



# China Air 2015

---

## Air Pollution Prevention and Control Progress in Chinese Cities



Clean Air Asia

# China Air 2015

Air Pollution Prevention and Control  
Progress in Chinese Cities

## About Clean Air Asia

---

Clean Air Asia (CAA) is an international non-profit organization established in 2001 by the Asian Development Bank, World Bank, and United States Agency for International Development (USAID). It aims to improve air quality and build livable cities by translating knowledge into policies and actions to reduce air pollution and greenhouse gas emissions from transportation, energy and other industries.

Headquartered in Manila, CAA has offices in Beijing and Delhi. The organization became a UN-recognized partner in 2007 with more than 250 member organizations from 31 countries in Asia and other parts of the world. CAA's operations cover eight country networks including China, India, Indonesia, Nepal, Pakistan, Philippines, Sri Lanka and Vietnam.

Clean Air Asia has worked in China for more than a decade to promote green transportation and improve the air quality in Chinese cities through elevating the government's capability in air quality management. In collaboration with the Foreign Economic Cooperation Office (FECO) of the Ministry of Environmental Protection (MEP), CAA established a City Air Quality Management (AQM) Network in China in 2005, and has, to date, organized 11 annual workshops and 5 training activities on air quality attended by more than 100 cities.

## About the Report Team

---

Authors: Dr. Fu Lu (China Director, CAA China Office)  
Dr. Wan Wei (Air Quality Specialist, CAA China Office)  
Zhang Weihao (Environmental Researcher, CAA China Office)

---

Reviewers: Bjarne Pedersen (Executive Director, CAA Manila Office)  
Glynda Bathan (Deputy Executive Director, CAA Manila Office)  
Kaye Patdu (Head of Programs, CAA Manila Office)

---

Supporting staff: Liu Mingming (Director Assistant, CAA China Office)  
Wang Qiuxia (Communications Officer, CAA China Office)

---

Report designer: Wang Yiqiang (Design Director, China Times)

## Acknowledgement

CAA would like to express sincere gratitude to Beijing Municipal Environmental Protection Bureau, Beijing Municipal Environmental Monitoring Center, Beijing Municipal Research Institute of Environmental Protection and Shanghai Municipal Environmental Monitoring Center for their close collaboration in completing the case studies of the report.

We would also like to thank Professor He Kebin from Tsinghua University and Professor Zhang Shiqiu from Peking University for their kind advice on the structure of the Report and review of the content.

We are grateful to the Rockefeller Brothers Fund and the Oak Foundation for their financial support to the series of Reports (2015 – 2018).

# Foreword

In 2013, many provinces and cities in China were hit by serious haze that caused extremely low visibility and high pollution. To tackle this environmental problem, China's State Council issued a policy document known as the Ten Measures of the State Council in June 2013 and officially released the Action Plan for Air Pollution Prevention and Control (the Action Plan) in September of the same year, which set forth the roadmap for the nation's air pollution prevention and control efforts for the period of 2013-2017. Chinese central and local governments subsequently promulgated a series of policies, laws and regulations, standards and technical guidelines to support the implementation of the Action Plan.

As an independent and leading NGO, Clean Air Asia (CAA) has worked in China for more than a decade, focused on improving the air quality management capability of Chinese cities. CAA has established a city network that provides sustained and progressive technical training to support the capability building of city policymakers, built a platform upon which local experience can be shared to promote regional cooperation, helped cities to address complicated air quality management issues, and initiated, established and promoted the development of green freight in China. A growing number of Chinese cities have sought capability-building support from CAA in the past two years, during which time CAA has witnessed the transformative process of those cities from worrying about the difficulties in meeting the new standards to having a strong will to achieve their emission-reduction targets.

CAA has thus decided to objectively record, from a neutral third-party perspective, the air pollution prevention and control policies that are being or will be adopted by the Chinese national and local governments from 2014 to 2017, as well as their implementation process and results. CAA will publish a bilingual annual report in Chinese and English between 2015 and 2018, which will include air quality data, policies issued at the national, regional and municipal levels and the progress achieved in implementing those policies, city experience in specific topics, and analysis of the effectiveness and cost-benefits of those policies. The report will incorporate more content and cover more cities each year. We hope this series of reports will help decision-makers, enterprises and private organizations to better understand the policies China has adopted and how such policies are being implemented. In addition, we hope our reports will help the whole of society support and oversee the promulgation and implementation of policies, thus helping to have a positive impact on future policy development and practice.

All the air quality data and policy information in the reports can be found on the Air Knowledge Hub ([www.allaboutair.cn](http://www.allaboutair.cn)), a Chinese online platform launched by CAA in November 2015. It aims to provide the best practices, knowledge and information of cities in air pollution prevention and control, tailored international experience, and materials for themed training, along with a Q&A help desk. CAA hopes to provide dynamic, convenient and comprehensive support through the Hub to air quality policymakers in Chinese cities.

We would not have succeeded in developing the report without the trust and support of Chinese cities and experts. CAA will continue working with old friends and welcomes new partners in perfecting this series of reports.

**Fu Lu**  
China Director  
Clean Air Asia



# Table of Contents

## Summary

|                               |   |
|-------------------------------|---|
| Content and Scope .....       | 7 |
| Development Methodology ..... | 7 |
| Main Conclusions .....        | 7 |

## I. Current Air Quality Status

## II. Policy Implementation and Progress

|  |    |
|--|----|
| Major Events of Air Pollution Prevention and Control .....                                   | 12 |
| Air Pollution Prevention and Control Policy Framework .....                                  | 14 |
| Action Plan for Air Pollution Prevention and Control and Local<br>Implementation Plans ..... | 15 |
| Air Quality Improvement Targets .....  | 18 |
| Capacity Building .....  | 20 |
| Air Quality Monitoring System Building and Reporting .....                                   | 20 |
| Pollution Alerting and Emergency Response .....  | 20 |
| Source Apportionment and Emission Inventory .....  | 20 |
| Emission-Reduction Measures .....  | 21 |

|  |    |
|--|----|
| Emission Reduction through Energy Structure Adjustment .....                   | 21 |
| Total Coal Consumption Control .....   | 21 |
| Central Heating System Upgrading .....   | 24 |
| Clean Energy Promotion .....   | 25 |
| Elimination of Yellow-Label and Outdated Vehicles .....                        | 26 |
| Vehicle Population Control .....   | 28 |
| Encourage Public Transportation Use .....                                      | 28 |
| Optimize Industrial Structure and Layout .....                                 | 29 |
| Emission Reduction in Combustion Processes .....                               | 32 |
| Clean Production .....   | 32 |
| Clean-Burning Coal .....   | 33 |
| Upgrading Fuel Quality .....   | 34 |
| Area Source Management .....   | 34 |
| Emission Reduction in Energy End Use .....                                     | 37 |
| Desulfurization, Denitration and Dust Elimination .....                        | 37 |
| Apply Special Emission Limits and Raise Industrial Emission<br>Standards ..... | 37 |
| Upgrading Vehicle Emission Standards .....                                     | 42 |
| New Measures .....   | 43 |
| VOCs Control .....   | 43 |
| Emissions from Non-Road Machinery and Ports and Vessels ...                    | 46 |
| Supporting Measures .....  | 47 |

---

|   |    |
|---|----|
| Economic Means .....  | 47 |
| Electricity and Energy Tariffs .....  | 47 |
| Pollutant Discharge Fees .....  | 47 |
| Project Subsidies and Special Funds .....   | 48 |
| Administrative Approaches .....   | 49 |
| Target Assessment and Liability Statement .....   | 49 |
| Air Quality Rankings .....  | 49 |
| Legislative Means .....   | 49 |
| Amendment of the Environmental Protection Law and the Law<br>on Prevention and Control of Air Pollution ..... | 49 |
| Monitoring of Major Pollution Sources and Information Disclosure .....  | 49 |

|                                      |    |
|--------------------------------------|----|
| History .....                        | 61 |
| Practical Information .....          | 62 |
| Expert Remarks .....                 | 63 |
| Source Apportionment .....           | 64 |
| History .....                        | 64 |
| Practical Information .....          | 64 |
| Expert Remarks .....                 | 65 |
| Emission Inventory Development ..... | 66 |
| History .....                        | 66 |
| Practical Information .....          | 67 |
| Expert Remarks .....                 | 67 |

### III. City Case Studies

---

|   |    |
|---|----|
| Summary of Beijing's Experience .....                           | 51 |
| Ambient Air Quality Monitoring, Forecasting and Reporting ..... | 52 |
| History .....   | 52 |
| Practical Information .....                                     | 55 |
| Expert Remarks .....  | 56 |
| Source Apportionment .....                                      | 57 |
| History .....   | 57 |
| Practical Information .....                                     | 58 |
| Expert Remarks .....  | 59 |
| Summary of Shanghai's Experience .....                          | 60 |
| Ambient Air Quality Monitoring, Forecasting and Reporting ..... | 61 |

### Conclusions

---

|  |    |
|--|----|
| There is still a Long Way to Go before the Attainment of Air Quality   |    |
| Standards .....  | 68 |
| Strategic Transformation of Air Pollution Prevention and Control       |    |
| Policies .....   | 68 |
| Improve Capacity to Serve Scientific Decision-making .....             | 69 |
| Various Measures to Ensure the Implementation of the Action Plan ..... | 70 |

# Figures

|   |    |   |    |
|---|----|---|----|
| Fig. 1: Annual Mean Concentration of PM <sub>2.5</sub> in 74 Cities and Key Regions .....                                     | S1 | Fig. 31: Outdated Production Capacity Elimination in the Steel Industry in Different Cities .....                       | 31 |
| Fig. 2: Annual Mean Concentration of PM <sub>10</sub> in 74 Cities and Key Regions .....                                      | S2 | Fig. 32: Outdated Production Capacity Elimination in the Electric Power Industry in Different Cities .....              | 32 |
| Fig. 3: Annual Mean Concentration of SO <sub>2</sub> in 74 Cities and Key regions .....                                       | S3 | Fig. 33: Clean Production Audit Targets of Different Cities .....   | 32 |
| Fig. 4: Annual Mean Concentration of NO <sub>2</sub> in 74 Cities and Key Regions .....                                       | S4 | Fig. 34: City Raw Coal Washing Target Rates .....   | 33 |
| Fig. 5: 24-Hour Mean Concentration of CO in 74 Cities and Key Regions .....   | S5 | Fig. 35: City Coal Quality Control Targets .....  | 33 |
| Fig. 6: Daily Maximum 8-Hour Average Concentration of O <sub>3</sub> in 74 Cities and Key Regions .....                       | S6 | Fig. 36: National Roadmap of Fuel-Quality Upgrading .....   | 34 |
| Fig. 7: Distribution of AQI in Some Cities in 2013 .....  | S7 | Fig. 37: City Kitchen-Exhaust Control Measures .....  | 35 |
| Fig. 8: Distribution of AQI in Some Cities in 2014 .....  | S7 | Fig. 38: City Target of Comprehensive Utilization Rates of Agricultural Waste .....                                     | 36 |
| Fig. 9: Number of Days with Different Primary Pollutants in Key Regions and Cities .....                                      | S8 | Fig. 39: City Progress of Desulfurization, Denitration and Dust Elimination .....                                       | 38 |
| Fig. 10: Number of Attainment Days in Key Cities in 2013 .....  | S8 | Fig. 40: City Vehicle Emission Standard Upgrading .....   | 42 |
| Fig. 11: Number of Attainment Days in Key Cities in 2014 .....  | S8 | Fig. 41: Oil-Vapor Recovery Progress in BTH and its Surrounding Areas .....   | 43 |
| Fig. 12: Major Events of Air Pollution Prevention and Control in 2013 and 2014 .....  | 13 | Fig. 42: Oil-Vapor Recovery Progress in YRD and PRD .....   | 44 |
| Fig. 13: China's Air Pollution Prevention and Control Policy Framework after the "Ten Measures of the State Council" .....    | 14 | Fig. 43: Oil-Vapor Recovery Progress in Other Major Cities .....  | 45 |
| Fig. 14: Timeline of Release of Municipal Action Plans .....  | 17 | Fig. 44: Charging Standards for SO <sub>2</sub> and NO <sub>x</sub> Emissions in Different Cities .....                 | 47 |
| Fig. 15: City Air Quality Improvement Targets (measured by reduction percentages compared with the benchmark year 2013) ..... | 18 | Fig. 45: Funding for Air Pollution Prevention and Control in Different Cities .....                                     | 48 |
| Fig. 16: City Air Quality Improvement Targets (measured by target concentration) .....  | 18 | Fig. 46: Distribution of Environmental Monitoring Stations in Beijing .....   | 52 |
| Fig. 17: City Air Quality Improvement Targets (measured by reduction percentages compared with the benchmark year 2012) ..... | 19 | Fig. 47: Distribution of Traffic-Pollution Monitoring Sites and Regional Background-Transmission Sites in Beijing ..... | 53 |
| Fig. 18: Three Steps in Establishing Air Quality Monitoring System .....  | 20 | Fig. 48: Three-dimensional Monitoring Network of Beijing .....  | 53 |
| Fig. 19: City PM <sub>2.5</sub> Source Apportionment Results .....  | 21 | Fig. 49: Development of Beijing's Air Quality Forecasting .....   | 54 |
| Fig. 20: Coal Consumption in Key Regions in 2012 (in 10,000 tons) .....   | 22 | Fig. 50: Multiple Means of Air Quality Reporting .....  | 54 |
| Fig. 21: Reduced Amount of Coal Consumption in Key Regions by 2017 (in 10,000 tons) .....                                     | 22 | Fig. 51: Forecasting and Alerting Structure .....   | 55 |
| Fig. 22: City Targets of Coal Consumption Control .....   | 22 | Fig. 52: Beijing's Air Pollution Forecasting and Alerting Technology System .....                                       | 55 |
| Fig. 23: Central Heating System Upgrading Targets .....   | 24 | Fig. 53: Team Composition and Division of Duties .....  | 56 |
| Fig. 24: City Clean Energy Promotion Targets .....  | 25 | Fig. 54: Development of Source Apportionment of Particulate Matter in Beijing .....                                     | 57 |
| Fig. 25: Yellow-Label Vehicle Elimination Targets and Progress in Three Key Regions (in 10,000 vehicles) .....                | 26 | Fig. 55: Emission Source Sampling and Processing Technical Approach .....   | 58 |
| Fig. 26: Yellow-Label Vehicle Elimination in Cities in 2013 .....   | 26 | Fig. 56: Comprehensive Source-Apportionment Technical Approach .....  | 59 |
| Fig. 27: Yellow-Label Vehicle Elimination in Cities in 2014 .....   | 27 | Fig. 57: Map of Air Quality Continuous Monitoring Stations in Shanghai .....  | 61 |
| Fig. 28: Public Transportation Use Targets in Cities .....  | 28 | Fig. 58: Development of Air Quality Forecasting in Shanghai .....   | 61 |
| Fig. 29: Outdated Production Capacity Elimination in the Cement Industry in Different Cities .....                            | 30 | Fig. 59: PM <sub>2.5</sub> Monitoring Equipment at State-Controlled Monitoring Sites .....                              | 62 |
| Fig. 30: Eliminated/Relocated Enterprises in Different Cities .....   | 30 | Fig. 60: Combined Use of Multiple Methods for PM <sub>2.5</sub> Source Apportionment .....                              | 64 |
|   |    | Fig. 61: History of Shanghai Ambient Air Pollution Source Inventory .....   | 66 |
|   |    | Table 1: Lab-based Component Analysis Methods and Monitoring Items .....  | 58 |
|   |    | Table 2: Analysis Method, Monitoring Cycle and Frequency of Ambient Air Quality Automatic Monitoring Items .....        | 63 |

### Content and Scope

As the first in the series of "China Air - Air Pollution Prevention and Control Progress in Chinese Cities" reports, this report provides air quality data for 74 major cities from 2013-2014, as well as the pollution-control policies of those cities, the three key regions - Beijing-Tianjin-Hebei Province (BTH), the Yangtze River Delta (YRD) and the Pearl River Delta (PRD) - and nationally, and analysis of Beijing and Shanghai's experiences in capability building, including air quality monitoring, forecasting and alerting, reporting, pollution source apportionment and emission inventory development. The 74 cities are in the three aforementioned regions, with all municipalities directly under the National Government, provincial capitals and cities designated by the National Government, and had finished the construction of State-controlled air quality monitoring sites and launched the monitoring process by the end of 2012, and had begun releasing real-time monitoring data from 2013.

### Development Methodology

In accordance with the principle of objective recording, the report has systematically incorporated air quality data and policy information to ensure the accuracy and comprehensiveness of the data and information, while faithfully reflecting the efforts and progress of the National Government, the three key regions and the 74 cities in air quality control between 2013 and 2014.

The data and information contained in the report have all been released and shared by the government. Specific sources include: 1) Air quality data: Air quality bulletins and official news released by the Ministry of Environmental Protection (MEP), provincial environmental protection departments and municipal environmental protection bureaus; 2) Policy information: Government documents, speeches by officials, meeting reports, and news reports by mainstream media citing official sources; 3) First-hand investigation: CAA has contacted through emails and telephone interviews the executive offices, pollution-prevention divisions, air quality divisions and other related offices of municipal environmental protection bureaus in the 74 major cities to inquire about and confirm information, particularly information about the implementation of prevention and control measures, and has obtained feedback from some cities.

To sum up the experience of these cities in air pollution prevention and control, we distributed more than 200 questionnaires to environmental-protection authorities in 45 provinces and cities and visited 11 provinces and cities to learn about their major progress, obstacles and main experiences in their air pollution prevention and control efforts in the past two years. On that basis, we determined that the experience-sharing section of the report should focus on the building of capability for scientific decision-making, and selected Beijing and Shanghai as the first two cities for experience-sharing. We held in-depth discussions with environmental-protection bureaus, monitoring stations and municipal research institutes in environmental protection in Beijing and Shanghai to understand both cities' efforts in monitoring, forecasting and alerting, reporting, pollution source apportionment and emission inventory

development, and compiled their experiences in the report to serve as a reference for policymakers in other cities.

### Main Conclusions

**Some initial improvement has been achieved in air quality, while the concentration of ozone has increased instead of falling and the "achievement of the target" is still daunting**

Between 2013 and 2014, the 74 cities experienced a decline in the average concentrations of five pollutants, including fine particulate matter (PM<sub>2.5</sub>), inhalable particulate matter (PM<sub>10</sub>), sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>) and carbon monoxide (CO), and the number of cities that met the target in terms of the concentrations of six pollutants (PM<sub>2.5</sub>, PM<sub>10</sub>, SO<sub>2</sub>, NO<sub>x</sub>, CO and ozone) increased. The three key regions saw greater improvement in air quality than other regions. Take BTH for example; the concentration of PM<sub>2.5</sub> decreased to 93 µg/m<sup>3</sup>, representing a 12.3% fall on a year-on-year basis. However, among the 74 cities that had conducted monitoring per the revised Ambient Air Quality Standards (GB3095-2012, the Revised Standards), nearly 90% of them (66 cities) failed to reach the Revised Standards in 2014, with particulate matter as the primary pollutant.

In contrast to the other five pollutants, the overall concentration of ozone (O<sub>3</sub>) increased slightly, which resulted in an increased number of non-attainment days with O<sub>3</sub> as the primary pollutant. The average concentration of O<sub>3</sub> in the 74 cities was 145 µg/m<sup>3</sup> in 2014, representing a year-on-year increase of 4.3%; the percentage of attainment cities was 67.6%, representing a year-on-year decrease of 9.4%. Although the overall air quality of the PRD is good and the region is expected to be the first region in China to meet the Revised Standards, O<sub>3</sub> pollution has become a major problem in the region.

Judging from the Air Quality Index (AQI), BTH and its surrounding areas can be regarded as the worst area. The top 10 cities with the lowest number of annual attainment days in 2014 are almost all located in the region and its surrounding areas, among which eight are in Hebei Province. In addition, some cities in Northeast, Central and Southwest China are showing disappointing results. For example, the annual mean concentration of PM<sub>2.5</sub> in Harbin, Shenyang, Xi'an, Wuhan and Chengdu in 2014 was more than two times above the Revised Standards. Chinese cities still have a long way to go to meet the Revised Standards.

### Strategic transformation of air pollution prevention and control policies

The goal of air pollution prevention and control in China has undergone a significant change from controlling the total volume of pollutant emissions to improving air quality. The Action Plan sets forth for the first time regional goals of air quality improvement, which demands that by 2017 the concentration of PM<sub>10</sub> in cities at and above prefecture levels be reduced by more than 10%, compared with the 2012 level, while the concentration of PM<sub>2.5</sub> in BTH, YRD

and PRD be reduced by about 25%, 20% and 15% respectively. The 74 cities referred to in the report have all proposed in their local action plans targets for air quality improvement and have set up the reduction percentages of the target year against the benchmark year or the target values of pollutant concentration. However, it is noteworthy that the targets set forth by governments at all levels for 2017 still exceed the maximum limits of pollutant concentration specified in the Revised Standards. National, provincial and municipal governments therefore need to formulate their mid and long-term roadmaps and attainment strategies to ensure that the ultimate goal of air pollution prevention and control is achieved.

The Action Plan, regional implementation rules and municipal action plans embody a strategy of coordinated and integrated control of multi-pollutants, with coal, motor vehicles and fuel as the three key targets for reduction efforts. The overall national coal consumption in 2014 was reduced by 2.9% compared with 2013 - a decrease for the first time over the past 15 years. 6,113,400 yellow-label and outdated vehicles were removed from the road between January and November 2014, exceeding the annual target of phasing out 6 million such vehicles.

China IV gasoline and diesel were introduced nationwide in 2014, while Beijing, Tianjin, Shanghai, Jiangsu Province, Guangdong Province and Shaanxi Province adopted China V gasoline and diesel fuel quality standards ahead of the national timeline to solve the long-standing mismatch between vehicles and fuel. Furthermore, China launched the drive to comprehensively control volatile organic compounds (VOCs) on a sector-by-sector basis, and cities focused their efforts on experimental projects of oil vapor recovery and leak detection and repair (LDAR) in the petrochemical industry in 2014. Meanwhile, the National Government also required pollution control of non-road mobile machinery such as engineering machinery and ships, and more than 30 cities incorporated such a requirement in their action plans for air pollution prevention and control.

The Action Plan emphasizes regional collaboration. Regional-coordination mechanisms have been successively established in BTH and YRD, which cover multiple provinces, municipalities directly under the National Government and autonomous regions. This is the first time that local governments broke jurisdictional barriers to set up regular cooperative mechanisms.

### Focus on capacity building and support for scientific decision-making

Benefiting from the release of the Revised Standards and its implementation in some key cities and regions ahead of the schedule, China has seen a great leap forward in ambient air quality monitoring. 1,436 monitoring sites in 338 cities at prefecture and above levels have all been able to implement the Revised Standards, and the three key regions (BTH, YRD and PRD) had also established regional air quality forecasting and alerting platforms by the end of 2014.

The lack of knowledge about the emission sources is one of the major challenges for Chinese cities in air pollution prevention and control. As China enters the crucial stage of the Ten Measures of the State Council in air pollution control, scientific decision-making and meticulous management have been continuously requested and emphasized. The purpose of conducting PM source apportionment and developing the emission inventory is to obtain clear knowledge of the sources of pollution and formulate emission-reduction strategies in line with reliable

research results and emission-source information, which are the first steps towards scientific decision-making.

The MEP issued the Technical Guidelines on Source Apportionment of Atmospheric Particulate Matter (Trial) in 2013. Based on the achievements in their scientific research over a long period of time, Beijing, Shanghai and Guangzhou took the lead in completing PM<sub>2.5</sub> source apportionment and reported the results by the end of 2014. The source apportionment results of Beijing and Shanghai indicate that vehicle emissions in the city, regional transportation and coal combustion are the three primary causes of air pollution. Moreover, the results have provided a scientific basis for the formulation and implementation of key control measures, such as eliminating yellow-label and outdated vehicles, upgrading vehicle-emission standards and fuel quality, controlling total coal consumption, defining (coal combustion) restricted zones and carrying out regional joint prevention and control. The results may also be utilized to evaluate the effects of those key control measures.

Due to inadequate technical expertise, a shortage of human and financial resources and poor data availability, most of the provinces and cities have not developed local emission inventories for air quality management. The city case studies in the report indicate that Shanghai developed its first edition of emission inventory as early as in 2003 and systematically updated it four times in the next decade based on scientific research projects carried out during that period. Beijing is the first to incorporate emission-inventory development into its regular environmental protection efforts and formulate standardized work plans and technical regulations that suit its own characteristics and needs. The MEP issued four technical guidelines on the development of emission inventories in 2014 and will carry out experimental projects in some cities to gradually roll out emission-inventory development at the municipal level.

### The implementation of the Action Plan is safeguarded by measures such as financial support and administrative assessment

To ensure the effective implementation of the Ten Measures of the State Council, the MEP has, in collaboration with other related ministries, departments and agencies, formulated 22 supporting measures that consist primarily of economic policies and assessment methods. 19 of these policies were launched by the end of 2014, which have enhanced the implementation of emission-reduction policies. The National Government increases its financial input in the special fund for air pollution prevention and control each year, from RMB 5 billion in 2013 to RMB 9.8 billion to date. The 74 cities are also gradually increasing input in their own special funds for air pollution prevention and control each year in the forms of awards and subsidies to encourage boiler retrofit, pollutant emissions control in key industries and the elimination of outdated production capacity and yellow-label vehicles.

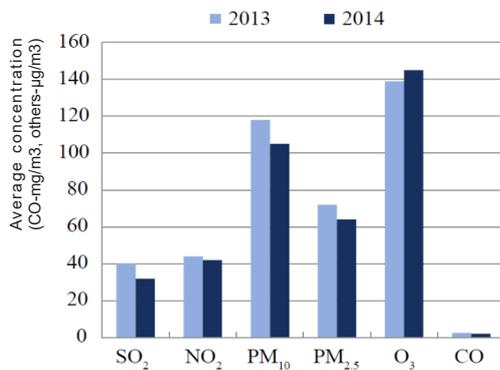
The Ten Measures of the State Council have expressly included the targets of air pollution prevention and control into officials' performance assessment system. The MEP produces monthly rankings of the best and worst cities in terms of air quality, while local governments are admonished by the Ministry for poor performance in air quality control. The pressure from these "three major policies" on local governments have turned into the impetus to drive the implementation of emission-reduction measures.

# Current Air Quality Status

At the beginning of 2013, 74 cities started to monitor and publish their air quality data according to the Revised Standards, providing real-time monitoring data on six pollutants (SO<sub>2</sub>, NO<sub>2</sub>, PM<sub>10</sub>, PM<sub>2.5</sub>, O<sub>3</sub>, and CO) to the public. Based on publicly available data sources from the government, the first part of the report demonstrates the status of and changes in air quality in 74 key cities in 2013 and 2014. The data used in this section is sourced from the Air Quality Bulletin, the Monthly Air Quality Report and official news issued by the MEP and environmental protection departments and bureaus. Some of the data is temporarily unavailable as some cities have yet to publish it.

**The condition is starting to improve, although the overall concentration is still not in compliance**

Compared with 2013, the annual mean concentrations of five of the six pollutants (PM<sub>2.5</sub>, PM<sub>10</sub>, SO<sub>2</sub>, NO<sub>2</sub> and CO) in the 74 cities decreased by 11.1%, 11.0%, 20%, 4.5% and 16.0% respectively in 2014. However, the annual mean concentrations of PM<sub>2.5</sub> and PM<sub>10</sub> were still significantly higher than the National Secondary Standard under the Revised Standards (the National Secondary Standard) at 1.8 times and 1.5 times respectively. The annual mean concentration of NO<sub>2</sub> was approaching the National Secondary Standard, while the annual mean concentrations of SO<sub>2</sub>, CO and O<sub>3</sub> were in compliance. Particulate matter remained the primary pollutants in the 74 cities. The O<sub>3</sub> pollution was becoming increasingly prominent, with a 4.3 percentage increase in the annual mean concentration.

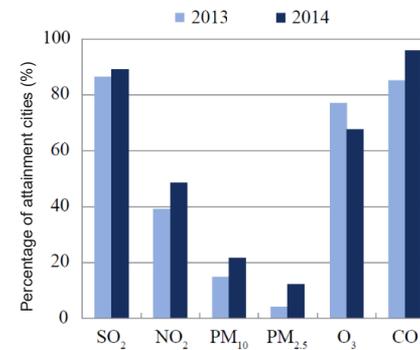


Source: 2014 China Environment Condition Communique

**The number of attainment cities has slightly increased, but the overall attainment percentage is still below 20%**

Concerning the six pollutants, the change in the number of attainment cities from 2013 to 2014 is consistent with that in annual mean concentration. Aside from O<sub>3</sub>, in terms of which the percentage of attainment cities declined by 9.4%, the percentage of attainment cities in terms of other pollutants

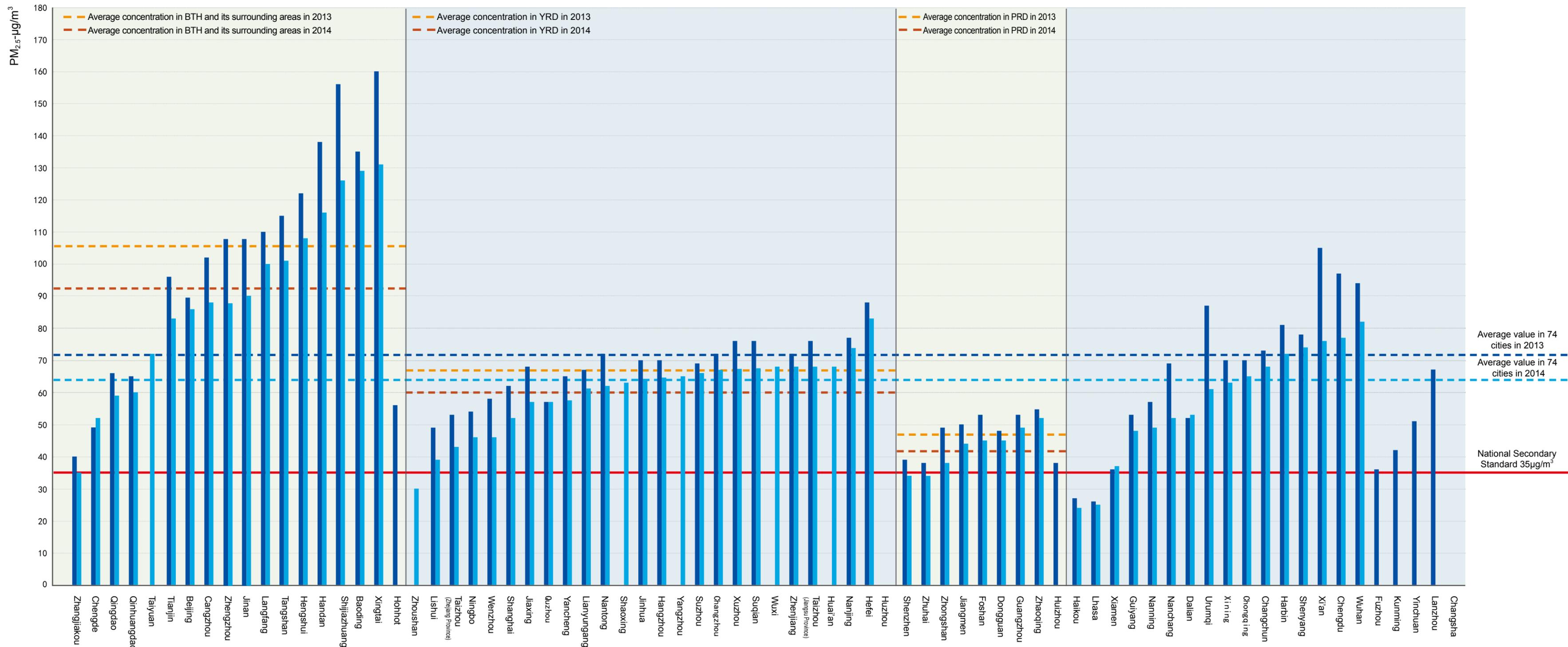
increased by 11.8% (CO), 9.4% (NO<sub>2</sub>), 8.1% (PM<sub>2.5</sub>), 6.7% (PM<sub>10</sub>) and 2.7% (SO<sub>2</sub>) respectively. 95.9% of the cities attained the target in terms of annual mean concentration of CO in 2014, representing the highest percentage of attainment. The number of cities whose annual mean concentrations of the six pollutants were all in compliance increased from three (Haikou, Lhasa and Zhoushan) in 2013 to eight (Haikou, Lhasa, Zhoushan, Shenzhen, Zhuhai, Fuzhou, Huizhou and Kunming) in 2014. All the other cities had exceeded the standards to some extent. For the non-attainment pollutants, particulate matter was still the primary pollutant. The annual mean concentration of PM<sub>2.5</sub> was 37-130 µg/m<sup>3</sup> higher than the National Secondary Standard (35 µg/m<sup>3</sup>), with 87.8% of the cities failing to reach the standard. The annual mean concentration of PM<sub>10</sub> was 71-233 µg/m<sup>3</sup> higher than the National Secondary Standard (70 µg/m<sup>3</sup>), with 78.4% of the cities failing to meet the standard.



Source: 2014 China Environment Condition Communique

**BTH and its surrounding areas are heavily polluted, while some cities in Northeast, Central and Southwest China also experience serious problems**

The three key regions have significant regional characteristics. The concentration of pollutants and the number of non-attainment days are significantly higher in BTH and its surrounding areas (Shandong Province, Shanxi Province, Inner Mongolia and Henan Province) than in YRD and PRD. The air quality in YRD is similar to the national average, while PRD has the best air quality. Aside from PM<sub>2.5</sub>, which is slightly higher than the standard, all the other five pollutants were in compliance in PRD. According to the list of the top 10 cities with the best air quality issued by the MEP in 2014, three of them are in PRD. On the list of the 10 cities with the worst air quality, all of them are in BTH and its surrounding areas, with eight cities from Hebei Province. Some cities in Northeast, Central and Southwest China have also experienced serious problems. The annual mean concentrations of PM<sub>2.5</sub> in Harbin, Shenyang, Xi'an, Wuhan, and Chengdu were two times higher than the National Secondary Standard in 2014.



**Fig. 1: Annual Mean Concentration of PM<sub>2.5</sub> in 74 Cities and Key Regions**

◆ The annual mean concentration of PM<sub>2.5</sub> decreased, yet still heavily exceeded the standards. The range of annual mean concentration of PM<sub>2.5</sub> in 74 cities decreased from 26-160 µg/m<sup>3</sup> to 23-130 µg/m<sup>3</sup>, and the mean concentration decreased from 72 µg/m<sup>3</sup> to 64 µg/m<sup>3</sup>, which are 2.1 and 1.8 times higher than the National Secondary Standard, respectively.

◆ The number of attainment cities increased: The percentage of attainment cities increased from 4.1% in 2013 to 12.2% in 2014.

◆ Among the three key regions, BTH and its surrounding areas experienced the greatest decrease in the annual mean concentration of PM<sub>2.5</sub>, yet are still ranked as the highest in terms of total emission. A 12.3% drop in the concentration in BTH was noted, from 106 µg/m<sup>3</sup> in 2013 to 93 µg/m<sup>3</sup>. A 10.4% decrease was noted in the YRD, from 67 µg/m<sup>3</sup> to 60 µg/m<sup>3</sup>, and a 10.6% decrease was noted in PRD, from 47 µg/m<sup>3</sup> to 42 µg/m<sup>3</sup>.

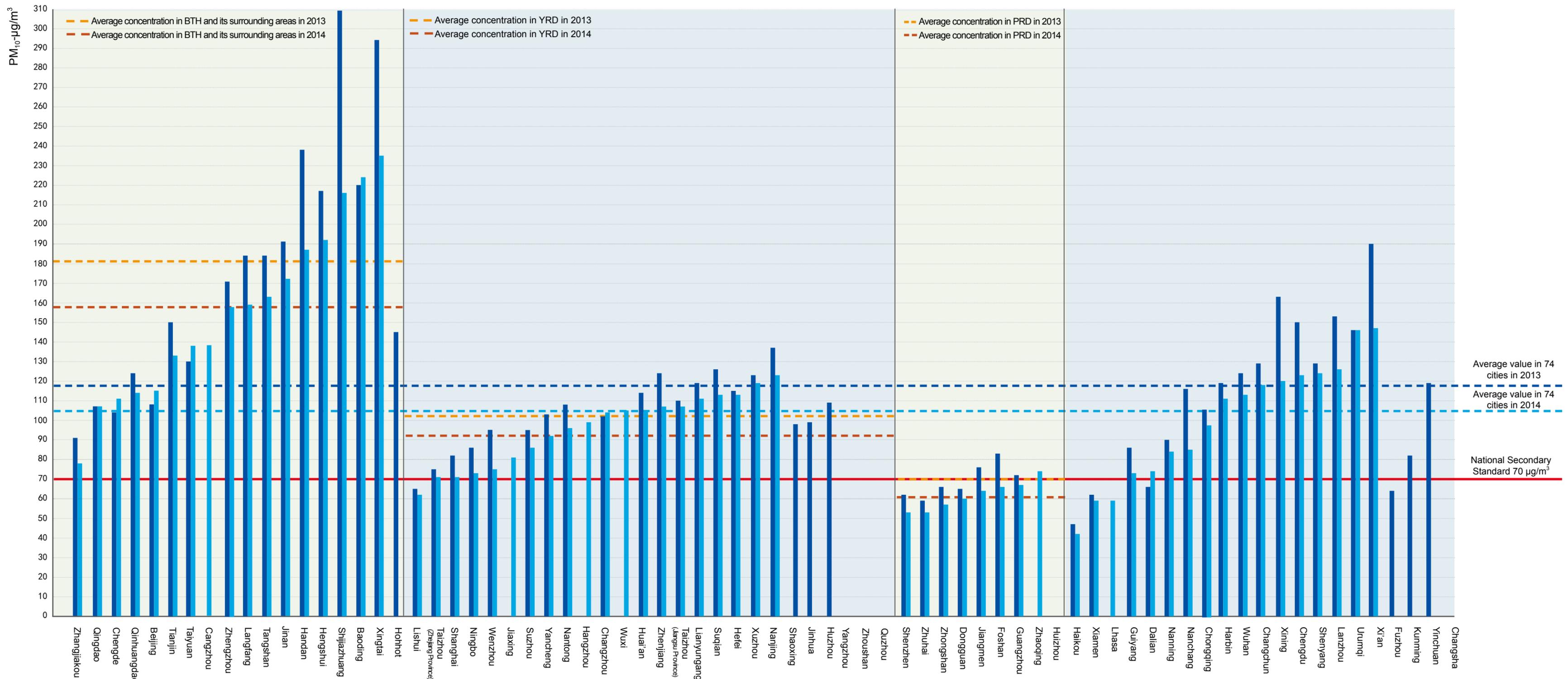


Fig. 2: Annual Mean Concentration of PM<sub>10</sub> in 74 Cities and Key Regions

◆ The annual mean concentration of PM<sub>10</sub> decreased, yet still heavily exceeded the standards. The range of annual mean concentration of PM<sub>10</sub> in 74 cities decreased from 47-135 µg/m<sup>3</sup> to 42-233 µg/m<sup>3</sup>, and the mean concentration decreased from 118 µg/m<sup>3</sup> to 105 µg/m<sup>3</sup>, which are 1.7 and 1.5 times higher than the National Secondary Standard (70 µg/m<sup>3</sup>), respectively.

◆ The number of attainment cities increased: The percentage of attainment cities increased from 14.9% in 2013 to 21.6% in 2014.

◆ The annual mean concentration of PM<sub>10</sub> decreased in all three key regions, yet BTH and its surrounding areas are still ranked as the highest in terms of the total emission. A 12.7% drop in the concentration was noted in BTH and its surrounding areas, from 181 µg/m<sup>3</sup> in 2013 to 158 µg/m<sup>3</sup> in 2014. A 10.7% decrease was noted in YRD, from 103 µg/m<sup>3</sup> to 92 µg/m<sup>3</sup>, and a 12.9% decrease was noted in PRD, from 70 µg/m<sup>3</sup> to 61 µg/m<sup>3</sup>.

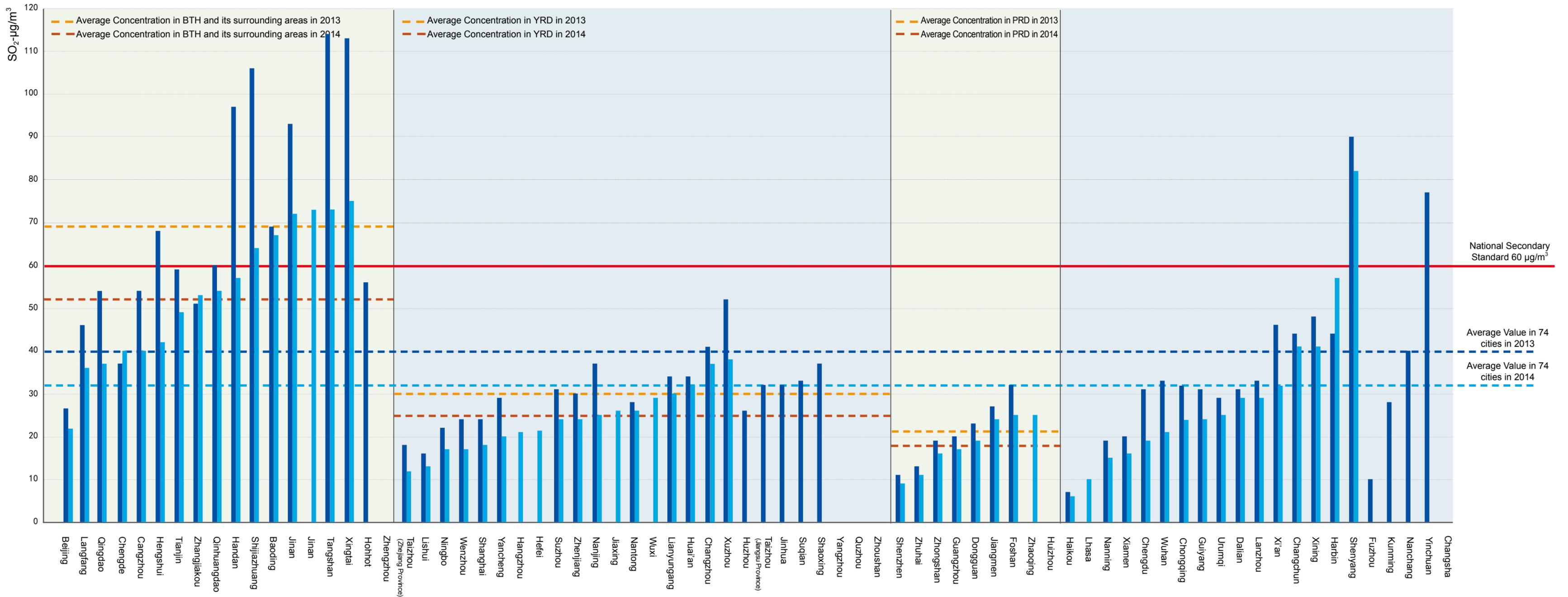


Fig. 3: Annual Mean Concentration of SO<sub>2</sub> in 74 Cities and Key regions

■ Annual Mean Concentration in 2013  
 ■ Annual Mean Concentration in 2014

◆ The annual mean concentration of SO<sub>2</sub> has already complied with the standards and further declined on that basis. The range of annual mean concentration in 74 cities decreased from 7-114 µg/m<sup>3</sup> to 6-82 µg/m<sup>3</sup>. The mean concentration decreased from 40 µg/m<sup>3</sup> to 32 µg/m<sup>3</sup>, complying with the National Secondary Standard (60 µg/m<sup>3</sup>).

◆ The number of attainment cities increased: The percentage of attainment cities increased from 86.5% in 2013 to 89.2% in 2014.

◆ All three key regions complied with the standards and experienced a decrease in the annual mean concentration of SO<sub>2</sub>. A 24.6% drop in the concentration was noted in BTH and its surrounding areas, from 69 µg/m<sup>3</sup> to 52 µg/m<sup>3</sup>. A 16.7% drop was noted in YRD, from 30 µg/m<sup>3</sup> to 25 µg/m<sup>3</sup>, and a 14.3% drop was noted in PRD, from 21 µg/m<sup>3</sup> to 18 µg/m<sup>3</sup>.

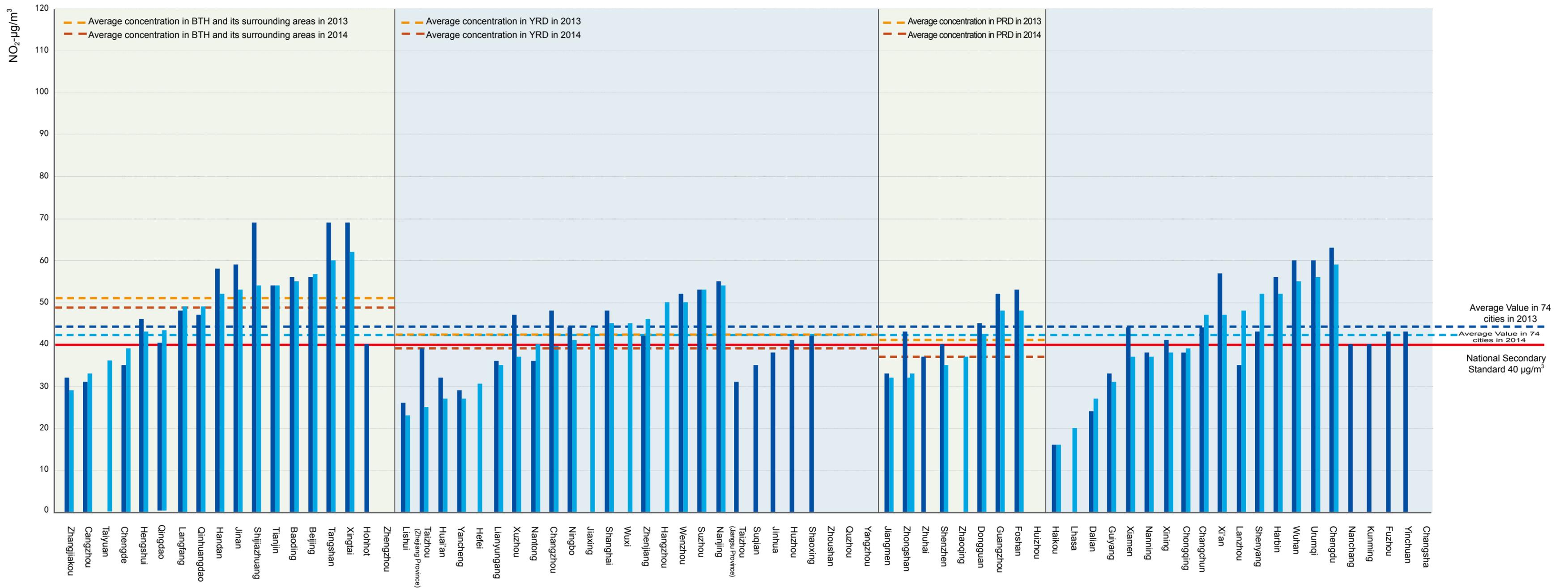
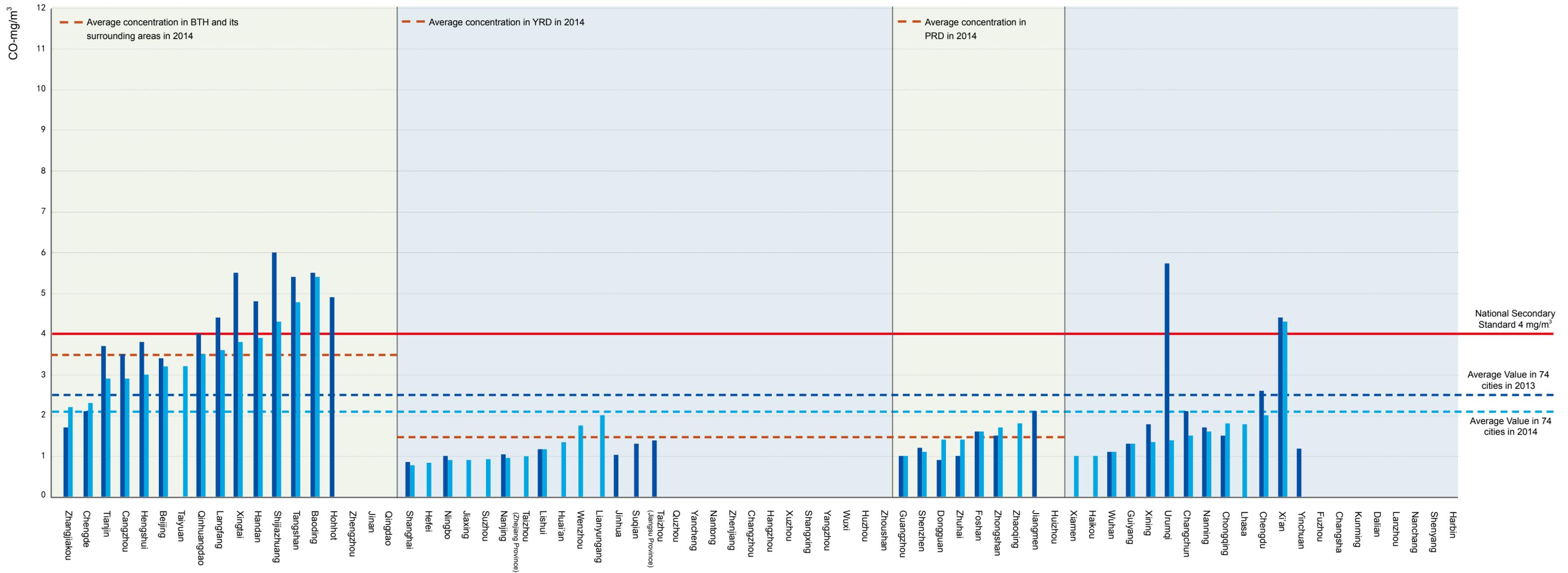


Fig. 4: Annual Mean Concentration of NO<sub>2</sub> in 74 Cities and Key Regions

■ Annual mean concentration in 2013  
 ■ Annual mean concentration in 2014

◆ The range of annual mean concentration of NO<sub>2</sub> in 74 cities decreased from 17-69 µg/m<sup>3</sup> to 16-61 µg/m<sup>3</sup>, and the mean concentration decreased from 44 µg/m<sup>3</sup> to 42 µg/m<sup>3</sup>, approaching the National Secondary Standard (40 µg/m<sup>3</sup>).  
 ◆ The number of attainment cities further increased: The percentage of attainment cities increased from 39.2% to 48.6%.

◆ All three key regions experienced a decrease in the annual mean concentration of NO<sub>2</sub>, and YRD and PRD have reached the standards. A 3.9% drop in the concentration was noted in BTH and its surrounding area, from 51 µg/m<sup>3</sup> to 49 µg/m<sup>3</sup>. A 7.1% drop was noted in YRD, from 42 µg/m<sup>3</sup> to 39 µg/m<sup>3</sup>, and a 9.8% drop was noted in PRD, from 41 µg/m<sup>3</sup> to 37 µg/m<sup>3</sup>.



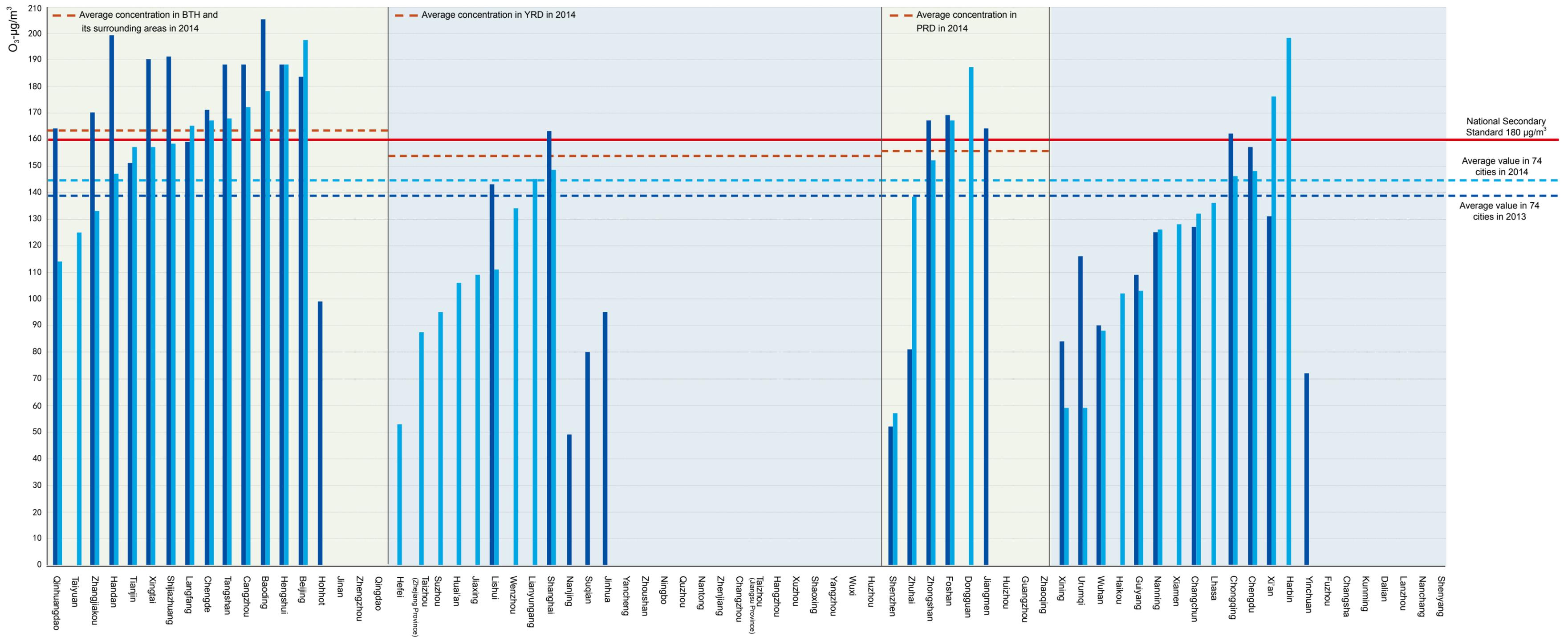
**Fig. 5: 24-Hour Mean Concentration of CO in 74 Cities and Key Regions**

■ Annual mean concentration in 2013  
 ■ Annual mean concentration in 2014

◆ The annual mean concentration of CO already complied with the standards and further declined on that basis. The 95th percentile of the daily average concentration range decreased from 1.0-5.9 mg/m<sup>3</sup> to 0.9-5.4 mg/m<sup>3</sup>. The average concentration decreased from 2.5 mg/m<sup>3</sup> to 2.1 mg/m<sup>3</sup>, complying with the National Secondary Standard (4 mg/m<sup>3</sup>).

◆ All the cities will soon reach the standards: The number of attainment cities has increased to 71, with the percentage increased from 85.1% to 95.9%.

◆ All three key regions complied with the standards and experienced a continued drop in the 24-hour mean concentration of CO. A 14.6% drop in the concentration was noted in BTH and its surrounding areas, from 4.1 mg/m<sup>3</sup> to 3.5 mg/m<sup>3</sup>. A 21.1% drop was noted in YRD, from 1.9 mg/m<sup>3</sup> to 1.5 mg/m<sup>3</sup>, and a 6.3% drop was noted in PRD, from 1.6 mg/m<sup>3</sup> to 1.5 mg/m<sup>3</sup>.



**Fig. 6: Daily Maximum 8-Hour Average Concentration of O<sub>3</sub> in 74 Cities and Key Regions**

█ Average value in 74 cities in 2013  
█ Average value in 74 cities in 2014

◆ Although the annual mean concentration of O<sub>3</sub> has complied with the standards, it is the only one of the six pollutants that experienced an increase in concentration. Even though the 90th percentile of the daily maximum 8-hour average concentration of O<sub>3</sub> is in compliance with the National Secondary Standard (160 µg/m<sup>3</sup>), the range of the concentration increased from 72-190 µg/m<sup>3</sup> to 69-200 µg/m<sup>3</sup>. The average concentration increased from 139 µg/m<sup>3</sup> to 145 µg/m<sup>3</sup>.

◆ Instead of increasing, the number of attainment cities decreased: The percentage

of attainment cities decreased from 77% to 67.6%.

◆ All three key regions experienced an increase in the 90th percentile of the daily maximum 8-hour average concentration of O<sub>3</sub>. The concentration of O<sub>3</sub> in YRD and PRD are still within the attainment standards. A 4.5% increase in the concentration was noted in BTH and its surrounding areas, from 155 µg/m<sup>3</sup> to 162 µg/m<sup>3</sup>. A 6.9% increase was noted in YRD, from 144 µg/m<sup>3</sup> to 154 µg/m<sup>3</sup>, and a 0.6% increase was noted in PRD, from 155 µg/m<sup>3</sup> to 156 µg/m<sup>3</sup>.

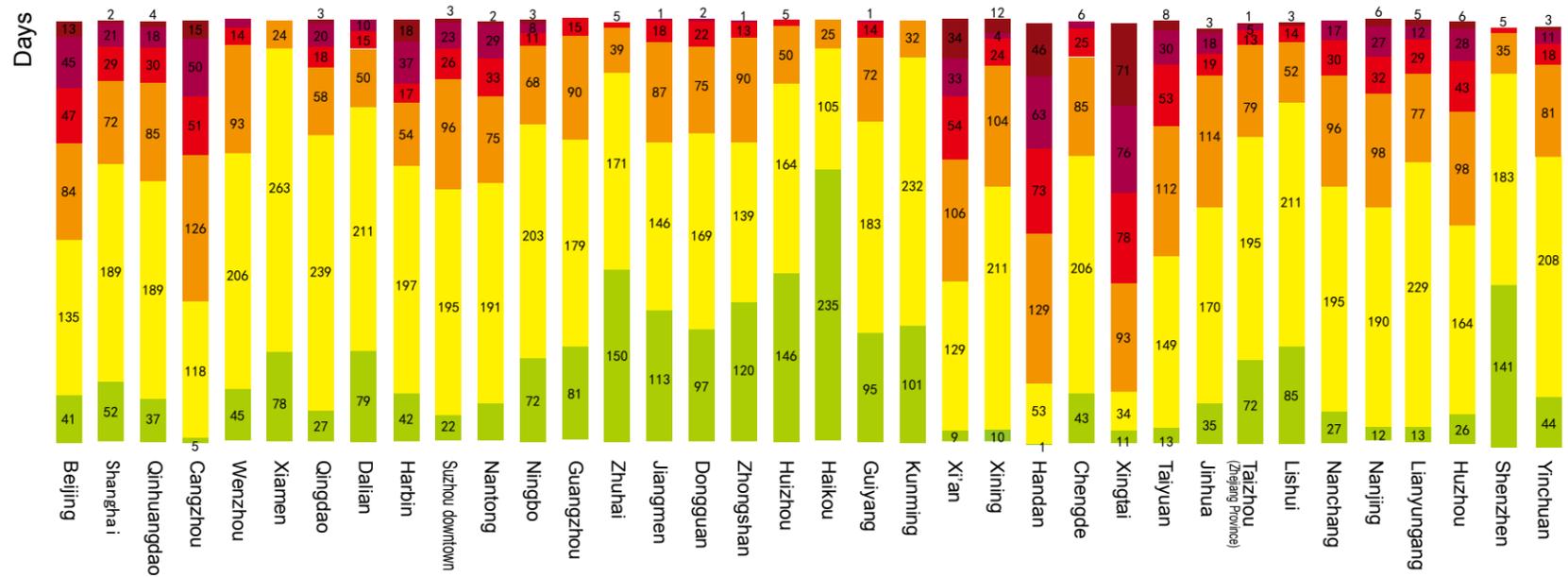


Fig. 7: Distribution of AQI in Selected Cities in 2013 \*

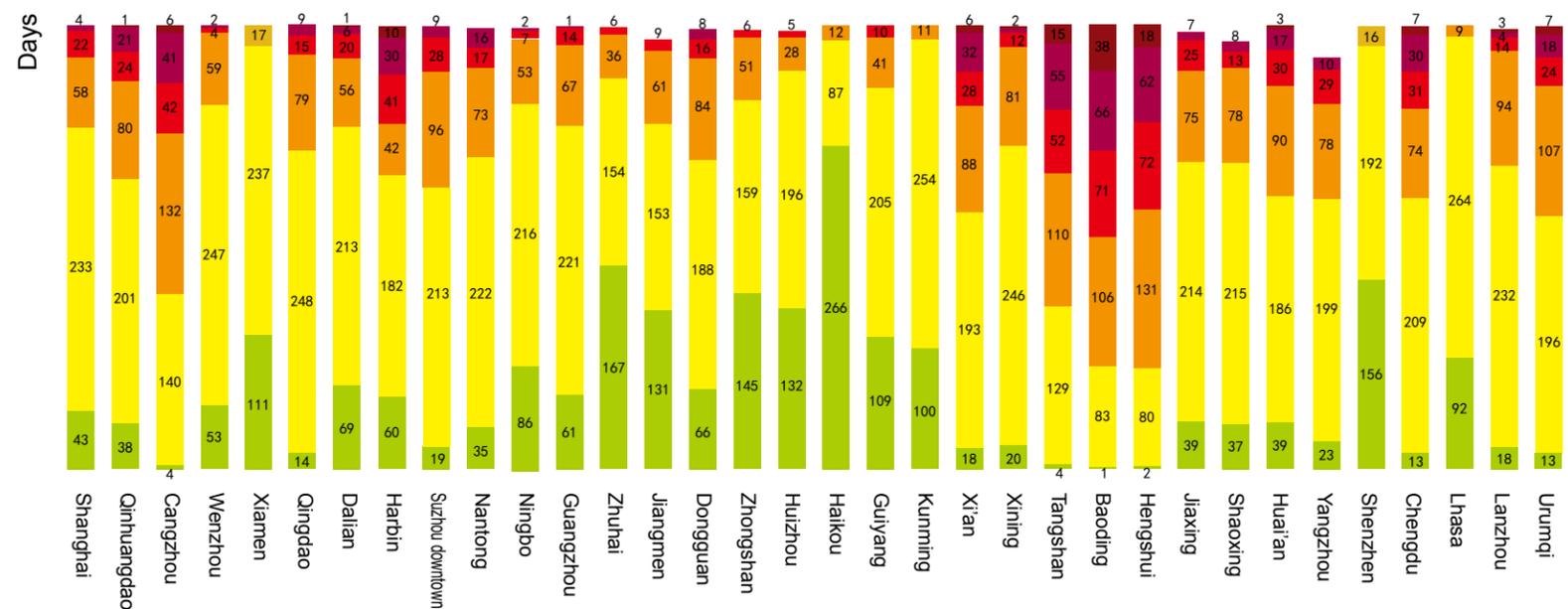
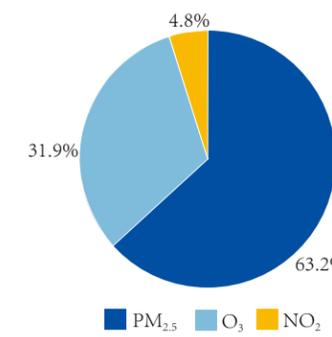


Fig. 8: Distribution of AQI in Selected Cities in 2014 \*

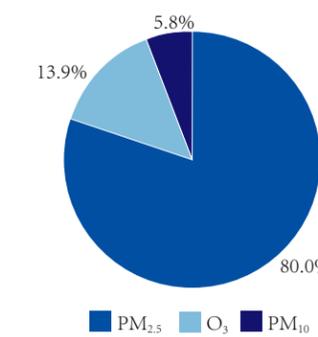
1-50 Good    51-100 Moderate    101-150 Unhealthy    151-200 Unhealthy    201-300 Very Unhealthy    >300 Hazardous  
for Sensitive Groups

\*Data collected from cities that publish their AQI distribution

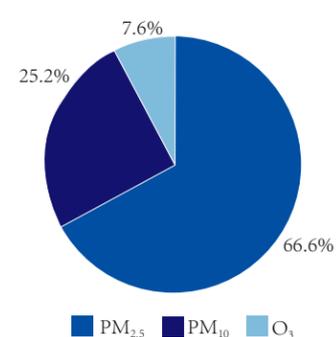
\*The Air Quality Index (AQI) translates pollutant concentrations to a number on a scale that is further divided into bands that correspond to a defined pollution concentration. Depending on the AQI value, these bands could be defined as "good", "moderate", "unhealthy for sensitive groups", "unhealthy", "very unhealthy", and "hazardous", which have different meanings for different vulnerable groups of the population. The index is also color-coded to make the information more comprehensible and visually appealing.



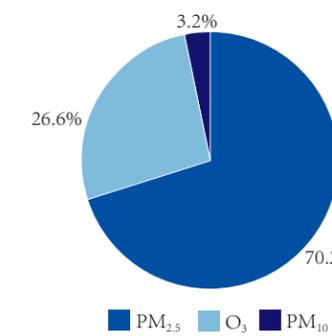
The number of non-attainment days in PRD was 86 in 2013.



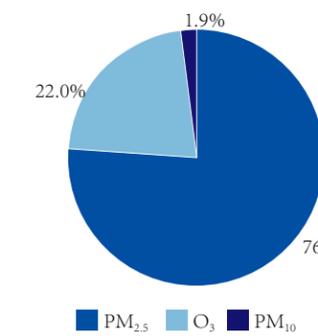
The number of non-attainment days in YRD was 130 in 2013.



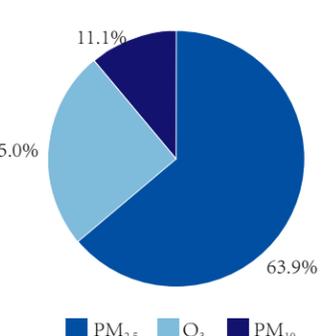
The number of non-attainment days in BTH and its surrounding areas was 228 in 2013.



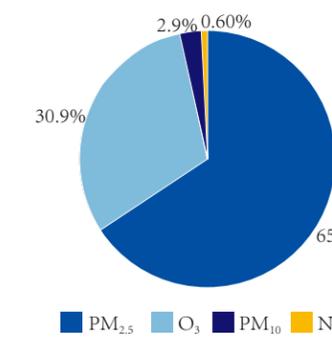
The number of non-attainment days in Shanghai was 124 in 2013.



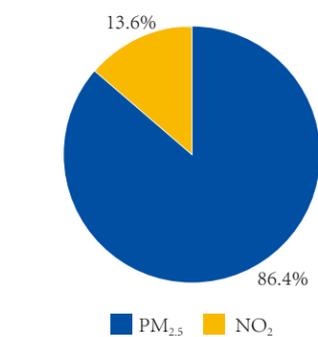
The number of non-attainment days in Chongqing was 159 in 2013.



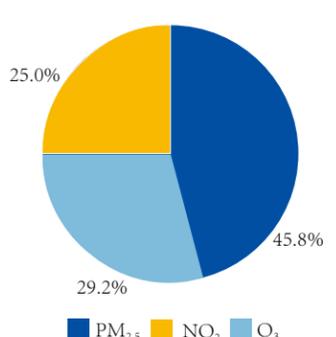
The number of non-attainment days in Zhoushan was 36 in 2013.



The number of non-attainment days in Huzhou was 175 in 2013.



The number of non-attainment days in Fuzhou was 22 in 2013.



The number of non-attainment days in Xiamen was 24 in 2013.

Fig. 9: Number of Days with Different Primary Pollutants in Key Regions and Cities

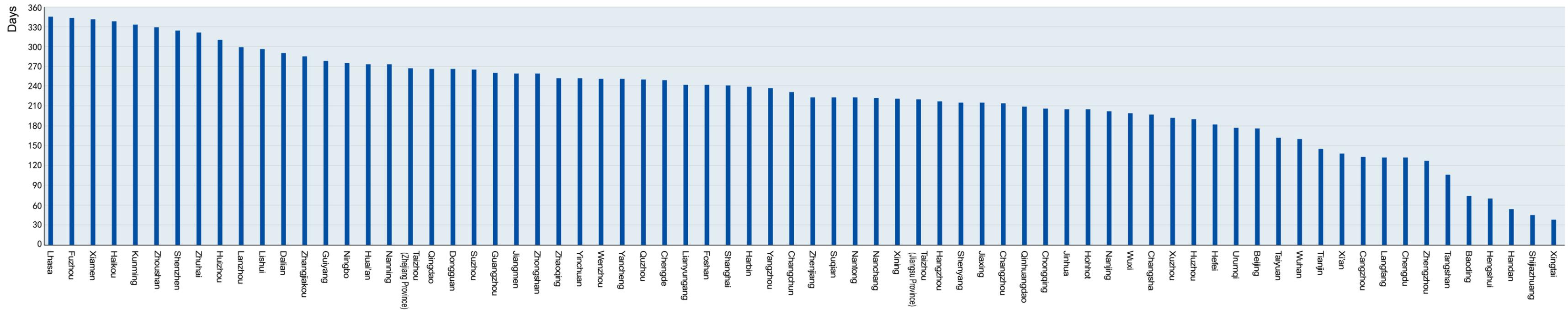


Fig. 10: Number of Attainment Days in Key Cities in 2013

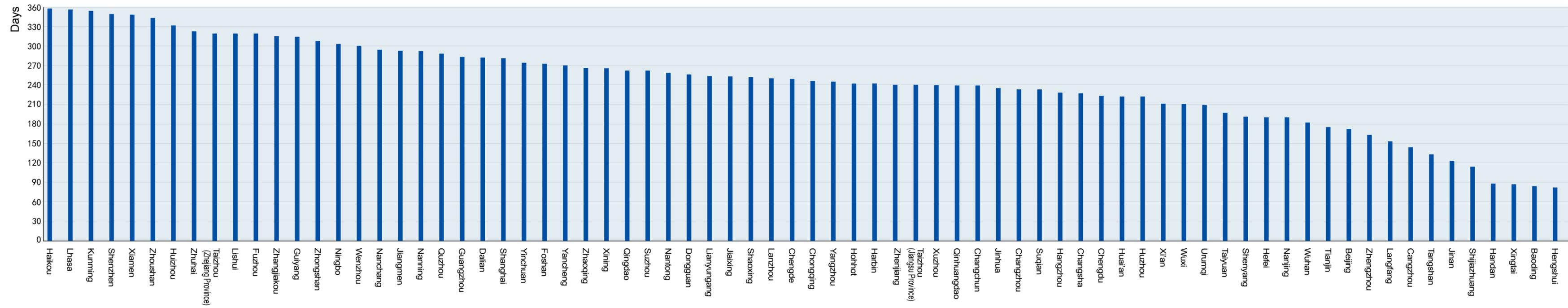


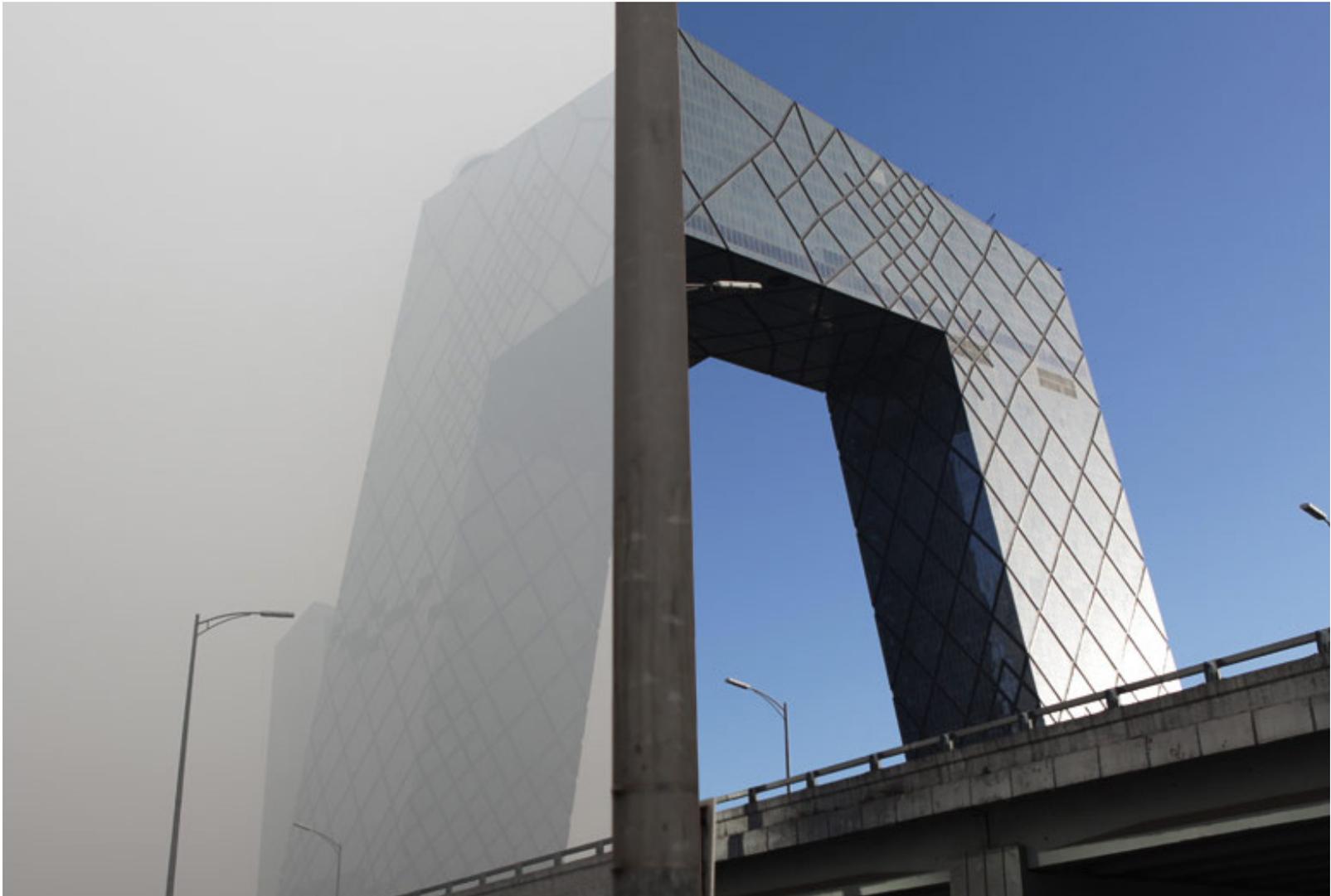
Fig. 11: Number of Attainment Days in Key Cities in 2014

The number of attainment days among the 74 major cities ranges from 38 to 345 in 2013 and from 82 to 358 in 2014. The average attainment days increased from 223 to 243.

# **Policy Implementation and Progress**

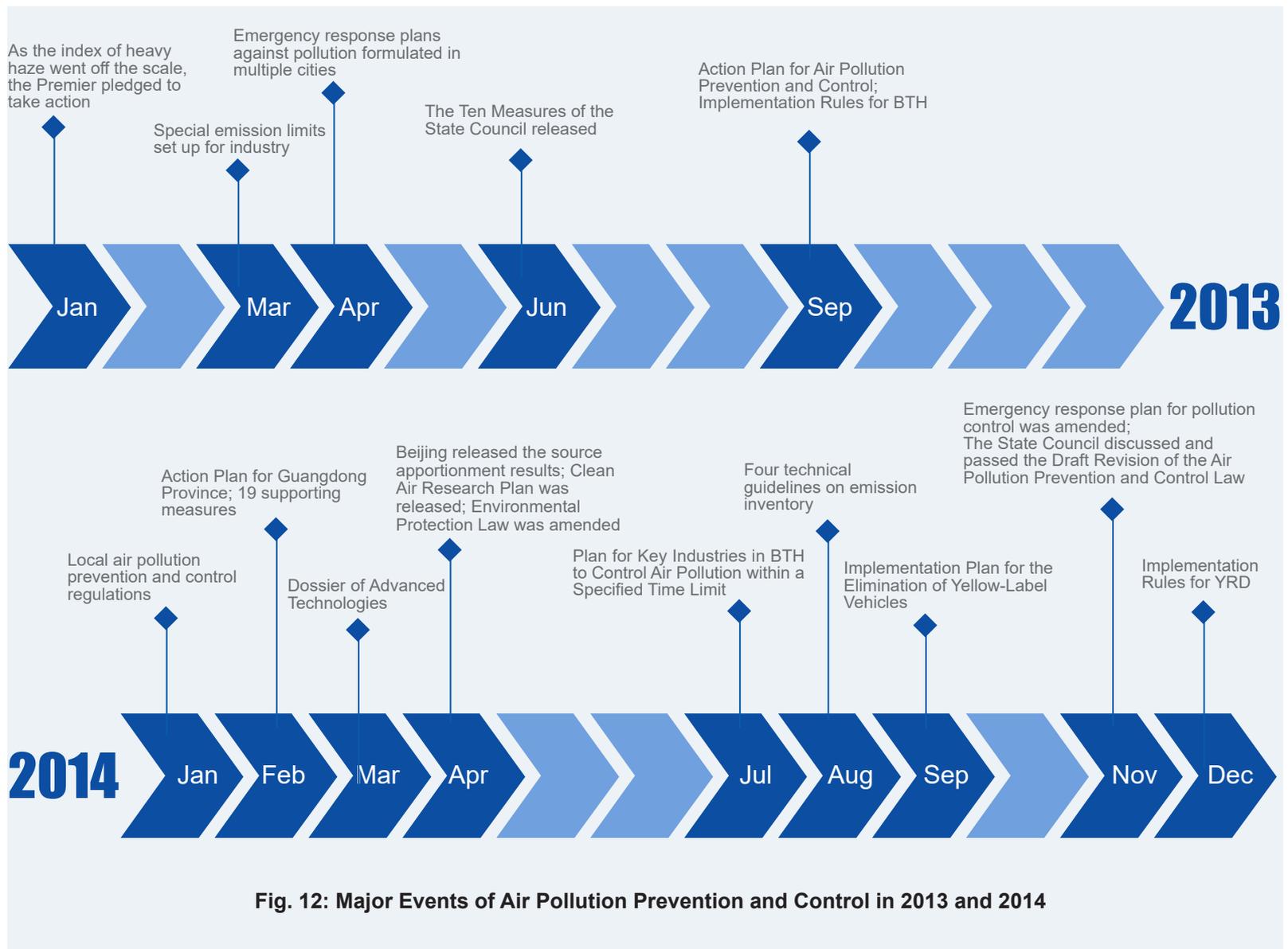
## Major Events of Air Pollution Prevention and Control

Many provinces and cities in China experienced serious haze in January 2013 that caused extremely low visibility and serious air pollution. In Beijing and its surrounding cities, the concentration of PM<sub>2.5</sub> went “beyond index”, which caused widespread concern. Li Keqiang, China’s then Vice-Premier, pledged to take actions for air pollution prevention and control. China’s State Council announced the well-known “Ten Measures” at its executive meeting in June 2013 and issued the Action Plan for Air Pollution Prevention and Control in September 2013, which set forth the development targets and roadmap for the next five years (2013-2017) and marked the beginning of a new epoch in China’s air pollution prevention and control efforts.



We must resolutely declare war against pollution as we do against poverty

- Li Keqiang, Member of the Standing Committee of the CPC Political Bureau and Premier of the State Council



Between 2013 and 2014, governments at the municipal, provincial, regional and national levels formulated corresponding implementation rules and plans and issued 19 related supporting measures to facilitate the implementation of the Action Plan. In addition to developing emission-reduction policies and supporting measures, governments also paid attention to capacity building to support scientific decision-making. Emphasis was placed on finding out the basics of pollution sources through monitoring, source apportionment and emission inventory development, and key regions were required to implement these ahead of others.

# Air Pollution Prevention and Control Policy Framework

China's air pollution prevention and control efforts date back to the 1970s. Following economic development, the primary sources of pollution and pollutants have shifted from coal combustion and industrial pollution to a mixture of coal combustion, industrial and vehicle pollution. In addition to total suspended particulates (TSP) and sulfur dioxide in the early days, new pollutants such as nitrogen oxides and particulate matter have now been added to the list of pollutants. Consequently, the Chinese government must continuously formulate policies to tackle these changes. During this period, the staging of major international events helped some megacities acquire advanced experience and knowledge of air quality management. The issuing of the Action Plan has helped streamline existing policies and put forward new policies and measures to effectively improve air quality, thus providing a top-down air pollution prevention and control policy framework that covers capacity building, emission-reduction measures and supporting measures.

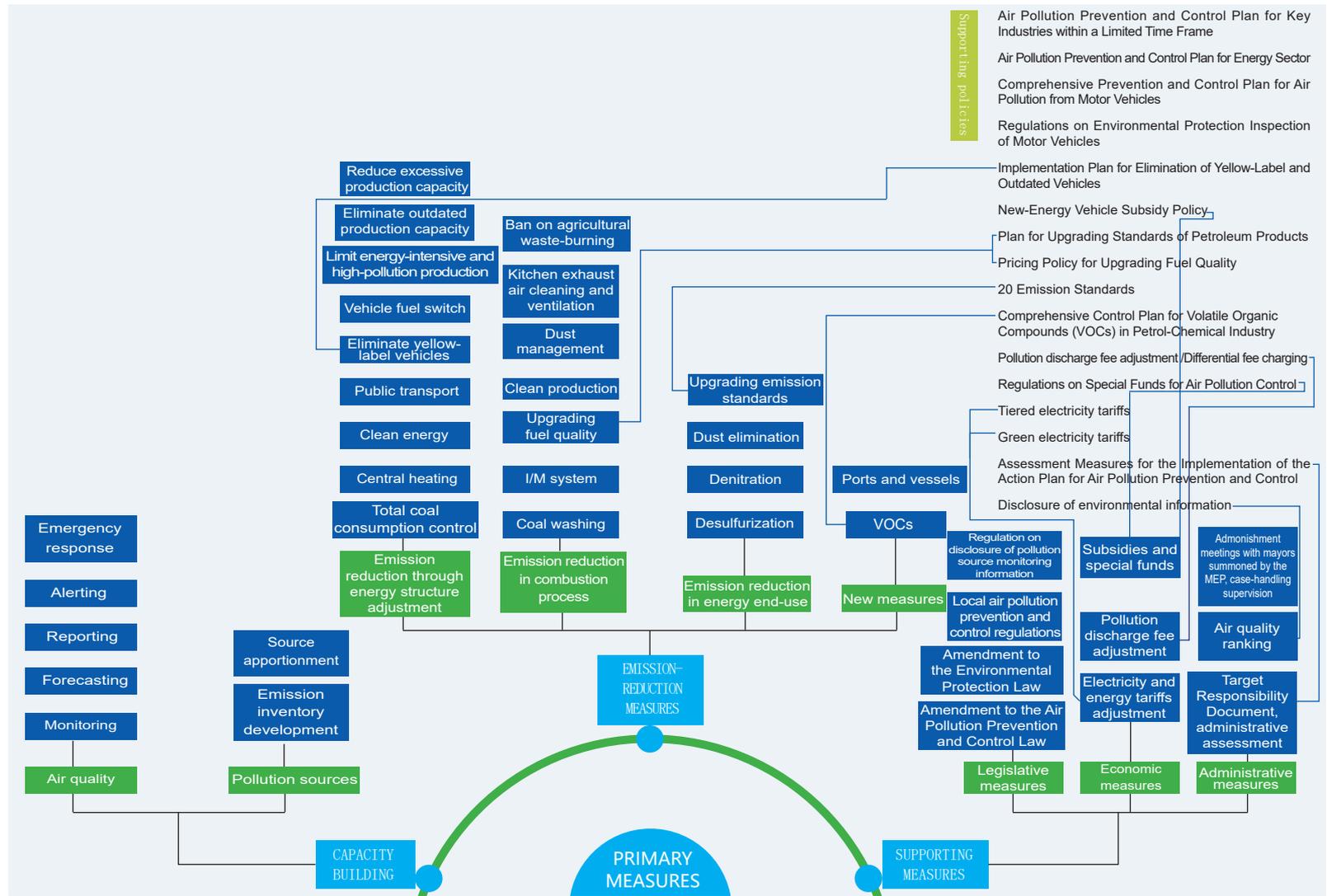


Fig. 13: China's Air Pollution Prevention and Control Policy Framework Measures after the Ten Measures of the State Council

## Action Plan for Air Pollution Prevention and Control and Local Implementation Plans



### National Government

Proposed in the executive meeting of the State Council, the “Ten Measures of the State Council” were drafted by the MEP and the Chinese Academy for Environmental Planning, and reviewed, edited and released by the State Council in June 2013. The ten measures are:

1. To step up efforts in pollution control and reduce multi-pollutant emissions;
2. To promote industrial restructuring, upgrading and transformation;
3. To accelerate the technological transformation of enterprises and improve their scientific innovation capabilities;
4. To accelerate energy restructuring and increase clean energy supply;
5. To set strict industry access standards for energy conservation and environmental protection and optimize industrial spatial layout;
6. To allow the market mechanism to run its course and improve environmental and economic policies;
7. To improve the legal system, tighten regulations and conduct stringent supervision in accordance with the law;

8. To establish regional coordination mechanisms for regional environmental management;
9. To establish monitoring, alerting and emergency response systems to properly address heavily polluted weather; and
10. To clarify the responsibilities of governments, enterprises and civil society and engage the public in environmental protection.

The Action Plan was officially released in September 2013, and provided detailed information on the Ten Measures. The plan has attracted widespread attention both at home and abroad as it for the first time sets clear targets for air quality improvement. With scaled-up efforts, the plan - which the media refers to as “the most stringent action plan for air pollution control” - demonstrates the Chinese government's resolve to tackle air pollution.

To fully implement the Action Plan for Air Pollution Prevention and Control, the State Council's executive meeting reviewed and approved the first batch of 22 supporting measures on February 12, 2014.

Nineteen supporting measures were announced by the end of 2014 involving three key aspects - energy structure adjustment, environmental and economic policies, and the clarification of responsibilities of all parties. The key tasks, responsible department(s), and deadline for each measure were identified.

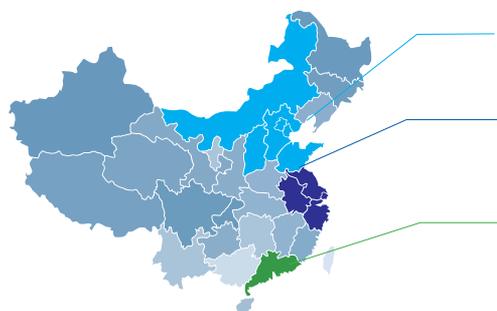
The financial measures include:

1. Regulations on special funds for air pollution control and raising pollution discharge fees, as well as tiered electricity and green electricity tariffs (raising the denitration compensation standard for power-generating enterprises and providing compensation for dust-elimination tariffs);
2. Implementation plans for petroleum products, pricing policy for upgrading fuel quality and subsidy policy for new energy vehicles targeting the energy and transportation sectors;
3. Environmental information-disclosure measures that involve public participation; and
4. Assessment methods that serve as incentives to local governments and an assessment system that directs major efforts in air quality improvement and encourages comprehensive air pollution control as a supporting method to fully mobilize local governments to take the initiative.

## Key Regions

The Action Plan emphasizes the need to establish regional coordination mechanisms to facilitate air pollution control and set BTH and its surrounding areas, YRD and PRD as the three key control regions.

**BTH:** BTH is the top priority among the three key regions. After the formal launch of the Action Plan, the State Council released the Implementation Rules for the Action Plan for Air Pollution Prevention and Control in BTH and Surrounding Areas. Local governments in the region strengthened the implementation of coal-consumption control, industrial structure adjustment and vehicle emission control in 2014. The MEP released the Air Pollution Control Plan for Key Industries in BTH and Surrounding Areas within a Limited Time



Six MACs, including the MEP, released the Implementation Rules for the Action Plan for Air Pollution Prevention and Control in BTH and Surrounding Areas in 2014.

Three provinces and one city in YRD (Shanghai, Jiangsu Province, Zhejiang Province and Anhui Province) and eight MACs officially launched the coordination mechanism for air pollution prevention and control in YRD in 2014, released the Implementation Rules for the Action Plan for Air Pollution Prevention and Control in YRD and formulated Key Suggestions for Air Pollution Prevention and Control Coordination in YRD in 2015.

Guangdong Province released the Action Plan for Air Pollution Prevention and Control in Guangdong Province (2014 – 2017) in February 2014, which sets more demanding air quality improvement targets and air pollution prevention and control measures in PRD. The Province released the Air Pollution Control Plan for Key Industries in PRD and Surrounding Areas in a Limited Time Frame the same November.

Frame in July of the same year, which requires electrical, steel, cement and plate-glass industries to implement air pollution control within a limited time frame to achieve a minimum goal of a 30% total emission reduction in major air pollutants such as sulfur dioxide, nitrogen oxides and dusts compared with 2013.

In October 2013, the Air Pollution Prevention and Control Coordination Mechanism of BTH and Surrounding Areas was established by Beijing, Tianjin, Hebei Province, Shanxi Province, the Inner Mongolia Autonomous Region, Shandong Province and eight ministries, administrations and commissions (MACs). Henan Province also subsequently joined the coordination mechanism.

Through the mechanism, meetings are held twice a year to promote the implementation of key tasks and solve major problems through coordination. An information exchange and sharing mechanism was also established to periodically release briefs that share information on local policies, measures and experience, along with a regional air pollution prevention and control expert committee and a heavy-pollution alerting and consultation platform among six provinces and cities to enable coordinated emergency response actions to be taken to address regional-scale heavy pollution, as demonstrated during the APEC Summit in 2014 when the mechanism proved successful.

Joint regional law enforcement activities targeting agricultural waste burning,

fuel quality and coal quality were also carried out, and a special coordination mechanism for vehicle emission prevention and control was established.

**YRD:** The Air Pollution Prevention and Control Coordination Mechanism of YRD was established in January 2014 by Shanghai, Jiangsu Province, Zhejiang Province, Anhui Province and eight MACs. Through the mechanism, YRD released regional implementation rules for the Action Plan for Air Pollution Prevention and Control and the regional joint control plan for heavy air pollution.

Tasks within the mechanism include: 1) Coordinating and promoting the implementation of national policies and important deployment plans for air pollution prevention and control in YRD; 2) Studying the major air pollution prevention and control issues in YRD; 3) Promoting the joint prevention and control of air pollution, reporting and exchanging information on the progress of

air pollution prevention and control and the status of air quality, and coordinating and solving major atmospheric environmental problems in YRD; 4) Promoting the gradual alignment and integration of environmental standards in energy conservation and emission reduction, pollution emissions, industry access and phase-out in YRD; and 5) Promoting the implementation of information-sharing on the atmospheric environment, forecasting and alerting, joint emergency response actions, joint law enforcement and R&D cooperation in YRD.

**PRD:** Guangdong Province released the Action Plan for Air Pollution Prevention and Control in Guangdong Province (2014-2017) in February 2014, which sets demanding air quality improvement targets and air pollution prevention and control measures in PRD. The province released the Air Pollution Control Plan for Key Industries in PRD and Surrounding Areas within a Limited Time Frame in November of the same year which requires that air pollution control by electrical, steel, cement and plate-glass industries be implemented in PRD and its surrounding areas (Guangdong Province, Jiangxi Province, Hunan Province, Guangxi Province and Hainan Province) within a limited time frame.

Since PRD cities are all under the same provincial administration (Guangdong Province), they were early in developing plans, policies and mechanisms for regional air pollution prevention and control, and established a joint regional meeting mechanism for air pollution prevention and control in 2008.

## Cities

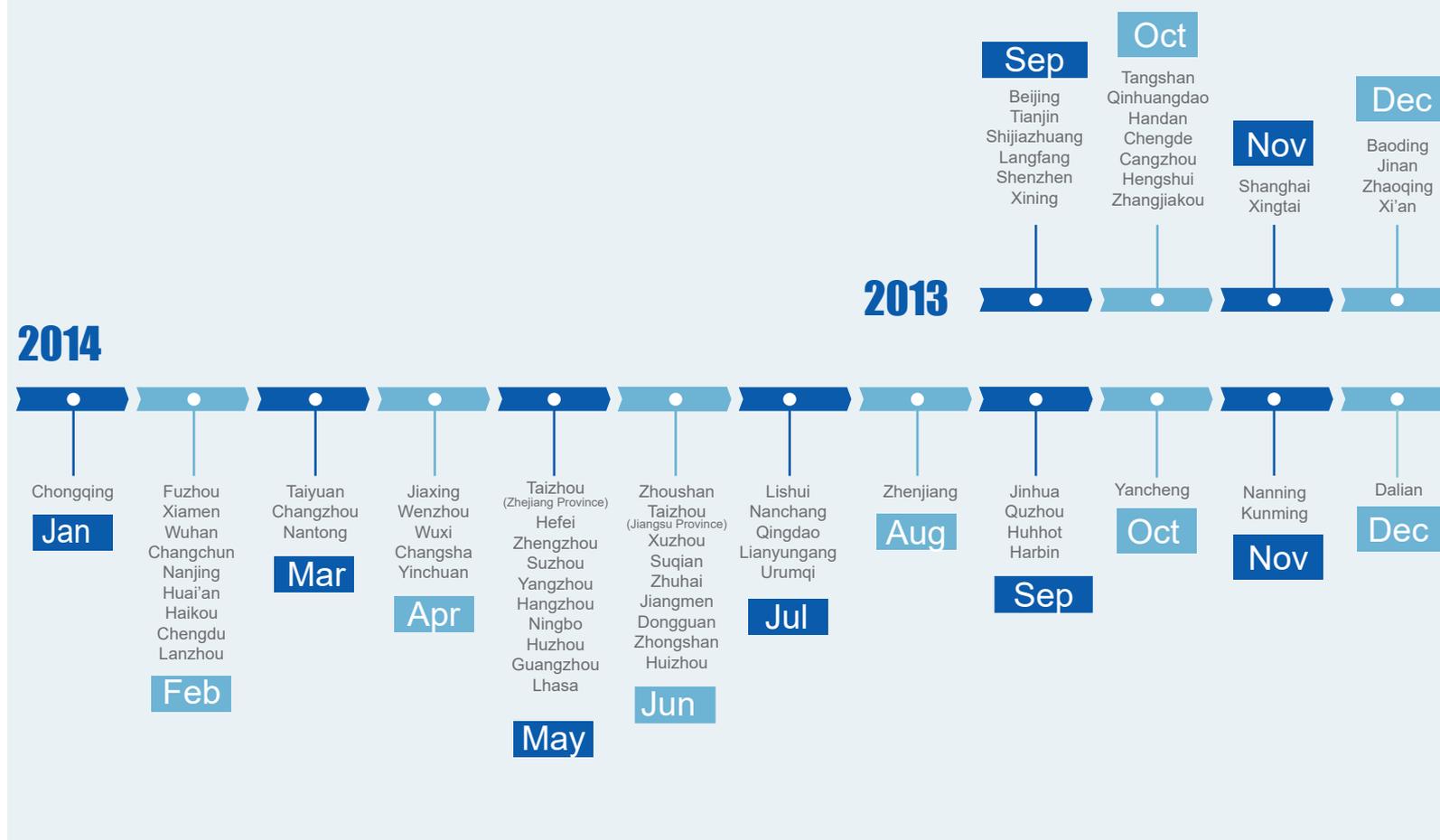
After the release of the Action Plan, provinces and cities began to develop corresponding local action plans. The 74 major cities covered by the report have all released their own phased action plans for air pollution prevention and control, most of which are five-year plans for the period from 2013 to 2017 (2014-2017 for some cities). The names of the local action plans differ, such as:

- Implementation Rules/Plans for the Action Plan for Air Pollution Prevention and Control (most cities)
- Clean Air Action Plan (Beijing, Tianjin, Shanghai, Taiyuan, Xiamen and Harbin)

- Action Plan for Tackling the Major Issues in Air Pollution Prevention and Control (Shijiazhuang, Tangshan and Handan)
- Blue Sky Action Plan/Program/Protection Plan (Chongqing, Shenyang and Guiyang)
- Air Quality Improvement Action Plan (Wuhan and Zhaoqing)
- Atmospheric Environment Quality Improvement Plan (Shenzhen)
- Suggestions on the Implementation of Air Pollution Prevention and Control (Xining)

Haikou, Xi'an and Lhasa have released annual action plans according to their own provincial/autonomous regional phased plans. See Figure 14 for the timeline of the release of municipal action plans by the end of 2014.

Fig. 14: Timeline of Release of Municipal Action Plans



# Air Quality Improvement Targets

## National Government

The Action Plan clearly puts forward regional air quality improvement targets, with the goal of air pollution prevention and control shifting from controlling the total mass of emissions to improving air quality. National air quality should see "overall improvement" by 2017, and the concentration of PM<sub>10</sub> in prefectural and higher administrative-level cities should be reduced by more than 10% compared with 2012, with the number of attainment days increasing each year. The concentrations of PM<sub>2.5</sub> in BTH, YRD and PRD should be reduced by about 25%, 20% and 15% respectively.

## Key Regions

**BTH:** By 2017, the concentration of PM<sub>2.5</sub> should have fallen by about 25% compared with 2012; the concentration of PM<sub>2.5</sub> should have decreased by 20% in Shanxi and Shandong Provinces and 10% in the Inner Mongolia Autonomous Region; and the annual mean concentration of PM<sub>2.5</sub> in Beijing should be controlled at about 60 µg/m<sup>3</sup>.

**YRD:** By 2017, the annual mean concentration of PM<sub>2.5</sub> should have fallen by about 20% compared with 2012.

**PRD:** By 2017, the annual mean concentrations of SO<sub>2</sub>, NO<sub>2</sub> and PM<sub>10</sub> in PRD should be within the limits; the annual mean concentration of PM<sub>2.5</sub> in PRD should have decreased by about 15% compared with 2012 and O<sub>3</sub> pollution should also have decreased; the annual mean concentration of PM<sub>2.5</sub> in Shenzhen, Zhongshan, Jiangmen and Zhaoqing should have fallen by 15%; the annual mean concentration of PM<sub>2.5</sub> in Zhuhai and Huizhou should not exceed 35 µg/m<sup>3</sup>; and the ambient air quality of cities outside PRD should meet national standards, with the annual mean concentration of PM<sub>10</sub> not exceeding 60 µg/m<sup>3</sup> and the annual mean concentration of PM<sub>2.5</sub> not exceeding 35 µg/m<sup>3</sup>.

## Cities

The 74 major cities have all included air quality improvement targets in their action plans, setting concentration reduction percentages for 2017 (2016 for Guangzhou and Nanning and 2018 for Zhengzhou) compared with the benchmark year, or target pollutant concentration levels for 2017. See Figures 15 to 17 for further details.

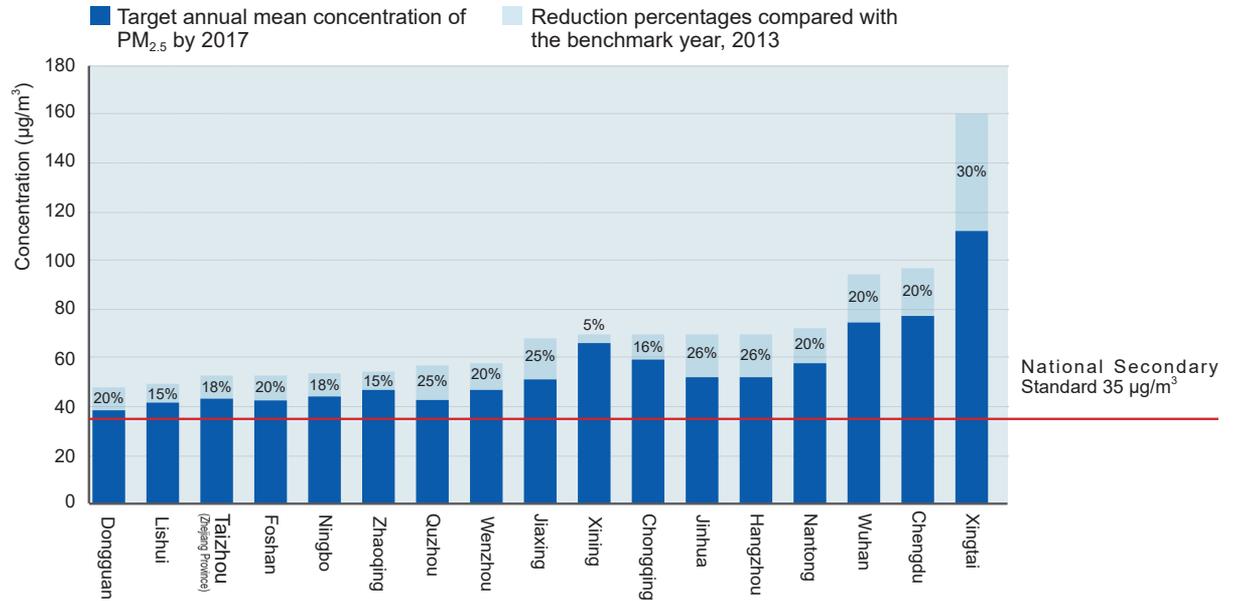


Fig. 15: City Air Quality Improvement Targets (measured by reduction percentages compared with the benchmark year, 2013)

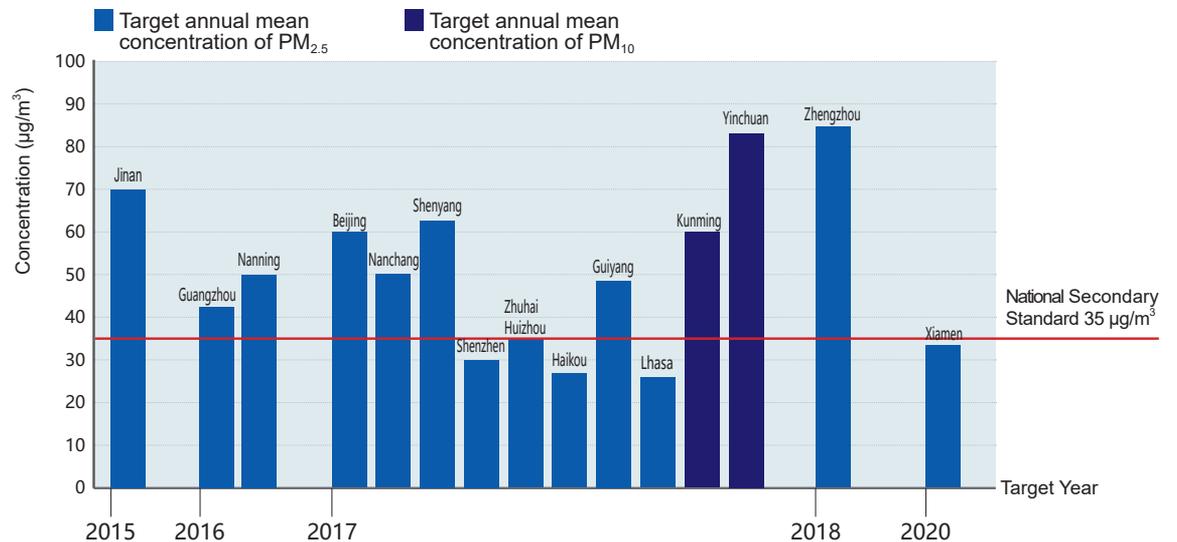


Fig. 16: City Air Quality Improvement Targets (measured by target concentration)

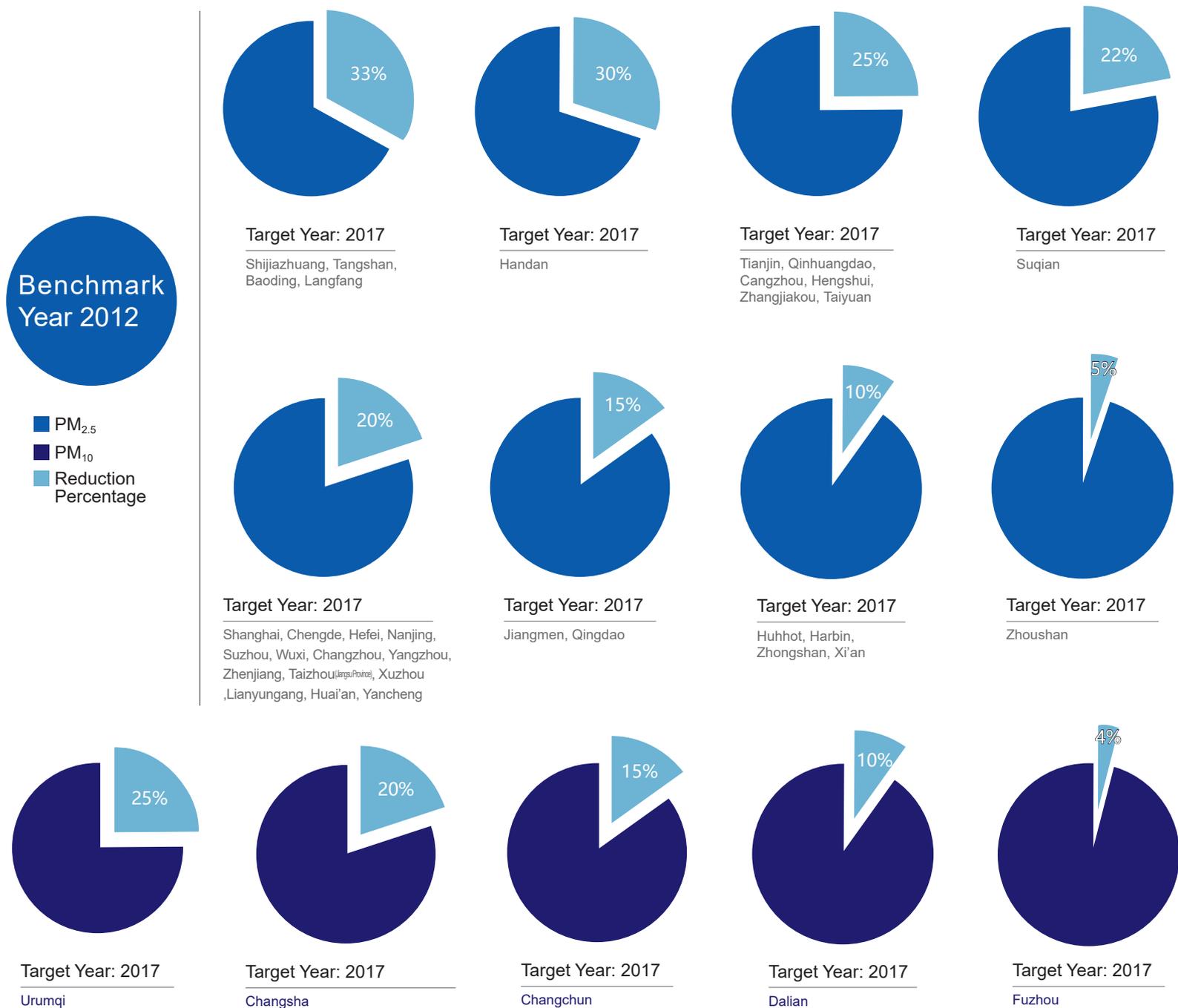
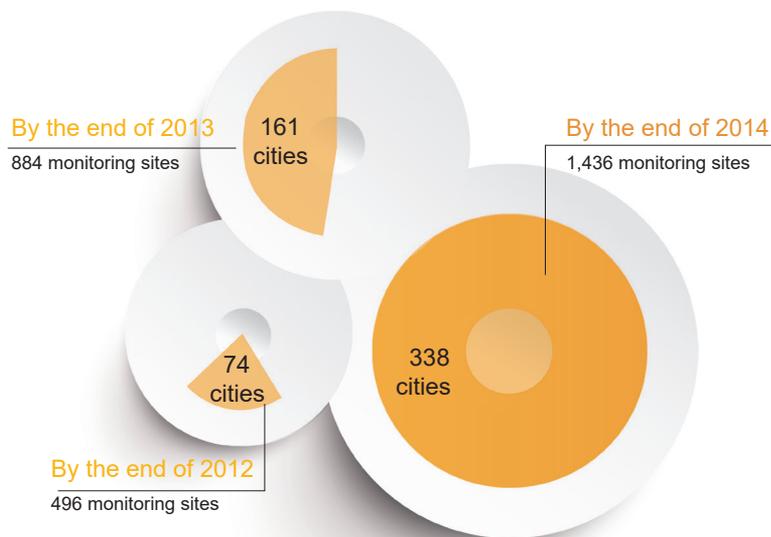


Fig. 17: City Air Quality Improvement Targets (measured by reduction percentages compared with the benchmark year, 2012)

## Capacity Building



**Fig. 18: Three Steps in Establishing an Air Quality Monitoring System**

### Air Quality Monitoring System Building and Reporting

Since the Revised Standards were released nationwide in 2012 and implemented in some major cities and regions, China has made a great leap forward in ambient air quality monitoring:

1. During the first stage, 496 state-controlled air quality monitoring sites in the 74 major cities (cities in BTH, YRD and PRD, municipalities directly under the National Government, and provincial capitals and cities designated by the National Government) should be established and begin to monitor air quality and report data by the end of 2012.
2. During the second stage, 884 state-controlled monitoring sites in 161 prefectural and higher administrative-level cities should be established and begin to monitor air quality and report data by October 2013.
3. During the third stage, 1,436 state-controlled monitoring sites in 338 prefectural and higher administrative-level cities should be able to complete the building of the monitoring network and report real-time data by November 2014.

After the three stages of construction and by the end of 2014, 1,436 monitoring sites in 338 prefectural and higher administrative-level cities were all able to implement the Revised Standards and report real-time hourly mean concentrations of the major monitored pollutants ( $PM_{2.5}$ ,  $PM_{10}$ ,  $SO_2$ ,  $NO_2$ ,  $O_3$  and CO) and corresponding air quality indicators. The three key regions (BTH, YRD and PRD) also established regional air quality forecasting and alerting platforms.

Among the 74 major cities, Beijing, Chongqing, Wuhan, Jinan, Xi'an, Dalian, Chengdu and Jiangmen established and began to operate super monitoring stations; Changsha, Xiamen, Nantong and Lianyungang also began to build such stations. The super monitoring stations were installed with such sophisticated instruments as high-resolution-time-of-flight aerosol mass spectrometers, scanning mobility particle counters, aerodynamic particle counters, single particle soot photometers and automatic ion analyzers. This equipment is operated in high resolution time at the super monitoring sites.

### Pollution Alerting and Emergency Response

In recent years, multiple Chinese provinces and cities have experienced frequent and enduring episodes of heavy pollution for which there are complicated causes and which is hard to rapidly eradicate. The government therefore requires the establishment of monitoring and alerting systems and emergency response systems. BTH, YRD and PRD each established a heavy air-pollution emergency response system in 2013 to coordinate regional, provincial and municipal efforts; the emergency response plans of the provinces and cities in those three regions were reported to the MEP by the end of the same year.

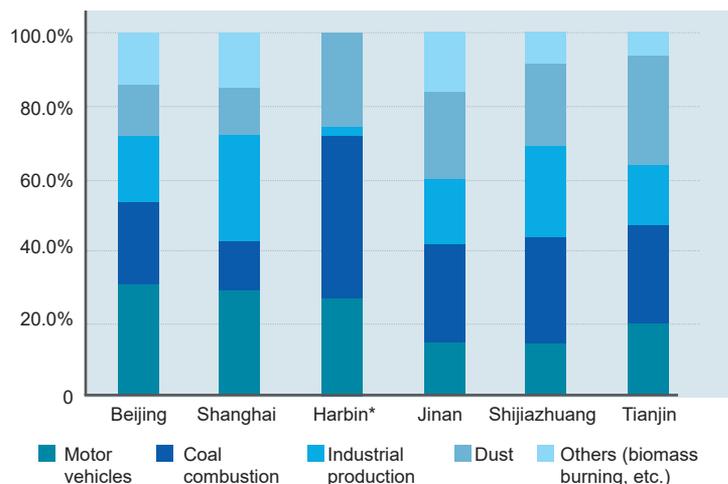
BTH, YRD and PRD began to establish heavy air-pollution monitoring and alerting systems in 2014, as well as carried out trend analyses of heavy pollution weather processes, improved study and decision-making consultation mechanisms, improved the accuracy of monitoring and alerting, and reported monitoring and alerting information in a timely manner. Seventy-three cities completed their municipal emergency response plans for heavily polluted weather by the end of 2014, with Kunming planned to complete the plan by 2015.

### Source Apportionment and Emission Inventory

A lack of knowledge about emission sources is one of the major difficulties in air-pollution prevention and control for Chinese cities. As China enters a key stage of air-pollution control with the air quality targets specified in the Ten Measures of the State Council, the concepts of scientific decision-making and meticulous management have been constantly put forward and emphasized. The source apportionment of atmospheric particulate matter and the development of emission inventories are designed to obtain reliable information about emission sources so that corresponding emission-reduction strategies can be formulated and implemented.

In January 2013, the MEP required local environmental monitoring agencies to carry out source apportionment and released the Technical Guidance on Source Apportionment of Atmospheric Particulate Matter (Trial), initiated by the Science, Technology and Standards Department of the MEP and drafted by Nankai University, the China Research Academy of Environmental Sciences, the Institute of Atmospheric Physics of the Chinese Academy of Sciences, Beijing University of Technology and Peking University.

35 cities (municipalities directly under the National Government, provincial capitals



\* The results of Harbin represent the PM<sub>2.5</sub> source apportionment in winter

**Fig. 19: City PM<sub>2.5</sub> Source Apportionment Results**

excluding Lhasa and cities specifically designated by the National Government) began the source apportionment of atmospheric particulate matter in January 2014. According to the State Council requirement, the MEP, the China Academy of Sciences and the Chinese Academy of Engineering had established a joint working mechanism and completed source apportionment verification in six major cities in BTH, YRD and PRD by the end of 2014. See Figure 19 for the cities that had published their source apportionment results by the end of 2014. The results from Harbin represent the PM<sub>2.5</sub> source apportionment in winter. In 2013, the MEP required environmental protection agencies at all levels to focus on tackling heavy air pollution and developing emission inventories in 2014. The MEP released four technical guidelines on emission inventories (as follows) in August 2014, and will carry out pilot projects in some cities to gradually promote emission inventory development at the municipal level.

- Technical Guidelines on the Development of Emission Inventory of Atmospheric Fine Particulate-Matter Primary Emission Source (Trial), initiated by the Science, Technology and Standards Department of the MEP, and developed by Tsinghua University, the Chinese Academy for Environmental Planning, etc.
- Technical Guidelines on the Development of Emission Inventory of Atmospheric Volatile Organic Compounds (VOCs) Source (Trial), initiated by the Science, Technology and Standards Department of the MEP and developed by Peking University, Tsinghua University, South China University of Technology, etc.
- Technical Guidelines on the Development of Emission Inventory of Atmospheric Ammonia Source (Trial), initiated by the Science, Technology and Standards Department of the MEP and developed by Peking University, Tsinghua University, Beijing University of Technology, Chinese Research Academy of Environmental Sciences, Shanxi University, etc.
- Technical Guidelines on Prioritized Control of Air Pollution Sources (Trial), initiated by the Science, Technology and Standards Department of the MEP and developed by Beijing University of Technology, Tsinghua University, the Chinese Research Academy of Environmental Sciences, the Beijing Municipal Research Institute of Environmental Protection, etc.

## Emission-Reduction Measures

### Emission Reduction through Energy Structure Adjustment

#### Total Coal Consumption Control

The Action Plan has set mid and long-term goals for controlling total coal consumption for the nation and key regions by 2017:

1. Coal consumption should account for less than 65% of total energy consumption;
2. Regions such as BTH, YRD and PRD should strive to achieve negative growth in total coal consumption; corresponding outdated or excess capacity elimination should be carried out for new, modified or expanded coal-fired projects; no new coal-fired power plant projects should be approved except for cogeneration power plants;
3. Cities should eliminate coal-fired boilers under 10t/h and should not construct new coal-fired boilers under 20t/h, while other regions (except for established zones in prefectural and higher administrative-level cities) should not build new coal-fired boilers under 10t/h in principle;
4. Regions that are not covered by heat and natural-gas supply networks should shift to electricity, new energy or clean coal and promote the use of highly efficient, energy-saving and environmentally friendly boilers;
5. In industrial clusters, centralized cogeneration power units will be built to phase out scattered coal-fired boilers; and
6. Installed nuclear capacity should reach 50GW and the percentage of non-fossil energy consumption should increase to 13%.

In 2014, total national coal consumption fell by 2.9% compared with 2013, representing negative growth for the first time in the past 15 years. At the regional level, China has introduced a series of policies and measures for BTH and surrounding areas that require a total coal-consumption reduction of 83 million tons, with a reduction of 13 million tons by Beijing, 10 million tons by Tianjin, 40 million tons by Hebei Province and 20 million tons by Shandong Province. Shanghai, Jiangsu Province and Zhejiang Province in YRD are required to achieve negative growth in total coal consumption; the same requirement applies to PRD. Coal consumption should account for less than 36% of total energy consumption in Guangdong Province by 2017. See Figures 20-21 for details.

The progress achieved by the three key regions between 2013 and 2014 includes: BTH reduced coal consumption by 19.8 million tonnes and replaced 3.9 million tons of coal with that of higher quality. The region and its six surrounding provinces and cities shut down outdated small coal-fired units with a total capacity of 60GW and 57,900 units of small boilers and restaurant boiling water furnaces, and converted 24,600t/h of boilers to clean energy. YRD realized the coal-to-gas switching of 13,000 units of coal-fired boilers, while Guangdong Province eliminated 1,962 units of coal-fired boilers.

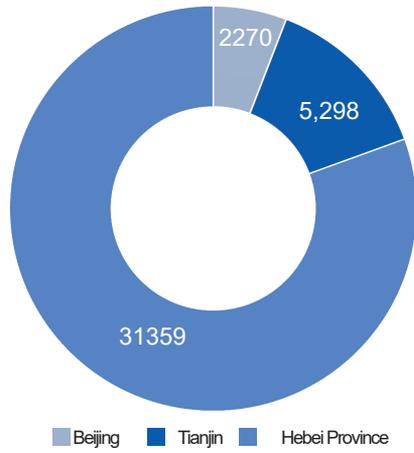


Fig. 20: Coal Consumption in Key Regions in 2012 (in 10,000 tons)

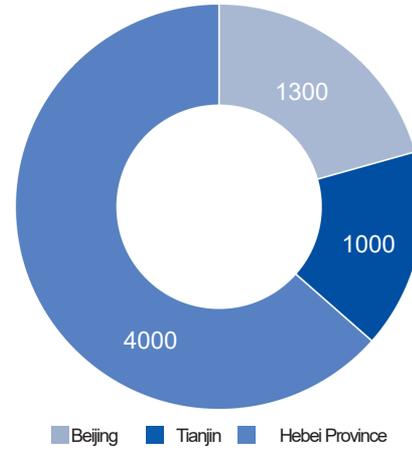
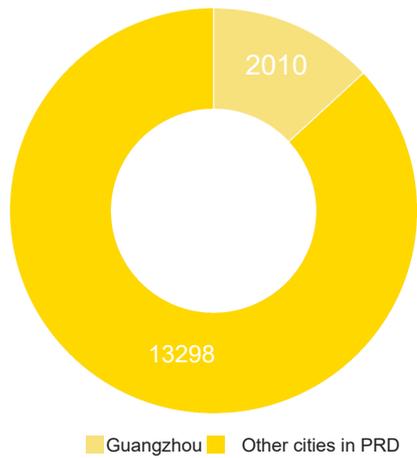
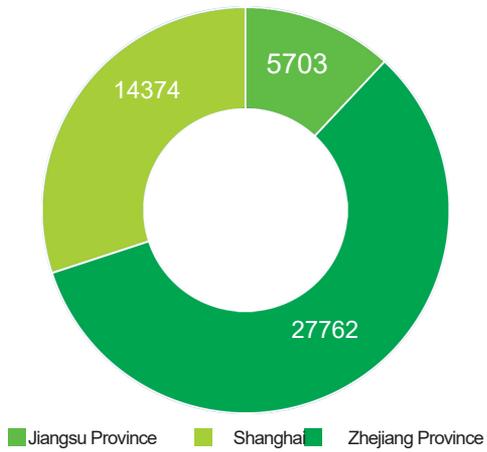


Fig. 21: Reduction Amount of Coal Consumption in Key Regions by 2017 (in 10,000 tons)



At the municipal level, major measures to control coal consumption include: Eliminating outdated or excess capacity for new, modified or expanded coal-fired projects; eliminating coal-fired boilers or retrofitting them to using clean energy; banning the construction of new small coal-fired boilers; establishing and expanding the restricted zones for highly-polluting fuel; strengthening central heating system upgrading; optimizing the central heating layout; and building and improving heating networks. All cities have set their 2017 goals for coal consumption control. See Figure 23 for details.

- Some cities set specific reduction amounts or percentages of coal consumption compared with 2012. For example, the target reduction amount set by Tianjin and Chongqing is 10 million and 15 million tons respectively, while the target reduction percentage set by both Taiyuan and Zhoushan is 10%.
- Some cities set the target percentages of coal consumption in total energy consumption. For example, the percentages set by Yangzhou, Dongguan, Changsha and Chengdu were less than 65%, 36%, 30% and 19% respectively.
- Some cities such as Wenzhou, Wuhan and Changchun set the goal of achieving negative or zero growth in total coal consumption compared with 2012.
- Some cities set a specific target amount of coal consumption. For example, the amount set by Nanjing was 30 million tons. Some cities such as Baoding set the goal of achieving a lower percentage of coal consumption in total energy consumption compared with 2012 but without quantitative indicators.
- Some cities such as Dalian aim to keep the annual growth of coal consumption to an absolute minimum.

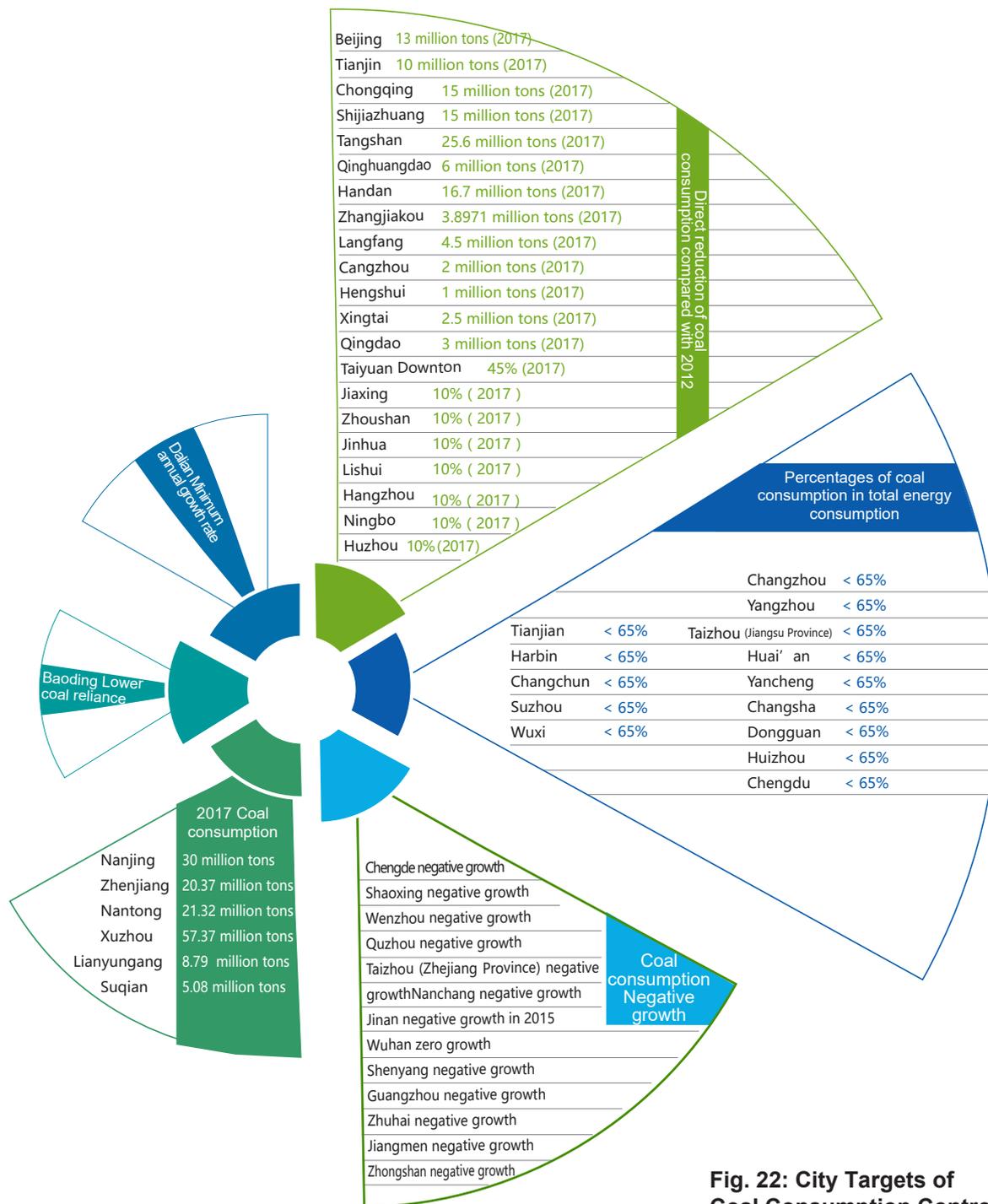


Fig. 22: City Targets of Coal Consumption Control

## Central Heating System Upgrading

More than 30 cities have set goals for upgrading the central heating system by 2017, including:

- Cities such as Quzhou, Taizhou (Zhejiang Province), Dongguan and Yinchuan require full coverage of central heating in their industrial zones;
- Some cities set target central heating coverage rates in their urban areas. For example, the target rates set by Harbin, Shijiazhuang, Jiangmen and Handan are 93%, 80%, 80% and 71% respectively; and
- Some cities set a target total area for central heating. For example, Lanzhou set a target total area of 45.2 million m<sup>2</sup>.

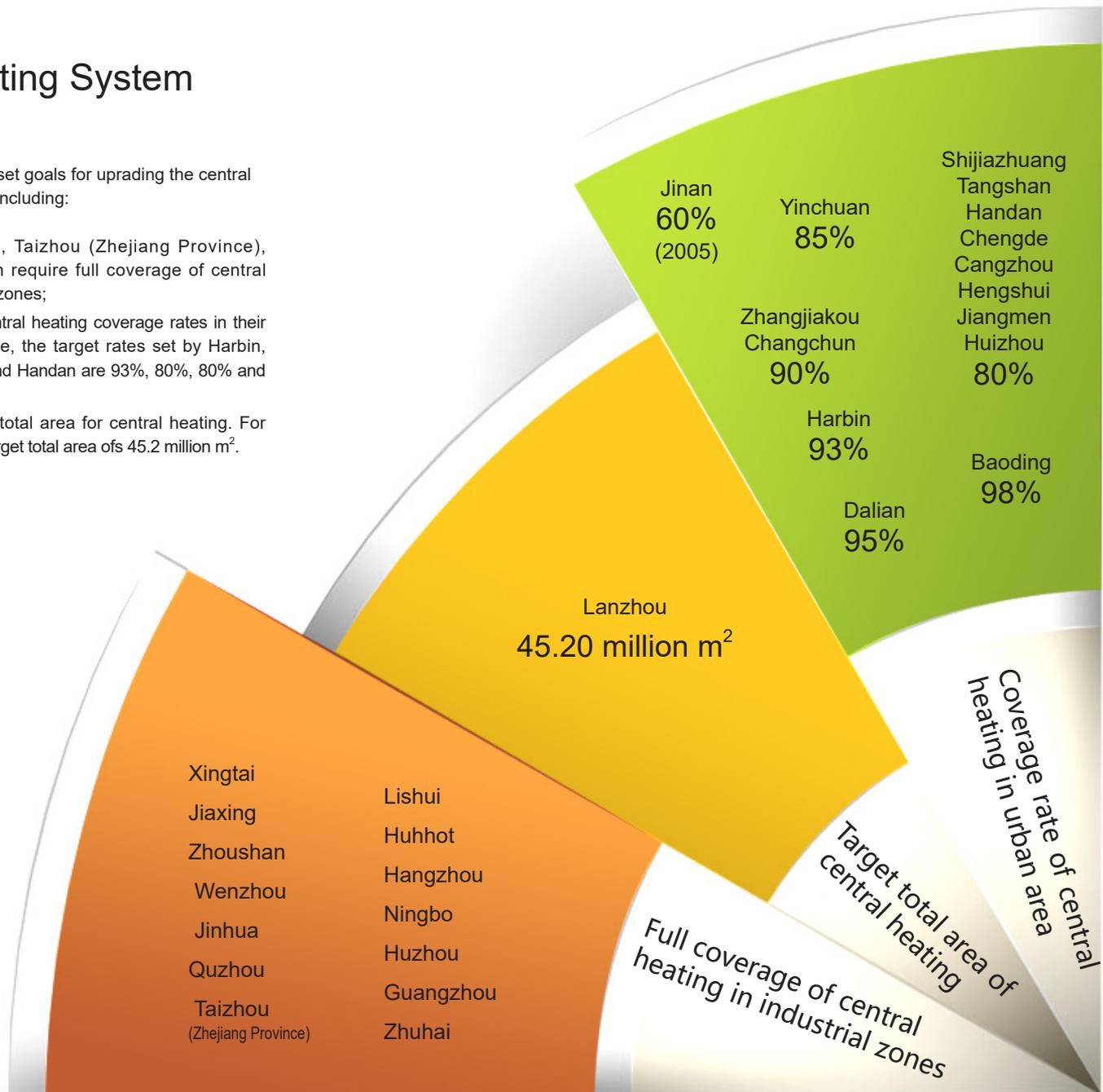


Fig. 23: Central Heating System Upgrading Targets

## Clean Energy Promotion

For alternative energy, more than 30 cities have proposed intensifying the promotion of clean energy, increasing the supply of clean energy such as natural gas, wind power, hydropower and solar power, and gradually increasing the percentage of clean energy consumption in their total energy consumption.

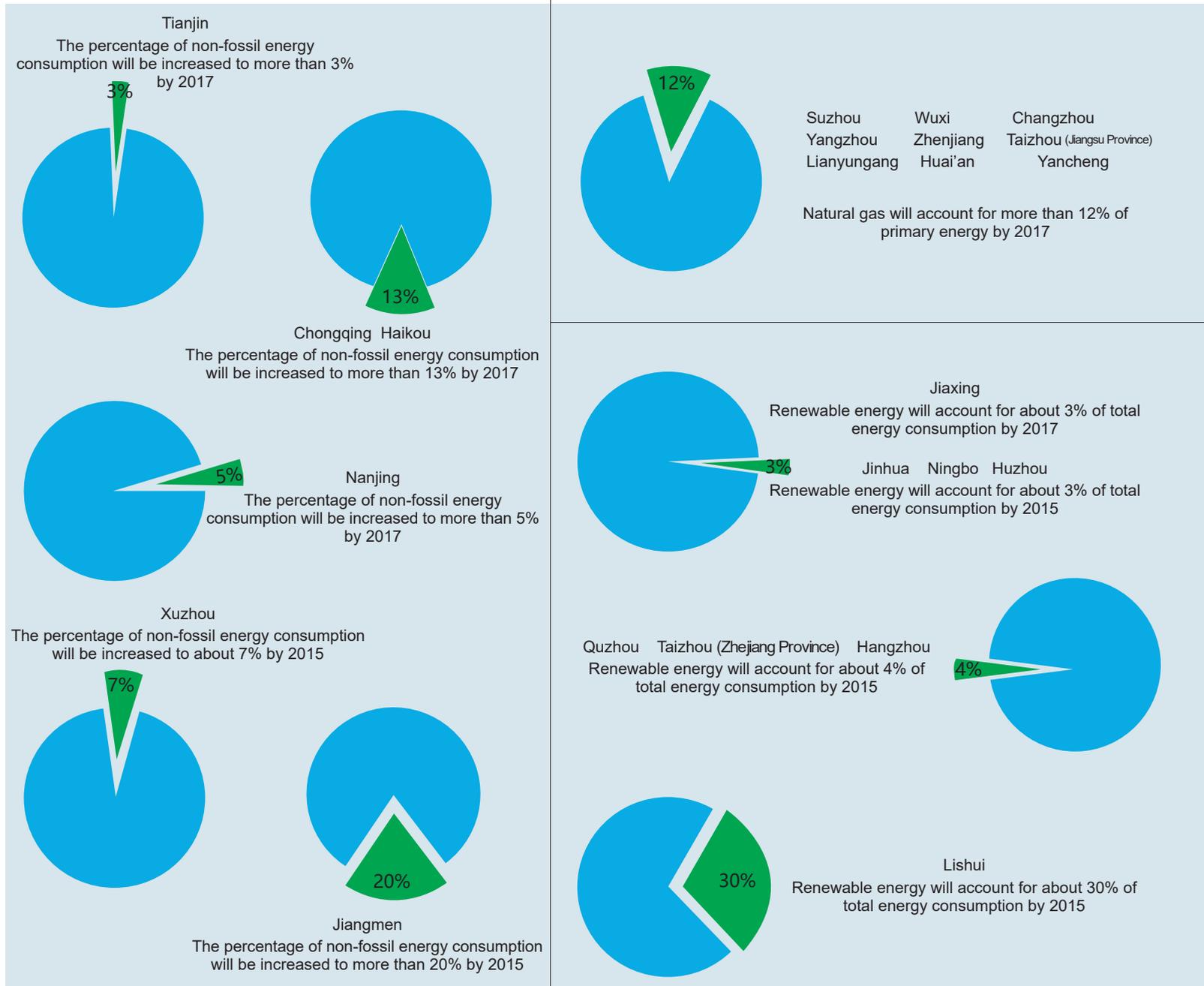
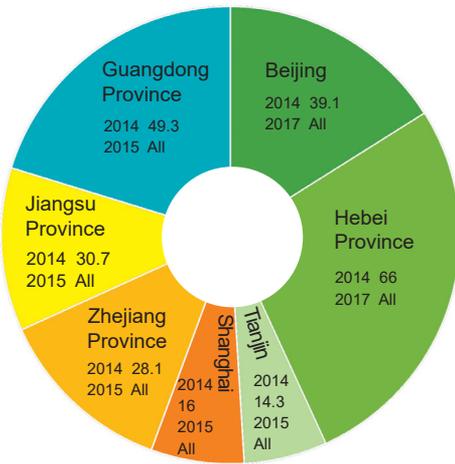


Fig. 24: City Clean Energy Promotion Targets

## Elimination of Yellow-label and Outdated Vehicles

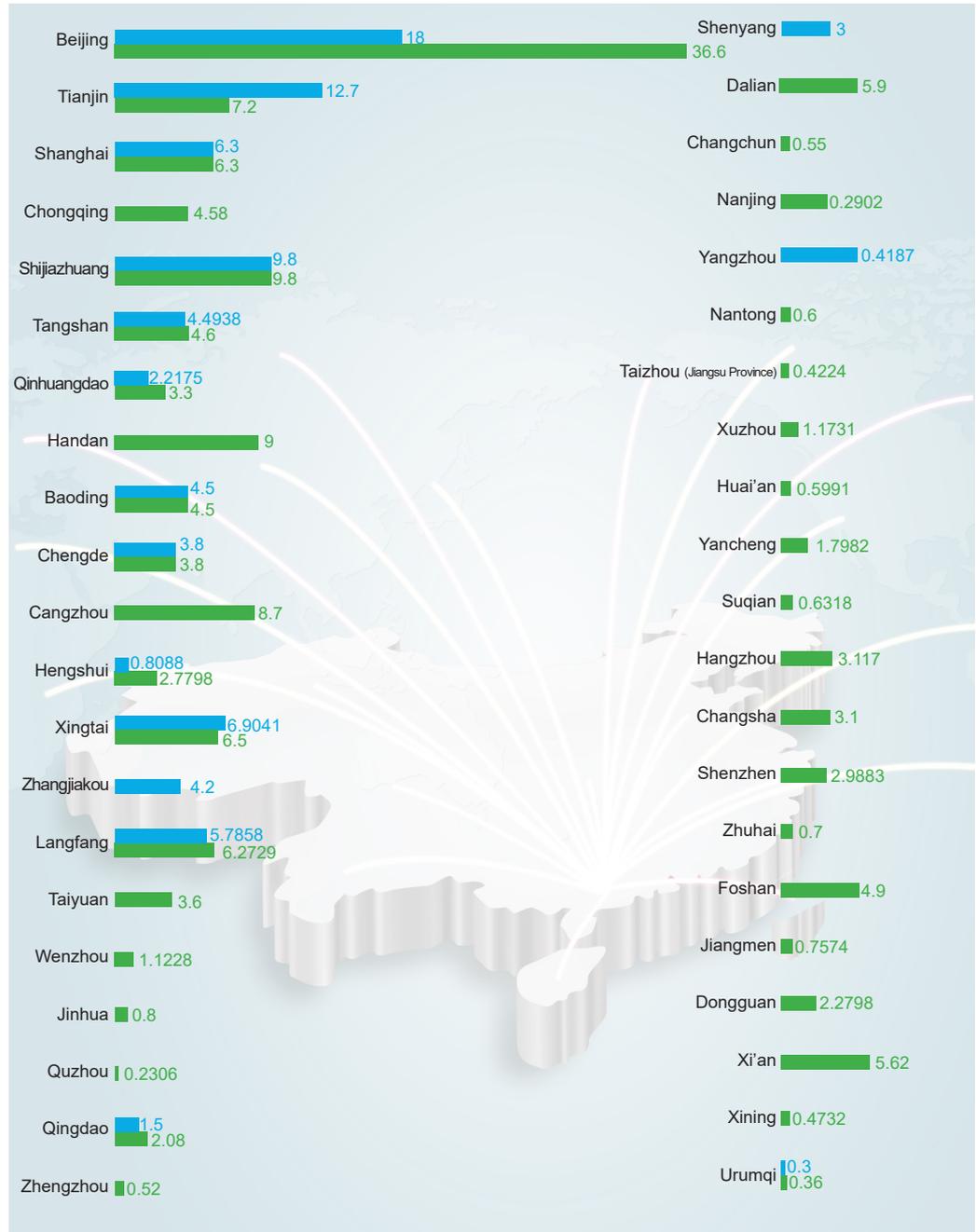
The Action Plan demands the gradual elimination of yellow-label and outdated vehicles through measures such as designating vehicle-free zones and financial compensation. Specifically, yellow-label vehicles that are registered and began operating before the end of 2005 will be eliminated by 2015, with 5 million such vehicles eliminated in BTH, YRD and PRD. All yellow-label vehicles in China will be eliminated by 2017. The 2014 Implementation Plan for Eliminating Yellow-Label and Outdated Vehicles demands the elimination of 6 million yellow-label and outdated vehicles in China by 2014. See Figure 25 for detailed information about the planned elimination of yellow-label and outdated vehicles in the three key regions.



**Fig. 25: Yellow-Label Vehicle Elimination Targets and Progress in Three Key Regions (in 10,000 vehicles)**

By 2014, BTH had eliminated more than 2.8 million yellow-label vehicles, YRD 1.29 million, and PRD 493,000. China, as a whole, eliminated 6.11 million yellow-label and outdated vehicles between January and November 2014, exceeding the annual target of phasing out 6 million such vehicles.

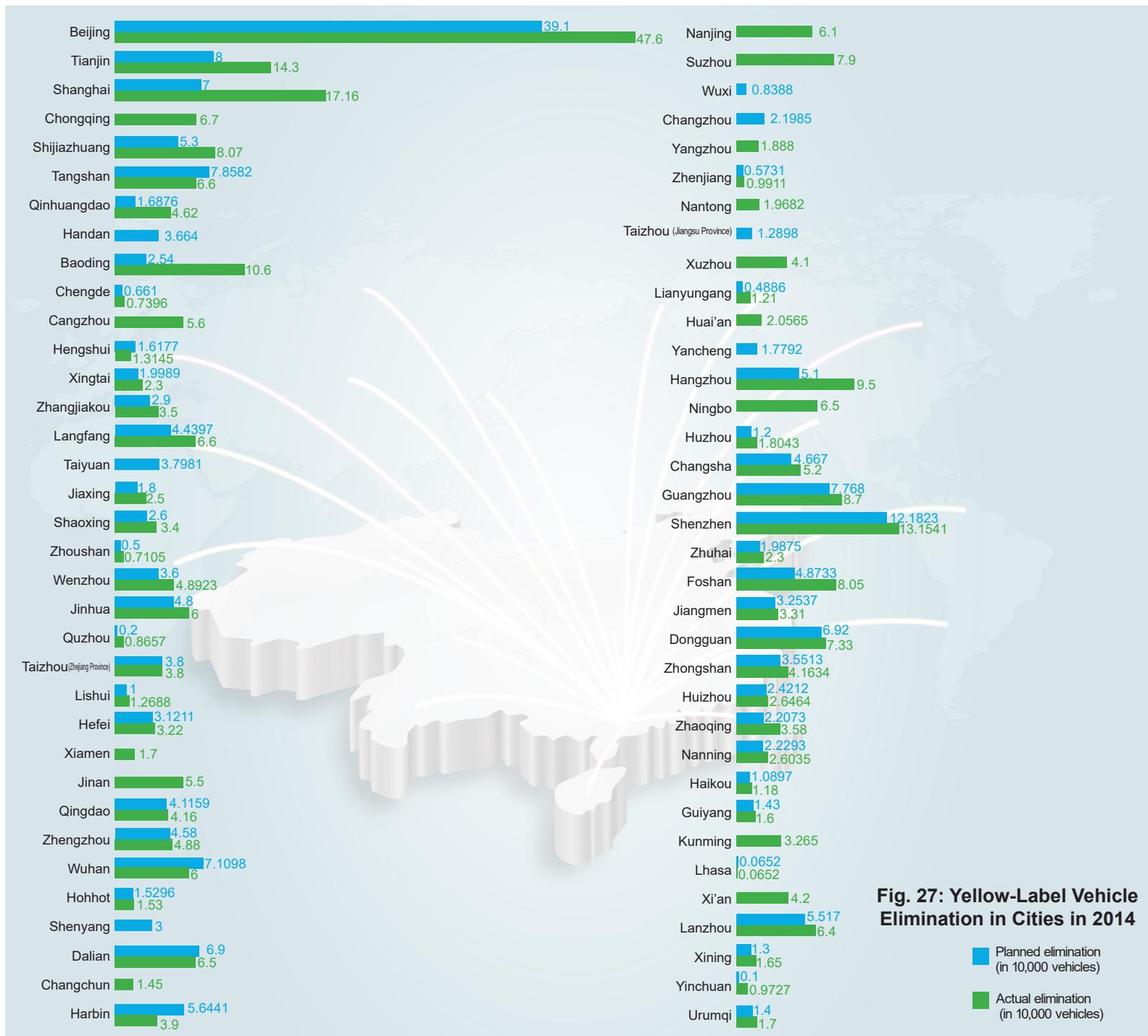
74 major cities have set annual targets for eliminating yellow-label vehicles and have phased out all of them as planned. See Figures 26-27 for their specific targets and progress.



**Fig. 26: Yellow-Label Vehicle Elimination in Cities in 2013**

■ Planned elimination (in 10,000 vehicles)  
 ■ Actual elimination (in 10,000 vehicles)

## Policy Implementation and Progress



**Fig. 27: Yellow-Label Vehicle Elimination in Cities in 2014**

■ Planned elimination (in 10,000 vehicles)  
■ Actual elimination (in 10,000 vehicles)

## Vehicle Population Control

Shanghai, Beijing, Guiyang, Guangzhou, Shijiazhuang, Tianjin, Hangzhou and Shenzhen have controlled their vehicle population to curb the rapid increase in motor vehicles. Those cities have promulgated regulations to control the quotas for new small passenger cars, which may only be acquired through a lottery system or bidding.

## Encourage Use Of Public Transport

The cities have formulated measures to encourage travel by public transportation, including increasing the number of people using public transport, giving priority to the development of public transportation and enhancing the construction of pedestrian and cycling systems, promoting greener ways of commuting and traveling, and reducing the intensity of vehicle use.

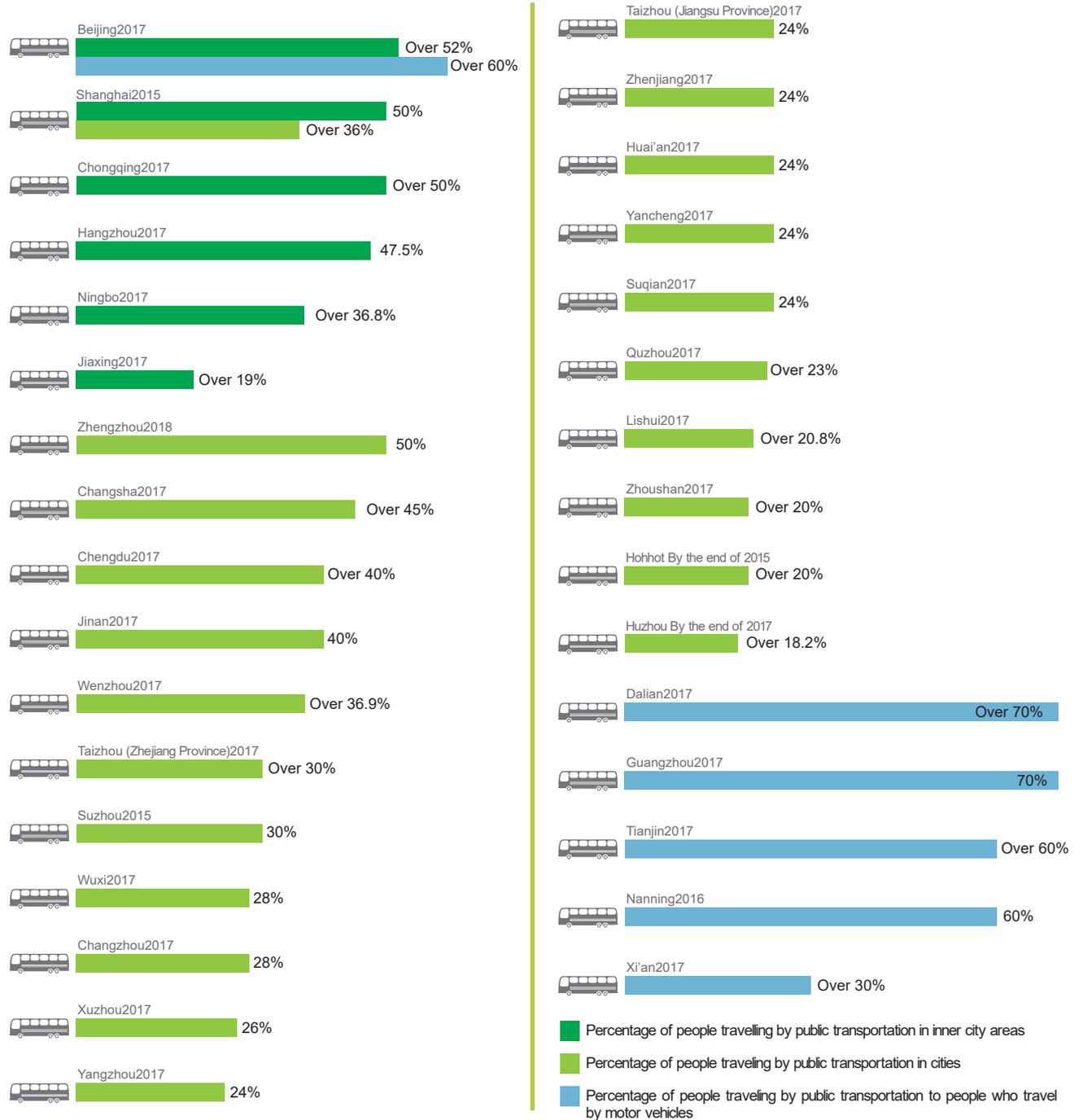


Fig. 28: Public Transportation Use Targets in Cities

## Optimize Industrial Structure and Layout

### National Government

As a key measure for structural emissions reduction, the National Government has revised the access requirements for high-energy consumption, high-pollution and resource-intensive industries and set the targets for resource and energy conservation and pollutant emissions. Relevant departments have also recommended that regions that meet these requirements should formulate their own industry access requirements which are stricter than those of the National Government and are aligned with local functional specialization. Capacity to be added to high-energy consumption and high-pollution industries must be strictly controlled. When projects are newly built, modified or expanded, equal or higher outdated or excessive production capacity will be correspondingly eliminated.

According to the requirements set forth in related policy documents, the task is to eliminate outdated production capacity in 21 key industries, including steel, cement, electrolytic aluminum and flat glass as required by the 12<sup>th</sup> Five-Year Plan - all of which must be completed one full year in advance. By the close of 2015, 15 million tons of iron, 15 million tons of steel, 100 million tons of cement (clinker and grinding capacity) and 20 million weight boxes of flat glass capacity will be eliminated.

Regions that have failed to meet the elimination target will face stringent restrictions on new investment projects to be assigned by the National Government, while the review, approval and registration procedures for construction projects in key industries in these regions will be suspended. More extensive and stringent policies for phasing out outdated production capacity will be formulated in 2016 and 2017 in different regions for the continued elimination of outdated production capacity.

The approval of new production-capacity projects of industries with severe excess production capacity is forbidden. Violating projects of industries with severe excess production capacity will be phased out. Projects that are under construction without permission, or under construction while awaiting permission, or permitted beyond authority are prohibited to start, while projects under current construction must stop.

### Key Regions

BTH and its surrounding areas: New capacity projects for industries with severe excess production capacity should not be approved, including steel, cement, electrolytic aluminum, flat glass and ship building, and the following quantitative goals are in place:

- Beijing: 1,200 high-pollution enterprises will be restructured and eliminated by the end of 2017.
- Tianjin: By the end of 2017, all steel production capacity, cement (clinker) production capacity and coal-fired generating capacity within the administrative jurisdiction will be limited to 20 million tons, 5 million tons and 14GW respectively.
- Hebei Province: By the end of 2017, more than 60 million tons of steel production capacity will be eliminated to ensure that total production capacity will be within the target as set forth in the Restructuring Scheme for Steel Industry in Hebei Province as approved by the

State Council. Coal-fired non-heat-and-power cogeneration units of less than 100MW will be completely phased out, while the elimination of units of less than 200MW will be kick-started. More than 61 million tons of outdated production capacity for cement (clinker and mill) will be eliminated during the 12<sup>th</sup> Five-Year Plan period, along with 36 million weight boxes of flat glass.

- Shanxi Province: By the close of 2017, 6.7 million tons of outdated steel production capacity will be eliminated, while 18 million tons of coke production capacity will be reduced and eliminated.
- Inner Mongolia Autonomous Region: 4.59 million tons of outdated cement production capacity will be eliminated by the end of 2017.
- Shandong Province: By the end of 2015, 21.11 million tons of iron production capacity and 22.57 million tons of steel production capacity will be eliminated, while more than 10 million tons of iron and steel production capacity will be reduced, with the total capacity controlled to no more than 50 million tons. Coke production capacity will also be reduced to 40 million tons by the end of 2017.

**YRD:** For new projects in high-energy consumption and high-emission industries, such as iron, steel and cement, equal or higher outdated or excessive production capacity will be eliminated, and equal or higher amount of energy consumption and pollutant emission will be correspondingly cut from the total. In Shanghai, new high-pollution projects will be banned in industries such as iron and steel, building materials, coking and non-ferrous metals. Strict controls are to be applied in petrochemical and chemical projects.

**PRD:** Considering the current industrial development and air quality in Guangdong Province, more extensive and stringent 2015-2017 phase-out policies and supporting measures will be developed. By 2014, Guangdong Province had already eliminated 2.5 million tons of excess steel production capacity (31% above the national plan), 15,000 tons of copper smelting, 4.43 million tons of cement (85% above the national plan), 210,000 tons of paper (250% above the national plan), 600,000 mark sheets of leather (20% above the national plan), 175.04 million meters of printing and dyeing (17% above the national plan) and 590,000 KVA of lead-acid batteries (18% above the national plan).

### Cities

High-energy consumption and high-pollution projects are to be strictly controlled and higher environmental access requirements are to be applied. Most cities will no longer approve new projects with significant production capacity in industries such as steel, cement, electrolytic aluminum, flat glass, shipbuilding, coking, nonferrous metals, calcium carbide and ferroalloy. For new, modified and expansion projects, equal or higher outdated or excessive production capacity will be eliminated correspondingly. For existing high-emission industries, the special emission limits of air pollutants will be applied, and enterprises that fail to meet these limits shall be subject to rectification within a limited time frame or shut down.

By eliminating outdated production capacity and reducing excessive production capacity, cities across China propose to achieve the target of phasing out of outdated production capacity ahead of the time frame set forth in the 12<sup>th</sup> Five-Year Plan. Chongqing, Zhengzhou, Lishui and Jiangmen also propose developing further stringent policies upon the completion of the phasing out programs under the 12<sup>th</sup> Five-Year Plan, which will assist in reducing outdated production capacity. See Figures 29-32.

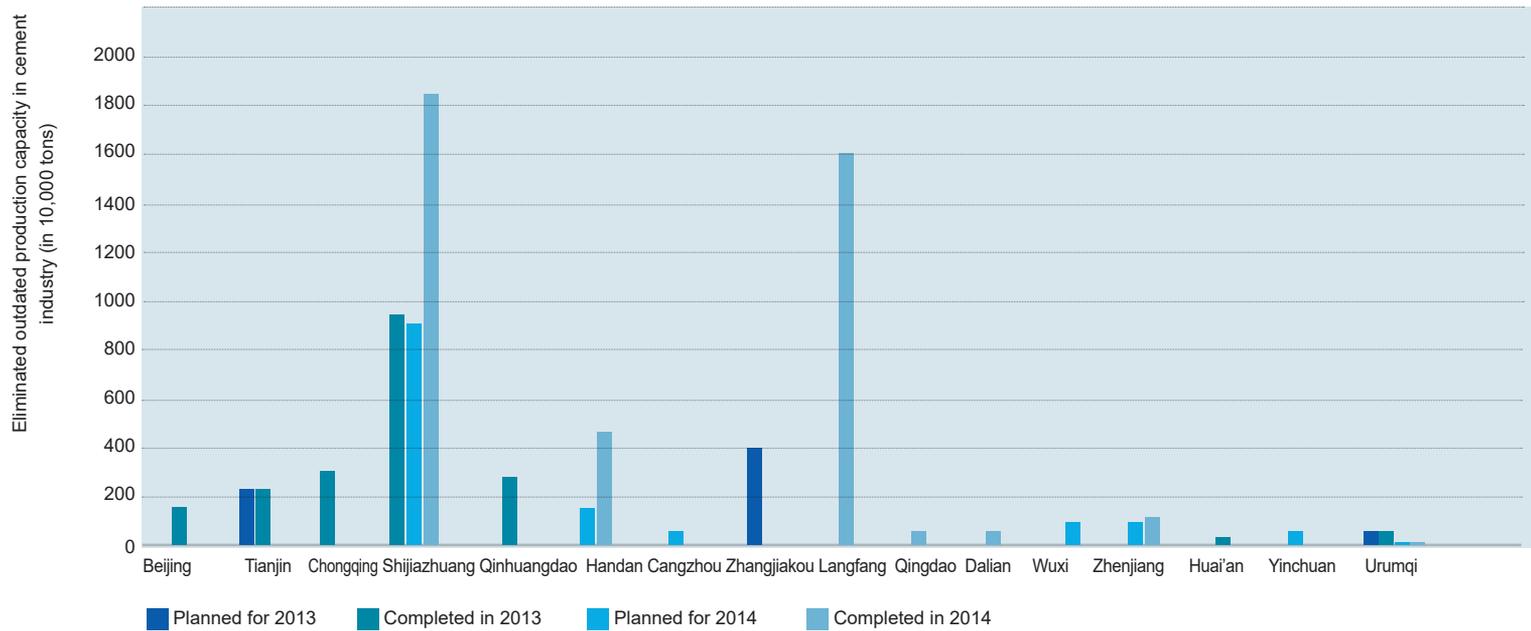


Fig. 29: Outdated Production Capacity Elimination in the Cement Industry in Different Cities

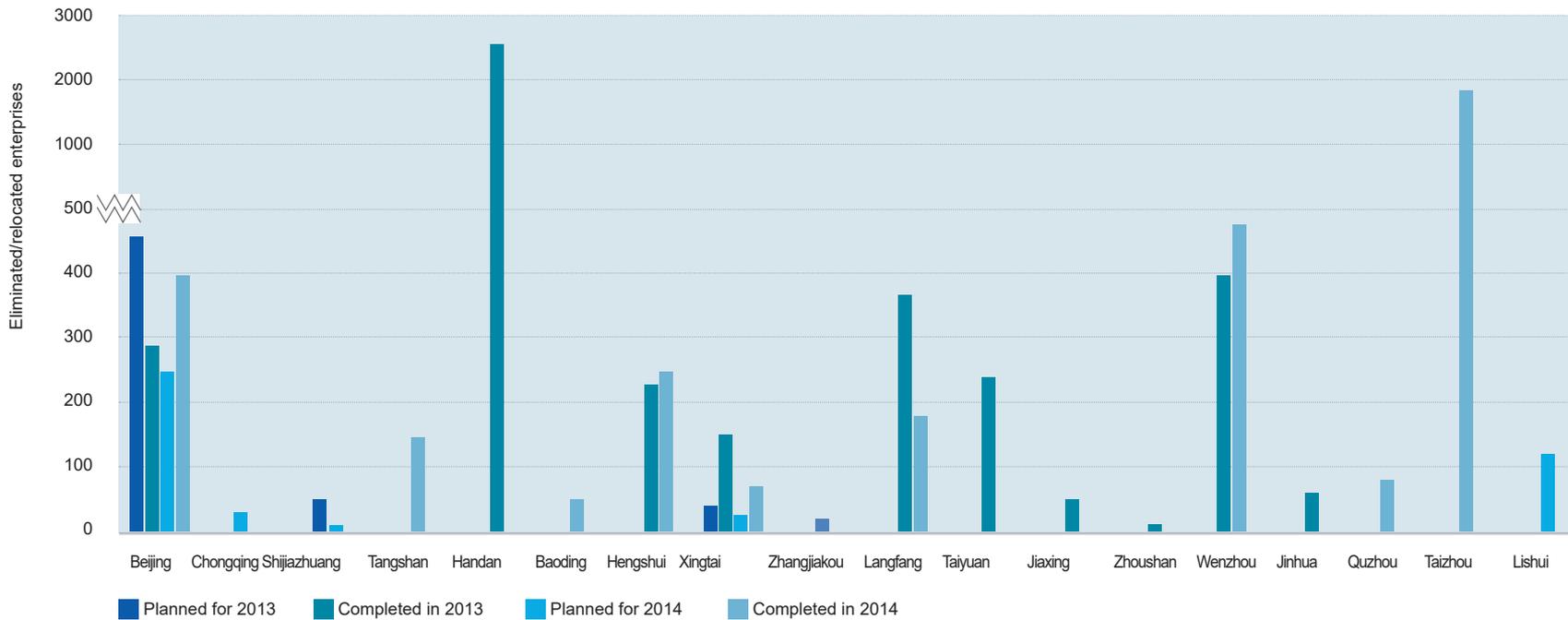


Fig. 30: Eliminated/Relocated Enterprises in Different Cities

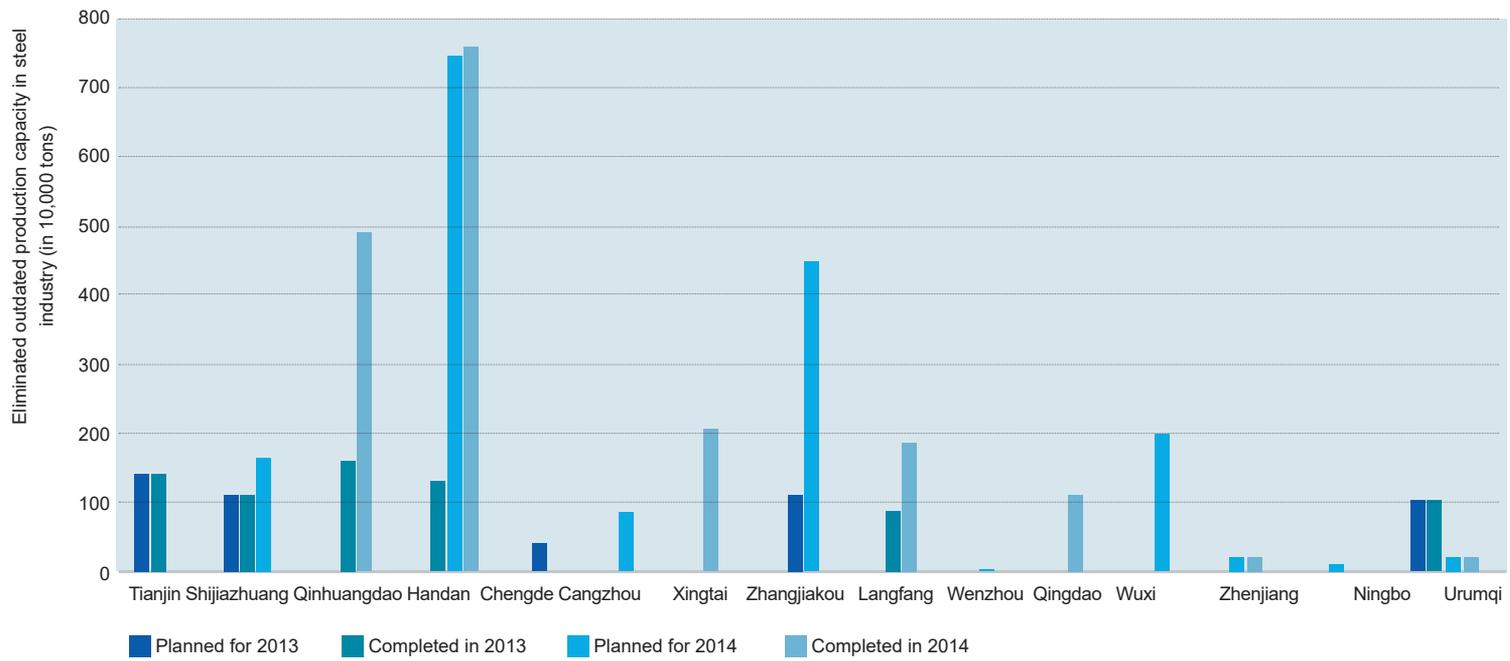
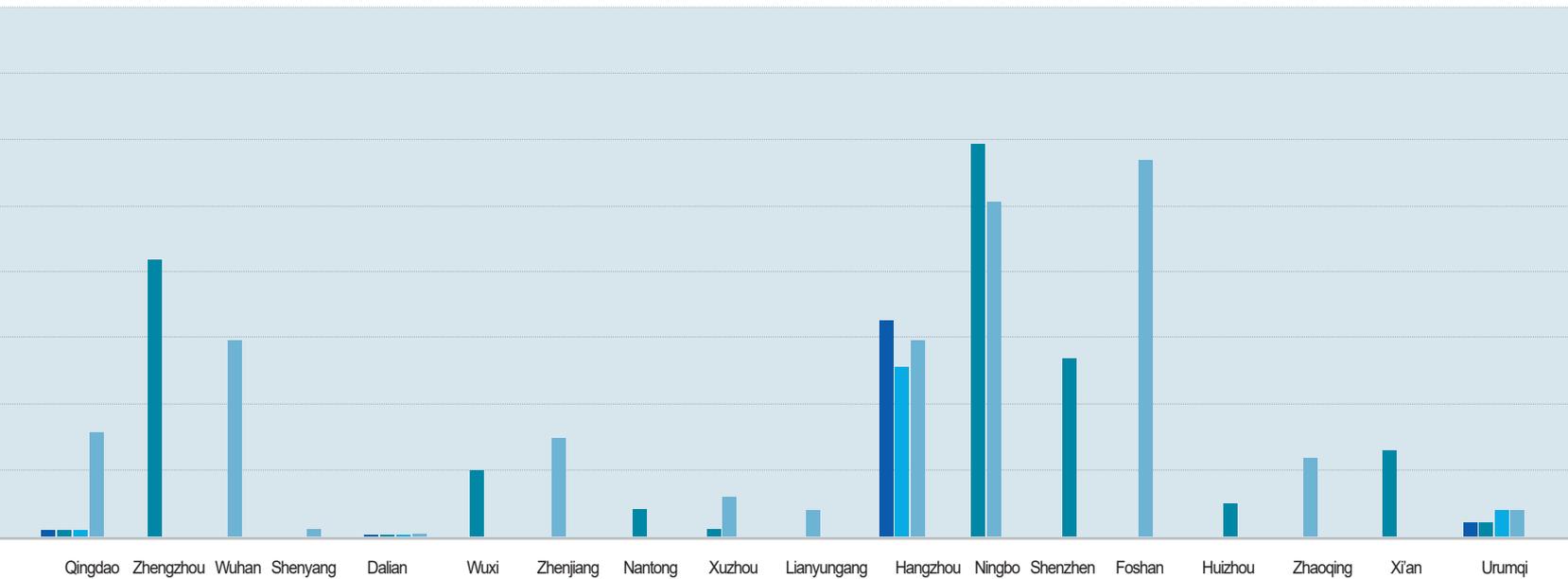
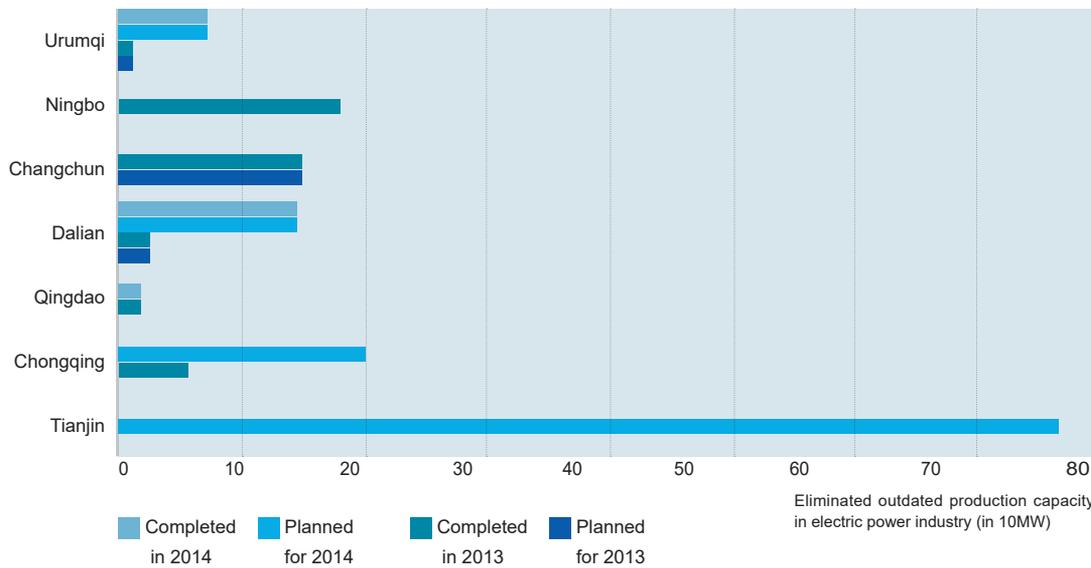


Fig. 31: Outdated Production Capacity Elimination in the Steel Industry in Different Cities





**Fig. 32: Outdated Production Capacity Elimination in the Electric Power Industry in Different Cities**

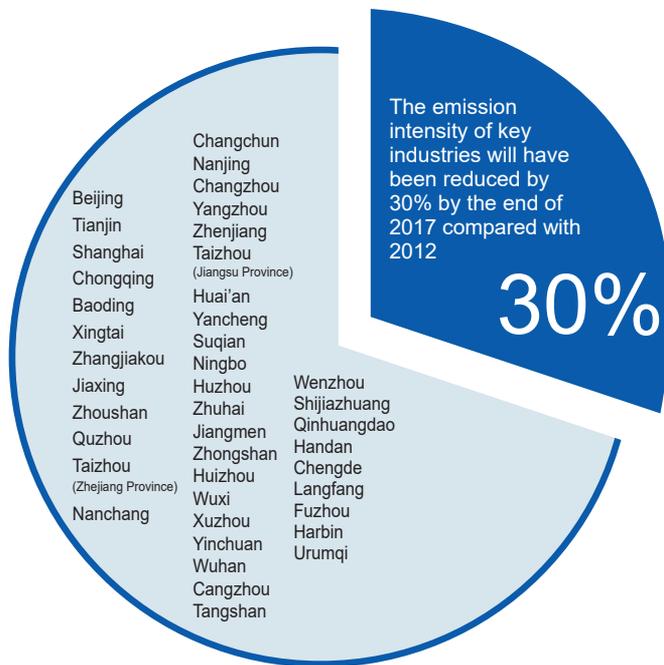
## Emission Reduction in Combustion Processes

### Clean Production

The Action Plan requires clean production audit and clean production technology retrofitting in key industries such as steel, cement, chemical engineering, petrochemical and non-ferrous metal smelting. The emission intensity in key industries should be reduced by more than 30% by 2017 compared with 2012.

New dry-cement kilns should use low-NOx combustion technology. The energy use per unit of industrial added value should be reduced by approximately 20% by 2017. More than 50% and 30% of the national industrial zones and provincial industrial zones respectively should implement retrofitting measures to promote a circular economy. About 40% of major non-ferrous metals and the iron and steel industry should achieve cyclic regeneration.

More than 50 cities have set a goal of reducing the emission intensity of major industries such as steel, cement, chemical engineering, petrochemical and non-ferrous metal smelting by more than 30% by 2017 compared with 2012.



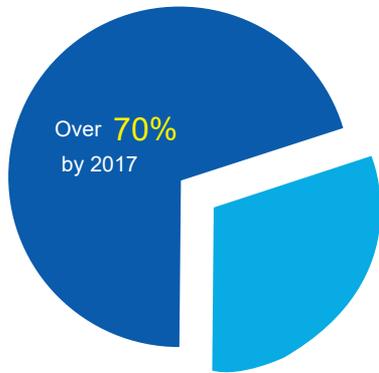
- Beijing will complete clean production audits of no less than 400 enterprises by 2017
- Tianjin will complete clean production audits of no less than 200 enterprises by 2017
- Shanghai will conduct clean production audits of 2,000 enterprises by 2017
- Chongqing will conduct clean production audits of more than 100 enterprises annually starting from 2017
- Cangzhou will complete clean production audits of 426 enterprises by the end of 2017
- Suzhou will complete clean production audits of 2,000 enterprises by 2015
- Guangzhou will complete clean production audits of 1,100 key enterprises by the end of 2016

**Fig. 33: Clean Production Audit Targets of Different Cities**

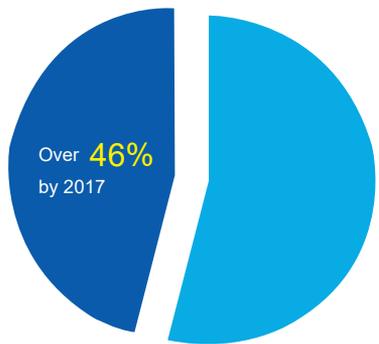
## Clean-Burning Coal

The Action Plan demands that by 2017 more than 70% of raw coal should be prepared and separated before being used. Loose coal with more than 16% ash content and more than 1% sulfur content will not be sold in BTH. Beijing, Tianjin and Hebei Province will establish county or district-based fully enclosed coal distribution centers and a clean-coal supply network that cover all villages and towns by the end of 2017, and the rate of clean-coal utilization will reach more than 90%.

More than 30 cities have set specific requirements to raise the coal washing and preparation rate, forbidding the use of low-quality coal with high ash and sulfur content, promoting clean-coal utilization, and increasing the utilization rate of clean coal.



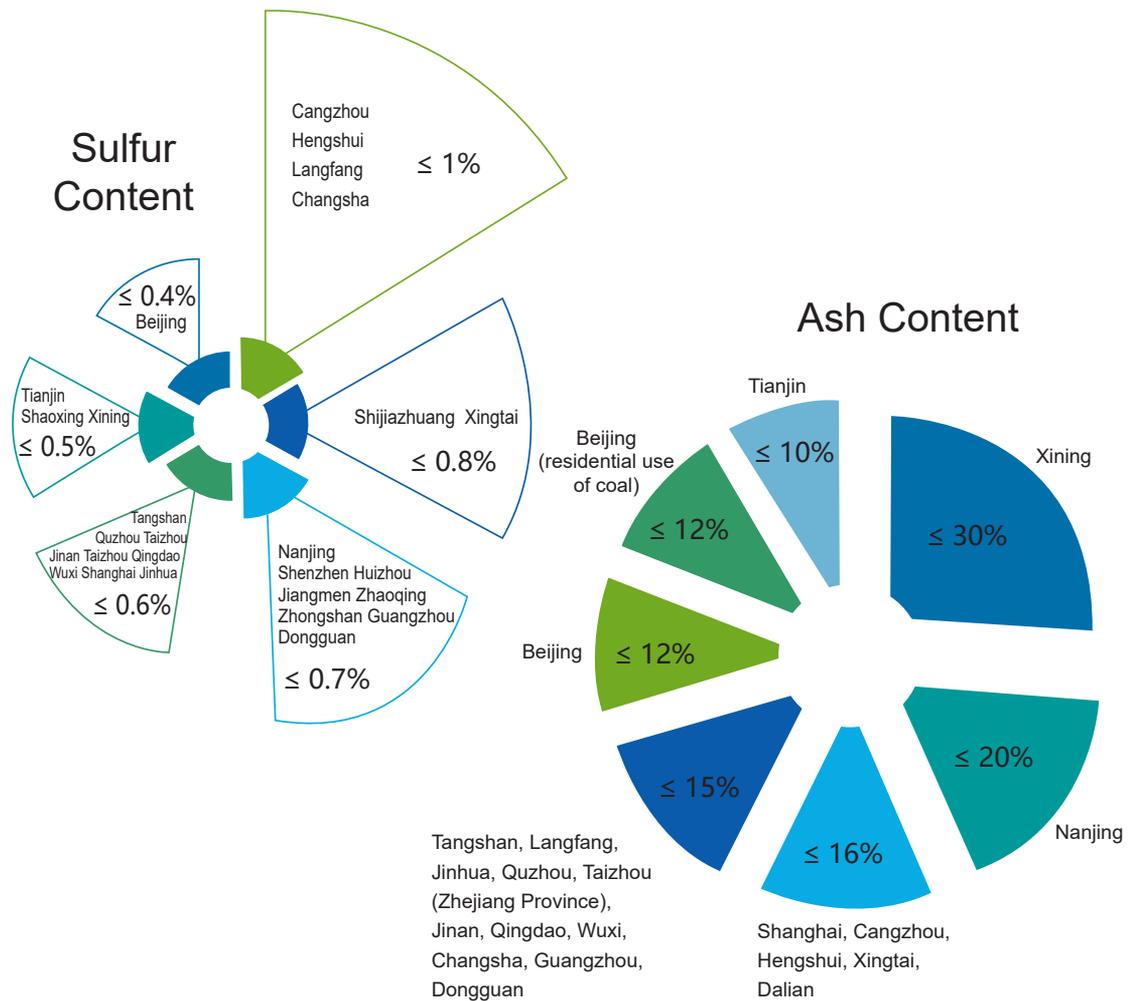
Chongqing, Handan, Baoding, Chengde, Zhangjiakou, Hohhot, Changchun, Harbin, Yinchuan, Xingtai



Taiyuan

■ Raw Coal Washing Rate

**Fig. 34: City Raw Coal Washing Target Rates**



**Fig. 35: City Coal Quality Control Targets**

## Upgrading Fuel Quality

According to the upgrading roadmap set by the Action Plan, China IV gasoline should be supplied nationwide by the end of 2013. China IV diesel should be supplied nationwide by the end of 2014. China V gasoline and diesel should be supplied in key cities in regions such as BTH, YRD and

PRD by the end of 2015 and should be supplied nationwide by the end of 2017. China IV gasoline and diesel were introduced nationwide as planned in 2014, and China V gasoline and diesel were introduced in cities and provinces such as Beijing, Tianjin, Shanghai, Jiangsu Province, Guangdong Province and Shaanxi Province ahead of the national timeline.

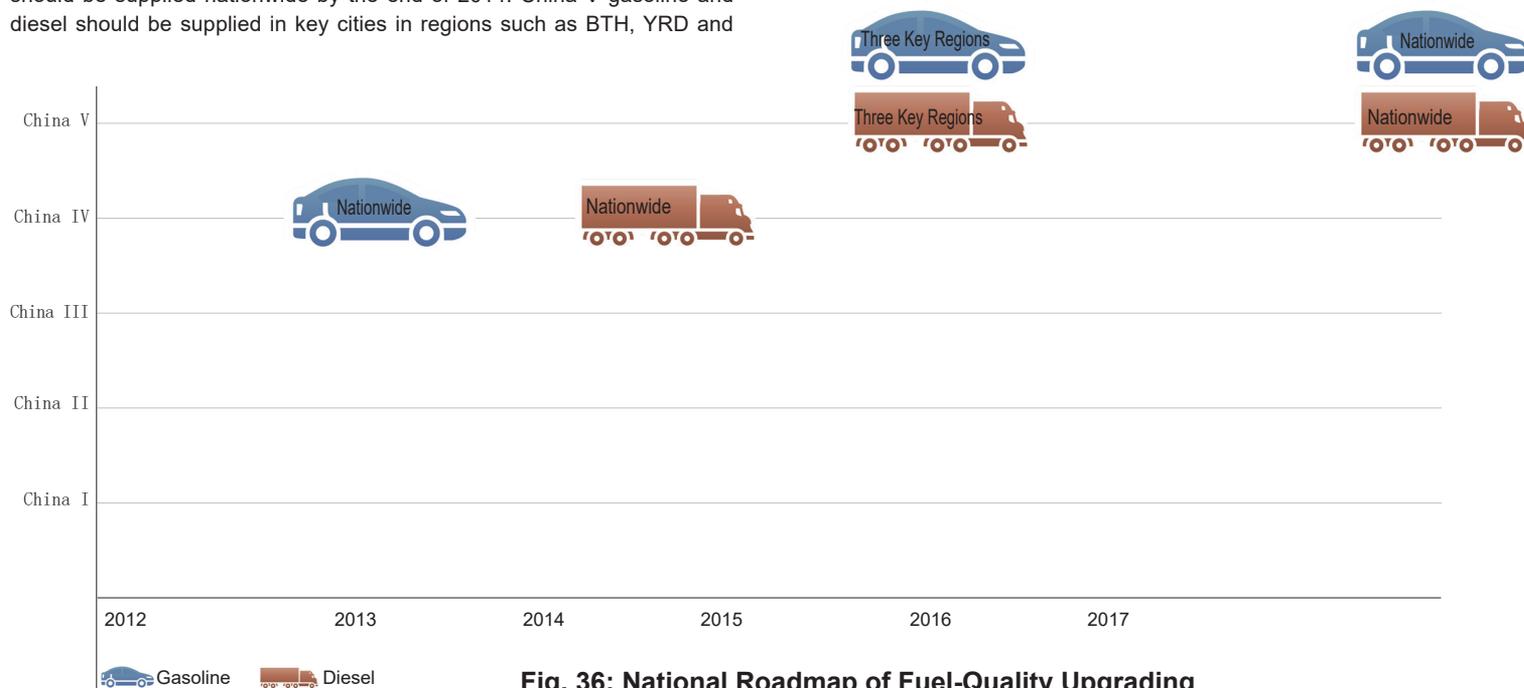


Fig. 36: National Roadmap of Fuel-Quality Upgrading

## Area Source Management: Dust, Catering and Agricultural Waste

The Action Plan requires the implementation of green construction nationwide: Construction sites should be fully enclosed with retaining walls, and roads in construction sites should be hardened. Vehicles for construction waste or debris transportation should be enclosed and gradually equipped with GPS systems. Low-dust operating procedures should be promoted, such as using street-cleaning machines. Large coal piles and stockpiles should be stored in enclosed areas and windproof and dust-suppression facilities should be built.

For kitchen-exhaust control in the catering industry, it is required that all catering sites in urban areas use highly efficient exhaust purification facilities, while the use of highly efficient rangehoods should be promoted in households.

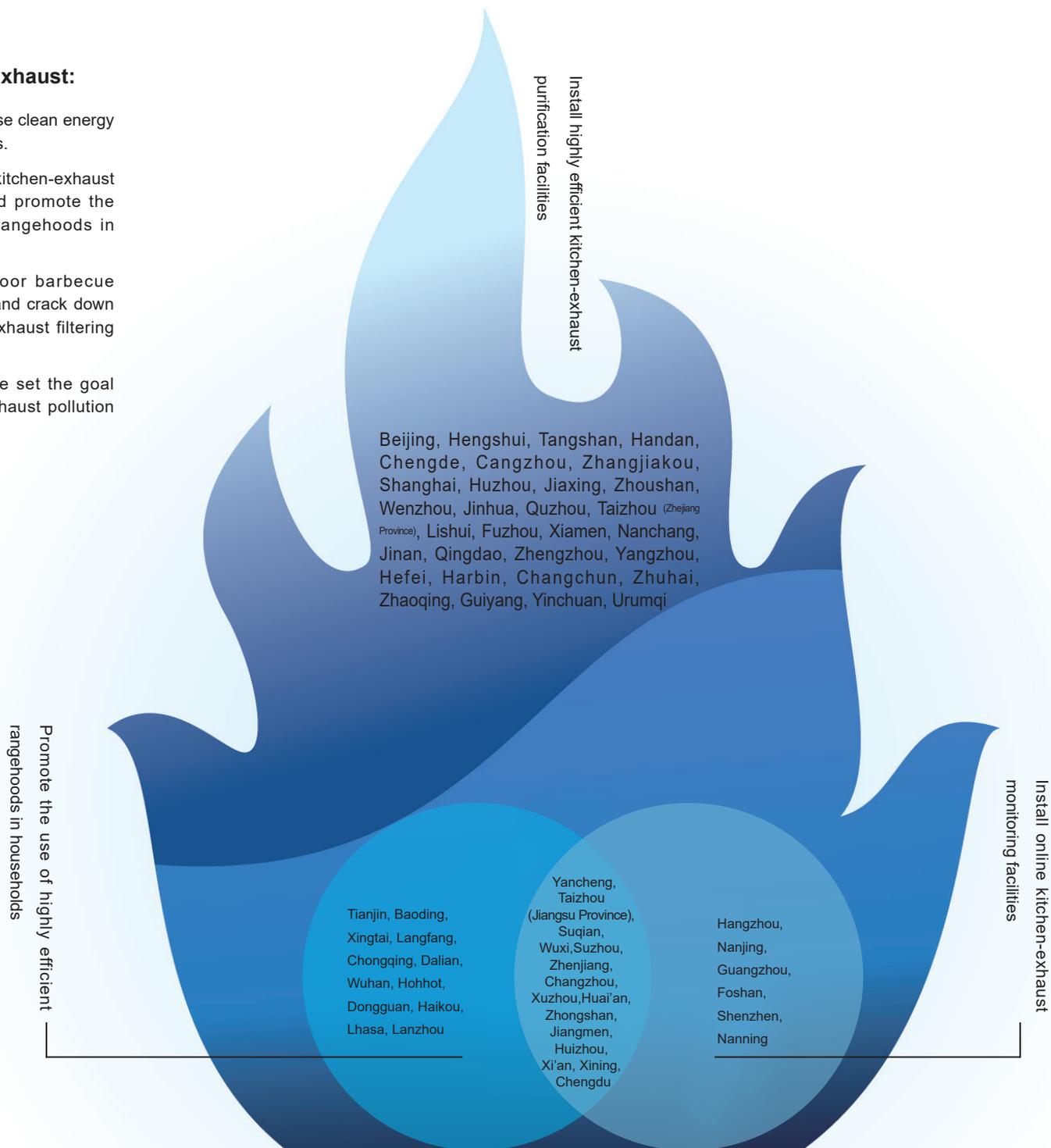
The cities have set specific requirements for dust, catering and agricultural waste management. To control the dust, the following must be done:

1. Strengthen dust-pollution control at construction sites, roads, demolition sites, stockpiles and mines; improve the installation rate of dust-suppression facilities; all construction sites should implement dust-control measures such as establishing retaining walls, road hardening, emission-source blocking, and water spraying and cleaning.
2. Large coal piles and stockpiles should be stored in enclosed areas or protected by windproof and dust-suppression facilities. Dust from construction waste transportation should be controlled. Vehicles for construction-waste transportation should be enclosed and gradually equipped with GPS systems.
3. Exposed soil in urban areas should be covered, afforested or hardened to control dust. Street-sweeping machines should be frequently used to clean urban expressways and highways, and water spraying should be increased to clean roads in downtown areas.

**To control kitchen exhaust:**

1. Urge catering sites to use clean energy and to retrofit their facilities.
2. Install highly efficient kitchen-exhaust purification facilities and promote the use of highly efficient rangehoods in households.
3. Strictly control outdoor barbecue activities in urban areas and crack down on restaurants without exhaust filtering and purification systems.

More than 50 cities have set the goal of completing kitchen-exhaust pollution control by 2015.



**Fig. 37: City Kitchen-Exhaust Control Measures**

## Policy Implementation and Progress

To control agricultural waste burning and agricultural ammonia emissions:

1. Outdoor agricultural waste and waste burning in urban and surrounding areas is strictly forbidden. Satellite remote-sensing technology should be used to identify key monitoring areas and monitor burning activities.
2. Improve the comprehensive utilization rate of agricultural waste: More

than 40 cities have set target comprehensive utilization rates for agricultural waste by 2017.

3. Control agricultural ammonia emissions: Introduce scientific fertilization practices to farmers to improve the efficiency of fertilizer use and lower the amount of fertilizer used on farms.

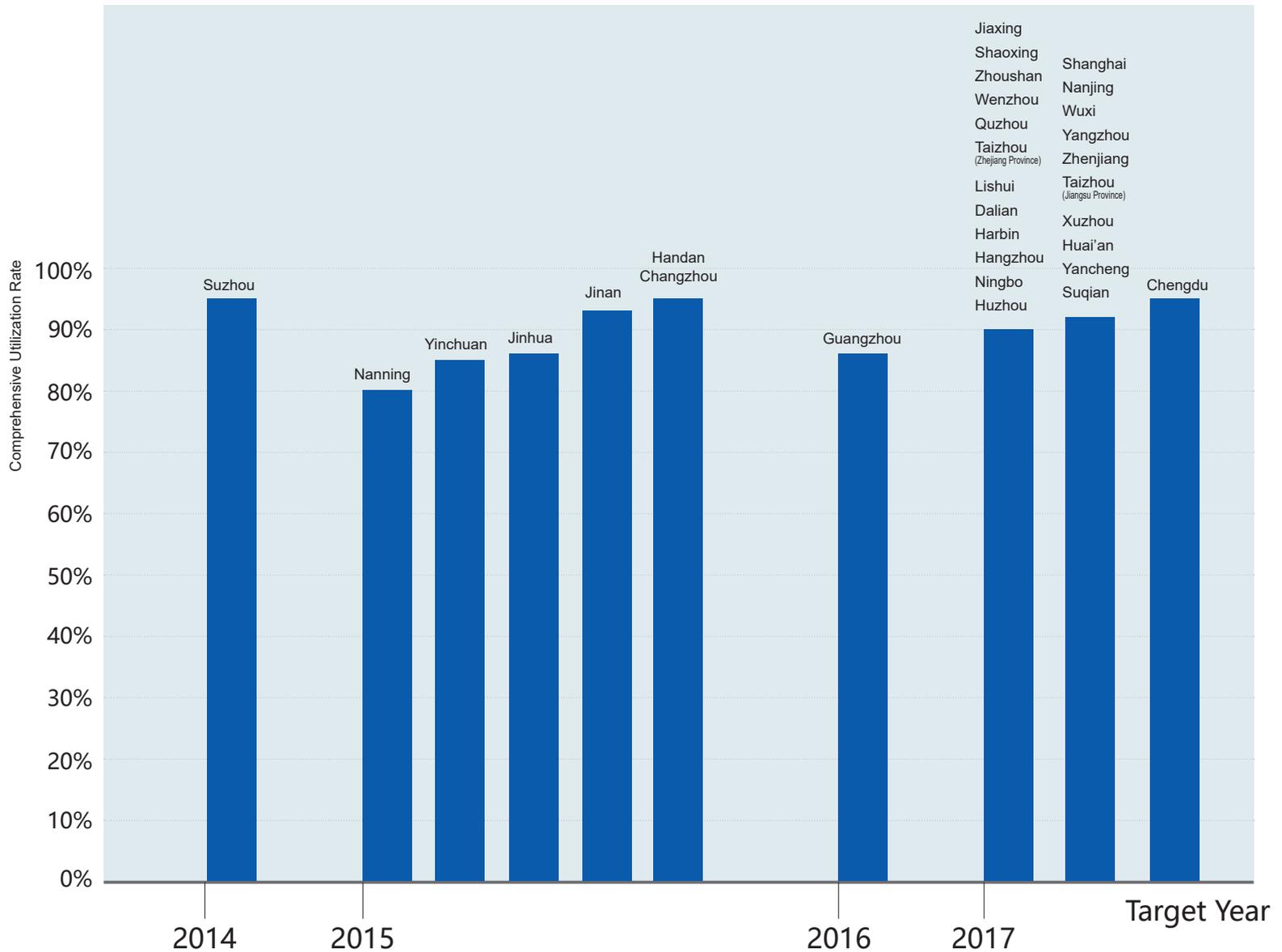


Fig. 38: City Target of Comprehensive Utilization Rates of Agricultural Waste

## Emission Reduction in Energy End Use

### Desulfurization, Denitration and Dust Elimination

At the national level, it is required that all coal-fired power plants, sinter machines and the pellet-production facilities of steel manufacturers, the catalytic cracking units of petroleum refineries and non-ferrous metal smelting plants be equipped with desulfurization facilities, and coal-fired boilers above 20t/h undergo desulfurization processes. All coal-fired units, except circulating fluidized bed boilers, will be equipped with denitration facilities, and new dry-cement kilns need to be retrofitted and equipped with denitration facilities. The dust-elimination facilities of coal-fired boilers and industrial kilns and boilers will be upgraded and retrofitted.

According to BTH implementation rules, by the end of 2015, BTH and its surrounding areas are expected to build or retrofit **59.7GW** of desulfurization capacity for coal-fired units, add or retrofit **16,000m<sup>2</sup>** of sinter machines for iron and steel manufacturers, add 110GW of denitration capacity for coal-fired power plants, and add or retrofit production capacity of **110** million tons of denitration cement clinker. The installed capacity or production capacity after dust-elimination upgrading and the retrofiting processes of the electric power, cement and steel industries should be no less than **25.74GW**, **33.25** million tons and **63.58** million tons respectively. **777** desulfurization, denitration and dust elimination projects in key industries were carried out in BTH between 2013 and 2014, and the denitration process for coal-fired power plants and cement kilns was almost completed. In Shanxi Province, the Inner Mongolia Autonomous Region and Shandong Province, **58.015GW**, **75.53GW** and **59.823** GW of coal-fired units respectively went through desulfurization, denitration and dust-elimination processes.

According to the Action Plan for Air Pollution Prevention and Control in Guangdong Province (2014-2017), coal-fired units above **125MW** are expected to achieve a desulfurization rate of more than **95%** and a denitration rate of more than **85%** by 2015. Guangdong Province had turned four coal-fired units into ultra-clean power plants, removed fuel gas bypass in all existing coal-fired units above **125MW** and completed retrofiting projects of low-NO<sub>x</sub> combustion and flue gas denitration for coal-fired units (excluding circulating fluidized bed boiler power units) by the end of 2014. Fifty-four cement clinker lines with a daily production capacity of more than **2,000** tons have completed the flue gas denitration retrofiting process, and six sinter machines and four fluid catalytic cracking units have completed the desulfurization retrofiting process.

The cities have all proposed to accelerate the construction and retrofiting of desulfurization facilities for key industries such as coal-fired power, petrochemical, steel and non-ferrous metal smelting, and of denitration facilities for key industries such as coal-fired power and cement. They have set targets for the construction and retrofiting of desulfurization, denitration and dust-elimination facilities in local pollution-discharge enterprises.

More than 40 cities have planned to achieve the control targets (2014 or 2015) for the coal-fired power sector and bring its emissions within the special emission limits stipulated in the Emission Standard of Air Pollutants for Thermal Power Plants (GB13223-2011). Cities such as Shijiazhuang, Tangshan, Xiamen and Qingdao have required that desulfurization and denitration efficiency rates be above **90%** and **70%** respectively for the coal-fired power sector. Cities in YRD, including Wuxi, Changzhou, Xuzhou and Yancheng, have required that the comprehensive denitration efficiency rate for cement production lines be more than **60%**. Guangzhou and Urumqi have required that the dust-elimination efficiency rate for coal-fired units be more than **99%**. See Figure 39 for details.

### Apply Special Emission Limits and Raise Industrial Emission Standards

According to the Action Plan, 42 newly built enterprises in industry sectors such as coal-fired power, steel, petrochemical, cement, non-ferrous metal smelting, chemical engineering and coal-fired boiler in the 74 major cities must apply the special emission limits on air pollutants. National industrial-emission standards revised or released between 2013 and 2014 include:

- Emission Standard of Air Pollutants for the Cement Industry (GB 4915-2013 replacing GB 4915-2004)
- Emission Standard of Pollutants for the Battery Industry (GB 30484-2013)
- Emission Standard of Air Pollutants for the Brick and Tile Industry (GB 29620-2013)
- Emission Standard of Air Pollutants for the Electronic Glass Industry (GB 29495-2013)
- Emission Standard of Air Pollutants for Boiler (GB 13271-2014)
- Emission Standards of Pollutants for Stannum, Antimony and Mercury Industries (GB 30770-2014)
- Standard for Pollution Control on the Municipal Solid Waste Incineration (GB 18485-2014)

Policy Implementation and Progress

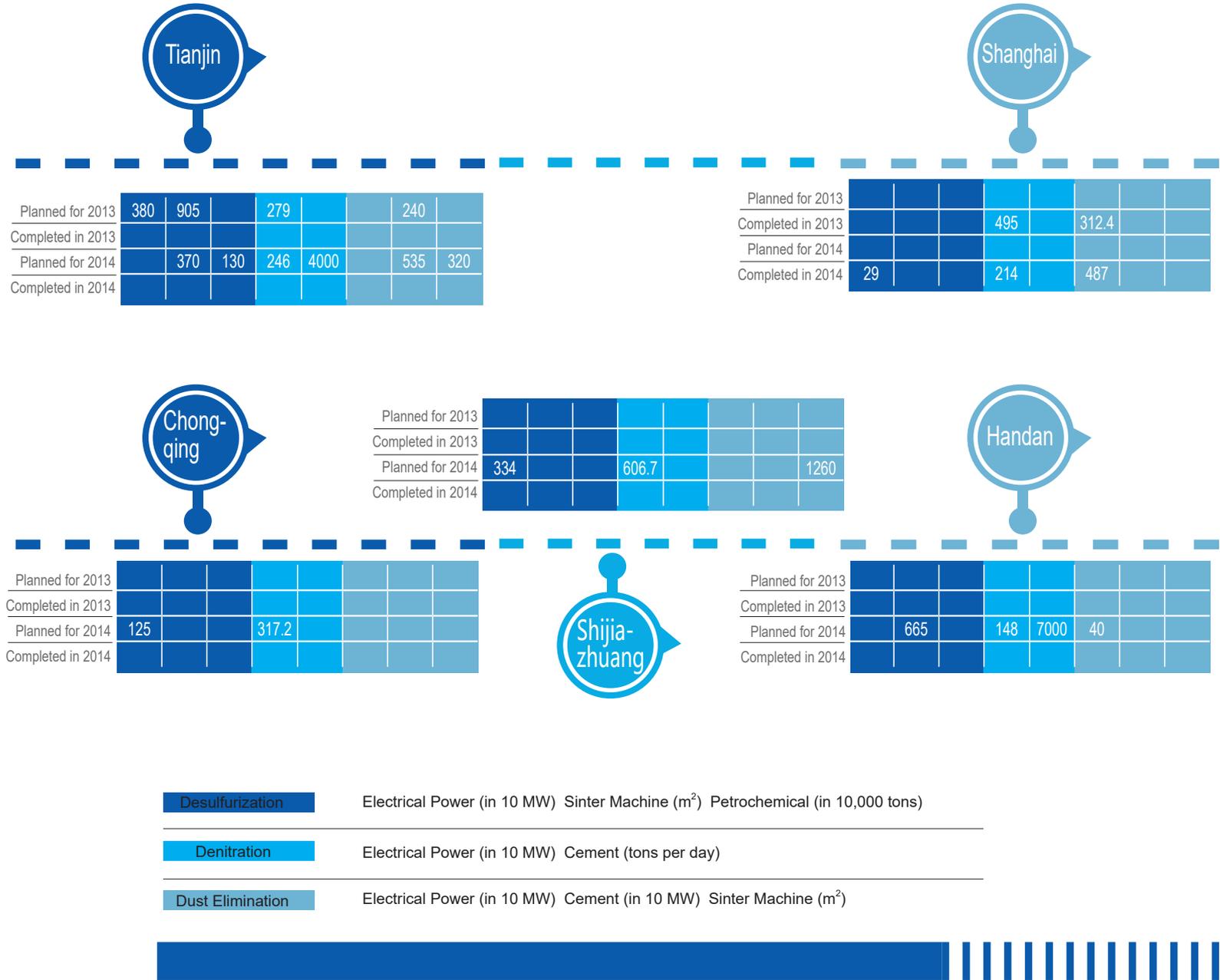


Fig. 39: City Progress of Desulfurization, Denitration and Dust Elimination

## Policy Implementation and Progress



|                   |    |  |    |     |  |  |
|-------------------|----|--|----|-----|--|--|
| Planned for 2013  | 66 |  | 93 | 126 |  |  |
| Completed in 2013 | 66 |  | 93 | 126 |  |  |
| Planned for 2014  |    |  |    |     |  |  |
| Completed in 2014 |    |  |    |     |  |  |



|                   |  |  |    |  |  |     |
|-------------------|--|--|----|--|--|-----|
| Planned for 2013  |  |  |    |  |  |     |
| Completed in 2013 |  |  |    |  |  |     |
| Planned for 2014  |  |  | 60 |  |  | 720 |
| Completed in 2014 |  |  |    |  |  |     |

|                   |    |    |       |  |  |  |
|-------------------|----|----|-------|--|--|--|
| Planned for 2013  |    |    |       |  |  |  |
| Completed in 2013 |    |    |       |  |  |  |
| Planned for 2014  | 92 | 40 | 16500 |  |  |  |
| Completed in 2014 |    |    |       |  |  |  |



|                   |  |  |     |    |  |  |
|-------------------|--|--|-----|----|--|--|
| Planned for 2013  |  |  |     |    |  |  |
| Completed in 2013 |  |  |     |    |  |  |
| Planned for 2014  |  |  | 210 | 60 |  |  |
| Completed in 2014 |  |  |     |    |  |  |



|                   |     |  |  |  |  |  |
|-------------------|-----|--|--|--|--|--|
| Planned for 2013  |     |  |  |  |  |  |
| Completed in 2013 |     |  |  |  |  |  |
| Planned for 2014  |     |  |  |  |  |  |
| Completed in 2014 | 500 |  |  |  |  |  |

|                   |  |  |      |  |  |  |
|-------------------|--|--|------|--|--|--|
| Planned for 2013  |  |  | 5150 |  |  |  |
| Completed in 2013 |  |  |      |  |  |  |
| Planned for 2014  |  |  |      |  |  |  |
| Completed in 2014 |  |  |      |  |  |  |



|                   |     |  |  |  |  |  |
|-------------------|-----|--|--|--|--|--|
| Planned for 2013  |     |  |  |  |  |  |
| Completed in 2013 |     |  |  |  |  |  |
| Planned for 2014  |     |  |  |  |  |  |
| Completed in 2014 | 105 |  |  |  |  |  |



|                   |     |     |       |       |  |  |
|-------------------|-----|-----|-------|-------|--|--|
| Planned for 2013  |     |     | 30    | 107.2 |  |  |
| Completed in 2013 | 72  |     | 32.4  | 109   |  |  |
| Planned for 2014  |     | 430 | 67    | 178.3 |  |  |
| Completed in 2014 | 198 | 430 | 100.6 | 178.3 |  |  |

|                   |  |  |     |  |  |  |
|-------------------|--|--|-----|--|--|--|
| Planned for 2013  |  |  |     |  |  |  |
| Completed in 2013 |  |  | 240 |  |  |  |
| Planned for 2014  |  |  |     |  |  |  |
| Completed in 2014 |  |  |     |  |  |  |



Policy Implementation and Progress



|                   |      |  |       |     |  |  |  |
|-------------------|------|--|-------|-----|--|--|--|
| Planned for 2013  |      |  |       |     |  |  |  |
| Completed in 2013 |      |  |       |     |  |  |  |
| Planned for 2014  | 1150 |  | 154.1 | 327 |  |  |  |
| Completed in 2014 |      |  |       |     |  |  |  |



|                   |       |     |       |       |       |  |  |
|-------------------|-------|-----|-------|-------|-------|--|--|
| Planned for 2013  | 18.9  |     | 147.5 | 36500 | 367.8 |  |  |
| Completed in 2013 | 276   |     | 76.2  | 8000  | 420.6 |  |  |
| Planned for 2014  | 52.3  | 180 | 61.2  | 4000  | 20.9  |  |  |
| Completed in 2014 | 184.3 |     | 376.5 | 32500 | 70.1  |  |  |

|                   |  |  |       |  |  |  |  |
|-------------------|--|--|-------|--|--|--|--|
| Planned for 2013  |  |  |       |  |  |  |  |
| Completed in 2013 |  |  |       |  |  |  |  |
| Planned for 2014  |  |  | 60000 |  |  |  |  |
| Completed in 2014 |  |  |       |  |  |  |  |



|                   |     |     |  |       |  |  |  |
|-------------------|-----|-----|--|-------|--|--|--|
| Planned for 2013  |     |     |  |       |  |  |  |
| Completed in 2013 |     |     |  |       |  |  |  |
| Planned for 2014  | 188 | 280 |  | 21050 |  |  |  |
| Completed in 2014 |     |     |  |       |  |  |  |



|                   |  |  |    |  |      |  |  |
|-------------------|--|--|----|--|------|--|--|
| Planned for 2013  |  |  |    |  |      |  |  |
| Completed in 2013 |  |  |    |  |      |  |  |
| Planned for 2014  |  |  | 27 |  | 35.4 |  |  |
| Completed in 2014 |  |  |    |  |      |  |  |

|                   |    |  |     |  |  |  |  |
|-------------------|----|--|-----|--|--|--|--|
| Planned for 2013  | 40 |  | 60  |  |  |  |  |
| Completed in 2013 | 40 |  | 60  |  |  |  |  |
| Planned for 2014  | 40 |  | 310 |  |  |  |  |
| Completed in 2014 | 40 |  | 310 |  |  |  |  |



|                   |  |  |  |       |  |  |  |
|-------------------|--|--|--|-------|--|--|--|
| Planned for 2013  |  |  |  |       |  |  |  |
| Completed in 2013 |  |  |  | 14000 |  |  |  |
| Planned for 2014  |  |  |  |       |  |  |  |
| Completed in 2014 |  |  |  | 14000 |  |  |  |



|                   |     |     |  |       |  |  |  |
|-------------------|-----|-----|--|-------|--|--|--|
| Planned for 2013  |     |     |  |       |  |  |  |
| Completed in 2013 |     |     |  |       |  |  |  |
| Planned for 2014  | 856 | 740 |  | 26500 |  |  |  |
| Completed in 2014 |     |     |  |       |  |  |  |

|                   |     |  |       |  |  |  |  |
|-------------------|-----|--|-------|--|--|--|--|
| Planned for 2013  |     |  |       |  |  |  |  |
| Completed in 2013 | 660 |  | 96    |  |  |  |  |
| Planned for 2014  | 240 |  | 321.5 |  |  |  |  |
| Completed in 2014 |     |  |       |  |  |  |  |



## Policy Implementation and Progress



|                   |  |  |    |  |  |  |  |
|-------------------|--|--|----|--|--|--|--|
| Planned for 2013  |  |  |    |  |  |  |  |
| Completed in 2013 |  |  |    |  |  |  |  |
| Planned for 2014  |  |  | 21 |  |  |  |  |
| Completed in 2014 |  |  |    |  |  |  |  |



|                   |      |  |  |      |       |  |  |
|-------------------|------|--|--|------|-------|--|--|
| Planned for 2013  | 2660 |  |  | 2660 | 24000 |  |  |
| Completed in 2013 |      |  |  | 2660 | 33000 |  |  |
| Planned for 2014  | 2660 |  |  | 2660 | 33000 |  |  |
| Completed in 2014 |      |  |  |      |       |  |  |

|                   |  |  |    |  |  |  |  |
|-------------------|--|--|----|--|--|--|--|
| Planned for 2013  |  |  |    |  |  |  |  |
| Completed in 2013 |  |  |    |  |  |  |  |
| Planned for 2014  |  |  | 40 |  |  |  |  |
| Completed in 2014 |  |  |    |  |  |  |  |



|                   |  |  |  |     |  |  |  |
|-------------------|--|--|--|-----|--|--|--|
| Planned for 2013  |  |  |  |     |  |  |  |
| Completed in 2013 |  |  |  | 210 |  |  |  |
| Planned for 2014  |  |  |  |     |  |  |  |
| Completed in 2014 |  |  |  |     |  |  |  |



|                   |     |  |    |       |  |  |  |
|-------------------|-----|--|----|-------|--|--|--|
| Planned for 2013  |     |  |    |       |  |  |  |
| Completed in 2013 |     |  |    |       |  |  |  |
| Planned for 2014  | 200 |  | 60 | 10500 |  |  |  |
| Completed in 2014 |     |  |    |       |  |  |  |

|                   |  |  |    |  |  |  |  |
|-------------------|--|--|----|--|--|--|--|
| Planned for 2013  |  |  |    |  |  |  |  |
| Completed in 2013 |  |  |    |  |  |  |  |
| Planned for 2014  |  |  | 70 |  |  |  |  |
| Completed in 2014 |  |  |    |  |  |  |  |



|                   |  |  |    |       |  |  |  |
|-------------------|--|--|----|-------|--|--|--|
| Planned for 2013  |  |  |    |       |  |  |  |
| Completed in 2013 |  |  |    |       |  |  |  |
| Planned for 2014  |  |  | 87 | 14100 |  |  |  |
| Completed in 2014 |  |  |    |       |  |  |  |



|                   |     |     |     |      |      |     |  |
|-------------------|-----|-----|-----|------|------|-----|--|
| Planned for 2013  | 30  | 530 | 220 | 207  |      | 30  |  |
| Completed in 2013 | 30  | 530 | 220 | 349  |      | 30  |  |
| Planned for 2014  | 256 |     | 140 | 142  | 4150 | 256 |  |
| Completed in 2014 | 256 |     | 140 | 1195 | 4150 | 256 |  |

|                   |     |     |       |       |     |  |  |
|-------------------|-----|-----|-------|-------|-----|--|--|
| Planned for 2013  |     |     |       |       |     |  |  |
| Completed in 2013 |     |     |       |       |     |  |  |
| Planned for 2014  | 265 | 420 | 224.6 | 232.5 | 187 |  |  |
| Completed in 2014 |     |     |       |       |     |  |  |



## Upgrading Vehicle Emission Standards

National vehicle emission standards revised or released between 2013 and 2014 include:

- Limits and Measurement Methods for Emissions from Light-Duty Vehicles (China V) (GB 18352.5-2013 replacing GB 18352.3-2005)
- Limits and Measurement Methods for Exhaust Pollutants from Diesel Engines of Urban Vehicles (WHTC) (HJ 689-2014)
- Limits and Measurement Methods for Exhaust Pollutants from Diesel Engines of Non-Road Mobile Machinery (China III and IV)

Beijing, Tianjin and Hebei Province will fully implement the China V vehicle emission standards by 2015; Shanxi Province, the Inner Mongolia Autonomous Region and Shandong Province will implement the standard by 2017. In YRD, Shanghai implemented the China V vehicle emission standards in April 2014 ahead of other cities and regions. PRD has implemented China IV diesel-vehicle emission standards since July 1, 2013, and has applied to the National Government to implement China V vehicle emission standards ahead of its planned schedule.

See Figure 40 for the upgrading of vehicle emission standards in different cities.

- **Tianjin** will implement China V vehicle emission standards by the end of 2015
- Shanghai** will implement China V standards for diesel, heavy-duty and new vehicles in 2015
- Shijiazhuang** will fully implement China V vehicle emission standards by the end of 2015
- Tangshan** will fully implement China V vehicle emission standards by the end of 2015
- Handan** will implement China V vehicle emission standards by the end of 2015
- Baoding** will implement China V vehicle emission standards by the end of 2015
- Chengde** will label all newly registered vehicles and vehicles transferred from other cities with logos indicating the implementation of China V vehicle emission standards by the end of 2015

**Cangzhou** will fully implement China V vehicle emission standards by the end of 2015

**Hengshui** will fully implement China V vehicle emission standards by the end of 2015

**Zhangjiakou** will fully implement China V vehicle emission standards by the end of 2015

**Langfang** will fully implement China V vehicle emission standards by the end of 2015

By the end of 2015, China V emission standards will be implemented for all newly added heavy-duty diesel vehicles

**Guangzhou, Shenzhen, Jiangmen, Dongguan, Zhuhai, Foshan, Zhongshan, Huizhou and Zhaoqing**

Since March 1, 2015, light-duty vehicles with spark-ignition engines that are sold, registered in or transferred to PRD should comply with national emission standards

Beijing will strive to implement Phase VI vehicle emission standards in 2016

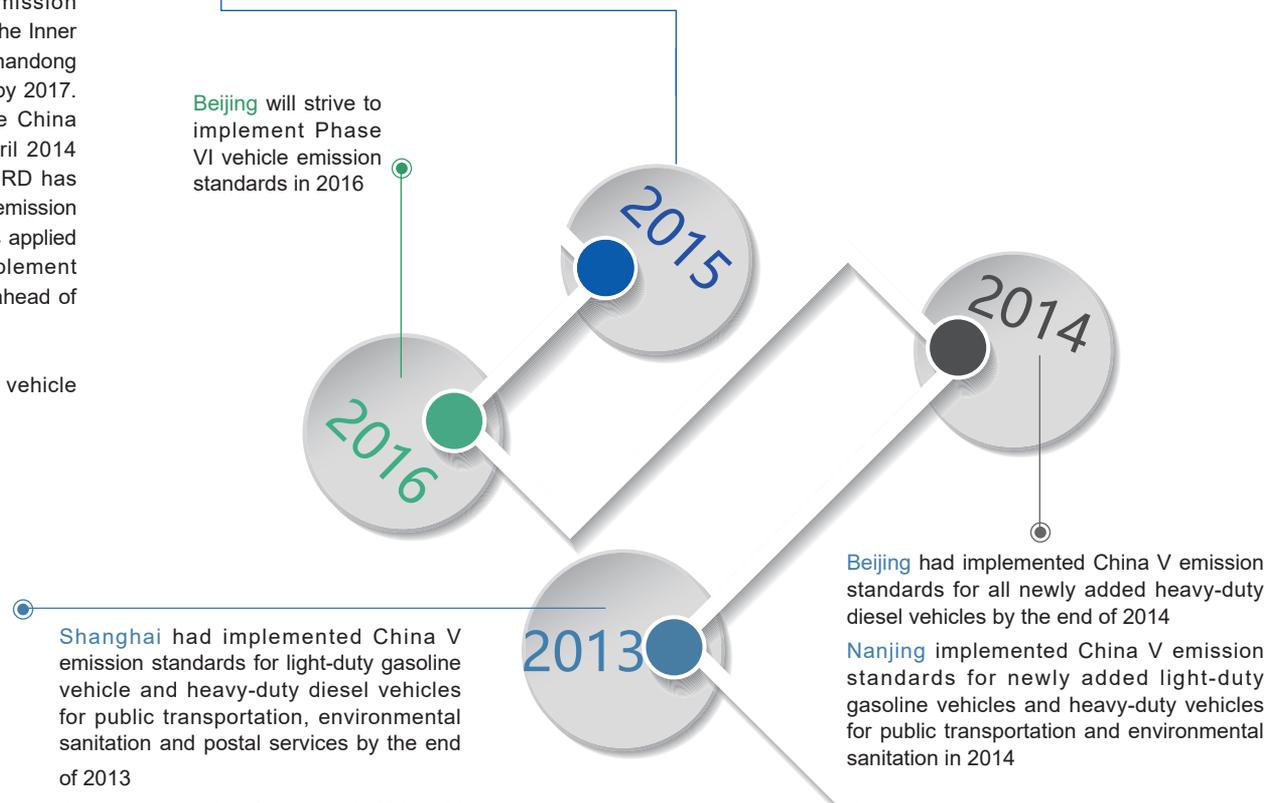


Fig. 40: City Vehicle Emission Standard Upgrading

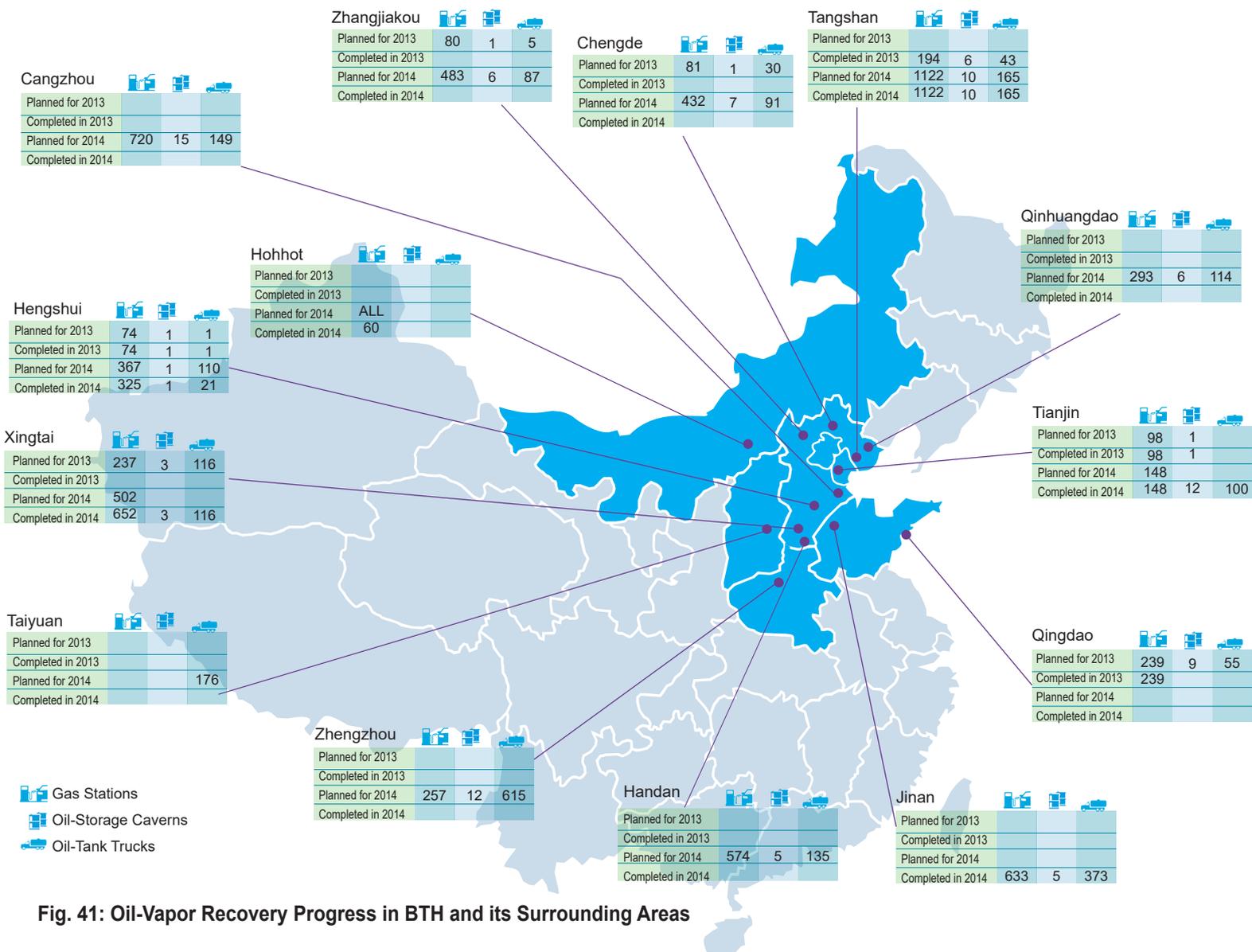


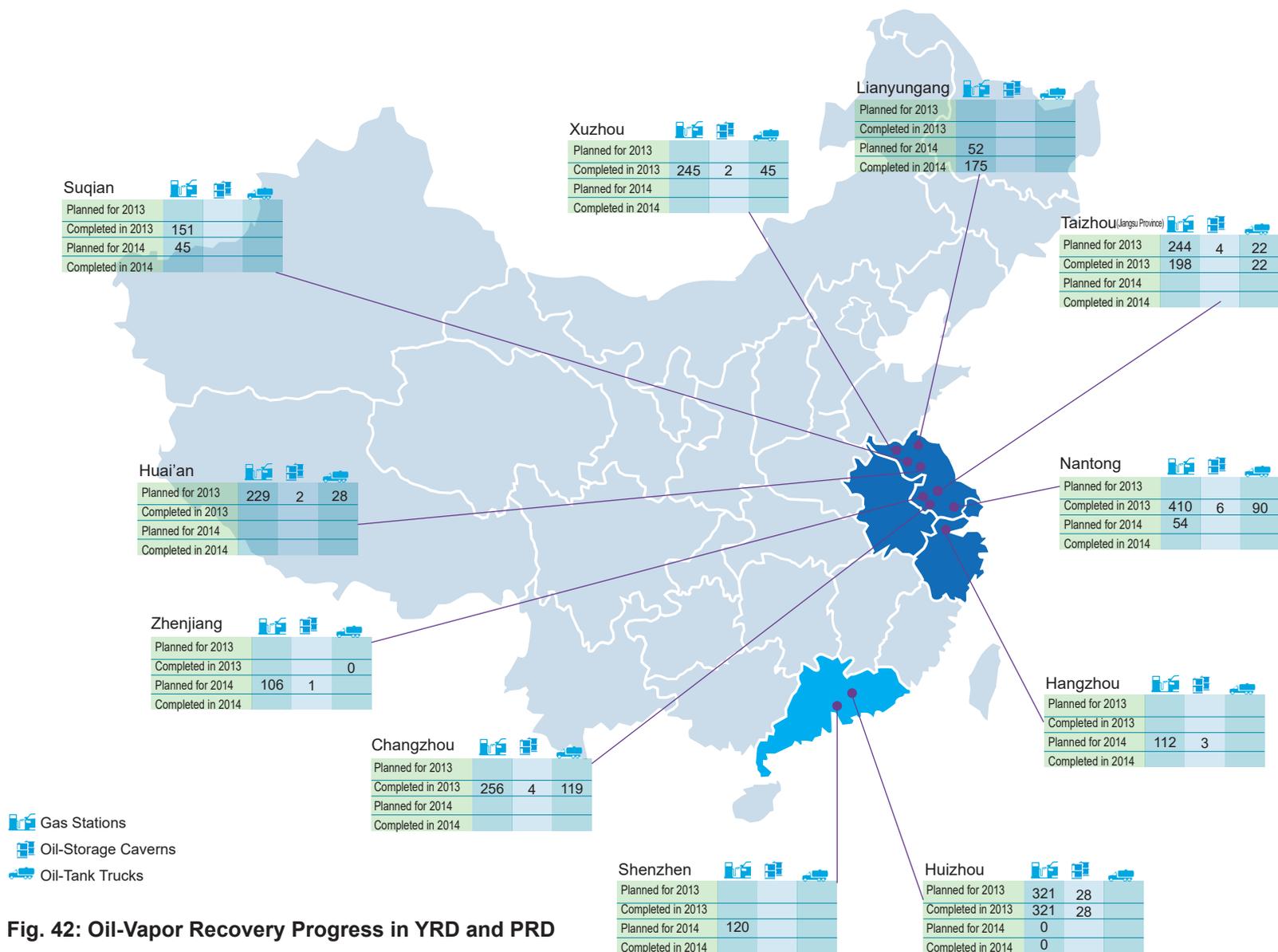
Fig. 41: Oil-Vapor Recovery Progress in BTH and its Surrounding Areas

## New Measures

### VOCs Control

The National Government requires comprehensive control of VOCs in such industries as petrochemical, organic chemical, surface coating and packaging and printing.

A Leak Detection and Repair (LDAR) system should be applied in the petrochemical industry, oil-vapor recovery needs to be completed in gas stations, oil-storage caverns and oil-tank trucks within a limited time frame, and oil-vapor recovery should be carried out in crude and product oil ports. The National Government also requires improvement in the standards of VOCs limits for painting and adhesive products, the promotion of water-based paint usage, and encouragement for the production, sale and use of organic solvents that are low in toxicity and volatility.



**Fig. 42: Oil-Vapor Recovery Progress in YRD and PRD**

BTH: The oil-vapor recovery process in gas stations, oil-storage caverns and oil-tank trucks should be completed by the end of 2014. LDAR technology will be fully implemented in the petrochemical industry by the end of 2015, while comprehensive control of VOCs for 559 enterprises in key industries such as organic chemical, pharmaceutical, surface coating, plastic and packaging and printing will be carried out by the end of 2017.

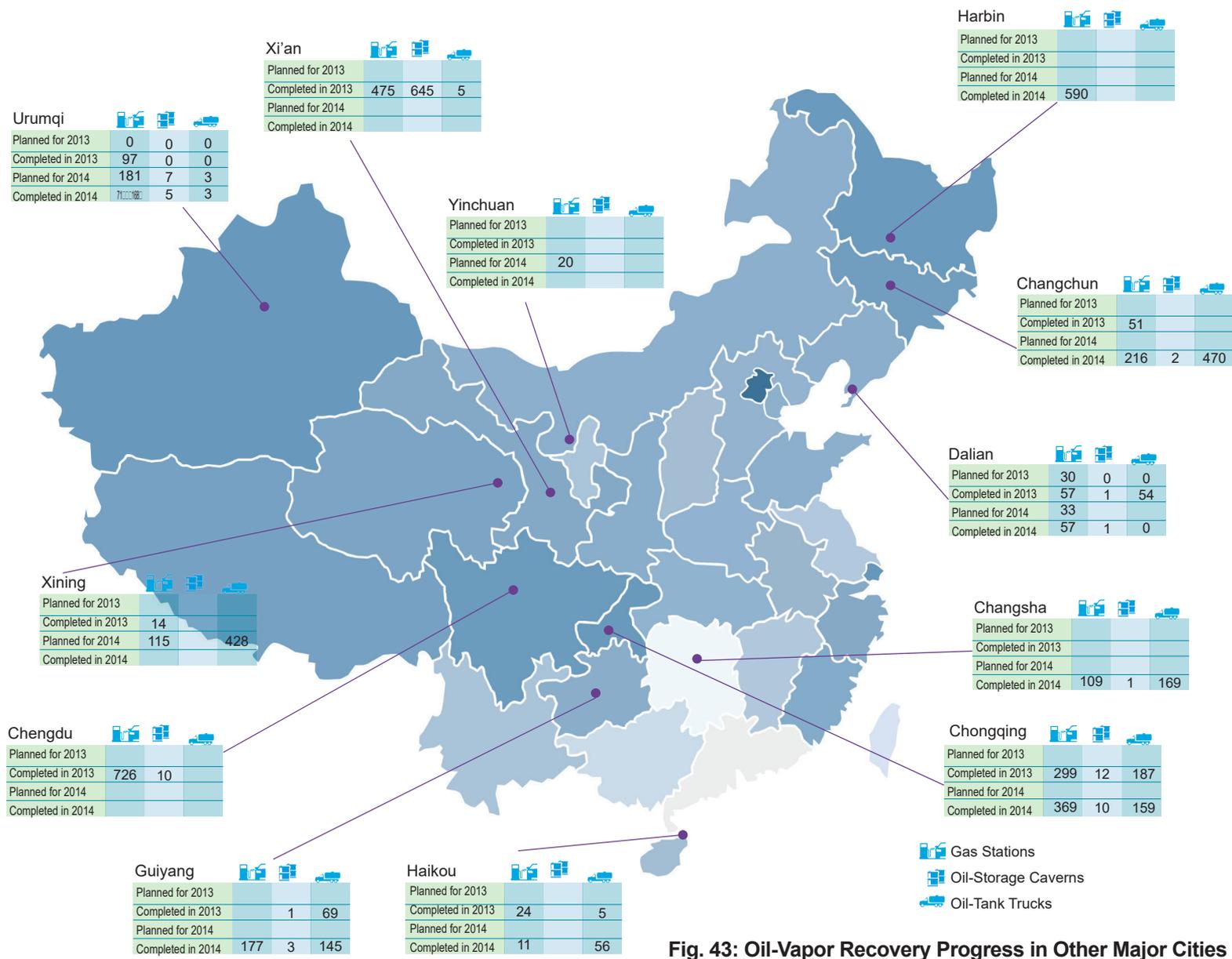
YRD: LDAR technology will be fully implemented in the petrochemical and chemical engineering industries, and waste-gas source control in key

chemical industrial zones (concentration districts) and enterprises completed by the end of 2017.

Shanghai will complete the control of VOCs for about 100 key enterprises in 2015 and further promote the control of VOCs in enterprises to ensure a 30% reduction in VOCs from industrial sources by 2017 compared with 2012.

PRD: The oil-vapor recovery process in gas stations, oil-storage caverns,

## Policy Implementation and Progress



**Fig. 43: Oil-Vapor Recovery Progress in Other Major Cities**

oil-tank trucks and the oil-storage tank zones of chemical enterprises and the construction of an online monitoring system for oil-vapor recovery should be completed by the end of 2014. All oil refineries in PRD will adopt LDAR technology by the end of 2015. Manufacturers of coating, printing ink, adhesives and pesticides should adopt enclosing processes in the manufacture of products and collect and purify waste gas that contains VOCs, with a purification efficiency rate of more than 90%.

Municipal governments demand comprehensive control of VOCs in key

industries such as organic chemical, surface coating, packaging and printing and furniture manufacturing: (1) Apply LDAR in the petrochemical industry and gradually reduce VOCs emissions each year, and complete oil-vapor recovery in gas stations, oil-storage caverns and oil-tank trucks (see Figures 41-43 for details about the oil-vapor recovery process in different cities); (2) Promote the innovation of non-solvent coating products and reduce VOCs emissions in manufacturing and use, and encourage the use of water-based coating and the production, sale and use of solvents that are low in toxicity and volatility.

## Emissions from Non-Road Mobile Machinery and Ports and Vessels

In the Action Plan, the National Government demands the control of pollution from non-road mobile machinery such as engineering machinery and vessels.

**YRD:** Shanghai has actively promoted the use of “shore power” by vessels and has completed shore-based power-supply pilot projects at the Shanghai Wusongkou International Cruise Terminal and the Shanghai Guandong International Container Terminal. The city has also promoted oil-to-electricity pilot projects for container-handling equipment such as rubber-tired gantry (RTG) cranes, and 400 LNG port trucks will be provided by the end of 2017. In Jiangsu Province, all RTG cranes will switch from oil to electricity or electricity-powered cranes will be used by 2017 in container terminals. More than 80%

of handling equipment will switch from oil to electricity (gas) in general cargo terminals.

**PRD:** Newly built cruise terminals must be equipped with shore power facilities, and newly built container terminals with a capacity of more than 100,000 tons must be equipped with shore power facilities or have the space and capacity to build such facilities. Comprehensive oil-vapor recovery in crude and product oil terminals should be completed by the end of 2017. PRD will improve the energy-consumption structure of ports, accelerate the oil-to-electricity and oil-to-gas switch of mobile machinery, transportation vehicles and port trailers, and promote the pilot projects of LNG conversion in vessels.

The region will complete the oil-to-electricity switch of RTG cranes in major seaports and inland ports by the end of 2017. The China I vessel-engine emission standards have been in effect since January 1, 2014. All working ships and port-management ships will use shore power by the end of 2017.



At municipal level, Beijing, Tianjin, Shanghai, Shijiazhuang, Tangshan, Handan, Baoding, Xingtai, Langfang, Lishui, Fuzhou, Xiamen, Nanchang, Jinan, Qingdao, Wuhan, Dalian, Changchun, Suzhou, Wuxi, Changzhou, Yangzhou, Zhenjiang, Taizhou (Jiangsu Province), Huai'an, Yancheng, Suqian, Guangzhou, Shenzhen, Zhuhai, Jiangmen, Dongguan, Zhongshan, Huizhou, Chengdu, Guiyang and Xining have proposed in their local Action Plans to strengthen the control of pollution from non-road mobile machinery such as engineering and agricultural machinery. Xiamen, Guangzhou, Zhongshan, Nanning, Chengdu and Urumqi have launched investigations into pollution from

non-road mobile sources in order to better understand the situation.

Cities that require the control of emissions from ports and vessels and the promotion of the oil-to-gas and oil-to-electricity switch in port transportation machinery include Tianjin, Shanghai, Tangshan, Handan, Quzhou, Lishui, Fuzhou, Xiamen, Nanchang, Wuhan, Dalian, Nanjing, Suzhou, Wuxi, Changzhou, Yangzhou, Zhenjiang, Taizhou (Jiangsu Province), Huai'an, Yancheng, Suqian, Hangzhou, Ningbo, Guangzhou, Shenzhen, Zhuhai, Jiangmen, Dongguan, Zhongshan, Huizhou and Zhaoqing.

## Supporting Measures

### Economic Means

In order to effectively implement the Action Plan, 19 of the 22 supporting measures - most of which were economic policies and assessment methods - were launched by the end of 2014. In relation to economic policies, 10 aspects were covered, including pricing policy, tax policy and investment policy.

#### Electricity and Energy Tariffs

Coal-fired generating units will be equipped with desulfurization, denitration and dust-elimination facilities for environmental protection purposes as required. On the basis of on-grid tariffs, on-grid electricity from such

generating units is subject to incentive prices for desulfurization, denitration and dust elimination. Currently, the incentive prices for desulfurization, denitration and dust elimination are RMB 0.015, RMB 0.01 and RMB 0.02 per kWh respectively.

#### Pollutant Discharge Fees

The government has proposed increasing the charging standards for pollutant discharge, as well as the gradual introduction of pollutant discharge fees on VOCs, construction dust, gas stations and kitchen exhaust from catering businesses.

In accordance with government requirements, cities are required to adopt a permit system for major enterprises that discharge sulfur dioxide (SO<sub>2</sub>), oxynitride (NO<sub>x</sub>), industrial smoke and dust, and VOCs, which will provide an important basis for total emission control, emission charges and environmental law enforcement. See Figure 44 for detailed charging standards for SO<sub>2</sub> and NO<sub>x</sub> emissions in different cities.

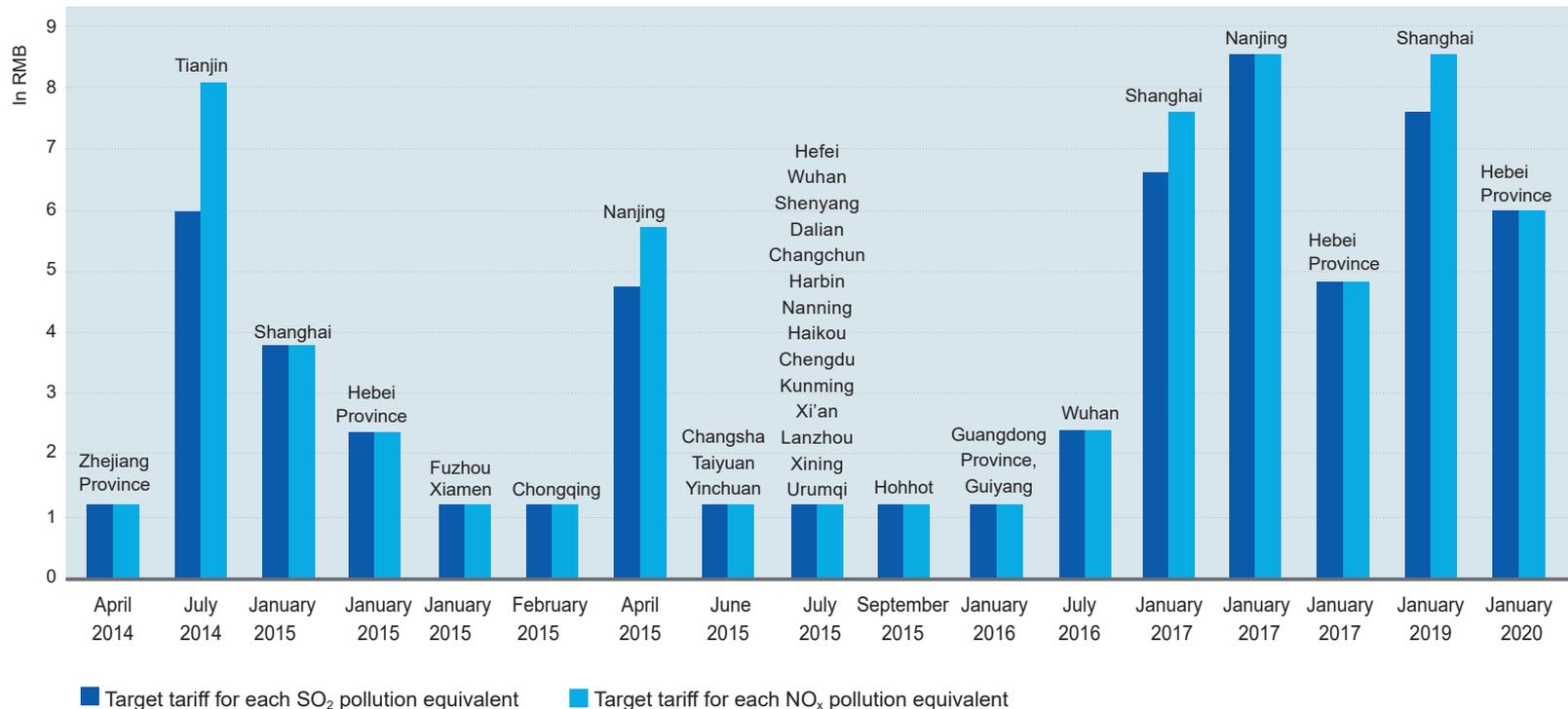


Fig. 44: Charging Standards for SO<sub>2</sub> and NO<sub>x</sub> Emissions in Different Cities

## Project Subsidies and Special Funds

The National Government has stepped up its support for programs concerning people's livelihood, including "coal-to-gas switch" projects, the elimination of yellow-label and outdated vehicles, and the replacement of low-speed trucks with light-duty trucks, and has offered funding support to clean-production demonstration projects in major industries. The National Government has also coordinated its spending and consolidated special projects for major pollutants emission reduction, set up a special fund for air pollution prevention and control, and introduced a policy of "replacing subsidies with rewards" to key areas in accordance with its pollution control results.

In 2013, the National Government established a 5 billion RMB special fund to

support air-pollution prevention and control in BTH and its surrounding regions, including Beijing, Tianjin, Hebei, Shandong and Shanxi Provinces and the Inner Mongolia Autonomous Region. In 2014, the National Government established a 9.8 billion RMB special fund in support of similar efforts in 10 provinces (and cities) across the key regions, including Jiangsu, Zhejiang, Anhui and Shanghai, in addition to the aforementioned six cities and provinces.

Cities have improved their taxation incentives and increased fiscal support for the elimination of outdated production capacity and offered funding support to encourage desulfurization and denitration projects, coal-fired power cleaning, the elimination of coal-fired boilers, coal-to-gas switching, VOCs pollution control, the elimination of yellow-label vehicles, vehicle fuel-to-gas projects, and exit mechanisms for enterprises in "high energy-consumption and high-pollution industries". See Figure 45 for details about funding support in different cities.

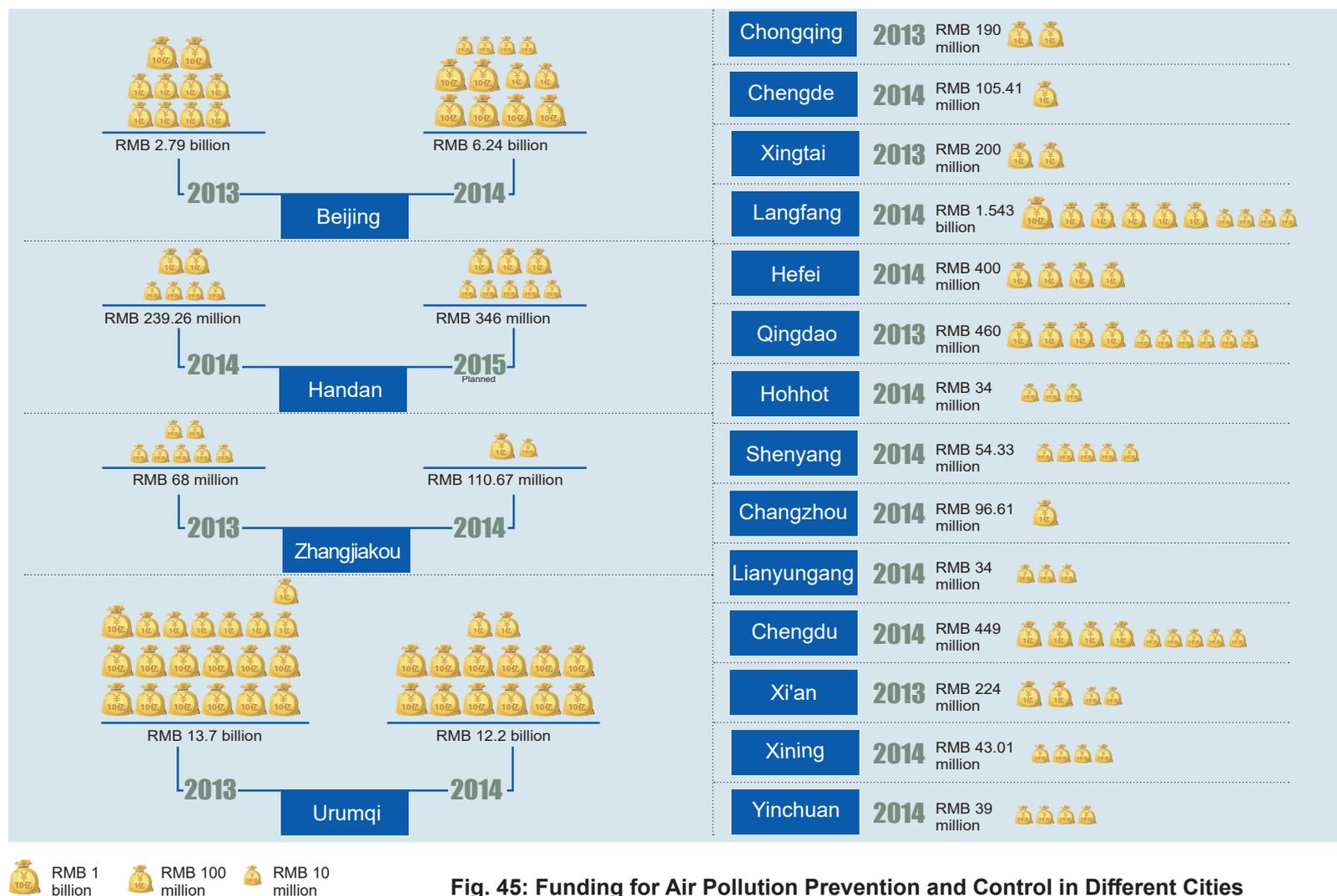


Fig. 45: Funding for Air Pollution Prevention and Control in Different Cities

## Administrative Approaches

### Target Assessment and Liability Statement

The Action Plan has for the first time incorporated PM<sub>2.5</sub> emission reduction into its obligatory targets and the improvement of environmental quality into government officials' appraisal system. The State Council has signed liability statements for air-pollution prevention and control with the people's governments of provinces (autonomous regions and municipalities directly under the National Government), breaking down targets and tasks and assigning them to local governments and enterprises, as well as setting the indicator of PM<sub>2.5</sub> in key areas and PM<sub>10</sub> in non-key areas as obligatory targets for economic and social development, hence establishing a target-driven appraisal system centered on improving environmental quality. In addition, municipal governments have also signed liability statements on air pollution prevention and control with county/district governments and relevant municipal departments.

More than 40 cities have formulated assessment measures for interim evaluation and final assessment, with the fulfilment of air pollution control objectives and responsibilities forming the basis to assess and evaluate the overall performance of executive teams and leading members. In the event of a failure to fulfil annual targets and tasks, supervisory authorities will hold relevant organizations and personnel accountable in accordance with related laws and disciplines.

### Air Quality Rankings

The National Government releases monthly air quality rankings of the 10 worst and 10 best cities. All provinces must publish the air quality rankings of cities above the prefecture level within their jurisdiction. The Regional Supervision Center of the MEP will hold admonitory talks with the local chief executives of the cities in which air quality continues to worsen. The ranking and admonitory talk mechanisms have placed significant pressure on local governments. For instance, a city in Hebei Province has set as its top priority for environmental

|   | 10 Cities with Best Air Quality | 10 Cities with Worst Air Quality |
|---|---------------------------------|----------------------------------|
| <br>Air Quality Rankings in<br>February 2015 | Lhasa                           | Baoding                          |
|   | Haikou                          | Xingtai                          |
|   | Xiamen                          | Shenyang                         |
|   | Kunming                         | Urumqi                           |
|   | Zhoushan                        | Harbin                           |
|   | Huizhou                         | Zhengzhou                        |
|   | Fuzhou                          | Hengshui                         |
|   | Zhangjiakou                     | Shijiazhuang                     |
|   | Lishui                          | Tangshan                         |
|   | Shenzhen                        | Handan                           |

protection exclusion from the list of cities with the worst air quality, while a city in Shandong Province suspended factory production and restricted vehicles running in order to control haze immediately after its chief officials were asked to attend an admonitory talk.

## Legislative Means

### Amendment of the Environmental Protection Law and the Law on Prevention and Control of Atmospheric Pollution

A draft amendment of the Environmental Protection Law was passed in 2014 and came into effect on January 1, 2015. The new law stipulates special provisions on issues concerning regional air pollution prevention and control, increases the intensity of punishment, and imposes consecutive daily penalties on polluting enterprises without upper limits. In December, 2014, the draft Law on Prevention and Control of Atmospheric Pollution was reviewed and passed after the first reading at an executive meeting of the State Council. Given the public attention surrounding the issue of air pollution prevention and control, the draft was thoroughly discussed by all sectors of society, and comments were submitted to the MEP. The two laws will help establish the long-term improvement measures of the Action Plan in legal form.

All the cities have also actively pressed ahead with legislation targeting local air pollution prevention and control, have continuously improved their air pollution control laws and regulations, have provided legal support for the implementation of various prevention and control measures, and have accelerated the process of pollution control in accordance with the law. The cities which have also revised their regulations on, or management measures for, air pollution prevention and control include Beijing, Tianjin, Shanghai, Zhengzhou, Shijiazhuang and Lanzhou. Nanjing, Jinan, Hefei, Qingdao and Changchun are either doing so or are in the planning process. Chongqing, Taiyuan, Hangzhou, Ningbo, Shenzhen and Chengdu are working on, or are planning to formulate, their own air pollution prevention and control rules and regulations.

### Monitoring of Major Pollution Sources and Information Disclosure

To establish and improve regulations on the monitoring of pollution sources and information disclosure, the MEP formulated Measures for Self-Monitoring and Information Disclosure by Enterprises Subject to Intensive State Supervision and Control (Trial) and Measures for Supervisory Monitoring of Pollution Sources and Information Disclosure by Enterprises Subject to Intensive State Monitoring and Control (Trial) in July 2013 to encourage enterprises to undertake their duties and obligations and carry out self-monitoring, while further standardizing supervisory monitoring by environmental protection authorities and promoting the disclosure of information about monitored pollution sources.

# City Case Studies



## Summary of Beijing's Experience

# Ambient Air Quality Monitoring, Forecasting and Reporting

## History

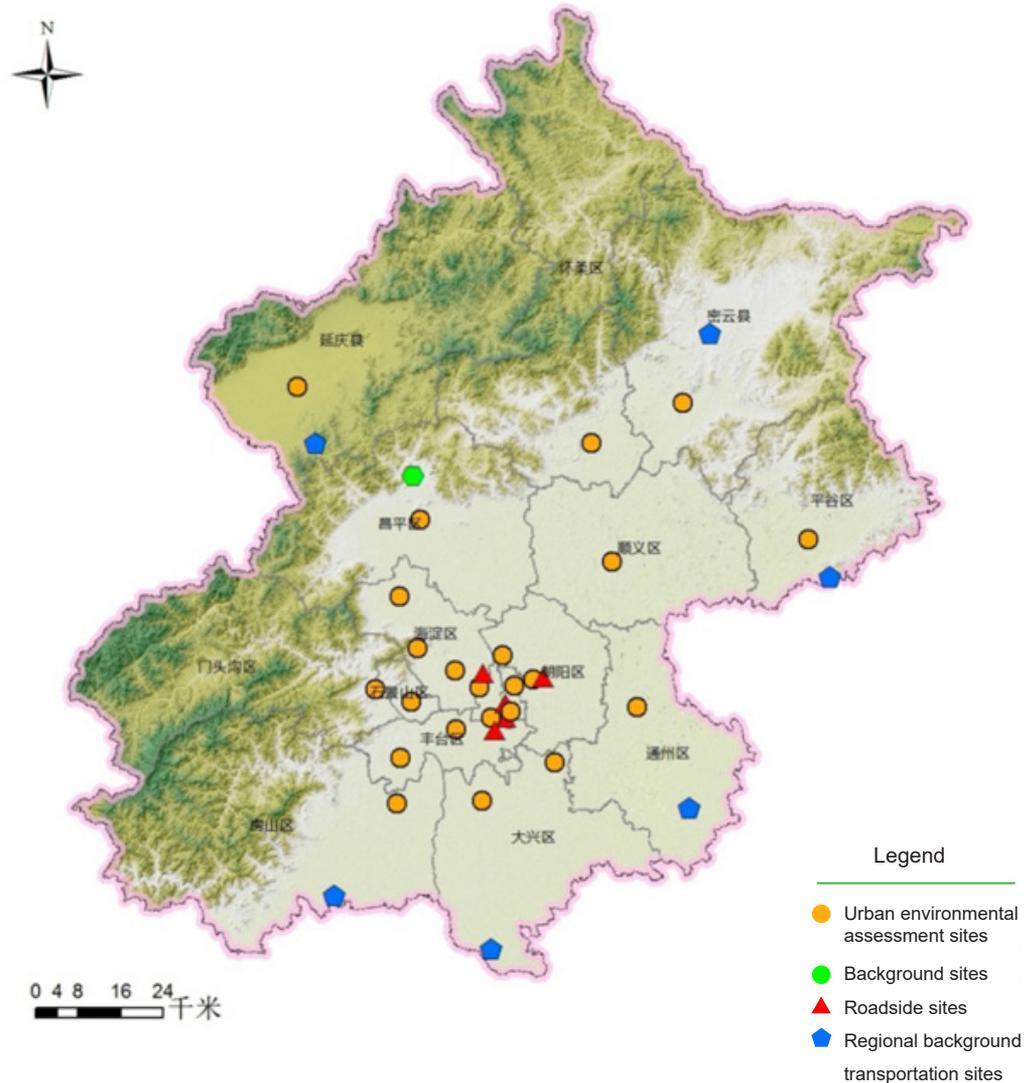
### Monitoring

Beijing's automatic air-quality monitoring system, established in 1984, is the first of its kind in China, and initially consisted of eight substations distributed across the city's then eight districts.

Through continued expansion, it evolved into a monitoring network specializing in assessing the city's ambient air quality comprised of 27 substations and covering all districts and affiliated counties. All stations automatically monitored  $\text{SO}_2$ ,  $\text{NO}_2$  and  $\text{PM}_{10}$  in the air around the clock in accordance with national standards. Beijing began to release weekly and daily air-quality reports from 1998 and 1999 respectively.

Following further expansion in 2012, the number of Beijing's monitoring stations has reached 35, and are further divided based on their monitoring functions. In addition to the 23 urban environmental assessment sites and one background site, six regional background transportation sites and five roadside sites are distributed along the 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> Ring Roads and other main arteries that are designed to reflect the city's regional background and pollutant transportation as well as near-road air quality.

The breakdown of these sites' functions has made it possible to fully capture the characteristics of combined atmospheric pollution, and has played a major role in subsequent air pollution prevention and control.



**Fig. 46: Distribution of Environmental Monitoring Stations in Beijing**

As required by China's Revised Standards, all 35 monitoring sites have added the monitoring capacity of PM<sub>2.5</sub>, O<sub>3</sub> and CO in addition to the original three pollutants. From January 2012, Beijing began to release real-time concentration data on PM<sub>2.5</sub> to the public. By October 2012, all 35 sites began releasing data to the public. In January 2013, Beijing became the first city nationwide to release real-time concentration data and the assessment results of all six pollutants through all of its monitoring stations.

In recent years, the city has built and continuously improved a three-dimensional monitoring network that shows the macro and micro-level physical and chemical characteristics of PM<sub>2.5</sub>. In addition to monitoring conventional pollutants, Beijing has also utilized various kinds of equipment, such as aerosol ion chromatography, OC/EC, particle-size spectrometer, flight mass spectrometer, VOCs, wind profiler and laser radar. The first remote-sensing platform in the country has also been built, which provides the capacity to monitor and track regional characteristics over a larger area in North China.

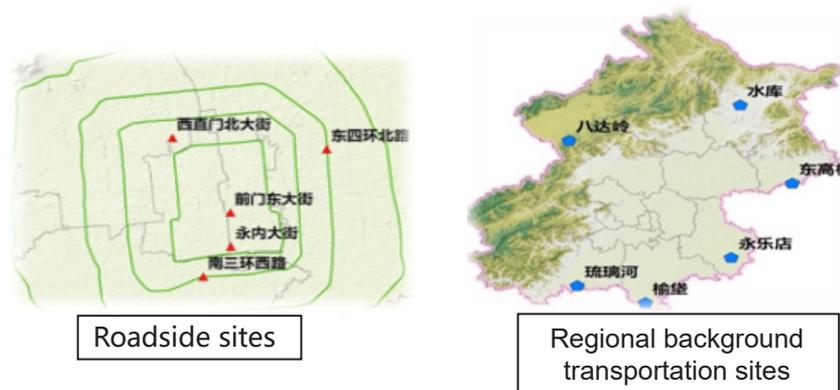


Fig. 47: Distribution of Roadside Sites and Regional Background Transportation Sites in Beijing

## Forecasting

Beijing began research on air-quality forecasting technologies in 1997 and was the first city in China to have established an environmental monitoring institution to forecast air quality. The existing forecasting system gradually came into being based on research and application. Important development milestones include:

- From 1999 to 2001, Beijing carried out air pollution forecasting research in urban and suburban areas, with operations driven by scientific research, and officially began to release API forecasts for three pollutants from 2001.

- From 2006 to 2008, Beijing established the first forecasting technology system in China, including dynamic statistical forecasting and integrated modeling forecasting, which played a critical role in the air-quality assurance project during the 2008 Olympic Games held in the city, hence creating important opportunities for the development of the city's air-quality forecasting operations. Building upon this foundation, Beijing further diversified its forecasting products to the provision of refined forecasting results by time and region, and the provision of trend forecasting products to relevant authorities.

- From 2012 to 2014, Beijing established a new-generation forecasting and alerting technology system based on AQI standards and three-dimensional monitoring, which provides crucial support for heavy-pollution emergency responses and major events organization, as well as guidance for day-to-day environmental management and healthy public

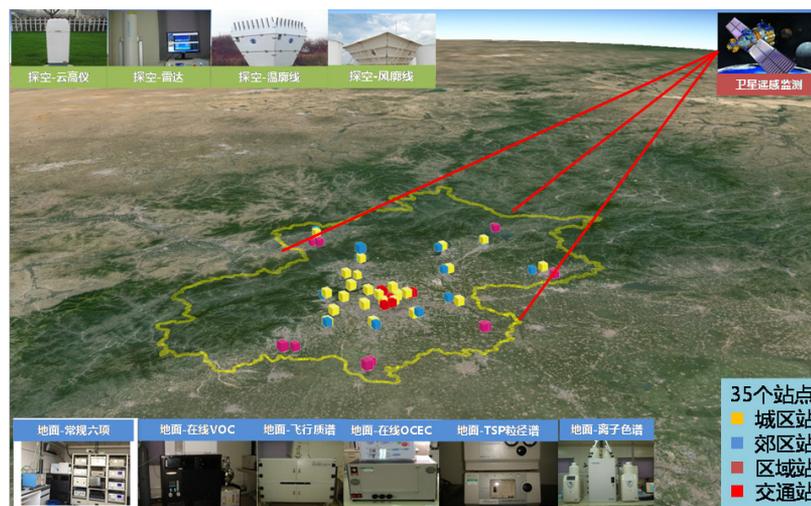
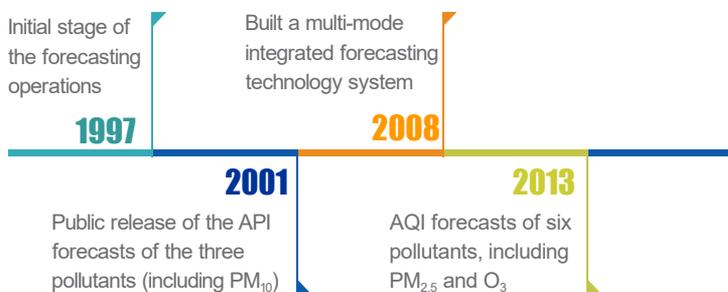


Fig. 48: Three-dimensional Monitoring Network of Beijing

travel. The city's air-quality forecasting system has served as a model for nationwide development. Moreover, it successfully supported air-quality assurance during the 2014 APEC Summit and the 70<sup>th</sup> anniversary of the victory of the Chinese People's War of Resistance against Japanese Aggression, achieving the "APEC blue" and "parade blue". From January 1, 2013, Beijing took the lead in officially releasing AQI forecasts (including PM<sub>2.5</sub>) in the country, achieving a seamless transition from API forecasts to AQI forecasts.

■ The city further expanded its forecasting operations around 2013. Based on early-stage cooperation and operations liaison, the Beijing Municipal Environmental Monitoring Center (BJMEMC), as the main venue for regional air-quality consultation in BTH, conducted the first regional video consultation on air-quality forecasting in collaboration with the China National Environmental Monitoring Center and sounding provinces during the 2014 APEC Summit meeting. A consultation was once again held during the International Association of Athletics Federations World Championships held in Beijing in 2015 and commemoration activities for the 70<sup>th</sup> anniversary of the victory of the Chinese People's War of Resistance against Japanese Aggression. Regional consultations provided clear-cut supporting information for the launching and strengthening of phased measures for air-quality assurance and ensured the achievement of air-quality targets during major events. Following countless drills, a complete set of mechanisms and processes for BTH regional consultations have been developed and which meet regional management requirements.



**Fig. 49: Development of Beijing's Air Quality Forecasting**

The integrated forecasting system was applied to air-quality assurance during the 2008 Olympic Games in Beijing and the 2014 APEC Summit and became a successful case study while also creating important opportunities for the development and progression of the city's air-quality forecasting operations.

## Reporting

Beijing provides environmental information services to society through multiple means and via a range of different channels, including real-time air quality and forecasting/alerting information, and works towards continuous improvement in the provision of such services.

Traditional means: Newspapers, television, mobile television on public transportation and radio, through which is provided detailed information on air-quality conditions and forecasting/alerting information for the public at different times of the day. The continued broadcasting of such information for more than a decade has resulted in a strong audience following.

New media channels: The city releases real-time data on the concentration of various pollutants, AQI indicators and forecasting/alerting information from the 35 monitoring stations throughout the city via official websites, as well as real-time data on the concentration of primary pollutants and air-quality forecasts by region through the Sina Weibo account "Beijing Environmental Monitoring".

Mobile-phone app and WeChat: In 2013, the city launched a mobile-phone app and created the WeChat account "Beijing Air Quality", which are compatible with both the Android and iOS systems. Users can hence access information about pollutants and air quality forecast/alerting on their mobile devices.



**Fig. 50: Multiple Means of Air Quality Reporting**

The BJMEMC has established media-reception positions to better communicate with the media (including new media) and to convey air-quality information to the public. In 2014, the Center established an official information-sharing mechanism by actively communicating with the Beijing Internet Information Office, mainstream network media and mobile-app release platforms. This provides data and customized information to the media and has widened the sphere of information releases.

# Practical Information

## Working Methods

### Operational Structure

Daily forecasting and alerting primarily consists of three parts: Forecasting, reporting and media releases. The main operations include pollution situation analyses, consultation, and determinations of the trends and results, as well as such relevant work as communication, interviews and reporting. During major events (such as the APEC Summit) and before/after episodes of heavy pollution, multi-layered examination, review, confirmation and decision-making are required to determine forecasting results.

### Technological System

Beijing's air-quality forecasting and alerting technology system consists of four modules: An environmental information and diagnostic analysis support system, a forecasting/alerting technology support system, an operation system, and a reporting and service system.

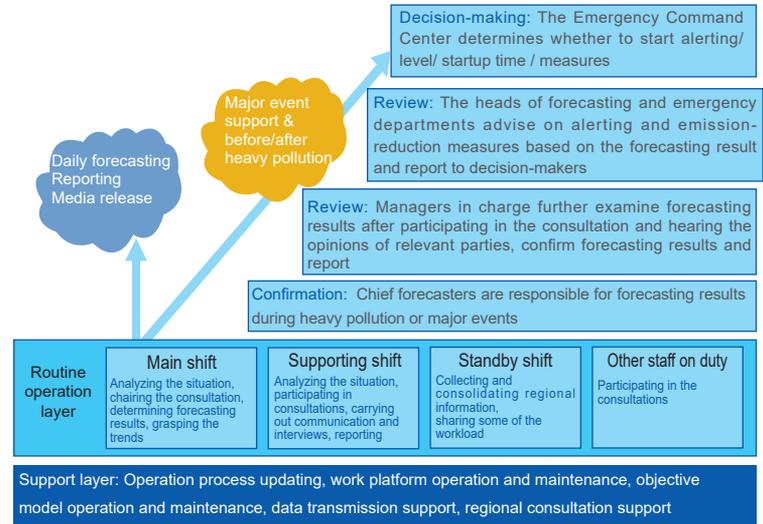


Fig. 51: Forecasting and Alerting Structure

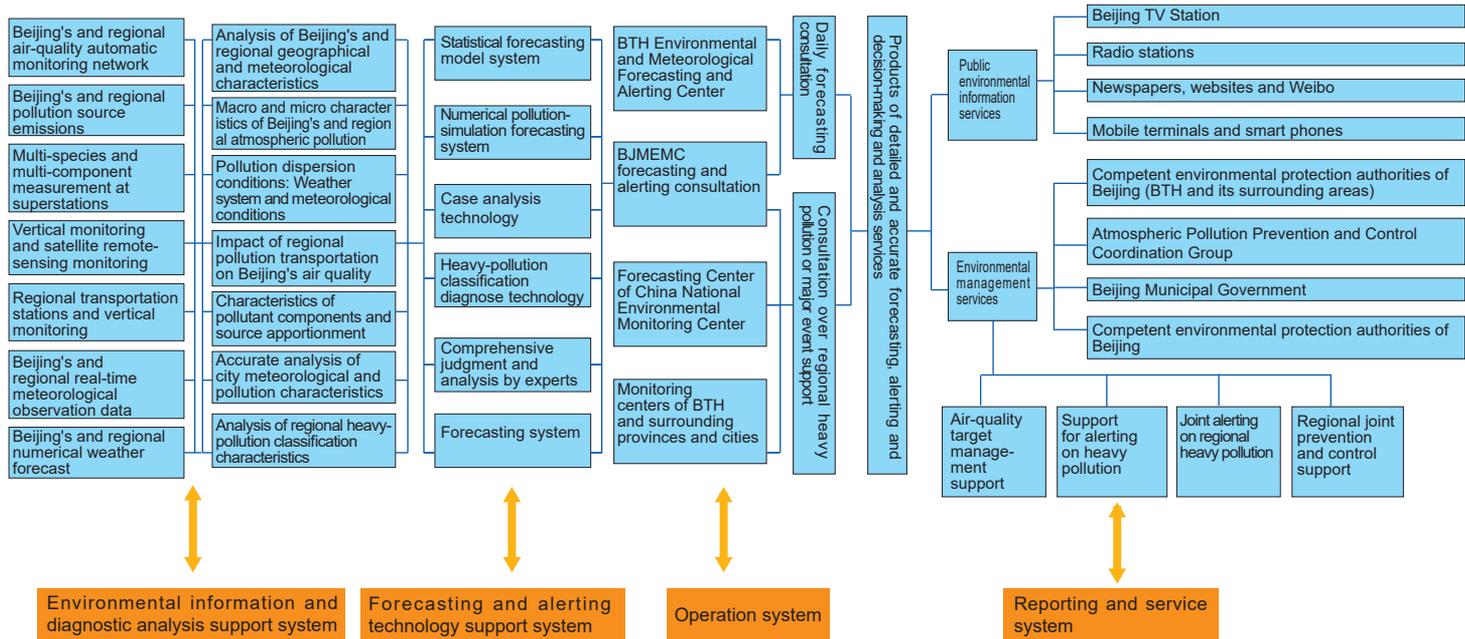


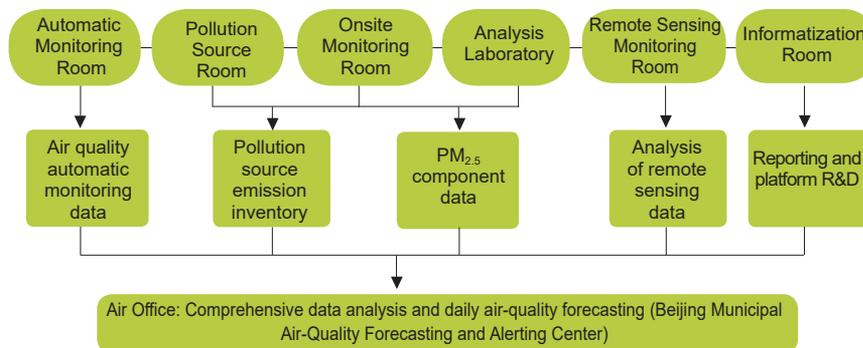
Fig. 52: Beijing's Air Pollution Forecasting and Alerting Technology System

## Team Composition

The Air Office of the Center is responsible for ambient air-quality monitoring and forecasting; its collaborators include the automatic monitoring, chemical analysis, pollution source, remote sensing and informatization sections. The Beijing Municipal Air-Quality Forecasting and Alerting Center was established in 2014, under which a 12-person air-quality forecasting team is responsible for analysis, daily reporting, forecasting and alerting. The team is comprised of three experts with more than 10 years' experience in analysis and forecasting, as well as other technical personnel specializing in the environment, meteorology, chemistry and computer science.

The precision of air-quality forecasting is largely reliant on experienced forecasters (at least five years of work experience is required) to make a diagnostic analysis and reach basic analytical conclusions for forecasting in accordance with the weather system, meteorological elements, pollution status, pollution sources and component information. They should also be able to analyze and clearly understand the evolution of weather conditions, the conditions surrounding meteorological elements, regional influence assessment, and air-quality development trends in order to determine forecasting levels.

In 2013, the BJMEMC established the first remote-sensing monitoring room of the environmental monitoring system in China, and has since worked tirelessly to develop remote-sensing monitoring, which is an important auxiliary monitoring mechanism from the perspective of management requirements and technological development trends.



**Fig. 53: Team Composition and Division of Duties**



## Expert Remarks

1. Professionals are most crucial: The statistical forecasting method requires relatively less information (primarily meteorological and monitoring data), and the process of establishing a statistical forecasting model can help forecasters better understand local conditions; however, it cannot be used to analyze more complex regional transportation effects and chemical component changes. The numerical forecasting model can make up for the shortcomings of the statistical forecasting method, but it has relatively high demands for hardware and data which make it difficult for small cities to use. The conclusions of any objective forecasting method can only serve as references; the key to the formation of final forecasting proposals remains in manual diagnosis and consultation by the forecasting team. A reliable forecasting team is hence of utmost importance. Beijing's superior advantage in air-quality forecasting is its forecasting team, which is comprised of experienced personnel who are unrivalled throughout the country.

2. Forecasting will be closely coordinated with city governance: The Beijing Municipal Government and the Municipal Environmental Protection Bureau have long attached great importance to air-quality forecasting and have created open channels to provide forecasting information for various major events throughout the city. The emphasis that senior officials place on forecasting may drive the needs of all sectors, encourage staff innovations in work methods and the achievement of new results, draw attention to forecasting from the perspective of city governance requirements and scientific theories and technologies in other areas, and help define the development direction of forecasting.

3. Comprehensive diagnosis and consultation are indispensable: Air-quality forecasting is derived from comprehensive expert diagnosis with a combination of technology and experience. In the event of complex pollution processes, consultation with meteorological departments, regional monitoring departments and the China National Environmental Monitoring Center is required. Merely relying on objective forecasts that are based on model results is a relatively high risk undertaking in alerting about heavy pollution, hence it is necessary for experienced forecasters, experts and officials to diagnose and amend forecasting results based on experience and case studies. Experienced forecasters have all grown from continuous analysis of local and regional pollution situations.

4. The trend is for customized forecasting services: The existing information products derived from air-quality monitoring and forecasting operations are diversified. With the explosion of information and in the "big data" era, it is all the more important to provide customized information to different service recipients, such as forecasting products that meet the different needs of the public, effective use of the various information-release channels, both traditional and new media, and refined forecasting results to satisfy city governance needs. This requires careful thinking and bold exploration on the part of staff involved in forecasting operations.

# Source Apportionment

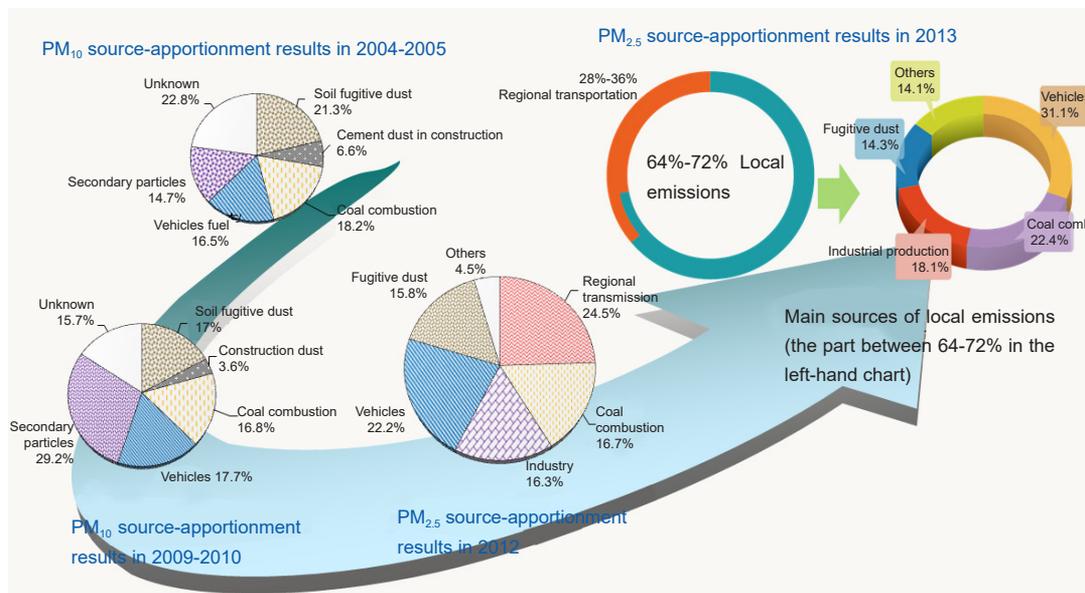
## History

Beijing began conducting particulate source apportionment in 2004, starting with the single-method source apportionment of coarse particles. After a decade of scientific research and exploration, the city developed a comprehensive source-apportionment concept that involved determining the law of atmospheric pollution, collecting accurate information on pollution-source emissions, and establishing quantitative associations between the two, and formulating source-apportionment technologies and methods ranging from sampling and analysis to modeling. This has met the city's pollution-source management requirements from the macro to the micro levels. The development of source apportionment has gone through the following stages:

- From 2004 to 2005: Carried out PM<sub>10</sub> source apportionment, collected more than 300 receptor samples and established six types of major PM<sub>10</sub> source profiles; the source-apportionment methods were the receptor model (CMB) and mathematical statistics (main factor analysis).
- From 2009 to 2010: Updated source profiles and applied the CMB model to update the PM<sub>10</sub> source-apportionment conclusion.
- In 2009: Cooperated with French research institutions in the sampling and component testing of fine particulate matter in the atmospheric environment,

and grasped the key monitoring technologies related to fine particulate sampling, testing and analysis methods, the use of instruments and quality control.

- From 2011 to 2012: Preliminarily established the main source profile of PM<sub>2.5</sub> and apportioned the sources of PM<sub>2.5</sub> using the CMB model and emission inventory, including the sources of secondary particles.
- From 2012 to 2013: Resolved a number of technical difficulties, including pollution-source sampling and component analysis, and put forth the concept of "comprehensive source apportionment". The technology patents, standards and methods derived from these drove technological progress within the sector. The PM<sub>2.5</sub> source apportionment covering all local industries strongly supported the city's formulation of the 2013-2017 Clean Air Action Plan. Relevant research projects took out first place in the 2015 Science and Technology Awards of Beijing.
- Since 2014: Improved its three-dimensional air-quality monitoring network, established a particulate chemical-components monitoring network and a dynamic update mechanism for the emission inventory, played a critical role in the air-quality assurance evaluation of major events (including the 2014 APEC Summit) and the annual assessment of atmospheric pollution prevention and control effects.



**Fig. 54: Development of Source Apportionment of Particulate Matter in Beijing**

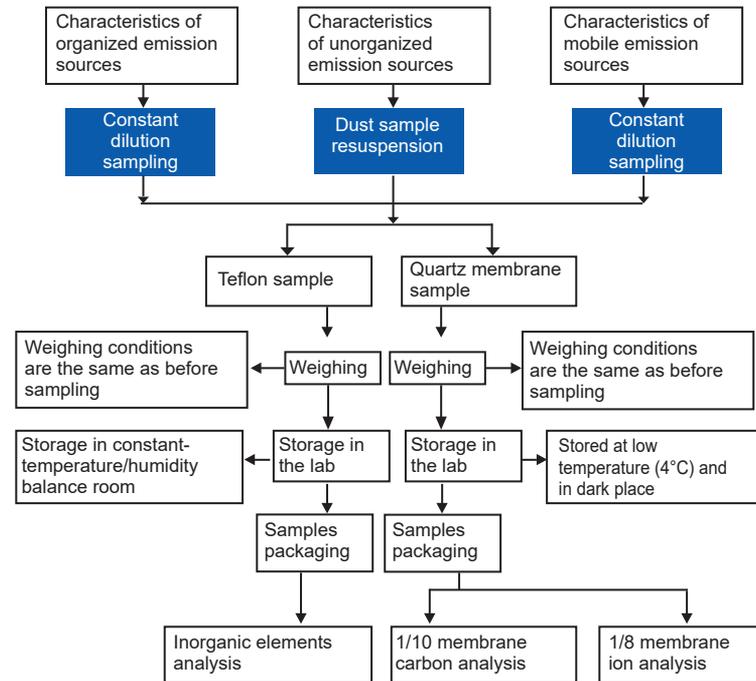
# Practical Information

## Working Methods

**1. Collect and analyze large numbers of particulate samples in ambient atmosphere and waste gases from pollution sources, study the changing patterns of atmospheric pollution in Beijing and establish particulate component spectral libraries for pollution sources.**

Collect environmental samples of PM<sub>2.5</sub> at nine environmental stations representing urban, suburban and traffic environments and border transportation. Collect samples for five to nine days each month, test and analyze 52 types of components and obtain more than 60,000 pieces of component data. See Table 1 for component analysis methods.

There are 10 types of emission sources, including stationary sources, mobile sources and fugitive dust sources, with 220 sets of samples collected and a localized PM<sub>2.5</sub> primary emission-source profile database established. See Figure 55 for source-emission sampling and processing methods. Break down and update social, economic, industrial, agricultural and other types of activity levels and emission inventories in terms of temporal and spatial resolutions.



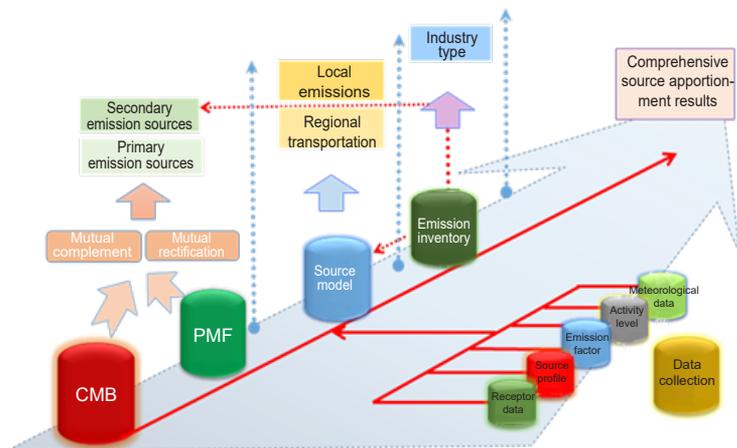
**Fig. 55: Technical Approach of Emission Source Sampling and Processing**

**Table 1: Lab-based Component Analysis Methods and Monitoring Items**

| Monitoring Item                                     | Analytical Method  | Instrument Used                               | Component   | Quality Control Rate |
|---|--|---|---|----------------------|
| OC-EC   | Photothermal method  | OC-EC analyzer, sunset Lag                    | OC-EC   | 60%                  |
| Water-soluble cationic                              | Ion chromatography   | IC Dionex-ICS-2000                            | NH <sub>4</sub> <sup>+</sup> , K <sup>+</sup> , Ca <sup>2+</sup> , Mg <sup>2+</sup> , Na <sup>+</sup> | 30%                  |
| Water-soluble anion                                 | Ion chromatography   | IC Dionex-ICS-3000                            | SO <sub>4</sub> <sup>2-</sup> , NO <sub>3</sub> <sup>-</sup> , Cl <sup>-</sup> , F <sup>-</sup>       | 30%                  |
| Water-soluble organic carbon<br>Polycyclic aromatic | Combustion oxidation - non-dispersive infrared absorption method | TOC-VCPH analyzer                             | WSOC  | 30%                  |
| Hydrocarbons<br>Arsenic                             | Meteorological chromatography mass spectrometry                  | Gas chromatography-mass spectrometer (GC-QQQ) | 24 types of PAHs  | 50%                  |
| Arsenic   | Atomic fluorescence spectrometry                                 | AFS-9130                                      | As  | 40%                  |
| Selenium  | Atomic fluorescence spectrometry                                 | AFS-9230                                      | Se  | 40%                  |
| Inorganic elements                                  | ICP emission spectrometry  | Intrepid II-XDL                               | 18 types of heavy metals  | 40%                  |

**2. Comprehensively apply receptor models, source models and source emission inventory to quantify the contribution of PM<sub>2.5</sub> sources.**

The technical approach of comprehensive source apportionment was put forth to overcome the limitations of the single-source apportionment modeling method, reduce the uncertainty of source-apportionment results and meet local pollution-source management requirements. The general thinking is: Use CMB and PMF - the two basic receptor models - to verify and complement each other, and obtain the contribution ratios of primary emission sources and secondary particles; use source models to identify the contributions of regional transportation and local emissions, evaluate the intensity of regional pollution-source emissions and calculate the contribution of regional transportation based on regional and local emission inventory data; and map PM<sub>2.5</sub> from secondary sources to primary emission sources based on local emission inventory data to obtain the main local PM<sub>2.5</sub> source types and their contributions.



**Fig. 56: Comprehensive Source-Apportionment Technical Approach**

**Team Composition**

1. Overall planning team, consisting of a project manager and five experts in the areas of model study, monitoring technology and analytical technology.
2. Ambient air PM sampling team, consisting of one technical expert as team leader and seven sampling personnel who have expertise in technology and a strong sense of responsibility, who sample particulate matter through a standardized quality-assurance process.
3. Pollution source PM sampling team, consisting of one expert as team leader and six key technical and sampling personnel who have expertise

in technology and a strong sense of responsibility, who sample particulate matter using innovative research methods and equipment.

4. Lab analysis team, consisting of one expert as team leader and eight analysts, who do substantial analysis and research, and innovate in analytical methods.
5. Data analysis, modeling and inventory team, consisting of one expert as team leader and several senior technical personnel responsible for CMB/PMF models, emission-inventory updates and application, numerical simulation, atmospheric-pollution analysis and research, and pollution-source emission analysis.

The overall planning team is responsible for top-level design and comprehensive report review, while the sampling team, analysis team and modeling and inventory team are responsible for applying their respective technologies to innovation, data quality and the development of sub-reports.



**Expert Remarks**

1. Comprehensive pollution source apportionment is a systematic project that needs continuous improvement, which requires us to skillfully master the changing patterns of atmospheric pollution, conduct accurate quantitative tracking of pollution-source emission levels based on a large number of samples and establish links between the two using the model system.
2. Strengthen the training of key versatile technical personnel specializing in the pollution source and environmental quality area. As source apportionment is a highly comprehensive task, only through the accumulation of experience and field practices can we cultivate all-round talents that have not only a good understanding of the requirements of pollution-source management, but also in-depth knowledge about atmospheric pollution. "All-rounders" are needed for the improvement and development of comprehensive source-apportionment technologies and methods.
3. Enhance technical exchanges and collaboration with scientific research institutions. Universities and scientific research institutes have greater advantages in model improvement and innovation, while environmental protection authorities have technical strength in the monitoring of the atmospheric environment and pollution sources. It is therefore necessary for both sides to strengthen technical cooperation, benefit from each other's advantages, and continuously introduce new technologies for refined PM source apportionment.
4. Continuously carry out source-apportionment research. As atmospheric pollution control progresses, the composition and emission characteristics of pollution sources will change accordingly. It is therefore necessary to continuously update the pollution-source emission inventory, source profiles and PM<sub>2.5</sub> chemical composition so as to ensure correspondence between environmental quality and source emissions, and detail and update the comprehensive PM source-apportionment conclusions.

# Summary of Shanghai's Experience



# Ambient Air Quality Monitoring, Forecasting and Reporting

## History

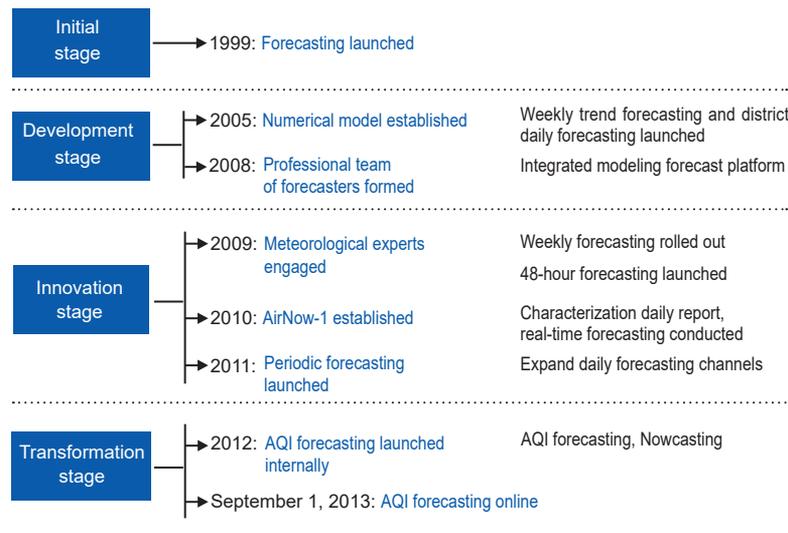
### Monitoring

Shanghai began ambient air-quality monitoring in the 1980s and enjoyed rapid progress thanks to the AirNow project in collaboration with the United States and the Expo 2010 organization. During this period, the air-quality data rapid-review system, air-quality forecasting system and reporting system were developed. The city currently has established 53 ambient air-quality automatic monitoring stations, including 10 State-controlled monitoring stations, covering all districts and counties in Shanghai Municipality and providing monitoring data for PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>2</sub>, PM<sub>10</sub>, CO and O<sub>3</sub>.

Shanghai began to release PM<sub>2.5</sub> data from June 2012. All 53 monitoring sites across the city have been able to monitor PM<sub>2.5</sub> and released real-time data to the public after June 2014. At present, Shanghai has built two combined air pollution monitoring super-stations that not only monitor regular factors, but also VOCs, NMHC, aerosol on-line ion chromatography, OC/EC, heavy metals, mercury, BC, aerosol scattering coefficient, particle size, visibility, laser radar, and wind profile radar. In addition, the city has also built a roadside air-monitoring network and construction-site dust-monitoring network to monitor roadside air-quality and dust emissions from construction sites.



**Fig. 57: Map of Air Quality Automatic Monitoring Stations in Shanghai**



**Fig. 58: Development of Air Quality Forecasting in Shanghai**

### Forecasting

To improve the precision of forecasting and provide more accurate information to the public in a timely manner, Shanghai has adopted a range of innovative approaches, including periodic forecasting, regional consultation, tool assistance, and a forecast accuracy-assessment system.

- **Periodic forecasting:** Forecasting is divided into three time segments to enable the public to receive more accurate information in a timely manner. Errors in pollution levels are corrected through rolling forecasting and prompt updating.
- **Regional consultation:** Shanghai initiated forecasting consultation via telephone in YRD as early as during the World Expo in 2010. Cross-region visualized consultation for air-quality forecasting was promoted between 2014 and 2015.
- As well as using forecasting models, Shanghai is also actively utilizing remote-sensing tools for forecasting.

■ Shanghai initiated a forecast precision scoring system in collaboration with meteorological institutions to assess such factors as the pollution level and primary pollutants, thus allowing forecasters to achieve targeted improvements.

To advance and further standardize air-quality forecasting, make it more scientific and provide a technical basis for emergency early warnings of unhealthy air quality, Shanghai has formulated Technical Specifications for Air-Quality Forecasting in Shanghai based on related national standards and specifications and local demands.

## Reporting

Shanghai places great emphasis on converting monitoring and forecasting results into environmental information services for the public, and is constantly improving air-quality reporting and striving to achieve the following:

- In principle, making air-quality information easily accessible, understandable and usable.
- Content: Providing real-time air-quality reports and forecasts, supplemented with pollution reminders, alerts and nowcastings.
- Channels: Primarily using four major channels - websites, mobile applications, Weibo and mobile television - to maximize the advantage of real-time reporting.

To help the public understand the reports, the “Air Baby” cartoon image was created in Shanghai. The Air Baby changes in its facial expression and color to indicate the level of air quality. This innovative approach has been widely recognized by Shanghai citizens and has helped environmental awareness take root in the public mindset.



Fig. 59: PM<sub>2.5</sub> Monitoring Equipment at State-Controlled Monitoring Sites

## Practical information

### Equipment

Shanghai's monitoring capacity has gradually expanded from mass-concentration monitoring to involve multiple facets such as chemical composition, environmental impacts and the regional transportation of air pollutants. A wide range of sophisticated instruments is also in place, such as atmospheric aerosol (PM<sub>2.5</sub>) chemical composition on-line ion chromatography, organic carbon on-line analyzers, absorption and scattering coefficient/ particle size spectrometer, VOCs on-line analyzers and particle size spectrometer. To strengthen regional transmission monitoring, equipment such as laser and wind-profile radars are being used to monitor the transportation of such pollutants as dust and regional particles.



## Working Methods

At the end of 2011, Shanghai begun conducting PM<sub>2.5</sub> automatic monitoring and manual sampling analysis comparison, and participated in centralized applicability comparison tests for PM<sub>2.5</sub> monitoring methods organized by the China National Environmental Monitoring Center. These moves resulted in positive contributions to the selection of PM<sub>2.5</sub> monitoring equipment for Shanghai and the State Monitoring Network.

**Table 2: Analysis Method, Monitoring Cycle and Frequency of Ambient Air Quality Automatic Monitoring Items**

| Monitoring item          | Monitoring and analysis method           | Brand & model  | Basic data frequency | Monitoring cycle      |
|--------------------------|--|--|----------------------|-----------------------|
| SO <sub>2</sub>          | Ultraviolet fluorescence spectrometry    | TE, API  | Hourly data          | Year round (24 hours) |
| NO <sub>2</sub>          | Chemiluminescence method                 | TE, API  | Hourly data          | Year round (24 hours) |
| CO                       | Gas filter correlation method            | TE, API  | Hourly data          | Year round (24 hours) |
| O <sub>3</sub>           | Ultraviolet spectrophotometry            | TE, API  | Hourly data          | Year round (24 hours) |
| PM <sub>10</sub>         | TEOM                                     | TE1405   | Hourly data          | Year round (24 hours) |
| PM <sub>2.5</sub>        | TEOM with compensation                   | TE1405F  | Hourly data          | Year round (24 hours) |
| VOCs                     | GC-FID                                   | Synspec GC955  | Hourly data          | Year round (24 hours) |
| NMHC                     | GC-FID                                   | Chromatotec airmoVOC   | Hourly data          | Year round (24 hours) |
| Water soluble ions       | On-line ion chromatography               | Synspec 115  | Hourly data          | Year round (24 hours) |
| OC/EC                    | Thermophotometry                         | MARGA  | Hourly data          | Year round (24 hours) |
| BC                       | Optical absorption method                | Sunset   | Hourly data          | Year round (24 hours) |
| Scattering coefficient   | Light-scattering method                  | Magee AE31   | Hourly data          | Year round (24 hours) |
| Mercury                  | Cold atomic fluorescence spectrometry    | Ecotech3000  | Hourly data          | Year round (24 hours) |
| Heavy metal              | X-ray fluorescence spectrometry          | TEKRA  | Hourly data          | Year round (24 hours) |
| Particle size            | Light-scattering/electromigration method | Cooper Xact625   | Data per minute      | Year round (24 hours) |
| Visibility               | Forward scattering method                | TSI APS/SMPS   | Hourly data          | Year round (24 hours) |
| Laser radar              | Mie scattering method                    | Vaisala PWD22<br>Anhui Institute of Optics and Fine Mechanics, Chinese Academy of Sciences | 6-minute data        | Year round (24 hours) |
| Wind-profile radar       | Electromagnetic (Doppler) method         | 23rd Institute of CASIC  | 5-minute data        | Year round (24 hours) |
| Meteorological parameter | Ultrasonic method                        | Vaisala  | Hourly data          | Year round (24 hours) |

## Team Composition and Fiscal Input

In addition to the Ambient Air Monitoring Office, Shanghai has also established a dedicated Information Technology Department which is focused on developing information-system platforms for data review, reporting and forecasting, and which is engaged in air-quality data review, daily reporting and forecasting. The Ambient Air-Monitoring Office of the Shanghai Environment Monitoring Center has 26 staff members, including six technicians working with one technician from the Information Department and involving core operations.

The Information Department has three staff members responsible for reporting operations. Like most cities, the environment-monitoring team in Shanghai is understaffed. The size of the workforce needs to be at least doubled to meet current operational needs. To further promote the standardized development of ambient air automatic monitoring and to upgrade the operational level of ambient air monitoring and forecasting, Shanghai took the lead in outsourcing the operations and maintenance of automatic air-monitoring stations to third parties. In so doing, the work mechanism has been optimized and the team from the Ambient Air Monitoring Office has been able to focus on data analysis and public services and enhancing technical support for environmental management.

According to the advice from the Center's experts, for smaller cities there should be a team with at least 12 members in place for ambient air quality monitoring, of which three to four members are involved in monitoring and data release, three to four are forecasters, and three to four are involved in comprehensive analysis. The expertise required for key forecasting positions includes: Numerical modeling, meteorology, atmospheric chemistry, remote sensing, data analysis, information technology, and speaking at press conferences.

Fiscal input was divided into two phases: Construction and operation. Shanghai had a long development process and fiscal input was relatively scattered. But in general, significant results were produced with a modest investment. For example, 2-3 million RMB was invested in information and 1.2-1.5 RMB million for a single monitoring station. Funds for software development were sourced from research-project funds in the early R&D stages and those for informatization during the late stages.



## Expert Remarks

1. Professional team-building: With new environmental problems emerging along with rising public demands for environmental monitoring, high requirements have been proposed for the transformation of environmental monitoring. Given the current situation, environmental monitoring needs to serve both the public and government authorities. The core resources for the construction of ambient air monitoring and alerting systems include reliable technical professionals; rationally staffed ambient air-monitoring teams; multi-talented professionals who are proficient in instrument use, data analysis, technology and management and who are knowledgeable about the environment and pollution sources; and air-quality forecasters with a solid background in ambient air science. Software and hardware construction is not difficult; the greatest challenge lies in cultivating experienced forecasters. It normally takes at least two years to train a qualified forecaster and five years for that person to become familiar with forecasting operations and pollution feature analysis.

2. Data quality assurance: A standard data-quality assurance and control system is the basis for providing accurate air-quality forecasting and reporting. In developing a monitoring team, a data-quality assurance procedure should be implemented in accordance with national standards and technical monitoring specifications, and, where possible, a more stringent inspection and approval process should be designed.

3. Support decision-making: Ambient air-quality monitoring is aimed at conducting regular monitoring and providing air-quality monitoring information to satisfy the public's need for information. It also provides scientific and technological support for the government in decision-making and policy effect evaluation by conducting comprehensive analyses based on regular monitoring results and indicators.

4. Tiered responsibility and inter-departmental collaboration: Ideally, the National Government should formulate a sound top-level design to ensure a clear division of responsibility among national, regional, provincial and municipal monitoring systems in establishing an information-sharing and technical-standardization mechanism. For ordinary cities, the construction of monitoring systems should be tailored to suit their local resources. It is important for the environment-monitoring system to have a good collaboration mechanism with the meteorological department and to train its own team, particularly highly professional forecasters.

# Source Apportionment

## History

Shanghai began to develop an emission inventory in 2003 to provide important support for source apportionment. The city launched a pilot haze-monitoring project for  $PM_{2.5}$  source apportionment in 2009 and released source apportionment research findings in 2011 and 2012.

Shanghai released the latest source apportionment research findings, according to MEP requirements, in January 2015. Source apportionment has since become a regular component of the work of the Shanghai Environment Monitoring Centre, which has established six monitoring stations for source apportionment sampling. During the current development stage, key breakthroughs need to be achieved in terms of  $PM_{2.5}$  real-time dynamic source apportionment and VOCs source apportionment.

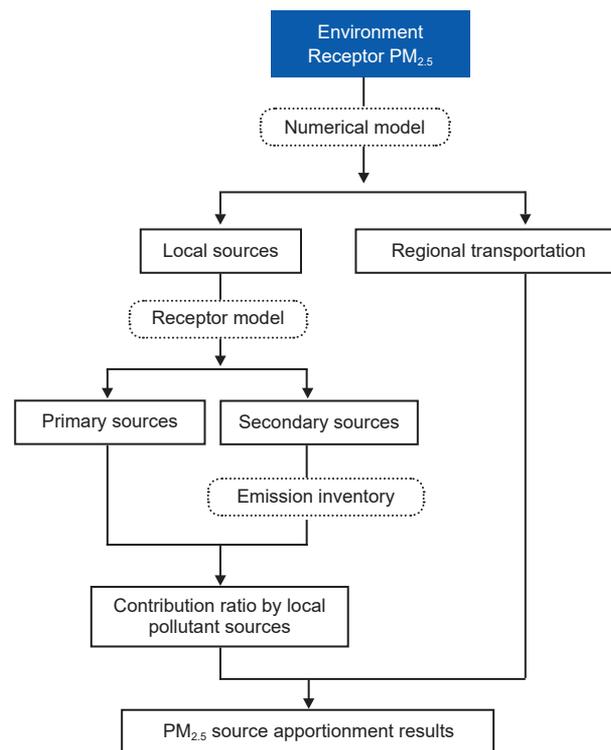
## Practical Information

### Equipment and Model Application

- To obtain more reliable source apportionment findings, Shanghai has procured various kinds of sampling equipment and applied multiple models to complete sampling and simulation.
- In terms of sampling equipment, small-flow (single-channel, four-channel, eight-channel), medium-flow (Leckel, Qingdao Laoying, Wuhan Tianhong) and large-flow (Tisch) equipment are all in place.
- The application of modeling tools is constantly expanded and improved, forming a technical system featuring combined use of multiple models.
- 2005: The air-quality numerical model system was established, which incorporated the NAQPMS (Nested Air-Quality Prediction Modeling System) independently developed by the Institute of Atmospheric Physics, Chinese Academy of Sciences.
- 2008: EMS was established, which fully upgraded NAQPMS and integrated Models-3/CMAQ, CAMx and WRF-Chem.
- 2009: The aforementioned models were used on a trial basis for particle source apportionment, based on the high-resolution Shanghai Ambient Air-Pollutant Emission Inventory.
- 2012: Numerical models, receptor models and the emission inventory were used to carry out particle source apportionment in Shanghai.

Multiple source apportionment methods were jointly used, following the principles of mutual complement and proof:

- **Mutual complement principle.** The advantages of three apportionment methods were used to complement the results. The numerical model was used for the quantitative estimation of  $PM_{2.5}$  in Shanghai and the proportion contributed by regional transportation; the receptor model was used to apportion the contribution ratio of primary particles by local pollutant-emission sectors in Shanghai; the emission inventory was used to further differentiate the contribution ratios of secondary particles by different sectors.
- **Mutual proof principle.** The overlapping part, if any, of the results obtained by the three apportionment methods should be consistent in principle. The deviations in quantitative contribution ratio should be within an acceptable range.



**Fig. 60: Combined Use of Multiple Methods for  $PM_{2.5}$  Source Apportionment**

## Working Methods

The collection and analysis of atmospheric receptor samples are the key technical aspects of apportioning pollution sources. Major points include the selection of sampling points, the selection of equipment and materials, the sampling period and the storage and analysis of samples.

- **Sampling sites:** The sampling points should support long-term and stable sampling activities. They also need to be protected from regional pollution sources, represent current meteorological conditions, and be safe and convenient for sample collection.
- **Equipment selection:** Select equipment of the same model; the stability and performance of the equipment should also be considered. Proper inspection of all equipment and equipment/channel comparison prior to sampling is required.
- **Membrane selection:** Different types of membranes need to be selected to meet varied chemical analysis needs. Additionally, a blank background value of the membrane should be as low as possible.
- **Sampling period:** According to the GB3095-2012 standard, each sampling point should have 60 valid samples per year and five to six samples taken each month.
- **Sample code:** Sample IDs should be manifested in a unified format. "City name + project name + sampling site name + membrane type" should be specified.
- **Sample storage:** Samples for inorganic elemental analyses should be dried and stored at room temperature; other samples should be stored at low temperature and avoid exposure to light.
- **Experimental conditions:** Proper temperature and humidity.
- **Quality control and quality assurance:** Blank test, parallel comparison, adequate sample volume, and pre-treatment.
- **Chemical analysis projects:** Water-soluble ions, OC/EC, elements, POA, SOA, carbon isotopes.
- **Analysis of key tracers:**  $K^+$  and levoglucosan are key tracers in biomass combustion, while  $Ca^{2+}$  and Al are good indicators of sand and dust. The aforementioned elements should be analyzed if possible.

## Team Composition and Fiscal Input

Five people are currently involved in source apportionment and related tasks in Shanghai. In terms of team allotment, one to two experts are needed to work with a few key professionals (including sampling and monitoring staff, quality controllers and analyzers) to form a hierarchical working structure. Further, laboratories with long-term collaboration can help to analyze the chemical compounds of the samples. For instance, ion chromatography is conducted at Pudong Monitoring Station in Shanghai while the South China Institute of Environmental Sciences is responsible for OC/EC analysis; Fudan University completes element analysis, Shanghai

University manages POA analysis, and the Institute of Applied Physics, Chinese Academy of Sciences, is responsible for isotopes of carbon.

In terms of fiscal input, the Shanghai source apportionment program has received financial support from various projects, including 3 million RMB from Haze Phase I and 3.5 million RMB from Haze Phase III. According to preliminary estimates, a single source apportionment project would cost about 2 million RMB, and the equipment investment for a single monitoring station is estimated at 300,000 RMB with the annual maintenance cost being 200,000-300,000 RMB.

## Expert Remarks

1. **Staffing:** In addition to being proficient in model application, staff should be professionals with extensive experience in, and familiarity with, local pollution sources and policies. Coordination among monitoring stations, research departments and management departments is needed to jointly participate, analyze and review the results of source apportionment and then apply the results to the local decision-making processes and policy performance assessments.
2. **Quality control and quality assurance:** Confirm the operation and maintenance schedule and establish standard operating procedures and third-party verification mechanisms; arrange for inspectors and supervisors to examine the original records and condition of equipment regarding possible maintenance.
3. **Offline sampling:** Online source apportionment can support immediate qualitative analysis on heavily polluted days. However, precise quantitative analysis still demands the analysis of manual offline sampling.
4. **Local source spectrum:** Because the source spectrum has strong local peculiarity, a local pollution source spectra pool is therefore needed. Both the sampling and the analytical method will affect the results; therefore the sampling and analytical procedure of source spectra should be standardized. Furthermore, comparison between different methods and between different source spectra can be made to provide technical support for the regulation of source spectra testing.
5. **Decision-making support:** Source apportionment will eventually be applied to policy-making and the assignment of emission-reduction tasks. In recent years, policy-making and effectiveness analysis in Shanghai have been developed and conducted based on source apportionment and emission inventory. For example, the results from traffic monitoring stations in 2014 showed that the phasing out of yellow-label vehicles was the main reason for the rapid decrease in black carbon and nitrogen oxides concentrations.

## Emission Inventory Development

### History

Since the first edition of the Shanghai Air-Pollutant Emission Inventory was developed in 2003, it has undergone four systematic updates in 2006, 2007, 2010 and 2012. In addition to regular updates, the 2012 Emission Inventory featured the addition of non-road mobile machinery emission estimates. Currently, the 2014 Emission Inventory is under development, which, on

the basis of regular compilation, features greater professionalism and more details and covers more emission factors ( $\text{SO}_2$ ,  $\text{NO}_x$ , CO, VOCs,  $\text{NH}_3$ ,  $\text{PM}_{10}$ ,  $\text{PM}_{2.5}$ , BC and OC) and sources (stationary pollution sources, industrial sources, road mobile sources, non-road mobile sources, open dust sources, solvent-use sources, waste-disposal sources, oil and gas storage and transport sources and other surface sources).

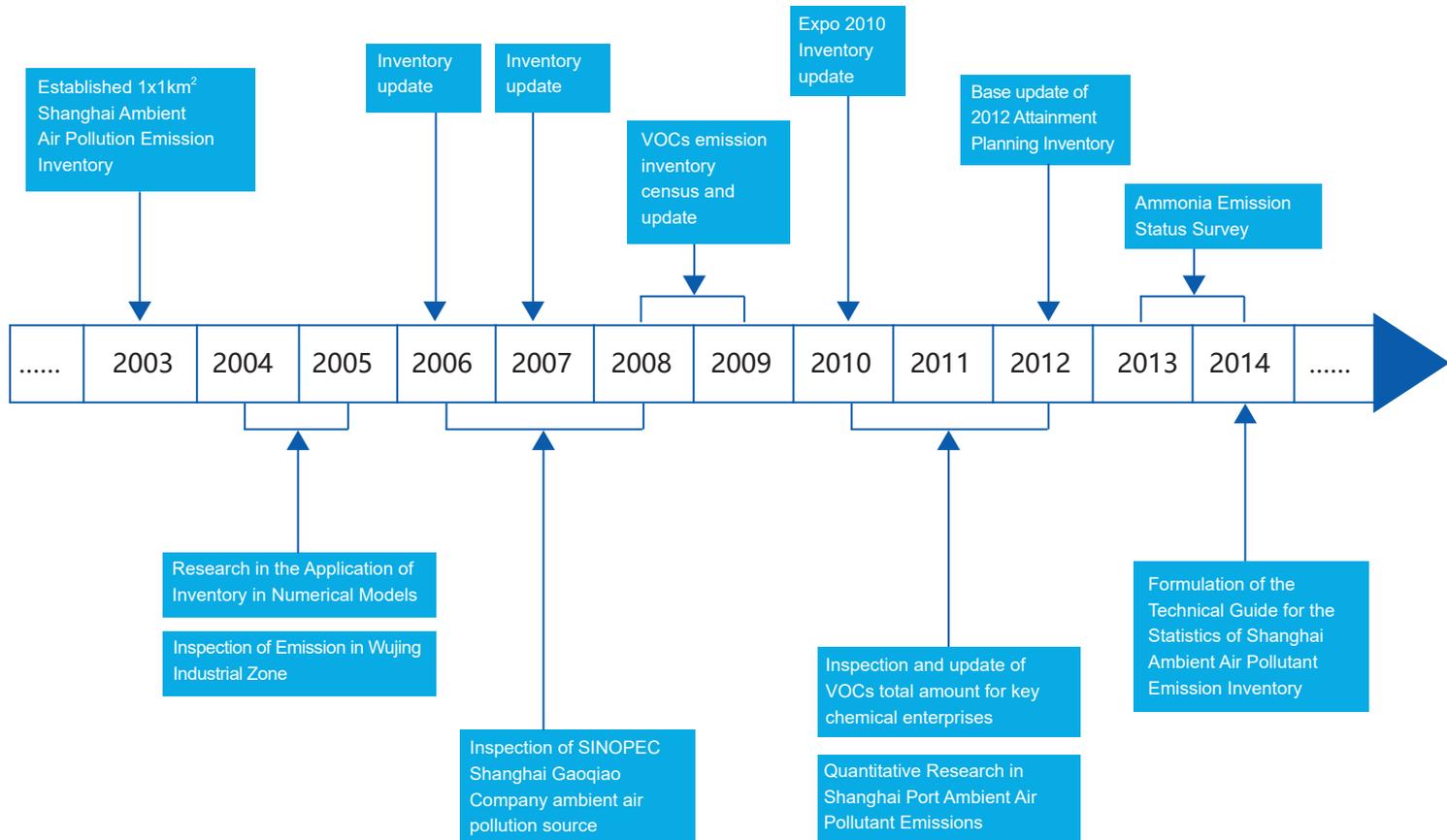


Fig. 61: History of Shanghai Ambient Air Pollution Source Inventory

## Practical Information

### Working Methods

Shanghai developed its air pollutant emission inventory based on field surveys and the inspection of major pollution sources, and established local pollutant emission factors in association with specific industries and general equipment, with reference made to the emission factors provided in the Manual for Industrial Pollutants Generation and Emission Factors and the standards and methods for inventory statistics adopted in Europe, the US and other developed countries (such as the US EPA's Air Chief, NEI and NIF, the EU's CORINAIR, and the UK's NAEI 1996).

The methods that Shanghai has applied to develop its air pollutant emission inventory include field surveys, fuel component analyses, energy or mass balances, emission models, project evaluations and empirical estimations. To promote and standardize the development of the emission inventory, the city has also prepared the Technical Guide for the Statistics and Update of Shanghai's Air Pollutant Emission Inventory.

### Team Composition

The development of the city air-pollution emission inventory involved many departments and required a significant amount of human resources and fiscal input. Environmental protection authorities should provide data on environmental impact assessments, pollutants discharge licenses and total emissions, while the Municipal Transport Commission, Housing and Urban and Rural Construction Commission, and Agricultural Commission should provide basic information on emission sources, including motor vehicles, ships, construction sites and livestock and poultry farming.

Industry associations need to provide basic emission source data on construction machinery and coating materials, while scientific research institutions should cooperate in providing data on specific emission sources such as vegetation.

The Shanghai Environment Monitoring Center (SEMC) and the Shanghai Academy of Environmental Sciences (SAES) split the responsibilities in their cooperation.

The SEMC departments in charge of atmosphere, motor vehicles, pollution sources, statistics, information and biology are jointly involved in developing the emission inventories of stationary pollution sources, sources of technological processes, road mobile sources, part of the non-road mobile sources, open dust sources, solvent use sources, waste disposal sources and oil and gas storage, and transport sources, while the research institutes of the SAES in charge of atmospheric environment, ecology and engineering are primarily responsible for developing the emission inventories of non-road mobile sources, biomass combustion sources, fumes from catering, hospitals, dry cleaning solvents and agricultural emission sources.



### Expert Remarks

1. Establish a regular update mechanism for basic emission-inventory data used by relevant commissions, offices and bureaus: Strengthen communication with relevant departments of the commissions, offices and bureaus, fix formats for the provision of basic data, and establish a collaborative and information-sharing mechanism among different departments.
2. Establish a basic data-update mechanism for polluting enterprises at both the municipal and district levels: Municipal bureaus are responsible for regularly updating data about municipality-controlled enterprises, while districts/counties perform the same for the district-controlled enterprises.
3. Establish a regular update mechanism for the emission-inventory database: Emission inventories used to serve management have to be time-based and effective so it is necessary to regularly update the emission-inventory database, improve data import/export functions, strengthen the analysis of visual effects, establish and improve an emission-factors library based on local conditions, and promote the analysis of emission inventories and ambient air-quality forecasting.
4. Accelerate the standardization of emission inventory-related work: Assign fixed personnel to such work, establish standardized workflow procedures and boost work efficiency.

## There Is Still a Long Way to Go before the Attainment of Air Quality Standards

### 1. Evident results have been achieved in air quality improvement, but "attainment" tasks are still arduous

With the implementation of the Action Plan, initial improvement in air quality across the cities is evident. Between 2013 and 2014, the average concentrations of the five pollutants except for O<sub>3</sub> all decreased, while the number of attainment cities rose. The three key regions (BTH, YRD and PRD) showed the most significant improvement. Take BTH for example, where the average concentration of PM<sub>2.5</sub> in the region dropped to 93 µg/m<sup>3</sup> or by 12.3%.

But of the 74 cities monitored under the Revised Standards in 2014, about 90% (or 66 cities) failed to attain relevant air quality standards to varying degrees, and PM pollution remains the primary pollution problem. The annual average non-attainment concentration range for PM<sub>2.5</sub> was 37-30 µg/m<sup>3</sup> (the National Secondary Standard is 35 µg/m<sup>3</sup>), and the percentage of non-attainment cities was 87.8%. The annual average non-attainment concentration range for PM<sub>10</sub> was 71-233 µg/m<sup>3</sup> (the National Secondary Standard is 70 µg/m<sup>3</sup>), and the percentage of non-attainment cities was 78.4%.

In terms of AQI, BTH and its surrounding areas are the hardest-hit by air pollution. In 2014, the 10 cities with the least attainment days were almost all found in BTH and its surrounding areas, with eight in Hebei Province. The situation of some cities in the Northeast, Central and Southwest China was also serious. The annual mean concentrations of PM<sub>2.5</sub> in Harbin, Shenyang, Xi'an, Wuhan and Chengdu were all two times above the National Secondary Standard. It will be an arduous task for these cities to meet the requirements of the Revised Standards, so much remains to be done.

### 2. Overall O<sub>3</sub> concentration rose slightly and non-attainment days with O<sub>3</sub> as the primary pollutant increased

Of the 74 cities, judging by the average concentrations of the six pollutants and the ratio of attainment cities by year, the concentration of O<sub>3</sub> rose, with the number of attainment cities falling, which contrasted starkly with the other five pollutants: The maximum eight-hour average concentration of O<sub>3</sub> was 145 µg/m<sup>3</sup>, up by 4.3% year on year.

The percentage of attainment cities was 67.6%, down by 9.4 percentage points year on year. The overall air quality of the PRD region was relatively

good, so it is most likely to be the first region to reach the Revised Standard, but O<sub>3</sub> pollution has become a chief concern of this region.

According to the environmental conditions report of Guangdong Province, the non-attainment days of the region with O<sub>3</sub> as the primary pollutant exceeded one-third of the year. The province also emphasizes addressing the O<sub>3</sub> pollution issue in its pollution prevention and control action plan. The issue of O<sub>3</sub> non-attainment and the control and emissions reduction of NO<sub>x</sub> and VOCs, the precursory pollutants of O<sub>3</sub>, will draw greater attention from more cities.

## Strategic Transformation of Air Pollution Prevention and Control Policies

### 1. Air pollution prevention and control targets have seen "quantity-to-quality" changes

China's air pollution prevention and control targets have realized material shifts from control over pollutant emissions to air quality improvement. The Action Plan has explicitly set forth the target of air quality improvement by region for the first time, requiring that by 2017 nationwide air quality be "improved generally", the concentration of PM<sub>10</sub> in cities above the prefecture level decrease by more than 10% compared with 2012, and attainment days increase year by year; the concentration of PM<sub>2.5</sub> in BTH, YRD and PRD are to drop by 25%, 20% and 15% respectively.

The 74 cities referred to in this report have all set air quality improvement targets in their air-pollution prevention and control action plans, including the concentration reduction ratios of target years relative to benchmark years, or target values of pollutant concentrations. Between 2013 and 2014, the key regions basically fulfilled their preset assessment targets for pollutant concentration reduction. However, it should be noted that a gap still exists between the current control targets and the concentration limits stated in the National Secondary Standard. The National Government and governments at provincial and municipal levels therefore still need to formulate mid and long-term measures and strategies for attaining air quality standards to ensure that air pollution prevention and control targets will be achieved.

### 2. Lifting the restrictions of administrative divisions and establishing a preliminary collaboration mechanism for BTH and YRD

The Action Plan emphasizes regional collaboration in promoting air pollution control. BTH and YRD, which consist of multiple provinces, municipalities directly under the National Government and autonomous

regions, have established regional coordination mechanisms. In 2013, the Air Pollution Prevention and Control Coordination Mechanism for BTH and its surrounding areas was established, which demanded setting up administrative agencies, establishing meeting mechanisms, announcing and implementing regional policies and measures, developing an information exchange and sharing mechanism, building a regional pollution alerting and emergency response platform, conducting environmental impact assessments and public consultations, organizing joint law enforcement operations and special coordination actions, and establishing expert committees.

In 2014, the Air Pollution Prevention and Control Coordination Mechanism for YRD was officially launched, with five working mechanisms established, which are based on the principles of conference consultation, division of work, information-sharing and joint action, scientific and technological cooperation and follow-up assessment. This is the first time local governments have broken administrative barriers and set up lasting and regular cooperative mechanisms.

### 3. Coordinated control of multi-pollutants

The Action Plan, regional implementation rules and municipal action plans indicate that the three core measures of emission reduction should include controlling coal consumption, eliminating yellow-label vehicles and upgrading fuel quality. The Action Plan establishes mid and long-term targets to control national total coal consumption - coal should account for less than 65% of total energy consumption in 2017. Regions such as BTH, YRD and PRD should strive to achieve negative growth in total coal consumption. In 2014, total coal consumption in China fell by 2.9% compared with the 2013 level, a decrease for the first time in the past 15 years.

Meanwhile, measures such as designating restricted areas and granting financial compensation have also accelerated the elimination of yellow-label and outdated vehicles. From January to November 2014, China eliminated 6,113,400 yellow-label and outdated vehicles, exceeding the annual target of phasing out 6 million such vehicles in 11 months. The Action Plan has also defined the roadmap and timeline for upgrading fuel quality. In 2014, China IV gasoline and diesel were introduced nationwide according to the established timeline, while Beijing, Tianjin, Shanghai, Jiangsu Province, Guangdong Province and Shaanxi Province began to use China V gasoline and diesel in advance of the nationwide timeline - a national effort to solve the long-term problem of vehicle/fuel mismatch.

In 2014, China took new measures to address VOCs in the petrochemical, organic chemical, surface coating, package printing and other industries, while cities focused their efforts on vapor recovery in gas stations, oil storage caverns and oil tank trucks, and LDAR pilot projects in the petrochemical industry. Meanwhile, the National Government also required the pollution control of non-road mobile machinery such as engineering machinery and vessels. More than 30 cities incorporated the requirement

of pollution control of non-road mobile machinery such as engineering and agricultural machinery into their air pollution prevention and control action plans. And more than 30 cities incorporated the requirement of emission control of ports and vessels into their action plans.

## Improve Capacity to Serve Scientific Decision-making

### 1. Three steps to significantly improve monitoring capacity and emphasize on reporting

As the Revised Standards are released and begin to be implemented in some major cities and regions, China has made a great leap forward in ambient air quality monitoring, with progress mainly evident in two areas: The establishment of a national monitoring network and the upgrading of the real-time reporting system for air quality data. According to the three-step implementation plan for the establishment of the monitoring network, cities are required to build monitoring sites by stages and report real-time data, including hourly mean concentrations of major monitoring pollutants and corresponding air-quality indicators. After three stages of construction and by the end of 2014, 1,436 monitoring sites in 338 prefecture-level cities and cities of higher administrative levels were able to implement the Revised Standards; the three key regions (BTH, YRD and PRD) had also established regional air-quality forecasting and alerting platforms.

City air-quality reporting has also been constantly improving. Top-tier cities such as Beijing and Shanghai in the past only reported air-quality information in the manner specified in local policies and regulations; however, they now they take the initiative to provide better services for the general public: (1) Reported air-quality information is easier for the public to understand. For example, Shanghai uses the facial expressions of a cartoon character and colors to indicate changes in air quality; (2) In addition to real-time air-quality reporting, top-tier cities also provide forecasting, pollution reminders and alerts and nowcasting to help the public obtain air quality information in a timely manner.

Air-quality forecasting has been a major development area in ambient monitoring system in the past two years. Beijing and Shanghai both have established a new-generation forecasting and alerting system that is based on AQI standards; the channels for reporting have diversified from traditional media such as televisions, radios and newspapers to new media such as websites, phone apps, mobile television, Weibo and WeChat. In 2014, the Beijing Municipal Environment Monitoring Center cooperated with the Beijing Internet Information Office and developed a regular information-sharing mechanism for reporting through new media channels and began to provide data and customized information to the media. All of those efforts have improved the availability of the information, facilitated the spread

of information among different groups of people, and raised public awareness about the issue of air quality.

### **2. First steps towards scientific decision-making based on a thorough understanding of pollution sources**

A lack of knowledge about emission sources is one of the major challenges for Chinese cities in air pollution prevention and control. As China enters the crucial stage of the Ten Measures of the State Council in air pollution control, scientific decision-making and meticulous management have been continuously requested and emphasized.

The purpose of conducting PM-source apportionment and developing the emission inventory is to obtain clear knowledge of the sources of pollution and formulate emission-reduction strategies in line with reliable research results and emission-source information, which are the first steps towards scientific decision-making.

To provide local governments with guidance on the source apportionment of atmospheric particulate matter, the MEP issued the Technical Guidelines on Source Apportionment of Atmospheric Particulate Matter (Trial) in 2013. Based on long-term achievements in scientific research, Beijing, Shanghai and Guangzhou took the lead in completing PM<sub>2.5</sub> source apportionment and had reported the results by the end of 2014.

The source apportionment results of Beijing and Shanghai indicate that vehicle emissions in the city, regional transportation and coal combustion are the three primary causes of air pollution. Moreover, the results have provided a scientific basis for the formulation and implementation of key control measures, such as eliminating yellow-label and outdated vehicles, upgrading vehicle-emission standards and fuel quality, controlling total coal consumption, defining (coal combustion) restricted zones and carrying out regional joint prevention and control. The results may also be utilized to evaluate the effects of those key control measures.

In 2014, the MEP issued four technical guidelines on the development of emission inventories, including pollution source categorization and prioritization, emission factors and activity data related to the development of emission inventories for particulate matter, VOCs and ammonia.

Prior to the release of these guidelines, Beijing and Shanghai had been able to develop their own emission inventories to serve their management needs. For example, Shanghai developed its first edition emission inventory as early as 2003, and systematically updated it four

times in the next decade based on scientific research projects carried out during that period.

Beijing is the first to incorporate emission-inventory development into its regular environmental protection efforts and formulate standardized work plans and technical regulations that suit its characteristics and needs.

However, most of other provinces and cities have not developed local emission inventories for air-quality management due to factors such as a lack of technical competence, a shortage of human and financial resources, and poor data availability. Following the release of the four technical guidelines, the MEP will carry out pilot projects in some cities to gradually roll out emission inventory development at the municipal level.

## Various Measures to Ensure Smooth Implementation of the Action Plan

To ensure the effective implementation of the Action Plan, the MEP has, in collaboration with other relevant ministries, departments and agencies, planned 22 supporting measures that consist primarily of economic policies and assessment methods.

Nineteen of these policies were released by the end of 2014, which has enhanced implementation of the emission-reduction policies. The National Government has increased financial input in the special fund for air pollution prevention and control each year, from 5 billion RMB in 2013 to 9.8 billion RMB to date.

The 74 cities are also gradually increasing input into their own special funds for air pollution prevention and control each year in the form of awards and subsidies to encourage boiler retrofitting, pollutant emissions control in key industries, and the elimination of outdated production capacity and yellow-label vehicles.

According to the Action Plan, targets for air quality prevention and control have been incorporated into officials' performance appraisal systems; the MEP releases monthly air-quality rankings of the 10 best and 10 worst cities; and local government officials are admonished by the MEP for poor performance in air-quality control. The pressure of those policies on local governments has further facilitated implementation of emission-reduction measures.

# Clean Air Asia



Tel/Fax: +86 10 8532 6172

Email: [china@cleanairasia.org](mailto:china@cleanairasia.org)

Web: [www.cleanairasia.org](http://www.cleanairasia.org), [www.allaboutair.cn](http://www.allaboutair.cn)

Address: 11-152, JianGuoMenWai Diplomatic Residence Compound, No.1 Xiushui Street, Chaoyang District, Beijing, 100600