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Development of Low Carbon Economy in China

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Abstract

As the biggest developing country and number one population country, China's energy demand and CO2 emission increased prominently. China made much effort in reducing CO2 emission and promote sustainable development, and received prominent achievement. There are four main challenges for China to further reduce its CO2 emission in the next stage. China is fighting hard toward the 40-45% emission reduction target by year 2020. Further reduction could not rely on current administrative measures, more market based tools should be introduced.

Introduction

This article introduce the status quo of China's economic development, energy development and CO2 emission, history and measures China had taken in recent years, main challenges of further reducing CO2 emission and long term prospection of CO2 emission toward year 2020 and 2050 in China.

1. Background

China is the largest developing country in the world. Since the opening and reform policy of 1978, China's economy has been booming for over 30 years, with average growth rate of 10.1%. After more than 35 years' development, China has become the second largest economy in the world. However, it is on the way of traditional industrialization development. How to shift from a high carbon development road toward low carbon development road is a big challenge to China.

2. Development of China's Low Carbon Economy

2.1 History of Economy Development, Energy Development and CO2 Emission in China

2.1.1 China's Socio-economic Development

China is the largest developing country in the world. It has a population of 1.338 trillion in year 2010, which is about 19.6% of the world. China's economy has been continuously growing for 35 years since 1978, when Mr. Deng Xiao Ping raised the concept of opening and reform policy. From year 1978 to 2012, the average growth rate of Gross Domestic Product (GDP) is as high as 9.83% (see figure 1). China's Gross Domestic Production ranking increased from number 11th in year 1980, 6th in year 2000, 3rd in year 2008 and 2nd in year 2010. In year 2010, China's GDP is 5878.6 trillion USD, which is about 9.3% of the world.

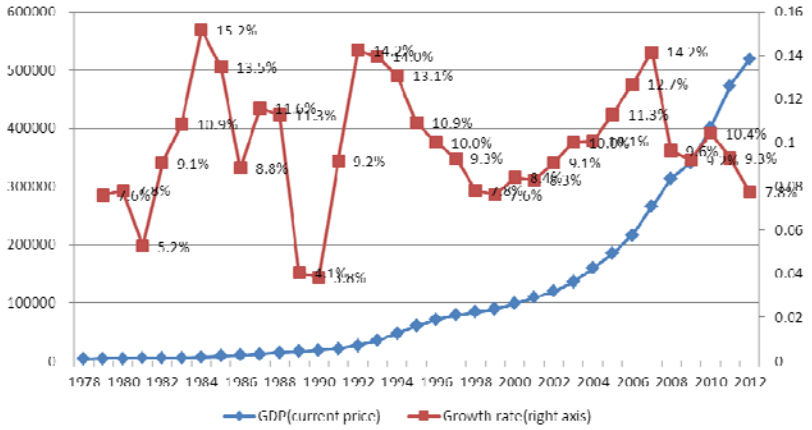

Figure1. GDP and growth rate of China
Source: China Statistical Yearbook 2013

However, China is still less developed. By year 2010, the Gross National Income (GNI) per capita of China was merely 4260 USD, with was a Low and Middle Income Country according to World Bank's Classification Standard. By year 2012, the GNI per capita of China had reached about 5680[1] USD(current US $). Therefore, China has stepped into the row of Upper Middle Income Country in the world. However, among all 214 countries and regions, the ranking of GNI of China is number 77, which is still very low.

In addition to poverty, development of China is quite unbalanced. Especially in recent years, the gap between east region and west region, between urban region and rural region, between the rich and the poor is becoming more and more prominent. The unbalanced dispatch of social wealth has resulted to more and more social problems. This is a big issue that may result to unstable of the whole society. Future Development of China's low carbon economy should in cooperate with China's social-economic development demand, which means not only eliminating poverty, but also decreasing the gap of each layer.

2.1.2 Energy Consumption of China

2.1.2.1 Total Primary Energy Consumption

Energy is the basis of modern civilization. Along with China's continuous economic growth, China's energy demand increased steadily in the past 35 years. In year 2010, China's Total Primary Energy Consumption (TPEC) exceeded United States for the first time, and China became the largest energy consuming country in the world. Though China's energy consumption is quite large, the energy consumption per capita remains low. In 2012, primary energy consumption per capita is only 2.67 tce., which is less than half of the average level of OECD countries.

[1] Source: world bank database, http://data.worldbank.org/

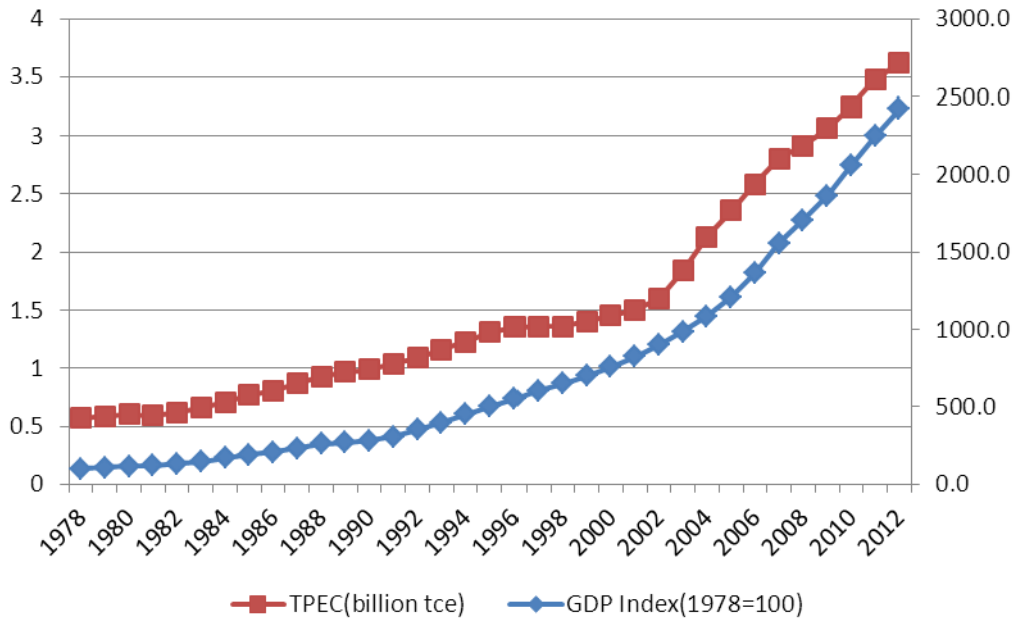

Figure 2. Total Primary Energy Consumption and GDP Index of China
Source: China Statistical Yearbook 2013

China's TPEC experienced an unprecedented growth since year 2002. By year 2012, China's TPEC reached 3.62 billion tce., which is 2.5 times of year 2000(see figure 2). The average growth rate of TPEC from year 2000-2012 reached 7.9%. In comparison, China's TEPC growth from year 1990 to 2000 is merely 4.0%, only half of the recent 12 years.

Table 1 Total Primary Energy Consumption and Elasticity Index of China from 2000-2012

year	TPEC/100 million tce	growth rate of TPEC /%	growth rate of GDP/%	elasticity of energy consumption
2000	14.5531	3.53	8.43	0.42
2001	15.0406	3.35	8.30	0.40
2002	15.9431	6.00	9.08	0.66
2003	18.3792	15.28	10.03	1.52
2004	21.3456	16.14	10.09	1.60
2005	23.5997	10.56	11.31	0.93
2006	25.8676	9.61	12.68	0.76
2007	28.0508	8.44	14.16	0.60
2008	29.1448	3.90	9.63	0.40
2009	30.6647	5.21	9.21	0.57
2010	32.4939	5.97	10.45	0.57
2011	34.8002	7.10	9.30	0.76
2012	36.17	3.94	7.75	0.51

Source: China Statistical Yearbook 2013

The elasticity of energy consumption, which is the ratio of TPEC growth rate to GDP growth rate, of year 2002 to year 2005 is relatively high (see Table 1). This shows China's economic development is heavily rely on the use of energy. The fast growth of China's energy consumption is due to two main reasons. First, China has stepped into the phase of "Homeland Construction". During this stage, huge amount of industrial enterprises and buildings were constructed. The rise of domestic demand of iron and steel, cement resulted to the fast development of energy intensive industries. Second, after

China joint World Trade Organization, more and more countries developed business with China. Due to China's cheap labour cost and good infrastructure, China became a "World Factory" during the past 10 years. The rise of external demand increased the energy consumption of China.

Since the 11th five-year-plan (2006-2010), more attention and much effort were devoted to energy conservation in China. By year 2012, energy consumption per GDP in China decreased by 23.5% compared with that of 2005. The energy elasticity decreased from 1.52 in year 2003 to about 0.6 since year 2007 (see Table 1).

2.1.2.2 Energy Consumption Structure

Over last 60 years, China's primary energy consumption heavily depends on coal. The world primary energy consumption structure has transferred from coal to oil and now is moving towards green energies, such as natural gas, nuclear power, hydro power and wind power. The share of coal in year 2012 is still in 66.6%, which decreased less than 3 percentage point only than year 2000(see table 2). Compared with this situation and trend, China's energy structure made China to a High Carbon development road. Realizing low carbon development is still very far.

Table 2 Energy Consumption Structure of China

	TPEC	Shares in TPEC (%)			
	（100 million tce）	Coal	Crude oil	Natural gas	Hydro power nuclear power and others
2000	14.6	69.2	22.2	2.2	6.4
2001	15.0	68.3	21.8	2.4	7.5
2002	15.9	68	22.3	2.4	7.3
2003	18.4	69.8	21.2	2.5	6.5
2004	21.3	69.5	21.3	2.5	6.7
2005	23.6	70.8	19.8	2.6	6.8
2006	25.9	71.1	19.3	2.9	6.7
2007	28.1	71.1	18.8	3.3	6.8
2008	29.1	70.3	18.3	3.7	7.7
2009	30.7	70.4	17.9	3.9	7.8
2010	32.5	68	19	4.4	8.6
2011	34.8	68.4	18.6	5	8
2012	36.2	66.6	18.8	5.2	9.4

Resource: China Statistical Yearbook 2013

2.1.2.3 Energy Consumption by Sector

China is in the middle of its industrialization and urbanization. Therefore, the energy consumption by sector is greatly difference from developed countries. In 2011, 70% of energy is consumed by industrial sectors. Service account for 14.8% and household consumption accounts for only 10.7%(see figure 3).

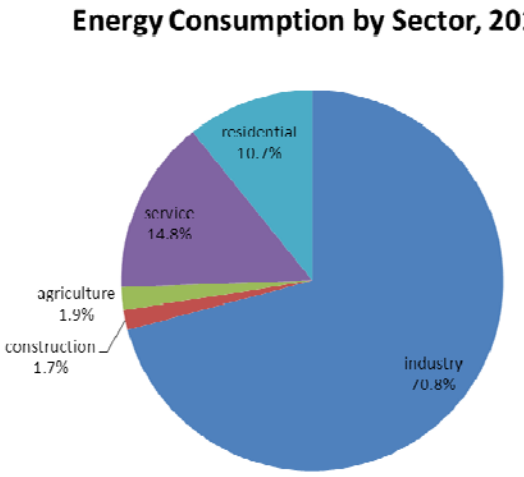

Figure 3. Energy consumption by sector

Industrial energy consumption was dominant in China for a long time. In year 1993, the share of industrial energy consumption was as high as 76%. After that, the share remains to be about 71% for almost 20 years. Only after year 2008, the share of industrial energy consumption begins to decrease slightly(see figure 4).

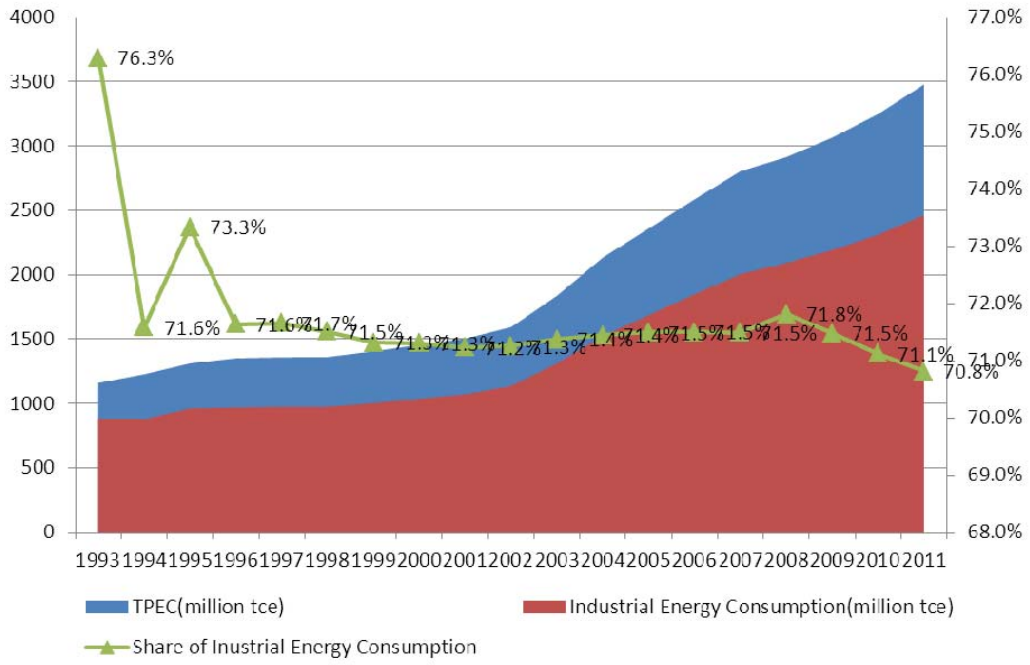

Figure 4. History of Industrial Energy consumption

2.1.3 CO2 Emission of China

Accompanied by fast increase of coal consumption, China's CO2 emission increased continuously. From 1995-2002, China's average emission growth rate of CO2 emission is less than 2%. However, from 2002-2010, the average growth rate of CO2 emission increased to 9.76%. As a result, the share

of China's CO2 emission in the world increased from 13.2% in year 1995 to 23.3% in 2010(Excluding LUCF)[2]. Presently, China has become the number one CO2 emitter in the world.

Especially in recent years, the contribution of CO2 emission from China is becoming more and more obvious. From year 2002-2010, among all the incremental CO2 emission of the world, China has contributed 61.9%. Therefore, China is blamed by many countries of its large amount and fast growth of its CO2 emission. It is said that the emission reduction achievements from OECD countries are offset by the emission growth from China. High pressures were stressed to Chinese society to reduce CO2 emission.

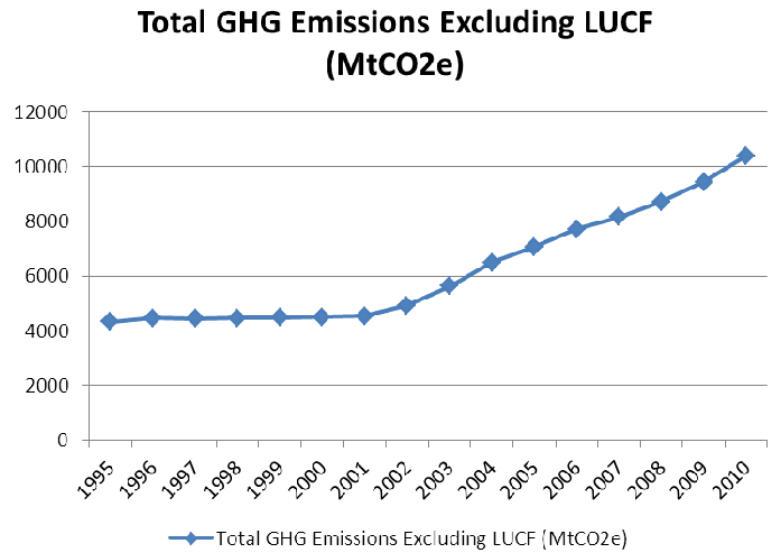

Figure 5. Total Primary Energy Consumption and GDP Index of China
Source: WRI's climate database

2.2 The History of China's Sustainable Development

As a developing country, the concept of environment protection, sustainable development and low carbon development are introduced from international society. Combined with China's local characteristic, China did some explorations to harmonize the conflict between socio-economic development and environment protection.

2.2.1 the History of Sustainable Development in the World

Seen from the global perspective, the environment awareness of human being has experienced three stages.

First stage: the stage of suffering from pollution. Since industrial revolution, human race has produced huge amount of wealth, however, serious disasters had happened as well. From 1940's to 1970's, serious environmental pollution disasters had happed in United Kingdom, United States and Japan respectively.

[2] Data come from database of World Resource Institute

Second Stage: the stage of raising environmental awareness. During this stage, more and more people began to recognize the fault of traditional development mode. Many famous books, such as Silence Spring, the Limits to Growth etc., were published and widespread to the whole world.

Third Stage: the stage of promoting sustainable development. Through a series of global conferences, including United Nation's Conference on Human and Environment in year 1972, the first UN Conference on Environment and Development in year 1992, the World Summit on Sustainable Development in year 2002, the United Nations Conference on Sustainable Development in year 2012 etc., the awareness of sustainable development was raised. As an important composition of sustainable development, Climate change and CO2 emission reduction received much attention as well.

2.2.2 the History of Sustainable Development in China

Influenced by the global development tendency, the awareness of sustainable development in China increased as well. From historical prospect of view, it could be classified into 5 stages:

1st stage: from 1970's to 1978. Chinese government sent delegation to attend the United Nation's Human and Environment Conference in 1972. In year 1973, the State Council of China organized the first National Environment Protection Conference, in which many basic principles of Environment Protection were raised.

2nd stage: from 1978-1992. Environment Protection was recognized as a Basic National Policy. 8 regulative policies were developed.

3rd stage from 1992-2002. Sustainable Development was recognized as a National Development Strategy. The 21 century Agenda of China was development. Environment protection and environment control was promoted during China's economic growth.

4th stage: 2002-2012. The Scientific Development Concept was raised as a top leading principle of China's socio-economic development. The goal of building up a resource conservation and environment friendly society was put forward. China began to explore a new path of environment protection, such as total emission control of SO2 emission from year 2006.

5th stage: 2012-present. A new concept, which is named Ecological Civilization, was raised by in the 18th Chinese Communist Party Congress. A new goal of building a Beautiful China was raised up. It is emphasised that environment protection and sustainable development concept should be incorporated into the overall design of China's social-economic development plan. Construction of ecological civilization should be incorporated to form a "five-in-one" arrangement, which means the integration of economic development, political development, cultural development, social development and ecological civilization development. More attention and efforts would be made to promote green, recycle and low-carbon development. These actions will increase the strategic position of combating climate change in China's overall economic and social development.

2.3 China's Policies and Measures to Promote of Low Carbon Economy Development

As the largest CO2 emitter and the largest developing country in the world, China's attitude and reactions that fight against climate change is quite active. China has taken CO2 emission as an important issue, and worked hard to induce China to take a low carbon development road. Especially in recent years, main activities had been organized. Main activities including:

2.3.1 Strengthening Government Institution

As a country shifting from planning economy to market economy, government of China takes a dominant role in socio-economic development of China. The State Council has recognized climate change is an important challenge that China will face in the future. In order to promote low carbon development, a series of new government institutions were setup in both central government and local government.

In year 2007, Chinese State Council established National Leading Group for Addressing Climate Change, Premier Wen Jiabao was the group leader, and ministers from National Development and Reform Commission, Ministry of Foreign Affair, Ministry of Finance etc. are group members. With the change of the Chinese government in year 2012, the State Council made an adjustment to the composition and personnel of the National Leading Group for Addressing Climate Change in in 2013. The new Premier, Mr. Li Keqiang, acted as group leader. Also, several functional departments, such as Ministry of Industry and Information Technology, were added. The National Leading Group for Addressing Climate Change is the top leading organization that makes important decisions in China.

Under the Leading Group, many ministries are involved in the climate change affair. China's National Development and Reform Commission is responsible for centralized administration. Ministries such as Ministry of Foreign Affair, Ministry of Finance etc. have their own responsibilities, as well. In 2012, the National Development and Reform Commission established a new institution, which is named the National Strategic Research and International Cooperation Center for Climate Change. This institution is specially aimed to provide decision consulting and a supporting service for climate change.

All the provincial level government (including the autonomous regions and municipalities directly under the central government) have established their leading groups for addressing climate change with the province governor serving as group leader respectively. Functional department of the provincial government is responsible for both provincial governor and related ministry of the central government. The provincial leading group is a inter-departmental coordination mechanism. Similar to central government, a number of provincial research institutions have been established to combat climate change and promote low-carbon development. For example, Tianjin Low-Carbon Development Research Center (TLCC) was founded in Tianjin City. Zhejiang Center for Climate Change and Low-carbon Development Cooperation was founded in Zhejiang Province. Beijing Climate Change Response Research and Education Centre (BCCRC) was established in Beijing City. Therefore, a climate change consulting and decision supporting system was formulated.

2.3.2 Legislation of Climate Change Laws

Not only government emphasized climate change, China's National People's Congress (NPC) is also preparing to establish a Climate Change Law. In recent years, the Environment Protection and

Resources Conservation Committee of the NPC is working together with the Legislative Affairs Office of the State Council to draft the Climate change law. A leading group of Climate Change Law Drafting was setup, and a basic legislative framework was established.

In the provincial level, provincial climate change laws are being drafted at the same time. Shanxi Province had issued the Measures on Addressing Climate Change in Shanxi Province. and Qinghai province have issued the Measures on Addressing Climate Change in Qinghai Province. Legislation in Sichuan and Jiangsu provinces are currently on a steady track. In October 2012, the Shenzhen Municipal People's Congress passed the Provisions of Carbon Emissions Management of the Shenzhen Special Economic Zone to strengthen the management of carbon emissions trading in Shenzhen. This is the first special law for carbon emission trading in China.

2.3.3 Composing Low Carbon Development Plan and Decomposition Responsibilities

The Outline of the 12th Five-Year Plan for National Economic and Social Development is the overall planning that guide China's economic development from 2011 to 2015. In the plan, there were 24 indicators were setup. Among all the indicators, 12 are binding indicators that requires central and local government to devote more efforts and support to realize. Among the 12 binding indicators, there were three indicators are related to China's low carbon development. They are: reducing energy consumption per unit of GDP by 16%c, cutting CO2 emissions per unit of GDP by 17%, and raising the proportion of non-fossil fuels of TPEC to 11.4% by 2015 comparing to year 2010.

Accordingly, ministries related with CO2 emission reduction in China developed low carbon development plan in their functional field. For example, Ministry of Industry and Information Technology developed Action Plan for Addressing Climate Change in Industry (2012-2020), Ministry of Science and Technology developed the National Plan for the Development of Science and Technology on Climate Change during the 12th Five-Year Plan etc. All related ministries were activated by the low carbon development requirement raised by the State Council.

The requirement raised by the Outline of the 12^{th} five-year plan is a heavy task, not only for all ministries in central government, but also for all provinces in all regions. The CO2 emission intensity target of 17% decrease by the central government was decomposed to all provinces (including the autonomous regions and municipalities directly under the central government) in mainland China. Quantitative targets of each province during the 12th Five-Year-Plan Period are given by central government (see Table 3). In this way, China's government system has built a target responsibility decomposition system of carbon intensity reduction. This could convey the pressure of the central government to the local government.

In order to evaluate the progress of each region's CO2 emission reduction, central government sent examination groups to provincial government to assess their work progress and listen to their feedback. In 2013, the National Development and Reform Commission, together with the relevant departments, formulated the first tentative assessment of the completion of the greenhouse gas emission control target of all provinces. Target achievement progress, carbon reduction measures, basic works, and capacity building activities at the provincial level in 2012 were evaluated by the assessment group from central government. This is a practical and efficient measure in China to

stimulate the awareness of local government in China of low carbon development in the kick-off stage.

Table 3 CO2 Emission Reduction Responsibility of Provinces in mainland China

	Target of CO2 Emission Reduction Per Unit GDP (%)	Target of Energy Consumption Reduction Per Unit GDP (%)
Beijing	18	17
Tianjin	19	18
Hebei	18	17
Shanxi	17	16
Inner Mongolia	16	15
Liaoning	18	17
Jilin	17	16
Heilongjiang	16	16
Shanghai	19	18
Jiangsu	19	18
Zhejiang	19	18
Anhui	17	16
Fujian	17.5	16
Jiangxi	17	16
Shandong	18	17
Henan	17	16
Hubei	17	16
Hunan	17	16
Guangdong	19.5	18
Guangxi	16	15
Hainan	11	10
Chongqing	17	16
Sichuan	17.5	16
Guizhou	16	15
Yunnan	16.5	15
Tibet	10	10
Shaanxi	17	16
Gansu	16	15
Qinghai	10	10
Ningxia	16	15
Xinjiang	11	10

Source: Working Scheme of GHG emission control of the 12th five-year plan
http://qhs.ndrc.gov.cn/zcfg/t20120228_467501.htm

2.3.4 Promoting Low Carbon Industry

The shift from high carbon development towards low carbon development requires the change of China's economic structure. Historically, China's economic development strongly relies on heavy industry, i.e. iron and steel production, cement production etc. Especially during year 2002 to 2008, heavy industry in China developed even faster. After year 2008, China begins to pay more attention

on the development of service industry and high-tech industry. Many favourable policies were given to support their development.

Since 2012, the central government decided to take a reform to replace the business tax with a value-added tax in the service industry. This is a very effective incentive policy to accelerate the development of service industry. Also, central government issued a series of policies, such as old-age service favourable policy to promote the development of service industry. By the end of year 2012, the share of service industry in China's economic structure increased 1.5 percentage point compared with year 2010.

Since 2009, Chinese government begins to select some new emerging industries to promote to increase a new incremental point to China's economy. After years of discussion, 7 Strategic Emerging Industries were selected, which are: energy conservation and environmental protection industry, new-generation of information technology industry, biology industry, high-end equipment manufacturing industry, new energy industry, new material industry and new-energy vehicle industry. The demand of the product from these industries is huge, and producing these products requires the latest technology advancement of the modern world. It should be notice that the development of these 7 emerging industries will be beneficial to the development of low carbon economy in China, especially the manufacture of energy efficient devices, renewable energy equipment and new energy vehicles.

China's central government issued a series of plans and policies to promote the development of seven strategic emerging industries. For example, the State Council issued the 12th-Five-Year Development Plan of National Strategic Emerging Industries in 2012. Ambitious goal of promoting the seven strategic emerging industries were put forward. Including: increasing the share of strategic emerging industry of total GDP to 8% by year 2015 and 15% by year 2020; promote the development of strategic emerging industry to annual growth rate of 20% etc. In order to realized the target, 20 "key Projects" was put forward in the plan, including: the project of the industrialization of energy conservation technology and equipment, the project of industrialization and demonstration of environmental protection and equipment, the project of broad-band China, the project of new type flat panel display etc. Central government and local government will provide favourable policy and government related investment towards these industries.

In China, there are some government involved capitals, such as the Special Fund of Strategic New Emerging Industry Development managed by Ministry of Finance. Many government funding had invested into these industries already. The planning developed by government of China raised the enthusiastic of the whole society. Many social venture capitals invested in these industries as well. By the end of year 2012, 138 venture capital funds have been set up, managing 38 billion RMB (about 6.1 billion USD). There are 38 venture capitals, with total amount of 11 billion RMB, are designed to stimulate the development of the energy-saving, environmental protection and new energy development.

2.3.5 Accelerating Technology Advancement

Technology is the kernel of low carbon development. In order to accelerate the shift from high carbon technology towards low carbon technology, much work had been done in China. Addressing

to existing production line and new established production line, different policies were developed by Chinese government.

Firstly, addressing to low efficient and out-dated industrial production lines, elimination policies were strongly propelled by Chinese government. The target of eliminating backward production capability during year 2011-2015, which is enlisted in table 4, was raised in the Energy Conservation and Emission Reduction 12th five-year Plan issued by the State Council. In order to realize this plan, the Ministry of Industry and Information Technology developed detail work schedule of all provinces and each year from 2011-2015. In each year, a name list of the enterprises with outdated production line is publicized in its website. Central government decompose the tasks to provinces. Provincial government breaks down the tasks and assign them to government of cities, towns and enterprises. Central government and local government will provide compensate to enterprises that obsoleted the backward equipment. Annually, central government will do evaluation of the progress in all provinces last year. After the evaluation in 2012, China eliminated obsolete production capacity in the following industries: iron smelting, 10.78 million tons; steel production, 9.37 million tons; coke, 24.93 million tons; cement (clinker and mill), 258.29 million tons; plate glass, 59.56 million cases; paper, 10.57 million tons; printing and dyeing, 3.26 billion meters; lead battery, 29.71 million kvah.

Table 4 Target of Eliminating Backward Production Capability during 2011-2015 (digested)

Industry	Main content	Unit	Capability to be eliminated
Power Generation	Single unit under (or equal) 100MW conventional coal-fired power generation unit in the main grid coverage. Single unit under (or equal) 50MW conventional power generation unit. Single unit under (or equal) 50MW oil-fired boiler and power generation unit.etc.	10MW	2000
Iron Production	Blast Furnace under (or equal) 400cubic meters	10 thousand ton	4800
Steel Production	Rotary Furnace and Electric Furnace under (or equal)30 ton	10 thousand ton	4800
Calcium carbide	Single unit under(or equal) 12500 KVA and open unit	10 thousand ton	380
Electronic Aluminium	Pre-baked Cell under (or eqal) 100kA	10 thousand ton	90
Cement	shaft kiln, dry kiln etc.	10 thousand ton	37000
Glass	Pull processes flat glass production line etc.	10 thousand heavy box	9000
Incandescent light bulbs	60 watt incandescent lamp for lighting	100 million unit	6

Source: digested from Energy Conservation and Emission Reduction 12th five-year Plan

At the same time, advanced low carbon technologies are demonstrated and promoted in China. NDRC issued the 5 batches of the Catalogue on the Promotion of National Key Energy Saving Technologies to the public, which enlisted 186 advanced technologies totally, from year 2007 to 2012. Users from enterprises could find latest energy efficient technologies from the catalogue. Also,

enterprises that conduct energy conservation retrofit could receive subsidy from central and local government. In year 2012, 2411 energy conservation retrofit projects from enterprises received subsidy of 7.5 billion RMB (1.2 billion USD) from central government to improve its energy efficiency. In addition, during the 12th Five-Year Plan period, NDRC initiated the National Low Carbon Tech Innovation and Model Industries Projects. According to this activity, 34 model projects have been launched in the coal, electric power, and building materials industries in 2012. Therefore advanced energy efficient technologies are promoted very quickly.

Carbon capture, use and storage technology (CCUS) is an important low carbon technology in future low carbon development. China has started to use CCUS on projects with the help of Chinese government. Sinopec Group has established the first full-phase demonstration project in China using CCUS for coal-fired power plants. By 2012, Shenhua Group's CCUS demonstration project has stored 57,000 tons of CO2 in total. By June 2013, China's first CO2 geological storage demonstration project in Ordos, Inner Mongolia has sequestrated 120,000 tons of CO2.

In order to promote technology innovation and research of low carbon technology, Chinese government developed a series of plans and favourable policies. For example, the Ministry of Science and Technology released Specific Plans for Clean Coal Technology During the 12th Five-Year Plan Period. In the plan, clean coal technology is regarded an important direction. Efficient clean coal-fired power generation, advanced coal conversion, advanced energy-efficient technology, pollution control and resource efficient utilization technologies are the focus of future development. As a research result, commercial demonstration of coal-based Integrated Gasification Combined-Cycle (IGCC) power station came into operation in Tianjin City by Huaneng company in December 2012. This power station is designed, constructed and operated by China independently. Its a landmark of China's breakthrough in next generation of clean coal power generation technology. As a coal base energy structure, the technology innovation of clean coal technology will bring strong influence of China's energy strategy and low carbon development in the future.

Due to strong government push and market pull, the penetration rate of low carbon technology increased very quick. For example, the share of thermal power units above 300GW increased from 42.7% in year 2000 to 75% in year 2011, the share by output of new type dry kiln in cement industry increased from 12% in year 2000 to 89% in year 2011. There are 54 supercritical coal-fired power generation units were in operation in China, with largest installation amount in the world.

Table 5 technology penetration rate improvement in different industries in China

Industry	technology	2000	2006	2008	2010	2011
Power generation	Share of units above (or eqal) 300MW thermal power generation unit /%	42.7	48.3	66.1	72.7	75
Iron and Steel	continuous casting ratio of steelmaking big iron and steel enterprises /%	82.5	98.6	99.2	99.47	99.50
	Penetration rate of dry coking of big enterprises/%	6	40	50	82.6	84.1
	TRT penetration rate of BF above 1000 cubic meters /%	50	95	98.6	100	100
Coking	Share of machinery coking to coke output/%	72	88	96.3	99	99

Electrolytic Aluminium	share of large pre-baked cell to aluminium output /%	52	82	86	90	95
Building materials	Share of new dry kiln of all cement output%	12	50	61.8	80	89
	Share of floating method glass production of all grass output /%	57	82	83	86	89.2
	Share of new type of wall material of all wall material output /%	28	40	50	55	61

Source: Wang Qingyi, Energy Data Collection 2012.

2.3.6 Promoting Low Carbon Energy

Energy structure is a decisive factor of low carbon development, which requires more renewable energy and nuclear energy. China had attached great importance on the development of low carbon energy. Total consumption of non-fossil energy in China increased from 93.1 million tce in year 2000 to 340.0 million tce in year 2012, with average growth rate of 11.4%.

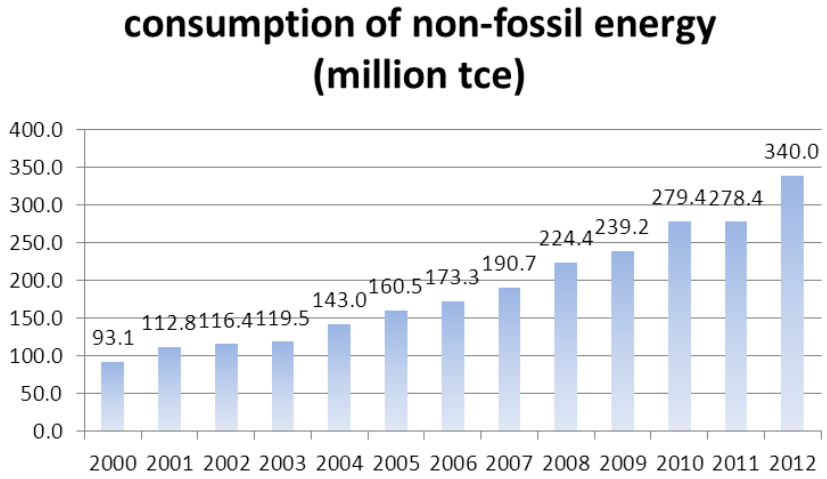

Figure 6. Consumption of non-fossil energy in China

By year 2012, the installation of hydro power plant in China reached 249 million kW, ranking first in the world. On-grid wind power installation capacity was 61.42 million kw, which was largest in the world. On-grid solar power reached 3.41 million kW, growing 60.6 percent from year 2011. Nuclear power plants installation reached 12.57 million kW, and the scale of nuclear plants under construction is the largest in the world. The share of power generation installation of non-fossil fuel is 28.5%, which is 4.2 percentage points higher than that of 2005. The share of electricity generated by non-fossil fuel occupies 21.4% of total on-grid electricity by 2012.

China's nuclear power development was influenced by the Fukushima nuclear accident which happened in year 2011. The construction of new nuclear power station was delayed for some time. However, after careful study and overall weighting between the defect of developing nuclear energy and the fast growth of energy demand, the urgent need of environment protection and GHG mitigation, the State Council of China decided to continue to develop nuclear energy in China. Nuclear power still remains to be an important measure to solve energy supply problem, and it is impractical to abandon nuclear completely, at least in next two decades.

2.3. 7 Promoting Regional Low Carbon Development Demonstrations

China is trying to find a low carbon development path towards a low carbon society. However, there is no existing model that could be copied to China. It is recognized that different regions with different resource condition, population density and different development stage, should adopt different low carbon development mode. In order to explore the successful mode in China's low carbon development, five provinces, which are Guangdong Province, Liaoning Province, Hubei Province, Shanxi Province and Yunnan Province, and eight cities, which are Tianjin City, Chongqing City, Shenzhen City, Xiamen City, Hangzhou City, Nanchang City, Guiyang City and Baoding City were selected to be the first group of regional pilot of low-carbon development. Each province and city developed their own plan, including optimizing energy structure, promoting low-carbon development in industrial sector, transportation sector and building sector, demonstrating low-carbon lifestyle, increasing forest area etc. In year 2012, 2nd group of low carbon provinces and cities, including 29 provinces and cities, such as Beijing City, Shanghai City, Shijiazhuang City, Hainan Province, were selected for low carbon pilot.

Active GHG emission goal are put forward by all these provinces and cities. In order to assess the result, carbon emission statistics and management systems of greenhouse gas emission are required to establish. Many activities and information campaigns, such as advocating low-carbon green lifestyle and conservative consumption model, were conducted in these regions. Some regions made commitment on total GHG emission control target and emission peak year of the region.

2.3.8 Starting Emission Trading Scheme Pilot

Emission trade is regarded as a useful tool to introduce market mechanism to make carbon emission more cost effective. In year 2011, five regions in China are permitted by National Development and Reform Commission to initialize carbon emission trading. These regions are: Beijing City, Tianjin City, Shanghai City, Chongqing City, Shenzhen City, Hubei Province and Guangdong Province. In October 2012, Shenzhen government issued management regulations of CO2 trading. From July to August, 2013, carbon emissions trading management regulations develop by Shanghai City, Guangdong Province and Hubei Province respectively are open for public to receive comments and recommendations. The range and number of enterprises that participate in the emission trading scheme are selected based on the local economic development trend, local energy saving and emission reduction target, the emission of individual enterprise and the emission level of the whole industry. Emission quotas were allocated to related enterprises by local government. Carbon emission and reduction calculation approaches and standards were developed. Historical data of enterprises' carbon emissions were collected. Government of Shanghai City issued carbon emission calculation guidelines for industries, such as Iron and steel Industry and power generation industry in October 2012. Government of Shenzhen City issued data reporting and verification guidance and detailed rules for construction industry in 2012 and April 2013 respectively. By the end of year 2013, the total trading volume conducted through carbon emission trading platform of Shenzhen City has been more than 110 thousand ton, and the turnover is more than 7 million RMB (1.1 million US $).

2.3. 9 Collecting Basic Information

Statistic data is the basis of policy development and carbon emission control. Comparing with OECD countries, the carbon statistical data and related accounting system in China is rather weak. Addressing to this situation, the National Bureau of Statistics developed detailed rules to establish a statistical indicator system of greenhouse gas emissions statistics. Presently, all industrial enterprises with energy consumption above 5000 tce are required to report their own energy use data and energy efficiency data to National Bureau of Statistics. Greenhouse gas emission inventories of year 2005 and year 2010 were developed in all 31 provinces (including autonomous regions and municipalities). Through this procedure, the basic information of greenhouse gas emissions is made clear.

Energy consumption data is not only collected by National Beau of Statistics, but also by related government departments at the same time. Government departments that in charge of energy conservation in industrial sector, building sector and public institution sector are collecting basic data through their own system respectively. For example, Government Office Administration of the State Council, which is in charge of energy conservation of public institutions, had collected energy consumption data and water consumption data of public Institutions of year 2011 and 2012. Data sheet from over 690,000 public institutions nation-wide were reported to Government Office Administration of the State Council. In order to provide more detailed and dynamic data of energy use and carbon emission, government of 23 cities decided to establish energy data centres in their own city.

Regarding the carbon sink data, the State Forestry Administration collected provincial forest resources and other forestry statistics, and measured the forested area and the changes in different provinces across the country.

2.3.10 Promoting Clean Development Mechanism Projects

Clean Development Mechanism (CDM) is a trade mechanism between OECD countries under Kyoto Protocol and developing countries. By the end of August 2012, there were 4540 CDM projects were ratified by Chinese government. These projects covers wide ranges, including new energy and renewable energy, energy conservation and the energy efficiency improvement, methane recycling etc. Estimated annual certified emissions reduction (CER) of these projects has reached 730 million tons of CO2 equivalent. Among these projects, there were 2364 projects had been registered in the United Nations Clean Development Mechanism Executive Board, accounting for 50.41% of the total registered project in the world. The estimated certified emission reduction (CER) has reached 420 million tons of CO2e annually, accounting for 54.54% of the global total. China tops the list in both numbers of registered projects and annual certified emissions reduction (CER). By the August of year 2012, there were 880 projects that registered had been approved, with total volume of 590 million tons of CO2e.

2.4 Persecutions of China's Low Carbon Development Path

Although China had made some progress in low carbon development, there is still a huge challenge in the coming future.

2.4.1 Challenges of China's Low Carbon Development

There are four main challenges for China to realize its low carbon development, which are: fast growth of energy demand, coal dominant energy mix, double burden of environmental issues, and middle income trap.

2.4.1.1 Grow of Total Energy Demand

China's energy demand is still increasing with a high volume. From year 2005 to 2012, the annual demand increased 180 million tce, which is the same as total energy consumption of Australia. Although China is the largest energy consumer in the world, its demand of energy has not reach its peak. By year 2011, the energy consumption per capita of China is only 2.9 tce, which is only 47% of the average of OECD countries (see figure 7). As a most energy efficient country, Japan's energy consumption per capita is still 5.2 tce, which is 1.8 times of China's current level. At the time that China reach its peak of energy consumption per capita, assuming China could gain 20% energy efficient than Japan's current level, China's energy consumption per capita will reach 4.1 tce. Multiplied by China's estimated population by year 2050, the total primary consumption of China at that time might reach 5800 million tce, which is 1.6 times of current level. However, this is a rather ideal case. If China's current economic structure and lifestyle remain unchanged, the total energy consumption will be much higher than 5800 million tce by year 2050.

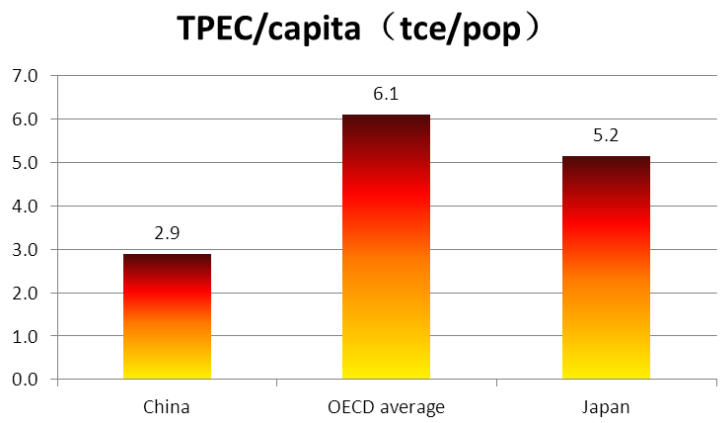

Figure 7. Comparison of TPEC per capita in China, OECD average and Japan
Source: IEA, Key World Energy Statistics 2013

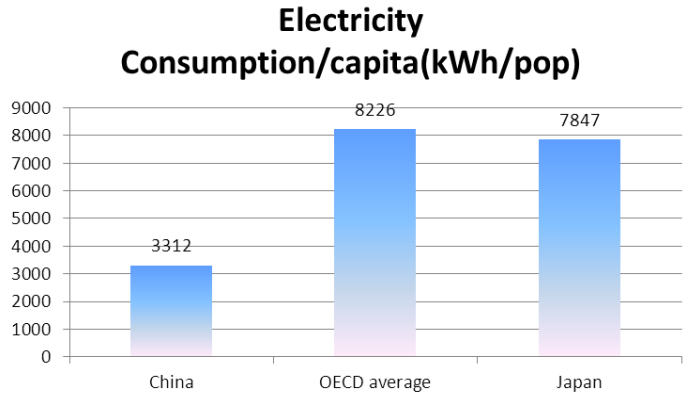

Figure 8. Comparison of TPEC per capita
Source: IEA, Key World Energy Statistics 2013

Also, electricity consumption per capita is another important indicator that shows living standard and economic development of a country. By year 2011, China's electricity consumption per capita is 3312 kWh/pop, which is only 40.3% of average level of OECD countries and 42.2% of Japan (see figure 8). That means when China reaches its goal of middle developed countries by year 2050, total installation of power generation stations will be at least doubled.

2.4.1.2 Difficulties in Energy Mix Optimization

In the next 30 years, the first urgent issue of China is to satisfy its huge energy demand. During this procedure, China should do its best to optimize its energy mix. Seen from the long history of human being, there had been two major energy mix shifts happened in the past thousands of years. The first major shift is from biomass to coal, which had started from 1860's. At that time, the innovation and fast promotion of steam engine enabled machinery to substitute human labour. After 50 years, coal became dominant energy in global energy mix and reached its peak in the energy structure. The second major shift is from coal to oil, which had started from 1880's. At that time, electricity generation device, electric motor and internal combustion engine were invented. With the development of human society, the better performance of oil product was accepted by more and more people. Thus, oil became dominant energy resource since 1970's, and the share of in energy mix peaks in 1980's (see Figure 9). Until present days, oil is still occupies 33% of total energy consumption in the world. The evolvement of energy mix in the world is the result of people's demand of an economic, convenient, efficient and clean fuel. Resource scarcity is not the main restrain of last two energy shifts.

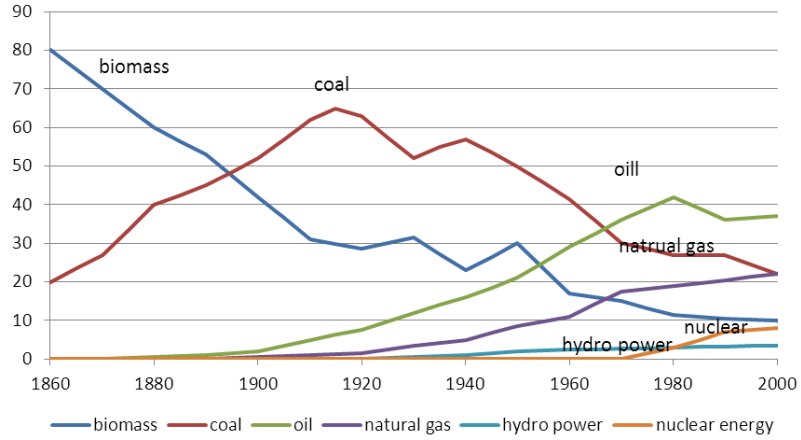

Figure 9. Evolvement of energy mix in the world
Source: Jiangzemin, Reflections of Energy Issue in China, Journal of Shanghai Jiaotong University

Comparing with involvement of world energy mix, China's energy mix optimization is only in the preliminary stage. Coal occupies about 70% of total energy consumption in China. China is abundant in coal resource and scarce in oil and natural gas resource. Comparing with oil, natural gas, nuclear electricity and renewable energy, coal is the cheapest in China's domestic energy market. This is the main reason of large CO2 emission.

Regarding to Chin's low carbon development, there are two ways to reduce the emission from coal utilization: the first way is to continue to use coal, but adopt clean coal technology and introduce CCS technology as soon as possible. This road is determined by technological advancement of clean

coal technology and CCS technology. It is commonly recognized that CCS technology could not come into commercial operation before 2030. The second road is to promote compulsory policies (either administrative measures or taxation measures) to control the usage of coal. Some experts begins to discuss control the consumption of coal, but this is really tough if the market signal, which is related to coal price and CO2 tax, remains unchanged.

2.4.1.3 Double Burdon of Environmental Tasks

The influence of economic development to environmental could be divided into local influence and global influence. Usually, local pollutions could raise the alert of people much easier than the global one. From the experience of human development history, it could be noticed that developed countries had solved their local pollution problems first. For example, there were Los Angeles Smog Disaster in 1943 in the United States, London Smog Disasters in 1950 in UK, Minamata disease in Japan in the 1960's. After years of fighting, these local pollutions were well treated. Global warming and climate change issue was realized and wide spread by scientist only after year 1980. In year 1992, United Nations Framework Convention on Climate Change was held at the United Nations Conference on Environment and Developmentsigned in Rio de Janeiro, Brazil. After the winning the combat of local pollutant, the developed countries have more strength to devote into the fighting against global environmental issues.

However, China is a developing country which its industrialization has not been completed. China's local pollution is becoming more and more serious, especially in recent years. Since year 2013, the air quality in China became even worse due to wide range of haze, which is mainly PM2.5. Besides PM2.5 pollution, other environmental problems such as acid rain, water pollution, soil pollution, food safety is still sever. China has to fight against local pollution and GHG emission simultaneously. Therefore, the stress of China is much larger than developed countries and other developing countries.

2.4.1.4 Difficulties in Economic Development

As china has stepped into high middle income countries, the difficulties of further development of its economy is becoming even more difficult. According to the economics research result, there is a phenomenon called Middle Income Trap. It means that when a country reaches the level of middle income, the former advantages (such as cheap labor cost) will be lost and new disadvantages (such as the unequal dispatch of social wealth) will appear. Therefore, the nation's economy will be stuck in the same level and could not further develop anymore. Brazil and South Africa had been stuck in the middle income trap for a long time.

After 30 years of economic development and accumulation of social wealth, the gap between the rich and the poor is becoming more and more obvious. Social problem has become more and more serious in recent years. At the same time, the overcapacity of happens among half of industrial sectors. According to the survey by National Development and Reform Commission, among all 39 industrial sectors in China, there are 21 sectors is in the status of overcapacity. In year 2013, the profit of producing a ton of steel is only 0.84 RMB, which is not enough to buy a bottle of Coke Cola in China. The income of industrial workers is influenced as well. China's economic growth rate had

decreased from 14.2% in year 2007 to 7.7% in year 2012. How to avoid the middle income trap is still wait to be seen.

2.4.2 China's low carbon development road in the future

Although there are great challenges in future development of China, China had decided to shift from high carbon development road to low carbon development road. Detailed quantitative targets of year 2015 and 2020 are put forward.

2.4.2.1 Reducing CO2 emission density 40-45% by year 2020

In year 2009, Chinese premier Wen Jiabao made a formal commitment of reducing unit CO2 emission per GDP by 40%-45% by year 2020 compare to year 2005. This is regarded a binding goal for China to design its social and economic development road. In the 11th five-year period, China's unit CO2 emission per GDP had decreased about 21%. This is the first step of realizing the 2020 target. The design of China's 12th five-year plan (2011-2015) is the second step, in which the CO2 reduction target was set to 17%. If the first two steps could be realized, then the goal of 13th five-year plan could be calculated. According to author's calculation, if the 2020 reduction target is 40%, then the target of the 13th five-year period will be about 8.5%; If the 2020 reduction target is 45%, then the target of the 13th five-year period will be about 16.1%. That means the CO2 emission intensity reduction target in the 13th five-year will be 8.5%~16.1%, if the 12th five-year CO2 emission reduction target could be realized smoothly.

However, realizing China's 12th five-year CO2 emission reduction target is not easy. Mr. Xie Zhenhua, Deputy Chairman of National Development and Reform Commission had express during the COP 19 conference that China had reduced its CO2 emission intensity by 28% from year 2005-2012. Much capital investment had been devoted into CO2 emission reduction. However, there is still a big gap towards the 40%-45% emission reduction target. In the future, the basis of emission reduction will be larger, and there are less and less "low hanging fruits". The difficulties will be much larger. He further confirmed that although there is great difficulties, China will not revise the 2020 emission reduction target, and do its best to get a better result.

2.4.2.2 CO2 emission in the long run

Nearly all estimations by research institutions showed that China will continue its CO2 emission before year 2020 without any doubt. The question is: when will China peak its CO2 emission? At present stage, no one can say for sure. According a report issued by Energy Research Institute of National Development and Reform Commission in year 2009, China's CO2 emission will continue to grow before year 2035. After year 2035, China's emission may vary in different scenarios. In the most ideal scenario, if most of the emission by OECD countries could be reduced strongly with widespread of CCS technology, China's CO2 emission may reduce to the year 2005 level. In the worst Energy Conservation scenario, the peaking period of CO2 in China will be very late, even later than year 2050. In the Low Carbon Scenario, China may begin to decrease its CO2 emission slowly after year 2035 (see figure 10).

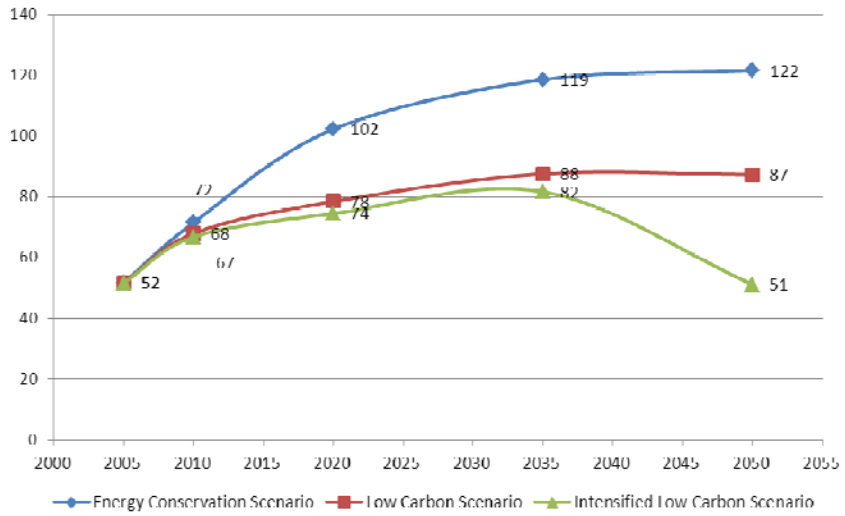

Figure 10. Long Term Emission Estimation of China (Unit: 100 Mil. ton of CO2)
Source: Energy Research Institute, China's Low Carbon Development Pathways by 2050

It has to be noticed that compared with the reality, ERI's estimation is still an ideal forecast. Actually, the CO2 emission of year 2010 of China has reached 7710 million tons of CO2. This is 7% higher than the Energy Conservation Scenario in year 2010, which is the highest point in the figure.

2.4.2.3 How to promote CO2 emission further

As described above, China had been fighting hard for its CO2 emission reduction. Much effort were done and the result is obvious. However, it could be noticed that almost all activities are dominated by Chinese government system, including different ministries in the central government and all level of government from different regions. A government dominate CO2 emission reduction activity has its own benefit, such as more easy to get government commitment, quick kicking off, easy to get government funding etc. However, it has its own defect: 1) the internal enthusiasm of enterprises could not be fully motivated; 2) supervision of all key energy users requires huge amount of human labour and work, which is a heavy burden of government budget and reduce the efficiency of government; 3) the risk of fake data and fake information reported from enterprises and basic government might mislead the decision making. After several years implementation, the defect of administrative measures is becoming more obvious.

In order to further promote CO2 emission reduction in China, besides the administrative measures, it is recommended to induce more market based measures in the next stage. This requires an in-depth reform of China's energy pricing system and taxation system. Currently, energy pricing in China could not reflect the supply and demand balance of the market, could not the scarce of local resource depletion and could not reflect the economic externalities of energy resource. Energy pricing reform, combined with taxation reform, including resource tax, CO2 emission tax etc., should receive much emphasis in policy development. As a country shifting from planning economy towards market economy, most officials are used to use administrative measures in policy development. They are not familiar and confident to use market based measures. However, after more than five years administrative policies, the marginal benefit of administrative policies are decreasing. There are less and less "low hanging fruit" in administrative policy development. Therefore, more and more market based policies should be adopted as soon as possible.

Conclusion

(1) Although China is a developing country, it has become the largest energy consumer and CO2 emitter. Taking a low carbon development road is not only the reaction from international stress, but also the internal demand of China's own sustainable development.

(2) A series of efforts were made in China with the strong propulsion of Chinese government. Good achievements were accomplished. From year 2005 to 2012, CO2 emission per GDP decreased 28%.

(3) There are four risks in CO2 emission reduction of China in the next stage, which are: fast growth of energy demand, coal dominant energy mix, double task of environment treatment, and step over the middle income trap. As there are less and less "low hanging fruit", its more and more difficult in further emission reduction.

(4) Reducing CO2 emission intensity targets is regarded as a binding indicator for China's low carbon development before 2020. Long term emission reduction is still uncertain. Combined with current administrative measures, China should adopt more market measures, such as pricing reform and carbon tax, to further activate the internal enthusiastic of enterprises and the whole society.

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Figure captions

Tables