



**China Council for International Cooperation on Environment and
Development (CCICED)**

**Performance Evaluation on the *Action Plan
of Air Pollution Prevention and Control* and
Regional Coordination Mechanism**

CCICED Special Policy Study Report

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Summary of Key Findings

- **A Thorough Appraisal System is Needed for Air Pollution Plans**

China is confronted with severe air pollution, especially regional atmospheric problems, including PM_{2.5}, which is becoming increasingly prominent. Among the 74 cities that first launched PM_{2.5} monitoring networks in the year 2013, 71 cannot reach the secondary air quality standard. The annual average concentration of PM_{2.5} of the 74 cities is 2.1 times the secondary standard. The average annual concentrations of the Beijing-Tianjin-Hebei Region, Yangtze River Delta and Pearl River Delta were 3.0, 1.9 and 1.3 times the secondary standard, respectively.

In order to improve air quality and protect the public health, the new government has adopted the *Action Plan of Air Pollution Prevention and Control* (hereinafter referred as “*action plan*”), the strictest air pollution control measures ever adopted in China. It is imperative to also establish a thorough performance appraisal system for scientific evaluation of the environmental, social and economic benefits generated by the pollution prevention and control measures. An integrated performance appraisal system should include pre-implementation analyses of implementation plans and follow-up appraisals of program implementation and results. An index system, including air quality improvement and program performance indicators, etc. needs to be established.

According to the pre-implementation analysis of the Beijing-Tianjin-Hebei Region action plan, PM_{2.5} concentrations are expected to drop significantly after implementation of *the action plan*. However, Tianjin municipality and Hebei province may not reach the 25% PM_{2.5} concentration reduction target by the year 2017. Resources and capacity for comprehensive implementation of the policy measures must be enhanced. We suggest that different regions should further refine *the action plan* and clearly quantify the various control measures and the expected emission reductions. Meanwhile, China should enhance control of NO_x, VOC and NH₃ – key components of PM_{2.5} – in order to realize synergistic air quality improvements.

- **China Faces Great Challenges to Reduce Emissions and Meet the Air Quality Standard**

Air quality in key cities should achieve the ambient air quality standard for PM_{2.5} (i.e., annual limit of 35 µg/m³) by 2030. Keeping this target in mind, we calculated the pollutant emission reduction targets nationwide and in all provinces. On the basis of 2012 emissions, SO₂, NO_x, PM_{2.5} and VOC emissions nationwide should be reduced by at least 52%, 65%, 57%, and 39%, respectively, by 2030, and NH₃ should decrease slightly. We should intensify emission control in heavily polluted areas. For example,

SO₂, NO_x, PM_{2.5}, VOC and NH₃ emissions in the Beijing-Tianjin-Hebei Region in 2030 should be reduced by at least 59%, 72%, 70%, 44%, and 21% respectively.

In order to reach the above emission reduction targets, China should carry out coordinated control efforts for multiple pollutants and emission sources in different regions, adopting control measures that can complement the process of adjusting the energy structure, improving energy efficiency and enhancing end-of-pipe pollution control, etc. In terms of energy structure and energy efficiency, China should cap its coal consumption; promote new energy and clean power generation, including clean fuels for commercial and residential sectors; promote advanced production techniques to accelerate the elimination of backward industrial capacity; increase fuel efficiency of motor vehicles and promote the application of the energy saving and new energy vehicles. With regard to end-of-pipe controls, power plants should adopt desulfurization, particulate controls and nitrogen oxides controls technologies; industrial sectors should gradually adopt efficient pollution control technologies, especially the most advanced particulate controls technology; residential and commercial sectors should gradually adopt efficient particulate controls technologies, advanced thermal coal and biomass combustion technologies; the vehicle population in cities should be properly controlled, and the new vehicle emission standards should be accelerated and strictly implemented and enforced, along with much stronger pollution prevention and control of non-road mobile sources, and unified fuel quality standards for road vehicles and non-road machines; and apply the EU VOCs emission standard in manufacturing and solvent use.

China's air pollution problem will require years to solve

China's air pollution problem is quite severe and it has evolved over several years of rapid industrialization. Therefore it is unrealistic to expect that it can be reversed overnight even with the best of intentions. High pollution episodes are inevitable in the short term when unfavorable weather conditions and stagnant air occur. International experience indicates that it usually takes decades to initially reverse the increasing pollution trends and then to bring about substantial air quality improvements. In order to achieve the short term 2017 targets laid out by the State Council, China needs to reduce the national SO₂, NO_x, PM_{2.5} and VOC emissions by at least 24%, 15%, 16%, and 2%, respectively, and limit the increase of NH₃ emissions to less than 10%, compared with that in 2012. The SO₂, NO_x, PM_{2.5} and VOC emissions in Beijing-Tianjin-Hebei Region must be reduced by at least 32%, 25%, 30%, and 11%, respectively, by 2017 on the basis of 2012 levels, and NH₃ emissions can only increase slightly.

In September 2013, the *Action Plan* was officially issued by the State Council, which included ten air pollution prevention and control measures. The Action Plan includes the strictest air pollution control measures ever adopted in China. However, the Action Plan has only been in effect for one year and will require several years to begin to show significant benefits. Cleaner and more efficient new cars and trucks take several years before they dominate the vehicle fleet. Reducing the increases in coal consumption and shutting down or relocating high polluting industrial facilities requires some time to develop alternatives. Designing and installing end of pipe controls on major power plants and industrial sources will also take several years. In the meantime, when poor meteorological conditions occur, high pollution episodes are inevitable. But with each passing year, international experience suggests that effective implementation of the Action Plan complemented by local air pollution control measures should result in gradual improvements in air quality and fewer and fewer high pollution episodes. By 2030, the SO₂, NO_x, PM_{2.5}, VOC and NH₃ emissions in Beijing-Tianjin-Hebei Region shall be reduced by at least 59%, 72%, 70%, 44%, and 21%, respectively and high air pollution episodes should be greatly diminished if not eliminated.

- **International Experience is an Important Reference for Regional Air Pollution Control and Coordination**

Europe and the US demand that the relevant local and state/national authorities achieve air quality standards within specified time frames. In order to realize the targets, the European Air Quality Plans (AQPs) and the American State Implementation Plans (SIPs) outline comprehensive strategies for emission reductions and air quality improvements. The strategies consist of (1) pollution prevention and control policies; (2) policy implementation timetables; (3) scientific and economic evaluation of emission reduction policies; (4) emergency programs for serious episodes of atmospheric pollution; and (5) resource adequacy demonstrations¹ for implementation and enforcement. Comprehensive air quality monitoring networks are used to evaluate progress toward meeting ambient air quality standards, and ensure transparency of relevant environment monitoring information.

Both Europe and the US have established integrated management mechanisms for regional air quality to coordinate regional air pollution prevention across states/nations. For example, the Convention on Long Range Transboundary Air Pollution (CLRTAP) aims to establish common strategies and policies, and monitoring systems for air quality under the United Nations Economic Commission for Europe (UN-ECE). All parties agree to restrict and gradually reduce air pollution as much as possible, including long-distance and cross border air pollution; the American Regional Planning Organizations (RPOs), set up through the concerted efforts of USEPA, the state governments and other stakeholders, enhances regional coordination and cooperation on air pollution planning and control.

- **China Lacks Strong Regional Coordination Institutions and Unified Plans, Objectives and Management**

Conventional air pollution control and management in China lacks consideration of air pollution transport and a systematic analysis of air pollution. For example, the air pollution problems in the Beijing-Tianjin-Hebei Region, the Yangtze River Delta, Shandong and Henan are greatly impacted by pollutants that are transported from surrounding areas. Therefore, integrated regional control must be adopted in these areas. In the future, regions should be scientifically grouped based on quantitative research based on satellites, ambient monitors and air quality models to enhance air quality management.

Because the government performance appraisal focuses on total emission control of SO₂ and NO_x pollution, local governments have, to some extent, not focused on air quality improvements. A lack of unified air quality objectives and lack of coordination among cities and provinces in terms of reducing PM and VOC emissions have hindered regional air quality improvements. Unless this is corrected by adoption of

¹ Including financial commitments as well as staffing.

unified air quality objectives and coordinated control measures and strategies, air quality objectives will not be achieved.

An initial mechanism has been established to support regional decision making and consultations in the three key regions. However, the regional coordination mechanism is limited, focused primarily on heavy pollution weather alerts and joint emergency responses. The regions lack unified plans, objectives, control requirements, supervision and administration. As to environmental information sharing, significant progress is needed to meet the requirements for regional air pollution prevention and control.

Summary of Main Policy Recommendations

Recommendation 1: Build an Air Quality-Oriented Air Pollution Management System

- **Improve the Legal Status of Standard Air Quality**

The *Atmospheric Pollution Prevention Law* should explicitly state that provincial and local governments must implement and enforce atmospheric protection programs based on air quality objectives. Government at all levels should improve air quality in substandard areas and prevent deterioration of air quality in compliant areas. These objectives should be binding requirements in performance evaluations of officials. Accountability provisions should levy economic punishments for areas that cannot achieve air quality goals on time, and include administrative accountability for persons in charge of the regional and/or local government.

- **Atmospheric Management Regions should be Based on Science**

The atmospheric management regions should not be based purely on political boundaries, but should be based on scientific assessments that consider spatial and temporal distribution of emissions, meteorology, terrain and pollution transport. The eastern provinces with heavy air pollution should be grouped into one region. Atmospheric management regions should have regional coordination organizations and mechanisms, unified laws and regulations, and united management and enforcement on air quality to enhance overall regional efforts to meet air quality objectives.

Recommendation 2: Deepen Joint Prevention and Control for Regional Air Pollution

- **Establish a Unified Standard Program for Regional Air Quality**

Based on the target of regional air quality compliance in key regions, such as eastern provinces, the schedule for achieving air quality standards in different cities should be considered at the national level, aiming to improve air quality while providing a reasonable and feasible pathway. Policies should promote coordinated control of regional air pollution, rigorously control the total emission amount and reduce pollution transport. The population, industry, energy and motor vehicle patterns in the region should be established or adjusted based on the distribution of regional atmospheric carrying capacity. Integrated and unified monitoring of air quality should be designed and conducted in the regions to support scientific assessment on the plans.

- **Establish a Clear-cut, Unified and Integrated Regional Air Pollution Control and Management Mechanism**

To enhance regional coordination, an environmental decision-making and consultation mechanism is needed along with enhanced information sharing about air quality management. Regional coordination can also be enhanced with consultation mechanisms for environment impact assessments (EIAs), including EIAs for major pollution sources, and for industrial planning; regional environmental law enforcement mechanisms for unified supervision and enforcement, as well as strict inspection and accountability; joint emergency response for episodes of heavy pollution with coordinated temporary emission reduction measures; and unified supervision.

- **Establish Regional Decision Support and Planning Agency**

Establish regional planning organizations funded by various ministries and commissions like the Ministry of Environmental Protection to provide national and local scientific and technological resources, and facilitate coordination among local and regional governments. To enhance our understanding of pollution transport, conduct research on emission tracking, transport, atmospheric pollutant transformation, and source identification of regional air pollution. To address air pollution cost effectively, recommend air pollution control techniques that can be effectively applied to all cities in the region.

Recommendation 3: Enhance Air Pollution Control Based on the Existing Measures

- **Clean, efficient and sustainable use of coal**

It is preferable to use coal in large-scale facilities with high-efficiency end-of-pipe control technologies; small-scale boilers and stoves should be phased out gradually, and district heating should be strongly promoted. China should make great effort to improve the energy efficiency of major coal-consuming sectors, such as power plants and industry. For example, the average energy efficiency of coal-fired power plants should be increased from 36% in 2010 to 42% in 2030 and the energy consumption per unit of production of industrial coal-fired boilers, cement production and coke ovens should be 24%, 16%, and 44% lower, respectively, in 2030 compared with 2010. China should increase the proportion of coal washing and promote clean coal technologies.

- **Accelerate Adjustment of the Energy Structure and Increase Clean Energy**

It is essential to commit to energy structure adjustments and cap the coal consumption. Coal's share of total energy consumption should be less than 50% by 2030. This will

require increased clean energy utilization, including natural gas, nuclear energy and renewable energy (biomass not included), up to 25% by 2030, and the clean utilization of biomass.

- **Enhance Coordinated Control over Various Sources of Pollution and Contaminants**

In order to meet the atmospheric quality and air pollutant emission control goals, China should stick to the strategic concept of “coordination”, “integration” and “joint action”. That is, China should carry out coordinated control over pollutants including SO₂, NO_x, primary PM_{2.5}, VOCs and NH₃. Regarding control of various pollution sources, China should launch comprehensive pollutant control of industrial sources, domestic and rural non-point sources and mobile sources. These policies should require joint prevention and control between regions and cities, and consider the key emitting sectors, the feasibility of control technologies, the challenges for different regions to reach the standard and the multiple environmental implications of pollutant emission reductions. Region-specific air pollution prevention and control strategies are likely necessary to address regional characteristics.

Recommendation 4: Establish Scientific Appraisal System

- **Establish Pre-implementation and Annual Appraisal System**

Pre-implementation and annual appraisal systems should be established so that local governments can assess progress and adjust measures as necessary to meet the goals. The pre-implementation indicators include projected reductions of PM_{2.5} concentrations and frequency of heavy pollution days. The annual appraisal indicators should include the actual monitored PM_{2.5} concentration (multi-year moving average), pollutant emission reductions and progress on control measures such as improving energy efficiency and adjusting the energy structure.

- **Establish Final Appraisal System**

A final appraisal system should be established to provide a technological basis for the sustained improvement of air quality. The appraisal indicators should include PM_{2.5} concentrations (multi-year moving average); number of heavy pollution days; economic, industrial and energy structures; and benefits to human health attributable to improved air quality.

Background and Implementation of the Project

With the rapid economic development and urbanization in China, especially the industrial development pattern featuring the chemical industry, coal-oriented energy structure and the rapid increase of motor vehicles, China's emissions of key pollutants ranks first in the world. This has generated serious atmospheric contamination with marked features like the superposition of various pollution sources and contaminants, the dual and overlapping challenges of urban and regional pollution, the connection between pollution and climate changes, etc. Thus the governance of China's air quality management is far more difficult than that in developed countries. Since 2011, the frequent and extensive dust-haze with heavy pollution has troubled the central and eastern region of China in winter and spring, seriously influencing industrial production as well as the lives and health of the people. The new government adopted air pollution control measures that are the strictest in the history of China so as to improve the air quality and protect the public health. The government also released the first *Action Plan of Air Pollution Prevention and Control* (hereinafter referred to as *Action Plan*) in August, 2013.

The Action Plan explicitly states the objective to improve air quality nationwide and in key areas, and provides ten measures, including 35 specific actions, to help achieve these objectives. In order to evaluate the progress in the implementation of the various measures and the relevant environmental, social and economic benefits which serve as the basis for future policy adjustment, this project focuses on exploring and establishing performance appraisal indicators and an appraisal system for the *Action Plan*. At the same time, this project also conducts pre-appraisal and follow-up appraisal on the implementation progress and the impact of the plan, for the purpose of recognizing the key factors that hinder the realization of the *Action Plan* goals, and raises the relevant policies and measures; the research incorporates the medium term objective of the 13th Five-Year Plan and the long term objective of 2030 in terms of air pollution prevention and control. The research has presented the medium and long-term air pollution prevention and control strategy and has projected the roadmap for air pollution prevention and control; meanwhile, it studies the solution for building a regional coordination mechanism and provides policy suggestions for improving regional air quality.

Since its proposal in February 2014, the project group held four working meetings in six months. The first meeting after the project launch adopted the implementation program through deliberation, and finalized topics, division of labor and schedule for the project research. At the second meeting held on May 26th, the individuals in charge of each subject reported the research progress and the initial conclusions. The project group conducted in-depth discussions and listened to the ideas of other research organizations, government sectors, non-government organizations and the industrial sectors. The group also identified the modifications and improvements to

the research, and reached consensus on future work. The third meeting was held on July 30th to August 1st in Washington. The Chinese members and the foreign experts of the research group conducted intensive communications on several important subjects. For example, the regulation on regional air quality management under the Clean Air Act in the US, the function and mode of operation of regional planning organizations, the formulation and implementation of cross-state air pollution rules, and the traffic pollution control, etc. The communication on these subjects enabled the researchers to better draw on the international experiences and summarize the policy suggestions. The fourth meeting was held on August 29th where researchers in charge of various subjects reported final research results. The project group and the experts who participated in the meeting carried out extensive discussions on the major research results and the policy suggestions, and put forward advice and direction for further modification of the first draft of the research report. The project group had full knowledge of further modification and promised to submit the revised draft on schedule.

In addition, on the 2014 ICDF round-table conference in May and the Third Joint Work Meeting between Chief Advisor and Secretariat of 2014 ICDF in July, Professor Kebin He, the core expert of the subject group, and the Chinese group leader Academician Jiming Hao reported the research progress and the future work plan respectively, which gained helpful suggestions from foreign and domestic experts at the meeting. Internal meetings were repeatedly held inside the project group. In short, the project group had absorbed the combined wisdom of experts from home and abroad by means of European and American experience case study, national analysis of conditions and assessment of the current policies in China, exchange of views and brainstorming, investigation, survey and discussion of special project policies, etc. The project group defined the ultimate policy suggestions after research and comparison of domestic and foreign systems, providing important scientific and technological support for the establishment of the performance appraisal method system of *the Action Plan* and the regional coordination mechanism.

Key Words: air pollution, air quality standard, regional coordination mechanism, energy conservation and emission reduction, policy, PM_{2.5}

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1. RESEARCH ON PERFORMANCE EVALUATION INDICATORS AND METHODOLOGY OF THE ACTION PLAN

At present, the atmospheric pollution situation in China is grim and regional atmospheric environmental problems, such as fine particle (PM_{2.5}) and inhalable particle (PM₁₀) concentrations, are increasingly prominent. According to the air quality monitoring data of 2013 issued by the China National Environmental Monitoring Centre (“CNEMC”), among the 74 cities that first launched the PM_{2.5} monitoring, 71 failed to reach the prescribed standard; the annual average concentration of PM_{2.5} in the 74 cities was 2.1 times the class II standard; the annual average concentrations of PM_{2.5} in the Beijing-Tianjin-Hebei Region, the Yangtze River Delta, and the Pearl River Delta were 3.0, 1.9, and 1.3 times the class II standard, respectively.²

In September 2013, *the Action Plan of Air Pollution Prevention and Control* was officially issued by the State Council, which included ten air pollution prevention and control measures (hereinafter referred to as “Ten Measures”). The Ten Measures include air quality improvement targets for 31 provinces in 2017 based on each province’s current situations of social and economic development and air quality of localities and agreed to through the signing of commitment letters about targets. The whole country is divided into key regions and non-key regions, and graded improvement targets are set for each region. Under this approach, to promote the implementation of provinces’ and municipalities’ responsibilities, it is necessary to establish an effective system of performance evaluation indicators and a methodology for the implementation of the *Action Plan* so as to evaluate and assist in offering guidance on the implementation of the *Action Plan* by all localities across the country.

1.1 Establishment of Performance Evaluation Indicators and Methodology

1.1.1 Performance Evaluation Methodology

The performance evaluation methodology involved in this research includes two evaluation methods, namely, pre-evaluation (ex-ante) of the implementation performance and follow-up evaluation (ex-post) of the implementation performance, as shown in Figure 1-1.

² According to the World Health Organization’s Global Burden of Disease study, approximately 1.2 million people died prematurely in 2010 in China as a result of exposure to particulate air pollution.

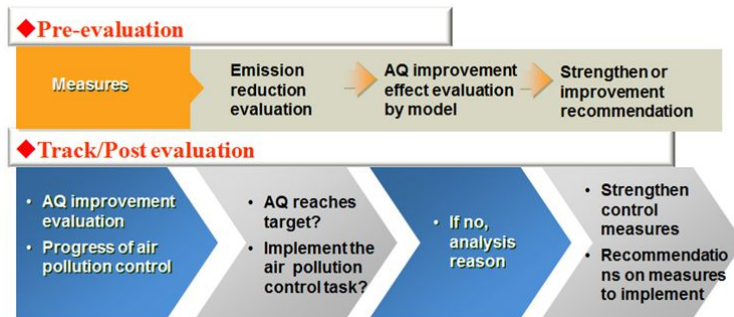


Figure 1-1 Performance evaluation methodology of the *Action Plan*

The term “pre-evaluation of the implementation performance” refers to a pre-evaluation of the effects of the current control measures on emission reductions and air quality improvements using emission inventories and an air quality model, with the aim to predict the atmospheric improvements after implementation of current policies and identify weaknesses in the current policies and the direction of further efforts. The term “follow-up evaluation of the implementation performance” refers to an evaluation of progress of control measure implementation and the actual impacts on air quality, with the aim to promote the gradual development of various tasks and the actual effects of the evaluation work.

1.1.2 Methods for Pre-evaluation of the Implementation Performance

In the pre-evaluation of the implementation performance, the implementation effects of the current control measures are evaluated using emission inventories and an air quality model. The specific pre-evaluation methods are illustrated by Figure 1-2.

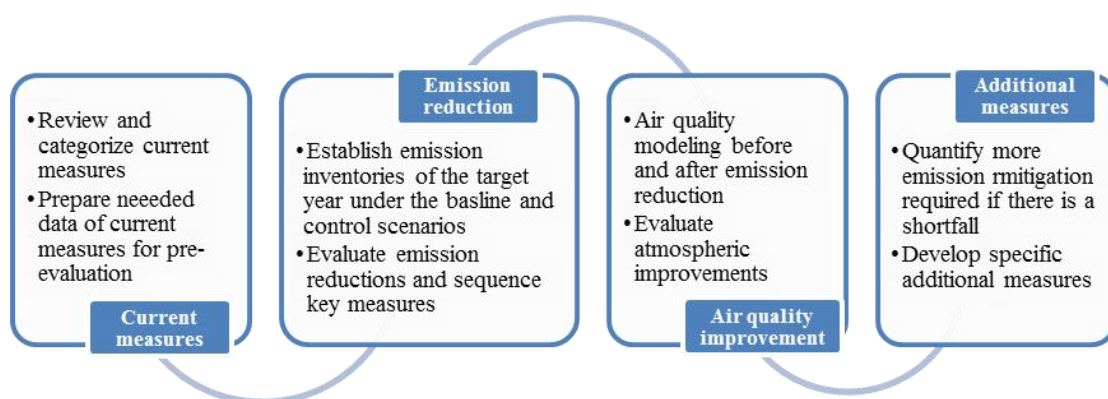


Figure 1-2 Methods for pre-evaluation of the implementation performance

1.1.3 Indicator System for Follow-up Evaluation of the Implementation Performance

In the follow-up evaluation of the implementation performance, two parts are examined: one is the ambient air quality, for assessing the impact of the control measures already implemented; and the other is the progress in implementing the planned control measures by all localities. Thus, two indicators are created, namely, a performance indicator of air quality improvement and an indicator of control strategy implementation. In particular, the performance indicator of air quality improvement shall serve as the key evaluation indicator for nationwide evaluation; and the indicator of control strategy implementation serves as the auxiliary secondary evaluation indicator for the annual evaluation in key regions.

1.1.3.1 Performance indicator of air quality improvement

The decrease, expressed as a percentage of the annual average concentration of PM₁₀ or PM_{2.5} is the key evaluation indicator of air quality improvement. Reductions in the number of days with heavy pollution and the percentage decrease of annual average concentrations of other pollutants (NO₂, SO₂, CO, O₃) serve as secondary evaluation indicators of air quality improvement. Table 1-1 summarizes the annual average concentration improvement targets of PM₁₀ or PM_{2.5} of all provinces and provincial-level municipalities in 2017 in the *Commitment Letter on Targets*. The Beijing-Tianjin-Hebei region and surrounding areas, the Yangtze River Delta, the Pearl River Delta, and Chongqing City have PM_{2.5} targets, and other regions have PM₁₀ targets.

Table 1-1 Air quality improvement targets of all localities in the *Commitment Letter on Targets*

Province	Decrease in the Annual Average Concentration of PM _{2.5}	Province	Decrease in the Annual Average Concentration of PM ₁₀	Province	Decrease in the Annual Average Concentration of PM ₁₀
Beijing	-25% (60 ug/m ³)	Henan	-15%	Sichuan	-10%
Tianjin	-25%	Shaanxi	-15%	Ningxia	-10%
Hebei	-25%	Qinghai	-15%	Heilongjiang	-5%
Shanxi	-20%	Xinjiang	-15%	Fujian	-5%
Shanghai	-20%	Hubei	-12%	Jiangxi	-5%
Jiangsu	-20%	Gansu	-12%	Guangxi	-5%
Zhejiang	-20%	Liaoning	-10%	Guizhou	-5%
Shandong	-20%	Jilin	-10%	Hainan	Continuous improvement

Guangdong	Pearl River Delta -15%	Anhui	-10%	Yunnan	Continuous improvement
Chongqing	-15%	Hunan	-10%	Tibet	Continuous improvement
Inner Mongolia	-10%	Guangdong	Other cities -10%		

Since the nationwide routine monitoring of PM_{2.5} was not initiated until 2013 and by taking the availability of monitoring data into account, 2012 was set as the base year for PM₁₀ and 2013 was set as the base year for PM_{2.5}. To avoid any inaction by local governments in the early years, an annual progress assessment should be established. For the annual assessment targets of PM_{2.5}, the annual average PM_{2.5} concentration declines from 2014 to 2017 could be set at 10%, 40%, 70%, and 100% of the targets in the *Commitment Letter on Targets*. It is proposed that the moving annual average (for example, the moving average values over three years) should be adopted for purposes of evaluation so as to remove the interference of meteorological factors and emphasize the role of human-influenced emission reductions.

1.1.3.2 Indicators of control strategy implementation

Indicators of control strategy implementation and indicators of emission reductions of air pollutants are used for investigating the completion of key tasks. Key work tasks in the Ten Measures are shown in Table 1-2, including industrial restructuring, energy structure optimization, industrial atmospheric pollution control, dust pollution control, motor vehicle pollution prevention and control, and heavy-pollution weather warning and so on. Meanwhile, a rating mechanism should be established for assessment of adequacy of measures and evaluation of progress toward air quality goals. Air pollutants closely related to particulate pollution (e.g., SO₂, NO_x, PM_{2.5}, VOC, NH₃) are considered for evaluating progress on the emission reduction measures. Task scores are determined on the basis of the importance of such tasks in the effects on air quality improvement and the operability and costs of the tasks. Indicators of assessment tasks shall be quantitative in principle.

Table 1-2 Indicators of control strategy implementation

Indicator	Sub-indicator	Indicator	Sub-indicator
Industrial restructuring	Reduction of surplus production capacity	Dust pollution control	Control of dust pollution in construction sites
	Elimination of outdated production capacity		Control of dust pollution on roads
	Relocation of enterprises with heavy pollution		

<p>Energy structure optimization</p> <p>Control of total coal consumption Optimization of coal consumption structure Improvement of coal quality Improvement of energy efficiency</p>	<p>Elimination of yellow-label (high-polluting) vehicles Improvement of fuel quality (diesel & gasoline) Strict standards for emissions of new motor vehicles Vehicle population and use restrictions Sales of New Energy Vehicles</p> <p>Motor vehicle pollution prevention and control</p>
<p>Industrial atmospheric pollution control</p> <p>Elimination of small and inefficient coal-fired boilers Desulfurization, nitrogen oxides controls, and particulate controls control of key sectors Control of volatile organic compounds Vapor recovery</p>	<p>Heavy-pollution weather warning</p> <p>Real-time warning issuance Building of emergency response plan system</p>

1.2 Pre-Evaluation Case Analysis-Based on the Beijing-Tianjin-Hebei Region

1.2.1 Summary of Measures in the Action Plan

The measures for the Beijing-Tianjin-Hebei Region in the *Action Plan* were mainly from the following several documents: the *Air Pollution Prevention and Control Action Plan*, the *Detailed Rules for the Implementation of the Air Pollution Prevention and Control Action Plan in the Beijing-Tianjin-Hebei Region and Surrounding Areas*, the *Action Plan of Beijing for Clean Air from 2013 to 2017*, the *Action Plan of Tianjin for Clean Air*, and the *Plan of Hebei for the Implementation of the Air Pollution Prevention and Control Action Plan*. These measures could be classified into two categories: structural adjustment measures and end-of-pipe control measures. Structural adjustment measures aim to reduce emissions from the front-end; and end-of-pipe control measures refer to the application and upgrading of end-of-pipe control technologies.

Energy structural adjustment is a prominent policy in the Ten Measures. Figure 1-2 shows projections of energy consumption in the Beijing-Tianjin-Hebei Region in 2017. By 2017, coal consumption in Beijing-Tianjin-Hebei shall be reduced by 63 million tons compared to 2012 according to the Ten Measures, specifically, 13, 10 and 40 million tons for Beijing, Tianjin and Hebei, respectively. In 2017, the proportion of coal in total energy consumption will be reduced to 65% or below and coal will be

replaced by taking such measures as gradual increase in the percentage of electricity from other regions, increase in natural gas supply, and increased use of non-fossil energy. Industrial restructuring is another important measure. By 2017, the Beijing-Tianjin-Hebei Region plans to eliminate outdated production capacity of cement of 70 million tons and steel production capacity in Hebei is to be reduced by 60 million tons compared to 2012.

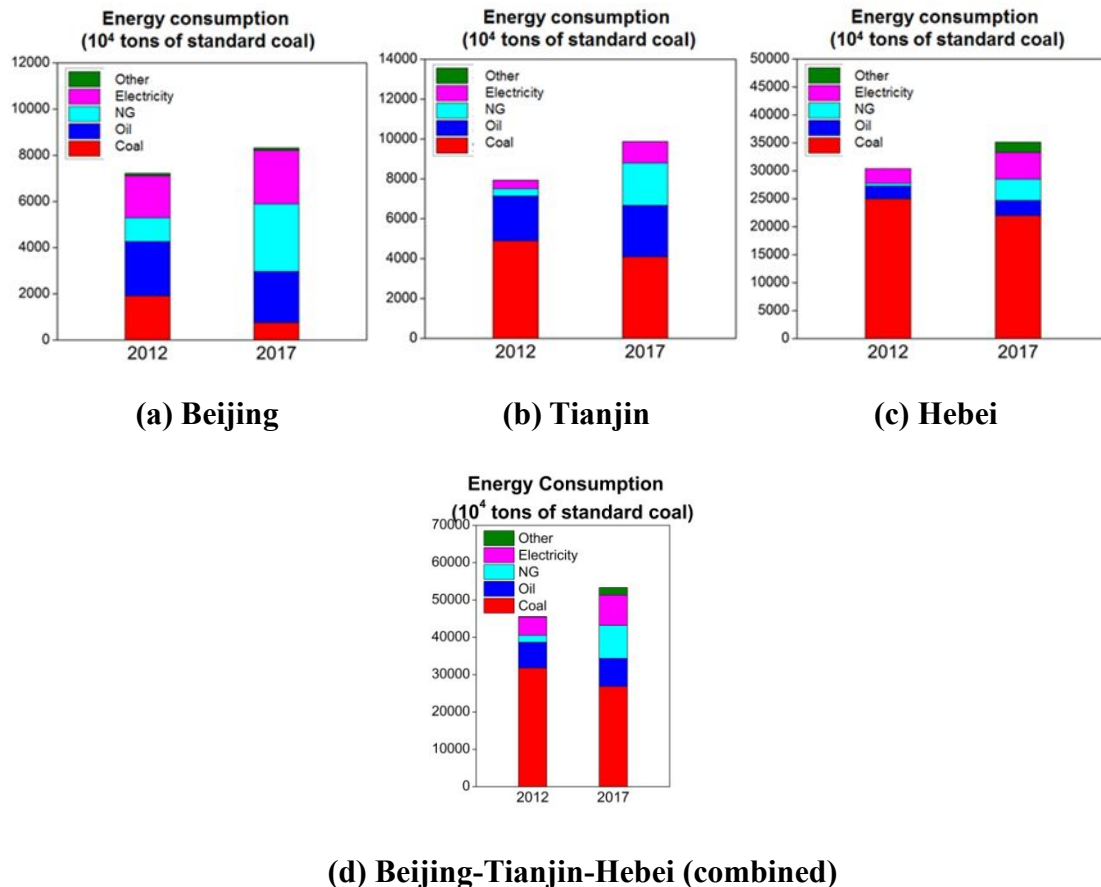


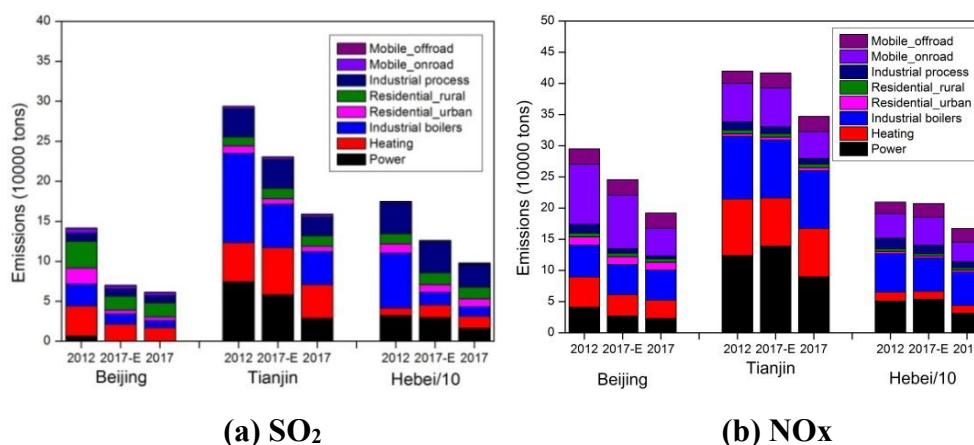
Figure 1-3 Projections of energy consumption in the Beijing-Tianjin-Hebei Region

The Ten Measures put forward a series of end-of-pipe control measures for accelerating the projects of desulfurization, nitrogen oxides controls, and particulate controls. All iron and steel mills shall install desulfurization technologies on sintering operations. Coal-fired boilers with capacity of 20 t/h (1 t/h=0.73 MW) or above shall use desulfurization technologies or techniques. Coal-fired units except circulating fluidized bed boilers shall install nitrogen oxides controls technologies. Precalciner cement kilns shall implement the technical transformation to low NO_x burners and install end-of-pipe nitrogen oxides controls technologies. Existing de-dusting facilities of coal-fired boilers and industrial kilns shall be upgraded. Control over vehicle emissions shall be continuously tightened. In 2015, the Beijing-Tianjin-Hebei Region will implement the China 5/V vehicle emission standard; Beijing plans to implement a stricter China 6/VI vehicle emission standard in 2016. It is further recommended that

China's three developed regions including the Beijing-Tianjin-Hebei Region implement China 6/VI in 2018 as fuels with a maximum sulfur content of 10 ppm will be mandatory across the entire country by the end of 2017.³

1.2.2 Evaluation of Emission Reduction Effects of Air Pollutants

The emission inventory of the base year (2012) is based on the Multi-resolution Emission Inventory for China (MEIC)⁴ developed by Tsinghua University and the emission inventory of the target year (2017) is quantified on the basis of the emission inventory of the base year and in accordance with the Ten Measures and the projection of energy consumption and penetrations of control technologies. The emissions of SO₂, NO_x, PM_{2.5} and VOCs of the Beijing-Tianjin-Hebei Region in 2017 are estimated to be 1.395 million, 2.212 million, 0.902 million, and 1.999 million tons, which are projected to decline by 32%, 21%, 24%, and 6%, respectively, compared with 2012 levels (see Figure 1-4). Hebei contributes the most in the emission reduction of pollutants of the Beijing-Tianjin-Hebei Region and it accounts for 71%, 71%, 74%, and 45% of emission reduction of SO₂, NO_x, PM_{2.5}, and VOC in the Beijing-Tianjin-Hebei Region; and the emission reduction rate of Beijing is the largest because it implements relatively stricter control measures.



³ As China's vehicle population continues to grow rapidly and as it increasingly dominates the new vehicle market, China should consider also taking a leadership role in the development of clean and efficient vehicle requirements. For example, California and the US EPA recently adopted standards for new cars that are 70% cleaner than Euro 6/VI requirements in addition to mandating longer in-use vehicle durability performance. In the future, China should consider not only adopting similar limits but also becoming the leader in pushing the clean vehicle technology envelope.

⁴ <http://www.meicmodel.org>

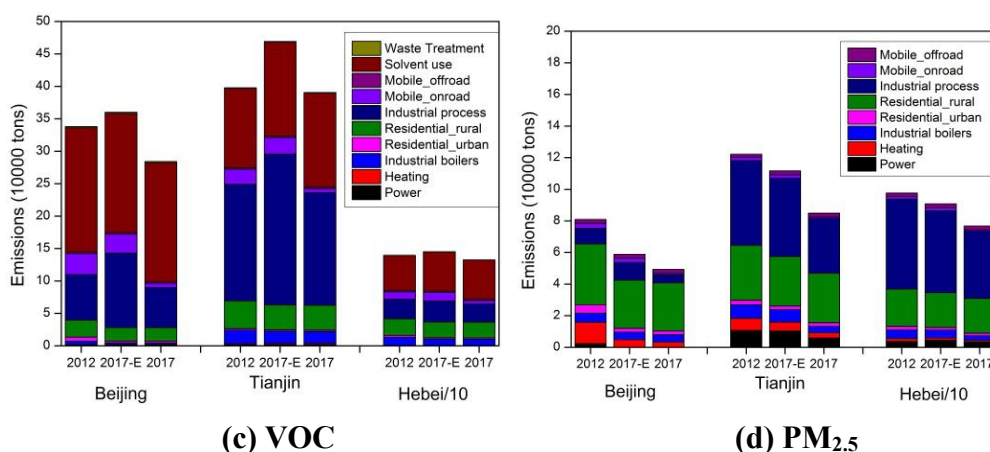


Figure 1-4 Emissions of key pollutants in the Beijing-Tianjin-Hebei Region in 2012 and 2017

The most effective control measures for SO₂ emission reductions are energy structure adjustment measures (contributes 41% of reductions) followed by desulfurization in the power sector (24%); the most effective control measures for NO_x emission reductions are nitrogen oxides controls in the power sector (46%) followed by reductions from vehicles (20%) and energy structure adjustment measures (19%); the most effective control measures for primary PM_{2.5} emission reductions are upgrading of dust collectors in the steel industry (29%) followed by energy structure adjustment measures (20%).

1.2.3 Evaluation of Air Quality Improvement Effects

To assess air quality improvement effects in the Beijing-Tianjin-Hebei Region under the Ten Measures, two air quality simulations was conducted based on the base year (2012) emission inventory and the target year (2017) emission scenario under the Ten Measures by using the Community Multiscale Air Quality (CMAQ)⁵ model. According to the simulated results (Figure 1-5), after the implementation of the Ten Measures, the annual average concentration of PM_{2.5} in Beijing, Tianjin and Hebei will be reduced to 65.8 μg/m³, 91.6 μg/m³, and 96.3 μg/m³ in 2017 from 88.3 μg/m³, 112.7 μg/m³, and 112.9 μg/m³ in 2012, declines of 25.6%, 18.7%, and 14.7%, respectively. The declines of the PM_{2.5} concentration in the Beijing-Tianjin-Hebei Region is remarkable, but there are still risks of failing to reach the target concentration reduction of 25% in 2017 in some areas in Tianjin and Hebei. In the decrease of the concentration of PM_{2.5}, sulfate, elemental carbon, organic components and other components make the largest contributions; nitrate makes relatively smaller contributions and its concentration even slightly increases, which is related to the nonlinear chemical reaction. The emission reduction measures of SO₂ and primary PM_{2.5} play great roles in the decline of the PM_{2.5} concentration. These effective measures include significant reductions in the use of coal in the Beijing-Tianjin-Hebei

⁵ <http://www.cmascenter.org>

Region, installing of desulfurization systems and controls of primary PM_{2.5} in steel and cement industry in Tianjin and Hebei. Great efforts shall be made to control emissions of NO_x, VOC, and NH₃ and collaborative emission reduction of PM_{2.5} by multiple components shall be implemented. Not only will these measures improve both PM_{2.5} and ozone air quality, they will also reduce short lived climate forcers such as black carbon and tropospheric background ozone as well as carbon dioxide, the most important greenhouse pollutant.

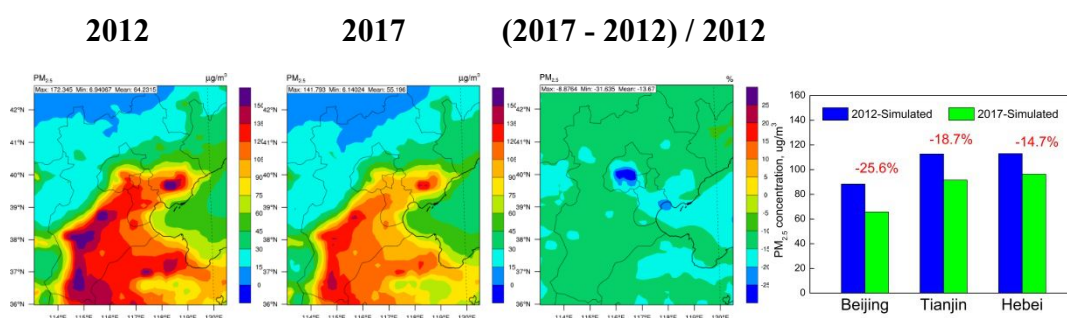


Figure 1-5 Simulations of spatial distribution of the annual average concentration of PM_{2.5} in the Beijing-Tianjin-Hebei Region

1.2.4 Strengthened Control Measures and Proposals for Improvement

The current policies have obvious effects on the control of SO₂, but have limited effects on the emission reduction of NO_x and primary PM_{2.5} and weak control over VOC and NH₃. The measures for emission reduction of SO₂ and PM_{2.5} have obvious effects on the decline of the PM_{2.5} concentration in the Beijing-Tianjin-Hebei Region, and Tianjin and Hebei shall pay special attention to control emissions of primary PM_{2.5} so as to ensure that the environmental objectives as made in the Ten Measures are reached. At the same time, great efforts must be made to the control over NO_x, VOC, and NH₃ and the collaborative emission reduction of PM_{2.5} by multiple components must be implemented.

The residential sector and industrial processes (steel, cement, and coking) make the greatest contributions to the emission of primary PM_{2.5}. Industrial processes and solvent use are primary sources of VOCs and fertilizer use and livestock are important sources of NH₃ emissions. In the Ten Measures, it is difficult to quantify measures for the residential sector as well as VOC and NH₃, and such measures must be subject to further elaboration and exploration.

1.3 Follow-up Evaluation Case Analysis-based on the Beijing-Tianjin-Hebei Region

1.3.1 Performance Indicator of Air Quality Improvement

Figure 1-6 shows changes in the air quality of the Beijing-Tianjin-Hebei Region in the

first quarter of 2014 compared with that in the same period of 2013. The average quarterly concentration of PM_{2.5} and the days with serious or above pollution in most heavily-polluted cities in 2014 dropped significantly compared with those in 2013, which showed that the Action Plan has achieved some control effects; however, in such regions with relatively clean air as Zhangjiakou City and Chengde City, the concentration of PM_{2.5} rebounded to some extent, which was possibly related to changes in the meteorological conditions. The interference of meteorological factors shall be removed during evaluation. Therefore, it is proposed that the moving average method (for example, the moving average values in three years) should be adopted during evaluation so as to emphasize the role of man-made emission reduction.

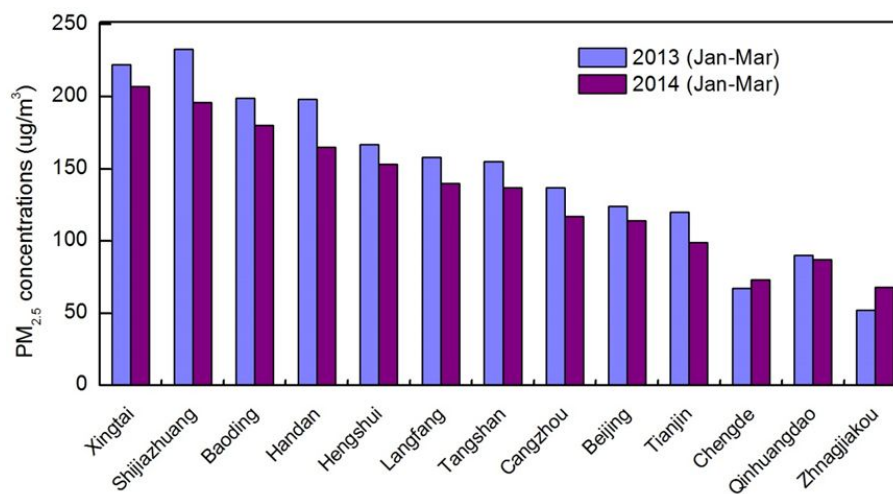


Figure 1-6 Changes in the concentration of PM_{2.5} in the Beijing-Tianjin-Hebei Region in the first quarter of 2014 compared to that in the same period of 2013⁶

1.3.2 Indicators of Control Strategy Implementation

Ranking of the various control measures must be based on their importance in terms of their effects on air quality improvements. Indicators of assessment tasks shall be quantitative. For example, 54% of primary PM_{2.5} emissions in the Beijing-Tianjin-Hebei Region come from the industrial sectors, in which 46%, 23% and 18% of industrial emissions are from the steel, building materials and coke industry. Considering that these industries greatly contribute to the emission of PM_{2.5} in the Beijing-Tianjin-Hebei Region, the ranking of control measures in these industries are correspondingly high.

⁶ Data source: National Ambient Air Quality Monitoring Network

1.4 Policy Proposals

1.4.1 Establishment of Pre-evaluation and Annual Evaluation Systems and Adjustment of Measures on the Basis of the Evaluation

Through the establishment of pre-evaluation and annual evaluation systems, annual measures can be adjusted on the basis of the evaluation so as to ensure that expected control targets are achieved. It is proposed that pre-evaluation indicators shall include: decreased concentration percentage of PM_{2.5} and decreased days with heavy pollution; and annual evaluation indicators shall include: annual reduction of the PM_{2.5} concentration (multi-years moving average), pollutant emission reduction, energy efficiency improvement, energy structure adjustment, and other completion progress of measures.

1.4.2 Establishment of Final Evaluation System

The final evaluation system provides a technological base for the continuous improvement of air quality. Indicators incorporated into the final evaluation shall include: decrease percentage of the concentration of PM_{2.5}, decreased days with heavy pollution, changes in economic and industrial structure, and human health benefits. Improvements in air quality should result in such health indicators as reduced asthma attacks in school children, and reduced hospital admissions due to a variety of respiratory and cardiovascular diseases.

1.4.3 Further Intensifying and Improving the Implementation Plans of Key Regions for the Action Plan

Pre-evaluation case results show that the concentration of PM_{2.5} in the Beijing-Tianjin-Hebei Region after the implementation of the Ten Measures has fallen remarkably; however, Tianjin and Hebei still have risks of failing to reach the target concentration reduction of 25% in 2017. All localities are advised to refine the Ten Measures, specify and quantify various control measures one by one, and implement the Ten Measures to reduce actual emissions. At the same time, more efforts shall be made to control NO_x, VOCs, and NH₃, each of which contributes to ambient levels of PM_{2.5}.

2. THE THIRTEENTH FIVE-YEAR PLAN AND THE GOAL AND ROADMAP OF AIR POLLUTION PREVENTION IN 2030

2.1 Prediction of Social and Economic Development From the Thirteenth Five-Year Plan Period to the Year 2030

Researchers used appropriate mathematical models to make prediction on the development trends of population, economy, energy, industry and transportation. In

this study, the BAU (Business as usual) scenario stuck to the existing policies, with enforcement of them staying as usual, and no new polices of energy conservation and emission reduction are adopted. Representative policies include: firstly, gross domestic production (GDP) will reach the level of moderately developed countries by 2050, which means the per capita GDP is 20,000 dollars; secondly, CO₂ emissions per-unit GDP will be reduced by 40%-45% compared with the year of 2005; thirdly, emission standards issued for power plant, cement, industrial furnace and motor vehicles before 2010 will continue to be put into force. Based on the above assumptions, under the BAU scenario, the researchers forecast the economic development trends, industrial and energy structures, urbanization rates and transportation modes and trends during the 13th Five-Year plan period and continuing up to 2030. Predictions are summarized in Table 2-1:

Table 2-1 Predictions for economic and social development from the 13th Five-Year to 2030 (BAU scenario)

Item	2010	2020	2030
GDP (2005 price)/billion yuan	31165	65741	117718
Population /billion	1.340	1.440	1.474
Urbanization rate /%	49.7	58.0	63.0
Electricity production/TWh	4205	6690	8506
Percentage of coal-fired power /%	75	74	73
Crude steel output /Mt	627	770	770
Cement output /Mt	1880	2400	2450
Vehicle held per thousand people	58.2	191.2	380.2
Share of new and renewable energy / % ^a	7.5	8.3	8.9
CO ₂ emission per GDP/(t/ten thousand yuan)	2.67	1.82	1.20

^a Includes hydropower, solar energy, wind electricity, ocean energy and nuclear power, etc. No utilization of biomass.

2.2 Medium-term Goal of Air Pollution Prevention in the Thirteenth Five-year Plan and the Long-term Goal up to 2030

Setting the medium and long term goal to prevent air pollution is based primarily on relevant plans and reports like the *Clean Air Action Plan* by the State Council, *Air Quality Guidelines* (update version in 2005) by WHO, and the *Macro Strategy Research on China's Environment* by Chinese Academy of Engineering and Ministry of Environmental Protection. Therefore, goals for controlling and preventing air pollution adapted to china's situation have been put forward, as given in Table 2-2:

Table 2-2 Medium and long term goals for control and prevention of air pollution in China

Year	National goal	Goals in key regions
2017	Reducing PM ₁₀ of cities at prefecture level and above by over 10% compared with the year of 2012	Reducing PM _{2.5} in Beijing-Tianjin-Hebei Region, Yangtze River Delta and Pearl River Delta PM _{2.5} by 25%, 20% and 15% respectively, and annual concentration of PM _{2.5} in Beijing should be reduced to 60 µg/m ³
2020	Concentration of PM _{2.5} in cities at prefecture level and above should be reduced by over 15% compared with that in 2012.	Concentration of PM _{2.5} in Beijing-Tianjin-Hebei Region and Yangtze River Delta should be reduced by over 35% and 30% respectively, and annual concentration of PM _{2.5} in Pearl River Delta should reach the standards, annual concentration of PM _{2.5} in Beijing should be reduced to 50 µg/m ³
2030	Annual concentration of ambient PM _{2.5} in most cities at prefecture level and above should meet the standard (GB3095-2012)	

2.3 The Roadmap for Controlling and Preventing Air Pollution in Medium and Long Term

2.3.1 Scenario Design

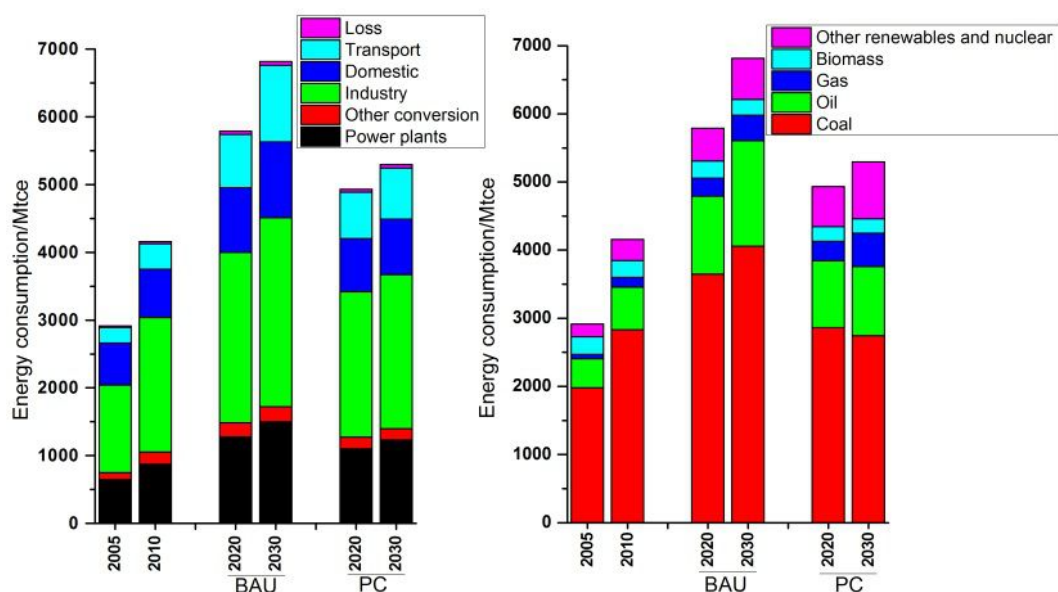
The researchers have developed different scenarios to prevent pollution in the medium and long term using an energy technology and pollution control model framework developed by Tsinghua University⁷. This research, based on the BAU, firstly designed a scenario for the sustainable energy policy (PC). Then, we set up three pollution-controlling strategies, namely the baseline strategy ([0] strategy), the progressive strategy ([1] strategy), and the maximum feasible reduction strategy ([2] strategy). After combining these two energy scenarios with three pollution-controlling strategies, six different pollution-controlling scenarios come into being, namely BAU [0], BAU [1], BAU [2], PC [0], PC [1], and PC [2]. Definitions of these scenarios are given in Table 2-3:

⁷ Zhao, B., et al. NO_x emissions in China: historical trends and future perspectives. *Atmospheric Chemistry and Physics*, 2013, 13: 9869-9897.

Table 2-3 Names and definitions of these six scenarios

Energy Scenario	Energy Scenario Definition	Pollution Control Strategy	Pollution Control Strategy Definition	Emission scenario
Business as Usual (BAU)	Current policies and compliance (till the end of 2010) are assumed, especially that CO ₂ intensity will be 40%-45% lower in 2020 than that of 2005.	Reference ([0])	Current policies and current implementation status (till the end of 2010).	BAU[0]
		Progressive ([1])	New pollution control policies are implemented from 2011 to 2015, representing progressive approach towards future environmental policies after 2016.	BAU[1]
		Maximum Feasible Reduction ([2])	Technically feasible control technologies are fully applied and regarded as the maximum feasible reduction strategy	BAU[2]
Alternative Policy Scenario (PC)	New energy-saving policies are introduced and enforced more stringently, including life style changes, structural adjustment and energy efficiency improvement.	Reference ([0])	Current policies and current implementation status (till the end of 2010).	PC[0]
		Progressive ([1])	New pollution control policies are implemented from 2011 to 2015, representing progressive approach towards future environmental policies after 2016.	PC[1]
		Maximum Feasible Reduction ([2])	Technically feasible control technologies are fully applied and regarded as the maximum feasible reduction strategy	PC[2]

2.3.2 Results of the Energy Scenarios



^a Biomass includes traditional burning material, methane, bio-fuel and biomass power

^b Other renewable energy resources include hydropower, solar energy, wind and ocean energy

Figure 2-1 Prediction on China's total energy consumption

Under the circumstances of BAU and PC scenarios, total energy consumed in China will increase from 4,159 Mtce in 2010 to 6,817 Mtce and 5,295 Mtce respectively in 2030. Coal has dominated the energy consumption, but its proportion will be reduced from 68.1% in 2010 to 59.5% and 51.8% in BAU and PC scenarios, respectively, in 2030. However, the proportion of crude oil will increase; this is mainly resulting from the continuous increase in the vehicle population. In terms of the PC scenario, due to the implementation of the sustainable energy strategy, the proportions of natural gas, clean utilization of biomass, nuclear power and other renewable energy resources are higher than that in the BAU scenario. Energy consumption of different resources is given in Figure 2-1.

2.3.3 Emission Control Scenarios

2.3.3.1 Design of emission control scenarios

BAU [0]/ PC [0] is mainly based on the current policy and standard.

For the BAU [1]/ PC [1] scenario:

- For the power sector implementation of the *National 12th Five-Year Plan* for

Environmental Protection and Emission Standard of Air Pollutants for Thermal Power Plants (2011) is assumed.

- For the industrial sector, it is assumed that the *National 12th Five-Year Plan for Environmental Protection* and relevant emission standards are put into practice from 2011 to 2015, and new polices come into being gradually after 2015.
- For the residential sector, it is assumed that high-efficiency particulate controls and low-sulfur coal will be adopted gradually; the total proportion of them will reach 20% in 2020 and 40% in 2030. In addition, this research has taken the application of advanced stoves and advanced biomass stoves into consideration.
- For the transportation sector, it is assumed that the vehicle ownership per thousand people will decrease from 380 to 325, to properly control the total vehicle population in cities. This scenario also assumes that the existing standards in Europe will be carried out in China step by step, and the interval of carrying out these two different standards should stay the same as or slightly shorter than in Europe.
- For the solvent use sector, we assume that the new emission standards of NMVOC (equivalent to the European standards of 1999/13/EC and 2004/42/EC) will be issued and carried out in key provinces during the 12th Five-Year Plan period, and they will be issued and carried out in the rest of the provinces during the 13th Five-Year Plan period. Later, the emission standards of NMVOC will become even stricter.

BAU [2]/ PC [2] assumes that China takes full advantage of the most advanced emission reduction technology available. Flue gas desulfurization (FGD) technology, low-nitrogen combustion (LNB) + selective catalytic reduction (SCR) technology, and particulate control will be fully applied for the power and industrial sectors. Apart from these control technologies, we will also promote advanced coal/biomass stoves in the residential sector and prohibit open burning with stronger enforcement. We will also accelerate our efforts to eliminate high-emission vehicles, and make sure all vehicles in use meet the most stringent emission standards of Europe by 2030.

2.3.4 Prediction of Atmospheric Pollutants Emissions

Emission of atmospheric pollutants from 2005 to 2030 is given in Figure 2-2. In 2010, the anthropogenic emissions of SO₂, NO_x, PM₁₀, PM_{2.5} and NMVOC in China were estimated to be 24.4 Mt, 26.1 Mt, 15.8 Mt, 11.8 Mt, and 22.9 Mt, respectively. Under current legislation and current implementation status (BAU[0] scenario), NO_x, SO₂, PM_{2.5}, and NMVOC emissions in China are estimated to change by 36%, 26%, -8%, and 27% respectively by 2030 from 2010 levels. Assuming enforcement of new energy-saving policies (PC [0] scenario), emissions of NO_x, SO₂, and PM_{2.5} in China are expected to decrease by about a third while NMVOC by 16% by 2030 compared with the BAU [0] scenario. The implementation of the “progressive” end-of-pipe

control measures (reflected by the difference between PC [1] and PC [0]) is expected to lead to about 55%, 41%, 31%, and 29% reductions of the baseline emissions of NO_x, SO₂, PM_{2.5}, and NMVOC, respectively. With the full implementation of maximum feasible reduction measures (PC [2] scenario), China's emissions of NO_x, SO₂, and PM_{2.5} would account in 2030 for only a quarter and NMVOC for a third of the baseline case (BAU [0] scenario).

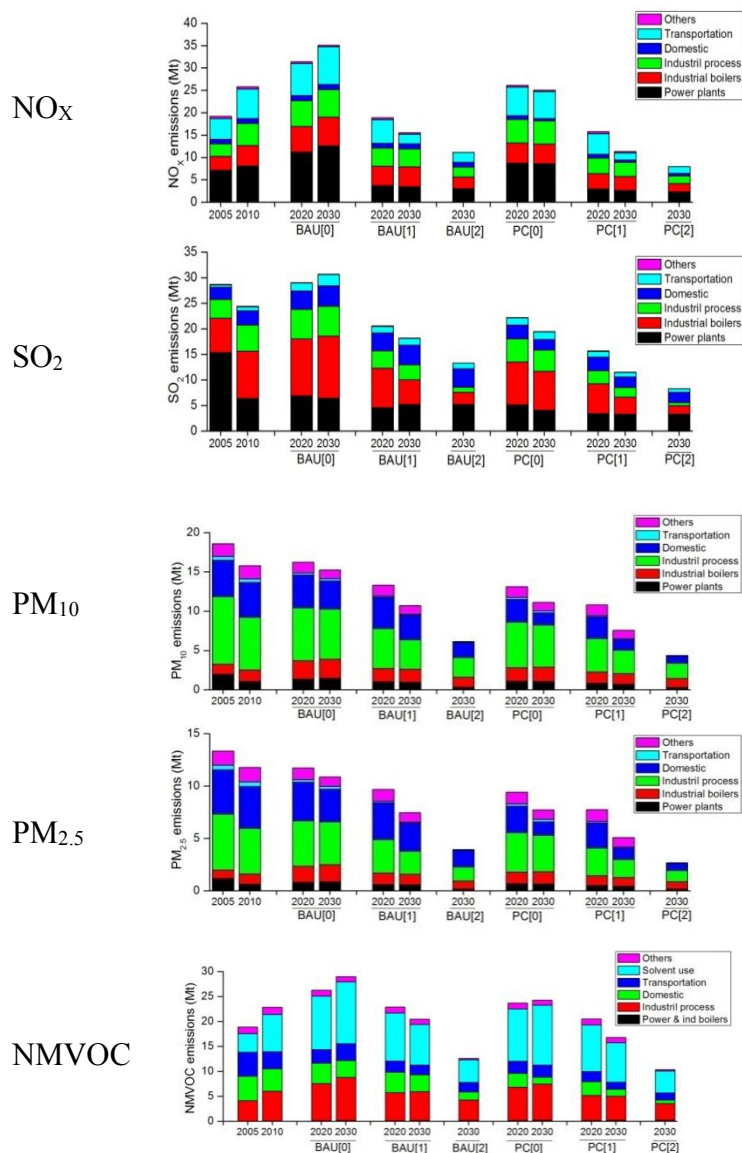


Figure 2-2 Air pollutant emissions from 2005 to 2030

2.3.5 Air Pollution Simulation and Emission Reduction to Achieve the Air Quality Target

In this study, the scientists used the CMAQ4.7.1 model developed by US EPA to simulate China's atmospheric conditions and assess air quality impacts of different emission levels. Based on simulation and experiment results, the scientists conducted

a statistical analysis and developed a response surface methodology (RSM) for emissions and pollutant concentrations. This allows them to rapidly estimate the impact different emission levels from different source categories can have on atmospheric pollutant concentrations. In addition, the RSM makes it possible to quickly assess different control measures for different regions to ensure that pollutant concentrations in target provinces and cities can reach the standards. Results of the analysis show that in 2017 China needs to reduce the national SO₂, NO_x, PM_{2.5} and VOC emissions by at least 24%, 15%, 16%, and 2%, respectively, and the increase of NH₃ emissions shall be limited to less than 10%, compared with that in 2012. By 2030, China needs to reduce national SO₂, NO_x, PM_{2.5} and VOC emissions by at least 52%, 65%, 57%, and 36%, respectively, and NH₃ emissions shall also decrease gradually. China needs to intensify the emission control in heavily polluted areas. For example, the SO₂, NO_x, PM_{2.5}, and VOC emissions in Beijing-Tianjin-Hebei Region shall be reduced by at least 32%, 25%, 30%, and 11%, respectively, by 2017 on the basis of 2012 levels, and NH₃ emissions can only increase slightly. By 2030, the SO₂, NO_x, PM_{2.5}, VOC and NH₃ emissions in Beijing-Tianjin-Hebei Region shall be reduced by at least 59%, 72%, 70%, 44%, and 21%, respectively. The emission targets for major pollutants in all provinces are given in Table 2-4.

Table 2-4 Target emission ratio for major pollutants in all provinces, taking 2012 as the benchmark (namely 1.0)

Pollutants	Primary PM _{2.5}		SO ₂		NO _x		NH ₃	
	2017	2030	2017	2030	2017	2030	2017	2030
The country	0.85	0.39	0.85	0.56	0.86	0.37	1.10	1.00
Beijing	0.65	0.43	0.62	0.48	0.66	0.26	1.10	0.65
Tianjin	0.70	0.33	0.70	0.45	0.69	0.28	1.10	1.00
Hebei	0.71	0.37	0.72	0.63	0.71	0.39	1.10	1.00
Shanxi	0.80	0.31	0.79	0.56	0.88	0.36	1.10	1.00
Inner Mongolia	0.82	0.35	0.85	0.67	0.89	0.36	1.10	1.00
Liaoning	0.92	0.33	0.99	0.62	0.93	0.36	1.10	1.00
Jilin	0.86	0.36	0.81	0.58	0.75	0.36	1.10	1.00
Heilongjiang	0.78	0.29	0.77	0.55	0.85	0.35	1.10	1.00
Shanghai	0.75	0.43	0.82	0.58	0.89	0.34	1.10	1.00
Jiangsu	0.77	0.38	0.88	0.58	0.86	0.34	1.10	1.00
Zhejiang	0.71	0.34	0.85	0.56	0.85	0.31	1.10	1.00
Anhui	0.90	0.42	0.88	0.66	0.87	0.42	1.10	1.00
Fujian	0.93	0.39	0.85	0.48	1.06	0.44	1.10	1.00
Jiangxi	0.92	0.33	0.80	0.50	0.91	0.42	1.10	1.00
Shandong	0.74	0.33	0.79	0.45	0.89	0.34	1.10	1.00
Henan	1.00	0.35	0.92	0.56	0.92	0.40	1.10	1.00
Hubei	0.84	0.40	0.65	0.45	0.76	0.35	1.10	1.00
Hunan	0.89	0.45	0.86	0.54	0.88	0.42	1.10	1.00

Guangdong	0.81	0.43	0.93	0.52	0.93	0.36	1.10	1.00
Guangxi	1.02	0.58	1.08	0.54	0.87	0.41	1.10	1.00
Hainan	0.86	0.52	1.09	0.49	0.87	0.36	1.10	1.00
Chongqing	0.92	0.45	0.86	0.54	0.83	0.41	1.10	1.00
Sichuan	0.89	0.36	0.84	0.51	0.85	0.37	1.10	1.00
Guizhou	1.06	0.71	1.05	0.94	0.89	0.46	1.10	1.00
Yunnan	0.83	0.46	0.95	0.54	0.83	0.39	1.10	1.00
Tibet	0.77	0.35	0.85	0.62	0.78	0.33	1.10	1.00
Shaanxi	0.86	0.29	0.86	0.61	0.83	0.36	1.10	1.00
Gansu	0.88	0.34	0.95	0.64	0.89	0.40	1.10	1.00
Qinghai	0.75	0.27	0.70	0.49	0.72	0.32	1.10	1.00
Ningxia	0.85	0.32	0.83	0.49	0.84	0.33	1.10	1.00
Xinjiang	0.87	0.38	0.81	0.43	0.81	0.34	1.10	1.0

2.4 Medium and Long Term Strategies For Controlling and Preventing Air Pollution

After determining the goals of emission reductions for different regions, sectors and pollutants, we use the technical model of energy and pollutant emission to further analyze the possible technical measures to achieve the above goals.

In terms of industrial restructuring and energy consumption, the percentage of coal accounting for the total energy consumption must be no more than 65% in 2017. Beijing-Tianjin-Hebei Region, Yangtze River Delta and Pearl River Delta will endeavor to achieve negative growth in coal consumption by means of increasing power transmission from other regions and natural gas supply, and using non-fossil energy to replace coal. Apart from keeping what is necessary, urban areas should eliminate coal-fired boilers with capacity of 10t/h or less, and forbid the building of coal-fired boilers with capacity of no more than 20 t/h. In industrial cluster districts like the chemical industry, paper making, tanning and pharmacy, must focus on constructing co-generation units to eliminate scattered coal-fired boilers. In Beijing-Tianjin-Hebei Region, Yangtze River Delta and Pearl River Delta, China must closely restrict vehicle ownership and use, and speed up upgrading and transforming the petroleum processing companies.

In 2030, besides the above measures, China must close down more facilities with outdated capacity, compress facilities with excess capacity and strive to develop energy-saving and environment-friendly industries. China must promote cleaner production in agriculture, industry, construction and the business service sector; to reduce the energy consumption and emissions of air pollutants. China should promote the cascaded utilization of energy and construction circular economy.

As for end-of-pipe emissions, China must implement the following technical measures in order to achieve the air quality targets.

2.4.1 Power Sector

Newly-built power plant must be equipped with low NO_x burners (LNB) and selective catalytic reduction (SCR), selective non-catalytic reduction (SNCR), or hybrid SCR/SNCR devices. The existing generator sets with capacity of more than 300 MW should install and operate SCR before 2015, and generator sets with capacity less than 300 MW should be gradually equipped with SCR after 2015. High-efficiency particulate controls, such as fabric filters, should be promoted gradually and should be used universally in key regions before 2030.

2.4.2 Industrial Enterprises

As to SO₂, flue gas desulfurization (FGD) will be put into use on a large scale. As to NO_x, newly-built industrial furnaces will be equipped with LNB and the existing boilers shall have the transformation to LNB from 2012 to 2017, and most of the boilers will be equipped with LNB by 2020. As to PM, electrostatic precipitators (ESP) and high efficiency particulate controls will gradually replace the inefficient wet PM scrubbers (WET).

2.4.3 Residential Sector and Open-Burning of Biomass

Adjustments of energy structure will play a key role in reducing emission in residential sector. In terms of end-of-pipe control, high efficiency particulate controls and coal with low sulfur will be utilized gradually in residential sector. In addition, China shall consider the use of advanced boilers and biomass stoves (such as restructuring combustion mode and using catalytic stoves), and take measures to forbid open burning.

2.4.4 Transport Sector

By the end of 2017, gasoline and diesel fuel for vehicle use that meet China 5/V standards will be provided nationwide; in the three key regions China 5/V fuels will be introduced even earlier, by the end of 2015. China must control the emissions from new vehicles; east China must implement the China 5/V emission standards ahead of the national schedule; China must eliminate the production of low speed agricultural trucks and substitute modern light-duty diesel vehicles meeting national emissions standards instead. Compliance with vehicle emissions standards must be greatly improved by strengthening the conformity of production enforcement and enhancing the oversight on in-use compliance. In addition, China must deal with high-emission vehicles by scrapping all the light vehicles produced before the implementation of the first-stage (China 1) national standards, and launch a pilot project to either scrap heavy-duty diesel vehicles with high emissions (i.e. produced before China III was implemented) or retrofit them with high performing diesel particulate filters (DPFs). China must vigorously develop energy-saving and new energy vehicles (like hybrid

vehicles, plug-in hybrid vehicles, battery electric vehicles and natural gas vehicles) for public transportation vehicles with high annual mileage (like taxis and buses). China must implement the China III emission standards for non-road machines in the year 2015.

From 2018 to 2030, except for the three key regions which will proceed on a quicker schedule, China shall establish a sound regulatory system along with a good enforcement capability for the rest of China. By the end of 2019, the gasoline and diesel fuel for vehicle use that meet China 6/VI standards will be provided nationwide, and the three key regions should achieve this goal in advance, to cut the evaporation of gasoline significantly. China must properly control the total vehicle population in cities by various means including a lottery system such as used in Beijing or an auction system as used in Shanghai. China must also implement the China 5/V emission standards for new vehicles nationwide in 2018, and phase in the China 6/VI emission standards for new vehicles nationwide in 2020. China 6/VI emission standards for new cars, trucks and buses must be introduced in 2018 in the three key regions; Beijing will introduce China 6/VI standards even earlier. China must actively develop the energy-conserving and new energy vehicles in the private vehicles; China must introduce the China IV emission standards for non-road machines in the year 2020, and unify the fuel standards for road vehicles and non-road machines step by step, to ensure that the emissions from non-road machines are at the same level as that from on-road motor vehicles. When it comes to formulating national emission standards for inland vessels and domestic flights, China should base requirements on air quality levels near the airports, ports and waterways in China, transport of pollutants from these localities, and the health and environmental damages which result, and also promote the use of cleaner fuel for ocean-going vessels.

2.4.5 The Utilization of Solvent

During the 12th Five-Year Plan, the new emission standards of NMVOC shall be issued and implemented in key provinces. While during the 13th Five-Year, the rest of the provinces shall follow the example of those key provinces. Later, emission standards of NMVOC will become stricter.

2.4.6 Agricultural Sector

Fertilizer utilization and livestock farming are important sources of NH₃ emissions. Improving fertilizer application structure and reducing the emission factor of urea are important in reducing emission in fertilizer utilization. For livestock emission reduction, the application of low-nitrogen feed, breeding house renovation, quick waste collection and mulch compost will be effective.

Conclusions Regarding Medium and Long Term Strategies

In short, to improve the ambient air quality and achieve the goals of controlling emissions of major air pollutants in stages, China should adhere to the coordinated, integrated and joint strategy. In controlling pollutants, China should exercise coordinated control over SO₂, NO_x, PM, NH₃ and NMVOC; in controlling pollution sources, China should attach importance to industrial pollution sources, area pollution sources and mobile pollution sources; and in making control strategies, China should make joint measures to connect regions and cities.

2.5 Policy Suggestion

2.5.1 Identify Medium and Long Term Targets for Control and Prevention of Air Pollution

China should identify the medium and long term targets to control and prevent air pollution: in 2020, concentration of PM_{2.5} in cities at prefecture level and above should be reduced by over 15% compared with that in 2012. Concentration of PM_{2.5} in Beijing-Tianjin-Hebei Region and Yangtze River Delta should be reduced by over 35% and 30% respectively, and annual concentration of PM_{2.5} in Pearl River Delta should reach the Chinese air quality standard; annual concentration of PM_{2.5} in Beijing should be reduced to 50 µg/m³. Annual concentration of ambient PM_{2.5} in most cities at prefecture level and above should meet the Chinese air quality standard (GB3095-2012).

2.5.2 Clean, Efficient and Sustainable Use of Coal

It is preferable to use coal in large-scale facilities with high-efficiency end-of-pipe control technologies; small-scale boilers and stoves should be phased out gradually, and district heating should be greatly promoted but with fully metered use.

China must make great effort to improve the energy efficiency of coal utilization. The average energy efficiency of coal-fired power plants should be increased from 36% in 2010 to 42% in 2030. The energy consumption per unit product of industrial coal-fired boilers, blast furnaces, cement production, coke ovens, and brick kilns is assumed to be 24%, 13%, 16%, 44%, and 27% lower, respectively, in 2030 compared with 2010.

Clean coal technologies should be encouraged. China should increase the proportion of coal washing. The import of high-ash and high-sulfur coal should be banned.

2.5.3 Speed up the Adjustment of Energy Structure; Increase the Use of Clean Energy

The total consumption of coal should be stringently restricted. By 2017, the share of coal in total energy consumption should be reduced to 65% or less, and Beijing,

Tianjin, the Yangtze River Delta, Pearl River Delta region should strive to achieve a negative growth of total coal consumption. By 2030, the proportion of the national coal consumption should account for no more than 50% of the total energy use.

China will speed up developing and exploiting clean energy to ensure that the total proportion of natural gas, nuclear and renewable resources (biomass not included) amounts to 25% of energy consumption. The supply of natural gas should be increased, and natural gas should satisfy the need of residential sector in priority. Hydro power, nuclear power, wind power, and solar power should be greatly promoted.

2.5.4 Strengthen the Coordinated Control on Multi-Sources and Multi-Pollutants

To improve the ambient air quality targets, China should adhere to the coordinated, integrated and joint strategies. That is to say: in controlling pollutants, China should exercise coordinated control over SO₂, NO_x, PM , VOCs and NH₃; in controlling pollution sources, China should attach importance to industrial pollution sources, area pollution sources and mobile pollution sources; and in making control strategies, China should make joint measures to connect regions and cities.

The recommended future emission reductions are as follows: On the basis of 2012 emissions, the national SO₂, NO_x, PM_{2.5} and VOC emissions should be reduced by at least 52%, 65%, 57%, and 39%, respectively, by 2030, and NH₃ should have a little decline. China should intensify the emission control in heavily polluted areas. For example, the SO₂, NO_x, PM_{2.5}, VOC and NH₃ emissions in Beijing-Tianjin-Hebei Region should be reduced by at least 59%, 72%, 70%, 44%, and 21%, respectively, by 2030 from the 2012 levels.

3. INTERNATIONAL EXPERIENCES OF COORDINATION MECHANISM FOR REGIONAL AIR POLLUTION MANAGEMENT

3.1 International Experience

3.1.1 Ambient Air Quality Standards, Action Plans, and Monitoring

Europe and the US establish science-based ambient air quality standards to adequately protect human health and the environment from excessive levels of pollution. Attainment of the standards is also required at hot spots where the public is exposed to pollution. Local and state/national authorities are given a timeframe to meet the ambient air quality standards. If an area fails to meet the ambient air quality standards, the relevant air quality authority is legally required to take actions to reduce pollution concentrations in an effort to bring the area into compliance with the standards. If an area fails to take sufficient action to meet ambient air quality standards, authorities can withdraw subsidies (e.g., highway construction funds in the US) provided by

national authorities.

Air Quality Plans (AQPs) [Europe] and State Implementation Plans (SIPS) [US] provide a comprehensive strategy for reducing emissions and pollution concentrations; AQPs and SIPs include among other items: (i) Analysis of source contributions, (ii) Pollution prevention and control policies, (iii) Schedules for implementing policies, (iv) Scientific and economic assessments to illustrate the potential emission reductions and their costs, (v) Emergency plans for severe air pollution episodes, and (vi) Implementation and enforcement resource adequacy demonstrations.

Europe and the US require comprehensive air quality monitoring networks to track progress toward attaining the ambient air quality standards.

In the US, EPA designates “nonattainment” areas – an area that includes one or more ambient monitors that are not attaining the standard, and nearby areas with emissions that contribute to the air quality problem. Europe has a similar procedure. Monitors are sited in different locations based on their measurement objectives – “background” stations, whether in urban or regional/rural areas, are placed in areas that are not affected by nearby sources (e.g., industrial areas or roadways); “traffic” and “industrial” stations are sited in hot spot areas (e.g., roadways) that represent the highest likely concentrations to which the general population may be exposed. Rigorous procedures to assure high data quality are set down.

Monitoring data are published and easily accessed by the public and interest groups; the public and interest groups can use the data to challenge air quality authorities in court if they believe the government is not adequately addressing the air pollution challenges.

In Europe, SO₂ and NO_x emissions have been reduced at roughly equal shares through (i) energy efficiency improvements (decoupling between GDP and energy consumption), (ii) changes in fuel input, i.e., substitution of coal by cleaner fuels, and (iii) dedicated end-of-pipe emission control measures, with strict enforcement mechanisms. Economic incentives have proven to be a very effective tool to encourage clean technologies. As a co-benefit, this triple approach has also led to a decline in CO₂ emissions.

3.1.2 Regional Air Quality Management

Europe and the US have spatially distributed emission reduction targets based on extensive measurements and modelling in an effort to determine the least cost approach to reducing emissions that cause or contribute to the ozone or PM_{2.5} problems.

European PM_{2.5} levels are significantly affected by NH₃ emissions, increasing the

prominence of NH₃ reductions in efforts to improve air quality.

European Member States must meet treaty obligations to limit pollution that contributes to downwind areas and adhere to national emission ceilings (i.e., total emission caps). European national emission ceilings are based on cost-effectiveness and distributional impacts. In addition, joint air quality planning cooperation is encouraged in the event of non-compliance with air quality standards due to transboundary pollution transport.

The US Clean Air Act requires upwind areas to prevent or control emissions that cause a downwind area to exceed the National Ambient Air Quality Standards. EPA worked with state governments and other stakeholders to create regional planning organizations (RPOs) to foster regional coordination and cooperation; RPOs were tasked to: (i) compile regional emission inventories, (ii) improve regional modeling capabilities, (iii) bolster monitoring programs, and (iv) build capacity for air quality management.

The US RPOs are independent organizations that facilitate regional coordination, but the legal forcing mechanisms within the US Clean Air Act (e.g., “Good Neighbor” provision, State Implementation Plan requirements) encourage participation and require action

The US focused many of the regional control programs on the power sector because the sector was responsible for a significant portion of total emissions and provided the most cost-effective emission prevention and control opportunities; other sectors (e.g., transportation) were also subject to stricter pollution prevention and control requirements.

US regional emission limits are based on the contribution to downwind air quality, cost-effectiveness of emission control, and the time required to implement control technologies.

Column 3-1 The Convention on Long-range Transboundary Air Pollution (CLRTAP)

CLRTAP is an international agreement for the establishment of common policies on strategies, monitoring systems and measurements in relation to air quality under the United Nations Economic Commission for Europe' (UN-ECE), Parties as fully-sovereign states agreed to limit and, as far as possible, gradually reduce and prevent air pollution including long-range transboundary air pollution. Parties to the Convention have agreed to specific obligations in 10 protocols, which among other things established common air quality monitoring and atmospheric dispersion modelling activities, and specific quantitative obligations to reduce emissions of single pollutants, such as SO₂, NO_x, VOC, heavy metals and POPs. Most recently, Parties agreed to an amendment of the Gothenburg protocol that also addresses health impacts from PM_{2.5} and includes country-specific emission reduction obligations to limit their national emissions of SO₂, NO_x, NH₃, VOCs and PM_{2.5} below specified ceilings and to recognize the close linkages between regional air pollution and global climate change.

3.1.3 National Emission Standards for Major Stationary Sources

The Industrial Emissions Directive (IED) [Europe] and New Source Performance Standards (NSPS) [US] establish emission limits for large stationary sources. The IED requires Member States to develop a plan outlining the strategy for implementing and enforcing the limits and to apply “best available emission control technology” defined EU-wide by institutionalized expert groups. The US and the EU requires that large stationary sources obtain a pre-construction permit (similar to an EIA) and an operating permit from the state environmental agency; the operating permit consolidates into a single document all the various air pollution and monitoring and reporting requirements that apply to the facility or enterprise.

Column 3-2 US experience in regional air quality management

The amendments to the Clean Air Act (CAA) in 1977 and 1990 include a “good neighbor” provision, which requires each state to have provisions in its overall air quality management plan that prohibit activities that lead to interstate transport of pollution that can “interfere” with the attainment and maintenance of the ambient air quality standards by another state. The CAA also includes a “bad neighbor” provision. This provision allows a downwind state to petition EPA to require emission reductions in a neighboring state, and gives EPA the authority to directly regulate a specific source (or group of sources) in the upwind state.

In the 1990 CAA amendments, Congress established the Ozone Transport Commission (OTC), charged with evaluating the interstate transport of ozone and its precursors, and designing regional pollution prevention and control policies. The 1990 CAA amendments also called for the establishment of the Grand Canyon Visibility Transport Commission (GCVTC). The GCVTC was a regional organization established in 1991 (comprised of 9 western states and 4 Tribal nations) charged with developing recommendations for measures to reduce visibility impairment (caused by emissions of fine particles and precursors such as SO₂ and NO_x) in 16 national parks and wilderness areas. The Commission’s report in 1996 provided important technical and policy foundation for the EPA to establish the Regional Haze program in 1999. In addition, the CAA also gives EPA the general authority to establish other interstate transport commissions.

In 2000 EPA provided initial funding for five Regional Planning Organizations (RPOs) across the US to assist with the coordination and cooperation needed to provide the technical, scientific foundation necessary to assist state agencies with developing regional air quality SIPs. EPA also developed guidelines for improving coordination among states and organized biannual meetings of all RPOs to share information and lessons. Among other activities, the RPOs were tasked with compiling emissions inventories, establishing emissions tracking systems, improving regional modeling capabilities, bolstering monitoring programs, and providing capacity building to state air quality agencies.

In the past, when states have been unable to agree on a final policy option for all states to adopt, EPA has then taken a lead role in developing a regulatory program applicable to a large group of states to reduce SO₂ and/or NO_x to address regional PM_{2.5} and ozone problems. The 2005 Clean Air Interstate Rule (CAIR) and the 2011 Cross-State Air Pollution Rule (CSAPR), both regional cap-and-trade programs designed to reduce emissions of SO₂ and NO_x from the power sector, were developed to address this type of situation. CSAPR established emission caps for each upwind state based on the state’s significant contribution to nonattainment in downwind states, including emission levels, sources to be controlled, and schedules for CSAPR, and under the CSAPR, states were required to develop a SIP describing how they would achieve state-level emission limits (i.e., emission caps). States also had the option of developing state-specific policies.

3.1.4 National Emission Standards for Mobile Sources

Europe and the US have stringent emission standards for on road vehicles and are expanding the standards to include more off road sources (e.g., construction and agricultural equipment and in some areas marine vessels and fuels).

The US has an effective recall program that requires vehicle manufacturers and importers to recall and correct engines or pollution controls that are unable to meet emission or durability requirements. It has also added a wide range of test conditions to type approval and in use compliance regimes.

Euro 6/VI substantially improves the type approval testing and in use compliance requirements compared to previous mandates.

As the above summary indicates, both Europe and the United States have strong and mature strategies to address air pollution. While they differ significantly in details, they have many important common elements. Based on the long term experience in both Europe and the United States, the following measures are recommended.

3.2 Recommendations for China's Air Quality Management based on the International Experience

3.2.1 China should adopt a strong regional program to assure close coordination by all parties whose emissions contribute to the air quality in a given air shed

Effective reductions of ambient PM_{2.5} and ozone in China require a coordinated regional approach taking into account that PM_{2.5}, ozone and their precursors are transported in the atmosphere over hundreds of kilometers. Therefore regional planning centers (RPCs) should be established to: (i) facilitate coordination and cooperation among provincial and municipal air and energy officials, (ii) build capacity through training, and sharing experiences and lessons, (iii) bring consistency to emission data, monitoring networks and methods, and modeling analysis, and (iv) leverage resources.

RPCs will likely require Central government financial and logistical support, oversight, and authority to compel provincial and municipal governments to participate in the RPC.

Definitions of air sheds should be based on meteorological, topographical and other conditions that define appropriate boundaries for effective emissions control to assure that air quality standards can be met. Consideration should be given to combining the three key regions – JJJ, YRD and PRD - and other associated provinces in Eastern China's industrialized, highly populated and highly polluted area into a single region. Such an approach would still likely require multiple sub regional planning centers to maximize the overall effectiveness.

3.2.2 Effective pollution prevention and control policies and planning are critical; therefore, China should carefully analyze experience with control measures and implement those found to be both environmentally and cost effective

Cost-effective reductions of ambient PM_{2.5} require significant cuts of SO₂, NO_x and VOC emissions from industrial sources and transportation are needed. Without additional and appropriate measures to control NH₃ emissions from agricultural sources, it is unlikely that the benefits from the reductions of SO₂ and NO_x will be realized, especially during peak pollution episodes. Emission reductions and the spatial and sectoral distributions of those reductions should be based on integrated modelling of all precursor emissions and regional discrepancies.

Integrated multi-sectorial policy approaches have been used to cost-effectively reduce emissions in Europe and the US and should be used in China – SO₂, NO_x, PM and VOCs emissions can be reduced through: (i) energy efficiency improvements (decoupling between GDP and energy consumption), (ii) changes in fuel input, i.e., substitution of coal by cleaner fuels, (iii) dedicated end-of-pipe emission control measures, with strict enforcement mechanisms. These policy approaches can take the form of regulatory measures or economic incentives and disincentives. Integrated multi-sectorial approaches should be used to maximize co-benefits of air pollution control, energy conservation, greenhouse gas emissions, oil imports, water resources and others.

Stationary sources: Minimum performance standards, which relate to what is achievable with advanced emission control technologies while not entailing excessive costs, should be required for all new major sources and any major sources undergoing significant modification or relocation from high-density urban areas. An institutional framework should be established to define “minimum performance standards” for different types of industries. In pollution control areas, local authorities should be authorized to impose stricter standards.

Mobile sources: Because motor vehicles travel across political boundaries, vehicle emission controls should be nationally consistent to the degree of stringency necessary to address the most serious air pollution problems. Local controls can supplement but not replace national controls. Once fuel of sufficient quality can be made available, the most stringent feasible vehicle standards have been found to be very cost effective in Europe and the US and should be adopted in China. Economic incentives, such as emission-dependent vehicle taxes and motorway charging schemes, should be used to promote faster modernization of the vehicle fleet or retrofit with exhaust gas treatment systems, like diesel particulate filters.

In parallel with tighter vehicle and fuel standards, Europe and the US have found it critical to substantially increase the focus on in-use compliance throughout the wide range of real in-use driving conditions; an upgraded compliance program is critical to

the success of China's vehicle pollution control efforts.

Air quality planning: Air quality action plans are a critical tool to help provincial and municipal air, energy, economic, and health officials develop strategies for enhancing air quality and reducing energy consumption; plans should include: (i) emission inventories to identify, assess, and rank pollution sources and sectors, and to evaluate progress in reducing emissions, (ii) pollution prevention and control strategies to achieve air quality targets, (iii) air quality modeling to assess the impact of economic trends and the expected effects of pollution prevention and control strategies, (iv) ambient monitoring and assessment strategies to measure progress toward air quality targets (v) implementation strategies to identify the required resources to implement and enforce the pollution prevention and control strategies, (vi) program evaluation procedures to assess progress and identify gaps, and (vii) contingency plans that can be implemented if the region fails to make reasonable progress toward the air quality targets. Air quality attainment and emission prevention and control timelines in the plan should be realistic; repeated failure of compliance despite reasonable efforts might compromise the policy approach.

In areas exceeding the air quality standards, economic growth should be conditioned on measures to offset any additional emissions; the amount of offset should be dependent on the degree the air quality standard is exceeded.

Assessments of the plan should be based on the air quality assessment, compliance assessment, and the pollution prevention and control measure impact analysis and implementation assessment.

3.2.3 China should focus on building a strong and effective compliance program

The effectiveness of the policies and control measures adopted by China is ultimately dependent on a well-funded and staffed compliance program. Forecasts of successful emission control efforts are dependent on the assumption that control measures are fully effective. Based on international experience, strong compliance programs must be included in all administrative levels of the clean air program to assure this effectiveness.

3.2.4 Setting appropriate air quality standards that will adequately protect public health and implementing a monitoring network that accurately assesses compliance with those standards should be the backbone of China's Clean Air Program

Air quality standards, that need to be attained, should be defined for and monitored in all areas, including in areas with high concentrations (e.g., hot spots), like road side locations or industrial centers, where the population is exposed to air pollution.

Ambient air pollution data quality should be ensured through carefully designed and

operated data quality assurance and quality control (QA/QC) procedures, including: (i) specifying the differing objectives of the various monitors (e.g., hot spots, background levels) and the appropriate siting conditions for each type, (ii) specifying the needed accuracy of the monitoring data specifically for the Beijing or other Action Plans work (data quality objectives), especially with a view to the need for accurately assessing annual improvements in the PM_{2.5} concentration, (iii) ensuring that the QA/QC procedures are adequate to provide the needed accuracy, (iv) ensuring the monitoring stations on which the PM_{2.5} reduction assessment is based are properly located, subjected to QA/QC, and stable, especially in terms of changes in nearby area use and activities. This requires regular cross-comparisons among the monitoring networks and calibration with the national standard to ensure data consistency across all networks. Finally, a successful air monitoring program will require an infusion of resources dedicated to this effort along with training and capacity building.

Ambient monitoring networks should be designed to enable the apportioning of the contributions from local sources, urban conurbations, and regional pollution sources based upon the data from the network, as an additional source of apportionment to that given by modelling.

3.2.5 A process for measuring the effectiveness of control measures and determining progress in improving air quality should be a priority for China

Meteorological and other conditions can significantly affect ambient pollution concentrations. The evaluation of annual air quality changes should be adjusted for inter-annual differences in these conditions in order to assess the progress towards the air quality goals as a result of the control measures, which is a main indicator for the success of the air quality action plans in JJJ, YRD and PRD. No specific method can be recommended, because it needs to be tailored to the meteorological conditions in China. Given the strong relevance the adjustment method should as far as possible be applicable everywhere to ensure a consistent and transparent way of measuring and comparing the achieved progress. However, it is important to recognize that air quality, regardless of meteorological conditions, has human health implications. Therefore, achieving the air quality standards in absolute terms under all meteorological conditions should be the goal for every region.

Measuring annual improvement in air quality is strongly linked with quality/accuracy of the monitored data, and the needed capacity for QAQC procedures. Air quality modeling can supplement air pollution monitoring to assess the annual pollution reduction rate, based upon the assessment of the annual reductions in the emissions.

3.2.6 China should highlight the climate change co-benefits of the air pollution control effort

China's air pollution control effort will reduce coal consumption, facilitate industrial

modernization, increase the use of renewable fuels, improve vehicle efficiency, and stimulate the increased production and sale of new energy vehicles beyond business as usual; each of these air pollution control steps will reduce CO₂ emissions as a co-benefit. Other clean air control strategies will also reduce CO₂ emissions. Further, actions to reduce PM emissions from diesel vehicles and other sources will also lower black carbon emission, a very important short lived climate forcing pollutant which recent evidence indicates may be second in importance only to CO₂ in terms of its climate impact. Finally, the reduction in NO_x and VOC emissions from all sources as a result of the clean air control measures should contribute to lowering of global tropospheric background ozone levels, also a potent greenhouse pollutant.

In light of the increasing urgency in addressing global climate change as well as China's recent emergence as the largest contributor to the problem along with the United States, it is extremely important to highlight the climate benefits of the clean air strategy and the win-win nature of the effort.

4. COORDINATION MECHANISM AND POLICY RESEARCH FOR THE REGIONAL AIR POLLUTION CONTROL

4.1 Current Situation of the Coordination Mechanism and Policies

4.1.1 The Zones Designated for Regional Air Pollution Control

4.1.1.1 Traditional management zones of regional air pollution control

Prior to year 2010, the scope of air pollution control was defined by administrative regions. Different administrative regions respectively make their own pollution control policies to achieve their own goals. However, air pollution does not abide by the administrative boundaries, so the "Twelfth Five-Year" Plan for the Key Regional Air Pollution Control (hereinafter referred to as the *Key Regional Planning*) breaks the administrative boundary constraints for the first time, marking out 13 areas (3 regions and 10 city clusters) for air pollution control, as shown in Figure 4-1. Defining of these zones is based on the fact that air pollution in China is highly dependent on economic development level and population density.

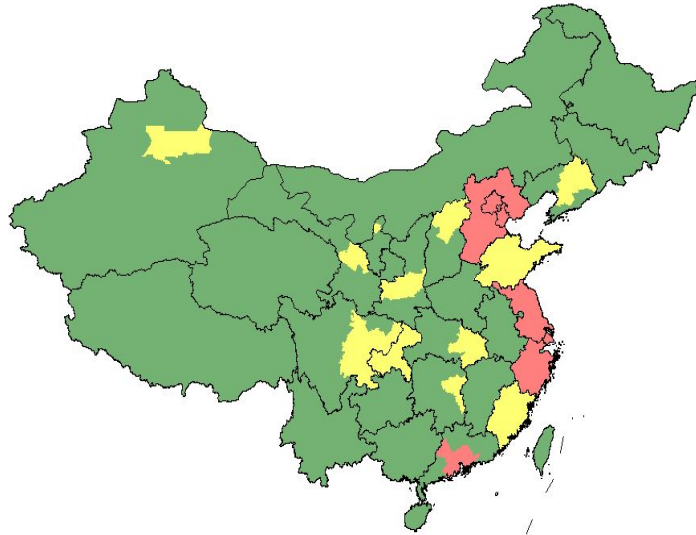


Figure 4-1 Regions set out in “*Twelfth Five-Year*” Plan for the Key Regional Air Pollution Control

4.1.1.2 Defining the zones based on the satellite remote sensing

According to the satellite remote sensing data, areas with high PM_{2.5} concentration include the following regions: Beijing-Tianjin-Hebei region, Yangtze River Delta region, Shandong, Chengdu-Chongqing, Wuhan, Chang-Zhu-Tan, Henan province and Anhui province. Northern China, Central China and Eastern China have formed into a large area of heavy PM_{2.5} pollution.

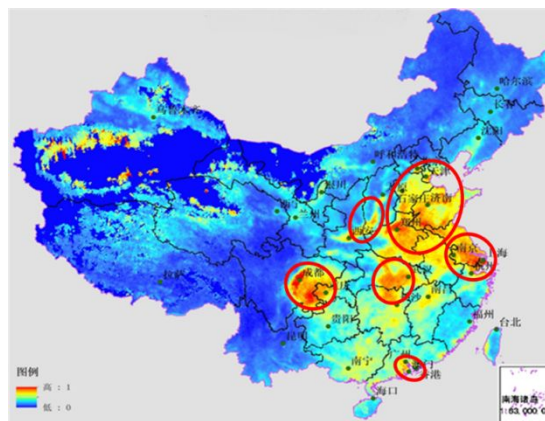


Figure 4-2 Spatial distribution of aerosol optical depth during 2011-2012⁸

⁸ Based on the data retrieved from MODIS, NASA.

4.1.1.3 Defining the zones based on the ground measurement

The neighboring cities always present similar trend and characteristics of air pollution due to similar surface and meteorology condition. Wang (2008)⁹ grouped 86 Chinese cities into 14 areas based on statistical analysis of API data, which is derived from ground measurement of air pollution concentrations (Figure 4-3).

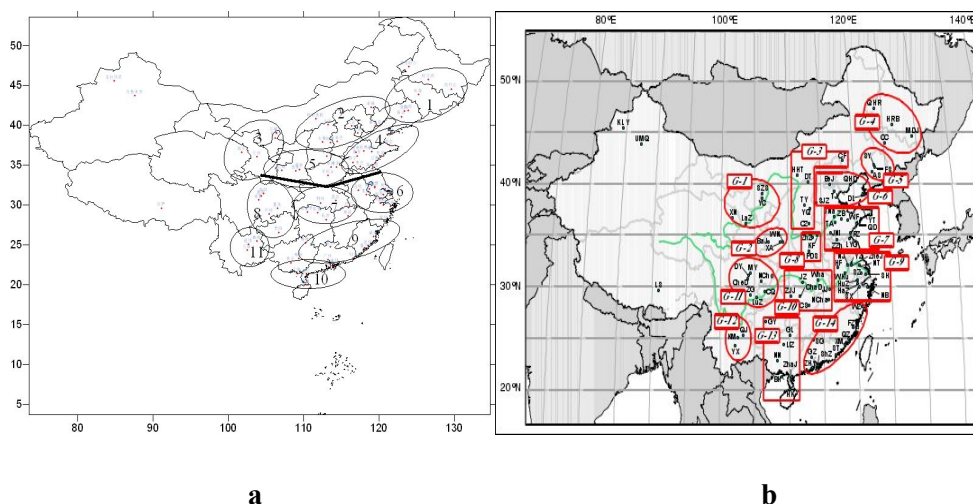


Figure 4-3 Partitioning of air pollution control

4.1.1.4 Indication from simulation of air pollution transport

Based on simulations of PM_{2.5} transport with Particulate matter sources tracking technology (PSAT) of CAMx air quality model, a PM_{2.5} transport matrix between 31 provinces (sources) to 333 prefecture cities (receptors) was developed¹⁰. The analysis results show that more than 50% of PM_{2.5} in the Beijing-Tianjin-Hebei region comes from Hebei province, followed by Beijing and Tianjin, with the contribution rate of 12% and 10% respectively; there are about 20% from regional transmission, such as Shandong, Henan and Shanxi, with the contribution rate of 6%, 5% and 5% respectively. The key zones for regional air pollution control should be adjusted according to the result.

⁹ Wang, B. Analyzing spatial and temporal characteristics of regional air pollution of China Based on Air Pollution Index (API), Dissertation of Ocean University of China, Qingdao, China. 2008.

¹⁰ Xue, W, et al. Numerical study on the characteristics of regional transport of PM_{2.5} in China. China Environmental Science, 34(6):1361-1368, 2014.

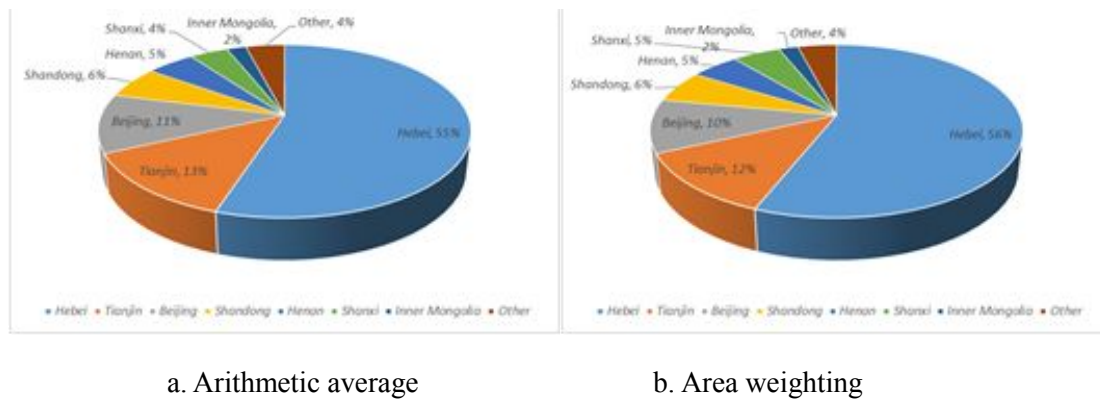


Figure 4-4 Source apportionment of PM_{2.5} in Beijing-Tianjin-Hebei region

4.1.1.5 A brief summary

The Key Regional Planning defines “three regions and ten city clusters” based on the regional characteristics of social and economic development. As more and more facts indicate a significant contribution from transport of air pollutants among provinces/regions, there should be adjustments to the definition of zones, based on facts from satellite observation, ground monitoring and modelling. The eastern part of China should be considered as a whole for regional management.

4.1.2 How Atmospheric Environmental Management Organized

4.1.2.1 From total emission control to air quality improvement

Since early 1970s, atmospheric environmental management in China has experienced a significant evolution. The management metric changed from emission standards during 1970-1995 to total emission control during 1995-2010, then to air quality after 2010.

During the “11th Five-Year Plan” period, total emission control was set as a national strategic target. Achieving the target led to a significant reduction of SO₂ emissions. However, the feelings of the public regarding bad air quality stimulated the government to change the goal of air pollution management from total emission control to air quality improvement.

In September 2013, the *Action Plan on Air Pollution Prevention and Control* (hereinafter referred to as the *Action Plan*) was issued. The binding targets of PM_{2.5} concentration reduction were agreed between central and provincial government. Annual average PM_{2.5} concentration should decline by 25%, 20% and 15% in the Beijing-Tianjin-Hebei region, Yangtze River Delta region and the Pearl River Delta region, respectively. Annual average PM₁₀ concentration should decline by 10% for other part of China.

4.1.2.2 Top-down approach

The top-down approach is applied in China's atmospheric environment management. Namely the central government determines the overall target and puts the target into detail from the top down. Then the target is decomposed to each province, taking into account the local environment quality as well as the economic and social development status. Then the target is further decomposed to even lower level such as cities.

4.1.2.3 A brief summary

To date, atmospheric environmental management in China has focused more on total emission control of SO₂ and NO_x. It contributed significantly to air quality improvement; however, improving air quality needs more integrated approaches. In one hand, the local governments should take air quality, instead of emission reduction of SO₂ and NO_x, as their soul target, in the other hand, approaches to reduce PM and VOCs emission should be more considered as well.

4.1.3. Coordination Mechanism of the Regional Air Pollution Control

4.1.3.1 Working mechanism

The state council has developed the MEP leading inter-ministerial coordination mechanism of the air pollution control to strengthen information communication between departments. The coordination mechanism for air pollution control in Beijing-Tianjin-Hebei region and its surrounding, Yangtze River Delta region and the Pearl River Delta region, is also developed, respectively led by Beijing, Shanghai and Guangdong provinces. Working rules were made to claim the explicit responsibility and focuses, and working conferences were held routinely to discuss the key issues of the cooperation.

Column 4-1 The coordination mechanism for air pollution control in Beijing-Tianjin-Hebei region and its surrounding areas

The team members of air pollution control in Beijing-Tianjin-Hebei region and its surrounding areas include Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Shandong and seven ministries and commissions. The main duties and responsibilities of the team are to coordinate and address the major regional environmental problems, and to coordinate with related ministries to formulate and implement the policies (such as energy, industry, transportation, construction, funds safeguard and so on) in favor of the improvement of regional air quality.

In October 2013, the collaborative team held the first working conference. The conference determined the working principles of “responsibility sharing, information sharing, consultation, mutual defense and joint control” and established working schemes.

In May 2014, the collaborative team held the second working conference. The conference examined and approved the prior work in 2014 and the working plan to promote new energy vehicles in public service; the conference also solicited opinions in terms of motor vehicle pollution control, atmospheric pollution control of the power, steel, cement and flat glass industries, clean control of the bulk coal as well as the comprehensive utilization of straw and the prohibition of straw burning. National energy administration signed the “coal to gas” agreement and the agreement on clean control of the bulk coal with CNPC, Sinopec and Shenhua group respectively; and signed the assignment book for the building project of the electricity transmission channel with State Grid Corporation of China and China Southern Power Grid.

4.1.3.2 Regional EIA consultation mechanism

Regional EIA consultation mechanism refers to the regional consultation and interactive mechanism to prevent potential regional atmospheric environmental problems caused by the plan or new installations. Requirements are put forward that the plans for national industrial parks involving coal-fired power generation, petrochemical industry, chemical industry, nonferrous metal, steel, and building materials in specific regions needs regional EIA consultation.

4.1.3.3 Regional joint enforcement mechanism

This mechanism refers to the joint law enforcement mechanism established within neighboring cities and related departments. By conducting joint investigations and peer review actions, it can unify the enforcement standards and achieve better performance to combat illegal environmental behaviors and handle environmental

events reasonably and in a coordinated manner.

After the publication of *Action Plan*, MEP launched monthly inspections in the Beijing-Tianjin-Hebei region. The results are reported to the government and published for the public. In addition, MEP and the MPS (Ministry of Public Security) jointly issued opinions on strengthening the cooperation with public security departments in law enforcement of environmental protection so as to improve the deterrent power of law enforcement.

4.1.3.4 Emergency response mechanism for heavy regional pollution

A 4-levels (country-key areas-province-city) air quality forecast framework has been preliminarily established. Among them, the national forecast and early-warning center and the center for Beijing-Tianjin-Hebei region have been operational, providing supportive information for regional emergency response.

Followed the *Guide for Emergency Plans of Cities' Heavy Atmospheric Pollution*, the local governments have made their specific emergency response plans for heavy air pollution. Emergency response will go into force followed the instruction from forecast and early-warning centers.

4.1.3.5 Information sharing mechanism

Regional environmental information sharing refers to sharing and exchanging information about air pollution control among different districts, departments and levels. It is clearly required in *Environmental Disclosure rules (trial implementation)* that environmental protection departments should offer 17 kinds of environmental information to the public with their extent of competence. To date, sharing of air quality information has been realized through real-time publication of air quality monitoring data; sharing of emissions information has been realized through annual report of the environmental status; and sharing of environmental performance information of key enterprises has been realized through the annual reports disclosure system for the 16 kinds of heavy pollution industries in stock markets.

MEP and MPC have established a trans-department information sharing system. Within this system, MEP transfers the legal cases to MPC, and MPC shares the status information of case processing with MEP, as well as the environmental pollution cases investigated and discovered by MPC.

MEP and Meteorological Administration have established a cooperation framework, including information sharing of chemical composition of air pollutants, monitoring data of ambient air quality, meteorological observation and forecasting, and data from the satellite.

4.1.3.6 A brief summary

China has developed a unified environmental decision-making and consultation working mechanism in three key areas. However, cooperation on pollution control and supervision still need to be strengthened. In addition, improving the air quality of the whole region rather than some key cities should be more focused.

In regard to regional EIA and Consultation, some specific aspects like confirming the scope and content of consultation and handling of the opinions from Consultation need further research and exploration. In regard to regional joint enforcement, there is a demand to further improve the regime of regional joint enforcement, explore diversified forms of regional joint enforcement, establish multi-sector joint law enforcement mechanisms, and perfect the linkage mechanism of law-enforcing and judicial departments. In regard to early weather warning of regional heavy pollution, grading standards of early warning in some areas still fails to achieve complete unification, and the emergency response plans need cost-effectiveness analysis. In regard to environmental information sharing, sharing of some key information such as EIA information of new installations, emission of air pollutants in some enterprises is still lacking, and the communication between local governments and relevant departments also needs to be enhanced.

4.1.4. Policies for regional air pollution control

In order to promote regional air pollution control, MEP together with other relevant departments has put forward 22 supporting policies and measures, which include 3 aspects like energy restructuring, economic incentives and responsibility. 11 of these 22 supporting policies and measures have been issued, and the rest will be put into effect before the end of this year.

Among these policies, an environmental electricity tariff, a tariff for better vehicle-used fuels, and cascading electricity prices for electrolytic aluminum were formulated by NDRC. MOF issued policies to promote new energy vehicles, and set up special funds for the control of air pollution. MEP issued the guidelines to appraise the performance of local governments to implement the Action Plan, as well as the requirement on information publication and the guidance on promoting public participation.

However, some aspects have not been covered yet. For example, some policies are needed to promote elimination of “yellow label” and old vehicles, and to expand the depth and breadth of information disclosure and public participation.

4.2 Policy Recommendations

4.2.1 Targeting Air Pollution Management to Better Air Quality

4.2.1.1 Set air quality compliance as a legally-binding target

An accountability and evaluation system with air quality compliance as the soul should be explicitly provided for in the *Law on the Prevention and Control of Atmospheric Pollution*. Compliance with ambient PM_{2.5} concentration standards should be set as a binding target for all cities.

4.2.1.2 Redefine the zones based on scientific evidence

The key zones for regional air quality control should be redefined taking into account the spatial and temporal distribution of air pollution, meteorology and topography, as well as pollution dispersion and transport. A wider region including Beijing-Tianjin-Hebei, the Yangtze-River Delta, and provinces between them should be considered as a whole for more effective regional air pollution control.

4.2.2 Developing the Coordination Mechanism for Joint Prevention and Control of Air Pollution

4.2.2.1 Developing a unified planning toward regional air quality compliance

A regional compliance plan should be formulated for the eastern part of China, clarifying the compliance timetable and roadmap, as well as reasonable and feasible control schemes for different parts of this region. An integrated approach in terms of economic and energy restructuring, urbanization and mobility, should be considered accordingly.

4.2.2.2 Perfecting the unified and coordinated working mechanism for regional air pollution control

Based on the established coordination mechanism and inter-ministerial coordination mechanism, more formal rules and procedures for coordination and policy making should be developed, and in-depth regional coordination on economy and energy issues that impact the regional air quality should be conducted.

4.2.2.3 Establishing regional EIA consultation mechanism

The major planning and the list of projects with significant impact on regional air quality should be asked for regional EIA consultation. The superior environmental protection administrative departments should organize the consultation, and the advice should be collected from those relevant administrative regions whose air

quality could possibly be affected by the planning or project.

4.2.2.4 Improving the regional joint enforcement mechanism

The regional enforcement capacity should be enhanced by developing a regional environmental supervision network and exploring cross investigations. The multi-sector joint enforcement system should be developed involving MEP, MIIT, and other administrations. A joint working system of the environmental administrative enforcing departments and judicial organs shall be perfected and the force against environmental crime will be intensified.

4.2.2.5 Integrating national science and technology power to offer regional decision support and scientific planning

Taking the full use of the national and provincial science and technology resources, there is a need to establish a regional planning organization, funded by MEP and other ministries, to carry out basic researches on causes, transport and changes of the regional atmospheric pollution. This organization could provide basic information to support regional PM_{2.5} pollution control, including emission inventory, source apportionment, emission abatement technologies, and cost-effect analysis. This organization could also develop regional air quality control planning and evaluations for central and provincial government.

4.2.2.6 Further deepening information sharing

The scope and content of environmental information sharing should be expanded, including early-warning and emergency response to heavy pollution, consultation mechanism of environmental impact assessment, joint environmental enforcement, and joint pollution control. There is a special demand in promoting the environmental impact assessment involved in the regional air quality monitoring, polluting source emission, key pollution sources, meteorological data and new projects, as well as key environmental information sharing such as supporting data, achievements of management technology, management experience and so on.

4.2.3. Improving the Policies for the Regional Air Pollution Control

4.2.3.1 Increasing the policy and financial support for the industrial structure adjustment in the key areas

The directories and standards of industrial restructuring should be strictly created in the key areas. Their special funds and fiscal transfer payments should be increased to boost the structure adjustment. Meanwhile, the number of the pilot cities substituting subsidies with rewards should be increased and more incentives are needed to reduce the outdated capacity and curb new projects in industries with overcapacity.

4.2.3.2 Setting economic incentive policies for the technical innovation of enterprises' environmental protection

The related state departments and local governments should explore the economic guiding policy of air pollution control to lead existing enterprises to the technical innovation of air pollution control and the sharp reduction in pollutant discharge, with the help of many approaches such as setting up special funds, issuing bonds, and offering discount, subsidies, and incentives.

4.2.3.3 Improving economic incentive policies for motor vehicle pollution control

It is proposed that motor vehicle fuel surcharge should be collected timely to lower the vehicle operation intensity. An atmospheric pollution control fund could be established with the surcharge to support infrastructure construction such as local public transportation and the control of air pollution. The policies should be made for the scrapping of the old motor vehicles, and the financial subsidies strength should be improved to eliminate yellow label and old vehicles, with the fiscal funds playing a guiding role. The “cash-for-clunkers” policy should be implemented under the coordination of related departments to promote the elimination of yellow label vehicles.