THE ANALYSIS ON PUBLIC ENVIRONMENTAL INVESTMENT – A COMPARISON BETWEEN P.R.C. AND U.S.A.

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A thesis submitted in partial fulfilment of the requirements for the degree of

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CERTIFICATE OF ORIGINALITY

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it reproduces no material previously published or written, nor material that has been accepted for the ward of any other degree or diploma, except where due acknowledgement has been made in the text.

(Signed)

Yuanning Jia (Name of student)

Abstract

Pollution of the environment has become an increasingly serious problem all over the world. Environmental pollution, which causes latent and lasting consequences, has direct impact on nature and human, with deteriorating survival environment imposing a threat to human life and health. Environmental pollution in China mainly includes water pollution, air pollution, and solid waste pollution.

Protecting environment concerns more than a single department or any individuals. To lead the cause is surely the duty of the government, but it is inappropriate of some people to assert that environmental degradation is completely due to government's malpractice. Actually, the increasing environmental protection input and achievement in basic implementation of environmental targets are the results of environmental protection departments' efforts. On the other hand, there still remain many problems. Apart from insufficient acts of related departments, the government's undue focus on GDP also plays a part. Overall, environmental protection is related to all of the society. Changing the current situation of environmental pollution needs both the power of people and the overall planning of the country.

This work aims at establishing an appropriate investment policy on public health and a reasonable investment schedule in order to ensure sustainable development of socio-economy in the P.R.C. The research was carried out based on an in-depth analysis of data and materials from both the government and academic sources on the current status

of hydrosphere, atmospheric and lithospheric environmental quality. Shortfalls in current environmental investment in P.R.C. These studies were carried out by comparing and contrasting the situation in P.R.C. with that in USA to further fine tune and optimize the public environmental investment, rules and policies.

USA is compared and contrasted with for the size of its GDP is of comparable order to that of the P.R.C. and also its wholesome legal regime is worth being compared with fuzzy regulations in China. Besides, the different percentage of overall GDP used as environmental investment by two countries is also noticeable.

In-depth analysis has revealed that P.R.C. and USA has different rules to protect environment. In P.R.C., a developing country, the percentage of GDP used as environmental investment is less than1%. However, in developed countries like USA, the percentage is 2%~3%. 1 % of GDP for environmental investment is substantially lower compared to developed countries. This underinvestment and the somewhat inappropriate investment schedule have resulted in ineffective pollution management and control, and they have manifested themselves as relatively severe hydrospheric, atmospheric and lithospheric pollutions.

Taking the experience of developed and developing countries into consideration, to ensure sustainable development, the public environmental investment should be set at 2.1 % of GDP to start with.

In conclusion, the global environmental protection industry needs to enter a stage of rapid development, and gradually become a supporting industry, which is an important

force in economic growth. Many countries (such as Japan, South Korea) make it an important key to and objective of adjusting industrial structure. Environmental protection industry in USA has become the main force of the global environmental protection market. China needs to draw lessons from USA's environmental protection experience in order to improve the effectiveness and efficiency of communal municipal waste treatment facilities.

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I would like to express my sincere gratitude to my Supervisors, Dr. KAN Chi-Wai, Dr. LO Kwan-yu, Prof. CHUA Hong for their kindly suggestions, supports and guidance.

I am grateful to The Hong Kong Polytechnic University for providing me with the opportunity of being a MPhil candidate of this university and for providing me with the financial support.

Last but not the least, I wish to express my profound gratitude to my families, to whom this thesis is dedicated. Without their everlasting love, support, devoted help and encouragement, I would never have embarked on my graduate study and would not have had the opportunity to write this thesis. I am indebted to them for so many things which cannot be described in words.

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Chapter 1. Introduction

1.1. Background

Rapid development brings about enormous benefits at the cost of damaging the environment and it creates substantial unhealthy material, such as life waste water, industrial emission and vehicle exhaust, making human's health and environment pollution two inescapable factors interrelating each other. It has become an increasingly serious problem that human beings are facing nowadays. The health effects of pollution imperil human lives. Enormous quantities of pathogens, plankton and microbial have been created by deteriorating environmental pollution. In order to treat diseases, human beings not only need to recognize human development and history of health and disease, but also need to know the relationship between health and environmental pollution. Failing to recognize the relationship, people cannot understand the health historically, and neither will they know how to treat the disease (Hass and Smith, 2002).

1.1.1. The effects of industrialization

In recent years, with development of economic, global ecosystems see deterioration in various degrees (Liu, 2010; Chen, 2013). Since the 19th Century, there have been earthshaking changes in industrial era. Along with the changes, forests have been destructed, rivers covered with soil, and animals transported to other places. In developing countries, most living sewage and industrial waste water are discharged directly into water without any treatment, of which the price is that 1.2 billion people are short of clean water, and over 250 million children are dead because of polluted water (Wuxi Environmental Protection Bureau, 2010; Chen, 2013).

In modern days, industrialization development continues to expand in developing countries, including China, Taiwan, India and Vietnam (Philip， 2007). Even though many countries have

issued severe rules, the speed of treatment is much slower than that of pollution (United States Environmental Protection Agency, 2017). The price paid for industrialization on environment continues to exist in current days, and to worsen, indeed. Many infectious diseases have been created by the deterioration of environment nowadays, and 40% of them can cause death, which is twice as much as before (Chen, 2013). The disease brought by environmental degradation is unimaginable. People are scratching their head over saving the environment without any conclusion, because once industrial revolution has started, it will not stop. Therefore, it is not difficult to imagine the relationship between disease and environmental protection in the developing countries during their industrializing processes.

1.1.2. The effects of urbanization

Urbanization is another big problem that brings about disease. With its acceleration, some pollution comes along due to the uneven distribution of population. High population density leads to further result in uneven distribution of resources. Around the world, over 75 percent of population of around six billion people lived in urban areas until the year of 2000 (Philip, 2007). Disease related with water might happen in area of high population density. Western Europe, Africa, North India, Southeast Asia, Latin America and east of Brazil are high-risk area of high population density. They have been marked as “hot point” areas; the diseases are from Coli diarrhea to the top danger of dengue fever (Zhang and Zhang, 2006).

There are a wide variety of things in the urban. Some are natural; others are manmade (American Heart Association, 2017). With the advent of advanced technology, the new type of disease and the deterioration of environment are manmade. Whether you live in a city where smog forecasts

are routine or in a thickly populated place, manmade particles in the air can lead to big problems for the health (The Guardian, 2014).

The effects of urbanization, related to high density of population brought about a sharp decrease of trees, loose soil, the deterioration of air standards and substantial polluted water, thus leading to unhealthy living environment, and diseases exist. Furthermore, urbanization called for industrialization is to satisfy the increased amount of product. Also, industrialization requires urbanization to better serve the industrial cities. To a larger extent, this is an unbreakable cycle once human beings' effects on environment have started.

1.1.3. The costs of environment

It is an unjustifiable claim that industrialization and urbanization surely lead to disease because there are more elements related to it. However, disease can be attributed to environmental degradation, an inevitable problem in current situation, which the key factor to ease is the attitude of people.

1.2. Critical Issues

It has to be emphasized that different regions have the peculiarity in their situation. Diverse stages of environment bring about different diseases. Although many research about diseases are defined by scientists, it may not make much sense by simply saying that all the diseases are related to environment problems. For example, HIV has now become the fifth major infectious diseases. A total of about 30 million people infected with HIV. 2.3 million people die from it each year. Because HIV is relating to environmental pollution, the worse environmental pollution is, the

worse HIV is. Two thirds of HIV patients are in south of the Sahara Desert. In such areas, 25% of adults are infected by HIV (Avert, 2016).

According to results of some studies by international organizations and economic experts, environmental pollution can be controlled effectively only when a country's public pollution treatment investment accounts for 1.0 to 1.5% of the GDP, and the improvement of environmental quality can occur significantly only when the environmental investment increases to 3 to 5% of GDP (Lu et al., 2004; Wang and Chang, 2003). However, this relies heavily on such factors as the structure of the economy, geographical and climatic characteristics, rate of economic development and the level of involvement of commercial companies in investment and operation of environmental treatment facilities.

1.3. Project objectives

It has to be emphasized that different countries have their own peculiar situations. Different stages of development also bring about diverse environmental problems with subtle and profound differences. Although much research has been conducted on environmental protection investment by some developed countries in recent years (Hass and Smith, 2002), there has been no systematic study on the impact of environmental investment on public health. In this project, the investigation focuses on P.R.C. and U.S.A. The former is a developing country and the latter is a developed one. In order to explore the impact of environmental investment on public health in these two counties, the following objectives were set:

(i) To analyse the fast-deteriorating environmental quality in the P.R.C. and U.S.A., in order to elucidate the urgent need for considerable effort in specific environmental fields.

(ii) To explore the relationship between socio-economic growth and environmental pollution in P.R.C. and U.S.A.

(iii) To compare the environmental investment in P.R.C. and U.S.A.

(iv) To evaluate the impact of environment investment on public health in P.R.C. and U.S.A.

1.4. Structure of the thesis

The structure of this thesis is summarized in Figure 1.1.

Chapter 1 is an introduction of the overall environmental issues that P.R.C and USA are facing nowadays, and provides an important relationship between investment, health and environmental pollution.

Chapter 2 is literature review and explains various information between investment and different types of pollution, and it also offers the background of research

Chapter 3 offers the scope of research and methodologies of the study.

Chapter 4 is the data analysis.

Chapter 5 undertakes critical analysis of U.S. and the major objective is to make a comparison between P.R.C and USA about the environmental circumstances and investment. Besides, Chapter 5 carries out environmental investment rules compared to P.R.C.

Chapter 6 summarizes the whole research works to come to some conclusions and suggests the future directions as a continuation of this research.

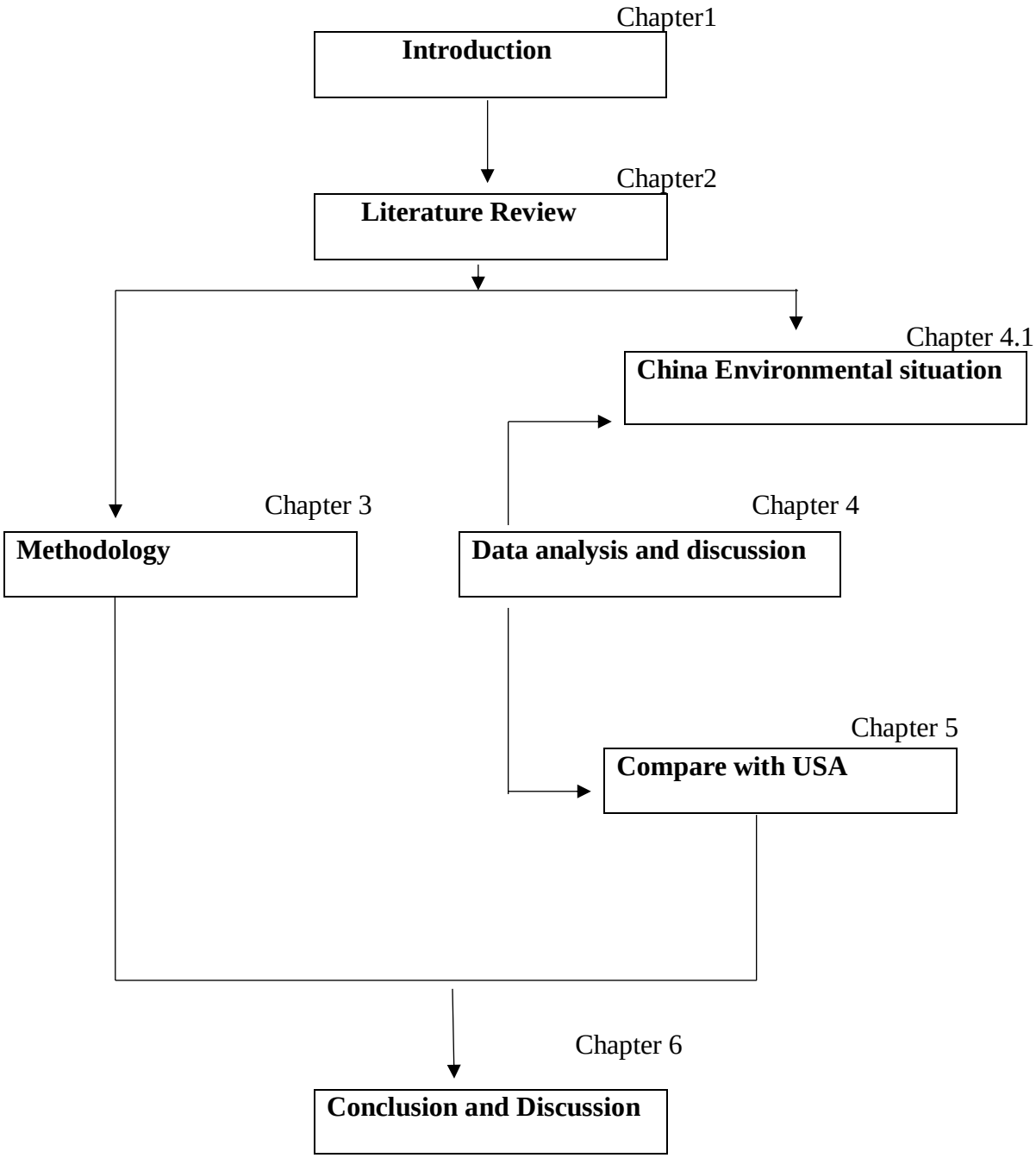


Figure 1.1. Structure of Thesis

Chapter 2. Literature Review

2.1. Economic loss due to deterioration of environmental resources

The relationship between the economy and the environment can be divided into three categories, which are coordination, imbalance and transition (Levine, 2005). However, if excessive exploitation of natural resources and serious pollution carry on, the transition mode can develop into the imbalance mode. Today's China is in the transition type and it will suffer significantly if the environment continues to get degraded (Zhang, 2009; Chen, 2013).

It is the fundamental resistance that is the main concern over environmental resources, which curbs economic development and jeopardizes sustainable development. The most obvious impact of environmental degradation on the society and the economy is the expenditure required to be incurred due to various environmental problems. A study by the Policy Research Center for Environment and Economy of the State Environmental Protection Administration said economic losses caused by environmental pollution are estimated to range from 3.5% to 8.3 % of China's GDP (Lin and Pilipinas 2003; Global Environment Facility, 2009; Zhang, 2009; China Development Bank, 2010).

According to the data released by China's National Bureau of Statistics, environmental accidents and incidents from the year 2000 to 2010 induced direct economic losses that averaged out at 140 Million Yuan, taking up about 0.013% of the average GDP during this period. Figure 2.1 shows the direct economic losses from 2000 to 2010in absolute monetary terms (RMB) (Chen,2013). Figure 2.2 represents the economic loss as a fraction of the GDP over the same period as showed in Figure 2.1. Environmental accidents and incidents include such cases as marine oil spills, eutrophication and algal blooms in surface water bodies, chemical spills in inland water bodies such as rivers, land contamination due to toxic organics and heavy metals, discharge of foul

industrial gases and chlorine leakages, etc. (Chen,2013; Jiangsu Provincial Environmental Protection Bureau, 2010).

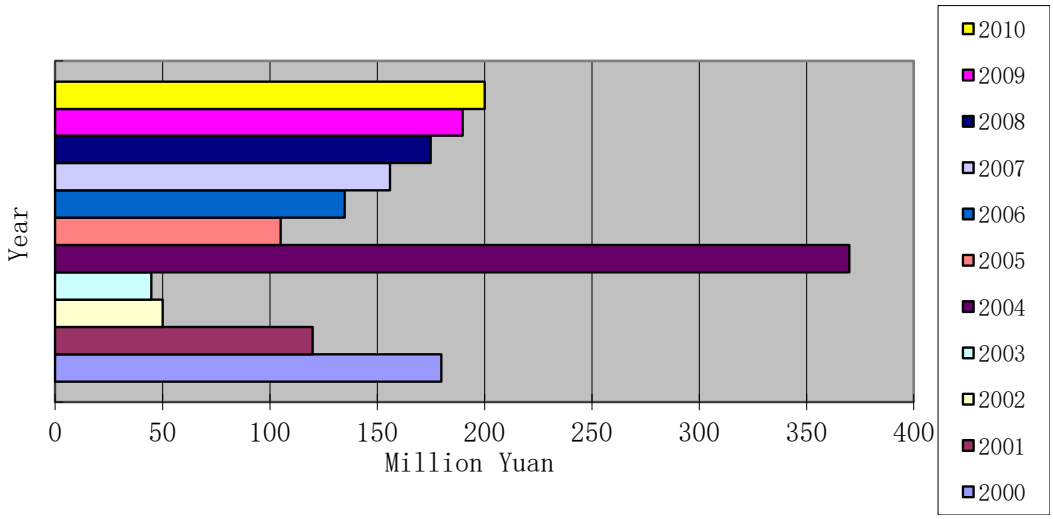


Figure 2.1. Direct economic losses in P.R.C. (Chen, 2013)

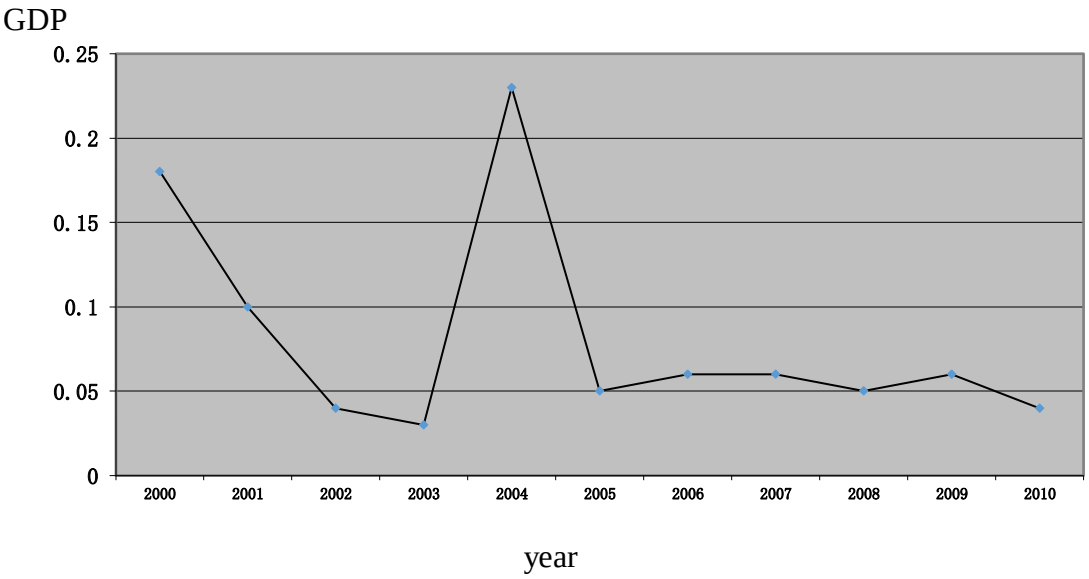


Figure 2.2. Economic loss in GDP (1/10000) (Chen, 2013)

2.1.1. Potential threat to public health and ecological balance

The environmental problems, particularly the severe cases, also cause direct harm to public health and ecological balances. The low-quality living conditions not only lead to a high disease rate and

excessive public expenditure on medical care and social insurance systems, but also influence environmental ecological balances in a negative way, and eventually affect the human food chain (Zhang, 2009; Chen, 2013).

2.1.2. Potential threat to human health

In recent years, with rapid rate of change in economic development and industrial development, the global ecological environment has deteriorated in various degrees, and with that, human health worsens every year. The deterioration of environment not only leads to various deadly disease and results in demand in medical care, but also creates new types of disease that technology nowadays still cannot cure.

2.1.2.1. The threats from water pollution

The water pollution generally refers to the ocean, rivers, swamps, and ground water. The water environment in general, includes suspended solids and dissolved substances in water. Sediment and aquatic organisms are the entire ecosystem or natural complex. Moreover, water can be divided into the ocean water and land water, of which land water is divided into surface water and underground water, and surface water is divided into rivers and lakes. Water pollution is a certain amount of wastewater. All kinds of waste and other pollutants flow into the water, and when it goes beyond the self-purification of water bodies and their pollutant carrying capacity, water pollution exists. The composition of physical sediment, chemical nature and biological community has changed, which has destroyed the survivals and the water function, and reduced the value of water. Factors of water pollution exist in many aspects: the body of water without proper treatment, urban pollutant, and being washed by the rain, among which, the first is the main factor of water

pollution. With the industrial production development and social economic prosperity, a large quantity of industrial wastewater and urban domestic wastewater has been discharged into water bodies, thus, water pollution becoming more and more serious. Moreover, under natural condition, the water often has a certain change, but this change is a natural phenomenon, which cannot be called water pollution (Zhang, 2009; Tsang, 2015).

2.1.2.1.1. Organic pollutants

There are a lot of organic pollutants in water, such as anilines and petroleum. For example, the main source of petroleum in industrial wastewater is from processing and transportation of crude oil. Part of the petroleum hydrocarbon floating on the water affects the surface of water, and dissolved oxygen will be consumed in the water, which worsens the water quality, and influences the aquatic organisms' survival.

2.1.2.1.2. Inorganic pollutants

Acid and alkali salts, sulfide and halide belong to the inorganic pollutants, which mainly come from mining, smelting, machinery manufacturing, building materials and chemical industry. After inorganic wastewater is discharged into water bodies, it makes the water PH change, and the poisoned aquatic organisms cannot survive indeed. Some inorganic compounds flowing into the water can make the dissolved oxygen reduced, which have harmful effects on water.

2.1.2.1.3. Physical contamination

Suspended matter refers to the insoluble material, including solid material and foam. It is caused by soil erosion of farmland or sewage, garbage and waste generated by industries like mining,

construction, food, papermaking that is discharged into water. Suspended material adversely influences the appearance of water body, photosynthesis of water plant, and decreases the oxygen dissolved in water.

2.1.2.1.4. Biological contamination

Bacteria, mildew element and virus in wastewater are biological pollutants. They mainly come from the hospitals, tanneries, and slaughterhouses. Sometimes rainwater also contains biological contaminants. Wastewater containing biological contamination will not only makes the dissolved oxygen reduced in water and thus reduces fishery production, but also adversely affects human health. Therefore, this kind of water should be strictly limited before discharged into normal water body (United States Environmental Protection Agency, 2017).

Diarrhea is the most common disease caused by water pollution, of which the annual number is 400 million deaths of 2 billion people, and the majority is infants. Mosquitoes and water-borne diseases are the deadly individually transmitted diseases. There are 500 million people infected and270 million deaths each year (Avert, 2016).

2.1.2.2. Threats from air pollution

According to the composition of air pollution and atmospheric pollution, air pollution can be divided into the four categories: soot pollution, oil pollution, mixed type of pollution and special type of pollution four. The soot pollution is caused by the use of flue gas emission and coal-fired equipment of the coal industry; air pollution in most Chinese cities belongs to this kind. Oil pollution is caused by the discharge of harmful substances into atmosphere. Mixed type of pollution is the air pollution which caused by the mixture of coal and oil produced in the

combustion. It is a kind of air pollution between soot pollution and oil pollution. Special type of air pollution is a special gas emission (chlorine, hydrogen sulphide, hydrogen fluoride, metal gas) discharged from various industries (Zhang, 2009).

According to different research purposes of pollution sources, there are different classification methods. It can be divided into stationary pollution sources (such as smoke and gas in industry) and mobile pollution source (such as a car, train, plane discharging smoke during moving). According to the way of discharging air pollution, it can be divided into elevated source, non-point source and line source. Based on the discharging time, it can be divided into continuous source, discontinuous source and instantaneous source. According to the type of polluters, it is divided into industrial pollution sources, household stove exhaust and car exhaust (Chen, 2013).

In addition, for the research of different objects, it can be divided into different types of atmospheric pollution. For the scope of pollution, it can be divided into the local area air pollution, regional air pollution, wide area of atmospheric pollution and global air pollution. For the form of pollutants, it can be divided into particulate pollutants and gaseous pollutants. Different types of pollution have different control measures and degrees of harm (Zhang, 2009; Tsang, 2015).

2.1.2.2.1. The source and harm of air pollution

The reasons of air pollution stand in two aspects in total: human activities and natural processes. Human activities include not only the production activities, but also general cooking, heating, transportation. Natural processes include volcanic activity and forest fires, tsunamis and rock weathering. In general, natural environment has self-cleaning function.

Air pollution caused by natural process will be cleaned up by itself after a certain amount of time. With the rapid growth of population, a large quantity of exhaust gas without proper treatment discharged into air is much more harmful than the pollution caused by natural discharge (Tong, 2009; Chen, 2013).

Harm of air pollution can be global, regional or local. Global atmospheric pollution stands for depletion of the ozone layer and intensifies global warming, which directly damages life support system. Regional atmospheric pollution refers to acid rain, which not only damages the health of human body, but also affects animal and plant growth. Urban and regional areas mainly have performance of physical characteristics and chemical characteristics (Yao, 2009).

Physical characteristics contain increasing time of smog, decreased visibility and urban heat island effect. Chemical characteristics will adversely affect human body, and they will cause cancer, respiratory system disease and cardiovascular disease (Zhang, 2009; Chen, 2013).

2.1.2.3. Threats from solid waste pollution

Solid waste is defined as any sludge, garbage, refuse from air pollution control facility or plants dealing with water supply or waste water and other discarded materials including solid, semi-solid, liquid or contained gaseous materials produced by mining, industrial, commercial and agricultural operations, and by community activities, whereas solid or dissolved materials in domestic sewage are excluded (Zhang, 2009; Guangzhou Liwan District Environmental Protection Bureau, 2010; Chen, 2013). The owners, operators, and/or occupants of any premises are responsible for the satisfactory and legal disposal of all solid waste generated or accumulated on the property (Zhang, 2009; Guangzhou Liwan District Environmental Protection Bureau, 2010; Chen 2013).

2.1.2.3.1. Classification of solid waste

2.1.2.3.1.1. Municipal solid waste

Municipal solid waste means solid waste incidental to, or caused by commercial, institutional, recreational, community or municipal activities, in which street cleanings, garbage, dead animals, rubbish, medical waste, ashes and all others are included (Texas Commission on Environmental Quality, 2016).

2.1.2.3.1.2. Nonindustrial solid waste

Nonindustrial solid waste is made up of electronic waste from commercial, institutional and municipal sources (including radiation-producing equipment like X-ray) (Texas Commission on Environmental Quality, 2017).

2.1.2.3.1.3. Industrial solid waste

Industrial solid waste is solid waste resulting from or incidental to any process of industry, manufacturing, mining, or agricultural operations. Industrial solid waste is classified as either hazardous or nonhazardous. Hazardous industrial waste includes any industrial solid waste or combination of industrial solid wastes identified or listed as a hazardous waste. Non-hazardous industrial waste is an industrial solid waste that is not identified or listed as a hazardous waste. If non-hazardous industrial solid waste is generated, it must be further classified(Texas Commission on Environmental Quality, 2016).

Special waste is a waste that requires special handling, trained people, and/or special disposal methods. A waste may be a special waste because of its quantity, concentration, or physical,

chemical, or biological characteristics. Special waste is defined in Title 30 Texas Administrative Code (Texas Commission on Environmental Quality, 2017).

2.1.2.4. Threats from other pollution

Artificial light and noise grow to fade natural landscapes. In the Arctic, gas and oil explorations produced too much noise that bowhead whales, belugas and other sea life has confronted difficulty feeding and breeding. Light pollution disrupts circadian rhythms for both humans and animals alike and may even contributes to the development of cancer. Light pollution also can impact sea turtles. Adult and hatchling in sea turtles are drawn toward lights along the beach, thinking they are heading toward the moon (Zhang, 2009; Chinese Research Academy of Environmental Science, 2010; Chen, 2013).

2.1.3. Resource-based development

The fast-paced industrial and economic development in China is greatly resource-based which will incur an extremely high cost for restoration and remediation of environment resource. For instance, drinking water greatly relies on rivers and underground water. Freshwater accounts for only 2.5% of the Earth's water, and most of it is frozen in glaciers and ice caps. The remaining unfrozen freshwater is mainly found as groundwater, with only a small fraction present above ground or in the air (Xiao, et al., 2007; Zhang, 2009; Chen, 2013).

In the 2011 National assessment, nine provinces, autonomous regions and municipalities including Beijing, Shanghai and Guangzhou saw more than 800 monitoring wells mouths assessed and over three-quarters (76.8%) did not meet the standards of groundwater sources of drinking water (Zhang, 2009; China Development Bank, 2010; Chen, 2013).

Due to the rapid economic growth and urbanization, China has an annual average of 40 billion tons of water deficiency. In 2015, a total of 665 cities consumed 44 billion tons of water, using an average of 66 million tons of water for each city. By 2020, when the proportion of China's urban population reached 60 percent, the city's water demand could reach 58 billion tons (Jing ,2008). Almost two-thirds of urban water is used in industry, agriculture and construction. The remaining one-third is used as household water (In 2011, 365 million people used 15.3 billion tons of water). Among them, laundry, bathing and dish washing water accounted for most (together more than 80%). Cooking and drinking water only took up slightly more than 2% (1.1 billion tons). In other words, most of the residents living water need not meet drinking water quality standards (Jiangsu Provincial Environmental Protection Bureau, 2010).

For a developing country like China, if we make it a standard to meet the standards of developed countries, more water will be needed. This will bring a number of environmental problems. For example, in Jiangsu province, if the "Ozone Activated Carbon" deep water treatment processes in the provincial quarter (5.3 million tons per day), the carbon dioxide emissions in 2020 will be increased by 28%. China needs a low-cost, high-performance method to minimize resource-based development (Zhang, 2009; Chen, 2013).

2.2. Environmental investment (EnvI) in P.R.C

2.2.1. The development of the environmental pollution investment and public health in China

Environmental protection is a basic national policy of China. Environmental pollution treatment investment in China is in rapid rate of change every year (Zhang et al., 2008). Total investment proportion of the total domestic output value is also increasing every year, and the proportion is for the first time over 1% in 2000 years. As a result of our country's nearly five "five-year plan"

periods, China's environmental pollution control investment increased from 16.62 billion yuan to 839.51 billion yuan in 5 years, having increased by nearly more than 50 times. During the 5 years all kinds of diseases related to public health have been decreased by 15% (Zhang, 2009; Chen, 2013). The more environmental investment is, the better public health gets, because basic environmental investment means money invested in environment aspects, which include air, water, solid waste. All these factors are related to human health, which is to say, without healthy environment, public health would be damaged.

Investment in China, overall, is getting larger year by year, along with a rapid rate of change in GDP; however, investment treatment is not high enough to guarantee the development of environment in a proper way. In other words, there is still imponderable distance between China and developed countries. According to the experience of developed countries, in the high-speed growth period of a country, the environmental protection investment at a certain time needs to steadily reach 1%-1.5% of GDP in order to effectively control pollution. Moreover, the environmental quality can be significantly improved if the proportion is over 3.0% (Zheng and Li, 2014). Therefore, the proportion of environmental pollution control investment in general is still low, and investment in China has to be further strengthened (Zhang, 2009; Yu, 2013; Chen, 2013). These resulted in the fact that the environmental quality deterioration associated with high mortality rate was not appropriately taken care of, and public environment spending on relevant aspects needs to be effective.

Table 2.1. USA investment in pollution control (updated from Environmental Protect Agency)
Unit: 0.1 billion dollars

Media or pollution	**1985~2015**
Total	**4500**
Air	**2650**
Water	**1830**
Other charges	**75**
Equipments	**25**

In 1985-2015 (From Table 2.1), USA government paid nearly 450 billion dollars for air and water governance, in which the expense for air protection is nearly 264 billion dollars and that for water pollution control is 283 billion dollars. The expenditure equals to 2% of GDP in 1976 to 1985. According to another expenses analysis, the new air control technology costs 7.5 billion dollars, in which 2.5 billion dollars is spent on the equipment of public institution.

According to the research of USA association of Washington D.C, America's chemical industry spends 0.33 billion dollars on pollution control equipment. It is estimated that the expenses will increase to 0.67 billion dollars, accounting for 11.6% of total equipment investment, in which the bulk is used for water protection equipment, about 0.37 billion dollars, followed by air protection equipment, about 0.26 billion dollars; the cost for solid waste treatment is 0.04 billion dollars.

In 1985-2015, DuPont company in USA planned to use 30% of its total budget for pollution control. Table 5.6 lists the expenses of DuPont company in USA.

2.2.2. Environment pollution situation

In the late 1990's, Chinese made the sustainable development the Chinese development strategy, and after that the environmental pollution control investment got adjusted, but in the process of industrialization over nearly 30 years in China, the results China got is "high input, high consumption, high pollution and low benefit", which brings about the phenomenon of "treatment

after pollution". Thus the prevention and control of environmental pollution has to be the focus of the environmental protection work in China. Otherwise, the situation of environmental pollution in China will be more severe (Jing et al., 2008).

From 1981 to 1987, the ratio of Environmental pollution source investment was increasing, from 1.44 billion yuan in 1981 to 45.82 billion yuan in 1987, which is nearly 30 times. In environmental pollution control investment, governance waste water, waste gas, solid waste, noise and other proportion of governance for many years average out at 41.5%, 38.1%, 8.2%, 1.1%, 8.2% respectively. Overall, waste water and waste gas treatment are the main part of the environmental pollution control investment, two of them accounting for 79.6% in total. Among them, in 2003, the proportion of waste water treatment in EnvI pollution control investment was the largest, but after 2005, waste gas treatment investment became the largest industrial pollution source management (Jing et al., 2008; Zhang, 2009; Chen, 2013).

2.2.3. Environmental legislation and regulations

Nothing can be accomplished without the establishment of effective standards. Legislation and regulations are vital for the government to impose harsher punishments upon polluters. Like many other developing countries, China was considerably more confused and relaxed than their counterparts of developed countries (Lo and Fryxell, 2005; Robins, 1990; Zhang, 2009; Guangzhou Environmental Protection Bureau, 2010).

Along with the increasing level of intensity of law enforcement, the industry needs to establish the corresponding pollution control facilities to meet the discharge of the pollutants concentration and the total emissions standards. China has made so many laws to prevent the environmental problems from getting worse. According to law, any new projects producing pollutants must have prevention

plan and equipment along with its stages of planning, constructing and operating (Zhang, 2009; Jiangsu Provincial Environmental Protection Bureau, 2010; Tsang, 2015).

However, the Chinese government has built up several environmental policies and legislation system, such as China plans cooperative, coordinated pollution control, national standards on environmental protection, and energy development. (Chinese Research Academy of Environmental Sciences, 2010)

2.2.4. Relationship between environment and society

It can be seen from past experiences in socio-economic development that the prosperity of industry is one of the most significant and indispensable factors in the massive economic growth (Shen, 1999; Wan, 1998; Chinese Academy of Social Sciences, 2009; 2010; Zhang, 2009; Tsang, 2015). Industrial development would inevitably entail inefficient consumption of limited and scarce environmental resources if its pursuit only adopts traditional path and means (Zhang, 2009; Chen, 2013).

New concepts are now being introduced and enforced by environmental authorities, which comprise such environmental and related issues and matters as animal welfare, human health, macro ecological balances, food hygiene and the application of new non-conventional reproductive technologies to the human species (Dickens, 1992; Zhang, 2009; Tsang, 2015).

The industrial-capitalist system has forced landlessness. Many homeless peasants were compelled to leave the rural land for industrialized cities, thus making great unevenness in population densities over different regions ensue (Chinese Academy of Social Sciences, 2009). Similar events have also happened in the history of socio-economic development in Europe (Barry, 2007; Zhang, 2009; Chen 2013).

It has been said that air and water pollution and other environmental problems are as old as the human species. It has been the prime concern in the P.R.C. not to fall into a similar path of development. However, to devise environmental protection measures calls for serious consideration of current per capita GDP, economic structure and others, i.e. the current stage of development in China (Jiang et al., 2005; Chen, 2007; Zhang, 2009; Chinese Research Academy of Environmental Sciences, 2010; Chen, 2013).

China is the second largest electricity producer and consumer in the world (Sinton et al., 1998; Zhang, 2009; Chen, 2013; Tsang, 2015), after the U.S. (Lin and Pilipinas, 2003). The installed capacity was 338 gigawatts (GW) and annual electricity generation was already 1,446 terawatt-hours by the end of 2001. Nuclear power contributes only about 1% of total while hydropower and thermal power come close to about one quarter and three quarters, respectively (Lin, 2005, 2007). Despite the fact that alternative renewable energies such as biodiesel and other biological fuels have research and development set about, it is still minimal of their actual full-scale applications (Ren et al., 2011). In the past 20 years, demand for electricity has been increasing more rapidly in China than anywhere else in the world (Sinton et al., 1998; Lin and Pilipinas, 2003; Levine, 2005; Tsang, 2015). The average 9% annual growth rate approximately equals to the growth rate of GDP during the same period. Most electricity is generated by power plants fired by oil and coal, which usually causes severe pollution because of its utilization of non-renewable forms of fuels, thus upsetting ecosystems in the environment (Zhang, 2009; Chen, 2013).

To meet the continuously mounting demand, it is to address issues like how to meet the great requirements of funds and how to prevent environmental deterioration that has become China's principal concern (Ma et al., 2000; Lo and Fryxell, 2005; Zhang, 2009; Chen, 2013).

The Asia Development Bank revealed that electricity demand grew by more than 60% between 2001 and 2010, from 1,446 terawatt-hours in 2001 to 2,362 terawatt-hours in 2010 (Lin and Pilipinas, 2003; Lin, 2005; Tsang, 2015). It is out of question that China has contributed a substantial share to this consumption (Zhang, 2009; Chen, 2013).

China's high dependency on coal for electricity generation is expected to continue due to two reasons (Lin and Pilipinas, 2003). One is the need to maintain low electricity tariffs and the other is the abundant domestic coal supply with rather low price (Lin, 2005, 20076; China Development Bank, 2010; Tsang, 2015).

Coal consumption is so high that great concerns are raised, and the reasons mainly lie in the high dependency on coal for electricity generation as well as the fast growth of power demand. 138 GW was expected from coal-fired power plants in the total incremental capacity of 187 GW during 2002 to 2010 (Lin and Pilipinas, 2003; Tsang, 2015).

New environmental protection and pollution abatement processes such as flue gas desulphurization, electrostatic precipitators for particulate removal and chemical scrubbers for volatile chemicals (including volatile hydrocarbons) removal, were installed for only about 20 percent of new plants until 2003. Most of them were located in more developed regions, such as the Eastern Coastal and the Southern PRD regions (Zhang, 2009; Guangzhou Environmental Protection Bureau, 2010; Jiangsu Provincial Environmental Protection Bureau, 2014; Tsang, 2015). Almost half of the newly constructed coal-fired power plants are expected to be equipped with facilities dealing with flue gas desulphurization and other relevant pollution treatment before 2013 (Lin and Pilipinas, 2003; Zhang, 2009; China Development Bank, 2010; Chen, 2013).

The rising of CO_2 (greenhouse gas) and other residual sulfurous gases (remains even after treatment) level caused by the burning of fossil fuels lead to severe atmospheric and even indoor

air pollution that influence public health in the long run (Schneider, 1989; Gareth, 2004; Zhang, 2009; Chen, 2013). There is still a lot to do for the world in pursuit of the ideal science and technology which can bring people a perfect world to live in with well protected environment and well balanced ecosystems, where all waste is recycled and reused by every member of the population and zero pollution would be generated (Gareth, 2004; Tsang, 2015). It seems technologically impossible, but research and development efforts and legislative enactments are undoubtedly moving in that general direction (Zhang, 2009; Chen, 2013).

Furthermore, activities such as coal mining and land excavation, related to energy consumption and other infrastructure developments, result in other lithospheric environmental problems. With a view to acquiring the useful resources, humans contribute to such environmental problems as deforestation as a result of changing the natural land environment (Philip, 2007; Zhang, 2009; Chen, 2013). Instead of direct investment of energy, time and resources into mere redemption of the worst effect of environmental deterioration, the concept of green economy emphasizes response to the roots of the problems (Barry, 2007; Tsang, 2015).

These aforementioned aspects of environmental protection have been discussed in many researches. However, these are mainly on the technology and management policy aspects of environmental protection. Very few studies have been conducted on the appropriate monetary value of public and commercial EnvI, and the impact on public health. There has been a serious lack of efforts put in for comparison of EnvI amount and schedule in different countries, by taking the peculiarity of each country into consideration (Zhang, 2009; Chen, 2013).

2.2.5. Energy saving and emission reduction strategy

Energy Saving and Emission Reduction (ESER) is one of the most important movements for implementing a scientific outlook on social-economic development. China government believes the ESER strategy is a significant move toward a 'scientifically-based outlook' on development and also the foundation of the 'harmonious society' (Chinese Academy of Social Sciences, 2009; Zhang, 2009; 2010; Chen, 2013). It is viewed as an important step for resource conservation and founding an environment-friendly society and policies. It is not only the way to improve the economic structure, by adjusting the growth mode and transforming the emphases, but also the inevitable requirement for enhancing the quality of life and safeguarding the long term and sustainable benefits of Chinese people. The ESER strategy helps to make sure that every functional district's environment conditions satisfy the standards. It is beneficial to driving the development of techniques and resource saving, carrying out the government policies, prioritizing the resources distribution and elevating the positivity of pollution treatment. Meanwhile, when the plan of national economic and social development embraces goals of industrial and traffic emission reduction, policies can be introduced by the environment protection department to support a comprehensive controlling strategy at a national level and scope (Chinese Development Bank, 2010; Lin, 2005; Zhang, 2009; Chen, 2013).

Emission reduction was the most important measure for environment protection in the 'Eleventh Five-Year Plan' period (Zhang et al., 2013). In the year 2010, emissions of COD (as a measurement of organic pollutants in water) and SO_2 (as a measure of pollutants in air) were to be reduced to 90% of that in 2005 (Chinese Research Academy of Environmental Sciences, 2010; Zhang, et al., 2013). That was not only a serious promise to the public by the Chinese government, but also the

environmental target to be reached in order to ensure sustainable development. According to this study, emission reduction is more than an environmental problem. The essence is the problem of social economics and politics. To reduce emission in an all-round way, it is fundamental to associating the marginal emission reduction control with the whole process such as cleaner production, recycle and reuse technologies updates, the cost of resources and energy, pollution treatment and monitoring, and development of novel environment-friendly materials. Environmental policies need to be reconstructed based on the ever changing environmental factors and the vision of overall control strategy (China Development Bank, 2010; Lu et al., 2004; Zhang, 2009; Chen, 2013). The overall emission reduction should be put in the core of the reconstructed policies, and the mechanism should be established to reduce resources and energy consumption, fuel the economic development and enforce pollution treatment by corporations in a systematic, effective and efficient manner (Zhang, 2009; Chen, 2013).

The task of emission reduction is tough and technologically challenging but it can be done. Since 2006, the Chinese government has carried out emission reduction work by establishment of policies and development of novel engineering methods which have never been used elsewhere in the world (Chinese Research Academy of Environmental Sciences, 2010; Chen, 2013). The environmental departments and local governments have put in a lot of efforts for emission reduction but completion of the task in 2006 was not as effective and fruitful as expected. The studies show the foremost importance should be attached to controlling the newly generated pollution, including the organic and heavy metals in the hydrospheric and lithospheric environments and the carbonaceous and sulfurous compounds in the atmosphere (Yi et al., 2007; Gansu Daily, 2007; Zhang, 2009; Chen, 2013).

However, the uncontrollable and somewhat overheated development of the economy has led to the biggest uncertainty about emission reduction. Published statistical data and studies suggest that it requires painstaking efforts to realize the major pollutants' emission reduction and currently the situation still looks dim. Compared with the COD, BOD_5, suspended solids, heavy metals and organic pollutants in water bodies, SO_2 emission is still considered an easier goal to realize the targeted reduction. The reason is that points of air pollutants emission sources are easier to control than the area and line sources of liquids discharge (Chinese Research Academy of Environmental Sciences, 2010; Xie, 2001; Sin et al., 2003a, 2003b; Xu, 2003).

In order to truly solve the systemic problems in environmental emission reduction, bold management measures and technological advancements are urgently needed. Except for the emission reduction plan's structural shortfalls, there are three other problems worth attention, which affect the work's effectiveness and continuity. Major reforms are needed in these areas. Firstly, the powers and efforts of government investment in various aspects of environmental protection are not enough. There are problems in statistics of environmental investment, authority division and performance management. For example, the investment for COD emission reduction is still not effective, especially the public spending part which is invested by the government. Secondly, the monitoring abilities are not enough for providing feedback information in order to refine the policies. The abilities to reduce emission and environmental pollution are impaired due to negative factors such as incomplete emission control standards, the weak abilities for environment monitoring, the low rate of law implementation and enforcement and the reconstruction of management policies. Thirdly, the rate and strength of policy implementation is low. Especially the economic policies, aiming at facilities for emission reduction, such as punitive policies, are weakly and inconsistently implemented. Some policies are even contrary to emission

reduction goals and are not efficient in serving the aim and efforts of the continuity in implementation of emission reduction and environmental protection (Zhang, 2009; Chen, 2013).

It is the environmental problems that are the prime and fundamental representation of general socio-economic problems faced when transformation of the 'agrarian society waste cycle' into an 'industrialized society waste cycle' occurred (Chinese Academy for Social Sciences, 2009; McAusland, 2004). In the past 30 years, too much of resources and environmental costs have been spent supporting the high-paced development of the economic civilization and the commercial-industrial aspects. The environmental loading is related directly to the population, per capita GDP growth and pollution loading per unit of GDP (Zhang, 2009; Chinese Research Academy of Environmental Sciences, 2010; Chen, 2013). It calls for rigorous answers in the related social and economic system to solve the environmental problems, for they serve as the essential keys to solve "dependent variables" through "independent variables", beyond the environmental system and waste cycles. According to the international experience, environmental problems in the entire social and economic system need to be solved. Hence, it is necessary to discuss the essence of emission reduction standards in all social and economic layers and comprehensive actions must be taken to solve the problems of the system, keeping the continuity, harmony and balance between environmental, social and economic systems. It is only when the government fulfills its responsibilities and genuinely implements the targeted environmental assessments and monitoring and carries out emission reduction along the entire commercial-industrial processes that can the public take part in a joined effort for environmental protection. Therefore, the governments of P.R.C. usually play 'number games' in their annual reports in order to avoid the ineffective emission reduction efforts (China Development Bank, 2010; Zhang, 2009; Chen, 2013).

The establishment of abiding by the pollutant emission standards directly reflects the quality and environmental efficiency of economic operations. Generally speaking, the pollutant emission standards are indices to indicate the situation and quality and sustainability of the economic operations. Although the positive and exciting background of high GDP growth rates faded the public intensity and attention to industrial emission, it is easy to see that the environmental pollution is much more severe than the developed countries (Chan et al., 1995; Chinese Academy of Social Sciences, 2009; Zhang, 2009; Chen, 2013). The amount of emission and the money spent on natural resources in China are always high because no ultimate change has been made in the development pattern with high investment, consumption and pollution. Most of the industries which contribute to GDP growth are large contributosr in pollution and energy consumption. Compared with the same period in the previous year, January to May 2007 witnessed a growth of 21.8% in long term loans relatively economically and environmentally efficient industries received from main banks and financial organizations. Heavy chemicals, thermal power, iron and steel and cement industries are always the main culprits in emissions. Some small steel, cement and thermal power factories, which are 'restricted' internationally, still exist in some areas in China, leading to excessive production. Some highly polluting industries in the eastern area, which had been declared obsolete in the process of industrial adjustment, changed their faces and moved to the west and less developed areas. The power industries, by means of the thermos-electric united production, enlarge their production. The aluminum oxide and coating chemicals industries have also developed rapidly. At the same time, the increase in raw steel exports accounts for 33% of the increase in steel production. Exports of Chinese coal occupy more than 50% of the world. During the Tenth-Five Year Plan period, the SO_2 trade deficit coursed by the foreign trade is as high as 1.5 million tons. China has had huge trade surplus for more than a decade while it suffers huge

"environmental resource deficit" and possibly "public health deficit". Large quantities of high-quality goods are exported each year while the pollutants generated during their production stay in China for many years to come. Therefore, bringing in purchase orders for manufactured products, to a certain extent, equals to "importing" pollution (Zhang, 2009; Chen, 2013).

Before realizing emission reduction, the economic development mode and structure must be refined and streamlined. Operating economic elements such as GDP, water consumption, industrial structure, energy consumption and technological advancements are also indispensable in terms of realizing emission reduction, environmental resource protection and sustainable development. Emission reduction is not to restrict development but to make it sustainable and reinforce the harmony of development. Seeing from this perspective, the goal of environment protection in the Tenth-Five Year Plan has not yet been realized, because the fundamental problems are the development pattern and the quality of economic operations. During the Tenth-Five Year Plan period, the average increase in GDP was 9.5%, with a total growth of 58%. Compared with the predicted average rate of 7.5%, there is 14.3% surplus (the planned rate for the next 5 years is 43.6% on a cumulative basis). The increasing growth rate of high pollution products such as raw steel, cement, power generation, ethylene and paper are 175%, 68%, 64%, 84%, 61% and 149%, respectively (Jiangsu Provincial Environmental Protection Bureau, 2014). These growth rates are obviously higher than growth rate of the GDP. Therefore, realizing the targeted aim of overall emission control is inevitably difficult. An alternative worth considering is to relocate and place these pollutants emitting industries in remote country sides. However, this has to be done at the expense of increased costs of transportation (Zhang, 2009; Li and Pan, 2013; Chen, 2013).

Environmental protection and emission reduction are also a political problem in China. It is true that the country's per capita emission is not extremely high, but the sum total emission of various pollutants such as COD, Hg and other heavy metals in the hydrospheric and lithospheric environments and SO_2, CO_2, particulate matter and hydrocarbons in the atmospheric environment has been ranked as the highest in the world (Guangzhou Environmental Protection Bureau, 2014; Ma and Ortalano, 2000; Zhang, 2009; Chen, 2013). China has seriously promised to the rest of the world to reduce emissions and it has attained high international praise and recognition. The emission reduction directly affects economic development and harmony of the society due to economic downturn and unemployment. Emission reduction has, therefore, been a political and social problem. The government is the major power to bear the responsibilities and implement the plans that may seem unfavorable in shorter terms. The implementation rate of emission reduction directly affects the assessment of the governments at each level, but this should eventually be beneficial to all in the long run (Zhang, 2009; Chen, 2013).

2.3. Conclusion of literature review

Environmental conditions can affect human health, but less widely known is that health can also affect the environment. Because of the interaction of human health and his environment, our health is considerable determined by the environment, the World Health Organization (WHO) definition of health emphasizes that "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity due to environment problems". Therefore, the human health and environment is closely related, so some questions come out: reducing human activities is imperative for environment protection strategy, along with improvement of the environment; there is no need to care about the human development due to environment protection.

Improvement in human health, such as reduced mortality, is also beneficial to environment in some aspects, such as promoting the cycle of ecological system. Overall, it is urgent for human beings to achieve an appropriate balance between environment and health.

There have been very few published researches and journals talking about the aspects of how to establish an appropriate balance between environment and health by taking the specificity of environment structure, per capita GDP, mortality rate due to in specific environment. There have also been very few investigations on the comparison and contrast between countries to emphasize the difference of mortality rate. Therefore, there lacks the effort and it is of urgent need.

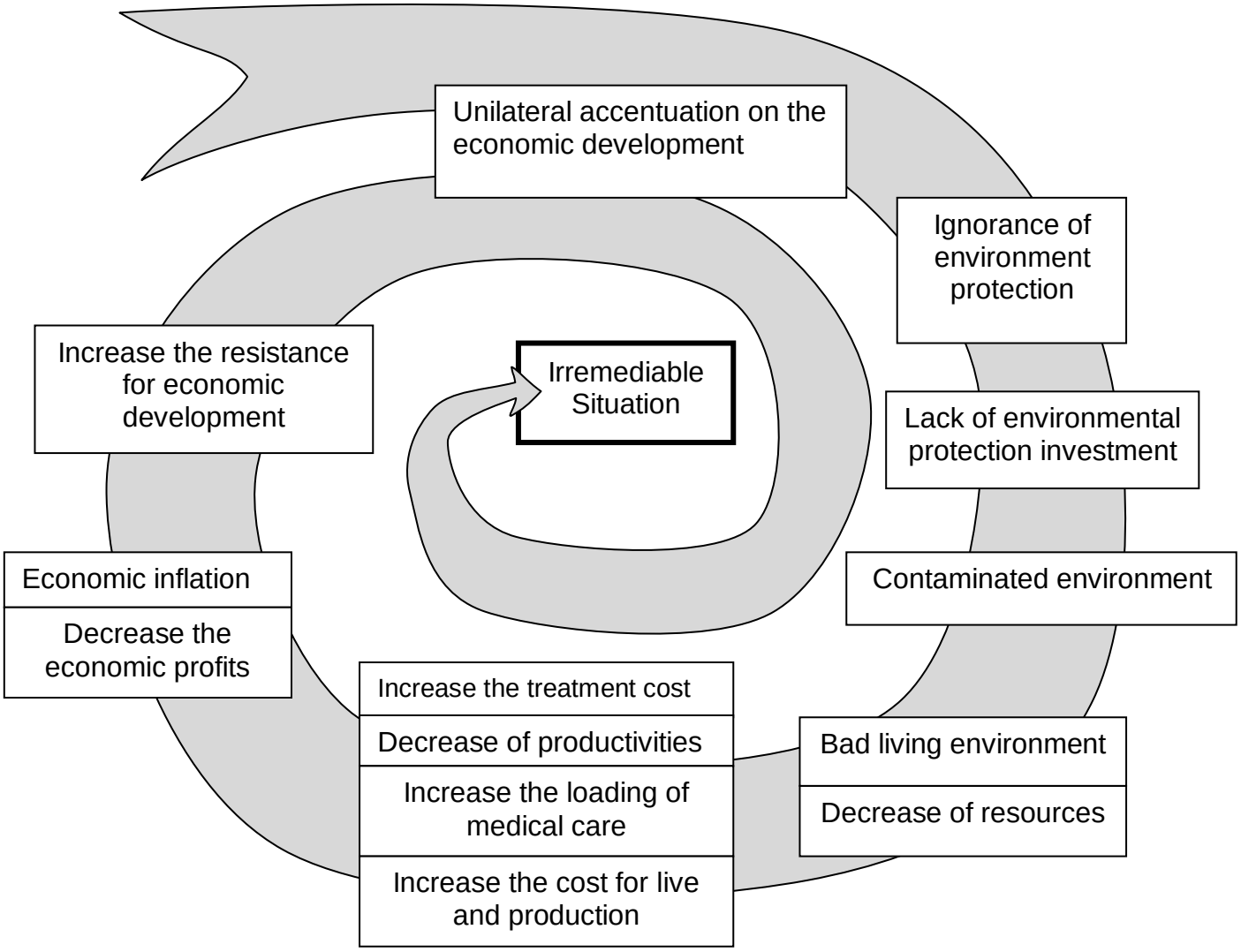


Figure 2.3. The circle of unilateral accentuation of economic development (Chen, 2013)

Figure 2.3 shows the final outcome of the neglect of environment protection, which eventually results in a situation that is beyond remedy. In order to avoid this, action must be taken promptly. Therefore, a suitable scale of EnvI should be worked out and established to improve the present unfavorable situation. The EnvI consists of two major parts, i.e., capital cost of environmental hardware fabrication and installation and operation and management expenditure for these

facilities. The environmental hardware is composed of the treatment facilities, management organizations, research and development centers and relevant educational arrangements. The operations expenditure comprises the operation and management of treatment facilities, research and development of innovative technologies, culture of the professionals and propaganda and promotional drives for environment protection knowledge. The published literature has been of the view that different countries have different situations, so every country should have suitable investment and distribution among the various aspects that are deemed fit for the specific contexts. However, as it has been previously pointed out, most of the previous studies in these aspects were carried out in foreign contexts. There is a serious lack of technical and scientific investigation for determining a suitable EnvI, including both public and commercial spending in P.R.C. on public health.

Chapter 3. Methodology

3.1. Research framework

Figure 3.1 shows the research problem defined in this study and following research work. The left-column in Figure 3.1 is the research flow and the right-column is the corresponding research objectives.

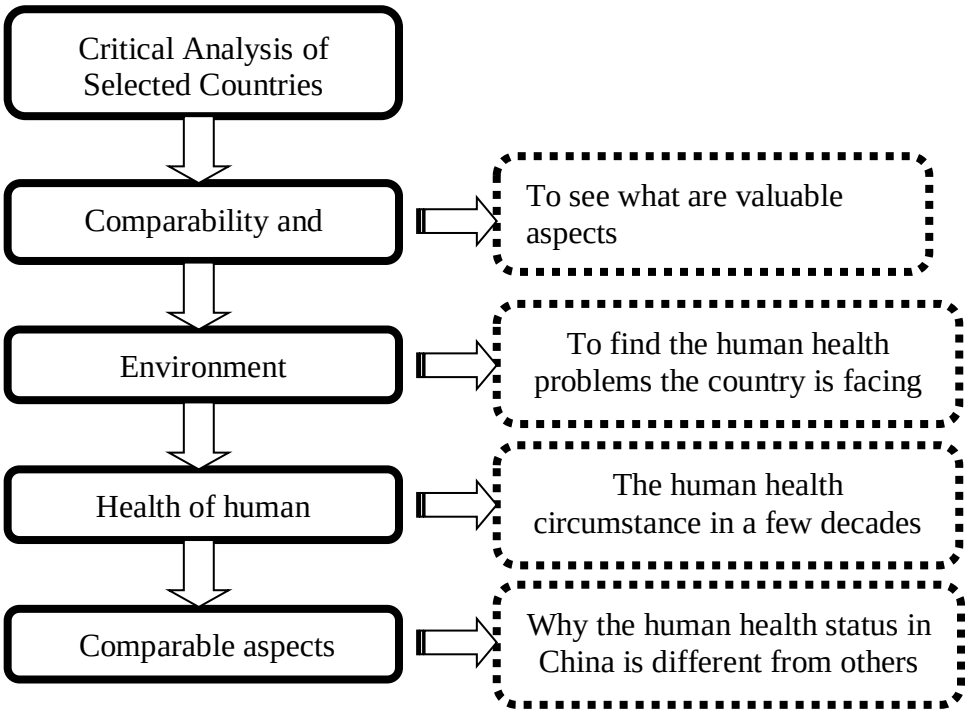


Figure 3.1. Research flow and objectives

3.2. Materials and data collection

There are two countries selected for the research. They are China and United States (U.S.). The reason to choose China is that China is the most representative of developing country, while U.S. is the most representative of developed country. The materials and data used in this dissertation are collected from the following sources:

China:

(1) the website of Chinese International Academic Journals;

(2) The website of World Health Organization (http://www.who.int/en/);

(3) The websites of Chinese Government (e.g. National Bureau of Statistic of China (http://www.stats.gov.cn/english/); and

(4) The website of National Health and Family Planning Commission of People's Republic of China (http://en.nhfpc.gov.cn/)

United States:

(1) the website of International Academic Journals;

(2) The website of World Health Organization (http://www.who.int/en/);

(3) The website of World Bank (http://www.worldbank.org/);

(4) The website of U.S. Department of Health and Human services (https://www.hhs.gov/); and

(5) The website of U.S. Environmental Protection Agency (https://www.epa.gov/)

For data related to China, those from the website of Chinese International Academic Journals have the priorities because it is the website where authorities post the largest amount of journals and the journals are the most authoritative and reliable. This study aims to assess the human disease relating to environment in China, so the second selected sources are the website of World Health Organization, and the website of Chinese Government.

As for the more recent information and opinions of current development, the website of National Health and Family Planning Commission of People's Republic of China and the website of Chinese Government have information throughout texts of this study.

For the other categories of data related to U.S., the website of U.S. Department of Health and Human Services will be firstly referred to, because it is just like the website of Chinese Government, which always posts the latest information and news, and revises them in time. The International Academic Journal also has a large number of journals relating to disease and environment in U.S. The World Health Organization is the most influential website for human health and disease. Even though it is not relating to environment, people can combine it with other website such as the website of the U.S. Environmental Protection Agency and U.S. Department of Health and Human Services. On it much recent information relating to disease is posted, some of which are related to environment.

3.3. Methods for assessment

The literature review is used to shape an overview first. Various parameters, such as the quantum of polluting emissions, GDP, per capita GDP, population density and EnvI amount are adopted to elucidate the situation of environmental protection investment and economic status (Garner, 1996). The reason to choose per capita GDP is that it is an important factor to measure the level of a country in aspects such as whether it is a developing country or developed, the number of people accepting education, and the level of heavy industry (it is vital for environmental pollution). The four factors are adopted to elucidate the situation of human health relating to environment. When the government makes regulations, they should take local people's per capita GDP into consideration. Thus the people's per capita GDP will be explored firstly by being compared with some representative developed countries, because to compare one country's environment, human being's health is relating very closely to environment. The second factor is population density and this factor represents human health distribution.

3.4. Methods for comparison and country selection

How to choose proper countries to undertake comparison and contrasting is vital for this study. Since human health relating to environment is determined by countless factors, such as the level of development of a country or the attitude towards environment and populace gain. The most important point was to select based on their fundamental representation of an irreplaceable part. The U.S. was selected for its being developed, and good attitude towards environment, and also well-developed heavy industry (which is the important influencing factor of the quality of country's environment). China is the main country selected for analysis because of its population and population density is an important factor, because it has the largest population in the world, and poor attitude towards environment development (Chen, 2013).

3.4.1. Factors affecting human health quality

Human health depends on many factors and constraints. Currently, the main factors affecting the health of people are environmental and social ones (United States Environmental Protection Agency, 2017). Environment's relationship with human being's health is the main topic in this study, and has been reshaped by and large in aspects such as urban expansion, high population density, and good or bad attitude.

3.4.1.1. Population and population density

Population density is an extremely important factor in this study. Population density, health and environment are very closely related, and it is indivisible that population directly determines human being's health (Philip, 2007). Because they live in a very crowded area, air standards, infectious disease plus rush development speed are greatly alike, and there is a strong possibility

of contacting disease. The ratio of getting infectious disease in urban area is much higher than that in countryside (Avert, 2016).

3.4.1.2. Urban expansion

As the speed of development in a society is in a rapid change every year, more buildings are built for GDP. Trees and parks are destroyed for buildings. Urban air pollution and water pollution is becoming more and more serious. Thus urban expand is an inescapable factor.

3.4.2. Countries classification

First of all, living area will be explored because human health depends on living standard. Although not all cries have similar economic strength to that of China, per capita GDP will be compared with that of China for comparability.

3.5. Study scope

3.5.1. Definition of environment

The definition of environment can be various. Here are some definitions of it that can be found.

In China, the definition of Environment is “The sum of surroundings of a living thing, which provides conditions for development and growth as well as for danger and damage”. While in USA, Roget's Thesaurus of English Words and Phrases (1988 version) explained environment as “situation, position, locality, attitude, place, site, bearings, and neighborhood”. Environment can also be defined as “the surroundings or conditions in which a person, animal or plant lives or operates”. In this study environment refers to third definition, which is the surroundings or conditions in which a person, animal or plant lives or operates.

3.5.2. Definition of disease

the definition of disease in USA is that a disorder of structure or function in a human, animal, or plant, especially one that produces specific symptoms or that affects a specific location, which is not simply a direct result of physical injury (Roget's Thesaurus of English Words and Phrases, 1988 version).On the other hand, in China disease is defined as "phenomenon where organisms suffer from bad health". It is important to define disease because of contemporary bio-medicine's power to intervene not just in people's health status but also in domains of their biology where the effects are morally, and economically, problematic. In this study disease refers to the reason for body having unusual status.

3.5.3. Definition of water pollution

Definition of water pollution refers to the phenomenon of a certain amount of wastewater. All kinds of waste and other pollutants flow into the water, and when they go beyond the self-purification of water bodies and the pollutant carrying capacity, water pollution exists. The composition of physical sediment, chemical nature and biological community has changed, which has destroyed the survivals and the water function, and reduced the value of water.

3.5.4. Definition of air pollution

In USA, the definition of air pollution is that in human living and industrial activities, a large amount of exhaust gas without proper treatment is discharged into air, of which the total amount of existing time and range are much greater than the pollution caused by natural discharge. The extra discharge of air is called air pollution. While in China, the definition of air pollution is as

“air pollution means air that has one or more contaminants which contains smoke, gas, fog, smell , or steam. The characteristics and duration time are enough to harm human health or animal and plant life ”

3.5.5. Definition of investment

In fact, the definition of investment can be divided into two aspects – finance and business. From the perspective of finance, investment is the process whereby money is put into something with the prospect of gain within an expected period of time. On the other hand, in business, investment can be defined as the purchase by a producer of a physical good, such as durable equipment or inventory, in hope of improving future business (Peng and Li, 2005). Nevertheless, in this project, investment refers to the expenditure provided by government or individuals on environmental protection.

3.5.6. Definitions of environmental protection investment

There are several definitions of environment protection investment all over the world. Generally speaking, environment protection investment is the expenditure incurred from the accumulation of social capital and various compensation funds by the related investment communities, and is used for the control of environmental pollution, maintaining ecological balance and related economic activities (Shen, 2009). In this economic activity, financial resources are provided to environment protection industry to protect environment from contamination, to keep ecological balance and to get access to a society with sustainable development (Peng and Li, 2005).

Environmental protection investment can be divided into three main categories in China, according to investment directions: investment in pollutants’ treatment, investment in ecological protection

and investment in environmental management and services for technology and self-construction (Jiang at el., 2005).

In this essay, our concern is focused on investment in the environmental management which consists of the capital cost and the operations cost, so investment in pollutant's treatment and ecological protection in this aspect is ignored.

The government's environmental protection investment for anti-pollution industry includes expenditures on the equipment purchase and maintenance and expense on the construction and maintenance of waste treatment plants.

However, the social input in China can hardly be calculated. One reason is there are not too many records about social investment in environmental protection. Another is that social investment activities have not been well stimulated (Lu et al., 2004; Wang and Chang, 2003). That means social expenditure really takes up a small part of the whole investment amount in China.

Chapter 4. Data analysis and discussion of P.R.C.

4.1. Environmental situation and investment in P.R.C.

More than a century ago, western countries underwent environmental problems during industrialization, and in recent 30 years, those problems have been rampant in China. The worsening environment has exerted a great number of influences on governmental policies and human living conditions because of heavy pollution burden and shortage of per-capita resources. For example, China's atmospheric air pollution has resulted in problems of sulfurous pollutants, hydrocarbons, particulates, etc., caused by the extensive and irrational use of coal (Linand, 2003; Lu et al., 2004). China today is challenged by relatively serious environmental problems, which were confronted by developed nations in the 1950s and 1960s, a period worst in terms of pollution (Wan, 1998; McDermott and Stainer, 2002). It is notable that the eastern coastal cities of China suffer from exacerbated environmental problems due to their population of high density that produces more industrial and residential pollutants than the environmental capacity can carry. In contrast, China's western provinces do not have such high population density, but the lack of resources such as well-trained teachers, proper environmental management and financial support for environmental protection programs led to the fact that environmental consciousness and education there are relatively poor (China Development Bank, 2010).

China Daily reported that the eleventh five-year plan witnessed an investment of 54 billion Yuan in industrial pollution treatment from Shanxi Province, known as the coal-rich province in northern China, and the results of assessment had to be calculated in the official achievements (Zhang and Zhang, 2006; Tsang, 2015). Northwest China's Lanzhou, known as one of the most polluted cities in the world, plans to spend 130 million Yuan (US$16.9 million) this year (2011) tackling and fighting against pollution in the Yellow River and its tributaries, which run through the center of

the city. It can be found that the environment and ecology have attracted much attention from the state and local governments. However, whether the expenditure can meet requirements of effective protection needs technical and administrative assessment because there is still one city in Shanxi province listed in the six most polluted cities revealed by the Blacksmith Institute in 2010, and also, Lanzhou's environmental quality was the lowest in all environmental quality standards and parameters in 2010, according to Lanzhou Daily (Zhang, 2009; Chen, 2013).

4.1.1. Environmental pollution in P.R.C.

Pollution levels of many countries have already substantially surpassed those of western countries and Japan (Stearns, 2007). China's chemical emissions take up 9% of the world's total amount, compared with 5% of Japan, 14% of the former Soviet Union and a thriving 18% of the U.S. This figure may seem reasonable, but it is on a rapidly increasing trend (Chinese Research Academy of Environmental Sciences, 2010; Shi, 2007; Tsang, 2015; Zhang, 2009; Chen, 2013).

4.1.1.1.1. Interrelation between industrial and domestic wastewater

Although the total discharge of major pollutants has widely surpassed the water environmental capacity for years, water pollution has been mitigated to some extent recently in China. Most cities are investing rapidly to expand their existing wastewater treatment facilities and construct new ones. Therefore, it is expected that improvements of water quality are likely to continue in the years to come. The declined function of water use will be improved by suspension of irrational exploitation of water and forests damage (Tsang, 2015).

The total amount of wastewater has been mounting in a rapid pace along with the fast growth of industrialization and urbanization, which over the past 10 years maintained an annual increase of

about 4%. The wastewater discharged increased in total from 41.52 billion tons in 2000 to 61.90 billion tons in 2014, at a rate of 2.7%~8.5%. The amount of discharge of domestic wastewater has gradually risen and it exceeded industrial wastewater in the year 2000; it accounted for about 54.2% of the sum total of discharge in 2004 (Figures 4.1 and 4.2). The traditional pollutants, measured in COD, BOD_5, suspended solids, total nitrogen and total phosphorus have also been increasing over the years. Furthermore, in municipal sewage, there are also some other poisonous and hazardous components found, which can be exemplified by toxic organics and heavy metal introduced by particular industries, and here domestic sewage is mixed with industrial liquid discharges with a proportion of 70-30 (Chinese Research Academy of Environmental Sciences, 2010; Tsang, 2015).

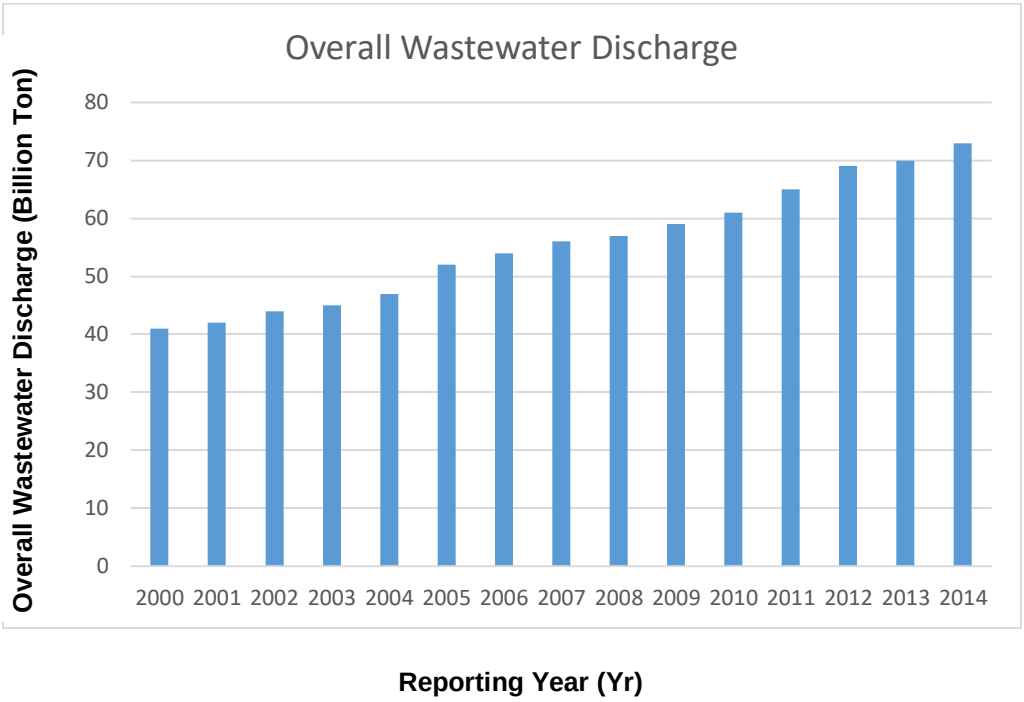


Figure 4.1 PRC overall wastewater annual discharge status (including industrial and domestic discharge) (Adapted from the website of National Bureau of Statistics of China) (with data extracted from Chen, 2013 and Tsang, 2015)

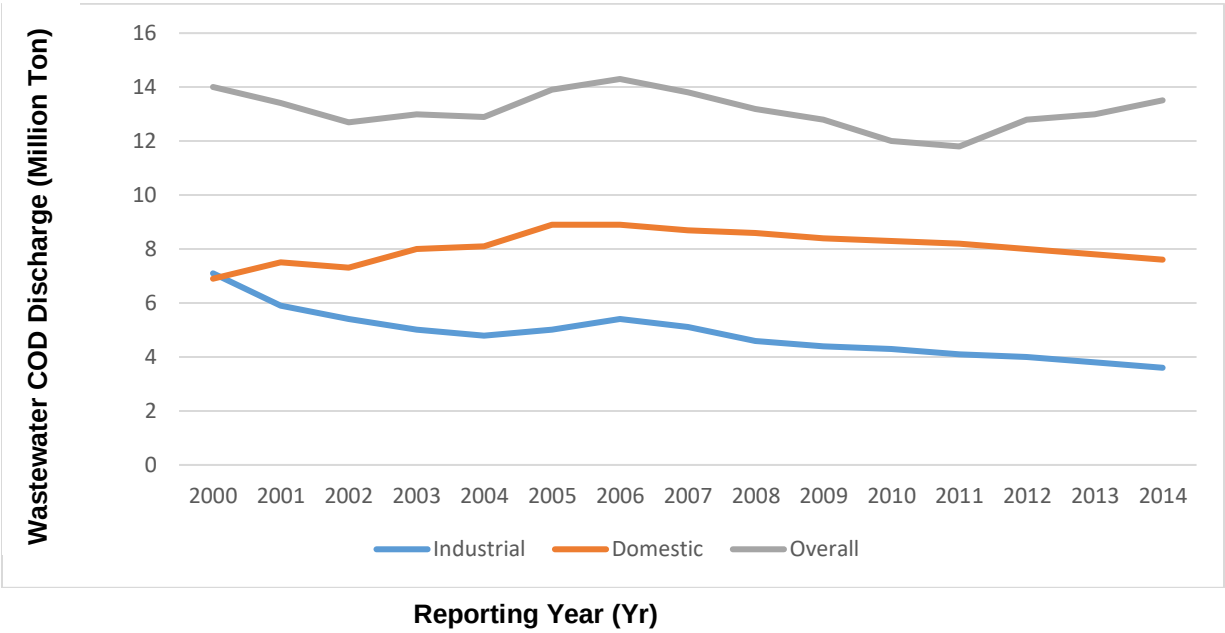


Figure 4.2 PRC wastewater COD annual discharge status (Adapted from the website of National Bureau of Statistics of China) (with data extracted from Chen, 2013 and Tsang, 2015)

However, the volume of ammonia-nitrogen discharged from domestic sources has been growing at a higher speed than that produced by industrial wastewater (Figure 4.3). The volume of domestic wastewater was almost twice much as industrial effluents from 2006 to 2010. This indicates a more complex sewage discharged by domestic households, which in turn, results in eutrophication and massive algal blooms in the recipient water bodies (Sin et al., 2003a, 2003b); if such wastewater is not extensively treated in the community municipal sewage treatment has to work (Chen, 2013; Tsang, 2015).

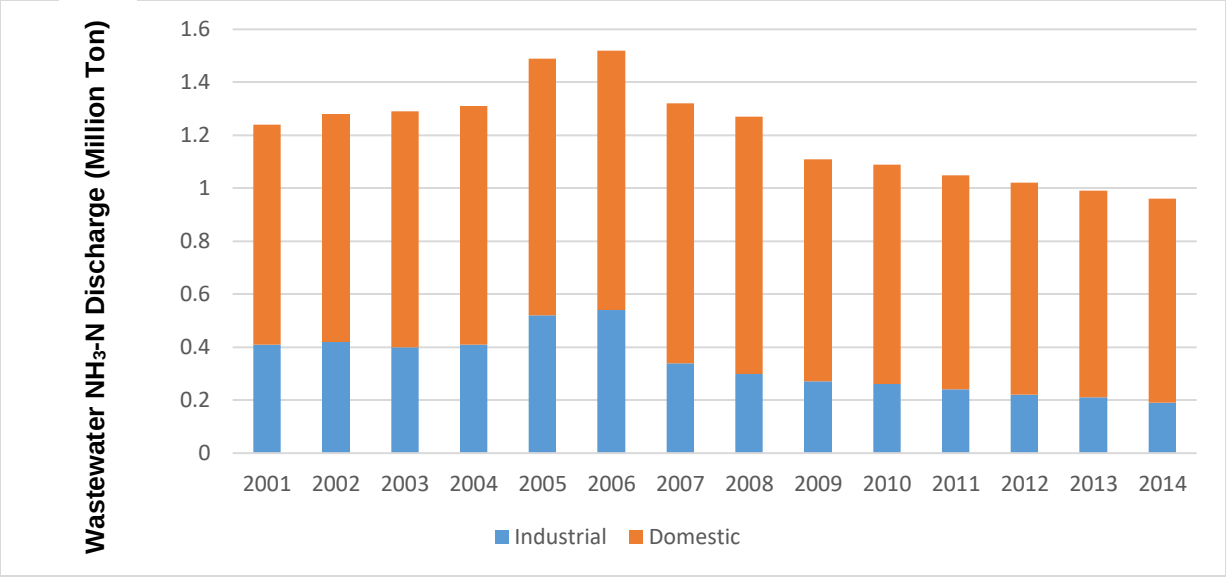


Figure 4.3 PRC wastewater ammonia-nitrogen annual discharge status (Adapted from the website of National Bureau of Statistic of China) (with data extracted from Chen, 2013 and Tsang, 2015)

It was suggested by Dollar (2007), US National Advisor and meanwhile the World Bank's Country Director for China and Mongolia in the East Asia and Pacific Region, that industry would cease to play the role of a main water pollution source if over 90% of its discharge disposed of reasonably. The number one source of environmental pollution is untreated or poorly treated household waste. Only slightly more than 50 percent of urban household wastewater is dealt with in complete secondary sewage treatment work. High concentrations of carbonaceous components (COD > 500 mg/L), nitrogenous components (TKN > 30 mg/L) and total phosphorus components (TP > 5 mg/L) were spotted in the remaining untreated domestic sewage (Chinese Research Academy of Environmental Sciences, 2010).

4.1.1.1.2. Industrial wastewater

Though domestic usage constitutes a key source of wastewater, industrialization has resulted in China incurring heavy pollution costs. In fact, the industrial wastewater still accounts for about one half of all wastewater discharged in many cities (Figure 4.4).

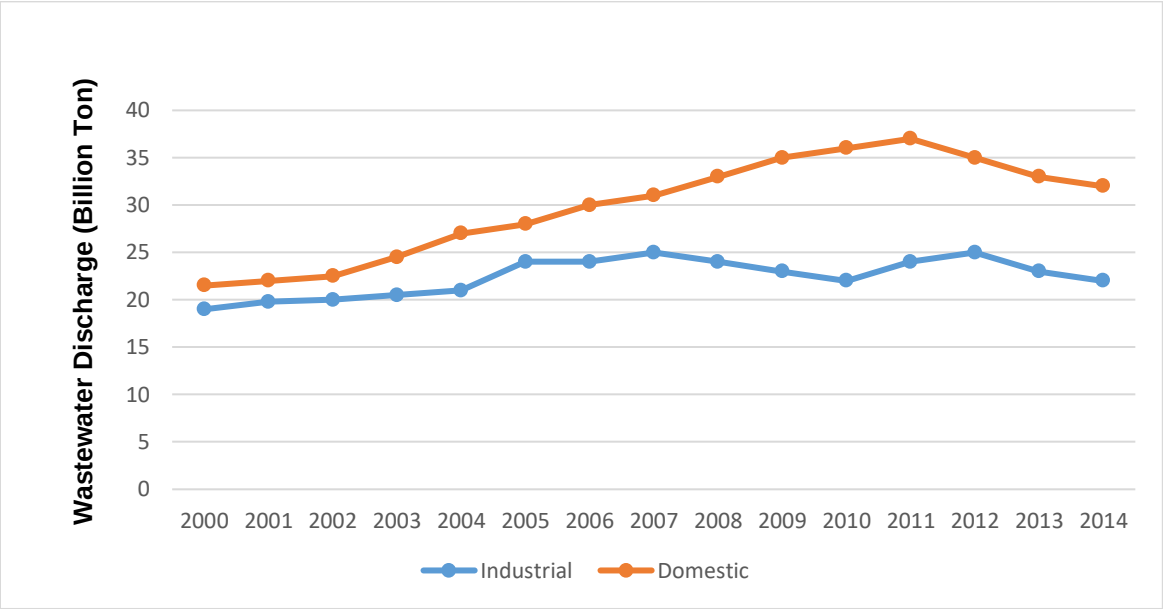


Figure 4.4 PRC industrial and domestic wastewater annual discharge status (Adapted from the website of National Bureau of Statistic of China) (with data extracted from Chen, 2013 and Tsang, 2015)

The top four sources of wastewater and industrial effluents discharge that account for nearly 80% of the total wastewater discharged are manufactures of four kinds: paper and paper products, foods and beverages, raw chemical materials and chemical products, and textiles (Figure 4.5) (Zhang, 2009; Chen, 2013; Tsang, 2015). We can see from the figure that manufacture of paper and paper products contributes the most while the food and beverages industry is the second largest polluter. These account for almost 80% of all and the other two sectors share the remaining 20%. Wastewater discharged by these industries typically contains such heavy metals as cadmium,

chromium, mercury, lead, nickel, cobalt, zinc, copper, etc. and a wide variety of toxic and xenobiotic organics because of the different chemical additives used in the manufacturing processes.

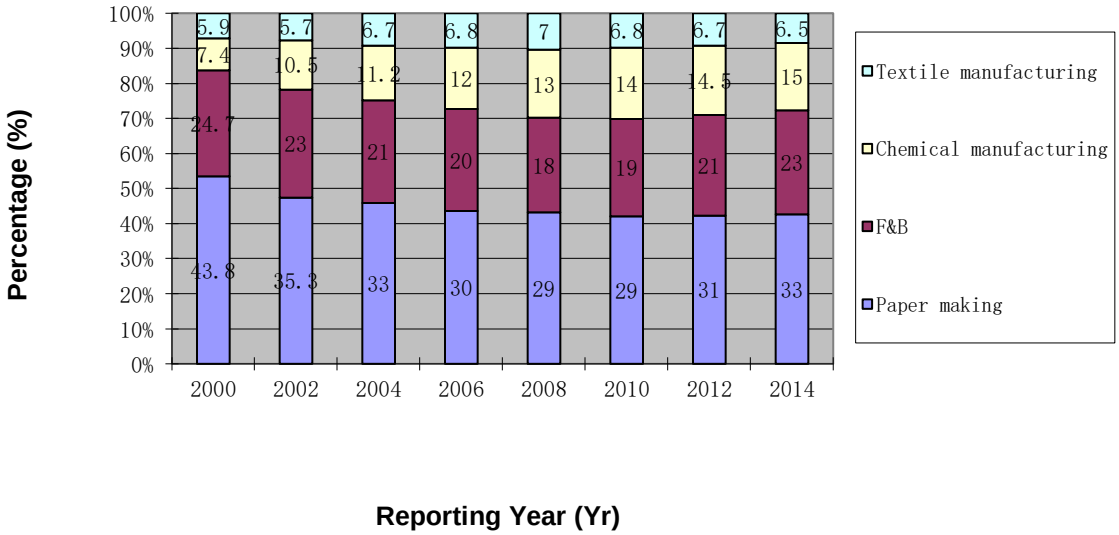


Figure 4.5 Ratio of profits to COD discharged of four sectors in 2000, 2002, 2004, 2006, 2008, 2010, 2012 and 2014

Figure 4.6 gives the impression that the major pollutants come from domestic wastewater. The ammonia discharge in domestic wastewater was nearly 1 million tons in 2006, or almost 70% of all ammonia discharged that year. The ammonia discharged from industry declined at a rate of 43% from the peak of 0.27 million tons in 2009 to 0.17million tons in 2014(Figure 4.6).

Figure 4.6 National ammonia-nitrogen discharge trend (Adapted from the website of National Bureau of Statistic of China) (with data extracted from Chen, 2013 and Tsang, 2015)

4.1.1.1.3. Wastewater treatment plants

Until 2004, 637 plants treating wastewater had been established, which were aimed at disposing of municipal wastewater of a daily volume of 42.55 million tons (including industrial effluents) every day. The total amount of treated wastewater reached 10.14 billion tons in 2004, and more than 80% of it (equals to 8.58 billion tons) was domestic wastewater. The actually collected sewage in public sewers and volume of wastewater appropriately treated through the intended secondary biological processes were only a little more than half of the designed capacity (Zhang, 2009; Chen, 2013; Tsang, 2015).

According to the government the main bottleneck is that the construction of the municipal sewerage system has lagged far behind the development of environmental infrastructural facilities. There are other obstacles to increasing the rate of wastewater treatment, including the issues in revenue ordinances, supervised regulations, operations and system management and law

enforcement, especially when commercial organizations manage and operate the facilities on build-on-transfer (BOT) basis.

4.1.1.2. Solid waste generation, discharge and utilization

4.1.1.2.1. Industrial solid waste

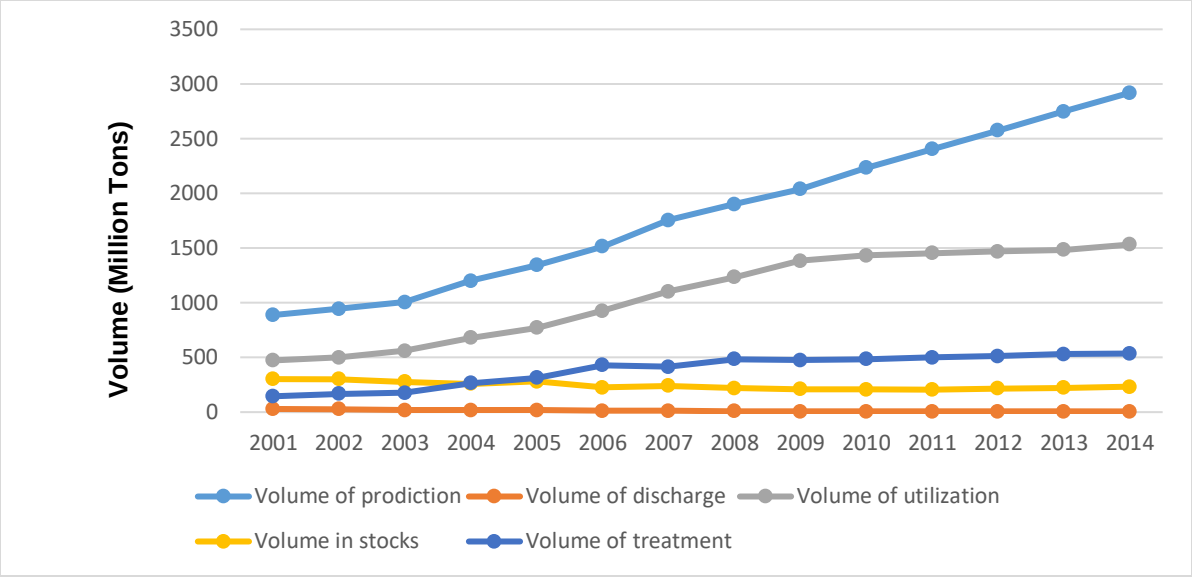
Despite the fact that industrial solid waste countrywide has apparently increased over the last ten years, quantity of discharge of certain industrial materials has sharply declined and recycling and comprehensive utilization have significantly increased. This indicates that technical advancements of recovering and disposing of solid waste have been realized in various manufacturing industries over the years, and there has also been remarkable improvement in the public and commercial investment in industrial solid waste treatment (Table 4.1) (Zhang, 2009; Chen, 2013; Tsang, 2015). This situation is particularly obvious in plastic wastes, which account for 10 to 15 percent (weight) of total municipal solid waste generation. Industrial plastic scrap and other disposable products are recycled and environment-friendly substitutes have been developed (Zhong et al., 2011, Chinese Research Academy of Environmental Sciences, 2010).

Table 4.1. Generation and processing of national industrial solid waste (Adapted from the website of National Bureau of Statistic of China) (with data extracted from Chen, 2013 and Tsang, 2015)

Year	Volume of production	Volume of discharge	Volume of utilization	Volume in stocks	Volume of treatment
2001	887.46	28.94	472.90	301.83	144.91
2002	945.09	26.35	500.61	300.40	166.18
2003	1004.28	19.41	560.40	276.67	177.51
2004	1200.30	17.62	677.96	260.12	266.35
2005	1344.49	16.55	769.93	278.76	312.59
2006	1515.41	13.02	926.01	223.98	428.83
2007	1756.32	11.97	1103.11	241.19	413.50
2008	1901.27	7.82	1234.82	218.83	482.91
2009	2039.43	7.10	1381.86	209.29	474.88
2010	2188.30	6.44	1546.30	200.08	482.95
2011	2519.46	5.85	1730.31	191.27	491.16
2012	2703.38	5.31	1936.21	182.86	499.15
2013	2900.73	5.82	2166.62	174.81	508.00
2014	3112.48	4.38	2424.45	167.12	516.64
Percentage change	250.7%	-84.9%	4.1%	-44.6%	256.5%

Unit: million tons

If we plot the data in Figure 4.7, it can be seen that the discharge volume of industrial solid waste decreased gradually from 28.9 million tons in the year 2001 to 4.3million tons in the year 2014, although the generation is rising at a rate of 10.9% per annum. This is because of the continuous increasing volume of comprehensive utilization and treatment (Xiao et al., 2007).



Year

Figure 4.7 Situation of national industrial solid waste.

4.1.1.2.2. Municipal solid waste

More than 100 million tons of municipal solid waste is generated annually and it is growing at a rate of 8%~9%; it accounts for 27 percent of the waste generated all over the world (Liu, 2005). Figure 4.8 describes the relationship between the amount of municipal solid waste and the population. The former is in proportion to the latter and the next 20 years are expected to be the peak period of growth of population and generation of municipal solid waste.

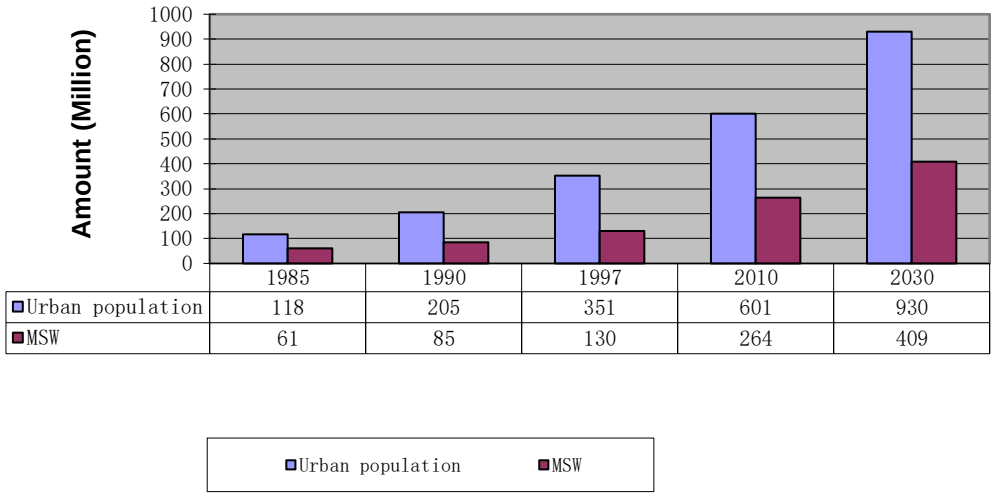


Figure 4.8 Relation between urban population and MSW.

Sanitary landfill, composting, pyrolytic incineration and integrated utilization are the common methods of processing municipal solid waste in China, among which sanitary landfill is the dominating way used, for more than 70 percent of all.

4.1.1.3. Air pollution

The air pollution is mostly contributed to by heavy industries with traditional technologies, such as thermal-power plants, cements factories and steel industries and traffic emission from an increasing number of vehicles. The air pollution in the P.R.C. relates closely to its large population and the industry- leading economic structure.

Air pollution has raised great concern among both the domestic and international communities. With suspended particulates and sulfur dioxide being the major pollutants, of which Table 4.2 shows the variations from 2001 to 2014, coal-smoke air pollution is caused mainly by the coal-based energy structure. Among these pollutants, discharge of SO_2 reached 18968 thousand tons in

2009, a reduction of 3.19% from that in 2008. The industrial dust emission and soot emission also decreased at a rate of 10.48% and 8.81%, respectively (Zhang, 2009; Chen, 2013; Tsang, 2015).

Table 4.2 National total waste gas emission (Adapted from Ministry of Environmental Protection of P.R.C.) (with data extracted from Chen, 2013 and Tsang, 2015)

Unit: thousand tons

	Emission of SO_2			Emission of Soot			Emission of Dust
	Subtotal	Industrial	Domestic	Subtotal	Industrial	Domestic	
2001	19478	15666	3812	10698	8519	2179	9906
2002	19266	15620	3646	10127	8042	2085	9410
2003	21587	17914	3673	10487	8462	2025	10210
2004	22549	18914	3635	10949	8865	2084	9048
2005	25493	21684	3809	11825	9489	2336	9112
2006	25888	22376	3512	10888	8645	2243	8084
2007	24681	21400	3281	9866	7711	2155	6987
2008	23212	19913	3299	9016	6707	2309	5849
2009	22471	18659	3812	8222	6043	2179	5236
2010	21754	17464	4404	7497	5444	2056	4684
2011	21060	16363	5089	6837	4905	1940	4193
2012	20388	15332	5881	6234	4420	1830	3754
2013	19593	14366	4966	5685	3982	1728	3360
2014	18968	13461	4196	5184	3588	1630	2285
Percentage change	-2.6%	-14.1%	10.1%	-51.5%	-55.9%	-25.2%	-76.9%

The patterns of variations in emission of SO_2, soot and dust are showed in Figure 4.9. It is obvious that all the three pollutants have declined steadily after a slight growth between 2002 and 2005. From 2005 to 2014, the emission of SO_2 gradually decreased from 25 thousands to 18 thousands**.** Although this expresses an improvement of air quality after 2005, we have a long way to go to decrease the air pollutants to a satisfactory level (Zhang, 2009; Chen, 2013; Tsang, 2015).

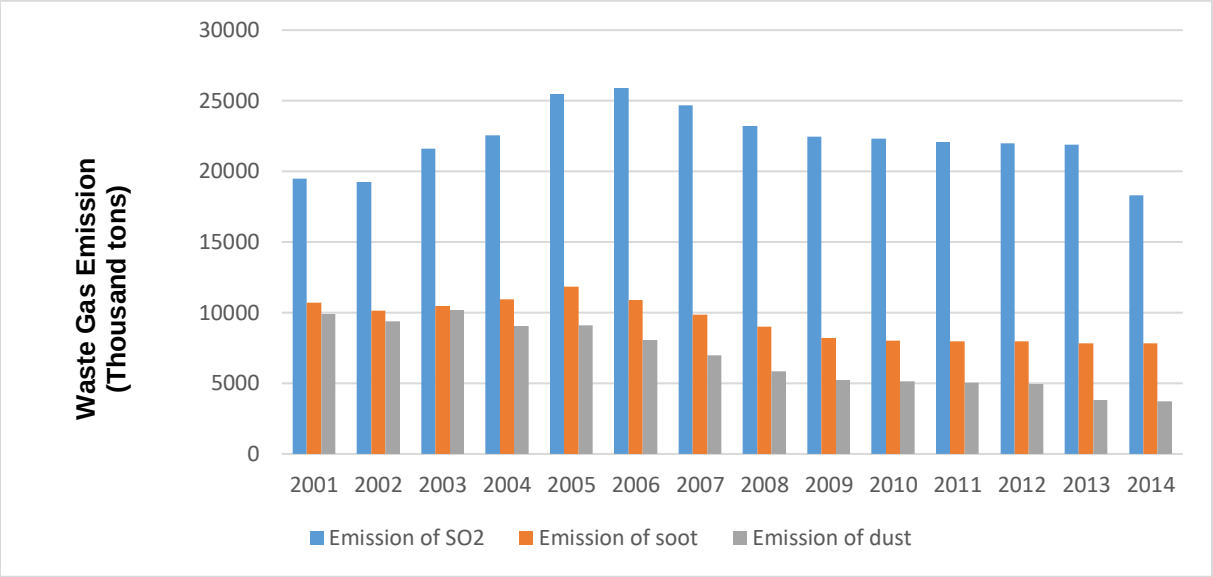


Figure 4.9 National total waste gas emission (thousand tons) (with data extracted from Chen, 2013 and Tsang, 2015)

4.1.1.3.1. Consumption of coal and fuel

Air pollution in the P.R.C. is primarily due to coal combustion. Figure 4.10 indicates that almost 70 percent of energy comes from combustion of coal while crude oil contributes another 20 percent. Other energy sources such as nuclear power, hydro power, wind power and natural gas share the remaining 10 percent of energy consumption.

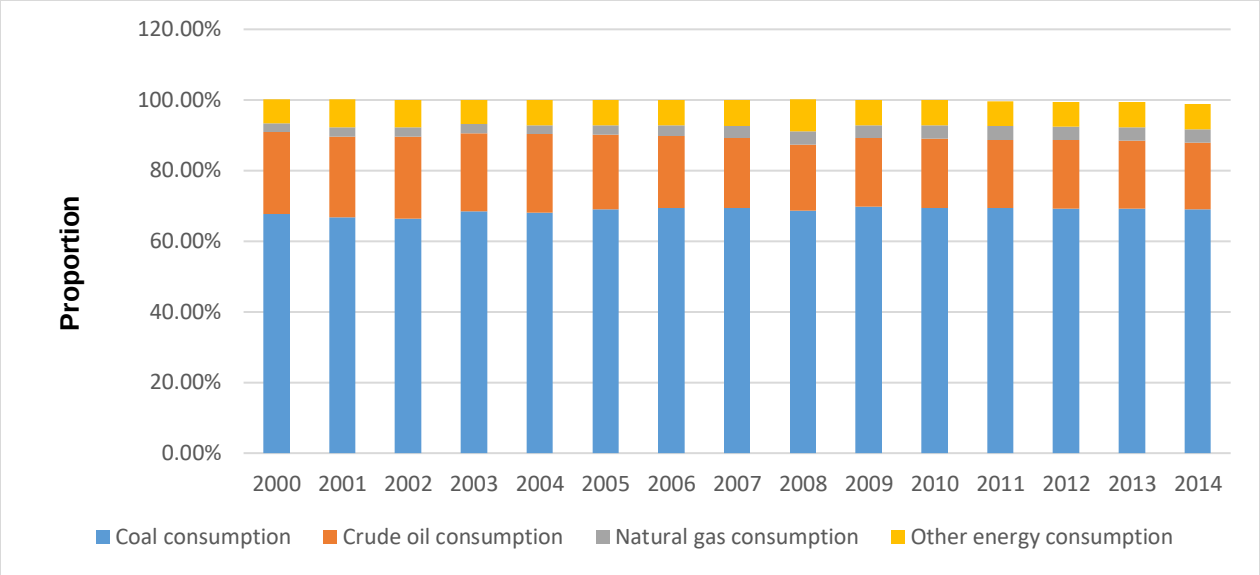


Figure 4.10 National energy consumption proportion.

Coal and fuel burning in coal-fired and oil-fired power plants, as well as in industrial parks, is the major cause for SO_x (sulfur oxides) and NO_x (nitrogen oxides) generation and these are related to acid rain and the eventual pollution in the downstream hydrospheric and lithospheric environments. Along with the fast-paced commercial and industrial development, coal and fuel consumption have experienced steady increase over the last two decades. With its annual growth rate averaging at 8%, coal consumption has made China the world's number two CO_2 emitting nation, just after the U.S., for over five years (OECD, 2005a, 2005b) as showed in Figure 4.11 (Chen, 2013; Tsang, 2015).

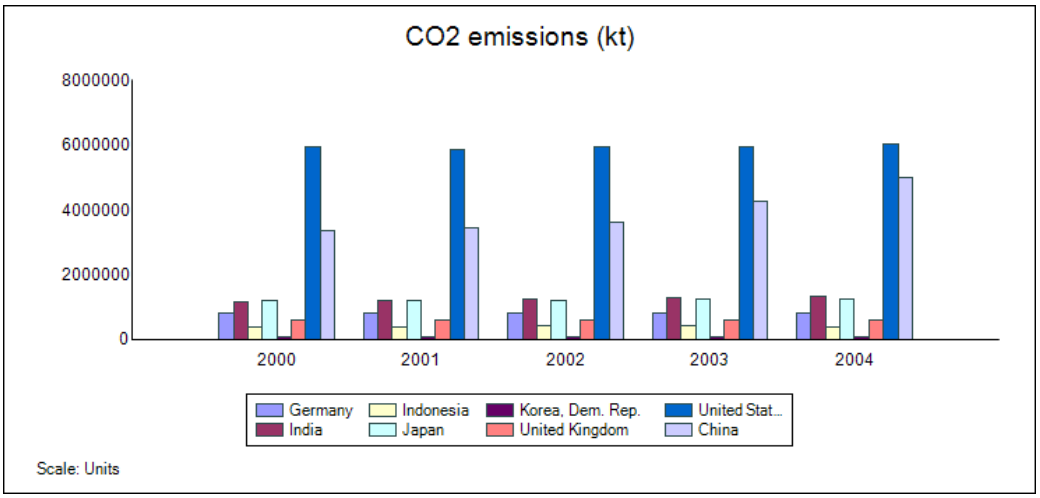


Figure 4.11 CO_2 emissions from different countries from 2000 to 2004 (with data extracted from Chen, 2013 and Tsang, 2015)

From the ten-year data that are currently available, we can see that the total amount of coal consumption in 2009 was 2.16 billion tons, 114% more than that in the year 2000. Consumption of coal in the manufacturing sector took up almost 90% of the total consumption, which increased by around 15% as compared to that in the year 2003. China consumed 200 million tons of domestic coal in 2004, equivalent to 10.2% of the total consumption; and this fairly stable figure has maintained the level over the last 10 years. On the other hand, total fuel consumption in 2004 reached a historical high of 27.34 million tons which grew by 4.2% as compared with that in 2003 (Figure 4.12) (Chen, 2013; Tsang, 2015).

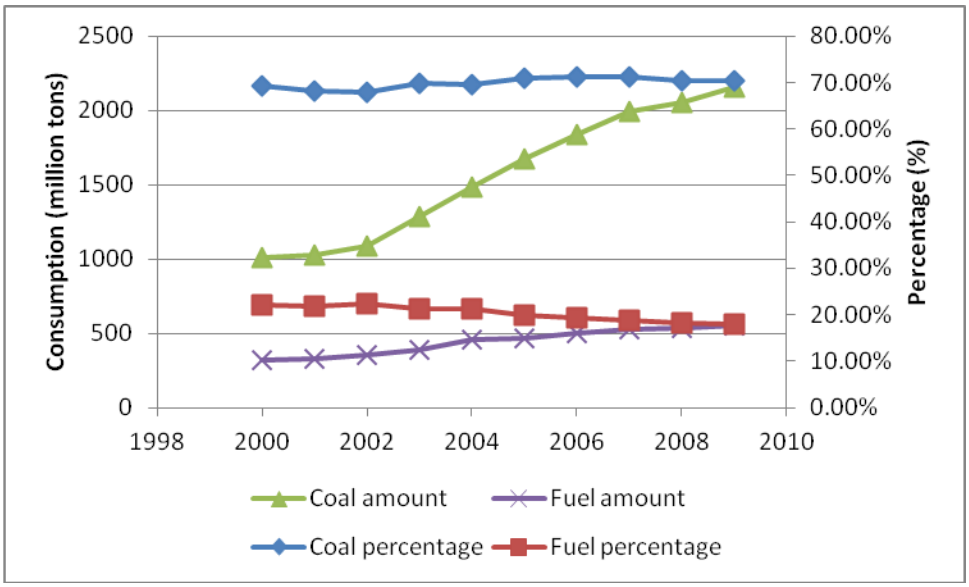


Figure 4.12 National total consumption of coal and fuel (million ton) (Liang and Zhou, 2008)

The consumption of coal and fuel continues to increase at the current rate. Table 4.3 tells that coal burning contributes to 85%, a high proportion, of the total amount of domestic energy consumption of China (Murray and Cook, 2002, China Development Bank, 2010). The traditional industrial production and energy consumption methods need to be changed with a sense of urgency. Otherwise, the situation where the resource-dependent economy would undergo the worst environmental pollution and resource depletion will have to occur before the time predicted (Chinese Research Academy of Environmental Sciences, 2010; Lin, 2005).

Alternative sources, particularly renewable sources of biological fuels including biodiesel and bio-hydrogen, should be developed and put on full-scale applications if the current unfavorable situation is to be significantly improved (Ren et al., 2011; China Development Bank 2010; Chinese Research Academy of Environmental Sciences, 2010).

Table 4.3 Energy use in China (Adapted from the website of National Bureau of Statistic of China) (with data extracted from Chen, 2013 and Tsang, 2015)

Unit: million tons

	End-use Consumption	Industry	Intermediate Consumption	Power Generation	Heating	Coking	Gas Production
1990	60205.9	35773.8	41257.8	27204.3	2995.5	10697.6	360.4
1995	66156.1	46050.3	69487.6	44440.2	5887.3	18396.4	763.7
2000	46821.39	34122.04	85178.61	55811.2	8794.07	16496.4	959.99
2004	59543.75	46082.95	134052.3	91961.56	11546.56	25349.58	1316.43
2005	62154.13	48040.74	154568.4	103263.5	13542.0	31667.06	1276.96
2006	61683.66	48006.53	177532.8	118763.9	14561.43	37450.09	1257.08
2007	56232.34	47233.52	162132.9	123245.6	13543.98	36433.89	1275.09
2008	57432.98	46938.90	17343.9	121239.7	15325.76	39873.90	1233.32
2009	48239.83	47232.74	15321.7	125432.23	13576.42	38746.43	1364.78
2010	42378.89	46323.86	16231.7	127923.98	13253.43	37231.56	1343.32

4.1.1.3.2. Industrial and domestic discharges of SO_2 and dust

In the year 2004, countrywide fouled air and industrial waste gas discharges were 23,769.6 billion cubic meters, which, compared to the year before, increased 20%, a considerable number. Among these, total emission of SO_2 arrived at 22.55 million tons. Over 80% was attributed to industrial production in the manufacturing bases and industrial parks (Zhang, 2009; Guangzhou Environmental Protection Bureau, 2010; Tsang, 2015). Furthermore, power plants and vehicular emissions are also substantial contributors.

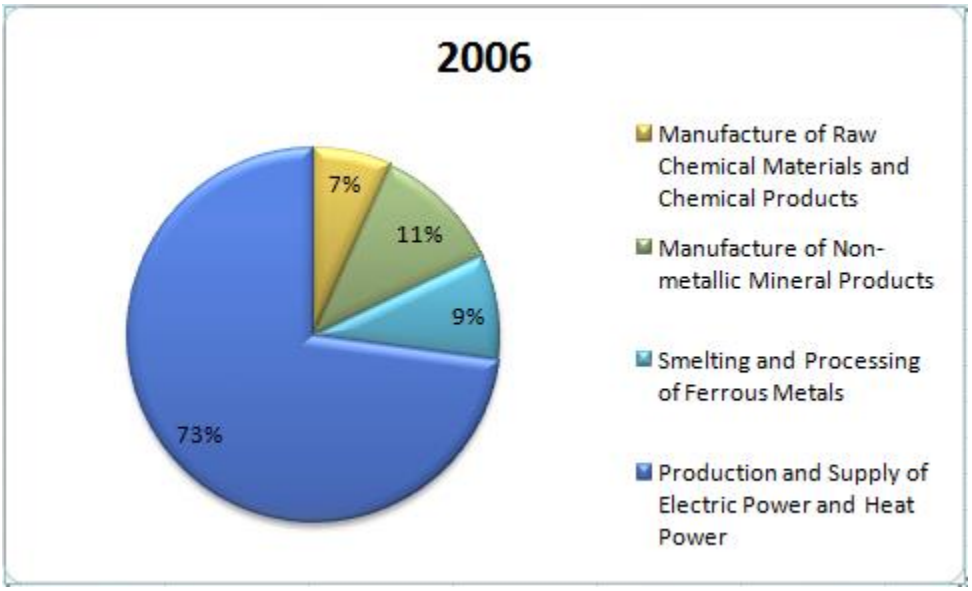
Great demand for materials in the fast developing economy has inevitably resulted in overheated development and high consumption of iron, cement and aluminum. In addition, industrial dust exhaust, industrial SO_2 emission and industrial coal consumption have obviously gathered momentum. Although domestic dust exhaust, SO_2 discharge and coal consumption have fluctuated only slightly due to alternative usage of nuclear, hydro, solar and oil energy resources, SO_2 emission and dust exhaust still climbed year by year on a countrywide basis. These factors have led to industrial air pollution, which constitutes over 80% of the total exhaust air pollution. These

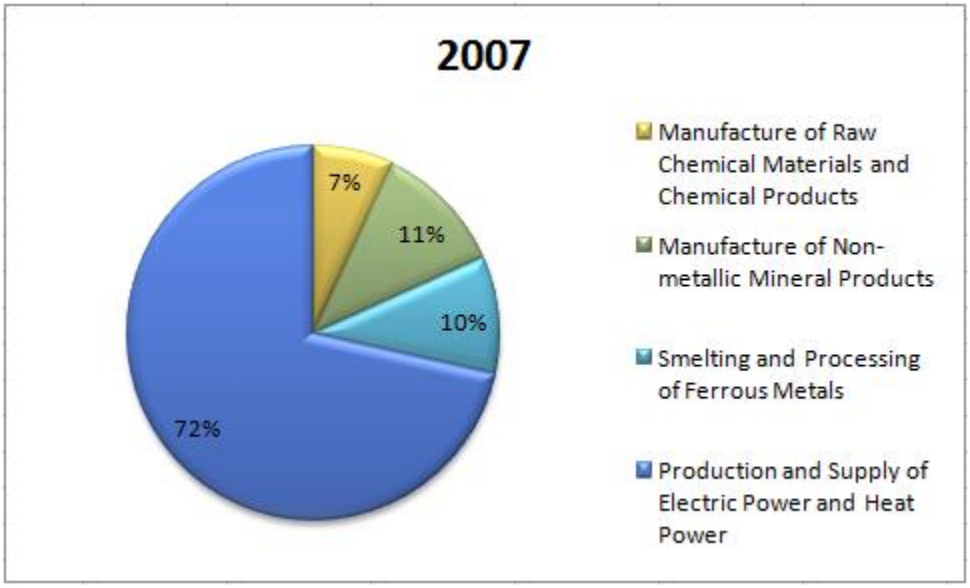
will, in the long run, cause severe downturn in public health, upset environmental ecosystems, and also affect the related water and land resources (Chen, 2013; Tsang, 2015).

4.1.1.3.3. Industrial air pollution

As mentioned before, the main pollutant of air is sulfur dioxide and a high level of more than 80% of sulfur dioxide comes from the manufacturing industries. The top four air pollution emission sectors (Figure 4.13), accounting for more than 80% of the total sulfur dioxide are electricity and heating power production and supply, non-metallic mineral products manufacturing, ferrous metals smelting and pressing plus raw chemical materials and chemical products manufacturing.. We can see that electric power and heating power produce more than 70 percent of the total industrial SO_2. The second largest polluter, non-metallic mineral products manufacturing, emits about 11% of all. The other two sectors share the rest. (Tsang, 2015; Zhao, 2012).

It is also notable that a great portion of China's national GDP comes from these four sectors, and thus to implement any rigid measures against them would be very difficult (China Development Bank, 2010; Jiangsu Provincial Environmental Protection Bureau, 2010).


2006
7%
11%
9%
73%
Manufacture of Raw Chemical Materials and Chemical Products
Manufacture of Non-metallic Mineral Products
Smelting and Processing of Ferrous Metals
Production and Supply of Electric Power and Heat Power


2007
7%
11%
10%
72%
Manufacture of Raw Chemical Materials and Chemical Products
Manufacture of Non-metallic Mineral Products
Smelting and Processing of Ferrous Metals
Production and Supply of Electric Power and Heat Power

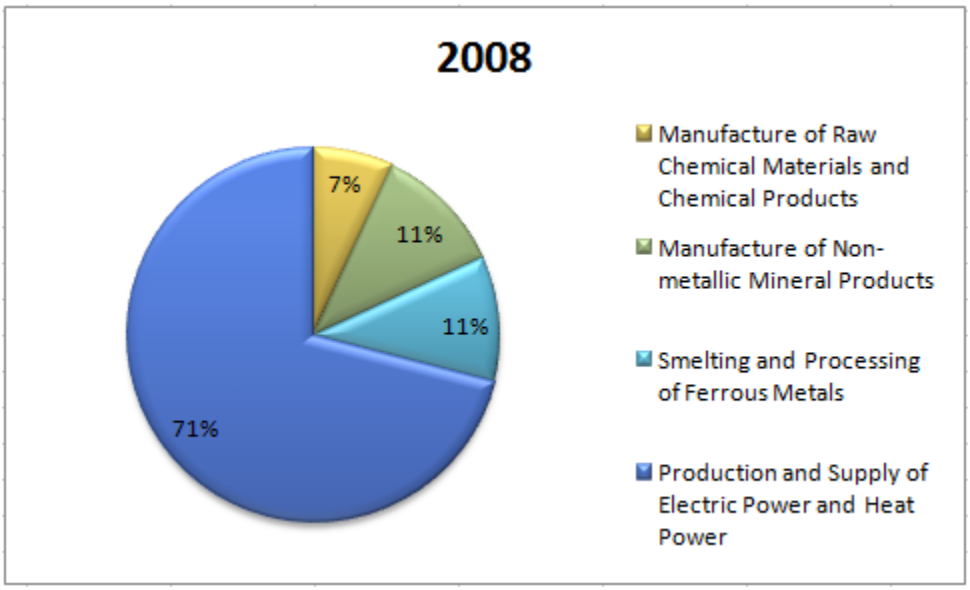


Figure 4.13 Ratio of profits to sulfur dioxide of four discharge sectors in 2006, 2007 and 2008 (Zhang, 2009; Chen, 2013)

From the economic point of view, the ratio of profits contributed by these four sectors to China's economy has been steady at a little more than 30 percent, which is too substantial to be omitted. Compared with its contribution to GPD, the electric power industry discharges a larger amount of sulfur dioxide (Table 4.4).

Table 4.4 Ratio profits to GDP and SO_2 of electric power industry (%)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
SO_2 contribution rate	60	58.9	58.9	57.6	56.8	55.1	55.0	54.7	54.3	53.6	53.3
GDP contribution rate	3.6	3.7	3.8	3.7	3.5	3.6	3.5	3.4	3.3	3.4	3.5

4.1.2. The interrelationship between environment and economy in P.R.C.

From the perspective of the social development, industrial growth in China, as in other industrialized countries, brought many people in new wealth and has substantially improved the

general standards of living (Chinese Academy of Social Sciences, 2010). In China, Central Government has always paid more heed to economic development than to the environmental issues and resource reduction, but now it should be questioned whether it is the right strategy for the current condition of economic development (Stearns, 2007; China Development Bank, 2010).

In retrospect, since the mid-1990s, the real or actual growth of the economy has mostly been determined by market demand, particularly from the rest of the world, thanks to the phenomenon of globalization. During this period, China experienced fabulous economic gains which arguably came at the expense of the deteriorating environmental quality and depleted environmental resources.

From another point of view, China is now in the middle of the process of industrialization, the tremendous growth of the economy depends heavily on development of energy consuming and severely polluting industries. Industrialization and social civilization are promoting China's development as happened in the UK two centuries ago and the U.S. 100 years ago, only at a much faster rate and on a much bigger scale (Zhang, 2009; Chen, 2013). Rural residents have flowed into cities due to fast urbanization and massive industrialization. The proportion of urban residents has risen from 3/10 to 7/10. Thus increased urban population density has led to a larger pressure on environmental problems and relevant infrastructural facilities in cities that include environmental management and pollution abatement facilities.

According to a detailed investigation of the industrial layouts in the late 90s, the number of state-owned and non-state-owned enterprises above a designated size was 219,463, and there existed 165080 state-owned and non-state-owned enterprises in 1998, the former being almost 1.5 times of the latter (Zhang, 2013). These included 6086 manufacturers of paper as well as paper products, 8282 manufacturers of food and beverages, 15,172 manufacturers of raw chemical materials and

chemical products and 17,144 textile companies, with aggregate industrial output of 18,722.07 billion Yuan accounting for 13.68% of GDP in 2004. These data show that high-polluting and resource-dependent industries are contributing a big share of the effort to propelling the national economic growth and social development (China Development Bank, 2010; Tsang, 2015).

Heavy industries and GDP growth are inseparable in the current structure of the economy. Table 4.5 shows the GDP growth rate, industrial production and other data relevant to environmental protection from 2000 to 2010.

Table 4.5 Overview of Chinese economy (Adapted from the website of National Bureau of Statistics of China) (with data extracted from Chen, 2013 and Tsang, 2015)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
(1) GDP (billion Yuan)	8950	9730	10520	11740	13690	13850	13923	14023	14032	15422	16320
(2) Environmental investment (billion Yuan)	101.5	110.7	136.7	162.8	191.0	201.0	211.3	215.0	220.2	230.5	238.0
(1)/(2) (%)	1.13	1.14	1.30	1.39	1.40	1.5%	1.9%	2.0%	2.3%	2.4%	2.7%
Direct economic loss due to pollution (billion Yuan)	0.178	0.122	0.046	0.034	0.0364	0.0352	0.0332	0.0295	0.0267	0.0259	0.0246
Industrial production takes in GDP (%)	43.6	43.5	43.7	45.2	45.9	45.6	45.3	45.9	46.1	45.3	45.7
Total Population (1 billion persons）	1.27	1.28	1.28	1.29	1.30	1.32	1.35	1.36	1.32	1.29	1.28

From Table 4.5, it is found that the growth rate of investment in treatment of pollution was faster than that of GDP in P.R.C. However, the former was still a small part of the latter. It was forecast that in 2020, the population of China would reach 1.4 billion to 1.5 billion, and GDP would double. In addition, the larger population will bring about more consumption and stronger need for a large amount of goods. Therefore, a continuous and quick rise of economy is necessary in the following 5 to 15 years.

It may be understood from the utilization of resources that China consumed 32%, 34%, 30% and 45% of world consumption of coal, ironstone, rolled steel and cement, respectively, in 2010, while accounting for no more than 4% of world GDP. Compared with developed countries, the discharge of wastewater per unit GDP in China is 5 times higher and solid waste produced per Unit Gross Industrial Output Value is 10 times the amount of that in developed countries. In the year 2008, sulfur dioxide emissions were the highest in the world. These data show the considerable growth of the economy has resulted in significant environmental degradation. And the fast growing gross industrial output value was mainly dragged by heavy industries year by year. So, it can imagine that if we do nothing for the protection of environment, pollution will be aggravated by 4 to 5 times, which cannot be afforded by the environment and the relevant resources.

The evolution of the society and the economy of China has followed the pattern witnessed in developed countries; it grew from an agricultural society to an industrial one and has now become a strong economy. The difference is that China has not completed its capital accumulation because its GDP, when looked upon on per capita basis, is much lower than that of developed nations (Table 4.6).

Table 4.6 GDP per capita in representative countries

	1975	1980	1985	1990	1995	2000	2005	2010
CHN	226	412.2	822.7	1303.1	2517.7	3928.0	6571.6	12526.98
HKG	2935.4	6514.9	10319.6	16512.1	21622.0	26044.5	NA	32125.98
SGP	2498.0	5265.4	7590.9	12040.7	17968.8	23744.3	29921.4	35675.53
JPN	5456.1	9209.8	13330.9	19241.8	23040.1	26219.8	30821.1	38423.28
USA	7529.7	12200.1	17532.5	23155.2	27780.4	33970.1	41853.6	48232.32
DEU	5497.3	9209.6	12664.9	17149.3	21352.1	25480.9	29308.6	35243.98

Unit: current international $

Another important indicator to evaluate economic policy is the unemployment rate. For social stability, unemployment rate should be kept within a limited range. The unemployment rate in P.R.C. has been around 4% since 2000. However, until 2002, there were 16.5% employed people working in manufacturing and construction industries which are closely related to industry structure as mentioned above. Table 4.7 makes a comparison between the employment structures of China and some developed countries. It indicates that both the industrial structure and unemployment rate show the economy's high dependency on heavy industry in P.R.C. and reveals the difficulty of treating environmental pollution while ensuring fast economic growth and high employment rate.

Table 4.7 Employment comparison between different countries by type of industry
Unit: %

Country	Primary industry		Secondary industry		Tertiary industry	
	2000	2001	2000	2001	2000	2001
China		50.0	22.5	22.3	27.5	27.7
United Kingdom	1.5	1.4	25.4	24.9	72.7	73.4
Unites States	2.6	2.4	22.9	22.4	74.5	75.2
Germany	2.7	2.6	33.4	32.5	63.8	64.7

Structure of the economy is also a factor affecting the pollution situation. Compared with developed countries, the primary industry (agriculture) accounts for a much larger proportion (half) than the others. The fact that developed countries where most people engage in tertiary industry have a better environment seems to prove that employment in different fields is another contributor that influences environmental problems.

4.1.3. Environmental investment in P.R.C

The EnvI in P.R.C. has been increasing in absolute terms but as fraction of GDP it is a different situation. In recent years, the growth of EnvI has failed to catch up with that of GDP. Besides,

most of the investment in P.R.C. has been used in waste treatment but little portion has been used for research and development.

Since the early 1980s, the total amount of environmental protection investment has experienced a stable increase. Especially in the end of 20th century, the total number had a huge leap. The EnvI ratio (percentage of GDP) also increased somewhat (Table 4.8).

Table 4.8 Gross amount and ratio of environmental investment to GDP in P.R.C. (Adapted from the website of National Bureau of Statistic of China) (with data extracted from Chen, 2013 and Tsang, 2015)

(Unit: billion Yuan)

Years	**GDP**	**Total investment in environmental protection**	**The proportion of investment in environmental protection**
During the Sixth Five-Year Plan(1981-1985)	3240.18	16.63	0.51%
1981	489.16	2.5	0.51%
1982	532.34	2.87	0.54%
1983	596.27	3.07	0.51%
1984	720.81	3.34	0.46%
1985	901.60	4.85	0.54%
During the Seventh Five-Year Plan (1986-1990)	7303.67	47.73	0.65%
1986	1027.52	7.39	0.72%
1987	1205.86	9.19	0.76%
1988	1504.28	9.99	0.66%
1989	1699.23	10.25	0.60%
1990	1866.78	10.91	0.58%
During the Eighth Five-Year Plan (1991-1995)	19303.05	130.66	0.68%
1991	2178.15	17.01	0.78%
1992	2692.35	20.56	0.76%
1993	3533.39	26.88	0.76%
1994	4819.79	30.72	0.64%
1995	6079.37	35.49	0.58%
During the Ninth Five-Year Plan (1996-2000)	42344.36	349.04	0.82%
1996	7117.66	42.82	0.60%
1997	7897.30	50.23	0.64%
1998	8440.23	72.18	0.86%
1999	8967.71	82.32	0.92%
2000	9921.46	101.49	1.02%
During the Tenth Five-Year Plan (2001-2005)	70890.64	839.39	1.18%
2001	10965.52	110.66	1.01%

2002	12033.27	136.34	1.13%
2003	13582.28	162.73	1.20%
2004	15987.83	190.86	1.19%
2005	18321.74	238.8	1.30%
During the Eleventh Five-year Plan	106094.51	1411.05	1.33%
2006	19325.09	218.56	1.13%
2007	19893.98	256.23	1.28%
2008	21543.56	298.56	1.38%
2009	22393.76	315.98	1.41%
2010	22938.12	321.72	1.40%
During the twelfth Five-Year Plan (2006-2010)	147840.73	2079.42	2.25%
2011	26392.09	350.83	2.08%
2012	28302.78	390.87	2.26%
2013	30028.67	413.98	2.35%
2014	31023.65	439.98	2.16%
2015	32093.54	483.76	2.23%

From Table 4.8, we can see that the total investment in environmental protection has been growing in recent years. Investment during the 7th Five-Year Plan increased to 47.74 billion from 16.63 billion in the 6th Five-Year Plan, an increase of 287%. Compared with 7th Five-Year Plan, the 8th Five-Year Plan also experienced a significant growth of 274%. The year of 2003 witnessed an investment of 136.34 billion Yuan in environmental pollution treatment, an increase rate of 23.2% compared to that in 2002. 78.53 billion Yuan out of the total amount of investment was spent on urban area's environmental infrastructure construction, 18.84 million Yuan on treatment of industrial pollution sources while 38.97 billion Yuan on environmental protection in projects newly constructed. The total amount of EnvI is growing fast and it was expected to reach 1375 billion Yuan during the 12th Five-Year Plan (Tsang, 2015; Dang et al., 2010);

However, the proportion of EnvI to GDP is still very low; it rose but fluctuated during these years (Figure 4.14). In general, the investment-to-GDP ratio too shows an upward tendency: it rose from

0.51% in 1981 to 1.33% in 2009. Nevertheless, before 1998, the investment-to-GDP ratio rose and fell from time to time. Take the investment during the 7th Five-Year Plan for an example: the EnvI ratio achieved more than 0.7% to GDP in 1986 and 1987, but it fell to 0.58% from 0.66% in the next 3 years. Compared with the first 3 years of the 8th Five-Year Plan in which EnvI had reached over 0.76%, the investment ratios in the following two years dropped to 0.64% and 0.58%, respectively. In 2000 it surpassed 1% for the first time. Since then the EnvI ratio has risen stably and achieved 1.33% in 2009.

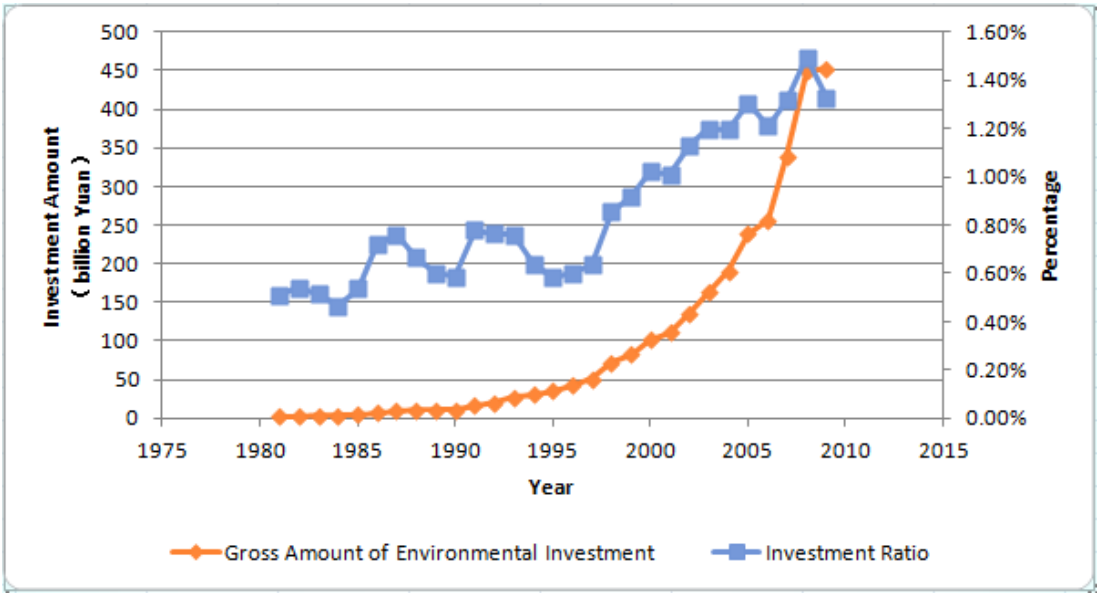


Figure 4.14. Gross amount and ratio of EnvI to GDP in P.R.C

Until now, environmental protection industry in P.R.C. has developed at an average rate of 17%. In 2002, the output of environmental protection industry was 220 billion Yuan, while in 1992 it was only 4 billion Yuan. At present, it is prosperous areas along the coast and rivers of southern and eastern China that are the main locations of such enterprises, among which 6% are large ones with fixed assets worth over 50 million Yuan. It can be predicted that the environmental industry will continue its rapid growth in the near future (Table 4.9).

Table 4.9 Investment Completed in the Treatment of Industrial Pollution (Adapted from the website of Ministry of Environmental Protection of the P.R.C.) (with data extracted from Chen, 2013 and Tsang, 2015)

Unit: billion Yuan

	Investment Completed in the Treatment of Industrial Pollution this year	Treatment of wastewater	Treatment of waste gas	Treatment of solid waste
2000	23.94	10.96	9.09	1.15
2001	17.45	7.29	6.58	1.87
2002	18.83	7.15	6.98	1.61
2003	22.18	8.74	9.21	1.62
2004	30.81	10.56	14.28	2.26
2005	45.82	13.37	21.3	2.74
2006	48.57	15.11	23.13	1.82
2007	55.24	19.61	27.53	1.83
2008	54.26	19.46	26.57	1.97
2009	56.34	19.84	26.49	1.98
2010	59.92	20.98	27.92	2.09
2011	60.98	21.09	28.67	2.10
2012	61.32	22.03	29.03	2.2
2013	61.93	22.74	29.93	2.21
2014	62.95	23.30	30.43	2.29

4.1.4. Correlation analysis of factors affecting environmental investment

In order to study the relationship between EnvI and other related factors, correlation analysis is used. Correlation analysis is a process of surveying the closeness of linear correlation between two variables and expressing it by proper indicators. Correlation analysis can be done only when there exists some relationship or probability thereof among the factors that are to be analyzed.

Although there are different kinds of methods of analysis, double interval variable is selected to conduct the correlation analysis for reason of accuracy. By this way, the calculation of pair-wise correlation coefficients helps indicate the degree of correlation.

4.1.4.1. Data selection

In this section, four factors were chosen as the variables, GDP, GDP per capita, investment efficiency and investment structure. The explanations of data are as follows.

1) GDP

GDP is a universally accepted indicator of national economic development level. It not only indicates a country's economic performance, but is also a representation of comprehensive national strength and wealth.

2) GDP per capita

GDP per capita is the result of GDP divided by population. It is often considered to be an indicator of a country's standard of living. It has more representativeness for EnvI discussion compared with GDP.

3) Investment structure (IS)

The following formula expresses the investment structure:

$$IS = \frac{\text{Industrial pollution treatment investment}}{\text{total investment}}$$

I use the proportion of investment in industrial pollution treatment to total EnvI to express the investment structure. That means, the bigger the result is, the more simplified the investment structure is.

4) Investment efficiency (IE)

$$IE = 1 - \frac{\text{direct loss by pollution}}{\text{total investment}}$$

As expressed by the formula, if the direct pollution loss is tiny, the investment efficiency can be considered high.

The useful data are summarized in Table 4.10.

Table 4.10 Useful data in the correlation analysis (Adapted from the website of Ministry of Environmental Protection of the P.R.C.)

Year	GDP (billion Yuan)	GDP per capita (Yuan)	Environmental investment (billion Yuan)	Direct loss by pollution (million Yuan)	Industrial pollution treatment investment (billion Yuan)
1986	1027.52	963	7.39	14.041	2.53
1987	1205.86	1112	9.19	80.872	3.2
1988	1504.28	1366	9.99	75.924	3.82
1989	1699.23	1519	10.25	33.825	3.95
1990	1866.78	1644	10.91	52.368	4.15
1991	2178.15	1893	17.01	62.937	5.57
1992	2692.35	2311	20.56	96.632	5.93
1993	3533.39	2998	26.88	118.272	6.34
1994	4819.79	4044	30.72	126.283	7.72
1995	6079.37	5046	35.49	99.379	9.28
1996	7117.66	5846	42.82	169.291	8.46
1997	7897.3	6420	50.23	83.661	10.78
1998	8440.23	6796	72.18	198.437	11.45
1999	8967.71	7159	82.32	57.106	12.81
2000	9921.46	7858	101.49	178.08	23.94
2001	10965.52	8622	110.66	122.72	17.45
2002	12033.27	9398	136.34	46.41	18.84
2003	13582.28	10542	162.73	33.75	22.18
2004	15987.83	12366	190.86	363.66	30.81
2005	18321.74	14053	238.8	105.15	45.82
2006	21192.35	16165	256.78	134.71	48.39
2007	25730.56	19524	338.76	32.78	55.24
2008	30067.00	23648	449.03	181.86	54.26
2009	34050.69	25439	452.53	433.54	44.25
2010	39054.76	27392	462.90	109.84	53.94
2011	41002.82	29324	472.38	110.02	59.08
2012	43928.75	31023	489.32	115.93	61.09
2013	45928.93	33928	491.93	119.83	63.02
2014	48392.32	34274	499.02	120.93	64.87

4.1.4.2. Correlation analysis

Pearson Correlation Coefficient is used for this correlation analysis. Its function is to assess the degree of linear correlation between two specific interval variables, with computational formula as follows (Yuan and James, 2002).

$$r = \frac{\sum_{i=1}^{n}(X_i - \overline{X})(Y_i - \overline{Y})}{\sqrt{\sum_{i=1}^{n}(X_i - \overline{X})^2}\sqrt{\sum_{i=1}^{n}(Y_i - \overline{Y})^2}}$$

Where

X and Y=specific variables

r=linear correlation degree of X and Y, $-1<r<1$

n=the number of samples, n=29

As we know, if $r>0$, it means the two variables have a positive correlation. If $r<0$, that indicates a negative correlation and a bigger absolute value implies a stronger correlation. If $r=0$, we believe that the two variables have no linear relationship.

The correlation analysis is conducted by Statistic Package for Social Science (SPSS) 17.0. The analysis result is summarized in Table 4.11.

Table 4.11 Correlation analysis result

	Investment	GDP	PPP	IE	IS
Investment Pearson Correlation	1.000	0.986	0.989	0.684	-0.755
GDP Pearson Correlation	0.986	1.000	0.999	0.675	-0.751
PPP Pearson Correlation	0.989	0.999	1.000	0.687	-0.765
IE Pearson Correlation	0.684	0.675	0.687	1.000	-0.793
IS Pearson Correlation	-0.755	-0.751	-0.765	-0.793	1.000

From Table 4.11, it can be found that the EnvI and GDP (or GDP per capita) show significant positive correlation, with a Pearson Correlation Coefficient of 0.986. The gross EnvI and investment efficiency (IE) have a medium positive correlation, with a Pearson Correlation Coefficient of 0.684. Nevertheless, on the other hand, the EnvI and investment structure (IS) exhibit a medium negative correlation. The result shows that the positive correlation leads to the fact that rise of investment efficiency and GDP (or GDP per capita) results in increased EnvI. However, simplification of investment structures could bring negative impact on the growth of EnvI in the event of a negative correlation.

Thus, following conclusions can be reached:

(1) Develop the economy to provide a solid economic foundation to promote EnvI.

(2) Enhance EnvI efficiency and reduce pollution losses.

(3) Optimize and diversify the structure of EnvI and avoid single investment direction.

4.1.5. Environment plan in P.R.C.

As the largest developing country in the world which has seen economic prosperity over the last 20 years, China has environmental problems draw much attention from the central government. The government has proposed a grandiose objective of constructing an overall well-off society before 2020 and in the meantime, a healthy and sustainable environment is an indispensable part of it (Zhang, 2009; Tsang, 2015; Chen, 2013).

A communique issued on February 3rd in 2005 announced a decision to enhance environmental protection. It stated briefly the intent to strengthen the basic framework for addressing environmental issues and a momentous research program was declared to be the priority listed in the state technology plans.

It has become the final goal to develop the environment protection industry during the period of the 10th Five-Year Plan, providing for technological guarantee and a material basis in order to adapt to the increasingly strict environment protection requirements to make the environment protection industry a new driver of economic growth. This showed a clear intention of the government to accelerate the development of environment protection technologies (Tsang, 2015; Chen, 2013).

4.2. The impact of public environment investment on public health

The impact of environment investment on public health is about the relationship between the amount of investment and the level of public health. Environment investment and public health seem two unrelated words, but in modern society, they have been two indivisible parts. People's health is determined by environment, and the environment is determined by government investment, so public health and environment investment has inseparable relationship.

Water is the most precious of human resources on earth, and is the material basis of human survival and the foothold of the urban development. Since the 21st century, water resource crisis has become one of the most serious problems. In recent years, the water pollution problem is a serious problem in China, especially for agricultural production. At present, the water pollution impact on public health is mainly manifested in the following respects:

(i) Mineral water pollution on public health

The inorganic pollutants in the water bodies consist of inorganic anions, metals as well as their compounds. Inorganic anions include: sulphide, sulfate, chloride, boron, cyanide, free chlorine, fluoride, chlorine and total iodide. As for metals and chemicals, they include silver, iron, arsenic, barium, beryllium, bismuth, aluminum, cadmium, cobalt, copper, manganese, nickel, mercury and molybdenum.

All kinds of inorganic acid, alkali, and salt flowing into the water, increase the salinity of fresh water resources and affect water quality. The major sources of salt pollution are domestic sewage and industrial wastewater as well as industrial waste residue. Besides, acid rain with a growing scale influences soil acidification, and groundwater salinity.

The Increasing inorganic salt water can improve the osmotic pressure of water, and adversely affect freshwater animals and plant growth. In the salinized area, the soil quality will be affected to a larger extent by the salt in surface water and groundwater.

To mitigate the impact of mineral water pollution on public health, Chinese government has invested 103 million yuan in it, of which inorganic pollutants received 53 million yuan (the website of enviroinvest, 2017) From 2006 to 2014, the inorganic pollutants decreased from 200000 pounds to 150000 pounds.

(ii) The pollution of pathogenic microorganisms in public health

The domestic wastewater, livestock and poultry farm wastewater, and wastewater discharge from leather, wool washing, slaughtering and hospital, often contains all kinds of pathogens, such as viruses, bacteria and parasites. Therefore, water will be contaminated with the pathogen and spread diseases like cholera, typhoid, schistosomiasis, dysentery and viral hepatitis.

The water contaminated with the pathogens is most likely to carry pathogenic bacteria, disease and virus eggs. They tend to coexist with other bacteria. The feature of water contaminated with the pathogen is: (1) the large quantity; (2) wide distribution; (3) survival for a long time; (4) fast breeding; (5) proneness to resistance, (6) difficulty in extinction.

(iii) The contamination of plant nutrients in public health

Plant nutrients such as nitrogen and phosphorus mainly refer to nutrients that can stimulate the growth of algae and aquatic plants, and water purification. Plant nutrients are widely distributed large in number. They include organic matter, detergent, chemical fertilizer, farm manure, industrial wastewater. The investment in the contamination of plant nutrients is about 183 million yuan (Tong, 2014). Every day each person brings about 50g nitrogen into wastewater. The sewage of phosphorus mainly comes from washing wastewater. 50%~80% of chemical fertilizers from fields flow into rivers, lakes and underground water. Phosphorus and nitrogen (particularly phosphorus) in natural water determine how plankton will grow to a certain extent. It will prompt sharp growth of some creatures, such as algae. Also shorter growth cycle will be caused. When a considerable amount of nitrogen and phosphorus is discharged into water body, and the bodies of algae and other plankton are decomposed by aerobic biological decomposition, the dissolved

oxygen in the water will be depleted or decomposed by anaerobic microbe, and then gas such as hydrogen sulfide will be continuously produced, making water quality deteriorate, and killing a large number of fish and other aquatic organisms.

In the process of decay the residue of algae and other plankton release nitrogen, phosphorus and other nutrients into water for the new generation. Therefore, after the eutrophication of water body, even if excessive sources of nutrients are eliminated, it is also hard to restore its normal level of nutrient.

(iv) The oxygen contamination

Industrial waste water released from food processing and paper contains carbohydrates, protein, fat, lignin and other organic substances. The investment in the oxygen from Chinese government is about 30 million yuan (Tong, 2014). Because it needs to consume oxygen in the process of its decomposition, it is called oxygen contamination. These pollutants can cause the dissolved oxygen to decrease, and thus affect the growth of fish and other aquatic organisms. After the dissolved oxygen in water is depleted, organic matters such as hydrogen sulphide, ammonia and mercaptan make anaerobic decomposition, and give off stinky smell, , which worsen water quality. They will finally be accumulated in human body, and cause harm to human health.

4.3. Chapter summary

As the analysis shown in the Chapter 4, we have attained dedicated conclusions about China's investment. The internal conclusion is necessary to be carried out to study the future direction which China would refer to.

4.3.1. Building and increasing diversified environmental protection investment and financing mechanism.

One thing to do is increase government investment in environmental protection. Governments at all levels need to put environmental protection into the main content of fiscal expenditures and increase investment in the field year by year. Increasing the capital investment in pollution control, ecological protection, and environmental regulatory capacity is also necessary. Also, they should strictly enforce national standards, and ensure the business spending of environmental protection administration, supervision, monitoring and other administration. The second thing is to guide the social capital to involve the investment in related work in the urban and rural environmental protection infrastructure.

4.3.2. Improve the environmental protection laws and regulations, and increase the penalties for polluting behavior.

One major problem is to formulate laws and regulations on ecological protection, biological safety, ozone layer protection, nuclear safety, recycling economy, environmental damages and the environmental monitoring. Besides, it is important to improve the environmental protection law of the People's Republic of China, and increase the intensity of punishment for illegal behavior.

Chapter 5. Critical analysis and discussion of USA

5.1. Comparability and limitation

5.1.1. Fundamental condition

USA is a federal constitutional republic composed of 50 states (48 continental states, plus Alaska and Hawaii the two newest states) and one federal district - Washington, D.C., the capital district. The country, situated in the central southern part of North America, is almost entirely within the Western Hemisphere. Washed by the Atlantic Ocean in the east and by the Pacific Ocean in the west, the contiguous USA borders Canada to the north and Mexico to the south. Besides, the state of Alaska is in the northwest of North America with Canada to its east, and the state of Hawaii is in the mid-Pacific. And among all USA states, Alaska is the largest, and Rhode Island the smallest (Boyanova, 2015).

The USA has a total area of 3,676,487 square miles (9,522,057 square kilometers) (Yan, 2015). The population of the USA was estimated at 302,578,792 (Gordon, 2015). The population is made up of the following ethnic and religious groups:

- Ethnic Groups (2015): White (74.7%), Black or African American (12.1%), Asians (4.3%), American Indian and Alaska Native (0.8%), Native Hawaiian and Pacific Islanders (0.1%). (Hispanic or Latino of any race 14.5%) (Boyanova, 2015)
- Religious Groups (2015): Protestant (52%), Roman Catholic (24%), Mormon (2%), Jewish 1%, Muslim 1%, other 10%, none 10% (Boyanova, 2015; CIA, 2017).
- **Languages:** English 82.1%, Spanish 10.7%, other Indo-European 3.8%, Asian and Pacific island 2.7%, other 0.7% (Boyanova, 2015; CIA, 2017).

Although its population is significantly smaller than that of India or China, the USA has the highest labor force participation rate in the world with 139.396 million employed. The table below shows the distribution of the employment by industry from 2002 to 2022 (Economy Watch, 2017).

Table 5.1. Employment by Major Industry Sector in USA (Extracted from the website of Bureau of Labor Statistics)

	Thousands of Jobs			Change		Percent Distribution		
Industry Sector	2002	2012	2022	2002 - 2012	2012 - 2022	2002	2012	2022
Total	142,294.9	145,355.8	160,983.7	3,060.9	15,627.9	100.0	100.0	100.0
Non-agriculture wage and salary	131,028.3	134,427.6	149,751.3	3,399.3	15,323.7	92.1	92.5	93.0
Goods-producing, excluding agriculture	22,486.7	18,360.3	19,554.2	-4,126.4	1,193.9	15.8	12.6	12.1
Mining	512.3	800.5	921.7	288.2	121.2	0.4	0.6	0.6
Construction	6,715.7	5,640.9	7,263.0	-1,074.8	1,622.1	4.7	3.9	4.5
Manufacturing	15,258.7	11,918.9	11,369.4	-3,339.8	-549.5	10.7	8.2	7.1
Services-providing	108,541.6	116,067.3	130,197.1	7,525.7	14,129.8	76.3	79.9	80.9
Utilities	596.3	554.2	497.8	-42.1	-56.4	0.4	0.4	0.3
Wholesale trade	5,652.4	5,672.8	6,143.2	20.4	470.4	4.0	3.9	3.8
Retail trade	15,025.1	14,875.3	15,966.2	-149.8	1,090.9	10.6	10.2	9.9
Transportation and warehousing	4,223.8	4,414.7	4,742.0	190.9	327.3	3.0	3.0	2.9
Information	3,394.6	2,677.6	2,612.4	-717.0	-65.2	2.4	1.8	1.6
Financial activities	7,847.1	7,786.3	8,537.3	-60.8	751.0	5.5	5.4	5.3

From Table 5.1, the majority of the labor force's occupations are managerial, professional, and technical. A further hold sales and office are manufacturing, extraction, transportation and crafts. Only small amount of them are in farming, forestry and fishing, and small amount of them have jobs in other services (Economy Watch, 2017).

USA has been the second largest energy consumer in the world since 2013 **(**Council of Great Lakes Industries, 2017). It ranks seventh in energy consumption per-capita behind Canada and other countries, and the majority of consumed energy is natural gas. (Table 5.2) Council of Great Lakes Industries, 2017)

Table 5.2. Energy consumption in USA (extracted from the website of USA Energy Information Administration) Council of Great Lakes Industries, 2017)

Energy consumption sector	**Billion dollars**
Coal	0.130
Coal Coke	0.001
Natural Gas	0.145
Crude Oil	0.095
Petroleum Products	0.731
Biofuels	0.008
Electricity	0.002

USA is the world's largest manufacturer. Industrial output in USA increased 0.40 percent year on year in 2015, which, compared to 1.1 percent rise in 2014, is the lowest gain since the 2009 recession, due to a 5.7 percent fall in mining while manufacturing growing 1.4 percent and utilities going up 1 percent. Industrial output in USA averaged out at 38400 tons from 1920 until 2015, reaching an all-time high of 62 percent in 1933 and a record low of -33.70 percent in 1946 (Figure 5.1) (Economy Watch, 2010).

Figure 5.1. Industrial output in USA in recent 8 years (adapted from the website of USA Energy Information Administration)

5.1.2. Economic aspect

USA is the world's largest national economy, accounting for 22% of nominal global GDP. In 2015, it ranked ninth in the world by GDP per capita. In possession of abundant natural resources, a well-developed infrastructure and high productivity, the country has been the world's largest national economy since at least the 1890s. And Americans have the highest average household and employee income. Over and above, USA dollar is the currency most used in international transactions and is also the world's foremost reserve currency, which several countries use as their official currency.

5.1.3. Social aspect

The employment rate is another important social indicator when measuring a country's success. Job gains occurred in professional and business services, health care, retail trade, food services and drinking places and construction, and total nonfarm payroll employment increased by 271,000 in 2015; the unemployment rate was essentially unchanged at 5.0 percent. Over the past 5 years, the unemployment rate and the number of unemployed persons were down by 0.7 percentage point and 1.1 million, respectively (USA Bureau of Labor Statistics, 2015; USA Bureau of Labor Statistics, 2017).

5.1.4. Limits

The employment distribution in three types of industries indicates the foundation of people's living. (Table 5.3) The majority of work force is in industries which have less pressure on the environment than others. Since the 1980s, the rate of goods producing is decreasing while that of service producing is rocketing. The proportion of work force in the services increased from 66% in 1980 to 80% in 2015. The employment proportion in industry declined annually from 31% in 1980 to 19%in 2015. The difference in the employment of the industries would be a limitation for comparison.

Table 5.3. Employment in agriculture, industry and services (extracted from the USA Environment Protection Agency) (Unit: %)

USA	2003	2005	2007	2009	2011	2013	2015
Employment in agriculture	2	2	2	2	2	2	1
Employment in industry	21	21	21	20	20	20	20
Employment in services	77	77	77	78	78	79	79

Figure 5.2 shows the employment distribution in each sector in 2015. Since 1980s, the USA economy has gradually shifted from production to professional, which enjoys a 10% higher proportion of work force than production. In 2015, professional has highest employment rate, while in 1980s services ranked top by employment rate. Although being less than those in professional, employees in production still take up a large part in total employment. The sector where women's employment rate is higher than men's is office administrative support and professional while construction and maintenance has few women employed. Although the economic power of USA has been the second largest in the world, its tertiary industry is declining annually compared with developing countries such as China. The sectors of professional and production represent a country's developing level, and 49% of total shows the USA is the largest economy.

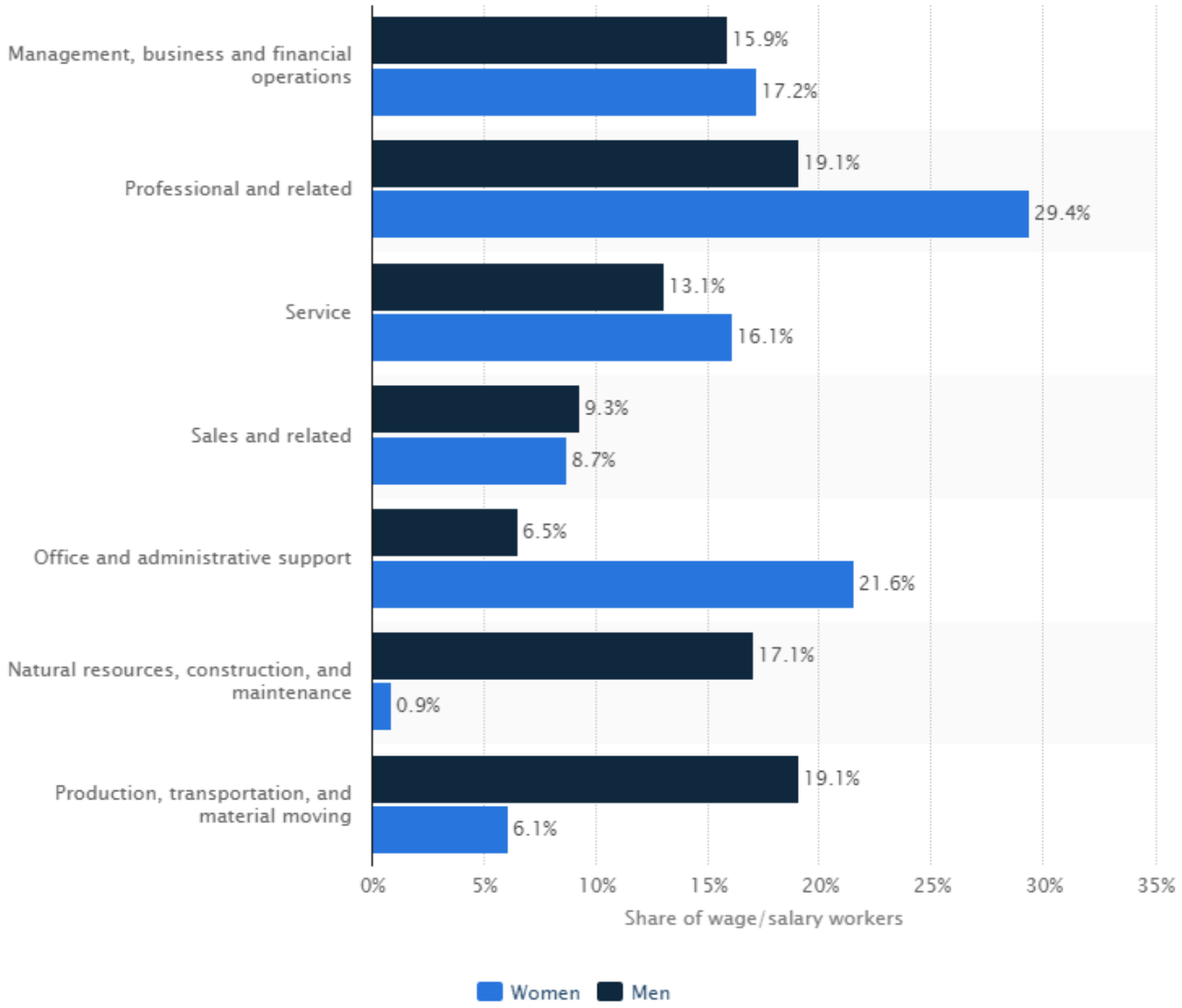


Figure 5.2. Employment distribution in each sector in 2015 (Adapted from USA Environment Protection Agency) (Council of Great Lakes Industries, 2017)

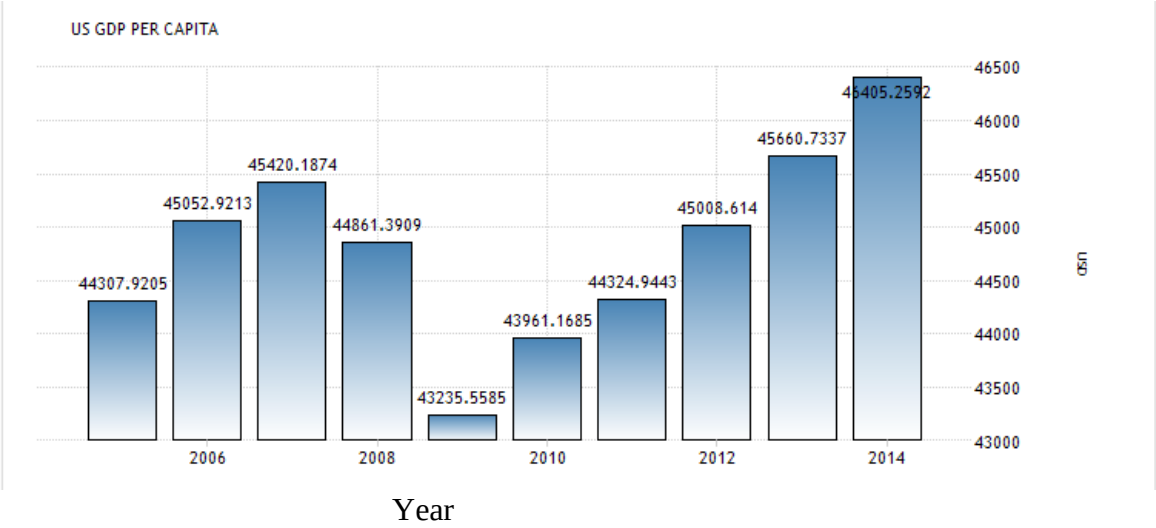


Figure 5.3 GDP per capita of USA (Adapted from World Bank database)

USA GDP per capita was 45052 dollars in 2006 while reached 46506 dollars in 2014, having increased by 1000 dollars in the past eight years (Figure 5.3). Thus, we can only choose the environmental investment the USA made in 2006 to be a comparative object. Nonetheless, as time went by, some definitions of investment and other indicators are altered.

5.2. Environmental situation and trend

5.2.1. Ambient air quality

In 1990, Environmental Protection Agency is required to set NAAQS (National Ambient Air Quality Standards) to consider whether the air quality is harmful to public health and environment. It established two types of National Ambient Air Quality Standards: Primary standards and Secondary standards. Primary standards provide health protection with people, including sensitive populations such as asthmatics, children and the elderly. Secondary standards provide welfare protection, including protection against damage to animals, crops, vegetation and buildings.

Table 5.4 illustrate the distribution of national total emissions from 1994 to 2015. It can be seen that, SO_2 emissions contributed about 20% of the total air emissions in 1990, while in 2015 the rate has increased to 25%. NH_3 was responsible for 19% in 1990, but in 2015, it occupies over 40% of total emissions.

Table 5.4. Air pollution in USA (extracted from World Bank database)

Years	Total emissions	Emissions from SO_2	Emissions from NH_3	Emissions from NO_x	
1994	1315396	273830	543736	4855909	
1995	1315076	286852	534850	481567	
1996	1339270	292490	547108	487569	
1997	1372493	301488	558273	499183	
1998	1390367	307578	566208	502433	
1999	1401148	318326	566173	501826	
2000	1434605	316614	582071	520930	
2001	1465840	318409	596852	535352	
2002	1475571	314212	609824	538390	
2003	1502708	329029	618335	541784	
2004	1554903	344503	632129	564757	
2005	1527517	323181	634801	555810	
2006	154042	336275	628411	561866	
2007	1548738	325475	648067	560926	
2008	1571709	320723	662168	573935	
2009	1580355	318634	667143	579104	
2010	1555460	315795	653101	571099	
2011	1580290	1580290	648278	575692	
2012	1533260	340637	611445	566810	
2013	1438269	337769	586926	502323	
2014	1475012	351353	590751	521330	
2015	1446842	359962	575746	498720	

5.2.2. Nutrient pollution

Nutrient pollution is the second largest worldwide and challenging problem, whose main effect is that excess nutrient flow into water.

5.3. Environmental policy and investment

5.3.1. Environmental policy

USA environmental policy, the federal governmental action to regulate activities that have an environmental impact on USA, is aimed at protecting environment from human destruction. 1960s is the boundary for environmental policy when several environmental laws were passed and, most importantly, the government has founded Environmental Policy Agency (EPA). After 1970s, there have been significant achievements achieved in fields including wastewater, air pollution and solid waste, thus having limited the greenhouse gas.

USA Environmental Investment Report 2012 pointed out that by the end of 2011, the environmental investment policy contained 3164, 2833 of which were made between USA and China and the other 331were international investment policies. The 21st century has witnessed unprecedented advancement in virtually all fields of daily life, and environment is no exception. For environmental issues, USA in the early 1970s began to focus on and gradually perfected its legislation. Along with the reinforcement and strengthening for USA environmental policy and the approval of international society processing environmental protection, USA environmental treatments in investment policy are consolidating and becoming a typical representative. Emphasizing the environmental treats in investment policy will be productive for development of a developed country, and at the same time it is also beneficial to adjusting China's environmental policy and can enlighten them to create new environmental policy and treats.

5.3.2 Environmental investment for protection

Table 5.5. USA investment in pollution control (updated from Environmental Protect Agency) Unit: 0.1 billion dollars

Media or pollution	**1985~2015**
Total	**4500**
Air	**2650**
Water	**1830**
Other charges	**75**
Equipments	**25**

In 1985-2015 (From Table 5.5), USA government paid nearly 450 billion dollars for air and water governance, in which the expense for air protection is nearly 264 billion dollars and that for water pollution control is 283 billion dollars. The expenditure equals to 2% of GDP in 1976 to 1985. According to another expenses analysis, the new air control technology costs 7.5 billion dollars, in which 2.5 billion dollars is spent on the equipment of public institution.

According to the research of USA association of Washington D.C, America's chemical industry spends 0.33 billion dollars on pollution control equipment. It is estimated that the expenses will increase to 0.67 billion dollars, accounting for 11.6% of total equipment investment, in which the bulk is used for water protection equipment, about 0.37 billion dollars, followed by air protection equipment, about 0.26 billion dollars; the cost for solid waste treatment is 0.04 billion dollars.

Table 5.6 lists the expenses of DuPont company in USA.

Table 5.6. Expenses of DuPont company in America for each category (updated from Environmental Protect Agency) (Unit: billion dollars per pollution control)

	1985	1990	1995	2000	2005	2010	2015
Air pollution	0.31	0.45	0.57	0.89	1	1.1	1.2
Water pollution	0.2	0.25	0.29	0.31	0.52	0.56	0.71
Solid waste	0.11	0.19	0.23	0.29	0.31	0.45	0.98
Total	0.62	0.89	0.59	1.49	1.83	2.11	2.87

According to the research of USA business department in late 2015, the expenses for environmental control equipment account for 5.6% of the total expenditure. Although the percentage is same as 2014's, the actual amount of money is 11.1% more than 2014's (Saunders, 2014). The total investment in environmental control equipment is 7.51 billion dollars in 2015 (6.76 billion dollars in 2014), of which air pollution costs 3.83 billion dollars, water pollution takes up 3.16 billion dollars and solid waste 0.52 billion dollars (The World Bank, 2017). Considering various manufactures, the cost of public equipment is 0.23 billion dollars, oil manufacture is 1.3 billion dollars, chemical industry is 0.7 billion dollars, iron industry is 0.6 billion dollars and metal industry is 0.4 billion dollars. (The World Bank, 2017).

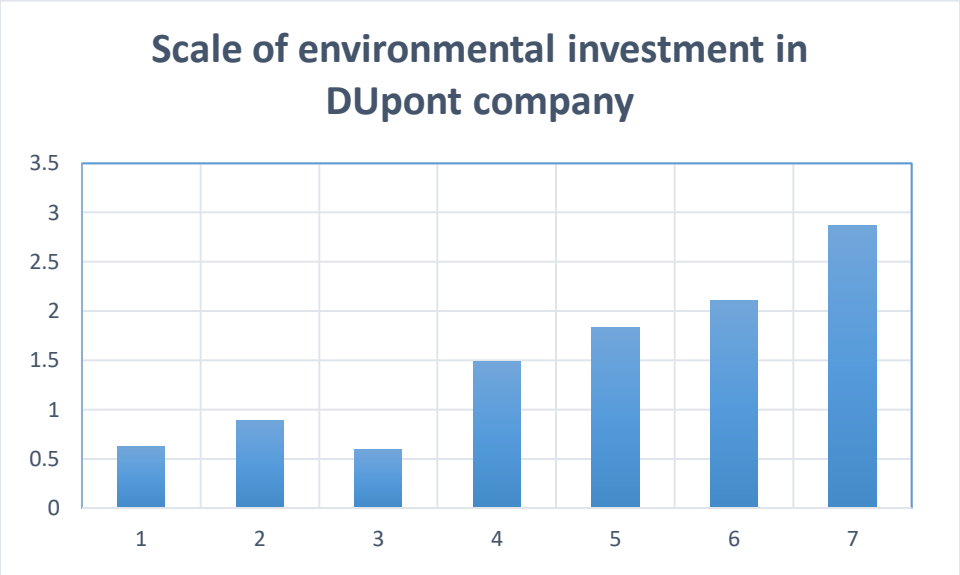


Figure 5.4. Scale of environmental investment in DuPont company (Updated from DuPont official website)

5.4. The confirmation and changes in USA environmental investment rules

The Figures 5.4 shown above, expect for that of 1995, suggest environmental investment is increasing at an almost constant speed, because USA Government has established environmental investment rules since 1982. Until 2016, USA has officially issued *Both Sides of Environmental Investment Model in 1984*, *Both Sides of Environmental Investment Model in 1994, Both Sides of Environmental Investment Model in 2004, Both Sides of Environmental Investment Model in 2015*. The rules mentioned above are the essential factor that influences America's environmental investment, and meanwhile, it is the reason why the investment in DuPont company is increasing at a fast and constant speed. However, in 1995, there appeared a decrease, because in 1995, environmental investment in the USA was suffering from a financial impact, causing a plunge in the company's environmental investment of that year (Council of Great Lakes Industries, 2017).

5.4.1. The new development of USA environmental investment rules *Model 2015*

In Feb. 2015, USA government issued Both Sides of Environmental Investment Model in 2015 (Council of Great Lakes Industries, 2017). In environmental aspect, Model 2015 has large improvement compared to Both Sides of Environmental Investment Model in 2004.

5.4.1.1. Revision background

In the 21stcentury, dealing with global climate change is the important topic for environmental protection, with *Kyoto Protocol* becoming effective, many countries including the USA begin to fulfill their responsibilities for decreasing the amount of pollution. Since then, USA has strengthened domestic legislation dealing with global climate change and the implementation of obligations to reduce carbon emissions (Table 5.7). The details are as follows:

(1) Pay more attention to make laws against global climate change. USA President George W. Bush signed the new energy treaty which is "National energy policy of 2005". Basically, the law was aimed at the country's energy supply, environmental protection, economic prosperity and national security. After elected as President of USA, Barack Obama attached great importance to the domestic legislation dealing with environmental investment. During President Obama's tenure, two pieces of domestic legislation, *American Clean Energy and Security Act of 2009* and *American Power Act of 2010* were introduced, designed to protect and invest in environment. Although these two laws have not been carried into effect yet, it shows the determination of Americans to protect environment.

Table 5.7. The domestic legislation established in recent years (Updated from Environmental Protect Agency)

Years	Name of the person who established it	Name of the legislation
1970	Richard Milhous Nixon	*Environmental Quality Improvement Method*
1972	Richard Milhous Nixon	*The Noise Control Act*
1973	Richard Milhous Nixon	*Endangered Species Act*
1975	Gerald Rudolph Ford Jr.	*Toxic Substances Transport Law*
1976	Gerald Rudolph Ford Jr.	*The Toxic Substances Control Act*
1980	James Earl Carter	*Superfund Law*
1982	The American council on environmental quality	*The Nuclear Waste Policy Act*
2009	Barack Obama	*The Clean Energy and Security Act of 2009*
2010	Barack Obama	*American Power Act of 2010*

(2) Improve the performance of global environmental investment. It is beneficial to dealing with the impact of environmental investment and environmental protection. Moreover, the aim is to

promote the implementation of environmental investment. USA government is searching for other laws to cope with environmental change. They fulfill their main tasks by investing more than past years and promoting clean and low carbon energy. Furthermore, the impact between investors and the country also has positive significance for environmental protection, because international investment in the field of clean energy and carbon emission reduction can contribute to the solutions for global environmental problems, especially those like global environmental change.

Table 5.8. The comparison between new development of USA and China's enlightenment

USA	China
Pay more attention to write laws to global climate change	The legislative mode confusion.
Improve the performance of global environmental investment	Imperfect environmental rules
	Environmental rules of thick line
	The weakening of environmental rules
	Public participation is weak

5.4.2. China's enlightenment: construction of environmental investment in China

Until 2015, China has signed 110 rules of environmental investment, and compared to the USA, the environmental investment of China has five major problems: The legislative mode confusion: based on the investigation into the investment treaty in China, it's easy to assert that China's investment treaty rules of environment are arbitrary and fail to establish a stable model of legislation. On the one hand, it shows the investment legislation of environmental protection is weak; on the other hand, it also shows that our investment legislation is not yet mature, and has not yet formed a unified strategic consciousness. The comparison between new development of USA and China's enlightenment is shown in Table 5.8 and the key differences are as follows:

(1) Imperfect environmental rules: as mentioned earlier, the investment treaty rules of environmental legislation in the USA have been in a trend of progressive elaboration and

strengthening, compared with which, in China's legislation of environmental investment exist the following problems: It is abstract the fact that in China, the government uses the term "public interest" instead of "environment" leads to the abstraction of the legislation, which, to a certain extent, can expand the scope of the rights and obligations, but, more noticeably, it may be harmful to settlement of environmental problems, because abstract treaties may offer the arbitrator wider space, thus affecting the final arbitration results.

(2) Environmental rules of ambiguity: USA investment treaty rules of environmental legislation is quite refined, only "investment and the environment" clause has been refined to 7 rules. While China's investment treaty provisions on environmental rules are not less, more than 2 rules. Detailed rules can measure the strength and applicable scope of host country environment. Environmental rules refinement is, as it were, a powerful weapon of the host countries and their own environmental interests grappling with investment promotion and environmental protection.

(3) The weakness of environmental rules: it is not hard to find in American investment treaty for environmental rules, the environmental protection of investors as well as the host country's right and obligation are enhanced.

USA investment treaty regulate, "the parties shall not directly or indirectly, tax or nationalize qualified investments, except environmental measures for public purpose".

Thus it has connected the implementation of environmental measures with direct tax and indirect tax, which indeed, can expand and strengthen the improvement scope of and measures on the host country environment. In addition, for a developing country, if environmental protection ~~in~~ 10 years

ago was a kind of moral obligations, then nowadays, it should be a mandatory obligation. Considering legal treaties on environmental protection, if only "should not", "agreed to relax" and other resembling words are used to describe the rights and obligations, it does not suffice to emphasize the attention on the environmental problems.

(4) Public participation is weak: public participation in environmental protection movement and the development of relevant legislation plays an important role, and because of this, both of the environmental legislation in many countries and the multilateral international environmental treaties were emphasizing public participation system. *The Model 2012* introduced the Public participation system, especially taking environmental protectionists as "friends of the court to join relevant investment dispute settlement procedures". It can reflect more transparency on environmental issues, and is conducive to balancing the interests of the investors and the host country, but the environment rules of legislation in China investment treaty did not manifest this. This also shows that investment legislation has not raised much consciousness in China's environmental protection. Once China's opponents are developed countries such as America, China in the negotiation would be easily put in a passive position, and a fair reasonable investment treaty would be difficult to conclude.

5.4.2.1. Methods

In the field of international investment, China is no longer merely a capital importer, but plays the roles of both capital importer and exporter. Besides, capital exporting countries not only include the developing countries, but also consist of a large number of developed countries. Moreover, in the era of energy, energy investment has become an important part of overseas investment, which

is inevitably involved in the host country's environmental protection. China should form a kind of consciousness, namely whether objects are developed countries or developing countries, the investment should adhere to certain laws.(Qian,2009) For the issue of the environmental protection for the sustainable development of mankind, investors or home investors should be of consistent attitudes or acting under unified policy. If a country's investment treaty varies when targeted at different countries, it is neither fair nor conducive to environmental protection. At present, China is undergoing a new round of investment treaty negotiations, where a strong environmental protection idea should be established, and reasonable environmental rules of investment treaty be formed. Table 5.9 summarizes the methods applicable to China.

Table 5.9. Methods to China

Establish the unified legislative model
Establish reasonable and perfect environmental rules
Clear environmental protection obligations
Clarify the obligations under the multilateral environmental treaties
Strengthen environmental regulation.
The establishment of public participation principle.

(1) Establish the unified legislative model: China’s investment treaty rules of environmental legislation mode can conform to the mode of "2012 Model". Based on the “2012 Model”, China is able to forma “preface + investment + compensation performance requirements + environmental + general exception + dispute settlement" mode, where the environmental protection issues are all incorporated into the investment treaty. It seems that such a high standard of legislative model may deter investors in terms of overseas investment in China. But in fact, in some cases, high standards of investment treaty are beneficial to investors.

For environment, on the one hand, it can prompt investors that they always pay great attention to environmental issues in the process of investment, making the environmental protection as an

important part of the investment management; on the other hand, it also can improve the quality of investors, in order to obtain further investment benefits. Unified legislative model surely does not mean that every investment treaty should have exactly identical environmental rules, but it can arrange the content of the rules of specific environment for developed countries and developing countries (Yang, et al., 2015).

(2) To protect environment, China can clarify environmental protection obligations at least from the following two aspects: (i) clear environmental protection obligations. (ii) clear obligations under the multilateral environmental treaties. Multilateral environmental treaties have assigned the environmental protection duties to developed countries, developing countries and undeveloped countries. Only based on the multilateral environmental treaties, can investment treaty be able to establish environmental protection obligations and coordinate the relationship between the investment promotion and environmental protection. In this way, possible conflicts between investment treaties and multilateral environmental treaties can be effectively solved, environmental protection level of different investment treaties can be distinguished and obligations of the contracting states can be clarified.

To clarify the extension of domestic environmental law: as the "World Investment Report 2012" released by the United Nation Conference on Trade and Development mentioned, state regulating is formulating, promulgating and implementing various laws, regulations and rules.

Without proper rules and regulations, the state is unlikely to attract foreign investors. For investors, they want the host country to provide a clear, stable and predictable investment condition. Therefore, China investment treaty can be clear by extending the domestic environmental law to the clause "investment and the environment", and giving a definition of domestic environmental

law which includes two aspects: the central and local environmental laws, regulations or rules. Thereupon, not only the transparency of the environmental law can be improved, but also the relevant investment disputes can be solved. Of course, the promise of conducting environmental law is to clean up all kinds of environmental and resources protection law in China, revising the terms that may be controversial.

(3) To strengthen environmental regulation: a country's environmental protection level often depends on the strength and range of its environmental measures. “2004 model” and “2012 model” do not include any general exception concerning 'health, safety and environment’. Such omission caused the government high uncertainty when protecting the well-being of the citizens and the environment from the hazards, which has weakened the government's ability to respond to such harm effectively, and to supplement the general “exception rule” is able to make a difference by giving enough clarity to the law in the field of public policy and offering the court guidelines. Besides, “general exception clause” ensures public interests protection including environmental protection measures that have been accused of indirect tax. It can be said that the lack of “general exception clause” does not favor the parties to exercise the right of environmental regulation. China can adopt the following plan to introduce general exception clause, namely general exception clause in investment treaty expressly excluding environmental measures. In addition, based on the environmental measures and the relationship, it can be specified in the “collection and compensation” clause of the host country's environmental measures that they shall not apply to regulations on “collection and compensation”.

(4) The establishment of public participation principle: both at the international level and the domestic level, the enthusiasm of the social public to participate in environmental protection is increasing day by day. The principle of public participation has become an important one for both the international and the domestic environmental legislation. Foreign investment is a matter of the public interests for the host country, so establishing the public participation system in investment treaty principles will be conducive to the protection of the host country's public interests. As for the way of public participation, China, on the one hand, can draw lessons from the 2012 Model to set a "friend of court" role to settle disputes during the procedures of international investment; on the other hand, it can be "investment and the environment" clause in the contracting states or other societies such as environmental protection agency that participates in international investment issues. In this way, the principle of public participation is able to effectively promote the environmental protection and focus on environmental protection issues in the international investment, thus fulfilling its proper role.

5.4.3. Practical arbitration experience of environmental rules and investment treaty in the USA

Since 1994, USA investment treaty has begun to focus on environmental issue. Under *American Free Trade Agreement,* dispute settlement mechanism and the international investment disputes resolution center, foreign investors and USA government, USA investors and foreign governments have been associated. Some of the disputes have occurred before the 2004 Model, and some have happened after "2004 Model". Those disputes more directly reflected the environmental rules of investment treaty as practical experience. Based on the investigation into the 5 investment disputes,

it is not difficult to find that the environmental investment treaty rules are many reflected in the following (Wu, et al., 2007):

Investment disputes related to the environment: although some disputes all involve environmental measures and levy relationship problems, whether the environmental measures leading to arbitration results of above five constitute indirect tax dispute or not is relatively not the same. Under dispute settlement mechanism in the North American Free Trade Agreement and the international investment disputes resolution center, the standards of judging whether an environmental measure forms indirect tax in tribunal are different. The standards of arbitrators deciding whether environmental measures constitute an indirect tax out of discrimination conform to the purpose and fully valid evidence.

For example, in the case of "MOS eisley company in Canada" (here referred to as the "MOS eisley company") in 1997, the Canadian government finally admitted that there is no evidence that low levels of gasoline antiknock can cause harm to human health and the environment; thus the government is responsible for the damage (Utah Department of Environmental Quality, 2017).

As for "Mayer case in Canada" in 2000 (here referred to as the "Mayer company"), the arbitrators of the arbitration tribunal believe that they have the right to forbid execution of the host country government.

The perfect domestic environmental legislation for USA government or investors laid a legal foundation, for which the three measures above are good instances that adopted in the environmental cases (including USA government) against investment disputes, in the majority of which USA won and only in the case of "mayer company" where the appeal company lost.

5.5. The use and investment of water resources in USA

USA is a country which abounds in water resources. The amount of freshwater is 2478000 million cubic meters, which per capita is 911 per cubic meters, ranking 59th in the world. USA is a country which manages and uses water by law. As early as in 1972, the federal government enacted the *Clean Water Act*. They have put forward strict requirement for the development of water, especially the water quality. Later, all states accordingly introduced a series of local law regulating water resources, environmental protection, water discharge and groundwater mining ways.

Table 5.10. Water quality in assessed water bodies (extracted from National Water Quality Inventory: Report to Congress, 2010)

Water source	Assessed amount	Percentage of the total	Percentage of waters assessed		
			Good	Threatened	Impaired
River and streams	563600 miles	23%	53%	3%	44%
Lakes, ponds, and reservoirs	16674834 acres	43%	35%	1%	64%
Bays and estuaries	27439 Square miles	39%	70%	1%	30%

As mentioned above (Table 5.10), in 1972, Florida water management, made clear in a regulation of Florida that water is all people's property, which is to say, the water resource is managed by local government, but serving for all the people. There are 5 environmental departments, which are in charge of the development, utilization, protection and management of water resources. They have rules that every citizen who owns the green area must pay for the tax of water management. Water usage and discharge permission systems are utilized.

Any state enterprise or resident like drainage and water and oil storage that may pollute water must be approved by the related department, and accept strict management and monitoring from the department. Other states also have issued the “safe use of water rules” to govern water, such as environmental protection laws and regulations. American laws and regulations related to water resources almost cover the whole process of the water resources development, from utilization, protection to management. And people, no matter they are in government, enterprises or residents, have followed the laws. If there is a dispute over water, it should be treated in accordance with legal procedures, responsibilities, rights and obligations. Due to early legislation and law enforcement, the development and utilization of water resources are orderly under government control. Water quality, especially the drinking water, has so reliable guarantee that tap water can serve as direct drinking water.

5.6. A clear division of responsibilities, tacit cooperation and restriction among each department

The management of water resources shall be provided by the Department of Agriculture, natural resource protection agency, the national geological survey of water resources, the environmental protection agency and the army corps of engineers. They function differently complying with the rights authorized by the federal government. The ministry of agriculture and natural resource protection agency are responsible for the development of agricultural water resources, utilization and environmental protection

National geological survey of water resources takes charge of collecting, monitoring, analyzing and providing the data on waters, and of four rivers have offices been set up. There are nearly 500

employees working for the government, enterprises and residents who provide detailed and accurate water data, and give suggestions on policy for the water conservancy project construction. Environmental protection agency (EPA), according to their needs for environmental protection, formulates the corresponding provisions and requirements to control the development and conserve the utilization of water resources, as well as prevent water contamination. The army corps of engineers serves to plan, design and construct large water conservancy engineering invested by the government.

Under the unified leadership of the federal government, each department is clear about its own responsibilities, and consequently the division of labor, mutual coordination, cooperation and constriction among each other are realized. They have formed "tacit understanding in cooperation" within the management system.

5.7. Environmental protection is top priority

USA Government attached great importance to protect water environment and to make sure the development, management and utilization of water have followed the principle of environmental protection is top priority. The importance of water protection is popularized with a variety of materials and common reading sent through radio, television and other news media. Meanwhile, it is ensured that anyone who polluted water will be incurred punishment according to relevant laws.

Moreover, money is raised to construct environmental project designedly, thus to improve the aquatic environment. Florida governance and lake pollution engineering is a typical project. At the end of World War II, the lake decreased year by year because of a lot of framers reclaiming land by destroying lakes, plus aquatic plants is growing at a fast speed, so the lakes were polluted.

In order to eradicate the pollution of the lake and recover the natural ecology of the lakes, the local government bought 20000 square meter land to transform into lakes. Water department has established two pumping stations which will be drawing water in big lake into wetland, and then the water filtered pumps back into the great lakes. For improving water quality, the government plans to use 3-5 years to restore the natural ecology of the lakes. At the same time, Florida is restoring a river which is degraded by fresh water erosion Euler Eva Ha River, and it is planning 3 years to retrieve the original fish populations in the river.

USA has rich water resources, but it is also extremely serious about the rational development and utilization of water resources. Arkansas was the major rice producing area, where farmers were irrigating their crops by drilling wells and pumping. Having been extracted for a long time, groundwater lost greatly, whose level was 30 meters lower in 1996 than in 1940s. Underground water level decline and its over-exploitation have drawn great attention of the state. Therefore, they have established a regulation to limit drilling and control water output, and at the same time, mandated farmers to use surface water for irrigation.

The practice of USA that attaches great importance to the protection of water resources does not totally conform to China's national conditions, and we do not need to copy it, but its principle of the rule of law in environmental protection and rational development is worth our reference.

5.8. Government materials is main resources (Zhang, 2006; Pan at al., 2011)

In USA all the water is with a large water conservancy project for construction and development, and the construction of flood control engineering investment is mainly in the charge of the federal, state and farmers, complying with the principle that government gains large and farmers gain small. Two levels of government are responsible for the cost of 65% to commonly 85%, farmers generally

burden 10% to 15%. For example, in Arkansas white water irrigation area need $300 million dollars, of which the federal government and state burden 65% and 20% respectively, and farmers burden the remaining 15%

5.9. Control measures against air pollution in USA

As one of the tough challenges facing the world, air pollution in urban areas has been taken into serious consideration. Air pollution control in China began in the 70s of last century when a series of laws and regulations have been issued. As a whole, air pollution control goal in China, especially for urban areas, has gone unmet. This paper reviews the experiences of air pollution control in USA in terms of legal measures against air pollution and the relevant standards, analyzing the legal and managerial measures against toxic air pollutants and comparing them with those being practiced in China (Walton, et al., 2001).

The rapid development of America's urbanization and industrialization, plus its rocketing increase of energy consumption, brings about a lot of air pollution in USA (Table 5.11). During the 1970s, coal smoke emission became the characteristic of America's industrial city. In the 80s, many southern cities suffering from serious acid rain harm. In recent years, the automobile exhausting emission of NO_X, CO and subsequent formation of photochemical smog, are deteriorating air quality in many big cities. Urban air pollution affects the health of urban residents and the development of the city. To control air pollution and protect the atmospheric environment quality, USA government has carried out many plans. Since the 1970s, the China government has strengthened the environmental protection work, enacting policies and taking measures to cope with air pollution, which has received certain effect, but overall speaking, environment pollution and destruction is still not fully controlled.

Table 5.11 Selected air pollutant emissions by pollutant and source in 2017 (Extracted from USA Environmental Protection Agency)

Source		NH_3	CO	NOx	PM10	SO_2	VOC
Total emission		4303	77683	17832	14805	11502	15927
Fuel combustion, Stationary sources	Electric utilities	34	699	3033	534	8372	50
	Industrial	16	1216	1736	330	1320	130
	Other fuel combustion	18	3369	727	466	578	1382
Industrial processes	Chemical product manufacturing	22	265	89	39	255	228
	Metal processing	3	947	68	79	290	46
	Petroleum industries	3	355	348	24	240	561
	Other	151	500	418	967	329	404
	Waste disposal and recycling	1	115	27	57	4	1303
	Storage and transport	26	1584	119	288	26	374
Highway vehicles		308	38866	5392	171	80	3418
Off highway		3	18036	4255	338	489	2932
Miscellaneous		3457	11731	260	11540	85	1923

5.9.1. The air pollution prevention and control laws and regulations system

The *Clean Air Act* was signed by congress in 1970, and was largely revised in 1977 and 1990. The main purpose of the legislation is to make ambient air where people live reach national ambient air quality standards (NAAQS) (Otero-Phillips, 1998). The environmental protection agency established national ambient air quality standards in 2015 as shown in Table 5.12. USA in 1990, made clear stipulations for the *Clean Air Act Amendments*, which made specific provisions on the

main air quality control area, state implementation plans, license, sulfur dioxide emissions quotas and trading and mobile pollution sources (Stern, 1982).

Table 5.12 National ambient air quality standards in 2015 (Updated from Environmental Protection Agency)

Pollutant(links to historical tables of NAAQS reviews)		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (CO)		primary	8 hours	9ppm	Not to be exceed more than once per year
			1 hour	35ppm	
Lead(Pb)		Primary and secondary	Rolling 3 months average	0.15μg/m^3	Not to be exceeded
Nitrogen Dioxide (NO_2)		primary	1 hour	100ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		Primary and secondary	1 year	53ppb	Annual Mean
Ozone(O_3)		Primary and secondary	8 hours	0.007 ppm	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particle Pollution (PM)	PM2.5	primary	1 year	12.0μg/m^3	annual mean, averaged over 3 years
		secondary	1 year	15.0μg/m^3	annual mean, averaged over 3 years
	PM10	Primary and secondary	24 hours	150μg/m^3	98th percentile, averaged over 3 years
Sulfur Dioxide(SO_2)		primary	1 hour	75ppb	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3 hours	0.5ppm	Not to be exceeded more than once per year

5.9.2. Air quality control

The Clean Air Act requires the federal environmental protection bureau designate air quality control. The country is divided into 24 air quality control area, air quality control line does not necessarily agree with the administrative boundaries. In addition to the state air quality control area, the federal environmental protection agency also has the right to delimit the interstate air quality control. The pollution problem of interstate air quality control is managed by the relevant department (McClain and Meier, 2013).

5.9.3. Sulfur dioxide emission quotas and trading

The Clean Air Act Amendments in 1990 stipulated the sulfur dioxide emissions permission and trading system. The goals are in two stages, one of which is that main power stations decrease the sulfur dioxide emissions by 10 million tons in 2010, and the other is to effectively reduce sulfur dioxide emissions fee. Main control object is the plant, which would get a permit of certain amount of emission according to the original outputs and its annual emissions must not exceed the quota of the year. The federal environmental protection agency auction a certain number of quotas each year, which can be sold, bought and saved.

5.9.4. The flow of pollution sources

The Clean Air Act Amendment (1990) is mainly committed to pollution emission standards, requiring car makers to cut vehicle emissions of hydrocarbons and nitrogen oxides with a promise that 40% of the vehicles sold in 1994 achieve this standard and 100% of the vehicles sold in 1996 be conforming to this standard. It also stipulates that mobile-pollutants discharge should be further cut by 50% from 2003 on. With the above standards, the law amended two fuel related planning.

5.9.5. The strategy of controlling toxic air pollutants

A distinct characteristic of management of USA environmental protection agency (EPA) for toxic air pollutants is object classification which adopts different management and fine management. And the perspectives of classifying are diverse, with standards of source, pollutant and region.

5.9.6. Control countermeasures for pollution source

The source of poisonous and harmful air pollutants is divided into two major categories: important source and non-point source. Important source is defined with two cases: one is 187 kinds of any sort of pollutants in atmospheric pollutants emissions by more than 10 tons; the other is 187 kinds of species of all kinds of pollutants discharge atmospheric pollution quantity is greater than the sum of 25 tons. The two mentioned above are classified as important sources of pollution, the key pollution sources on which the major management is generally imposed. Key pollution sources other than pollution sources, both as non-point source pollution sources to control

Important sources of pollution Control Technology is based on Maximum Available Control Technology (MACT). USA environmental protection agency (EPA) began to practice MACT from 1990 in different industries, and it was basically completed in 2002. MACT initially only considered the technical level, neglecting basic economic and healthy factors. Each MACT is implemented every eight years for risk assessment, such as strict standard requirements, and it is needed to carry out environmental and economic benefit evaluation.

5.9.7. The concrete control equipment of all kinds of pollution sources (Ping, 2006)

(1) Industrial and commercial pollution sources control: environmental protection agency control regulations cover 80 kinds of industrial sources, such as chemical industry, oil refining industry, aerospace and steel; besides, there is a smaller class includes totally 142 sources, such as dry cleaning industry, commercial sterilization equipment, regenerated lead smelters and chromium plating facilities. According to the discharge characteristics of each set type of source, the environmental protection agency has made specific emission control act. These rules can reduce about 1.5 million tons every year.

(2) Control of cars and trucks: on February 9, 2007, the environmental protection agency has signed on law of control mobile source of poisonous and harmful air pollutants. The law imposed limitations on the content of the benzene in gasoline, thus to reduce volatile toxic substances in the vehicle and tank. It is estimated that by 2030 the implementation of the law will have reduced more than 30t toxic substances and more than 100 million tons of VOC emissions will have been limited. In addition, in order to control the hydrocarbon, particulate matter and nitrogen oxides pollutants, the environmental protection agency has issued a road emission control regulation. Moreover, USA environmental protection agency has issued a special law for controlling small road gasoline engine, small diesel engines and small Marine engine emissions; for further reducing the risk, USA has also launched campaigns like a clean school bus, voluntary diesel reformation and national clean diesel.

(3) The indoor pollutants control: in order to reduce office, family, school and other indoor environment pollutant concentration, USA environmental protection agency is working closely

with other federal agencies and the private enterprise on further studying of indoor air pollution so as to control technology.

5.9.8. To prevent pollution from serious deterioration

In 1977, the environmental protection agency amended the regions where the air quality is better than that of the NAAQS (National Ambient Air Quality Standards) area will be regarded as Prevention of Significant Deterioration region, known as the PSD. This region must take measures to prevent serious deterioration. In addition, the state's plans must also contain a part to prevent serious deterioration of air quality. The main content of the PSD program includes the clean area classification, main emission source protection plan of visibility and license application (EPA, 2016a).

5.9.9. Clean area classification

According to the concentration of pollutants, it can be divided into three kinds of areas, namely:

(1) The first area: the region's air quality allows only slight damage, and should expel any major air pollution sources. International park, covering an area of more than 5000 acres of national ecological nature reserve and national memorial park belong to this class.

(2) The second area: the regional atmospheric pollutants concentration allows a moderate increase, and it is restrained within NAAQS. All other than the type of clean area is for the second area, and states can add partition to the second area, from which three kinds of lower-level areas can be drawn.

(3) The third area: a larger increase of pollution is tolerable in such regions. Usually, industrial development is allowed to stay here, but the ultimate increase of pollutants may not make the pollutants concentration of the higher than the National Ambient Air Quality Standards.

5.10. Main emission source license application

New-main pollution sources in PSD area must-apply for construction permits. The pollution source shall adopt the Best Available Control Technology (BACT). Main pollution sources refer to manufactures whose annual discharge is or that have the potential to produce more than 100 tons (including 100 tons) of 28 kinds of fixed source of air pollutants, such as fire power plants, pulp mill, cement plant, metal smelting and mineral processing plants (South Coast Air Quality Management District, 2014).

5.10.1. Visibility protection program

Visibility is mandatory for the first class area, which means it not necessary for areas of other classes. It is the best air quality in part of the country. USA Environmental Protection Agency made visibility protection regulations so as to provide appropriate technical methods for the state to implement the plan of visibility maintenance.

5.10.2. The rules for non-attainment areas

The rules for areas below standard (non-attainment areas) were amended and supplemented in 1977. As long as any kind of pollutants fails to meet the National Ambient Air Quality Standards in an area, it is defined as NA (Non - attainment Areas). This is because that for some developed industrial and densely populated areas, only to be controlled under general emission reductions is

not sufficient to make the pollutants concentration drop to the level required by national environmental air quality. In order to strengthen the control of air pollution in these areas and urge it to meet standards as soon as possible, Environmental Protection Agency specially promulgated regulations called rules for non-attainment areas. In the early 1990s, USA NA area covered 20% of the total land area. Main countermeasures for non-attainment areas include limited period of the air quality standard's implementation, permit system, compulsory inspection of motor vehicles and maintenance system (EPA, 2016; Perhac, 1985; Walton, et al., 2001).

5.10.3. Due date of national environmental quality standards

According to the standards of 6 kinds of pollutants, different due dates were made. The due date designated for areas below ambient air quality standards forces those areas to meet the standard as soon as possible since the day regarded as non-attainment areas, which shall not exceed the established date. And delay must get Environmental Protection Agency approval. However, due date for non-attainment areas to meet secondary ambient air quality standards can barely be deferred.

5.10.4. Permit system

New major pollution sources shall practice a system of permits, which means those did not get the permits cannot be constructed or expanded. One of the functions of such license is to ensure the discharge of the pollutants must conform to the conditions of Lowest Achievable Emission Rate, LAER, and meet the requirements of offset policy. That means, in areas below standards, new source must adopt the technology that controls the emissions at the lowest level (EPA, 2016b)

The practice of America's air pollutant emission permit system is later than that of water pollutants discharge permit system. Although in 1977 Environmental Protection Agency amended license requirements in the clean area and non-attainment areas, it was not until 1990 that Environmental Protection Agency specially added license chapter, which strengthened the relevant provisions of the license. Environmental Protection Agency and the detailed rules bring about a comprehensive plan for controlling air pollution regulations called the Operating Permit Program. Operating permit system is in the charge of state or lower level government agencies. Operating permit system can be illustrated by the Figure 5.5 (Lynch, et al., 2000).

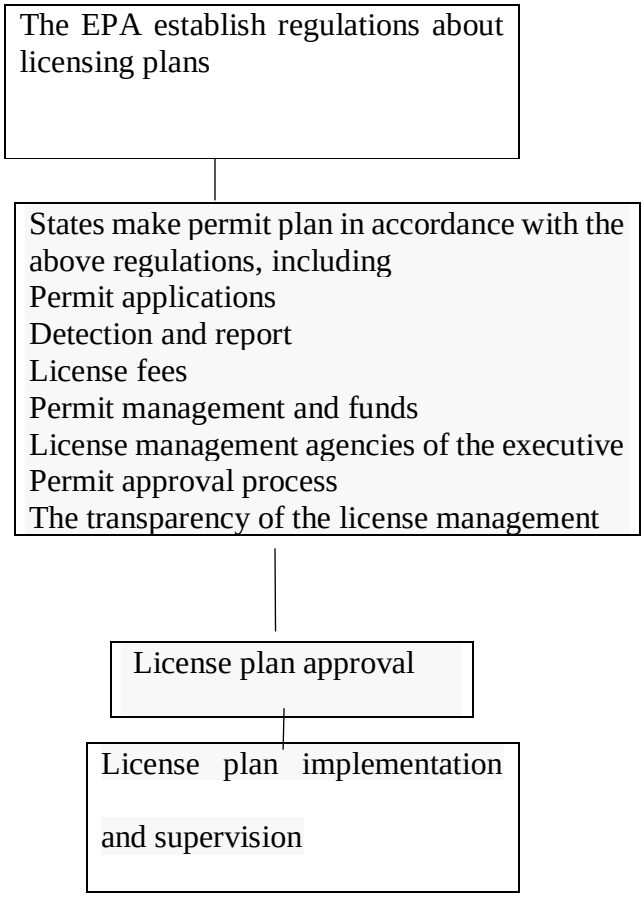


Figure 5.5 Operating permit system

(1) The license's management objects: the point controlled under the acid rain provisions, critical point source which discharges harmful air pollutants, the pollution sources regulated by clauses preventing the air quality from descending and those governing non-attainment areas and other point sources specified by the Environmental Protection Agency are included.

(2) The basic terms of license: discharge restrictions and standards, standard plan, monitoring and reporting, on-site inspection, valid duration (generally no more than 5 months), the type of license (general or special) and other provisions necessary to comply with the Environmental Protection Agency.

5.10.5. "Bubble" policy, the implementation of emission trading (EPA, 2016c; Xue and Hao, 2003)

(1) Bubble policy: bubble policy is to make total amount of air pollutant in a factory or a district to be a "bubble". Factories can discharge air pollutants under certain conditions prescribed by the Environmental Protection Agency. They can selectively use air pollution control fund or adjust the discharge outlets, providing that all the sum total of the air pollution emissions must not exceed the Environmental Protection Agency standards. Bubbles can be either small or big, and can be within a single factory or a company which contains more than one industry or a particular area. Nevertheless, the application of the bubble policy is strictly limited by the EPA, whose purpose is to curb abuse of bubble policy, which could cause the decline of air quality.

(2) Use economic and market techniques to control air pollution

In USA, traditional and essential way to control the air pollution is called command and control regulations, under which, regardless of their scales, all the pollution sources were imposed on

stringent emission limits by the Environmental Protection Agency. In the mid-1970s, this kind of air pollution control measures put increasingly great economic pressure on industrial enterprises. In this case, the Environmental Protection Agency began to introduce economic ways in environmental management, and carried out the offset policy and bubble policy. USA economist had also been calling for use of market mechanisms to reduce pollution, but in a long time people remained skeptical. It was not until 1990 when Environmental Protection Agency amended acid rain program that emission trading scheme formally came up. Today, emission trading within an area as an environmental management method has become a new trend.

5.11. Compare USA toxic air pollutants control laws and regulations with China's

5.11.1. Ambient air quality standard classification is different from that of China

The National Ambient Air Quality Standards is divided into two levels, but be it an area designated for primary standard or secondary standard, it must apply national secondary standard, which means each region must meet secondary standards within the prescribed time at first, and then reach the standard level as soon as possible. China's air quality standards are divided into three levels, respectively corresponding to the hierarchy of area functions. For example, area of level function is to implement level one standard and that of second level function is to implement the secondary standard.

5.11.2. Implementation plan of state (Ron, 2003)

State implementation plan is a key link of the toxic air pollutants control. When a new or revised standard (National Ambient Air Quality Standards or emission standards) is promulgated, states must submit to the Environmental Protection Agency with detailed implementation plans of the

state. This method is more flexible, practical and easier to implement, which is worth referring to. China is a traditional administrative country and it has also achieved good effect in practice of the prevention and control of atmospheric pollution problem, with distinctive administration and administrative enforcement as characteristics, while the national standards, total amount control and tradable permits as contents.

5.11.3. Using the market mechanism is flexible to control pollution (Zhou, 1997; Zhou and An, 1997; The International Trade Administration, 2016)

Because unnecessary spending and cumbersome administration caused by the traditional command and control of environmental regulations had grown increasingly prominent, since 1980, USA gradually adopted some market-based environmental policies, such as offset policy and bubble policy. In 1990, emissions trading system was officially written into Environmental Protection Agency standards, which turned out to prove that market-based environmental policies can greatly reduce the cost of pollution control. China is also conducting pilot study on atmospheric pollutant emission trading in some cities in recent years. China is unlikely to replicate early pollution control mode in USA, which wants huge investment because environmental problems in China are extremely serious while the national strength is limited. Therefore, to learn from the advanced experience of USA and utilize market mechanisms to reduce pollution control costs is of prominent significance (EPA, 2016c).

5.12. Solid waste in USA (Cheng, 2010; Cheng, 2005)

In recent years, with the development of society and economy, the amount of solid waste is increasing rapidly, which has caused great pollution and damage to our environment. It has been

an increasingly concerned social problem to decrease the solid waste pollution appropriately. However, the decontamination rate of solid waste in our country is still low and the related laws and regulations are deficient. This paper mainly compared the solid waste legislation of China's and America's, through which some experiences were summarized for China.

5.12.1. The solid waste legislation enlightenment to China

In the *Resource Conservation and Recovery Act*, the solid waste can be divided into harmful solid waste and harmless solid waste. The former refers to waste that has potential negative effects on health or the environment such as industrial waste, cleaning fluid, pesticides, by-product in the process of manufacturing or hazardous waste like daily food leftover which contains corrosive, toxic, flammable or active ingredient of waste material, while the latter is usually attributed to the general wastes, including everyday refuse like products packaging, bottles, food scraps and paper, which usually come from family, school, hospital or trade activities (EPA, 2016d).

The law of the People's Republic of China on the prevention and control of environmental pollution by solid waste defines solid waste as material whose value has diminished as a result of production, daily life and other activities, which is categorized into industrial solid waste, municipal solid waste and hazardous waste. Among the three, industrial solid waste is produced in active industry, municipal solid waste in daily life or for daily life activity while hazardous one refers to waste that is covered in national hazardous waste list or that is defined risky by national standards of hazardous solid waste.

Despite the fact that the legal definition and classification of solid waste in China and USA legislation resemble each other to some extent, in comparison, those in USA *Resource Conservation and Recovery Act* are much more detailed than those in China's laws (EPA, 2016d).

China’s relevant law just provides a general definition of solid waste, which is too broad. Taking the expression “whose value has diminished” as an example, the definition of the loss of a substance’s value is still in want of a unified standard. Therefore, in the process of following and enforcing the law, it's hard to find the regulations exact to go by. The laws must be observed and strictly enforced, and law-breakers must be prosecuted.

Pollution prevention and environmental protection policies fail to be efficient; thus although the law on environmental protection in China is presented, it is more often than not difficult to follow. On the other hand, the definition and classification of solid waste in the *Resource Conservation and Recovery Act* in USA are obviously more scientific. Firstly, solid waste can be divided into hazardous and nonhazardous. For hazardous solid waste, it doesn't pollute the environment. For harmless solid waste, it also will not cause waste of resources, so that it can achieve waste recycling (EPA, 2016d).

Second, under the framework of hazardous and non-hazardous solid waste in USA *Resource Conservation and Recovery Act*, elaboration is adopted for various types of garbage, for instance, harmful household garbage refers to everyday food leftover containing corrosive, toxic, or flammable ingredients, which clearly illustrates how household rubbish can be harmful. It provides the basis for the administrative department of law, and also determines the standard for the public. Thus, for the future relevant legislation of solid waste in China, it should draw lessons from USA about the process of refining solid waste classification standards and methods in order to establish more detailed rules and standards (EPA, 2016d).

5.12.2. The solid waste legislation

In early 1965, USA passed the *Solid Waste Disposal Act*, and became the first country that designated waste recycling as legal form and as a later amendment, the *Resource Conservation and Recovery Act* (RCRA) was enacted to provide guidelines for hazardous and non-hazardous solid waste disposal. Based on the laws promulgated and created by the federal government on October 21, 1976, it was aimed at solving the problem of the growing urban and industrial waste along with the economic development. Its objectives are: to protect human health and the environment from potential hazards, carry out waste disposal, save energy, conserve the natural resources, reduce loading that is generated and ensure that the disposal of waste will not cause damage to the environment. In order to ensure the actualization of these goals, RCRA set up three areas: hazardous waste projects, non-hazardous waste projects and underground storage tanks (World Bank Group, 2016; EPA, 20-16d).

Hazardous waste program under RCRA, has set up a kind of system regulating the whole process from generation to treatment and disposal of hazardous solid waste, known as the “cradle” to “grave" model. Non-hazardous waste project under RCRA, has encouraged states to develop their comprehensive plan to deal with harmless industrial solid waste. It has also established standards for local solid waste landfill and other solid waste cleanup facilities, and public dumping of solid waste is prohibited.

The direction of *Resource Conservation and Recovery Act* (RCRA) is broadly set by the Congress which presented waste management project, while it is USA Environmental Protection Agency (EPA) that is authorized by the Congress and ordered to establish a complete set of rules to ensure the implementation of the law, for example, the Resource Conservation and Recovery Act bans all

dumping of solid waste in public, encourages resource conservation and recycling and promotes the safety of the local solid waste disposal (EPA, 2016d).

In general, according to the authorization of RCRA system USA Environmental Protection Agency sets a series of supporting regulations related to the treatment of solid waste, for example, the hazardous wastes can be divided into two categories: one stated in a clear list of waste including the F-list of waste from non-specific sources, K-list of that from specific sources and P-list & U-list of abandoned industrial chemical products; the other is those identified with the characteristics of hazardous waste, which are regulated in the federal code chapter 261 40, including flammable substances, corrosive substances, active substances and toxic substances (EPA, 2016e).

China's law on the prevention and control of environmental pollution by solid waste is the fundamental legislation in this field at present in China, which was made in 1995 and revised in 2010. The law has determined the principle of environmental pollution by solid waste management that the generator of pollution should take responsibility for the treatment. Its legislative purpose is to prevent the environmental pollution by solid waste, safeguard human health, protect ecological safety, and promote economic and social development. For the prevention and control of environmental pollution by solid waste, it is critical to prevent and reduce the solid waste that is bad for the environment (EPA, 2016e)

It says in the third article of this law's general provisions," When preventing and controlling environmental pollution by solid waste, China is decreasing the discharge of solid waste, curbing its harmfulness, utilizing clean and safe treatment and disposal with purpose of promoting cleaner production and circular economy. Bearing the fully recovery and rational utilization of solid waste in mind, China shall adopt conducive economic and technical measures and policies". Article 7 stipulated," China encourages companies and individuals to buy and use recycled and recyclable

products". It is specified in article 18," There is a legally established list of products and packaging materials demanding compulsory recovery, and any enterprise that produces or trades such items shall recover them in accordance with the state's relevant law." It is regulated in article 38, "The people's governments at all levels shall blueprint the construction of facilities dealing with household garbage - its collection, transportation and disposal, which should be aimed at the industrialization of the process and gradually establishing and improving a safe and clean system for the prevention and control of environmental pollution". The 42nd article stipulates, "The urban garbage produced in daily life shall be cleaned up and transported away without delay, collected and transported after classification, and its rational utilization and harmless disposal should be carried out". According to article 43, "The relevant departments of a town or city shall make the overall planning and reasonably arrange trading system of household waste in order to make its recycling more efficient". Article 45 says, "After being recycled, household garbage must be used in accordance with the purposes or standard prescribed by China, not for products which may endanger human body health". The above articles are general provisions of the recycling of solid waste, and also are the principle of governing environmental pollution by solid waste that have played a guiding role at certain degree, but provided no method for further implementation (Guangdong Energy Conservation Association, 2009; China Mining Association (2010).

Comparison between the two countries' related law reveals that USA *Resource Conservation and Recovery Act* prohibits public dumping of solid waste, establishes a perfect system for cleaning and recycling of solid waste and sets the standard for the local legislation while China's law on the prevention and control of environmental pollution by solid waste only makes principle rules but failed to establish the related laws and regulations that provide particular methods to achieve goals such as the rule in article 38 that people's governments issue overall arrangement of urban

and rural garbage collection and the proposition in article 43 that people's governments plan for the establishment of household waste purchasing system. As a matter of fact, such rough and unspecific principles and regulations are far from enough for efficient law enforcement, which is why the work of recycling of solid waste is difficult to proceed (EPA, 2016d; The Centre for Sustainable Design, 1995).

5.12.3. The enlightenment to China on solid waste legislation

(1) The current solid waste legislation system is based on the *Resource Conservation and Recovery Act*. The laws enacted by USA Environmental Protection Agency (EPA) are specific detailed rules ensuring the effectiveness of the integrated legal system, which, compared with that of China, is a relatively comprehensive. In the aspect of solid waste pollution prevention and control, China has only promulgated "the prevention and control of environmental pollution by solid waste" as the main law, while other relevant supporting regulations are yet to be fully established and developed. Therefore, China should encourage as well as urge all localities to, combining their own regional characteristics, formulate relevant legal norms and propose specific standards and measures in the process of recycling solid waste. Only by this, can they accomplish a complete and orderly legal system to ensure the recycling of solid waste and environmental protection (Ministry of Environmental Protection, 2016).

(2) In USA *Resource Conservation and Recovery Act,* detailed description is given to the definition and classification of solid waste as well as the governance standards. In the Act, the solid waste can be divided into harmful and harmless, under which two categories, more elaborate divisions are made to describe and illustrate various kinds of solid waste. And at the same time USA has established the solid waste disposal standards and penalties. However, the solid waste legislation

in China only provides rough definition and classification without embodiment, where unified and specified standard of recycling is missing. This often causes difficulties during the process of solid waste recycling such as inability to distinguish between the harmful and harmless, the flammable and incombustible or recyclable waste and non-recyclables, which may consequently lead to resource waste and environmental pollution. Therefore, China should classify solid waste as soon as possible, and set up specific viable standards and measures concerning producing, transporting cleaning, recycling and utilizing such substance to minimize its damage to environment (The Centre for Sustainable Design, 1995).

Finally, from the *Resource Conservation and Recovery Act* in USA, it can be seen that its legislative idea is to recycle solid waste as a resource both to protect the environment and to save resources. On the other hand, China's conception on the prevention and control of environmental pollution by solid waste is still confined to "treatment after pollution", considering all the solid waste is hazardous that should be eliminated instead of being recycled, thus causing the waste of resources. In a word, China should eventually convert its legislative idea into a fresh one that garbage is resources put in wrong place and endeavor to build a resource-conserving environment of society at an early date (The Centre for Sustainable Design, 1995).

5.12.4. The industry of solid waste

In Orlando Florida, Baker Company made a covenant with the Environmental Research and Education Foundation that it would conduct the research work of the solid waste treatment. The work started in November 2010 to April 2016, having acquired a lot of firsthand digital statistics which enjoyed praise and recognition from USA Environmental Research and Education

Foundation. Baker's report on the waste industry expounded on every single aspect such as income and employee management agencies (Environmental Research & Education Foundation, 2017).

There are three kinds of organizations engaged in the solid waste collection, handling, recycling, incineration and compost or other treatment: listed private companies, unlisted private companies and public sectors, of which the first one is private enterprises that are issuing stocks on the national stock exchange, the second is private companies that are not trading on national stock exchange and the third is owned by the government (region, county, town).

The solid waste industry has a total of 27028 companies in USA, of which the public sector takes up 56% and private companies account for 44%; 99.8% of those private companies are unlisted private firms, while only 0.2% of them are listed. This industry in USA employs 367800 in total, and those working in the private companies account for 74% (272172 people), and to be more specific, personnel hired by the unlisted private companies cover 42% (154476 people) of the total, and those hired by the listed private companies take up 32% (117696 people); employees in public sector are 26% (95628 people) of the total number of workers in waste industry. Statistics mentioned above are visualized by following picture (Figure 5.6) (Ying and Zhou, 2006).

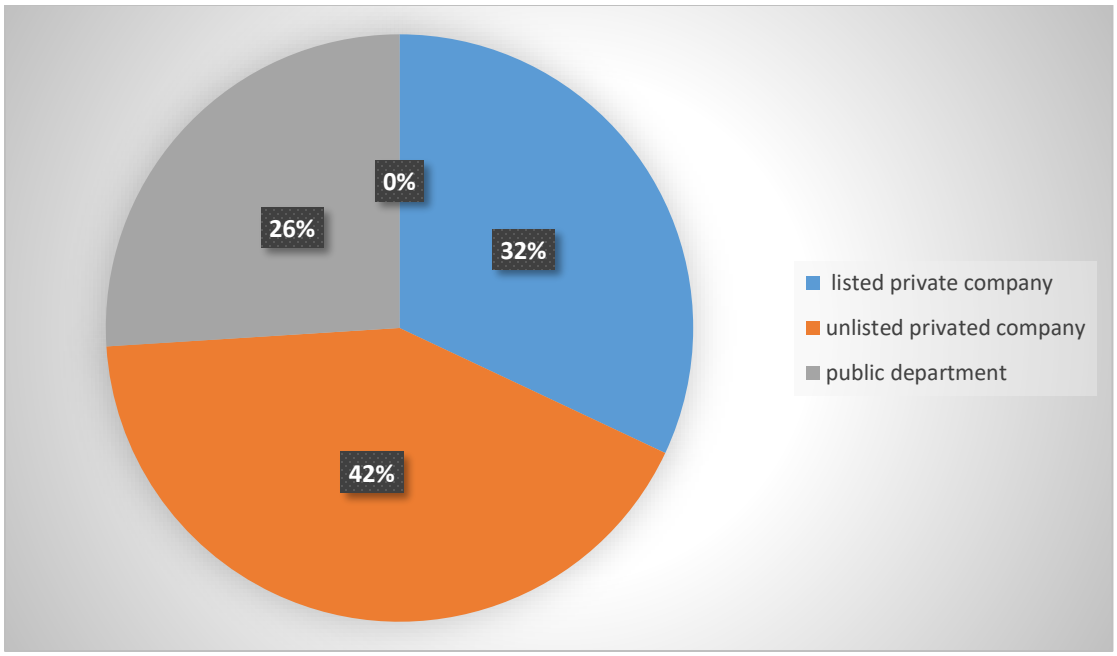


Figure 5.6. Distribution of the solid waste industry personnel (adapted from Environmental Protection Agency)

In 2016, total revenue of the solid waste industry was $43.3 billion. Of the total number, the income of public sector accounted for 24% ($10.4 billion) while that of the private company covered 76% ($32.9 billion), of which the listed ones took up 47% ($20.35 billion) of the total revenues of solid waste industry and the income from unlisted ones was 29% of the total number (12.55 billion dollars) (Figure 5.7) (Wang, 2010).

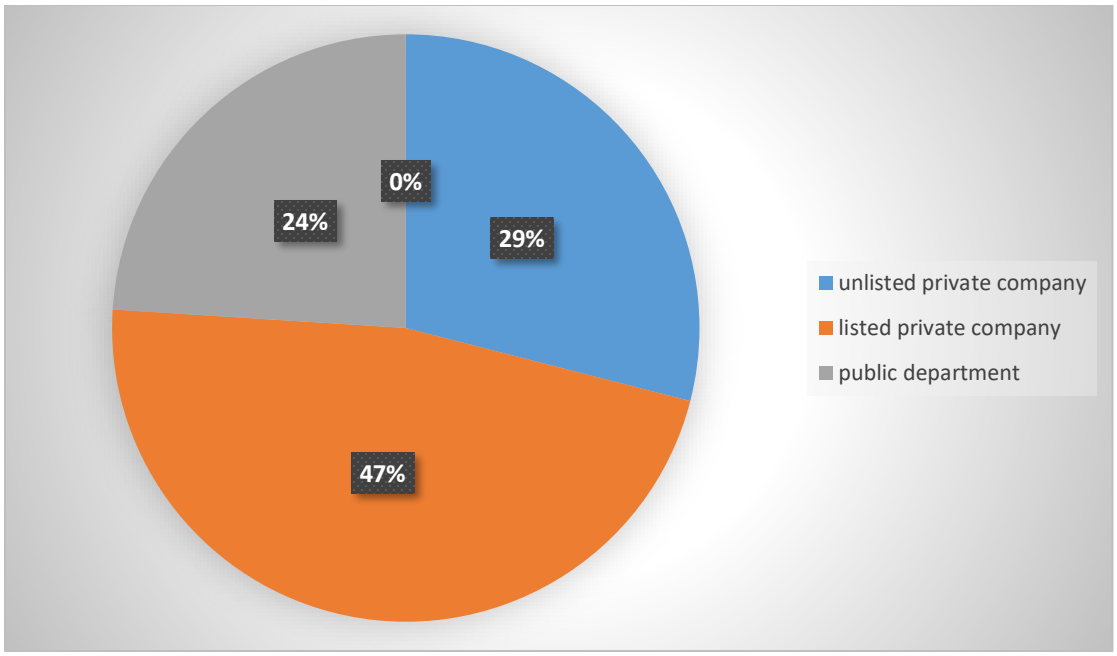


Figure 5.7. Income distribution of the solid waste industry (Adapted from Environmental Protection Agency)

In 2016, total income of employees in solid waste industry (including subsidies) was $10 billion dollars. Solid waste industry salary (including allowance) was $27200 per worker, 23.1% of which was subsidies. Private listed company offered the highest pay with an average of $36000 each; contrarily, employees in unlisted private company earned lowest income that averaged out at $22350 per person. When further divided, unlisted private companies had two types—large and small enterprises: the average income of employees in large unlisted private company was $30600, while the small unlisted private company only paid the employees $14100 at average. In terms of outstanding staff recruitment, the listed private companies and large unlisted private firms have more preferential treatment provided to employees.

In 2016, there were 27028 private and public enterprises in solid waste industry. About 15406 companies (57% of the total) only provided the waste collecting service and did not participate in its treatment because they were in want of such processing facilities.

The rest 11622 companies operated 15700 solid waste treatment facilities, of which 53% were owned by the private enterprises, while public sector was in possession of 47% of the facilities disposing of solid waste. As for private company having such facilities, the listed ones had 12% of the whole industry's solid waste disposal facilities, and non-listed ones own 41% of such equipment, as shown in Table 5.13.

Table 5.13. Ownership distribution of the solid waste treatment facilities in USA (Adapted from the website of Ministry of Environment)

Facilities type	Listed Private Company	Unlisted private company	Public department	Percentage
Municipal solid waste landfill	700	400	2100	20%
Construction waste landfill	50	200	400	4%
Transfer station	400	500	30	20%
Waste recycling facilities	40	30	1700	22%
Composting facilities	50	200	3400	10%
Other facilities	100	3400	100	23%
Total	1840	6430	7470	100%

In 2016, the industry solid waste treated about 545 million tons of solid waste, of which 371 million tons of solid waste were dealt with through landfill, accounting for 68% of the total amount, 5% of them, namely 0.27 million tons, were burned and the remaining 147 million tons, 27% of the total, were recycled. The listed private companies coped with 40% of the total solid waste, while the proportion of non-listed private companies' accomplishment was 29%, so to sum up, private companies disposed of as much as 69% of the solid waste. On the other hand, public sector contributed 31% of the solid waste treatment results (Figure 5.8) (Mani and Wheeler, 1998).

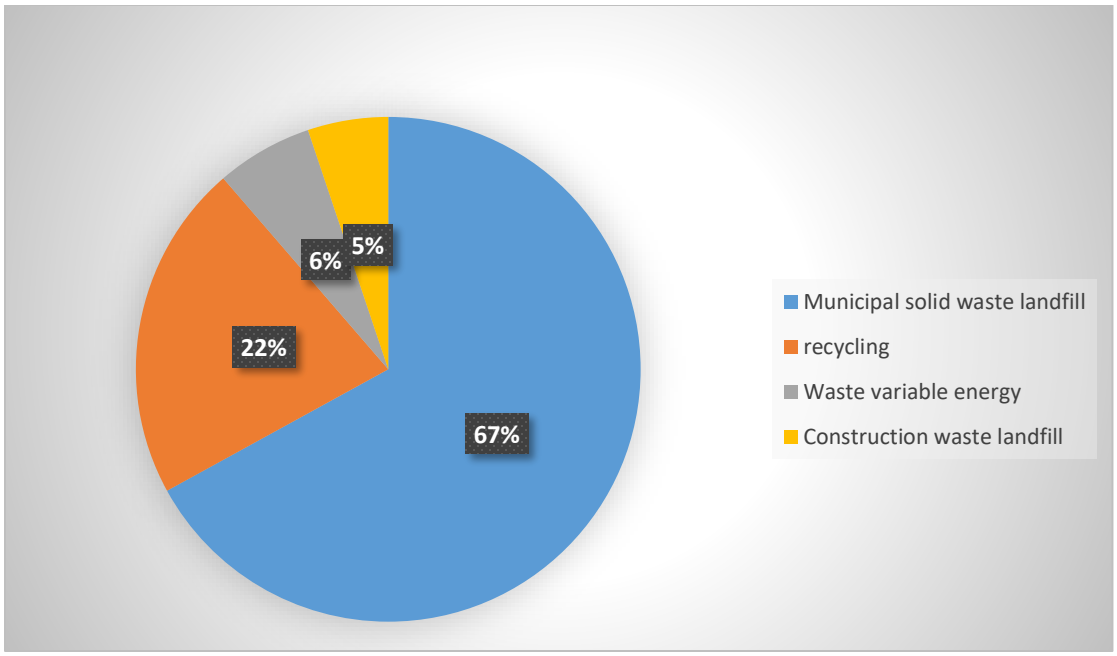


Figure 5.8. Proportion of waste disposal ways in the solid waste industry (Adapted from Environmental Protection Agency.)

The solid waste department owns 206300 of motor vehicles and machines. Private companies have the largest equipment share (81%). Among them, the listed private companies' possession accounts for 32% of the total, and that of the unlisted private firms takes up 49%. And the public sector owns 19%. About 72% of the motor vehicles and equipment are used for collecting, which means there are 148536 vehicles are engaged in the collection and transportation of solid waste. 26819 of them are bulldozers and load car, accounting for 13%. Another proportion of 11%, which is 20630 in number, are landfill compacting and packing machine. And the remaining 10315 are processing equipment, such as crusher and grinding mill, covering 5% of the total. Please see Figure 5.9

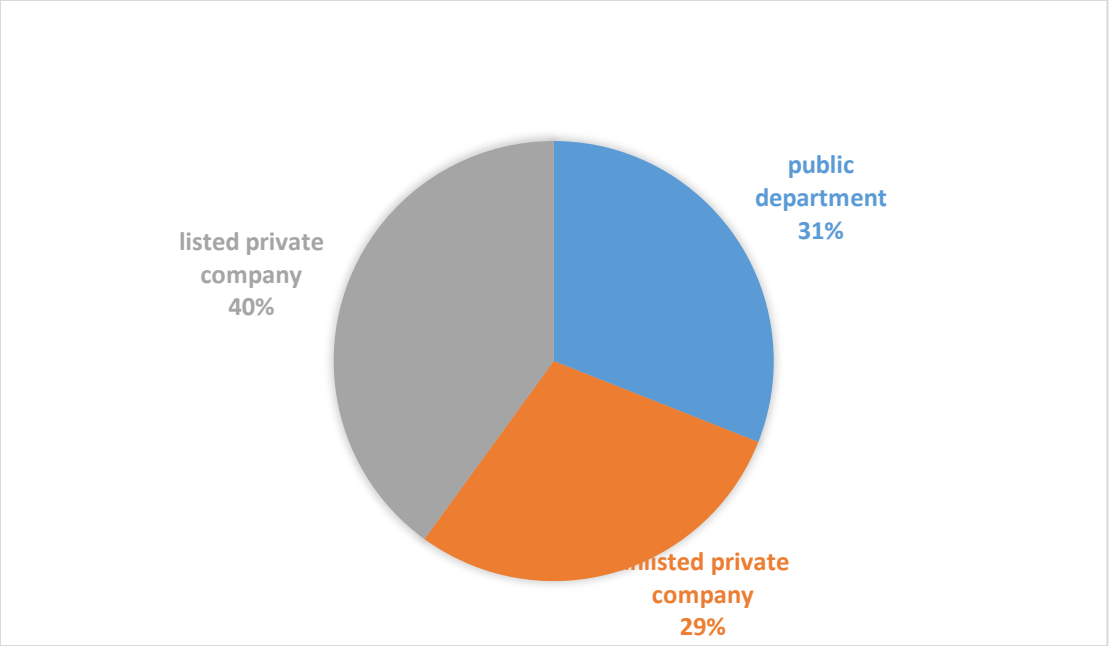


Figure 5.9. Owning vehicles and machinery in solid waste industry (Adapted from Environmental Protection Agency)

The solid waste industry plays a very important role in USA economy, and it causes both direct and indirect effect. Direct effect includes sales, employment and income and the indirect one refers to additional economic demand and value created by waste treating or other necessary equipment purchasing and increased purchasing demands resulting from job opportunities provided by waste industry in society.

The solid waste industry's annual sales totaled $43.3 billion and provided its employees with $10 billion of income. What's more, considering both of its direct effect and indirect effect, the industry created 948000 jobs for USA economy, provided employees with salary of $29 billion and achieved annual sales of $96.5 billion.

In general, the solid waste industry generated $14.1 billion of direct and indirect taxes for the federal government and state and local governments. Among them, paid the tax payment of $8.9 billion dollars to the federal government, paid the tax to the state and local governments of 5.2

billion. With its annual production taking up about 0.5% of the total amount of domestic production, the solid waste industry occupies an important place in the national economy, and plays a key role in social and public service sector in USA Due to its various types of waste disposal and treatment enterprises, solid waste industry provided millions of jobs for USA labor market. Also through buying tens of thousands of sets of big motor vehicles, machines and equipment, it successfully stimulated the development of American industry, and paid a substantial amount of tax revenue to the federal, state and local governments.

5.12.5. USA environmental protection investment and financing policy

Since the late 1960s, environmental protection has become the focus of the public and the government in USA. Relying on the mature market mechanism, the developed capital market, strong economic foundation and perfect environmental management laws and regulations, USA established a relatively complete and efficient system of environmental protection investment and financing policy. Historically, in the process of industrialization in USA, a series of environmental pollution issues arose. USA environmental protection work turned each concentrated outbreak of environmental problems into milestones of their development. Along with a series of environmental protection movement and serious environmental events, USA environmental protection investment and financing has largely drawn the public's attention for several times, although the movements' scale and influence were differentiated (Zhou and An, 1997; Environmental Science, 2017).

In 60s and 70s of the 20th century, water pollution grew very serious, because in addition to the long existing destruction of water environment caused by industrial sector, a lot of new emissions of toxic substances occurred and elevated the extent of water pollution of the environment. During

this period, the federal environmental protection spent more than a half of its fiscal support on sewage treatment facilities, issued the amendment to the *Federal Water Pollution Control Act* and further improved environmental tax policy, emission trading policy and a series of environmental protection investment and financing policy (EPA 2017a).

The motivation of USA to establish the system of the *Clean Air Act* originates from two environmental pollution incidents: one is 1943 Los Angeles smog, another is the Donora incident in 1948, which were caused by serious air pollution. Afterwards, a 1977 Amendment and 1990 Amendment were published followed by several revisions, and as a result of these gradual improvements, established in the *Clean Air Act Amendment* (1990) air pollution rights trading. Superfund program (*Comprehensive Environmental Response, Compensation and Liability Act of 1980*) was proposed to deal with the situation in the late 20th century when a large number of enterprises left sites contaminated to different degrees, known as "brownfield land". It was initiated in order to improve the management of hazardous materials leakage and cost burden (2017b).

1987 Clean Water State Revolving Fund was designed to deal with rural source pollution. All of the money is provided as a cheap, or interest-free loan to support important waste water treatment and environmental protection projects, and then to ensure the security of state drinking water, Drinking Water State Revolving Fund was established to help states to build special fund to support the improvement of the public water supply system.

The *Energy Policy Act of 2005* marked the formal establishment of a long-term energy policy towards the 21st century. With the purpose of energy saving and environmental protection, the provisions of the Act provide about $14 billion dollars as tax breaks on issues like electric car production and clean coal technology. The government again enacted *American Clean Energy and*

Security Act of 2009, whose essential goal is to limit carbon emissions. Every year the government would allocate 1 billion dollars to scientific research on carbon capture of power generation through coal combustion and equipment modification (EPA 2017c; EPA, 2016f).

5.12.6. The USA environmental protection investment and financing scale

Total amount of capital invested in USA pollution reduction and environment protection is considerable and there is a growing momentum. This is determined by USA economic strength and the public's environmental awareness. Referring to the sum of money USA cost annually in pollution control during 2000-2016 (including direct capital investment and operating cost), we can find that environmental protection investment in USA is climbing, typified by the fact that the environmental protection investment in 2016 is 5.7 times more than that in 2000, and the ratio of environmental protection investment to GDP increased to 2.6% (Environmental Science, 2017),

5.12.7. USA environmental protection investment and financing channels

USA has established a relatively perfect environmental protection investment and financing system. In terms of the financing channels, they are mainly divided into the government public financial support and market channels (Grossman and Krueger, 1995).

5.12.8. The public financial support - Federal and state financial support

It mainly refers to that the federal government handle the shortage of environmental protection through the establishment of Superfund or resembling programs that could offer environmental protection projects financial help. In sewage treatment, for example, USA established a Clean Water State Revolving Fund and its purpose was to make up for funding shortage of wastewater

treatment project. During 1987-2001, a total of 10900 clean water projects received $34.3 billion in low-interest loans from the Fund. In order to expand the amount of funds, out of 50 states which had set up the revolving fund, there were 34 that also issued "balanced bonds" (using 1 dollar as guarantee and getting 2 dollars in loan), and by this the Fund provided another 4.4 billion available dollars (Grossman and Krueger, 1995).

5.12.9. Issuing municipal bonds

In USA, the municipal bonds are securities issued by the state and local government or its authorized agencies. Such bonds are aimed at general or specific project financing. In terms of support for environmental protection development in USA, the great part of its capital source can be traced back to the issuance of municipal bonds to perform the task. Taking the water market in USA (including water supply, sewage pipe network and processing facilities) as an example, 85% of its constructive investment demand each year is addressed by municipal bond earnings (Gao, 2005).

5.12.10. Environmental tax

USA introduced the environmental tax policies to environmental protection causes in in the early 70s and 80s of the 20th century, including environmental taxes, tax reduction and total tax exemption. Environmental tax is in accordance with the principle that he who contaminates the environment should pay for it, and it covers levies on air pollution, water pollution, solid waste, agricultural pollution, noise pollution and energy consumption. In 1986, in order to realize comprehensive utilization of resources, the enterprise’s income tax was relieved by USA government. In 1991, 23 states implemented a rule that sale tax generated in buying recycling

equipment shall be exempted. In 2005, the *Energy Policy Act* was launched, which provided about $14 billion in tax breaks to the electric car production and clean coal technology. Within 10 years since 2010, USA will provide $14.6 billion in tax credits to energy companies as an incentive to encourage oil, natural gas, gas and electric power enterprises to conserve energy. Since 2010, the implementation of the production tax credit (PTC) and the investment tax credit (ITC) has had a positive influence on the development of the American solar industry. In addition, USA government implemented complete tax-free policy for municipal sewage treatment, solid waste treatment construction and investment of public utilities (Gao, 2005).

5.12.11. Environmental costs

Citizens shall also pay for environmental protection, including sewage treatment cost, cost of automobile exhaust purification, household wastewater disposal and municipal sewage pipe connection fees as well as building costs of household septic tank (Gao, 2005).

5.12.12. Market financing - Emission permits trading

It is common to trade emission permits USA and the market is actually quite active. USA emissions trading includes three modes, namely emission reduction credit model, total distribution pattern and the discontinuous cutting mode. Emission cut credit, generally speaking is that pollution sources take voluntary measures to make its emission pollution lower than allowed amount. Total distribution pattern: it refers to the government allocating limited pollution rights to polluters by some programs. Emission reduction credit model was initially prevailing and then total distribution pattern from 1990s began to become the main trend of emissions trading. The two patterns were the practice of tradable permits throughout USA for more than 20 years, while discontinuous

emission cut model is the latest one. Emission trading is the real emission cuts. Discontinuous cutting pattern has just been carried out in recent years and it is basically the improvement of emission reduction credit model in flexibility (Chang and Wang, 2010).

5.12.13. Enterprise self-raised funds

Enterprise self-raised funds are money collected by enterprise itself through a series of financial activities, such as bank lending, enterprise bonds issuing, issuing stocks, and the trust financing. The reason for enterprises' awareness to raise funds for investment in environmental protection is that on the one hand, the enterprises expect to meet the needs of the development of society and times; on the other hand, they want to retain profit and need to maintain lasting competitiveness (CMR of Xiamen University, 2015).

5.12.14. Public-Private Partnership

Public-private partnership (PPP) includes privatization, contract, lease, new infrastructure project financing methods, as well as the field of development aid partnerships between the public sector and private sector. George's county, Maryland, USA is a typical example in USA that carried out the PPP mode in water pollution control in 2011. After more than two years of unremitting efforts, it achieved spectacular improvement in water pollution situation. 30% - 40% of the new water infrastructure was funded by the private sector. Besides, nearly 80% of the money required for water pollution prevention also came from the private sector (World Bank Group, 2016b).

5.12.15. Environmental insurance

In recent years, many insurance companies have entered the environmental domain in USA, thus making a new kind of environmental insurance industry emerge at the historic moment. Currently, main environmental insurance business run by the insurance companies are mainly two types: one is targeted at the liability of general enterprises or institutions for environmental damage; the other is aimed at professional environmental protection needs companies may encounter such as consulting, design, engineering and other service. Environmental insurance is a jointly established cooperation platform between economic and environmental fields, for it has not only promoted the enterprise positive environmental input but also enabled the company to avoid possible economic losses due caused by legal environmental responsibility and ensured the normal economic operation (International Risk Management Institute, 2017).

5.13 Overall analysis and discussion

As the analysis shown in former chapter, we have completely dedicated the difference between China and USA. The overall comparison will be discussed for further research.

5.13.1 Expand the scale of environmental protection investment.

The scale of the environmental protection investment in a certain extent reflects a country's degree of emphasis to the environmental protection. environmental protection investment is an effective way to improve the environment quality. From the environmental investment table(Table5.14), 2004-2016 years, China’s environmental protection investment is absolute rising steadily, from 17.7 billion dollars in 2004 rose to 137.5 billion dollars in 2016, increased by 7.77 times. On the other hand, in USA, the GDP is 14510 billion dollars, environmental investment is 464.31 billion

dollars. The percentage of environmental investment in GDP is 3.2%, higher than 1.59% compared to China in same year. Therefore, in order to catch the increasing speed of USA, China must expand the scale of environmental protection investment.

Table 5.14 the scale of environmental protection investment in 2016 (Adapted from environmental Protection Agency)

Unit: billion dollars

Project	China	USA
GDP	8647.79	14510
EnvI	137.5	464.31
Env. Exp. Percentage of GDP	1.59%	3.2%

5.13.2. Reasonable distribution of the investment

According to the experience of USA, China should have a strict plan for the investment distribution. Learning from the present environmental status and the experience of USA, China should invest more in the research and development of environmental technologies such as promotion of environmental industry patents registration, and China also should develop clean energy in order to reduce pollution from the source and improve the treatment efficiency and the emission generation.

Chapter 6: Conclusion and Recommendations

6.1. Conclusions

With the in-depth analysis of the current environmental investment and public health in China, as well as the comparison of public environmental situations between the P.R.C and USA, this paper can arrive at a number of conclusions and implications as follows.

(1) Increase output and growth rate of environmental investment

In 2015, operating income of environmental investment was about 3.98 trillion yuan, due to its growth rate, its output should be increasing 15%; therefore, in 2016, it could generate a sum of 4.5 trillion yuan, from which it was easy to see that environmental investment has become a new pillar industry of national economy. Furthermore, increasing output of environmental investment significantly impacts on public health, and it affects public health in a variety of ways. The interaction between public health and environmental investment has been extensively studied. As the output and growth rate of environmental investment increase, human health improves every year. The World Health Organization (WHO) has estimated that thirteen million deaths annually are attributable to environmental issues. Increasing output and growth rate of environmental investment will effectively decrease the death number, thus improving public health. In addition, the government presented various environmental policy could also accelerate the growth of investment in environmental protection, thus public health will be accelerated by decreasing number of death in various aspects.

(2) Further enhance the investment in environmental protection

China was in a period of rapid development of industrialization and urbanization when the change of economic growth pattern was more likely to cause historic environmental "default" and environmental situation was still grim, and public health was worsening every year. But fortunately, people's awareness had arisen; consequently the further investment in environmental protection industry and to achieve more goals of public health had become the most prominent feature of developing the environmental protection industry in China.

(3) Expand the overall size of environmental investment

According to research of environmental protection agency, in 2014, the national environmental protection industry had 25710 units with 3.28 million employees, which had an annual operating income of 3981 billion yuan and an operating profit of 277.72 billion yuan per year. Nonetheless, in order to increase the investment in environmental protection, the scale of the public health must be significantly enlarged on a full scale.

(4) Increase the proportion of environmental investment in GDP

China's environmental protection investment to GDP ratio had been relatively stable with slight growth, but it usually appeared fluctuating. According to the result of researches conducted by some international organizations and economic experts, when a country's environmental protection investment accounted for 1% ~ 2% of its GDP, it could generally control the deterioration of public health; to achieve robust improvement of environmental quality, the country need to make sure 3% ~ 5% of its GDP had been spent on environmental protection investment. At the same time, public health will meet the standard of developed country. Considering the

current situations of countries all over the world, developed countries often utilized 2% ~ 3% of their GDP in environmental protection. China's environmental protection investment in 2000 just covered 1% of her GDP, which was a tiny share of it, and was still insufficient. That means China at present had not yet met the standards of environmental investment, showing public health is still poor in China. Public health still sees a large room of improving to the standards of ameliorating the state of the environment. Therefore, in the future ten years, China should increase the proportion of environmental investment in GDP by 1%, to reach the average standards of developed countries. Thus it can meet the standard of good public health in foreseeable future.

(5) Increase the proportion of environmental investment in fiscal expenditure

Although the absolute amount of environmental protection investment from 2000 to 2012 had increased by 7.77 times, its proportion accounting for fiscal expenditure had been stable, remaining at 6.5% ~ 8.5%. All levels of government budget for environmental protection was far behind that for other projects. Before the year of 2010, in the respect of the fiscal budget, environmental investment was not as a basic construction as culture and education, which were independent subjects, so the result of supervision and management of government budget in the field of environmental protection was remarkably different from that in other causes. And public health also did not get full support from the central government and local governments. Although since 2010 the environmental protection had been regarded as an independent subject of government budget, as fiscal budget at all levels had to be allocated to various projects, environmental protection still got a minimum share. This reflected that the public health correlating to environmental investment did not draw enough attention of government departments, and also failed to be top priority of the current government investment.

(6) Optimize the use of environmental protection investment

Environmental protection investment was a public externality, and investment in all directions of this field needs balancing. Over the years, the increasing speed of management investment in industrial pollution source and its ratio to general environmental investment were much lower than those of urban environmental infrastructure and construction projects. At the same time, public health needs to be enhanced in urban city. It was one of the important concerns over environmental governance. The focus of environmental protection investment needs adjusting and so does public health.

It was advised that the direction of environmental protection funds should tilt to the governance of industrial pollution, especially that caused by heavy industry, and meanwhile, normal operation of environment protection facilities be strengthened and ensured. In addition, to implement clean technology and promote the enterprise in aspects of product development, raw material selection, process design, technique progress, production management and the industrial pollution was also conducive to eliminating environmental pollution before and during the production.

(7) Perfect laws and regulations on the environmental protection system.

It was helpful to establish and perfect, on the basis of *Environmental Protection Law of the People's Republic of China* and *Law on Prevention and Control of Atmospheric Pollution*, legislation of public green consumption of tradable permits and that related to environmental protection investment and financing. At the same time, it was also necessary to train a large number of qualified personnel to realize the smooth progress of environmental protection investment.

(8) Establish environmental expenditure accounts

Establishing environmental expenditure accounts would elevate the importance of environmental protection to the same level of education and technology and strengthen the accounting of environmental protection investment and public health. Environmental protection expenditure accounts could cover money spent in a range of pollution control, environmental monitoring and environmental evaluation and public health. Over and above, it could also make the use of environmental funds more transparent so that unreasonable use and embezzlement could be avoided.

(9) Improve the technical strength of the environmental protection facilities.

The industry could improve the technological strength of the environmental protection facilities by increasing input in the environmental protection technology and equipment upgrade. It would be beneficial to speed up the environmental technology research and development process of public health, especially increased the input of new material capital investment. Besides, to carry out new equipment inspection, promotion of the project and active development of the core technology of pollution prevention are also necessary. Finally, much importance should be attached to professional and technical personnel cultivation and new equipment innovation.

6.2. Implication and future research

By the analysis of different impacts of China's public environmental investment on public health and that of USA, this dissertation provides how much total amount of environmental investment should be achieved，and give following recommendations:

(1) Increase the output and growth rate of industry to accelerate the growth of investment in environmental protection industry.

(2) To achieve more goals of environmental protection by investing more in environmental protection industry

(3) Overall scale of the industry must be expanded to acquire more investment input.

(4) China ought to increase the proportion of environmental investment in GDP by 1% in future ten years.

(5) Environmental problems should draw enough attention of government departments and make it to be most important government investing subject.

(6) The direction of environmental protection funds will tilt to the governance of industrial pollution.

(7) Train a large number of qualified personnel for environmental protection industry.

(8) Establish environmental expenditure accounts.

(9) The government should increase input in the environmental protection technology and equipment upgrade.

Further research could be done based on comparison of investment in various countries, such as India, Australia, Japan, Singapore, and Canada, namely to compare the environmental investment in both developing and developed countries. Investment in environmental protection differs in the developing country and the developed ones, and each of them has a particular situation of public health as well. In this essay, only two countries are compared. In the future study, the number of countries to be compared with each other can be increased to 5, all of which have different levels of public health and situations of investment. Therefore, there are numerous chances to study and research into each country's situation.

The environmental investment financing channel and investment benefits were also not discussed in this study. Same as environmental investment and public health, the environmental investment financing and investment benefits are two correlated aspects, on which future studies can focus to reveal the relationship between them. Furthermore, the two are related to GDP, so future studies can use GDP to be an interaction between them.

In addition, whether the environmental investment should be increased or not is another problem that warrants further research works. This study concentrates on the correlation between investment and public health, leaving out the detailed discussion on the justification of increasing environmental investment. Therefore, in the future, studies can be conducted on whether or not environmental investment should be raised.

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