Country Synthesis Report on
Urban Air Quality Management

People's Republic of China

Discussion Draft, December 2006

ADB

CLEAN AIR INITIATIVE
for Asian Cities

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Abbreviations

ADB	Asian Development Bank
API	Air Pollution Index
APPCL	Air Pollution Prevention and Control Law
AQ	air quality
BRT	bus rapid transit
CAI-Asia	Clean Air Initiative for Asian Cities
CIIC	China Internet Information Center
CO	Carbon monoxide
DSS	dust and sandstorm/s
GDP	gross domestic product
Gg	gigagrams
HC	hydrocarbon
IESAP	Integrated Emission Standard of Air Pollutants
kg	kilogram
km	kilometer
km^2	square kilometer
LPG	liquefied petroleum gas
MRT	mass rapid transit
Mt	metric tons
Mtce	Million tons of coal equivalent
NAAQS	National Ambient Air Quality Standards
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
O_3	Ozone
Pb	Lead
PLS	Pollution Levy System
PM_{10}	particle matter with a diameter equal or less than 10 micrometers
$PM_{2.5}$	particle matter with a diameter equal or less than 2.5 micrometers
PRC	People's Republic of China
SEPA	State Environmental Protection Administration
SO_2	Sulfur dioxide
TCA	Two Control Areas
TCZ	Two Control Zones
TEC	Total Emission Control
Tg	teragrams
TSP	total suspended particulates
USEPA	United States Environmental Protection Agency
VOC	volatile organic compounds
WHO	World Health Organization
WPRB	Western Pacific Region-B

Note: "$" means "US dollar" in this publication.

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» Part One

General Information

Geography and Climate

The People's Republic of China (PRC) is the third largest country in the world with a total area of 9.6 million square kilometers (km^2). It lies in the northeastern part of Asia and is bounded by the Pacific Ocean on the east, Central Asia on the west, the Russian Federation and Mongolia on the north, and Southeast Asia on the south. The PRC's climate is dominated by dry seasons and wet monsoons. Climate patterns vary greatly from region to region because of the sheer size of the country and its complex topography. The North has extremely cold winters that make indoor heating a requirement in the winter months. The northwestern part of the PRC, with its generally dry topography and vast desert areas, has been a major source of dust and sandstorms (DSS) that are affecting large parts of the country. The PRC's desert areas have expanded to 2.64 million km^2, which accounted for 27.5% of the country's total land area as of 2004 (China National Committee for the Implementation of the United Nations Convention to Combat Desertification {UNCCD} [CCICCD] 2006).

Dust clouds blowing east from Asia are a common occurrence in the springtime (from April to June). In the PRC, the most serious sandstorms occur in the period from March to April. The dust cloud originates when strong winds from Siberia kick up millions of tons of dust from the Gobi Desert and Takla Makan Desert in Mongolia and in the PRC, respectively. Huge dust plumes travel hundreds of miles to Beijing and other cities in northeastern PRC, picking up particles from industrial pollution as they move over urban areas.

Population and Urbanization

With a population of 1.30756 billion, the PRC is the country with the largest population in the world (Gov.cn 2006a). Its population is quite unevenly distributed due to the country's complex natural conditions. The highest population density—more than 400 persons/km^2—lies in the eastern half of the PRC. The central region has about 200 persons/km^2 while the sparsely populated plateaus in the west have less than 10 persons/km^2 (China Internet Information Center [CIIC] 2006a).

While the total population of the PRC is expected to grow to 1.44 billion by 2025 (13% growth from 2000 levels), the urban population is expected to increase from 35.8% in 2000 to 57.2% in 2025. Data from the *Chinese Statistical Yearbook of 2005* showed that the proportion of the total population living in urban areas in the PRC has reached 43% in 2005, more than double the 1980 levels.

Cities are categorized according to population size—megacity (urban population of 1 million or more), large city (urban population of more than 500,000), medium city (population ranging from 200,000 to 500,000), and small city (population of less than 200,000). As of 2002, the PRC had 660 cities, of which 171 are megacities (10 cities with more than 4 million persons each, 23 cities between 2 and 4 million persons, and 138 cities between 1 and 2 million); 279 large cities; 171 medium cities; and 39 small cities (CIIC 2006a).

Economy and Industry

The Eleventh Congress of the Communist Party of the PRC (CPC), held in December 1978, marked the beginning of the economic reform era in the PRC. Since then, the PRC has adopted a comprehensive set of reforms that has enabled the country to sustain an annual growth rate of about 10% year-on-year. Gross domestic product (GDP) has risen from yuan (CNY) 362.4 billion in 1978 at the start of the reform period, to CNY13.7 trillion in 2004. In parallel, annual per capita disposable incomes of urban households increased 6.8 times—

from CNY1,374 in 1989 to CNY9,422 in 2004—according to the *PRC Statistical Yearbook of 2005*. The annual per capita disposable income in major cities, such as Shanghai, increased from CNY10,932 in 1999 to CNY16,683 in 2004 and in Beijing, from CNY9,183 to CNY15,638 (National Bureau of Statistics 2000, 2005).

2006 marks the beginning of the PRC's 11th Five-Year Plan, and it is seen as a starting point for the country to enter a new stage characterized by stable growth rather than accelerated growth. The economy is expected to grow at an annual rate of 7.5% during the period of the 11th Five-Year Plan (2006–2010), according to the National Development and Reform Commission (NDRC). Recent data, however, shows a GDP growth of 10.9% in the first half of 2006.

The share of the primary[1] industry in total GDP had fallen from 28% in 1978, at the beginning of the reform period, to 15% in 2004. The decline was caused by slow growth in the agriculture sector compared with that in the other economic sectors. Since the 1980s, the GDP share of manufacturing and construction (secondary industry) averaged 45%; at the same time, the share of tertiary industry grew from 24% to 32% as the services sector proliferated (Chinability 2006).

The establishment of the motor vehicle industry in the 1980s, and its subsequent growth, had special relevance to urban air quality management. Every major international car manufacturer is now present in the Chinese market and are increasingly setting up local assembly and production plants, generally in conjunction with domestic joint-venture partners. The China Automotive Industry Association (CAIA) expects the auto market to maintain a 10%–15% growth, with auto sales reaching between 5.6 million and 6.4 million units in 2006. The PRC has also become the world's largest producer of motorized two-wheelers, with an annual production of 17.77 million in 2005 (CIIC 2006b).

Chinese cities play an important role in the entire national economy, contributing 43.94% to the national GDP. Fifteen of the largest cities (in terms of population) contribute 28.79% to the national GDP. It is expected that economic growth of these cities will continue to serve as the engines of economic growth of the whole country in the years to come.

Energy

Overall Production and Consumption

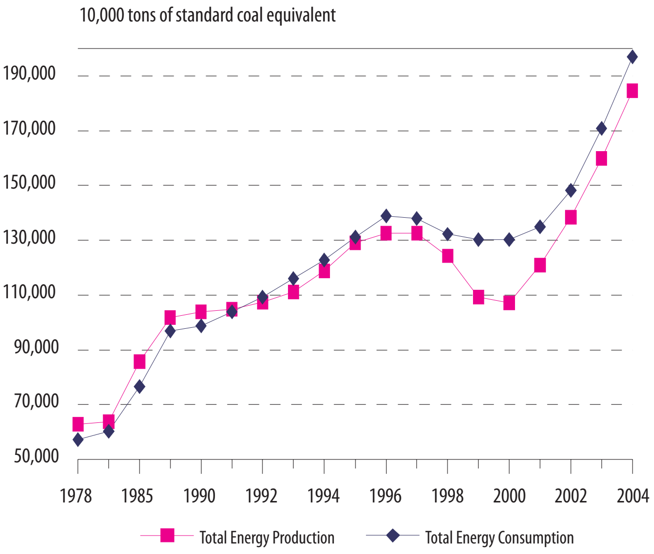
The PRC is the world's third largest energy producer (after the United States and the Russian Federation), accounting for 10.6% of the world's annual total energy production. At the same time, the country is the second largest energy consumer after the United States, accounting for 10.8% of the world's total annual energy consumption.

The large growth in energy demand resulted in the PRC becoming a net energy importer during the 1990s. It is estimated that the PRC will have to double its electricity-generating capacity every decade in order to keep up with the country's rate of economic growth.

A historical summary of the PRC's energy consumption and production is shown in Figure 1.1. In the wake of the Asian financial crisis, the PRC slowed power plant constructions in anticipation of reduced power consumption growth,[2] which indeed occurred. However, a sharp rebound in power demand in 1999–2000 caught the Government unaware, prompting power shortages. Since 2000, power consumption growth has outpaced the growth in power capacity, which continued to

FIGURE 1.1

Energy Consumption and Production in the PRC



Source: PRC National Bureau of Statistics (2005).

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[1] The primary industry refers to agriculture, forestry, animal husbandry, and fishery. The secondary industry refers to mining and quarrying, manufacturing, production and supply of electricity, water and gas, and construction, while the tertiary industry refers to all other economic activities not included in primary or secondary industry.

[2] Energy Research Institute under the National Development Reform Commission.

decline until 2003, when it climbed to 9.1% (compared with 4.3% in 2002). However, in 2003, power demand climbed even more rapidly by 15.8%, continuing through 2004 at a similar rate of growth, while energy production increase averaged 15% since 2002. An energy outlook report showed that the PRC's steadily growing economy will remain the principal driver of energy demand, forcing the country to expand domestic power production and step up its efforts to secure mineral resources (KPMG 2005).

Energy Consumption and Production by Fuel Type

The rapid increase in energy demand in the PRC has been especially large since 2002 (Figure 1.2). This has been met by increased consumption of coal. The increase in coal consumption is expected to continue—from 1.3 billion tons (t) in 2000 to between 2.1 billion and 2.9 billion t in 2020—dominating more than 50% of primary energy share until 2020. Petroleum/crude oil will account for about 27% of total primary energy in 2020. Consumption is estimated to increase from 4.6 million barrels per day in 2000 to between 9 million and 12.2 million barrels per day in 2020 (Wu 2006).

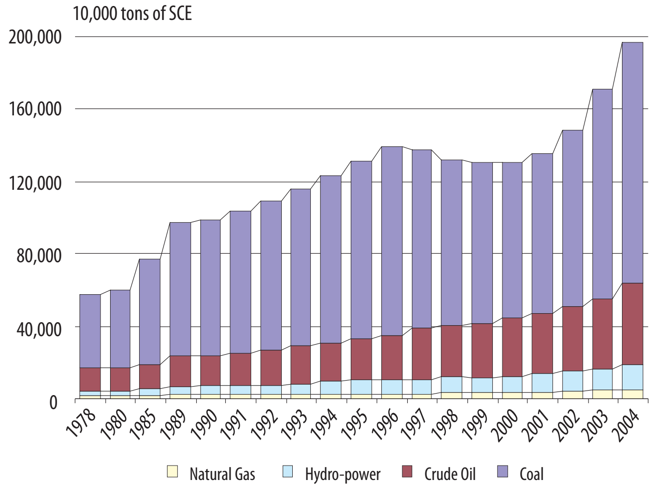


FIGURE 1.2

Energy Consumption in the PRC, 1978–2004

Source: PRC National Statistics Bureau (2005).

Petroleum/crude oil. The PRC is currently the world's fifth highest crude oil-producing country, accounting for about 4.9% of the world's total annual crude oil production. The country's growing demand for oil—which increased by more than 5.5% per year during the 1990s—has greatly outstripped its domestic production capabilities. In the early 1990s, the PRC became a net oil importer.

Coal. The world's largest coal producer—accounting for about 30% of the world's total annual coal production—the PRC is also the world's largest coal consumer, accounting for more than 28% of the world's total annual coal consumption. 2003 data from the National Statistics Bureau shows that the industry accounted for 92% (1,505 million t SCE); residential, 5%; and agriculture, construction, and other services accounted for the remaining 3% of the total coal consumption. Three quarters of proven recoverable reserves of coal in the PRC are in the north and northwest, particularly in the provinces of Shanxi, Shaanxi, and Inner Mongolia. The average ash content of Chinese coal is about 28% and sulfur content is 1.1%. Statistics indicate that medium-sulfur coal (1%–2% S content) accounted for 40% of use, while high-sulfur coal (more than 2% S content) accounted for 14% of use.

Natural gas. The PRC does not heavily rely on natural gas in its energy supply mix, accounting for only 3% of its total primary energy supply. However, the demand for this kind of clean energy is expected to rise by 12% annually in the next 15 years, according to a forecast of the PRC National Offshore Oil Corporation. Most of the natural gas consumed in the PRC is used for industrial purposes, especially as a chemical feedstock. Residential usage only accounts for about 13% of the gas consumption, and another 10% is used for electricity and district heat generation. In recent years, natural gas has been an alternative source of fuel to industries located in certain cities that used coal-fired boilers before. Natural gas is now mainly consumed in the provinces where it is produced. The PRC has plans for quadrupling its gas production and servicing other provinces by 2010 through cross-country pipelines from the resource-rich west to the energy-hungry east and south. The 24,000-km of natural gas pipelines in the country will be extended to 36,000 km by 2010. The market demand is expected to reach 120 billion cubic meters ($m^{3)}$ by 2010 and 200 billion m^3 by 2020. However, it is expected that only 80 billion m^3 and 120 billion m^3 in 2010 and 2020, respectively, will be met using indigenous sources. The difference is expected to be sourced from other countries, such as Australia, Kazakhstan, Russian Federation, and Turkmenistan (Wang 2006).

Hydropower and other renewable energy source. Hydropower energy, which accounted for 7.9% of the total energy production in 2004, had been generated from 388 large hydropower stations (40 megawatt [MW] and above) with 56,000 MW in total hydropower capacity (Chinadam 2006). The PRC's Three Gorges Dam—the world's largest hydroelectric dam that was completed in April 2006—is expected to generate 84.7 billion kilowatt-hour annually and provide energy equivalent to 10% of the total electricity demand of the country when it becomes fully operational in 2009 (China View 2006a). The PRC is committed to the development of renewable sources of energy and has started with the development of wind power.

Nuclear energy. The country has rich uranium resources, and a complete nuclear fuel cycle system is in place. In the late 1970s, the PRC began considering nuclear energy as an alternative to burning coal. As part of an effort to increase domestic nuclear capability, the PRC National Nuclear Corporation (CNNC) was established in 1988. The country now has six nuclear power stations with a capacity of 9 million kilowatts. Nuclear power accounts for 2% of total power generation capacity. According to the PRC Atomic Information Network, the country will increase its nuclear power-generation capacity to 40 million kilowatts, or 4% of the total, by 2020 (People's Daily Online [PDO] 2006a).

Dusts and Sandstorms

With up to 58% of the country's land area classified as arid or semiarid, nearly one third of the PRC's land suffers from the effects of desertification. Each year, an additional estimated 3,000 km^2 of land turns into deserts, compared to the annual expansion rate of 1,560 km^2 in the 1970s and 2,100 km^2 in the 1980s. The pace of desertification has been accelerating due to rapid population growth and unsustainable human activities, such as excessive land conversion, overgrazing, overlogging, and irrational utilization of water resources. Consequently, a considerable number of villages have been lost to expanding deserts. It is estimated that some 24,000 villages; 1,400 km of railway lines; 30,000 km of highways; and 50,000 km of canals and waterways are subject to the constant threat of desertification (United Nations Convention to Combat Desertification [UNCCD] 2001). Desertification caused direct economic losses of CNY54 billion ($6.75 billion) a year and affected the lives of about 400 million people. But the trend has been turned, in recent years, with an annual desert shrinking of 7,585 km^2, compared with an annual expansion of 10,400 km^2 at the end of the last century (China View 2006b).

Although DSS are natural phenomena that have plagued the PRC for centuries, their increased frequency and severity is one of the manifestations of desertification that the country is experiencing. Before 1949, northwestern PRC saw dust storms, on average, every 31 years. After 1990, the average jumped to one such storm per year and, in recent years, five or six dust storms a year (NASA 2006). In the first 5 months of 2006 alone, 14 DSS struck Beijing (Northeastern PRC), demonstrating an increased frequency (Shanghai Daily 2006), which can be attributed to high temperatures, prolonged drought, and frequent cold air (China View 2006c). In one of the more recent dust storms that hit Beijing, an estimated 300,000 t of dust were dumped in the city (Telegraph News 2006).

Transportation

According to the PRC's *Report on the Environment for 2005*, the ownership of automobiles and motorcycles has exceeded 43 million and 94 million, respectively, by the end of 2005. Compared to 2004 figures, the number of automobiles increased by 20.6%, while the number of motorcycles increased by 23.6% (State Environmental Protection Administration [SEPA] 2006a).

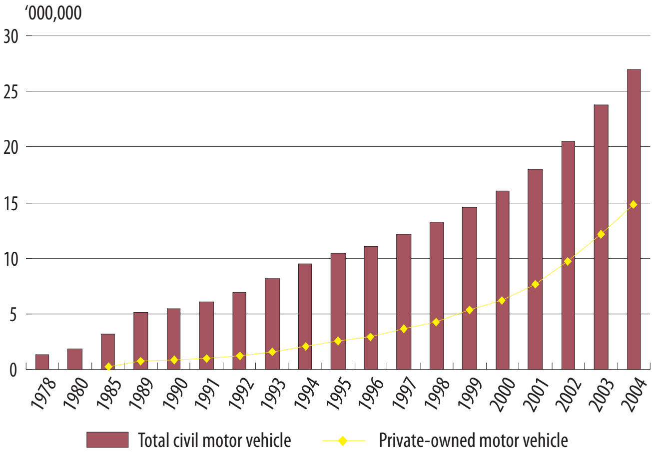
Private car ownership has shown high annual rates of increase (23%) bringing the number of private vehicles in the PRC to 14.8 million, or about 55% of total number of vehicles in 2004 (Figure 1.3). The high growth rates are directly correlated with the growing economic prosperity in Chinese cities. In Beijing, the vehicle fleet has quadrupled from 0.5 million in 1990 to 2 million in 2002.

This rapid rate of motorization is expected to continue in the next decades. It is generally expected that the total number of 4-wheeled motor vehicles in the PRC will be between 100 million and 130 million by 2020. The total number of motor vehicles in the PRC is estimated to reach 248 million by 2015, with the highest rate of increase found in cars and SUVs followed by 2-wheelers (Figure 1.4). The number of 2-wheelers is expected to decline after 2025 when personal incomes will have reached a level that allows people to purchase a car instead of a motorcycle.

Based on information on automotive fuel consumption, there appears to be an increase in the number of diesel vehicles. From 1990 to 2002, diesel consumption for vehicles

FIGURE 1.3

Motor Vehicle (of 4 or more wheels) Population in the PRC, 1978–2004



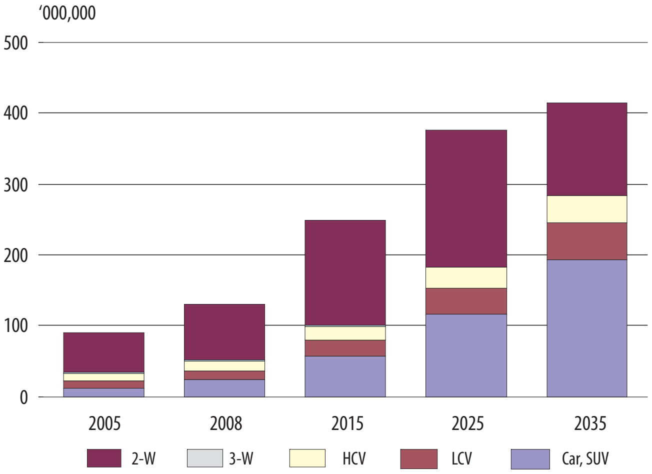
Note: Forecasts used were developed by Segment Y Ltd (www.segmenty.com) based on the Goldman Sachs economic forecast in their "Dreaming with BRICs" report.
Source: PRC Statistical Yearbook (2005).

increased annually by 23% compared to only 7.7% of gasoline consumption. Diesel consumption for vehicle use increased from 17.3% in 1990 to 22.1% in 2002, while gasoline consumption declined from 92% in 1990 to 87% in 2002 (China Clean Auto 2006).

The Chinese urban transportation system is dominated by private cars, buses, taxis, motorcycles, scooters, and bicycles. Most cities, such as Beijing, Guangzhou, and Shanghai, still have dedicated and separated lanes for bicycle traffic in the urban area. These lanes, however, are not sufficiently integrated into the whole transportation network,

FIGURE 1.4

Forecast of Vehicle Populations in the PRC



2-W = two-wheeled vehicles; 3-W = three-wheeled vehicles; HCV = heavy-duty commercial vehicles; LCV = light-duty commercial vehicles.
Note: Forecasts used were developed by Segment Y Ltd (www.segmenty.com) based on the Goldman Sachs economic forecast in their "Dreaming with BRICs" report.
Source: Asian Development Bank (ADB), 2006a.

Trip patterns in Chinese cities indicate that the largest share of trips are still made by walking and cycling (65%), followed by public transport (19%) and private motor vehicles (16%) according to Kenworthy and Laube (2001) (cited in Kenworthy and Hu 2002). However, the number of walking and cycling trips is expected to decline as the number of trips by private motor vehicles begins to increase.

In Xi'an, motorcycles number about 14 million but take up only 5% of the total share of modal trips in the city. Walking, bus trips, and bicycle trips play a major role in modal trips, with shares of about 22% for walking and 33% for bus trips and cycling (ADB 2006b).

» Part Two

Sources of Air Pollution

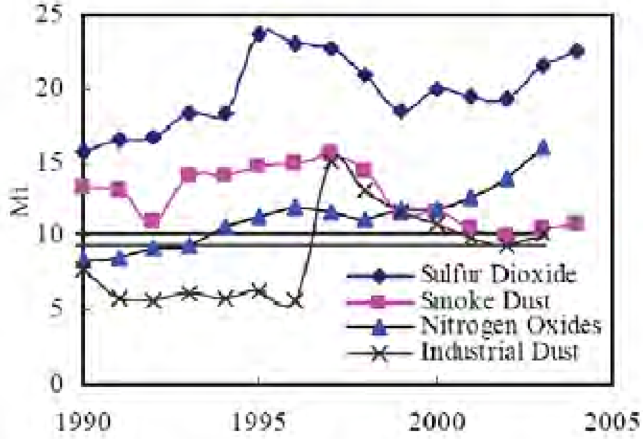
Unlike other countries in the region whose urban air pollution problem is often attributed largely to pressures from mobile sources, the PRC's urban air pollution problem is caused by diverse pressures brought about by mobile, stationary and area sources, from anthropogenic and natural sources. Quantitative and reliable knowledge of the amounts and sources of various pollutant emissions is an important component of air quality management as it allows better targeting of control measures. In the PRC, emissions inventories are composed either on a sectoral basis or on a per pollutant basis. Some of the emissions inventories are on a city basis, others are on a regional or a national scale.

Total Pollutant Emissions Inventory

SEPA routinely estimates emissions of Sulfur dioxide (SO_2), Nitrogen oxide (NO_x), smoke dust, and industrial dust in the country. Figure 2.1 shows the trends of emissions over a 14-year period (from 1990 to 2004) as compiled by SEPA. SO_2 emissions in the PRC increased steadily from 1990 up to 1995 but slowly dipped from 1995 to 1999, after which they started to increase again. For 2004, the total SO_2 emissions amounted to about 22.5 metric tons (Mt), as reported by SEPA. NO_x emissions increased consistently and, in 2003, were almost twice the 1990 emissions. Smoke dust and industrial dust, on the other hand, have shown decreasing trends since 1997. Smoke dust, which has shown a decline over the last years, is now estimated at 10.95 Mt. Industrial dust is also declining and is now estimated at 9.05 Mt (Hao et al. 2005).

FIGURE 2.1

Emissions Inventories of SO_2, NO_x, Smoke Dust, and Industrial Dust in the PRC, 1990–2005



Note: Industrial Soot Emission refers to volume of soot in smoke emitted in process of fuel burning in premises of enterprises. Industrial Dust Emission refers to volume of dust emitted by production process of enterprises and suspended in the air for a given period of time, including dust from refractory material of iron and steel works, dust from coke-screening systems and sintering machines of coke plants, dust from lime kilns, and dust from cement production in building material enterprises, but excluding soot and dust emitted from power plants.

Source: Hao et al., 2005.

Spatial Distribution of Emissions and Source Contributions

Emissions are influenced greatly by drivers, such as urbanization, economic activity, and motorization, which are highly diverse for different parts of the PRC. Emission contributions per city or region are, therefore, expected to vary. Some emissions inventory techniques applied in the PRC allow for mapping of these emissions by region.

Black Carbon

National emissions of black carbon (BC) in the PRC in 1995 amounted to 1,342 gigagrams (Gg), with contributions from the following fuel types: coal, 51.6%; biofuels (including field combustion), 44.0%; and oil, 4.4%. Areas consuming the most volume of low-quality coal (such as Sichuan) had the highest BC emissions (Streets et al. 2001).

Mercury Emissions

The PRC's emissions of mercury for 1999 amounted to 536 t of total Mercury, about 45% of which comes from non-ferrous metals smelting, 38% from coal combustion, and 17% from miscellaneous activities (e.g. battery and fluorescent lamp production and cement production). Emissions were heaviest in Liaoning Province (Northeast PRC) and Guangdong Province (South PRC) due to extensive smelting, and in Guizhou Province (South PRC) for much small-scale combustion of high-mercury coal without emission control devices (Streets et al. 2005).

SO_2 Emissions

In an emissions inventory for Asia, SO_2 emissions were found to be highest in the PRC. In 2000, the estimated emissions of SO_2 in PRC amounted to 20.4 teragrams (Tg), or 59% of all the countries covered (Streets et al. 2003). This is largely in agreement with the official SEPA estimate of 19.95 Tg and is only slightly higher because of additional sources, such as domestic biofuel combustion (450 Gg) and biomass burning (83 Gg). SO_2 emissions in the PRC are seen to be concentrated mostly in the Central and East coastal areas where heavy industries are located. SO_2 emissions are dominated by emissions from power generation and industry (Hao et al. 2005).

NO_x Emissions

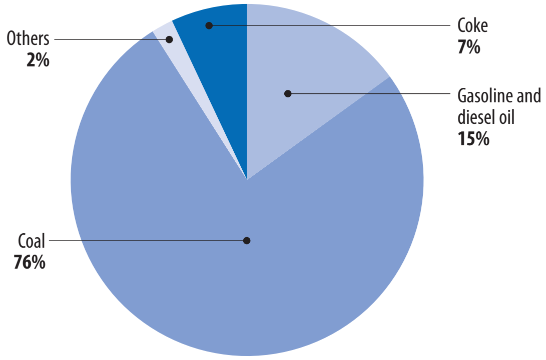
The PRC emitted 11.3 Tg of NO_x, equivalent to 42% of total NO_x emissions in the countries covered (Streets et al. 2003). NO_x emissions come mostly from power (39%), and industry and transport (25% each) (Hao et al. 2005).

The magnitude of NO_x emissions in the PRC is increasing and is giving cause for concern. NO_x emissions from coal combustion accounted for 1.3 Mt in 1989, 2.65 Mt in 1995, and 2.85 Mt in 2000. The most widely used technique for reducing NO_x emissions are low-NO_x coal-combustion techniques, which include circulating fluidized-bed (CFB) boilers and low-NO_x burners. The investment in low-NO_x burners is about 0.03% of the capital cost of a power plant and 0.18% of the capital cost of a boiler. Over the years, low-NO_x burners have been installed in 130 boilers in 69 coal-fired power plants. In addition, low-NO_x, pulverized-coal combustion techniques have been developed by research institutes and universities in the PRC for different types of coal-fired utility boilers. Chinese utility power plants are now beginning to use modern selective catalytic reduction (SCR) to reduce NO_x emissions (Xu et al. 2004).

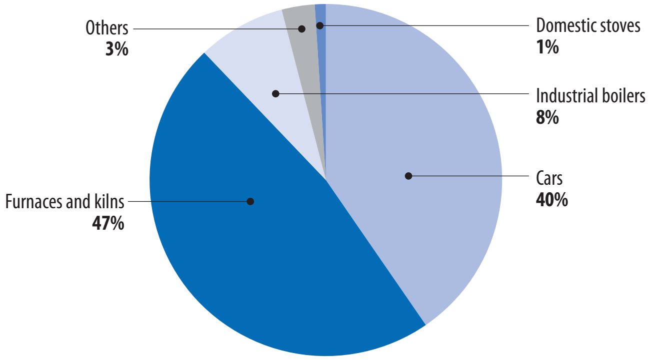
FIGURE 2.2

NO_x Emissions Sources

(a) PRC



(b) Beijing



Source: Xu et al., 2004.

Emissions from Mobile Sources

Estimates of emissions per vehicle type in 2005 are presented in Table 2.1. Particle matter (PM) emissions are mainly from 2-wheelers followed by heavy freight trucks, while NO_x emissions are mainly attributed to heavy freight trucks followed by minibuses and paratransit and buses. This may be due to the low(er) engine technology of these types of vehicles. The rapid increase in the number of 4-wheeled vehicles will lead to future increase in the contribution made by 4-wheeled vehicles and a relative decrease in the share of 2-wheelers.

TABLE 2.1

Total Pollutant Emissions from On-road Vehicles by Vehicle Type, 2005

Vehicle Type	Emissions, '000 Metric Tons of PM	Emissions, '000 Metric Tons of NOx
Light-Duty Vehicle	37.1	175.4
Medium Freight Truck	22.9	285.8
Heavy Freight Truck	36.2	483.2
2-wheelers	61.9	120.7
3-wheelers	0.0	0.0
Buses	19.6	260.8
Minibuses and paratransit	24.9	330.8
Total	**202.7**	**1,656.6**

PM= particulate matter, NOx = Nitrogen oxide
Source: IEA-SMP transport model reference case projections (http://library.iea.org/Textbase/subjectqueries/keyresult.asp?KEYWORD_ID=4121).

The modeling conducted by the International Energy Agency forecasted emissions from mobile sources over the next 20 years. Modeling assumptions include the phase-in of improved technology and increased efficiency in enforcement of environmental standards. Results indicate that the current pollutants of concern—PM and NO_x—will increase until 2015 after which they will show a decline. For other pollutants, such as volatile organic compounds (VOC), CO, and lead (Pb), quicker reductions can be expected.

TABLE 2.2

Emissions of Major Air Pollutants from On-road Vehicles (1,000 tons)

Pollutant	2000	2005	2015	2025
PM	183	203	219	135
NO_x	1,529	1,657	2,050	1,425
VOC	2,841	2,717	2,206	902
CO	15,334	14,856	13,608	5,858
Pb	1.17	0.25	0.00	0.00

Source: IEA-SMP transport model reference case projections.

Emissions from Stationary Sources

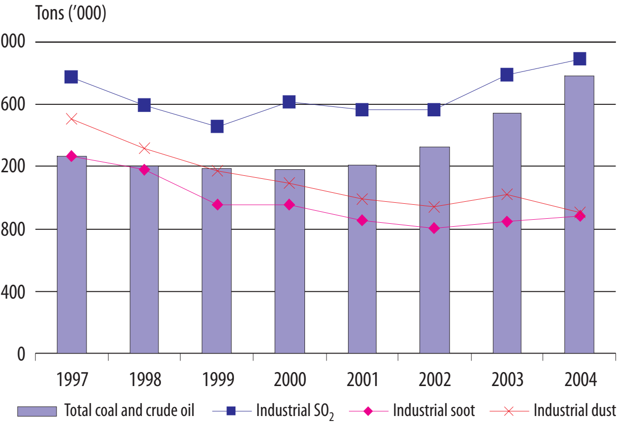
In the PRC, emissions of air pollutants from stationary sources come from two major categories—industry (manufacturing) process and energy/power generation, both of which contribute largely to SO_2, soot, and dust emissions, as well as NO_x. Stationary sources accounted for 60.8% of total NO_x emission in 2000 (China National Environmental Monitoring Center [CNEMC] 2006).

The trends in coal and crude oil consumption in relation to industrial emissions from 1997 to 2004 are shown in Figure 2.3. There is a strong correlation between increase in total coal and crude oil use and SO_2 emissions. PM emissions, on the other hand, have decreased consistently, with industrial soot being stable over the last few years while total amount of fuel used has increased.

In the 1980s, the PRC instituted a nationwide system of self-reporting for air pollution emissions from industry. Within the PRC, these data are used for national and regional planning; setting emissions permit levels, and enforcement of the national pollution levy. Studies indicate that industries may be under-reporting emissions by a factor of two or more (Florig and Song 2000).

FIGURE 2.3

Coal and Crude Oil Consumption and Industrial Emissions



Source: PRC National Bureau of Statistics, 2005.

» Part Three

Status of Air Quality

The quality of air in the PRC can be assessed in two ways: through trends analyses of the air pollution index (API) or through actual ambient concentrations. Although the second method is preferable, actual data on ambient air quality are not always readily available on urban air quality in the PRC.

Air Quality Monitoring

Environmental monitoring related to air pollution in the PRC consists of ambient air quality monitoring, acid rain monitoring, and sandstorm monitoring to track status and common pollutants, progress of acid rain precursors (SO_2, NO_2), and dust.

Ambient Air Quality Monitoring

Ambient air quality monitoring is conducted at various administrative levels: national, province, city, and county levels. Overall, there are 2,289 monitoring stations (1 national, 39 provincial, 399 city, and 1,850 county) in the country that employ more than 45,849 personnel to conduct monitoring work (SEPA 2006b [in Chinese] and Wang 2005). The number of monitoring sites in urban areas is determined by the population number as indicated in Table 3.1.

TABLE 3.1

Number of Sites for Urban Ambient Air Quality Monitoring

Population	Sites (no.)
<500,000	2–3
500,000–1,000,000	4
1,000,000–2,000,000	5
2,000,000–4,000,000	6
>4,000,000	7

Source: Wang, 2005.

There is a trend toward automatic air quality monitoring in the PRC especially since the Government's Five-Year Plan for ambient air quality monitoring for all cities directly under a province requires the establishment of an urban automatic ambient air monitoring system, as well as an urban acid rain monitoring system, for all cities by end of 2005. As of June 2004, 688 automatic air quality monitoring units were in place in 234 cities—a marked improvement from its June 2002 levels of 474 units in 179 cities. SO_2, NO_2, and PM_{10} pollutants, as well as meteorological indicators are the required parameters in automatic ambient monitoring, while other pollutants, such as O_3 and CO, are only optional parameters (Wang 2005, Liu et al. 2002).

To ensure that quality results are generated from the ambient air monitoring networks, quality assurance and quality control procedures are being implemented in the PRC. In most cases, the Environment Monitoring Centers of the cities (e.g. the Beijing Environmental Monitoring Center [BJEMC] and the Shanghai Environment Monitoring Center [SEMC]), which are subordinate offices of local government environmental protection bureaus, have laboratories that routinely calibrate instruments and analyzers. In addition, data centers are equipped with software to check for abnormal data and provide for auto-calibration reports. The Environment Monitoring Centers' quality assurance and quality control programs, such as that of SEMC, are accredited and recognized by the PRC National Accreditation Committee.

Many cities, such as Shanghai, Beijing, Guangzhou, and Xi'an are evolving their monitoring capacity and improving their networks to include roadside monitoring stations in order to be able to assess the contribution of mobile sources to the overall air pollution. However, guidelines for the positioning of these stations and their features are lacking and needed to be developed by the Government.

Acid Rain Monitoring

More and more cities in the PRC are monitoring acid rain: in 2001, 274 cities were monitored for acid rain and, in 2004, the number of cities increased to 527 (SEPA 2002, 2005). Acid rain monitoring includes measuring parameters, such as pH and chemical composition of precipitation. Of these cities, four are participating in a regional acid monitoring network called EANET (Acid Deposition Monitoring Network in East Asia)[1]. In 2005, more than 690 cities monitored pH of precipitation and 300 cities monitored chemical composition of precipitation (Wang 2005).

Dust and Sandstorms Monitoring

DSS are generally monitored through satellite imagery and computer modeling techniques. The National Institute for Environmental Studies (NIES) in Japan forecasts distribution of Asian dust and anthropogenic aerosols in East Asia and publishes results through its website.[2] The forecast employs the Chemical Weather Forecasting System (CFORS) developed by the Kyushu University in Japan.

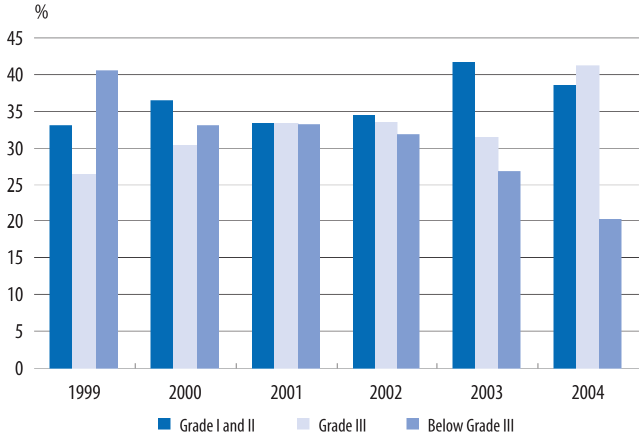
The National Meteorological Bureau of the PRC has set up six special sandstorm monitoring stations equipped with automatic devices at the source and along major routes of sandstorms in North PRC's Inner Mongolia as part of SEPA's Sandstorm Project. Doppler weather radar stations, satellite earth stations, and a satellite communications network have been set up in Inner Mongolia for better analysis, monitoring, and forecasting of sandstorms (China Meteorological Association [CMA] 2006).

Air Pollution Index Trends

The trends of air quality in API format from 1999 to 2004 (shown in Figure 3.1) suggest the general improvement in air quality in cities in the PRC. This is confirmed by the decrease in percentage of cities with air quality worse than Grade 3 of National Ambient Air Quality Standards (NAAQS) from 40.5% in 1999 to 20.3% in 2004 and the percentage increase of cities complying with Grade 2 (from 33.1% in 1999 to 38.6% in 2004) and Grade 3 (from 26.3% in 1999 to 41.2% in 2004) of NAAQS. Grade 1 standards apply to specially protected areas, such as natural conservation areas, scenic spots, and historical sites. Grade 2 standards apply to residential areas, mixed commercial/residential areas, cultural, industrial, and rural areas. Grade 3 standards apply to special industrial areas.

FIGURE 3.1

Percentage of Cities Meeting API, 1999–2004



Note: Sample size includes about 340 cities.

This general improvement in trends, however, does not mean that the air pollution problem has been resolved. A large number of cities are still not able to meet the required Grade 2 standards. In 2004, 61.4% of 342 cities failed to meet standards and 20.3% were still in rigid noncompliance—meaning that these cities cannot even meet Grade 3 standards. The share of the population living in cities meeting NAAQS accounted for 33.1% of the total in 2004, decreasing by 3.3% compared with 2003 figure. The metropolises with a population exceeding 1 million had the most serious air pollution problem: PM$_{10}$ and SO$_2$ concentrations are higher than the standard.

Urban Ambient Air Quality Levels

PM$_{10}$ has been the predominant pollutant in most Chinese cities for the past several years. In 2004, 46.8% of the cities were unable to meet Grade 2 of the PM$_{10}$ NAAQS while 14.3% of the cities were unable to comply with Grade 3 standards. These cities are mainly located in Shanxi, Inner Mongolia, Liaoning, Henan, and Sichuan provinces. The air quality status of 31 cities in terms of different pollutants for 2003 and 2004

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[1] See http://www.eanet.cc.

[2] See http://www-cfors.nies.go.jp/%7Ecfors/.

are shown in Figure 3.2. The data confirms that PM_{10} is the main pollutant in cities in the PRC, followed by SO_2.

Increasing diesel use has raised the relative contribution of PM_{10} to the overall pollution burden. Rapid motorization has also contributed to the emergence of photochemical smog, which is formed from NO_x and hydrocarbon (HC) in hot, sunny weather conditions in certain cities.

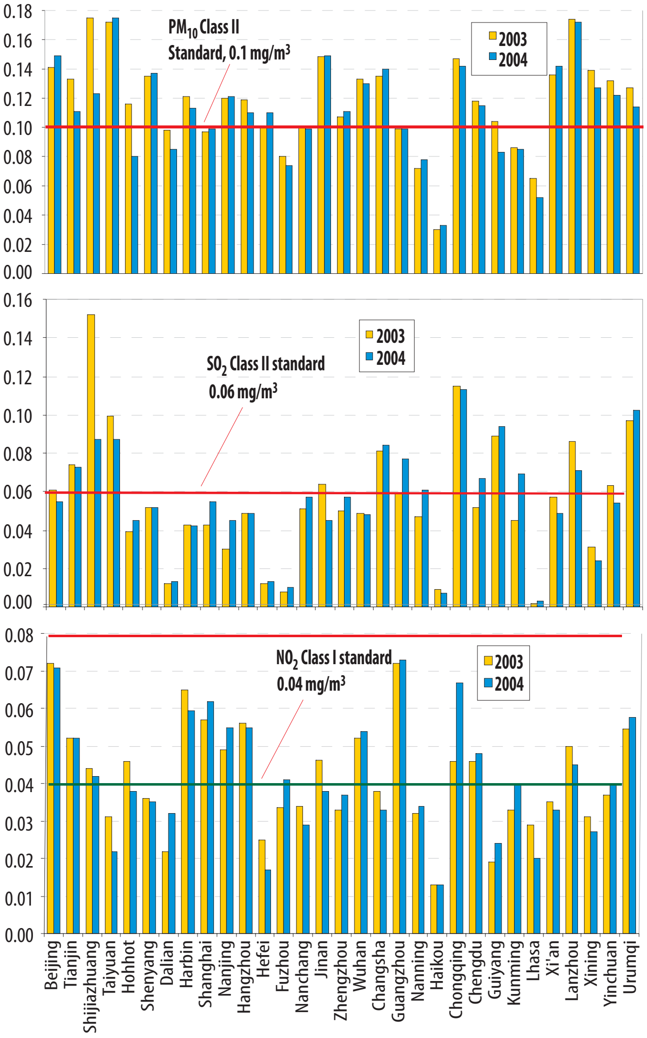
Particulate Matter

The 31 cities registered an average PM_{10} concentration of 0.11 mg/m^3, which exceeds Grade 2 PM_{10} standard of 0.10 mg/m^3. The following trends were also observed (Figure 3.2):

- 10 of the 31 cities exceeded Grade 2 PM_{10} standards in 2004.
- From 2003 to 2004,13 cities experienced improved PM_{10} levels, 4 showed deteriorating PM_{10} quality, and the remaining 14 generally maintained the same PM_{10} levels.
- Haikou had the lowest concentrations of PM_{10} while Taiyuan and Langzhou had the highest.

FIGURE 3.2

Ambient PM_{10} (top), SO_2 (center), and NO_2 (bottom) in Selected Cities in the PRC



Source: PRC Statistical Yearbook (2004, 2005).

Sulfur Dioxide

The SO_2 concentration observed in 31 Chinese cities averaged 0.055 mg/m^3 in 2004, which barely met the 0.06 mg/m^3 Grade 2 standard imposed by the law. Further observations (Figure 3.2) show that

- 11 cities did not meet Grade 2 SO_2 standards in 2004.
- From 2003 to 2004, eight cities experienced improved SO_2 levels, 10 showed deteriorating SO_2 quality, and the remaining 13 generally maintained the same levels.
- Lhasa registered the lowest SO_2 levels. Chongqing had the worst SO_2 record in 2004 (exceeding the Grade 2 level almost twice). Shijiazhuang had the worst SO_2 levels in 2003, exceeding Grade 2 standards 2.5 times and even exceeding Grade 3 standards.

Nitrogen Dioxide

Seven cities exhibited increased NO_2 levels from 2003 to 2004. However, all 31 cities met the Grade 2 NO_2 standards in both years (Figure 3.2). In fact, 19 of these cities even met Grade 1 standards in 2004. The overall average NO_2 for all 31 cities remained the same—at 0.042 mg/m^3 —for both 2003 and 2004.

Ozone

Ozone (O_3) is a secondary pollutant that is formed from photochemical reactions between NO_x and HC in sunlight. With the rapid growth of motorization in the PRC, and its documented impact on agriculture, O_3 is expected to become an emerging pollutant of concern. Although O_3 concentrations are being monitored by some local environmental protection bureaus (EPBs), the information gathered is not readily available since publishing of O_3 data is not required by law. Consequently, quality assurance and quality control measures for O_3 monitoring do not receive the same attention compared with those for other pollutants.

SEPA is considering having O_3, CO, and $PM_{2.5}$ measurements compulsory within the next 2 years (SEPA, PCD, 2006). The cities of Shanghai, Beijing, and Suzhou are already equipped with $PM_{2.5}$ analyzers.

Long-term Ambient AQ Trends in Selected Major Cities

There is a growing tendency in the PRC to make ambient air quality data more readily available. In some cities, air quality information—more commonly available in API formats—is being published online or in some special reports.

CAI–Asia has been documenting, for a number of years, the air quality trends for a sample of 20 cities.[3] Work has started to set up a similar sample for Chinese cities. Initial results indicate that in large cities of the PRC, PM_{10} is declining though still well above the recently tightened annual standards or guideline values of World Health Organization (WHO) and the European Union.[4] The trend for SO_2 levels is inconclusive: while some cities show a decline in SO_2, others (Shanghai and Guangzhou) show an increase over the last 2 years. NO_2 levels—generally stable and above Q: Grade II but below Grade III—are increasing in middle-size and large cities, along with the increase in the motorization rates, representing a shifting trend from a stationary source-related pollution toward a mobile source-related one.

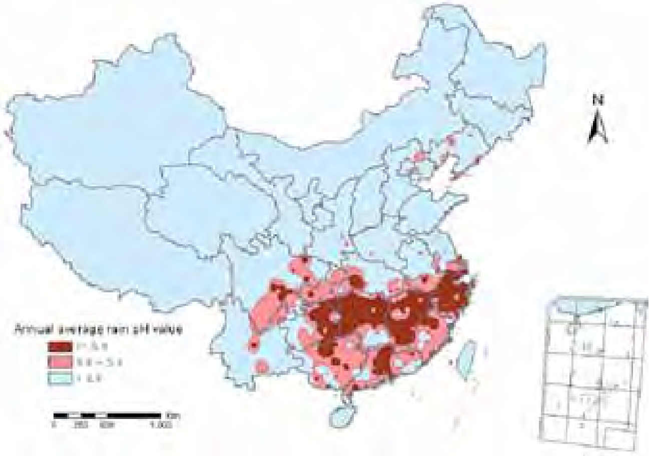
Acid Rain Surveys

Of the 527 cities surveyed for acid rain in 2004, 298 cities (or 56.5%) recorded occurrence of acid rain. High acidity of precipitation (pH less than 4.0) was recorded in Changsha, Changde, and Jishou in Hunan Province; Shaoguang in Guangdong Province; and Gao'an in Jiangxi Province. Incidence of acid rain was also 100% in the following areas: Changde of Hunan Province; Dexing of Jiangxi Province; and Lishui, Anji, and Kaihua of Zhejiang Province. In comparison to 2003 figures, the number of cities that experienced acid rain increased by 2.1 percentage points and the percentage of cities with acid rain incidence exceeding 80% was up by 1.6 percentage points. These and other data suggest that acid rain has intensified (SEPA 2005).

The distribution of acid rain areas (Figure 3.3) was basically stable when compared with that in previous years. Acid rain is mainly concentrated in Central, Southwest, East, and South PRC, with Central PRC experiencing the most serious acid rain. About 58.3% of the cities in Central PRC experienced acid rain, with 21.4% experiencing acid rain occurrence of more than 80% of rainfall events. Acid rain pollution also deteriorated in South PRC. A slight improvement was experienced in Southwest PRC (SEPA 2005).

FIGURE 3.3

Acid Rain Distribution Map of the PRC, 2004



Source: SEPA, 2005.

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[3] Air Quality in Asian Cities. Graphs compiled by CAI–Asia available at this link: http://www.cleanairnet.org/caiasia/1412/article-59689.html

[4] PM_{10} limits: 20 µg/m^3 (WHO 2005) and 40 µg/m^3 (EU 2000).

TABLE 3.2

Ambient Air Concentrations of Selected Cities in the PRC (in µg/m^3)

TSP	1997	1998	1999	2000	2001	2002	2003	2004	2005	Tendency
Shanghai	233	215	168	156	162	167	140			decreasing
Chongqing	199	234	204	248						inconclusive
Guangzhou		204	182	158	150	161	178			inconclusive
Tianjin	339	340	348	340	283	278				inconclusive
PM_{10}	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**Tendency**
Beijing			180	162	165	166	141	149		decreasing
Guangzhou					73	82	98	96		increasing
Guiyang				180			103	80		decreasing
Jinan							149	150	127	decreasing
Luoyang							209	175	127	decreasing
Shanghai				102	100	108	97	99		unchanged
Shijazhuang							171	123	132	increasing
Tianjin					167	138	133	111		decreasing
Urumqi							129	117	114	decreasing
Wuhan							120	130	116	inconclusive
Xi'an							135	142	129	inconclusive
SO_2	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**Tendency**
Beijing	125	120	80	71	64	67	61	55		decreasing
Chongqing	207	183	171	156			115	113		decreasing
Guangzhou		61	54	45	51	58	60	78		inconclusive
Guiyang				132			89	80		decreasing
Jinan							65	45	60	inconclusive
Luoyang							105	99	62	decreasing
Shanghai	68	53	44	45	43	35	43	55		inconclusive
Shijazhuang							89	89	55	inconclusive
Tianjin	80	82	68	56	76	69	73	73		decreasing
Urumqi							101	106	117	inconclusive
Wuhan							43	45	48	inconclusive
Xi'an							57	45	45	inconclusive
NO_2	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**Tendency**
Beijing (NOx)	133	152	140	126	127	136	132	119		decreasing
Chongqing	66	56	62	68			46	67		unchanged
Guangzhou					71	68	74	75		Increasing
Guiyang				27			19	24		inconclusive
Jinan							46	39	25	Decreasing
Luoyang							60	37	40	Inconclusive
Shanghai	69	67	63	61	63	58	57	62		unchanged
Shijazhuang							46	32	41	Inconclusive
Tianjin	42	43	45	43	53	46	52	52		unchanged
Urumqi							57	58	56	Inconclusive
Wuhan							49	52	52	Inconclusive
Xi'an							35	33	32	inconclusive

» Part Four

Impacts of Air Pollution

Air pollution impacts on health, environment, and economy, in most cases, are studied and measured separately. There is a growing tendency, however, to correlate all three in integrated assessments, such as the one employed in Shanghai and Beijing under the Integrated Environmental Strategy Program (USEPA 2006).

Health

WHO estimates that urban air pollution contributed to approximately 355,000 deaths and 2,504,000 years of life lost in 2000 in the Western Pacific Region B (WPRB) (WHO 2002). Since the PRC makes up 83% of WPRB, the health impact of outdoor air pollution in the PRC is substantial and warrants the attention of policymakers (see Table 4.1).

The estimates in Table 4.1 were obtained by applying a large cohort study's concentration-response function over the range of 7.5 µg/m^3 to 50 µg/m^3 for annual average concentrations of PM$_{2.5}$. As the PM$_{2.5}$ levels in the PRC are often well above 50 µg/m^3, different extrapolation functions and/or extrapolation over a larger range of concentrations could result in higher estimates.

TABLE 4.1

Burden of Disease from Urban Outdoor Air Pollution in Western Pacific Region B and the PRC, 2000

Region	Health End-point	Age Group	Deaths (000s)	Years of Life Loss (000s)
World	**Total**		**799**	**6,404**
WPR-B	Cardiopulmonary disease	≥30 years	317	1,992
	Lung cancer	≥30 years	32	309
	Acute respiratory infections	0-4 years	6	204
	Total		**355**	**2,504**
PRC	Cardiopulmonary disease	≥30 years	263	1,653
	Lung cancer	≥30 years	27	256
	Acute respiratory infections	0-4 years	5	169
	Total		**295**	**2,078**

WPR-B = Western Pacific Region B, PRC = People's Republic of China

Source: Cohen et al., 2004.

Although the above estimates of health impact have been based on studies in other countries, the impact of air pollution on public health in the PRC is well-documented (both in Chinese and in English). From 1980 to June 2005, 63 publications (in refereed journals) have been identified. The principal health outcomes studies in the PRC have examined mortality and respiratory-related symptoms and diseases. Other studies examined other outcomes, including biomarkers, birth outcomes, hospital admissions and outpatient visits, lung cancer incidence, and economic assessments (Health Effects Institute [HEI] 2006).

Environmental Impacts

Environmental impacts of urban air pollution extend well beyond the cities where air pollution originates. This is especially true for O$_3$,a secondary pollutant formed from NO$_x$ and HC in warm weather conditions. The highest O$_3$ concentrations can be found 50–70 kilometers downwind from the cities where NO$_X$ and HC originated.

The harmful effects of surface ozone on agricultural crops and other plants have been well documented for the United States and Europe; some studies have also confirmed the same impacts in the PRC. MOZART-2, a sophisticated atmospheric chemistry model, was used to simulate O$_3$ concentrations for 1990 and 2020 over Asia. Results showed that O$_3$ concentrations can be held responsible for 1%–9% yield loss in wheat, rice, and corn and for 23%–27% yield loss in soybeans for the PRC, Japan, and Republic of Korea. Assuming that there is no change in agricultural production practices, projections of O_3 concentrations for 2020 will cause an expected 2%–16% yield loss in wheat, rice, and corn and 28%–35% yield loss in soybeans (Wang and Mauzerall 2004).

The Government aims to maintain grain self-sufficiency to protect the livelihood of two thirds of the people in the rural areas. If not given due consideration, increasing urban air pollution will threaten and impact this food security policy.

Economic Impacts

A number of studies conducted in the 1990s have documented the economic costs of air pollution. Depending on the methodology used and assumptions applied, the studies projected an annual cost ranging from 0.5% to 7.1% of GNP.

In Shanghai, the health benefits to be derived from implementing various policies in controlling air pollution are estimated to range from $113 million to $950 million in 2010 and from $327 million to $2 billion in 2020. Similarly, the estimates derived for Beijing from air quality management measures will range from $270 million to $760 million for 2010 and from $380 million to $1 billion for 2020 (Chen et al. 2001).

Few studies so far have investigated the monetary costs of air pollution impacts on agriculture in the PRC. Economic losses due to damage caused by acid rain to forests and farmlands, which increased five times from 1996 to 2000, was estimated by SEPA at $13.25 billion in 2000 (Shah et al. 2000). Compliance with O_3 air quality standards in East Asia would increase yield by a value of $2.6 billion–$2.7 billion in grain revenues, a large part of which is in the PRC (Wang and Mauzerall 2004).

Episodes of DSS also have a substantial impact on the PRC economy. For example, the May 1993 DSS episode—which hit 1.1 million km^2 of the country—left 85 people dead, 246 more injured, 4,412 houses destroyed, 12,000 livestock dead or lost, and 273,000 hectares of cropland damaged. It was estimated to cost the PRC economy an equivalent of $66 million in 2003 currency exchange rates (ADB 2003).

Public Perception on Air Pollution

Cities, such as Shanghai, Beijing, Guangzhou, and Wuhan, were included in a survey conducted in 2004 to gather public perception on how air pollution affects their lives. When asked on whether they felt that the air quality was improving or not, 1,920 respondents from said cities were almost equally distributed in thinking that air quality was getting better (36%), getting worse (31%), and just the same (33%). A large majority (84%) of the respondents, however, considered air pollution a problem and 37% thought that the problem was out of control and that they could not do anything about it. About 87% would take action if they knew better how to contribute. Most of the respondents attributed air pollution to motor vehicles (70%) (Synovate 2005).

TABLE 4.2

Economic Losses Caused by Air Pollution

Studies	Base Year	Economy Losses (billion CNY)	Research Categories	GNP (%)
Guo & Zhang	1983	12.4		2.2
Xia	1992	57.9	Health, crops, animals, and materials	2.4
Sun	1992	60.5		2.5
Zheng et al.	1995	30	Health damage due to TSP pollution, crop, forest, and materials damage due to acid rain	0.5
Xu	1993	39.1	Health agriculture, acid rain, household upkeep (cleaning)	1.1
Smil	1999	15.1 ± 4.1		0.86 ± 0.16
World Bank	1995	44.88	Health effects from urban air pollution, damage from indoor rural air pollution; crop, forest, materials, and ecosystem damage from acid rain; lead exposure for children	7.1

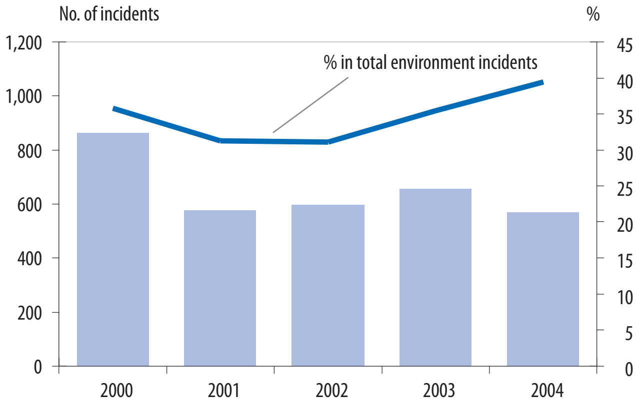
Source: He and Pan, 2003.

In the PRC, a mechanism allows the public to submit environment-related complaints to the authorities. Air pollution is one of the topics included. In Beijing, for example, air pollution-related complaints have been increasing steadily from 1999 to 2004, accounting for about 50% of all complaints. This may be viewed as an indicator that air pollution is worsening or, alternatively, that the public is more vigilant and aware of the air quality status in their cities.

Authorities in the PRC also take into account environmental incidents, which have decreased in number and have generally stabilized from 2001 to 2004 compared with 2000 counts. The relative share of air pollution-related cases from overall environmental incidents has been increasing from 2002 to 2004 (Figure 4.1).

FIGURE 4.1

Air Pollution-related Incidents in the PRC, 2000–2004



Source: PRC Statistical Yearbook (2005).

» Part Five

Air Quality Management

Legislation and Mandate

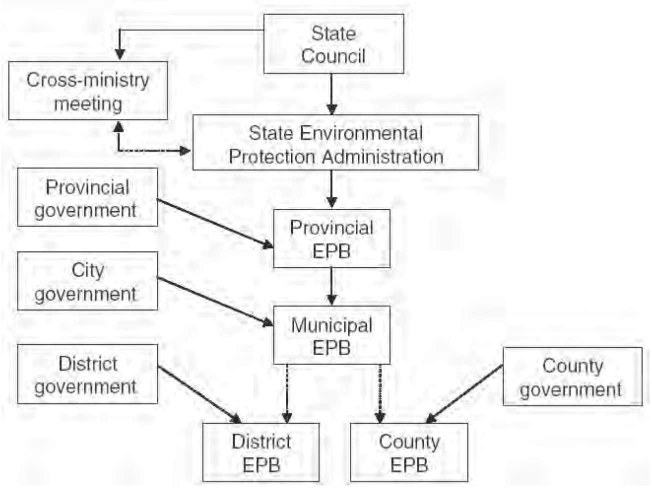
The Environmental Protection Law (EPL) of the PRC, adopted in 1989, is the country's primary law that provides the legal framework for the prevention and control of pollution. Specific to air pollution prevention, the country has adopted the 1987 Prevention and Control of Atmospheric Pollution Law (LPCAP), which was updated in 1995 and in 2000. LPCAP allowed the adoption of regulatory measures that include pollutant discharge fees; emission control and emission licenses; prohibition of industrial pollution; boiler emission standards; installation of dust removal devices; and regulating emissions from motor vehicles, including a ban on the use of leaded gasoline.

Under the environmental protection administrative system in the PRC, the State Environmental Protection Administration (SEPA), which is under the State Council, conducts unified supervision and management of environmental protection throughout the country. SEPA's local counterparts are Environmental Protection Bureaus (EPBs) or offices (EPOs) and they administer, supervise, and manage environmental protection activities at the provincial, municipal, county, district and, in some places, township levels (see Figure 5.1).

The primary responsibility for urban air quality management rests with SEPA's Pollution Control Department. SEPA can call upon the assistance of the National Environment Monitoring Centre, as well as other specialized departments in SEPA, and associated institutes, such as the PRC Research Academy for Environmental Sciences. Strong cooperation also exists with a range of universities of which the Tsinghua University is the most important in terms of research assistance, policy advice, and capacity building. The limited institutional capacity combined with the size of the country means that local city governments have a strong responsibility in taking the lead in implementing national level guidelines through the development and implementation of air quality management strategies.

FIGURE 5.1

Organizational Flowchart of Environmental Protection Responsibility in the PRC



Air quality management capabilities of cities vary considerably. Generally, cities in the coastal belt have better developed capacity than the Western cities. Several cities either have received or are still receiving assistance from bilateral development agencies to strengthen their air quality management systems. These agencies include NORAD (implemented through NILU[1]) for Taiyuan and Guangzhou; Sino-Italian partnership for Suzhou, Lanzhou, Urumqi, Beijing, and Shanghai; and EU commission for Jinan and Liaoning Province. To strengthen the air quality management capabilities of cities especially in the western part of the country, SEPA and CAI–Asia have jointly established the CAI–Asia PRC Project. This project works with Changsha, Chengdu, Chongqing, Guangzhou, Guiyang, Hangzhou, Harbin, Luoyang, Qingdao, Tianjin, and Urumqi.

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[1] Shanxi Province and the cities of Taiyuan, Datong, and Yangquan.

The PRC is the beneficiary of a large number of foreign-funded air quality programs and projects, part of which are at the national level while others have specific target provinces and cities.[2]

Ambient Air Quality Standards and Air Pollution Index

The National Ambient Air Quality Standards (NAAQS) of the PRC were put into effect in October 1996 and amended in January 2000. The standard limits are categorized into three Grades, whereby different functional zones are expected to comply with specific Grade limits. Cities are required to comply with Grade 2 of NAAQS. Table 5.1 compares the PRC standards with WHO guideline values. This table also shows that Grade 2 standards for SO_2, NO_2, and O_3 are lenient than the values set by 2005 updated WHO air quality guideline.

TABLE 5.1

PRC Standards vs. WHO Guideline Values (mg/m^3)

Pollutant	Averaging Time	Grade 1	Grade 2	Grade 3	WHO
SO_2	1 year	0.02	0.06	0.1	
	24 hours	0.05	0.15	0.25	0.20
	1 hour	0.15	0.5	0.7	
	10 min	-			0.5
TSP	1 year	0.08	0.2	0.3	
	24 hours	0.12	0.3	0.5	-
PM_{10}	1 year	0.04	0.1	0.15	0.02
	24 hours	0.05	0.15	0.25	0.05
NO_2	1 year	0.04	0.08	0.08	0.04
	24 hours	0.08	0.12	0.12	-
	1 hour	0.12	0.24	0.24	0.20
CO	24 hours	4	4	6	
O_3	1 hr	10	10	20	
	8 hours				0.10
	1 hr	0.16	0.20	0.20	-

Notes:

Grade 1 standards apply to specially protected areas, such as natural conservation areas, scenic spots, and historical sites.

Grade 2 standards apply to residential areas, mixed commercial/residential areas, cultural, industrial, and rural areas.

Grade 3 standards apply to special industrial areas.

Source: GB 3095–1996 and its first amendment and WHO, 2005. (The Chinese version can be downloaded from http://www.sepa.gov.cn/image20010518/5298.pdf)

Management of Mobile Sources

Vehicle Emission and Fuel Quality Regulations

The PRC has adopted a road map for new vehicle standards, laying out a schedule to introduce vehicle emissions standards equivalent to the Euro emissions standards for light-duty vehicles. Table 5.2 shows the country-wide schedule of the implementation of vehicle emissions standards in the PRC and in Beijing. The State Council of the PRC has approved, in December 2005, the implementation of Phase III in 2005 and Phase IV in 2007 standards for Beijing for light-duty and heavy-duty vehicles. The State Council has required Beijing to ascertain the availability of corresponding fuel quality by the time of implementation.

Other major cities are closely following the move of Beijing to implement stricter standards. Guangzhou has announced the adoption of Phase III standards in September 2006 and became the second city to implement Euro 3 equivalent standards in the PRC. Shanghai, which currently has Euro 2 equivalent emission standards for vehicles that came into force in 2003, is also considering the adoption of Euro 3 standards and has requested the approval of the State Council for its implementation. Shanghai is also implementing strict measures to restrict the circulation of non-Euro 2 compliant vehicles in some major road arteries.

While a road map for vehicle emissions has been developed, this is not yet the case for fuel standards. Consequently, the implementation of vehicle emission standards is potentially endangered because of the possibility of nonavailability of cleaner fuels at the time the stricter emission standards come into force. The key constraint is the sulfur level in gasoline and diesel. To achieve the emission reductions required under Euro 4, sulfur levels in gasoline and diesel must be reduced to 50 parts per million. The reduction of sulfur levels in diesel to the required levels poses a large challenge to PRC's refining industry.

PRC's inspection and maintenance system for in-use, on-road vehicles has recently been tightened especially the emissions

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[2] An overview of the programs and projects related to air quality management in the PRC is available at the CAI–Asia website (see http://www.cleanairnet.org/caiasia/1412/article-70690.html).

TABLE 5.2

Schedule of Vehicle Emissions Standards in the PRC and Beijing

	PRC		Beijing	
	Type Approval Effective From	Production Conformity Effective From	Light Vehicles Fueled by Gasoline and Gases Effective From	Light Vehicles Fueled by Diesel Effective From
Phase I (~Euro 1)	2000.01.01	2000.07.01		
Phase II (~Euro 2)	2004.07.01	2005.07.01		
Phase III (~Euro 3)	2007.07.01	2007.07.01	2005.12.30	
Phase IV (~Euro 4)	2010.07.01	2010.07.01		2007.01.01

Source: GB 18352.1-3.

TABLE 5.3

Emission Standards for In-use Gasoline Vehicles

		CO,%		HC, ppm	
Gasoline Vehicles		Light Duty	Heavy Duty	Light Duty	Heavy Duty
Produced before 1 July 1995	Idle speed	4.5	5.0	1200	2000
	High speed idle	3.0	3.5	900	1200
Produced after 1 July 1995	Speed idle	4.5	4.5	900	1200
	High speed idle	3.0	3.0	900	900
First type of light-duty vehicles[a] produced after 1 July 2003	Speed Idle	0.8		150	
	High speed idle	0.3		100	
Second type of light-duty vehicles[b] produced after 1 October 2000	Speed Idle	1.0		200	
	High speed idle	0.5		150	
Heavy-duty vehicles produced after 1 September 2004	Speed idle		1.5		250
	High speed idle		0.7		200

[a] Passenger vehicles with 4 wheels (or 3 wheels, with gross weight not more than 1 ton), passenger vehicles with 6 or less wheels and with weight not more than 2.5 tons.

[b] Other light-duty vehicles.

Source: GB 18285-2005.

TABLE 5.4

Emission Standards for In-use Diesel Vehicles at Free Acceleration Condition

Produced	Limit for smoke	
Before 30 June 1995	5.0Rb	Filter type smokemeter
1 Jul 1995–30 Sep 2001	4.5Rb	
1 Oct 2001–1 Jul 2005	Natural inlet air type: 2.5m^{-1}	Smoke opacimeter
	Turbo charging type: 3.0m^{-1}	
After 1 July 2005	Limits of type approval + 0.5m^{-1}	Smoke opacimeter

Rb = Filter or Bosch smoke meter unit.

Source: GB 3847-2005.

TABLE 5.5

Emission Standard for In-use Motorcycle and Mopeds Under Idle Conditions

		HC, ppm	
	CO, %	4-stroke	2-stroke
Motorcycles produced before 1 July 2003	4.5	2200	8000
Motorcycles produced after 1 July 2003	4.5	1200	4500

Source: GB14621-2002.

TABLE 5.6

Emission Standards for In-use 3-wheeled Vehicles and Low-speed Freight Vehicles

Phase	Manufacturing Date	Rb	
		Equipped with Single-cylinder Diesel Engine	Equipped with multi-cylinders diesel engines
I	Before 1 July 2002	6.0	4.5
II	Between 1 July 2002 and 30 June 2004	5.5	4.5
III	After 1 July 2004	5.0	4.0

test component in the newly issued 'criterion' of vehicle maintenance, inspection, and diagnostic technology. The program requires all vehicles to be periodically inspected, maintained, and repaired as required (ADB 2006a). Tables 5.3 through 5.6 show the in-use emissions standards for gasoline and diesel vehicles.

From 1 July 2005, the limits and measurement methods under two-speed idle conditions for in-use gasoline vehicles became mandatory. At the same time, in areas where vehicle emission pollution is serious, the administrative departments at the provincial level can adopt the methods under simple driving mode conditions for in-use gasoline vehicles and the methods under lug down conditions for in-use diesel vehicles. Some pilot cities, such as Beijing, Jinan, Suzhou, Harbin, etc., have begun their trials.

To complement and support the enforcement of in-use vehicle emission standards, SEPA has engaged in consultations with different stakeholders at the national and local levels. In doing so, SEPA is actively reaching out to the international development community, such as the World Bank and the United States Environmental Protection Agency to provide assistance in the development of more effective in-use vehicle emission control strategies.

Fuel Economy Standards

In 2002, the Government decided to establish a framework, including government cooperation, research team, and international support, to develop vehicle fuel efficiency standards and regulations to help control the national total oil consumption and keep it less than 400 million metric tons per year.

The first fuel efficiency standard, Fuel Consumption Limits for Light-Duty Passenger Vehicles, was published on 2 September 2004 and was implemented in July 2005. The fuel economy standards have maximum values that vary according to vehicle weight.

With the implementation of this fuel economy standard, it is forecast that 13 million tons (t) of fuel will be saved in 2020 and 31 million t in 2030. Discussions on more stringent fuel economy standards to be put into force possibly after 2009 are ongoing. A further 25% reduction in vehicle fuel consumption to 5.6 liters/100 kilometers (km) (the European requirement for 2008) could be established by 2012 for light-duty passenger cars and a fuel consumption level of 4.8 liters/100 km could be developed to catch up with Europe and Japan by 2016. If these recommendations were implemented, an additional 19 million t of oil would have been saved in 2020 and 60 million t in 2030 (ADB 2006a).

Alternative Fuels for Vehicles

The PRC had a total of 97,200 natural gas vehicles (NGV) as of January 2005, with light-duty vehicles (cars) accounting for 48% and buses, 52%. Monthly sales for natural gas averaged 92,000,000 cubic meters. The country has a total of 253 public and 102 private natural gas refueling stations; another 230 are under construction (Asian NGV Communications 2006).

The Government actively promotes the use of alternative fuels, including liquefied petroleum gas (LPG), to address rising prices of conventional fuels and air pollution from vehicles. By 2001, there were 84,673 LPG vehicles in the PRC. Several filling stations have also been constructed in cities to service the current LPG-fueled vehicles.

Although relatively small in terms of overall numbers, compressed natural gas (CNG)- and LPG-fueled vehicles are starting to make an impact on vehicle emissions in selected cities. This is due to the emphasis in government policies targeting buses and other highly used fleet vehicles, such as taxis, for CNG and LPG use.

Biofuels are starting to receive more attention in the PRC as in other countries in Asia; however, so far they do not play a major role as a transportation fuel. The PRC has unfolded a trial use of bio-ethanol gasoline. Currently, eight provinces have made E10—a mixture of 10% ethanol and 90% gasoline—mandatory at local petrol pumps. At the same time, the PRC has become the world's third largest ethanol producer (after Brazil and the United States) with an annual output of 10.2 million t of bio-ethanol gasoline, accounting for 20% of its overall gasoline consumption. The country plans to build four major manufacturing plants of bio-ethanol, with annual yield capacity of about 1 million t (China Daily 2006, PDO 2006b). The National Development and Reform Commission has proposed that by 2010, consumption of substitute fuels will reach 2 million t and by 2020, will reach 10 million t, accounting for 15% of the transport sector's fuel demand (Liu 2006).

Electric Bicycles and Scooters

The production and sales of electric bicycles and scooters have soared rapidly in the last 5 years. Annual electric bike sales in the PRC grew from 40,000 in 1998 to 10 million in 2005 (Weinert et al, 2006) and largely brought about by legislations banning gasoline-fueled scooters and bicycles, introduced from 1996 onwards in several major Chinese cities, including Beijing and Shanghai.

Electric bikes are gaining an increasing share of two-wheeled transportation in the PRC. In Shanghai, an estimated 1 million electric two-wheelers ply in the city (Fairley 2005). In cities, such as Chengdu and Suzhou, electric bikes have reportedly surpassed the share of regular bicycles (Weinert et al, 2006).

Electric bikes, which use lead batteries as the main source of stored energy, are touted as a zero emission form of transportation that can help improve urban air quality. However, strong concerns that the environmental impacts of the emissions of lead—considering the limited lifetime of a lead battery used for electric bikes—may negate some of the benefits derived from the absence of tailpipe emissions.

Urban Public Transportation and Non-Motorized Transportation

The 11th Five-Year Plan, which started in 2006, will prioritize the development of public transportation with mass rapid transit (MRT) as a key transport mode in megacities. A State Council guideline issued in September 2005 included the following policy directions[3]:

- A public-transportation-oriented city development and land allocation should be established.
- Integrated systems between different modes of transport: normal buses, bus rapid transit (BRT) buses, and rail trains should be established.
- The cities, as appropriate, should develop BRT system combined with the rebuilding of the urban street network.
- The public transportation enterprises should scientifically assign buses and formulate operation map; increase the bus density; shorten the waiting time; choose safe, comfortable, energy-efficient, and environment-friendly buses; and scrap the high-polluting and low-technology buses.
- The government fund to be used in urban transportation construction shall lean toward public transportation.
- The people's governments of the cities shall implement economic subsidy and compensation policy for the public transportation.
- The price of public transportation shall be determined scientifically and reasonably by paying attention to both economic benefits and social benefits and considering the business cost of the enterprises and the paying capacity of the mass. The utilization rate of the public transportation should be increased.

Limited municipal government budgets will make it difficult for a large number of cities to develop extensive and comprehensive urban rail-based projects, which typically require substantial investments but which are often still the preferred solution in many of the PRC's cities (ADB 2005). Instead, it is more likely that the bulk of cities in the PRC will have to focus on improvements of bus systems, including the development of BRT systems.

Metros and Light-rail Rails. Urban rail systems (including metros [subways], light rails, and urban heavy rails) are currently operating in Beijing, Changchun, Chongqing, Dalian,

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[3] The State Council Office, 23 September 2005, Suggestions on Prioritizing Urban Public Transportation Development.

Guangzhou, Nanjing, Shanghai, Shenzhen, Tianjin, and Wuhan, with a total length of 420 km. A number of other large- and medium-sized cities are considering new or expanded MRT systems as the backbone of their integrated transportation network plans. Fifteen cities have proposed building MRT systems to the State Council as part of their urban transport development plans. These MRT projects could lead to the construction of 65 routes totaling 1,700 km in length at a total investment cost of about CNY600 billion over the next decade (ADB 2005).

Bus Rapid Transit. In 2005, the PRC has been the scene of the most frenetic BRT development in the world. BRT systems were being planned or constructed in several major cities, such as Beijing, Hangzhou, Guangzhou, Chengdu, Xi'an, Kunming, and Jinan. A Construction Ministry decree and ongoing promotional efforts by the Energy Foundation and others have played an important role in this rapid expansion. The PRC Sustainable Transportation Center was established by the Energy Foundation to take the lead in coordinating and guiding the efforts to promote BRT systems in the PRC (ITDP 2005).

Nonmotorized Transport (Pedestrians and Cyclists) . Efforts to segregate vehicle and nonmotorized traffic have been made in most cities in the PRC. The country is known for having a very large number of bicycles, especially in urban areas, such as Beijing and Hangzhou. Up to the early 1990s, the number of bicycles in major urban areas compared to the population was 1 bicycle per person (Traffic Management Bureau in Beijing and Hangzhou, cited in Kenworthy and Hu 2002). Since then, the number of cyclists has dropped as rapidly as private car ownership has expanded. As the city authorities make it harder for cyclists to get around, the Ministry of Construction of the PRC has recently indicated its opposition to the elimination of bicycle lanes and has ordered cities to restore them (China View 2006d).

Overall, local government policies have been found to favor infrastructure requirements and the use of cars and other forms of motorized transport over the use of bicycles and walking.

BOX 5.1

BRT in the PRC

Beijing

The Beijing BRT system—only 5.5 km long and carried less than 1,500 daily passengers during its opening in 2005—was initially not fully successful. However, after expanding the first corridor to 16 km and canceling several competing bus lines in January 2006, the situation has greatly improved. Ridership has increased to about 75,000 passenger boardings per weekday in March 2006, and on some days has reportedly exceeded 100,000 passengers.

The second Beijing BRT line—starting in the Chaoyangmen commercial business district area and extending westward along Chaoyang Rd to Dingfuzhuang—has already been identified and could capture significant passenger demand. A third BRT line to the north of the city center, which will serve the Olympic Park area, is also under implementation.

Hangzhou

The country's longest BRT line, Hangzhou BRT No.1 line, began trial operation on 26 April 2006. During the 76-day trial operation (from 26 April to July 10), the line carried a total of 2.87 million passengers, with an average daily ridership of 380,000 passengers and average speed of 25.3 km/h. As in Beijing, the Government paid for the BRT buses and provides an operational subsidy to the system's operator.

Xi'an

Xi'an City started its first BRT line civil works procurement in July 2006. According to the project construction plan, the first BRT line is 18.12 km in length, which is on the east–west traffic corridor of the city, connecting western electric district, and the central city commercial area with the eastern textile town. The first phase of the BRT line is 4.69 km inside the Ming Dynasty City Wall and is scheduled to start operation by the end of 2008. The design shows that the 4-meter wide BRT lines are in the middle of the street in each direction and are expected to carry 68,000–110,000 passengers per day in each direction when they become operational by 2008. The BRT Project preparation has been technically and financially supported by the Energy Foundation.

Source: CAI–Asia update based on ITDP (2005) Sustainable Transport e-update. December 2005. No. 21.

Management of Stationary Sources

Emissions Standards for Stationary Sources

The PRC's emission standards for stationary sources relating to air pollutants can be divided into two categories: (1) those for particular industries or particular types of pollution and (2) general standards specified in the Integrated Emission

Standard of Air Pollutants (IESAP). These standards were laid down by SEPA based on the Law on the Prevention and Control of Atmospheric Pollution. Emission standards are at the national level, but the local government of a particular region can require more stringent standards.

Integrated Emissions Standard of Air Pollutants (IESAP). The PRC's IESAP was enacted in 1996 and came into effect in 1997. The standard prescribed two sets of emission limits—one set for new facilities installed on or after 1 January 1997 and another set for existing facilities installed prior to that date. As many as 33 air pollutants—ranging from general pollutants, such as SO_2 and NO_x, through to hazardous heavy metals and organic chemical compounds, and to nonmethane hydrocarbons, which produce photochemical oxidants—are covered in the integrated standard.

Pollutant emission levels are regulated according to three measurement categories: (1) concentration (mg/m^3) at a standard state of 0°C and pressure of 1 atmosphere, (2) emission rate per hour (kg/h), and (3) concentration of monitored fugitive emissions. Emission rates are specified by stack height and by the air quality level applicable to the location of the emission source. The air quality levels are divided into Grade 2 and Grade 3, where Grade 2 standards are stricter than Grade 3. No emission limits are set for Grade 1 because installation of new facilities in an area ranked as Grade 1 is not permitted by law. As new plants are required to meet both the emission concentration standard and the emission rate standard, dilution by air is not permitted.

The standards also cover the concentration of monitored fugitive emissions, released into the atmosphere without passing through a smokestack. Fugitive emissions are measured at the perimeter of the stationary source. Methods employed to measure their emission rates and concentrations must comply with SEPA regulations.

Particular Type of Industry. Stationary sources of air pollution are classified as boilers, thermal power plants, industrial kilns and furnaces, coke ovens, and cement plants. The PRC has promulgated and implemented a series of air pollutant emission standards for stationary sources (http://www.zhb.gov.cn/english/). In addition to these specific emission standards, these sources are also required to comply with IESAP.

Sulfur Dioxide Control

The first general measure to address SO_2 emissions dates back to 1982 when the pollution levy was applied to industrial SO_2 emissions. In April 2000, the People's Congress adopted sweeping changes to the 1987 Air Pollution Prevention and Control Law (APPCL) that incorporate the policies and measures developed during the 1990s and provide a stronger legal basis for their implementation. These changes focus regulatory efforts on the most polluted areas, changing the emphasis of control from emission rates to total emission discharges, shifting the base of the pollution levy from excess emissions to total emissions, and establishing emission permits as the vehicle by which national policy would be implemented at the local level.

This last provision was an important step away from a centrally directed, project specific approach to a more decentralized and comprehensive structure for controlling SO_2 emissions. The conditions governing emissions are to be specified in permits issued to individual facilities by the local authorities. Facility permits were tried on a pilot project basis in 16 cities starting in 1991, and the basis for generalizing their use was provided by the year 2000 revisions of APPCL. Although nontradable, facility permits are correctly seen as a precondition for emissions trading and, in fact, some limited trading has occurred in the 16 trial cities. The three principal components of existing SO_2 emissions control policy are the Pollution Levy System (PLS), Two Control Areas (TCA), and Total Emissions Control (TEC).

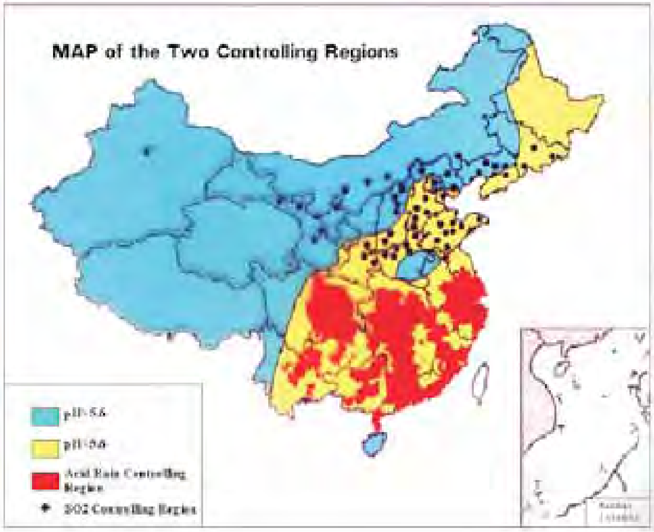
Pollution Levy System versus the Total Emission Control. One of the PRC's responses to air pollution has been its PLS, which is based on the polluter pays principle. In the early 1980s, PLS was officially incorporated into law and gradually expanded to cover the entire country. Although supervised by the central government, PLS is implemented by the provincial and local governments. Self-reporting is quite extensive in the Chinese system. Polluters report their emissions, and the local environmental authorities are responsible for verification. Data cleared by the environmental authorities are used for assessments computed from the levy calculation manual. The levy can be reduced or even eliminated at the discretion of local regulators after appropriate inspections. The levy may also be postponed if the polluter cannot afford to pay it, although reductions or exemptions are not allowed in such cases. In PLS, the levy was only charged on the single pollutant that most exceeded the standards. The amount to be paid by emission sources is often low compared to the cost of reducing emissions. Most emission sources in the PRC prefer pay the pollution levy rather than invest in other technical solutions, such as purchasing desulfurizing scrubbers or washed coal.

The concept of Total Emission Control (TEC) was introduced to PLS in 2000 to further reduce SO_2 emissions. TEC sets a "ceiling" on SO_2 emissions, addresses transboundary emissions issues, and changes the concentration-based principle to a load-based principle. The ceiling in TEC is not a fixed cap, but it can be seen as a measure for judging if the pollution controls are effective. The reformed PLS incorporating the TEC concept is trying to achieve both environmental and administrative benefits. A levy rate is made of each pollutant according to its effects. Because a uniform rate is charged, the reformed PLS simplifies the task of levying and avoids ignoring the environmental harm of the sources.

The primary PLS allows industries to discharge the pollutants as much as they want if their pollution concentration is lower than government standards. The reformed PLS limits the discharge to within a specified level and levies the charge when any pollution is discharged. The levy collection is proportional to the total discharged pollution. The 10th Five-Year Plan (2001– 2005) has set a national TEC ceiling for 2005 of 18 million t of SO_2 for the PRC (about 10% below 2000 level), and a more restricted total of 10 million t for Two Control Zones.

FIGURE 5.2

Map of the Two Controlling Regions



To strengthen controls on pollution caused by SO_2, two control areas (TCA)—designated as "SO_2 control zones" and "acid rain control zones"—were set up in 1998. The PRC adopted national legislation to limit ambient SO_2 pollution and halt the increase of acid rain. The program became known as the "Two Control Zones (TCZs) Plan," because of its geographical coverage of (1) cities with high ambient levels of SO_2 that were subject to ambient concentration compliance requirements; and (2) regions with serious acidification problems that were required to reduce the incidence of acid rain through reductions in SO_2 emissions (SEPA 2002).

The TCA component of SO_2 control policy is not an instrument like the pollution levy for affecting abatement behavior, but rather a means for prioritizing SO_2 control efforts. It designates the standard and, thereby, the cities and regions that should receive extra attention and resources from the national government. The SO_2 Control Zone comprises cities in North PRC where the ambient SO_2 concentration exceeds 60 µg/m^3. The Acid Rain Control Zone includes areas in South PRC where the pH value of precipitation is lower than 4.5 and sulfur deposition exceeds the critical load. Within the two control areas, certain municipalities are designated as "key," and are slated to receive more aggressive emissions control targets.

BOX 5.2

The Clean Energy Action Plan

At the end of 2001, the Government of the PRC initiated the Clean Energy Action Plan to control air pollution caused by coal combustion. Eighteen pilot cities were chosen to promote clean-energy sources and clean-energy technologies.

The first step in the plan was to assess the status of energy consumption and environmental pollution in the pilot cities. The results showed that in 2000, total consumption of primary energy was 207.6 Million tons of coal equivalent (Mtce), average consumption of primary energy per city was 11.5 Mtce, and average coal consumption per city was 7.7 Mtce. The proportion of coal consumption in 13 of the 18 cities was more than 60%. Oil consumption per city averaged 2.3 Mtce; oil consumption in seven cities was more than 20%. The average natural gas consumption per city was 2.7 billion cubic meters; gas consumption in only two cities was more than 10%.

In 2000, mean coal consumption was about 64%; oil and oil products accounted for 27%; and the total of natural gas, hydropower, nuclear power, and wind power was about 9%.

It is expected that by 2005, as a result of the implementation of clean-energy sources and clean-energy technologies, the consumption of coal for primary energy will have been reduced to 60%; oil and oil products will increase to 29%; natural gas will increase to 5%; and hydropower, nuclear power, and wind energy will be about 6%.

Source: Fan and Yu 2004.

Few power plants or industrial coal users have adopted specific sulfur-emission control technologies.[4] According to SEPA, the major targets on environmental protection during the recently completed 10th Five-Year Plan (2000–2005) had not been achieved. The PRC had set a target of cutting SO_2 discharges by 10% in 2000–2005, but industrial SO_2 is still increasing. According to SEPA, this is due to lack of awareness, insufficient planning, and a weak legal framework.

The national and local SO_2 emission reduction goals in the period of the 11th Five-Year Plan (2006–2010), decided upon by SEPA on 15 May 2006, call for a 10% emission reduction goal that must be realized by 2010. The principles of emission reduction task distribution are macro control, total quantity reduction, identified priorities, and different requirements in different regions. The other consideration factors include emission benchmark, emission intensity, and reduction capacity of different regions.

Management and Emission Control in the Energy Sector

The PRC's Law on Energy Conservation was approved in November 1997 and legislated on January 1998. It has been the country's primary law governing the energy sector. A more comprehensive and updated Energy Law for the PRC is still in the formulation process and is expected to be available in early 2007. This planned Energy Law is expected to reflect the strategic goals of energy conservation under the 11th Five-Year Plan (2006–2010), which targets that energy consumption per unit of gross domestic product (GDP) will be down 20% its 2005 level in 2010 and the total discharge of major pollutants down 10%.[5]

The 11th Five-Year Plan further calls for policy that prioritizes energy efficiency; diversification of energy sources with coal as major source of supply; strengthen exploitation of petroleum and natural gas but develop gradually alternative forms of energy to petroleum; encourage hydropower development; further development of nuclear power generation and accelerate research; and scale up utilization of wind, solar, and biomass energy and other renewable energy.

A Renewable Energy Law of the PRC, implemented in January 2006, provides a policy framework to develop PRC's renewable energy resources, such as wind power. By 2010, renewable energy, excluding large hydropower, will account for 5%f of the PRC's total primary energy consumption. The percentage is expected to rise to 10% by 2020. Abundant wind energy resources give the country the potential for mass-produced wind power. Prior to this Renewable Energy Law, the Government had already invested CNY1.5 billion from 2001 to 2005 to fund installation of 200,000 units of small wind generators to generate power for agriculture and pastoral areas. The national installed capacity of wind energy is expected to increase by 1 million kilowatts (kW) every year and to reach 20 million kW by 2020. Also, Asia's largest demonstration base for solar heating and cooling technologies in Yuzhong County, Gansu Province, has become the training center of applied solar technologies for developing countries (Gov.cn 2006b). The PRC is set to spend $200 billion on renewable energy over the next 15 years to increase the share of renewable energy in total primary energy consumption to 15% by 2020 compared with only 7% in 2006 (China Daily 2006, SEPA-Vehicle Emission Control Center [VECC] 2006).

Emissions Trading

The PRC is experimenting with total emissions control (TEC) combined with emissions trading to reduce SO_2. Emissions trading use market-based mechanisms to encourage emissions reductions at the lowest possible economic cost and of which policies are modeled on the "cap and trade" system used in the United States to control acid rain. To accomplish emissions trading, environmental authorities first cap pollution from factories and power plants. If the emissions level is below the cap, the source accumulates credits or permits toward future emissions, or trade with other sources who are unable to meet the cap. Thus, sellers of credits are compensated for environmental protection efforts, and purchasers have an expanded emission quota.

In 1999, SEPA and the United States Environmental Protection Agency (USEPA) began a collaborative study to assess the feasibility of introducing SO_2 emission trading in the PRC. This study began with significant discussions about the theories, conditions, foundations, and methods of emissions trading. The project further explored the opportunities and barriers to implementing SO_2 emissions trading in PRC's power sector. Through the collaborative effort, several workshops

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[4] Urbanization, Energy, and Air Pollution in PRC: The Challenges Ahead—Proceedings of a Symposium (2004), http://www.nap.edu/openbook/0309093236/html/79.html

[5] Facts and figures: PRC's main targets for 2006–2010, http://english.gov.cn/2006-03/06/content_219504.htm.

and training activities have been conducted. As a result, a number of Chinese management and research personnel have a much better understanding of how emissions trading works and the conditions necessary for an effective program. The collaborative effort has promoted emissions trading in the PRC.

Management of Area Sources

The Government of the PRC has taken concrete measures to combat desertification, which impacts the intensity and frequency of DSS that plague the country. One of the important measures is the Chinese government's ratification to the UN Convention to Combat Desertification (CCD) in December 1996. As a follow-up, a PRC National Committee to Implement the UN CCD (CCICCD) was set up and a PRC National Action Program (NAP) to Combat Desertification was also prepared (China Desertification Information Network 2006). In addition, the Government also earmarked CNY54 billion (about $6.5 billion) for a 10-year program to address the DSS concern in the northern PRC (ADB 2002).

» Part Six

Conclusion

No country in Asia faces a larger challenge in addressing urban air quality issues than the PRC. The combination of an enormous nation, population and economy, rapid urbanization, economic growth, industrialization, high demands for energy, and urban mobility are major issues. In addition, DSS are also exerting a substantial pressure on the urban air quality of northern Chinese cities.

The highest concentrations of PM and SO_2 in cities in the PRC are among the highest recorded in cities in the world.

Trends of APIs from 1999 to 2004 suggest that air quality in Chinese cities is generally improving, although not in all cities. This is confirmed by the percentage increase of cities complying with Grade 2 (from 33.1% in 1999 to 38.6% in 2004). However, the actual ambient air quality levels for PM_{10}, SO_2, and NO_2, though generally improving, are still above the WHO guidelines. PM is the most important air pollutant in most Chinese cities. In 2004, 46.8% of the cities were unable to meet Grade 2 of the PM_{10} NAAQS while 14.3% of the cities were unable to comply with Grade 3. Acid rain continues to affect large areas of the country and, in some cases, its intensity is still increasing.

Unlike most countries, PRC's urban air quality issues are associated with a diverse range of emission sources, including industrial, vehicle, and diffuse sources.

To improve urban air quality, the Government has established continuous ambient air quality monitoring networks in its major cities. As of June 2004, 688 automatic monitoring stations were operating in 234 cities. It has also established acid rain monitoring stations in 527 cities and six special sandstorm monitoring sites along the major routes of sandstorms in North PRC's Inner Mongolia.

The relatively poor air quality in many cities in the PRC is associated with a high burden on public health and the environment. A considerable number of studies have estimated the heavy impacts and costs of air pollution to the nation. The scale of the emissions has led to regional concerns about transboundary air pollution.

The high economic growth over the last 20 years has enabled millions of Chinese to achieve personal motorized mobility. Although efforts have been made to increase and improve public transportation, private vehicle ownership is expected to increase up to 15 times in 2035. Although the Government is actively pursuing stricter emissions standards for vehicles and improved fuel quality and fuel economy standards, public transportation will require considerable investment and improvement if air pollution is to be adequately addressed.

The high demand for energy in the PRC has intensified the use of coal. Coal from the PRC has variable and some high levels of sulfur that contribute to SO_2 emissions. From 1995 to 1999, emissions of SO_2 appear to have declined due to decreases in coal consumption, especially in the use of high-sulfur coals. However, since 2000, the emission levels of SO_2 have increased following the increase in coal consumption driven by the rapid growth in electricity demand.

This has prompted the Government to underscore its commitment to reduce emissions from industrial and power sectors by highlighting its SO_2 control policy in the 11th Five-Year Plan. The country is implementing a comprehensive policy to reduce SO_2 emissions from industries through several measures, such as a pollution levy system; total emissions control policy that sets a ceiling on SO_2 emissions; a focus on improvement of end-of-pipe technologies; and emissions trading. These combined measures aim to achieve a reduction of SO_2 emissions of 10% in absolute terms. NO_x emissions regulations for coal combustion also need to be developed and enforced.

Air quality management capabilities in PRC cities vary considerably. Generally, cities in the coastal belt have better developed capacity than western cities. Several cities are benefiting from the assistance provided by bilateral and multilateral development agencies to strengthen their air quality management systems.

To meet the air quality goals for the coming years, improvements will need to be made in the monitoring of air quality, the capacity to develop and implement air quality management plans at the national and local levels, and coordination among relevant bureaus and agencies at different levels of government in implementing and developing air quality management policies.

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