban-scale building energy efficiency and renewable energy application	GEF	1200	2013-2018
10	Energy efficiency improvement project of industrial heating system and high energy consuming special equipment	GEF	538	2014-2018
11	Promotion project of energy conservation and emission reduction of Hebei	GEF	365	2013-2018
12	Jiangxi Ji'an sustainable urban transport project	GEF	255	2014-
13	Jiangxi Fuzhou urban integrated infrastructure improvement project	GEF	255	2013-
14	Renewable energy large-scale development program phase II	GEF	2728	2013-2018
15	Green energy schemes for low-carbon city in Shanghai	GEF	435	2013-2018
16	Project on easing urban traffic jam and reducing GHG emissions	GEF	1818	2013-2018
17	Research and pilot project on comprehensive traffic development strategies of city clusters of China	GEF	480	2011-2016
18	Energy efficiency improvement project of Chinese industrial enterprises	GEF	400	2011-2016
19	Technology need assessment on climate change	GEF	500	2012-2016
	Total		13,215	

Source: Ministry of Finance.

1.2.2 Financial Support from Multilateral Agencies

The Chinese government attaches much importance to the multilateral cooperation with Asian Development Bank (ADB) and European Investment Bank (EIB). Between 2010 and 2016, China reached agreements with the Asian Development Bank on 23 technical assistance projects, with a total amount of USD 18.15 million, and with the European Investment Bank on 1 technical assistance project, with a total contract amount of USD 8 million; There were total 24 projects amounting to USD 26.15 million. See Table 4-2 for finance support.

Table 4-2 Grants Received by China from Multilateral Institutions (10,000 dollars)

	Project Name	Finance source	Finance Amount	project Cycle
1	Strengthening capacity in the implementation of the green financing platform for the greater Beijing–Tianjin–Hebei region	ADB	50	2016-2018
2	Promoting partnerships for south-south cooperation	ADB	40	2015-2019
3	Developing cost-effective policies and investments to achieve climate and air quality goals in the Beijing–Tianjin–Hebei region	ADB	83	2016-2018
4	Shaanxi energy efficiency and environment improvement financing program	ADB	60	2015-2016
5	Research on sustainable and climate-resilient land management in the western regions in China	ADB	525	2015-2019
6	Developing innovative financing mechanism and incentive policies to promote demand-side management in the electricity sector	ADB	70	2015-2017
7	Strategic analysis and recommendations for achieving the 2020 low-carbon goal	ADB	95	2014-2016
8	Improving energy efficiency, emission control, and compliance management of the manufacturing industry in China	ADB	35	2014-2016
9	Qingdao smart low-carbon regional energy project	ADB	60	2014-2016
10	Strengthening capacity for promoting distributed renewable energy utilization in Hebei province	ADB	30	2014-2015
11	Low-carbon district heating modification project in Hohhot in Inner Mongolia autonomous region	ADB	60	2013-2016
12	Strengthening capacity for low-carbon development in Ningbo	ADB	50	2013-2015
13	Chemical industry energy efficiency and emission reduction project	ADB	70	2013-2016

	Project Name	Finance source	Finance Amount	project Cycle
14	Gansu Jinta concentrated solar power project	ADB	55	2013-2015
15	Strengthening capacity for implementing the new energy city program in Gansu province	ADB	75	2012-2015
16	Pilot on advancing Shanghai carbon market through emissions trading scheme	ADB	50	2012-2014
17	Promoting energy-efficient products by strengthening the energy efficiency labeling scheme	ADB	40	2012-2014
18	Program of energy system for strengthening low-carbon development of China	ADB	72	2012-2015
19	Pilot on developing Tianjin emission trading system	ADB	75	2012-2013
20	Heilongjiang energy efficient regional heating project	ADB	55	2011-2013
21	Shaanxi energy efficiency and environment improvement program	ADB	55	2011-2013
22	Tianjin promoting energy conservation	ADB	40	2010-2013
23	Qingdao renewable energy development	ADB	70	2010-2012
24	China partnership for market readiness project	PMR	800	2014-2018
	Total		2,615	

Source: Official website of WB, ADB and the Ministry of Finance. Considering double counting, the projects whose finance received from GEF but are executed by WB are not listed here.

In addition, from 2010 to 2016, 14 provinces (districts and cities) have received accumulative USD 4.08 billion concessional loans from WB and ADB, which were mainly used in the 43 projects in the fields of urban sustainable development, sustainable transportation system construction and clean energy supply. See Table 4-3 for support details.

Table 4-3 Concessional Loans Projects Received by China from Multilateral Institutions (million dollars)

	Project Name	Finance Source	Finance Amount	Project Cycle
1	Ningbo sustainable urbanization project	WB	150	2016-2021
2	Hebei air pollution control project	WB	500	2016-2018
3	Huaxia bank air pollution control project	WB	500	2016-2022
4	Hebei clean heating demo project	WB	100	2016-2021
5	Hebei rural new energy development project	WB	72	2015-2020

	Project Name	Finance Source	Finance Amount	Project Cycle
6	China climate smart staple crop production	WB	25	2014-2020
7	Shanghai energy conservation of buildings and low-carbon district construction demonstration project	WB	100	2013-2018
8	Liaoning urban infrastructure and environmental governance project in the coastal economic belt	WB	150	2013-2018
9	China energy efficiency financing project	WB	100	2011-
10	Beijing-Tianjin-Hebei emission governance policy reforms program	ADB	300	2015-2017
11	Jiangxi Ji'an sustainable urban transport project	ADB	120	2015-2020
12	Low-Carbon district heating modification project in Hohhot in Inner Mongolia autonomous region	ADB	150	2015-2020
13	Xinjiang Akesu integrated urban development and environment improvement project	ADB	150	2016-2021
14	Anhui intermodal sustainable transport project	ADB	100	2014-2021
15	Qinghai Delhi concentrated solar thermal power project	ADB	150	2014-2019
16	Hubei Yichang sustainable urban transport project	ADB	150	2014-2018
17	Heilongjiang energy saving demo district heating project	ADB	150	2013-2018
18	Hebei energy efficiency improvement and emission reduction project	ADB	100	2014-2018
19	Jiangxi sustainable forest ecological system project	ADB	40	2011-2017
20	Henan Xinyang wind power project	EIB	64	2009-2010
21	Hainan Dongfang wind power project	EIB	27	2009-2010
22	Guangdong Zhanjiang Dengloujiao wind power project	EIB	27	2009-2010
23	Guangdong Zhanjiang Yongshi wind power project	EIB	27	2009-2010
24	Inner Mongolia Carbon Sink Forest Demonstration Project	EIB	27	2011-2015
25	Jiangxi Biomass Energy Forest Demonstration Project	EIB	27	2009-2013
26	Sichuan post-earthquake restoration and reconstruction project	EIB	85	2009-2013
27	Shandong Jinan comprehensive energy conservation transformation project for cogeneration	EIB	33	2015-2017
28	Hubei Yichang small hydropower development project	EIB	28	2009-2012
29	Energy conservation and emission reduction project of China Aohua Chemical Group	EIB	71	2010-2013
30	Liaoning forestry project	EIB	32	2014-2017
31	Hunan Camellia Oleifera Abel development project	EIB	37	2015-2019
32	Heilongjiang Harbin energy conservation transformation project of existing buildings	EIB	53	2013-2015

	Project Name	Finance Source	Finance Amount	Project Cycle
33	Xinjiang Urumuqi energy conservation transformation project of existing public buildings	EIB	43	2015-2018
34	Chongqing forestry development project	EIB	32	2015-2019
35	Regional forestry project (national forestry and grassland administration bundling rare tree species)	EIB	107	2015-2019
36	Shandong coastal protection forest building project	EIB	35	2015-2019
37	Shanxi ecological restoration and forestry project along the yellow river	EIB	27	2015-2019
38	Fujian forestry project	EIB	32	2016-2020
39	Henan Gushi biomass cogeneration project	EIB	32	2014-2017
40	Shandong Weifang heating and cooling energy conservation and emission reduction renovation project	EIB	41	2015-2017
41	Guizhou Qiandongnan sustainable management of forest	EIB	27	2016-2020
42	Jiangxi forest quality improvement demonstration project in Poyang Lake Basin	EIB	27	2016-2020
43	Heilongjiang sustainable cultivation project of special northern trees	EIB	27	2016-2020
Total			4,075	

Source: Official website of Ministry of Finance and ADB. The amount has been uniformly converted into US dollars at the exchange rate of 2015. In that year, the exchange rate of US dollars to euro was 0.937.

1.2.3 Financial Supports through Bilateral Channels

China also seeks to conduct pragmatic cooperation with contracting parties in Annex 2 of the Convention in the fields of climate change and green and low-carbon development. The country has carried out many fruitful cooperation projects with EU, France, Germany, Italy, Norway, Denmark, Switzerland, etc. in the fields of carbon market, energy efficiency, low-carbon city and adaptation to climate change, with the contract amount totaling to USD 997 million, as shown in Table 4-4.

Table 4-4 Supports Secured by China from Bilateral Cooperation Programs for Addressing Climate Change (10,000 dollars)

	Project Name	Finance Source	Finance Amount	Project Cycle
1	Sino-Swiss low carbon cities project	Switzerland	693	2015-2019
2	EU-China emission trading capacity building project	European Union	534	2014-2017
3	Europe-China eco-cities link (EC-LINK) project	European Union	999	2014-2017
4	Chongqing & Guangdong low-carbon product certification project	European Union/ UNDP	96	2013-2014
5	Sino-Italian capacity building for addressing climate change	Italy	299	2012-2017
6	Research on the application of china's national strategy for climate change adaptation in the 12th FYP Period	Norway	10	2010-2016
7	Sino-Norwegian biodiversity and climate change project	Norway	232	2011-2014
8	Sino-Danish renewable energy development (RED) project	Denmark	1,430	2009-2013
9	Shanxi Jinzhong centralized heating	France	2,988	2010-
10	Shanxi Taiyuan centralized heating	France	4,269	2010-
11	Hubei Wuhan energy conservation of public buildings	France	2,134	2010-
12	Hubei Xiangyang small hydropower	France	2,241	2010-
13	Shandong Jinan centralized heating	France	4,269	2012-
14	Hunan sustainable operation of forestry	France	3,266	2013-
15	Heilongjiang Yichun cogeneration	France	3,735	2014-
16	Shandong Qingdao national high-tech industrial development zone CCHP	France	2,134	2016-
17	Shandong Zibo central district heating	France	2,732	2016-
18	Sino-German cooperation project: key stakeholder capacity building for China's building energy efficiency	Germany	208	2013-2016
19	Sino-German public building energy conservation project	Germany	320	2011-2015
20	Building energy conservation and climate protection: energy-consumption baseline research for existing residential buildings in north China	Germany	213	2010-2013
21	Qingdao Kai Yuan Group Xujiadongshan centralized heating	Germany	3,821	2011-
22	Sichuan sustainable operation of forestry	Germany	1,067	2011-
23	Jilin Tonghua energy conservation renovation of existing building	Germany	3,882	2012-
24	Hebei Tangshan energy conservation renovation of existing residential buildings in government-subsidized housing project	Germany	2,455	2012-

	Project Name	Finance Source	Finance Amount	Project Cycle
25	Gansu Tainshui east district centralized heating	Germany	1,654	2012-
26	Gansu Wuwei urban heating	Germany	7,150	2013-
27	Centralized heating in Qiaokao and Sanhe Village heat source plant area by Hohhot Chengfa Investment & Management Co., Ltd.	Germany	3,735	2013-
28	Gansu Linxia centralized heating in urban area	Germany	4,269	2014-
29	Centralized heating in Pingyao County and Qixian County, Shanxi	Germany	38,815	2014-
	Total		99,650	

Source: The data of financial supports from bilateral channels are from the First Biennial Update Report on Climate Change of the People's Republic of China. Some projects whose details and amount of aid unavailable are not listed in this table. The financial supports from EU, Norway, Denmark and Switzerland were respectively paid in euro, Norwegian krone, Danish krone and Swiss franc. The amount has been uniformly converted into US dollars at the exchange rate of 2015. In that year, the exchange rate of US dollars to euro was 0.937, to Norwegian krone was 8.392, to Danish krone was 6.991, and to Swiss franc was 1.001.

1.2.4 Current Problems and Challenges

Firstly, the financial supports from developed countries are not enough to close the finance gap of China to address climate change. From 2016 to 2030, besides the inputs of domestic public and private sectors, China will additionally need an average of 1.3 trillion yuan annually. Since 2010, China has only received about USD 5.2 billion grants and concessional loans based on the finance mechanism of the Convention and the multilateral and bilateral channels, which are not sufficient to meet the growing finance need in addressing climate change. Developed countries should further expand finance scale to provide financial support for China to address climate change.

Secondly, the received international financial supports are mainly for climate change mitigation, but less for climate change adaptation. Of the finance received by China no matter through the finance mechanism of the Convention, or the multilateral or bilateral channels, most were used to mitigate climate change. Only a few projects for adapting to climate change were given with small-scale financial support. With great pressure on adapting to climate change,

China has an increasing needs on financial support, but it cannot obtain sufficient financial support to meet the actual adaptation requirements. So it is increasingly urgent for China to obtain the financial support for climate change adaptation.

Chapter 2 Technology Needs and Support Received

2.1 Technology Needs for Addressing Climate Change

Based on the technology needs set forth in the Second National Communication, research institutions including Tsinghua University updated technology needs for China's responding to climate change, based on China Climate Technology Needs Assessment Project implemented by the World Bank and in reference to relevant recent strategic and action plans of China on climate change related technologies.

2.1.1 Technology Needs for Climate Change Mitigation

China has made some progress in mitigation technologies, but the marginal cost for emission reduction is still high. With coal being a major source of energy, China is unlikely to make fundamental changes in its pattern of consumption in the long term. The high-parameter & large capacity ultra-supercritical power generation technology, and the combined gas and steam cycle power generation technology are critical mitigation technologies for China at present. Besides, to develop nuclear power in an efficient, reasonable and safe manner, to strengthen the capability for developing and manufacturing nuclear power equipment, and to accelerate the research of shale gas technologies and the development of renewable resources, are of great strategic importance for optimizing energy resource structure, improving energy efficiency, promoting energy conservation & emission reduction, and socio-economic development. Therefore, China is in urgent need of such technologies as advanced nuclear power technology, technology for fracturing and horizontal well exploitation of shale gas, double reheat power generation technology, offshore wind power technology, and thin-film photovoltaic battery technology. Besides, the iron and steel industry, the transportation industry, the construction material industry, and the chemical industry are all important basic industries. Their reduction in energy consumption is vital to China's low carbon development. The key core technologies in the fields

of electric vehicles and aircraft engines, the optimization technologies regarding freight vehicles modes, the energy consumption monitoring and statistical analysis technologies, the smelting recovery iron making technology, and, the intelligent optimization and control system for cement kiln, the technology for the production of methanol with high CO_2-content natural gas, and the CO_2 emission free pulverized coal pressure conveying technology are technologies with high priority as needed by China. See Table 4-5 for the detail list.

Table 4-5 List for Prioritized Mitigation Technology Needs

Sectors/ Industries	Technology type	**Core technology and description**
Energy	1,000 MW high-parameter & large-capacity ultra super critical power generation technology	Design and manufacturing of associated boilers and steam turbines: the main technical equipment includes high-parameter and large-capacity ultra super critical boilers and steam turbines. Boilers can provide high-efficiency working substance with steam pressure higher than 30 MPa and temperature higher than 620 ℃.
	Combined gas and steam cycle power generation technology (150 MW level)	Key components including high-temperature components, controlling systems and rotors: the power generation system adopts lower heating value (LHV) gas in a combined cycle power plant (CCPP), such byproduct gases as those from blast furnaces of iron and steel enterprises are transferred through the iron and steel energy pipe network, purified with a dust collector, pressurized, and mixed with the air that is purified with air filter and pressurized, before entering into the combustion chamber of the gas turbine for mixed combustion; high temperature & high pressure flue gas expands and works in the gas turbine, drives the air compressor and the generator for single-cycle power generation.
	Shale gas development technology	Equipment and technology in shale gas development: CO_2-ESGR technology refers to the injection of CO_2, which features great flowing through shale reservoir pores and better absorption into shale matrix, into the shale reservoir to expel and replace shale gas. The technology not only improves shale gas yield and daily production, but stores CO_2 in the reservoir.
	Nuclear power generation technology	By research and development of the large forgings for key nuclear power equipment and key parts, such key technology for the melting, forging, machining and bending of large stainless steel forgings are to be grasped.
	Steam turbine systems retrofit	Advanced steam turbine design (including blade profile and stage number) is employed to improve the structure of the steam turbine, the tightness of its cylinders and its efficiency.
Renewable energy	Offshore wind power technology	Direct drive electric machines, flexible gearboxes for doubly-fed electric machines, offshore wind turbine foundation, technology for the design and laying of submarine cable, and technology for the protection of wind turbines against typhoon: at the same height, the speed of wind is usually 25% higher than that on the road 10 kilometers offshore. As offshore wind has a low turbulence intensity and a stable prevailing direction, the unit carries low fatigue load, and will have a longer life; as the wind shear is less, the tower can be set lower. In addition, an offshore wind power is normally close to the load center since most coastal areas in China are developed regions.
	Thin-film photovoltaic battery technology	Thin-film battery uses TCO glass substrates, and thin-film battery industrialization making techniques with efficiency higher than 10% (sputtering technology): the battery uses a little silicon thus to reduce more costs; besides the product is energy efficient one, and new-type building material, which can be better integrated with a building. The thin-film battery has another unique advantage, namely little power loss by the negative influence of shade.
Iron and steel industry	Smelting restoration technology for iron making (including corex and finex)	COREX C-3000 core technologies: improvement of furnace structure, operation of shaft furnace, adjustment in gas distribution, improvement and repair of equipment, prolonging of the life of COREX, and optimization of furnace operation. FINEX's core technologies: (1) craft of fluidized bed reduction of iron ore; (2) craft of placing partially reduced briquette iron into a melting gasifier; (3) approach to add coal; (4) equipment to remove CO_2 from coal gas. The FINEX process is a major improvement and continuous technological innovation for the COREX process. In particular, the development and application of the pulverized coal utilization technology and the export gas utilization technology significantly enhance the technological competitiveness of the process. As for the current COREX process, the problem in the design of large shaft furnaces and the problem in the smooth running for the connection between the shaft furnace and the gasifier have to be addressed,

Sectors/ Industries	Technology type	Core technology and description
		major improvement and innovation have to be made in expansion of coal resources, utilization of pulverized coal, quality of the fuel for the furnace, optimization of fuel composition, and effective utilization of export gas, and the costs of crude fuel and molten iron have to be significantly reduced before the competitiveness of this process can be enhanced.
Construction material industry	Intelligent optimization and control system for cement furnace	Pre-treatment thermal equipment before household refuse enters the kiln: such advanced algorithms as fuzzy logic, neural network and genetic optimization are adopted to establish the models related to the calcination in the cement kiln; in light of the features of crude fuel and production conditions, the production and control parameters are adjusted in an intelligent manner to stabilize production conditions and reduce heat consumption by calcination.
Transportation industry	Electric vehicles	Battery grouping technology: The electric vehicle is a vehicle adopting on-board battery as the power output, driving wheels with motor, and complying with the requirements in the regulations on road traffic safety and national standards.
	Aircraft engine	Aircraft engine energy-conservation renovation: by retrofitting of aircraft engines for energy conservation, the lives of engines can be significantly prolonged, aircraft maintenance costs and fuel oil consumption can be significantly reduced.
	Freight transportation organization model optimization technology	Information-based technology that combines GPRS, GPS and vehicle-mounted terminals for real-time dispatching, monitoring and management of vehicles and goods collection, loading, unified distribution, etc., and based on vehicle features, supply of goods and operation lines, to make scientific use of efficient transportation organization modes such as drop and pull transportation and optimize transportation model, so as to improve the actual load rate and operation efficiency of freight vehicles.
	Road transportation enterprise energy consumption monitoring and statistical analysis technology	It mainly uses vehicle-mounted terminals to collect motor running data, vehicle information, driver's behavior and GPS positioning information and transmit such information to the data processing center in real time. The data processing center conducts real-time analysis and sorting of the mass data it has received and provides detailed and real quantized data to such links as corporate operation management, driver management, vehicle oil consumption quota setting and vehicle matching.
Residential building and commercial building	External insulating intumescent fire-retardant paint for foam material and cellulose material	Expanded polystyrene (EPS) modified with graphite: EPS modified with graphite, invented by BASF, a German chemical enterprise, is the raw material for graphite EPS boards. There are two production processes: suspension polymerization and extrusion polymerization. Due to the addition of infrared absorbent, EPS modified with graphite can better absorb and reflect thermal radiation, thereby greatly improving the thermal insulation performance of material.
	Self-expanding seal tape for energy-efficient windows	Self-expanding seal tape for energy-efficient windows: the tape is used for sealing the seams between doors, windows and walls, the external thermal insulation systems for window boards and outer walls, and those between penetrating members and insulation layers. It features protection against wind and water, as well as gas tightness and acoustic insulation.
	Heat and moisture exchange membrane for heat recovery from fresh air and exhaust air	Heat and moisture exchange membrane for heat recovery from fresh air and exhaust air: the material with such technology can realize high-efficiency (more than 75%) heat and moisture exchange between the air flows at two sides; and the air flows will not mix or pollute with each other, and the material features bacteriostasis and antibiosis. The material may be used in the heat recovery for the ventilation with the outside in the air conditioning system of residential buildings or commercial buildings, to recover the heat and moisture in exhaust air, preheat and humidify fresh air (winter), or precool and dehumidify fresh air (summer), reduce the load of the air conditioning system, and improve its energy efficiency.
Waste disposal industry	Combined gas-steam cycle for incineration plants and power plants (waste-to-energy and gas turbine, WtE-GT).	Internal combustion engine, steam turbine and micro turbines: the waste incineration power plant and the natural gas power plant are combined for operation (WtE-GT); the tail gas exhausted by the gas turbine is used to further increase the temperature of the steam from the waste incineration heat recovery steam generator (HRSG), and thus to improve the thermal efficiency of the waste incineration plant.
	Reheat cycle system	Reheat cycle system: in a waste incineration power plant, the boiler superheater heats saturated steam into superheated steam, which enters the high-pressure casing of the steam turbine through the superheated steam outlet for working; the vent from the high-pressure casing enters the boiler again through pipes, and gets heated by the reheater in the boiler to improve its temperature and enthalpy; the reheated steam enters the low-pressure casing for working again through the reheater outlet pipe; after working, the vent from the LP casing enters the condenser to form condensate, which is pumped into the boiler by the feed pump.
Chemical industry	Production technology of methanol with high co_2 content natural gas	Top-fired reformer; water-cooled shell-and-tube methanol reactor system: the natural gas with high content of CO_2 and N_2 is adopted as raw material, with CO_2 and N_2 being more than 20%, and CH_4 less than 60%. The most typical and proprietary water-cooled shell-and-tube methanol reactor system of LURGI is adopted, and it is a reactor with the highest heat recovery efficiency, the evenest distribution of bed temperatures, the least

Sectors/ Industries	Technology type	Core technology and description
		byproducts, simplest loading and unloading of catalyst, operation and control, and the largest unit production capacity among the reactors of the same type.
	CO_2-free pulverized coal pressure conveying technology	High-pressure dynamic sealing technology, sealing material and high-density conveying technology: the traditional pulverized coal pressure conveying technology and system adopt pressure and pneumatic conveying with lock hopper. This process consumes and discharge large amount of CO_2, and has such disadvantages as high energy consumption, slow speed, and excessive equipment dimension, while the new-type pulverized coal pressure conveying system can avoid CO_2 emission.

2.1.2 Technology Needs for Climate Change Adaptation

China's needs for adaptation technologies bear some similarity to those of other developing countries. Among other things, China has the most technology needs in the field of agriculture, which currently need such adaptation technologies as agricultural water-saving technology, selection and breeding of stress-resistant agricultural varieties, and agronomic water conservation technology. While disaster warnings favor high-and-new technologies like assessment technologies for integrated impacts of climate and climate change, and meteorological data reanalysis technology, technologies applied in the water resource industry mainly adopt such modern technologies as the solar photovoltaic water-saving irrigation technology. As for urban planning and infrastructure developing, adjustment technologies like sponge city plan and practical technology, urban green space layout and optimization technology, rooftop greening technology, and permeable pavement application technology to improve the city's capacity in climate change adaptation. See Table 4-6 for the detail list.

2.2 Technical Support Received by China

China has conducted a number of capacity building activities related to the development and transfer of technology addressing climate change by international cooperation; however, on the whole, these activities focus on the research of the feasibility of advanced technology, capacity building or incentive policies, and there are few projects on the actual transfer of the technologies needed. Developing countries including China are in urgent need of technology transfer and support under the Convention, while face obstacles created by the domestic policies and technological embargoes of developed countries. China has conducted many rounds of technology needs assessment, but has not obtained enough actual support under the convention.

Table 4-6 Demand List for Prioritized Adaptation Technologies Needs

Industries	Sub-industry	Core technology and description
Agricultural forest and ecological environment	Agricultural water-saving technology	Degradable mulch production technology: degradable moisture conservation materials include photo degradable and biodegradable mulch. Degradable mulch is mainly used to raise the ground temperature, store water and conserve moisture, reduce the evaporation of soil water, improve the physico-chemical properties of soil, suppress weeds and increase plant photosynthetic efficiency, thus improving the survival rate of afforestation and promoting the growth of saplings.
	Selection and breeding of stress-resistant agricultural varieties	Technologies including insect-resistant cotton, illness-resistant rice, scab-resistant wheat and drought-resistant wheat and corns: These technologies are about designing and building new varieties with specific traits by virtue of identified genes. For example, the toxin genes of resisting helicoverpaarmigera can be implanted into the genome of cotton seeds to produce cotton with insect resistance. Peasants can apply less pesticide or none while planting the variety of cotton, which not only protects the environment but also increase peasants' income.
	Forestry ecosystem	Develop climate-adaptive measures on forest management by applying landscape disturbance model LANDIS-II, and set different adaptive forest management plans for forest felling and fell application: (1) Scale control measure. Form gaps in different spatial position and scales by felling, with the purpose of diversifying the stand age structure and species and improving the forest's resistance to climate change. (2) Stand Age Control Measure. Fell the mature stands to boost and accelerate their update on the progress towards climax, so as to improve the forest's resistance to influences brought by climate change. (3) Composition Control Measure. Decide whether a variety is felled or retained based on its response to climate change and the simulated result of management value. (4) Forest management technologies considering both forest products and service supply ability: Apply the process-based forest model LandClim to analyze the forest dynamic and its goods and services function under different climate change and management scenarios, the intrinsic connection between wood production and forest diversification as well as the most valuable capability for goods and services.
	Water source engineering construction	Solar photovoltaic water lifting, irrigation and water saving technology: photovoltaic water lifting is about converting the polar radiant energy into electric energy which drives water pump for irrigation. Solar photovoltaic water lifting system is comprised of photocell, controller and solar photovoltaic water pump.
Urban adaptation	Develop and perfect infrastructure facility	(1) Sponge city plan and practical technology: prepare a whole-process plan to realize a sound urban water circulation with several technological methods including "seepage, retention, storage, purification, utilization and drainage" and improve the urban capabilities for run-off rainwater seepage, regulation, storage, purification, utilization and drainage. China still far lags behind foreign countries in sponge city whole-process planning method and specific LID project design. (2) Key technology for long-range high-lift mass-flow water diversion works: replace the domestic traditional multistage lifting way with one-stage pump station, so as to reduce energy consumption and construction investment, of which high-lift mass-flow pump is the key preparation. (3) Roof greening technology: apply such technologies as roof plants configuration and plant roots penetration avoidance to improve plants' resistance to wind, enhance the roof load, insulate and preserve heat for buildings and mitigate surface runoff. (4) Permeable road surface application technology: pave permeable materials such as permeable asphalt, permeable concrete, porous turf and open joint blocks on the road surface to improve the infiltration of surface runoff. Meanwhile, regular road surface maintenance should also be configured to keep its effective drainage.
	Urban planning	Urban green space layout and optimization technology: it is about forming an effective urban ventilation corridor by establishing a basic database, simulating on software digital platform, deducing and generating an optimized measure, and implementing the microclimate measure into urban green space of different levels and scales.
Disaster warning and weather monitoring	Impact assessment and adaptation	Assessment technologies for integrated impacts of climate and climate change: to study the interaction of climate change's natural and biological process with human activities, the major interdisciplinary coordination involved, in particular the relationship between nature, society and economy, as well as the feedback on Integrated Assessment Model (IAM) for climate change.
	Data analysis	Meteorological data reanalysis technology (including global and regional products for atmosphere reanalysis): utilize the numerical weather forecast data assimilation system to carry out various model experiments and diagnostic analysis in the context of past weather development digitalization and compare different simulation tools, so as to help people learn how atmosphere moves, the climate change and its rate of change in different spatial and temporal scales.

Chapter 3 Capacity Building Needs

3.1 Capacity Building Needs for Addressing Climate Change

3.1.1 Capacity Building Needs for Climate Change Mitigation

Preparation of greenhouse gas inventories, and strengthening of the capability for the statistical work and MRV of GHG emissions is fundamental work to address climate change, and there are great needs for capacity building in these fields. First, China has not a perfect institutionalized system for the preparation of greenhouse gas inventories, and the work on the preparation of National GHG Inventories is still conducted on a project basis; if a complete, stable and efficient inventory preparation mechanism is to be established, China faces capacity building challenges in finance, personnel and intergovernmental coordination. Second, China has a bewildering variety of GHG emission sources and sinks, shows a dramatic difference in emissions between regions or industries, and the capacity building needs for the preparation of local greenhouse gas inventories; localized research on emission factors are to be strengthened to reduce the uncertainty in local activity data and calculation of emission factors. Third, China needs to improve the technology level and competence of the inventory compilers from statistics departments, enterprises and local institutes by cooperation, exchange, and personnel training.

The local governments in China have carried out much exploration in the pilot programs for addressing climate change and pursuing low carbon development, but there are still greater needs for capacity building compared with the provinces, states and regions of developed countries. Chinese local governments need support to improve the systematic design and strategic planning capacity and further enhance its technological support for low-carbon development, better the policy system for low-carbon development sector, accelerate local legislative progress, and improve professional training in order to improve technological R&D capacity for low-carbon development.

China needs a lot in capacity building for market mechanism and for promoting enterprises' participation in emission reduction. Although China initiated the

national carbon emission trading system in 2017, China needs to continue its exploration for establishing carbon emission trading rules that suit its national circumstances and development requirements, and cover such major industrial sectors as iron and steel, electric power, chemistry, construction material, paper-making and non-ferrous metal, enhance its capacity building for data reporting and submission, registration, establishment of detailed rules on trading, and perfecting of trading rules, and improve the capability of technical personnel that work in local authorities, major emitting enterprises and units, or third party audit institutions, and participating in the development of the carbon market.

3.1.2 Capacity Building Needs for Climate Change Adaptation

To reduce the impact of climate change and increase the capacity for adapting to climate change, China has great capacity building needs for climate change adaptation. First, China needs to increase its capacity for the construction, operation, scheduling, maintenance and repair of infrastructure, and the capacity for adapting to climate change in the fields that are vulnerable to climate change, such as agriculture, water resources, ecosystem, cities, human health, and major projects. Second, China needs to increase its capacity for the comprehensive monitoring and early warning of climatic disasters, forecasting, and service, strengthen the scientific research, observation and impact assessment of climate change, enhance the capacity building for addressing extreme weather and climate event, and reduce the disaster risk of extreme events. China needs to develop climate change adaptation projects through international cooperation and exchange, improve the capacity for interdisciplinary integrated research in key industries or fields that are subject to the influence of climate change, such as water-saving irrigation, water conservation irrigation, water resources allocation, and integrated coastal zone management and conservation.

3.1.3 Capacity Building Needs for Education and Training in Addressing Climate Change, and Raising of Public Awareness

China should improve its education, publicity and training related to response to climate change, and enhance public awareness and participation, which is a demand from transformation of traditional production and consumption mode, and also a requirement for fulfillment of the Convention. First, China has great capacity building needs for education and training in respect of addressing climate change, and raising of public awareness; China needs to further create an atmosphere favoring enterprises' participation and the public's voluntary actions

as guided by the government, raise enterprises' consciousness of social responsibility, improve public awareness and increase public participation capacity. Second, China needs to continue to develop and improve its approaches for education and training in respect of addressing climate change, and raising of public awareness, open more channels for public participation and strive to raise the public awareness for addressing climate change. Third, China needs to increase the participation by experts and scientific research institutions, carry out international cooperation to provide education and training to government officials, enterprise management personnel, media practitioners, and relevant professional personnel in respect of addressing climate change, improve their awareness and capacity, promote objective and continuous media coverage, raise the public's awareness of global climate change and their initiative in taking corresponding actions.

3.2 Capacity Building Support Received by China

The capacity building support received by China through the finance mechanism under the Convention includes the project for the preparation of China's Third National Communication on Climate Change and biennial update report, and upgrading of small hydroelectricity projects in China; the capacity building support received from multilateral institutions includes such projects as China: Partnership for Market Readiness Project, China's Technology Need Assessment, Strengthening Capacity in the Implementation of the Green Financing Platform for the Greater Beijing–Tianjin–Hebei Region, and Strengthening Capacity for Low-Carbon Development in Ningbo; the support received by China from bilateral cooperation program for addressing climate change includes such projects as EU-China Carbon Emission Trading Capacity Building Project, Sino-Italian Capacity Building for Environmental Protection and Climate Change, and Sino-German Cooperation Project on Capacity Building for Key Actors in the Building Energy Efficiency Sector (KABEE). The capacity building support received by China is still limited, and cannot meet the demand from the implementation of increasingly more policies and actions.

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

Hong Kong is a special administrative region of the People's Republic of China. It is a vibrant city with mild climate, limited natural resources, high population density and highly-developed service industry. It is also an eminent international financial, trading and shipping hub.

Chapter 1 Hong Kong's GHG Inventory in 2014

In the process of compiling Hong Kong's GHG inventory, references had been made to *Revised 1996 IPCC Guidelines*, *IPCC Good Practice Guidance* and *2006 IPCC Guidelines*. The reporting year was 2014, and the scopes covered areas including energy, industrial processes, agriculture, land-use change and forestry as well as waste. The reported GHGs cover carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride.

1.1 Overview

In 2014, Hong Kong's net total GHG emissions (including land-use change and forestry), amounted to about 44.547 Mt CO_2 eq, amongst which the carbon sink from land-use change and forestry accounted for about 0.452 Mt CO_2 eq. When excluding land-use change and forestry, Hong Kong's total GHG emissions in 2014 stood at about 44.999 Mt CO_2 eq, amongst which carbon dioxide accounted for about 41.162 Mt CO_2 eq; methane about 2.376 Mt CO_2 eq; nitrous oxide about 0.368 Mt CO_2 eq; hydrofluorocarbons about 1.022 Mt CO_2 eq; and sulfur hexafluoride about 0.07 Mt CO_2 eq (Table 5-1). Table 5-2 sets out the emissions inventory of carbon dioxide, methane and nitrous oxide in 2014 by sources. Table 5-3 sets out the major sources and inventory of fluorinated gas emissions in 2014.

Table 5-1 Hong Kong's GHG Emissions in 2014 (**kt CO_2 eq)**

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Energy	40,597	40	157				40,794
Industrial processes	549	NE	NE	1,022	0	70	1,641
Agriculture		12	18				31
Waste	15	2,325	194				2,534
LUCF	-452	NE	NE				-452
Total (without LUCF)	41,162	2,376	368	1,022	0	70	44,999
Total (with LUCF)	40,709	2,376	368	1,022	0	70	44,547

Note:1. Shaded cells do not require entries.
2. Due to rounding, a slight discrepancy may exist between table breakdowns and the total figure.
3. NE (Not Estimated) indicates that existing emissions and removals have not been estimated.

Energy activities are the primary source of GHG emissions in Hong Kong. In 2014, GHG emissions from energy accounted for 90.65% of the total GHG emissions, while GHG emissions from waste, industrial processes and agriculture accounted for 5.63%, 3.65% and 0.07% of the total emissions respectively. Figure 5-1 illustrates Hong Kong's GHG emissions by sources.

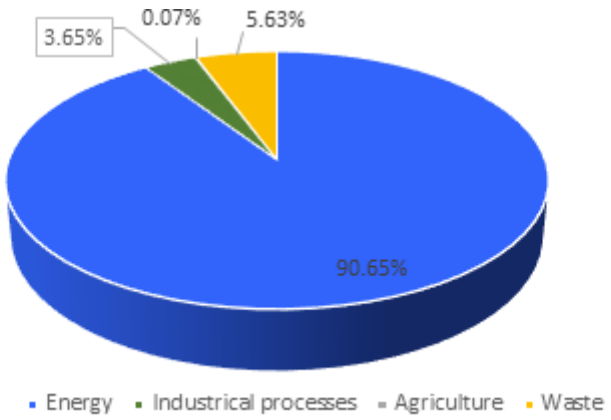

Figure 5-1 Hong Kong's GHG emissions by sources in 2014

The GHG emissions in Hong Kong are primarily carbon dioxide. In 2014, carbon dioxide accounted for 91.47% of the total emissions, while methane, fluorinated gases and nitrous oxide accounted for 5.28%, 2.43% and 0.82% of the total emissions respectively (See Figure 5-2).

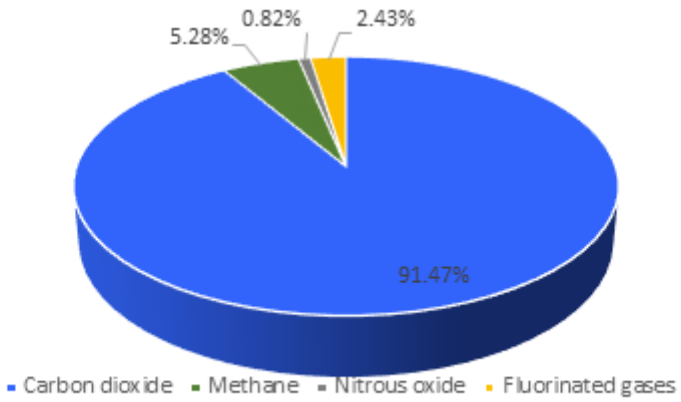

Figure 5-2 Hong Kong's GHG emissions by gas in 2014

In 2014, the GHG emissions from special regional routes and international bunker fuel amounted to 39.474 Mt CO_2 eq, which included 11.139 Mt CO_2 eq from special regional marine and aviation emissions, and 28.336 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 emissions.

Table 5-2 Hong Kong's emissions of carbon dioxide, methane and nitrous oxide in 2014(kt)

GHG sources and sink categories	CO_2	CH_4	N_2O
Total(w/o LUCF)	41,161.7	113.1	1.2
Total(w/ LUCF)	40,709.4	113.1	1.2
1. Energy	40,597.3	1.9	0.5
—Fuel combustion	40,597.3	0.7	0.5
♦Energy industries	31,094.6	0.6	0.4
♦Manufacturing industries and construction	673.9	0.0	0.0
♦Transport	7,306.5	0.0	0.1
♦Other sectors	1,522.2	0.0	0.0
—Fugitive emission		1.2	
♦Oil and natural gas system		1.2	
♦Coal mining		NO	
2. Industrial processes	549.0	NE	NE
3. Agriculture		0.6	0.1
—Enteric fermentation		0.2	

—Manure management		0.4	0.0
—Rice cultivation		NO	
—Agricultural soils		NO	NO
—Prescribed burning of savannas		0.0	0.0
4. Land-use change and forestry	-452.2	NE	NE
—Changes in forest and other woody biomass stocks	-452.2		
—Forest conversion	NE	NE	NE
5. Waste	15.4	110.7	0.6
—Solid waste disposal on land	15.4	105.8	NO
—Wastewater handling		4.8	0.6
Memo Items			
—Special regional aviation	1,853.4	0.1	0.1
—Special regional marine	9,173.3	0.8	0.2
—International aviation	13,102.4	0.1	0.4
—International marine	14,953.8	1.4	0.4

Note: 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 totals. 0.0 indicates calculation results that are negligible;
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 the Mainland China.

1.2 Energy

1.2.1 Scope

The inventory for energy mainly covers fuel combustion and fugitive emission. Fuel combustion refers to emissions of carbon dioxide, methane and nitrous oxide from fossil fuel burning in energy industry, manufacturing industry, construction industry, transportation sector and other sectors, while fugitive emission refers to fugitive methane emissions of oil and gas systems.

1.2.2 Methodologies

The estimation of emissions from energy activities is mainly based on *2006 IPCC Guidelines*. Tier 3 method was adopted to estimate emissions of carbon dioxide, methane and nitrous oxide in thermal power generation. Tier 2 method was

adopted to estimate carbon dioxide emissions while Tier 1 method was adopted to estimate methane and nitrous oxide emissions in towngas production. Tier 2 method was adopted to estimate carbon dioxide emissions while Tier 1 method was adopted to estimate methane and nitrous oxide emissions in utilizing landfill gas for energy purpose. As for the manufacturing and construction industries and other sectors, Tier 2 method was adopted to calculate carbon dioxide emissions while Tier 1 method was adopted to calculate methane and nitrous oxide emissions.

Table 5-3 Emissions of Fluorinated Gas in Hong Kong in 2014 (kt CO_2 eq)

GHG source and sink categories	**HFCs**					**PFCs**		**SF_6**	**Total**
	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-227ea	CF_4	C_2F_6		
Total	5.3	30.7	920.0	10.0	55.9	0.0	0.0	70.2	1,092.1
Energy									
Industrial processes	5.3	30.7	920.0	10.0	55.9	0.0	0.0	70.2	1,092.1
—Mineral products									
—Chemical industry									
—Metal production						NO	NO		
—Production of halocarbons and SF_6	NO	NO	NO	NO	NO	NO	NO	NO	NO
—Consumption of halocarbons and SF_6	5.3	30.7	920.0	10.0	55.9	0.0	0.0	70.2	1,092.1
3. Agriculture									
4. LUCF									
5. Waste									

Tier 1 and 2 methods were adopted to estimate emissions of carbon dioxide, methane and nitrous oxide from local aviation and marine, rail, non-road transport

and road transport sources.

Special regional transport means aviation and marine transport activities departing from Hong Kong with destinations in other parts of Mainland China while international transport means aviation and marine transport activities departing from Hong Kong with destinations in places other than Mainland China. Tier 3(a) method was adopted for the estimation of emissions of carbon dioxide, methane and nitrous oxide from special regional and international aviation. Tier 1 method was adopted to estimate emissions of carbon dioxide, methane and nitrous oxide from special regional and international marine.

Tier 1 method was adopted to estimate fugitive methane emissions from the gas transmission while Tier 3 method was adopted to estimate other fugitive methane emissions.

1.2.3 GHG Emissions

In 2014, GHG emissions from energy activities amounted to 40.794 Mt CO_2 eq, or 90.65% of Hong Kong's total emissions. Amongst them, 40.597 Mt, 0.04 Mt CO_2 eq and 0.157Mt CO_2 eq were emissions of carbon dioxide, methane and nitrous oxide respectively. Carbon dioxide emissions from energy activities accounted for 98.63% of the total of such emissions.

Of the GHG emissions from energy activities in 2014, 31.095 Mt CO_2 eq, or 76.53% were from energy industry (electricity and towngas production); 7.307 Mt CO_2 eq, or 18.01% were from transport; 1.525 Mt CO_2 eq, or 3.74% were from other sectors (including commercial and residential sectors); 0.677 Mt CO_2 eq, or 1.66% were from manufacturing and construction industries; 0.024 Mt CO_2 eq, or about 0.06% were from fugitive emission of methane.

1.3 Industrial Processes

1.3.1 Scope

The inventory for industrial processes mainly covers the emissions of carbon dioxide from the production of cement; the emissions of hydrofluorocarbons and perfluorocarbons from refrigerating, air-conditioning and fire-fighting equipment;

and the emissions of sulfur hexafluoride from electrical equipment.

1.3.2 Methodologies

According to clinker production and related data, Tier 2 method of *Revised 1996 IPCC Guidelines* was adopted and reference was made to related parameters of *2006 IPCC Guidelines* in estimating carbon dioxide emissions from cement production. Tier 2(b) method of *2006 IPCC Guidelines* was adopted to estimate hydrofluorocarbons emissions from air-conditioning of buses, rail trains, large-scale commercial establishments and government buildings, as well as industrial refrigeration. Tier 2(a) method was adopted to estimate hydrofluorocarbons emissions from air conditioning of motor vehicles, goods vehicles, industrial/commercial buildings, and refrigeration for domestic and commercial uses. Tier 1 method of *2006 IPCC Guidelines* was adopted to estimate perfluorocarbons emissions from solvents. Tier 1(a) method of *2006 IPCC Guidelines* was adopted to estimate emissions of hydrofluorocarbons and perfluorocarbons from fire-fighting equipment. Tier 3 method of *2006 IPCC Guidelines* was adopted to estimate emissions of sulfur hexafluoride used in electrical equipment.

1.3.3 GHG Emissions

In 2014, GHG emissions from industrial processes in Hong Kong were around 1.641 Mt CO_2 eq, accounting for 3.65% of the total emissions, amongst which 0.549 Mt CO_2 eq were emitted from cement production. Hydrofluorocarbons and sulfur hexafluoride emissions from refrigeration, air-conditioning, fire-fighting and electrical equipment were 1.022 and 0.07 Mt CO_2 eq respectively, while perfluorocarbons emissions was 0.0 t CO_2 eq.

1.4 Agriculture

1.4.1 Scope

The inventory for agriculture mainly covers emissions of methane and nitrous oxide from livestock enteric fermentation and manure management; emissions of nitrous oxide from agricultural soils; and emissions of carbon dioxide, methane and nitrous oxide from savanna burning.

1.4.2 Methodologies

Tier 1 method of *Revised 1996 IPCC Guidelines* was adopted and reference was made to the default emission factors in *2006 IPCC Guidelines* in calculating methane emissions from enteric fermentation. Tier 1 method of *2006 IPCC Guidelines* was adopted for direct and indirect emissions of nitrous oxide from agricultural soils. Tier 1 method of *2006 IPCC Guidelines* was adopted for emissions of methane and nitrous oxide from prescribed savanna burning.

1.4.3 GHG Emissions

In 2014, GHG emissions from agricultural activities in Hong Kong amounted to approximately 0.031 Mt CO_2 eq, or 0.07% of the total emissions. Methane and nitrous oxide emissions from livestock enteric fermentation and manure management amounted to 0.016 Mt CO_2 eq while nitrous oxide emissions from agricultural soils were approximately 0.015 Mt CO_2 eq.

1.5 Land-Use Change and Forestry

1.5.1 Scope

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

1.5.2 Methodologies

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

1.5.3 GHG Removals

In 2014, as carbon sinks, land-use change and forestry had a net removal of approximately 0.452 million tons of carbon dioxide 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.

1.6 Waste

1.6.1 Scope

The inventory for waste treatment mainly covers methane emissions from solid waste landfilling; methane and nitrous oxide emissions from treatment of domestic sewage and industrial wastewater; and carbon dioxide emissions from waste incineration.

1.6.2 Methodologies

The calculation of emissions from waste treatment was mainly based on *2006 IPCC Guidelines*. Tier 2 method was adopted estimate methane emissions from landfilling of solid waste. Tier 1 method was adopted for the emissions of methane and nitrous oxide from wastewater treatment, and Tier 1 method was also adopted for the emissions of carbon dioxide from waste incineration.

1.6.3 GHG Emissions

In 2014, GHG emissions from waste treatment in Hong Kong amounted to 2.534 Mt CO_2 eq, or 5.63% of the total emissions. Most of such emissions were methane which amounted to 2.325 Mt CO_2 eq, or 97.82% of the total methane emissions in Hong Kong.

1.7 Quality Assurance and Quality Control of the GHG Inventory

1.7.1 Quality Assurance and Quality Control in Compiling this Inventory

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 preparation of the inventory. The efforts mainly include:

1) In compiling the guidelines, the guidelines provided by the IPCC were strictly followed to ensure the scientificity, comparability and transparency of the inventory compilation;

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 analyzing the activity data, the institutions worked closely with the relevant departments to strive to acquire authoritative first-hand official information, which was then managed, checked and examined by specialized personnel, to ensure the authoritativeness and rationality of the data used.

4) In determining the emission factors, emission factors in compliance with Hong Kong's actual circumstances were adopted as far as practicable. In the absence of emission factors possessing the characteristics of Hong Kong, reference was made to the default emission factors provided by the IPCC Guidelines to ensure the accuracy of the results in the inventory.

1.7.2 Uncertainty Analysis in this Inventory

Based on the uncertainty analysis in accordance with *2006 IPCC Guidelines*, the uncertainty of Hong Kong's GHG inventory in 2014 is around 4.34%. Emissions produced in the process of coal-fired power generation were the major reason for the uncertainty mainly due to the limitation of the statistics on the type and quantity of coal consumption at power plants.

Chapter 2 Mitigation Measures and Their Effects

The Hong Kong government has been continuing to implement various policies and measures to mitigate GHG emissions since 2010. A quantitative GHG emission reduction target was first set in the Hong Kong's Climate Change Strategy and Action Agenda published in 2014 to reduce carbon intensity by 50% to 60% by 2020 as compared with the 2005 level. Hong Kong's Climate Action Plan 2030+ published in January 2017 further set a target of reducing the carbon intensity by 65% to 70% by 2030 using 2005 as the base, which is equivalent to an absolute reduction of 26% to 36% and a reduction to 3.3 to 3.8 tons on a per capita basis.

To achieve the above targets, Hong Kong has adopted multi-faceted policies and measures. In the energy sector, Hong Kong will phase down coal-fired electricity

generation and install new gas-fired generation units with the majority of the coal-fired generation units expected to be replaced by 2030. Furthermore, Hong Kong is vigorously promoting the development of renewable energy (RE), including introducing Feed-in Tariff to encourage the private sector and the community to invest in distributed RE, selling of RE certificates by the power companies for electricity from RE sources and facilitating the distributed RE grid connection arrangements, etc. In the building sector, the energy efficiency of buildings is enhanced continuously, and the Buildings Energy Efficiency Ordinance has been promulgated and implemented; specific energy saving targets are set for government buildings and energy audits are conducted for major government buildings; the energy efficiency of electrical appliances is enhanced through the implementation of the Mandatory Energy Efficiency Labelling Scheme; carbon audit for buildings is promoted; and carbon audit guidebooks for buildings are published. In the transport sector, the railway network is expanded continuously. Having regard to transport demand, cost-effectiveness and the development needs of new development areas and other new development projects, as well as the potential housing supply that may be brought about by railway development, the Government will implement the new railway projects recommended in the Railway Development Strategy 2014 in a timely manner. The railway network is targeted to serve areas inhabited by about 75% of the local population and about 85% of job opportunities. A wider use of electric vehicles is actively promoted by launching various policies and measures, including waiving of the First Registration Tax on electric vehicles. In the waste management sector, waste reduction is encouraged by advocating waste reduction, recovery and recycling; waste-to-energy is promoted as shown in the utilization of landfill gas in all operating strategic landfills to generate electricity for use by their own infrastructural facilities, and the generation of energy for use by leachate treatment plants; recycling of waste is enhanced and the study on the planning of future waste management and transfer facilities is strengthened. In the tree-planting and urban greening sector, the adoption of a comprehensive and sustainable approach in dealing with urban landscape design and tree

management initiatives is promoted. Details of the mitigation measures in various sectors and their effects are set out in Table 5-4.

Through implementing the above series of GHG emission control policies and actions, the GHG emission control in Hong Kong has achieved remarkable results: from 2005 to 2016, Hong Kong's population growth was 7.7% and the average annual real GDP growth was 3.3%, but the carbon dioxide emissions per unit GDP dropped around 29% and the GHG emissions per capita in 2016 remained at about 5.7 tons CO_2 eq.

Table 5-4 List of Hong Kong's Mitigation Actions

No.	Action Name	Targets or Major Components	Sectors/ GHG covered	Time frame	Nature of action	Supervisory department	Status	Progress information	Methodologies and assumptions	Estimated emission reduction effect	Supported by
1	Hong Kong's Climate Action Plan 2030+	The Hong Kong SAR Government released Hong Kong's Climate Action Plan 2030+ (hereinafter "Action Plan") in January 2017, setting a new target for 2030: to reduce Hong Kong SAR's carbon intensity by 65% to 70% using 2005 as the base, which is equivalent to an absolute reduction of 26% to 36% and will result in a per capita emission of 3.3 to 3.8 tonnes in 2030. Besides the aforementioned carbon reduction target, the Action Plan also outlines the details of the key measures on mitigation, adaptation and resilience to combat climate change	All/ CO_2	2017 - 2030	Mandatory/ government	ENB	In progress	The carbon dioxide emissions per unit of GDP in 2016 was lowered by 29% from the 2005 level	The rate of decrease of carbon intensity = (1 - Target year carbon intensity/ base year carbon intensity) × 100%	/	The SAR Government
Maximising Energy Efficiency											
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 new target of energy saving	All/ CO_2	2015 - 2025+	Mandatory/ government	ENB	In progress	Electricity demand reduction	Emission reduction= energy savings×emission factors	Emission reduction is expected to be 140×10^4 t/year by 2025	The SAR Government
3	Buildings Energy Efficiency Ordinance	The Buildings Energy Efficiency Ordinance and its Building Energy Codes (BEC) cover lighting, air conditioning, lift and escalator installations, stipulating the minimum energy performance standards (MEPS) of these installations. The Codes will be regularly reviewed at 3-year intervals to keep pace with the technological development	Building/ CO_2	2012- present	Mandatory/ government	EMSD	In progress	Electricity demand reduction	Emission reduction= energy savings× emission factors	Emission reduction is expected to be 1.4M t/year by 2025. (Emission reduction is 1.9M t/year by 2028)	The SAR Government

No.	Action Name	Targets or Major Components	Sectors/ GHG covered	Time frame	Nature of action	Supervisory department	Status	Progress information	Methodologies and assumptions	Estimated emission reduction effect	Supported by
4	Mandatory Energy Efficiency Labelling Scheme (MEELS)	MEELS covers eight types of prescribed electrical products, namely room air conditioners, refrigerating appliances, compact fluorescent lamps (CFLs), washing machines, dehumidifiers, televisions, water storage type electric water heaters and induction cookers, which together account for about 70% of the annual electricity consumption in the residential sector	All/ CO_2	2009-present	Mandatory/ government	EMSD	In progress	Electricity demand reduction	Emission reduction= energy savings × emission factors	Emission reduction is expected to be 0.68M t/year by 2025	The SAR 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 project will be implemented in 3 phases from 2011 to 2025	Energy/ CO_2	2011 - 2025	Construction: Mandatory/ government Use: Voluntary/ market	EMSD	In progress	Electricity demand reduction	Emission reduction= energy savings × emission factors	The estimated emission reduction is 60 kt/year once the DCS is fully implemented in 2025.	The SAR Government
6	Wider use of energy efficient water-cooled air-conditioning system using fresh water cooling tower	Over 2 000 cooling towers were built and have commenced operation since the launch of the Fresh Water Cooling Tower Scheme in 2000 to the end of 2015. It is estimated that the construction of about 1 500 cooling towers will be completed from 2016 to 2025. The EMSD will continue to promote a wider use of fresh water cooling towers	Energy / CO_2	2000 onwards	Voluntary/ government	EMSD/ ENB	In progress	Electricity demand reduction	Emission reduction =energy savings × emission factors	Emission reduction is expected to be 0.5 Mt/year by 2025.	The SAR Government

No.	Action Name	Targets or Major Components	Sectors/ GHG covered	Time frame	Nature of action	Supervisory department	Status	Progress information	Methodologies and assumptions	Estimated emission reduction effect	Supported by
Turning Waste to Energy											
7	Sludge treatment facility	Phase 1 of the dedicated Sludge Treatment Facility at Tsang Tsui, Tuen Mun 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 as a secondary power source for the community of Hong Kong	Energy and Waste/ CO_2, CH_4	2010 - present	Mandatory / government	EPD	In progress	Reduction of GHGs	Emission reduction=Amount of alternative fossil energy×emission factors	0.26 Mt/year	The SAR Government
8	Organic Resources Recovery Centre (ORRC)	The ORRC Phase 1 was completed for operation in July 2018. The ORRC will adopt biological treatment technologies to turn food waste from commercial and industrial sectors into useful resources such as biogas and compost products	Energy and Waste/ CO_2, CH_4, N_2O	2018 onwards	Construction: Government Use: Voluntary/ market/ government	EPD	In progress	Reduction of GHGs	Emission reduction=Amount of alternative fossil energy×emission factors	25 kt/year for Phase 1	The SAR Government
9	Integrated Waste Management Facilities (IWMF) Phase 1	The Hong Kong SAR Government started the design and construction of the IWMF Phase 1 in Dec 2017 and the facility will adopt modern waste-to-energy technology to substantially reduce the volume of waste and turn waste into energy.	Energy and Waste/ CO_2	2024	Mandatory/ government	EPD	In progress	Reduction of GHGs	Emission reduction=Amount of alternative fossil energy×emission factors+landfill gas emission avoided	0.44 Mt/year	The SAR Government

Part VI Basic Information of Macao SAR on Addressing Climate Change

Macao is a Special Administrative Region (SAR) of the People's Republic of China. It is a city with mild climate, limited natural resources, high population density and well-developed gaming industry. Being full of vibrancy, it is also a world famous center of tourism and leisure activities.

Chapter 1 Macao's GHG Inventory in 2014

Macao's GHG Inventory in 2014 was based on the methodologies recommended by *Revised 1996 IPCC Guidelines* and *IPCC Good Practice Guidance*. Some default emission factors from *2006 IPCC Inventory Guidelines* were also used. According to the actual conditions in Macao and the availability of relevant data, Macao's GHG Inventory in 2014 mainly covers GHG emissions from energy-related activities and waste disposal. Reported GHG include CO_2, CH_4 and N_2O.

1.1 Overview

Due to Macao's social and geographical characteristics, the only emissions in its administrative division are those from energy and waste sector. In 2014, Macao's total GHG emission was 1.095 Mt CO_2 eq (Table 6-1), of which the emission from energy accounted for 97.8%, and the emission from waste disposal 2.2% (Figure 6-1). The total emissions of CO_2, CH_4 and N_2O were 1.054 Mt, 0.004 Mt CO_2 eq and 0.037 Mt CO_2 eq, accounting for 96.6%, 0.37% and 3.37% of the total GHG emission respectively (Figure 6-2).

Macao's GHG emissions from its international aviation and special regional aviation in 2014 were about 563 kt CO_2 eq and those from special regional waterborne-navigation were about 205 kt CO_2 eq. Besides, CO_2 emissions from urban biomass waste burning were about 147 kt. The total GHG emissions from above activities were about 915 kt CO_2 eq which were not counted into the total emissions but only listed as a Memo item as required.

Table 6-1 2014 Macao's Total GHG emissions (kt CO_2 eq)

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
1. Energy	1050	4	17				1,071
2. Industrial processes	NO	NO	NO	NE	NO	NO	NE/NO
3. Agriculture		NO	NO				NO
4. Waste	4	0	20				24
5. LUCF	NE	NO	NE				NE/NO
Total (w/o LUCF)	1,054	4	37	NO	NO	NO	1,095
Total (w/ LUCF)	1,054	4	37	NO	NO	NO	1,095

Note: 1. Due to rounding, the aggregation of various items may have slight difference with the total.
2. NO (Not Occurring) for activities or processes that do not occur for a particular gas or source/sink category within Macao. NE (Not Estimated) for existing emissions and removals which have not been estimated.

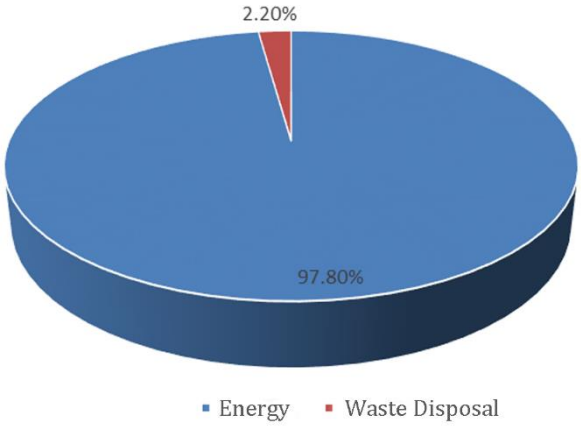

Figure 6-1 2014 GHG Emissions in Macao by Sector

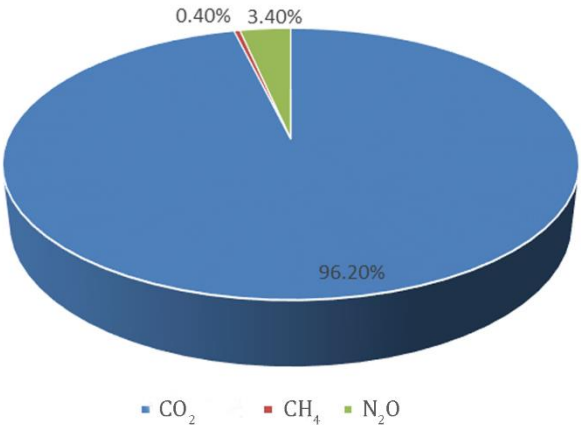

Figure 6-2 2014 GHG Emissions in Macao by Gas Category

1.2 Energy

1.2.1 Scope

For energy activities, the reporting scope of the Macao's GHG Inventory in 2014 mainly covers the CO_2, CH_4 and N_2O emissions from fossil fuel combustion in energy industries, manufacturing industries and construction, road transportation and other sectors. Considering the fact that incineration is the major approach for waste handling, and 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 are counted into energy activities, while CO_2 emissions from biomass combustion of urban waste are not counted into the total emissions but only listed as a Memo item.

1.2.2 Methodologies

For the GHG inventory for energy activities, Tier 1 method recommended in *Revised 1996 IPCC Inventory Guidelines* has been applied for CO_2, CH_4 and N_2O emissions caused by fossil fuel combustion from the energy industry, the manufacturing industry, the construction industry, and other sectors as well as fossil-fuel burning during water transportation in special regions, while for those from the road transportation and international and special regional aviation, the Tier 2 method recommended in *Revised 1996 IPCC Inventory Guidelines* was used.

The activity level data were the statistical and sectoral data released in Macao. Both sector and fuel categories are basically the same as those given in *1996 IPCC Inventory Guidelines*.

The emission factors were mainly from *Revised 1996 IPCC Inventory Guidelines*. If applicable, the default values were taken from *2006 IPCC Inventory Guidelines*.

1.2.3 GHG Emissions

Macao's GHG emissions from energy-related activities in 2014 were about 1,071 kt CO_2 eq (1,050 kt CO_2, 4 kt CH_4 and 17 kt N_2O), accounting for 97.8% of its total emissions. CO_2 emissions from energy sector accounted for 99.6% of the total emissions (Table 6-2).

Among Macao's total GHG emission from energy sector in 2014, 410 kt CO_2 eq was from road transportation, accounting for 38.2%; 306 kt CO_2 eq from energy transformation, accounting for 28.6%; 212 kt CO_2 eq from the manufacturing and construction sectors, accounting for 19.8%; and 144 kt CO_2 eq from other sectors (including commercial business, restaurants, hotels and residential), accounting for 13.4%.

Table 6-2 2014 Macao's GHG Inventory (kt)

Source/ Sink Categories	CO_2	CH_4	N_2O
Total (without LUCF)	1,053.90	0.20	0.11
1. Energy	1,050.01	0.20	0.05
—Fuel combustion	1,050.01	0.20	0.05
♦ Energy industries	304.64	0.02	0.00
♦ Manufacturing industries and construction	143.59	0.00	0.00
♦ Transport	391.80	0.15	0.05
♦ Other sectors	209.98	0.03	0.00
—Fugitive emissions from fuels	NE	NE	
2. Industrial processes	NO	NO	NO
3. Agriculture		NO	NO
4. Land-use change and forestry	NE	NO	NE
5. Waste	3.89	0.00	0.06
—Solid waste disposal on land	3.89	NO	0.00
—Wastewater handling		0.00	0.06
Memo items			
— Special regional aviation	313.77	0.00	0.01
— Special regional marine	204.95	0.00	0.00
—International aviation	244.37	0.00	0.01
—International marine	NO	NO	NO
—Biomass burning	147.11		

1. Due to rounding, the aggregation of various items may have slight difference with the total.
2. NO (Not Occurring) for activities or processes that do not occur for a particular gas or source/sink category within Macao. NE (Not Estimated) for existing emissions and removals which have not been estimated;
3. The data of HFCs, PFC_S and SF_6 related activities that are not collected and estimated in the industrial processes are presented as NE in totals;
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 and Taiwan).

1.3 Waste

1.3.1 Scope

The reporting scope of Macao's GHG inventory for waste disposal mainly covers CH_4 and N_2O emissions from urban sewage treatment, and CO_2 and N_2O emissions from solid waste incineration. The Inventory only reports CH_4 emissions from industrial sewage treatment as Macao's urban sewage is treated with aerobe.

1.3.2 Methodologies

Methodologies given in *Revised 1996 IPCC Inventory Guidelines* were used.

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

1.3.3 GHG Emissions

In 2014, Macao's total GHG emission from waste disposal was 24 kt CO_2 eq, accounting for 2.2% of the total emission of Macao, of which emissions from wastewater handling and waste incineration were 19 kt CO_2 eq and 5 kt CO_2 eq, accounting for 79.2% and 20.8% of the total respectively.

1.4 Quality Assurance and Quality Control

1.4.1 Efforts to Reduce Uncertainties

To reduce uncertainties of the inventory, from methodological perspective, methodologies from *Revised 1996 IPCC Inventory Guidelines* and *IPCC Good Practice Guidance* have been used, taking into account the approaches from *2006 IPCC Inventory Guidelines* to ensure that the methodologies were scientific, comparable and consistent. The institutions engaged in the preparation of the inventory in Macao have selected the higher-tier methods as many as condition allows. For example, road transportation, international aviation and aviation in special regions adopt the Tier 2 method. As for activity data, the institutions have used the data verified by Macao governmental departments such as Statistics and Census Bureau, 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.

1.4.2 Uncertainty Analysis

Although great efforts have been made in reporting scope, methodology and quality by the Macao Inventory Team in the preparation of its 2014 GHG Inventory, some uncertainties still exist.

The Tier 1 approach from *IPCC Good Practice Guidance* has been applied by Macao Inventory Team to calculate uncertainties, taking into account the emission factor uncertainty estimation approach in *1996 IPCC Inventory Guidelines* and *2006 IPCC Inventory Guidelines*. The uncertainty of Macao's total GHG emissions in 2014 was about 3.2%. The uncertainty of energy and waste were 3.2% and 17.4% respectively. See Table 6-3.

Table 6-3 Results of Uncertainty Analysis of National Greenhouse Gas Inventory of 2014

	Emissions (kt CO_2 eq)	**Uncertainty (%)**
Energy	1,071	3.2
Waste	24	17.4
Total uncertainty		3.2

1.5 Macao GHG Information in Previous Years

In the Second National Communication, Macao reported its 2005 GHG inventory. Total emissions were 1,803 kt CO_2 eq. Macao's total GHG emissions in 2014 reduced by 39.3% (about 708 kt CO_2 eq) over 2005. The main reason was that the increase of purchased electric power reduced the emission from local energy-related activities.

Macao's 2014 and 2005 Inventories were the same in methodologies and GHG categories, What's different is that, CO_2emissions from biomass burning among urban wastes were included under the Memo items.

Chapter 2 Mitigation Actions and Their Effects

In 2010, Macao government proposed a concept of "building a low-carbon Macao, creating green living together" to actively support and synergize with national policies

and actions in addressing climate change. To protect its environment systematically and achieve its GHG emission reduction goal, Macao designed *Macao's Plan for Environmental Protection (2010-2020)* in 2010 and *Macao SAR Five-Year Development Plan (2016-2020)* in 2016, making it clear to actively support national green development strategy and vigorously promote a civilized and healthy mode of life that pursues green, low carbon and emission reduction. To be specific, the goal that Macao set to control the GHG emission is that Macao's GHG emission per unit of regional GDP in 2020 will decrease by 40%-45% over 2005.

To achieve the goal mentioned above, Macao took a series of mitigation actions. In the energy industry, Macao gradually increased the proportion of natural gas power generation. Macao initiated the construction of public natural gas pipe network to supply natural gas to residents and schools and reduce the consumption of liquefied petroleum gas. Macao also generalized renewable energy sources such as photovoltaic power and reducing the consumption of heavy oil to improve its energy consumption structure so as to reduce its GHG emission. The percentage of power generation by natural gas in Macao increased from 30.9% in 2008 to 52.9% in 2017. **As for transportation**, Macao actively reduced energy consumption and carbon emission at airports, implemented the public-transportation-first policy, developed a light-rail-centered public transportation network, and promoted the use of environment-friendly energy-saving vehicles. By 2016, Macao had introduced 465 environment-friendly buses accumulatively that meet Euro IV or V standards, 50% more than 2015. Macao government also put the energy management mechanism into place in a comprehensive manner by making energy conservation plans for its public departments and organizations, and monitoring and managing the use of energy to improve their energy efficiency and achieve the goal that the annual energy consumption of departments concerned is reduced by 5%. Macao implemented the LED Street Lamps Replacement Plan gradually by installing more than 1,600 LED street lamps in various regions in 2016 and 2017. In terms of the hotel industry and tourism, since 2007, Macao has held the "Green Hotel Award" annually to promote hotel and related industries in an environment-friendly, low-carbon and clean way. Macao government also planted new trees continuously to **actively increase the proportion of green space in Macao** and increase its 3D greening space in various regions. In 2015, Macao's total green area was increased to about 8.66 million square meters; from 2015-2017, more than 1,900 trees were planted in parks, rest areas and sidewalk; more than 10,000 mangrove saplings were planted in the rest areas along the Taipa seaside; and over 4,000 trees

further were cultivated to transform the forest region in Coloane.

As a result of 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 2014 was reduced by about 21.9% over 2010; and GHG emission (expressed in CO_2 eq) per unit of regional GDP was reduced by about 37.1% over 2010. See Table 6-4 for detailed mitigation measures and effects.

Table 6-4 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	Gradually increase the share of natural gas power generation	Macao introduced electricity generated by natural gas in 2008	Energy/ CO_2	Since 2008	Government	Energy Industry Development Office	In Progress		Emission reductions= (natural gas consumption×natural gas emission factor)－(natural gas generation×average emission factor of China Southern Power Grid from 2008 to 2016) Reference year: 2008	Total GHG Emission Reductions from 2008 to Q3 2017: 0.2 Mt CO_2 eq.	Macao SAR 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 reduce airport carbon emission	Energy, Waste/ CO_2,CH_4, N_2O	2012 - 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 reference 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 28.7% in 2017 compare to 2012.	Macao International Airport Co., Ltd, Macao Airport Management Co., Ltd and Energy Saving Fund

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
3	Promoted the use of environment-friendly vehicle	Provided tax benefits for new motor vehicles complying with standards 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	Energy/ CO_2	Since 2012	Goverment / Voluntary	Environmental Protection Bureau is responsible for compilation of measures and standards. Finance Bureau and Transport Bureau are responsible for implementation	In Progress		Emission reduction = fuel savings × CO_2 emission factors caused by gasoline combustion Reference Year: 2012	From 2012 to 2017, total reduction: 0.04 Mt CO_2 eq.	Macao government
4	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. The public sectors reduce energy consumption by 5% annually	Energy/ CO_2	Since 2007	Governme nt/ Voluntary	Energy Industry Development Office	In Progress	Launched in 2007, the project has saved a total of 1240 kWh power till 2017	Emission reduction = Power savings × average emission factor for the Southern grid 2008-2016 Reference Year: 2008	From 2008 to 2017, total emission reduction: 9 kt CO_2 eq.	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
5	LED public outdoor lighting application	Based on "Macao Public Outdoor Lighting Design Guidance", the demonstration projects were conducted to identify the effect of LED lighting outdoors and it is planned to replace all the street lights across the whole Macao. Electricity consumption is reduced by 30% compared with before the street lamps were replaced	Energy/ CO_2	Since 2010	Government	Energy Industry Development Office	In Progress	LED street lamps were applied in Seac Pai Van and Zona Nova de Aterros do Porto Exterior respectively in 2013 and 2016, and more than 1,600 LED street lamps were installed in various regions in 2016 and 2017. About 14,000 existing street lamps in Macao will then be gradually replaced	Emission reduction = Power savings × average emission factor for the Southern grid 2010-2016 Reference Year: 2010	From 2010 to 2017, total reduction: 1 kt CO_2 eq.	Macao government