Second National Communication on Climate Change of The People's Republic of China

Foreword

Global climate change, which has profound impacts on human survival and development, poses a major challenge to all nations. The *United Nations Framework Convention on Climate Change* (UNFCCC) provides that all Parties to the Convention should, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities, safeguard the climate system for the present and future generations of mankind; and that the developed countries should take the lead in addressing climate change and its adverse impacts. UNFCCC and its Kyoto Protocol have become the international legal basis for addressing climate change, as recognized by various Parties to the Convention; the principle of common but differentiated responsibilities has become the consensus for enhancing cooperation among all Parties; taking a green low-carbon development pathway and achieving harmony between mankind and nature have become the common goal of all Parties.

In accordance with the provision of UNFCCC, each Party has an obligation to submit its National Communication, including the national greenhouse inventory, measures taken and to be taken for the implementation of the Convention, as well as other information that the Party considers relevant. The Chinese government always attaches great significance to fulfilling its international commitments. As early as in 2004, China submitted its *Initial National Communication on Climate Change*, and launched in 2008 launched the preparation of its *Second National Communication* by organizing the government departments concerned, scientific research institutions, universities, state-owned enterprises and civil societies, according to the guidelines for the preparation of the second national communications from non-Annex I Parties, which were adopted by the Conference of the Parties (COP) at its eighth session. With the 4-year efforts, the *Second National Communication on Climate Change of the People's Republic of China* has been completed. This report has been approved by the State Council based on broad comments, through multiple and repeated revisions, and after elaborations at the meeting of the National Leading Group on Climate Change.

The *Second National Communication on Climate Change of the People's Republic of China*, is divided into 8 parts with relevant chapters underneath: national circumstances, national GHG inventory, climate change impacts and adaptation, policies and actions for climate change mitigation, other relevant information on achieving the objective of the Convention, needs for funds, technologies and capacity building, basic information of the Hong Kong SAR on addressing climate change, and basic information of the Macao SAR on addressing climate change, presenting a full picture of China's national circumstances related to climate change. According to the relevant decisions of UNFCCC, taking into consideration China's national circumstances, the National GHG Inventory as presented herein is based on the data of 2005; however, the relevant data and informationin other chapters is generally updated to 2010. In accordance with the relevant principles in the *Basic Law of the Hong Kong SAR of the People's*

Republic of China (PRC) and the *Basic Law of the Macao SAR of PRC*, the basic information of these two SARs in this report are provided by the Environment Protection Department of the Hong Kong SAR Government, and by the Meteorological and Geophysical Bureau of the Macao SAR Government respectively.

Climate change is an environment issue, but also, and more importantly, a development issue. China can only advance its efforts to address climate change in the course of sustainable development, and meet the challenge through common development of all countries. Considering its basic national circumstances and the characteristics of its development stage, China will step up its efforts to shape the green and low-carbon development concepts, to quicken the pace toward resource-saving and environment-friendly production model and consumption pattern, to enhance the capability for sustainable development, and to improve the ecological civilization. The Chinese government will continue, as always, to fulfill its own obligations under the Convention, to follow the principle of common but differentiated responsibilities, to take a series of effective policies, measures and targeted actions, to achieve the action goals in greenhouse gas (GHG) emission control, to actively participate in international negotiations, to accelerate establishment of a fair and plausible international system in response to climate change, to enhance international exchanges and dialogues on strategic policies in the field of climate change, to conduct practical cooperation in scientific research, technological R&D, capacity building and in other aspects, to facilitate creation of an international cooperative platform and a management system for finance and technology transfer, and to make new contribution to safeguarding the global climate.

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Executive Summary

The contents and national data covered in this report do not include those from the Hong Kong SAR, Macao SAR and Taiwan Province, with only exceptions of the administrative delineations, total national land area, and information specified otherwise.

1. National Circumstances

As a country with complex climatic conditions and vulnerable ecological environment, China is susceptible to climate change. Covering a land area of approximately 9.6 million km^2, China consists of 23 provinces, 5 autonomous regions, 4 municipalities and 2 Special Administrative Regions. China's mainland terrain is high in the west and low in the east, forming three distinct ladder-shaped terraces in between, and its landscape varies with mountains, plateaus and hills, accounting for 66% of the total land area. China's climate is characterized by significant continental monsoon as well as complex and diverse climate categories. Precipitation, with significant temporal and spatial variations across China, mostly concentrates in summer varying largely from region to region. As a country short of water resources, the per capita water availability in China is about 28% of the world's average. Its per capita energy resource availability is less than half of the world's average.

China is the most populous nation in the world. By the end of 2005, the total population in the mainland China was 1.308 billion, accounting for 20.3% of the world total. By the end of 2010, it reached 1.341 billion. In 2005, China's natural population-growth rate was 5.89‰, which was well below the global average (11.9‰) in the same period. In 2010, this rate further declined to 4.79‰. In 2005, China's total employed population was 758.25 million, and employment ratios shared by the three industries were 44.8:23.8:31.4. In 2010, China's total employed population was 761.05 million and the ratios were 36.7:28.7:34.6 among the three industries. China's urbanization level was 43.0% in 2005, and it reached 49.95% in 2010.

China is a developing country with a lower level of economic development, which is strikingly imbalanced and less coordinated between urban and rural areas and between regions. In 2005, China's gross domestic product (GDP) was RMB 18.4937 trillion *Yuan* and per capita GDP was 14,185 *Yuan*. In 2010, the GDP was 40.1513 trillion *Yuan* and per capita GDP was 30,015 *Yuan*. In 2005, the contribution ratios of the three industries to GDP were 12.1:47.4:40.5; in 2010 the ratios were 10.1:46.7:43.2. In 2005, the per capita disposable income for Chinese urban residents was 10,493 *Yuan,* whereas the figure was 3,255 *Yuan* for the rural residents. In 2010, the per capita disposable income for Chinese urban residents was 19,109 *Yuan* and that for the rural residents was 5,919 *Yuan*. In 2005, China's per capita GDP in the eastern coastal regions was 23,530 *Yuan* compared with only 9,465 *Yuan* in the western regions, accounting for 40.23% of the former. In 2010, the per capita GDP in the eastern coastal regions was 45,510 *Yuan,* while the figure in the western regions was 22,570 *Yuan*, accounting for 49.59% of the former. In 2005, manufactured goods accounted for 93.6% of China's total export, and the percentage went up to 94.8% in 2010. In 2005, the average number of automobiles owned per hundred households was 3.37 and per capita residential electricity consumption was 221 kWh in the urban areas. In 2010, these two figures were 13.1 and 383 kWh respectively. Due to relatively lower economic development level and vulnerable ecological environment, China still has a large number of poor people living in rural areas.

As a responsible nation, China attaches great significance to issues of global climate change. The State Council has set up the National Leading Group on Climate Change, which is composed of multiple relevant departments, and it has released the *China's National Climate Change Programme*. The Standing Committee of the National People's Congress (NPC) has endorsed the *Resolution on Tackling Climate Change*, by which the active response to climate change is one of major strategies for the national economic and social development. In the *12th Five-Year Plan for National Economic and Social Development* reviewed and approved by NPC, it is clearly stated that the scientific development is the theme while the acceleration of transforming economic growth modes is the cardinal line; and the green and low-carbon development is an important guiding policy. In this plan, the reduction of CO_2 emissions per unit of GDP by 17% is set for the first time as a binding target, and key tasks for the Chinese government to address climate change in 2011-2015 have been made clear.

2. National Greenhouse Gas Inventory

The reporting scope of the China's National Greenhouse Gas Inventory 2005 covers five major sectors, i.e. energy activities, industrial processes, agricultural activities, land use change and forestry, and waste treatment, involving six greenhouse gases including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbon (HFC), perfluorocarbon (PFC) and sulfur hexafluoride (SF_6). The institutions that engaged in the preparation of this inventory mainly followed the methodologies provided in the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (hereinafter referred to as the *Revised 1996 IPCC Guidelines*) and the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (hereinafter referred to as the *IPCC Good Practice Guidance*) and referred to the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (hereinafter referred to as the *2006 IPCC Guidelines*). Based on China's national circumstances, including definition of emission sources, identification of key emission sources, availability of activity level data and emission factors, the institutions that engaged in the inventory preparation had made in-depth analysis on applicability of the IPCC methodologies to China, and identified specific methods for preparing the China's National Greenhouse Gas Inventory 2005 to ensure the consistency of methodologies and the comparability of results.

In 2005, China's total greenhouse gas (GHG) emission was approximately 7.467 Gt CO_2 eq, of which carbon dioxide accounted for 80.03%, methane for 12.49%, nitrous oxide for 5.27%, and fluorinated gases for 2.21% respectively. In 2005, the total GHG remove through land use change and forestry was about 421 Mt CO_2 eq. By deducting the remove, China's total net GHG emission in 2005 was around 7.046 Gt CO_2 eq, of which carbon dioxide accounted for 78.82%, methane for 13.25%, nitrous oxide for 5.59% and fluorinated gases for 2.34% respectively (CO_2 equivalent was calculated based on the Global Warming Potentials of various greenhouse gases on a 100-year time scale given in the *IPCC Second Assessment Report*).

In 2005, China's total CO_2 emission was 5.976 Gt, of which the emission from the energy activities was 5.404 Gt, accounting for 90.4%; and the emission from industrial processes was 569 Mt, accounting for 9.5%. The CO_2 remove through land use change and forestry was 422 Mt and China's net CO_2 emission was 5.554 Gt. In 2005, China's total methane emission was 44.454 Mt, of which the emission from agricultural activities was 25.169 Mt, accounting for 56.62%, the emission from energy activities was 15.429 Mt, accounting for 34.71%, and the emission from waste treatments was 3.824 Mt, accounting for 8.60%. In 2005, China's total nitrous oxide emission was about 1271 Kt, of which the emission from agricultural activities was 938 Kt, accounting for 73.79%, the emission from energy activities was 134 Kt, the emission from industrial processes was 106 Kt, and the emission from waste treatments was 93 Kt. In 2005, China's total fluorinated gas emission from the industrial processes was about 165 Mt CO_2 eq.

To reduce uncertainties of the 2005 national GHG inventory, the institutions engaged in inventory preparation have done a wide range of work on methodologies, activity levels and emission factors. Depending on data availability, more detailed methods have been selected. In cases that no official statistics are available, the institutions have made a large number of surveys and research work, trying to use as many as possible the emission factors that reflect China's actual circumstances. However, due to limited scientific understanding and means of testing, uncertainties still exist, to certain extent, in the China's GHG Inventory 2005, which are mainly found as follows: (1) China's current statistical indicator system is not fully consistent with that required for the inventory preparation, and some activity level indicators have not been incorporated in China's current statistical system; (2) adequacy of the activity level samples from typical surveys is limited; (3) some parameters relevant to the emission factors derived from sample tests and *in-situ* measurements are not representative enough; and (4) due to lack of the country-specific emission factors in some sectors, the default values from the IPCC Inventory Guidelines are used.

With its economic development and improved people's living standard, China's GHG emissions including CO_2 showed a rapidly increasing tendency in 2005 compared with 1994. In 1994-2005, China's total emission of CO_2, CH_4 and N_2O increased from 3.65 Gt CO_2 eq to 6.881

Gt CO_2 eq, or an increase of 0.89 times. Out of the total, CO_2 emission increased fastest and it increased 1.09 times, while CH_4 and N_2O emissions increased 0.3 and 0.5 times respectively. It should be noted that China's current per capita emission is still at a lower level, and CO_2 emission per unit of GDP shows a rapid decline. According to the IEA statistics, in 2005 China's per capita CO_2 emission from fossil fuel combustions was about 3.88 tons, which was equivalent to 34.5% of the average of the Annex I Parties; China's CO_2 emission from fossil fuels combustion per unit of GDP decreased by 46% relative to 1990, with its decreasing rate faster than the 15% world average declining rate in the same period.

Taking into account the main factors for GHG emissions, China's GHG emissions will still keep growing to certain extent for a coming period. From global perspective, energy consumption and its CO_2 emissions is clearly related to economic development level. Considering China's national circumstances, China's GDP will keep growing annually around 7% in the next 10 years. Although it will contribute to reducing CO_2 emission per unit of GDP in energy activities with the quickened pace to transform economic development modes, greater efforts for energy conservation and lower energy consumption, and rapid development of renewable energies, however as the industrialization and urbanization continue, there will be reasonable demands for construction of larger scale infrastructures, and for mobility and housing by residents. Therefore, overall China will maintain a certain growth rate in both energy demand and CO_2 emission in the next decade.

3. Climate Change Impacts and Adaptation

Available observations and studies show that in the last 100 years climate warming in China is basically consistent with the global trend. The annual mean surface temperature on the mainland China has increased by 0.98°C, with a warming rate of nearly 0.10°C per decade, which is slightly above the global warming rate in the same period. In the past century, the 1920s-40s and post mid-1980s were the two significantly warmer episodes. Except for the *Sichuan* Basin and the northern *Yunnan-Guizhou* Plateau where temperature decreased slightly, the rest of the country witnessed an increase in annual mean surface temperature, especially in the northwestern China, northern Qinghai-Tibetan Plateau and most Inner Mongolia, where the temperature increase was particularly significant. The mainland China showed no significant trend in annual precipitation, but a clear trend in seasonal precipitation. There was an increasing trend in summer precipitation, especially a significant precipitation increase after 1990s. In contrast, both spring and autumn precipitation showed a significant decrease. The changes in precipitation were characterized by large regional differences, and seasonal precipitation also showed clear geographical variations. The mainland China experienced more extreme warm events, significantly less extreme cold events, and more frequent meteorological droughts with wider impacts.

Most existing climate models show that under different global GHG emission scenarios, the annual mean surface temperature of the mainland China will likely continue increasing. The northeastern, western and northern China will witness a higher temperature increase. The temperature increase in winter will be higher than that in summer and the warming rate of minimum temperature will be higher than that of maximum temperature. Under most global GHG emission scenarios, the mainland China is likely to see a significant increase in annual precipitation in the future. Under the high GHG emission scenario (A1B), in 2021-2030 the mean surface temperature will increase in a 0.5°C-1.5°C range on the mainland China, relative to 1971-2000. By 2040, the annual average precipitation nationwide will likely increase by 2%-4%. There are still larger uncertainties in the projected climate change trend in future China, mostly due to limitations in developing future GHG emission scenarios and climate models.

Climate change has already had certain impacts on China's agriculture, which will still be negative in the future. The changing climate has prolonged the crop growth period in higher latitudes in China by shifting the boundary of thermophilic crops northward. Compared with the 1960s, the growth period has been prolonged by about 10 days in most Northeast China region. But, climate change has caused a drop of wheat and corn production by 5% in China in the last 30 years. It has led to more frequent extreme events like floods and droughts. In 1950-2000, 9.37 million hectares of croplands were flooded in China on annual average, causing a grain yield reduction accounting for about 3% of the national average food production for the same period. Without taking any adaptation measures, climate change will lead to a reduction of major crop yields in the country, e.g. rice, corn and wheat. The vulnerability of China's agriculture to climate change is highly regional, and the transition zones between cropping and nomadic areas, where annual precipitation is around 400 mm, plus the *Hexi* Corridor in the northwest are among the most vulnerable regions for agricultural production.

The changing climate has already changed distribution of water resources in China, and its impacts will be even more significant in the future. Climate change has caused a reduction of water resources in the northern China and an increase in the southern China. In the last 30 years, both river runoff and total water resource in the southern China have increased by about 4%, while those in the northern China have decreased by 12%. Climate change has brought about more extreme events, e.g. floods and droughts, especially in the last decade when the average drought-hit and drought-damage rates reached 16.95% and 10.05% respectively. Climate change has led to a widespread retreat of glaciers and shrinkage of lakes in China. Since the last 6 decades, 82% of glaciers are retreating, mostly those on the fringes of the *Qingha*i-Tibetan Plateau. 142 lakes over 10 km^2 across the country are shrinking, accounting for 12% of the total lake space. In the next 3 decades, the major rivers in China will continue to show an overall trend of runoff reduction in the north and a slight increase in the south, possibly aggravating the current dry-north and wet-south conditions. The water sources in the *Haihe* River and *Luanhe* River basins are most vulnerable to climate change in China.

The impacts of climate warming on China's forest ecosystems are mainly felt in the following aspects: polar-ward shifting of boundaries of some tree species, tree line rising to a higher elevation, earlier phenological events and potential higher risks of forest fires, pests and diseases. Compared with pre-1980s, in the last 30 years, phenological period in spring has been advanced by 2 days, showing significant spatial variations. The widespread higher temperature and precipitation decrease have caused a general decline of the forage yield, and the ongoing desertification in the north is one of factors for grassland degradation. Climate change has led to degradation of wetlands and lake ecosystems, evident shrinkage of rain-fed wetlands and widespread retreat and salinization of lakes in China. The changing climate and human activities have impacted plant and animal diversity, habitats and landscape diversity. In the future, climate change will lead to a slow polar-ward shifting of vegetation zones in the eastern China, higher risk of forest fires, and possible exacerbation of physiological disease and pest outbreaks in forests. The grassland in the northern arid zones will advance toward wet zones, with various grassland boundaries shifting east. The regional warming and drying climate will further degrade wetlands and reduce specie diversity . The regions where climate change has increased vulnerability of the ecosystems are mainly found in the northern China.

Climate change shows a noticeable trend of sea level rise along China's coasts. In the last 30 years, the coastal sea level has risen at a mean rate of 2.6 mm per year, higher than that of the global sea level rise (1.7 mm/year). Under global climate change, the severity of storm surge-induced disasters is increasing in China's coastal zones. According to statistics, in the past 20 years, 3 storm surges of the orange warning level hit China's coasts annually, showing a slow increasing trend. Climate change has worsened some coastal erosion events, including the segment in *Yingkou, Liaoning* province, where the land erosion rate is nearly 5 m per year. Climate change tends to alter marine species, shift mangrove boundaries further north, and bleach corals. In the next 3 decades, the sea level will continue to rise along China's coasts with the mean rising amplitude in 80-130 mm. Moreover, the extreme water level will be higher; the return periods of severe storm surges will be shortened; all delta regions will be severely eroded; and coral reefs in the *Nansha* waters may stop growing.

Climate change has also direct and indirect impacts on human health. The high temperature weather (heat wave) is a major factor for the higher mortality in summer. The heat wave has significant impacts on infants, children, elderly and chronic patients suffering respiratory or cardiovascular/cerebrovascular diseases, contributing to higher morbidity and mortality. Climate change has much to do with the vector-borne diseases by prolonging the malaria transmission season in China's high prevalence areas, and shifting further north the northern boundary of potential distribution zone of schistosome intermediate host snails in the future.

China has taken a series of policies and actions on climate change adaptation. These policies and actions mainly include: (1) adjusting agricultural structure, deploying high-efficiency water irrigation and rain-fed cropland water-saving techniques, expanding the scope of the pasture-for-grassland projects, and further enforcing grassland conservation measures, e.g. balanced grazing, grazing ban, deferment and rotational grazing on pastoral grasslands; (2) enhancing constructions of control projects of flood, sediment and drought, disaster reduction, water resource exploitation and conservation projects, and intensifying institutional buildup for flood and drought control systems; (3) enhancing key project constructions for natural forest conservation, sand/dust source control for protecting Beijing and Tianjin, the Northwest, North and Northeast China shelter forests, and regional (e.g. Yangtze River Basin) shelter forests, Project on Conversion of Slopy Cropland into Forests; creating nature reserves in climate change sensitive areas, and enhancing protection and management of wetland ecosystems; (4) enhancing capacity of infrastructures in coastal zones and areas in adaptation to sea level rise by heightening and fortifying seawalls; (5) establishing direct online reporting systems for infectious disease outbreaks and public health emergencies; and establishing and improving an emergency response system for breaking public health events, a disease prevention and control system as well as a health supervision and law enforcement system, among others.

China will further take effective policies and measures to enhance climate change adaptation capability, e.g. developing an overall national strategy for climate change adaptation; and enhancing scientific research on climate change, observations and impact assessments. The climate change factor will be taken into full account in designing and developing productivity distribution, infrastructures and key projects. Capacity building will be enhanced in adaptation to climate change, especially in coping with extreme climate events; development and deployment of adaptation technologies will be accelerated; and climate change adaptations in key sectors such as agriculture, forestry and water and in coastal and ecologically vulnerable areas will be improved. The monitoring, prediction and early warning of extreme weather and climate events will be strengthened, and capabilities in natural disaster preparedness and mitigation will be enhanced.

4. Policies and Actions for Climate Change Mitigation

As a responsible developing country, China has made clear its action targets for controlling GHG emissions. In 2007, the Chinese government launched the *China's National Climate Change Programme*, in which the relevant targets for GHG emission control by 2010 were clearly stated. In 2009, the Chinese government announced that, by 2020 CO_2 emission per unit of GDP will be reduced by 40-45% compared with 2005, the non-fossil energy will account for about 15% of the total primary energy consumption, the forest area will be increased by 40 million hectares and the forest stock volume will be increased by 1.3 billion m^3

relative to 2005. These are voluntary actions taken by China according to its national circumstances. During the 12th FYP period (2011-2015), China will decrease CO_2 emission per unit of GDP by 17% as a binding target, further call for a reasonable control of its total energy consumption, accelerate development and deployment of low-carbon technologies, control GHG emissions from industry, construction, transport and agriculture among other sectors, explore to set up low-carbon product standards, labeling and certification systems, put in place and improve a GHG-emission statistical accounting system, gradually establish a carbon emission trading market, and launch low-carbon demonstration projects on a pilot basis, to ensure that targets for GHG emission control will be met by 2020.

(1) Accelerating economic and industrial restructuring to effectively control GHG emissions. The Chinese government takes the industrial restructuring seriously, in order to facilitate economic transformation, to lower resource and energy consumptions, and to reinforce the guiding role of industrial policies and special plans. In 2007, the *Opinions Concerning Accelerating the Development of the Service Industry* was released. In 2010, the State Council issued the *Decision on Accelerating the Forstering and Development of Strategic Emerging Industries*. The Chinese government has also taken policies and regulations on management of newly started projects to intensify land use supervision, energy-saving evaluation and environment impact assessment, formulated and released criteria for market access by high energy-consuming industries, and readjusted export tax rebates and tariffs. In the 11th FYP period (2006-2010), the added value of China's tertiary industry increased by 2.7%, and growth of high energy-consuming industries was gradually declining. During the 12th FYP period, China will continue to take a new pathway for industrialization with Chinese characteristics, vigorously develop strategic emerging industries, and accelerate development of the service sector in an effort to increase its proportion in GDP by 4%.

(2) Striving for energy conservation and lower energy consumptions to reduce the GHG emission intensity. Energy conservation is a major strategy for China's economic and social development. Significant progress has been made in energy conservation through policies and actions for improving legislation, regulations and standards, reinforcing accountabilities and assessments, phasing out backward production capacity, implementing key projects, and making technological advances. In 2007, the National People's Congress approved the revised *Energy Conservation Law.* Some major systems have been established for assessing energy efficiency target-based accountabilities, and for energy-efficiency assessment and approval on fixed-asset investment projects. The Chinese government has released supportive regulatory documents such as the *Regulations on Energy Conservation in Civil Buildings*, the *Regulations on Energy Conservation by Public Institutions*, the *Opinions on Accelerating the Implementation of Energy Management Contracting and Promoting the*

Energy Conservation Service Industry, and the *Directory of Products for Energy Efficiency Labeling Implemented in the People's Republic of China*. The Chinese government has allocated the resolved energy conservation targets to individual provinces, autonomous regions or municipalities, and launched the '1000 Energy-Efficiency Enterprises' Program. Since 2007, the energy-saving targets and measures implemented by provincial governments and the 1000 selected enterprises have been assessed annually, and the results have been made open to general public. The Chinese government has formulated some policies on financial subsidies for energy efficiency products, and reinforced implementation of differential electricity prices. In the 11^{th} FYP period, by pursuing the policy of developing large energy-efficiency units and suppressing small energy inefficiency units, China had shut down small coal-fired power generation units totaling 76.82 GW, phased out 120-Mt backward production capacity for iron making, 72-Mt for steel making and 370-Mt for cement production, promoted use of energy-saving lamps (over 360 million in accumulation), and constructed a total energy-saving buildings of 4.857 billion m^2, accounting for 23.1% of the total. In the same period, China saved or used less energy which was about 630 Mtce, equivalent to CO_2 emission reduction by 1.46 Gt, making an important contribution to global response to climate change from a big responsible country. During the 12^{th} FYP period, China will further implement the strategy that gives high priority to energy conservation, and it will focus on energy conservations in industry, construction, transport and public institutions; China will develop, improve and strictly enforce energy consumption quotas for major energy-consuming products and standards of energy-efficiency products, enhance energy-efficiency assessments and approval for fixed-asset investment projects, accelerate energy contracting and electricity demand side management, and improve energy efficiency labeling, energy-saving product certification and mandatory government procurement of energy-saving products.

(3) Actively adjusting the energy mix to reduce per unit energy CO_2 emission. China is committed to developing a secure, stable and clean modern energy industry, and accelerating development of renewable and new energies like wind and nuclear power through improved regulations and standards, enhanced planning and guidance, increased capital investment, and improved policies and incentives. In 2005, NPC adopted the *Renewable Energy Law*, which was revised in 2009. In 2007, the relevant departments under the State Council issued the *Midium and Long-term Plan for Development of Renewable Energies*, the *Medium and Long-term Plan for Nuclear Power Development*, and the *11^{th} Five-Year Plan for Renewable Energy Developmen*t among others. For recent years, the Chinese government has launched a series of financial and taxation policies aimed at promoting development of renewable energies, nuclear power and natural gas. In 2006, the *Interim Management Measures on Special Fund for Demonstration Projects Using Renewable Energy in Buildings* was issued. In 2007, the *Notice on Issues concerning the Taxation Policy on Nuclear Power Industry* was issued. In 2008, the *Interim Management Measures on Special Fund for Commercialization of Wind Power Generation Equipment* was issued. In 2009, the *Interim Measures on Management of Public Subsidies for Golden Sun Demonstration Projects* and the *Implementation Opinions on Accelerating Solar Photovoltaic Use in Buildings* were issued. In 2006-2010, China saw a significant development and utilization of renewable resources, the installed hydropower capacity was 210 GW with the annual power generation reaching 650 billion kWh; the total wind power capacity was 40 GW (including off-grid units); the total installed photovoltaic power capacity was 800 MW; the total space of installed solar water heaters was 168 million m^2; the total floor area using solar thermal energy was 1.48 billion m^2; the total floorage using shallow geothermal energy was 227 million m^2; the installed biomass power-generation capacity was 5.5 GW; and the households using biogas reached 40 million. By the end of 2010, China's total installed nuclear power capacity was 10.82 GW, and its in-construction units accounted for 40% of the world total. China's natural gas production increased from 49.3 billion m^3 in 2005 to 94.85 billion m^3. Over 6 billion m^3 coal-bed methane was extracted, of which 3.6 billion m^3 was utilized. During the 12^{th} FYP period, China will further intensify exploration of natural gas, accelerate development and utilization of unconventional oil and gas resources (e.g. coal-bed methane and shale gas), actively develop hydropower on condition that issues on ecological protection and resettlement of displaced people are properly addressed, enhance construction of supportive grid projects, effectively develop wind power, actively develop other renewable energy sources, e.g. solar, biomass, geothermal and ocean energies, efficiently develop nuclear power on condition that safety is ensured, and vigorously develop a new energy industry.

(4) Enhancing afforestation and forest management to increase forest carbon sinks. China highly values the unique role of forestry in coping with climate change. China has maintained a continual growth in forest area and stock volume through a series of policies and actions on forest conservation and development to accelerate the forest tenure reform, to encourage nationwide voluntary tree-planting, to implement key afforestation projects, and to enhance sustainable forest management. The State Council has promulgated the *National Forest Land Protection and Utilization Guideline (2010-2020)*, based on which the central financial subsidies to afforestation has been increased, with the per *Mu* (1/15 hectare) subsidy increased from 100 to 200 RMB *Yuan*. The relevant departments have formulated and released the *Forestry Action Plan to address Climate Change*, and created the China Green Carbon Foundation. In the 11^{th} FYP period, 24.67 million hectares of land were afforested, with 11.72 billion trees planted Compulsorily; the urban carbon sinks were increased through urban greening. By the end of 2010, the greenery coverage in urban built-up areas was 38.62%, and the per capita greenery area in parks was 11.18 m^2. During the 12^{th} FYP period, China will continue to implement policies and actions on forest conservation and development. China's forest area will be increased by 12.50 million hectares and its forest stock volume by 600 million m^3 through afforestation and sustainable forest management, striving for a forest coverage that will account for 21.66% of its total land.

(5) Taking comprehensive policies and measures to enhance control of GHG emissions from industrial processes, agriculture and other sectors. China attaches great significance to controlling emissions from non-energy sectors and non-CO_2 GHG sources. The GHG emissions from metallurgical, building material manufacturing and chemical industries have effectively curbed through reinforcing relevant industrial policies, developing circular economy, and enhancing the measures for methane and nitrous oxide recovery and reuse. In the industrial processes, carbide slag has replaced limestone in cement clinker production; blast furnace slag and fly ash are used as mixed additives in cement production; the secondary and tertiary treatment methods are used to handle nitrous oxide from the nitric acid production; catalytic and thermal-oxidative decomposition is used to treat nitrous oxide emissions from adipic acid production processes; and thermal oxidation approach is adopted to capture and remove HFC-23. In the agricultural sector, a range of technical measures has been deployed, e.g. high-yield rice varieties with lower emissions, intermittent paddy field irrigation, improved ruminant animal breeds, intensive livestock management, and biogas from treatment of livestock and poultry manures. Moreover, the soil test-based fertilization across country has been practiced. In waste treatments, the urban waste-disposal standards have been improved; a fee-charging system for household waste treatment has been established; advanced waste incineration technologies have been deployed; and incentive policies have been formulated to promote landfill gas recovery. During the 12th FYP period, China will strictly control overall expansion of metallurgical and building material manufacturing industries, accelerate pilot projects for circular economy in industry and other key sectors, enhance the technologies used for nitrous oxide recovery and control, expedite innovation and deployment of agricultural bio-breeding technologies, develop and improve a waste sorting and recycle system.

(6) Establishing and improving innovative institutions and mechanisms to enhance GHG emission control. In its climate change mitigation practice, China continues to make innovations in management systems and work mechanisms, to gradually establish and improve GHG emissions control-related statistical accounting and evaluation systems as well as market-based mechanisms. In 2005, the relevant departments formulated and implemented the *Measures for the Operation and Management of Clean Development Mechanism Projects*. By the end of 2010, the Chinese government approved 2847 CDM projects, 1186 of which were successfully registered in the Executive Board of the United Nations Clean Development Mechanism, accounting for 42.7% of the total. The Chinese government encourages trading of voluntary GHG reductions, and it has started to launch carbon emission trading in selected areas on a pilot basis. In 2008, the National Bureau of Statistics of China set up the

Department of Energy Statistics to enhance its energy statistical work. During the 12th FYP period, China will further accelerate system and mechanism buildup for climate change mitigation. It will set up and improve its GHG emission statistical accounting systems, it will explore to set up the low-carbon product standards, labeling and certification systems, and gradually establish a carbon emission trading market.

5. Other Relevant Information on Achieving Targets of the Convention

The essential tasks proposed in the *China's National Climate Change Programme* are to enhance climate system observations, to accelerate scientific research and technological development in field of climate change, to increase financial inputs in scientific and technological work related to climate change, to strengthen public education, communication and training on climate change, to encourage public participation, to increase people's awareness of climate change, and to pursue extensive international cooperation and exchanges on climate change. These tasks are also the important activities of the Chinese government for effectively implementing the Convention.

China has put in place an integrated climate observing system that combines land-based, airborne, space-based and sea-based components, and is self-contained and basically well distributed. Currently, the Chinese meteorological department has an automated observing network for measuring basic surface weather elements, which is composed of 2419 surface stations at national level. The China's agrometeorological observation network consists of 653 stations to observe crop, soil and phenology etc. China has a terrestrial hydrological observation network consisting of 39,800 stations. There are nearly 40 field stations for ecological observations across the country. The Chinese oceanic department has deployed 107 offshore ocean observing stations and 24 buoys to monitor any abnormal changes in sea level and marine environment. The Chinese meteorological, oceanic and hydrological departments have enhanced collection and management of observations on the climate system, and they have also archived a large quantity of valuable proxy paleoclimate data. However, overall, China's integrated climate observing system is still inadequate to a certain extent: (1) the ground-based stations are unevenly distributed, being dense in east and sparse in west; (2) its integrated observing capability, stability, reliability and automation level need to be further improved; (3) the rapid urbanization pace has evidently compromised representativeness of the ambient environment surround the observing stations; (4) the climate parameters derived from satellite remote sensing are limited in number and short in time series. In the future, China will further enhance planning and construction of the national climate system observations, strive to improve the automation level of climate observations, strengthen construction of a new network of national reference climate stations, improve the satellite observing capabilities, accelerate development of an urban climate observing system, and actively involve in international cooperation in climate system observations.

China has enhanced scientific and technological advances and innovations in the field of climate change, and it has actively promoted international scientific and technological cooperation. In 2006, the Chinese government issued the *National Guideline for Medium- and Long-term Plan for Scientific and Technological Development (2006-2020)*, in which the global environmental change monitoring and response strategies were clearly defined as one of the priority themes. In 2007, the *China's Scientific and Technological Actions on Climate Change* was issued. The implementation of the *National Basic Research Program* (P 973) and its supportive projects has enhanced the basic scientific research on climate change. The implementation of the *National Key Science and Technology R&D Program* and the *National High Technology Research and Development Program of China* (P 863) has accelerated technological R&D for climate change mitigation and adaptation. The implementation of the energy-saving and new-energy demonstration projects (e.g. '10 Cities with 1,000 New Energy Vehicles', '10 Cities with 10,000 LED Lamps' and 'Golden Sun') has facilitated new technology demonstration and industrialization. The international cooperation in climate change science and technology on a bilateral, multilateral and South-South basis has seen a rapid progress. In the 11^{th} FYP period, the accumulative inputs from the state-led S&T programs in the research on energy conservation, emission reduction and climate change exceeded RMB 13 billion *Yuan*, having supported more than 150 R&D projects. A number of internationally recognized findings on climate change patterns, mechanisms, regional climate change response and interactions with human activities have been obtained. Currently, there are still some inadequacies in scientific research in the field of climate change in China, which are mainly found in the following aspects: the basic research lags behind in time; comprehensive research is inadequate; modeling tools and research methodologies are less innovative; and researches in support of the core technologies in coping with climate change are still insufficient. In the future, China will enhance the climate change research, observations and impact assessments, and accelerate the research, development and deployment of low-carbon technologies.

China attaches great importance to public education and outreach on climate change in an effort to increase public awareness of climate change. China has incorporated the climate change knowledge into the national education system for the basic education, adult education and higher learning education as a quality-oriented education component. As early as in 2002, a number of websites on climate change was set up, including the China Climate Change Information Website. Since 2007, a TV and a brochure series entitled *Coping with Climate Change – China in Action* are produced annually in four languages (Chinese, English, French and Spanish). Since 2008, China issues a white paper or annual report entitled *China's Policies and Actions to Address Climate Change,* which elaborates the progress and latest findings in coping with climate change. China has hosted high-level conferences, forums and workshops on climate change. In 2008, the Chinese government and the United Nations co-sponsored the High-level Conference on Climate Change: Technology Development and Technology Transfer. Premier Wen Jiabao addressed the meeting at its opening ceremony. In 2010, China successfully hosted the United Nations Climate Change Conference in Tianjin. The Beijing Olympic Games 2008 adopted the *Green Olympics* as one of its themes, during which the green, environment-friendly and low-carbon practices were outreached. The Shanghai World Expo 2010, which themed ‘Better City, Better Life’, launched the ‘Green Travel Card’, ‘Voluntary Reduction for Expo’ and ‘Low-carbon Expo Forest’ among others. For recent years, China has witnessed increasingly emerging NGOs in the field of climate change, which have played an important role in disseminating climate change knowledge, and in enhancing public awareness and participations.

China has enhanced the learning by and training on officials in an effort to improve their competence in understanding and tackling climate change. The Political Bureau of Communist Party of China (CPC) Central Committee convened two collective learning sessions on climate change in 2008 and 2010 respectively. Topics included the ‘global climate change and strengthening China’s capacity building for addressing climate change’, and ‘GHG emission control action targets to be met in China by 2020’, etc. When chairing the sessions, President Hu Jintao once emphasized the need to take more effective policies and measures, to fully enhance capacity building for addressing climate change, to take the responses to climate change as a major strategy for China’s economic and social development and a major opportunity to accelerate transformation of economic development modes and economic restructuring, and to further accomplish various work in tacking climate change, to ensure the China’s targets for GHG emission control will be met by 2020. The Standing Committee of the 11^{th} Chinese People’s Political Consultative Conference (CPPCC) organized a learning seminar on climate change and enhancing China’s capacity building for addressing it. The Party School of the Central Committee of CPC arranged a lecture themed ‘paying serious attention to challenges imposed by global climate change and enhancing China’s capacity building for dealing with climate change’, which was targeted to leaders of ministerial, provincial and prefecture levels as well as young and middle-aged managers under a training program. Training workshops were organized focusing on the ‘climate change, sustainable development and environmental management’, the ‘capacity building for provincial decision-makers on addressing climate change’, the ‘capacity building for local officials on CDM management’, the ‘capacity building in adaptation to climate change’, and the ‘capacity building for preparation of GHG inventory at a provincial level’, etc.

China has actively participated in external exchanges and project-based cooperation on climate change. Through its foreign aid projects on clean energy, agricultural drought- resistant techniques, water use and management, sustainable forest management, and capacity building for adaptation to climate change, China has helped other developing countries to enhance their capacities in addressing climate change. In 2004-2010, totally 115 projects were implemented or ongoing for assisting other developing countries in tackling climate change, with a total investment of around RMB 1.17 billion *Yuan*. For examples, they included establishments of agricultural technology demonstration centers in several African countries, the water conservancy facility reparation project in Parwan, Afghanistan, the solar power generation and solar water heater installation projects in Morocco and Lebanon, the water exploration and municipal water supply project in Niger, and the technical cooperation on rain-fed crop demonstration in Congo (Kinshasa). In the 11^{th} FYP period, 85 foreign aid and training projects were implemented, including technical training seminars on small-sized hydropower stations for African countries, water-soil conservation and rain-fed farming for African countries, solar energy applications, water-saving irrigation, forest conservation and exploitation in developing countries, CDM training workshops for African countries, rainwater collection and utilisation in developing countries, and climate system and climate change.

6. Needs for Funds, Technologies and Capacity building

Funds and technologies are essential for climate change mitigation and adaptation. The developed countries should fulfill their commitments by providing funds, technologies and supports in capacity building to the developing countries, which is the fundamental assurance for the developing countries to effectively address climate change. As China is a populous developing country with lower economic development level and vulnerable ecological environment, coal-dominated energy mix, and relatively backward technologies. Therefore, China requires huge financial investments and strenuous efforts to achieve national economic and social development goals, to actively cope with global climate change, and to effectively fulfill the commitments under the Convention. It is also necessary for the Annex-I Parties to provide support in terms of funds, technologies and capacity building, according to requirements of the Convention to improve China's capacity in coping with climate change.

Addressing climate change relies on technologies, technological innovations and technology transfer, which are the basis and underlying support for coping with it. As it is clearly stated in Clause 5 of the Article 4 in the Convention: "the developed country Parties and other developed Parties included in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention." The international community should establish an effective mechanism for technological cooperation and technology transfer to facilitate technology R&D, deployment and transfer in coping with climate change. The developed countries should fulfill their commitments by providing funds and transferring technologies to the developing countries, removing the obstacles that exist in policies, institutions, procedures, financial resources and protection of intellectual property rights for technology transfer, and taking incentive measures for technological cooperation and technology transfer, to ensure that the developing countries can access to affordable and usable advanced climate-friendly technologies. China is scaling up its infrastructure constructions, and it has strong demands for technologies to reduce GHG emissions. A list of technologies required by relevant sectors is given in the *China's National Climate Change Programme.*

Capacity building is crucial for the developing countries to effectively cope with climate change. The Fifth Conference of Parties of the Convention endorsed the decision on capacity building for the developing countries, emphasizing that the capacity building shall mainly focus on the developing countries, reflecting their priority requirements, being implemented in them. It also decided that the financing mechanism of the Convention should provide financial and technological supports for the developing countries. The *Marrakech Accords* put forward in more details the framework of capacity building for the developing countries, in which a preliminary scope for capacity building required by the developing countries was outlined. As a developing country, China has stronger demands for capacity building in preparation of the national GHG inventory, establishing a statistical system for GHG emissions, using market mechanisms to control GHG emissions, enhancing adaptation to climate change, and improving decision making for addressing climate change at local level. China is willing to carry out practicable cooperation in order to further enhance its capability in dealing with climate change.

7. Basic Information of the Hong Kong Special Administrative Region on Addressing Climate Change

Hong Kong is a Special Administrative Region (SAR) of the People's Republic of China. It is a city with a mild climate zone, scarce natural resources, high population density and well-developed service sector, being full of vibrancy. Hong Kong is also a world-renowned international finance, trade and shipping center. Hong Kong covers a land area of 1,104 km^2, with an annual mean temperature of 23.1°C and annual average precipitation of about 2,380 mm. In 2005, Hong Kong's population was about 6.84 million. Its Gross Local Product (GLP) then was approximately 1.43 trillion HK dollars and the per capita GLP was 210,000 HK dollars, with an economy dominated by the tertiary industry. There is barely any local primary energy production in Hong Kong; however the city's primary energy demand in 2005 was equivalent to 20.06 Mtce. Hong Kong has a diversified and efficient public transportation system, whose average daily number of passengers in 2005 accounted for 90% of the city's total. The Hong Kong SAR Government is committed to promoting the work in response to climate change. In 2007, an Interdepartmental Working Group on Climate Change was set up, comprising 5 bureaus and 17 departments or offices, and it has been led by the Environmental Protection Department since then.

The reporting scope of the 2005 GHG Emissions Inventory of Hong Kong covers energy activities, industrial processes, agricultural activities, land use change and forestry as well as waste treatment. The greenhouse gases it reports include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). The inventory has made references to the *Revised 1996 IPCC Guidelines*, the *IPCC Good Practice Guidance* and the *2006 IPCC Guidelines*. In 2005, the total GHG emission in Hong Kong was 41.565 Mt CO_2 eq, of which approximately 412 Kt CO_2 were absorbed by sinks in land use change and forestry, and the total net GHG emission was about 41.153 Mt CO_2 eq. Among the total GHG emission, CO_2 was about 38.12 Mt, accounting for 91.7% of the total; methane was about 2178 Kt CO_2 eq, accounting for 5.2%; nitrous oxide was around 399 Kt CO_2 eq, accounting for 1.0%; and other GHG gases were about 868 Kt CO_2 eq, accounting for 2.1%. The energy activities are the major GHG emission sources in Hong Kong, accounting for about 92.4% of the total, followed by waste treatment, industrial processes and agricultural emissions. It is projected that the future total GHG emission in Hong Kong will remain stable and gradually decline.

In 2010, the Hong Kong SAR Government accomplished its first assessment on the climate change impacts, vulnerability and adaptability. The available observations and assessments show that the trend of climate change in Hong Kong is basically consistent with the global one. The annual mean temperature increased at a rate of 0.12 °C per decade in 1885-2009; Significant sea level rise was observed at the Victoria Harbor of Hong Kong in 1954-2009, with a mean rising rate of 2.6 mm per year; it is projected that the annual mean air temperature in 2090-2099 will be about 4°C-5°C above 23.1°C, the mean value in 1980-1999; and the average annual precipitation will increase by approximately 11% in the late 21^{st} century. Hong Kong's most vulnerable segments to climate change impacts are biodiversity and nature conservation, building environment, infrastructure, business & industries, energy supply, food supply & security, sanitation & health, and water resources. The Hong Kong SAR Government has vigorously pursed the capacity building for climate change adaptation, reinforced infrastructure construction in adaptation to climate change, and established relevant work mechanisms. To further enhance the capacity for climate change adaptation, the SAR Government will further intensify surveys, research, capacity and institutional building, disaster management and public outreach, etc.

Hong Kong always pays great attention to climate change mitigation. It will make a positive contribution to the effective GHG emission control through policies and actions, e.g. adjusting the energy mix, improving energy efficiency, developing low-carbon transport system, fostering green and low-carbon communities, and making stronger efforts in afforestation. In 2010, the SAR Government launched public consultations on the climate change strategy and action agenda, including the recommended voluntary action target for reducing the carbon intensity by 50-60% by 2020, compared with the 2005 level; and it put forward a series of measures for reducing GHG emissions. In 2008, the SAR Government prepared the *Guidelines to Account for and Report on Greenhouse Gas Emissions and Removals for Buildings in Hong Kong*, and signed a new *Scheme of Control Agreement* with two power companies, adding relevant provisions on GHG emission reduction. In 2009, the SAR Government launched the *Building Energy Efficiency Funding Scheme* to assist private owners in making comprehensive energy and carbon audits and energy-efficiency projects for their buildings. While improving the public transportation system and intensifying infrastructure constructions, Hong Kong has also taken policies and measures for promoting use of electric vehicles, adjusting or shortening transport routes, and abating taxes. Hong Kong advocates for resource conservation, reduction of discards and green lifestyle. Each year, a region-wide greening scheme is planned, for which totally 23 country parks and 17 special areas have been identified. In 1990-2008, CO_2 emission per unit of GDP declined by around 43% in Hong Kong.

Hong Kong has launched a wide range of activities to enhance climate system observation and research, climate change-related education, outreach, training, and to encourage public participation, in order to raise public awareness of climate change, and to broaden regional and international cooperation and exchanges. For many years, the Hong Kong Observatory has been making climate change observations and research, and the Hong Kong Environmental Protection Department has set up an air quality monitoring network that consists of 14 air quality monitoring stations. Hong Kong joined the C40 Large Cities Climate Leadership Group in 2007, and launched the 'Green Hong Kong • Carbon Audit' campaign in 2008, to encourage all social communities to conduct carbon audit and carbon reduction activities for their buildings. In 2010, Hong Kong hosted the International Conference on Climate Change under the theme of 'Low Carbon Cities' in conjunction with the C40 Forum. Hong Kong also expects supports from the international community in funds, technologies and capacity building.

8. Basic Information of the Macao Special Administrative Region on Addressing Climate Change

Macao is a Special Administrative Region of the People's Republic of China. It is a city with mild climate, scarce natural resources, high population density and well-developed gaming industry, full of vibrancy, and it is also a world famous leisure center for tourists. In 2005, Macao's land area was 28.2 km^2. The annual mean temperature in Macao is 22.4°C, and its annual average precipitation is 2,133.4 mm. 98% of the city's water supply comes from the *Xijiang* River, a tributary of the Pearl River. In 2005, Macao's total population was 484,000; its Gross Local Product (GLP) was 92.19 billion Patacas, and its per capita GLP was 194,000 Patacas. The lottery industry, financial service, hotel & catering services and manufacturing are the pillar industries in Macao's economy. In 2005, Macao's total primary energy consumption was equivalent to 854 Ktce, of which heavy oil accounted for 56.9%. The Macao SAR Government has always attached great importance to climate change, and it has organized various governmental departments to deal with climate change in synergy.

The reporting scope of the Macao's 2005 GHG Emission Inventory covers energy activities and urban waste treatment. The reported greenhouse gases include CO_2, CH_4 and N_2O. The inventory has mainly used the methodologies provided in the *Revised 1996 IPCC Guidelines*, and the *IPCC Good Practice Guidance*. In 2005, the total GHG emissions in Macao was 1.803 Mt CO_2 eq, of which the emission from the energy activities accounted for 98.3%, and the emission from the waste treatments accounted for 1.7%. The total emissions of CO_2, CH_4 and N_2O were 1.757 Mt, and 19 Kt CO_2 eq and 27 Kt CO_2 eq, accounting for 97.4%, 1.1% and 1.5% of the total GHG emission respectively.

Macao began to make assessments on climate change impacts in the late 1990s; and currently the relevant assessment work is still in an initial stage. Temperature changes in Macao in 1901-2007 was basically consistent with the global trend; although the last 100-year linear climate warming trend showed a temperature increase by 0.66°C, the warming rate has been intensified since 1970s. No significant inter-annual precipitation changes have been detected in Macao, and precipitation increases by about 51.2 mm per decade. More precipitation was observed in the 1970s, during which precipitation increase was most significant in summers. The future mean temperature will continue to show a warming trend in Macao, and by the end of the 21st century, Macao's mean temperature will increase by 1.4°C-4.1°C relative to 1971-2000. The sea level rises at a rate of 1.25 mm per year on average in Macao, which has been increased over the last 50 years, rising approximately by 2.2 mm per year. In the past century, Macao was severely hit by 8 strong storm surges, 5 of which occurred in the last 20 years. It is projected that both severity and frequency of seawater intrusion due to astronomical tides will be exacerbated, and the chance of being affected by strong storm surges will possibly increase. Over recent years, some measures and actions have been taken in adaptation to climate change in Macao, e.g. increasing amount of raw water intake, raising the datum levels of new lands reclaimed from sea and new building foundations, and establishing a storm surge warning system.

Macao has always attached great importance to climate change mitigation, and it is committed to building low-carbon economy and society through implementation of such policies and actions as energy mix optimization, energy conservation, energy efficiency improvement, and preference to public transportation. In the Annual Report 2010 of the Macao SAR Government, the concept of 'building a low-carbon Macao, creating green living together' was initiated, and the target was set for reducing the local GHG emission intensity per unit of GDP by 40% -45% by 2020 compared with 2005 level. The *Public Sector Energy Efficiency and Conservation Plan* was released in 2007, and a plan for corridor lamp replacements in public buildings was implemented in 2008 to improve the lighting systems, and partial replacement of heavy oil by natural gas in power generation was formally realized. The proportion of natural gas in power generation rose from 16.2% in 2008 to 62.1% in 2010. In 2009, the *Technical Guidelines on Optimization of Energy Consumption in Buildings* was published, and campaigns to promote home-appliance energy labeling were launched. In 2010, the *Ideas for Macao's Overall Land Transport Policy (2010 -2020)* was released, by which it was planned to increase the proportion of public transport from 30% in 2009 to 50%-55% by 2020.

Macao has launched a series of activities to enhance climate system observations and research, climate change-related education, outreach and training, to encourage public participation, and to raise public awareness of climate change. Macao has set up a rather dense atmospheric and oceanic observation network, including 11 automatic weather stations. Macao has a long history in meteorological observations and it has created a century-long (1901-2000) dataset, which provides a solid basis for climate change research and other relevant studies. Macao has initiated the work to formulate relevant action plans for dealing with climate change. Macao highly values public outreach and education on climate change, which are regarded by the SAR Government as a work it strongly advocates and promotes. Since 2007, it has organized a range of activities, e.g. Carnival for Application of the *Kyoto Protocol* to Macao, and Essay Contest on Climate Change, Photography Contest -‘Our Climate’, and Macao Student Drawing Competition -‘Unite! We Combat Climate Change’. Macao also expects supports from the international community in funds, technologies and capacity building.

Part I National Circumstances

China is a country with a huge population, a relatively lower economic development level, complex climate and vulnerable eco-environment, and it is one of the countries which are most susceptible to adverse impacts of climate change. As the largest developing country in the world, the Chinese government has attached great significance to the issues of global climate change. It has set up a National Leading Group on Climate Change, and it has been actively addressing climate change as one of its key strategies for national economic and social development.

Chapter 1 Natural Conditions and Resources

The People's Republic of China is situated in the East Asia on the western coast of the Pacific, with a total land area of 9.6 million km^2. The country consists of 23 provinces (including Taiwan), 5 autonomous regions, 4 municipalities and 2 special administrative regions (Figure 1.1).

Figure 1.1 Administrative map of the People's Republic of China

1.1 Natural Conditions

1.1.1 Topography and Landforms

China's terrain is high in the west and low in the east with 3 tiered terraces in between, facing the Pacific from its easternmost coast. The highest terrace is the *Qinghai*-Tibetan Plateau with an average elevation of 4,000-5,000 m above the sea level, roughly accounting for 1/4 of the national total land. Across the plateau region lie many high mountains, glaciers, frozen soils and snow covers. Mt. *Qomolangma* (Everest), the highest peak in the *Himalaya* mountain range, is 8848.3 m above the sea level, known as top of the world. The second terrace extends north and east from the *Qinghai*-Tibetan Plateau to the *Yunnan-Guizhou*, Loess and Inner-Mongolian plateaus, with an average elevation declining to 2000-1000 m. In between the plateaus lie the *Sichuan*, *Tarim* and *Junggar* basins. The region starting from the east of the Greater *Khingan, Taihangshan, Wushan* and *Xuefengshan* mountains generally at an elevation below 500-1000 m to the eastern coast is the third terrace, where the *Liaodong*, *Shandong*, *Zhejiang-Fujian* and the *Guangdong-Guangxi* hills spread out, with the Northeast China plain and North China plain, Middle- and Lower–reach Yangtze plain and Pearl River Delta plain lying in between. Off the eastern coastline are the *Boha*i Sea (China's inner sea), Yellow Sea, East China Sea and South China Sea (marginal seas), and the water depths gradually increase from north to south. Off China's long coastline is a broad continental shelf (Figure 1.2).

China's topography is complex with varying landforms. Mountains, plateaus and hills account for 69% of the total land area, plains for 12%, and basins for 19%. The *Taklimakan* Desert in the northwest is one of largest deserts in the world.

Figure 1.2 A geomorphological map of China

1.1.2 Climate and climatic hazards

The country is classified into 3 climatic zones based on its natural geographic and climatic characteristics. The eastern China is one of the regions in the world where monsoon prevails, featuring 4 distinct seasons. Once monsoon behavior becomes abnormal, widespread droughts or floods will occur. To the south of the *Qinling* Mountain and the *Huaihe* River is a humid zone, while most Northeast and North China regions are semi-humid zones. The northwestern region is under a typical continental arid climate, cold in winter and warm in summer. Due to high elevation with its annual mean temperature mostly below 0°C, the *Qinghai*-Tibetan Plateau falls into a plateau climate category.

The temperature in China has significant seasonal variations which are mostly more intense compared with other parts of the world in the same latitudes. By temperature indicators, the country is divided from south to north into six belts, i.e. equatorial, tropical, subtropical, warm temperate, temperate and cold temperate zones.

The precipitation in China varies significantly in time and space. Rainfall mostly concentrates in summertime. Although warm temperature plus rainfall provide favorable conditions for agricultural productions, the seasonally concentrated and unevenly distributed precipitation often lead to floods or droughts. The annual precipitation varies largely from region to region, and it may range from over 1,500 mm in the southeastern coastal region, gradually declining inland, to less than 50 mm in the extremely dry regions in the Northwest.

China is subject to impacts of severe climate hazards. Featuring high frequency, intensity and wide exposure, they may cause huge direct losses. Since 1980s, the eastern China region has experienced a change in the precipitation pattern, causing inundations in the south and droughts in the north; and the northern China has been plagued by droughts for more than 20 years. Over recent years, both intensity and frequency of extreme weather and climate events have shown an increasing trend in most parts of the country, which have apparently worsened the hazards.

1.2 Natural Resources

1.2.1 Fossil energy and mineral resources

Although China possesses abundant fossil energy resources, the per capita possession is lower than world average level. In 2008, China's basic coal reserve was 326.144 billion tons, and the reserve bases of oil and natural gas were 2.89 billion tons and 3.404962 trillion m^3 respectively. The per capita reserve base of coal was equivalent to 70% of the world average level, but those of oil and natural gas were only about 1/15 of the world average.

More than 170 different mineral resources have been discovered in China, nearly 160 are proven reserves, of which 10 are energy minerals, 54 are metal ores, 92 are non-metallic minerals, and 3 are mineral water, underground water and gas. China is among the forefront in coal, iron, copper, bauxite, lead and zinc reserves.

1.2.2 Land resources

The composition and distribution of China's land resources have the following three typical features: (1) the land types are complex and diverse. Arable lands, forests, grasslands, deserts and beach lands are distributed extensively across China, but the lands suitable for agriculture only account for 17.34% of the total land area; (2) the per capita cropland is little. In 2008, China's cropland area was 121.72 million hectares, or 0.093 hectare per capita; and (3) they are unevenly distributed. The Northeast China Plain, North China Plain, Middle- and Lower-reach Yangtze Plain, Pearl River Delta and Sichuan Basin are the areas where croplands mostly concentrate, grasslands are mainly distributed in the northern and western China, and forests mainly concentrate in the Northeast, Southwest and South China.

1.2.3 Water resources

Within the territory of China, there are over 1500 rivers with the total area of catchments exceeding 1000 km^2. Most of them, including the Yangtze, Yellow, *Heilongjian*g, Pearl, *Liaohe*, *Haihe*, *Huaihe* and *Lancangjiang* rivers, flow into the Pacific, whilst the *Nujiang* and *Yalu Tsangpo* rivers run into the Indian Ocean, and the *Ertix* River in northwestern *Xinjiang* merges into the Arctic Ocean.

China is short of water resources, which are unevenly distributed in time and space. Its total annual surface water resource averaged in multiple years is 2.8 trillion m^3, and its per capita water availability is about 28% of the world average. The total volume of water resources in the northern region which is dominated by the *Songhua*, *Liaohe*, *Haihe*, Yellow, *Huaihe* river basins plus those in the Northwest China is 595.1 billion m^3, accounting for 21.2% of the country's total; in contrast the total water volume in the southern region dominated by the Yangtze River (including *Taihu* Lake) and the Pearl River basins including those in southeast and southwest is 2.2102 trillion m^3, accounting for 78.8% of the national total.

In 2008, China's annual average precipitation was 654.8 mm, equivalent to 6.2 trillion m^3 in total, which was about 20% less than the global annual average precipitation over land. River runoff totaled 2.7115 trillion m^3, of which the precipitation supply accounted for 71%, groundwater recharge for 27%, and ice/snow melt water supply for 2%. Being virtually consistent with the precipitation pattern, the river runoff distribution showed a gradual decline from the southeast coast to the northwest inland regions, ranging from 1800-2000 mm to only 50 mm in runoff depth, even below 10 mm in deserts.

The theoretical potential of annual hydropower resources in the Mainland China is 6.0829 trillion kWh; the technically exploitable installed capacity is 541.64 GW; and the annual hydropower generation capacity is 2.474 trillion kWh. China's exploitable hydropower resources are mainly distributed in the southwest, mostly in *Sichuan*, Tibet and *Yunnan*, where the technically exploitable installed capacity accounts for 61% of the national total. The technically exploitable hydropower capacity from rivers mainly concentrates in the catchments of the Yangtze River, *Yalu Tsangpo* River and Yellow River, accounting for 47%, 13% and 7% of the national total respectively.

1.2.4 Forest resources

In 2008, China's forest area was 195.45 million hectares with the total standing stock volume of 14.9 billion m^3, among which the forest stock volume was 13.7 billion m^3, accounting for 92% of the total. The area of forests plantation had increased to 61.69 million hectares, and the total forest coverage reached 20.36%. The total area of woodlands was 83,000 hectares.

1.2.5 Marine resources

China's continental coastline extends beyond 18,000 km; the area of the coastal zones is 280,000 km^2; and the area of beach lands is 20,800 km^2. China has a wide variety of marine resources, e.g. abundant marine organisms, oil, natural gas, minerals, renewable energies, and resources for coastal tourism among others. Its marine organism resources are over 20,000 species including over 3,000 species of fish. The theoretical marine renewable energy reserve is 630 GW. There are more than 1,500 coastal sites of tourist attractions. The over

400-km deep-water shoreline provides more than 60 deep-water seaports. China has built 71 nature reserves for conservation of marine and coastal ecosystems as well as rare marine fauna and flora, with the total area of 822,000 hectares.

1.2.6 Biodiversity

China is one of the countries with the richest biodiversity in the world. It possesses nearly 35,000 species of higher plants, ranking third in the world; over 10,000 identified fungi varieties, accounting for 14% of the world total; and nearly 6,500 species of vertebrates, accounting 13.7% of the world total, among which 420 species have been listed in the National Key Protected Wildlife Catalogue as rare and endangered wild animals. Giant panda, crested ibis, golden monkey, Tibet antelope and dawn redwood, silver fir and ginkgo are China's unique wildlife and plants. China is also rich in germplasm resources of cultivated plants, domesticated animals and their wild relatives. It is the origin of rice, soybeans and other crops, and a major origin of some wild and cultivated fruit trees. China hosts 1,339 cultivated crops and 1,930 species of wild relatives, and its fruit-tree species rank first in the world. Meanwhile, China is also one of the countries with the richest domesticated animal species, totaling 576.

Chapter 2 Social and Economic Development

2.1 Social Development

2.1.1 Population

China is the most populous country in the world, and its population is unevenly distributed to a great extent. By the end of 2005, the total population in mainland China was 1.308 billion, accounting for 20.3% of the world total. By the end of 2010, the figure rose to 1.341 billion. The 11 eastern coastal provinces (municipalities or autonomous regions) accommodate 41.3% of China's total population on a land that only accounts for 11.1% of the national total with a population density of 518 people/km^2 in 2010. The 12 western inland provinces however host 27% of the total population in a vast area that accounts for 71.5% of the total land with a population density of 53 people/km^2 in the same year.

Since 1970s, China has implemented the family planning policy, which has brought the excessive population growth under control. The natural population growth rate declined from 25.83 ‰ in 1970 to 5.89 ‰ in 2005, which was significantly lower than the global average (11.9 ‰). In 2010, the rate further fell to 4.79 ‰ (Figure 1.3).

Figure 1.3 Changes of China's total population and natural growth rate (1980-2010)

With continual improvements of the Chinese people's living standards, educational, health and medical care level, the life expectancy has also been increased. The average life expectancy for men and women in 2005 were 70.83 and 75.25 years in age respectively, both were higher than the world average (Table 1-1). The proportion of the elderly population is gradually increasing. In 2000, the proportion of the Chinese population aged 60 or above was 10.33% of the total, compared with 13.26% in 2010.

Table 1-1 comparison of China's demographic indicators in 2005 with world average

	Natural growth rate (‰)	Birth rate (‰)	Mortality rate (‰)	Average life expectancy (male, age)	Average life expectancy (female, age)
China	5.89	12.4	6.51	70.83	75.25
World	11.9	20.32	8.32	66.17	70.38

Source: World Bank statistics database.

China's urbanization level is continuously rising. In 2005, it was 43.0% which was lower than the world average (48.7%). With economic and social developments, it is gradually increasing. In 2010 it rose to 49.95%.

2.1.2 Employment

In 2005, China's total employed population was 758.25 million. Breaking it down by the three industries, the employees in the primary, secondary and tertiary industries were 339.70 million, 180.84 million and 237.71 million, accounting for 44.8%, 23.8% and 31.4% of the total employed population respectively. By urban or rural household registry, the labor forces in urban and rural areas were 273.31 million and 484.94 million respectively, the ratio of urban to rural employees was 36.04:63.96.

Since 2000, China's new-born population has been kept around 17 million annually, with an average annual net growth of about 7 million. On annual average, more than 10 million urban people need jobs. Meanwhile, with advance of urbanization, each year more than 10 million rural labor forces move to urban areas.

In 2010, China's total employed population was 761.05 million, among which the primary, secondary and tertiary industries took 279.31, 218.42 and 263.32 million, accounting for 36.7%, 28.7% and 34.6% of the total respectively (Table 1-2). The ratio of urban to rural employees was 45.6:54.4.

Table 1-2 Changes of China's employment structure in 2005 and 2010

Year	Primary industry (%)	Secondary industry (%)	Tertiary industry (%)
2005	44.8	23.8	31.4
2010	36.7	28.7	34.6

2.1.3 Education and medical care

In 2005, there were 108.641 million primary school pupils and 85.809 million secondary school students receiving regular education, as well as 15.618 million university students in China. On average, the numbers of students in higher learning institutions, senior secondary, junior secondary and primary schools per 10,000 people were 161, 307, 478 and 836 respectively. In 2010, there were 99.407 million primary school pupils, 77.032 million secondary school students, and 22.318 million university students in China. The average numbers of students in higher learning institutions, senior secondary, junior secondary and primary schools per 10,000 people were 219, 350, 396 and 745 respectively. Over the past 30 years, China has seen a significant declining trend in illiteracy rate, which was 6.7% in 2000 compared with 4.08% in 2010.

In 2005, there were 882,000 health care facilities, 4.564 million health care workers and 3.368 million beds, and there were 15 doctors and 25 beds per 10,000 people in China. In 2010, there were 937,000 health care facilities, 5.876 million healthcare workers, and 4.787 million beds in China, and there are 18 doctors and 36 beds per 10,000 people. A large gap in health care and medical facilities still exists in China compared with the developed countries. (Table 1-3).

Table 1-3 Comparison of China's medical care infrastructure in 2005 compared with the average level of high income countries

	Number of doctors per 10,000 people	**Number of hospital beds per 10,000 people**
China	15.2	24.5
World average	13.8①	29.4
Average level of high-income countries	28.6①	59.5

Note: ① data of year 2009.

2.1.4 Population in poverty

Due to a relatively lower economic development level and larger differences in natural conditions, China has a large number of poor people living in rural areas. Since 1986, the Chinese government has taken a series of major measures for poverty reduction, and it has implemented the medium- and long-term programs including the *8-7 National Plan for Poverty Reduction* and the *Outline for Poverty Reduction and Development in China's Rural Areas (2001-2010)*. In 1978-2008, by the poverty line set by the Chinese Government, the absolute poor population in rural areas dropped from 250 million to 21.48 million, with 7.62 million people being lifted out of poverty on annual average.

In 2009, the Chinese government adjusted the poverty line by raising the minimum per capita annual income to RMB 1,196 *Yuan*, which was still below the World Bank's poverty line. According to the World Bank report entitled *From Poor Areas to Poor People: China's Evolving Poverty Alleviation Agenda*, in 2005 China still had 254 million people consuming less than $1.25 per day (in 2005 PPP), accounting for 19.5% of the total population. Currently, the poor people are mainly living in resource-scarcity areas under poor natural conditions, creating greater challenges to poverty eradication.

2.1.5 Environment protection

China is still under heavy pressure for environment protection. In 2005 alone, China emitted 25.49 Mt sulfur dioxide, 11.83 Mt soot, and 9.11 Mt industrial particles. The acid rain areas are mainly found to the south of the Yangtze River, and to the east of *Sichuan* and *Yunnan* provinces, accounting for more than 30% of the total national land. Through implementation of a series of technical and policy measures, in 2010, the sulfur dioxide emission fell to 21.85 Mt, which was lowered by 14.29% relative to 2005, and the soot and industrial dust emissions fell to 8.29 Mt and 4.49 Mt respectively. Areas that were severely affected by acid rain mainly concentrate, along the Yangtze River, on the region to the south of the river and regions to the east of the *Qinghai*-Tibet Plateau.

In 2005, the total wastewater discharge was 52.45 billion tons, among which the industrial wastewater was 24.31 billion tons and 91.2% was in compliance with national standards after treatment, and the household sewage discharge was 28.14 billion tons. In 2010, the total discharged wastewater increased up to 61.73 billion tons, of which the industrial wastewater was 23.75 billion tons and 95.3% reached national criteria through treatments, and the household sewage discharge was 37.98 billion tons. By taking a series of engineering and policy measures, China's total COD emission was 12.381 Mt in 2010, decreasing by 12.45% compared with 2005, and ammonia/nitrogen emission was 1.203 Mt, which was reduced by 19.69% relative to 2005.

In 2005, China generated 1.34449 Gt solid industrial wastes with a total discharged volumn of 16.547 Mt; the comprehensive waste utilization amount was 769.93 Mt with a comprehensive utilization rate of 56.1%. In 2010, the above figures and the percentage were 2.40944 Gt, 4.982 Mt, 161.772 Mt respectively, with the comprehensive utilization rate of 66.7%. In 2005, China cleaned up and removed 155.77 Mt household wastes, of which 80.51 Mt had been treated through environment-friendly landfills, composting and incinerations, accounting for 85.2%, 4.3% and 9.8% respectively, with a rate of household waste treatment reaching 51.7%. In 2010, the total household waste removal in China was 158.05 Mt, of which 123.18 Mt had been treated through environment-friendly landfills, composting and incinerations, accounting for 77.9%, 1.5% and 18.8% of the total respectively, with the rate of household waste treatment rising to 77.9%.

2.2 Economic Development

2.2.1 Economic development level

China is a developing country with a lower economic development level. In 2005, China's GDP was RMB 18.4937 trillion *Yuan* and the per capita GDP was 14,185 *Yuan*. In 2010, these two figures were RMB 40.1513 trillion *Yuan* and about RMB 30,015 *Yuan* respectively. In 2005-2010, China's GDP growth rate was 11.21% on annual average.

In 2005, China was the world largest agricultural producer of grain, meat, cotton, rapeseed and fruit, and it ranked first in production of crude steel, coal, cement, fertilizer and cotton cloth among other industrial products. The per capita crude oil, power generation and cereal production were below the world averages, but the per capita steel, cement, coal, fertilizer and meat production were above the world average levels.

2.2.2 Economic development structure and industrial development

2.2.2.1 Three-industry structure

In 2005, the proportions of the three industries in China's GDP were 12.1:47.4:40.5. In 2010, they were 10.1:46.7:43.2. The share of the primary industry declined by 2% relative to 2005, and that of the tertiary industry increased by 2.7% (Figure 1.4).

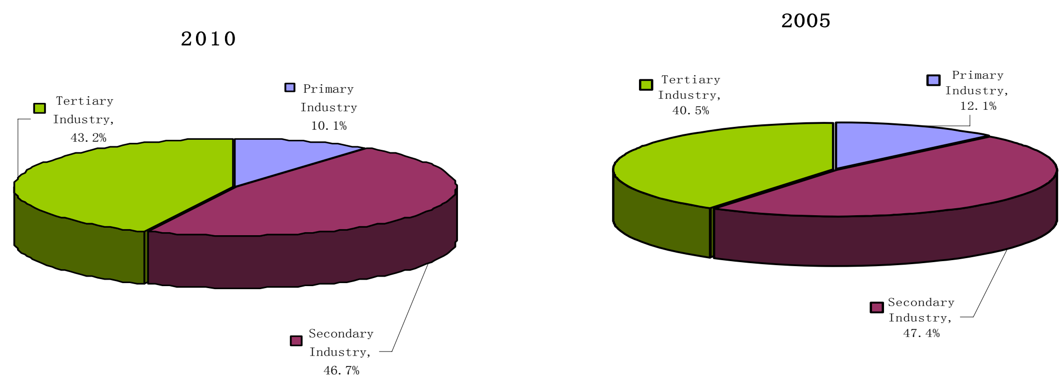


Figure 1.4 Structure of China's three industries

2.2.2.2 Agricultural development

In 2005, China's gross output of agriculture, forestry, livestock and fishery was RMB 3.9451 trillion *Yuan*, and the total crop planting area was 155.488 million hectares, of which the grain planting area was 104.278 million hectares, accounting for 67.07% of the total, and the grain output was 484.022 Mt. Rice planting is an important portion in China's farming. In 2005, rice planting area was 28.85 million hectares, accounting for 27.66% of the total grain planting area. In the same year, China raised 128.948 million heads of livestock, among which 109.908 million were cattle. In addition, there were 147 million goats, 151 million sheep and 433 million pigs. The total power of agricultural machinery of the year was 683.978 million kW, of which the total power of farming tractors was 189.544 million kW. The total consumption of chemical fertilizers was 47.662 Mt, including 22.293 Mt nitrogen fertilizers, accounting for 46.77% of the total.

In 2010, China's gross output from agriculture, forestry, livestock and fishery rose to RMB 6.93198 trillion *Yuan*, and the total cropping area was 160.675 million hectares, of which the grain planting area was 109.876 million hectares, accounting for 68.4% of the total, and the total grain yield increased to 546.48 Mt. In 2010, the livestock population was 122.39 million, among which 106.26 million were cattle. Additionally, there were 142 million goats, 139 million sheep and 465 million pigs. In 2010, the total agricultural machinery power was 927.86 GW, of which the total power of farming tractors was 284.45 GW. The fertilizer consumption in the year was increased to 55.617 Mt.

2.2.2.3 Industrial development

In 2005, China's gross industrial output (GIP) from scaled enterprises was RMB 25.16 trillion *Yuan*, in which the total output from light and heavy industries accounted for 31.1% and 68.9% respectively. In 2010, GIP was RMB 69.86 trillion *Yuan,* of which the total outputs of the light and heavy industries accounted for 28.6% and 71.4% respectively. In the industrial sector, the following 7 industries took the largest shares in GIP, i.e. textile, chemical materials & chemical product manufacturing, ferrous metal smelting & rolling, transportation equipment manufacturing, electrical machinery & equipment manufacturing, telecommunication, computer & other electronic equipment manufacturing, power & heat production and supply. In 2010, the total output from the 7 industries all combined accounted for 46.2% of the GIP.

In 2005, China's cement output was 1.069 billion tons, and that of cement clinker was about 674 Mt; the lime output was about 125 Mt, which were mainly used in construction, metallurgy, chemical industries among other sectors; the crude steel output was 353 Mt and pig iron output was 344 Mt; the calcium carbide output was about 8.9457 Mt (converted in 300L/kg). In 2010, the outputs of cement, crude steel and pig iron productions were 1.882 Gt, 637 Mt and 597 Mt respectively.

In 2005, China's primary energy production was equivalent to 2.162 Gtce; the coal production output was 2.35 Gt, accounting for 77.6% of the total primary energy production; crude oil production was 180 Mt, and natural gas production was 49.32 billion m^3, accounting for 12.0% and 3.0% respectively. The proportion of other energy resources (e.g. hydropower, nuclear and wind power) accounted for about 7.4%. In 2010, China's primary energy production was equivalent to 2.97 Gtce, among which the coal accounted for 76.5%, oil fell to 9.8%, and natural gas rose to 4.3%. The proportion of hydropower, nuclear and wind power among others all combined increased to 9.4%.

In 2005, China's total installed capacity for power generation was 517.185 GW, and in 2010 it rose to 966.41 GW. In 2005, China's power generation capacity was 2.50026 trillion kWh, of which 397.02 billion kWh were generated from hydropower plants, and 2.04734 trillion kWh from coal-fired power plants, accounting for 15.9% and 81.9% of the total power respectively. In 2010, China's total power generation capacity was 4.20716 trillion kWh, among which 722.17 billion kWh was generated from hydropower, 3.33193 trillion kWh from thermal power, 73.88 billion kWh from nuclear power, and 27.6 billion kWh from wind power, accounting for 17.2%, 79.2%, 1.8 % and 0.75% of the total power respectively.

2.2.2.4 Development of the tertiary industry

The added-value of the tertiary industry in China increased from RMB 7.49 trillion *Yuan* in 2005 to 17.31 trillion *Yuan* in 2010, coupled with a structural change (Table 1-4), but its structure was still dominated by the traditional services, e.g. transportation, warehousing and postal service, wholesale and retail, hotel and catering.

Table 1-4 Composition of China's added value of tertiary industry in 1994-2010

Unit: %

Industry	1994	2000	2005	2010
Transportation, warehousing and postal services	17.2	15.9	14.2	11.0
Wholesale and retail	23.3	21.1	18.6	20.7
Hotel and catering	6.2	5.5	5.6	4.7
Finance	13.8	10.6	8.1	12.1
Real estate	11.8	10.7	11.4	12.9
Others	27.6	36.2	42.0	38.7

China has established an integrated transportation network that is mainly composed of road, rail, aviation and water transport routes. In 1994-2010, the lengths of all routes had increased to a varying degree (Table 1-5).

Table 1-5 China's mileages of transport routes (1994-2010)

Unit: 10,000 km

Item	1994	2000	2005	2010
Railway mileage	5.9	6.9	7.5	9.1
National electrified railway mileage	0.9	1.5	1.9	3.3
Road mileage	111.8	140.3	334.5	400.8
Highways	0.2	1.6	4.1	7.41
Inland waterway mileage	11.0	11.9	12.3	12.4
Civil aviation routes	104.6	150.3	199.9	276.5
International routes	35.2	50.8	85.6	
Pipelines	1.7	2.5	4.4	7.85

Source: 2011 China Statistical Yearbook

In 2005, the passenger traffic in China reached 18.47 billion, and it rose to 32.695 billion in 2010, of which the proportion of railway passenger traffic continued to decline from 6.26%

in 2005 to 5.13% in 2010. Over the same period, the road passenger traffic increased from 91.9% to 93.37%. The passenger turnover in 2005 was 1.7467 trillion person-km, and it increased to 2.7894 trillion person-km in 2010, in which the percentage of railway passenger turnover declined from 34.71% in 2005 to 31.41%, but the road passenger turnover rose from 53.20% to 53.85%, and the civil aviation transport increased from 11.71% to 14.48%.

China's total cargo transport increased from 18.62 Gt in 2005 to 32.42 Gt in 2010, among which the road transport accounted for 75.5% of the total, followed by railway and water route transports, accounting for around 11.2% and 11.7% respectively. In 2005, the cargo turnover was 8.0258 trillion ton-km and it rose to 14.1837 trillion ton-km in 2010, among which the cargo turnover by railway declined from 25.8% in 2005 to 19.5% in 2010, the share of road transport increased from 10.8% to 30.6%, and that of water route transport fell from 61.9% to 48.2%.

2.2.3 Income and consumption levels

China's per capita income has shown a steady increase. In 2005, the per capita disposable income of urban households was RMB 10,493 *Yuan,* and the per capita net income of rural households was 3,255 *Yuan*. The per capita consumption expenditures of urban and rural residents were 7,943 *Yuan* and 2,555 *Yuan* respectively. The per capita residential building area of urban residents was 27.8 m^2 and the per capita housing area of rural residents was 29.7 m^2. The per capita residential electricity consumption was 221 kWh. In 2010, the per capita disposable income of urban residents was 19,109 *Yuan,* and the per capita net income of rural resident was 5,919 *Yuan*; the per capita consumption expenditure of urban or rural resident was 13,471 *Yuan* or 4,382 *Yuan*. The per capita residential building area of urban resident was 31.6 m^2, and the per capita housing area of rural resident was 34.1 m^2.

Spending on food takes a larger proportion in consumption expenditures of both urban and rural residents in China. In 2005, the Engel coefficient of urban residents was 36.7%, followed by educational, cultural and entertainment services, accounting for 13.8%. As spending on food also takes the largest proportion in the consumption expenditure of rural residents, the Engel coefficient was 45.5%, followed by housing on the one hand, and cultural, educational, recreational products and services on the other hand, accounting for 14.5% and 11.6% respectively. With continual improvement of people’s living standards, the number of durable consumer goods owned per household had increased significantly (Table 1-6).

Table 1-6 China's average urban household year-end possession of major durable consumer goods per 100 households

Item	1994	2000	2005	2010
Refrigerator	62.10	80.1	90.72	96.6
Color TV set	86.21	116.6	134.8	137.4
Air conditioner	5.00	30.80	80.67	112.1
Personal computer	-	9.7	41.52	71.2
Mobile phone	-	19.5	137	188.9
Family car	-	0.5	3.37	13.1

Source: 1995 China Statistical Yearbook; 2001 China Statistical Yearbook; 2006 China Statistical Yearbook; 2011 China Statistical Abstract.

2.2.4 Regional development

China's economic and social development varies largely from region to region. In 2005, the per capita GDP in the eastern coastal regions was RMB 23,530 *Yuan* compared with only 9,465 *Yuan* in the western regions accounting for 40.23% of the former. In 2010, the per capita GDP in the eastern coastal regions was 45,510 *Yuan*, and that in the western regions was 22,570 *Yuan* accounting for 49.59% of the former (Table 1-7). The development level in the eastern coastal regions is obviously higher than those in the central and western regions.

Table 1-7 Variations of development gaps among eastern, central and western China

Region	1994			2005			2010		
	GDP (100 million *Yuan*)	Percentage of national total (%)	Per capita GDP (*Yuan*)	GDP (100 million *Yuan*)	Percentage of national total (%)	Per capita GDP (*Yuan*)	GDP (100 million *Yuan*)	Percentage of national total (%)	Per capita GDP (*Yuan*)
Eastern	25,705	56.7	5,733	118,575	59.5	23,530	250,488	57.3	45,510
Central	11,206	24.7	2,799	46,545	23.4	11,174	105,146	24.1	24,871
Western	8,435	18.6	2,492	34,086	17.1	9,465	81,408	18.6	22,570

Source: 1995 China Statistical Yearbook; 2006 China Statistical Yearbook; 2011 China Statistical Yearbook.

2.2.5 Foreign trade

In 2005, China's total import and export value was 1.42191 trillion USD, accounting for 6.7% of the world total trade of the year, among which the total import was 659.95 billion USD and the total export was 761.95 billion USD. In 2010, China's total import and export value rose to 2.97276 trillion USD, of which the total export was 1.57793 trillion USD and the total import was 1.39483 trillion USD. From perspective of product mix, China's export commodities have been dominated by manufactured goods. The proportion of primary products shows an evident declining trend in its total export. In 2005, the proportion of industrial products in the total export was 93.6%. In 2010, it rose to 94.8% (Table 1-8).

Table 1-8 Variations of China's import and export product mix

Year	Total value of imports and exports (100 million USD)		Proportion of primary products (%)		Proportion of manufactured goods (%)	
	Import	Export	Import	Export	Import	Export
1994	1,156.1	1,210.1	14.26	16.29	85.73	83.71
2000	2,250.9	2,492.0	20.76	10.22	79.24	89.78
2005	6,599.5	7,619.5	22.38	6.44	77.62	93.56
2010	13,948.3	15,779.3	31.01	5.18	68.99	94.82

Source: 1995 China Statistical Yearbook and 2011 China Statistical Abstract.

In 2005, China had exported 71.68 Mt coal, 8.07 Mt crude oil and 20.52 Mt steel; and it had imported 26.17 Mt coal, 126.82 Mt crude oil, 31.43 Mt refined oil, and 275.23 Mt iron ore and ore concentrates. In 2010, China had exported 22.38 Mt coal, 3.03 Mt crude oil, 42.56 Mt steel; and it had imported 164.78 Mt coal, 239.31 Mt crude oil, 36.88 Mt refined oil, and 618.63 Mt iron ore and ore concentrates.

In 2005, foreign capital that had been actually used by China was 63.805 billion USD, among which foreign direct investment was 60.325 billion USD. In 2010, the foreign capital used by China rose to 108.8 billion USD, among which 105.73 billion USD were from direct foreign investments.

Table 1-9 China's basic facts in 2005

Indicator	**2005**
Population (10,000, by the end of the year)①	130,756
Land area (km^2)	9,600,000
Gross Domestic Product (100 million USD, 1USD=8.1917 RMB *Yuan*)	22,576
Per capita GDP (USD)	1,732
Estimation of the share of informal sectors in GDP (%)	Inestimable
The share of industry in GDP (%)②	42.0
The share of service sector in GDP (%)	40.0
The share of Agriculture in GDP (%)③	12.5
Area of land used for agricultural purposes (km^2)④	1,300,392
The percentage of urban population in the total population	42.99
Heavy livestock inventory (10,000 heads)	12,894.8
Cattle (10,000 heads)	10,990.8
Horse (10,000 heads)	740.0
Pig (10,000 heads)	43,319.1
Sheep (10,000 heads)	29,792.7
Forest land (10,000 km^2)	284.93
population in poverty (10,000 people)⑤	2,365
Life expectancy (Year)	70 for male，73 for female
Literacy rate (%)	90.92

Notes:

① Total population of mainland China, excluding population of Hong Kong and Macao special administrative regions and Taiwan Province;

② Industries include mining and quarrying, manufacturing, electricity, heat, gas and water production and supply, excluding building industry which accounts for about 5.5%;

③ Agriculture, including farming, animal husbandry, forestry, fishery and related service sector;

④ Arable area;

⑤ Per capita annual net income equal to or less than RMB 683 *Yuan* was the poverty line set by the Chinese government in 2005.

Chapter 3 National Development Strategies and Targets

China adopts a "three-step" strategy toward modernization. In the first two decades of this century, China will continue to thoroughly implement the scientific development concepts, the strategy of rejuvenating the country through science and education, the strategy of strengthening the nation with trained personnel, and the strategy of sustainable development. China will join all efforts to build a moderately prosperous society of higher level for the benefit of its over 1.3 billion people, turn China into a country which will have basically accomplished industrialization, with its overall strength significantly enhanced. China will be a country whose people are better off and enjoy a good ecological environment and more extensive democratic rights, showing higher ethical standards and looking forward to greater cultural achievements. The country will be more open and friendly to the outside world and make greater contributions to human civilization. Building on what is achieved at this stage and carrying it on for several more decades, China will have in the main accomplished the modernization program and turned itself into a strong, prosperous, democratic and culturally advanced socialist country by the middle of this century. The objectives of building a moderately prosperous society in all respects are to:

- promote balanced development to ensure sound and rapid economic growth. The development pattern will be significantly transformed. China will quadruple the per capita GDP of the year 2000 by 2020 through optimizing the economic structure and improving economic returns while reducing consumption of resources and protecting the environment. China will greatly enhance its capacity for independent innovation, enabling scientific and technological advancement to contribute much more to the economic growth and making China an innovative country. The proportion of urban residents will notably increase.
- expand socialist democracy to better safeguard the people's rights and interests as well as social equity and justice. Citizens' participation in political affairs will expand in an orderly way. The rule of law will be carried out more thoroughly as a fundamental principle, public awareness of law will be further enhanced, and new progress will be made in government administration based on the rule of law. Primary-level democracy will be improved. The government will markedly enhance its capability in providing basic public services.
- promote cultural development and notably enhance the cultural and ethical quality of the whole nation. Socialist core values will prevail among the people, and fine ideological and ethical trends will be encouraged. A basic system of public cultural services will cover the whole society, the cultural industry will account for much more of the national economy and become more competitive internationally, and more abundant supply of cultural products will be available to meet the people's needs
- accelerate the development of social programs and improve every aspect of the people's well-being. The modern system of national education will be further improved. The educational attainment of the whole nation will rise to a much higher level, and the training of innovative personnel will be improved markedly. Employment will be further expanded. A basic system of social security will cover both urban and rural residents so that everyone is assured of basic living standards. A reasonable and orderly pattern of income distribution will be basically in place. Everyone will have

access to basic medical and health care services. The system of social management will be further improved.

- promote a conservation culture by basically forming an energy- and resource-efficiency and environment-friendly structure of industries, model of growth and pattern of consumption. China will have a large-scale circular economy and considerably increase the proportion of renewable energy sources in total energy consumption. The discharge of major pollutants will be brought under effective control and the ecological and environmental quality will improve notably. Awareness of conservation will be firmly established in the whole of society.

In 2010, the National People's Congress approved the *Outline of 12th Five-Year Plan for National Economic and Social Development* (hereinafter referred to as the *Outline*). Taking the scientific development as the theme, accelerating the transformation of the economic development model as the cardinal line, and pursing green and low-carbon development as an important policy guideline, the *Outline* is a strategic document for guiding the China's economic and social development in the next 5 years. The major targets proposed in the *Outline* for the socio-economic development in the next period include: keeping annual GDP growth by 7% on average; increasing the added value of the tertiary industry in GDP by 4%; increasing spending on R&D up to 2.2% of GDP; keeping the total population within the limit of 1.39 billion; increasing the urbanization level by 4%; creating 45 million new jobs in urban areas; increasing both per capita disposable income of urban residents and per capita net income of rural residents by over 7%. For the first time, the *Outline* has taken the reduction of CO_2 emission intensity per unit of GDP by 17% as a binding target, and further specified the key tasks for GHG emission control, capacity building for climate change adaptation and extensive international cooperation among other aspects.

Chapter 4 National Climate Change Addressing Institutions

The Chinese government has attached great significance to climate change issues. It set up the *National Coordination Group on Climate Change* as early as in 1990. This body was restructured as the *National Coordination Group on Climate Change Response Strategies* in 1998. To enhance the leadership on issues related to climate change, China established the *National Leading Group on Climate Change* in 2007, which now consists of representatives from relevant ministries and institutions, and is mandated to develop major strategies, guidelines and policies on climate change, to take actions in response to climate change, to review the response plans for international cooperation and negotiations, and to coordinate and address the major issues in addressing climate change. *National Leading Group on Climate Change* is headed by Premier Wen Jiabao, and its office is hosted by National Development and Reform Commission (NDRC), which does the routine work for *National*

Leading Group on Climate Change. Since the institutional restructuring of the State Council in 2008, the *National Leading Group on Climate Change* composition has been extended from 18 to 20 departments, and the Department of Climate Change has been created under NDRC. In line with the *China's National Climate Change Programme*, almost all provincial governments have set up the Leading Groups on Climate Change, which are headed by provincial leaders, and composed of relevant local agencies. These groups are responsible for taking actions in response to climate change at local level, and executive bodies for addressing climate change have also been put in place under the Provincial Development and Reform Committees. Many governments at prefecture and county levels have also set up the leading groups on climate change and working bodies (Figure 1.5).

In support of the science-based national decision-making on climate change, China has established the National Panel of Experts on Climate Change, which provides scientific advisories and policy-relevant suggestions on strategies, guidelines, policies, legislations & regulations, and measures for coping with climate change.

China's National Leading Group on Climate Change

Composition:
Ministry of Foreign Affaires
National Development and Reform Commission
Ministry of Science and Technology
Ministry of Industry and Information Technology
Ministry of Finance
Ministry of Land and Resources
Ministry of Environmental Protection
Ministry of Housing and Urban-Rural Development
Ministry of Transport
Ministry of Water Resources
Ministry of Agriculture
Ministry of Commerce
Ministry of Health
National Bureau of Statistics
State Forestry Administration
Chinese Academy of Sciences
China Meteorological Administration
National Energy Administration
China Civil Aviation Administration
State Oceanic Administration

Provincial Leading Group on Climate Change

Composition:
Provincial Development and Reform Committee (PDRC);
Provincial Finance Department

Office of Leading Group on Climate Change:

Hosted by PDRC

National Leading Group on Climate Change Office: hosted by NDRC
Implementation Unit: Department of Climate Change, NDRC

Figure 1.5 Organizational structure of China's National Leading Group on Climate Change

In accordance with *National Leading Group on Climate Change*'s decisions, NDRC is responsible for preparing the *China's Second National Communication on Climate Change*, and it has organized relevant institutions in preparation of the *National GHG Inventory 2005* (Table 1-10).

Table 1-10 Institutions engaged in preparation of National GHG Inventory 2005

Department/institution	Responsibility
National Development and Reform Commission	Overall responsibility
Energy Research Institute, NDRC	GHG inventory for energy activities, and buildup of GHG inventory database
Tsinghua University	GHG inventory for industrial processes
Chinese Academy of Agricultural Sciences, and Institute of Atmospheric Physics, CAS	GHG inventory for agricultural activities
Chinese Academy of Forestry	GHG inventory for forestry
Chinese Academy of Environmental Sciences	GHG inventory for waste treatments

To enhance the overall guidance on preparation of the *National Communication*, NDRC has set up a Project Steering Committee, which is composed of representatives from NDRC, Ministry of Foreign Affairs, Ministry of Finance, Ministry of Science and Technology, Ministry of Environment Protection, National Bureau of Statistics, China Meteorological Administration among others. The Department of Climate Change established a Project Management Office for the *National Communication* to supervise and manage the implementation of the project.

Part II National Greenhouse Gas Inventory

At its eighth session, the Conference of the Parties of the United Nations Framework Convention on Climate Change (UNFCCC) adopted the guidelines for preparing national communications from non-Annex I Parties in its Decision 17/CP.8. In accordance with the guidelines and China's actual circumstances, the reporting scope of the National Greenhouse Gas Inventory 2005 in the Second National Communication on Climate Change of China mainly covers the following five sectors: energy activities, industrial processes, agricultural activities, land use change and forestry, and waste treatment, reporting six types of greenhouse gases (GHG): carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Compared with the National Greenhouse Gas Inventory 1994, the estimated GHGs were extended from three to six types, and the scope of GHG emission sources has further expanded in all these sectors.

To develop the National Greenhouse Gas Inventory 2005, the relevant institutions have mainly adopted the methodologies provided in the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (hereafter referred to as the *Revised 1996 IPCC Guidelines*) and the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (hereafter referred to as the *IPCC Good Practice Guidance*), and they have also referred to the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (hereafter referred to as the *2006 IPCC Guidelines*). Based on China's actual circumstances, taking into account identifications of emission sources, determination of key emission sources, availability of activity data and emission factors among others, the institutions involved in preparation of the inventory have analyzed the applicability of IPCC methods to China to ensure consistency and comparability of the GHG inventories.

Chapter 1 National Greenhouse Gas Inventory 2005

1.1 Overview

In 2005, China's total GHG emission was approximately 7.467 Gt CO_2 eq (Table 2-1), of which carbon dioxide accounted for 80.03%，methane for 12.49%, nitrous oxide for 5.27%, and fluorinated gases for 2.21% respectively (Table 2-2). The total net GHG remove through land use change and forestry was about 421 Mt CO_2 eq. Therefore, by deducting the remove, China's total net GHG emission in 2005 was around 7.046 Gt CO_2 eq, of which carbon dioxide accounted for 78.82%, methane for 13.25%, nitrous oxide for 5.59% and fluorinated gases for 2.34% respectively.

Table 2-1 China's Total GHG Emissions in 2005

Unit: 10^4 t CO_2 eq

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Total GHG emission	**597,557**	**93,282**	**39,370**	**14,890**	**570**	**1,040**	**746,709**
Energy activities	540,431	32,403	4,030				576,864
Industrial processes	56,860		3,410	14,890	570	1,040	76,770
Agricultural activities		52,857	29,140				81,997
Waste treatment	266	8,022	2,790				11,078
Land use change and forestry	-42,153	66	7				-42,080
Total net GHG emission (including land use change and forestry)	**555,404**	**93,348**	**39,377**	**14,890**	**570**	**1,040**	**704,629**

Note: For Global Warming Potentials (GWP), their 100-year values given in the IPCC Second Assessment Report are adopted (Table 2-3)。

Table 2-2 Composition of China's GHG emissions in 2005

	Including land use change & forestry		**Excluding land use change & forestry**	
GHGs	Carbon dioxide equivalent (in 10^4 t CO_2 eq)	Share (%)	Carbon dioxide equivalent (in 10^4 t CO_2 eq)	Share (%)
Carbon dioxide	555,404	78.82	597,557	80.03
Methane	93,348	13.25	93,282	12.49
Nitrous oxide	39,377	5.59	39,370	5.27
Fluorinated gases	16,500	2.34	16,500	2.21
Total	**704,629**	**100**	**746,709**	**100**

Note: Being rounded to nearest whole numbers, the sums of all percentages may slightly differ from the totals.

Table 2-3 100-year Global Warming Potentials for the Greenhouse Gases in the Inventory

GHG Types	100-year GWP	GHG Types	100-year GWP
CO_2	1	HFC-152a	140
CH_4	21	HFC-227en	2,900
N_2O	310	HFC-236fa	6,300
HFC-23(CHF_3)	11,700	HFC-245fa	560
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		

By GHG types, China's net emissions of carbon dioxide, methane and nitrous oxide were 5.554 Gt, 44.45 Mt and 1.27 Mt respectively in 2005, totaling 6.881 Gt CO_2 eq (Table 2-4). Among the fluorinated gasses, the hydrofluorocarbon, perfluorocarbon and sulphur hexafluoride emissions from industrial processes were 5.053, 8.249 and 4.367 Mt respectively, totaling 165 Mt CO_2 eq (Table 2-5).

From sectoral perspective, excluding land use change and forestry, the China's GHG emissions from energy activities, industrial processes, agricultural activities and waste treatments were 5.769 Gt CO_2 eq, 768 Mt CO_2 eq, 820 Mt CO_2 eq and 111 Mt CO_2 eq respectively in 2005, accounting for 77.27%, 10.26%, 10.97% and 1.50% of the total emission accordingly (see Figure 2.1).

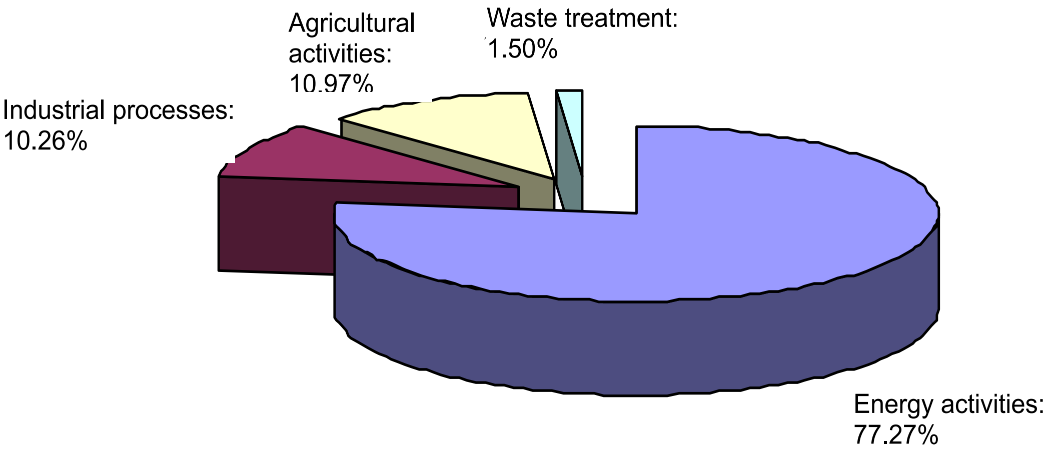


Figure 2.1 Composition of China's GHG emission sectors in 2005 (excluding Land Use Change and Forestry)

In addition, the carbon dioxide emission from China's international bunker fuels (international aviation and navigation) was about 21.17 Mt in 2005.

Table 2-4 China's carbon dioxide, methane and nitrous oxide inventory 2005

Unit: 10^4 t

GHG source and sink categories	CO_2	CH_4	N_2O
Total national emission (net emission)	555,404	4,445	127
1. Energy activities	540,431	1,543	13
A. Fuel combustion	540,431	229	13
(1) Fuel production, processing and conversion	240,828		3
(2) Manufacturing industries and construction	211,403		
(3) Transport	41,574	13	4
(4) Business	13,680		
(5) Residents	26,273		
(6) Agriculture	6,673		
(7) Biomass combustion (for energy uses)		216	6
B. Fugitive emissions from fuels		1,314	
(1) Oil and natural gas systems		22	
(2) Coal mining		1,292	
2. Industrial processes	56,860		11
A. Cement	41,167		
B. Lime	8,562		
C. Iron and steel	4,695		
D. Calcium carbide	1,032		
E. Limestone and dolomite uses	1,404		
F. Adipic acid			6
G. Nitric acid			5
3. Agricultural activities		2,517	94
A. Enteric fermentation		1,438	
B. Manure management		286	27
C. Rice cultivation		793	
D. Agricultural lands			67
4. Land-use change and forestry	-42,153	3.1	0.02
A. Change in forest and other woody biomass stocks	-44,634		
B. Forest conversion	2,481	3.1	0.02
5. Waste treatment	266	382	9
A. Solid waste disposal on land		220	
B. Wastewater treatment		162	9
C. Waste incineration	266		
Memo items			
International aviation	995		
International navigation (marine)	1,122		

Notes:

1. Being rounded to nearest whole numbers, the sums of all percentages may slightly differ from the totals.
2. CO_2 emissions from bunker fuels are not counted in the total emission.

Table 2-5 China's hydroflurocarbon, perflurorocarbon and sulphur hexafluroride emissions in 2005

Unit: 10^4 t

GHG source and sink categories	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 national emission (net emission)	0.9	0.4	0.4	1.4	0.1	1.1	0.1	246.5*	254.4*	733.4*	91.5*	436.7*
2. Industrial processes	0.9	0.4	0.4	1.4	0.1	1.1	0.1	246.5*	254.4*	733.4*	91.5*	436.7*
A. semi conductor	4.4*									22.5*	0.7*	2.4*
B. ODS production and utilization		0.4	0.4	1.4	0.1	1.1	0.1	246.5*	254.4*			
C. chlorodifluoromethane	0.9											
D. aluminum										710.9*	90.8*	
E. magnesium												21.8*
F. manufacturing equipments for power transmission and distribution												412.5*

Note:

1. The data with asterisks are expressed in metric ton.

1.2 Carbon Dioxide Emissions

Energy activities and industrial processes dominate China's carbon dioxide emissions. In 2005, China's CO_2 emissions were 5.976 Gt, of which the emission from the energy activities was 5.404 Gt, accounting for 90.4%, the emission from industrial processes was 569 Mt, accounting for 9.5%, and the emission from incineration of solid wastes of mineral origins was 2.658 Mt, taking a tiny share only. Nevertheless, the net CO_2 remove through land use change and forestry was 422 Mt. In 2005, China's net CO_2 emission was 5.554 Gt.

1.3 Methane Emissions

China's methane emissions are mainly from agriculture, energy and waste treatment. In 2005, China's methane emissions were 44.455 Mt, of which the emission from agricultural activities was 25.169 Mt，accounting for 56.62%, the emission from energy activities was 15.429 Mt, accounting for 34.71%, and that from waste treatments was 3.824 Mt, accounting for 8.60%. Furthermore, forest conversions also contributed to the methane emission to a less extent, which was about 31 Kt.

Table 2-6 China's methane emissions in 2005

Emission source categories	Methane (10^4 t)	Component (%)
Energy activities	1,543	34.71
Agricultural activities	2,517	56.62
Waste treatment	382	8.60
Land use change and forestry	3.1	0.07
Total	**4,445**	**100.00**

1.4 Nitrous Oxide Emissions

Although agriculture is the major source of nitrous oxide emissions in China, energy activities, industrial processes and waste treatments are also contributors to some extent. In 2005, China's N_2O emissions were about 1271 Kt, of which the emission from agricultural activities was 938 Kt, accounting for 73.79%, the emission from energy activities was 134 Kt, accounting for 10.54%, the emission from industrial processes was 106 Kt, accounting for 8.34%, the emission from waste treatments was 93 Kt, accounting for 7.32%, and that from land use change and forestry was 0.2 Kt, accounting for 0.01%.

Table 2-7 China's nitrous oxide emissions in 2005

Emission source categories	**Nitrous oxide (10^4 t)**	**Components (%)**
Agricultural activities	94	73.79
Energy activities	13	10.54
Industrial processes	11	8.34
Waste treatments	9	7.32
Land use change and forestry	0.02	0.01
Total	**127**	**100**

1.5 Fluorinated Gas Emissions

For the first time, the estimated anthropogenic fluorinated gas emissions mainly from industrial processes are reported in China's National Greenhouse Gas Inventory 2005. In 2005, China's fluorinated gas emissions from the industrial processes were about 165 Mt CO_2 eq.

Chapter 2 Greenhouse Gas Inventories by Sectors

2.1 Energy Activities

In 2005, China's total GHG emission from energy activities was 5.77 Gt CO_2 eq, of which the emission from fuel combustions was 5.494 Gt CO_2 eq, accounting for 95.2%, the fugitive emission was 276 Mt CO_2 eq, accounting for about 4.78%. Among the total, the CO_2 emission was 5.404 Gt, accounting for 93.7% of the total GHG emission from the energy activities; the CH_4 emission was 324 Mt CO_2 eq, accounting for about 5.6%; and the N_2O emission was 41 Mt CO_2 eq, accounting for around 0.7% (Table 2-8).

Table 2-8 China's GHG emissions from energy activities in 2005

Energy activities	**CO_2 (10^8 t)**	**CH_4 (10^4 t)**	**N_2O (10^4 t)**	**in CO_2 eq (10^8 t)**
1. Fossil fuel combustions	54.04	12.6	7.0	54.29
2. Biomass combustion	-	216.3	6.4	0.65
3. Fugitive emissions from coal mining	-	1,292.2	-	2.71
4. Fugitive emissions from oil and gas systems	-	21.8	-	0.046
Total	**54.04**	**1,542.9**	**13.4**	**57.70**

2.1.1 Reporting Scope

The reporting scope of China's 2005 inventory of GHG emissions from the energy activities covers two components: emissions from fuel combustions and fugitive emissions; the former includes fossil fuel and biomass combustions, with their CO_2, CH_4 and N_2O emissions being estimated; the latter includes CH_4 fugitive emissions from coal mining and post-mining activities, and from abandoned coal mines, as well as from oil and natural gas systems.

2.1.2 Methodologies

2.1.2.1 Fuel Combustions

The sectoral approach recommended in the *Revised 1996 IPCC Guidelines* is used to estimate China's CO_2 emissions from fossil fuel combustions in 2005, and the reference approach is used for verifications. The classification by sector and fuel variety is basically the same as that given in the *Revised 1996 IPCC Guidelines*, in which transport sector is defined as transport and transportation in the whole society, but somewhat differs from China's statistic scope. In this report, the emission sources from power generation and heat supply are defined as electricity and heat from public thermal power plants in China, and emissions from autonomous power plants and other heat suppliers are reported to associated sectors accordingly. The stationary sources include power-generation boilers, heat-supply boilers, industrial boilers and kilns, etc. The mobile emission sources include a wide range of road transportation vehicles, aircrafts, railway engines and shipping vessels among others. The activity data are mainly based on the energy statistics provided by the National Bureau of Statistics of China (NBSC), which are complemented with sectoral data, typical surveys and expert estimations. The emission factors are mostly based on the country-specific data that reflect China's actual circumstances. Taking into consideration China's coal-dominated energy mix, the institutions that involved in preparation of the inventory have launched special surveys on coal production quantities of individual coal mines, coal sales to individual sectors including coal quality, and carbon oxidation rate of main coal burners, to determine the potential and actual emission factors of coal combustions for different sectors. The CO_2 emission factors for other fossil fuels are based on the relevant data from NBSC or the default values from the *Revised 1996 IPCC Guidelines* and the *2006 IPCC Guidelines*.

Apart from CH_4 and N_2O emissions from fossil fuel combustions as well as N_2O estimates from power generation at stationary sites, CH_4 and N_2O emissions from mobile sources are also estimated for the first time. Depending on availability of the activity data and the emission factors, Tier 1 method from the *Revised 1996 IPCC Guidelines* is used to calculate N_2O emissions from power generations. IPCC sector-specific Tier 3 is utilized to calculate CH_4 and N_2O emissions from road transportations, and the Tier 1 method is used for other mobile sources.

Apart from estimation of CH_4 emissions from the biomass fuel combustions, N_2O emissions are also estimated for the first time. Depending on availability of emission factors, the IPCC sector-specific Tier 1 and Tier 2 methods are used respectively. For residential sector, as its activity level accounts for above 90% of all biomass combustion activities, therefore the emission factors for such major devices as fuel wood-saving stoves and traditional stoves, and for major fuels like crop residues and fuel wood have been derived from historical data and on-site tests among others, and the Tier 2 method is used to calculate their emissions. For other sectors, due to lack of relevant emission factors and rather limited activity data, The tier 1 method is used, and IPCC default values are also used for calculations.

2.1.2.2 Fugitive Emissions

Coal mining, post-mining activities and abandoned coal mines are the major sources of the fugitive CH_4 emissions from the energy activities. The fugitive CH_4 emissions from coal mining and post-mining activities in 2005 are estimated with the statistical data from China's coal industry using Tier 2 method (coal field averaging approach) in combination with Tier 3 method (*in-situ* mining well measuring approach) from the *Revised 1996 IPCC Guidelines*, and the *in-situ* measurements are the monitoring statistics from 15,000 wells. For the first time, the fugitive CH_4 emissions from abandoned wells are included in the inventory using the method recommended in the *2006 IPCC Guidelines*.

For the fugitive CH_4 emissions from oil and natural gas systems, Tier 1 method (production-based emission factor averaging approach) is used in combination with Tier 3 method (accurate specific emission source identification approach) from the *Revised 1996 IPCC Guidelines*. These emission factors have taken into account the IPCC default values and comparable emission factors from other countries for reference.

2.1.3 Emission Inventory

In 2005, China's CO_2 emissions from energy activities were 5.404 Gt, which were all originated from fossil fuel combustions. Among the CO_2 emissions, the energy production and conversion sectors emitted 2.408 Gt, accounting for about 44.55%, with significant increase in absolute emissions and shares compared with those in 1994; the emission from manufacturing and construction industries was 2.114 Gt, accounting for 39.11%; the emission from transport sectors was 416 Mt, accounting for 7.70%; the emission from the residential sector was 263 Mt, accounting for 4.87%; the emission from business sector was 137 Mt, accounting for 2.53%; and that from other sectors (agriculture) was 67 Mt, accounting for 1.24% (Table 2-2).

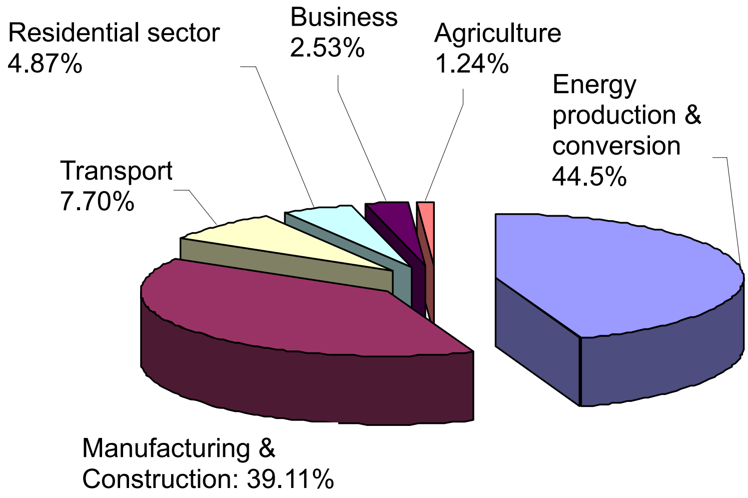


Figure 2.2 Composition of CO_2 emissions from energy activity sectors

In 2005, China's methane emissions from the energy activities were 15.429 Mt. The coal mining and post-mining activities, biomass combustion, oil and natural gas systems dominated CH_4 emission sources. In 2005, the fugitive methane emissions from coal mining and post-mining activities, and from abandoned coal mines were 12.922 Mt in total, accounting for 83.75% of the total CH_4 emission from the energy activities, out of which the CH_4 emission from the coal mining alone was about 11.411 Mt, and the net CH_4 emission was approximately 10.741 Mt after deducting 0.67 Mt recovered for reuse, accounting for 83.1%; the CH_4 emission from post coal mining activities was about 2.053 Mt; and the CH_4 emission from abandoned mines was 0.127 Mt (Table 2-9). In 2005, the CH_4 emission from biomass combustion was 2.163 Mt, the sources of which were dominated by fuel wood and crop residue combustions, with small contributions from animal manures and charcoals. In 2005, China's fugitive CH_4 emissions from oil and natural gas systems were 0.218 Mt, and the major resources were natural gas and conventional crude oil exploitations including natural gas transportation. The fugitive CH_4 emission from natural gas exploitations accounted for 26.2%, crude oil exploitations for 22.8%, natural gas transportation for 16.1%. In 2005, the CH_4 emission from fossil fuel combustions from mobile sources was around 0.126 Mt, of which 97.5% was from road transports.

Table 2-9 China's fugitive methane emissions from coal mining in 2005

Underground mining/ Mm^3	Open-pit-mining/ Mm^3	post-mining activities/ Mm^3	Abandoned mines/ Mm^3	Uses/ Mm^3	Total emissions	
					Mm^3	Gg
16,798.2	234	3,063.8	190.2	1,000	19,286.23	12,921.8

Note:
1. methane density: 0.67 kg/m^3

In 2005, China's N_2O emissions from the energy activities were 0.134 Mt, of which the emission from biomass fuel combustions was about 0.064 Mt, accounting for 47.76%, as the largest source of N_2O emission; next to it, the N_2O emission from fossil fuel combustions of mobile sources was approximately 0.04 Mt, accounting for 29.85%; the N_2O emission from thermal power generations was about 0.03 Mt, accounting for 22.39%.

2.2 Industrial Processes

In 2005, China's total GHG emission from the industrial processes was 767 Mt CO_2 eq, of which the emission from cement production accounted for 53.7%, chlorodifluoromethane production for 13.9%, lime production for 11.2%, iron/steel production for 6.1%, and emission from remaining 9 production processes was relatively small, accounting for 15.1% (Table 2-10).

Table 2-10 China's GHG emissions from industrial processes in 2005

Unit: Mt CO_2 eq

Emission sources	**CO_2**	**N_2O**	**HFCs**	**PFCs**	**SF_6**	**Total emissions**
Cement	411.7					411.7
Lime	85.6					85.6
Iron/Steel	47.0					47.0
Calcium carbide	10.3					10.3
Limestone & dolomite uses	14.0					14.0
Adipic acid		18.5				18.5
Nitric acid		14.5				14.5
Aluminum				5.5		5.5
Magnesium					0.5	0.5
Power equipment manufacturing and operation					9.9	9.9
Semi conductor			0.1	0.2	0.1	0.3
Chlorodifluoromethane			106.3			106.3
Production and use of alternatives of ozone depleting substances			42.5			42.5
Total emissions	**568.6**	**33.0**	**148.9**	**5.7**	**10.4**	**766.6**

2.2.1 Reporting Scope

Based on status of the industrial production activities in China, the emission sources defined in China's 2005 GHG inventory for industrial processes include cement, lime, iron/steel, calcium carbide, adipic acid, nitric acid, semi-conductor, chlorodifluoromethane, aluminum, magnesium products among others; productions and uses of alternatives of the ozone depleting substances; power equipment manufacture and operation; and limestone and dolomite uses. The greenhouse gases from industrial processes include five types: carbon dioxide, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride, of which the CO_2 emission also includes the CO_2 estimates from cement, lime, iron/steel, calcium carbide production processes, and from uses of limestone and dolomite; the N_2O emissions only give the estimates from adipic acid and nitric acid production processes.

2.2.2 Methodologies

The methods used to estimate China's CO_2 emissions from industrial processes in 2005 are broadly based on 3 categories: production quantity, use amount and carbon balance, as recommended in the IPCC Inventory Guidelines. The Tier 2 method from the *1996 IPCC Inventory Guidelines* is used to estimate the CO_2 emissions from cement production processes, cement clinker production quantities are used as the activity data, and emission factors are derived from *in-situ* surveys. Production quantity is used to estimate CO_2 emissions from lime production processes as the activity data. Limes are divided into 4 types: metallurgical lime, lime used for chemical industries, construction lime, and other limes. The data used for estimation are from targeted surveys and investigations from 1004 enterprises. The emission factors for lime are also established through surveys, with 959 effective samples being collected. The carbon balance-based approach is used to estimate CO_2 emissions from iron and steel production processes. The CO_2 emission from the carbon degradation processes is also calculated by taking into account the difference in carbon contents between pig iron and steel. The activity data are originated from the National Statistical Yearbooks and sector-specific statistics. The carbon contents of pig irons and steel materials are derived from typical surveys. The method recommended in the *1996 IPCC Inventory Guidelines* is used to estimate the CO_2 emissions from calcium carbide production processes based on its production quantities and emission factors. The emission factors are estimated with the technical and economic parameters from the *Cleaner Production Standard – Calcium Carbide Industry*. The estimation of the CO_2 emissions from the limestone and dolomite uses is based on the quantities of these two agents, and both activity data and emission factors are from special surveys.

The Tier 2 method recommended in the *IPCC Good Practice Guidance* is used to estimate the N_2O emissions from China's adipic acid production processes in 2005, with both activity data and emission factors being derived from enterprise surveys. The Tier 2 method is also used to estimate the N_2O emissions from nitric acid production processes. Depending on its production techniques and control technologies, nitric acid production is divided into 7 processes: non-selective and selective catalytic reduction under high pressure, medium pressure, normal pressure, dual pressure, integrated, and low pressure. The activity data and emission factors are estimated with data from typical surveys on 50 enterprises.

The methods of the *IPCC Good Practice Guidance* is used to estimate China's perfluorocarbon (PFC) emissions from aluminum production processes in 2005; the Tier 1 method of the *2006 IPCC Inventory Guidelines* is used to estimate the sulfur hexafluoride (SF_6) emissions from the magnesium production processes; the Tier 2 method of the *1996 IPCC Inventory Guidelines* is used to estimate SF_6 emissions from power equipment manufacturing processes; and the Tier 1 method from the *1996 IPCC Inventory Guidelines* is used to estimate emissions from the processes of manufacturing alternatives to the ozone depleting substances (ODS). According to the requirements of the *IPCC Good Practice Guidance*, the trifluoromethane (HFC-23) emissions from the chlorodifluoromethane (HCFC-22) production processes are estimated separately using the Tier 2 method from the *1996 IPCC Inventory Guidelines*, with both activity data and emission factors being derived from sectoral surveys.

2.2.3 Emission Inventory

In 2005, China's CO_2 emissions from the industrial processes were about 569 Mt, in which the cement production dominated and emitted about 411 Mt CO_2, accounting for 72.4%. The CO_2 emissions from lime, iron and steel and calcium carbide production, as well as from limestone and dolomite uses were 85, 47, 10 and 14 Mt respectively, accounting for 15.1%, 8.3%, 1.8% and 2.5% accordingly. The N_2O emissions were about 106.3 Kt, of which the N_2O emission from adipic acid production processes was 59.5 Kt, accounting for 56%; and the N_2O emission from nitric acid production processes was 46.8 Kt, accounting for 44%. The emissions of fluorinated gases were 165 Mt CO_2 eq, of which the hydrofluorocarbon emission was 149 Mt CO_2 eq, accounting for 90.27%, sulfur hexafluoride emission was 11 Mt CO_2 eq, accounting for 6.33%, and the perfluorocarbon emission was 5 Mt CO_2 eq, accounting for 3.40%. The hydrofluorocarbons from the chlorodifluoromethane (HCFC-22) production processes were the largest sources of fluorinated gas emissions, which were dominated by trifluoromethane (HFC-23), accounting for 64.43% of the total emission of the fluorinated gases.

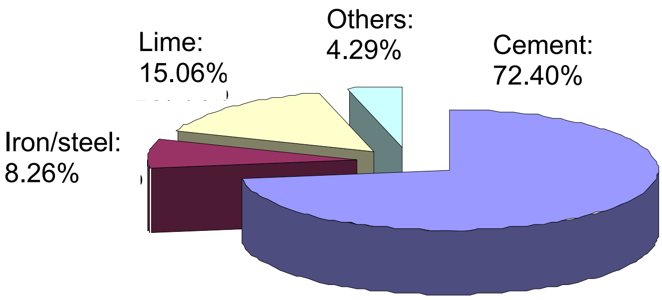


Figure 2.3 Composition of CO_2 emissions from industrial processes

2.3 Agricultural Activities

In 2005, China's total GHG emission from agricultural activities was approximately 819 Mt CO_2 eq, of which the emission from rice cultivation and agricultural land uses was 374 Mt CO_2 eq, accounting for 45.7%, and the emission from enteric fermentation and manure management was 445 Mt CO_2 eq, accounting for 54.3%.

2.3.1 Reporting Scope

The reporting scope of China's 2005 inventory of GHG emissions from agricultural activities mainly covers CH_4 emissions from rice cultivation, N_2O emissions from agricultural land uses, CH_4 emissions from enteric fermentations, as well as CH_4 and N_2O emissions from manure management.

2.3.2 Methodologies

In 2005, China's CH_4 emissions from rice paddy fields are derived by multiplying a rice cultivation area of a different paddy field type by its corresponding CH_4 emission factor. The paddy fields are divided into four categories: single-cropping rice, double-cropping early rice, double-cropping late rice, and winter-flooded rice. The emission factors for the first three paddy field types have been calculated with a model (CH4MOD) for simulating CH_4 emission processes from paddy fields, whereas the emission factor for the latter has been calculated with an empirical equation.

The N_2O emissions from agricultural land uses include direct and indirect emissions, which are derived from quantity of nitrogen input multiplied by N_2O emission factor. In direct emission estimation, agricultural lands are divided into 6 types in the following four categories: crop land, rice paddy field, orchard and tea plantation, as well as grazing land. Different agricultural land types vary in nitrogen inputs, including nitrogen fertilizer, nitrogen from manure and return of crop residues to fields. The nitrogen inputs are calculated using a regional nitrogen cycle model - IAP-N with a relevant N_2O emission factor. With exceptions of orchards and tea plantations, the

N_2O emission factors for all agricultural land types are statistically derived from observational data, with exception for orchards and tea plantations, for which the average values observed in vegetable fields and orchards are used for N_2O emission factors for orchards and tea plantations. The indirect emissions include two categories: N_2O emissions induced by nitrogen depositions from the atmosphere, and those caused by nitrogen through leaching and runoff. The former is divided into nitrogen depositions on agricultural lands or otherwise beyond, and their sources include volatile nitrogen gases from livestock and poultry manures, as well as nitrogen emissions from agricultural residue burning as fuels; the latter is derived from the quantity of nitrogen inputs in aforementioned agricultural lands multiplied by lost rate of nitrogen from leaching and runoff, and further by the N_2O emission factor as result of the nitrogen leaching, which uses the default values given in the *2006 IPCC Inventory Guidelines*.

The sources of CH_4 emissions from enteric fermentations are consistent with those defined by IPCC, including 10 types of animals: dairy cattle, non-diary cattle, buffalos, goats, sheep, camels, horses, asses, mules and pigs. In accordance with the principles for determination of key sources and for choice of methodologies as suggested in the *IPCC Good Practice Guidance*, considering importance of emission sources and availability of relevant data, the non-dairy cattle, buffalos, goats, sheep, dairy cattle and pigs have been identified as key sources of CH_4 emissions from enteric fermentation. With only exception of pigs, the IPCC Tier 2 method is used to estimate other key CH_4 emission sources. Horses, asses, mules and camels have been identified as non-key sources, for which the Tier 1 method is used for estimations.

Apart from the above 10 types of animals, the CH_4 and N_2O emissions from manure management of poultry are also included, and their manure management processes include pasture/range, daily spread, solid storage, dry lot, liquid/slurry, lagoon, pit below animal confinement, biogas digesters, manure burned, straw bedding, manure compost, aerobic treatment. Pigs, non-dairy cattle, dairy cattle and poultry are the key CH_4 emission sources. Depending on data availability, the Tier 2 method is used to estimate the CH_4 emissions from manure management for pigs, dairy cows, sheep, goats, buffalos and dairy cows, whereas the Tier 1 method is used to estimate CH_4 emissions from poultry, asses, horses, mules and camels. Although the methods recommended by IPCC are used for N_2O emissions from all animal manure managements, however pigs, non-dairy cattle, sheep, goats, buffalos, poultry, asses/mules are identified as key sources of N_2O emissions from animal manure management, and the manure characteristics in China and management parameters are used to estimate their N_2O emissions. For non-key sources, the IPCC default parameters are used.

2.3.3 Emission Inventory

In 2005, it was estimated that China's CH_4 emissions from rice cultivation were 7.926 Mt, of which the emission from single-cropping rice was 3.676 Mt, accounting for 46.38%, and the emission from double-cropping early and late rice was 1.533 and 1.607 Mt respectively, accounting for 39.62% in total, and the emission from winter-flooded paddy fields during rice non-growing periods was 1.109 Mt, accounting for 13.99%. In 2005, CH_4 emission from enteric fermentation was 14.379 Mt, which was dominated by that from the non-dairy cattle, accounting for 49.47%, followed by that from buffalos, accounting for 13.64%. Although pigs are not ruminant animals, due to large quantity of pigs in pens, CH_4 emissions from pigs exceeded 5% of the total. In 2005, CH_4 emission from animal manure management was around 2.864 Mt, and pig manure management was the main source of CH_4 emissions, accounting for 75.70%, followed by that of non-dairy cattle, which accounted for 10.71%.

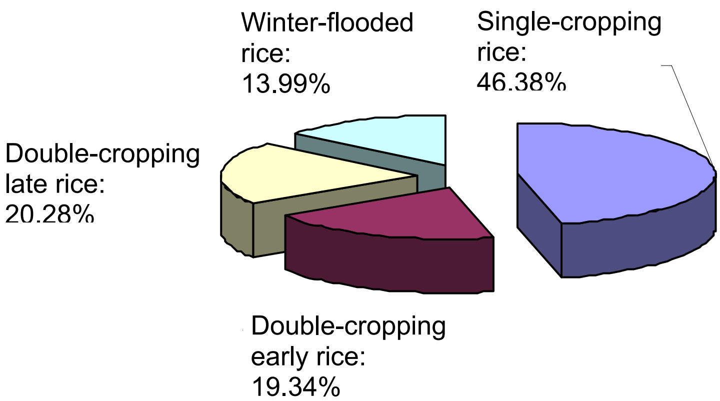


Figure 2.4 Composition of methane emissions from paddy fields in 2005

In 2005, China's primary sources of N_2O emissions were agricultural land uses and animal manure management, with the former emitting 0.672 Mt, accounting for 71.65%, and with the latter releasing 0.266 Mt, accounting for 28.35%. Among the N_2O emissions from agricultural land uses, 69.86% was from direct emissions from agricultural lands, and 30.14% was originated from indirect emissions. N_2O emissions from the manure management were 0.266 Mt, in which the pig manure management was the largest source, accounting for 32.4%, followed by non-dairy cows, accounting for 22.8%, and poultry accounting for 19.5% of the total. From the manure management perspective, the dry lot in animal farms was the largest N_2O emission source, accounting for 46.4%, followed by other manure managements accounting for 23.7%, solid storage for 12.7%, manure compost for 5.2%, and pasture for 5.0% respectively.

Table 2-11 China's nitrous oxide emissions from agricultural activities in 2005

Emission source categories	Nitrous oxide (10^3 t)	Composition (%)
Direct emissions from croplands	470	50.11
Indirect emissions from croplands	202	21.54
Animal manure management	266	28.36
Total	**938**	**100**

2.4 Land Use Change and Forestry

In 2005, China's net CO_2 remove through land use change and forestry was 422 Mt, and there were still minor CH_4 and N_2O emissions from forest conversions, which were about 0.73 Mt CO_2 eq.

2.4.1 Reporting Scope

The reporting scope of China's 2005 inventory of GHG emissions from land use change and forestry covers three components: carbon stock changes of forests and other woody biomasses, including CO_2 remove by living woods (arbor forests, open forests, scattered trees and four-side trees—trees growing along house side, village side, road side and water side), bamboo forests, economic forests and shrubs, and CO_2 emissions from forest consumptions and conversions to non-forest lands. The carbon stock changes due to cropland and grassland managements were not reported in this inventory.

2.4.2 Methodologies

The biomass conversion factors are used in combination with growth rate of stock volume and forest consumption rate to estimate China's carbon stock changes in arbor forest, open forest, four-side trees and scattered tree biomasses in 2005. The carbon stock change in bamboo forest, economic forest and shrub biomasses are estimated by using biomass carbon contents per unit area and annual variations of the area. The data used in the inventory are mainly from the official activity data and a wide range of emission factors at the national level. For some parameters that are difficult to derive, the IPCC default values, or expert judgments, or empirical values are adopted.

To estimate China's GHG emissions from forests conversions in 2005, major consideration has been given to the processes of arbor tree, bamboo and economic forest conversion to non-forest lands, and to GHG emissions as result of above ground biomass loses, including CO_2 emissions from on-site biomass combustions and those burned off-site, biomass oxidation and decomposition processes, and non-CO_2 GHG emissions as result of on-site biomass combustions. Among the total emission, CO_2 emissions from forest conversions are estimated according to above ground biomass losses, burnt biomass decomposition ratios, oxidation fractions and carbon contents both before and after the conversions, while the non-CO_2 emissions are estimated based on the emission proportion of various non-CO_2 GHG.

2.4.3 Emission Inventory

In China's 2005 GHG inventory of land use change and forestry, the carbon stock changes of forests and other woody biomasses included both CO_2 emissions and removes, of which the remove by arbor tree forests in growth was 756 Mt as the largest carbon sink, and the removes by bamboo forests, shrubs and other forests (e.g. open forests, scattered trees and four-side trees) were 13, 89 and 86 Mt respectively, and the GHG emissions from forest consumptions were 492 Mt, and net emission from the economic forests was 7 Mt. Therefore, the net CO_2 remove by forests and other woody biomasses was 446 Mt; CO_2 emissions from forest conversions were 25 Mt, while CH_4 and N_2O emissions were 31 and 0.2 Kt respectively (Table 2-12)。

Table 2-12 China's GHG emissions from land use change and forestry in 2005

Unit: 10^4 t

Emission sources/sinks	Sub-categories	CO_2 remove/emission	CH_4 emission	N_2O emission
Carbon stock changes of forests and other woody biomasses	Arbor tree forests	-75,644		
	Bamboo forests	-1,345		
	Economic forests	723		
	Shrubs	-8,926		
	Open forests, scattered trees and four-side trees	-8,599		
	Forest consumptions	49,156		
	Subtotal	**-44,634**		
Forest conversions	on-site combustions	720	3.1	0.02
	off-site Combustions	960		
	Emissions from decompositions	800		
	Subtotal	**2,481**		
Total		**-42,153**	**3.1**	**0.02**

Note: the minus sign (-) in the table represents net CO_2 remove.

2.5 Waste treatment

In 2005, China's GHG emission from waste treatment was about 112 Mt CO_2 eq, of which CO_2 emission from waste incineration was 2.658 Mt, accounting for 2%, the CH_4 emission from the solid waste and wastewater treatments was 80.305 Mt CO_2 eq, accounting for 72%, and the N_2O emission from the wastewater treatment was 28.847 Mt CO_2 eq, accounting for 26%.

2.5.1 Reporting Scope

The reporting scope of China's 2005 inventory of GHG emissions from waste treatments mainly covers CH_4 and CO_2 emissions from municipal solid waste treatments, CH_4 and N_2O emissions from municipal and industrial wastewater treatments. For the first time, the CO_2 emissions from waste incinerations are included in the inventory, in which the CO_2 emission from incinerations of such organic wastes as paper, food stuff and woody materials is simply given for information, but excluded in the total emission, whereas the emission from incinerations of such wastes as plastics, rubbers, liquid solvent, waste oils and hazardous wastes, which are originated from fossilized materials, have been reported under waste treatment sectors and included in the total emission. The N_2O emission from wastewater treatments only include indirect emissions generated from wastewater after being discharged into sewage networks, lakes and oceans, excluding the direct emissions from wastewater treatment plants.

2.5.2 Methodologies

The First Order Decay (FOD) method recommended in the *IPCC Good Practice Guidance* is used to estimate China's CH_4 emissions from municipal solid waste landfills in 2005, while taking into account the *2006 IPCC Inventory Guidelines*. When calculating the Methane Correction Factors (MCF), the differences in city sizes and regional economic development levels are considered. According to the actual circumstances, the 1956-2005 timeframe is divided into four periods: 1956-1978, 1979-1990, 1991-2000 and 2001-2005, for which the differences in management of waste treatment sites have been identified respectively. When defining degradable organic carbons (DOC) in wastes, considerations have also been given to the different living habits of local residents, apart from the regional climate characteristics, and half-decay time and methane generation rates that comply with China's actual circumstances are defined according to the available research findings.

The method recommended in the *IPCC Good Practice Guidance* is used to estimate the CH_4 emissions from the wastewater treatment. When calculating the methane correction factors, considerations are given to China's wastewater treatment systems and processes in specific stages, a percentage of each system is allocated and its weighted mean value is calculated, and China's unique maximum methane emission factor (B_0) has been defined according to its actual status in wastewater treatment.

The estimation of CH_4 emissions from the industrial wastewater treatment is based on the *IPCC Good Practice Guidance*, taking into account the calculation methods given in the *2006 IPCC Inventory Guidelines*. For some sectors using similar industrial wastewater treatment systems and processes, the mean value of the methane correction factor is derived through expert judgment.

Based on the *IPCC Good Practice Guidance*, the estimation of N_2O emissions from wastewater treatment take into consideration the method recommended in the *2006 IPCC Inventory Guidelines*; the activity level data are China's population and per capita food protein content; and N_2O emission factor is the IPCC default value.

The estimation of CO_2 emissions from waste incinerations is also based on the *IPCC Good Practice Guidance*, and takes into consideration the recommended method in the *2006 IPCC Inventory Guidelines.* The CO_2 emissions from incinerations of fossilized material- and organic wastes are estimated according to their physical composition ratios.

2.5.3 Emission Inventory

The CO_2 emission from incinerations of fossilized material-originated wastes in 2005 was 2.658 Mt, and emission from organic waste incinerations was 3.927 Mt (excluded in the total). The CH_4 emission from waste treatments in 2005 was 3.824 Mt, of which the CH_4 emission from solid waste disposals was 2.204 Mt, accounting for 57.62%; and the CH_4 emission wastewater treatments was 1.621 Mt. For the first time, the N_2O emissions from industrial and municipal wastewater treatments were estimated in China's 2005 GHG inventory, and they were around 93 Kt (Table 2-13)。

Table 2-13 China's GHG emissions from waste treatments in 2005

Unit: 10^4 t

GHGs	CO_2		CH_4	N_2O
Solid waste disposals	-		220.4	-
Industrial wastewater treatment	-		122	9.3
Wastewater treatments	-		40	
Waste incinerations	Origin	Emission	-	-
	Fossilized	265.8		
	organic*	392.7		
Total emission	265.8		382.4	9.3
Total (CO_2 eq)	**11,181.0**			

Note: the value for item with an asterisk was not accounted in the total emission amount.

Chapter 3 Uncertainties in the Greenhouse Gas Inventory

3.1 Work on Uncertainty Reduction in Preparation of the Inventory

To reduce uncertainties of the GHG estimates in the inventory, the institutions that involved in preparation of this inventory have made a range of efforts targeted to preparation approaches, activity data and emission factors.

In preparation of the inventory, the institutions involved have followed the methodologies from the *Revised 1996 IPCC Guidelines* and the *IPCC Good Practice Guidance*, and they have taken into account the *2006 IPCC Guidelines*, to ensure use of scientific estimation methods in the inventory, comparability, transparency and consistency of the estimates. Depending on data availability, more detailed methods are selected.

For activity data, the inventory focuses on reliability and accuracy of the data used. Firstly, this report uses as many official statistics as possible. The institutions that involved in preparation of the inventory have established close cooperation with the National Bureau of Statistics of China, relevant professional statistic agencies and industrial associations to ensure that the official statistical data are authoritative and reliable. In cases that no official statistics are available, they have made a large number of surveys and research work on such parameters as consumptions of coal in various types by major industrial sectors, lime production, limestone and dolomite consumptions, nitric acid production enterprises, animal fodder and animal productions. For some activity data, the enterprise-level data are used directly.

For emission factors, in order to use as many as possible the emission factors that reflect China's actual circumstances, the institutions involved have made many surveys, tests and model analyses. The major efforts include sectoral surveys on lower heating values and carbon contents by coal types, sample tests of carbon oxidation factors for power plant boilers and industrial boilers, statistical analyses on intensity data of fugitive methane emissions from coal mining under tests, emission factor tests for cooking stoves in rural areas, sample surveys on calcium oxide contents in cement clinkers, and improvement of the methane-emission models for paddy fields among others. For some parameters that lack of tests and supports from scientific literatures, the institutions involved have reached consensus through judgments by authoritative experts.

3.2 Uncertainties in the Inventory

With the efforts of the institutions involved, China's Greenhouse Gas Inventory 2005 has been significantly improved in terms of reporting scope, methodologies and quality of the inventory, etc., compared with the 1994 National GHG Inventory. However due to limited scientific understanding and restricted basic conditions, uncertainties still exist, to some extent, in the China's GHG Inventory 2005, which are mainly found as follows:

For its activity data, as China's basis on which its statistical data are established is still relatively weaker, its current statistical indicator system is not fully consistent with that required for the inventory preparation, some indicators on activity data have not been incorporated in its current statistical system, and some uncertainties exist in the statistical data itself. On the other hand, the activity data derived from typical surveys and by expert judgments among others may also lead to larger uncertainties.

In terms of emission factors, although the institutions involved have gathered, to a varying degree, relevant information of the emission factors through sample tests, *in-situ* observations and measurements among other means, the temporal scales of the observations at observing or sampling sites are not representative enough, due to limited resources and time at disposal among other reasons. For some sectors, due to lack of the country-specific emission factors in some sectors, the default values from the *IPCC Inventory Guidelines* are used, which also lead to some uncertainties in the GHG estimates in the inventory.

Using the methods for quality assessments and uncertainty analyses recommended in the *IPCC Good Practice Guidance*, the institutions that engaged in preparation of the inventory have made a preliminary analysis on the quality of relevant data used in the inventory, and the uncertainties that exist in the sectoral inventories mainly focusing on the following aspects:

3.2.1 Energy activities

The uncertainties in the energy activity inventory are mostly coal-related. Firstly, the energy statistical system differs from the IPCC requirements in classification of coal types; the institutions involved have derived the coal consumptions by major sectors and coal types from their extensive surveys at production and circulation ends; and all these may lead to some uncertainties. Secondly, the tests on lower heating values and carbon contents of various coal types are still inadequate in terms of integrity and continuity. Thirdly, the carbon oxidation factors of coal-fired equipments, especially the industrial boilers and kilns, vary largely. Fourthly, although the monitoring of fugitive methane emissions from coal mining has a wide coverage, the test frequency is relatively low, which affect the accuracies of the tests to certain degree. Additionally, due to relatively weaker basis on which the activity data statistics are established for non-commodity energy (biomass energy), and due to restricted range of statistical tests as the emission factors of small cooking stoves in rural areas are subject to multiple impacts, therefore the emission factors for oil and natural gas systems are mostly defined by considering the experience from other countries, which may have impacts on the accuracy of the energy activity inventory.

3.2.2 Industrial processes

The industrial processes cover 13 relevant sectors, and the activity data uncertainties mainly originated from errors of sectoral statistics. For examples, the statistical basis for lime used for construction and as building material is rather weak; consumptions of dolomite and limestone are excluded in the sectoral statistics; incomplete statistics for nitric acid production need corrections; and some small power-equipment manufacturers are not covered in the statistical range. The major sources of uncertainties in emission factors are errors in sample surveys, chemical analyses and representiveness of survey data, etc.

3.2.3 Agricultural activities

In estimating CH_4 emissions from paddy fields, apart from observational errors and model accuracy-related uncertainties, the major sources of uncertainties are regional parameters, i.e. soil sand content, crop residue return to fields, organic fertilizer applications, rice-growing area, rice variety, per unit production statistics, and paddy-field water management practices. The uncertainties in N_2O emissions from agricultural lands mainly attribute to representativeness of the emission factors, including that observational data are less evenly distributed in the overall nitrogen fertilizer application scope; that the observations on conditions for nitrogen fertilization are scarce; and that ammonia and nitrogen oxides released from industrial processes may have impacts, to some extent, on soil nitrogen balance and residue.

For GHG emissions from enteric fermentation and manure management, the uncertainties in activity data are mostly attributable to statistic errors. However, the major uncertainty sources in emission factors can be traced back to the uncertainties in relevant parameters. On the one hand, the sample surveys not necessarily give a full picture of animal-husbandry practices, fodder varieties and diverse climate characteristics. On the other hand, uses of the methane production potential, methane conversion factor and defaults for emissions from manures provided in the *Revised 1996 IPCC Guidelines* and *IPCC Good Practice* also give rise to uncertainties in emission factors.

3.2.4 Land use change and forestry

The uncertainties in the inventory for land use change and forestry are mostly shown in the following aspects: (1) forest area, growing stock and forest area that is converted annually to other lands in 2005 are derived by interpolating or extrapolating the available data from forest surveys; (2) errors exist in the biomass expansion factors, while these factors for the open forests, scattered trees and four-side trees vary largely from the stands of different forest types, nevertheless the same factor is used in the inventory due to lack of data, which may also lead to certain errors; (3) certain errors exist in the biomass of various economic forests, bamboo forests and shrubs, with the national mean value exposing to a larger uncertainty; and (4) certain uncertainties also exist in the IPCC default value (0.5) as carbon contents.

3.2.5 Waste treatment

On the one hand, the uncertainties in the inventory of GHG emissions from waste treatments are originated from relevant methods. For example, the uncertainties of total CH_4 generated in the life cycle of solid waste landfills and those in its allocations exist in the first order decay method. On the other hand, uncertainties attribute to various parameters, e.g. methane correction factor and degradable organic carbon; and the IPCC defaults are used for some parameters, due to lack of *in-situ* measurements to reflect national circumstances. As the IPCC parameters are mostly from the developed countries with *in-situ* detecting capabilities, this may also contribute to uncertainties when these parameters are used in the developing countries.

Chapter 4 Change of Trends in Greenhouse Gas Emission

4.1 Key Factors Affecting GHG Emission

There are many factors that affect GHG emissions, including economic development and industrial structure, population growth and people's living standard, energy mix and technological advance among others.

4.1.1 Economic development and industrial structure

From global perspective, the per capita energy consumption is clearly related to CO_2 emissions and economic development level. The per capita CO_2 emission will usually increase at a quicker pace until the per capita GDP reaches the 10,000~15,000 USD level, after which the increase of CO_2 emission will slow down. Similarly, China's economic development was in the past, is at present and will be in future the most important factor affecting its CO_2 emissions. In the next decade, China's annual GDP growth rate will be likely at around 7%. Although China's per capita GDP will be still less than 10,000 USD by 2020, its energy consumptions and CO_2 emissions, as needed, will continue to increase accordingly.

China now is in the middle of industrialization, with a relatively larger share of its secondary industry. The rapid growth of heavy chemical industries in recent years has allowed the heavy industry to account for about 70% of all industries; the average energy consumption intensity is more than twice of that of the light industry; and the energy consumption intensity of the secondary industry is far higher than that of the tertiary industry. However, China's tertiary industry will take an increasingly higher share of its all industries in the next 10 years; with rigid control of metallurgical and building-material industries, and by fostering and developing its strategic emerging industries, China's secondary industry will contribute to incremental reduction of energy consumption and CO_2 emission per unit of GDP.

4.1.2 Population growth and residents' living standard

Both population growth and improvement of living standard are the key drivers for energy consumptions and CO_2 emissions in the future. In 2000-2010, China's population increased by 7,230,000 on annual average, and its urbanization rate rose by 1.37% per year. In the next decade, China's population will continue to grow steadily, and its urbanization rate will further rise. The growing population and the higher urbanization level will inevitably require large-scale urban infrastructure constructions, more iron and steel, cement and other high energy consuming products, leading to additional energy uses and CO_2 emissions accordingly.

With the economic development and the continuously improvement of residents' living standard, the quantity of durable consuming goods owned by residents has been increasing rapidly, and residents' consumption patterns are mainly shifting from 'clothing' and 'food' toward 'housing' and 'mobility'. In 2000-2010, on annual averages, the per capita personal disposable income of urban residents increased by RMB 1283 *Yuan* in China, the per capita housing floor space increased by 1 m^2 in rural areas, and private cars increase by 5,310,000. In the next decade, with economic development and higher living standard of residents, the per capita ownership of home appliances, cars and housing floor space by urban residents will increase further.

4.1.3 Energy mix and technological level

The major approaches for controlling future energy consumptions and CO_2 emissions are to adjust the energy mix and improve energy use efficiency. In 2000-2010, the share of raw coal in the total primary energy production increased from 73.2% to 76.6%, however its share in the total energy consumption decreased from 69.2% to 68.0%. The natural resource endowment featuring more coal but less oil and natural gas determines the coal-dominated energy mix that China has been keeping for long, leading to the CO_2 emission level per unit of energy consumption far beyond the world average. In the next 10 years, with strong efforts in developing new and renewable energies, China will do its utmost to make non-fossil energies account for about 15% of its primary energy consumption, and to further adjust its energy mix.

With strong efforts to extensively deploy advanced energy technologies, to enhance reuse of waste heat and gases, and to phase out backward production capacity among other measures, China's energy use efficiency will be continuously improved. Although China's energy consumption per unit of GDP was lowered by 17.6% in 2000-2010, China's per unit energy consumption of partial high energy consuming products was about 20% higher than the world advanced level. In the next decade, China will strive for energy conservation and lower energy consumption, and effectively control its energy consumptions and CO_2 emissions by inhibiting overgrowth of high energy consumption industries, by focusing on effective energy conservations in industrial, construction and transport sectors as well as in public institutions, and by promoting advanced energy-saving technologies and products among others.

4.2 Greenhouse Gas Emission Changes

Along with its economic development and further improvement of people's living standard, China's total GHG emission including CO_2 has shown a rapidly increasing trend. In 1994-2005, China's total CO_2, CH_4 and N_2O emission increased from 3.65 Gt CO_2 eq to 6.881 Gt CO_2 eq, with an increase of 0.89 times, of which CO_2 emission increased fastest with an increase of 1.09 times, while CH_4 and N_2O emissions increased by 0.3 and 0.5 times respectively. In the same period, CO_2 emissions from the energy activities increased by 0.93 times, and CO_2 emissions from industrial processes increased by 1.05 times.

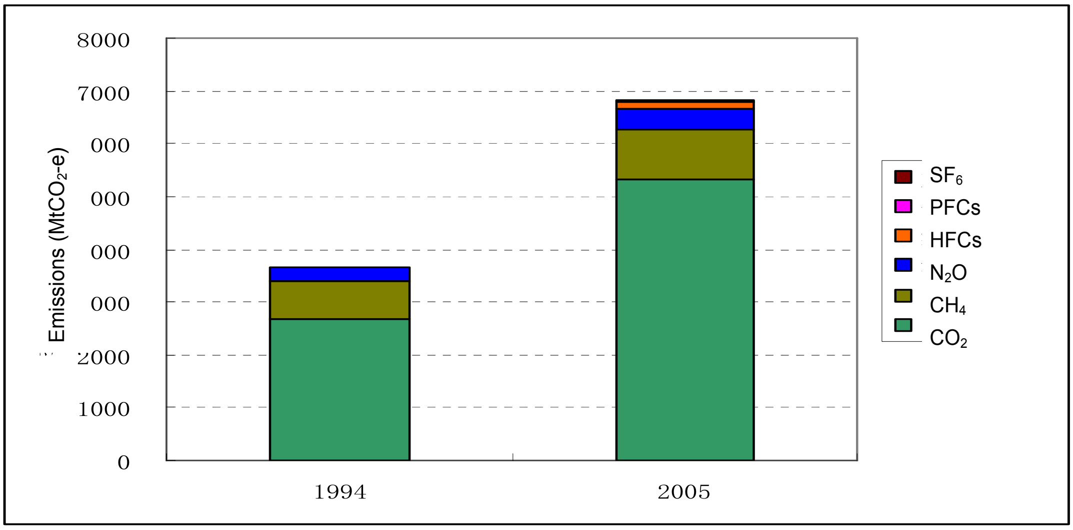


Figure 2.5 Comparison of China's GHG emissions between 1994 and 2005

China's historical GHG emissions are very low, its per capita emission is still at a relatively low level, and its CO_2 emission per unit of GDP shows a fast declining trend. According to the research findings of the World Resources Institute, China's CO_2 emissions from fossil fuel combustion in 1950 were just 79 Mt, accounting for 1.31% of the world total at the time. China's accumulated per capita CO_2 emission in 1950-2005 was approximately 69.9 tons, ranking the 89^{th} in the world. Based on IEA statistics, China's per capita CO_2 emission from fossil fuel combustions in 2005 was about 3.88 tons, which was equivalent to 92% of the world average, or 34.5% of the average level of the Annex I Parties; China's CO_2 emission from fossil fuels per unit of GDP decreased by 46% relative to 1990, with its decreasing rate far beyond the world average level (15%) in the same period.

4.3 Future Changing Trend of CO_2 Emissions from Energy Activities

4.3.1 Analysis method and scenario assumptions

To analyze the changing trend of CO_2 emissions from the energy activities in China, the method of scenario analysis is used in this report. Altogether, three scenarios have been designed: baseline scenario, policy scenario and enhanced policy scenario, and they all presume that China's annual economic growth rate will keep at 7% in the next 10 years. The baseline scenario keeps the policies taken before 2005, with its energy consumption intensity basically following the changing trend of the intensity in the 10^{th} FYP period (2001-2005). This policy scenario takes into account a series of powerful policies and measures taken to lower the energy consumption intensity in the 11^{th} FYP period (2006-2010), and China's tertiary industry will account for about 46% of its GDP by 2020. The enhanced policy scenario not only considers the various policies and measures taken in the 11^{th} FYP period, but also takes into account the targets set to effectively control GHG emissions, as well as a range of policies and measures to be further taken during the 12^{th} FYP period (2011-2015) and 13^{th} FYP period (2016-2020), including those to foster and develop higher value-added industries such as strategic emerging industries, to strive for energy conservation, and to focus on uses of new and renewable energies and alike; and the tertiary industry will take about 50% of the GDP by 2020.

4.3.2 A preliminary analysis of modeling outcomes

Under the baseline scenario, China's primary energy demands will increase from 2.36 Gtce in 2005 up to 6.4 Gtce by 2020, with little changes in the energy demand structure by 2020 relative to 2005. Under the policy scenario, the primary energy demand will be lowered to 5.7 Gtce by 2020, the share of coal in the primary energy demand will be reduced from 70% in 2005 to 65% by 2020, and the share of non-fossil energies in the primary energy demand will increase from 6.7% in 2005 to 12% by 2020. Under the enhanced policy scenario, China's primary energy demand will be further controlled within a range of 4.9 Gtce by 2020, the share of coal in the primary energy demand will be further reduced to about 60%, whereas the percentage of the non-fossil energies in the primary energy demand will further increase up to 15% by 2020. Figure 2.5 shows comparisons of China's primary energy demands and their compositions under the three scenarios.

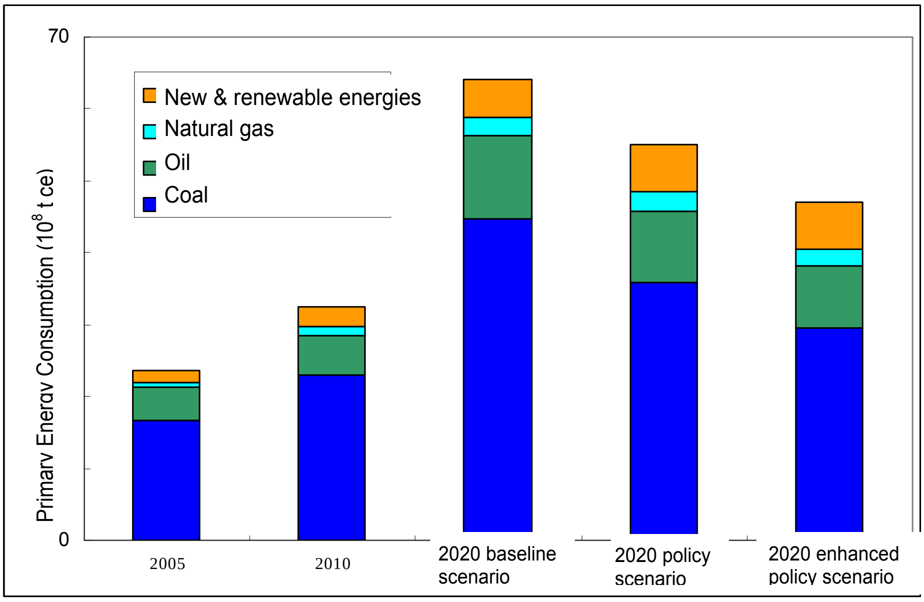


Figure 2.6 China's primary energy demand and composition by 2020 under different scenarios

By 2020, China's CO_2 emissions from its energy activities will reach 14.4 Gt under the baseline scenario, which will be reduced to 11.7 Gt under the policy scenario, and further down to 9.9 Gt under the enhanced policy scenario. In other words, compared with the baseline scenario, the CO_2 emission will decline by 20% under the policy scenario, and by 32% under the enhanced policy scenario respectively. By 2020, relative to 2005, China's CO_2 emission per unit of GDP will decrease by 20% under the baseline scenario, by 35% under the policy scenario, and by 45% under the enhanced policy scenario respectively (Figures 2.7 and 2.8).

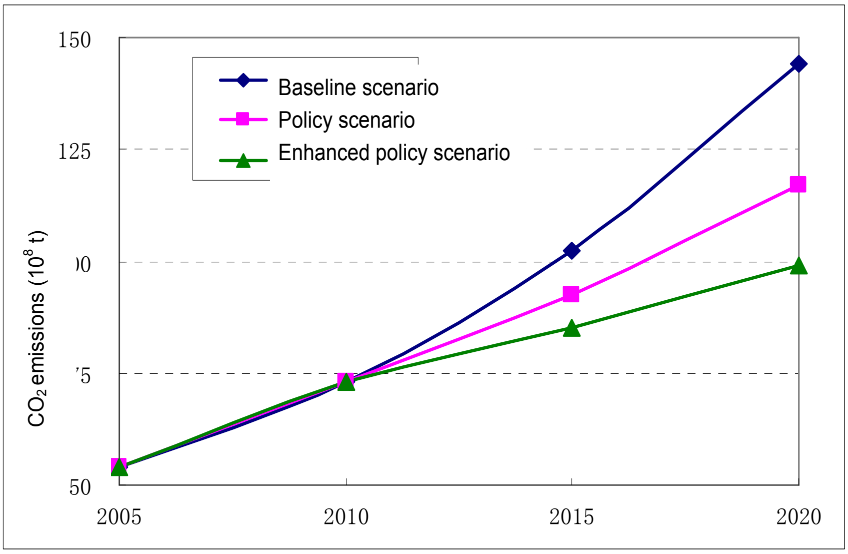


Figure 2.7 China's CO_2 emissions by 2020 under three scenarios

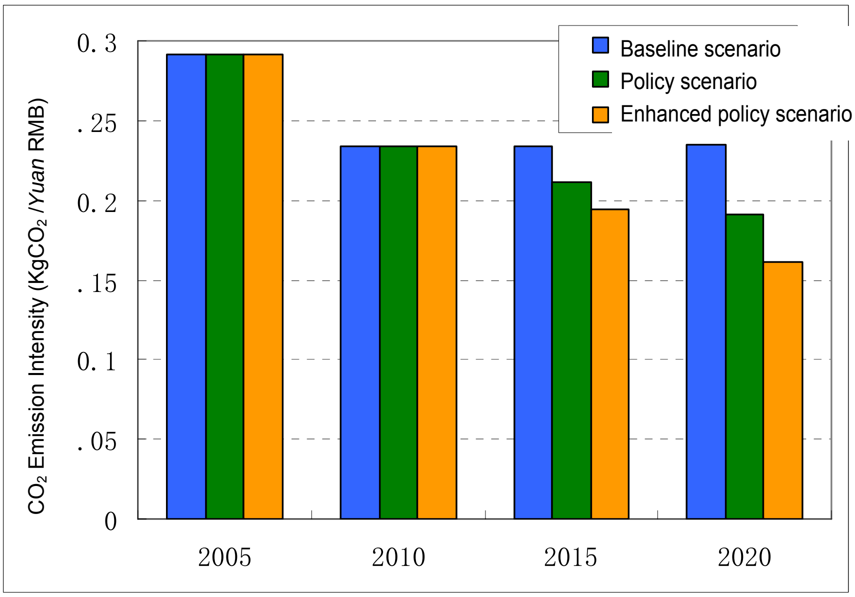


Figure 2.8 China's CO_2 emission intensity by 2020 under the three scenarios

4.3.3 Analysis of uncertainties in future changing trend of CO_2 emissions

Scenario analysis, which is based on scientific presumptions, gives a qualitative or quantitative description of various environmental, social and economic status in the future, but it is not a prediction or forecast of their futures. A number of research institutions both in China and overseas have analyzed and investigated China's future energy and CO_2 emission scenarios. Their findings show that as China is still in the stage of industrialization with a faster economic growth, the uncertainties in its future energy and CO_2 emission scenarios are far larger than those of the developed countries.

China has taken and will continue to take a full range of stringent policies and measures, endeavoring to achieve its action targets in controlling GHG emissions by 2020, including CO_2 emission reduction per unit of GDP and development of non-fossil energies. Therefore, the largest uncertainty in China's CO_2 emissions from the energy activities will lie in its economic growth rate. If China keeps a GDP growth rate at 7% level in the next 10 years and its CO_2 emission intensity will decline by 45% by 2020 relative to 2005, it is estimated that China's primary energy demand will be around 4.8 Gtce, and its CO_2 emissions from fossil fuels will be about 9.9 Gt by 2020. If the GDP growth rate increases by 1%, the primary energy demand will increase by about 400 Mtce and the CO_2 emissions will increase by 900 Mt by then. After 2020, with the g of China's target of building up an overall well-off society, the national economy will tend to move toward the intensive growth pattern, and the increasing rate of China's energy demands and CO_2 emission will gradually slow down.

Part III Impacts of Climate Change and Adaptation

Available observations and studies show that the climate warming trend in China is basically consistent with the global trend over the past century, which has already had and will continue to have significant impacts on the natural and socio-economic systems in China. The Chinese government has already taken and will further take effective policies and actions in adaptation climate change to enhance its adaptation capacity.

Chapter 1 Characteristics and Trend of Climate Change

Using a long series of continuous observations from about 740 meteorological stations, the Chinese scientists has made systematic studies on the behaviors of climate change at surface and upper-air level in China over the past 110 years, especially in the last 60 years. They have also simulated and projected the possible trends of future climate change in mainland China using the climate models developed by China and other countries. Their work has laid a firm foundation for studies on climate change impacts and adaptation at the national and regional level.

1.1 Temperature Change

Since 1901, the annual mean surface air temperature in Mainland China has shown a clear increasing trend, which has been increased by 0.98°C with a warming rate of nearly 0.10°C per decade, and which is slightly above the global warming magnitude. The temperature in the two episodes (1920s-1940s & post mid-1980s) was apparently warmer (Figure 3.1). The annual mean surface air temperature in China over the last 6 decades showed an evident warming trend at a rate of 0.25°C/decade, which was significantly warmer than global warming amplitude in the same period. With exception of the *Sichuan* basin and the northern *Yunnan-Guizhou* Plateau where the temperature declined slightly, the rest China saw an increasing trend in mean surface temperature, especially in the Northwest China and the northern *Qinghai*-Tibetan Plateau, most Inner Mongolia, most Northeast China, northern part of the North China, coastal regions in the South China.

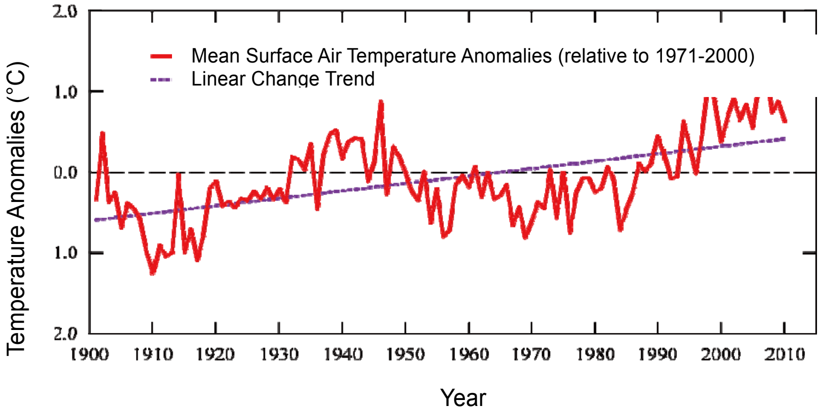


Figure 3.1 Changes of annual mean surface temperature in mainland China in past 100 years

1.2 Precipitation Change

Since the early 20th century, no significant change in annual precipitation has been detected in mainland China, and no significant change has been observed for the past 60 years (Figure 3.2). However, the seasonal precipitation in the past 6 decades had shown evident variations. The summer precipitation showed an increasing trend, especially substantial increase occurred after 1990s; however, the precipitation in spring and autumn decreased significantly at rates of 3.2 mm/decade and 3.6 mm/decade respectively; no evident change has been found in winter precipitation, but it has shown an increasing tendency to certain extent since late 1980s.

The characteristics of both annual and seasonal precipitation changes vary largely from region to region across China. In the past 50 years, the annual precipitation showed a decreasing trend in the Northeast China, Yellow- *Huaihe*- and *Haihe*-river plains, loess plateau, *Shandong* Peninsular, central and western *Sichuan* basin; in contrast, there was an increasing tendency, to a varying degree, in the western China, western part of the Southwest China, middle- and lower-reaches of the Yangtze River, and regions to the south of the Yangtze. The regions with increasingly drier winters included the Inner Mongolia, North China, southern part of Northeast China and eastern *Xinjiang*, but the rest regions showed no evident changes or they might become wetter. The spring precipitation showed an evident increasing trend in the Southwest China, eastern *Qinghai*-Tibetan Plateau and southern part of the Northeast China, but it had decreased to some extent in most Central and East China regions, especially in the Yangtze River basin. The summer precipitation increased in middle- and lower-reaches of the Yangtze River, South China and western part of the Northwest China; however it witnessed a significant decrease in the *Haihe* and *Huaihe* river basins. The precipitation in autumn showed a decreasing tendency in most eastern China regions, compared with an overall increasing trend in the western China regions.

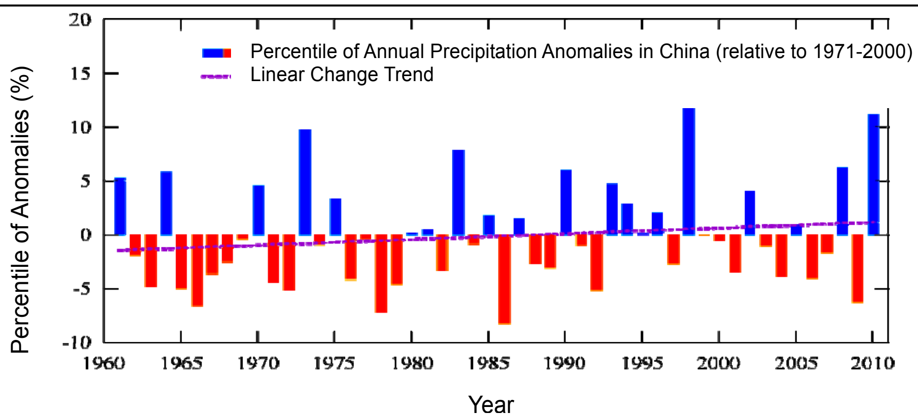


Figure 3.2 Changes of annual average precipitation in mainland China in past 50 years

1.3 Changes of Extreme Climate Events

The extreme warm events in mainland China have increased, the extreme cold events have decreased, and the frequency of droughts and scope of their impacts have increased. In the last 60 years, the frequency of cold waves in most northern and eastern China regions decreased significantly. The average number of heavy rainy days nationwide showed a slight increasing trend, which was relatively more significant in the south compared with a decreasing trend in the north. In last 6 decades, the percentage of area hit by meteorological droughts showed an increasing trend in mainland China, which was relatively more evident in the *Liaohe and Haihe* river basins, northern *Huaihe* River basin and most parts of the Yellow River basin. In 1950s-1960s, the frequency of typhoons that landed on China was higher; it was lower in 1991-2008, but it showed an increasing trend in the last decade to certain extent. In the past half a century and beyond, the precipitation associated with tropical cyclones or typhoons showed a decreasing trend in both summers and autumns.

1.4 Future Trend of Climate Change

The outputs from most Global Climate Models (GCMs) and Regional Climate Models (RCMs) under different GHG emission scenarios have shown that the annual mean surface temperature in mainland China will most likely continue to increase at a higher warming rate in the Northeast, West and North China; the warming rate in winters will be higher than that in summers; and the increasing rate of minimum temperature will be higher than that of the maximum temperature. Under the high GHG emission scenario (A1B), the annual mean surface air temperature increase in Mainland China will range from 0.5°C to 1.5°C in 2021-2030 relative to 1971-2000, at a higher warming rate in the north and west, with the highest warming rate zone in the mid-west of the *Qinghai*-Tibetan Plateau, and at a less warming rate in the southeast region (Figure 3.3). By the end of 21st century, the number of high temperature days in summers in most China, especially in the North China, will significantly increase, while the number of comfortable or low temperature days will significantly decrease. In contrast, the number of cold-wave days in the eastern China will substantially decrease in the future, and the frequency of cold summer events will decrease in the Northeast China.

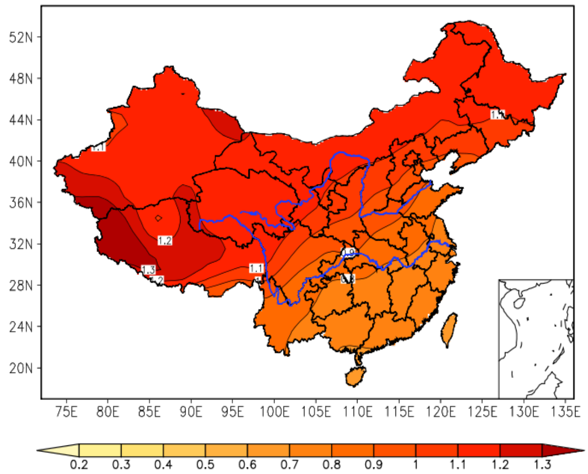


Figure 3.3 Future changes of annual mean surface temperature based on 11 GCM models under A1B scenario

Under most GHGs emission scenarios, the most GCMs have projected that the annual precipitation in mainland China will increase significantly. Under A1B, by 2040s the average annual precipitation countrywide will possibly increase by 2%-4%; the number of heavy rain and excessively heavy rainy days will likely increase in the eastern China; the intensity of precipitation, especially that of heavy and excessively heavy rain will possibly increase; the number of rainy days of this category will decrease in the southwest; and the amplitude of precipitation increase in the *Haihe* and *Huaihe* river basins as well as those in the northwest will be relatively larger. Under the high GHG emission scenario (A2), it is projected that the annual average precipitation will slightly increase in China; and the precipitation in the *Haihe*, *Huaihe* and Yellow river basins and those in the northwest will increase by 3%-6%. The precipitation change in the south will be minor under all scenarios.

Larger uncertainties still exist in the projections of the future climate change in China. The major uncertainties are originated from future GHG emission scenarios, deficiency of observational data used for verification and parameterization of climate models, and restrictions on climate model development, especially on regional and local scales, leading to larger uncertainties in climate change projections. To reduce the uncertainties in the climate change projections from the climate models for China region, the relevant institutions are improving the climate system models by developing multi-model ensemble projection methodologies, and by improving both dynamic and statistical downscaling techniques, all aimed at improving the outcomes of future climate change projections.

Chapter 2 Assessment on Climate Change Impacts and Vulnerability

Due to its complex climatic conditions, vulnerable ecosystems, and limited usable land and water resources, China is one of the countries that are most susceptible to the impacts of climate change. The changing climate has extensive impacts on the ecosystems and economic sectors in China. Particularly, some facts of climate change impacts have been observed in agriculture, natural ecosystems, water resource, human health, coastal zones and offshore ecosystems, and most of these impacts are negative. Future climate change will have further profound impacts on various sectors in China.

2.1 Assessment on Climate Change Impacts on Agriculture and Vulnerability

2.1.1 Climate change impacts on cropping systems

The climate change has prolonged the crop growth period in higher latitudes in China, the boundaries of thermophilic crops have shifted northward, leading to cropping structure adjustments. Compared with 1960s, the crop growth period in most parts of the Northeast China has been prolonged by around 10 days. Due to climate warming, the northern boundary of winter wheat in this region has shifted further north and extended west; and the rice planting area has enlarged by a big margin and its northern boundary has shifted to about 52°N. The growing area of late-maturing corn varieties has shifted north by 4 degrees in latitude, the area of double cropping rice has shifted from 28°N to 30°N. The multi-cropping index nationwide increased from 109.4% in 1980 to 128.9% in 2006, and the increase of index was relatively larger in the *Qinghai*-Tibetan Plateau, Northwest, Southwest, East China and hilly areas in the South China. In 1981-2007, under the warming temperature and increased cumulative temperature, the northern boundaries of yearly double-cropping and triple-cropping have shifted northward to varying extents relative to 1950-1980. It is likely that China's cropping system will possibly experience larger changes in the future.

2.1.2 Impacts of climate change on agricultural diseases and pests

Crop diseases and pests will be aggravated due to climate change. As research findings show, 11 diseases (e.g. rice blast, rice bacterial blight, rice sheath blight, flax leaf spot) that seriously affect crops in China are closely related to meteorological conditions. The onset, development, affecting scope and transmission routes of crop diseases have changed to a varying degree. Since early 1970s, the scope, frequency, and severity of crop disease and pest outbreaks in China have exacerbated year by year. In normal years, the diseases and pests will reduce the crop yield by 10%-15%, cotton yield by more than 20%, and the total loss due to crop diseases, pest and weeds will account for about 20%-25% of the gross agricultural output.

The boundaries of disease and pest outbreaks will shift north under context of climate warming in the future, with their scope being expanded and severity aggravated. The northern winter survival boundary of army worms, rice plant-hoppers and leaf rollers will shift north by 1-2 degrees in latitude. The boundary of the pink bollworms will shift northward from the southern to central *Heibei* (e.g. around *Baoding* and *Dingzhou*). Climate warming will change the original phenological synchronization of insects and host plants with their natural enemies, creating greater challenges to crop disease and pest control.

2.1.3 Impacts of extreme weather/climate events on agriculture

The climate change has led to more frequent extreme weather/climate events and heavier losses in agricultural production. In the past 60 years, the area, crop yield and economic loss that were affected by drought and floods had increased year by year. The area affected by droughts had enlarged from 3.8 million hectares in 1950s to 14.5 million hectares in 2000-2008, a nearly 4-fold increase; and the loss of production had increased from about 1.9 Mt to 35 Mt, increasing by 18 folds (Figure 3.4). The croplands that were affected by floods were 9.37 million hectares on annual average in 1950-2000, and the yield decrease due to floods accounted for 3% of the total in the same period.

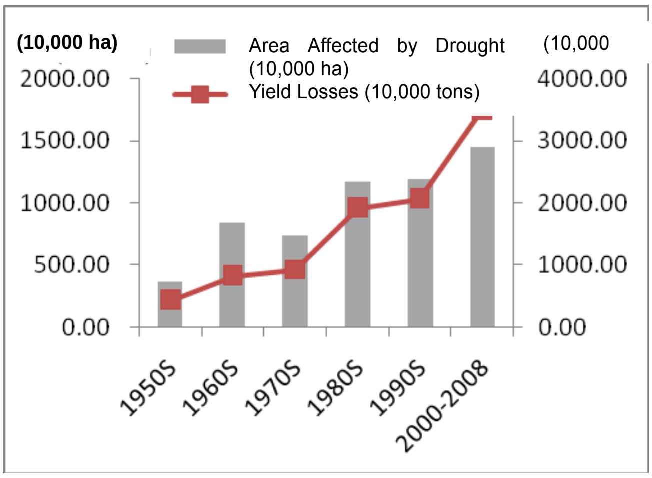


Figure 3.4 Impacts of extreme droughts on agriculture in China

Both frequency and intensity of extreme weather/climate events will further increase due to climate change in the future. The more severe droughts and floods will lead to a higher inter-annual variability and a low-yield probability, which will bring about adverse impacts on the agricultural production.

2.1.4 Climate change impacts on major crops yields

The climate change has already had evident impacts on grain yields in China. Studies show that even major crop yields in China had maintained a steady increase through technological advances, but the wheat and corn yields decreased by 5%, although the rice and soybean yields saw a slight increase under the changing climate in the last 3 decades. From the regional perspective, although climate change has brought about 3%-5% increase in grain output in the Northeast China and higher-elevation regions, it has also led to grain yield decreases in the North, Northwest and Southwest China, especially in the agricultural-pastoral transition zones. The adverse impacts of climate change on grain production are most evident. For example, the crop yield on the Loess Plateau had dropped by around 10% due to the warming in the last 30 years; and the impacts of climate warming on the grain yields in the East and Mid-south China were insignificant.

The future climate change could lead to yield reduction of major crops, including rice, corn and wheat, if no adaptation measures are taken. By 2050, the total grain output will possibly drop by about 20% at most without considering the CO_2 fertilization effect or by 5% at most if the effect is taken into account. Water resource will be the most important factor limiting the increase of the total grain output.

2.1.5 Vulnerability of agricultural production to climate change

The vulnerability of agricultural production to climate change in China is highly regional and differs from one region to another. Over the past 20 years, the most vulnerable regions are found in the agricultural-pastoral transition zones where the annual precipitation is about 400 mm, including the *Hexi* Corridor in the Northwest China; the agricultural productions in the Northwest, North, Southwest and Southeast China are also vulnerable to climate change. The vulnerability of the grain productions in the East and Mid-south China to climate change is insignificant; the Northeast China is not vulnerable to climate change, where the yields of rice and corn have increased by taking the advantage of increased heat resources (Figure 3.5). However, the vulnerability of the agriculture sector to the extreme weather/climate events and to crop diseases and pests has increased under climate warming.

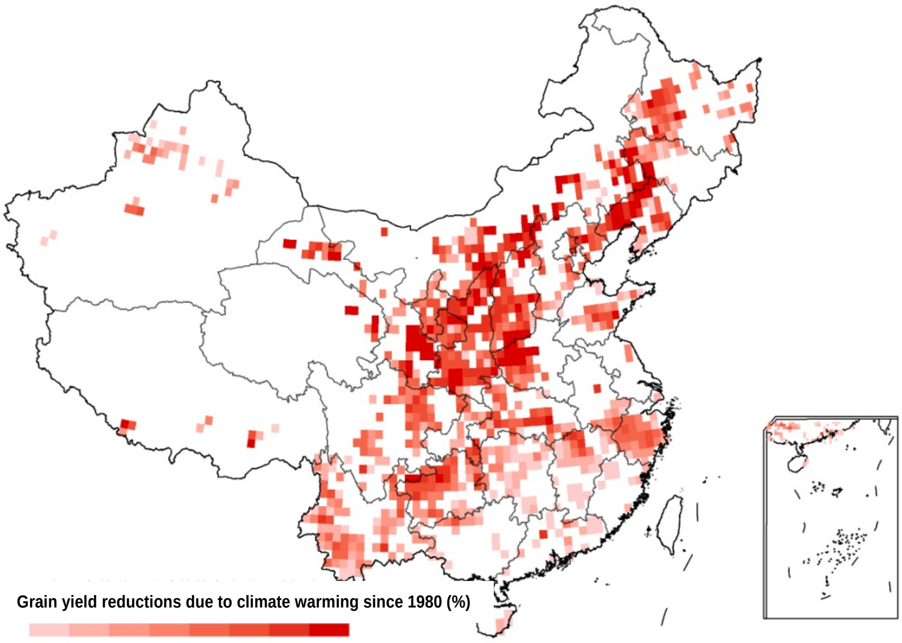


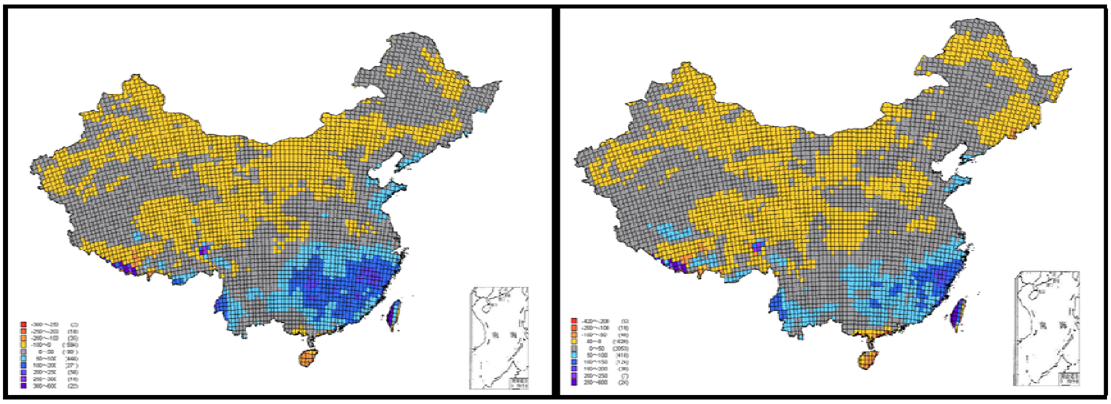
Figure 3.5 Vulnerability of grain production to climate change in China in last 30 years

2.2 Climate Change Impacts on Water Resources and Vulnerabilities

2.2.1 Climate change impacts on distribution of water resources

Climate change has led to a decrease of water resources in the north and an increase in the south in general. In the last 30 years, the water resources in the north have decreased significantly, showing a larger inter-annual variability; and imbalanced distribution of water resources featuring wetter south and drier north has become even more prominent. Both river runoffs and total water resource in the south have increased by about 4%, while the water resources in the north have noticeably decreased. The runoffs from the Yellow, *Huaihe*, *Haihe* and *Liaohe* rivers have declined by 17% and the total quantity of water resources in the north has decreased by 12%. The contribution of climate change to the runoff reduction in the middle reaches of the Yellow River is about 30%-40%.

In the next 30 years, there will be an overall tendency that the annual runoffs of major rivers in China will continue to decrease in the north but slightly increase in the south. In most northeast region, the runoff depth will decline with warming temperature in summers; the runoff depth in the southwestern *Xinjiang* (*Tahe* River basin) will rise in springs and summers, but the rest Northwest China regions will maintain the current warm and dry conditions with little change in runoff depth; the northern part of the East China will remain unchanged with the only exception of the *Shandong* Peninsula where the runoff depth will increase in springtime; the runoff depth will generally increase in the south, including the southern part of the East China, Central and South China, especially in the southern part of the East China where the increase of runoff depth will be more significant, which will worsen flood severity in summertime; the runoff depth in the south, especially in the South China regions, will generally witness significant decreases in wintertime (Figure 3.6).



(a) (b)

Figure 3.6 Changes of national multi-year averaged runoff depth by 2020s (2011-2040) in the context of climate change (baseline period: 1961-1990); (a) under A2 2020s; (b) under B2 2020s

2.2.2 Climate change impacts on droughts and floods

The climate change has given rise to more frequent extreme climate events in China, e.g. floods and droughts. In the past 50 years, the area hit by droughts in the north had expanded, and floods aggravated in the south, showing frequent and concurrent extreme weather events (e.g. local heavy rain, super typhoons, heat waves and droughts, freezing rain and snow). Especially, in the last 20 years, basin-wise or regional severe floods occurred consecutively in the Yangtze, Pearl, *Songhuajiang*, *Huaihe* river basins, *Taihu* Lake region and Yellow River basin, while droughts in the western part of the Northeast China, most North China, and eastern part of the Northwest China showed a trend of a longer duration, a higher intensity and a wider coverage. In the last decade, the average drought-affected area ratio and average drought-induced disaster rate reached 16.95% and 10.05%, which were 2.3 and 4.3 times higher than those in 1950s respectively.

In the next 30 years, climate change will intensify the current dry-north/wet-south status. Under the high GHG emission scenario (A2), droughts in the western part of the Northeast China will be exacerbated in springtime; spring droughts in the North China and in the region to the north of the *Huaihe* River will be mitigated to some extent, but consecutive droughts through summer and autumn will be aggravated; droughts in the extremely dry areas of the *Gansu* and *Qinghai* provinces in the Northwest China region will be worsened; autumn droughts in the *Hainan* area will become more severe; spring droughts in the southwest and summer droughts in the Yangtze River basin and in the *Boyang* and *Dongting* lake regions will be mitigated to a certain extent. Under moderate GHG emission scenario (B2), droughts in all regions and seasons will be worsened to varying degrees, with exception of spring droughts in the North and Southwest China regions, which will be somewhat mitigated; there is a higher probability that consecutive droughts will occur throughout spring, summer and autumn in the western part of the Northeast, and will occur throughout summer and autumn in the North China as well as in the regions to the north of the *Huaihe* River; and the trend of water shortage in the north will be intensified.

In the same period, it is more likely that the moderate flooding will occur in the middle reaches of the Yellow River, upper reaches of the *Huaihe* River, middle- and lower-reaches of the Yangtze River and the Pearl River basins; the vulnerabilities of key flash flood-control zones within most small- and medium-sized river basins in the south will increase, and the vulnerabilities of normal control zones in northern part of the North and Southwest China will tend to increase.

2.2.3 Climate change impacts on glaciers and lakes

The climate change has led to the retreats of glaciers and shrinkages of lakes. Since the last 60 years, 82% of glaciers in China have been retreating. Particularly, the retreat of the glacier on the edge of the *Qinghai*-Tibetan Plateau has taken the largest proportion of the total retreat (Figure 3.7). The area of glaciers has dwindled by 7.4% on average, and by over 20% in the worst case. The retreating rate has been accelerated since 1990s. There are 142 lakes with water area over 10 km^2 each in China, which have shrunk with the total diminished area of 9,574 km^2, accounting for 12% of the total lake area, and water storage capacity has decreased by 51.6 billion m^3, accounting for 6.5% of the total.

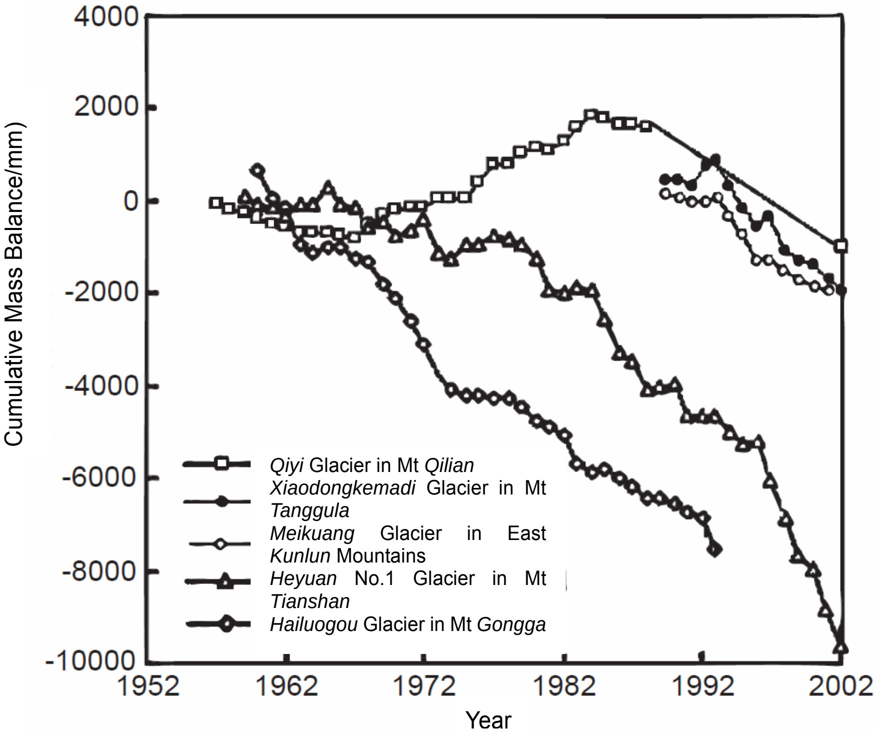


Figure 3.7 Changing process of cumulative mass balances of typical glaciers in China

In the next 50 years, the glaciers with an area less than 2 km^2 will gradually disappear and the larger glaciers will tend to retreat significantly as well. The total area of glaciers and ice reserve in the source region of the Yangtze River will shrink by about 8%, and 11% respectively, and the runoff from the river source region will increases by approximately 25%-30%.

2.2.4 Vulnerability of water resources to the climate change impacts

The regions where the water resources are most vulnerable to the climate change are the *Haihe* River basin, followed by the *Huaihe* and Yellow river basins. All inland river basins are also relatively more vulnerable. In the future, the vulnerability in terms of water demand and supply in the north will increase, leading to aggravation of droughts and water shortages. The extreme precipitation will tend to increase in the Yangtze River basin and in the regions to its south, therefore the flash flood risks in small- and medium-sized rivers and storm surge risks in coastal zones can not be ignored. The river runoff recharges from the melt glacier water and their seasonal regulating capacity will significantly decline. In next 50-100 years, climate change will further reduce the per capita runoff in the eastern part of the Northwest China, northern parts of the North and Northeast China. In the next 50 years, the mid-west provinces in the Northwest China region will be highly vulnerable to climate change.

2.3 Climate Change Impacts on Terrestrial Ecosystems and Their Vulnerabilities

2.3.1 Climate change impacts on forest ecosystems

The impacts of climate warming on forest ecosystems in China have mainly shown that boundaries of some tree species have shifted northward, forest lines have risen to higher elevations, phenology become earlier, and forest fires as well as pest/diseases have been aggravated. For example, the distribution boundary of the Dahurian Larch (*Larix gmelinii*) on the Greater *Khingan* Mountains and those of spruce, fir and redwood among other species on the Lesser *Khingan* Mountains have shifted north. The alpine meadow boundaries and forest lines of typical tree species growing in the transitional zone of *Wutai* mountains in the *Shanxi* province have clearly shifted to a higher elevation. The forest line in the Dry-Hot Valley in the *Yunnan* province has shifted up by 8.5 meters per decade. Compared with the early 1980s, the phenological period in springtime has been advanced by 2 days earlier on average, varying significantly in space; the phenological periods in the northeast, north and lower reaches of Yangtze River among other regions also become earlier, while the phenological periods in regions like the eastern part of the southwest and the middle reaches of the Yangtze River are postponed. The warmer and drier climate has led to more and wider forest fires in spring and summer. The frequent and persistent high temperature events and droughts have led to more forest fires in summertime. Under climate warming, both 3^{rd} and 4^{th} generation larvae of *dendrolimi* have survived winter altogether, compared with only survival of its 3^{rd} generation larvae in the past. The hazards of pine wood nematode have spread out in 11 provinces (municipalities) in the southern China. The impacts of extreme climate events on forestry have been aggravated.

In the future, the vegetation distributions in the eastern China will possibly shift northward at a slow pace; the area of deciduous coniferous forests in cold temperate zone will dwindle; the areas of the mixed coniferous forests and deciduous broad-leaved forests in the temperate zones of the East and Northeast China will shrink; and the areas of the evergreen deciduous broad-leaved forests in the warm temperate zone and grasslands in temperate zone will increase. The forest productivity in both Northeast and North China will continue to decline. By 2070-2100, the productivity may reduce to 80% of the average value in 1961-1990, but the reduction in productivity of other forests will be insignificant. With the increasing temperature and more frequent extreme climate events, the forest fire risks will likely increase. The extreme climate events and warm winters will also exacerbate physiological diseases and pest outbreaks.

2.3.2 Climate change impacts on grassland ecosystems

The major impacts of climate change on grassland ecosystems have been mainly found in grassland degradation and distribution changes. In the past 50 years, the grasslands in China degraded quickly. The drying trend in the north was one of the key factors for grassland degradation. In the grassland ecosystems around the river source region of the *Qinghai*-Tibetan Plateau, some meadows evolved into desert, and alpine swamp meadows and pastures changed into alpine steppes and alpine meadows respectively. Forage yields have generally declined in the southern Qinghai and Gansu, Inner Mongolia, Haibei State in the Qilian Mountains and other regions due to the warming temperature and decreasing precipitation.

In the future, the types of grasslands distributed in the arid zone of the northern China will shift toward the humid zone, and the boundaries of various grasslands will shift eastward. The lines of grasslands on the *Qinghai*-Tibetan Plateau, *Tianshan* and *Qilian* mountains among other regions will shift up by 380-600 m. The area of alpine grasslands in the *Qinghai*-Tibetan Plateau region will shrink significantly, but the area of alpine meadows and shrubs will slightly increase, and so will the grasslands, shrubs/meadows in the temperate climate zone.

2.3.3 Climate change impacts on wetlands and lake ecosystems

Climate change has led to degradation of ecosystems in some wetlands and lakes in China. The area of rain-fed wetlands has dwindled significantly, the wetlands in the Northeast and North of China have shrunk at a faster rate, and the area of the *Zoige* Wetland in the upper reaches of the Yellow River has retreated substantially. The rain-fed lakes have shrunk and become more saline, water levels of many medium-sized and large lakes have dropped, some have turned into a cluster of salty lakes, and a large number of small lakes are disappearing. The most melt snow or glacier water-fed lakes in the *Qinghai*-Tibetan Plateau have been mostly enlarged. The water areas of the *Namutso* Lake and other major lakes in the southeastern *Nagqu* region in Tibet have significantly increased in the past 30 years, and the area of the *Hala* Lake in the *Qilian* mountainous region has also increased considerably due to the melt snow/ice water.

In the future, the regional climate warming and drying trend will lead to further degradation of wetlands. The wetland resources in the Three-river Plain in the northeast China will further diminish, leading to weaker resilience for additional threats, less biodiversity, more endangered species, quicker degradation of ecosystems, with a larger area of swamp wetlands evolving into meadows. The evaporation from wetlands in the Three-river source region in the *Qinghai*-Tibetan Plateau will increase, and ecological issues (e.g. wetland degradation) will become more prominent.

2.3.4 Climate change impacts on biodiversity

The climate change and human activities have already impacted the diversity of species, habitats and landscapes among others. Some species in desert zones in China, e.g. *Xinjiang* tigers, Mongolian wild horses, *Saiga tatarica* and *Xinjiang* big-head schizothracin (*Aspiorhynchus laticeps*) have already been extinct due to climate change and human activities. Green peacocks were widely found in the *Hunan, Hubei, Sichuan, Guangdong, Guangxi* and *Yunnan* in the past, but now they only exist in the western, central and southern parts of *Yunnan* alone*.* The Prezewalski gazelles were used to be found in such regions as Inner Mongolia, *Qinghai* and *Gansu*, but they are only confined in the *Qinghai* Lake region. Climate warming has increased the extent and magnitude of damages due to indigenous plant diseases, pests and rats, and it has expanded the scope of alien specie intrusions, e.g. water hyacinth (*Eichhornia crassipes*), *Canadian Goldenrod* and *Crofton Weed*, etc. The warmer and drier climate has enlarged the area of shifting sands in the *Hulunbeier* Sandy Land, shrunk vegetation coverage and posed threats to the species in the habitat. The landscape diversity has been changed, *inter alia*, in Karst areas in the southwest, and in the south of *Tenggeli* and *Maowusu* desert.

In the future, climate change will alter distributions of species and reduce biodiversity. The distributions of giant Pandas, *Yunnan* snub-nosed monkeys, white-lipped deer and other animals will be fragmented under climate change. Among the 3,735 analyzed plant species, the distribution scopes of 29 will possibly shrink, those of 4 will expand, but the Dahurian Larch will disappear. The changing climate will also alter the distributions and increase the damage of harmful species

2.3.5 Vulnerability of terrestrial ecosystems to climate change impacts

In the past 30 years, the areas where the vulnerabilities of ecosystems have been increased under climate change are mainly found in the northern China, accounting for 43.7% of the total land area, and the increased ecosystem vulnerabilities mostly range from slight or light to moderate severity. The ecosystems in the Northeast of China have been mostly exposed to a slight or light increase in vulnerability, and those on the Loess Plateau have mostly witnessed a lightly increase vulnerability, compared with moderate vulnerabilities in *Gansu* and *Xinjiang*. The vulnerabilities of ecosystems in the eastern, northern, western *Qinghai*-Tibetan Plateau regions have increased to varying degrees. The areas, where the ecosystem vulnerabilities have been mitigated, only account for 19.9% of China's total land, mainly in the Yellow, *Huaihe,* and *Haihe* river basins, central *Qinghai*-Tibetan Plateau, and some localities in the *Xinjiang, Gansu, Ningxia* and Inner Mongolia. The vulnerabilities of ecosystems in the humid zones under climate change are virtually insignificant in the southern China, with exception of the Dry-Hot Valley in the *Yunnan* province, where local vulnerability of ecosystems has either decreased or increased partially.

Under the moderate GHG emission scenarios (B2), by the end of 21st century, the vulnerable ecosystems in China are projected to increase by about 22%, and the highly and extremely vulnerable terrestrial ecosystems will be mainly distributed in the ecological transition zones in the Inner Mongolia, Northeast and Northwest China as well as in desert-steppe areas, and the ecosystem vulnerability in most South and Southwest China regions will increase to some extent under climate change, but the vulnerability in the North and Northeast China will be mitigated to a certain degree.

2.3.6 Climate change impacts on geological environment

The impacts of extreme weather events on geological environment are mainly felt through frequent geological disasters (mountain collapse, landslide and mud-and-rock flow). In the 11th FYP period, 196,258 geological disasters occurred in China, and they left 5,611 people dead or missing, increasing by 97.1% and 29.5% respectively compared with the 10th FYP period.

Widespread (or local) heavy rain has induced massive and concurrent landslides, mountain collapses, mud-and-rock flows. In 1981, an excessively heavy rainfall had induced more than 60,000 landslides altogether in the *Sichuan* basin alone. In 2010, local short-time heavy rainfalls had caused historically rare mud-and-rock flows in the *Zhouqu* county, *Guansu* province on 8 August and in Sichuan basin on 13 August respectively. In case of drought immediately followed by flood or meeting a heavy rainfall soon after an extreme drought, it is more likely to cause massive disastrous landslides. In 2010, the southwest was first hit by a prolonged drought then followed by local heavy rain, a landslide was induced on 5 June, leaving 99 persons dead or missing in the *Guanling county, Guizhou* province; a similar event had almost completely ruined a newly-built migrants' living quarters in the *Wangong* township, *Hanyuan* county, Sichuan province on 27 July, with 20 people reported missing and 1,500 people being affected.

2.4 Climate Change Impacts on Coastal Zones and Regions as well as Vulnerabilities

2.4.1 Climate change impacts on sea level

The changing climate has led to a significant sea-level rising trend along China's coasts. In the last 30 years, the coastal sea level has shown a mean rising rate of 2.6 mm/year, higher than the rate of global sea level rise (1.7 mm/year). The annual mean rising rates of the sea levels in the *Bohai* Sea, Yellow Sea, East China Sea and South China Sea were 2.5 mm, 2.8 mm, 2.8 mm, and 2.5mm respectively in 2010 (Figure 3.8).

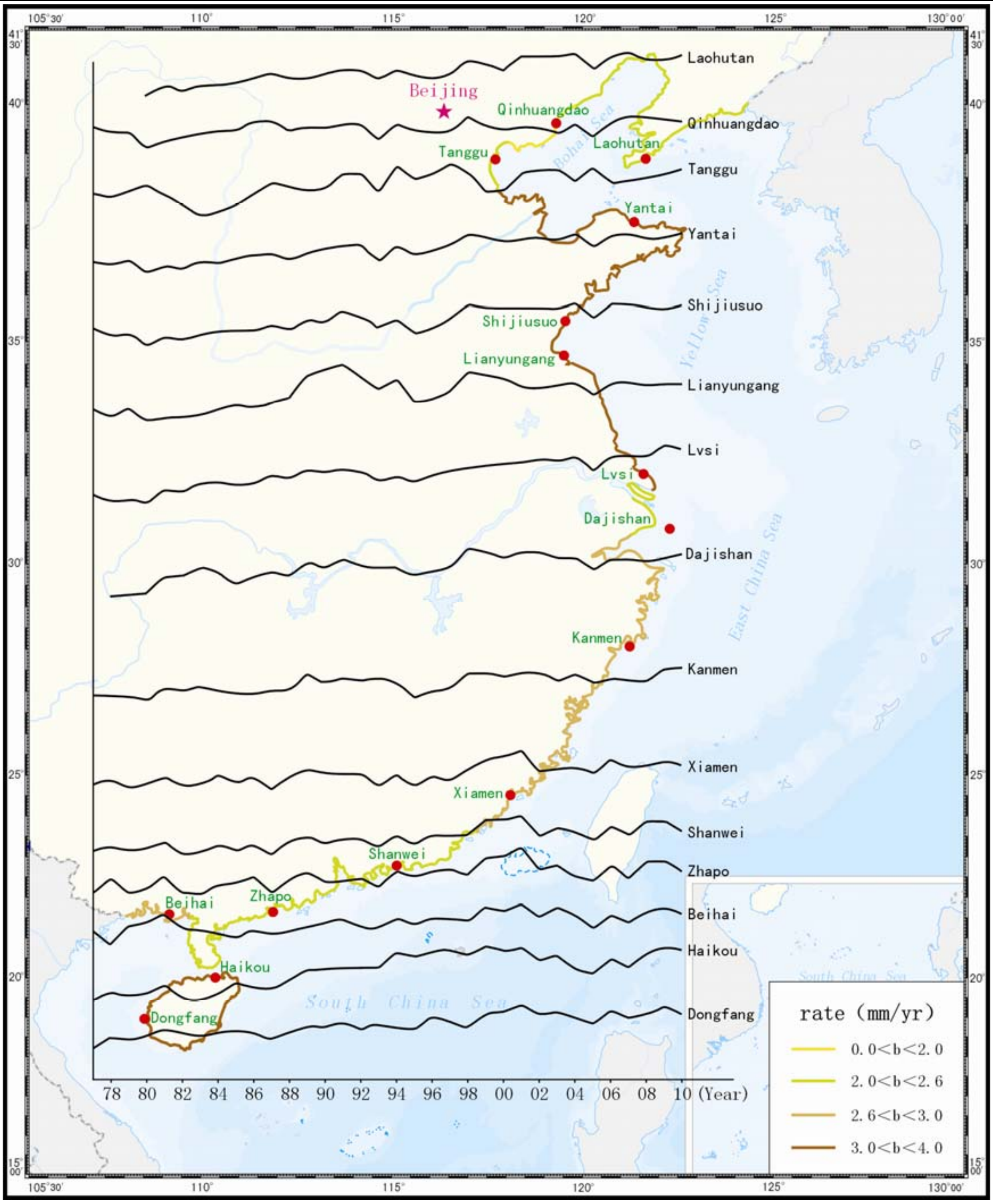


Figure 3.8 Sea level changes along China's coastline in 2010 from main monitoring stations

In the next 30 years, China's coastal sea levels will continue to rise, with the average rising amplitude ranging from 80 mm to 130 mm. The sea level rise in the four sea areas and various coastal provinces will show different spatial characteristics. (Tables 3-1 and 3-2)

Table 3-1 Projected sea level rises of various sea regions along China's coastline (relative to sea levels of 2010)

Sea area	Projected values by 2040（mm）
Bohai Sea	74-122
Yellow Sea	81-128
East China Sea	83-132
South China Sea	78-130
Sea regions as a whole	80-130

Table 3-2 Projected sea level rises by coastal provinces (autonomous region or municipalities) (relative to sea levels of 2010)

Province/municipality	Projected values by 2038（mm）
Liaoning	75-119
Hebei	72-118
Tianjin	76-135
Shandong	85-132
Jiangsu	77-128
Shanghai	91-143
Zhejiang	84-139
Fujian	76-118
Guangdong	84-149
Guangxi	78-116
Hainan	85-132

2.4.2 Climate change impacts on storm surges

The storm surges along China's coastline have become increasingly severe in the context of climate change. The statistics show that the mainland China's coasts had been hit by 3 storm surges in the 'Orange' warning category per year over the past two decades, showing a slow increasing trend. The coastal zones that have been hit most hard by typhoon-induced storm surges are the *Guangdong, Fujian* and *Zhejiang* coasts; and the coastal zones that have been worst hit by temperate storm surges are the *Shandong*, *Hebei* and *Tianjin* coasts. The sea level rise under climate warming will increase the extreme coastal sea levels, which in return will substantially shorten the return period of severe storm surges and significantly reduce capacities of current infrastructures (e.g. seawalls) against inundation disasters.

2.4.3 Climate change impacts on coast erosions

The climate change has aggravated the coast erosions in some regions. The sea level rise has increased tidal difference and wave height, and worsened the coast erosions in the *Shandong* and *Liaoning*. A survey on impacts of sea level changes in 2010 showed that the maximum erosion rate was 2.5 m/year in the *Huludao*, *Liaoning*, and nearly 5 m/year in some segments of the *Yingkou*, severely damaging the coastal eco-environment and croplands; some beaches in the *Beidaihe, Hebei* retreated by nearly 100 m; partial coastline in the *Penglai, Shandong* retreated by 500 m in the past 50 years, and 700 m in the worst case, and the maximum annual erosion rate in the *Yantai* was more than 4 m/year.

Climate warming will lead to stronger impacts of tropical storms and extra-temperate cyclones, quicker sea level rise, and less sand inflows from estuaries. In the future, all delta regions in China will be exposed to more severe erosions, even possible significant retreats, while the Yellow River Delta has already faced such erosion risks.

2.4.4 Climate change impacts on seawater intrusion

Under the combined impacts of rising sea level and declining ground water table, China's coastal zones had been generally intruded by seawater in the past 4 decades. A segment in the *Binzhou, Shandong* was once overwhelmed by seawater invading beyond 21 km inland, and soil salinization in the *Xiaolinghe* River in the *Jinzhou, Liaoning* reached 6.2‰ in maximum water-soluble salt content, seriously affecting the water supply for local residents and agricultural production.

2.4.5 Impacts of sea-level rise on river deltas

Taking into account such factors as sea-level rise amplitude, regional socio-economic environmental quality, intensity of disaster-inducing factors and resilience, the regions that are most sensitive to sea level rise are the *Haihe*-Yellow river delta, Yangtze River Delta and Pearl River Delta. With the current seawalls, as the sea level rises, by 2050 over 300 km^2 on-shore lands in the Pearl River Delta will be affected by a record high tide or 1-in-100-year tide, affecting 2.2% of its population with a potential loss of 2.1% of local GDP.

2.4.6 Climate change impacts on offshore ecosystems

Climate change has led to changes of marine organisms, north shift of mangroves and coral bleaching, etc. In the last 20 years, some marine species in China's offshore seas have shifted north due to climate warming and increasing sea temperature; the abundancy of warm water zooplanktons at the estuary of the Yangtze River and in the East China Sea have increased, but warm-temperate species have decreased. Among the marine catches in the Taiwan Strait, the share of warm water fishes have increased, while temperate water fishes have decreased by 10-20%. Under climate warming, the boundaries of both naturally distributed and cultivated mangroves have shifted to higher latitudes, turning some zones that used to be unsuitable for mangroves into those suitable for their growth; the boundary of cultivated mangroves has shifted northward to the southern coast of the *Zhejiang* in 1980s, and to offshore waters to south of the Yangtze River estuary now. Coral bleaching has been found along China's south and southeast coasts, and the bleaching has become severe in the *Weizhou* Island in the *Beibu* Gulf of the South China Sea (Figure 3.9).

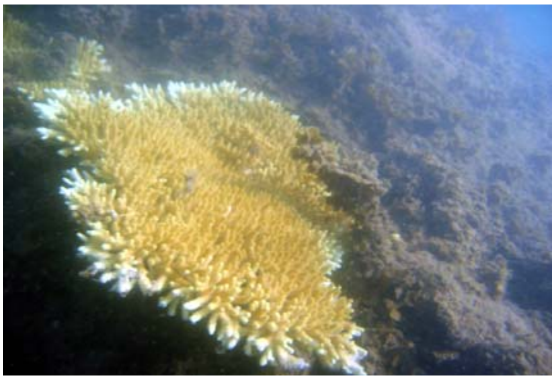


Figure 3.9 Coral bleaching off west coast in *Leizhou* Peninsula, China

If future temperature increases by 2°C, the boundaries of mangroves will possibly shift further north by 2.5 degrees in latitude on average, and ecological communities will increase. However, if air temperature is beyond 35°C, the root structure, seedling growth and photosynthesis of mangroves will be seriously affected. The sea temperature warming will have important impacts on fish migration routes, distances and destinations, and distributions of warm- and cold-water species will change. Coral reefs around the *Nansha* Islands may stop growing; and some reef-building organisms may be at risk of extinction, which may be lethal to coral reef biodiversity.

2.4.7 Vulnerabilities of coastal zones to climate change

It is very likely that the sea level along China's coastline will continues to rise. Based on comprehensive assessments on multiple factors, e.g. coastal land elevation, coastal protective structure criteria, storm surge intensity and ecosystems, the 5 major zones that are vulnerable to future climate change will be the Yellow River Delta & coast of the *Bolai* Bay, Northern *Jiangsu* Plain & Yangtze River Delta, Pearl River Delta, *Liaodong* Bay area, low-lying land along west coast of the Taiwan province.

2.5 Climate Change Impacts on Human Health

2.5.1 Direct impacts of climate change on human health

High temperature weather has become one of factors for higher mortality in summertime. Heat waves have more significant impacts on the health of infants, young children, elderly people and patients of chronic diseases, e.g. respiratory and cardio-vascular diseases, often leading to higher morbidity and mortality.

2.5.2 Indirect impacts of climate change on human health

Climate change had evident impacts on vector-borne infectious diseases. Climate change has led to extension of the malaria transmission season in the areas of high prevalence. The climate change impacts on the transmission of schistosomiasis are mainly found in the intensified magnitude and scope of the disease. Floods will increase the risks of its transmission, and the area of *oncomelania* habitats in a flooding year is 2.6 times larger than that in normal year along the middle- and lower-reaches of the Yangtze River. Climate warming had also significant impacts on distribution of the Dengue fever. *Hainan*, a province with high prevalence of the disease had witnessed the north-shift of the Dengue fever in last 25 years. It is projected that the potential northern boundary of the *oncomelania*, the intermediate host of schistosomiasis, will shift north in the eastern China, especially in the *Jiangsu* and *Anhui* provinces. In the meantime, the transmission intensity of the schistosomiasis disease will increase significantly around the Yangtze River basin, *Dongting* and *Boyang* lakes, especially around the *Dongting* Lake and along the Yangtze River segment in the *Hubei* province.

Chapter 3 Policies and Actions in Adaptation to Climate Change

In the process of its active response to climate change, China holds the principle of 'addressing climate change under the framework of sustainable development' and 'attaching equal importance to both mitigation and adaptation'. China has incorporated adaptation policies and actions in its overall national strategy for coping with climate change, issued a series of policies and regulations related to climate change adaptation, and enhanced the capability building in adaptation to climate change.

3.1 Polices and Actions Taken in the 11th FYP Period

3.1.1 Agriculture

China has taken a series of measures aimed at promoting climate change adaptation in agriculture. The major measures include: adjusting agricultural structure, deploying high-efficiency water-saving irrigation and rain-fed water efficiency farming techniques, and increasing subsides for water-saving irrigation machineries; implementing regional plans for competitive agricultural product layout, and increasing subsides for improved crop varieties; actively developing intensive and standard livestock production and aquaculture, and facilitating construction of an animal epidemic disease prevention system; expanding coverage of the project on recovery of grassland by reducing grazing intensity, and enhancing managed grasslands; gradually establishing a grassland ecological compensation mechanism, further implementing protective measures, e.g. forage-livestock balance, grazing ban, rest, and rotational grazing, to restore natural grassland vegetation and to control grassland degradation.

3.1.2 Water resources

The adaptation measures in water resource sector taken by China fall into two categories: engineering and non-engineering measures. The former includes the projects for flood control and sedimentation reduction, drought control and disaster mitigation, water resource development and utilization, water resource protection, soil and water conservation, urban flood prevention, rainwater collection and local processing systems among others. The latter includes buildup of a flood/drought control mechanism, water-saving society, and unified management of water resources, etc.

3.1.3 Terrestrial ecosystems

The adaptation measures that have been taken for China's terrestrial ecosystems mainly include enhancing construction of key projects, e.g. natural forest conservation, sand/dust source control in Beijing and Tianjin, and the greening shelter forests in Northwest, North & Northeast China, the Yangtze and Pearl River basins as well as on the *Taihang* Mountains; implementing projects on conversion of sloppy cropland into forestry; creating natural reserves in areas with high risks of climate change; reinforcing management and protection of terrestrial ecosystems; enhancing recovery and rehabilitation of degraded ecosystems to reduce climate change risks; enclosing sensitive grasslands; reinforcing protection and management of wetland ecosystems to increase their resilience to climate change risks; establishing and improving an integrated terrestrial ecosystem monitoring system at the national level.

3.1.4 Coastal zone and regions

The adaptation measures that have been taken for China's coastal zones and regions mainly include enhancing basic capacity building for protecting coastal zones and regions in adaptation to sea level rise; heightening and fortifying seawalls against typhoon-induced storm surges, and establishing an emergency response mechanism for typhoon and storm surge preparedness; and improving relevant laws, regulations and policies to constantly enhance marine ecosystem conservation and rehabilitation.

3.1.5 Human health

The climate change adaptation measures taken by China in human health sector mainly include establishing a network-based direct reporting system for infectious disease outbreaks and public health emergencies; increasing investment in public health system to establish a sound public health emergency response system, a disease control and prevention system and a health supervision and law enforcement system; vigorously conducting research on climate change impacts on human health, and pursing scientific knowledge outreach and training.

3.2 Policies and Actions to be Taken during the 12th FYP Period

Based on its *12th Five-Year Plan for National Economic and Social Development*, China will further enhance its capacity in adaptation to climate change during the 12th FYP period (2011-2015). The main policies and actions include developing the national overall strategy for climate change adaptation; enhancing scientific research, observation and impact assessment on climate change; taking into full account climate change factors in designing and accomplishing productivity distribution, infrastructures and key projects; enhancing capacity building for climate change adaptation, especially in coping with extreme climate events; accelerating R&D and deployment of adaptation technologies; and improving climate change adaptations in key sectors like agriculture, forestry and water resources and in coastal regions and ecologically vulnerable areas. China will enhance monitoring, early warning of and preparedness for extreme weather and climate events to improve its capacity for natural disaster prevention and mitigation.

In agricultural sector, China will continue to implement soil-fertility engineering and soil test-based fertilization, develop conservation tillage farming, and intensify construction of water resource projects, and increase water supply probability for agriculture; it will practically enhance construction of cropland irrigation & drainage facilities, implement ancillary facility buildup and water-saving alteration in the irrigated areas nationwide, develop water-saving irrigation and rain-fed farming with water efficiency, and accomplish large pump-drainage station upgrading and alterations; it will develop new crop varieties, and promote high-yield and high-quality crop varieties (e.g. super hybrid rice) and high-efficiency cultivation techniques and models.

In water resource sector, China will strongly pursue cropland irrigation & drainage constructions, accelerate small- and medium-sized river harnesses and small reservoir reinforcements, address engineering water shortage as a matter of urgency, and enhance emergency response capacity for drought and flood control; it will fully expedite construction of water conservancy infrastructures, harness large rivers and lakes, enhance construction of water resource allocation projects, improve soil and water conservation and protection of aquatic ecosystems, and intensify supportive role of hydro-meteorological and hydraulic sciences and technologies, enforce most stringent water management regulations, and set up a water control system based on total water use limit and efficiency; it will establish an accountability and assessment system for water resource management, accelerate construction of water conservancy projects and institutional management reforms, improve grass-root water supply regimes, and actively push forward water pricing reforms.

In forestry ecosystem sector, China will further improve the adaptability of planted forest ecosystems, establish nature reserves for typical forest species, intensify conservation of priority species, enhance capability to monitor and warn of wildlife epidemic diseases and their sources; reinforce vegetation protection in desertified areas and the basic work on wetland conservation, establish and improve a network of wetland nature reserves.

In coastal zones and regions, China will further facilitate establishment of an operational marine climate observing (monitoring) system, establish and improve climate change-related marine hazard monitoring, early warning and climate predictions, enhance research on climate change impact assessment and adaptation strategies, pursue marine hazard risk assessment and zoning, and enhance conservation of ecosystems on islands and in coastal zones.

In the public health sector, China will establish extreme climate event related human health monitoring network to watch, analyze and assess on real-time basis the potential health hazards due to extreme climate events; it will enhance current capacity building for monitoring weather and human heath to expand monitoring elements; it will study climate change impacts on human health in urban and rural areas, especially impacts of the extreme weather and climate events (e.g. heat wave, rainstorm, flood, high wind, sand/dust storm, drought and haze) on disease incidences that are sensitive to climate change nationwide, develop and establish an early warning system for climate change and human health, emergency response plans and relevant methodologies and techniques; and it will evaluate effectiveness of the early warning system and other intervention policies and measures.

Part IV. Policies and Actions for Climate Change Mitigation

As a responsible developing country, according to the relevant provisions of the Convention and its Kyoto Protocol, taking into account the overall requirements of its national strategies for sustainable development, China has taken a series of policies and measures to adjust its economic structure, to change development modes, to improve energy efficiency and conservation, to develop renewable energy and nuclear power, to optimize energy mix, and to plant trees among others, with significant results having been achieved. China will further incorporate the responses to climate change in its economic and social development plans. China will take GHG emission control action targets by 2020 as its strategic tasks for addressing climate change in both current and future periods, and significantly reduce energy consumption intensity and CO_2 emissions through multiple means such as adjusting industrial structure and energy mix in combination with energy conservation, improved energy efficiency, and increased forest carbon sinks, in order to effectively control GHG emissions, and to make a new contribution to safeguarding the global climate.

Chapter 1 Actions and Targets for GHG Emission Control

1.1 Actions and targets for GHG emission control by 2020

In November 2009, the State Council set the action targets for GHG emission control by 2020: China's CO_2 emission per unit of GDP will be reduced by 40%-45% by 2020 compared with 2005, which has been incorporated in the medium and long-term economic and social development plans as a binding target, and for which national statistical, monitoring and assessment methods will be developed accordingly. The non-fossil fuels will account for about 15% of the total primary energy consumption by 2020 through vigorously developing renewable energy among others; the forest area will be increased by 40 million hectares compared to 2005 through afforestation and enhanced forest management, and the forest stock volume will be increased by 1.3 billion m^3 relative to 2005. This is a voluntary action taken by China according to its national circumstances, showing the direction for China to actively address global climate change in the medium and long-term.

1.2 Actions for GHG Emission Control and Effectiveness in the 11th FYP Period

The 11th Five-Year Plan for National Economic and Social Development of PRC set forth for the first time the objective to "bring GHG emissions under effective control". In June 2007, the Chinese government issued the *China's National Climate Change Programme*, which clearly set the relevant targets for GHG emission control by 2010.

According to preliminary statistics, by the end of 2010 the energy consumption per unit of GDP had been reduced by 19.1% from 1.276 tce per RMB 10,000 *Yuan* to 1.033 tce per 10,000 *Yuan* relative to 2005. In the 11th FYP period, 630 Mtce was saved through energy conservation and improved energy efficiency, and the trend of high energy consumption per unit GDP in the late 10th FYP period was curbed. The total non-fossil fuel consumption reached 280 Mtce, and its share in the primary energy production increased up to 9.4%. The emission of nitrous oxide from industrial processes was basically stabilized at the level of the year 2005, and increase of methane emissions was brought under control to a certain extent. The forest coverage reached 20.36%, and the total forest stock volume was 13.7 billion m^3.

1.3 Targets and Actions for GHG Emission Control in the 12th FYP Period

To ensure that China's targets for GHG emission control are met by 2020, the *12th Five-Year Plan for National Economic and Social Development of PRC* has set for the first time a binding target for reducing CO_2 emissions per unit of GDP by 17%, and it has also set the specific action targets for GHG emission control: energy consumption per unit of GDP will be lowered by 16%; the non-fossil fuels will account for 11.4% of the primary energy consumption; the forest coverage will be increased to 21.66%; and forest stock volume will be increased by 600 million m^3.

During the 12th FYP period, China will change its development modes, and take a green and low-carbon development pathway with Chinese characteristics by reasonably controlling its total energy consumption, imposing strict management on energy uses, accelerating formulation of energy development plan, setting a clear-cut target for controlling its total energy consumption and dividing it into regional targets for local governments, pursuing afforestation, expediting R&D and deployment of low-carbon technologies, curbing GHG emissions in industry, construction, transport and agriculture and other sectors, exploring to establish low-carbon product standards, labeling and certification system, establishing and improving a statistical GHG emission accounting system, gradually creating a carbon emission trading market, and promoting low-carbon pilot demonstration programs, to ensure that the GHG emission control action targets are met by 2020.

Chapter 2 Economic and Industrial Restructuring

China is at the stage of rapid development toward industrialization, urbanization and internationalization, and its industrial structure is characterized with relatively higher proportion of the secondary industry in GDP and relatively slow development of the tertiary industry. Economic and industrial restructuring is an important approach for GHG emission control.

2.1 Polices and Actions Taken in the 11th FYP Period

During the 11th FYP period, the Chinese government has attached great significance to industrial restructuring, focusing on promotion of economic transformation and reduction of resource and energy consumptions, reinforcing the guiding role of industrial policies and special plans. On the one hand, China has been vigorously accelerating development of the tertiary industry and encouraging the development of emerging industries; on the other hand, it has attached importance to restructuring the secondary industry to facilitate its optimization.

2.1.1 Promoting development of the service sector

In December 2005, the State Council issued the decision on implementation of the *Interim Provisions on Promoting Industrial Restructuring*, which clearly defined the targets, principles, orientations and priorities for the industrial restructuring for the current and coming periods. In 2007, the Chinese government issued the *Opinions Concerning Accelerating the Development of the Service Industry*, which requested to increase the added value of the services sector by 3% in GDP by 2010 relative to 2005, providing a clear policy in support of key areas, weak links and the development of emerging industries in the service sector. In 2008, the State Council issued the *Suggestions on Implementation of Several Measures for Accelerating Development of Service Industry* in support of improvement of the policy system for accelerating development of services sector. Since 2009, China has formulated a series of policy documents to accelerate the development of the tertiary industry, stating that the development of tertiary industry shall be considered as a strategic initiative to quicken the transformation of the economic development modes and economic restructuring. In the 11th FYP period, the added value of the tertiary industry in GDP increased from 40.5% in 2005 to 43.2% in 2010.

2.1.2 Promoting and fostering high-tech industries

In 2007, China formulated the 11th five-year plans for the high-tech, information, bio-tech industries among others respectively, and provided clear policies and measures to improve and promote developments of digital television, software, integrated circuits, bio-tech and other high-tech industries to expedite their development in compliance with the energy-saving and emission reduction requirements. In 2010, the Chinese high-tech industrial output reached RMB 7.5 trillion *Yuan*, with a growth rate of 16% per year in the 11th FYP period. Since 2009, China has launched the ‘Emerging Industries Venture Capital Program’, under which 61 venture capital funds have been created in support of innovative business growth in the area of energy conservation, environment protection and renewable energy. Some cities have been selected to build low-carbon renewable energy industrial parks to promote growth of the emerging industries.

2.1.3 Controlling overgrowth of high energy consumption and high emission industries

The governmental departments concerned have intensified the efforts to revise the *Guiding Catalogue for the Industrial Restructuring* and the *Catalogue for Guidance of Foreign Investment Industries*, further highlighting improvement and transformation of traditional manufacturing industries and restriction of high pollution, high energy and resource consuming projects. In 2009, the Chinese government issued and implemented the industrial restructuring and revitalization plan for 10 major industries, and one of its priorities was to phase out backward production capacity, to improve technological level, and to reduce energy consumption and pollutant emission in support of quicker technological transformation in iron- and steel-making, nonferrous metal, petrochemical, power-generating and other industries, reduction of energy consumption and comprehensive utilization of resources. In July 2009, the State Council transmitted and issued the *Opinions on Restraining Excessive Production Capacity and Redundant Construction in Some Industries to Guide for Healthy Industrial Development*, in which the relevant policies and requirements were stated for restraining excessive *production capacity*, and by which the momentum for redundant construction of industries with excessive production capacity was preliminarily curbed. In 2010, China launched the demonstration projects on low-carbon technological innovations and industrialization to meet demands for low-carbon technologies in industry, energy, building, transport and other sectors. The Chinese government also issued relevant policies and regulations on management of newly-started projects, strictly enforced the national industrial policy and project management regulations, strengthened the land use approval, energy-saving assessments and environmental impact evaluations, formulated and issued higher market access criteria for high energy-consuming industries, took such measures as adjustments to export tax rebates and tariffs to suppress the export of products of high pollution, high energy and resource consumption. New projects of high energy consumption, high pollutant emission industries and those with redundant production capacity were strictly controlled. In the 11th FYP period, the growth rate of China's high energy consuming industries showed a gradual declining trend.

2.2 Policies and Actions to be Taken during the 12th FYP Period

China will adhere to the new pathway toward industrialization with Chinese characteristics by developing a modern industrial system featuring optimized structures, advanced technologies, clean and safe development, high added values and more job opportunities. Firstly, China will transform and upgrade its manufacturing industries. The key industries will be restructured, including equipment manufacturing, shipbuilding, automobile, metallurgical, building material, petrochemical, textile, packaging, electronic & information, building and other industries. Secondly, China will foster and develop strategic emerging industries. Leapfrog development of the key sectors will be facilitated, and strategic emerging industries like energy conservation, environment protection, new generation IT, bio-tech, high-end equipment manufacturing, renewable energies, new material and new energy vehicle industries will be strongly developed. Thirdly, China will accelerate development of the service sector, expand financial services in a well-coordinated manner, vigorously develop modern logistics, foster and develop high-tech services, regulate and improve commercial services, strongly enhance customer services and facilitate integration of producer services with advanced manufacturing industries, and accelerate development of services sector. By the end of the 12th FYP period, China will strive to achieve a substantial progress in industrial restructuring, continue to optimize industrial structure, and make breakthroughs in developing strategic emerging industries; and the added value of the service sector in GDP will be increased by 4%.

Box 4-1 China has quickened the pace to foster and develop its strategic emerging industries

In 2010, China issued the *Decision of the State Council on Accelerating the Fostering and Development of Strategic Emerging Industries*, which stated that in current stage the priority should be given to fostering and developing energy conservation and environment protection, new generation IT, biotech, high-end equipment manufacturing, renewable energy, new material, new energy vehicle industries, etc. It is requested that by 2015, the strategic emerging industries will basically take a healthy and coordinated development shape, playing a more significant role in driving the industrial structure upgrading, and their total added value in GDP will account for about 8% with tremendous efforts. By 2020, the share of strategic emerging industries in GDP will account for around 15% through hard efforts, with the labour force absorbing and job creating capacity being significantly enhanced. The energy conservation, environment protection, new generation IT, biotech, and high-end equipment manufacturing industries will become pillars in the national economy; the renewable energy, new material, and new energy vehicle industries will be the forerunners in the national economy. China's innovation capability will be enhanced dramatically, acquiring a number of key core-technologies, reaching the world advanced level in some aspects. China will shape a group of large enterprises with international influence and a large number of small and medium-sized enterprises with strong innovative capacity, and create a cluster of strategic emerging industry zones with a sound industrial chain, stronger creativity and distinctive features. Through efforts for another decade, the overall innovation capability and development of the strategic emerging industries will catch up with the world advanced level, providing a strong support for the sustainable economic and social development.

Chapter 3 Energy Conservation and Improvement of Energy Efficiency

Energy conservation is a major strategy for China's economic and social development. Significant progress has been made in energy conservation through a series of policies and measures, e.g. improving regulations and standards, reinforcing accountability, phasing out backward production capacity, implementing key projects, promoting technological advances, intensifying policy incentives, enhancing supervision and management, and encouraging social participation. In the 11th FYP period, 630 Mtce were saved or less used in accumulation, equivalent to an emission reduction of 1.46 Gt CO_2 eq.

3.1 Polices and Actions Taken in the 11th FYP Period

3.1.1 Improvement of the *Energy Conservation Law* and regulations

The *Energy Conservation Law* is a basic law to guide China's energy conservation. The *Energy Conservation Law* was amended in 2007, which came into effect on 1 April 2008. The revised *Energy Conservation Law* expands its legal regulatory scope with building energy efficiency, transportation energy saving and energy conservation in public institutions being added. This law improves energy management and standardization systems, establishes the mechanisms for energy conservation target-based accountability and assessment, energy efficiency assessment and approval on fixed-asset investment projects, phasing out backward high energy-consuming products, equipments and production processes, energy-saving management of key energy use units, energy efficiency labeling management, and energy-saving incentives. It improves economic policies to promote energy conservation, and both central and provincial fiscal authorities allocated energy-conservation funds in support of R&D of energy-saving technologies, demonstration and deployment of energy-saving technologies and products, implementation of key energy-saving projects, energy conservation outreach and training, information services and incentives, etc. This law enacts some enabling policies including tax concessions for using energy-saving technologies and manufacturing the products listed in the guiding catalogue, and provides financial subsidies for diffusion and use of energy-saving lighting devices and products. It defines the actors for energy conservation management and supervision, specifies an energy management mechanism featuring unified management, interactive work division, collaboration and coordination, and defines responsibilities of the competent and relevant departments for energy conservation supervision and management; and it reinforces legal obligations and spells out 19 specific legal responsibilities.

To implement the *Energy Conservation Law*, to enhance preparation of relevant ancillary regulations and standards, and to enhance its operability and expected implementation results, the State Council issued the ancillary regulatory documents, e.g. the *Regulations on Energy Conservation in Civil Buildings* and the *Regulations on Energy Conservation in Public Institutions*, and its relevant departments issued the *Interim Measures for Energy-Efficiency Assessment and Approval on Fixed-Asset Investment Projects* and the *Measures for Energy Efficiency Supervision and Management of Special High Energy*

Consuming Equipments among others. The Standing Committee of the National People's Congress included the implementation status of the *Energy Conservation Law* in its supervision work plan for 2006 and 2010. The focus of the law enforcement in 2010 was to check if the ancillary regulations, especially those for building energy efficiency were put in place or improved, if the statutory responsibilities were fulfilled by governments, agencies, enterprises and institutions at all levels, including overall progress, major problems and solutions in their current work on building energy efficiency, as well as opinions and suggestions on law amendment and improvement. The implementation and further improvement of the *Energy Conservation Law* has not only substantially promoted energy conservation work, but also effectively facilitated implementation of the resolutions on addressing climate change and relevant regulations approved by the Standing Committee of the National People's Congress.

3.1.2 Reinforcing energy conservation target accountability and assessment

The energy-conservation target accountability and assessment mechanism is an important component of the energy management system with Chinese characteristics, and it is also an important means to enhance the sense of energy-saving responsibility of the leaders at all levels and to reinforce governmental leadership. China has divided and allocated its energy-conservation target for reducing energy consumption per unit of GDP to each province, autonomous region and municipality, based on which a target accountability system has been created, and local government officials are held accountable for failure in meeting their targets. Among the enterprises with independent accounting in the 9 key energy-consumption segments, i.e. iron/steel making, nonferrous metal, coal, power, petroleum and petrochemical, chemical, building material, textile and paper industries, NDRC, State Energy Office (SEO), National Bureau of Statistics (NBS), General Administration of Quality Supervision, Inspection and Quarantine (GAQSIQ), and State-owned Assets Supervision and Administration Commission of the State Council (SASAC) launched the '1000 Enterprises' Energy Conservation Campaign by selecting totally 1008 major energy-consuming enterprises, whose total energy consumption was beyond 180 Ktce each in 2004.

Since 2007, the Chinese government has assessed the performances of the provincial governments and the 1000 enterprises in meeting their energy-conservation targets and in implementing the energy-saving measures; and the results of the assessments were publicized. Together with relevant departments, NDRC has also organized special inspections on the energy conservations, to supervise those areas where the annual targets are not met. Preliminary statistics show that by the end of 2010, the majority of provinces (autonomous regions and municipalities) had met their targets in the 11^{th} FYP period. By the end of 2010, the '1,000 Enterprises' Energy Conservation Campaign had achieved significant results, saving 165 Mtce in accumulation.

3.1.3 Quickening the pace to phase out backward production capacity

Phasing out backward production capacity is an important means for energy conservation and emission reduction, and the efforts has been intensified constantly in this direction. In 2007, the Chinese government released work plans for phasing out backward production capacity in 13 industries divided by areas and years in the 11^{th} FYP period. In February 2007, the State Council issued the *Notice on Further Enhancing the Work to Phase out Backward production capacity*, to further quicken the pace of phasing out backward production capacity, focusing on iron/steel-making, cement, flat glass, nonferrous metal, charcoal, paper, leather making, printing and dyeing industries, and to take a series of comprehensive measures, e.g. dividing the overall target into sub-targets and strengthening individual responsibilities, improving effects of binding policies, and establishing incentive, supervision and inspection mechanisms to ensure that the tasks were fulfilled on schedule. In the 11^{th} FYP period, pursuing the policy of developing large energy-efficiency units and suppressing small energy inefficiency units, China had shut down small coal-fired power generation units totaling 76.82 GW, phased out 120-Mt backward production capacity for iron making, 72-Mt for steel making and 370-Mt for cement production.

Box 4-2 The coal industry in *Shanxi* Province makes a difference in phasing out its backward production capacity

As a province with abundant coal resources, the *Shanxi* province developed and implemented a series of targeted policy for phasing out backward coal production capacity, achieving positive results. The provincial government had issued the *Shanxi Province Energy-Conservation Regulation*s, the *Shanxi Province Coal Management Regulations*, the *Implementation Measures on Industrial Restructuring in Shanxi*, and the *Shanxi Charcoal Industry Management Regulations* among other policies and regulations, to facilitate optimization of industrial structure of the coal industry. By the end of 2009, major phasal progress had been made in coal resource integration and in coal mine annexation and reorganization in the province, with the number of mines being reduced from 2600 to 1053 across the province; the cut of backward high-carbon production capacity had improved the average technical level of the coal industry.

3.1.4 Establishing and improving energy efficiency systems and standards

China has formulated the *Interim Measures for Energy-Efficiency Assessment and approval on Fixed-Asset Investment Projects*, and promoted the energy efficiency assessment on fixed-asset investment projects. Since the release of the *Products Catalogue* *of Implementing Energy Efficiency Labels of the People's Republic of China (first batch)* for the first time in 2005, China has issued 6 additional *Products Catalogue* (2^{nd}-7^{th} *batches)*, covering totally 23 categories of products including flat panel TVs, microwave ovens, power transformers, household refrigerators, air conditioners, high pressure sodium lamps and water chilling units. China has established standards that set energy consumption limits for alumina making and lead recycling, and prepared energy-efficiency benchmarking guides for key energy consumption industries including iron/steel-making, cement and caustic soda productions, etc. The standards that set fuel consumption limits of road transport vehicles and access systems have been implemented. In the stage of designing new buildings in cities and towns countrywide, the ratio of the designs implementing mandatory energy-efficiency standards has increased from 56.5% to 99.5%, and in construction stage the ratio has increased from 24.4% to 95.4%. Dozens of basic standards have been developed, e.g. energy management system and methods for calculating enterprise energy efficiency. China has released economic compensation measures for supplying power generated from energy-saving units to improve and promote energy-saving power scheduling. China has established a compulsory system for government procurement of energy-saving products.

3.1.5 Implementing pricing policies favorable for energy conservation

China has adjusted the resource taxation for some mineral products and the natural gas price as appropriate, conducted refined oil pricing and taxation reforms, and it has made multiple adjustments to the oil price to constantly improve the pricing mechanism. In June 2010, China raised the producer's price basis of natural gas, cancelled the two-tiered pricing system with its floating range being expanded, to guide the rational allocation of natural gas resources. The energy-saving power scheduling system has been implemented. In November 2009, China raised the national electricity price to further optimize electricity price structure, and to better reflect the principle of fair cost sharing. To intensify implementation of differential electricity pricing, since June 2010, the added electricity price for the restricted enterprises in the 8 industries (e.g. electrolytic aluminum and ferroalloy) was increased from RMB 0.05 *Yuan*/kWh to 0.10 *Yuan*/kWh, and that for the enterprises to be phased out was increased from 0.20 *Yuan*/kWh to 0.30 *Yuan*/kWh. China has issued a series of capital management measures in support of enterprise energy-saving technological alterations, promotion of high-efficiency lighting products, building heat metering and energy-saving alterations. China also issued the price concession policies to encourage purchases of energy-saving and environment-friendly automobiles with small exhaustion volumes.

3.1.6 Implementing key energy conservation projects

Based on the *Medium and Long-Term Energy Conservation Plan*, NDRC and other departments prepared and released the *Suggestions on Implementation of Ten Key Energy Conservation Projects in the* 11^{th} *Five-Year Plan Period*. These projects were coal-fired industrial boiler (kiln) retrofit, district heat and power cogeneration, waste heat and pressure utilization, petroleum conservation and alternatives, motor energy efficiency, energy system optimization, building energy conservation, green lighting, government institution energy saving, energy-saving monitoring, and construction of a technological service system. According to the preliminary statistics, the total allocation from the central finance in support of local and enterprise-oriented key energy-conservation projects was RMB 28.76 billion *Yuan* in 2006-2009, creating an energy conservation capacity of 140 Mtce. In the 11th FYP period, the total area of the completed energy-efficiency buildings was 4.857 billion m^2 in accumulation, accounting for 23.1% of the existing building area, and China had retrofitted the existing residential buildings by installing heat meters and using energy-saving technologies totaling 182 million m^2.

3.1.7 Accelerating energy management contracting (EMC) and promoting development of energy conservation service (ECS) industry

In 2010, in association with other departments, NDRC formulated the *Opinions on Accelerating the Implementation of Energy Management Contracting and Promoting the Development of Energy Conservation Service Industry*, which intensified the support to EMC projects and ECS companies in terms of investment, fiscal allocation, taxation, finance, etc., and basically removed the policy and institutional barriers that constrained EMC practices. In 2010, totally RMB 1.24 billion *Yuan* from central finance was allocated in support of ECS companies that implemented enterprise retrofit for energy-saving through EMC. Various local governments actively implemented the national policy in support of ECS industry, and made meaningful explorations. Shanghai established a market-based ECS mechanism, issued a series of EMC specifications and polices, established a third-party energy-saving audit system and an ECS archival/management system, and set up a number of ECS companies.

3.1.8 Promoting energy conservation and low-carbon consumption

To promote energy-saving products and energy-efficiency equipments, the Chinese government has launched a series of polices on financial subsidies for using energy-efficiency products and energy-saving or new-energy automobiles, including the 'Project to Promote Energy-efficiency Products for the Benefit of the People', e.g. energy-efficiency air conditioners and home appliances. By the end of 2010, approximately 20 million sets of energy-efficiency air conditioners were sold in total, with their market share increasing form 5% to over 80%. In 2006-2010, over 360 million energy-saving lamps were used in accumulation. NDRC, the Ministry of Finance (MOF) and the State Administration of Taxation (SAT) among other departments have also expanded demonstration and promotion of energy-saving and new-energy vehicles for public services and household uses through polices to lower automobile consumption tax, and to provide subsidies for purchasing new-energy vehicles. These policies and measures have played a positive driving role in shaping low-carbon green consumption patterns and lifestyles.

3.1.9 Development of circular economy

China has taken various policies and measures to strongly develop circular economy, which have contributed to conservation and efficient utilization of energy resources. China has promulgated the *Circular Economy Law*, released the *Opinions on Accelerating the Development of Circular Economy*, defining the overall route, short-term goals, basic approaches, policies and measures for developing circular economy, issued the circular economy assessment indicator system, prepared and released the supportive technologies for the circular economy in the key sectors. China has actively initiated circular economy demonstrations, organized 178 pilot projects in two batches and 14 pilot projects on remanufacture of automobile components; it has selected 60 cases as typical circular economy models, and constructed the ‘urban mineral’ demonstration bases, where up to 25 Mt renewable resources have been recycled and utilized; it has selected 33 cities for food wastes recycling and disposal in an environment-friendly manner on pilot basis; it has preliminarily set up a recycling system, using a wide range of renewable resources; and established a number of circular economy education and demonstration bases.

3.2 Policies and Actions to be Taken during the 12th FYP Period

During the 12th FYP period, China will pursue the industrial structure optimization in combination with further technological advances, enhanced project measures, strengthened management and guidance to substantially improve its energy efficiency. China will curb overgrowth of the high energy consumption and high emission industries, reasonably control its total energy consumption, fully enhance energy use management in industry, construction, transportation, public institutions, urban and rural construction as well as consumption sectors, enhance energy conservation management of major energy consumers, and let ten thousand enterprises take energy-saving and low-carbon actions. China will reinforce energy-saving target accountability and assessment, and enhance applications of the assessment results. China will improve the *Energy Conservation Law* and relevant regulations to enforce strict energy conservation assessments and approval, building energy-efficiency standards and design specifications, and to raise the market access criteria. China will promote market-oriented energy conservation mechanism to intensify energy-efficiency labeling and energy-saving product certification, establish the “Top Runner” standardization practice, enhance energy-saving power scheduling and power demand side management, and accelerate energy management contracting. China will implement green government procurement to improve the mandatory and preferential procurement systems, accelerate development and deployment of energy-saving technologies, enhance basic energy conservation capacity building, expedite construction of the energy-saving standard system, and prepare and revise energy consumption limit per unit product, as well as national mandatory energy efficiency standard for key sectors. China will further take nationwide energy conservation and pollutant emission reduction actions, and implement 5 key energy-saving projects: energy-saving retrofits, promotion of energy-efficiency products for the benefit of the people, demonstrations for industrializing the energy-saving technologies, promotion of energy management contracting, and capability building for energy conservations.

Box 4-3 China's key energy-conservation projects during the 12th FYP period

1. Energy-saving retrofit projects

China will continue to implement combined heat and power cogeneration, electric motor system energy efficiency, waste heat and pressure utilizations, boiler (kiln) retrofits, petroleum conservation and alternatives, building energy efficiency, transportation fuel conservation, green lighting among others.

2. Projects to promote energy-efficiency products for the benefit of the people

China will intensify provision of subsides to promote energy efficiency home appliances, automobiles, electric motors, and lighting products, and to expand the implementation scope.

3. Demonstration projects for industrializing the energy-saving technologies

China will support demonstration projects of waste heat and pressure utilizations, high efficiency electric motor products and other major or key energy-saving technologies or products to promote their scaled productions and applications.

4. Projects to promote energy management contracting

China will promote energy conservation retrofit for energy use units by ECS companies through EMC to enable the energy service industry to grow full-fledged.

5. Capability building projects for energy conservation

Chapter 4 Development of New and Renewable Energy

China is vigorously developing new and renewable energy, and actively adjusting its energy mix. The releases of the *Renewable Energy Law* and a series of ancillary policies and measures provided a stable supportive platform for the leapfrog development of new and renewable energies in China in the 11th FYP period. Looking ahead for the 12th FYP, the development of new and renewable energies will continue in China, and lay a solid foundation for achieving China's targets for non-fossil energy development by 2020 and effective GHG emission control.

4.1 Polices and Actions Taken in the 11th FYP Period

4.1.1 Vigorous development of renewable energy

The improvement of The *Renewable Energy Law of the People's Republic of China* (hereafter referred to as the *Renewable Energy Law*) and relevant regulations is the basic assurance for vigorous development of new and renewable energy and positive energy mix restructuring. The *Renewable Energy Law* was elaborated and endorsed by the 10th NPC Standing Committee in 2005 and entered into force on January 2006. It was amended by the 11th NPC Standing Committee on 26 December 2009 and came into effect on 1 April 2010.

The amended *Renewable Energy Law* has further enhanced the position and role of the renewable energy development and utilization plan, and it clearly stated that the national plan for renewable energy development and utilization shall be developed according to the energy development strategy and the development status of renewable energy technologies, submitted to the State Council, and implemented after its approval. This law has further improved the system of guaranteeing the purchase of power generated by using renewable resources in full amount. It is clearly stated that the energy departments of the State Council, together with its national electricity regulatory and financial departments shall prepare the annual quotas and implementation plan for purchasing the power generated from renewable energies across the country according to the national plan for development and utilization of renewable resources; they shall determine and publicize the minimum quotas of the power generated from renewable energy that the power grid enterprises shall reach in their guaranteed purchases in full amount; it is also explicitly stated that power grid enterprises shall purchase the on-grid power generated from the renewable energy projects not less than the minimum quotas to enhance the responsibility of the power grid enterprises for planning and constructing ancillary power-grid facilities; it further spells out the relevant provisions on the establishment of the renewable energy development fund, which shall be the governmental fund created by the state; the resource of the fund shall include the special funds allocated from central finance in a fiscal year and surcharges from renewable energy tariffs; and the fund management method shall be developed by the financial department of the State Council together with its relevant competent energy and pricing departments.

In accordance with the relevant provisions of the *Renewable Energy Law*, the NDRC released in 2007 the *Medium and Long-term Development Plan for Renewable Energies* and the *11th Five-Year Plan for Renewable Energy Development*, as scientific plans made for development of China's renewable energies from perspective of the national energy development strategy. These two documents have clearly defined the guidelines, basic principles, development goals and key areas of renewable energy development and utilization in China. The *Medium- and Long-term Development Plan for Renewable Energies* has explicitly put forward that the overall goals of renewable energy development in China in the next 15 years are to increase the proportion of renewable energy in its total energy consumption, to address the problems for people living without electricity in remote areas and fuel shortage in rural areas, to facilitate use of energy from organic wastes, and to promote industrialized development of renewable energy technologies.

The major development indicators proposed in the *11th Five-Year Plan for Renewable Energy Development* included that the proportion of renewable energy in the total energy consumption would account for 10% by 2010; national renewable energy utilization would reach the level equivalent to 300 Mtce; renewable energy development and utilization in combination with power grid construction and modification would solve the basic power use problems for about 11.5 million people living without electricity; the majority of domestic renewable energy equipments would be made in China; hydropower equipments and solar water heaters would become internationally competitive; domestic wind power equipment manufacturers would be in a position to produce 1.5 MW class units in batches; the manufacture of agricultural and forestry biomass power generation equipments would be localized; and China would basically have the capability to produce the solar PV poly-silicon materials.

In recent years, the Chinese government launched a series of fiscal and taxation policies aimed at promoting renewable energy development. In 2008, the relevant departments issued the *Interim Measures on Management of Special Project Funds for Industrialization of Wind Power Generation Equipment*, which provided that for the first 50 manufactured wind turbines, the enterprises that met the criteria would be subsidized for RMB 600 *Yuan*/kW in support of technological advances in developing wind turbines and industrialized production of key components. In 2009, the Ministry of Finance, the Ministry of Science and Technology and the National Energy Bureau jointly issued the *Interim Measures on Management of Fiscal Subsidies for the Golden Sun Demonstration Project*, which provided that for photovoltaic power generation projects within a given scope, the subsidies should be in principle 50% of the total investment in a PV system and its ancillary power transmission and distribution projects, and for the standalone PV systems in remote areas without electricity the subsidies should be 70% of the total investment. In the *Interim Measures for Public Finance Subsidy Management for Solar Photovoltaic Use in Buildings,* it was clearly stated that the subsidy level in 2009 was in principle RMB 20 *Yuan*/watt-peak, and the annual subsidy level in the following years will be adjusted as appropriate according to development of the industry. In the *Notice for Consummating Wind Power Grid Tariff Policy* issued by relevant departments, four feed-in-tariff classes were defined for different regions, i.e. 0.51, 0.54, 0.58, and 0.61 *Yuan/kWh*, to further regulate the management of wind power pricing and to promote healthy and sustainable development of the wind power industry.

In the 11th FYP period, China saw a significant development and utilization of renewable resources. By the end of 2010, the annual total renewable energy use in China had reached about 300 Mtce (including biogas, solar thermal utilization among other non-commodity renewable resources); the installed hydropower capacity was 210 GW and its annual power generation reached 650 billion kWh, equivalent to 208 Mtce, ranking first in the world for multiple years; the total installed wind power capacity was 40 GW, ranking second in the world; Currently, there are more than 80 enterprises in China, manufacturing the complete wind turbines, and the localization of 1.5 MW level wind turbines up was over 70%; the production level of solar PV modules reached 10 GW, accounting for 45% of the world total, the installed PV power generation modules totaled 800 MW, the annual production of PV module manufacturing industry accounted for 40% of the world market and the installed solar water heaters were 160 million m^2 in total; the installed biomass power-generation capacity was 5.5 GW, about 1.8 Mt ethanol and more than 500 Kt of biodiesel were utilized; there were 40 million households using biogas, 65,000 small and 4700 medium and large-sized biogas digesters, and the total biogas production from the biogas projects in rural areas was 14 billion m^3.

Table 4-1 Current status on development and deployment of renewable energies in China

	Utilization	**2005**	**2010**	**Increasing rate**
Hydropower	Power generation	117 GW	210 GW	79.5%
		38 GW from small-sized hydropower stations	58.4 GW from small-sized hydropower stations	53.7%
Wind power	Power generation	1.26 GW	31 GW	2,360.3%
Solar energy	PV	70 MW	Installed capacity 800 MW	1,042.9%
	Heat utilization	Exposure size of water heaters: 80 million m^2	Exposure size of water heaters: 168 million m^2	110%
Biomass	Power generation	2 GW	5.5 GW	150%
	Fuel	1.02 Mt bioethanol	1.8 Mt bioethanol	76.5%
		50 Kt biodiesel	500 Kt biodiesel	900%
	Others	8 billion m^3 of biogas	14 billion m^3 of biogas	75.0%

4.1.2 Active development of nuclear power

Nuclear power is a clean and low-carbon energy, and its development is an imperative and strategic option for China in adjusting its energy mix. The construction of the *Qinshan* Phase I nuclear power plant with a capacity of 300 MW began in 1981, marking the official start of nuclear power development in China. In the 9th FYP period (1996-2000), China had constructed 4 nuclear power projects: *Qinshan* Phase II, *Ling'ao* in Guangdong, *Qinshan* Phase III and *Tianwan*, to maintain continuity of nuclear power development. At the national working conference on nuclear power construction in 2003, a concept was proposed that "nuclear power development should be organized under unified leadership, following a common technological roadmap, and introducing advanced foreign technologies to accelerate the self-reliant constructions". In October 2007, the State Council released the *Medium- and Long-Term Plan for Nuclear Power Development (2006-2020)*, in which the overall target and technological roadmap were explicitly set for accelerating the nuclear power development in China. In 2007, MOF together with SAT issued the *Notice on Relevant Issues concerning the Taxation Policies for Nuclear Power Industry* (MOF/SAT No. 38 [2008]), which provided that for the nuclear power generation enterprises producing and selling electric power products, a certain ratio of the value-added tax that had been credited to the state treasury would be refunded within 15 years, and which became a major driving force for investing in and financing for China's nuclear power industry. In the 11th FYP period (2006-2010), China also implemented the *Special Plan for Developing Major Technological Equipments and Major Industrial Technologies in the 11th Five-Year Plan Period* and the *Restructuring and Revitalization Plan for Equipment Manufacturing Industries*. The major nuclear power enterprises in China have made a large-scale investments and dedicated technical innovations, making China's equipments from its nuclear power equipment manufacturing bases comparable with the world advanced level, with its R&D and manufacturing capability being significantly improved. The localization of the improved 2nd-generation nuclear power equipments accounts for more than 80%. The localization of key equipments used for the 3rd generation nuclear power plants is increasing steadily. The nuclear energy R&D and demonstration projects under the national key S&T program entitled *Nuclear Power Plants Using Advanced Large-scale Pressurized Water Reactors and High Temperature Gas-cooled Reactors* have advanced in all fronts; new progress has been made in building up a nuclear power R&D platform, and a new nuclear power R&D base is under construction.

In response to demands for accelerating development of the nuclear power industry, a major adjustment was made to the management of China's nuclear-power sector in the reform of the State Council institutions in 2008, which contributed to healthy, safe and rapid development of the nuclear power industry. China also issued the *Regulations on Supervision and Management of Civil Nuclear Safety Equipments*, the *Regulations on Safety Management of Radioactive Material Transportation* and the *Notice on Further Strengthening Nuclear Safety Management at the Construction Stage of Commercial Nuclear Power Plants*. All these further enhanced supervision on construction, operation and safety of nuclear power plants, and defined responsibilities and qualifications of nuclear power plant operators and prime contractors for 'nuclear island' projects within nuclear power plants. Currently, legislation for the *Atomic Energy Law* and the *12th Five-Year Plan for the Nuclear Industry*, the *Nuclear Power Safety Plan* and the *Regulations for Nuclear Power Management* are under preparation. They will strongly enhance the core capacity building for the nuclear power industry and independent S&T innovations, further improve productivity and technical level of nuclear fuel cycle industries, and standardize governance of decommissioned nuclear reactors, nuclear safety and emergency responses.

In 2010, the Unit No. 1 of the *Ling'ao* Phase II nuclear power plant, which was the only nuclear power project under construction in the 10th FYP period (2001-2005), together with the Unit No. 3 of the Phase II expansion project for the *Qinshan* nuclear power plant were officially put into commercial operations, marking the harvest time of China's nuclear power constructions. By the end of 2010, the total installed capacity for nuclear power generation was 10.82 GW, and 34 nuclear power generation units had been approved for construction, 28 of which were being built, accounting for 40% of the world in-construction units. Today, China is a country with the largest in-construction nuclear power units in the world. It is investigating the feasibility to adjust its medium- and long-term plan for nuclear power development, to accelerate its coastal nuclear power development, and to actively advance in-land nuclear power projects. China is also endeavouring to widely deploy the 3rd generation nuclear power technology as the mainstream technical roadmap in the short term. Additionally, China is also doing R&D of the 4th generation nuclear power technology represented by fast reactor, very high temperature gas-cooled reactor and supercritical water reactor, in order to pave the way for further nuclear power development.

4.1.3 Accelerating development of natural gas and coal bed methane

Natural gas and coal bed methane are high-quality fossil fuels. China has developed a strategy which attaches equal importance to oil and natural gas, to encourage natural gas exploitations. As proposed in the 11th Five-Year Plan for Energy Development, the target was to make the natural gas account for 5.3% of total primary energy consumption by 2010. In the 11th FYP period (2006-2010), the *Oil and Natural Gas Law* was amended to improve the energy law and regulation system applicable to the socialist market-economy system. China enhanced supervision and control of its oil and natural gas industries, and improved the market access system. It also developed the natural gas utilization policy to reinforce demand side management and ensure natural gas security. Meanwhile, adjustment to natural gas price was enhanced to guide rational use of oil/gas resources, and to promote resource saving and development. To address large-scale power grid incidents and oil/natural gas supply disruptions, China has developed and improved an energy security early warning system and an emergency response mechanism. In the *Comprehensive Working Scheme on Energy conservation and Emission Reduction,* it is proposed to accelerate the pricing reform of resource products and natural gas in an active, steady and appropriate manner.

In the 11th FYP period, a major breakthrough was made in natural gas exploration and development in China, and its production increased by more than 10% in 5 successive years;

the oil pipe enterprises seriously implemented the *Law on Protection of Oil and Natural Gas Pipelines,* to improve pipeline construction, operation and management. The national main-trunk networks of oil and natural gas pipelines are basically in shape, and the rated pipeline capacity of the project for transporting natural gas from west to east is up to 12 billion m^3 on annual average. The liquefied natural gas market in China is prosperous, with its import volume being increased year by year, and domestic construction projects in this field are proceeding smoothly. China's natural gas output increased from 49.3 billion m^3 in 2005 to 96.8 billion m^3 by the end of 2010, which was almost doubled in 5 years, accounting for 4.3% in China's energy consumption structure.

To expedite exploitation and use of coal bed methane, China's National Development and Reform Commission among others prepared the *Exploitation and Utilization Plan for Coal Bed Methane/Coal Mine Gas in "the 11th Five-Year Plan Period* in 2006, and the Ministry of Finance issued the *Implementation Comments on Subsidies for Coal Bed Methane (Coal Mine Gas) Exploitation and Utilization* in 2007. The central financial subsidies were granted at RMB 0.2 *Yuan* per cubic meter to enterprises for extracting coal bed methane sold for or used as household gas or their chemical raw materials. By the end of 2010, the coal bed methane extracted from pits was over 6 billion m^3 in China, and 18 mining areas with annual extraction volume of 0.1 billion m^3 each had been built. The use of coal bed methane was 3.6 billion m^3.

Box 4-4 Vigorous development of renewable energy in the western China

The Inner Mongolia Autonomous Region takes advantage of local wind resources to vigorously develop the renewable energy. By 2010, the installed capacity of large grid-connected wind power farms exceeded 8.35 GW in the region, ranking first in the country, accounting for 13.6% of total installed power capacity across the region. Its wind power output was 14,000 GWh, sharing 6.5% of its total electricity output. *Guangxi* enacted the *Interim Measures for Management of Vehicle Ethanol in Guangxi Zhuang Autonomous Region.* It has fully deployed vehicle ethanol since 2008, and it is the first province in the country, where non-grain crop (cassava) is used as raw material for ethanol production, with gasoline consumption being reduced by 10% annually. The Tibet Autonomous Region is strongly developing biogas in rural areas. By 2010, it had built 200,000 biogas digesters for rural households and 734 biogas delivery sites in rural areas. The *Gansu* Province has implemented the development strategy - *Building up Hexi Wind Power Corridor and Constructing in-land 'Three Gorges' in the western China,* and it has fully initiated the construction of a 10 GW-level wind power base in *Jiuquan*. The *Ningxia Hui* Autonomous Region has been actively developing renewable energies including solar energy. In 2010, it achieved grid connection for a 40 MW large solar PV power plant, producing 100 MW PV power with an annual output of 2,000 GWh. It also strives to complete a 2 GW PV grid-connected project by 2020.

4.2 Policies and Actions to Be Taken during the 12th FYP Period

During the 12th FYP period (2011-2015), China will further develop green and low-carbon energy resources, to promote development of new energy industries, and to adjust or optimize its energy mix in the following six aspects: (i) reinforcing exploration and development of natural gas resources for rapid output increase, and promoting exploitation of such non-conventional oil/gas resources as coal bed methane and shale gas; (ii) actively developing hydropower on condition that ecological conservation and resettlements of displaced people are ensured, focusing on construction of large-scale hydropower stations in the southwestern China, development of hydro-energy resources from medium- and small-sized rivers according to local conditions, scientific planning and construction of pumped-storage power stations and large-scale hydropower stations in major river basins like *Jinsha*, *Yalong* and *Dadu* rivers, and launching hydropower projects with a 120 GW capacity; (iii) enhancing construction of supportive on-grid projects to effectively develop wind power, and building up 6 on-land and 2 coastal or offshore large wind power bases with a new 70 GW installed capacity; (iv) actively developing such renewable energies as solar, biomass, geothermal and ocean energies, and building solar power stations with total output beyond 5 GW mainly in provinces (autonomous regions) such as Tibet, Inner Mongolia, *Gansu*, *Ningxia*, *Qinghai*, *Xinjiang* and *Yunnan*; (v) efficiently developing nuclear power while ensuring safety, to accelerate nuclear power development in coastal provinces, to steadily advance nuclear power constructions in central provinces, and to initiate construction of 40 GW nuclear power projects; and (vi) vigorously developing new energy industries, focusing on the next generation nuclear energy, deployment of solar thermal energy, PV power generation, wind power equipments, smart grid, biomass energy, and plug-in hybrid vehicles, electric-drive and fuel cell vehicles.

Chapter 5 Stabilization and Increase of Forest Carbon Sink

The Chinese government highly values the unique role of forestry in coping with climate change. Since 2005, under the overall declining trend of global forest resources, China has kept a continuously increasing trend in its forest area and reserves, further improving the forest carbon sink capacity, and making a positive contribution to mitigation of global climate warming while maintaining China's ecological security, through developing and implementing a series of policies and measures to protect and develop forest resources.

5.1 Policies and Actions to Cope with Climate Change through Forestry in the 11th FYP Period

5.1.1 Actively pursuing collective forest-tenure reform to further motivate farmer's initiatives in afforestation and forest conservation. The mainframe reform for clear-cut tenures and household contracts has been basically completed in 18 provinces (autonomous regions, municipalities). More than 800,000 disputes over forest tenures have been settled across country, and tenures for 168 million hectares of forest lands have been devolved to individual households, accounting for 92.23% of total collectively owned forest area nationwide. There are 82.2225 million households in rural areas that have obtained the forest-tenure certificates, and 300 million farmers have benefited from the reform. This policy has significantly increased farmers' family assets, and greatly encouraged their enthusiasm for forest conservation and management through afforestation, which has provided the policy support to let forestry play a long-term and stable role in addressing climate change.

5.1.2 Continuously implementing the national key ecological projects to conserve and increase forest resources. The natural forest resources conservation projects have been continuously implemented, and its first phase has been successfully completed; the policy on conversion of sloppy land into forest has been further improved, which has ensured effective implementation of the projects; the layout of projects have been further enhanced, and the key projects have been further pursued, such as shelter forest building in Northwest, North and Northeast China regions, coastal and Yangtze River basin, and the Beijing-Tianjin sandstorm source control project, as well as construction of fast-growing forest bases, achieving significant and effective results. The green covers in urban built-up areas nationwide have been further enlarged through in-depth urban afforestation, social mobilization for tree planting, greening alongside railways and roads, and efforts to build up forest cities, townships, villages and campuses. In July 2010, the State Council approved the *Outline of National Plan for Forest Land Conservation and Utilization (2010-2020).* It is proposed that China will ensure a steady increase in its national forest stock volume in the next decade, for which the quota management system for forest land expropriation has been adopted to reinforce forest land conservation. In the 11^{th} FYP period, China increased afforestation subsidies from RMB 100 to 200 *Yuan* per *Mu* (1/15 hectare). These measures have effectively protected and increased forest resources in China. According to statistics, in 2006-2010, totally 24.67 million hectares of lands were afforested, and 11.72 billion trees were planted on voluntary basis in China. Its forest area was 195 million hectares, accounting for 20.36% of its land area, and the standing forest reserve was 14.913 billion m^3. China's afforested area was 62 million hectares, ranking first in the world. China's green coverage in urban build-up areas was 38.22%, and its total green coverage was 34.13%.

5.1.3 Pursuing sustainable forest management to improve forest quality. To address the low quality of the existing forest resources, China has actively launched sustainable forest management actions, focusing on pilot projects for tending young- and middle-aged forest by issuing the *Guidelines for Sustainable Forest Management in China*, by revising the *Regulations on Forest Tending*, and by developing and implementing the technical rules and management measures related to young- and middle-aged forest tending and management. The central finance has allocated special funds for young- and middle-aged forest tending. In 2010, the central finance earmarked RMB 2 billion *Yuan* to subsidize the pilot projects for tending young- and middle-aged forests. In the 11th FYP period, the total forest tending area was 31.55 million hectares. China also revised the *Interim Measures for National-Level Public Welfare Forest Management*, and implemented the *Measures for Regionalization and Demarcation of National-Level Public Welfare Forests*. The central finance also increased annual subsidies from RMB 5 to 10 *Yuan* per *Mu* (1/15 hectare) for the national-level public welfare forests on collective-owned forest lands, to enhance management of the public welfare eco-forests. In the same time, China also implemented the *Medium- and Long-Term Development Planning for National Forest Fire Prevention* to enhance capacity building, responsibilities and measures for forest fire prevention and control. The annual average forest fire frequency, burnt areas and casualties declined by 27.2%, 82.6% and 80.3% respectively. China fully enhanced prevention and control of harmful organisms, defined responsibilities for local governments and competent forestry departments, shaped an effective mechanism for joint prevention and control, facilitated construction of harmful organism monitoring and forecasting sites, and enhanced the capability to cope with forest hazards, with the accuracy of hazard forecasts reaching 85%, and with the hazard ratio dropping to less than 0.5‰.

5.1.4 Actively promoting relevant work in forestry to cope with climate change. The Chinese government actively advocates that forests should fully play a unique role in coping with climate change. At the 15th APEC Economic Leaders' Meeting in September 2007, President Hu Jintao proposed to establish the "Asia-Pacific Network for Forest Rehabilitation and Sustainable Management". At the United Nations Summit on Climate Change in September 2009, President Hu also stated that China would strive to increase forest resources and carbon sinks, and to increase forest area by 40 million hectares and forest stock volume by 1.3 billion m^3 by 2020 relative to 2005 levels. All these indicate that the Chinese government has fully recognized the multiple effects of forests in climate change mitigation and adaptation, and in facilitating sustainable socio-economic development, and it has taken forestry development as a strategic option to cope with climate change. To achieve the targets and tasks for increasing and protecting forest ecosystem's carbon sinks set in the *China's National Climate Change Programme*, China developed and released the *Forestry Action Plan to address Climate Change* in 2009, in which the action targets and 22 specific actions for forestry were proposed to cope with climate change in 2010-2050, from perspective of improving the capacity for climate change mitigation and adaptation through forestry. China implemented the reforestation project in the Pearl River Basin in *Guangxi* - the first reforestation project in the world under CDM, initiated the pilot projects of carbon-sink afforestation in the country, and developed relevant technical regulations to explore and establish a national forest carbon accounting and monitoring system. Meanwhile, China also created the China Green Carbon Foundation, under which domestic enterprises, organizations, individuals and social communities were mobilized to make voluntary donations to public welfare activities for "afforestation, increasing carbon sinks, participation in carbon compensation, and carbon footprint removal" among others. The foundation received more than RMB 400 million *Yuan* from hundreds enterprises, including the China National Petroleum Corporation and China *Guodian* Corporation. With these donations, more than 100,000 *Mu* carbon-sink forests were built, which played an active role in increasing enterprises and citizens' awareness of social responsibilities to cope with climate change.

5.2 Policies and Actions to Be Taken to Cope with Climate Change through Forestry during the 12th FYP Period

During the 12th FYP period (2011-2015), China will continue to implement policies and actions for forest conservation and development. By strongly pursuing afforestation and sustainable forest management, the forest area will be enlarged by 12.5 million hectares and forest stock volume by 600 million m^3, striving to achieve the forest coverage of 21.66%, to lay a solid foundation for increasing forest area by 40 million hectares, and forest stock volume by 1.3 billion m^3 by 2020, compared with 2005 levels.

5.2.1 Focusing on forest resource conservation and continuously pursing in-depth reform in forest tenure system. Upon completion of collective forest-tenure licensing, China will establish a forest tenure protection and management system step by step, quicken the pace to regulate forest-tenure transfer, to advance forest insurance and forest-tenure mortgage policies, and to revitalize forest assets, accelerate establishment of a socialized service system in order to attract investments from various capital flows, further adjust relevant policies for forest resource management to motivate initiatives of forest farmers and all social communities for investing in forest resource conservation and development in collective-owned forest areas. China will further accelerate, on a pilot basis, reforms of state-owned forest farms and areas, to establish a policy system that contributes to conservation and development of state-owned forest resources.

5.2.2 Continuously increasing forest resources through key forestry-focused ecological projects. In line with the *Forestry Action Plan to Address Climate Change*, the objectives will be set for stabilizing and increasing forest carbon sinks, to further implement specific actions in expanding forest resources. Firstly, afforestation and greening will be reinforced. In accordance with the *Outline of the National Afforestation and Greening Plan (2011-2020)*, the afforestation and greening tasks will be fully fulfilled. The afforestation and greening models will be optimized to increase shares of the mixed forests, indigenous and rare tree species. Secondly, the phase II projects for natural forest resource conservation will be implemented, and construction tasks will be seriously fulfilled, following the so-called ‘Four Assignments (i.e. targets, tasks, funds and responsibilities) to Provinces’. Thirdly, plans for the projects under the policy on conversion of sloppy land into forest, key shelter forests in the ‘Three-North’ and middle and lower-reaches of the Yangtze River basin, and the Beijing-Tianjin sandstorm source control among others will be actively prepared and implemented in the 12th FYP period. The coastal shelter forests and high yield fast-growing forests will be further pursued.

5.2.3 Continuously advancing sustainable forest management to increase carbon sink of the existing forest resources. Based on surveys on current status of forest management, the *Mid- and Long-Term Plan for National Forest Management* and relevant special plans will be prepared and implemented. China will continue to provide subsidies for forest tending from central finance, in an effort to increase subsidy level, to expand subsidy scale, and to improve subsidy-related policies. During the 12th FYP period, it is planned to build young- and mid-aged forest tending areas and transform low-yield forest areas totaling 35 million hectares. Amendments will be made to relevant technical standards for forest tending, to establish a technical standard system for local and regional forest tending and management under the macro guidance of the national standards. Studies on forest management models and policies will be enhanced; and pilot projects on sustainable forest resources management will be launched, focusing on forest-harvest management reform and preparation of forest management plan, to improve relevant forest management systems. Pilot projects on carbon sink-increasing through forest management will be actively initiated. The national strategy will be actively developed and implemented to reduce emissions from deforestation and forest degradation, and to increase forest carbon stock through forest conservation and sustainable management.

5.2.4 Improving relevant policies and measures in support of forest resource conservation and development. The following policies and measures will be taken: (i) continuously implementing subsidy, compensation and allowance policies for afforestation, elite tree species, wetland conservation, young and middle-aged forest tending, wildlife and forest insurance premium, to significantly increase the subsidy level for forest management and conservation, public welfare forest tending and social insurance. The financial support system and enabling tax policies will be improved; (ii) enhancing research on difficult-site afforestation, forest management and lightning-induced forest fire prevention techniques, and striving to make new breakthroughs in forest carbon sink monitoring and accounting, biomass energy, resource conservation, and eco-service function estimation, etc.; (iii) reinforcing intellectual property right protection and application of new plant variety, and enhancing forest bio-security and genetic resource management; (iv) further amending the *Forest Law*, accelerating legislation for natural reserves, revising administrative regulations such as those for coastal shelter forest, wetland conservation, and forest diseases/pests control; and (v) further encouraging enterprises, organizations, social communities and individuals to actively involve in afforestation and carbon-sink increasing actions through various platforms e.g. "China's Green Carbon Foundation", to enhance their awareness of coping with climate change.

Box 4-5 China's policy on conversion of sloppy land into forest and its effectiveness
China's policy on conversion of sloppy land into forest is an important policy of the Chinese government in implementing its Western Development Strategy. In 1999, to protect and improve the ecological environment in the western China, the Chinese government decided to cease cultivation for vegetation restoration, in a planned and phased manner, on sloped croplands prone to soil erosion and water runoff and non-sloped croplands prone to sandification. The government provides the farmers under China's policy on conversion of sloppy land into forest with appropriate food, seedling and afforestation fund and cash allowance within a certain period of time, according to the audited area of the croplands. For example, a farmer in the Yellow River basin and Northern China receives 100 Kg raw grain and RMB 20 *Yuan* per *Mu* (1/15 hectare) annually as subsidies for the croplands according to China's policy on conversion of sloppy land into forest. The subsidy for the sloppy land converted to eco-forest lasts at least for 8 years, economic forests for 5 years, and grassland for 2 years. Under China's policy on conversion of sloppy land into forest, the subsidy for seedling and afforestation is RMB 50 *Yuan* per *Mu* of the converted sloppy cropland and barry land suitable for afforestation. According to statistics, in 1999-2009, through the projects on conversion of sloppy land into forest, 27.7 million-hectare forests had been built, with the forest cover in the project area which accounted for 82% of China's total land increasing by more than 3%. These forests have not only significantly mitigated soil erosions, water runoff and sandstorm hazards in the project areas, reducing substantially sediments in the rivers, but they have also improved China's capabilities for disaster prevention and mitigation in the project area, and for increasing its overall forest carbon sink. In return, the implemented policy on conversion of sloppy land into forest has provided 124 million relevant farmers with RMB 2000 *Yuan* subsidy per person from the central finance, accounting for 10% of per capita annual net income of these farmers.

Chapter 6 Control of GHG Emissions from Industrial Processes, Agriculture and Other Sectors

To make a positive contribution to climate change mitigation, China has effectively controlled GHG emissions from industrial processes, agricultural activities, waste treatments by reinforcing policies on metallurgy, building materials and chemical industry, by developing circular economy, improving resource availability and enforcing various measures for nitrous oxide and methane recovery, reuse and emission control.

6.1 Policies and Actions Taken in the 11th FYP Period

6.1.1 Industrial Processes

In recent years, China has better controlled GHG emissions from industrial processes by the following means: (i) phasing out backward cement and iron/steel production capacity to appropriately control their production outputs; (ii) introducing alternative technologies to replace limestone with carbide slag for cement clinker production; (iii) improving production processes using blast furnace slag and fly ash as mixed additives to cement production; (iv) recycling waste resources like scrap steel; (v) using secondary and tertiary treatment methods to process nitrous oxide emissions from the nitric acid production processes; (vi) using catalytic and thermal-oxidative decomposition to handle nitrous oxide emissions from the adipic acid production process; and (vii) using thermal oxidation approach to capture and remove HFC-23. In the meantime, through international cooperation that promotes CDM projects for the adipic acid producers, the departments concerned have actively sought for funds and technical assistance required for controlling GHG emissions of nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) among others, to reduce GHG emissions.

6.1.2 Agricultural Activities

Agricultural activities are a major source of methane and nitrous oxide emissions as GHGs. The Chinese government has achieved better results in reducing GHG emissions by formulating relevant laws and regulations, promoting low-emission agricultural technologies, enhancing water use and fertilization management for agriculture, upgrading farming machinery, reinforcing intensive agricultural production, and developing biogas. The following policies and measures have been taken: (i) enhancing formulation and implementation of relevant policies and regulations. The legislative and regulatory systems have been improved, which can contribute to agricultural productivity and carbon stock of agricultural ecosystems, based on laws including the *Agriculture Law*, *Grassland Law*, and *Land Administration Law* of P.R.C, plans for cropland and grassland protection and development have been prepared to strictly control land reclamation, grassland destruction and land wastage in the regions where ecological environments are vulnerable, and all these have made a positive contribution to control of GHG emissions from the agricultural and forestry sectors; (ii) taking a range of technical measures that are useful for mitigating GHG emissions, e.g. high-yield rice varieties with lower emissions, rice cultivation in semi-arid areas, intermittent paddy field irrigation, fine ruminant animal breeds, scaled livestock raising management, crop residue silage and ammoniation, biogas from treatment of livestock and poultry manures, crop residue return to fields, and minimum- or non-tillage; (iii) practicing soil test-based fertilization across country since 2005. By 2007, these actions had been taken in 1200 counties to guide farmers for scientific fertilization, and by the end of 2009 this practice had covered more than 1 billion *Mu*. With this done, irrational use of nitrogen fertilizer was reduced by 700 Kt (net amount equivalent) in wheat, corn and rape growing regions in 2009; and (iv) fully promoting transformation from traditional livestock herding to the modern model for scientific, scaled and intensive livestock farming, with animal manures from it being treated with standardized and scientific approaches, to reduce GHG emissions from livestock farming through scientific management.

6.1.3 Waste treatment

In recent years, the Chinese government has reinforced development and supervision of the waste-disposal sector. China has continuously improved urban waste-disposal standards, formulated regulations and intensified technical development and applications. Advanced waste incineration technologies have been widely deployed, and their localization has been increased to effectively lower the costs of production, and to facilitate their industrialization. Such measures as charging for household waste treatment, and contract-based service and responsibility system established for the environmental sanitation sector, and adoption of enterprise management by public units have contributed to the structural reform of waste treatment system. Incentive policies have been formulated to promote landfill gas recovery, encouraging enterprises to build and use a landfill gas collection and utilization system.

6.2 Policies and Actions to Be Taken during the 12th FYP Period

During the 12th FYP period, China will accelerate R&D and application of GHG control technologies to effectively control GHG emissions from industrial processes and agriculture. The following measures will be taken to: (i) strictly control export of high energy consuming, high polluting and resource products as well as overall expansion of the sectors with redundant metallurgical or building-material manufacturing production capacity, and accelerate the pilot demonstration projects for clean production and circular economy in agriculture, industry and other key sectors, to control waste production and GHG emissions from their original sources and entire processes; (ii) accelerate transformation of agricultural development models, facilitate strategic agricultural restructuring, optimize agricultural production pattern, quicken the pace toward facility agriculture, improve livestock farming, facilitate construction of modern agriculture demonstration areas, expedite innovation and deployment of agricultural bio-breeding technologies, and enhance integrated technical innovation and diffusion of high efficiency cultivation practices; and (iii) develop and improve a waste sorting and recycle system, and advocate civilized, economical, green and low-carbon consumption concepts, to shape green lifestyle and consumption patterns in line with China’s national circumstances.

Chapter 7 Enhancement of Institutions and Mechanisms for GHG Emission Control

The institutional and mechanism supports are required to effectively control GHG emissions. In its practices, China has continued innovating and improving its institutions and mechanisms for climate change mitigation, and it has steadily developed and improved its statistical and assessment systems related to GHG emission control and market-based GHG emission control mechanisms, etc.

7.1 Policies and Actions Taken in the 11th FYP Period

7.1.1 Improved energy statistical and energy-saving accounting systems

To meet the requirements for enhancing energy statistics and tackling climate change, and to strengthen its energy statistical work, the National Bureau of Statistics of China set up the Department of Energy Statistics in September 2008. The department is responsible for organizing and implementing energy statistical surveys, collection, compilation and delivery of relevant survey data, as well as monitoring the statistics of energy conservations by major energy consuming sectors and energy use, energy conservation and resource recycle of major energy consuming enterprises at national and sub-regional levels. The Indicator, survey and monitoring systems for energy statistics have been established, the accounting system for energy consumption per unit of GDP has been further improved, and a series of energy statistical, evaluation and accounting systems have been set up or improved. The local institutional setups and staffing have also been improved, and the energy statistical work has been strengthened.

7.1.2 Exploring a market-based mechanism for GHG emission control

The Chinese government has issued and implemented the *Measures for Operation and Management of Clean Development Mechanism Projects* (hereafter referred to as the Measures). It has specified the basis, fundamental principles and admission requirements for projects and activities under the Clean Development Mechanism (CDM), management and implementation bodies of CDM projects as well as their corresponding responsibilities, the application, approval, implementation, validation and verification procedures for CDM projects among others. In accordance with the Measures, the Chinese government convenes experts to calculate the grid baseline emission factors annually, based on which relevant information are released and shared in a timely manner, having greatly improved efficiency in CDM project development, validation and verification. The CDM projects are being actively developed at local level. Altogether, 28 CDM technical service centers have been set up at national level, which have provided trainings for nearly 10,000 person/times, to facilitate CDM development and capacity building in China.

By the end of 2010, the Chinese government had approved 2,847 CDM projects, of which 1,186 were successfully registered in the UN CDM Executive Board, accounting for 42.7% of all registered projects in the world. The development of CDM projects has effectively promoted the international cooperation in response to climate change, encouraged enterprises to actively participate in coping with climate change, and provided incentives for them to play a key role in mitigating GHG emissions in China.

In recent years, China has explored the voluntary GHG emission trading step by step. More than 10 environment and/or energy exchanges have been set up in China, such as the Beijing Environment Exchange, Shanghai Environment and Energy Exchange, Tianjin Climate Exchange, and some of them have established their own platforms for voluntary emission reduction trading, with a series of trading activities being carried out. According to incomplete statistics, dozens of voluntary emission reduction trading have been closed, with trading volume reaching several million tons within a range of RMB 10-50 *Yuan*/ton.

7.2 Policies and Actions to be Taken during the 12^{th} FYP Period

During 2011-2015, China will further accelerate institutional and mechanism buildup for mitigating climate change. It will set up and improve its GHG emission statistical accounting systems, and explore to set up the low-carbon product standards, labeling and certification systems, and eventually establish a carbon emission trading market.

7.2.1 Improving the statistical system and assessment methods

China will study the approach to set up its GHG emission statistical accounting system, and improve its energy and energy-saving statistical system. China will prepare the national and local GHG emission inventories. it will improve the integrated assessment methodologies for local socio-economic development by shifting GHG emission assessment priorities from technical energy-saving indicators to macro-perspective and systematic reduction of carbon emission intensity, which will guide local governments to properly control the scale of investments in fixed assets, and contain the growing demands of high energy consumption sectors. China will adjust its industrial distribution to optimize urban layout and functions, to promote building energy conservation and use of renewable energy by buildings; it will give a high priority to development of public transportation; it will set up the national fossil fuel consumption control action target and corresponding division mechanism, which will be gradually included in the assessment.

7.2.2 Making full use of market-based mechanism for GHG emission control

China will continue promoting cooperation on CDM projects and implement the *Interim*

Measures on Voluntary GHG Emission Reduction Trading, to encourage and regulate voluntary trading activities in the country. China has launched pilot programs for carbon emission trading in selected provinces and cities with suitable conditions, meanwhile Chinese government will enhance construction of relevant technical support systems, expand experience and practices from the pilot programs, and to gradually establish a national carbon trading market. China will intensify research on incentive policies including fiscal, taxation, pricing and financial policies and their enforcements. It will strongly promote energy management contract and voluntary energy-saving agreements.

Part V Other Relevant Information on Achieving Targets of the Convention

The major tasks listed in the *China's National Climate Change Programme* include: (1) enhancing climate system observation; (2) advancing R&D in key fields of climate change; (3) increasing investment in S&T related to climate change; (4) intensifying education, outreach and training on climate change; (5) encouraging participation of general public and increasing their awareness of climate change; and (6) extensively conducting international cooperation and exchanges on climate change. All these are important activities for the Chinese government to effectively implement the Convention.

Chapter 1 Climate System Observation

1.1 Current Status of Climate System Observations in China

China has basically established an integrated climate observing system incorporating ground-based, airborne and space-based components, which is self-contained in ways and means of observations and reasonably well distributed across the country.

1.1.1 Land- and sea-based observations

Currently, the Chinese meteorological system has an automated observing network for measuring basic surface weather elements, which is composed of 2,419 surface stations at national level, and it has newly set up 31,536 automatic weather stations at sub-regional level. Additionally, it has deployed 164 new-generation weather radars, 120 L-band radiosonde systems, 508 GPS/MET stations, 314 thunderstorm and lightning detection stations, as well as 100 solar radiation stations. It has been operating both polar-orbiting and geostationary meteorological satellites for operational applications. From what has been mentioned above, it can be seen that a technical supportive system of meteorological equipment has been basically established to ensure stable operation of the climate observing systems.

China's atmospheric composition observing system includes a global atmospheric watch (GAW) observatory, regional atmospheric background observing stations, acid rain observing stations and ozone measurement stations. So far, there are 4 regional background stations, 28 atmospheric composition observing stations, 29 sand or dust storm observing stations and 342 acid rain observing stations in China. At present, China has one GAW observatory, which is located on the Qinghai-Tibetan Plateau for measuring CO_2, methane, black carbon aerosols among others. It is the only global baseline station on the Eurasia continent to provide continental in-land atmospheric background. Three sub-regional atmospheric background stations have been set up and put into operation in Mt. *Longfeng* (*Heilongjiang*), *Shangdianzi* (Beijing) and *Lin'an* (*Zhejiang*) respectively. Another 3 sub-regional atmospheric background stations are under construction in Shangri-La (*Yunnan*), *Akedala* (*Xinjiang*) and *Jinsha* (*Hubei*).

China has preliminarily built a 3-Dimentional ocean observing network for climate, which is composed of coastal stations, buoys, ships, radars, satellite and aircraft remote sensing etc. for monitoring such marine environment elements as tide level, water temperature, salinity, sea wave, ocean current, sea ice in offshore and marginal sea areas, as well as marine hazards like storm surges, high waves, red tides, sea level changes and salt tide intrusions.

China has a terrestrial hydrological observation network consisting of 39,800 stations, among which 3,183 are basic hydrological stations, 1,407 are water level stations, 15,750 are rainfall stations, 6,097 are water quality monitoring stations, and 12,522 are ground water monitoring stations. In total, China has 10,294 water monitoring stations and 1,110 hydrological forecasting stations. 271 water environment monitoring centers or sub-centers have been established, basically covering all major rivers, lakes and reservoirs for water quality measurements.

The Chinese Ecosystem Research Network consists of ecological stations, sub-centers and comprehensive centers. Currently, China has nearly 40 field stations at selected sites for targeted observations of ecological and environmental elements on a long-term and standardized basis.

Ice, snow and frozen soil are observed in China. The *Tianshan* Glacier Observation and Experiment Station monitors the accumulation, melting, motion, temperature, thickness and energy balance of the glacier, as well as glacier and non-glacier runoff. The Integrated Observation and Research Stations on the Qinghai-Tibetan Plateau focus on plateau permafrost and atmospheric physics. At present the networks have been basically set up to monitor natural and roadbed frozen soils along the Qinghai-Tibet and *Qing-Kang* Highways, to monitor hydrothermal dynamic changes in active layer of frozen soil along the *Qinghai*-Tibet Highway, and to have experimental observations of different underlying surfaces at *Wudaoliang* and Mt. *Fenghuo*.

The Chinese Agrometeorological Observation Network has about 653 stations to observe crop, soil and phenology etc., of which the observations on crop include crop growth stages and status (height, plant density, etc.), growth volume measurements, yield structure analysis, agrometeorological hazards, crop pests and diseases surveys, etc.

The China Environment Monitoring Network covers major cities and towns. The National Environmental Quality Monitoring Network includes air quality, sandstorm and acid rain monitoring, etc. The National Air Quality Monitoring Network has 661 automatic stations for air quality monitoring, 82 sand/dust storm stations and more than 500 acid rain monitoring stations in 113 key cities. In 2010, there are 800 sections to monitor the quality of surface water and 150 automatic surface water quality monitoring stations in China. The Offshore Environment Monitoring Network consists of more than 70 stations.

1.1.2 Space-based observations

Since 1988, China has successfully launched four Fengyun (FY)-1 series polar-orbiting satellites, five FY-2 series geostationary satellites, two FY-3 series polar-orbiting meteorological satellites, as well as Haiyang (HY)-1A, HY-1B and HY-2 oceanic satellites, with which it has been achieved to observe with a couple of satellites. For the geostationary meteorological satellites, the 'dual-satellite observation with mutual in-orbit backup' has been achieved; the polar-orbiting meteorological satellites have been upgraded, and a space-based observing network with two polar orbiters has been configured in such way that one covers the morning orbit and the other operates along an afternoon orbit. These meteorological satellites monitor severe weather and climate events and resource environment not only for China, but also for Asia and other parts of the world. Currently, the data processing system for polar-orbiting meteorological satellites is capable to simultaneously process data from FY-1 and FY-3 series as well as the National Oceanic and Atmospheric Administration (NOAA) satellites, providing 97 products including vegetation index, outgoing long-wave radiation, snow cover, atmospheric temperature, humidity, sea surface temperature, ozone content and various imageries. The data processing system for geostationary meteorological satellites has the capacity to process data from FY-2 series, Japanese and EUMETSAT geostationary satellites, generating 27 products like outgoing long-wave radiation, cloud winds, precipitation estimates, sea surface temperature and surface luminance temperature and a variety of images. The HJ-1 satellite launched in 2008 provides important supports for monitoring eco-environmental changes and natural disasters.

1.1.3 Information management

China's climate system observation information are collected and managed by a number of agencies or institutions respectively including meteorological, oceanic, water resource and environment protection departments, as well as the Chinese Academy of Sciences among others. Data archived by the meteorological department include national and global data from conventional surface, upper-air, ship observations; data from national solar radiation stations, agro-meteorological stations, global and regional atmospheric background stations, ozone and acid rain observing stations; data from major scientific experiments and excursions as well as proxy data based on tree rings, etc. The oceanic department archives oceanographic data and products, mainly including a marine environment database, marine environment and disaster information and products, analyses and products about ocean tides and current, etc. The water resource department has compiled and published hydrological data before 1949. Since 1958, the hydrological data from all river basins and systems in China have been published annually. After 1990, a national basic hydrological database began to set up. The ecological observations maintained by the Chinese Academy of Sciences include long-term measurements of targeted ecological environment elements from the field stations, and information required for scientific researches on ecosystem processes.

China has also accumulated a large amount of valuable proxy paleoclimate data, including natural and historical records such as tree rings, historical literature, ice cores, lake and marsh sediments, pollens, corals and stalagmites. These proxy data are archived by research institutions or operational departments including the China Meteorological Administration, Chinese Academy of Sciences, Ministry of Land and Resources and some universities.

1.2 Problems and Prospects of Climate System Observations

1.2.1 Existing problems

In general, the following gaps and inadequacies still exist in China's current integrated climate observing system. The comprehensive observing capability, system operating stability, reliability and its automation level need to be improved; the contradiction between protection of the meteorological observing environment and socio-economic development becomes increasingly prominent; the layout of observation networks needs to be more scientifically representative; the capability to provide scientific and technical supports to the system is weak; the training of qualified experts lags behind; the human resource development system and mechanisms need to be improved; the quality control of various observational data and the ability for comprehensive applications need to be further enhanced.

The observing stations are unevenly distributed featuring a high density in the east and a sparse layout in the west. There are only a few observing stations on the *Qinghai*-Tibetan Plateau with an average density of 1.06 stations per 10,000 km^2 only. In the *Xinjiang* Autonomous Region, there are only 4.7 stations per 10,000 km^2. The number of atmospheric composition observing stations is rather limited without a scientifically reasonable coverage.

The ocean observing stations are sparsely and unevenly distributed in China's coastal seas, to which the ocean observing facilities are mainly confined, and China lacks of ability for making long-term and stable observations of the oceanic environment in open seas and major oceans.

It poses increasingly serious challenges to protection of the basic conditions for climate observations. Most China's existing ground-based reference climate stations and basic weather stations are located in vicinity of cities and townships. Due to rapid urbanization, the representativeness of data and observing environment of many ground observation stations has been badly compromised.

The climate parameters derived from satellite remote sensing are limited and their time sequences are short. The instruments, equipments and methods used for surface and upper-air observations are relatively backward, and it is difficult to meet the needs for climate change monitoring and research. The long-sequence data currently archived in the satellite database have not yet been processed to derive climate parameters in a standardized and serialized manner. Some observing instruments and equipments have lower stability, reliability and maintainability. The technical support systems are relatively weaker. Only a limited number of elements have been derived from oceanic and terrestrial ecosystem observations and atmospheric composition measurements. For example, observations are still inadequate on sea water salinity, sea ice, marine organism activities, sea surface CO_2 partial pressure and ocean currents, etc.

At present, China faces more serious challenges, e.g. non-unified data formats and quality standards for a large quantity of basic climate data, as well as data heterogeneity. Most basic long-sequence climate data have not been homogenized, and they may lead to errors when used in climate change monitoring and research.

1.2.2 Future prospects

China will enhance its planning and construction of climate system observing networks at national level. By 2015, it will set up an improved national climate observing network, national synoptic observation network, specialized meteorological observation network and regional meteorological observation networks, and put in place an integrated climate observing system incorporating ground-based, airborne, sea- and space-based observing components that are mutually complementary and operating in a stable manner. For this, China will:

(1) improve the automation level of climate observations, enhance observing capabilities in data-sparse areas on land and at sea, and enhance capabilities for making integrated upper-air climate observations and for monitoring extreme weather and climate events;

(2) construct or adjust the layout of national reference climate stations, select the sites that can representing regional climate background through scientific assessments, and construct a national reference climate observing system, which could be used for future climate change monitoring and research in a sustainable manner;

(3) improve the capabilities of satellite observations, maintain stabile operation of the geostationary satellite observing systems, develop FY-4 satellites to upgrade the current geostationary meteorological satellites, develop FY-3 series operational satellites to improve the capability of the polar-orbiting satellites in measuring GHG gases, and improve ground satellite application systems and capabilities for comprehensive use of satellite data and products.

(4) accelerate constructions of urban climate observing systems which will be designed by taking into account city sizes, economic development levels, weather and climate characteristics, and improve the demonstration of climate observing systems in metropolitans, e.g. Beijing and Shanghai, in a short term;

(5) enhance construction of the technical support system for climate observing systems, to ensure stable and reliable operation of the observing systems, and to improve continuity and accuracy of observations;

(6) actively promote international cooperation in the field of climate system observations and participate in international programs, e.g. Coordinated Observation and Prediction of the Earth System (COPES), actively participate in the design and related activities of WMO Integrated Global Observing System (WIGOS), improve implementation level of the Global Atmosphere Watch (GAW) among other international programs, and accelerate implementation of the Global Climate Observing System (GCOS) in China;

(7) make quality control and homogeneous processing of the historical data, facilitate construction of climate data management system on the one hand, and data sharing at different levels on the other hand, and promote climate data applications in national and international climate change research and operations.

Chapter 2 Advances in Climate Change Research

As one of the countries in the world, which have been long involved in climate change research, China strives to make scientific and technological advances and innovations in climate change field, and actively promotes international scientific & technological cooperation. In 2006, the Chinese government released the *National Guideline for Medium- and Long-term Plan for Scientific and Technological Development (2006-2020),* which identified energy and environment as the first priorities for scientific and technological development, and enlisted the global environment change monitoring and response strategies as one of the priority research themes in the environmental field. In 2007, in association with the National Development and Reform Commission and other 13 ministries or commissions, the Ministry of Science and Technology (MOST) released the *China's Scientific and Technological Actions on Climate Change*. In 2010, together with other relevant departments, MOST organized the preparation of the national scientific and technological development plan for addressing climate change for the 12th FYP period, and it made an overall deployment for scientific and technological work in response to climate change in this FYP period. For recent years, China has continuously enhanced the macro management and coordination for scientific research and technological development, and increased investments in the field. In support of research on energy conservation, emission reduction and addressing climate change, China had invested over RMB 13 billion *Yuan* in total in the key S&T research programs, under which more than 150 research projects had been funded in the 11th FYP period. China has made a significant progress on scientific research and technological development in response to climate change, with its S&T capacity for tackling climate change having been fully improved.

2.1 Current Status on Climate Change Research

2.1.1 Basic research

In terms of basic scientific research on climate change, MOST has implemented a wide range of projects under the *National Basic Research Program* (973 Program) and S&T Enabling program, including the *Research on Carbon Cycle and Its Driving Mechanism in China's Terrestrial Ecosystems; Study on Atmospheric Aerosols and Their Climatic Effects; Environmental Changes on the Qinghai-Tibetan Plateau, Their Response to Global Change and Adaptation Strategies; Using Greenhouse Gas as a Resource to Enhance the Petroleum Recovery Ratio and Underground Storage; Aridity Trend in Northern China and Human Adaptation; Study on Theories and Methods for Monitoring and Prediction of Heavy Rain-induced Floods in Southern China; Changing Characteristics of Extreme Weather/ Climate Events and Their Impacts in China in the Last 100 Years*; *Research on Climate Change Detection and Projection Techniques*; *Development and Validation of High-Resolution Climate System Model*, etc. Additionally, in July 2010, MOST launched a major national scientific research program on global change to address some fundamental issues in the basic research on climate change. Totally RMB 580 million *Yuan* was invested in 20 research projects, including the *Characteristics of Carbon Sources and Sinks in China's Terrestrial Ecosystems and Their Global Implications*; *Research on Climate System Changes on the Qinghai-Tibetan Plateau, Their Mechanisms and Impacts on the East Asia*; *Impacts of Large Scale Land Use Change on Global Climate*; and *Impact Mechanisms of Climate Change on Food Production Systems in China and Adaptation*. The National Natural Science Foundation of China created a number of key research projects, e.g. *Research on Tree Rings and Climate Change in the Last 1,000 Years in China*; *Carbon and Nitrogen Exchanges between the Earth and Atmosphere and Their Interactions with Climate*; as well as *Study on Characteristics and Behaviors of Climate Change in China over the Past 1,000 Years*. The Chinese Academy of Sciences also initiated a strategic leading research projects: Carbon Budget Certification and Its Related Issues on Climate Change.

2.1.2 Technological Research and Development

In the 11th FYP period, MOST had systematically forged ahead with technological R&D for climate change mitigation and adaptation under the National S&T Enabling Program and the National High-tech R&D Program (863 Program), and it had systematically deployed a number of research projects for developing energy conservation technologies and new energies for climate change mitigation and adaptation. Those projects have provided effective technological supports and reserves for addressing climate change.

Vigorously pursuing R&D of energy-conservation technologies. Under the 863 program and S&T enabling program, MOST has launched a series of R&D projects, e.g. technologies for efficient use of clean energies; energy conservation technologies and equipments used in key industries; key energy-saving technologies and materials for buildings; technologies used for integrated resource exploration and development, ecological management and restoration; and key technologies and equipments for clean productions in major industries.

Actively promoting R&D of new energies and other mitigation technologies. MOST has deployed a number of projects on development and utilization of renewable or new energies and key smart-grid technologies. Among them, the carbon capture, utilization and storage, CO_2 reduction and utilization for blast furnace iron-making, high concentration CO_2 capture and geological storage in coal-to-oil production, CO_2 capture from oxygen-enriched combustions, Integrated Gasification Combined Cycle (IGCC) with carbon capture, CO_2 utilization and storage, CO_2 mineralization, biodiesel production from biofixation of CO_2 by microalgae, etc., have been deployed by MOST under its S&T Enabling Program.

Strongly enhancing R&D of climate change adaptation and monitoring technologies. Under its S&T Enabling Program and 863 Program, MOST has defined themes for a number of research projects, e.g. key technologies for addressing climate change impacts and adaptation; technology demonstration in adaptation to climate change in typical vulnerable regions; research and demonstration of carbon sequestration and emission reduction technologies for major agricultural and forestry ecosystems, and key technologies for forestry eco-construction, and research on technologies for monitoring, early warning and controlling of major climate-induced agricultural hazards.

2.1.3 Technology demonstration and industrialization

The Chinese government has launched a number of energy-conservation and new energy technology demonstration projects, e.g. ‘Ten Cities-Thousand New Energy Vehicles’, ‘Ten Cities-Ten Thousand LED Lamps’ and ‘Golden Sun’. Under the ‘Ten Cities-Thousand New Energy Vehicles’, it was originally planned to promote use of hybrid-electric, all-electric and fuel cell vehicles in the public transport sector in more than cities in a modular manner. By 2010, the demonstration pilot cities under this project had increased to 25. Under the ‘Ten Cities-Ten Thousand LED Lamps’, the LED lighting pilot cities have reached 37 now, to promote common use of semi-conductor lighting products for quicker development of the industry. It is estimated that the LED lighting will account for 30% of China’s general lighting market by 2015, saving more than 100 billion kWh each year. Under the ‘Golden Sun’ project, it is planned in next 2-3 years to provide upfront subsidies for qualified solar PV demonstration projects with a project size of no less than 500 MW. By 2015, the newly installed capacity of PV power systems will be 2.5 GW and the annual output value of PV power will reach RMB 20 billion *Yuan* in the domestic market. Moreover, some scientific and technological achievements, e.g. new energy vehicle, LED lighting, clean energy and smart grid technologies were broadly applied and demonstrated during the 2008 Beijing Olympic Games and the World Expo 2010 Shanghai.

2.1.4 International cooperation

China has actively participated in multilateral S&T cooperation on climate change. China plays an important role in international scientific programs and organizations, including World Climate Research Programme (WCRP), International Geosphere-Biosphere Programme (IGBP), International Human Dimensions Programme on Global Environmental Change (IHDP), International Programme of Biodiversity Science (DIVERSITAS), Earth System Science Partnership (ESSP), Intergovernmental Group on Earth Observations (GEO), Global Climate Observation System (GCOS). China has actively participated in preparations of the Intergovernmental Panel on Climate Change (IPCC) Assessment Reports. In 2007, MOST and NDRC released the *International Science and Technology Cooperation Program on New and Renewable Energies*. China also initiated some international cooperation programs at regional level, e.g. the Monsoon Asia Integrated Regional Study (MAIRS) and the Northwest Pacific Ocean Circulation and Climate Experiment (NPOCE), through which studies on global change were made, taking into account both China's unique features and global implications.

China has strongly promoted the international S&T cooperation with the developed countries. So far, China has signed 103 S&T cooperation protocols with 97 countries. In 2010, the Ministry of Science and Technology of China and the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety signed the *Memorandum of Understanding on Sino-German Cooperation in Climate Protection and Electric Vehicles* and the *Agreement on Implementation of Sino-German Cooperation in Electric Vehicles and Climate Protection*. China and the United States have agreed to invest 150 million USD together to create a joint Sino-US Clean Energy Research Center, and the two countries will make joint research in 3 priority areas: building energy efficiency, clean coal/carbon capture & storage(CCS), and clean energy vehicles. China and EU have held 8 conferences on energy cooperation, and in 2010 the two sides established the Europe-China Clean Energy Center. In 2007, the Chinese and Japanese governments signed the *Joint Statement on Strengthening Scientific and Technological Cooperation on Climate Change,* and initiated the China-Japan exchange program on climate change research. China has actively participated in the cooperation under the Clean Energy Ministerial (CEM), and launched China (Shanghai) International Electric Vehicle Pilot City Demonstration Program. Under the framework of

Asia-Europe Meeting (ASEM), the Asia-Europe Water Resources Research & Utilization Center has been established. Together with other countries and international organizations e.g. Australia, Italia, UK, EU, IEA and Carbon Sequestration Leadership Forum (CSLF), China has initiated a number of cooperative projects on carbon capture and storage. In 2010, China launched CCS projects with Australia, Italia, EU and other countries, which made positive contributions to China's capacity building for development of CCS demonstration projects. In 2009, NDRC of China, UK Department for International Development and Swiss Agency for Development and Cooperation jointly implemented a project - Adapting to Climate Change in China, which played an exemplary role in facilitating China's scientific and technological work in adaptation to climate change. Furthermore, China has also conducted extensive S&T cooperation with UK, Italy, Japan and Republic of Korea in the fields of energy-saving buildings, low-carbon demonstration townships, and smart grid, etc.

China has actively carried out S&T cooperation on climate change with other developing countries. Climate change, clean energy and environment are the priority areas of the cooperation between China, India, South Africa and Brazil among others. MOST organized the preparation of the *Applicable Technology Manual for South-South Cooperation on Science and Technology to Address Climate Change,* and launched the Network/Platform for International Science and Technology Cooperation for Addressing Climate Change. MOST and United Nations Environment Programme (UNEP) signed a *Memorandum of Understanding on Framework of Technical and Institutional Cooperation on Environment in Africa* (2008) and an *Implementation Agreement on Joint Projects on Environment in Africa* (2009), under which MOST had implemented some demonstration projects in Africa, e.g. technologies for drought early warning system and adaptation to drought, to help African countries improve their capacities to tackle climate change. In 2010, China and Brazil established the Tsinghua-UFRJ China-Brazil Center for Climate Change and Energy Technology Innovation in Tsinghua University, which enhanced the cooperation of the two countries in this field. Additionally, the China State Oceanic Administration implemented Indonesia-China Center for Ocean and Climate.

2.2 Major Findings in Climate Change Research

Through effective implementation of the national key research projects and international cooperative projects, China has made some internationally recognized findings in studies on climate change pattern, mechanisms, regional responses and interactions with human activities, which have provided valuable scientific basis for national policy and decision-making in response to global climate change.

In basic scientific research on climate change, China keeps up with the world pace in paleoclimate research by analyzing loess, stalagmites, ice cores, lake cores and historical records; world advanced research platforms have been established for carbon flux observations, control tests and remote sensing invertions, and it is for the first time that continuous carbon flux/storage measurements have been made on 10 terrestrial ecosystems in China; both forming and changing mechanisms of China's terrestrial carbon sinks have been revealed by making quantitative analyses of climate and land use change impacts on carbon equilibrium; high-resolution temperature variations in the last 2,000 years over the *Qinghai*-Tibetan Plateau have been reconstructed; more in-depth knowledge has been explored about the aridification behaviors and mechanisms in the northern china and the turning points in the last 2,000 years by developing multiple aridification process modules and the conceptual regional models of the Earth system; a high-resolution time sequence of Asian monsoon variations over past 9,000 years has been established on a preliminary basis; a multiple synoptic model has been proposed to describe the storm-forming weather systems in the early flood-prone season in South China; more understanding has been gained of the historical facts and trend of climate change over China, including the causes and mechanisms of regional climate change, by systematically investigating the changes of key surface climate elements and climate extremes over past 100 (50) years in China region; global and regional climate models have been developed with its own intellectual property rights, which has improved China's ability to simulate climate change, extreme weather and climate events as well as abrupt climate change over the region.

In aspect of climate change impact assessments and adaptation strategies, some internationally comparable methodologies for research on the dangerous level of climate change have been developed; some convenient tools have been developed for regional climate risk detection and assessment; some optimal methods have been developed for screening and selecting climate change adaptation technologies; adaptation strategies have been proposed for agriculture, forestry, water resources, ecosystems, desertification, human health, coastal zones and sea level, extreme weather hazards among others.

In terms of socio-economic analysis and mitigation strategies under climate change, China's and global energy and climate change evaluation models have been developed by regions, to simulate energy consumptions in China, major countries and regions under various CO_2 emission scenarios; preliminary analyses and assessments have been made on emission reduction potentials and costs of China's energy end-use sectors and key technologies (e.g. new and renewable energies and CCS); China's future GHG emission reduction targets and the resolved sub-targets by sectors and regions have been investigated; the *Research Report on Roadmap of China's Carbon Capture, Utilization and Storage Technologies* has been prepared, which is based on the organized studies.

2.3 Problems and Orientations of Climate Change Research

2.3.1 Gaps in China's climate change research

In spite of more rapid progress made in climate change research, China still lags behind compared with the world advanced level.

(1) Basic research lags behind and comprehensive research is inadequate. The in-depth understanding of the mechanism of climate change system is inadequate. Theoretic guidance is insufficient for making cost-benefit analyses of response strategies for climate change impacts, adaptation and mitigation. There is a shortage of methods for addressing key issues, e.g. economic analysis of non-market factors in economics, and principles for decision-making with uncertainties. Deficiency still exists in making comprehensive and interdisciplinary studies.

(2) Research models and methodologies need to be innovated. China's current coupled GCM and RCM models are still under development and improvement. For studies on climate change impacts and adaptation, although quantitative analysis-based models, which are linked to the scenarios in the global climate models, have been widely used in recent years, these models are mostly introduced from abroad and China still lacks of comprehensive climate change assessment models.

(3) China lacks of supportive research on core technologies for climate change mitigation and adaptation, e.g. integrated gasification combined-cycle (IGCC) technology used for coal-fired power plants in the power-generation industry; large wind power equipment, PV cell, fuel cell, biomass energy, nitrogen energy for developing new energy technologies; automobile fuel economy and hybrid vehicle technologies in the transport sector; energy saving and high-efficiency technologies in metallurgy and chemical industries; and optimal design of the energy-saving schemes for energy-efficiency buildings, among other gaps.

2.3.2 Main areas of future research on climate change in China

The main areas of China's future research on climate change include scientific basis of climate change, impacts & adaptation, mitigation and sustainable socio-economic development.

(1) For basic scientific studies, the main research areas include theories, methodologies and technologies for climate change observations; reconstruction of highly precise long sequences of past climate; behaviors and mechanisms of global climate change; multi-sourced and multi-scale data integration; development of an Earth system model; and climate change simulations and predictions.

(2) In aspect of climate change impacts and adaptation, the main research areas cover mechanisms of climate change impacts in key sectors (e.g. water resource, agriculture, forestry, ocean, human health, ecosystem, major construction projects, disaster prevention and mitigation) and assessment methodologies; R&D of climate change adaptation theories and technologies; adaptation demonstrations in typical vulnerable regions and sectors.

(3) For mitigation, the main research areas contain innovations and marketing of non-fossil energy and clean coal technologies, development of new energy saving and high-efficiency technologies in key sectors (e.g. industry, building and transport); R&D of key technologies for forestry carbon sinks and industrial carbon sequestration; cost reduction and market-oriented applications of key technologies (e.g. carbon capture, utilization and storage); carbon emission statistical and monitoring systems in support of achieving the binding targets of CO_2 emission and energy consumption intensities.

(4) From perspective of sustainable socio-economic development, the main research areas include major strategies and policies on climate change; construction and comprehensive demonstration of technological support systems for low-carbon and sustainable development; raising public awareness of participation in actions to tackle climate change; and international collaborative research.

Chapter 3 Education, Outreach and Public Awareness

Education and outreach are an important approach for raising public awareness and actively addressing climate change. In recent years, China has carried out a wide range of public education and outreach activities on climate change in different forms, which have intensified public participations in response to climate change, raised public awareness noticeably, and enhanced their ability to tackle climate change.

3.1 Education and Raising Public Awareness

It is clearly stated in the *China's National Climate Change Programme* that climate change public outreach and education should be incorporated into the framework of basic education, adult education and higher education as an important component of China's overall quality education. With efforts made for some years, the education on climate change has entered in classrooms, social practices and minds of all walks of life.

3.1.1 Education on climate change has been included in the elementary education system

Currently, the subjects of geography, biology and chemistry in primary and secondary schools have touched environment and sustainable development, and the content of climate change has been incorporated in classroom teaching. In some primary and middle schools, special courses on climate change are provided. Apart from classroom teaching, schools have also included the education on climate change in students' social practices, for example, on the World Meteorological Day, World Environment Day, World Earth Day, National Energy Conservation Week, schools provide climate change-related education around the theme of the day. Meteorologists from local meteorological bureaus give lectures in classrooms, conduct touring exhibition to disseminate scientific knowledge on climate change, and donate graphics, readings and disks to schools, all aimed at outreaching scientific knowledge on climate change, and raising students' awareness of climate change.

Figure 5.1 Students' social practices for environment protection & climate change knowledge

3.1.2 Climate change subjects have been included in China's professional education system

Colleges and universities in Chinahave enhanced the education on environment and climate change.

1. Major subjects on environmental and climate change sciences have been set up and continuously improved. An interdisciplinary education system has been established covering environmental engineering, environmental science, climatology, applied meteorology, energy and environmental system engineering. According to incomplete statistics, by 2009 China had 778 undergraduate degree-conferring units, 198 for associate degrees, 560 for master degrees, 209 for doctoral degrees for students majoring in environmental and climate change sciences, and 278 higher learning institutions for adults specializing in environmental and climate change subjects.

2. Some universities have run interdisciplinary courses on climate change to disseminate climate change-related knowledge to students of all majors. For example, in 2008 Peking University offered BELL (Business, Environment, Learning and Leadership) demonstration course, which took climate change as the theme offering topics on wind power, solar power and CCS, open to students from other high-learning institutions. In 2010, together with some foreign universities including East Carolina University, *Shandong* University created an online course on global climate change, providing

professors and students of different countries with a platform for addressing climate change-related issues.

3. Universities have enhanced development of education and scientific research bases focusing on climate change, for examples, the Center for Climate Studies of the Peking University, Climate Change and Low Carbon Development Polices Research Center of the Tsinghua University, Global Climate Change & Water Security Research Center of the Hehai University have been set up over recent years. These centers have played an important role in nurturing high-level professionals on climate change.

3.2 Outreach and Raising Public Awareness

It is stated in the *China's National Climate Change Programme* that mass media such as books, newspapers, periodicals, audio and video products should be fully used to disseminate knowledge of climate change. Since 2005, the Chinese government has launched a series of outreach activities on climate change through mass media, meetings, thematic activities and social events, etc., having achieved positive results.

3.2.1 Outreach through media

China has made full use of media, e.g. TV and radio, for climate change outreach, and it has intensified reporting of energy conservation, emission reduction and other actions to tackle climate change. According to CCTV statistics, it had broadcasted climate change-related programs with a total length of over 12,400 min and more than 550 pieces of relevant news, and it released over 8100 news reports via CCTV website (cctv.com) during 2005-2010. CCTV, Xinhua News Agency and other media have launched special reports on climate change, e.g. *Facing Climate Change*; *Addressing Global Warming - China in Action*; and a TV series entitled *Climate Change Focus*. All major Chinese media covered UN Climate Change Conferences in their special columns.

CCTV中国应对全球变暖 一

CCTV中国应对全球变暖 九

Figure 5.2 A TV documentary series: Addressing global warming – China in Action

Since 2007, China has produced a TV series and a brochure entitled *Addressing Climate*

Change - China in Action in Chinese, English, French and Spanish every year; other TV series - *High Level Interviews on Climate Change*, and *Exploring Paleoclimate,* and some educational video footages - *Secrets of Climate Change* targeted to primary school pupils, and *Record-breaking Climate Event*s oriented to middle school students. TV stations in provinces and cities levels have also highlighted climate change outreach. For example, in 2009, the *Tianjin* Cable TV initiated a daily documentary series - *Green Heroes,* and the *Jiangsu* Cable TV launched a weekly special program - Climate Change Talks.

China highly values the role of Internet in climate change outreach. A number of climate change-related websites have been set up and upgraded, e.g. website of the Department of Climate Change under NDRC, China Climate Change Info-net (www.ccchina.gov.cn), Climate Change Adaptation in China (www.ccadaptation.org.cn), Clean Development Mechanism in China (cdm.ccchina.gov.cn) and China Climate Change (www.ipcc.cma.gov.cn). These websites have played an active role in disseminating knowledge on climate change, telling readers about status on tackling climate change in China and overseas, publicizing relevant policies and measures, and raising public awareness of climate change. The well-known websites in China, e.g. XinhuaNet (www.xinhuanet.com), People's Net (www.people.com.cn), *Sohu* (www.sohu.com) and *Sina* (www.sina.com), have also involved in climate change outreach in various forms. China Energy website (www.china5e.com) releases monthly video programs - *Climate Dialogue*, in which officials, experts, entrepreneurs and public figures are invited to discuss climate-related topics.

The Chinese government recognizes the role of publications in climate change outreach. Since 2008, China has published annual white paper or report - *China's Policies and Actions on Climate Change*, which elaborates China's progress and latest achievements in tackling climate change. Since 2005, China has published a large number of books on climate change, e.g. first and second *China's National Assessment Report on Climate Change*, green papers - *Annual Report on Climate Change Actions (2009): the Road to Copenhagen, and Annual report on Actions to Address Climate Change (2010): Challenges in Cancun and China's Actions;* Guidelines on China's CDM Project Development; *Global Climate Change: A Challenge to Mankind*; *Manual on Promoting Energy Conservation and Emission Reduction - Quantitative Emission Reduction Potentials of 36 Daily Behaviors*, etc. In addition, China has also published multiple journals, e.g. *Climate Change Development* and *Advances in Climate Change Research*, and special editions on climate change in journals like *Science News Biweekly* and the *World Environment*.

3.2.2 Outreach through meetings

In recent years, China has held a number of high-level conferences, forums and workshops, which have played an important role in raising public awareness of climate change. In 2008, the Chinese government and UN cosponsored the Beijing High-Level

Conference on Climate Change: Technology Development and Technology Transfer, and Premier Wen Jiabao delivered a speech at its opening ceremony. More than 700 officials and representatives from over 70 countries, international organizations, enterprises, academic institutions and NGOs participated in the event. In the same year, the Chinese government hosted a large international Forum on Climate Change and Science & Technology Innovation for the first time, which was attended by more than 600 participants, including officials and experts from over 30 countries and 10 international organizations, as well as representatives from enterprises and NGOs. In 2009, a National Forum on Climate Change: Challenges, Opportunities and Actions was held in Beijing, in which representatives from the Chinese People's Political Consultative Conference, government departments, scientific, industrial and financial communities actively exchanged views and discussed around 6 themes: climate change impacts and adaptation; mitigation policies and measures; local and industrial actions; financing; public participation; and S&T innovations. In 2010, China hosted the United Nations Climate Change Conference in Tianjin, which was widely recognized for its role in increasing publicity and raising public awareness of climate change.

Figure 5.3 Beijing High-Level Conference on Climate Change: Technology Development and Transfer

Figure 5.4 Press Conference of the International Forum on Climate Change and Science & Technology Innovation

Figure 5.5 A Forum on Climate Change: Challenges, Opportunities & Actions

Figure 5.6 United Nations Climate Change Conference 2010, Tianjin

3.2.3 Thematic outreach

Thematic outreach on tackling climate change is one of the important approaches taken by the Chinese government to raise public awareness of climate change. Since 2005, China has held China (Beijing) International Energy Saving and Environment Protection Exhibition (BIESEPE) every year, which is themed on energy conservation and emission reduction. The theme of BIESEPE 2010 was 'Low-carbon Technologies and Green Economy'.

'Green Olympics' was one of the themes of the Beijing 2008 Olympic Games, during which the green, environment-friendly and low-carbon concepts and practices were broadly communicated, and a platform was created for the public to take part in actions in addressing climate change, which has profound social implications. As a survey shows, most respondents believe that the 'Green Olympic' event including its preparatory stage has raised public awareness of environment and changed people's social behaviors and lifestyle. The public have become green concept actors through low-carbon travel and carbon neutrality.

The World Expo 2010 Shanghai was themed on 'Better City, Better Life'. The green, environment-friendly and low carbon concepts were incorporated in the Expo Park planning, construction engineering, venue operations and displays. Thanks to a series of initiatives taken during the Expo, e.g. 'green travel card', 'Expo voluntary emission reduction' and 'low carbon Expo forest', multiple approaches have been explored for general public to better protect environment and tackle climate change, and pleasant environmental conditions have been created for them, all playing a positive role in raising public awareness of environment.

In 2010, the 20^{th} National Book Expo was held in *Chengdu*, during which a scientific knowledge outreach initiative themed on 'Earth - Our Home' was launched. By putting on a series of novel and humorous dramas, climate change knowledge was well communicated to the audience, arousing their concerns on climate change and awareness of potential risks.

The Chinese government has also initiated climate change outreaches through thematic events, e.g. National Energy Conservation Week, World Environment Day, World Meteorological Day, World Earth Day, Disaster Prevention and Reduction Day, Science Day.

3.2.4 Outreach by Civil Societies

In recent years, the Chinese non-governmental organizations (NGOs) working on environment protection have been increasingly growing stronger, and they have played an important role in disseminating climate change knowledge and raising the public awareness.

Friends of Nature, Global Village – Beijing, Green Earth Volunteers, Institute of Public & Environmental Affairs, Action Aid, etc. have taken the lead in having established the China Civil Society on Climate Change. This body has openly sought, via mass media, e.g. internet and newspapers, positions of Chinese citizens on issues like tackling climate change, and it has organized a series of talks.

China Youth Climate Action Network (CYCAN) composed of the College Environmental Forum and other 6 NGOs has invited the University Forum on Environment protection to promote building of resource-saving campuses and call on China's youth to involve in tackling climate change and environment protection activities. So far, youth groups from over 300 universities and more than 100 enterprises have responded positively to the initiative.

Figure 5.7 An outreach activity on 'China Youth Climate Change Action Day'

Moreover, China's social communities actively responded to the 'Earth Hour' initiated by the World Wide Fund for Nature. The outreach activities like '1,000 Environment-Friendly Youth Ambassadors Action' were carried out in organizations, schools, communities, barracks, enterprises, parks and squares to communicate environment-friendly concepts and advocate low-carbon lifestyle and green consumption.

Figure 5.8 Beijing Palace Museum before and in the 'Earth Hour'

3.3 Improving Understanding of Climate Change by Leaders at All Levels

Through learning and training in various forms, leaders in China at all levels have improved their understanding and abilities of addressing climate change. The Political Bureau of CPC Central Committee has convened two collective learning sessions on the issue of climate change, focusing on 'Global Climate Change and Enhancing China's

Capacity Building for Addressing Climate Change' and 'China's Action Targets for GHG Emission Control by 2020' respectively. When presiding over the learning sessions, the General Secretary of CPC Central Committee Hu Jintao emphasized that the government should take more powerful policies and measures to fully enhance capacity building for addressing climate change; the government should take the response to climate change as a major strategy for China's socio-economic development, and as a major opportunity to accelerate transformation of the economic development model and economic restructuring; the government should continue to do a good job in addressing climate change, to ensure that China's action targets for GHG Emission Control are met by 2020.

The Standing Committee of the 11th CPPCC National Committee organized a lecture on climate change and enhancing China's capacity building for addressing climate change. Mr. Jia Qinglin, Member of the Standing Committee of the Political Bureau of CPC Central Committee and Chairman of CPPCC, chaired the lecture and delivered a speech.

In 2009, the Party School of CPC Central Committee convened a lecture session - "Paying More Attention to Global Climate Change and Enhancing China's Capacity Building for Addressing Climate Change" for ministerial and provincial leaders, young and middle-aged officials. In 2010, the Organization Department of CPC Central Committee held a Training Course on Environment protection & Climate Change with lecturers from the Ministry of Environmental Protection, Ministry of Science and Technology and China Meteorological Administration.

The National Development and Reform Commission has organized a 'Training Seminar on Climate Change, Sustainable Development and Environmental Management', a 'Training Workshop on Capacity Building for Addressing Climate Change Targeted to Decision Makers at Provincial Level', a 'Training Course on Capacity Building for CDM Management Oriented to Officials from Local Governments', a 'Training Seminar on Capacity Building for Climate Change Adaptation', and a 'Training Course on Preparation of GHG Emission Inventory at Provincial Level", etc. The Ministry of Environmental Protection, China Meteorological Administration, Ministry of Finance, Ministry of Foreign Affairs, State Administration of Taxation have included the contents about climate change, energy conservation and emission reduction in their leadership training programs, which have effectively improved the leaders' awareness of climate change and their science-based managerial ability.

Local governments have also actively organized relevant training activities on climate change. For example, the *Jiangxi*, *Shanxi* and *Qinghai* CPC Provincial Committees have organized collective learning sessions on issues related to climate change respectively. CPPCC Committee of the *Anhui* Province invited experts to give lectures on climate change for its members. The *Qinghai* Meteorological Service has held a 'Training Seminar on Climate Change Adaptation for the Eastern *Qinghai* Region', etc.

As a whole, China has made meaningful explorations and attempts in public outreach, education and participation in actions to tackle climate change for recent years, and it has accumulated abundant experience and substantially improved public awareness of climate change. The ‘Survey on Climate Change Public Awareness’ launched by the Horizon Research Consultancy Group in 2009 shows that among all respondents, 69.8% are concerned about climate change, and 83% are willing to take practicable actions for improving climate environment.

Looking ahead, China will seriously fulfill the relevant requirements in education, training and public awareness under the United Nations Framework Convention on Climate Change. China will continue to explore new approaches and improve the existing ones for climate change outreach and public participation, in a greater effort to improve all people’s awareness of tackling climate change, to enhance China’s capacity to address climate change, to promote more balanced economic and social development in harmony with environment, and to make a due contribution to global climate change mitigation and adaptation. Meanwhile, China will further carry out international cooperation on climate change outreach and social participation, and assist other developing countries in raising public awareness of climate change and enhancing their capacities to tackle climate change.

Chapter 4 Cooperation and Exchanges with Other Developing Countries

In recent years, China has actively promoted South-South cooperation in addressing climate change and implemented a number of foreign aid projects, e.g. on clean energy, agricultural drought-resistance techniques, use and management of water resources, sustainable forest management, grain cropping, capacity building for climate change adaptation, soil conservation, and meteorological information service to assist other developing countries in enhancing their capacities to cope with climate change.

In 2005-2010, altogether 115 foreign aid projects on tackling climate change had been completed or under implementation, with a total amount of RMB 1.17 billion *Yuan.* Among them, 30 cooperative projects were implemented by providing whole sets of equipments, goods and techniques with an amount of about RMB 1.05 billion *Yuan*, e.g. establishment of Agricultural Technology Demonstration Centers in several African countries; reparation of the Parvan water conservation project in Afghanistan; installation of solar power generation equipments and solar water heaters in Morocco and Lebanon; water resource exploration and municipal water supply in Niger; rain-fed farming technique demonstration in the Democratic Republic of the Congo. The rest 85 foreign-aid projects included the training courses on technologies used for small hydropower stations; soil conservation and rain-fed cropping techniques; application of solar energy technologies; diffusion of desert-control techniques; water-saving irrigation; training of meteorological managers; and training events on forest resource conservation, development and utilization, Clean Development Mechanism, cement production, meteorological hazard prevention and reduction, renewable energy technologies, rain-water harvesting and use techniques, climate system and climate change for other developing countries. Altogether, 3,506 professionals working in climate change-related sectors from 122 developing countries have received training on the skills that they badly need.

The implementation of above cooperative projects has effectively improved the capabilities of some other developing countries in tackling climate change, which have been highly recognized by the governments and people of these developing countries. During 2011-2015, China plans to roughly double its aid for addressing climate change relative to 2005-2010, considering practicable requirements of other developing countries.

Part VI Needs for Finance, Technologies and Capacity Building

Finance and technologies are essential for climate change mitigation and adaptation. The developed countries should fulfill their commitments by providing finance, technologies and supports in capacity building to the developing countries, which is the fundamental assurance for the developing countries to effectively address climate change. As China is a country with a large population, weak foundation and imbalanced development, facing many challenges, it is necessary for China to continue endeavouring to achieve the goals of its socio-economic development, to actively cope with climate change, and to effectively fulfill the commitments under the Convention. It is also necessary for the Annex-I Parties to provide support in terms of finance, technologies and capacity building, according to requirements of the Convention to improve China's capacity in tackling climate change.

Chapter 1 Finance Needed for Addressing Climate Change

China is a developing country with a big population, lower economic development level and vulnerable ecological environment, coal-dominated energy mix, and relatively backward technologies. A huge financial input is required in addressing climate change, and special difficulties still exist in GHG emission controls.

1.1 Lower Economic Development Level in China

Although China's aggregate economic volume ranks among the forefront in the world, its population accounts for about 1/5 of the world total, and its per capita GDP still ranks around 100^{th} in the world, which is just about half of the world average level, or less than one tenth of that of the United States and Japan among other developed countries. By the United Nations criteria, about 150 million people are still living under the poverty line. The economic and social developments are imbalanced between urban and rural areas, and from region to region. The per capita disposable income and consumption spending in rural areas only account for about one third of those in urban areas. The total per capita retail sale of consumer goods in the eastern region is more than twice over that in the western region. China's exported products rely on the low-price advantage to take a market share, and there are both reasonable factors (e.g. cheaper labour costs) and unreasonable factors that have not fully reflected the prices of resources and environmental costs in support of this advantage. Either from perspective of per capita development indicators used internationally, or from perspective of economic and social structures, China is still the largest developing country, requiring a large amount of funds to develop its economy, to improve people's livelihood, and to enhance buildup of its ecological civilization.

1.2 A Large Gap in Finance Needed for Climate Change Adaptation in China

The total desert area in China is about 2.63 million km^2, accounting for 27.4% of its total land territory. China's pastures are mostly alpine or desert grasslands, 90% of which are exposing to degradation to a varying degree, and grasslands in the northern temperate zone are also subject to degradation and desertification due to impacts of droughts, overgrazing, and deterioration of ecological environment. The managed forests in China tend to be in one species vulnerable to diseases and pests, and current forestable lands are mostly located in the areas under desertification, stony desertification and poor natural conditions. China's soil-erosion area is 3.5692 million km^2, accounting for 37.2% of its total land, with its inland fresh-water ecosystems being exposed to various threats, with some major wetlands deteriorating. Being flat and low in altitude, most China's coastal zones are more susceptible to such risks as shoreline erosion, seawater intrusion, soil salinization and seawater intrusion in estuaries due to sea level rise. China's climate conditions are relatively harsher, featuring frequent extreme weather and climate events, wider disaster-affected areas, multiple disasters, greater severity and larger affected population, so rare in other parts of the world. It is imperative to enhance capacity building for tackling climate change, especially climate extremes, and to significantly increase financial inputs in adaptation projects for effective protection of people's lives and properties.

1.3 A Large Amount of Finance Required by China to Substantively Reduce CO_2 Emission per Unit of GDP

China is a coal-dominated country, and coal accounts for a high percentage in China's energy mix. In 2005, although coal only accounted for 27.8% of the world primary energy consumption, it accounted for 70.8% in China. In 2010, coal still accounted for 70.9% in China's primary energy consumption structure. As China's energy mix restructuring is, to some extent, restricted by its structure of energy resources, with China's increasing energy demand, it will be difficult to make a fundamental change from its coal-dominated energy resources and consumption structure for a quite long period in the future. Apart from its relatively backward coal production and consumption modes, all this making China face greater difficulties in reducing CO_2 emission intensity per unit of energy resource, compared with other countries. Considering the fact that the low-cost energy saving potential has been tapped through energy conservation efforts for many years, China will increasingly rely on the energy-conservation technologies that require more funds in the future. Since the costs of developing non-fossil energies are still higher than those of traditional energy resources, they will be hardly lowered by a big margin in a short run, while afforestation will proceed under harsher conditions. As a preliminary estimation shows, to achieve the target of reducing CO_2 emission per unit of GDP by 40-45% by 2020, in China, investment needs in energy conservation and optimization of energy mix alone will exceed RMB 10 trillion *Yuan*.

Chapter 2 Technologies Needed for Addressing Climate Change

Addressing climate change relies on technologies, technological innovations and technology transfer, which are the basis and underlying support for coping with it. As it is clearly stated in Clause 5 of the Article 4 in the Convention: "the developed country Parties and other developed Parties included in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention." The international community should establish an effective mechanism for technological cooperation and technology transfer to facilitate technology R&D, deployment and transfer in addressing climate change. The developed countries should fulfill their commitments by providing finance and transferring technologies to the developing countries, removing the obstacles that exist in policies, institutions, procedures, financial resources and protection of intellectual property rights for technology transfer, and taking incentive measures for technological cooperation and technology transfer, to ensure that the developing countries can access to affordable and usable advanced climate-friendly technologies. The Chinese government highly values scientific and technological advances in response to climate change by organizing relevant institutions to assess China's technology requirements, and to propose a list of technologies needed for climate change mitigation and adaptation.

2.1 Technologies Required for GHG Emission Mitigation

Being in the stage of large-scale infrastructure constructions, China has a strong demand for key technologies used for mitigating GHG emissions. In the *China's National Climate Change Programme*, key technologies have been proposed for advanced energy production and utilization, for environment protection and comprehensive utilization of resources, for high-efficiency transportation, and for new material and new-type building material production. Among these technologies, the deployment and diffusion of the technologies used for high-efficiency and low-pollution coal-fired power generation, large hydropower generation unit, new-generation nuclear energy, renewable energies, building energy conservation, clean fuel vehicle, hybrid vehicle, urban rail traffic, fuel cell and nitrogen energy, oxygen-rich coal-spray blast furnace with long-life cycle, comprehensive transformation and expansion of medium- and small-sized nitrogenous fertilizer production facilities, new paving materials, new-type wall materials will make a significant difference in mitigation of GHG emissions in China. A list of required technologies for mitigation has been proposed by relevant Chinese research institutions, as shown in Table 6-1.

Table 6-1 A list of mitigation technologies needed by China

Sector	Technology
Energy	IGCC power generation; multi-generation; converting liquid fuels from coal; coal gasification;
	New-generation fast reactor; nuclear fusion;
	Large scale offshore wind power generation;
	Core technology for solar thermal power generation; solar photovoltaic power generation;
	Advanced geothermal power generation; nitrogen energy and fuel cell; advanced ocean-energy power generation; biomass energy;
	Smart grid and energy storage;
	Carbon Capture and Storage.
Iron & Steel	Large scale gas-turbine;
	Smelting reduction;
	Novel direct steelmaking;
Transport	Improved fuel-thrift engines, transmission systems; vehicle lightweight;
	Advanced low-emission diesel engines; high-quality vehicle diesel engines;
	Hybrid power vehicles; high-efficiency electric vehicles.
Building	LED;
	New-type building enclosure materials and sectors; advanced ventilation and air conditioning systems;
	District co-generation; geothermal heat pump.
General-purpose	High-power electronic devices, especially power-semiconductor components;
	Direct current permanent–magnet brushless motors.

2.2 Technologies Required for Climate Change Adaptation

As one of the countries that are most susceptible to adverse impacts of climate change, China has an urgent need for major adaptation technologies. In the *China's National Climate Change Programme*, the adaptation technologies have been proposed for climate change observation, monitoring, prediction and warning; agricultural production; water resources management; ecological protection and rehabilitation; coastal zone protection, etc., among which deployment and diffusion of the technologies used for high-efficiency water-saving agriculture like spray or drip irrigation; industrial water-saving and recycling; industrial and domestic wastewater treatment; domestic water saving; high-efficiency flood control; agro-biological engineering; crop breading; new-type fertilizer; disease and pest control in cropland, forest and grassland; cultivation of fast-growing high-yield forest and high-efficiency fireweed forest; recovery and reconstruction of wetland, mangrove and coral reef ecosystems;

observation and early warning of flood, drought, sea level rise and agricultural disasters will help China reinforce its capacity in adaptation to climate change. A list of adaptation technologies has been put forward by relevant Chinese research institutions, as shown in Table 6-2.

Table 6-2 A list of adaptation technologies needed by China

Sector	Technology
Comprehensive observation	Conventional observations, including use of wind profilers, and application of GPS in upper-air meteorological observations, etc.;
	Non-conventional observations, including development of satellite remote-sensing instruments and ground-based remote sensing technologies, etc.
Numerical prediction	Data analysis and assimilation, including setup of 4-DVAR data assimilation system, direct assimilation & application of massive satellite data, quick assimilation & application of near surface intensive measurements, parallel high-efficiency computation of global high-resolution 4-DVAR data assimilation system, etc.;
	Numerical prediction models, including optimized physic-process parameterization scheme and its coordination with dynamic models and data assimilation system, establishment of perturbation method for peculiar vector initial value, and improved initialization method for typhoon vortex, etc.
Agriculture	Crop breeding, including use of molecular techniques for large-scale seed quality innovations and breeding new seed varieties;
	Efficient water resource allocation and non-water intensive irrigation, etc.;
	Agricultural product recycling, including new-type food production platforms, comprehensive use of agricultural & livestock products, as well as storage, preservation, packaging and circulation of agricultural products, etc.
Coastal zone protection	Ocean monitoring & observations, including imported tight anchorage buoys, and profile-measurements from moored buoys;
	Sea level rise prediction & evaluation, including aeronautical remote-sensing image processing, numerical sea level rise prediction, and global sea-air-ice-land-vegetation coupling, etc.
Ecosystem	Forest fire & disease/pest monitoring, early warning and post-disaster response technology; prevention & recovery from extreme weather events; adaptation management of forest ecosystems;
	In-situ and *ex-situ* species conservation; habitat restoration; species diversity adaptation in ecologically vulnerable areas; adaptation management; rare and endangered species monitoring, prediction and early warning; hazardous organisms monitoring, prediction and early warning.

Chapter 3 Capacity Building Required for Addressing Climate Change

Capacity building is crucial for developing countries to effectively deal with climate change. The Fifth Conference of Parties (COP-5) of the Convention endorsed the decision on capacity building for the developing countries, emphasizing that the capacity building shall mainly focus on the developing countries, reflecting their priority requirements, being implemented in them. COP-5 also decided that the financing mechanism of the Convention should provide financial and technological supports for the developing countries. The *Marrakech Accords* put forward in more details the framework of capacity building for the developing countries, in which a preliminary scope for capacity building required by the developing countries was outlined. As a developing country, China has stronger demands for capacity building in preparation of the national GHG inventory, establishment of a statistical system for GHG emissions, enhancing adaptation to climate change, and improving decision making for coping with climate change at local level. China is willing to carry out practicable cooperation in order to further enhance its capability in coping with climate change.

3.1 Preparation of the National Greenhouse Gas Inventory

Preparation of the national GHG inventory is not only a basic requirement for the UNFCCC Parties, but also a fundamental work for addressing climate change. The Chinese government attaches great significance to preparation of the national GHG inventory by organizing research and preparation teams with wide participations of relevant governmental departments and research institutions. However, due to variety and complexity of GHG sources and sinks, regional and sectoral emissions differ immensely. To reduce uncertainties in the inventory, there is a higher demand for capacity building in personnel training, methodology development and data acquisition. According to the continuously revised IPCC guidelines for preparation of national GHG inventories, as preparation of the National Communication proceeds in-depth, international cooperation is required in training for qualified personnel, methodology development and data sharing, to further improve technical level and skills of the Chinese personnel who have been engaged in preparation of the GHG inventory.

3.2 Establishment and Improvement of GHG Statistical Accounting System

Establishment and improvement of China's statistical accounting system for GHG emissions help improve authoritativeness of its national GHG inventory and data transparency, facilitate, formalization, standardization and normalization in preparing the national GHG inventory. As the current statistic indicator system is still found inadequate in meeting the statistical data requirements for the inventory preparation, and its data statistic scope differ to certain extent from the statistic methods, therefore it is necessary to set up statistical indicators and methodologies for China's GHG emissions, to improve statistical data underlying the national GHG inventory, to measure and monitor specific emission factors (e.g. coal combustion), and to enhance training of personnel from relevant statistical institutions and enterprises, according to data demands in preparation of the national GHG inventory, based on China's existing statistical system, and through international cooperation and exchanges.

3.3 Enhancing Capacity for Climate Change Adaptation

In order to effectively cope with climate change, to ensure smooth economic and social developments, and to protect people's life and property, China must enhance its capacity in adaptation to climate change. Currently, China is relatively weaker in enhancing its scientific research on climate change, climate observation and impact assessments, its capacity building in climate change adaptation, especially in dealing with extreme weather and climate events including their monitoring, early warning and preparedness, and its capabilities to prevent and mitigate natural disasters. Therefore, international cooperation and exchanges are required for China to develop climate change adaptation projects, to launch case studies on extreme climate events, to improve its climate observation system, and to enhance monitoring, early warning and prediction of various extreme weather and climate events, and data sharing.

3.4 Improving local Decision-making Capabilities in Addressing Climate Change

Addressing climate change is a systematic engineering task, involving all aspects of economy, politics, culture and society, and it requires enhanced leadership, improved planning, good coordination, implementation measures, and enhanced capabilities to organize and accomplish the work in dealing with to climate change. Although provincial leading groups on climate change, working bodies and local expert teams for addressing climate change have already been set up at request of the central government, overall, local government officials still lack of awareness in response to climate change without sufficient working capabilities in this aspect. It is imperative for local governments to enhance their capabilities in preparation of local GHG inventories, technological R&D for addressing climate change, and development of CDM projects among others. It is urgent to enhance education and training on climate change for local management teams. At the same time, capacity building for teams in support of local decision making on climate change should also be intensified through extensive international cooperation and exchanges, to effectively enhance local capabilities in addressing with climate change.

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

Hong Kong is a special administrative region of the People's Republic of China, which is characterized by its mild climate, limited natural resources, high population density, highly developed service sector and dynamic activities. It is also an eminent international financial, trading and shipping hub.

Chapter 1 Regional Circumstances

1.1 Natural Conditions and Resources

The Hong Kong Special Administrative Region (hereinafter "HKSAR") is in the southern part of China, neighbouring *Shenzhen* City of *Guangdong* Province to its north and surrounded by sea on the other three sides. It has a land area of 1,104 square kilometers, comprising *Hong Kong Island*, *Kowloon*, the *New Territories* and *Outlying Islands*. It is hilly with only 263 square kilometers developed for living and economic activities. More than 500 square kilometers of the remaining area have been designated as "protected areas", including countryside parks, special areas and conservation areas.

Hong Kong is located within the sub-tropical region with mild climate. The annual mean temperature is 23.1°C, with the average highest being 25.6°C and the average lowest 21.1°C. The average yearly rainfall is about 2,380 mm. Extreme weather conditions that occur in Hong Kong include tropical cyclones, strong monsoons, monsoon troughs and strong convective weather. The vegetation of Hong Kong is mainly characterized by sub-tropical evergreen broadleaf forest. Its marine waters are suitable for both tropical and temperate flora and fauna with a rich assemblage of fish and crustaceans. However, fresh water resource is relatively scarce and it is mainly replenished by *Dongjiang River* in *Guangdong* Province.

1.2 Population and Society

The population of Hong Kong was around 6.84 million in 2005 and 7.03 million in 2009. The average annual rate of increase is 0.7%. The labour force was around 3.53 million in 2005 with 55.2% being male and 44.8% female. In 2005, there were some 370,000 primary students and 410,000 secondary students studying in public and subsidised schools. Public expenditure on education amounted to HK$54.3 billion in the 2005-06 financial year, which accounted for 21.6% of the total public expenditure.

1.3 Economic Development

Hong Kong is a highly urbanized economy. The Gross Domestic Product (GDP) of Hong

Kong in 2005 was approximately HK$1.43 trillion (in chained 2009 dollars), or aboutHK$210,000 per capita. Hong Kong's economy is predominately tertiary industry based, and its share in GDP increased from 87% in 2000 to 93% in 2009. In 2009, the total value of merchandise trade was HK$5.16 trillion, of which import was HK$2.69 trillion and re-export was HK$2.41 trillion. The primary industry accounts for a relatively small percentage of Hong Kong's GDP and employs a very small percentage of the total workforce. Figure 7.1 shows the long-term change of local GDP since 1980.

Hong Kong is also an international financial centre. As of the end of 2005, there were 1,135 companies listed in the Hong Kong Stock Exchange with a total market value of HK$8.18 trillion. Hong Kong is also a hub for global trading, shipping, finance and telecommunication. Its volume of passenger traffic and cargo throughput are among the highest in the world. The values of inward and outward direct investment of Hong Kong are massive, which was HK$4.1 trillion and HK$3.7 trillion respectively at the end of 2005. They were 2.93 and 2.64 times of Hong Kong's GDP respectively.

On the whole, Hong Kong does not have primary energy production. In 2005, the local primary energy demand was about 20.06 Mtce, which mainly relied on imports. The demand for coal products and oil and gas products were 9.86 and 9.45 Mtce respectively. Local thermal power is the main electricity supply in Hong Kong and nuclear power from Guangdong Province is a main supplement. In 2005, coal, natural gas, and nuclear power accounted for 55%, 23% and 22% of Hong Kong's electricity supply respectively.

Hong Kong has a diversified and highly efficient public transport system which on average carried 11.17 million passenger trips daily in 2005. This represented 90% of the total passengers, amongst which, 4.05 million passenger trips were served by rail transport. In 2005, there were 600,000 registered vehicles in Hong Kong, around 390,000 being private cars and their average mileage totalled 30.66 million kilometers daily.

Tourism is one of the pillar industries in Hong Kong. In 2005, a total of 23.36 million visitors came to Hong Kong, among which 12.54 million were from the Mainland.

The agriculture and fishing sector in Hong Kong is relatively small. In 2005, its added value was HK$0.9 billion and the sector employed about 8,700 people. Fresh fish is one of the most important primary products in Hong Kong. In 2005, fish captured and cultured were around 166,000 tons, totaling HK$1.7 billion.

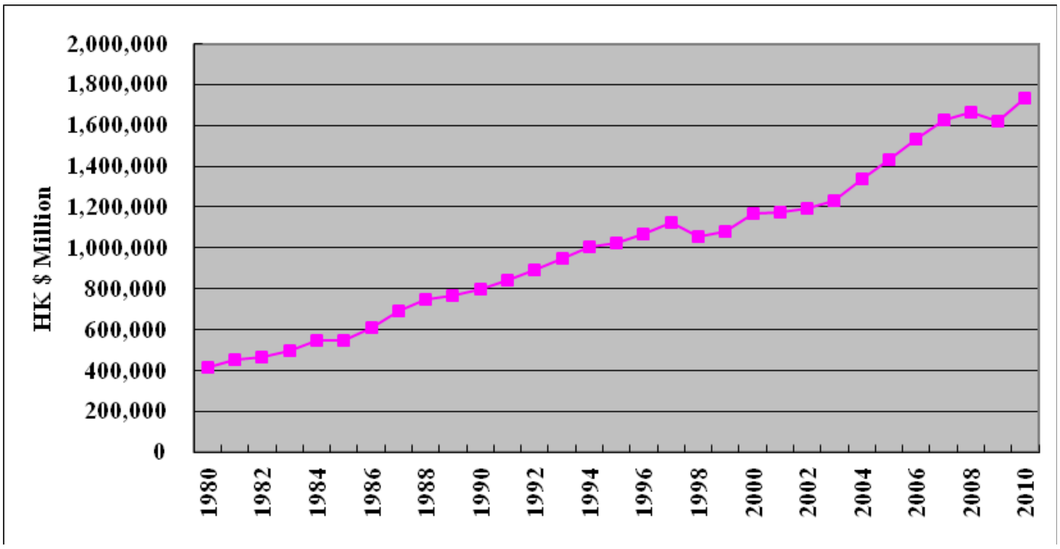


Figure 7.1 GDP in chained 2009 dollars of HKSAR in 1980-2010

1.4 Institutional Arrangements for the Preparation of Climate Change Information of Second National Communication

Hong Kong is committed to combating climate change. In 2000, the HKSAR Government started compiling its greenhouse gas (GHG) inventory whereby the Environmental Protection Department collected necessary information, data and research results from related departments / agencies. An Inter-departmental Working Group on Climate Change was set up in 2007, which was led by Environment Bureau with member representatives from five policy bureaux and 17 departments.

For the purpose of collating necessary information on Hong Kong for contributing to Second National Communication, the HKSAR Government commissioned a consultancy study in 2008 to assess the impact of climate change on Hong Kong, review and update the GHG inventories, as well as to make recommendations on appropriate climate change mitigation and adaptation strategies and measures. In 2011, Hong Kong submitted the basic information on combating climate change to the Central Government.

Table 7-1 Summary of HKSAR's Circumstances in 2005

Criteria	2005
Population（million, year-end）	6.838
Land area (square kilometer)	1,104
GDP（US$ billion, at current market prices）	177.779
Per capita GDP（US$, at current market prices）	26,093
Estimated share of the informal sector in the economy in GDP	statistics not available
Percentage share of industry in GDP[1]	8.8
Percentage share of services in GDP	91.2
Percentage share of agriculture and fishing in GDP	0.1
Land area for agriculture purposes[2] (square kilometer)	55
Urban population as percentage of total population	not applicable[3]
Number of livestocks	
Cattle	1,268
Horse	1,702
Pig	216,640
Sheep	130
Forest area (square kilometer)	257
Population in absolute poverty	statistics not available
Life expectancy at birth (year)	male: 78.8；female: 84.6
Literacy rate（percentage）	statistics not available

Note: [1]Industry includes mining and quarrying, manufacturing, electricity, gas and water supply, waste management and construction；

[2] Arable land；

[3] Not applicable as HKSAR is on the whole a municipality.

Chapter 2 Hong Kong's Greenhouse Gas Inventory in 2005

In the process of compiling the Hong Kong GHG inventory, references had been made to the *Revised 1996 IPCC Guidelines*, the *IPCC Good Practice Guidance* and *2006 IPCC Guidelines*. The reporting year was 2005, and it covered emission of six GHGs from 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.

2.1 The 2005 GHG Inventory

In 2005, Hong Kong's GHG emissions amounted to 41.565 Mt CO_2 eq. After deducting the carbon sink of 0.412 Mt CO_2 eq from land-use change and forestry, Hong Kong's net GHG emissions in 2005 stood at 41.153 Mt CO_2 eq. Amongst which carbon dioxide accounted for 38.12 Mt, or 91.7%; methane 2.178 Mt CO_2 eq, or 5.2%; nitrous oxide 0.399 Mt CO_2 eq, or 1.0% (Table 7-2); hydrofluorocarbons 0.743 Mt CO_2 eq, or 1.8%; perfluorocarbons 2,000 t CO_2 eq, or less than 0.1%; and sulfur hexafluoride about 0.123 Mt CO_2 eq, or 0.3% of the total (Table 7-3).

Table 7-2 2005 GHG Inventory of Hong Kong

Unit: Kt CO_2 eq

GHG source and sink categories	Carbon dioxide	Methane	Nitrous oxide	Fluorine containing gases	Total
Total emission	38,120	2,178	399	868	41,565
Net emission	37,708	2,178	399	868	41,153
1. All Energy	38,093	89	214		38,396
Fuel combustion	38,093	9	214		38,316
Energy and transformation industries	28,423	6	143		28,572
Manufacturing and construction industry	298	0	1		299
Transport	7,681	2	68		7,751
Other sectors	1,690	1	2		1,693
Fugitive emission		80			80
Oil and gas system	0	80			80
Coal mining					
2. Industrial processes	0			868	868
3. Agriculture	1	31	42		74
Animal enteric fermentation		6			6
Management of animal waste		24	12		36
Rice cultivation					
Agricultural land			30		30
Limited savanna burning of savannahs	1	0	0		1
4. Land-use change and forestry	-412				—412
Change in forest and other woody biomass stock changes	-412				—412
Forest conservation					
Soil carbon					
5. Disposal of waste	26	2,058	143		2,227
Solid waste treatment		1,980			1,980
Wastewater treatment		78	143		221
Incineration of waste	26				26
Memo Items	28,104	35	248		28,387
Special regional aviation	1,270	0	13		1,283
Special regional navigation	6,929	13	57		6,999
International aviation	8,930	1	88		9,019
International navigation	10,975	21	90		11,086

Note：Due to rounding, a slight discrepancy may exist between table breakdowns and the total figure.

Table 7-3 Emissions of GHG Containing Fluorine in 2005

Unit: Kt CO_2 eq

GHG source and sink categories	HFCs				PFCs				SF_6
	HFC-134a	HFC-404a	HFC-407c	HFC-227ea	$C_8F_{16}O$	$C_{12}F_{27}N$	$C_{15}F_{33}N$	$C_9F_{21}N$	
2. Industrial processes	679	13	15	36	0	0	0	2	123
Halocarbons and sulfur hexafluoride consumption	679	13	15	36	0	0	0	2	123

Energy activity is the primary source of GHG emissions in Hong Kong. In 2005, energy accounted for 92.4% of Hong Kong's GHG emissions while disposal of waste, industrial processes and agriculture accounted for 5.4%, 2.1% and 0.1% of the total emissions respectively Figure 7.2.

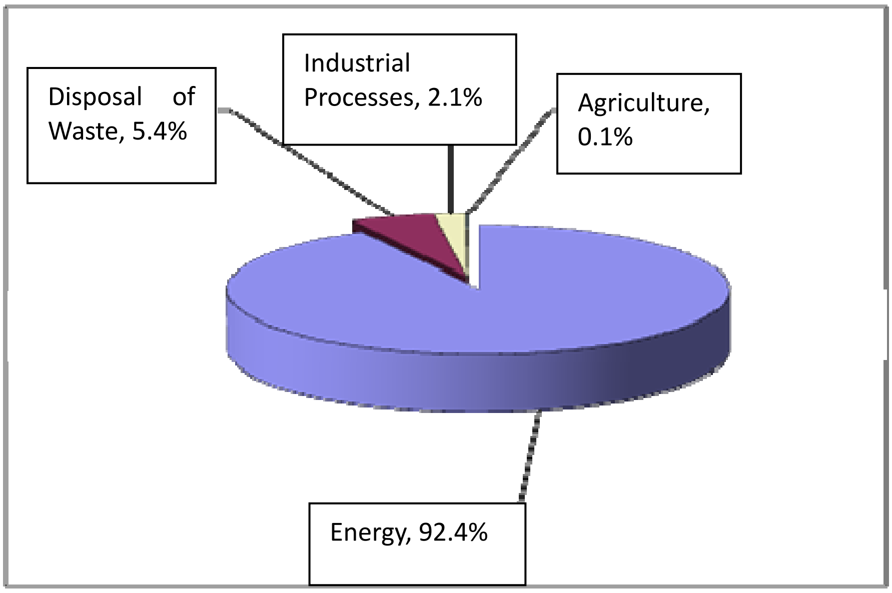


Figure 7.2 2005 Hong Kong GHG Inventory by Sources

In 2005, the GHG emissions from special regional and international bunker fuel of HKSAR amounted to 28.387 Mt CO_2 eq, which were deemed as memo items and not counted in the total emissions. The amount mentioned above included 8.282 Mt CO_2 eq from special regional navigation and aviation emissions, and 20.105 Mt CO_2 eq from international navigation and aviation.

2.2 Energy

2.2.1 Scope of Inventory Reporting

GHG emissions from energy activities mainly include emissions of carbon dioxide, methane and nitrous oxide from fossil fuel burning in energy industry, manufacturing industry, commerce, domestic households, and transportation sector; fugitive methane emissions of oil and gas systems; and methane and nitrous oxide emissions in combustion of biomass fuels.

2.2.2 Inventory Compilation Methodology

Based on the specific activities and fuel data of individual power generation units in Hong Kong, Tier 3 method of the *2006 IPCC Guidelines* was adopted to calculate emissions of carbon dioxide, methane and nitrous oxide in electricity production. Since there is plant-specific fuel data for towngas production, Tier 2 method of the *2006 IPCC Guidelines* was adopted for calculating carbon dioxide emissions in towngas production while Tier 1 method was adopted to calculate methane and nitrous oxide emissions. Since all landfills in Hong Kong had specific data on landfill gas burning, Tier 2 method of the *2006 IPCC Guidelines* was adopted to calculate carbon dioxide emissions in utilizing landfill gas for energy purpose, while Tier 1 method was adopted to assess methane and nitrous oxide emissions in burning landfill gases for energy purpose. Tier 2 method of the *2006 IPCC Guidelines* was adopted to calculate carbon dioxide emissions of manufacturing and construction industries and other sectors while Tier 1 method of the *2006 IPCC Guidelines* was adopted to calculate methane and nitrous oxide emissions.

Tier 1 and 2 methods of the *2006 IPCC Guidelines* were adopted to calculate emissions of carbon dioxide, methane and nitrous oxide from local aviation and navigation, rail and non-road transport sources. Tier 1 and 2 methods of the *2006 IPCC Guidelines* were adopted to calculate emissions of carbon dioxide, methane and nitrous oxide from road transport. Special regional transport means aviation and navigation transport activities departing from Hong Kong with destinations in other parts of China; while international transport means aviation and navigation transport activities departing from Hong Kong with destinations in places other than China. Hong Kong had detailed data and related parameters of the level of its special regional and international aviation activities, Tier 3a method of the *2006 IPCC Guidelines* was adopted for calculation of emissions of carbon dioxide, methane and nitrous oxide from these activities. Hong Kong also had a complete set of fuel data of its special regional and international navigation transport activities and Tier 1 method of the *2006 IPCC Guidelines* was adopted to calculate emissions of carbon dioxide, methane and nitrous oxide from these activities.

Tier 3 method of the *2006 IPCC Guidelines* was adopted to calculate fugitive emissions of carbon dioxide and methane in fuel systems. Based on the operational data of towngas piping system, natural gas transmission system as well as towngas composition data, Tier 1 method of the *2006 IPCC Guidelines* was adopted to calculate fugitive emissions of carbon oxide and methane from gas transmission.

2.2.3 Emissions Inventory

In 2005, GHG emissions from energy activities in Hong Kong amounted to 38.396 Mt CO_2

eq, or 92.4% of Hong Kong's total emissions. Among them 38.093, 0.089 and 0.214 Mt CO_2 eq were emissions of carbon dioxide, methane and nitrous oxide respectively. Carbon dioxide emissions from energy accounted for 99.9% of the total of such emissions.

Of 2005 Hong Kong's emissions from energy activities, 28.572 Mt CO_2 eq, or 74.4% were from energy industry (electricity and towngas production); 7.751 Mt CO_2 eq, or 20.2% were from transport; 299,000 t CO_2 eq, or 0.8% were from manufacturing and construction industries; 1.693 Mt CO_2 eq, or 4.4% were from other sectors; 80,000 t CO_2 eq, or 0.2% were from fugitive emission of methane.

2.3 Industrial Processes

2.3.1 Scope of Inventory Reporting

Industrial processes mainly cover emissions of carbon dioxide from production of cement; hydrofluorocarbons and perfluorocarbons emissions from refrigerating, air-conditioning and fire fighting equipment; and sulfur hexafluoride emissions from electrical equipment.

2.3.2 Inventory Compilation Methodology

According to clinker production and related data, Tier 2 method of the *Revised 1996 IPCC Guidelines* was adopted in estimating carbon dioxide emissions from cement production. At the same time, related parameters of the *2006 IPCC Guidelines* were also referenced. Tier 2(b) method of the *2006 IPCC Guidelines* was adopted to calculate 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 calculate hydrofluorocarbons emissions from air conditioning of motor vehicles, goods vehicles, industrial/commercial buildings, and refrigeration for domestic and commercial uses. Tier 1 method of the *2006 IPCC Guidelines* was adopted to calculate perfluorocarbons emissions from solvents. Tier 1(a) method of the *2006 IPCC Guidelines* was adopted to calculate emissions of hydrofluorocarbons and perfluorocarbons from firefighting equipment. Tier 3 method of the *2006 IPCC Guidelines* was adopted to calculate emissions of sulfur hexafluoride used in electrical equipment.

2.3.3 Emissions Inventory

In 2005, 868,000 t CO_2 eq of GHG were released from industrial processes in Hong Kong, which accounted for 2.1% of the total emissions. Since clinker for cement production was mainly imported to Hong Kong in 2005, there were no emissions from cement production in that year. There were 743,000 t, 2,000 t and 123,000 t CO_2 eq of hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride emissions respectively from refrigeration, air-conditioning, fire fighting and electrical equipment in Hong Kong in 2005.

2.4 Agriculture

2.4.1 Scope of Inventory Reporting

Emissions from agriculture mainly include: methane and nitrous oxide emissions from livestock enteric fermentation and manure management; nitrous oxide emissions from agricultural soils and emissions of carbon dioxide, methane and nitrous oxide from savanna burning.

2.4.2 Inventory Compilation Methodology

Emissions from Hong Kong's livestock are consistent with the source categories of the *Revised 1996 IPCC Guidelines*, i.e. they are from seven major livestock (dairy cattle, non-dairy cattle, buffalo, sheep, horse, swine and poultry). Tier 1 method of the 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 the *2006 IPCC Guidelines* was adopted to calculate the direct and indirect nitrous oxide emissions from managed soil, as well as the emissions of carbon dioxide, methane and nitrous oxide from savanna and grassland burning.

2.4.3 Emissions Inventory

In 2005, Hong Kong emitted approximately 74,000 t CO_2 eq from agriculture, or 0.1 % of its total emissions. Methane and nitrous oxide emissions from livestock enteric fermentation and manure management amounted to 42,000 t CO_2 eq while the nitrous oxide emissions from agricultural soil were approximately 30,000 t CO_2 eq.

2.5 Land-use Change and Forestry

2.5.1 Scope of Inventory Reporting

The reporting under land-use change and forestry mainly covers: changes in biomass carbon stock caused by conversion of forestland, cropland and grassland.

2.5.2 Inventory Compilation Methodology

Taking account of the characteristics of Hong Kong's land-use change and forestry activities, Tier 1 method of the *2006 IPCC Guidelines* was adopted and reference was made to relevant emission factors in estimating carbon dioxide emissions/removals in relation to changes in biomass carbon stock caused by conversion of forestland, cropland and grassland and in calculating nitrous oxide emissions from managed soils. By using information about the areas of forestland, shrub, grassland and cropland in Hong Kong, Tier 1 method of the *2006 IPCC Guidelines* was adopted to calculate the emissions and removals of carbon dioxide caused by changes in biomass stock of forestland and other woody biomass.

2.5.3 Emissions Inventory

In 2005, as carbon sinks, land-use change and forestry activities had a net removal of carbon dioxide totaling approximately 412,000 tons, all being carbon absorbed through conversion of forestland and grassland that lead to carbon stock increase in forestry and other woody biomass.

2.6 Disposal of Waste

2.6.1 Scope of Inventory Reporting

The reporting under disposal of waste mainly includes: methane emissions from solid waste landfilling; nitrous oxide emissions from treatment of domestic sewage and industrial wastewater; and carbon dioxide emissions from waste incineration.

2.6.2 Inventory Compilation Methodology

In Hong Kong, we have relatively complete historical and statistical data on waste disposal at both closed and operating landfills. In view of this, we adopted Tier 2 method of the *2006 IPCC Guidelines* to estimate methane emissions from landfilling of solid waste. Hong Kong also has specific data on its large-scale sewerage treatment plants, so Tier 1 method of the *2006 IPCC Guidelines* was adopted to calculate the emissions of methane and nitrous oxide from wastewater treatment. As Hong Kong has relatively detailed statistical data on incineration of solid waste and treatment of chemical waste, and considering that there was only liquid fossil waste for chemical waste treatment in 2005, Tier 1 method of the *2006 IPCC Guidelines* was adopted to estimate the emissions of carbon dioxide from chemical waste treatment.

2.6.3 Emissions Inventory

In 2005, Hong Kong emitted 2.227 Mt CO_2 eq from waste treatment, which accounted for 5.4% of its total emissions. Most of such emissions were methane which amounted to 2.058 Mt CO_2 eq, or 94.5% of the total emissions of methane in Hong Kong.

2.7 Uncertainty Analysis

2.7.1 Efforts to Minimize Uncertainties

To reduce the uncertainty level of our reporting, a three-pronged approach was adopted in assessing the emission levels. Firstly, official statistics, local measured emission factors and parameters, as well as the latest parameters and emission factors of the *2006 IPCC Guidelines* were adopted with a view to improving the data collection process. Secondly, based on data availability, higher-tiered methods were used where appropriate to assess and compile the emissions inventory. Thirdly and finally, professional consultants were appointed to conduct independent reviews and certification of the inventory compilation process with a view to achieving stringent quality control. At the same time, key emission sources analysis was conducted to ensure data quality.

2.7.2 Uncertainties that Exist in the Inventory and Key Source Categories

According to the propagation of error analysis in the *2006 IPCC Guidelines* and expert judgment, the uncertainty of 2005 Hong Kong's GHG inventory is around 4% to 5%. The limitation of the statistics on the type and quantity of coal consumption at power plants is the major reason for the uncertainty. As regards key source categories in Hong Kong, as ascertained by the inventory, they include: carbon dioxide emissions from energy industries, carbon dioxide emissions from transport sector, carbon dioxide emissions from other energies and methane emissions from solid waste treatment.

2.8 Major Factors Affecting Future Emissions

Major factors that will affect Hong Kong's future GHG emissions include: population size, economic development and structural changes, as well as lifestyle changes. It is anticipated that the total GHG emissions in future will remain stable with gradual reduction in the longer run.

2.8.1 Population Growth

In 2009, Hong Kong's population was around 7.03 million and it is projected to increase to 7.73 million by 2020, i.e. a 10% increase is expected when compared to 2009. In 2039, the population will be around 8.89 million, or an increase of 26% when compared to 2009. This will exert substantial pressure on local efforts in controlling GHG emissions.

2.8.2 Economic Development and Structural Changes

During the past 20 years, Hong Kong's economic growth rate has been higher than the global average, and it is expected that the local economy will continue to grow. Continuous economic growth will lead to corresponding increase in the demand on energy and transportation. On the other hand, with the steady growth of output value and proportion of the local tertiary industry, GHG emissions per unit of GDP in Hong Kong is expected to be reduced continuously.

2.8.3 Lifestyle and Consumption Patterns Changes and Technological Advancement

With vigorous promotion efforts initiated by the HKSAR Government, enterprises and the public in general are pitching in to combat climate change. There have been gradual changes in production, lifestyle and consumption patterns, continued development of clean energy, and progress has been made in low-carbon energy-saving technologies. Hong Kong recognises emerging new, green and low-carbon opportunities, and development of a green and low-carbon economy will help reduce its GHG emissions.

Chapter 3 Impacts of Climate Change and Adaptation

In 2010, the HKSAR Government completed its first assessment on vulnerability and adaptation to the impacts of climate change. According to past observations and assessment results, there is an increasing trend for warmer climate in Hong Kong which has resulted in rise in sea level and more frequent occurrence of extreme weather events. There are some uncertainties in part of the assessment since this was a novel exercise to Hong Kong, and further improvement to the data and statistics as well as capacity building in conducting vulnerability assessment is needed.

3.1 Assessment Methodology

We made reference to the UNFCCC guidelines for assessing vulnerability and adaptation, and adopted a risk management approach when conducting our first assessment study on vulnerability and adaptation to impacts of climate change. Based on simulation of climatic scenarios for the 21st century as conducted by the Hong Kong Observatory, our assessment study analyzed climate change impacts to different systems, sensitivity of the systems to the impacts, potential consequences and their adaptive capacities, as well as identified Hong Kong's key vulnerable sectors or areas. For those sectors or areas which did not have sufficient data for detail analysis, expert judgments were exercised to determine the risk areas and assess the associated vulnerability and adaptation capacity.

3.2 Climate Change Analysis and Projections

3.2.1 Climate Characteristics

In general, the trend of climate change in Hong Kong is basically consistent with the overall global trend. Hong Kong Observatory started systematic observation of meteorological parameters in the 1880s (Figure 7.3). The temperature trend indicates that the annual mean temperature increased at an average rate of 0.12 degree Celsius per decade from 1885 to 2009; 0.16 degree Celsius per decade from 1947 to 2009; and 0.28 degree Celsius per decade from 1980 to 2009.

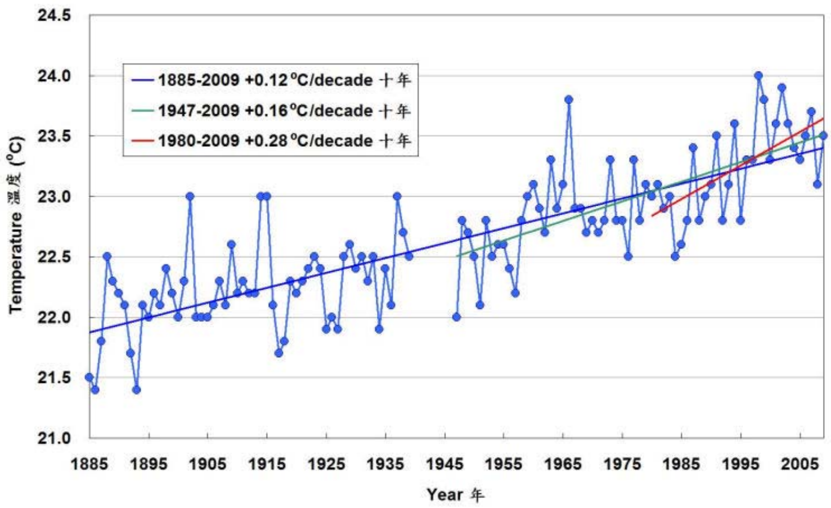


Figure 7.3 Annual mean temperature at the Hong Kong Observatory Headquarters（1885-2009）

There was noticeable rise in sea level at Hong Kong's Victoria Harbour, and the mean sea level rose at an average rate of 2.6 mm per year from 1954 to 2009. As regards extreme weather events in Hong Kong, the annual number of heavy rain days (with hourly rainfall over 30 mm) increased by 0.43 days per decade from 1947 to 2009 while the annual number of thunderstorm days increased by 1.8 days per decade in the same period.

3.2.2 The Future Trend of Climate change

The Hong Kong Observatory projected Hong Kong's future temperature and rainfall trends by downscaling the simulation results of the IPCC global climate models under different emission scenarios, taking into account the past temperature and rainfall records of Hong Kong and neighbouring areas. The projection had taken into consideration the influence of the urban heat island effect. The conclusions of the projections are as follows: (1) Hong Kong's annual mean temperature in the period 2090 - 2099 will be four to five degrees Celsius higher than that in the period 1980 - 1999 which is 23.1 degrees Celsius; (2) There will be an increase in the number of hot nights (with daily minimum temperature equals to or above 28 degrees Celsius) and very hot days (with daily maximum temperature equals to or above 33 degrees Celsius) in summer, and a continual decrease in the number of cold days (with daily minimum temperature equals to or below 12 degrees Celsius) in winter; (3) The average annual rainfall in Hong Kong will rise to 2,572 mm in the late 21st century (2090-2099), 248 mm (or 11%) higher than 2,324 mm, the average yearly rainfall in 1980 - 1999. Moreover, year-to-year variability in annual rainfall will increase. The number of extremely wet years (with annual rainfall over 3,187 mm) will increase substantially from three in the period 1885 - 2008 to ten in the 21st century while the number of extremely dry years (with annual rainfall below 1,282 mm) will increase from two to four at the same time, and there will be a marked increase in the number of heavy rainy days; (4) There will be a rise in mean sea level in the South China Sea (including Hong Kong waters), which is consistent with the global projected trend at the end of the 21st century. The rise in sea level will also bring about the rise in extremely high water levels.

3.3 Major Vulnerable Sectors

Major areas or sectors in Hong Kong which are more vulnerable to climate change impacts are: biodiversity and nature conservation, built environment and infrastructure, business and industry, energy supply, financial services, food resources and food safety, human health, and water resources.

3.3.1 Biodiversity and Nature Conservation

The hilly landscape and the warm and humid sub-tropical climate of Hong Kong provide a suitable habitat for numerous species of animal and plant. At present, there are over 3,100 species of vascular plants (around 2,100 species are native species), about 56 species of mammals, over 500 species of birds, about 80 species of reptiles and over 20 species of amphibians. There is also a great variety of insect species, with 235 species of butterflies and 115 species of dragonflies. The rise in temperature and sea level brought about by climate change and the increase in the frequency and strength of extreme weather events will have significant impacts on the survival, reproduction and migration of the species. If the climatic condition changes too fast, certain species might become extinct and invasive species might be able to reproduce rapidly. This might result in an imbalance of the ecosystem. Mangroves and coral reefs are most likely to be affected.

3.3.2 Built Environment and Infrastructure

Hong Kong residents mainly use the coastal area, reclaimed land and flat land for living and economic activities. The rise of sea level, increased rainfall and extreme weather events will pose great threat to the built environment and infrastructure like roads, drainage systems, traffic and transport systems and communication systems. According to the projection in the IPCC Fourth Assessment Report, global sea level is expected to rise 59 cm in the 21st century. Together with storm surge caused by tropical cyclones, the initial projection indicates that about 7% of commercial and residential areas in Hong Kong and 26% of resident population would under the threat of flooding in the end of the 21st century. Apart from the above, rainstorms and extreme weather will lead to softening of building foundations, infiltration of rainwater, damages to utility facilities, landslides and debris flows, and interruption of the traffic and public transport services

3.3.3 Business and Industry

Impacts on Hong Kong's business and industrial sectors due to climate change are very obvious as these sectors rely much on international goods and service trades, with trading and logistics account for about 25% of Hong Kong's GDP. The vulnerability of food resources, water resources, and transport and infrastructure sectors due to climate change will also lead to increased risks and therefore increase vulnerability in the business and industrial sectors.

3.3.4 Energy Supply

Since Hong Kong's energy resources are mainly imported, its energy supply chain is obviously subject to impacts due to climate change. As an international metropolitan, Hong Kong relies heavily on stable and secure energy supply and any disruption in energy supply would have serious impact on Hong Kong's economy and society. The vulnerability of Hong Kong's energy supply is increased as the energy supply chain might possibly be affected by climate change. Moreover, climate change will result in drastic increase in demand for electricity due to more use of air-conditioning and refrigeration, which in turn will exert pressure on power generation and transmission systems. The increase in frequency and magnitude of impacts of extreme weather events, flooding, thunderstorms, landslides and debris flow will all have serious impact on the electricity cables and energy supply infrastructure.

3.3.5 Financial Services

Hong Kong is an international financial centre. The operation of financial services sector, especially the sector's communication and computer systems, relies on other systems and on the support of infrastructure and electricity supply. Therefore, the impacts of extreme weather events on other sectors will bring about additional risks and therefore increase in vulnerability of the financial services sector. Moreover, individual businesses and investment risks within the financial services sector will change as a result of climate change, leading to increase in uncertainty of impacts to the sector.

3.3.6 Food Resources and Food Safety

Hong Kong's food supply is mainly dependent on imports and some of the import sources are rather concentrated, e.g. rice from Thailand and Vietnam. The impact of climate change on Hong Kong and on places where the food is imported, as well as on the food supply chain might result in a reduced quantity of food supply to Hong Kong. This will increase the vulnerability of the food resources sector leading to rise in prices for food and the related commodities. Climate change may also increase the quantity of pest and boost the disease rate and thus affect the supply of fresh poultries and livestock. This will lead to reduced import quantity and therefore bring about a rise in price.

3.3.7 Human Health

Climate change may bring about changes in pattern of diseases in Hong Kong and modes of transmission of infectious diseases. Rise in temperature will directly cause heat stress, asthma exacerbation, and heat stroke to be more common. Climate change will increase the frequency and severity of extreme and bad weather events, which will result in increased occurrences of accidents and emergency situations; thus increasing the burden on the health care system. It is anticipated that climate change will also lead to deterioration of chronic health problems, such as cardiovascular and respiratory conditions. The vulnerability of certain social groups will also be increased as climate change will bring about different degrees of impact on the hygiene and health of people from different social groups.

3.3.8 Water Resources

Hong Kong has inadequate fresh water resources. Apart from local yield collected from reservoirs, Hong Kong mainly relies on the water supply from Dong River in Guangdong. The sustainability of future water supply to Hong Kong will be affected by change in future rainfall quantity and patterns in Hong Kong and its neighbouring areas, development of the whole region and increase in demand for drinking water due to temperature rise. Rise in sea level due to climate change may cause salinification of fresh water layers in Hong Kong and in the region resulting in reduced quantity of the possible supply of underground water. Moreover, fresh water volume will be reduced as a result of increased consumer demand for water due to climate change and increase in water evaporation rate due to rise in temperature.

3.4 Existing Climate Change Adaptation Measures

HKSAR Government has put in notable efforts in capacity building on adaptation to climate change, and developing infrastructural facilities and institutional arrangements for combating possible impacts of climate change. In recent years, extreme weather events happened occasionally, and the established infrastructural facilities and institutional arrangements were proved to be effective, which had helped mitigate the adverse effects of climate change.

Relevant measures and mechanisms include: adopting comprehensive emergency response plans led by the Security Bureau for responding to emergencies due to extreme weather events and natural disasters; taking into account of the rise in mean sea level at a rate of 10 mm per year by all works departments since 1990 when designing public works projects; drawing up monitoring and contingency mechanisms by concerned government departments and service providers for disastrous weathers, like landslides, debris flows and flooding so as to reduce the damage to buildings, banks, communications, public transport, energy and food supplies; providing emergency rescue services to the public so affected; establishing forecasting and warning systems to monitor closely changes in ecological system and water resources.

3.5 Future Climate Change Adaptation Measures

In order to strengthen its adaptive capacity to climate change, HKSAR Government will further step up research and investigation, capacity building and institutional arrangements for disasters management, as well as publicity and public education work.

(a) On research and investigation, HKSAR Government will conduct in-depth study of vulnerable sectors and trades so as to prioritise various improvement measures, enhance statistical data, assess potential risks, and improve the monitoring and verification systems.

(b) On capacity building and institutional arrangements, HKSAR Government will enhance and improve the existing institutional set up in order to enhance the adaptive capacity to climate change and to formulate various contingent and response measures for possible adverse impacts on the major vulnerable sectors.

(c) On publicity and public education, HKSAR Government will widely publicize the knowledge of combating climate change including the possible impacts on various trades and sectors so as to enhance the public awareness of climate change problem. It will also provide assistance to the vulnerable groups and communities for them to be better prepared for possible disasters.

Chapter 4 Policies and Measures Related to Climate Change Mitigation

Being an international city, Hong Kong has all along attached much importance to the issue of climate change. To echo with national actions, Hong Kong has proactively contributed in reducing greenhouse gas emissions by introducing various policies and measures including adjusting fuel mix for power generation, enhancing energy efficiency, developing low-carbon transport systems, and promoting green low-carbon communities and tree-planting.

4.1 Policies and Objectives

Since the 1990s, Hong Kong has proactively implemented a series of practical measures to mitigate GHG emissions and contributed to national and international efforts in combating climate change. In 2007, HKSAR Government announced an energy intensity target aiming at reducing the local energy intensity by at least 25% in 2030 as compared with 2005 level. In 2008, it further emphasized the enhancement of energy efficiency and development of a low-carbon economy. In 2010, it conducted a public consultation on Hong Kong's climate change strategy and action agenda, which among other things put forward a voluntary carbon intensity reduction target of 50-60 % by 2020 when compared with 2005 level, and set out a series of measures to mitigate GHG emissions.

4.2 Energy Industry

Electricity generation is Hong Kong's major source of carbon dioxide emissions. Mitigation policies and actions taken in this connection include: (1) Banning the construction of new coal-fired generating unit and improving the fuel mix for power generation. In 1994, the construction of the Daya Bay Nuclear Power Plant in the Guangdong Province was completed with an installed capacity of 2,000 MW. About 70% of the power generated is delivered to Hong Kong which accounted for about 23% of Hong Kong's electricity consumption. (2) Active development of renewable energy for power generation. There is limited potential to develop renewable energy in Hong Kong under the existing technological level due to constraints from geographical and climatic conditions. Despite the limitations, great efforts have been made by electricity companies in developing renewable energy. In 2006, the first commercial-scale wind turbine was completed with an installed capacity of 800 kilowatt and an annual electricity generation of 1 million kWh. In 2010, Hong Kong's largest solar photovoltaic system was completed with an installed capacity of 550 kilowatt. (3) Strengthening the GHG management of electricity companies. In 2008, the HKSAR Government signed the new Scheme of Control Agreements with the two electricity companies with new conditions imposed for reducing GHG emissions, such as incentivizing the development of renewable energy.

Mitigation policies and actions by other sectors of energy industry include: introducing natural gas to replace oil as the raw material for part of the towngas production since 2006 and the proportion of natural gas as raw material for towngas production was raised substantially to about 60% in 2009; encouraging enterprises to use biodiesel produced from food waste and other biological materials in their facilities and as motor fuel.

4.3 Buildings

Electricity consumption of buildings accounts for about 89% of Hong Kong's total electricity consumption. Major mitigation policies and actions include：

Enhancing energy efficiency of buildings. The Building (Energy Efficiency) Regulation, which came into effect in July 1995, imposes energy efficiency requirements for buildings. It aims at reducing heat transfer through building envelopes thus saving the electricity consumption for air-conditioning by requiring the external walls and roofs of commercial or hotel buildings to be designed and constructed to have a suitable Overall Thermal Transfer Value (OTTV). The suitable level of OTTV and the methodology of OTTV calculations are specified in the Code of Practice for Overall Thermal Transfer Value in Buildings 1995 published by the Buildings Department. In 1998, the HKSAR Government promulgated a set of Building Energy Codes for voluntary compliance which would become mandatory in 2010. Since 2005, all new government buildings and all retrofitting works of existing government buildings are required to meet the requirements under the Building Energy Codes. In April 2009, the HKSAR Government rolled out the Buildings Energy Efficiency Funding Schemes. Through the schemes, private property owners were incentivized to conduct energy-cum-carbon audits and carry out energy efficiency projects for their buildings. Moreover, in January 2011, the HKSAR Government promulgated a set of sustainable building design guidelines on building separation and site coverage of greenery. The guidelines also advocate registration of buildings in accordance with the latest version of the Hong Kong Building Environmental Assessment Method. From 2002 to 2007, the electricity consumption of government buildings and facilities had been reduced by around 6%.

Promoting carbon audit for buildings. In July 2008, the HKSAR Government published a set of "Guidelines to Account for and Report on Greenhouse Gas Emissions and Removals for Buildings (Commercial, Residential or Institutional Purpose) in Hong Kong", which provided guidance on a systematic and scientific approach to report on the GHG emissions of buildings, facilitating voluntary reduction and offsetting of GHG emissions.

Enhancing the energy efficiency of electrical appliances. Introduced a voluntary Energy Efficiency Labelling Scheme which covers 12 types of appliances, 7 types of office equipment, and one type of petrol private vehicle. This Scheme facilitates the selection and use of more energy efficient products by general public. The HKSAR Government had enacted the mandatory implementation of the Energy Efficiency Labelling Scheme in 2008 to cover air-conditioners, refrigerating appliances, compact fluorescent lamps, washing machines and dehumidifiers.

Other energy-saving low-carbon measures include: continue to introduce energy efficiency demonstration projects for demonstrating application of advanced energy saving designs and technologies; carrying out energy audit and carbon audit in government premises and facilities and maintaining office air-conditioning temperature at 25.5 degree Celsius in summer. From 2008 to 2012, the HKSAR Government has replaced conventional traffic lights with LED traffic lights by phases. LED lighting systems are also installed in new public housing estates as well as public facilities. Energy efficient glass panes and mixed ventilation systems are also installed in shopping arcades.

4.4 Transport

In Hong Kong, apart from further improving our public transport systems and strengthening our infrastructural facilities, the HKSAR Government has embarked on further policies and measures including promoting the use of electric vehicles and granting tax concessions for environmental-friendly vehicles so as to provide a more environmental-friendly transport system. Mitigation policies and actions for the transport sector include:

Promoting the use of electric vehicles. In April 2009, the HKSAR Government set up a Steering Committee on the Promotion of the Use of Electric Vehicles to implement initiatives and work plans to promote the use of electric vehicles in Hong Kong. Over 440 charging stations for electric vehicles have been set up over the territory. The HKSAR Government has also taken the lead in using electric vehicles, hybrid vehicles and other environmental-friendly vehicles. In March 2011, the HKSAR Government further set up a HK$300 million Pilot Green Transport

Fund to encourage the transport sector to use more environmental-friendly vehicles including electric vehicles.

Rationalisation of flight routes to shorten flight journey. Since 2009, the Civil Aviation Department of the HKSAR Government has adjusted the flight routes for planes arriving from the west and north of Hong Kong, thereby shortening the arrival routes. After the adjustment, each flight can shorten its flight route by up to about 210 kilometres, or save up to about 14 minutes in flight time. Apart from saving time for travellers, the adjusted flight routes also reduce fuel consumption and the quantity of GHG emitted.

Low emission tax concessions. Since 2007, the HKSAR Government has introduced concessions in respect of the First Registration Tax for newly registered low emission, high fuel efficiency and environmental-friendly vehicles. At present, concessions for the First Registration Tax is 45% of the tax amount and the ceiling is HK$75,000. In 2007, the HKSAR Government has made the tax-free concession for biodiesel as a long-term policy and in 2010, specifications for biodiesel were set out by regulations.

4.5 Waste Management

Hong Kong encourages energy saving, waste reduction and green living style. Mitigation policies and actions in respect of waste management are as follows:

Support waste reduction. Since 2005, the HKSAR Government has promoted source-separation of waste and advocated waste reduction, recovery and recycling.

Waste to energy. All operating landfills in Hong Kong utilize landfill gas for electricity generation for use by landfill infrastructural facilities and as fuel for leachate treatment plants. Methane gas generated in the four large-scale secondary sewage treatment plants in Hong Kong is directly used for electricity generation for use by the plant facilities, and as fuel for boilers for plant heating. In 2010, 52% of municipal solid waste generated in Hong Kong were recovered.

Enhance recycling of waste. In 2008, Hong Kong commissioned a pilot plant for treatment of food waste. By around 2015, it is anticipated that the first phase of the Organic Waste Treatment Facilities would be completed for operation. The facilities would adopt biological treatment technologies to turn food waste from commercial and industrial sectors into useful resources such as compost products and biogas. The HKSAR Government is now constructing a sludge treatment plant with advanced incineration technologies, and plans to develop an Integrated Waste Management Facility with incineration as core technology to turn municipal solid waste into energy.

4.6 Tree-planting and Urban Greening

Every year, Hong Kong draws up its territory-wide greening plans and tries to increase greening as much as possible. In formulating the green master plans, greening work will be implemented in densely populated areas, such as adopting greening design for the rooftops and external walls of public housing estates and greening of footbridges. This will help reduce the heat island effect and slow down the speed of temperature rise in the city. By early 2011, Hong Kong has designated a total of 24 country parks and 22 special areas and the total area was as large as 440 square kilometres. There are around 43% of land in Hong Kong being protected by law which, in addition to help maintaining the rich biodiversity in Hong Kong, can further enhance Hong Kong's carbon dioxide removal capacity.

4.7 Achievements

The series of GHG mitigation measures implemented in Hong Kong has gained public support and active participation. Public awareness of energy efficiency and low-carbon living continues to rise which has led to slowering of the growth of energy consumption in Hong Kong in recent years. From 2005 to 2009, Hong Kong's population growth was 2.9% and the real GDP growth was 13.4%, but electricity consumption in the same period only rose by 3.6%. From 1990 to 2008, Hong Kong's carbon dioxide emissions per unit GDP dropped by around 43%.

Chapter 5 Other Relevant Information

Hong Kong has kicked off a series of activities in combating climate change, including strengthening monitoring of and research on climate systems; enhancing public education, publicity and capacity building on climate change; encouraging public engagement; enhancing public awareness; and developing co-operations and exchanges with counterparts in the country and abroad.

5.1 Monitoring and Research on Weather Systems

The Hong Kong Observatory was set up in 1883, and is a government department responsible for conducting scientific researches on climate change. Over the years, the Observatory has been carrying out monitoring and related research work on climate change. Other major services of the Observatory include weather forecast and warning, and dissemination of real-time weather information, tropical cyclone information, weather maps, and satellite imaginaries. The Hong Kong Observatory also conducts research on climate change, analyses the impacts of climate and weather on society, and forecasts annual rainfall and yearly number of tropical cyclones affecting Hong Kong. The long meteorological records held by the Hong Kong Observatory have significant bearing on forecasting possible impacts of future climate change in Hong Kong.

The Environmental Protection Department (EPD) of HKSAR Government has set up an air quality monitoring network. Since 1995, there has been regular monitoring of the concentration of different air pollutants in the atmosphere, such as sulphur dioxide, nitrogen oxides, ozone, total suspended particulates, respirable suspended particulates and carbon monoxide. The network comprises 14 air quality monitoring stations, three of which also collect data on wet fallout and dry fallout for analysis.

5.2 Education, Publicity and Public Awareness

Hong Kong has attached much importance to education and publicity work in the areas of environmental protection and climate change with a view to enhancing public awareness in these areas. The topic of climate change has been included in subjects such as general studies, geography, history and science of primary and secondary school curricula. In order to enrich knowledge on climate change among primary and secondary students, a series of reading materials have been published. Different departments of the HKSAR Government have made efforts through various channels to enhance public awareness on climate change, extreme weather, energy conservation and greening, and strive to lead a change in lifestyle and behaviour within the community.

The “Hong Kong Sustainable Technology Net” website has been set up to introduce technologies relating to renewable energy, energy efficiency and green building, in particular those that are applicable to Hong Kong so as to facilitate their wider adoption. The HKSAR Government also provides the public with information on climate change by holding technical seminars, online education programmes, school talks and publishing publicity leaflets. In 2008, the EPD rolled out a Green Hong Kong · Carbon Audit campaign and encouraged various community sectors to carry out carbon audit and carbon reduction activities in buildings.

The HKSAR Government established an Environment and Conservation Fund in 1994 to subsidize local non-profit making organisations to implement environmental and nature conservation related projects and activities. Since 2008, the Fund has widened its funding scope to small-scale projects including rooftop greening and installation of renewable energy and energy saving facilities for demonstrating climate change mitigation in non-profit making organizations and schools. This further enhanced the understanding of climate change issues in the community and among students.

5.3 Strengthening Co-operations with Other Places in China and Abroad

Strengthening co-operation with other places in China. In 2008, the HKSAR Government and the Guangdong Provincial Government signed the “Co-operation Agreement to Promote the Development of Energy Efficiency, Cleaner Production and Comprehensive Utilization of

Resources by Hong Kong and Guangdong Enterprises", which formed a useful co-operation basis for both parties in promoting energy conservation and cleaner production for Hong Kong and Guangdong enterprises. In 2010, Hong Kong and Guangdong also signed the "Hong Kong-Guangdong Co-operation Framework Agreement", under which both sides agreed to build the greater Pearl River Delta Region into a low-carbon, high-technology, and low-pollution quality living cluster of cities, to promote wider use of electric vehicles, to exchange and facilitate researches and development, production and general application of electric vehicles, and to develop businesses relevant to electric vehicle parts in the greater Pearl River Delta Region. Exchanges and co-operation were also conducted on researches in regional development strategies on clean energy and renewable energy, including the promotion of development and application of clean energy and renewable energy; support to energy saving and emission reduction at enterprises; implementation of climate change-related scientific researches; development and application of technologies; education and capacity building work.

Strengthening of international co-operation. Hong Kong joined the C40 Cities Climate Leadership Group in 2007 to promote joint efforts among large cities in the world to combat climate change and enhance energy efficiency. In 2010, Hong Kong hosted the Climate Dialogue: Low Carbon Cities for High Quality Living, C40 Workshop and Eco Expo Asia, the latter adopting "Business Solutions to Climate Change" as the theme.

5.4 Technologies and Capacity Building Needs

5.4.1 Needs for Technologies

Major needs for technologies for mitigating climate change include those on building energy efficiency, new wall materials, hybrid power and electric power vehicles (including large public vehicles), high efficiency fast recharging facilities for electric vehicles, high efficiency batteries and materials, renewable energy (in particular building-integrated photovoltaics (BIPV) system), etc.

Needs for technologies for adaptation to climate change include those for the protection of vulnerable species and habitats and ecosystems that are vulnerable to climate change; climate risk assessment tools for built environment and infrastructure developments; those for forecasting energy demand and supply changes; and those for analyzing the impacts on food supply chain, food hazards and water resources.

5.4.2 Needs for Capacity Building

Major needs for capacity building include: strengthening of existing laws and regulations, enactment of new legislations, stepping up of relevant monitoring, fostering institutional capacity in public and private sectors, bringing up-to-date disaster management and contingency plans, conducting relevant studies and investigations and enhancing the awareness and understanding of climate change issues in government and the community.

Part VIII 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 and it is also a world famous leisure centre for tourists.

Chapter 1 Regional Circumstances

1.1 Natural Conditions and Resources

1.1.1 Geographical location and land area

The Macao Special Administrative Region (hereafter referred to as Macao SAR) is situated in the west side of the estuary of the Pearl River Delta on the South China coast, bordering the *Zhuhai* City of the *Guangdong* Province in the north, overlooking the Hong Kong SAR which is located in the east side of the Pearl River's estuary, facing the South China Sea to the south, being separated by seawater from the adjacent *Wanzai*, *Xiaohengqin* and *Dahengqin* islands of the *Zhuhai* City to the west. With its three sides being engulfed by sea, Macao's land area was only 28.2 km^2 in 2005, which mainly consists of 4 components: Macao Peninsula, *Taipa* and *Coloane* islands as well as *Cotai* land area reclaimed from sea.

1.1.2 Climate

Under the subtropical maritime climate, Macao is significantly influenced by monsoon. Macao has a mild climate with an annual mean temperature of 22.4°C; January is the coldest month and the monthly mean temperature is 14.8°C; July is the warmest month and the monthly mean temperature is 28.6°C. Rainfall is plentiful in Macao and its annual average precipitation is 2,133.4 mm with significant seasonal differences. Macao's rainy season lasts from April to September, accounting for more than 85% of its total annual precipitation, during which extreme heavy-precipitation events may lead to a maximum daily rainfall above 300 mm. The extreme weather and climate events that influence Macao include tropical cyclones and associated storm surges, strong monsoons, rainstorms and thunderstorms. About 5-6 tropical cyclones impact Macao on annual average, among which 1-2 may bring high winds up to Force 8 or even beyond in Beaufort wind scale to Macao.

1.1.3 Land and water resources

Macao's land resources are extremely limited, and traditionally its land area has been increased through land reclamations from sea. In 2009, its total land area had been enlarged up to 29.5 km^2, increasing by 4.6% relative to 2005.

The local water storage facilities in Macao are insufficient and about 98% of its water supply needs to be introduced from the *Xijiang* River, a tributary of the Pearl River in *Guangdong* Province. In 2005, Macao's total water consumption was up to 55.86 million m^3, among which the household water consumption accounted for 50%, followed by the business sector accounting for 32.9% and industries accounting for 5.3%, and all rest were consumed by governmental and other facilities.

1.2 Economic and Social Development

1.2.1 Social Development

Macao is so densely populated that is quite rare in the world. In 2005, Macao's total population was 484,000, and its population density was approximately 17,000 per square kilometer. In 2009, its total population reached 542,000 showing an increasing trend. In 2005, the estimated total labour force in Macao was about 248,000, of which 238,000 were employed population. According to the *2006 Mid-year Population Estimate of Macao*, the primary industry only accounted for 0.8% of the total employed population, the secondary industry for 22.2%, and the tertiary industry for 77%.

In the 2005-2006 academic year, the total number of non-tertiary education schools in Macao was 123, with 91,000 students receiving regular education; there were also about 16,000 students attending higher education, among which the resident students accounted for 73.5%, and the non-resident students for 26.5%. However, in the 2008-2009 academic year, there were about 76,000 students, decreasing by 16.5%, and the reason behind the decrease was the declining birth rate.

In 2005, there were 1,032 doctors, 1,134 nurses and 984 hospital beds in Macao. In other words, there were 21.3 doctors, 23.4 nurses and 20.3 hospital beds per 10,000 people in the region. The spending on hospitals totaled 1.6 billion Patacas, accounting for 7.6% of the total expenditure of the SAR government, which was equivalent to 1.7% of GLP.

1.2.2 Economic development

In 2005, the Gross Local Product (GLP) (based on price of 2005) was 92.19 billion Patacas, and the per-capita GLP was 194,000 Patacas. In 2009, the GLP was 169.34 billion Patacas (based on price of 2009) and the per-capita GLP was 311,000 Patacas, which were approaching to the world advanced level, increasing by 83.7% and 60.3% respectively, compared with 2005.

In Macao's GLP in 2005, the contribution from the primary industry was barely null, but those from the secondary and tertiary industries accounted for 15.2% and 84.8% of the GLP respectively. The gaming industry, financial service, hotel and catering services as well as manufacturing industries are the pillars of Macao's economy, and they accounted for 34.9%, 22.2%, 11.9% and 4.3% of GLP respectively.

1.3 Summary of Major Sectors

1.3.1 Energy

Macao's primary energy consumption is dominated by heavy oil. In 2005, its total primary energy consumption was 25,000 terajoules (TJ), equivalent to 854 Ktce, among which the heavy oil accounted for 56.9%, light diesel for 29%, gasoline for 7%, petroleum gas for 5.7%, and kerosene for 1.4% respectively. In the total primary energy consumption, the fuel processing and conversion sector accounted for 63.9%, land-road transportation for 11.3%, waterway transportation for 8.2%, commercial, catering and hotel sector for 7.8%, households for 3.3%, manufacturing and construction industries for 2.5% each, and the rest for 0.6%.

1.3.2 Electricity

Macao's power-generation industry is dominated by heavy oil and natural gas, which is supplemented by electricity input from the *Guangdong* Province. In 2005, Macao's local power generation was about 2.03 billion kWh, and the electricity input was 340 million kWh. In 2009, the total local power generation decreased to about 1.47 billion kWh, and the electricity input increased up to 2.23 billion kWh.

1.3.3 Transportation

Transportation system in Macao consists of 3 components: land roads, waterway and aviation. In 2005, the total road length in Macao was 368.2 km, with 152,000 vehicles and 92,000 passenger ferry trips. In aviation, the statistics showed that the commercial flights by destinations to and from the Macao International Airport totaled 21,000 in 2005. The ferry trips rose to 132,000 in 2009, while the commercial flights declined slightly down to 19,000.

1.4 Institutional Arrangements in Preparation of Climate Change Related Information

The Government of the Macao SAR has always attached great importance to climate change issues, and it has organized the governmental departments to address climate change in synergy. The preparation of the basic information of Macao on addressing climate change for the *Second National Communications on Climate Change* has been coordinated by the Macao Meteorological and Geophysical Bureau, and other relevant governmental departments have been involved in data collection and delivery, mainly including the Statistics and Census Service, Civic and Municipal Affairs Bureau, Environmental Protection Bureau, Transport Bureau, Energy Sector Development Office, Infrastructure Development Office, Civil Aviation Authority, Maritime Administration, Cartography and Cadastre Bureau, Education and Youth Affairs Bureau, Health Bureau, Labour Affairs Bureau, Fire Services Bureau, Social Welfare Bureau, Financial Services Bureau, and Macao Economic Services.

Table 8-1 Basic information of the Macao SAR in 2005

Indicator	2005
Population (in 10,000 at year end)	48.4
Land area (km^2)	28.2
GLP (in 100 million USD, 1 USD = 8.011 Patacas)	115.1
per capita GLP (in USD)	24,169
Estimated proportion of informal sectors in GLP (%)	NE
Proportion of industries in GLP (%)	15.2
Proportion of service sector in local GLP (%)	84.8
Proportion of agriculture in local GLP (%)	0
Area of land used for agricultural purposes (km^2)	0
Percentage of urban population in total	100
Large livestock (in 10,000 heads)	0
Cattle (in 10,000 heads)	0
Horses (in 10,000 heads)	0
Pigs (in 10,000 heads)	0
Sheep (in 10,000 heads)	0
Woodland area (10,000 km^2)①	0
Population in poverty (in 10,000)	NE
Life expectancy (years old)	78.7 for male, 83.4 for female
Literacy rate (%)③	NE

Note: ① Macao only collects data on green area instead of woodland area. No data was available for 2005. Green area was 5.7 km^2 in 2006; ② Poverty line has not been defined in Macao, therefore it is not estimable; ③ No relevant statistics have been made in Macao.

Chapter 2 Macao's Greenhouse Gas Inventory in 2005

To prepare the Macao's Greenhouse Gas Inventory 2005, the methodologies recommended by the *Revised 1996 IPCC Guidelines* have been mainly utilized, and the *IPCC Good Practice Guidance* has also been taken into account. The reporting scope of Macao's Greenhouse Gas Inventory 2005 mainly covers greenhouse gas (GHG) emissions from energy activities and urban waste treatments. The estimated GHGs include carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). However, Macao's hydrofluorocarbon, perfluorocarbon and sulfur hexafluoride are excluded from this inventory due to lack of data.

2.1 Overview of the Macao GHG Inventory 2005

In 2005, Macao's total GHG emission was 1.803 Mt CO_2 eq (Table 8-2), of which the emission from the energy activities accounted for 98.3%, and the emission from waste treatments accounted for 1.7% (Figure 8.1). The total emissions of CO_2, CH_4 and N_2O were 1.757 Mt, 19 Kt CO_2 eq and 27 Kt CO_2 eq, accounting for 97.4%, 1.1% and 1.5% of the total GHG emission respectively.

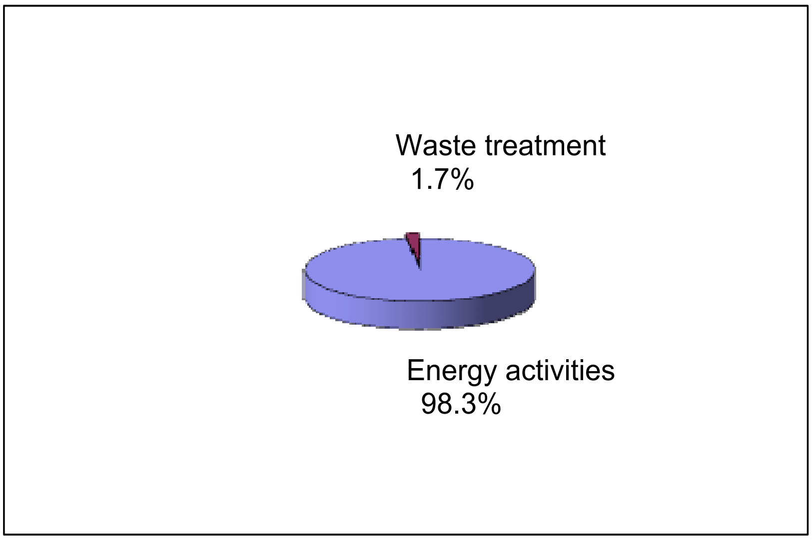


Figure 8.1 Composition of GHG emissions in Macao in 2005

Additionally, in 2005 the total emission from aviation and water transport in the Macao SAR was 571 Kt CO_2 eq, among which CO_2 was 566 Kt. The total emission from international aviation and water transport was 144 Kt CO_2 eq, among which CO_2 was 143 Kt. The emissions from the above two sources are provided for information only, and they have not been counted in the total GHG emission in Macao.

Table 8-2 Macao's Greenhouse Gas Inventory 2005

Unit: Kt CO_2 eq

GHG source and sink categories	Carbon dioxide	Methane	Nitrous dioxide	Total
Total emission	**1,757**	**19**	**27**	**1,803**
1. Energy activities	**1,757**	**5**	**10**	**1,772**
A. Fuel combustion (by sectors)	1,757	5	10	1,772
1. Fuel processing & conversion	1,266	2	5	1,273
2. Manufacturing & construction	92	0	0	92
3. Land transport	205	2	4	211
4. Other sectors	194	1	1	196
B. Fugitive emission from fuels	NE	NE, NO		NE, NO
2 Industrial processes	NO	NO	NO	NE, NO
3 Agriculture	NO	NO	NO	NO
4 Land-use change and forestry	NO	NO	NO	NO
5 Waste	0	14	17	31
A. Urban waste treatment		NO		NO
B. Wastewater treatment		14	14	28
C. Waste incineration	0		3	3
D. Others (please specify)		NO	NO	NO
Memo Items	**709**	**0**	**6**	**715**
Special regional navigation	149	0	1	150
Special regional aviation	417	0	4	421
International navigation	NO	NO	NO	NO
International aviation	143	0	1	144

Note:

1) Being rounded to nearest whole numbers, the sums of all sub-items may slightly differ from the totals;

2) NO (Non-occurrence) means neither GHG emission sources nor removal sinks occur in the territory;

3) NE (Non-estimable) means that GHG emission sources and removal sinks can not be estimated;

4) Values given in 'Memo Items' are not counted in the total emission. Among the total, CO_2 emissions from biomass combustion only include those from biogenic waste incinerations.

2.2 GHG Inventories by Sectors

Given that there is barely any agriculture and industries are few in Macao, the Macao's GHG Inventory 2005 only includes GHG emissions from the energy activities and urban waste treatments.

2.2.1 Energy activities

2.2.1.1 Reporting scope

For energy activities, the reporting scope of the Macao's GHG Inventory 2005 mainly covers the CO_2, CH_4 and N_2O emissions from fuel processing & conversions, manufacturing and construction, fossil fuel combustions in land transport and other sectors.

2.2.1.2 Methodologies

In the GHG inventory for energy activities, fossil fuel combustion is the major source of GHG emissions which is dominated by CO_2. In the process of preparing the GHG inventory for fossil fuel combustions, both reference methodologies recommended in the *1996 IPCC Inventory Guidelines* and the sectoral approach with more technical details have been adopted. For energy conversion, land & sea transports and aviation in SAR with sufficient underlying data, the sectoral approaches have been used respectively; and for the emission sources without adequate underlying data, the methodologies described in the *1996 IPCC Inventory Guidelines* have been utilized.

2.2.1.3 Activity data

The activity data are the statistical and sectoral data that have been publicized in Macao. Both sector and fuel type classifications are basically the same as those given in the *1996 IPCC Inventory Guidelines*.

Moreover, navigation and aviation transports are divided into two categories according to their origins and destinations: special regional navigation and aviation and international navigation and aviation. Fossil fuel emissions there from have not been counted in the total GHG emission in Macao, but they have been only listed under the 'Memo Items' for references by the international community.

2.2.1.4 GHG emissions

In 2005, Macao's total GHG emission from energy activities was 1.772 Mt CO_2 eq, accounting for 98.3% of the total. The CO_2 emissions from fossil fuel combustions were the main sources in energy activities, of which 1.273 Mt CO_2 eq was originated from the fuel processing and conversion, accounting for 71.8%, 211 Kt CO_2 eq was emitted from the land transport, accounting for 11.9%, 196 Kt CO_2 eq was released from other sectors (including commercial business, residents and fishery) accounting for 11.1%, and 92 Kt CO_2 eq was contributed by the manufacturing and construction sectors accounting for 5.2%.

2.2.2 Waste treatment

2.2.2.1 Reporting scope

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

2.2.2.2 Methodologies

Methodologies given in the *1996 IPCC Inventory Guidelines* have been utilized.

2.2.2.3 Activity data

CH_4 emission from wastewater treatment was estimated with actual statistics on chemical oxygen demand in wastewater and IPCC default emission factors; N_2O emission level in wastewater treatments was based on the total population provided by the Macao Statistics Bureau (MSB), China's per capita annual protein consumption in 2005 from the Food and Agriculture Organization of the United Nations, and IPCC default emission factors; CO_2 and N_2O emissions from waste incinerations were estimated using the activity parameters provided by MSB and IPCC default emission factors.

2.2.2.4 GHG emissions

In 2005, Macao's GHG emission from waste treatments was 31 Kt CO_2 eq, accounting for 1.7% of the total, among which emissions from wastewater treatment and waste incineration were 28 Kt CO_2 eq and 3 Kt CO_2 eq respectively.

2.3 Uncertainty Analysis

2.3.1 Work on reducing uncertainties

To reduce uncertainties in the estimates of the GHG inventory, from methodological perspective, the institutions engaged in preparation of the inventory in Macao have selected the higher tier approaches from the *1996 IPCC Inventory Guidelines* and *IPCC Good Practice Guidance* as many as conditions allow. As for activity level data, the institutions have used the data from the Macao Statistics and Census Service, Civil and Municipal Affairs Bureau, Environmental Protection Bureau and other governmental departments as much as possible to ensure the authority of the activity data.

2.3.2 Existing uncertainties in the inventory

Although a lot of preparatory work has been done by relevant institutions engaged in development of the Macao's 2005 GHG Inventory in terms of reporting scope, methodology and quality, there are still some uncertainties. Tier 1 approach from the *IPCC Good Practice Guidance* has been used to calculate uncertainties, and the overall uncertainty of GHG emissions in Macao is about 5.0%.

2.4 Major Factors Affecting Future Emissions

The economic development, population growth and increasing tourists are major factors that will affect future GHG emissions in Macao. Fuel processing, conversion and transportation are the main sources of emissions. GHG emissions will be effectively controlled by continuously introducing clean energies, developing and deploying low-carbon technologies, and promoting low-carbon lifestyles and consumption patterns.

Chapter 3 Impacts of Climate Change and Adaptation

The assessments on climate change impacts started in the late 1990s in Macao, and now the relevant work is still in an initial stage.

3.1 Assessment Methods and Models

Climate change impacts on Macao have been assessed by analyzing the time sequence of climate change, mainly with a more complete dataset of climate observations in 1901-2007; and climate change in Macao for the 21st century has been predicted by utilizing a statistical downscaling method, based on GCM simulations under a range of emission scenarios, which have been used in the IPCC *Fourth Assessment Report* (AR4).

The studies of climate change impacts on Macao are still in a planning stage. At present, Macao is organizing relevant departments and research institutions to monitor and assess the impacts of climate change on water resources, terrestrial ecosystems and human health among others, as groundwork for making policies on climate change mitigation and adaptation in the future.

3.2 Analysis and Prediction of Climate Change in Macao

3.2.1 Characteristics of climate change

Based on the analysis of daily mean temperature and precipitation data in 1901-2007, the climate change in Macao is characterized as follows:

The temperature change in Macao in the past 107 years was virtually consistent with the global trend. The 100-year linear warming trend is 0.66°C, and the warming rate tends to accelerate since 1970s. Among the 10 warmest years in the past 107 years, 7 occurred after 1990s. The temperatures in all seasons show an increasing trend in Macao. The amplitude of temperature increase in spring is most significant, which is about 0.097°C/10 years, followed by winter (about 0.075°C/10 years) and autumn (0.05°C/10 years), and the warming rate is least significant in summer, which is about 0.038°C/10 years.

The daily maximum and minimum temperatures in Macao are showing a similar increasing trend as well. The inter-annual variability of the daily maximum temperature is significant but without showing an evident warming trend. However, the warming trend in the daily minimum temperature is quite significant, and the daily temperature range tends to be narrowed.

The inter-annual precipitation variability is significant in Macao. Overall, it showed an increasing trend in the 20th century with the precipitation increment of about 51.2 mm per decade, and the highest precipitation amount was recorded in the 1970s. The amplitude of precipitation increase is most significant in summer, and there is little change in rest seasons. Based on the definition made by the Expert Team on Climate Change Detection, Monitoring and Indices (ETCCDMI), the Macao Meteorological and Geophysical Bureau has derived the climate change indices (Table 8-3), which show an overall warming trend, and increasing trends in precipitation intensity and maximum precipitation for 5 consecutive days.

The inter-annual variability of hot days with the daily maximum temperature of above 33°C is significant, but the number of hot days has not shown any significant increase. However, the cold nights (minimum temperature ≤ 12°C) and warm nights (minimum temperature ≥ 27°C) are more significant, all showing a continuously changing trend. The number of cold nights decreases by about 1.3 days/decade, while the number of warm nights increases around 2.1 days/decade. Additionally, the frequencies of heavy rain (above 50 mm/day) and rainstorms (above 100 mm/day) have increased, showing the 100-year linear trends of 4.6 and 1.9 days respectively.

Both frequency and intensity of extreme weather and climate events in Macao have increased. Based on a return-period analysis, the hot night with the minimum temperature above 29°C has been shortened to 1-in-7 years from 1-in-20 years in the mid 20th century, while the intensity of 1-in-10-year heavy rain has increased from 200 mm/day in the early 20th century to 330 mm/day in recent years.

Table 8-3 Climate change indices in Macao (based on data in 1901-2007)

Index	Phenomenon	Change per decade
ID12	cold days	-0.039 day
CD12	cold nights	-1.31 night
SU33	hot days	0.3 day
TR27	hot nights	0.21 night
TX90P	warm days	0.319%
TN90P	warm nights	0.908%
TX10P	cool days	-0.322%
TN10P	cool nights	-0.855%
TXx	annual maximum temperature	0.024°C
TNx	highest annual daily minimum temperature	0.05°C
TXn	lowest annual daily maximum temperature	0.05°C
TNn	annual minimum temperature	0.057°C
WSDI	persistent warm days	0.116 day
CSDI	persistent cold days	-0.818 day
SDII	average daily precipitation intensity	0.558 mm/day
Rx5day	maximum precipitation for 5 consecutive days	11.64 mm
R95p	precipitation in humid days	36.86 mm

3.2.2 Future trend of climate change

An assessment has been made on climate change in Macao for the 21st century, based on the local climate observations, using climate model outputs under different GHG emission scenarios from IPCC AR4.

It is expected that the mean air temperature in Macao will continue to show an increasing trend. As research findings show, the temperature will increase in a range of 1.4°C-4.1°C by the end of 21st century (2091-2100) compared to the average temperature between 1971 and 2000 under all scenarios, and a comprehensive assessment shows a temperature increase by about 2.7°C in the same period. The annual average precipitation is estimated to decrease by 3.3% in 2021-2030, which is followed by an increase of 3.9% by the end of the 21st century (Table 8-4). Although projections vary largely from model to model, they show an overall trend of precipitation decrease followed by an increase.

Table 8-4 Multi-model projected temperature and precipitation changes in Macao (relative to 1971-2000)

	GHG Emission Scenarios	2021-2030	2041-2050	2071-2080	2091-2100
Temperature (°C)	B1	0.8	1.2	1.6	1.9
	A1B	0.8	1.4	2.4	2.8
	A2	0.6	1.2	2.2	3.4
	Average	0.7	1.3	2.1	2.7
	Upper limit	1.2	2.0	3.6	4.1
	Lower limit	0.1	0.6	0.9	1.4
Precipitation (%)	B1	-2.9	-2.1	4.9	3.2
	A1B	-0.4	0.8	4.4	6.7
	A2	-6.4	-3.9	3.3	1.6
	Average	-3.3	-1.4	4.2	3.9
	Upper limit	12.0	12.7	20.8	38.7
	Lower limit	-25.3	-21.0	-13.4	-16.7

The research findings have also demonstrated that the temperature in all seasons by the mid-late 21st century shows an increasing trend, especially most significant in winter followed by spring and summer. The precipitation varies from season to season, showing a trend of concentrated rainfalls in spring and summer and continuously decreasing precipitation in winter (Table 8-5).

Table 8-5 Future seasonal temperature and precipitation changes in Macao (relative to 1971-2000)

	Season	2041-2050	2091-2100
Temperature (°C)	Spring	1.3	2.7
	Summer	0.9	1.9
	Autumn	1.3	2.7
	Winter	1.4	2.9
Precipitation (%)	Spring	-9.3	-7.5
	Summer	1.5	8.5
	Autumn	5.0	11.6
	Winter	-11.0	-20.5

3.3 Major Vulnerable Aspects in Macao

3.3.1 Water resources

As 98% of Macao's water supply comes from the *Xijiang* River (a tributary of the Pearl River), the future changes of water resources in Macao mainly depends on precipitation changes in the Pearl River Basin, usage of water resources in the upper reaches and sea-level change in the South China Sea. Based on an analysis on the observations of the major river runoffs in the last 40 years in the mainland China, although the Pearl River runoff decreased little, the urban water consumption increased by a factor of 5.6 and beyond in 28 years (1980-2008) due to rapid economic development in the Pearl River Delta. Additionally, sea level rise in the South China Sea combined with astronomical tides in a low water level period in winter had led to seawater intrusions in the Pearl River Basin in recent years, posing direct threats to the water security in a number of large cities including Macao. Since 1989, the strong 'saline tides' have occurred in 9 winters.

Despite the expectation that the runoff may possibly increase by 5%-10% in the Pearl River basin in mid-late 21st century, but it is still difficult to meet the growing demands for water due to the rapid urbanization and population growth in the Pearl River Delta region. Moreover, the precipitation in southern China will be likely concentrated in summer and autumn, and the precipitation in winter and spring will continue to decrease in the future. In the context of global warming and sea level rise, there will be a potential higher occurrence of 'saline tides' during the low water level periods in winter and spring in the future. Particularly, it will be important to address such issues as how to properly store and use the rain water in summer and autumn when heavy rainfalls are more frequent.

3.3.2 Terrestrial ecosystems

As observations show, the faster growth of tropical lianas in the forest vegetation on mountains in Macao has affected the stand structure and normal growth of other plants for several decades. Meanwhile, both quality and quantity of fruits from the *Matsu* orchards in *Coloane* have declined due to frequent outbreaks of pests and diseases. Preliminary assessments show that it may be related to the increased CO_2 concentration and temperature, but it is still rather difficult to distinguish the impacts of climate change from the urbanization factors.

To have in-depth understanding of climate change impacts on ecosystems in Macao, apart from creation of special nature reserves, the Macao SAR government has initially completed a baseline survey on plants in association with domestic scientific research units, and it is also planning to launch a baseline survey on animals, and to conduct monitoring-based research on animals and plants that are sensitive to the meteorological conditions on a regular basis in a effort to establish robust data in preparation of assessments on future climate change.

3.3.3 Diseases and human health

Due to lack of past monitoring data in Macao, considering the fact that the living standard, medical science & technology, and preventative health care are continuously improving, no robust evidence has shown that climate change has direct impacts on some diseases and human health in Macao.

3.3.4 Sea-level changes and costal ecosystems

According to the analysis of data from tide-gauge stations in 1925-2003, the mean sea level is rising at a rate of 1.25 mm/year in Macao, and the rising rate has increased to about 2.2 mm/year in the past 50 years. Macao is a coastal city and the west bank of the Macao peninsula is the lowest land, which is most vulnerable to the impacts of sea level rise. When a stronger tropical cyclone is approaching or landing on coasts of the Pearl River estuary, it will either lead to a storm surge, or serious seawater intrusion plus a widespread inundation in case of coinciding with an astronomical tide. In the past 100 years, Macao had been hit by 8 severe storm surges, 5 of which happened in the last 20 years. It is expected that both severity and frequency of the astronomical tide-induced seawater intrusions and consequent inundations will intensify; and the chance of being affected by severe storm surges will also increase in the future.

3.4 Adaptation Measures Taken

The Macao SAR government has actively dealt with climate change impacts, and it is now mobilizing forces from all communities to investigate response strategies in its adaptation, but the research is still in an initial stage without a perfect strategy so far. Macao has taken some measures and actions in adaptation to climate change for recent years, which have played a positive role in this direction.

3.4.1 Water resources

In order to stabilize the water supply in Macao, and to minimize the ‘saline tides’, Macao’s adaptation strategies focus on enhancing water resource management on the one hand, and building a water-conservation society on the other. The measures and actions that have been taken include: setting up a special working group to develop and coordinate various measures in response to ‘saline tides’, to disseminate water-saving knowledge, and to manage and prepare an overall plan for development of water resources in the future; entrusting research institutions to compile the *Research Report on a Comprehensive Water Conservation Programme for Macao*; providing a 450 million RMB interest-free loan to the ‘*Zhuyin* Water Resources Project’ in Guangdong in form of prepayment for the growth in water rates, upon completion of which Macao will divert about 40% or 1.6 million cubic meters of the reservoir’s storage capacity; and allocating 800 million RMB in support of resettlement of local residents for construction of the *Dateng* Gorges Project, soil and water conservation as well as environmental rehabilitation in *Guangxi* under the project.

3.4.2 Terrestrial Ecosystem

In 2001, the SAR Government established its first wetland ecological conservation zone in the western part of the *Cotai* Reclamation Area, covering 55 hectares in total with more than 100 species of animals and plants being protected. Additionally, Macao has also imposed strict controls on deforestation.

3.4.3 Sea level and coastal zone

To reduce losses from inundations caused by storm surges plus astronomical tides for its economic development and municipal operations, Macao has set higher standards to further protect urban infrastructures against floods. By these standards, the power distribution boxes and transformers will be gradually lifted up by 0.3 m from their present heights to ensure security of power supply; datum levels of newly reclaimed lands and new building foundations are raised up by 0.5 m or beyond; a storm surge warning system has been set up to enhance capacity of the governmental departments and citizens for disaster prevention and emergency responses. Furthermore, mangroves have been monitored and protected on a regular basis, and the fruits and hypocotyls of the Macao’s virgin mangroves are collected in a phased manner for transplanting in the right places when appropriate, to ensure biodiversity of the tidal flat ecosystem.

3.5 Adaptation Measures to be Taken

Macao needs to expand and enhance its work on sustained climate change monitoring and data collection so as to set up a comprehensive database, in order to provide adequate and credible data sources for relevant reports, research projects and policy-making in the future. Meanwhile, for its vulnerable aspects, Macao will build up a science-based strategy in response to climate change, which will be regularly assessed, adjusted and improved as appropriate. The available mechanism for natural disaster early warning and emergency response will be enhanced to address such issues as potentially intensified extreme and severe weather events and water shortages among others due to climate change; the strategies for addressing climate change impacts and adaptation will be incorporated in all economic and social development plans in order to enhance Macao’s overall capacity for dealing with climate change.

Chapter 4 Policies and Actions for Climate Change Mitigation

Macao has always attached great importance to climate change mitigation, and it has dedicated to building a low-carbon economy and society by taking policies and measures on energy mix optimization, energy conservation, energy efficiency improvement, and preference to public transports, etc., to mitigate climate change.

4.1 Policies and Targets for GHG Emission Control

The *Environmental Framework Law*, which was enacted as early as in 1991, has defined a framework and basic principles in response to climate change in Macao. In 2010, in its administrative report, the SAR government proposed a concept of 'building a low-carbon Macao, creating green living together' to ensure Macao's sustainable development, to actively support and synergize national policies and actions in addressing climate change, to develop low-carbon products and technologies, to promote of green and low-carbon industrial development, and to accelerate transition toward a low-emission and low-consumption economic development model. Macao's target for GHG emission control is to reduce GHG emission per unit of Gross Local Products by 40%-45% relative to 2005 level by 2020.

4.2 Actions for GHG Emission Control

4.2.1 Energy industry

With the socio-economic development and increasing power demands, there is a rising trend in Macao's electricity purchase from the mainland China year by year. At the same time, to mitigate power-related emissions, Macao has introduced a large amount of natural gas to replace heavy oil, and formal power generation by natural gas has been realized since 2008. Based on the *Statistics of Electricity and Natural Gas in the 1st Quarter of 2010*, the proportion of power generated by natural gas increased from 16.2% in 2008 to 62.1% in 2010 in Macao, leading to a significant reduction of power-related GHG emissions accordingly; Macao will further increase the proportion of natural gas in power generation to mitigate climate change.

The SAR government has deployed renewable energy resources. In 2008-2009, Macao initiated an experimental program on utilization of solar hot water; in 2010, the Energy Sector Development Office (GDSE), in association with the Housing Bureau, had developed the solar PV power generation system installed on the Housing Bureau building for indoor lighting. GDSE, in collaboration with the Institute for Tourism Studies, also developed the waste heat recovery technology for the central air-conditioning systems. In 1992, the Waste Incineration Center was built up to effectively use household wastes for power generation. Apart from its own consumption, the waste-based power generation system at this Center can also deliver

21 MWh of electricity to the public grid at the peak hour, which can meet the electricity demand by more than 33,000 households. In the past decade, this center had delivered about 600 GWh of electricity to the public grid, which was equivalent to about 3% of the total power consumption in the same period in Macao.

4.2.2 Energy conservation and energy efficiency improvement

In energy conservation management, Macao implemented the *Public Sector Energy Efficiency and Conservation Plan* in 2007, and released the *Recommendations on Preparation of Internal Guidelines on Energy Saving Commitments of Public Sectors and Institutions* in 2008; altogether 63 units from 58 departments and institutions participated in a pilot project, aiming to reduce energy consumption by 5%. In 2008, a plan for corridor lamp replacements in public buildings was launched to improve the lighting systems, and a relevant project was implemented. It is expected that all this will save electricity by 35% on annual average. The project further expanded to 18 public buildings across Macao in 2009.

From perspective of building energy optimization, the *Technical Guidelines for Building Energy Optimization in Macao* was published in 2009, calling upon general public and industrial sectors to pay greater attention to environment-friendly and energy-saving technologies used for buildings and to energy efficiency management. Technical standards and construction guidelines for environment-friendly buildings have been defined in the technical chapter of the revised *Urban Building Regulations* (2010), to promote use of low-carbon designs and building materials. In the same time, relevant governmental departments have incorporated the low-carbon concept in designs of public civil engineering projects, and proposed low-carbon specifications in tender invitations, with building greening and energy conservation requirements being included.

For energy efficiency labeling and certification, an outreach campaign on energy efficiency labeling for home appliances was launched in 2009, telling citizens what the label meant, raising their awareness of energy efficiency, and encouraging them to choose energy-saving products.

4.2.3 Transportation

Macao has formulated a transportation policy mainly giving ‘Public Transport Priority’. The *General Policy Framework for Transit and Land Transportation in Macao (2010-2020),* which was released in 2010, states that through optimizing the road network, improving the public transport system, establishing a rail transit system, and making favorable policies for using public transport systems among other measures, the proportion of passengers taking public transport will increase up to 50%-55% by 2020 compared with 30% in 2009, as planned, in order to increase the efficiency of public transportation, to reduce energy waste due to traffic jams and pollution from vehicle exhaust. Now the first phase of light rail transit system is under construction. Upon its completion, it is expected that the one-way peak transportation capacity per hour will be 8,000 person-times in the beginning, and it will gradually reach 14,200 person-times by 2020. Furthermore, the SAR Government is also investigating the possibility to introduce environment-friendly vehicles, and to improve current measures like tax concessions and subsidies to encourage use of green vehicles.

4.2.4 Greening the city

The Macao SAR government is committed to managing the green spaces, maintaining trees in the outskirts and protecting other relevant ecosystems in Macao. Over recent years, the Civic and Municipal Affairs Bureau has set up an effective database through 'Tree Management and Maintenance System' to optimize the management of trees in parks, on streets and green zones across Macao. A well-developed city greening system not only provides citizens with good living environment but also allow plants to absorb carbon dioxide.

Chapter 5 Other Relevant Information

Macao has initiated a series of activities to enhance climate system observations and relevant researches, to intensify education, outreach and training on climate change, to encourage public participation, and to raise their awareness of climate change.

5.1 Climate System Observations

Despite its small size, Macao has a rather dense atmospheric and oceanic observing network, including 11 automatic weather stations, 1 climate observing station, 1 atmospheric radiation monitoring station, 5 air quality monitoring stations, 2 tide monitoring stations and 1 sea wave monitoring station. Additionally, in response to seawater intrusions caused by storm surge plus astronomical tides, 9 land-based automatic water level monitoring stations were set up in 2009 to monitor water levels and inundations in Macao's coastal zones.

5.2 Research on Climate Change

Macao's long history of meteorological observation has left it systematic and detailed records. By compiling these data, the Macao Meteorological and Geophysical Bureau has created a 100-year dataset (1901-2000), which provides a solid basis for research on climate change and relevant studies, with high-level research findings having been published. Apart from its enhanced conventional meteorological and sea-level monitoring, analysis and research, relevant institutions in Macao have supplemented the dataset by proving ecological monitoring data which are comparatively less in quantity and shorter in time sequence. Migratory birds have been monitored and baseline surveys on various plants have been made.

Research will be made to prepare Macao's action plan on climate change. This requires multiple basic and thematic research work in support of policy making. Major research work include compiling meteorological data since 1901; introducing multiple GCM models; analyzing and assessing climate change impacts on Macao, especially on water supply through downscaling; investigating climate change impacts on extreme weather events (e.g. typhoon, heavy rainfall, etc.); and assessing severe weather risks, especially the potential social and economic losses caused by typhoon-induced storm surges.

5.3 Education, Outreach and Public Awareness

The Macao SAR Government highly values public outreach and education on climate change as well as effort to raise their awareness, and it advocates for joint actions to safeguard global climate and environment. For outreach and education on climate change oriented to citizens, special attention should be given to helping primary school pupils adopt right attitudes and behaviors. For regular education, the Macao SAR government has officially incorporated the knowledge of nature and environmental protection into the natural science education since the 1995/1996 academic year.

Apart from promoting energy-saving, emission-reduction, green and low-carbon lifestyles through media (e.g. TV, Internet, newspapers), the relevant departments and institutions have also tracked and reported international negotiations under the *United Nations Framework Convention on Climate Change* and *Kyoto Protocol*, in order to increase public awareness of tackling climate change. A wide range of outreach materials on climate change have also been prepared and published, e.g. *'Let's Care about Climate Change and Start from Me for Emission Reduction and Energy Conservation'*, *'Together We Tackle Climate Change'*, '*Newsletter on Energy Conservation Campus'* among other brochures. A cartoon entitled *Carbon Family* has also been co-published in Hong Kong and Macao.

The Macao SAR Government has also regarded high-profile public outreach and education activities as a work it advocates for and promotes. It has actively launched a series of activities, e.g. Earth Day, World Environment Day, World Vehicle-free Day, World Meteorological Day, Earth Hour, Macao Energy Saving Week, 'energy efficiency education promotional activities', 'school energy saving culture series', and Green Businesses Companionship, including the Carnival for Application of the *Kyoto Protocol* to Macao in 2007; Essay Contest on Climate Change in 2008, Photography Contest themed on 'Our Climate' in 2009, and Macao Student Drawing Competition - 'Unite! We Combat Climate Change' in 2010. All these activities have delivered a clear message about climate change to the public from various angles.

Figure 8.2 Brochures on tackling climate change published by the Macao Environment Committee with Meteorological and Geophysical Bureau

Figure 8.3 A carnival for application of Kyoto Protocol to Macao in December 2007

5.4 Needs for Technologies and Capacity Building

Macao highly values the technologies and capacity building in the field of climate change. The ‘Environmental Protection and Energy Conservation Fund’ has been created to support the medium and small-sized businesses, social communities and institutions, to promote their participation in environmental protection (EP) and energy conservation (EC), to broaden the space for development of EP/EC industries, and to facilitate their diversified development. Meanwhile appropriate financial arrangements have been made in the budgets of the various governmental departments for research and accomplishment of the relevant work in response to climate change. Although Macao has taken a series of measures and actions in dealing with climate change, it still faces some challenges in multiple fields due to lack of technologies.

For climate change mitigation, the primary technological needs include: high-efficiency solar energy application technologies, high-efficiency lighting systems, and waste recycling technologies. For climate change adaptation, main technological needs include: recycled water utilization technologies, methodologies and approaches used to assess severe weather events due to climate change. For capacity building, it is needed to build up a nonlinear dynamic model coupling with energy resources-economy-environment-population for assessing the future energy demands in Macao; executive capabilities of the governmental institutions needs to be enhanced for public education and outreach on climate change, and to raise their awareness, so as to build low-carbon society and economy at a quicker pace.

Macao hopes that the technological and capacity building levels will be raised through extensive cooperation, in order to better deal with climate change altogether.