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Mohajan, Haradhan

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Haradhan Kumar Mohajan

Premier University, Chittagong, Bangladesh
Email: haradhan_km@yahoo.com

Abstract

Every nation of the world confirms that human-related greenhouse gas emissions are the major driver of the present global climate change. About 20% populations of the world live in China and the emissions of greenhouse gases of it are very high due to the large population, inefficient capital investment, heavy reliance on coal and inefficient planed urbanization. China is now the second largest economy in the world, behind the USA but at present it is facing severe environmental problems from its rapid economic growth. With the rapid economic growth in China, the transportation sector is also growing rapidly, consequently increasing greenhouse gas emissions due to over burning fossil fuels. China is the world's greatest coal producer and accounts for about 28% of the world's total annual coal production. China is also the world's greatest coal consumer, accounting for more than 26% of the world's total annual coal consumption. Experts from Chinese Academy for Environmental Planning and Policy Research Center of State Environmental Protection Administration have taken various steps to reduce greenhouse gas emissions. Scientists expressed that global warming and climate change is due to increase of greenhouse gas emissions. Hence the over greenhouse gas emissions of China is not only affecting its environment but also is contributing to the global warming. This paper emphasizes on the environment pollution and climate change and recommended to reduce greenhouse gas emissions.

Keywords: Chinese economy, Climate change, Coal and oil consumption, Greenhouse gas emissions.

1 Introduction

People's Republic of China is situated in the Eastern Asia on the western shores of the Pacific Ocean, Beijing is its capital city and Shanghai is its largest city. Its area is 9,640,821 km^2 and it is considered as the 3rd largest country (after Russia and Canada) in the world. In 2010, its population becomes about 1,339,724,852, which is in the 1st position in the world (20% of the world's total) and density of population is 138.96/km^2, which is the 53rd in the world. China has a comparatively low level of urbanization, with an urbanization increased to 44.9% in 2007, which is lower than the world's average. As the urbanization process moves forward, tens of millions of rural laborers transfer to the urban areas every year. Coasts of China are on the East China Sea, Korea Bay, Yellow Sea, and South China Sea. It has a continental coastline extending over 18,000 km and an adjacent sea area of 4.73 million km^2. China has administrative control over 22 provinces (excluding Taiwan Province) .

At present China faces four environmental problems such as: air pollution, water pollution (both create various fatal diseases), the emission of CO_2 in the atmosphere which causes global warming and shortage of future energy supply that relies on exhaustible resources. Environmental pollution mainly from coal combustion is damaging human health, air and water quality, agriculture and ultimately the economy [10]. The United States of America (USA) takes seriously the greenhouse gas (GHG) emissions of China because of its environmental and economic implications. The lack of China's reporting, transparency and acceptance of international review of GHG emissions estimates has been a major point of disputation among China and the USA and other countries in the United Nations Framework Convention on Climate Change (UNFCCC) negotiations [30].

Global warming is not a regional issue which is due to GHG emissions. Global climate change and its adverse effects on nature become severe during the last three decades. Due to the industrial revolution in the developed countries, competition in economic development, have increased the atmospheric concentrations of GHGs, produced evident impacts on the natural ecosystems of the earth, and posed severe challenges to the survival and development of human society. China has averagely suffered from economic loss 3% to 6% of gross domestic product (GDP) caused by climate damage annually.

The emissions of carbon dioxide (CO_2) of China are very high due to the large population, inefficient capital investment, heavy reliance on coal and inefficient planed urbanization. The per capita income of the USA is very high but that of China is very low. The GHG emissions of China are higher than the USA [31]. Coal emits far more CO_2 for the amount of energy it provides than other fossil fuels. It is calculated that coal's "emission factor" is about 30% higher than that of crude oil, and about 70% more than natural gas, on average. As a result the GHG emissions in China are increasing due to the high use of coal and of fossil fuels [30]. According to International Energy Agency (IEA) data [18], the USA and China are approximately tied and leading global emitters of GHG emissions. Together they emit approximately 40% of global CO_2 emissions (21% China and 19% the USA), and about 35% of total GHGs. India is the 3rd largest CO_2 emitter in the world pushing Russia into fourth place. Per capita GHG emissions some of the world's smallest countries and islands are higher than the developed countries. For example, Gibraltar emits the highest 152 tons/capita (1 ton = 1,000 kg) in the world but its total annual emission is only 4.38 million tons in 2009. The Virgin Islands of the USA emit 114 tons/capita but its total annual emission is about 13 million tons in 2009. The USA is still number one in terms of per capita emissions among the larger economies, with 18 tons emitted per person. On the other hand China emits under 6 tons/person, and India only 1.38 tons/person.

China produces about 80% of its electricity by the fossil fuel-fired technologies and it emits one-fifth of world's GHG emissions from power generation. In 2006 it has become the world's largest GHGs emitter. The potential investors of China are confronted with uncertainty in the design of China's future climate policy. International Energy Agency [17] expects that power generation in China will grow with an average 4.9% per annum. It is estimated that the installed capacity will reach 1,775 Giga Watts (GW) by 2030, which is nearly as high as the current installed capacity of the USA and the European Union (EU) combined [47]. Recently China is investing in construction of roads, public transit, to produce electricity and housing which will have implications for resource consumption, consequently liable of GHG emissions. As it is a large country so that total GHG emissions of it become highest in the world. It is expected that GHG emissions will not decrease within a very short time even if it is taken steps to reduce GHG emissions [70].

The Chinese Academy of Environmental Planning estimated that environmental damage in 2010 cost the equivalent of 3.5% of gross domestic product (GDP). The burning of coal is the main source of air pollution, which accounts about 19%, while vehicle emissions contribute 6%. One-third of major river systems, 85% of lakes, and 57% of underground water in monitoring sites are polluted. About 300 million rural residents lack access to clean drinking water and some major rivers have become too polluted to supply drinking water [25].

The adverse effects due to GHG emissions in China are visible in agriculture and livestock breeding, forestry, natural ecosystems and water resources, and in coastal and eco-fragile zones. China has taken serious actions to reduce its energy and carbon intensity by setting both a short-term energy intensity reduction goal for 2006–2010 as well as a long-term carbon intensity reduction goal for 2020. Environmental degradation has been a great problem for China for the last 5 decades and the Government of China is becoming more conscious of the consequences of this problem. Like other industrial countries China has increasingly focused on the finer PM_{10} and $PM_{2.5}$ (particulate matter (PM) whose particles are less than 10 and 2.5 μm in diameter respectively, 1 km = 1,000 m and 1 $\mu m = 10^{-3}$m) fractions, which have more significant health effects, and these are considerably more difficult to monitor and regulate.

2 Effects of GHG Emissions on Chinese Environment

The six gases [37]; Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphurhexafluouride (SF_6), hydrofluourocarbon (HFC) and perfluourocarbon (PFC), together constitutes six GHG emissions. These six gases briefly called carbon dioxide equivalents (CO_2e). Stern [50] expressed that the current concentrations of GHG in space have increased since 1750 from a CO_2e of 280 ppm (parts per million) to 430 ppm. These six gas emissions reduce the ozone layer and contribute to the greenhouse effect. The scientists forecasted that at the end of the 21st century the global average temperature will raise to about 4^0C to 5.8^0C.

2.1 Evidence of Global Warming

Every nation of the world confirms that human-related GHG emissions are a major driver of the global climate change. Scientific research shows that ice loss from Antarctica and Greenland has accelerated over the last 20 years which will raise the sea level. From satellite data and climate models, scientists calculated that the two polar ice sheets are losing enough ice to raise sea levels by 1.3 mm (1 km = 10^6 mm) each year and scientists observed that the sea levels are rising by about 3 mm per year. By 2006, the Greenland and Antarctic sheets were losing a combined mass of 475 gigatons (GT) of ice per year. If these increases continue water from the two polar ice sheets could have added 15 cm (1 km = 10^5 cm) to the average global sea level by 2050 [37].

After the industrial revolution the global average temperature increases about 0.76^0C and is expected to further rise by 1.1 to 6.4^0C by the end of the 21st century. The global surface temperature has increased ≈ 0.2^0C per decade in the past 30 years. Global warming is now $+0.6^0$C [36] in the past three decades and $+0.8^0$C in the past century, and continued warming in the first half of the 21st century is consistent with the recent rate of $+0.2^0$C per decade [37].

It is well established that the effects of GHGs are extremely dangerous. The living organisms in land and water are in dangerous position and some species have already extinct and some other will extinct in future if global warming cannot be controlled [36]. It is clear to environment experts of all nations that emissions of CO_2 and other GHGs are liable to global warming [50]. The National Academy of Sciences (NAS) has expressed its expert opinion that concentrations of CO_2 in the atmosphere have increased and continue to increase more rapidly due to human activities [39, 40]. According to a report of the World Health Organization (WHO) in 1998, of the 10 most polluted cities in the world, 7 can be found in China.

According to the National Oceanic and Atmospheric Administration in 2011 the USA had a record twelve weather disasters that cost more than $1 billion. Scientists stated that this extreme weather related calamities are due to global warming [36].

2.2 Recent Climate Situation of China

The climate of China is extremely varied, with tropical areas in the south to subarctic areas in the north. The northern zone has summer daytime temperatures of more than 30^0C and winters of arctic severity, with the lowest temperature of -30^0C in northernmost Heilongjiang province. The central zone has a temperate continental climate, with very hot summer and cold winter. The unevenly seasonal and spatial distribution of rainfall in China may cause floods in South China and droughts in North China. It experiences typhoons, monsoons, tsunamis, etc., which are also unusual worldwide due to mainly global warming.

At present China is facing severe environmental problems from its rapid economic growth. The latest information is released by the China Meteorological Administration shows that the average temperature of the earth's surface in China has risen by 1.1^{0}C over the past century, from 1908 to 2007, and that China has experienced 21 warm winters from 1986 to 2007. Extreme climate phenomena, such as high temperatures, number of heat waves in summer, heavy rainfall and severe droughts, have increased in frequency and intensity. Heavy rainfall, rainstorms and floods (including the low-temperature freezing rain and snow) have increased in southern China, spring and summer droughts in the middle and lower have affected of the Yangtze River, droughts have grown worse in northern China and the occurrence of snow disasters and autumn rains have risen in western China and serious water logging in Beijing. In China's coastal zones, the sea surface temperature and sea level have risen by 0.9^{0}C and 90 mm, (1 m =1,000 mm) respectively, over the past 30 years. Scientific research predicts that the above adverse effects will increase in future. Only in 2011, natural disasters have affected 430 million people and caused direct economic losses of 309.6 billion yuan [67].

Environment current issues of China are [12]:

- air pollution (GHGs, SO_2) from reliance on coal produces acid rain,
- water shortages, particularly in the northern side of the country,
- water pollution from untreated wastes,
- deforestation,
- estimated loss of one-fifth of agricultural land since 1949 to soil erosion and economic development, desertification, and
- trade in endangered species.

Desertification is a great problem in China, due to large part to overgrazing, drought and environmental deterioration and leads to the loss of about 5,800 mile^2 of grasslands every year. In addition, 31% of national land area experiences soil erosion and 85% of the total grassland area is degraded [25]. The rate of lung cancer has increased by 465% in the last 30 years and about 650,000 deaths are caused annually due to air pollution [5, 67].

2.3 GHG Emissions in China

Environmental data from China are vague. As a result none knows precisely the scale of China's GHG emissions or its removals of CO_2 from the atmosphere by vegetation. CO_2 emissions in atmosphere are affecting the global physical and biological systems. The total GHG emission of China in 2004 was about 6,100 million metric tons (MMT) CO_2e, of which 5,050 MMT was CO_2, 720 MMT was CH_4 and 330 MMT was N_2O. Estimated GHG emissions in China in 2005 were around 7–7.5 billion metric tons of CO_2e with CO_2 constituting 78–84% of the total, CH_4 emissions were around 11–13%, N_2O about 1% and the synthetic gases (SF_6, PFC and HFC) together less than 1%. From 1994 to 2004, the average annual growth rate of GHG emissions is about 4% per annum. During 2001–2011 periods Chinese GHG emissions increased even more rapidly by 166%. The International Energy Agency (IEA) indicates that per capita CO_2 emissions from fossil fuel combustion were 3.65 tons in 2004 in China, equivalent to only 87% of the world average and 33% of the level of the Organization for Economic Cooperation and Development (OECD) countries.

The Pew Center on Global Climate Change estimated that, in 2003, electricity and heat made up 42% of China's GHG emissions, industry 21%, agriculture 20%, households and services 9%, transportation 5%, and waste 3% [46]. According to IEA estimates, of China's 2005 GHG emissions, about 68% came from fuel combustion in all sectors, about 5% evaporated as methane from energy related systems, another 10% came from industrial processes, and about 14% came from agriculture. Waste and miscellaneous sources accounted for the remaining 4% of China's GHG emissions that year [19].

GHG emissions can be calculated using the following equation [69]:

$$\text{Emissions} = \alpha_1 \times \text{domestic fuel} + \alpha_2 \times \text{electricity} + \alpha_3 \times \text{transportation} + \alpha_4 \times \text{heating}. \qquad (1)$$

Here each α_i is defined as the emissions factor vector. For example, α_2 is defined as CO_2 emissions for per megawatt hour of power generation. The first term of (1) expresses the total CO_2 emissions from domestic fuel use, the second term represents the total CO_2 emissions from electricity productions, the third term represents energy use from a vector of activities including liters of annual gasoline consumed for transportation, the forth term is for total CO_2 emissions for various heating processes.

2.4 Methane is a Powerful GHG

CH_4 is present in the atmosphere low compared to CO_2 (14%) but it is 21 times more potent per unit as a greenhouse gas. As a result, CH_4 emissions currently contribute more than one-third of today's anthropogenic warming [13]. In the pre-industrial period CH_4 was 715 ppb (parts per billion) but in 2005 it increased 148% to reach 1,774 ppb [26]. About half of this increase is due to decomposition of wastes in landfills, natural gas systems, and enteric fermentation [13].

Over the last two centuries methane (CH_4) concentrations in the atmosphere have more than doubled but in the last decade CH_4 concentration increases rapidly. All the nations emphasized to the reduction of CO_2 emissions but no nation take CH_4 emissions seriously. But CH_4 is 21 times more potent than CO_2, so that all nations must take steps to reduce fugitive emissions of CH_4 [38].

CH_4 is the second most important GHG which emits 20% of global GHG emissions from anthropogenic and natural sources. In 2005, global GHG emissions calculated to over 44 GT CO_2e and CH_4 accounted 7 GT CO_2e. Approximately 60% of CH_4 emits from agricultural, coal mining, landfills, natural gas and oil activities, and the rest are from natural resources. Global anthropogenic CH_4 emissions are projected to increase by 15% to reach 8 GT CO_2e by 2020 [20].

A vast expanse of permafrost in Siberia and Alaska has started to melt for the first time since it formed 11,000 years ago. It is caused by the recent 3°C rise in local temperature over the past 40 years which is more than four times the global average. Peat bogs cover an area of a million square miles (or almost a quarter of the earth's land surface) to a depth of 25 m. This has the capacity to release billions of tons of CH_4 trapped by ice below the surface. It is estimated that the west Siberian bog alone contains about 70 billion tons of CH_4, a quarter of all the CH_4 stored on the land surface of the world. This is equivalent to emitting 1.7 trillion tons of CO_2, which is more GHG than has been emitted by humans in the past 200 years. We can easily reduce our CO_2 emissions from fossil fuels if we try but we could not reduce CH_4 emissions once if they started to emit [37, 40].

2.4.1 CH_4 Emissions in China

China is the single largest emitter of CH_4 in the world [55]. Global CH_4 emissions in 2010 totaled 7.2 GT CO_2e, of which China produced about 925 MMT CO_2e, surpassing both India and the USA. CH_4 emissions of China are due to its large population and economic activities, such as, energy use and production, waste disposal and agricultural processes [55]. CH_4 emissions from organic waste account for about 20% of China's total CH_4 emissions, which includes CH_4 produced from the degradation of the organic fractions of municipal solid waste (MSW) in landfills, agricultural manure management and wastewater treatment and discharge [55]. CH_4 leaked from fossil fuel production accounts for about 33% of China's total CH_4 emissions [2].

China is rich in coal-related CH_4 resources which are buried to a depth of 2 km are over 34 trillion m^3, 12.5% of the world's total, ranking the 3rd in the world [9]. In 2009, about 96 MMT CO_2e was captured from Chinese coalmine and 25 MMT CO_2e was utilized [11].

Reductions in CH_4 emissions can slow the rate of near-term global warming and reduce global air pollution in ozone sphere, as a result improve human health and reduce crop-yield losses globally [56].

3 Economic Developments and Environment Pollutions of China

Economic development of a country is required for poverty reduction but to do it the country releases more GHGs for vehicular traffic, energy use and other development activities. The economy of China has grown with an average 10% per annum during the last two decades (growing by factor of 16 over the period). Its outstanding rate of economic growth in recent decades becomes important impacts on the world economy. About 20% of the world populations are enjoying the fruitful results of this economic growth. Its per capita gross domestic product (GDP) in Purchasing Power Parity (PPP) has increased more than 20 times from $379 in 1980 to $7,632 in 2010 [4]. In the past decade, China's annual growth rates varied between 8% and 14%, over which time its economy has tripled in size. It is now the second largest economy in the world, behind the USA. Much of its recent economic growth occurred for industrial production, especially of goods for export, which led to severe environmental degradation [30]. During this period it received large amounts of foreign direct investment which increased international trade with China. As a result of the basic repudiation of Maoist economics, it has undergone rapid economic growth, development, and industrialization, which lift millions of Chinese out of poverty.

Chinese economy is rigidly political control to a more market oriented that has a rapidly growing private sector and is a major player in the global economy. In 2003 Chinese GDP was estimated in PPP terms at 59% of the size of the USA.

Carbon dioxide emissions are one way of measuring a country's economic growth. Economically developed countries emit more CO_2 in the atmosphere. Because, CO_2 emissions of a country depend on energy consumption and this happen due to industrialization and rapid urbanization, which increase of vehicles for transportations. Within the period of 1979 to 2007, the Chinese economy grew at an average 9.8% per annum. China acquired $1.5 trillion in foreign exchange resources by the end of 2007 and $3.2 trillion foreign reserve at the end of 2011, which is the world's largest foreign reserve [53]. About 600 million citizens have improved their standards of living within this period. The literacy rate of China has increased from 20% in 1980 to 91% in 2010, and the life expectancy has increased from 65 to 75 during this period. In 2011 some economic experts claimed that China is now a developed country, but yet it is a developing country. World Bank in 2005 estimated that up to 200 million people in China lived on less than $1.25/day.

Hallding et al. [15] indicate that although China has large foreign reserve and rich economic development, but about half of the populations live on less than $2 per day. So that China has not eradicated poverty and cannot create a field to increase per capita income which is a drawback to overcome poverty of the citizens of China. In most parts of China environ pollution has become so worst that social and political stabilities become at risk. In 2007, World Bank and the Government of China estimated that the cost of outdoor air and water pollution to China's economy totaled around $100 billion per annum which is 5.8% of China's gross domestic product (GDP) [59]. At present China have 16 out of the 20 most polluted cities in the world [63].

In 2005, the per capita GDP of China was about $1,714 which is only about one-fourth of the world average. But per capita GDP of different regions of China are different. For example, in 2005, the per capita GDP of the eastern areas (mainly in Shanghai the per capita GDP was $7,000 in 2006) of China was $2,877, while that of the western areas was $ 1,136. The income inequality between rural and urban residents is also noteworthy. In 2005, the per capita disposable income of the urban residents was $1,281, while that of the rural residents was only $397 [54].

Urbanization in China is increasing rapidly. Hence Chinese household carbon emissions could rise dramatically which could have large potential impacts on global CO_2 emissions. Statistics from the IMF show that the per capita GDP of China in 2007 was $2,461, ranking the 106th, a low to middle place, among 181 countries and regions. Both air and water in the urban areas of China are among the most polluted in the world. Mercury released into the air by coal fired power plants is confined by raindrops, and transferred to the soil and groundwater. The groundwater is also polluted by runoff from factories, smelters and mining operations.

The year 2010 marked two important milestones for China which are as follows [21]:

i) In July 2010 the energy demand of China surpassed the USA and become the world's largest energy consumer.

ii) In August 2010 China overtakes Japan as the world's second largest economy.

3.1 Effect of Pollution in China

The World Bank [58] estimates that in 1995 about 178,000 premature deaths, 346,000 registered hospital admissions, more than 75 million asthma incidences happened in China due to the air pollution. The World Bank report also highlights that air and water pollution together costs every year between 3.5 and 8% of China's GDP. According to the World Bank [58], the air pollution in China ranks among the highest in the world. According to World Bank [59] recently in certain cities of China, the air pollution and smog impair visibility become so much that sometimes airports are temporarily forced to shut down. The health care costs have subsequently increased as a result of environmental pollutions of the country.

3.2 Sulfur dioxide (SO_2) Emissions in China

Sulfur dioxide (SO_2) is not considered as a GHG under Kyoto Protocol 1997 but due to the extremely emission of this gas acid rain is happening in China. China now becomes the highest SO_2 emitter in the world due to its reliance on coal for energy generation. Acid rain destroys various living organisms and structures (paints, buildings, infrastructure, and cultural resources). We have described above that energy sector of China highly depends on coal consumption. As a result SO_2 emissions are very high in China. Atmospheric SO_2 emissions are a major contributor to $PM_{2.5}$, (whose particles are less than 2.5 μm in diameter) in China. The Government of China has established national goals to reduce SO_2 emissions by 10% in the 10th and 11th Five–Year Plan periods, 2001–2005 and 2006–2010, respectively. During the 10th Five-Year Plan period, economy-wide SO_2 emissions increased at an average rate of 5.5% annually. After the adaption of a number of policies and introducing new instruments during the 11th Five-Year Plan, SO_2 emissions were declined by 14% [48]. The World Health Organization (WHO) [60] estimated that acid rain seriously affects 30% of China's total land area. Tianbao [54] indicates that China is one of the countries in the world which suffers from severe acid rain contamination. Acid rain causes many hazards to the environment, affects the standard of living, and is even harmful to human health. Due to China's SO_2 emissions, both Japan and Korea are experiencing increases in acid rain.

3.3 Environment Economics in China

In 1978 for the first time the environmental economics and Eight Years Developing Program of Environmental Protection Technology and Economic (1978–1985) were introduced in China. After mid 1980s with success of a group of experts and the practice of relating theories and methodology of environmental economic, prominent environmental economic research achievements were made and professional books were published in the field of environmental valuation, environmental pollution damage measuring and environmental economic models. Some of the remarkable progresses in environmental economics are as follows:

- Ecological Economics (Chinese Academy for Environmental Planning, [3],
- Natural Resources Accounting [61],
- Practical Environmental Economics [27],
- Environmental Economics: Theory, Methodology and Policy [28],
- Environmental Economics [62, 64],
- Environmental and Resources Economics [70],

At present experts from Chinese Academy for Environmental Planning (CAEP), Policy Research Center of State Environmental Protection Administration (SEPA), Renmin University of China, and Chinese Academy of Social Sciences have many years' experiences and publications in environmental economics studies and made achievements in environmental economics policy, environmental valuations, environmental investment and financing, environment and trade, environmental economic analysis. In 2002, the third phase of China Council for International Cooperation on Environment and Development (CCICED) approved the taskforce of China environmental protection investment and financing mechanics and got the support from Japan [29]. National Clean Production Center (NCPC) and Policy Research Center under SEPA have undertaken research about foreign circular economic legislation, methodology and developing circular economic model initially.

4 Comparison of GHG emissions between China and the USA

The population of China is about 4.5 times larger than that of the USA, its economy, as measured using nominal exchange rates, was only about one-sixth as large. At present per capita carbon emissions in the USA are about 5 times than that of China, which implies that if China's per capita GHG emissions rose to the US levels, then global carbon emissions would increase by more than 50%. About 40% of the US CO_2 emissions are related to residential and personal transportation but CO_2 emissions are very few in these sectors (table 1) in China. China requires 50% more energy to produce one billion dollars of GDP compared with the USA.

When the UNFCCC was opened for signature in 1992, the already industrialized countries emitted almost 80% of the global CO_2 from energy and industry. At that time the global CO_2 emissions of the USA, the EU and China were about 23%, 20% and 11% (unfortunately in 2013, global CO_2 emissions of China becomes 21%) respectively. At the same period all the developing countries contributed about one-third of the global CO_2 emissions [30].

Coal is the relatively cheap natural fossil energy source for China. In China coal-fired power plants produce more than 2,500 terawatt-hours (TWh) electricity per year. Because of heavy reliance on coal, the electricity and heat sector is responsible for about 50% of China's CO_2

Country	China	The USA
Population (millions)	1,339	307
Population growth (annual %)	0.5	0.9
GDP (billions $)	2, 244	12,398
GNI using PPP ($)	9,091	14,119
GNI per capita ($)	6,828	45,989
GDP growth (%)	14.2	1.9
Energy consumption per capita (kg oil equivalent per capita)	1,316	7,893
Electricity consumption per capita (kWh per capita)	2,791	13,506
CO_2 emissions (MMT CO_2) in 2010	8,333	6,145
GHG emissions (MMT CO_2e) in 2005	7,527	7,282
GHG emissions per capita (metric tons per capita) in 2005	6	25
GHG emissions per GNI (tons per 1000 $ GNI, using PPP) in 2005	1.4	0.6

Table 1: Selected statistics for China and the USA in 2005, Source: [30].

emissions from fuel combustion [22]. In 2007, it is estimated that China's coal contribution is about 70%, in petroleum is 20%, in gas is 3%, and hydroelectric and nuclear contribute 7% for its total energy needs (figure 1).

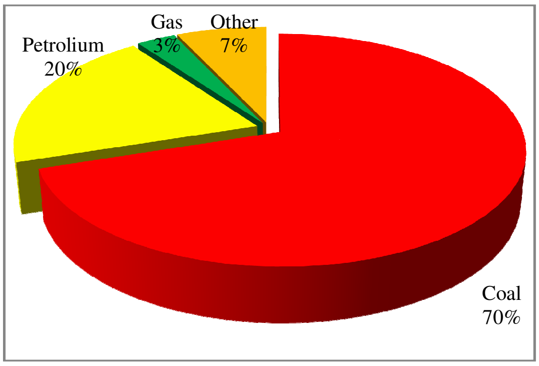

Figure 1: Energy use in percent to produce electricity in China. Source: Prepared by the author.

While the USA used petroleum about 40%, coal and natural gas provide about 25%, and nuclear and hydroelectric contributing 10% for its total energy needs. Hence China in 2007 consumed about twice as much coal each year as the USA. On the other hand China is the world's largest producer of hydroelectricity generating over 397 TWh per year, which is 16% to the total annual electricity production. In 2004 China estimated that its total GHG emissions in 2007 would be about 6,100 MMTCO_2e which is a growth of 50% in one decade. Of the estimated GHG emissions of China in 2004 were, about 83% CO_2, 12% CH_4 and 5% N_2O, with less than 1% of SF_6, HFC and PFC.

We have seen that China is a leading GHG emitter, its GHG emissions per capita is below than that of the USA, other industrialized countries and world average. In 2005 Chinese emissions per capita was about 6 tons compare to the USA at 25 tons and Russia at 15 tons. Even China's emission per capita is also below the world average which is 7 tons, but the GHG emissions intensity is highest in the world. China's emissions is about 1.4 MMTCO_2e per billion US dollars of Gross National Income (GNI) using purchasing power parities (GNI_{ppp}), Russia is about 1.33, India is at 0.98 and the USA is 0.9 MMT CO_2e/GNI_{ppp} (table 2). Hence China's GHG intensity is about twice the world average. As China wants to increase per capita income so that it will increase GHG emissions. These emissions can be reduced by using efficient technologies in the industrial sectors. The World Bank's World Development indicators observed that China's GHG emission intensity fell more than 66% from 1990 to 2005, the USA dropped 48% and the world average declined by 43% [31].

Country or world	China	Russia	India	World	USA
GHG/GNI (MMTCO_2e/billion $ GNI_{ppp}) in 2005	1.40	1.33	0.98	0.78	0.59

Table 2: Estimated GHG intensities in 2005. Source: [31].

In 2002 China accounted for 13.6% of global CO_2 emissions from fossil fuel use (compared to the USA at 27.5%) [30].

5 Coal Reserves and Use in China

Coal is the most abundant fossil fuel in the world and it accounts for two-thirds of the fossil fuel resource base. The largest coal resources are held by the USA, followed by Russia, China, India, and Australia. The US recoverable coal resources of 270 billion metric tons (GT) are about 250 times of current annual production; while China's recoverable resources of 190 GT are about 80 times of its current annual production. China and the USA are the world's two largest producers and consumers of coal. Together they are responsible for half of world coal production. The USA produces more than 1 GT of coal each year. More than 90% of the US coal supply is used to generate electricity in some 600 coal-fired power plants. About half of the US electricity supply is generated using coal-fired power plants which produce 330 billion watts (GW) of electricity. In China, more than half of the coal supply is used to produce electricity. There are more than 2,000 power plants in China which produce 600 GW of electricity (in 2006). In 2004, the use of coal accounted 2.6 billion metric tons (GT) of heat trapping CO_2 emissions in China and 3.9 GT of CO_2 in the USA. It is forecast that by 2030, China's CO_2 emissions from coal could grow to more than 8 GT and the US CO_2 emissions could be about 3 GT [43].

China has proven recoverable coal reserves of about 126 billion short tons (1 short ton = 907.18474 kg), and potential reserves of as much as 4 trillion short tons. Nearly 80% of China's coal reserves are low sulphur bituminous coal, with 15% of lignite and 6% of anthracite. Most of the coals are located in the northern part of the country (provinces of Shanxi, Shaanxi, Anhui, Inner Mongolia, Shandong and Henan) [33]. In 2011 the top five coal producing countries in decreasing order are China, the USA, India, Australia and Indonesia. Coal fuels more than 40% of the world's electricity, though this figure is much higher in many countries, such as in South Africa (93%), China (79%), India (69%) and the USA (49%) [23].

Coal mining industry of China is the most dangerous in the world. It produced about 40% of the world's coal in 2005; it reported 80% (4,746 people) of the total deaths in coal mine accidents, which is 100 times more likely than the USA. In addition, about 300,000 coal miners suffer from black lung disease in China, with 5,000 to 8,000 new cases arising each year [43].

6 GHG Emissions in Transportation Sector

With the rapid economic growth in China, the transportation sector of China is developing rapidly. In the early 1980s, a private car is rarely seen in China. But due to the development of China's economy middle-class society is increasing rapidly. According to the report of China National Statistics Bureau, by 2001, China had 7.71 million private cars, a number which may increase strongly to 140 million by 2020 [7]. It is estimated that for a 15-year period between 2005 and 2020, energy consumption from China's light duty transport fleet would increase over 300%. Numbers of motor vehicles per 1,000 inhabitants in 2005 were in China 15, in France 596 and in the USA 808. But car sales in China increased five-fold during 1999–2005 periods due to increase per capita GDP. Recently the numbers of vehicle users are increasing rapidly due to increase of middle-class citizens in China. Energy use in transportation sector became triple over the last two decades. Domestic oil production capacity of China is limited and it has to import oil every year. In 2000 it imported 70 million tons of oil which is about 30% of that year's total oil consumption. Import of oil in China has increased 30% over the past decade.

At present China has become the 3rd largest oil consumer in the world with an annual rate of increase of 4% after the USA and Japan. A major cause of the increase of consumption of oil in China is due to the rapid growth of the transportation sector. In China, passenger and freight road transportation have increased by 8 and 15 times, respectively, during 1980–2000 [57]. In 2000 the total consumption of oil in transportation sector was 210 million tons. It is estimated that if no control measures are implemented, the annual oil demand by China's road vehicles will reach 363 million tons by 2030. As a result China emits a large amount of CO_2 in the atmosphere. Total CO_2 emissions from Chinese on-road vehicles are estimated to be 148 million tons in 1997 and 230 million tons in 2002, an increase of 55% in five years. It is expected that in future this rate of emissions will increase in continuous rate. The Energy Conservation Law of China was promulgated in 1997 and took effect in 1998. As Chinese oil consumption in the transport sector has increased, the Government currently has stressed to establish vehicle fuel economy standards in the country. Total road transport energy use in China can be expressed as [16];

$$FC = \sum_n \left(VP_n \times VMT_n \times EF_n^{-1} \times FD_n \right) \tag{2}$$

where FC = fuel consumption in million tons, n = vehicle type (for example, buses and truck of heavy-duty (gross vehicle weight of trucks, $GVWT \geq 14$ tons and total vehicle length for buses, $TVLB \geq 10$ m), medium-duty ($GVWB$, 6–14 tons and $TVLB$, 7–10 m), light-duty (GVW, 1.8–6 tons and $TVLB$, 3.5–7 m), and mini types ($GVW \leq 1.8$ tons and $TVLB \leq 3.5$ m), cars, motor cycles etc.), VP_n = the vehicle population of vehicle type n in million units (by the end of 2002, the total number of vehicles in China reached about 20 million), FE_n = the average value of on-road fuel economy of vehicle type n in kilometers/liter, FD_n = the fuel density in kilograms/liter, VMT_n = the average vehicle mileage traveled in thousand kilometers.

In a given year j; VMT (in thousand km) per vehicle of vehicle type n are calculated based on the total fright/passenger traffic volume (TV, in billion ton-km or passenger-km), and volume share γ, average load capacity (ALC) in tons/seat, VP (millions) and actual load rate of each type β expressed as [16];

$$VMT_n = \sum_n \frac{\gamma_{n,j} \times TV_j}{\beta_{n,j} \times ALC_{n,j} \times VP_{n,j}}. \tag{3}$$

At present, China does not have mandatory national standards for vehicle fuel economy. The labeled fuel economy (LFE) reflects at best the technology level of the vehicle model. The conditions of vehicle use such as vehicle age, driving speed, and drive habits can also influence the fuel economy level of a particular vehicle. The fuel quality and road quality can influence the fuel economy of a vehicle. An adjustment factor α was applied to represent the impacts of these factors. Hence, the actual on-road fuel economy (RFE) of vehicle type n can be expressed as [16];

$$RFE_n = \alpha_n \times LFE_n. \tag{4}$$

The total emissions of CO_2 in China are given in the China Statistical Yearbooks of different years. Total CO_2 emissions are calculated based on the assumption that all carbon in fuels is converted into CO_2. The calculated values using equations (2), (3) and (4) are given in several studies [16, 57, 68].

Electricity generation of China relies extensively on coal (79%), the other important generation source at present being hydro (16%), with nuclear, gas, oil and non-hydro renewable providing the remainder. China has released one GHG inventory, for the year 1994. In 1994 China estimated its total GHG emissions to be 4,060 MMT CO_2e, only after a decade in 2004 total GHG emissions increased 50% and estimated GHG emissions become 6,100 MMT CO_2e. The electric sector of China becomes an essential part of the country's development and climate change challenge. As economy of China has grown at remarkable rates energy-related CO_2 emissions grew by 50% between 1990 and 2000, and doubled in the last decade, reaching 7 billion tons of CO_2 in 2010 (figure 2). To decrease CO_2 emissions China decided to decrease to install capacity of carbon-free sources (e.g., hydro, nuclear, wind and solar) of electricity more than double between 2010 and 2020 to reach in 600 GW. On the other hand to meet the demand of energy for emerging economy China projected the cheaper coal-based electricity to reach 1,190 GW by 2020, against 710 GW in 2010 [24].

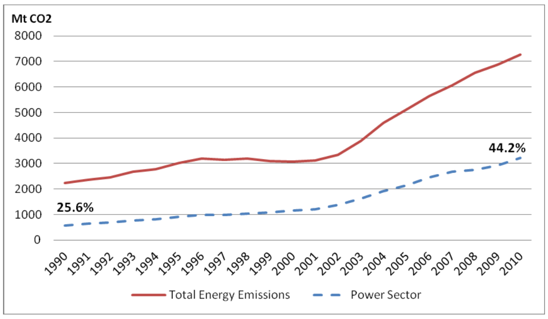

Figure 2: Energy and electricity-related CO_2 emissions in China (1990–2010). Source: [24].

In 2004, CO_2 emissions in transportation sector estimated at 352 MMT, which is approximately 9% of China's total CO_2 emissions. If this emission rate continues, annual CO_2 emissions on transportation sector would reach to 1,800 MMT by 2025. The fuel economy of Chinese new vehicles in 2004 was 10–15% lower than that in Europe, 5–20% lower than that in the USA, and 20–25% lower than that in Japan for an equivalent vehicle type [16]. Private cars are heavily used in urban areas of China; hence urban transport bears a significant share of the total transport energy use and GHG emissions. Motorization is causing severe problem and is creating urban road congestion and accidents and is worsening urban air quality.

7 Power Sector of China

Energy consumption of China is very high due to the largest and fastest growing emerging economies and energy consumption for the period 2002–2008 was as high as 16.8%. It has the world's second largest reserves of coal and the extraction is relatively cheap due to low cost labor [1]. About 70% of the country's primary energy is produced with coal and oil made up 19%, which cause heavy CO_2 emissions [17]. CO_2 emission of China from consumption of energy is 8.321 billion MT in 2010. Coal-fired power plants of China produce more than 2,500 terra watt hour (TWh) electricity per year [21]. Crude oil is the 2nd largest source of energy supply followed by hydroelectricity, natural gas and nuclear energy. By 2002 China was the world's 3rd largest energy producer and the 2nd largest energy consumer, which creates various problems in the country such as, deterioration of air quality, public health problems and local climate change.

In 2002, China accounted for 10.5% of world energy use (the USA at 23%) and is projected by 2025 to account for 15% of global energy use. It has about 9.4% of the world's installed electricity generation capacity (second only to the USA) and over the next three decades is predicted to be responsible for up to 25% of the increase in global energy generation [32]. In the 1900s, China was the world's 3rd largest importer of energy but as of July 2010, has risen to become the largest importer [52]. If it becomes more energy efficient then it would have to import less energy from other nations and the country becomes economically more developed.

Power capacity of China will be more than double by 2030 and renewable including large hydro will account for more than half of new plants, eroding coal's dominant share and attracting investment of $1.4 trillion. McKibbin [32] estimated that China has the largest hydroelectric capacity in the world which is currently generating 20% of Chinese electricity. It will add 88 GW of new power plants annually from now until 2030, which is equivalent to building the UK's total generating capacity every year. Over the next two decades it could add more than 1,500 GW of new generating capacity and invest more than $3.9 trillion in power sector assets.

At present China is the world's greatest coal producer and accounts for about 28% of the world's total annual coal production. China is also the world's greatest coal consumer, accounting for more than 26% of the world's total annual coal consumption. Coal covers about two-third of China's total energy consumption and is responsible for 70–80% of electricity generation, 75% of energy used in industry, and over 80% of household energy. In 2002 coal consumption of China was 1.42 billion short tons [33]. In 2011 China consumed about 49.4% (3.12 GT) of global total coal consumption. Over the period of 2011–2030, it forecasts to account for 67% of global coal growth to 2030 and remains the largest coal consumer, increasing its share of global consumption from 48% to 53% [49]. Residential burning of coal accounted for 83% of black carbon emissions in 1995, which is due to the fact that 80% of Chinese households use solid/biomass fuels for cooking and heating [60]. Black carbon is the fine particulates that are released from imperfect combustion of carbonaceous materials such as coal, wood, grass, agriculture waste etc. Black carbon is classified as an aerosol and is therefore not included in the Kyoto Protocol but it is a critical issue for air pollution of China (reduced visibility, serious health problems, damage to buildings etc.). Streets [51] argued that black carbon is the second most important warming agent behind CO_2. Using circulation models, Menon et al. [34] estimated that black carbon is responsible for local climate problems in China such as increased drought in northern China and summer floods in southern China.

China has proven recoverable coal reserves of about 126 billion short tons, and potential reserves of as much as 4 trillion short tons. About 80% of coal reserves are low sulfur bituminous coal, 15% of lignite and 6% of anthracite. Most of the highest quality coal reserves are located in the northern part of the country and far from the coal consumption cities and the transportation of coal into the sites is one of the largest problems of Chinese coal production [33]. In China, coal combustion produces 70% of CO_2 emissions and 90% of SO_2 emissions, and 67% of nitrogen oxide (NO_x) emissions.

Electricity production of China was about 1.42 trillion kWh in 2004, 2.19 trillion kWh in 2006 and 4.604 trillion kWh in 2012 (table 3).

China	2004	2005	2006	2007	2008	2009	2010	2011	2012
Electricity (trillion kWh)	1.42	1.91	2.19	2.50	3.26	3.26	3.45	3.45	4.6

Table 3: Electricity production of China from 2004 to 2012, Source: [12].

China is the 3rd largest consumer of oil and is estimated to have the world's 6th largest proven reserves of oil. The stock of proved reserves of crude oil in barrels (bbl) in China is given in the table 4. The major source of demand for energy in China is industry which used about 70% of the total energy of the country in 2002 and the next two sectors are household use at 12% and transportation at only 7%.

China	2003	2004	2006	2008	2010	2011
Oil reserve (million bbl)	26,750	18,260	16,100	19,600	20,350	14,800

Table 4: Oil proved reserve of China from 2003 to 2011. Source: [12].

The total oil produced in barrels per day (bbl/day) was 3,300 thousand bbl/day in 2001 and 4,073 thousand bbl/day in 2011 (table 5).

China	2001	2003	2004	2005	2008	2009	2011
Product oil (thousand bbl/day)	3,300	3,392	3,504	3,631	3,725	3,991	4,073

Table 5: Oil production of China from 2002 to 2011. Source: [12].

China imports crude oil for the increased demand of energy. The total oil imported in barrels per day (bbl/day) are, 1,207 thousand bbl/day in 2001, about 3,181 thousand bbl/day in 2001 and 5,080 thousand bbl/day in 2011 (table 6).

China	2001	2002	2004	2005	2007	2008	2011
Import oil (1,000 bbl/day)	1,207	2,414	3,226	3,181	4,210	4,393	5,080

Table 6: Import of crude oil of China from 2001 to 2011. Source: [12].

8 GHG Mitigation Policies of China

In 1992, the United Nations Framework Convention on Climate Change (UNFCCC) supported 192 countries including China and the USA to stabilize "*greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system*." In the UNFCCC all the countries unanimously agrees to GHG concentrations [31]. One of the aims of these countries is to reduce GHG emissions by 55% of the 1990 levels by 2012. With the support from the UN and the USA, China hopes to board on a multi-million dollar renewable energy strategy to combat environment pollution.

Due to GHG emissions China realized the effect of warming of climate. Recently China has observed that impacts of storm intensity, rising sea levels, decrease in agricultural productivity, shifting water availability already affecting the people of the country. In the 11th Five-Year Plan China has taken attempts for the creation of clean and renewable energy as an important national policy. So that it is developing hydropower, solar power, wind power, natural gas, and biomass fuel technologies. It forecasts that the nuclear power use in electricity generation is expected to increase to 4% in 2025 from 1% current production which will contribute in the reduction of GHG emissions.

China had decided in its Five-Year economic plan an input indicator as a constraint, requires that the energy use per unit of GDP be cut by 20% during the 11th Five-Year Plan period 2006–2010. This Five-Year Plan also incorporated the goal of reducing SO_2 emissions and chemical oxygen demand discharge by 10% by 2010, relative to 2005 levels [66].

In 2011, the Chinese Government issued the Work Plan for Controlling GHG emissions during the 12th Five-Year Plan Period, which assigns specific carbon intensity reduction targets to all provinces, autonomous regions and municipalities directly under the central government. It targets to reduce energy consumption per unit of GDP by 16%, cut CO_2 emissions per unit of GDP by 17% and to raise the proportion of non-fossil fuels in the overall primary energy mix to 11.4% [8].

The 12th Five-Year Plan of China for environmental protection, (2011–2015) sets out a blueprint with 7 major targets to achieve by 2015, with a special emphasis on improving quality of water and air, and protection of ecosystems. This plan also promotes environment-friendly growth, as three out of seven priority industries are aimed at cleaner and more sustainable growth. It also calls for advancement of environmental protection tax reform and improvement in waste disposal fees. Resource tax reforms have been piloted in some regions since 2010 and, in 2011; taxes on crude oil and natural gas were raised [25]. In this Plan the Chinese leaders have set targets to further reduce energy intensity by 16% by 2015. To reduce pollution and increase the shares of non-fossil fuels in the energy sector, China has set goals to improve its CO_2 intensity by 40–45% by 2020, with an interim target in the 12th Five-Year Plan of 17% by 2015 [30].

China initiated circular economy during the 12th Five-Year Plan Period; some of them are recycling projects in 22 industrial parks, recovering mineral resources from city waste in 7 industrial parks, re-use of kitchen waste in 16 cities, re-use of industrial solid waste in 12 regions. The Ministry of Finance and the Ministry of Transport have allocated special funds for energy conservation and emission reduction to subsidize 402 projects in 2011 and 2012 that achieved a reduction of 1.837 MT of CO_2 emissions [8].

In Copenhagen Climate Change Summit in December 2009, China pledged to cut carbon intensity by 40% to 45% relative to 2005 level by 2020. This commitment stressed that renewable and nuclear energy would increase up to 15% by 2020 and it would expand forest cover by 40 million hectares and forest volume by 1.3 billion cubic meters compared to 2005 [35].

Jun Ying, country manager and head of research for China at Bloomberg New Energy Finance, said, "China has started to change course towards a cleaner future. But despite significant progress in renewable energy deployment, coal looks set to remain dominant to 2030. More support for renewable energy, natural gas and energy efficiency will be needed if China wants to reduce its reliance on coal more quickly."

The Government of China has introduced measures to reduce car emissions in some cities and planted trees to combat desertification. To improve monitoring, the authorities have established a nationwide air and water quality monitoring network. But the Organization for Economic Co-operation and Development (OECD) highlights that enforcement remains a key challenge because it is mainly delegated to local governments that lack sufficient capacity; fines are too small to act as an effective deterrent; and criminal charges, while possible, are difficult in practice and rarely used [45].

According to IEA estimations of GHG emissions of China from 1990 to 2005 the total amount of CO_2 increased from 2,545 MMT CO_2 (144%) but total GHG emissions increased from 3,905 MMT CO_2e to 7,527 MMT CO_2e (152%) [19]. From 2006 to 2007, CO_2 emissions of China increased up to 8%. In 2005 the growth rate of population was 0.6% compared to 1.1% in 1990s which is a positive attempt to decrease GHG emissions. On the other hand from 1991 to 2005 its real GDP grew at an average 10.2% per annum and its energy growth rate was 5.6% per annum [41]. These progresses came from economic restructuring and energy efficiency improvements. Recently China has wanted to decrease electricity production from coal to control GHG emissions [31]. The Chinese Government hopes that more than 50% energy will come from nuclear and renewable energy sources (wind, biomass, solar and hydro-electric energy) by 2050 [6].

The Pew Centre on Global Climate Change estimated that, in 2003, the GHG emissions of China release 42% from electricity and heat made up, 21% from industry, 20% from agriculture, 9% from household and services, 5% from transportation and 3% from waste [46]. China's target is 20% reduction in energy intensity between 2005 and 2010. This mandate expresses that the reductions in each year be 4%. Accordingly expected GHG emissions reduction would be 700 MMT CO_2 by 2010.

China takes an attempt to produce 16% of all energy from renewable resources by 2020. It expects that wind, solar, geothermal and tidal energy will reduce 60 MMT CO_2, biomass will reduce 30 MMT CO_2 and hydroelectricity will reduce 30 MMT CO_2 [14, 44].

Recently China started to build energy saving buildings and announced that new buildings constructed from 2006 to 2010, the buildings should be designed in standard to energy conservation by 50%. The Government of China estimated that the standards and levels for refrigerators, air conditioners, washing machines and color televisions will save 33.5 TWh and reduce GHG emissions by 11.3 MMT CO_2 by 2020 [71]. China joins Post-Kyoto agreement and promises to stabilize CO_2 emissions on the 450 ppm level to reach the two degree goal. So it has to reduce emissions until 2020 by 22% compared to the baseline. To reach the target it must reduce the share of coal-fired power plants quickly and hydro-electricity, nuclear and wind power increases their share [47]. To develop renewable energy China invested $36 billion in renewable energy in 2009. Its target is to produce at least 300 GW in hydropower, 180 GW in wind power and 30 GW for bio-power and to produce 10 MT of ethanol and 2 MT of bio-diesel by 2020 [65].

China, in 2004, set passenger vehicle fuel economy standards in step by step whose average speed will be 36 miles (1 mile = 1.61 km) per gallon (mpg) in 2008. It also emphasis same conditions on trucks and agricultural vehicles. After implementation of these standards China could reduce 488 MMT CO_2 by 2030. The Chinese Ministry of finance adopted taxes on vehicles which is affected September1, 2008. This law doubled taxes on large vehicles and reduced taxes on small vehicles. Purchasers of cars with engines above 4 liters (1 gallon = 3.79 liters) capacity will pay a rise tax of 40%, the vehicles with engine capacity between 3 and 4 liters will rise 15% to 25%. On the other hand engines with one liter capacity will reduced from 3% to 1% [31]. In 2007 China has become world's largest CO_2 emitter despite its effort to scale up energy efficiency and aggressively promote renewable energy use [18].

According to China's National Climate Change Program, China offset a portion of its GHG emissions with sequestration by forests [31], "*From 1980 to 2005, a total of 3.06 billion tons of* CO_2 *were absorbed by forestation, a total of 1.62 million tons of* CO_2 *were absorbed by forest management, and 430 million tons of* CO_2 *from deforestation were saved*."

In 1979, China passed the Environmental Protection Law for Trial Implementation. The 1982 Constitution of China included important environmental protection provisions. The Government of China has been enacted a number of special laws to reduce GHG emissions. These include the Water Pollution Prevention and Control Law of 1984, the Air Pollution Prevention and Control Law of 1987, the Water and Soil Conservation Law of 1991, the Solid Waste Law of 1995, the Energy Conservation Law of 1997 and several important international agreements including the Kyoto and Montreal Protocols. China's national legislature, through its promotion of "Cleaner Production" and other attempts to reduce air pollution, has significantly revised the Law on the Prevention and Control of Air Pollution in 2002. On the national level, policies are formulated by the State Environmental Protection Administration (SEPA) which was established in 1998. It spread national environmental policy and regulations, collect data and provide technological advice on both national and international environmental issues. In June 2002, China enacted the Cleaner Production Promotion Law, which established revelation programmes for pollution regulation in 10 major Chinese cities, and designated several river valleys as priority areas [10].

GHG mitigation strategies for transportation sector in China are, Transportation Demand Management (TDM) programmes, vehicle fuel efficiency improvement policy and increase of use of alternative fuels. TDM is the progress of transportation strategies and policies to encourage the use of less energy-intensive forms of transportation such as, public transportation, especially bus rapid transit, vehicle and manufacturing taxes, fuel taxes, road use and parking policies, environmentally-friendly vehicle rating system. Recently hybrid electric vehicles (HEV) are marketed which emit less GHG but more expensive than diesel fuel vehicles. Other advanced technologies include mini-cars, electric-drive vehicles, and fuel-cell vehicles. Alternative fuels are using in China are compressed natural gas (CNG), ethanol and bio-diesel. CNG saves up to 25% CO_2 emissions, ethanol is renewable alternative to gasoline which saves 30–70% life-cycle GHG emissions and currently supported by Chinese Government with subsidies, bio-diesel which can be made from waste oil and grease, saves 90% life-cycle GHG emissions,

The Chinese Government and international organizations in the transportation sector suggested for improving this sector as follows:

1. to give priority for public transport,
2. to encourage non-motorized traffic,
3. ensuring that users of private automobiles fully internalize the costs they impose, and
4. urban planning and the dynamics of urban expansion to create compact cities.

The State Council has disseminated the Plan for Industrial Transformation and Upgrading (2011–2015) drawn up by the Ministry of Industry and Information Technology to promote green and low-carbon industrial development, such as, boost industrial transformation and upgrading in a number of key industries, including iron and steel, non-ferrous metals, building materials, petrochemicals and chemicals, energy-saving and new-energy vehicles, industrial energy conservation, bulk solid waste and clean production [8].

8.1 *GHG Abatement Policies of China*

China pledged under the 2009 Copenhagen Accord to achieve a 40 to 45% reduction in its carbon intensity by 2020. By 2007, when China was under strong international pressure to negotiate GHG reduction targets under the UNFCCC for the period beyond 2012, it released its National Climate Change Program, a plan to address climate change [30].

To reduce GHG emissions China close of thousands of small, inefficient, and polluting coal-fired power plants, iron and steel mills, cement kilns, aluminum plants, and others. It also closed old coal-fired power plants exceeding 71 GW of capacity in 2006–2010, and another 11 GW in the first half of 2011 have emitted 164 MMT CO_2 annually. On the other hand the stock of carbon stored in forests increased by an estimated 13 billion cubic meters [30].

The Government has initiated some policies in 2010 and aimed continue into the future. Some of them are as follows [30]:

- ❖ development of existing coal fired industrial boilers and investment in ultra-efficient coal fired electricity generation,
- ❖ closure of inefficient energy and industrial sector, and expansion of combined heat-and-power,
- ❖ improvement of industrial motor efficiencies and development of the vehicle efficiency that exceeded those of the USA,
- ❖ green finance in renewable energy and energy saving projects;
- ❖ increase of production of energy efficient lighting, buildings, and efficiency labels for appliances,

In the 12th Five-Year Plan the Government of China has announced a number of its targets to reduce growth of GHG emissions by 2015 as follows [30]:

i) Energy intensity should improve by 16% by 2015.
ii) Carbon intensity should improve 17% by 2015, reaching 40–45% relative to 2005 levels by 2020.
iii) The length of high-speed railways is planned to increase to 45,000 km.
iv) The share of non-fossil energy should reach 11.4% by 2015 and 15% by 2020.
v) Nine pilot CO_2 cap and trade programmes have been established across several Cities.
vi) Forest coverage should increase by 12.5 million hectares by 2015 and 40 million hectares by 2020.

The Government of China estimates that the country offset a portion of its GHG emissions with sequestration by forests: "*from 1980 to 2005, a total of 3.0 billion tons of CO_2 were absorbed by afforestation, a total of 1.6 million tons of CO_2 were absorbed by forest management, and 0.430 million tons of CO_2 from deforestation were saved*" [43].

9 Recommendations

To decrease GHG emissions and sustainable development, China should reduce coal consumption and increase the proportion of renewable energy sources. Parallel with an increase in gas-based generation, would drive the share of coal-fired power generation capacity down from 67% in 2012 to 44% in 2030.

China can reduce the rate of GHG emissions by using alternative energy to coal such as natural gas, nuclear, ethanol and solar, reducing the use of electricity at homes, offices and factories, and controlling the amount of CO_2 emissions by reducing the burning of forests and capturing the amount of carbon from coal burning.

The Government of China must find ways to successfully implement efficient policies in every sector to maintain sustainable economic growth and social welfare.

The strategies which can improve the qualities of the vehicles and can reduce the GHG emissions as follows:

- ❖ in the short term, by improving the fuel efficiency of existing vehicle fleets,
- ❖ in the medium term by facilitating a shift away from private car use, and
- ❖ in the long term by supporting the development of compact cities built about public transport corridors.

The Government of China and other non-government organizations must be active to create consciousness among the citizens to create environment friendly atmosphere throughout the country. The government must apply green technologies to reduce GHG emissions.

10 Concluding Remarks

In this study we have discussed GHG emissions of China. In 2006 it became the largest GHG emitter in the world. China heavily depends on coal to produce electricity. Coal emits more CO_2 in the atmosphere than other fossil fuels. To make the world a living place of all the creatures, China can take necessary steps with other nations to reduce GHG emissions. Recently it takes some steps to reduce GHG emissions. In the study we have discussed the GHG emissions between the USA and China. We have stressed that all the nations must take necessary steps to save the world from destruction. Industrial countries are emitting more GHGs than the developing countries. So that industrial countries will try to reduce GHG emissions efficiently.

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