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Atmospheric environmental protection in China: Current status, developmental trend and research emphasis

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Abstract

Atmospheric environmental quality in China has been improving due to a variety of programs implemented by the Chinese government in recent decades. However, air pollution is still serious because of rapid socioeconomic development and increased energy consumption. Atmospheric environmental problems appear to be complex and regional in nature, and China's climate is aggravated by global climatic change. Air pollution originates from multiple sources and the effect on public human health will increase. The influence of acid rain in southern China will be long term, and the impact of climate change will rise. In order to reduce the adverse effects of air pollutants on the environment, the total number of emission sources from major industry, fine particle pollutants, SO_2 emissions from power plants and the vehicle exhaust must be lowered and strictly controlled. The energy structure will affect the quality of the atmosphere for a long time. Increased energy efficiency, optimization of energy structure and the generation of a sustainable consumption and production patterns will provide opportunities to resolve regional and the global environmental problems.

Keywords: Atmosphere; Environmental protection; China

1. Introduction

Air pollution is a serious environmental problem worldwide, especially in the developing countries like China. Most cities suffer from poor air quality, which has received increasing attention in the past decade (Mayer, 1999). Since the late 1970s when China started its economic reform, it has achieved rapid socioeconomic growth, industrialization, increased energy consumption and urbanization. The urban population increased by 15% from 1990 to 2004 (NBSC, 2005a). The total energy consumption of China increased about 200% from 1980 to 2004, as shown in Fig. 1 (NBSC, 2005b). Urbanization has improved societal development, industrialization and the modernization of the nation; however, it has led to substantial pressure on public facilities and natural resources. As a result, air pollution in many cities has deteriorated since the 1980s. To prevent the urban atmospheric environment from worsening, a variety of abatement strategies have been implemented by the Chinese government and the air quality standards (Chinese National Ambient Air Quality Standards—CNAAQS) have become more stringent. Compared with the National Ambient Air Quality Standards (NAAQS) of the US Environmental Protection Agency (EPA), generally, the revised monitoring standard used in the US was found to be more frequent and the standard values for the mass concentration are higher as compared to those used in China. However, the control of particulate matter (PM) is more stringent in the US. The detailed comparison is given in Table 1.

Although control measures have mitigated air quality deterioration in China, air pollution remains a serious environmental concern having been transformed from traditional coal-burning pollution to mixed source pollution. This paper discusses the current status and future trends of air quality in China and identifies the research emphasis for atmospheric environmental protection.

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2. Current status of air quality in China

2.1. Improvement in atmospheric environmental quality in China

In recent years, the atmospheric environmental quality in China has been improving. According to the Report on the State of the Environment in China (SEPA, 1990, 1995, 2000, 2005), the national urban atmospheric average concentration of total suspended particles (TSP) decreased from 0.323 mg/m^3 in 1995 to 0.270 mg/m^3 in 2000 while the average concentration of SO_2 and NO_x dropped from 0.091 and 0.048 mg/m^3 in 1995 to 0.049 and 0.037 mg/m^3 in 2000, respectively (Fig. 2). The percentage of cities exceeding Grade II of the CNAAQS decreased from 75.4% in 1991 to 61.4% in 2004, and the percentage exceeding Grade III improved from 53.8% to 20.2%, as shown in Fig. 3.

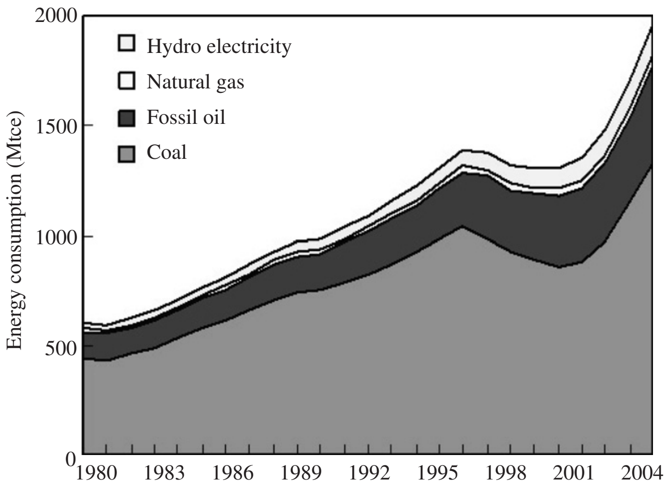

Fig. 1. Energy consumption growth and structure in China from 1980 to 2004.

The air quality of 15 key cities including Guiyang, Shenyang, Lanzhou, Chengdu and Nanjing were also improved. In Beijing, the capital of China, the air pollution level was remarkably reduced with the number of days reaching Grade II of the CNAAQS increasing from 15% in 1998 to 62.5% in 2004 for PM_{10}. Furthermore, the mean annual concentration of SO_2 in Beijing reached Grade II of the CNAAQS for the first time in 2004 (BJEPB, 1999, 2005). However, the areas affected by acid rain were only slightly reduced and the degree of contamination of the southwestern portion of the nation was alleviated only by a small amount.

2.2. Seriousness in air pollution issues

Although air quality in some areas improved, air pollution is still serious because of new problems caused by rapid

Table 1
Comparison of Ambient Air Quality Standard (mg/m^3)

Pollutant	Averaging time	CNAAQS[a]			EPA NAAQS[b]	
		Grade I	Grade II	Grade III	Primary stds.	Secondary stds.
SO_2	Annual	0.02	0.06	0.10	0.08	NA[c]
	Daily	0.05	0.15	0.25	0.365	NA
	Hourly	0.15	0.50	0.70	NA	NA
	3 h	NA	NA	NA	NA	1.3
TSP	Annual	0.08	0.20	0.30	NA	NA
	Daily	0.12	0.30	0.50	NA	NA
PM_{10}	Annual	0.04	0.10	0.15	0.05	0.05
	Daily	0.05	0.15	0.25	NA	0.15
$PM_{2.5}$	Annual	NA	NA	NA	0.015	0.015
	Daily	NA	NA	NA	0.065	0.065
NO_2	Annual	0.04	0.08	0.08	0.1	0.1
	Daily	0.08	0.12	0.12	NA	NA
	Hourly	0.12	0.24	0.24	NA	NA
CO	Daily	4	4	6	NA	NA
	Hourly	10	10	20	40	NA
	8 h	NA	NA	NA	10	NA
O_3	Hourly	0.16	0.20	0.20	0.235	0.235
	8 h	NA	NA	NA	0.175	0.175

[a]The Grade I standard is for natural reserves, national parks and other protected areas. The Grade II standard is for urban residential, commerce–traffic–resident mixed, common industrial and rural areas. The Grade III standard is for special industrial areas.

[b]Primary standards set limits to protect public health, including the health of "sensitive" populations, such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation and buildings.

[c]Not applicable.

socioeconomic development and increased energy consumption in China. In the 342 cities monitored in 2004, the percentage of cities that had good air quality, light pollution and heavy pollution was 38.6%, 41.2% and 20.2%, respectively (SEPA, 2005). Most heavily polluted were usually constituted of large cities. The highest pollution levels of SO_2 and PM appeared in mega-cities. Fig. 4 compares the air pollution index (API) values of some Chinese cities in 2000 with other cities worldwide in 1995 (SEPA, 2002a).

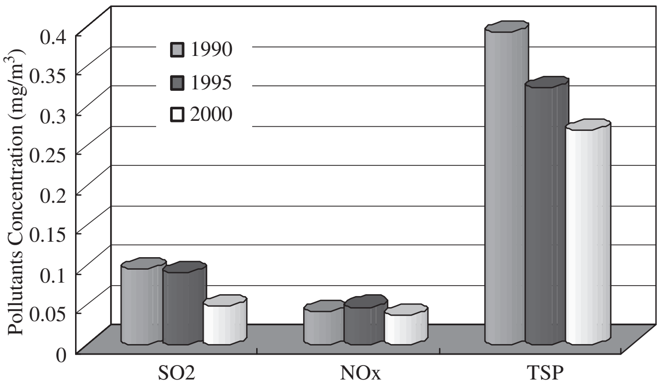

Fig. 2. Urban atmospheric average pollutants concentration in China.

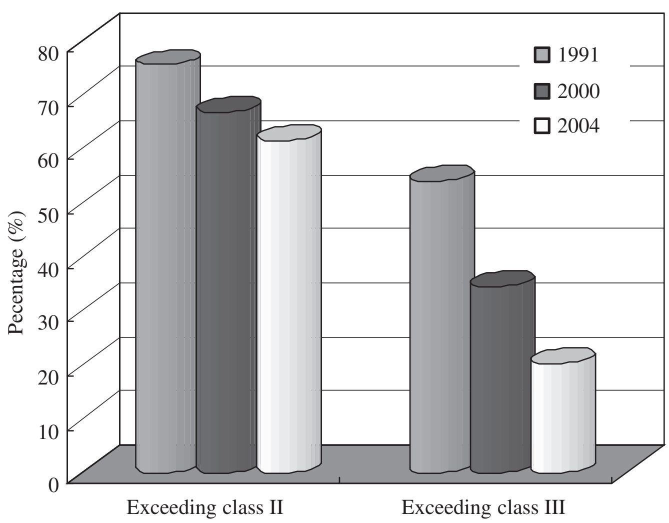

Fig. 3. Urban air quality in China cities that exceed Classes II and III.

Fig. 4 shows that the atmospheric pollution in Chinese cities is severe. The level of atmospheric pollution is related to several aspects, such as energy structure, control measures applied, geographic location and climatic conditions. For example, St. Paul and Shenyang are both important industry centers with the similar landform and climate; however, Shenyang implemented environmental prevention strategies later than St. Paul. As a result, the API of Shenyang in 2000 was similar to that reached by St. Paul in 1995.

Almost 30% of the area of China suffers from acid rain (SEPA, 2002b). In 2004, the emissions of SO_2 were 22.55 million tons in China (SEPA, 2005), which was the highest in the world. Acid precipitation, photochemical smog and fine PM have resulted in heavy regional pollution in some populous areas. Based on present trends, the World Bank Group estimated that China would pay 390 billion dollars for diseases caused by coal combustion pollution in 2020, which would be about 13% of GDP at that time (UNEPPA, 2000). In addition to the high level of acid rain in the southwestern and southern China, eastern China is increasingly subjected to acid rain pollution.

PM, especially PM_{10}, is the primary pollutant in most cities and affects public health because of the low dust abatement efficiency of present air pollution control devices. Photochemical ozone, caused by volatile organic compounds (VOCs) and NO_x precursors, is appearing in some Chinese cities.

2.3. *Complexity and regional properties of atmospheric environmental quality*

Rapid economic development and excessive population growth since the 1980s have exacerbated environmental

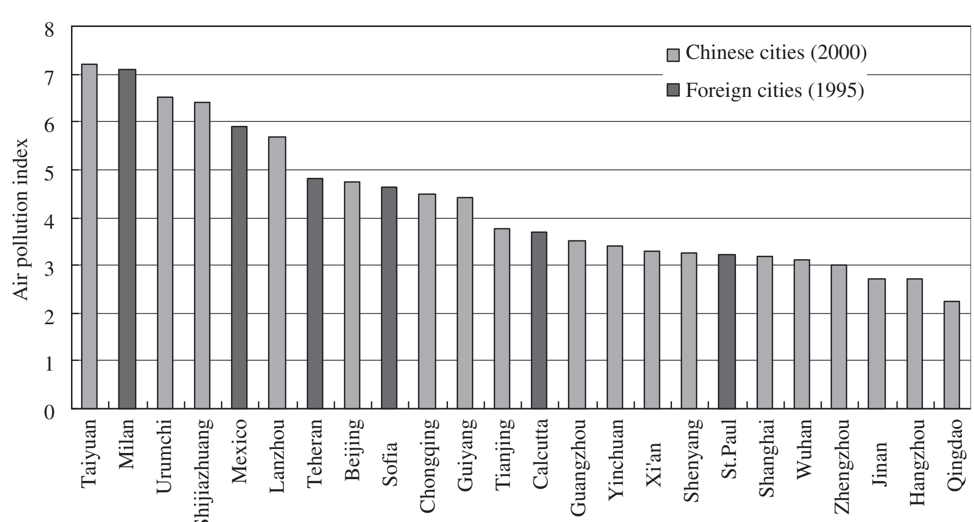

Fig. 4. Comparison of urban air quality between Chinese cities and foreign cities.

problems. In the 1980s, acid rain was monitored in many cities in south China which was caused by the sulfur dioxide from coal combustion. Since that time, the government has focused its attention on SO_2 and the TSP emitted from coal combustion. However, since the 1990s, there has been rapid vehicle growth. In Beijing, the quantity of the vehicles increased approximately four times from 0.5 million in 1990 to 2 million in 2002. Due to the rapid expansion of energy consumption and the swift development of the industry, high concentrations of PM_{10} and NO_x have worsened atmospheric visibility in urban regions. In the past 5 years, PM_{10} has become the primary pollutant in Beijing and in other large and medium-sized cities. In 2004, 53.2% of the monitored cities had PM concentrations exceeding China's Grade II standard. 25.7% of the cities had SO_2 concentrations above the Grade II standard (SEPA, 2005). Based on an analysis of atmospheric monitoring data, the primary air pollutant in China today is PM_{10} instead of SO_2 as in the past, and the quality of the atmospheric environment appears to be complex and regional in nature. According to the annual average of daily API, there are two large pollution areas, one in the northern, northeastern and part of northwestern China; and another in the middle and lower reach of the Changjiang River located in southern China (Ren et al., 2004).

2.4. Global climatic change

The last 140 years were the warmest period during the past 1000 years, during which global average atmospheric temperature rose by about 0.6 °C and the content of greenhouse gases in atmosphere rapidly increased. During the last 100 years, the average surface temperature in China and mean sea level rose by 0.6–0.7 °C and 10–20 mm, respectively. Annual precipitation in northern China was reduced by about 10% in past 50 years. The economic losses caused by meteorological disasters were about 3–6% of GDP in China, which was the largest among countries throughout the world.

At present, the annual quantities of greenhouse gases and aerosols emitted in China are the largest in the world except for CO_2 that is only lower than the US, as shown in Table 2. These gases caused not only serious environmental pollution, but also increasing pressure for China to honor international agreements that involve climate change. China has already signed many international agreements/treaties that deal with environmental protection, five of which are directly related to atmospheric protection, as shown in Table 3.

3. Developmental trend of air pollution in China

3.1. Effects of energy structure on atmospheric environment

By the end of the last century, the explosion of economic growth made China the world's second largest energy consumer after the US (He et al., 2002). The energy consumption of China accounted for about 10% of total global consumption. China has abundant coal resources and a relative shortage of petroleum and natural gas resources and, therefore, the energy structure of China is different from the Organization for Economic Co-operation and Development (OECD) countries, European Union (EU) and the world, as shown in Fig. 5 (BP, 2005).

In this century, with the annual increases in GNP of 7%, the total energy consumption will reached 1677 million tons of coal equivalent (Mtce) in 2010 and 2057 Mtce in 2020 and coal will still be the primary energy source in China, as shown in Fig. 6 (NDRC, 1998). Although the coal proportion of total energy consumption in China will be reduced from 67% in 2000 to 54% in 2020, the coal demand will increase because of the growth of total energy consumption.

Coal-burning boilers are the principal pollution sources of many air pollutants, such as TSP and SO_2. In addition to coal-fired power plants, there are also 410 thousand industrial boilers and 180 thousand industrial furnaces that burn coal, which accounted for about 45%, 30% and 20% of total coal consumption. In some regions of China, inefficient facilities and low-quality coal are still in use. Therefore, pollution from coal combustion will continue and these emissions will increase annually. Fig. 7 shows the forecast of principal air pollutants over the next 20 years (CRAES, 2001). Without further control measures, the emissions of atmospheric pollutants will raise consistent with the rapid socio-economic development and increased energy consumption. However, the continued implementation of more stringent control strategies and measures will mitigate this problem. From Fig. 7, we can see that the increased rate of pollutants emitted will reach a maximum in 2010 and decrease thereafter.

Table 2
Annual emission quantities of greenhouse gases and aerosol in China

	CO_2 (million tons)	CH_4 (million tons of CO_2 equivalent)	N_2O (million tons of CO_2 equivalent)	Sand dust (million tons)	Black carbon (million tons)	SO_2 (million tons)
China (1999)	3051	959	538	800	1.19 (1996)	19.95 (2002)
Amount of world	23,172	6340	3570	3000	6.63	105
Chinese position	2	1	1	1	1	1

Table 3
International agreements/treaties related to atmospheric protection signed by China

Catalog	Time
Vienna convention on the protection of ozone layer	3-22-1985
Montreal protocol on substances that deplete the ozone layer (revised)	9-16-1987
United Nations framework convention on climate change	6-11-1992
Kyoto protocol	12-10-1997
United Nations convention to combat desertification	6-7-1994

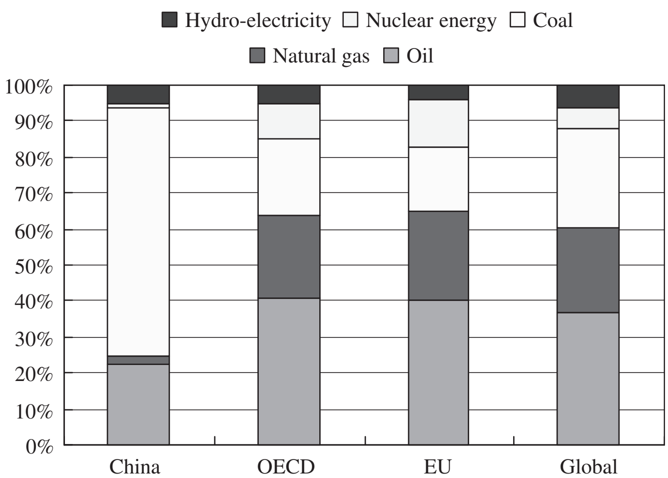

Fig. 5. Comparison of energy structure among China, OECD, EU and world (2004).

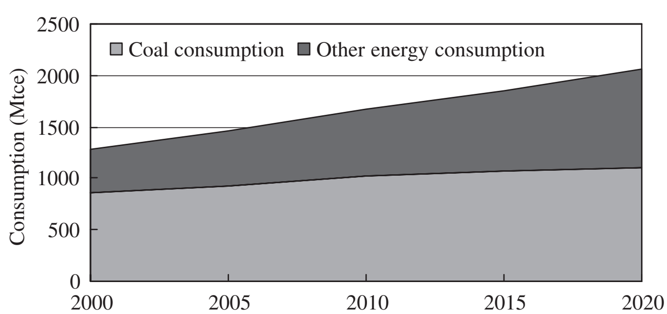

Fig. 6. The forecast of medium-term and long-term energy consumption in China.

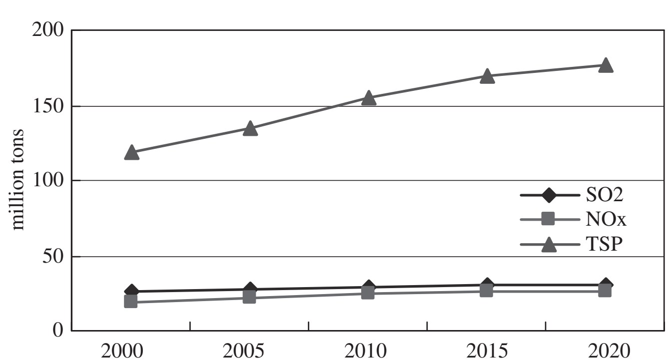

Fig. 7. The forecast of principal air pollutant quantity in the next 20 years.

3.2. Urban vehicle pollution

Based on the monitoring data, vehicles have become one of the main pollution sources in the mega-city. Table 4 shows that about 80% of CO and 41–70% of NO_x in the urban atmosphere are generated from vehicle exhaust in some Chinese typical cities. The current and predicted emissions of automobile pollutant in Beijing and Shanghai are shown in Table 5. Compared with the emissions in 2002, NO_x and CO emissions in Beijing will decrease 31% and 38.7% by 2008, respectively; and the NO_x emissions in Shanghai will decline by about 35.3% by 2010 if stricter programs are implemented. The continued implementation of control strategies and measures can reverse the trend of vehicular emissions in spite of the increasing vehicle population. In recent decades, photochemical pollution has appeared frequently in some large cities, such as Beijing, Shanghai, Guangzhou and Shenzhen. Smog is formed from the chemical reaction between unburned hydrocarbons and the oxides of nitrogen in vehicle exhaust and other sources. Cars and trucks are the most important source of ozone precursors in urban air. Research indicated that photochemical pollution in Chinese cities will continue grow and extend from the city zone to adjoining suburban areas.

3.3. Multiple origins of air pollution and increased impact on public human health

NO_x and VOCs from vehicles are diversifying urban air pollution that traditionally was mostly composed of pollutants like SO_2 and TSP. In the future, some cities will likely convert from coal-burning pollution to mixed-type pollution, and a few cities will have high levels of NO_x especially those cities whose population exceeds 1 million.

Table 4
Contribution of automobile pollutants in Chinese typical cities (%)

City	Year	NO_x	CO	HC	Data source
Beijing	1995	41.0	82.5	46.0–86.6	Xie et al. (2000)
	2000	68.2	76.5	NA	THU (2002)
Shanghai	1995	44	76	93	Xie et al. (2000)
	2002	70	NA	NA	Fu et al. (2004)
Guangzhou	1995	42.3	84.8	NA	Xie et al. (2000)

Table 5
Current and predicted emissions of automobile pollutant (million tons)

City	Year	NO_x	CO	Data source
Beijing	2002	0.087	0.93	Hao et al. (2005)
	2008	0.06	0.57	
Shanghai	2002	0.085	NA	Fu et al. (2004)
	2010	0.055	NA	

At the meantime, the origin of TSP, the primary pollutant in urban air, is increasingly complex.

More and more attention has been paid to the hazards of fine particles. Fine particle matter and ultra-fine particle matter are more harmful to human health than coarse particles. Many indicators of health have a close relationship with the time of exposure to certain concentrations of fine particles. Therefore, the USA established the limit value of PM_{10} in EPA NAAQS in 1985. In China, we began to control TSP in the 1980s and its pollution level has declined. In 1996, the standards for PM_{10} were first established in a revised CNAAQS reflecting a change of control emphasis from TSP to PM_{10}. However, the control of fine particles has only been recent and the time has been insufficient for thorough research of the fine particle production, their action mechanisms and the control technologies. Although traditional air pollution control devices have high collection efficiency to capture TSP, the removal efficiency for fine particles is limited. Therefore, the emission level of fine particles is not been significantly reduced. People living in urban areas have suffered from high PM_{10} for long time, during which the PM_{10} concentration occasionally exceeded the WHO standard by up to four times. High-level fine particle pollution not only harms the human health, but also decreases urban visibility.

As a result of the serious air pollution, the incidence and the mortally rate from respiratory disease are increasing more notable than before. Investigation showed that about 50% respiratory diseases were caused by air pollution. In the 11 largest cities in China, about 50,000 people died due to soot and fine particles from coal burning and other 400,000 people suffered the chronic bronchitis (UNDP, 2000). The number of people dying from lung cancer in areas with serious air pollution is 4.7–8.8 times higher than in non-polluted areas; in a northern city of China, the blood lead content of about 40% of the children exceeded the standard in 2000 (UNDP, 2002). Furthermore, some persistent organic pollutants and endocrine interferon were found frequently in our ambient medium. In some cities of the Zhujiang Delta, for example (Fu et al., 2003), volatile organic carcinogens (benzene, toluene, dimethylbenzene, etc.) in the air are much higher than in the developed countries.

3.4. *Long-term influence of acid rain on the atmospheric environment in south China*

The areas covering the east of Qinghai–Tibet Plain and the south of the Yangtze River are currently the third largest acid rain area in the world after Northern Europe and North America. The acid rain in China is predominantly sulfuric acid, which is characterized by a low pH value with high ion concentration; in particular, it has a much higher the concentration of the sulfate radical (SO_4^{2-}), ammonium (NH_4^+) and the calcium ion (Ca^{2+}) than is present in Europe and America, and a much lower the concentration of nitrate radical (NO^{3-}).

The SO_2 emissions from burning coal are the major source (85%) of total SO_2 emissions. Moreover, SO_2 from power plants are the most important cause of acid rain formation. In the Ninth Five-year Plan period (1995–2000), SO_2 emissions have been reduced, mainly because the small heating plants were closed and the thermoelectric power plants in the two major acid rain areas converted to burning coal with low sulfur content. SO_2 emissions from coal-burning power plants will still be the main source of SO_2 for a long time to come. Even if the thermal power industry reduced SO_2 emissions by 10% every 5 years, it would have little impact on acid rain formation in the short term, as shown in Table 6.

In recent years, the proportion of the nitrate radical ion in the acid rain has increased. This is due to the sharp increase of the vehicle population and by yet-to-be implemented NO_x control measures for some stationary sources that emit a significant amount of NO_x. In 2003, NO_x emissions were approximately 16.13 million tons (Tian, 2005); since nearly 70% is from direct coal burning, stationary sources are an important source of NO_x emission. Streets and Waldhoff (2000) estimated that in 2020, NO_x emissions in our country will amount to 26.6 million tons. Thus, acid rain pollution from primarily sulfuric acid will change to sulfuric acid/nitric acid pollution, and NO_x control will contribute to acid rain reduction. Overall, the influence of acid rain on the atmospheric environment in south China will last for a long time and it will take at least 20 years to significantly lower this pollution.

Table 6
Predictive desulfurating ability of heating plants in China

Year	2000	2005	2010	2015	2020
Electricity generated (billion kW h)	1107.9	1457.42	1946.9	2450	2850
Coal consumption (million tons)	54.723	697.81	882.66	1092.8	1193.81
Sulfur content of coal (%)	1	0.95	0.9	0.85	0.8
Generated SO_2 (million tons)	8.76	10.61	13.81	15.79	16.24
Target emission quantity of SO_2 (reduced 10%) (million tons)	8.37	7.54	6.78	6.1	5.49
Required SO_2 quantity to reduce (million tons)	NA	3.07	7.03	9.69	10.75
Required desulfurating ability (million kW)	5	41.37	97.79	140.08	165.41

3.5. Rising pressure of climate change

The Intergovernmental Panel on Climate Change forecasts that the globe will become warmer at a faster rate and the temperature will raise 1.4–5.8 °C during this century. Due to this trend, the Yellow River valley will be short of 20 billion tons of water in the 2030s even if strict water conservation programs are implemented. Sea levels will raise 1–16 cm in 2030 and 30–70 cm at the end of 21st century, which will lead to calamitous consequences.

As the world's second largest greenhouse gas emitting country after the US, China will be facing more and more pressure to protect the climate and carry out international agreements to mitigate climate change.

4. Research emphasis of atmospheric environmental protection

4.1. Control of the total amount of the major industry pollution emissions

The amount of SO_2 emissions from electric power industry is 55% of total, 11.4% from non-metal mineral production industry, 10.9% from the metallurgy industry and 5.4% from the chemical industry in 2002 (SEPA, 2002c). The remaining SO_2 from other sources is less than 20% of total. Therefore, controlling sulfur dioxide from these four industries is crucial. Industrial development should occur with no pollution increase, and, preferably, by decreasing pollution. To achieve this, we should not only adjust the industry configuration, but also implement two compliance systems, that involve total pollution emission control and pollution emission permits. Further, mines containing more than 3% sulfur coal should be closed. Coal cleaning techniques will replace outdated technology to avoid more serious air pollution.

4.2. Active control of the fine particle pollutants

China has implemented a series of measures to control PM emissions. These include: increasing the number of dust control units on coal-burning boilers and furnaces, modifying existing de-dusting equipment and boilers to achieve lower emissions, providing clean fuels for vehicles, controlling dust from constructions sites and roads, and increasing the area of afforestation. In addition, policies, rules and regulations have been implemented to lower PM. During the 1995–2000 period, all new power plants were required to be equipped with electrostatic precipitators. Simultaneously, the National Electric Power Company completed 318 dust collection projects. The number of dust removing facilities increased from 55% in 1995 to 80% in 2000 (based on capacity). The average dust collection efficiency of power plants was enhanced from about 95% in 1995 to over 98% in 2000 (NDRC, 2004). Fine particle pollutants (PM_{10}, etc.) should be the new control focus to improve the air quality. PM_{10} pollution can be mitigated by modifying dust control devices, improving fuel quality or using clean fuel (nature gas) and upgrading the emission controls of the small, low polluting sources. As a result, the fine particle concentration in the atmosphere will gradually be reduced and urban visibility and environmental quality will improve.

4.3. Decrease in SO_2 emissions from power plants

Through economic, policy and management approaches, we will assure that the low-sulfur coal (LSC) has a priority for use. High-sulfur coal (HSC) can be used in power plants provided the coal is cleaned before use or a flue gas desulfurization facility is installed. As mentioned, SO_2 emission mitigation so far mainly consists of closing the small heating plants and changing to LSC during the 1995–2000 period. However, considering the resources of China, it is difficult to further reduce the sulfur content of coal in the future. Therefore, flue gas desulfurization of power plants should be increased. At present, resources to invest in desulfurization are inadequate and the removal efficiency of SO_2 is low. According to the environmental statistical data in 2001, the operating cost of the desulfurization facilities only accounts for 0.7% of gross industrial output value of the power plants, and there were only 886 desulfurization facilities in 1033 power plants. Nevertheless, desulfurization technologies developed domestically for electric power plants have been installed and are operating. The construction and operating cost of the desulfurization projects can be reduced by additional research and promotion of the domestic desulfurization technologies. New power plants in the "Two Controlled Zones" (the acid rain controlled and the sulfur dioxide controlled zones) must be equipped with desulfurizers and new power plants in the other areas should also be controlled. Existing power plants should gradually install desulfurizing equipment where HSC is used.

4.4. Control of the vehicle exhaust

Control of vehicle exhaust can be achieved by a number of measures including the development of public transport and clean fuel vehicles. New vehicles should soon comply with Euro2 and Euro3 vehicles exhaust emission standards. In-use vehicle inspection and maintenance (IM) system must be strengthened to eliminate gross polluters. High-emission vehicles should be identified and repaired or scrapped; and fuel quality should be improved.

The proportion of in-use vehicles is increasing. Therefore, upgrading IM program will achieve a better benefit/cost effect than the control the emissions of new vehicles. While it becomes more costly to reduce emissions as emission standards become more stringent, further emission reduction will bring positive economic benefits as well (THU, 2001).

4.5. Enhancement of the energy use efficiency

Energy conservation is important. Also, it is necessary to develop energy conservation products and reduce the energy use in society. Establishment and improvement of energy conservation standards will promote building quality and enhance heat preservation performance. Energy conservation must be an important management goal in the industrial production sectors of electric power, chemical industry, coal and steel and iron. Furthermore, energy and material consumption of unit products can be reduced by improving production techniques and developing energy conservation equipment.

4.6. Optimization of energy structure and generation of sustainable consumption and production pattern

Because most energy in China is supplied by coal and the per capita energy use is low, there is opportunity to adjust and optimize China's energy structure, establish a sustainable energy system, develop clean coal technology, require energy savings by improving energy utilization efficiency and reduce the impact of energy consumption on the environment. Hydroelectricity should be fully developed and increased. To lower energy risks, an energy strategic reserve system could be established, especially for petroleum to make China's energy supply safe from interruption (Lang and Wang, 2004). Research and development should continue on clean production technologies, including energy conservation techniques, clean burning technology, and clean energy development and use.

4.7. Promotion of renewable energy resources

Sustainable development is achieved by economizing limited resources and developing abundant renewable energies, such as water energy, wind energy, solar energy, geothermal energy and energy derived from the marine environment.

In 2000, China's renewable energy consumption was 0.256 billion tce, which contributed 19.7% of total primary energy. It is estimated that the obtainable renewable energy in China is about 7.3 billion tce annually. The exploitation capacity in 2000 is less than 4000 Mtce, so there are sufficient resources to use. Furthermore, as the technologies are maturating, and efficiency is improving, the development of renewable energy on a large scale is possible (Zhou, 2004).

The Chinese government has encouraged the acceleration of renewable energy development, such as wind, solar and biologic energy (SCC, 2005). By the end of 2004, installed capacity of hydroelectricity provided 0.108 billion kW. Moreover, solar water heating and marsh gas use reached 65 million m^2 and 5 billion m^3, respectively (Zhang, 2005). Since January 1, 2006, the "Law of renewable energies of P. R. China" was officially implemented. Between 1995 and 2000, the utilization ratio of new renewable energy is about 11.2% annually in China. Assuming a ratio of 10%/year, the new renewable energy consumption in 2010 can reach 110 Mtce. Additionally, bio-energy consumption is 170 Mtce, which means that the total renewable energy consumption can reach 280 Mtce. Thus, new renewable energy sources could contribute 40% of the total energy consumption in all of the country.

5. Conclusions

Urban air pollution and its impact on urban air quality is a worldwide problem (Fenger, 1999). Air quality in cities is worsening as the population, traffic, industrialization and energy use increases. Due to the insufficient air quality information in China, it is necessary to improve the monitoring and evaluation systems for urban air pollution.

The strategic planning of atmospheric environmental protection is dependent upon the legislative, economic, political and technological decisions; the climate and topography; and the species and quality of the available energy sources. Different departments of the government should cooperate to perform integrated and extensive research.

Sustainable development is achieved by efficiently using limited non-renewable resources and developing abundant renewable energy resources. China's energy policy, should obtain a better balance between using conventional and renewable energy sources, and enhancing the efficiency of energy use will help solve the regional and the global environmental problems discussed above.

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