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CAAC Clean Air Management Report

This series applies CAAC management and evaluation tools to support Chinese provinces and cities to systematically evaluate their air quality management systems. The goal is to assist them in a sustainable manner to construct and ameliorate their quality management systems, and to select and implement efficient air quality management measures. This series of reports is compiled together by CAAC secretariat, CAAC member provinces and cities and CAAC experts.

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Content

CAAC

Clean Air Management Series

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Executive Summary

In recent years, the dire air pollution in China has aroused extensive concerns from both the government and the general public as well as attracted attentions from international community. In 2013, the State Council officially promulgated the "Air Pollution Prevention and Control Action Plan (2013-2017)" (hereafter referred to as the "Ten Measures of Air"). As a result of this Plan, all provinces, autonomous regions and municipalities directly under the central government (hereinafter referred to as "provinces/cities") made unprecedented efforts to control air pollution in order to meet the targets set in the Ten Measures of Air.

One year after the launch of Ten Measures of Air, China's overall air quality has improved greatly. In 2014, the annual average concentration of $PM_{2.5}$ fell by 11.92% across ten provinces/cities/region (Beijing, Tianjin, Hebei, Shandong, Shanxi, Shanghai, Jiangsu, Zhejiang, Pearl River Delta and Chongqing) in key $PM_{2.5}$ control areas. Among 74 key cities, the number of the cities with air quality that attained China's Ambient Air Quality Standards (AAQS GB 3095-2012) has increased from three to eight[1]. The annual average concentrations of $PM_{2.5}$, PM_{10}, SO_2 and NO_2 in these 74 cities also declined since 2013[2]. Through the joint efforts of Beijing and its surrounding provinces, Beijing's average $PM_{2.5}$ concentration has decreased 40% [3](compared with the business as usual level) during the 2014 APEC conference, reaching 43 μg/m^3.

According to international experiences, sustainable air quality improvement requires scientific tools and systematic management support. This report analyzes air quality conditions, efforts around emission control (including co-control of greenhouse gases emissions) and air quality management, as well as various challenges faced in 2014 across 30 provinces/cities in mainland China except Tibet, which was not included due to data availability. The report serves to provide information to help provinces/cities improve air quality management strategies.

Major findings of this report include:

▲ China's overall air quality significantly improved in 2014

The annual average $PM_{2.5}$ concentration in

1. Ministry of Environmental Protection http://www.zhb.gov.cn/gkml/hbb/qt/201502/t20150202_295333.htm?COLLCC=3600076364&

2. Data from The State of Environment in China in 2014

3. Beijing Municipal Environmental Protection Bureau http://www.bjepb.gov.cn/bjepb/324122/416697/index.html

the majority of key $PM_{2.5}$ control areas decreased significantly from 2013 levels. The average $PM_{2.5}$ reduction across ten major provinces/cities/region including Beijing, Tianjin, Hebei, Shandong, Shanxi, Shanghai, Jiangsu, Zhejiang, Pearl River Delta and Chongqing reached 11.92%. $PM_{2.5}$ annual average concentrations in Shanxi, Shandong and Shanghai all declined more than 16% when compared to 2013 levels and were significantly closer to the $PM_{2.5}$ targets for 2017. Out of the 27 provinces/cities that published annual average PM_{10} concentrations, six met AAQS secondary standards. Looking at other major pollutants, out of nine provinces/cities that published the annual average O_3 concentrations[4], only one exceeded the upper limits of AAQS standards; out of 27 provinces/cities that published annual average SO_2 concentrations, all met AAQS standards; and out of 27 provinces/cities that published annual average NO_2 concentrations, five exceeded upper limits of the AAQS standards. All 9 provinces/cities that published the annual average CO concentrations[5] met AAQS standards.

▲ PM pollution posed the most significant problem with pollution levels varying widely in different areas. Some regions still faced enormous challenges in the future

Among 30 provinces/cities, the most server pollution category was PM pollution, closely followed by O_3 and NO_2 pollution. In northern regions, excessive SO_2 concentration occured frequently during winter heating seasons.

Areas with serious $PM_{2.5}$ pollution were Beijing, Tianjin, Hebei (also known as the Jing-Jin-Ji regions) and their surrounding regions and Henan, among which Henan was one of the most polluted provinces. Some areas in Hubei, Hunan, Shichuan and Chongqing were also heavily polluted by $PM_{2.5}$, and experienced concentrations higher than that of the Yangtze River Delta region.

The Jing-Jin-Ji and their surrounding regions had the highest concentrations in China for all six major pollutants (regulated by the AAQS standards) and had also most frequently issued warnings for air pollution episodes. Therefore, these areas were facing higher pressure to take control of regional air quality all met AAQS standards; and out of 27 provinces/cities that published annual average NO_2 concentrations, five exceeded upper limits of the AAQS standards. All 9 provinces/cities that published the annual average CO concentrations met AAQS standards.

▲ SO_2 and NO_X emissions reduced significantly. Improvements were also made in controlling mercury emissions and the co-control of greenhouse gas emissions.

4. According to the annual evaluation calculation method given by the Code of Ambient Air Quality Evaluation Technologies (Pilot Version), the 90th percentile of the moving average value of daily maximum eight hours is taken as the annual average concentration of O_3.

5. According to the annual evaluation calculation method given by the Code of Ambient Air Quality Evaluation Technologies (Pilot Version), the 95th percentile of the mean concentration over 24 hours is taken as the annual average concentration of CO.

When compared to 2013 levels, national SO_2 and NO_X emissions in 2014 were reduced by 3.4% and 6.7%, respectively[4]. Most provinces/cities achieved significant SO_2 and NO_X emissions reductions, especially Xinjiang. An increasing amount of attention was paid to mercury emissions; six provinces/cities promulgated Implementation Plans for Mercury Pollution Control. Moreover, more measures for co-controlling greenhouse gas emissions were developed. A negative growth of total coal consumption—2.9% decrease from 2013—was seen throughout China for the first time over the past 15 years[6], and 14 provinces/cities set up targets to control total coal consumption. All tasks of removing outdated vehicles and yellow-label vehicles that do not meet emission requirements were completed.

▲ Central and local legislation and standards improved dramatically. Progress was made in monitoring systems, information disclosure efforts and economic mechanisms.

The 2014 revised Environmental Protection Law is known as the most stringent environmental law in the history of China. Recently, the new Law of Prevention and Control of Air Pollution also passed the first review by National People's Congress. Altogether, 15 national air pollution standards were issued and 15 new local standards were implemented in 2014. The whole country is one year ahead of schedule for executing new urban air quality monitoring system. Some progress was seen around information disclosure efforts, especially in Tianjin, Shandong and Jiangsu. Gaps for transparency still remained in releasing historical monitoring data and review of air pollution control implementation plans. There was also progress around economic mechanisms to enforce policies, such as pollution discharge fees and administrative penalties.

▲ There are obvious discrepancies among regions when looking at upcoming challenges in air quality control. Industrial structure, energy consumption and vehicle emission are facing increasing reform pressures.

Industrial structure, energy consumption and vehicle emissions all have the potential to affect regional air pollution levels. Therefore, it is necessary to assess, plan and manage pollution sources from the beginning. Industrial structure in Beijing, Shanghai and Guangdong perform relatively well in terms of impact on air quality, but other provinces/cities are facing large pressures to change industrial structure. There are seven provinces/cities where heavily polluting industries contribute to more than 60% of local GDP. Additionally, seven provinces/cities have more than 80% of their primary energy needs provided by coal. Coal consumption per square kilometer differs greatly among these regions, as well as consumption per unit GDP—Ningxia, for example has a relatively higher consumption.

6.Data from The State of Environment in China in 2014

7. Data from Statistical Communiqué on National Economic and Social Development 2014

In terms of transportation, vehicles retained per capita in 29 provinces/cities (except for Beijing) were at least 13% higher in 2013 than in 2012, highlighting the pollution control pressures. Some provinces/cities including Beijing, Shanghai, Jiangsu and Guangdong introduced stricter vehicle gasoline/diesel standards.

Shenzhen is the only mega city with over 10 million populations that attained the AAQS standards in China in 2014. While strengthening pollution control efforts, Shenzhen continues to regulate its industrial structure and energy systems and vigorously promotes new-energy vehicles. The city’s work to meet air quality standards while maintaining economic development is worth of recognition.

Chapter 1 Introduction

With the support of experts of the Clean Air Alliance of China (CAAC), the Innovation Center for Clean-air Solutions (ICCS) analyzed current air quality conditions and progress in efforts around pollutant emission control and management. The study looked at 30 provinces/cities in mainland China except for Tibet, which was not included due to data availability. The objectives of this report are: to provide references for air quality management strategies, to help individual province/city understand the status quo of its pollution and to discover pollution control difficulties and challenges. By using existing cases, provinces/cities can push for larger improvements in air quality.

The China Air Quality Management Assessment Report is a series of documents that include national, provincial and municipal level reports. The China Air Quality Management Assessment Report (2015) Lite Edition is a national report in the series. The default data the report uses are collected during year 2014. Since some data are unavailable, data collected in 2013 or 2012 are used in some places in the report with footnote. China Air Quality Management Assessment Report (2015) Complete Edition will be released at the end of 2015. The data in the report will then be updated, and more contents will be included.

Chapter 2 Current Situations of Air Quality

In order to analyze the air quality in each individual province/city in China, this report investigates the annual average concentrations of six air pollutants ($PM_{2.5}$, PM_{10}, O_3[6], SO_2, NO_2 and CO[7]) and the warnings for air pollution episodes mainly based on the Report on the State of the Environment released by each individual province/city.

2.1 Analysis of $PM_{2.5}$ pollution

$PM_{2.5}$ pollution varied greatly among different areas

The satellite inversion graph on the ground level $PM_{2.5}$ concentration throughout China in 2014 is shown in Fig 2-1. The figure shows that China's $PM_{2.5}$ pollution varied in different areas and was especially severe in several regions.

A large continuous area composing of Jing-Jin-Ji and their surrounding regions, and Henan were seriously polluted by $PM_{2.5}$, of which Henan Province is especially polluted

Fig. 2-1 shows that a large continuous area composing of Jing-Jin-Ji and their surrounding regions, and Henan were severely polluted by $PM_{2.5}$. Of this area, Beijing and south of Beijing were most heavily polluted. Parts of Henan had $PM_{2.5}$ annual average concentrations close to 150 mg/m^3.

Parts of Hubei, Hunan, Sichuan and Chongqing were more polluted than the Yangtze River Delta.

Fig 2-1 shows that parts of Hubei, Hunan, Sichuan and Chongqing were two additional areas with heavy $PM_{2.5}$ pollution that were more severe than that of the Yangtze River Delta. The Yangtze River Delta and the Pearl River Delta also had notable $PM_{2.5}$ pollution.

In 2014, the average $PM_{2.5}$ reduction across ten major provinces/municipalities/autonomous regions was 11.92%, when compared to that of 2013. The regions were Beijing, Tianjin, Hebei, Shandong, Shanxi, Shanghai, Jiangsu, Zhejiang, Pearl River Delta and Chongqing.

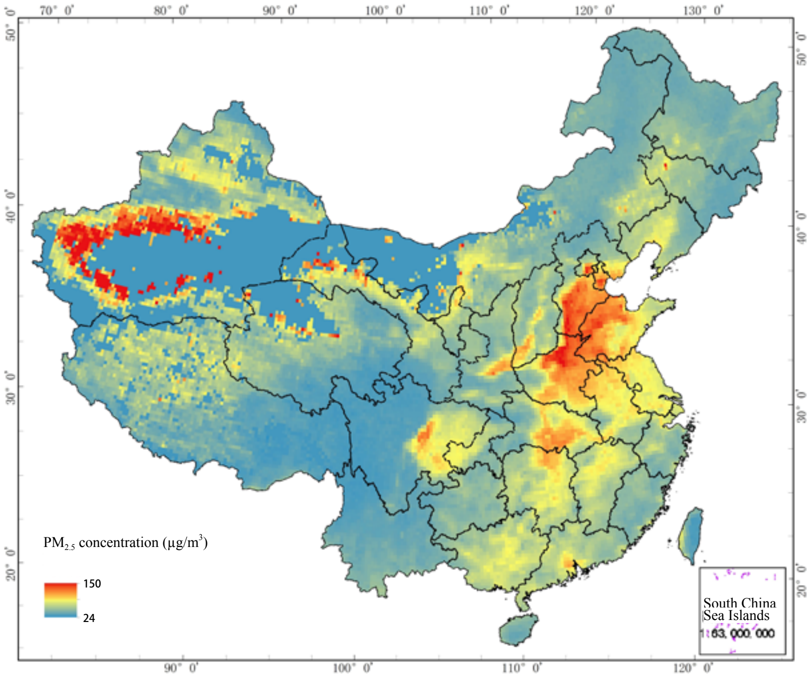

Fig 2-1. Satellite inversion graph of ground level $PM_{2.5}$ concentrations throughout China in 2014[8]

According to the data released by each province/city on the Report on the State of the Environment, the annual average $PM_{2.5}$ concentration in Tianjin, Hebei, Shandong and Shanxi[9] in Jing-Jin-Ji and their surrounding regions decreased by more than 10% in 2014 when compared to 2013 data, of which Shanxi and Shandong decreased $PM_{2.5}$ by more than 16%. Beijing's $PM_{2.5}$ was reduced by only 4%. In the Yangtze River Delta, Shanghai achieved the largest $PM_{2.5}$ reduction with 16.1%, and Zhejiang and Jiangsu reduced $PM_{2.5}$ by around 10%. The annual average $PM_{2.5}$ concentration in the Pearl River Delta was lower than that of the regions around Jing-Jin-Ji and the Yangtze River Delta. With a 10% decrease in 2014, Pearl River Delta's $PM_{2.5}$ concentration was closest to meeting national standards[10]. Chongqing also decreased its annual average $PM_{2.5}$ concentration.

8.The bright, reflective ground surfaces in desert and snowy regions can affect satellites' efforts to pick up information about particle concentrations. As a result, the high levels of $PM_{2.5}$ concentration depicted in West China deviate significantly from real-life situations.

9.Data of Shanxi are gathered not from the Report on the State of the Environment, but from news.cn: http://news.xinhuaet.com/local/2015-01/16/c_1114021310.htm

10. The national standards for the six pollutants mentioned in this report are derived from the Ambient Air Quality Standard (GB3095-2012) (also known as the "New Standards on Air Quality").

2.2 Analysis of PM_{10} pollution

Since 2013, 10 provinces/cities increased annual average PM_{10} concentrations in 2014.

Of the 27 provinces/cities that have released their annual average PM_{10} concentrations in 2014, six provinces met standards, which were Hainan, Yunnan, Guangdong, Guizhou, Heilongjiang and Guangxi. Between 2013 and 2014, of the 20 provinces/cities that failed to meet the standards, 10 provinces/cities lowered their PM_{10} concentrations, and are ranked starting from Zhejiang with the biggest drop in pollution levels, to Shanghai, Hebei, Tianjin, Shandong, Jiangsu, Chongqing, Sichuan, Anhui and Jiangxi with the smallest. However, the PM_{10} concentrations in 10 provinces/cites increased. They were Ningxia, Shaanxi, Liaoning, Inner Mongolia, Hubei, Gansu, Beijing, Xinjiang, Henan and Jilin. These provinces/cities are mainly located in the central, northeast and west of China.

2.3 Analysis of O_3 pollution

Most of the 9 provinces/cities that released annual average O_3 concentrations had values that were close to the standard limit, but Beijing failed to meet standard

Of the 9 provinces/cities that have released their annual average O_3 concentrations, Beijing was the only one that failed to meet standard, exceeding upper limits by 23.25%. The O_3 concentrations in 8 provinces/cities, including Hebei, Tianjin, Jiangsu, Zhejiang, Shanghai, Guangdong, Chongqing and Liaoning, were near the upper-limit.

2.4 Analysis of SO_2 pollution

All of the 27 provinces/cities that have released their annual average SO_2 concentrations met standards, but the data given by Shandong and Hebei were close to the upper limit. The excessive SO_2 concentrations during winter heating seasons in northern China should not be ignored.

In 2014, annual average SO_2 concentrations released by 27 provinces/cities all met national standards. This shows that China has made great achievements in SO_2 control. However, the annual average SO_2 concentrations in Shandong and Hebei were very close to the standard limit. Since the main source of SO_2 emission comes from burning sulfur coal, the excessive SO_2 concentrations occurred during the heating seasons in North China, such as Shandong, should not be taken lightly.

2.5 Analysis of NO_2 pollution

Of 27 provinces/cities that have released annual average NO_2 data, most met national standards. However, Beijing, Tianjin, Hebei, Shandong and Shanghai (altogether 5 provinces/cities) exceeded standard. Of the non-compliant cities, Beijing, Tianjin, Hebei and Shandong are located in the Jing-Jin-Ji and the surrounding areas. Beijing and Tianjin were over-limit the most, exceeding standards by 42% and 35%, respectively. Located in the Yangtze River Delta, Shanghai also exceeded limits by 10%.

2.6 Analysis of CO pollution

The annual average CO concentrations in all of the 9 provinces/cities that have released their data met the standards.

2.7 Number of air pollution episode warnings

The Jing-Jin-Ji regions issued warnings most frequently

According to the Report on the State of the Environment of China (2014), more than 170 warnings of air pollution episodes were issued throughout China in 2014, of which, the Jing-Jin-Ji regions issued more than 60 warning that were yellow or above.

According to local province/city's Report on the State of the Environment (2014), only Beijing and Chongqing have counted and released the number of warnings of air pollution episodes in 2014. Beijing issued 18 warnings and Chongqing issued 8 warnings.

2.8 Summary

This chapter states that among the 6 main pollutants in 30 provinces/cities, $PM_{2.5}$ and PM_{10} were the most severe pollutants, followed by O_3 and NO_2, while SO_2 and CO both met the standards[11].

In 2014, the annual average $PM_{2.5}$ concentrations in most key control areas significantly decreased since 2013. The average decrease was 11.92% in 10 provinces/cities/regions: Beijing, Tianjin, Hebei, Shandong, Shanxi, Shanghai, Jiangsu, Zhejiang, Pearl River Delta and Chongqing. $PM_{2.5}$ pollution varied greatly among different areas. A large continuous area composing of Jing-Jin-Ji and their surrounding regions, and Henan were seriously polluted by $PM_{2.5}$, of which Henan was heavily polluted. $PM_{2.5}$ pollution in parts of Hubei , Hunan, Sichuan and Chongqing were also relatively serious, and were even more severe than that of the Yangtze River Delta.

Jing-Jin-Ji and their surrounding areas had the highest concentrations of the six major pollutants and the highest number of issuances of air pollution episode warnings. These regions are facing intense pressure to treat their situation.

11. This conclusion is only valid for provinces/cities that have released data in their individual Report on the State of the Environment (2014) by July 2015.

Chapter 3 Progress in Controlling Pollutant Emissions

This chapter analyzes the progress in air pollution emission reduction of the whole country and each individual province/city from the aspects of control of SO_2, NO_X and mercury emissions, and co-control of GHG emissions.

3.1 Emission control of key pollutants

China has made prominent progress in reducing air pollutant emission in 2014. The SO_2 and NO_X emissions in China were reduced by 3.4% and 6.7%, respectively[12] in 2014 compared with that in 2013. Compared with the situation in 2013, most provinces/cities have significantly reduced their SO_2 and NO_X emissions, among which Xinjiang made the most outstanding achievements.

The Minamata Convention on Mercury signed by China in October 2013 specifies regulations on the production and discarge of mercury among all mercury-related stages. In order to better control the mercury emission, the Emission Standard of Air Pollutants for Thermal Power Plants (GB 13223-2011), the Emission Standard of Air Pollutants for Boiler (GB13271-2014), the Standard for Pollution Control on the Municipal Solid Waste Incineration (GB18485-2014), and the pollutant emission standards of the non-ferrous metal industry issued by China all have regulations on emission limit of mercury. By the end of 2014, 6 provinces/cities, including Shaanxi, Shanxi, Qinghai , Gansu, Beijing and Shanghai have released their Implementation Schemes of the Prevention and Treatment of Mercury Pollution.

3.2 Progress made through putting into effect the co-control measures of GHG emissions

While China is reducing air pollutant emissions, it is also facing the pressure imposed by the international community on GHG emissions reduction. It should seek for low sulfur emissions, low nitrogen emissions, low particle emissions, as well as low carbon emissions[13]. Therefore, the co-control of GHGs and multiple air pollutants is a new way of protecting the environment, which suits China's current industrial conditions and characteristics.

12. Data are collected from the Report on the State of the Environment of China (2014).

13. HU Tao (2015) Implementation of Co-control over Multiple Pollutants and Greenhouse Gases. Strategic Suggestion Collection of Prevention and Treatment of Air Pollution Specified in the "13th Five Year Plan" (Discussion Draft), 11-13.http://www.cleanairchina.org/product/7222.html

Since air pollutants and GHGs are largely produced by the same sources, the measures taken to reduce emission of both kinds of gases are usually consistent. For instance, some measures to control total coal consumption, such as the replacement of coal by clean energy resources and the elimination of small boilers, can reduce not only the emission of SO_2, NO_X and particles, but also the emission of GHGs, such as CO_2. The elimination of yellow-label vehicles and outdated vehicles can not only reduce the emission of NO_X, particles and GHGs (such as CO_2), but also decrease the emission and production of short-lived climate pollutants (SLCPs), such as black carbon and O_3. Volatile organic chemicals (VOCs) themselves are a kind of air pollutants. As a VOC, CH_4 is also a kind of SLCP. In addition, since VOCs are important precursors of the formation of O_3 (an SLCP), the control over VOC emission is also a co-control measure.

3.2.1 Setting goals for controlling the total coal consumption

Chinese total coal consumption exhibits a negative growth in 2014

According to the data given by the National Economy and Social Development Statistical Bulletin (2014), a negative growth of total coal consumption in 2014—2.9% decrease from 2013—was seen throughout China for the first time over the past 15 years

In order to improve air quality, the State Council Air Pollution Prevention and Control Action Plan requires the formulation of a national mid and long-term goal to control total coal consumption, and achieve by target-oriented responsibility management. By 2017, the percentage of coal in total energy consumption should be reduced to less than 65%,and the Jing-Jin-Ji, the Yangtze River Delta and the Pearl River Delta regions should seek to achieve negative growth in the total coal consumption.

Controlling the total coal consumption is also conducive to reducing greenhouse gas emissions. The article, Enhanced Actions on Climate Change: China's Intended Nationally Determined Contributions published by China in 2015 clearly states that controlling total coal consumption is an important measure to reduce greenhouse gas emissions.

Fourteen provinces/cities have set goals to control total coal consumption by 2014, including Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Henan, Hubei, Hunan, Guangdong and Chongqing. These goals can effectively attract concerns from all walks of life about the control over coal consumption, and can promote energy restructuring. They are conducive to the improvement of air quality and emission reduction of GHGs.

3.2.2 Removal of yellow-label vehicles and outdated vehicles

By the end of 2013, China has more than 130 million yellow-label vehicles, accounting for about 10% of the car owership. Pollutants emitted by these vehicles account for around 50% of total pollutant emissions by vehicles[14]. Therefore, accelerating the removal of yellow-label vehicles and outdated vehicles is an important means to improve air quality. In the meantime, the removal of those vehicles also has the co-benefit of reducing GHG emissions, such as CO_2 and black carbon.

The tasks of removing outdated vehicles and yellow-label vehicles that do not meet emission requirements were over-fullfilled. The over-fulfillment ratio in ten provinces/cities were more than 120%.

In 2014, the State Council of PRC assigned the mission of eliminating altogether 6 million yellow-label vehicles and outdated vehicles[14]. In 2014, 28 provinces/cities that have released their progress in removing the yellow-label vehicles and outdated vehicles all accomplished the mission, of which 10 provinces/cities, including Hainan, Jiangsu, Qinghai, Shaanxi, Shandong, Zhejiang, Liaoning, Yunnan, Hebei and Beijing, completed the task with an over-fullfillment ratio of above 120%.

14. Ministry of Environmental Protection of PRC http://www.zhb.gov.cn/gkml/hbb/qt/201406/t20140610_276685.htm

Chapter 4 Progress in Air Quality Management

This chapter analyzes the central government and the provincial/municipal governments' progress in managing air quality from the following five aspects: legislation, standard formulation, monitoring, information disclosure and economic measures.

4.1 Legislation

4.1.1 State-level legislations

The new Environmental Protection Law of PRC was issued in 2014, and the Law on Prevention of Air Pollution of PRC began amendment processes.

2014 is a very crucial year in the history of China's environmental protection legislation. On April 24 2014, the Eighth Session of the Standing Committee of the Twelfth National People's Congress voted to approve the new Environmental Protection Law of PRC. The new law changes the low cost of violating environmental protection laws for companies, addresses the balance of governments' rights and responsibilities, and promotes public engagement efforts.

On September 9 2014, the Legislative Affairs Office of the State Council of PRC asked for public opinions on the Law on Prevention of Air Pollution of PRC (Revised Draft for Public Review). On November 26, the executive meeting of the State Council approved the Law on Prevention of Air Pollution of PRC (Revised Draft). On December 22, the revised draft of the Law on Prevention of Air Pollution of PRC was submitted to Standing Committee of the National People's Congress for initial review.

4.1.2 Local legislations

By the end of 2014, Shaanxi, Beijing and Shanghai issued local Regulations on Prevention of Air Pollution.

Along with the issuance of the State Council Air Pollution Prevention and Control Action Plan, and a series of state-level legislation activities such as the release of the Environmental Protection Law of PRC and the amendment of Law on Prevention of Air Pollution of PRC, Shaanxi, Beijing and Shanghai updated and implemented their new local Regulations on Prevention of Air Pollution in 2014.

4.2 Establishing standards

4.2.1 State-level standards

China has issued 15 environmental standards regarding air pollution in 2014

In 2014, China issued 15 standards on air pollution, consisting of sampling and monitoring standards for volatile organic chemicals/semi-volatile organic chemicals, emission standards for industries/facilities, exhaust gas monitoring standards for stationary pollution sources and other ambient airborne substances, and emission quantity and monitoring standards for off-road mobile diesel engines.

4.2.2 Local-level standards

In 2014, 7 provinces/cities, which are Beijing, Tianjin, Hebei, Heilongjiang, Shanghai, Zhejiang and Guizhou, have put into effect 15 new local environmental standards regarding air pollution

In 2014, 7 provinces/cities, which are Beijing, Tianjin, Hebei, Heilongjiang, Shanghai, Zhejiang and Guizhou, enacted 15 new air pollution standards. These standards mainly involve pollution industries/facilities, motor vehicles, hazardous wastes/municipal solid waste incineration, volatile organic chemicals produced by industrial enterprises, etc.

4.3 Monitoring

All air quality monitoring network stations have been built or updated to meet requirements for urban air quality monitoring, as stated by the State Council Air Pollution Prevention and Control Action Plan.

The Ambient Air Quality Standards (GB3095-2012) were issued in 2012. To comply with new Ambient Air Quality Standards, many regions in China have started to build or update air quality monitoring network stations accordingly. By the end of 2014, 1,436 monitoring network stations in 338 prefecture-level or above cities have were established, and real-time monitoring data of six controlled pollutants (PM_{10}, $PM_{2.5}$, SO_2, NO_2, O_3 and CO) and the air quality index (AQI) are now available to the public. This symbolizes the successful implementation of new standards.

4.4 Information disclosure

Tianjin, Shandong and Jiangsu are the top three provinces/cities in terms of air quality management information disclosure.

In 2014, the average score of 30 provinces/cities for air quality information disclosure was 5.95 out of 10. Tianjin, Shandong and Jiangsu were the top three provinces/cities with the best scores of 8.5, 8.0 and 8.0.

The following aspects regarding information disclosure need further improvements:

Among the 30 provinces/cities, Tianjin was the first to attempt to release evaluation reports of the city's work. It is suggested that in the future, the working progress of air pollution prevention and control measures should be opened to the public.

By the end of 2014, official websites of all provincial/municipal environmental protection offices have released real-time monitoring data of ambient air quality, yet no access were found to keep historical monitoring data. It is suggested that each province/city should improve its air quality data tracking system to help the public learn about previous air quality conditions.

By the end of 2014, 9 provinces/cities, including Tianjin, Shandong, Jiangsu, Anhui, Hunan, Henan, Jiangxi, Chongqing and Shaanxi have involved public engagement when formulating air pollution regulations, standards and planning. It is suggested that all provinces/cities should improve public engagement mechanisms to expand information disclosure content and channels, and make efforts to analyze and respond to public suggestions.

4.5 Economic measures

4.5.1 Increasing the standards of pollution discharge fees

The Notice on Adjusting Pollution Charge Standards and Related Issues, released on September 1, 2014, specifies pollution discharge fee standards of SO_2 and NO_X exhaust gases should be doubled by the end of June 2015, to push enterprises to reduce emissions.

By the end of 2014, 7 provinces/cities have raised the discharg fee standards in advance. Beijing and Tianjin have raised the standards to a level far higher than the national requirements.

By the end of 2014, 7 provinces/cities have raised pollution discharge fees before national deadlines. Beijing and Tianjin have significantly increased the standards of the discharg fees of national requirements. Beijing raised standards by 15.87 times and the Tianjin raised by 9.5 times. Jiangsu has doubled its standards since 2007. Ningxia, Xinjiang, Guangdong and Zhejiang have accomplished national requirements for raising standards ahead of time by doubling their discharg fee standards in 2012, 2012, 2013 and 2014, respectively.

4.5.2 Changes in fines

Most provinces/cities' environmental fine sums in 2014 were higher than that in 2013. Fine sums in Shaanxi, Beijing, Henan and Sichuan have more than doubled

Eleven provinces/cities have released sums of collected fines in 2013 and 2014, and the fine's growth rate between 2013 and 2014 in the Report on the State of the Environment of China. Most of provinces/cities increased their fine sums from 2013 to 2014. Shaanxi, Beijing, Henan and Sichuan's fine sums have increased by more than twice.

Chapter 5 Challenges in Air Pollution Control

This charpter investigates the challenges and difficulties in addressing air pollution control in different regions in four dimensions: air pollution purification capacity, industrial structure, energy use, and vehicle emissions.

5.1 Self-purification capacity

Air pollution in a region is related to the region's self-purification capacity, but also the emission level and regional transport of pollutants.

The self-purification capacity measures the comprehensive capability of diffusion, and dilution without considering pollutant emissions. The capacity refers to the self-purification of atmospheric pollutants under natural climatic and geographical conditions. The national distribution of self-purification capacities in 2014 is shown in Figure 5-1.

Comparing Figure 5-1 and Figure 2-1, it can be found that the self-purification capacities are low in areas that are heavily polluted by $PM_{2.5}$, as indicated in Figure 2-1. The areas include Beijing, Tianjin, Hebei and the surrounding areas, Henan, Hubei, Hunan, Sichuan and Chongqing, as well as the Yangtze River Delta. However, low-capacity areas in Figure 5-1 do not completely overlap the $PM_{2.5}$ polluted areas, indicating that the level of air pollution in a region is subject to emission levels and transport mechanisms, in addition to the natural self-purification capacity.

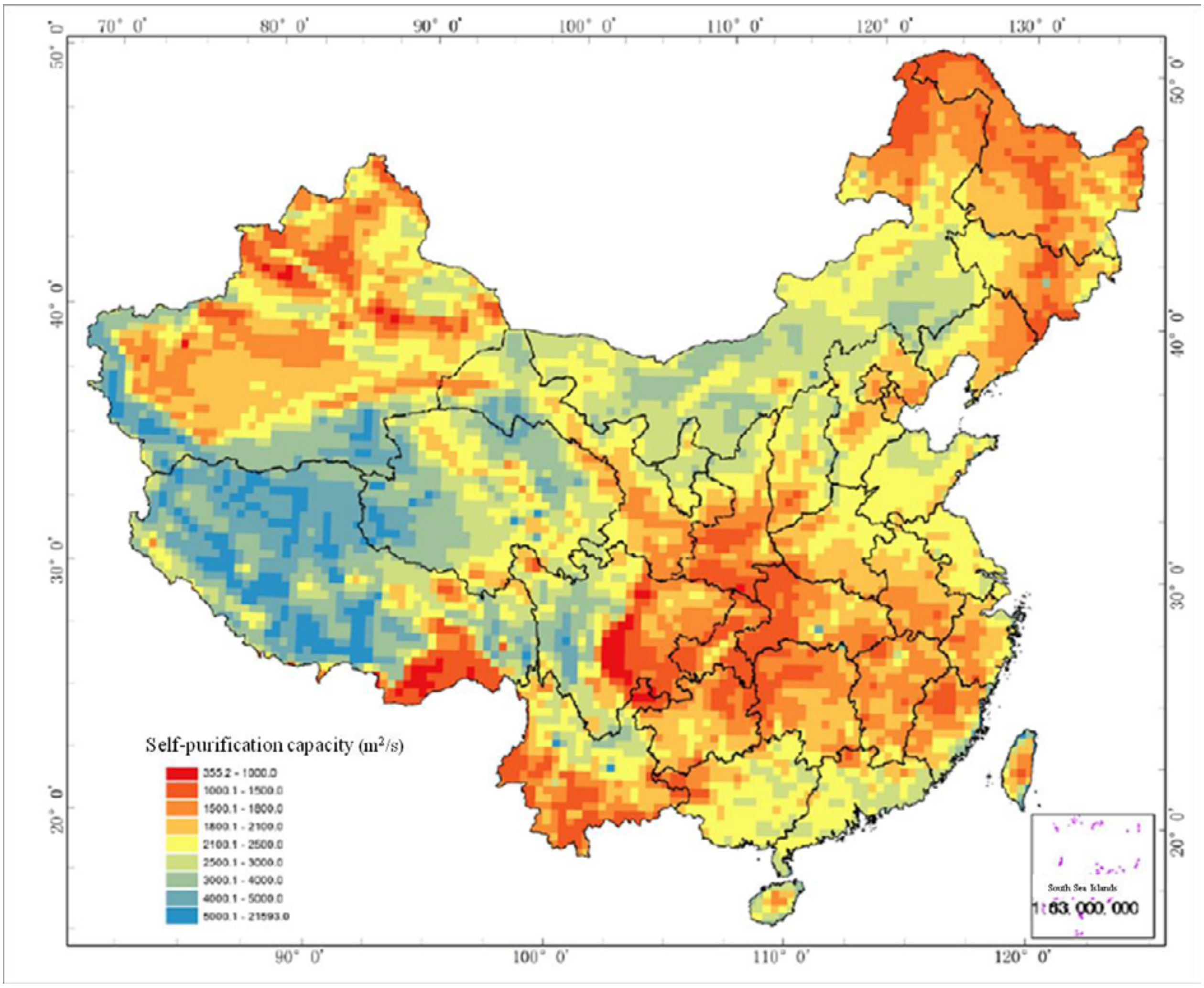

Figure 5-1 National distribution of self-purification capacities in China （2014）

5.2 Industrial structure

Industrial structure is mainly evaluated by two indicators: the proportion of secondary to tertiary industries and the contribution of heavily polluting industries[15] to GDP. In current production processes, secondary industries are often the dominant source of air pollutant emissions. Relatively speaking, a high proportion of secondary to tertiary industries would result in larger needs for air pollution control. Within the secondary industries, the contribution of heavily polluting industries to GDP reflects the relationship between regional industrial structure and air pollution. Relatively speaking, large contribution of heavily polluting industries would result in greater needs to address air pollution.

15. Heavily polluting industries refer to steel, cement, petrochemical, chemical and non-ferrous industries set out in the 12th Five-Year Plan for Air Pollution Prevention and Control in Key Areas.

5.2.1 Proportion of secondary to tertiary industries

Beijing, Shanghai and Guangdong had obvious advantages in industrial structure, and Hainan and Guizhou should consider balancing industrial structures in their economic development processes.

According to the analysis of 30 provinces/cities (municipalities) in 2013, the proportion of secondary to tertiary industries was lowest in Beijing, Hainan, Shanghai, Guizhou, and Guangdong. Taking per capita GDP into account, Beijing, Shanghai, and Guangdong delivered superior performance in both economic development and industrial restructuring. In contrast, Hainan and Guizhou suffered relatively low per capita GDP levels, with Guizhou experienced the lowest in the nation. Therefore, efforts to balance the industrial structure are needed in the process of economic development.

Great pressure on industrial structure adjustment in some provinces/cities

Qinghai, Henan, Anhui, Shaanxi, and Jiangxi registered the highest proportion of secondary to tertiary industries in 2013, but had lower per capita GDP than that of the national average. These regions should adjust their industrial structures to reduce excess capacity and strive for innovation-driven economic development.

5.2.2 Contribution of heavily polluting industries to GDP

Heavily polluting industries accounted for more than 60% of GDP in Shandong, Jiangxi, Liaoning, Hebei, Ningxia, Qinghai, and Jiangsu

According to the analysis of GDP data in 17 provinces (municipalities) with high proportion of secondary to tertiary industries, the contribution of heavily polluting industries to GDP exceeded 60% in Shandong, Jiangxi, Liaoning, Hebei, Ningxia, and Qinghai in 2013, which placed great pressure of air pollution control

5.3 Energy structure and consumption

Energy use is examined through three indicators: the share of coal in primary energy, coal consumption per unit of area, and energy consumption per 10,000 RMB of GDP

5.3.1 Share of Coal in Primary Energy

Coal took up more than 80% of the primary energy in Shanxi, Inner Mongolia, Ningxia, Guizhou, Anhui, Hebei, and Shaanxi.

Among the observed 30 provinces/cities, in 2012, coal provided for 80% or more of primary energy consumption in Shanxi, Inner Mongolia, Ningxia, Guizhou, Anhui, Hebei, and Shaanxi, and lower than 40% in Beijing, Hainan, and Shanghai. Beijing had the lowest level of less than 30%.

5.3.2 Coal consumption per unit of area

The coal consumption per unit of area differed among provinces/cities

Among the observed 30 provinces/cities, the 10 areas with the highest coal consumption per unit area in 2012 were Tianjin, Shanghai, Shandong, Shanxi, Hebei, Beijing, Henan, Jiangsu, and Zhejiang. In these areas, the emissions from coal consumption pose huge air quality challenges. Shanghai, Jiangsu, and Zhejiang ranked the 1st, 3rd and 8th respectively and formed a coal-intensive region that creates great challenges for air quality control in the Yangtze River Delta. When air dispersion is poor, this area is likely to put a very large pressure on air quality management systems.

5.3.3 Energy consumption per 10,000 RMB of GDP

The energy consumption per 10,000 RMB of GDP was small in economically developed areas like Beijing, but large in the less economically developed areas like Ningxia

5.4 Vehicle emissions

5.4.1 Number of vehicles per 100 Persons

With the continued rapid development of economy and improvement of living standards, the vehicle population has massively expanded in recent years and brought prominent air pollution problems. According to the latest source apportionment of urban pollutants, vehicle emissions were responsible for 31.1% of the $PM_{2.5}$ pollution in Beijing[16] and mobile sources, including motor vehicles, account for 29.2% of the $PM_{2.5}$ pollution in Shanghai[17]. Motor vehicles have risen as a major source of urban air pollution.

China faces unprecedented pressure to control motor vehicle pollution as the number of vehicles increased by more than 13% in all of the observed 30 provinces/cities except Beijing

Among these 30 provinces/cities, the number of vehicles per 100 persons averaged 7.75 in 2013. In Beijing, Tianjin and Zhejiang, the number was around twice the national average, posing huge pressures on vehicle emissions control. Introducing license-plate lottery, Beijing began controlling vehicles and achieved the lowest vehicle growth in China, increasing by only 2.5% from 2012 to 2013. while Tianjin and Zhejiang had growths of 16% and 18%, respectively.

5.4.2 Sulfur content of motor gasoline / diesel

As fuel upgrades impact both current and new vehicles, implementing more stringent fuel standards will produce more significant effects than raising emission standards for new vehicles. Improving fuel quality, such as reducing sulfur content, is a precondition for tightening emissions standards and for applying advanced pollution control technologies. For example, in order to use diesel particulate filter (DPF) and achieve high efficiency, low sulfur content in the diesel is a prerequisite.

16. Beijing Environmental Protection Bureau http://www.bjepb.gov.cn/bjepb/323474/331443/331937/333896/396191/index.html
17. Shanghai Environmental Protection Bureau http://www.sepb.gov.cn/fa/cms/shhj//shhj2272/shhj2159/2015/01/88463.htm

The gasoline/diesel standards for motor vehicles in Beijing, Shanghai, Jiangsu, and Guangdong are higher than the national average.

By the end of 2014, in all the observed 30 provinces /cities, gasoline and diesel fuel met standard IV and III, respectively, so that the sulfur content was less than 50ppm and 350ppm. In addition, in Beijing, Shanghai, some prefecture-level cities in Jiangsu and Guangdong, gasoline standard V (sulfur content less than 10ppm) and diesel standards IV and V (sulfur content less than 50 and 10ppm) were implemented. Therefore, fuel sulfur content was reduced by more than 80% in these areas .

5.5 Comprehensive analysis

To help comprehensively analyze air pollution conditions and governance challenges in different provinces/cites, the report introduced the $PM_{2.5}$ Carrying Capacity Index in the study on PM pollution. The Index reflects the maximum allowable emissions allowed to still meet national standards for average annual $PM_{2.5}$ concentration (for attainment areas, the current emission caps prevail according to the Principle of Anti-degradation)[18]. Figure 5-2 shows, by quadrants, the annual average PM_{10} concentrations (which represent the PM pollution level since data on $PM_{2.5}$ concentration are limited) and per unit area $PM_{2.5}$ carrying capacity index of 27 provinces/cities.

Through detailed analysis of provinces/cities in each quadrant, covering per capita GDP, industrial structure, energy use and vehicle emissions, the report made some preliminary key conclusions around air pollution control in some provinces/cities.

Beijing had the lowest $PM_{2.5}$ carrying capacity index per unit urban area.

Among the observed provinces/cities, Beijing exhibited the lowest $PM_{2.5}$ carrying capacity per unit urban area and faced the greatest air pollution control challenge.

18. $PM_{2.5}$ Carrying Capacity Index is calculated according to the Simulation of Atmospheric Environmental Capacity Based on the National Attainment of Urban $PM_{2.5}$ Standards. Using the WRF-CAMx model and the National Emission Inventory, this paper obtains through iterative calculations the environmental capacities of key components of $PM_{2.5}$ (sulfates, nitrates, primary $PM_{2.5}$, and ammonium salt) in 31 provinces/cities under the premise that all 333 cities in the country meet the requirements for annual average $PM_{2.5}$ concentration in the Ambient Air Quality Standards (GB3095-2012) (for cities attaining the $PM_{2.5}$ standards in 2010, the emission caps for 2010 prevail according to the Principle of Anti-Degradation). Based on the results and the average shares of key components in 333 cities in 2010, the paper calculated the conversion factors and ultimately the $PM_{2.5}$ carrying capacity index in 31 provinces/cities.

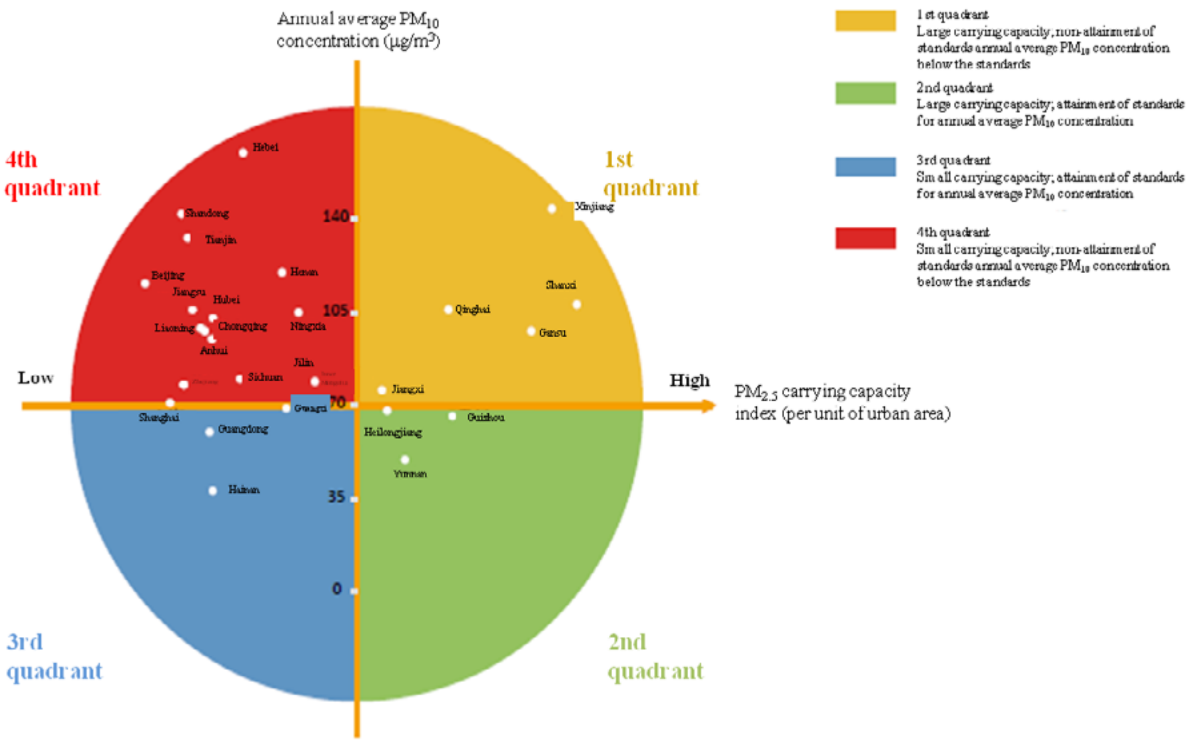

Figure 5-2 Quadrant analysis of PM pollution and carrying capacity in 27 provinces/cities

Jing-Jin-Ji and their surrounding areas, Henan, Yangtze River Delta, Hubei, Sichuan and Chongqing were all categorized into the fourth quadrant

Hebei, Shandong, Tianjin, Beijing, and Inner Mongolia in the Jing-Jin-Ji and their surrounding areas, and Henan were all located in the 4th quadrant, meaning high pollution and low carrying capacity. Heavy polluting industries took a large or dominant share in Hebei, Shandong, Henan, and Inner Mongolia, and coal consumption per unit of area remained high in Tianjin, Shandong, and Hebei. In addition, Beijing, Tianjin, Shandong, and Inner Mongolia face considerable pressure around motor vehicle pollution.

Jiangsu, Zhejiang, and Shanghai in the Yangtze River Delta were also in the 4th quadrant, where the PM_{10} pollution was severe, but slightly better than Jing-Jin-Ji and their surrounding regions. Among these areas, Jiangsu had a high proportion of heavily polluting industries. Shanghai, Jiangsu, and Zhejiang ranked the 1st, 3rd and 8th respectively by coal consumption per unit of area, of which the latter two also face large pressure from motor vehicle pollution.

Hubei, Chongqing, and Sichuan were also in the 4th quadrant, suffering more serious $PM_{2.5}$ pollution than the Yangtze River Delta (Figure 2-1). All of the 3 provinces/cities bore a moderate or low level of pressure from the industrial structure, energy use, and vehicle emissions, but the low carrying capacities may be one of the causes of heavier PM pollution.

Chapter 6 Conclusions and Recommendations

▲ China's air quality significantly improved in 2014. PM pollution remained prominent with pollution levels varying widely in different areas, and some regions will still face enormous challenges in the future

In 2014, China's overall air quality improved significantly from 2013. The average $PM_{2.5}$ concentration fell by 11.92% in ten major provinces/cities/regions, including Beijing, Tianjin, Hebei, Shandong, Shanxi, Shanghai, Jiangsu, Zhejiang, Pearl River Delta and Chongqing. The average annual concentrations of $PM_{2.5}$, PM_{10}, SO_2 and NO_2 also decreased in 74 key provinces/cities, among which, eight met the ambient air quality standards, which was five more than the previous year.

On a national scale, the most severe pollutant was PM, followed by O_3 and NO_2, while the SO_2 pollution persisted during the heating season in the northern region. The areas with the most severe $PM_{2.5}$ pollution were Jing-Jin-Ji and their surrounding areas, and notably Henan. Areas in Hubei, Hunan, Sichuan and Chongqing were also confronted with $PM_{2.5}$ problems and suffered higher $PM_{2.5}$ concentrations than the Yangtze River Delta. Among all these areas, the Jing-Jin-Ji and their surrounding regions registered the highest concentrations of the six major pollutants (regulated by the ambient air quality standards) and issued the highest number of warnings on air pollution episodes, implying high pressure to control air quality.

▲ The co-control of both air pollutants and GHGs should be beefed up based on the current intense efforts to control emissions

In 2014, the national SO_2 and NO_X emissions were cut by 3.4% and 6.7%, respectively, over the previous year. SO_2 and NO_X reductions were seen in the majority of provinces/cities, notably Xinjiang. Mercury emissions control also received increasing attention, with the introduction of the Implementation Plan for Mercury Pollution Prevention and Control in six provinces/cities. The total coal consumption was also brought under control, and effective measures to phase out yellow-label vehicles and outdated cars were taken.

In the future, co-control of air pollutants and GHGs should be furthered, with emission reduction targets and energy saving targets properly coordinated to maximize benefits for all parties.

▲ Progress was made in air quality management. In the future, systemic air quality improvement / compliance management should be extended to local levels

A newly revised environmental protection law that was known as the most stringent one of its kind was unveiled in 2014; the new ambient air quality law passed the first review in the National People's Congress. Additionally, 15 national air pollution standards were issued and 15 local ones were implemented. Urban air quality monitoring tasks, in line with the requirements of the Action Plan for Air Pollution Prevention and Control, were completed one year before deadline. Progress was seen in information disclosure, particularly in Tianjin, Shandong, and Jiangsu. Economic mechanisms covering pollution discharge fees and administrative penalties have also produced results.

Air quality improvement / compliance management is the core of air quality management. In this model, the local governments bear primary responsibility to manage air quality in a scientific way through designing and assessing various laws and measures. Systematically managing air quality involves the seeing of linkages between pollution source control and air quality improvement, and assessing costs and benefits of abatement measures. On this basis, appropriate air quality compliance plans and reasonable emission reduction strategies are designed to accomplish the Action Plan for Air Pollution Prevention and Control and ultimately ambient air quality standards.

▲ Overall air pollution control remains difficult, and the priorities will be industrial restructuring, total coal consumption control and vehicle emissions control

Currently, China has an industry heavy economic structure. In more than half of the provinces/cities, the proportion of secondary to tertiary industries was up to 1.2; in some provinces/cities, heavily polluting industries are the major contributor to GDP. It is therefore necessary to initiate industrial restructuring, such as prospecting measures that encompass strict controls of heavily polluting industries, economic policies such as differentiated discharge fees and differentiated energy prices, and incentives to reduce emission and discharge of heavy polluting enterprises. Looking at the dominance of coal in most areas, provinces/cities should set out targets and plans to control total coal consumption, and introduce incentive schemes to the development and use of clean energy sources for the purpose of energy mix optimization. To address the fast-growing vehicle emissions, more stringent emission standards and oil standards should be combined with the strategies for controlling the population of motor vehicles.

Clean Air Alliance of China (CAAC)

To address the air pollution challenge in China, ten leading Chinese technical institutions in the air quality field joined hands to launch the Clean Air Alliance of China (CAAC). It is envisioned that CAAC will provide an integrated platform for provinces and cities to access the international experience, tools and practices on the one hand; and facilitate the communication and collaboration among provinces and cities on the other. The overarching goal is to improve air quality of Chinese provinces and cities and mitigate the negative impacts on public health due to air pollution. CAAC will be led and supervised by the alliance steering committee, and be managed by the alliance secretariat regarding general operation and coordination.

Ten Founding Members

Tsinghua University, Appraisal Center for Environment & Engineering of MEP, Chinese Academy for Environmental Planning (CAEP), Nanjing University, Beijing Normal University, Fudan University, Chinese Research Academy of Environmental Sciences (CRAES), Peking University, Renmin University of China, Vehicle Emission Control Center (VECC) of MEP

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