The Contradiction in China's Economic Growth, Energy Consumption and Pollution

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Abstract

China, as a developing country with a population of 1.3 billion, has to develop the economy to improve people's living standards on one hand, and energy consumption, which would cause environmental damage and pollution, on the other hand. At the beginning of 2015, a documentary Under the Dome (Chai, 2015), which discussed the smog and pollution situation in China, triggered the Chinese people's awareness to recognize and understand $PM_{2.5}$ (particulate matter under 2.5 microns in diameter). People began to think deeply about the smog problem in China. Which is more important, environmental protection or the livelihood of Chinese people? How should a decision like this be made? There are economics and sociology accountings under any choice. In other words, there is loss and gain no matter what is chosen. This paper analyzes economic development, energy structure transition, and the environmental situation in China, to help people understand China's energy situation and have confidence in China's future.

1. Introduction

China is one of the biggest developing countries in the world with about one fifth of the total population of the world. The relationship between energy and economic growth matters greatly in China. With rapid economic development, China is faced with an unprecedented challenge in environmental protection. China's energy structure has been in the coal stage. In the process of using coal, it has caused serious environmental and health problems. Coal is the first cause of smog in many parts of China. The emissions of sulfur dioxide (SO_2) and carbon (C) particles in the process of using coal react to form organic carbon (OC) and sulfates, which are the main components of $PM_{2.5}$. Energy consumption contributes to carbon dioxide (CO_2) emissions significantly; and the burning of fossil fuels is currently the leading cause of increased C in the atmosphere. China relies mainly on fossil energy production and consumption, which causes high C emissions, accounting for 70% of the total C emissions in the atmosphere (China National Information Center, 2014).

The theoretical research on energy consumption and environmental pollution problems can be traced back to the pioneer of the famous environmental protection organization, the club of Rome, which did the first report of *Limits to Growth* to the world in 1972. The report emphasizes the restriction faction of the energy situation to economic growth and social development (Meadows, Randers, & Meadows, 2006). Similar research has been conducted recently in China. Zheng, Deng, Yan, and Zhao (2005) set up three kinds of scenarios, forecasting and analyzing future energy consumption and the environmental impact situation in China. They concluded that due to the energy consumption in the future, SO_2, NOx, CO_2 and soot emissions will remain high.

They further stated that energy consumption and environmental problems can be solved by improving energy efficiency and strengthening the development and utilization of clean energy. Shen and Su (2013), and Zhu, Peng, Lu, and Wu (2009) set up a decomposition model based on the extended Kaya identity and analysis of energy consumption and carbon emission from 1980 to 2007 in China. The results showed that the economic output effect contributed the most to the energy consumption and the C emissions at that time. Ma and Zhang (2014) used the spatial effect method, building the space Environmental Kuznets Curve (EKC Curve) regression model, discussing, and analyzing smog pollution from the perspective of energy structure and spatial effect.

Kuznets curve model showed that when the energy consumption structure in coal rises 1%, $PM_{2.5}$ concentrations will increase 0.52% to 0.64% accordingly. This indicates that both industry structure change and energy consumption structure change will cause corresponding changes in smog pollution. The pollution level is closely related to energy structure and industrial structure change. Zhang, Wang, Xing, Zhao, and Hao (2008) established China's 2000 and 2005 NOx emissions inventory; Shi, et al. (2014) also established a 2000-2014 NOx emissions inventory. The results of the analysis showed that NOx emissions continued rising with the increase of energy consumption. But in the policy scenario, the total emissions can be controlled and were less than expected. Similarly, CO_2 emission rises with the increase of energy consumption. Lin, Yao,and Liu (2010) established optimization models that reflected the optimal energy structure under the restriction of energy conservation and emissions, leading to the computable general equilibrium model.

The results showed that the government's renewable energy plan had significant positive effects on CO_2 emissions. Zhang, Yang, and Wang (2014) utilized the system dynamic theory and method to predict the demand of energy and CO_2 emissions in China by applying the situation analysis.

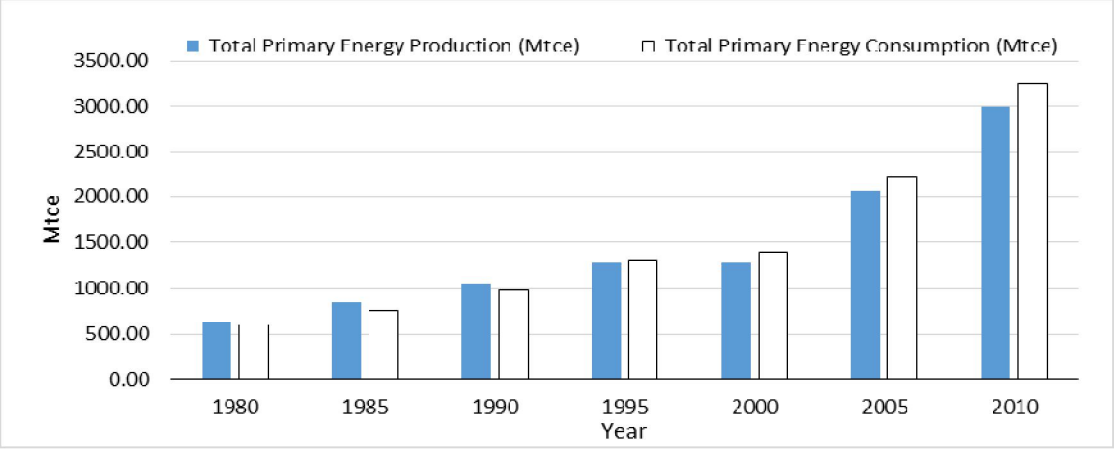
The results showed that there was a 58% reduction in the carbon intensity (the carbon emission per unit GDP, the unit is ton/10,000 RMB) compared with the carbon intensity in 2005under the low carbon scenario, which means that low carbon is the best option for the future development of China's energy structure. It is in accordance with the requirement of future development.

2. Discussion

2.1. China Energy Consumption and Smog

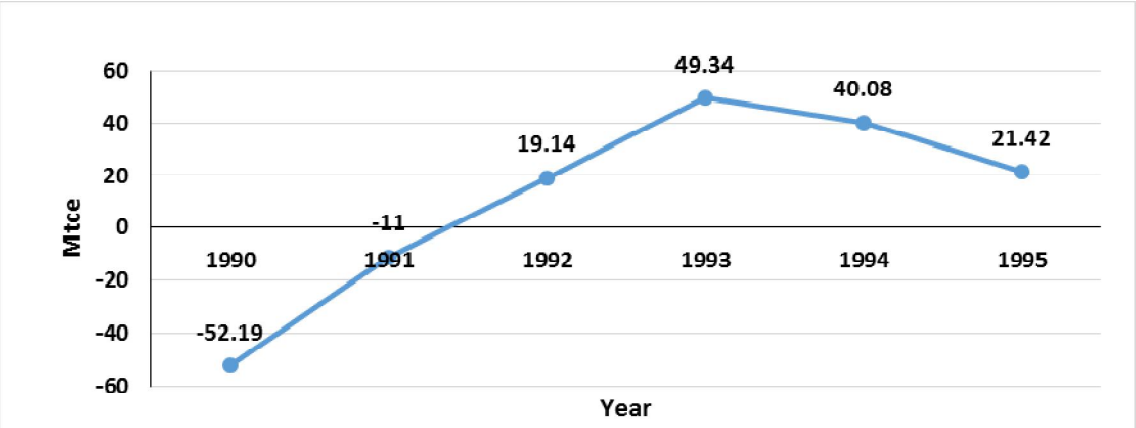
The constraints of resource and environment became serious issues in social and economic sustainable development. In 1980, China's energy consumption was only 600 million tons coal equivalent (Mtce); then it went up to 1400 Mtce in 2000, 3250 Mtce in 2010 (China Energy Statistical Yearbook, 2011), and 3750 Mtce in 2013 (British Petroleum, 2014). China accounted for about 12% of global GDP, but their energy consumption accounts for about 22% of the world's consumption, and carbon emissions close to 30% of the world's emissions (Kang, 2015). Since reform and opening in 1978, economic growth has been rapid. Primary energy consumption has also grown accordingly and gradually increased faster than the energy production gains (Figure 1). Until 1992, China's total energy consumption was greater than the total energy production (Figure 2).

Figure 1: Total primary energy production and consumption from 1980 to 2010.



Data source: China Statistical Yearbooks, 2011; China National Statistics Bureau

Figure 2*:* Difference of energy consumption and production from 1990 to 1995.



Data Source: China Statistical Yearbooks, 2011; China National Statistics Bureau

In 2005, China was the second largest energy producer and consumer. From 1980 to 2006, China's energy consumption grew by an average of 5.6% in support of a growing national economy with an average growth of 9.8% annually (China Energy Strategy, n.d.). Especially in the 21st century, China's energy consumption has continued to increase, which leads to serious pollution problems.

2.2. A sharp contradiction between the economic growth and environmental protection

At the beginning of 2015, the documentary *Under the Dome* raised people's attention to smog. Since $PM_{2.5}$ monitoring data became available to the public in 2012 in China, people felt that smog had suddenly appeared.
PM is the abbreviation for particulate matter. Usually, the air dynamic force under the equivalent of 10 microns in diameter of particles is called PM_{10}, also known as inhalable particles or fly ash, and the air dynamic force under 2.5 microns in diameter particles are known as $PM_{2.5}$, which are also known as reparable particles or fine particles. The concentration unit for PM is $\mu g/m^3$. In general, the particle sizes between 2.5 to 10 microns in diameter are mainly from road dust. $PM_{2.5}$ is mainly from the burning of fossil fuels, such as oil and coal.

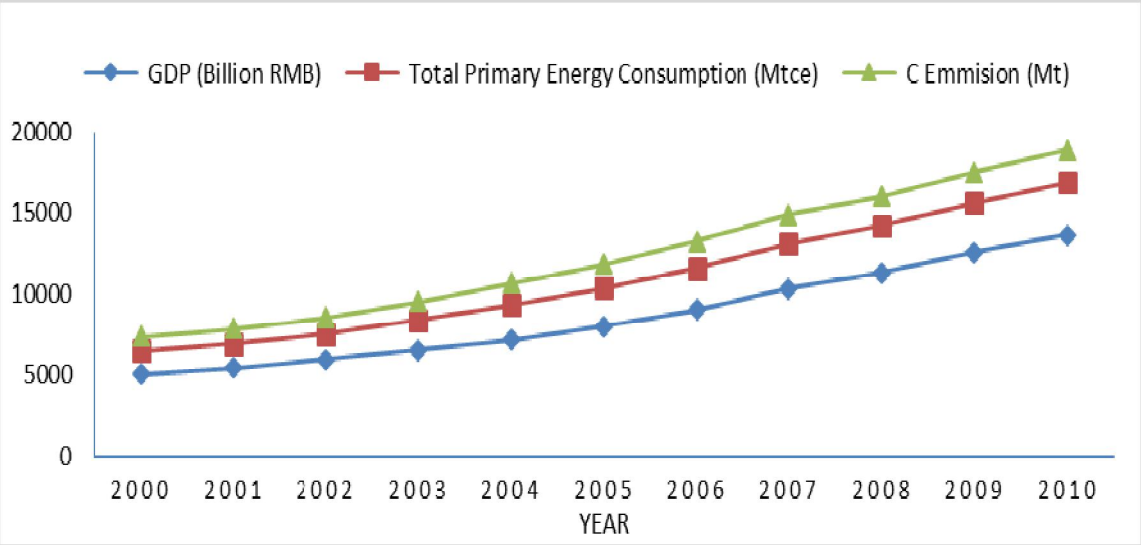
The source and composition of $PM_{2.5}$ is complex. The main ingredients of $PM_{2.5}$ are elemental carbon, organic carbon compounds, sulfates, nitrates, and ammonium salt. Although $PM_{2.5}$contains only a few of the components of earth's atmospheric composition, it has an important effect on visibility and air quality. Compared with coarser atmospheric particulates, the volume of $PM_{2.5}$ is small, but rich in poisonous and harmful substances.

$PM_{2.5}$ can remain in the atmosphere for a long time, and be carried long distances and affecting human health and the atmospheric environment quality. $PM_{2.5}$ mainly causes damage to the respiratory and cardiovascular systems, including irritation of the respiratory tract, coughing, dyspnea, reduced lung function, increased asthma, chronic bronchitis, arrhythmia, non-fatal heart attack, and heart and lung disease or premature death (China Environmental Protection Network, n.d.).

Actually, the smog has long been existed in China. Why was it taken into account in recent years? Before, the Chinese officials had reported fog instead of smog, and the news propaganda also used "fog" instead of "air pollution" or "smog." For example, in 2003-2008, the Chinese were in a particularly serious smog period, but no one knew this should be called smog, since all instances were considered to be fog. The documentary recorded that on December 2, 2004, the Beijing area encountered severe winter heating smog with visibility of less than 200 meters in the densest smog, and flights could not depart at the airport. The title of the news reports throughout the day was*The Beijing Capital Airport had the Most Serious Flight Delays in Recent Years Due to the Fog* (China News Service Network, n.d.). After presenting $PM_{2.5}$ to the public, people had more knowledge about smog and air pollution. Because smog is harmful to the environment and human health, more people began to pay attention to it and they are even afraid of it.

Figures 3-6 show that there is an apparent contradiction between China's energy development and environmental protection. From 2001 to 2010, the overall national pollution level was on a rising trend. In this period, China's coal consumption accounted for 70% of its total energy consumption (China Statistic Bureau, 2011).From 2000 to 2010, the GDP grew and the primary energy and C emissions increased as depicted in Figure 3.

Figure 3: Comparison of GDP, primary energy consumption and C emissions from 2000 to 2010



Environmental pollution has affected the sustainable development of the national economy and people's health. As shown in Figures 4-5, the total emission of major pollutants such as SO_2 and soot was increasing from 2001 to 2005. In 2005, the SO_2 emissions were 25.5 Mt and soot emissions were 11.82 Mt. The SO_2 and soot emissions caused by coal accounted for 70% ~ 80% of the total emissions. Acid rain areas formed from SO_2 emissions were a third of the total land area. Industrial SO_2 and soot emissions accounted for 80% of the total emission respectively. With the energy structure adjustment and energy conservation and emissions reduction at the eleventh five-year-plan (11^{th} FYP, 2005-2010) period, SO_2, soot, and industrial dust emissions dropped year by year, but still remained at a higher level (Figures 4-6). C emissions continued to grow with the increase of energy consumption, but the emission intensity dropped (Table 1).

Figure 4: Comparison of industrial and domestic SO_2 emission from 2001 to 2009.

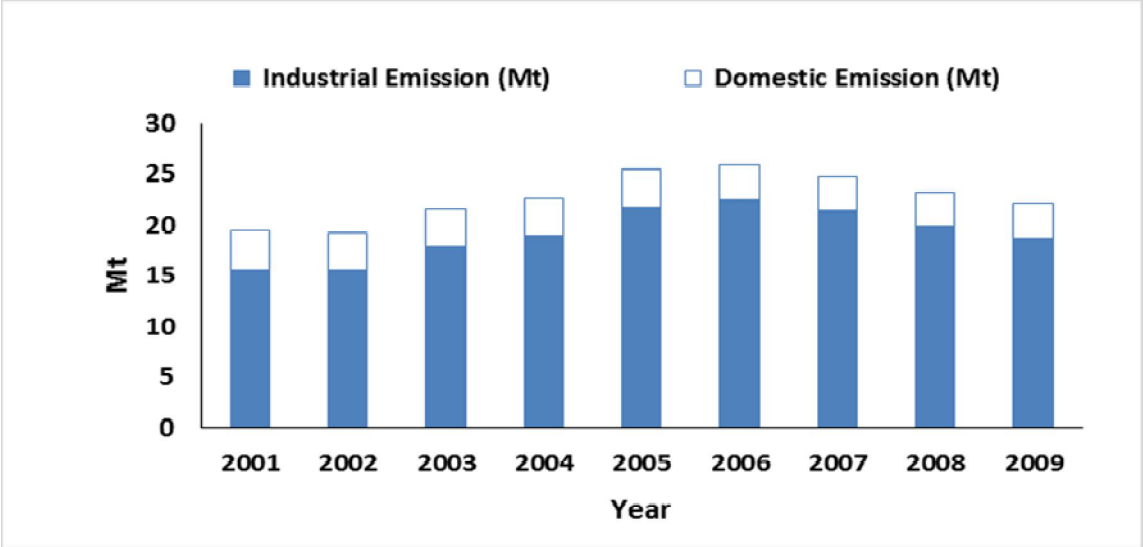


Figure 5: Comparison of industrial and domestic soot emission from 2001 to 2009

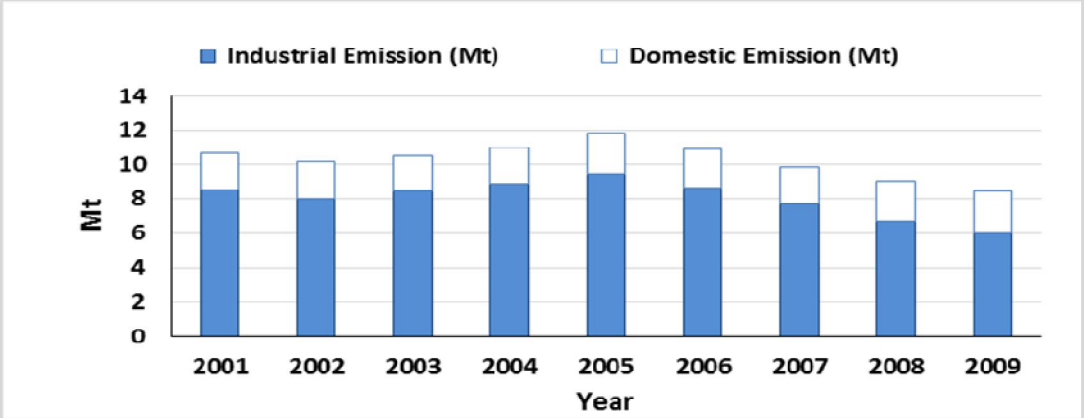


Figure 6: Industrial dust emission from 2001 to 2009.

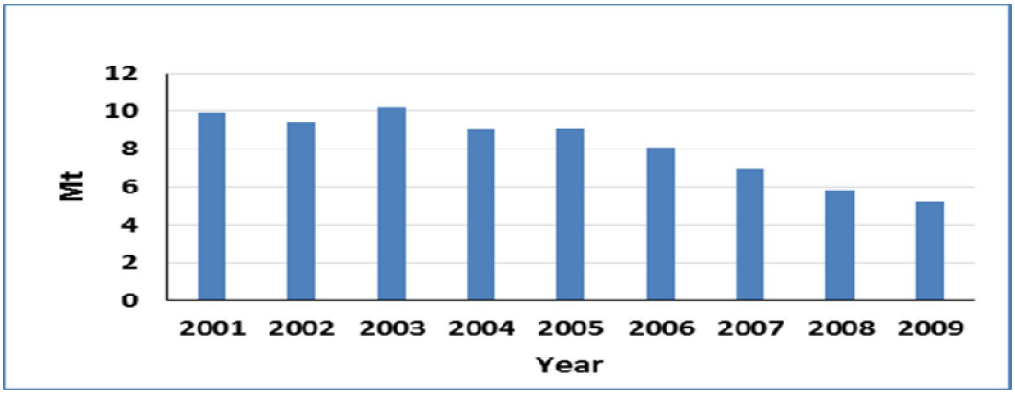


Table 1:*2001-2009 C Emission*

Year	C Emission (Mt)	C Emission Intensity
2000	909.60	1.81
2001	928.37	1.70
2002	985.02	1.66
2003	1148.87	1.76
2004	1330.89	1.85
2005	1474.96	1.84
2006	1618.44	1.79
2007	1752.09	1.70
2008	1800.70	1.59
2009	1892.67	1.53
2010	1976.29	1.45

Data Source: China's Environmental Situation Report, 2006, 2009

Because PM_{10} can enter the human upper respiratory tract, it has a close association with human respiratory system disease. Many cities in China monitor the density of PM_{10}. In fact, $PM_{2.5}$ has more effect on human health than PM_{10}. The data released by World Health Organization (WHO) also showed that $PM_{2.5}$ can increase the risk of death (China Environmental Protection Network, n.d.). In 2012, Chinese people began to realize that $PM_{2.5}$was one of the main forms of smog pollution and a serious threat to people's daily life and health. Fine particles received more and more attention due to the increased cancer risk. Smog had become an obstacle to attracting foreign investment and foreign tourists in China, especially having an effect on the image of Beijing and other international cities, far more than the loss of economic interest. In the spring of 2013, after China suffered the most serious wide range of smog days, air pollution and environmental problems immediately became the hot topic (China News Service Network, n.d.).

$PM_{2.5}$ existed long before the dawn of mankind. Volcanic eruptions and forest fires emit a large number of fine particles. From cutting and burning wood, human beings started learning how to use energy, and human activities started producing $PM_{2.5}$. Large amounts of coal usage brought serious amounts of smog to the UK and Germany. In the oil era, fuel oil brought heavy atmospheric pollution to the United States and Japan. Since 1978, China has become the world's fastest growing developing country, consuming large amounts of coal and oil. The smog in China was basically the pollutants emitted from burning coal and oil. Even worse, these pollutants were not diffused; instead, they generated a variety of reactions in the atmosphere and produced secondary particles (Chai, 2015). Now, more than 20 out of 31 provinces in China have serious smog pollution, and most of them are in the central area and the north east region. The concentration of $PM_{2.5}$is over 30 $\mu g/m^3$, which is far beyond the WHO recommended levels of 10 $\mu g/m^3$ (Ma & Zhang, 2014).

2.3. Fossil fuel combustion is the main source of smog

Smog is mainly caused by high carbon energy consumption. One of the major components of the smog in China is $PM_{2.5}$; sixty percent of it comes from burning of fossil fuels, such as coal and oil. Due to the fact that China had long been closed and undeveloped before the beginning of the reform and opening in 1978, it was urgent to start Off industry with a huge amount of energy. China's energy production and consumption structure has heavily relied on coal as shown in Figures 7-8.

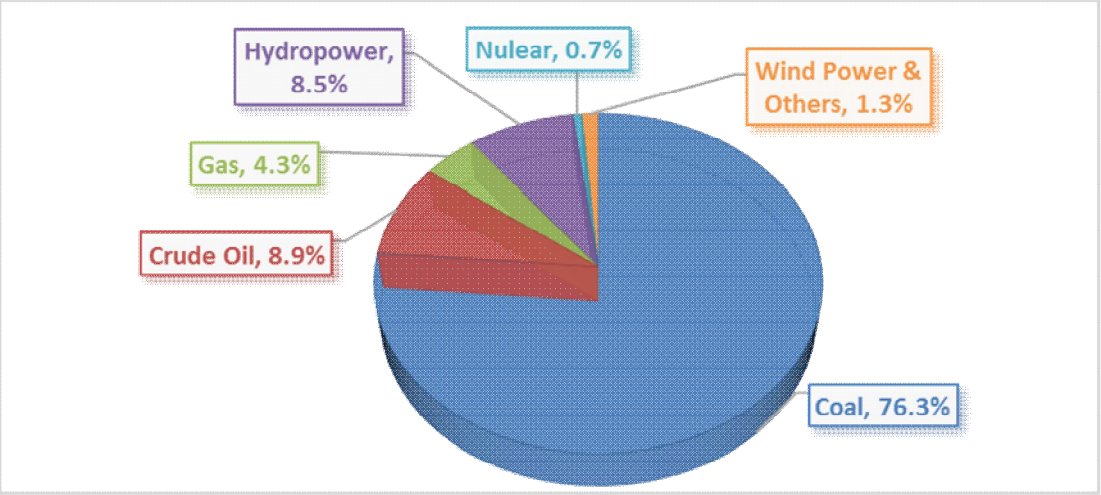


Figure 7. China's energy production structure in 2012.

Data Source: China National Renewable Energy Center, China Energy Bureau

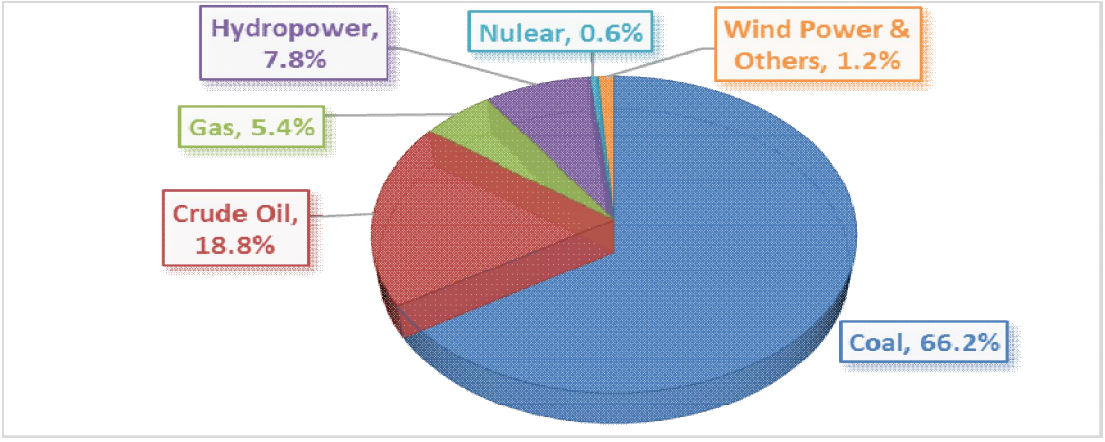


Figure 8: China's energy consumption structure in 2012.

Data Source: China National Renewable Energy Center, China Energy Bureau

According to statistics, industry consumes more than 90% of the total coal (Table 2). In the years of heavy use of coal, people did encounter the choking smog from coal burning, but coal provided energy, which was more important at that time. For the country with a huge population and desire to fully develop, the pipes and chimneys are considered to be a sign of progress.

Table 2: 2011 China Eight High Coal Consumption Industries

Industry	Coal Consumption (Mt)	Proportion of Total Coal Consumption (%)
The electric power, heat production and supply industry	1707.44	49.79
Oil processing and coking and nuclear fuel processing	340.87	9.94
Black metal smelting and rolling processing	299.71	8.74
Non-metallic mineral content system product industry	250.31	7.30
Coal mining and washing industry	246.29	7.18
Chemical raw materials and products manufacturing	161.77	4.72
Non-ferrous metal smelting and rolling plus	62.27	1.82
Paper and paper products industry	44.66	1.30
Total	311.32	90.79

Data Source: China Energy Statistical Yearbook (2012).

Unfortunately, China lacked the experience, technology, and knowledge to control emissions. There was no criterion for emission standards. Coal consumption is the main cause of the smog. The higher the coal consumption is, the higher pollution levels are (Ma & Zhang, 2014).Although the amount of the coal burning was far less than today, the amount of emissions was huge, and the average $PM_{2.5}$ concentration in 2006 was much higher than today (Chai, 2015).

With a large amount of coal consumed year by year, China became a net importer of coal in 2009, and the amount imported continued to surge. In 2011, China became the world's biggest consumer of coal, and coal became the country's leading imported good, 1600 Mt. In 2012 and 2013, imported coal surged to 289 Mt and 327 Mt, respectively. Coal imports increased 59% in 2012 compared to the previous year (Table 3).

Table 3: 2007-2013 Coal Imports

Year	Net Coal Imports (Mt)	Lignite Imports(Mt)	Lignite Imports / Coal Imports (%)
2007	-20.0	0.6	1.2
92008	-20.0	3.3	8.1
2009	100.0	6.0	4.8
2010	140.0	20.1	12.3
2011	1600.0	40.2	
2012	289.0	53.8	18.8
2013	327.0	59.8	

Data Source: China Energy Statistical Yearbook, China Coal Research Institute

Imported coal or lower degree coal (e.g. lignite coal) has significant effects on $PM_{2.5}$. Lignite (also called brown coal) is the lowest degree of carbonation coal mining. It is a lackluster and brownish or brown-black low grade coal, mainly used for power plant fuel. Lignite contains 60% ~ 77% carbon, its density is 1.1 to 1.2 g/cm^3, and its volatile component is greater than 40%. Because lignite is rich in volatile composition, it is easy to burn and emits SO_2. Although lignite proportion in coal imports is not high, it heavily affects the air quality. Table 7 shows that lignite imported in China grew significantly in recent years. From 2009 to 2012, the amount of lignite imports had grown from 4.8% of the coal imports proportion in 2009 to 18.8% in 2012. As a result, it increased the proportion of coal in the energy consumption structure, and then increased the rate of industry emissions on the environment. In October 2013, the China Development and Reform Committee issued *Interim Measures of Coal Quality Management* to control the coal imports, especially the imports of low degree coal. The purpose was to control the smog and pollution in the short term and improve the air quality (Ma& Zhang, 2014).

Due to China having gone through industrialization in 30 years, compared to a hundred years by developed countries, it was not only polluted by coal, but also polluted by oil. The amount of oil used by China is two or three times less than developed countries, and most of the oil was used in the motor vehicles. China has increased the number of vehicles by one million in the last decade, and many of the large size diesel motor vehicles do not have emission controls in their manufacturing facilities. As a result, the particulate emissions of a single diesel vehicle would be 500 times that of the standard engine. Just like lignite, the proportion of diesel fueled vehicle is not high, only 17% of motor vehicles, but it accounts for 70% of the NOx emissions from motor vehicles and more than 90% of primary particle emissions. Diesel exhausted particulate, and nitrated polycyclic aromatic hydrocarbons, are far more toxic than the general motor vehicle exhausts of polycyclic aromatic hydrocarbons. Nitrated polycyclic aromatic hydrocarbons also have a high carcinogenicity. If the diesel quality from China III standard (sulfur content is 350 ppm) improve to China IV standard (sulfur content is 50 ppm), or from China IV standard to China V standard (sulfur content is 10 ppm), the emission can be reduced by 30%--50%, even more (Chai, 2015).

2.4. Is there any relationship between economic development and pollution?

Increasing energy consumption is necessary for an economically developed society. In the past 100 years, developed countries consumed large amounts of energy resources from the earth as they completed their industrialization. At present, China is in the stage of rapid industrialization, especially in the manufacturing stage, which is high energy consumption, high emissions, and high pollution stage. This fact needs to be looked at objectively.

Since the reform and opening in 1978, China's economic growth was at the expense of energy consumption. A country developing from a low-income to a high-income stage cannot skip the pollution stage. Especially for such a big country with a population of 1.3 billion, the pollution stage definitely could not be skipped.

The focus of the controversy created by the documentary is the question of which is more important, the environmental protection or the livelihood of China? One group will consider smog and the environmental damage caused by the energy consumption as more important. On the other hand, the necessity of increasing the livelihood of China is believed to be more important. How should China choose? There are economic and sociological issues with either choice. In other words, there is loss and gain no matter which is chosen. DDT (dichloro-diphenyl-trichloroethane), for example, was invented to kill and eliminate mosquitoes in order to reduce malaria. In 1962, the famous book, *Silent Spring* by Rachel Carlson, was published and pointed out that DDT is a carcinogen and pollutes the environment (Carlson, 1962). At that time, *Silent Spring* became the bible of environmentalists and eventually led to DDT being completely banned. Unfortunately, there were no effective chemicals to control mosquitoes at that time. As a result of stopping the use of DDT, there was an increasing number of malaria cases in Africa. One malaria outbreak in South Africa in the mid of 1980s resulted in the death of at least 100,000 people.

Because of the banning of DDT, there were at least 300 million malaria patients in the world by 2000.More than one million people were killed by malaria each year, and most of them were children (Berezo, 2011). For this reason, scientists began calling for the reuse of DDT. In 2006, even the WHO called on African countries to resume using DDT. At that time, more than 20 million people had died of malaria.

According to the principle of the *Kyoto Protocol* "common but differentiated responsibilities," China as a developing country does not have the obligation to reducing emission of greenhouse gases. When the economy is lagging behind, economic development is the priority consideration. On the one hand, for a long time, China still needs to use energy to sustain the economic growth. It cannot skip the pollution stage. On the other hand, although the *Kyoto Protocol* did not have specific emission reduction targets for developing countries, China should not avoid the responsibility of maintaining energy security while maintaining the economic growth.
On December 7, 2009, at the Copenhagen Conference, China made a commitment to the world that in 2020, non-fossil fuel consumption will account for 15% of primary energy consumption and CO_2emissions intensity will be lower by40% ~ 45% than in 2005.

3. Conclusions

Economies cannot develop without consuming energy, and emissions are inevitable. Since reforming and opening in 1978, China's economy has experienced rapid growth. In 30 years, China has gone through the industrialization stage, which took developed countries a hundred years to go through.

The energy consumption structure has long been heavily relying on fossil fuels, and lacks the experience of emission controls. Coal consumption is the main cause of smog.

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