The research of long-term haze pollution in Shanghai, China
--Analysis, Plans and Scenarios

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Abstract

With the rapid development of the social economy, the industrialization and urbanization process is accelerating, and the harm of serious environmental pollution has become increasingly evident. Among them, the atmosphere as the essential factor for human survival, has been a threat to survive and healthy of humans and other organisms. And the pollution sources have the diversity and specificity. This paper analyzes the causes of the formation of Shanghai haze pollution, as well as the characteristics and sources of major PM2.5 components. According to the analysis, point out that the adverse weather conditions is the culprit for the formation of haze pollution, and air pollutants are the accomplices. Base on the specific nature of pollution sources and regional particularity, to develop a strategic plan for Shanghai haze governance.

To optimize and maintain the urban environment, it requires the city government to develop scientific plans for the controlling of economy and key sources of pollution. Urban residents also need to consciously participate into the environmental protection work, advocating green and low-carbon life, and friendly living and travel habits. Overall, the Shanghai government should make a good job in green environmental protection from the details.
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1 Introduction

1.1 Background of the issue

With the rapid rise of economic development and population, the process of urbanization is accelerating in China. The process of urbanism is accompanied with a series of environmental problems. That is especially serious in the Yangtze River Delta and the coastal industrial regions. Among the most prominent environmental problems is haze from airborne SO$_2$, NO$_X$ and inhalable particle. This haze phenomenon reduces the visibility in large-scale area of the city, and it also expected to lead to more incidences of asthma and pneumonia, and even lung cancer (Tang, 2013). In recent years, with the increase of the haze, experts included haze and fog weather as severe weather warning forecast. The pollution of fog and haze in Shanghai has become increasingly serious in the last 10 years (Gao, 2012). Until now, fog-haze weathers are still a threat to most of the big cities in China. As the air quality monitoring data showed, the Air Quality Index (AQI) reached extreme values of 500 µg/m$^3$regionally (e.g. Dingling, Badaling, Miyun Reservoir). This is the highest level in Level-Six pollution (Chen, 2013).

![Figure 1 Haze pollution in different regions of Shanghai](image)

The present haze problems in China reminds to the 19th century when Britain entered a period of rapid industrial development. The exhaust gases from the many factories in London formed a very thick grayish yellow smoke. Particularly in the 1950s, this annually caused around 50 "Misty Days" (a day sight of less than 1000 meters). From December the 5$^{th}$ to 9$^{th}$ (Xu, 2013), due to a variety of coal combustion and pollutant gases accumulated over London, fog enveloped the city for four consecutive days. Due to the low visibility, the transportation
system was almost paralyzed. The haze continued to December 10th, and then gradually dispersed (Xu, 2013). Since that, the British began to reflect on the hazardous consequence of the air pollution, and established the world’s first air pollution control bill, i.e. the Clean Air Act (Zhou, 2013). Furthermore, the British government implemented a series of air pollution prevention and control acts, which included strict constraints for gas emissions and clear penalty measures to effectively reduce soot and particulate matter. After half a century of efforts to control air pollution, eventually, the British successfully took off the title “the city of fog”.

It seemed Britain government curb the extreme haze pollution in a relative short time, and efficiently deals with the pollution during the industry development period. Faced to long-term haze pollution in Shanghai, the Chinese state and the government have spent a lot of human and financial resources to control and management. Unfortunately there are no apparent effects yet (Gao, 2014). Many experts have made research studies of the haze issue, they all used different methods and techniques to measure the aerosol characteristics of the different regions in China, as well as fog and haze pollution. Some main pollution sources of haze pollution were also proposed depending on different regions (Hanqing, 2013). In the report of Tao & Xiaolong (2012), according to the development characteristics of Beijing, they proposed appropriate governance plans, and pointed out some shortcomings in the process of the measures implementation, as well as the future direction of government work.

### 1.2 Objectives and research questions

The objective of this research project is to find out efficient measures for curbing the spread of haze pollution in Shanghai. More specifically, this project aims to make an overview of the haze weather characteristics in different regions, like London, Los Angeles and Beijing, as well as the different causes and pollution sources, as well as the main control measures that government implemented. The control measures will be compared with the strategies adopted by London, Los Angeles and Beijing. This will enable to learn from the experience of these three case studies, and to discuss and identify future governance directions and strategies for the Shanghai current situation. In order to achieve the objective, there are three main parts in this project:

1) **Analysis of the long-term haze weather in Shanghai**
   - What are the main characteristics of the aerosols of the Shanghai haze pollution (physical properties, chemical properties, optical Properties)?
Is there variation in the major components of the haze pollution between different regions?

What are the main sources of pollution according to the main pollutant (man-made or natural phenomenon)?

2) Review and analysis the haze pollution situation in three different case studies (London, Los Angeles and Beijing)

- What are the main sources of haze pollution?
- What are the significant features of the pollution?
- What measures did the government take to control pollution at different period?
- In the process of governance, whether encountered any obstacles? And how to deal with?

3) Appropriate governance and control measures for haze pollution in Shanghai

- In what ways, i.e. in terms of strategies and scenarios, can the government curb the proliferation of haze pollution? (Two aspects: controlling & management)
- How does the government (or environmental department) make assessment to evaluate the efficiency of these measures and policies?

2 Research methods and means

This chapter will illustrate the methodological and practical approaches that are used in the thesis to resolve the research questions and carry out the work. Overall, the report will analyze the trend of pollution with existing data and cases for the Shanghai and other regions, as well as the analysis of current pollution situation in Shanghai, and give the reasons why we should develop strategic scenarios to combat the pollution in Shanghai urgently, and how can we achieve that.

2.1 Current haze pollution situation in Shanghai

First, Internet sources and literature will be used to understand what are the haze pollution, as well as the main pollutants in haze weather. In this step, I primarily distinguish between haze pollution and other air pollution, as well as its severity. To carry out this work, scientific papers in Chinese and English only
After understanding the general information of haze pollution, chapter 3 will focus on the analysis of the current haze pollution situation in Shanghai. The website of Weather China is consulted to understand the specific atmospheric circumstances of Shanghai haze pollution. The PM 2.5 monitoring website is used to map the haze pollution levels in different areas of Shanghai, to identify the major components of the haze pollution in different regions, and find the main source of pollution. Where possible, the governmental documents will help to define the future targets. Based on these available information and questions, then the case studies analysis and research will be performed in chapter 4.

2.2 Case studies and the table analysis

Chapter 4 analyses three case studies that concentrate on the Metropolises: London, Los Angeles and Beijing, which will focus on a number of following aspects. Then the case analyses will be concluded the different measures of controlling the haze pollution in the three metropolises, and help to develop the new strategies for Shanghai’s haze. The analysis will focus on following aspects:

- Timing and duration of the period
- Significant pollutants and pollution sources (Man-made or natural)
- Measures for managing and control the pollution (legislation, industry reform, mobility transform, public awareness, urban layout redesign, etc.)
- The effect of governance measure
- Improvement and development

The content of each aspect will be identified in an iterative way for each case. The information would be selected by each case when analyzed category of factor in order to find the available and suitable governance measures for the haze pollution in Shanghai.

The case studies relate to different periods in history, and the report will discuss the causes of haze pollution in different periods. Just like the London and Los Angeles haze mainly happened in the period of industrial development, due to the fast speed of industrial development, more and more people ignored the importance of the environment. However, the economic and industrial developments in contemporary Shanghai are relatively mature. At that time, London and Los Angeles more effectively found out the measures to control haze, and got significant results, but although the Shanghai spent a lot of human and
financial resources, sometimes it does not work effective. Why are there still so serious haze problems. The case of Beijing here is a good example to present the current measures of haze controlling in China. As Beijing is the “haze Capital” in China, even though it is still an urgent problem, but it will give a lot of inspiration here.

The results for the three cases will be summarized in one table that presented a framework to identify different factors (actors, sources, possible measures etc.). The table analysis would be developed by the discussion of case studies, and the structure of the table will be performed in the end of them.

2.3 Application of the table analysis For Shanghai haze pollution

In order to formulate suitable governance strategies for the haze pollution in Shanghai, the table analysis will be used to develop the haze control plans and scenarios for Shanghai haze pollution. However, the result of the table analysis would not be imitated totally. The report will combine with the specific circumstances of the Shanghai region to establish the urban development policy governance that suitable for Shanghai. For instance, rapid urbanization, urban spatial planning, the urban capacity evaluation index system of the atmosphere, energy revolution, etc. The report will also compare with the measures that Shanghai government takes for the haze pollution before, and find out the similarities and differences to the other three case studies.

Due to the difference in the regional situation and national conditions, the table analysis will probably be difficult to fill in completely, as well as the application in the specific case, Shanghai. But it is the most important part in the report, and more detailed descriptions and content would be performed in the corresponding chapters of the report.
3 Background of haze pollution in Shanghai

In the beginning of December 2013, Shanghai suffered from sustained severe air pollution, and the index of PM2.5 were continuously exceeded (Tencent Info, 2013). The haze pollution in Shanghai is mainly due to the accumulation of pollutants transported from the north (Chen, 2013). A report of Professor Chen Jianmin research group in Fudan University points out that the main pollutants are polycyclic aromatic hydrocarbon, and the haze levels of pollutants after the raining are 500 times higher than usual (Chen, 2013).

![Haze pollution in Huangpu River, Shanghai](image)

The following table is the air quality report of Shanghai in December 2013. AQI is the short for the air quality index, which is a relatively popular way to represent the pros and cons of air quality. The air quality in accordance with the Air Quality Index is divided into six levels, corresponding to the six categories of air quality index, the larger the index, the higher the level of the contamination, and the greater hazard to human health. AQI is divided into six categories, respectively excellent, good, slightly polluted, moderate pollution, severe pollution and serious pollution. AQI's air quality status uses different colors to represent the classification of pollution, which is more intuitive.
Table 1 Shanghai Air Quality Index (AQI) in December 2013 ($\mu g/m^3$)

<table>
<thead>
<tr>
<th>Dates</th>
<th>Air Quality Index (AQI)</th>
<th>Contamination level</th>
<th>Rank</th>
<th>PM 2.5 $\mu g/m^3$</th>
<th>PM 10 $\mu g/m^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>197</td>
<td></td>
<td>107</td>
<td>218</td>
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<td>157</td>
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<td>149</td>
<td>112</td>
<td>142</td>
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</tbody>
</table>

As can be seen from the above table, Shanghai in December 2013, more than half time of the month, the AQI had reached a moderately polluted, or even more seriously. The most serious pollution when PM2.5 and PM10 concentration even reached 461μg/m³ and 475μg/m³ respectively.

In general, the weather of fog and haze is a situation of atmospheric pollution. Haze is generally understood as excessive levels of suspended particulate matter in polluted air (Peng, 2013). The condition of haze generation is in the low humidity, and closed to saturated air, the structure of atmosphere is stable. The air does not generate convection, as well not spread to the surrounding. The presence of the cooling conditions is also a necessary factor (Zhang, 2013). Due to the stable weather situation, the air pollutants are not easily spread outward in the horizontal and vertical directions, resulting in atmospheric pollutants accumulation near the surface, and getting more seriously, which is the most important reason for leading a wide range of haze weather in China.(Zhang, 2013)

The major pollutants and pollution sources are classified and conclusion in the Figure 2. The haze is mainly composed by sulfur dioxide (SO₂), nitrogen oxides (NOₓ) and particulate matter (PM), which combined with fog and instantly make the sky gloomy and gray. More specific, the contaminants of haze can be divided into primary and secondary pollutants. The primary pollutants are discharged directly from the pollution sources and fossil fuels. Secondary pollutants are some particulate contaminants (i.e. NO₃-, SO₄²-, NH⁺) that converted from the primary pollutants in exception weather conditions, thereby aggravating haze pollution (Peng, 2013). According to the latest data analysis, the main sources of haze pollution in Shanghai accounted for 59% from industrial and transportation (including industrial emission, transportation, boilers and furnaces emission and power plants, etc.) (Yu, 2014)
Table 2 Major pollutants and pollution sources (Peng, 2013)

<table>
<thead>
<tr>
<th>Pollutants</th>
<th>CO</th>
<th>NO₂</th>
<th>SO₂</th>
<th>NO₃⁻</th>
<th>SO₄²⁻</th>
<th>NH⁺</th>
<th>OM</th>
<th>EC</th>
<th>Dust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle exhaust</td>
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<td>Fossil fuels</td>
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<td>Coal fired</td>
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<td>Restaurant emission</td>
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<td>Architecture</td>
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<td>Power plants</td>
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</table>

The air pollution is mainly caused by two factors: First, the meteorological conditions; Second, pollution sources (Du, 2013). The generation of haze in the air is mainly due to the presence of dust, sulfuric acid, organic hydrocarbons and other small haze particles in the atmosphere (Zhang, 2013). The haze pollution usually originates from a mixture of sources, such as car exhaust, industrial emissions, construction dust, waste incineration, and even volcanic eruptions, etc. From the perspective of emission sources, the prevention and control efforts in pollution is increasing in Shanghai, as well the emissions sources are reduced (Gao, 2012). However, there is still so heavy pollution. The main reason is that emissions still exist, in an extreme adverse weather conditions, and it will accumulate to form a more serious pollution (Gao, 2012). Shanghai is a really huge city, with a lot of pollution sources. For instance, thermal power generation, ship emissions, construction site dust, and the vehicle exhaust emissions every day are the most direct sources of serious air pollution. The particulate matter in the polluting gases can easily be trapped water molecules when the weather is wet, then condensed into toxic fog and haze weather (Zhou, 1981). Admittedly the haze in winter and spring is the result that high winds blowing north frozen soil then transferred to the Shanghai region (Zhou, 1987). That is the impact of dust storms on the north to Shanghai. And now the spring haze is mostly caused by human activity. Currently, in the spring and summer, city buildings block the airflow diffusion, as well as the great relative humidity great and urban pollution, the increasing tiny suspended particles result into the ripe conditions of haze formation (Zhou, 1987). Therefore, the haze pollution is getting worse recently. The summer haze is more terrible than the winter haze. In fact, the human factor
of haze formation is larger than the natural, the summer haze is impossible to destroy, but can be reduced (Hu, 2014). The major measure is to control emissions of polluting gases, and reducing the value of particulate matter.

Another main reason of the pollution phenomenon due to residents’ lifestyle from the local, of course, does not exclude the meteorological conditions. Based on local emission sources, which account for a large proportion of motor vehicle exhaust. There are a large number of private car owner in Shanghai, the data shows that the Shanghai’s car ownership had reached 2.8 million in the end of 2013 (Jian, 2013). Living in this fast-paced city, do not allow people to have the slightest hesitation. Therefore, the people of Shanghai are very seriously to the concept of time. Private car has become a necessity of people’s fast-paced life. Faced the trend of gradually increasing private cars, the government is getting more difficult to manage the environment.

Shanghai as an international metropolis with a high population density, and the economy is also very developed. However, with the economic development and increasing richer lives of people, we should also realize the environmental threats faced to the people of Shanghai. In China, the industrial development of Shanghai is among the top of all cities. As the data shows, until the end of 2013, the total resident population of the Shanghai had reached 2,415.15 million, faced an increase of 34.72 million over the last year (Xu, 2013). The Gross Domestic Product (GDP) reached 21602.12 million, and more than 7.7% over the previous year². With the Air Quality Index as the evaluation criteria, the Shanghai air quality days in 2013 were 241 days, and the excellent rate was only accounted for 66.0% (Liu, 2014). In the process of industrial development, the accompanied negative influence for environment should not to be underestimated. This is a top issue that has plagued the Chinese government for a long time. How to ease the current situation of haze pollution, and reduce the harm to people lives, is an urgent problem now.

4 Analysis of three metropolises

In the global development history, haze pollution has never been a new word. While blindly peruse of rapid economic development, the government would ignore the environmental impacts, and result in serious environmental pollution phenomenon (Zhang, 2014). In this chapter, three cases studies will be chosen and analyzed about their governance and management process in haze pollution.

4.1 The fog city of London

The current experience of haze pollution in Shanghai makes us very reminiscent of the previous fog city, London. Although the pollutants and pollution sources are different, but the British experience tells us, there is not impossible to control haze. Britain was the first country to carry out the industrial revolution, and the industrial revolution also brought to Britain the most advanced productive forces and creating unprecedented economic prosperity. At the same time, the unexpected environmental disasters also occurred immediately in the 1950s century, which called “London haze events”.

Figure 4 A London policeman was on duty that wearing anti-haze mask in 1962 (Cheng, 2013)

As the British industrial revolution began in the late 18th century, coals had been widely utilized in the United Kingdom. Coals provided sufficient energy and power to London, Manchester, Liverpool and other cities. But those dense
chimneys constantly emitted thick and black smoke that seriously polluting the British sky. In 19th century the industrial England was struggled with varied smoke, but the double maximum diurnal cycle in smoke was related to the regular lighting of fire for domestic heating (Harrison, 2009). As the data showed, the concentration of polycyclic aromatic hydrocarbons (PAH), the major pollutants of haze pollution, increased significantly in 1991 (Brown, 1996). Especially five major components (PH, F, P, BcPH and BNTH) accounted for 70% of total PAH Concentration (Brown, 1996). By the early 20th century, London was becoming a black and dark industrial capital. In December 1952, an unprecedented tragedy occurred in London. The winter in London was long-time and frigid. The local residents needed more coals for heating in winter. The high consumption of fired coals resulted in greatly increasing smoke in the air, and then combined with geographical and meteorological factors, the haze weather was gradually appeared. From December 5th, the city center was located in a high atmospheric pressure (Cheng, 2013). The gas emission, like carbon monoxide, sulfur dioxide, dust and other pollutants that generated by the coal combustion, accumulated over the city and formed yellow and black fog. The witness who experienced the haze period in London described this event, "the fog was everywhere, very pungent, dirty and dark, and the room was gray. In the evening, the fog was very thick, most of the cinemas had to stopped the show, because the audience cannot see the stage. The city traffic is basically paralyzed. The fog had slowed downfall modes of transport, the visibility became very poor, People not only considered how to go to work, but more important was how to back home " (Gu, 2013). This event was one of the famous pollution incidents in human history. According to statistics, in this time, there were total 4,703 people deaths in London, which more than 3,000-4,000 compared with the same period last year. Within the next two months, there were nearly 8,000 people deaths of respiratory diseases (Cheng, 2013).

This haze event brought to London painful memories, but also made the UK government deeply realize the urgency and determined to control the air pollution. The London haze pollution caused the central government and the community’s attention. After the incident, the government appointed a special committee to investigate the situation of victims. Since that, the government adopted a series of effective measures to cure the atmospheric pollution.

4.1.1 Strict regulation

Strict legislation was the main measure to control air pollution in the UK, and the
main subject was national legislation. Throughout the governance process, the British government strengthened legislation power, and enacted a variety of laws and regulations to lay the foundation for the controlling of air pollution.

As the early of 1863, the British Parliament passed the first "Environmental Law of Industrial Development "("Alkali Industry Act"), to control the gas emissions of alkali process. After eleven years later, the council enacted the second version--"alkali industry and chemical factories Law", developed a statutory maximum emissions of hydrogen chloride (Cheng, 2013).After the London haze event in1956, the British government had issued the world's first law of air pollution prevention--"Clean Air Act". In this new version, a large-scale transformation of the traditional stoves for urban residents were implemented, as well as the progressive realization of living natural gas, reducing coal consumption and taking central heating in winter. The government established smoke-free areas in the city and the urban areas were prohibited the use of fuel that generating smoke. Large power plants and industrial enterprises were forced to relocate to the suburbs (Zhou, 2013).The results had proved that the new act had laid the foundation for the successfully control of air pollution for London in the future.

In 1974, the London government had promulgated the "Air Pollution Control Act" (Zhou, 2013), regulated the rigid standards of sulfur content in the fuel industry. With these rigid policies, the sulfur dioxide emissions produced by burning coal had significantly reduced, and the air pollution obviously improved better. Moreover, the law provided a comprehensive and systematic controlling provision of air protection, land use, rivers management and noise reduction, etc. By 1975, the foggy days in London had reduced to only 15 days one year, and even in 1980 there were only 5 days (Zhou, 2013).At this time, London had already successfully removed the nickname of fog city.

In addition, there were other acts on the controlling of air pollution like “Public Health Law” “Radioactive Substances Act” “Automobile Use Terms” and varied energy laws (Cheng, 2013).The above decrees played important roles on the air pollution control and the protection of the urban environment. Based on the Strengthening of legislation, the British government paid special attention on strict law enforcement. For instance, the cost of illegal pollution of the environment was very high in UK (Cheng, 2013).If someone violated the relevant provisions of environmental law, they must bear the corresponding criminal responsibility and civil liability. The law enforcement departments would impose fines in accordance with the degree of illegal behaviors. If the public was not satisfied with the work of the environmental protection departments, they can also sue the relevant departments (Zhou, 2013).
At present, the Britain had formed social consensus of against haze. From the beginning of January 1993, the British force all new cars must install catalytic converters to reduce pollution emissions (Tang, 2013). In 1995, the British adopted the "Environmental Law" (Xu, 2013), required the development of a national strategy to control pollution, and established the target of reducing haze in the 2005, requiring the industrial sector, traffic management departments and local governments to work together to reduce emissions of carbon monoxide and other eight common pollutants. In December 2010, the Britain published the final version of the "National Air Quality Strategy" (Xu, 2013), that aimed to reduce emissions from transportation, residential, office and various development perspectives, and also emphasized to raise awareness of air quality issues. For the area of poor air quality, the government developed specific response plans for transformation of residential and office spaces to make it more energy-efficient.

4.1.2 Clean Air Technologies

After the London haze, the two weapons for improving air quality in the UK, one was the strict laws and regulations, and the other was the rapid development of clean air technologies. Almost all clean technology companies in Britain were searching and discovering various scientific ways to reduce haze pollution, and try to make the science and technology theories into products (Cheng, 2013). For instance, strengthened the technological transformation of the automotive industry, designed and produced the advanced and environment-friendly cars, thereby reducing the emission of pollutants from pollution sources. In terms of air pollution, the London government paid attentions to the participations of scientific research strength. Many national research institutes and universities were involved in research work (Cheng, 2013). For instance the Warren Springs Laboratory, according to the measurement results of more than 1,200 stations in Britain, estimated the content of soot and sulfur dioxide in the air, therefore proposed various measures and plans in different areas of air pollution control (Cheng, 2013). Some universities such as University of Wales, University of Sheffield, Leeds University, respectively made deep research for the vehicle exhaust, air quality standards, control pollutant emissions, as well as the design and installation of the chimney and other environmental products (Zhao, 2014).

In addition, the London government made a lot of effort to improve the energy structures. In 1950s, the relevant departments through the atmospheric pollution analysis, and found the main pollutants were from industrial and
domestic coals (Gu, 2013). Therefore, the government tried to change the energy structures from coal to natural gas and electricity, to set the priority of increasing the proportion of clean energy. To speed up the change in the fuel mix, the government adopted the subsidies to help residents switch to natural gas, and required all industries in urban and suburban areas that cannot use coal and industrial wood as fuels, exhaust gases should be processing with the physical and chemical methods before discharge (Gu, 2013). As a result of these measures, until 1965, the proportion of coal in the fuel mix fell 27%. In 1980, further reduced to 5%. In the other way, electricity and clean gaseous fuels accounted for 24.5%, and in 1980 increased to 51% (Cheng, 2013).

The London government had also came up with a lot of new tricks for anti-haze. For example, in the most seriously polluted road in London, the Mary LeBeau and Thames Street, they used a dust binder of constituting magnesium acetate and calcium acetate that can effectively absorb dust in the air. The data showed that the sorbent could reduce air pollution by 14% (Zhou, 2013).

Now, the green economy industry is one of the growth areas of the economy in Britain. According to the British government’s plan, by 2020, the renewable energy should account for 15% of the energy supply and 40% of electricity from green energy, including the green transformation of thermal power plants, as well as the development of wind power and other green energy (Shuang, 2013). The Government had also developed a plan to promote solar energy, and subsidies support for solar panels installations. As an island nation, the UK also made full use of offshore wind energy, and the capacity of the wind power plants had ranked on the top of the world (Shuang, 2013). Low-carbon energy has become fashionable in British social life. Some retail industries had built zero-carbon supermarkets, which producing energy by biomass generators and recycling rainwater in order to create a low-carbon shopping environment. (Shuang, 2013)

4.1.3 Restrict private vehicle traffic and develop the public transport

In the early 1980s, the amount of motor vehicles had reached 240,000 in London (Cheng, 2013). The traffic congestion was getting worse. In the meanwhile, due to the increasing number of cars, the emissions also increased the pollution of the atmosphere. Faced with this urgent situation, the London government had taken
a series of comprehensive management and effective measures to control the pollution.

First, the government introduced the transport development strategy for the transformation of traffic modes, which encouraged walking, cycling and other non-polluting ways to travel, in order to reduce the dependence on cars, as well as effectively reduce carbon dioxide emissions vehicle. In addition, the government established the bus lanes, set up the tree-lined trail network, and invested in the development of new energy-saving and pollution-free buses (Jin, 2013). The Government published the White Paper documents on traffic conditions, and announced the parking fee should be increased in order to limit the number of cars and release traffic jams in 2000 (Zhang, 2013).

In 2003, the government introduced the provisions of Congestion Charge to reduce the downtown traffic volume, thereby reduce exhaust gases (Atkinson, 2009). From 7:00 am to 6:30 pm on the weekday, those private cars entering into the city center within the range of about 20 square kilometers must pay 5 pounds of the "congestion charge" (Yu, 2012). The revenue would be entirely used to improve the public transport system in London. The charging area continued to expand, as well the current charges also increased to 8 pounds later (Yu, 2012). Until February 2008, the congestion charge for high emissions cars had risen to 25 pounds per day, and a monthly parking space rent up to over 650 pounds (Gu, 2013). With the policy of Congestion Charge, the private cars cannot afford the fee into the city center, which effective controlled urban traffic flow. The Congestion charge policy achieved great success, the number of vehicles entering the charging zone in London reduced about 60,000 every day, and emissions also reduced by 12% compared with the past (Gu, 2013). More and more people didn’t drive to work, instead of taking the bus and subway.

In addition, London had also established the first Low Emission Zone (LEZ) that almost covered the whole city (Yu, 2012). LEZs are the specific areas that vehicles do not meet a minimum standard for vehicle emissions are limited from entering, and are subject to high fines if they enter (Ellison, 2013). Through the traffic pollution charge system, reducing the emissions of diesel-powered commercial vehicles. LEZ policy limited excessive exhaust vehicles to enter the London city, to improve air quality in London. The charge time in LEZ was throughout the whole year, seven days a week, and 24 hours per day, including weekends and holidays (Yu, 2012). The Specific operating procedure was, when the cars entered a low-emission zone, the camera will automatically recognized the license number of the vehicle and checked the database. Once the vehicle license matched the database data of Transport for London (TfL), indicating that the vehicles met emissions standards, or fees had been paid enough, and vehicle
photograph would be automatically deleted (Yu, 2012). In the beginning, the vehicles with a gross vehicle weight of more than 12 tones entering in the LEZs must be required to meet a minimum of the Euro III standard. In July 2008, this policy was extended to freight vehicles more than 3.5 tones as well as buses and coaches more than 5 tones (Ellison, 2013). The owners of vehicles that violate the minimum standards of LEZs requirement need to pay a charge for each day they are in the LEZs. The charge is £100 for large vans or £200 for heavy vehicles (Ellison, 2013). The Figure 4 shows the major LEZs in central London areas.

![Map of London's Low Emission Zone](image)

In terms of the PM$_{10}$ that contributed by the traffic emission, the Britain government also established the Urban Scale Integrated Assessment Model (USIAM) to the exceedance of air quality objectives for fine particulate matter (Antonio, 2006). The USIAM was used to identify the different sources and locations of the pollutants, as well as the distribution of receptor location. In order to define source-receptor relationships for the calculation of the contribution of pollution sources to the concentration for each receptor (Antonio, 2006). This measure can be used to cover all sources of PM$_{10}$, and to search for different scenarios, investing the sensitivity to assumptions and uncertainties about different measures, including the integration of technological solutions and financial support (Antonio, 2006).

Traffic control not only played a key role for controlling haze London, but also
provided a guarantee for the future development of the green economy in London.

4.2 Los Angeles and the photochemical smog

As one of the major cities in the U.S. West Coast, many of the mining and manufacturing companies were gathered in Los Angeles in the early 20th century (Zhou, 2013). The rapid development of industries resulted in a large number of industrial smoke first appeared in Los Angeles in 1903, leading to local residents mistakenly thought solar eclipse occurred (Dong, 2013). From 1905 to 1912, the Los Angeles government had taken some measures to control smoke emissions (Dong, 2013). But with the outbreak of World War I and World War II, Los Angeles continued to strengthen the position as a heavy industrial base, as well as the rising number of cars, the U.S. government focused on manufacturing rather than city life improvement (Hou, 2014). The air quality in Los Angeles continued deterioration from 1939 to 1943. In July 26, the first time of photochemical pollution occurred in Los Angeles (Davidson, 1998). However, people didn’t know the cause of the smoke. Since then, the government began to attention to research the haze pollution. In 1947, the Los Angeles County Air Pollution Control District was formed to deal with the smog problem, which was caused by a combination of poor atmospheric ventilation, strong solar radiation, confining topography, and generally uncontrolled pollutant emissions (Davidson, 1998). And finally found the Los Angeles smog related to the sunlight catalytic, and pointed out that the sources of the smoke came from automobile exhaust and industrial emissions. With the efforts to the haze control, the urban pollution levels had significantly declined in the end of 20th century (Kinney & Özkaynak, 1991).

4.2.1 Regional Environmental Management System

In order to strengthen the comprehensive environmental management, the United States established a regional environmental management system. The U.S. Environmental Protection Agency (EPA) divided the nation into ten large geographical areas, and according to this division established ten regional offices (Zheng, 2013). These ten regions are modeled with geographical and socio-economic areas, and spliced different states together for the unified management. Therefore, the regional offices were able to flexibility cooperate
with other states for the pollution problems, and tried many new approaches to control the pollution (Zheng, 2013). Compared to the rigid administrative divisions, this cross-regional management mechanism was more scientific, as well overcoming the shortcomings of local protectionism. The environmental agencies were also gave the law enforcement right for the legislation formulation and penalties, etc. In the meantime, the EPA constantly improved governance technologies for coordinated work to make the enforcement greatly enhanced (Zheng, 2013).

In this regional environmental management system, the government still played a dominant role (Ding, 2010). As the most effective force of dealing with environmental problems, the government shared a wealth of information resources and appropriate facilities. But there were still many other pollution treatment sectors in fact. If blindly taking the multiple management, it would not only waste the administrative resources, but also cause the pollution treatment ineffective. Therefore, the L.A. government cooperated with the scientific research and medical departments, to develop research-based for the scientific policy of pollution prevention (Ding, 2010). The "South Coast Air Quality Management District" as a function branch of government departments, in addition to establish the administrative office systems, also set up specific offices of law, regional planning, construction and public affairs, etc. From the structure of office systems, the agency had the right to formulate and revise local air pollution laws and regulations, as well as a series of important powers like the clean air technologies. These rights made the local air pollution governance agency to become the most important leader and organizer, to give the support of organization and administrative agencies for improving the air quality. (Ding, 2010)

4.2.2 Legislation to establish air quality standards

In 1955, the United States established the first federal air pollution prevention law--"Air Pollution Control Law". After 1960, 1963, 1965 and 1967, the government continually introduced the "Air Pollution Control Law" "Clean Air Act" "Motor Vehicle air Pollution Control Law" and "Air Quality Act", respectively (Zheng, 2013). However, the above legislations had been not able to effectively control the U.S. air pollution, mainly due to the lack of effective management system. There was a big contradiction between federal and state government on the implementation of standards and legal issues. Therefore, the urgency of controlling air pollution ultimately led to the introduction of the "Clean Air Act" (CAA) in 1970(Zheng, 2013). The Act greatly strengthened the powers of the federal government, and played a key role in the subsequent environmental protection. The U.S. EPA included PM in the National Ambient Air Quality
Standards (NAAQS) as a criteria pollutant. And under the CAA, each state must develop a plan to describe how it will attain and maintain the NAAQS (S. Hasheminassab et al., 2014).

Actually the introduction of the Clean Air Act was not very easy. In 1967, the Congress firstly passed this act, and the main content was to extend the functions of the federal government in environmental protection, but did not develop the testing standards and enforcement measures in fact. Eventually, it was proved to be a failure act (Zhou, 2010). In 1970, the reversion of the Clean Air Act was published. The atmosphere pollutants in the new Clean Air Act were divided into two types basis air pollutants and harmful air pollutants, and firstly defined the composition of air pollutants (Zhou, 2010). The Congress also authorized the government to set up the U.S. Environmental Protection Agency to responsible for the implementing of the act. A series of bills and regulations constituted a relatively complete legal system, and the environmental protection work was also included in the legal system. According to the Clean Air Act, the EPA should periodically review air quality monitoring standards and timely make the review and summarize.

The U.S. Clean Air Act not only provided systems and plans for reducing air pollution emissions, but also set the safeguards for the effective implementation of the law (Ding, 2010). This included administrative safeguards, civil litigation and criminal safeguard measures. In terms of the administrative management, the applicable groups were the national administrative agencies, including the federal Environmental Protection Agency and state governments. The Clean Air Act also established citizen suit provisions. The plaintiff can be the citizen, local government or non-governmental organizations. That means anybody may bring an action for the individual or organizations, even government who violate environmental laws. The criminal safeguards refer to the serious environmental pollution behaviors that violated criminal law, the federal Environmental Protection Agency and the Justice Department could access to the courts, and request to investigate the illegal enterprises and criminally responsible (Xue, 2013).

In addition, the U.S. Clean Air Act paid great attention from the pollution sources in controlling air pollution. Apart from the above important principles and provisions, it also included special vehicle fuel management projects, the prevention of acid rain, stratospheric ozone layer management projects, etc. (Xue, 2013). From the data between 2002-2013 showed, the vehicular emissions were the second major contributor to PM2.5, with approximate 20% contribution to total mass (S. Hasheminassab et al., 2014). Therefore several federal, state, and local governments developed and implemented regulations on vehicular
emissions (S. Hasheminassab et al., 2014).

Overall, the implementation of the Clean Air Act was a milestone in American anti-haze history, which marking the controlling of L.A. haze achieved initial success.

### 4.2.3 Fiscal policy and tax support

The photochemical smog air pollution in Los Angeles events is one of the major events in the 20th century. This photochemical smog event promoted the introduction of the "Clean Air Act" in 1970, and then the criteria of PM2.5 was included in the American National Standards (Zheng, 2013). Through the efforts of the U.S. government, the air quality was improved markedly. The United States was a typical country with market economy, so the use of market-based instruments to solve the air pollution problem was its maximal characteristic (Zhao, 2013). Therefore, the U.S. government largely used financial and taxation methods to the governance of haze pollution.

The financial subsidy was one of the primary means of market regulation (Zhao, 2013). As the re-use of various exhausts was often large investment and less profitable, in order to encourage enterprises to engage the research and investment of recycling waste gas resources, the U.S. Environmental Protection Agency in 1978 began to provide financial subsidies for setting exhaust gas recycling system depend on different circumstances. The amount of subsidy amounted from 10% to 90% (Zhao, 2013). The U.S. state government required companies to give priority to buying products manufactured recycled materials to encourage recycling, and promote the development of environmental protection industry and recycling economy, new materials, in order to reduce emissions during the production process. The United States also set up special funds for the air pollution controlling, and provided preferential loans to promote rapid and healthy development of the industry. (Zhao, 2013) For the green facilities that can reduce environmental pollution, the government gave the adequate support of loans. Not only the loan interest rates below market rates, but also the repayment conditions were very favorable.

In addition to the financial subsidy, the U.S. tax system had been adjusted several times. Many types of air pollution charges were reformed to the standardized tax (Zhao, 2013).
• **Fresh material tax**

The purpose of this tax was to encourage people use less virgin materials, and promote more recycling in order to control the production of new materials at the source, and reduce air pollution and production resource waste.

• **Ecological tax**

Including the consumption tax for chemicals damage of the ozone layer, in order to reduce the use of Freon in the foam article; the gasoline tax was to encourage consumers to use energy-efficient vehicles, reduce vehicle emissions; the mining tariff was used for reducing oil production.

The Profit-driven development was always the first impetus in the United States strategic plans. The investment for the environment, the fundamental reason was because that’s not only a public investment, but also the new opportunity for private profit investment. The president Obama in orders to maintain its global economic position, and pushed the energy saving industry to the national strategy. In the “Economic Stimulus Plan in 2009” mentioned, within the total financial support of 787 billion dollars, the green investments for the alternative energy and other green economy reached 150 billion, and the investments areas included Infrastructure development, medical, public health and other investment projects (Zhao, 2013). The reductions of pollution emissions had become an important part of the development of ecological economy.

### 4.3 “Magic city” of Beijing

Beijing, as a famous large city all over the world, was also seriously threatened by the haze pollution in the 20th century. In addition, the huge population growth, as well as the pollution root caused by human activities in the city, and brought great challenge to the ability of air self-purification (Wu, 2013). In February 2012, the number of vehicles in Beijing had exceeded 500 million. According to statistics from environmental department, in the percentage of the pollution sources of haze in Beijing, the road dust and emissions caused by the motor vehicle accounted for 20%-30%, the coal and other industrial emissions accounted for 30%-40%(Wu, 2013). And with the relevant analysis, the mixture of water vapor and flue gas emissions caused by the winter heating boiler desulphurization facilities were another major cause of winter fog and haze.
In January 2013, the haze pollution was getting worse in Beijing. From the northeast to the middle part, there were a wide range of serious air pollution, and the widespread fog and haze triggered a series of "chain reaction", including traffic jam, flight delays, increased respiratory and other patients (Wu, 2013). With the economic development, the public environmental awareness raised apparently. The requirements of environmental quality had become more sophisticated. The large-scale of fog and haze persistent aroused the attention of air pollution and atmospheric environmental quality (Li, 2013).

4.3.1 Control vehicle emissions

For radical improvement in urban air quality, the government must make further efforts to reduce the emission of pollutants from sources. The largest impact in Beijing air quality was the local emission of the motor vehicle. Therefore, the control of motor vehicle pollution was the top priority.

1) Create basic conditions for the promotion of green travel

The Beijing Government promoted public bicycle service system and built the bicycle parking facilities surrounding the subway stations, transportation hub, and residential areas, to certain a large-scale public bicycle service system (Peng, 2013). At the same time, ensure the work of repair and maintenance of roads, to provide a good environment for walking, cycling road system, as well as other green trips.

2) Develop public transport and the use of new energy vehicles

In order to enhance the attraction of railway and buses, therefore the government speeded up the construction of public transport facilities, especially the parking facilities of railway and transportation hub, to continuously improve the proportion of public transport (Peng, 2013). The different environmental protection departments implemented relevant incentive policies to promote the use of electric, liquefied natural gas, hybrid and other new green energy vehicles in a variety of industries and government agencies (public transportation, sanitation, postal services, etc.), and to encourage individuals to purchase and use the new energy vehicles.

3) Speed up the elimination of old high-emission vehicles

The Beijing government developed and implemented update scenarios of old
cars. From January to November in 2012, the city departments scrapped 202,000 vehicles (Zhou, 2012). The Beijing government had also made unified arrangements by shortening the taxi retirement age and implementing more strict safety standards for motor vehicles, and developed the plans for eliminating 300,000 old high-emission vehicles in 2015, as well as 900,000 in 2020 (Peng, 2013). The Motor vehicle emissions management center carried out strict inspection for the vehicles on the road, and controlled the rampant utilization of motor vehicles with excessive emissions.

4.3.2 Optimize the industrial structure

In recent years, the Beijing government had taken many measures to adjust the industrial structure and promote industrial upgrading. A number of large energy companies had moved out of the center of Beijing. The power sources of winter heating equipment for local residents had been replaced from coals to gases significantly (Wu, 2013). In addition, the Beijing government continued to promote clean energy instead of coal-fired boilers and strengthen the regulation of industrial emissions and other soot pollution control, check out more than 50 coal-fired boiler flue gas emissions (Zhu, 2013). Moreover, strengthening the supervision of coal and boiler emissions was still the priority of the government work in optimizing the industrial structure, which continue to consolidate the updating work of "coal to electricity" and enhance the operation of law enforcement inspection to the small coal stove, open-air barbecue, opening burning and other illegal activities (Zhu, 2013).

4.3.3 Developed contingency plans for heavy pollution weather

To control the air pollution, the Beijing government adheres to tackling the problem. Under the present circumstances, which are not fundamentally reversed the situation of pollution reduction, strengthening emergency measures and contingency plans for heavy pollution days are particularly important. In January 2013, the Beijing government implemented the "Contingency plan in heavy air pollution days" (Peng, 2013), by starting emergency measures during the heavily polluted day that can partially offset the adverse effects of weather conditions. Generally divided into three levels: severe pollution days, serious pollution days and heavy pollution days. To prevent the pollution, the plans can take different measures according to the different pollution levels.
According to the results of the air quality forecast, the government would start yellow alert, orange alert and red alert depends on the pollution levels, as well taking appropriate pollution emergency measures, including health protection measures, the proposed pollution abatement measures and mandatory pollution reduction measures (Lu, 2013). The specific measures include:

1) When the air quality forecast is heavy pollution, the government promulgates health protection measures and proposals of reduce emissions. More specifically, the health protection measures include: reminding children, the elderly and someone suffering from heart disease to stop outdoor sports, shorten the time of outdoor activities. The emission reduction measures include: advocating the public transportation, increasing the frequency of road sweeping and cleaning and so on.

2) When the air quality forecast is serious pollution, in addition to publishing the implementation of health protection measures and emission reduction proposals, the government should also timely develop mandatory measures to reduce emissions. The mandatory reduction measures include: increasing the pollution monitoring frequency, reducing the size of excavation site, stopping building demolition, and increasing road sweeping. As well setting a target of 15% emission reduction for the major industrial.

3) When the air quality forecast is most heavy pollution, the government would implement more stringent health protection measures and mandatory measures for emissions reduction. The proposal of emission reduction add the strategies of the implementations of mitigation measures to reduce motor vehicle daytime running, and reduce the use of raw materials containing volatile organic compounds. The mandatory emission reduction measures primarily to stop operation of construction sites, and increase the emission reduction target to 30%, etc. (Peng, 2013).

According to the weather emergency plans, when there is heavy pollution haze weather, the Meteorological Bureau would provide meteorological monitoring and forecasting information to the City Emergency Management Office and related departments. The Environmental Protection Agency would cooperate with Municipal Meteorological Bureau through television, radio, Internet, newspapers, to publish the information of haze pollution level, in order to make local residents keep abreast of air quality status and trends, and enhance individual self-protection. In the meanwhile, the relevant departments should coordinate with each other immediately to take quick and concrete actions to deal with the haze pollution (Lu, 2013).
5 Strategic Plans for Shanghai haze pollution

For a long period past, when the Beijing, Tianjin and Hebei experienced the seriously haze pollution, Shanghai as an international city, was proud of the good quality air (He, 2013). Now, however, some researchers showed that Shanghai and the Yangtze River Delta region had exceeded Beijing and the Pearl River Delta cities, to become the worst hit of haze pollution in China (He, 2013). The Shanghai government also clearly realized the urgency of addressing air pollution. In October 2013, the Shanghai government had just issued the "Shanghai Clean Air Action Plan" to define the city's overall goal: until 2017, significantly reduce heavy pollution weather, and obviously improve air quality. The annual average concentrations of PM2.5 should decrease by 20% compared to 2012 (Gao, 2013). The following Table 3 makes a conclusion of haze governance measures of three metropolises, and through the analysis a new version of strategic plan will be presented in this chapter, to achieve the targets that made in Shanghai government documents.
Table 3 The comparisons of three big cities in the measure of controlling haze pollution

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<th>Los Angels</th>
<th>Beijing</th>
<th>Shanghai presently</th>
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</thead>
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<td>1940s</td>
<td>20th century</td>
<td>Now</td>
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<tr>
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<td>Carbon monoxide, nitrogen dioxide, hydrocarbons, etc.</td>
<td>Sulfur dioxide, nitrogen oxides, secondary inorganic, etc.</td>
<td>Sulfur dioxide, nitrogen oxides, dust, etc.</td>
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<tr>
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<td><em>Clean Air Act</em></td>
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<td>Energy</td>
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<tr>
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<td>Replace low-quality coal with high-quality low-sulfur coal</td>
<td></td>
</tr>
<tr>
<td>Low carbon economy and life</td>
<td>The rise of Green industry employment rate, Eco-Town, Zero carbon supermarket and community</td>
<td>Priority to purchase products using recycled materials, encourage recycling, reduce exhaust emissions</td>
<td>Reduce PM2.5 emissions in the restaurant industry, Ecological rural areas</td>
<td></td>
</tr>
<tr>
<td>Public participation</td>
<td>Freedom of Information Act, to disclose the air monitoring information and accept public supervision.</td>
<td>Public-private partnerships (PPP), to invest in low-carbon technology research and development</td>
<td>Environmental law enforcement supervision, to participation in the Environmental Impact Assessment (EIA)</td>
<td></td>
</tr>
<tr>
<td>Special plans</td>
<td>/</td>
<td>Contingency plans for heavy pollution weather</td>
<td>/</td>
<td></td>
</tr>
<tr>
<td>The result of haze management</td>
<td>Less than 10 days a year in fog, get rid the title of fog city</td>
<td>In 2007 the entire Los Angeles areas really achieved clean air standards, and</td>
<td>Achieved great success in the 2008 Beijing Olympics, but a rebound trend, still struggling</td>
<td>Still explore more efficient governance measures</td>
</tr>
</tbody>
</table>
5.1 Legislation to strictly control the spread of haze

Nowadays, the increasingly serious air pollution is affecting the human living environment more seriously, merely using a series of economic measures and technological innovation to control atmospheric pollution seems insufficient to eradicate the haze problem. The government must pay attention to legal means to combat through legislation. To management atmospheric pollution, the Chinese State Council issued the "People's Republic of China Constitution" and "People's Republic of China Environmental Protection Law", in order to make a unified environmental protection requirements, as well enact environmental protection laws which targeted at specific environmental factors (Li, 2013). In terms of atmospheric administration, the government formulated the "People's Republic of China Air Pollution Prevention Law" "Ambient Air Quality Standard" "Boiler air pollutants emission standards" and other environmental standards applicable ambient air quality assessment and management (Li, 2013). For long-term prevention and treatment of a wide range of current air pollution, the joint control prevention measures should be taken across the different regions, not only restricted in Shanghai and other big cities (Li, 2013).

In China, "Atmospheric Pollution Prevention Act" is the most important environmental atmospheric governance legislation. According to this law, the environmental protection departments strengthen supervision of atmospheric pollution and management, and establish emissions reporting of air pollutants, sewage charges, and atmospheric quality monitoring and other related systems. But there are still some problems in the existing laws, for instance the deviation of legislative purpose, the confusion of supervision and management system, and inadequate control means, etc. The legislation does not play its due role in the implementation process, therefore need to be improved as soon as possible.

1) Adjust the legislative purpose. The "Atmospheric Pollution Prevention Act" defined its legislative intent as "protect and improve the living environment and ecological environment, protect human health", and "to promote sustainable economic and social development" (Mao, 2013). In fact, in the process of the legislative implementation, it is difficult to find a balance between environmental and economic interests, and lead to poor law enforcement. In order to overcome this situation, the government should base on "ecological civilization" concept as a guide, to modify the purpose of the relevant legislation (Mao, 2013).In dealing with the relationship
between economic growth and environmental protection, abandon the concept of the coordinated development in the traditional environmental legislation, to establish the priority legal status ecological and environmental protection. If face the conflict between environmental and economic interests, the government should based on ecological interests, so that economic development should be carried out within the allowable range of environmental quality.

2) Explicitly regulatory responsibilities. Based on Atmospheric Pollution Prevention Act, the model of atmospheric management system is the environmental protection department in the dominant role and coordinates with other relevant departments (Mao, 2013). The government should improve the relevant legislations to establish leadership of environmental protection authorities in the field of air pollution control, and specified the specific responsibilities of transportation, railway, fisheries and other sectors related in this field, making the relevant departments to deal with events such as haze air pollution, as well carry out their duties and rapid response.

3) Improve the relevant measures in the legislations. In order to timely and effective manage haze pollution, the legal measures need to be improved as soon as possible. On the one hand, the government should support the creation of new measures to encourage enterprises and improve management techniques to reduce the use of fossil fuels, in order to gradually reduce emissions of particulate matter. On the other hand, developing emission standards of air pollutant, from the sources controlling particulate emissions; strengthen penalties for particulate matter excessive emissions, and increase the cost of illegal emissions; develop PM monitoring standards, so that raise the domestic standards with international standards unity; widen the scope and channels of atmospheric environmental quality information, strengthen the social supervision.

5.2 Optimize transport structure

In the various factors resulting in the haze weather, the vehicle emissions is one of the most important sources, thus comprehensive prevention of haze pollution should focus on the optimal management of motor vehicle. Therefore, the management departments need to develop appropriate supporting policies and measures, including more efficient use of carbon finance mechanisms, accelerate
the development of rail transportation, the traffic congestion costs, improve new energy vehicles subsidy policy, the integration of road use, encourage low-carbon travel and other systems for the promotion of environmentally friendly transport policy, in order to ensure the realization of the strategic objectives.

5.2.1 Priority to the development low carbon transport modes

In the formulation of future transport development plan, the government should priority to the development of low-carbon transport modes, and accelerates railway and metro transportation. In the meantime, the government should reasonable control the development of road traffic, and moderate the civil aviation industry. Some European countries have adjusted to the development of transportation in the priorities of railway, and formulated some relevant policies. For instance the Germany government in the development of new transportation network plan, one important starting point was based on ecological and environmental protection, and promote the environmental-friendly transportation modes -- rail and water shipping (Zhou, 2014).

In 2013, the China State Council issued "The comments of strengthening of urban infrastructure" that referred to "promote the construction of city subway and metro transit systems, and strength key roles as the subway and other public transport"(Zhou, 2014), in order to driven the development of urban public transport and related industries. The document also mentioned "by 2015, the mileage of national rail transport should increase 1000km" (Zhou, 2014). Then according to the development of rail transportation, the government should actively promote the comprehensive supporting of other transportation modes, improve the integrated mobility hub, and increase the transportation efficiency, with less traffic tools to complete the largest transportation volume.

5.2.2 Transportation carbon tax & congestion charge

Carbon tax is used for carbon dioxide emissions or fossil fuel, which aims to control and reduce carbon dioxide emissions (Cai, 2011). Motor vehicle carbon tax is one of the important components of carbon taxes. To impose the taxation for the private motor vehicles, which aims to guide consumers to buy low-emission vehicles, and reduce vehicle carbon dioxide emissions. Transport
sector carbon tax can be divided into two parts, the first part is for transportation fuels, that is taxation for motor vehicle fuels such as gasoline and diesel; the second part is to impose taxation directly against the motor vehicle (Cai, 2011).

China has begun to research the reform of environmental tax, which means vehicle emissions will be included in the scope of environmental taxes. Although the specific plan has not yet formulated, but it is certain that the owners of the purchase of high emission vehicles will pay more than the low-emission vehicles. Once implement the carbon tax, the owners have to pay for emissions generated by themselves. The transport sector through the introduction of carbon tax, one side to guide people to buy low-emission cars or new energy vehicles, on the other side appeal to choose low-carbon transport modes.

Congestion charge refers to the motor vehicles driving on congested roads during peak periods have to pay additional charges, in order to adjust the distribution of vehicles on the urban road network space and time through the price mechanism, and reduce network traffic congestion. Facing the increasingly severe traffic congestion, many European cities, like London and Stockholm, had implemented congestion charge policy, and achieved remarkable effect (Zhou, 2014). For example in London, the implementation of the congestion charge policy made more than 40 million people to give up private cars and switch to other modes of public transport. The number of motor vehicles entering the city center during peak hours reduced 44.5%, as well as the traffic congestion dropped 30%. The regional air quality had improved significantly (Zhou, 2014). This policy can be considered to implement in some cities with relatively complete transportation facilities, such as Beijing, Shanghai and Guangzhou, and then gradually expand the scope and improve them.

5.2.3 Preferential policies for new energy vehicles

In the case of the difficulty to transform the huge amounts of road transport, the adjustment of new low-carbon vehicles is the most realistic approach (Zhou, 2014). The specific measures are to accelerate the development of new energy vehicles, and optimize the vehicles’ energy consumption structure, which requires the introduction of a set of incentive policy. For instance, the subsidies for the purchase of new energy vehicles, etc. However, it is still needed to reduce the purchase cost and the use cost of new energy vehicles from the sources, including increased battery research and development investments to reduce battery costs, relaxation of the licensing and other preferential policies (Zhou,
Furthermore, the government should improve the urban vehicle management system, and develop integrated governance approach for urban mobility. Through these integrated management strategies, to make sure motor vehicle traveling smoothly, reducing parking time, thereby significantly reducing vehicle emissions.

5.3 Economic development model and Energy structure adjustment

The construction of ecological civilization in China is not a simple environmental governance problem, but to explore a new ecological model different from Western countries. The Western industrial civilization model with high consumption and high cost is a special part for a few developed countries. This mode cannot adapt to the modern civilization for a large population country like China. To control haze from the sources, the government need search for the ecological civilization mode of self-interest and altruistic.

5.3.1 Restructuring economic mode: from GDP to national interests

After solving the country's food and clothing problems, the improvement of national welfare and happiness is contained incomprehensive social welfare assistance including environment, welfare, mental well-being, physical well-being and social justice, which is not purely economic growth can be met. The economic growth to meet the targets of maximizing the public welfare, can contain the vicious competition of government blindly purse GDP growth, as well curb the black GDP growth that expense of the environment. Under the constraints of national welfare-oriented economic growth, it will be a high-welfare and low-cost sustainable development model.

The development mode of national welfare is suitable develop pattern of ecological civilization for China. Therefore, the primary task of Chinese government is to promote the construction of ecological civilization, to achieve the transformation of economic and social development goals. The cause of Chinese haze pollution is the result of city development goals lost. If the urban development goals cannot be transformed to the new model, it will be caught in a vicious circle: on the one hand the additional cost will continue to expand the economy, and increase the output of the government's finances; the other hand is to spend a lot of social resources to eliminate the haze pollution problems by
the blindly economic growth, increasing the burden on the government management.

5.3.2 Reform the energy structure: from fossil fuels to green energy

For a long time, the demand of coal was huge in China, and the development and use of natural gas was still rare. In recent years, the Chinese experts found that the content of natural gas was relatively abundant, including coal bed methane, shale gas, and tight gas (Zhu, 2013). A significant reduction in coal consumption, improve natural gas and renewable energy as well as electricity and other clean energy ratio is a key measure to improve the city clean energy rate. Recently the major targets of urban energy consumption are industrial, building and motor vehicle. In future urban development, building clean energy pathway should be based on electricity and natural gas consumption, as well as renewable energy supplement. Therefore, the government should speed up the development and improvement of the proportion of the natural gas in primary energy consumption structure, and replace oil and coal in the industries and household. But the problem is that the two major energy conversions were not completed in China, and the energy consumption is still dominated by coal. The data shows that coal occupied around 70% in primary energy consumption share, and the natural gas only accounted for 3%--4% (Zhu, 2013). Even if the government efforts to increase the utilization of natural gas, and increases gas imports, it is still very difficult to replace oil and coal in the energy consumption.

Due to natural gas can only replace a small part of the oil and coal, as the increasing supply of natural gas, in order to achieve environmental benefits, the natural gas utilization should be priority on household and transportation. The pollution caused by household waste and mobility is most serious, and most difficult to management. The coal power plants are good at clean using coal in the electricity sector, so they should not be replaced by natural gas power plants, as well not be a priority for large thermal power plant. If the coal-fired power plants with strict emission measures and stringent emission management, the pollution will be less than the motor vehicle exhaust. Instead, the government should appropriate increase the proportion of total coal consumption in coal-fired plants, which means in addition to the coal consumption in the iron, steel, chemical and other industrial enterprises, the most of coal consumption should be used for electricity generation. Only in this way, the coal consumption will not continue generate serious haze pollution.

The electricity sector is the cleanest use of coal (Zhu, 2013). In the process of
coal into electricity, the emission caused by coal-fired can be basically eliminated, like soot, sulfur dioxide and nitrogen oxides (Zhu, 2013). However, the coal-fired power plants cannot replace other coal sectors, only if all sectors achieve the clean use of coal, the haze problem will be resolved. Therefore, clean energy sources like natural gas and electricity can be used to replace to coals for dispersed users, then the rest coals can be used by coal fired power plants and other stringent pollution control departments.

5.4 Raise public awareness of environmental protection and green consumption patterns

To fundamentally improve the environment, relying only on substantial capital investment and mandatory government measures are not enough. The state should enhance the environmental awareness of the whole nation, and the rational use of natural resources. Only when each one spontaneously protects the environment, the haze control and management will achieve success for all. And raise environmental awareness should take different measures for various groups.

To enhance public awareness of environmental protection, education is a good way. In this aspect Japan is done quite well, and China can learn from the experience (Lu, 2013). Japanese environmental education is divided into three levels: school environmental education, family environmental education, and social environmental education. Environmental education is started from primary to high school, and it is compulsory. The education content and theories are informative. The school environmental educations not only allow students to learn knowledge in the classroom, but also make practice from the local environment to learn how to protect the environment in real life. The family environmental educations are a cooperation and communication between the school and parents, and coordinate with schools to raise environmental education from courses to real life. Social education is a conscious action in the entire society. In terms of this, in various public places of the community, either store or parks, parking lots, streets, the garbage bins can be seen everywhere, and placed orderly. The garbage recycling is responsible by specific departments (Lu, 2013).

The government should priority take advantage of press conferences and other public forms to timely introduce major events and important environmental
protection laws and regulations. Secondly, the government should further promote the socialization of environmental publicity and education. All levels of environmental protection departments should promote the coordination work to gain the support and participation of journalism, publishing, science and technology sectors and other social groups. Through promotional activities of environmental knowledge, gradually standardize public behaviors.

6 Conclusion

Although the extremely adverse weather conditions is the direct cause of the haze pollution, but the air pollutants by coal, motor vehicles, industry and other sources are also the vital sources to lead the serious air pollution in the process. Shanghai as one of largest city in China, the urban emissions of various pollutants is really huge. When the air conditions are adverse for the spread of pollutants, the air pollution will be increasing serious. In order to thoroughly improve urban air quality, the reduction of emission pollutants need for further efforts. Urban air pollution controlling should adhere to tackling the problem. In the current stage of the pollution reduction cannot be reversed significantly, the research and formulation of the contingency plans for heavy pollution weather is very important.

The prevention and control of haze pollution is a global problem all over the world now. From the prior research and experience show the different national government mainly through the improvement of laws and regulations on environmental protection, to reduce and control emissions of air pollutants. However, due to the development of industrialization and urbanization, these measures can not completely resolve the current haze pollution problems, even in London with decades of experience of haze governance is not yet completely out of the haze problems. The haze generated in China related to the current industrialization and urbanization, as well as urban management ability and person’s lifestyle. The government needs to establish a regional joint prevention and control mechanism, to jointly cope with public participation to promote green living concept.
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