

ENVIROMENT PROTECTION AND NATURAL GAS DEVELOPMENT IN CHINA

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Abstract

The paper describes the results of the monitoring on 322 cities. It shows total suspended particulate (TSP) is over the national air quality standard, SO₂ pollution is very obvious in some cities and NO_x pollution is serious in some metropolies.

On the whole, air pollution did not deteriorate continuously. However, We can't be optimistic, since 3/4 of the cities can't meet the standard. Acid rain takes place over an area of around 30% of the total territorial area of China.

In 1998, the primary energy consumption mix of China was coal 69.6%, the primary energy consumption depends too much on coal and it is inevitable to be low efficient, low benefits and serious pollution.

China has rich natural gas (NG) resource. But the percentage of natural gas rose to 2 %, the figure has been lingering around 2%. In order to improve environment quality, China should be to development NG. So author analysis the increase of demand for natural gas and natural gas supply.

1. Atmospheric environmental status in China

1.1 General status of urban air pollution

The results of the monitoring on 322 cities show total suspended particulate (TSP) is over the national air quality standard, SO₂ pollution is very obvious in some cities, and NO_x pollution is serious in some metropolises.

● TSP

TSP is one of the major pollutants in urban areas in China. Among the monitored 322 cities in 1998, 68% and 37.69% cities' TSP are over the national standard second grade and third grade respectively. The top 20 cities in terms of TSP concentration are located at 4 provinces in

northwest China, namely Shaanxi, Gansu, Ningxia and Xinjiang. TSP of 308 cities (95%) is over the value recommended by the World Health Organization (WHO), only 13 cities meet the WHO's recommended value, such as Haikou, Xiamen, Sanya, Beihai etc., See table 1.1.

● SO₂

29.2% and 15.22% of the cities are over the national standard second grade and third grade respectively. 32.8%(109 cities) are over the WHO recommended value.

The cities seriously polluted by SO₂ are located in Guizhou, Sichuan, Guangxi, Shanxi, Shandong, Hebei, Shaanxi, Gansu, Chongqing and Beijing. Most serious pollution took place in Guizhou.

64 of monitoring cities are located at SO₂ control zone, only 32.8% of them meet the national standard second grade, 67.2% and 37.5% are over the national standard second grade and third grade respectively. 102 cities are located at SO₂ control zone in China, of which 29.4% and 15.7% are over the national standard second grade and third grade respectively.

● NO_x

Serious NO_x pollution mainly takes place in metropolises with a population over 1 million, such as Beijing, Guangzhou, Shanghai, Wuhan, Wulumuqi, Jilin, Hangzhou etc.. Beijing and Guangzhou are the top cities in terms of NO_x, its concentration in 1998 increased 10% compared to that in 1997.

Table1.1 TSP pollution statistics by grade in China

Percentage of the cities (%)	1998	1997
air quality		
Meet second grade (%)	32.09	31.43
Over second grade (%)	67.78	68.57
Over third grade (%)	37.67	41.27
Average urban TSP concentration (mg/m ³)	0.289	0.298
Air quality standard in residential areas (annual average second grade)	0.20 (mg/m ³)	
Air quality standard in industrial areas (annual average third grade)	0.30 (mg/m ³)	
WHO recommended value	0.09 (mg/m ³)	

(annual average concentration)	
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Table1.2 SO₂ pollution statistics by grade in China

Percentage of the cities (%)	1998	1997
air quality		
Meet second grade (%)	70.81	66.46
Over second grade (%)	29.19	33.54
Over third grade (%)	15.22	19.43
Average urban SO ₂ concentration (mg/m ³)	0.056	0.064
Air quality standard in residential areas (annual average second grade)	0.06 (mg/m ³)	
Air quality standard in industrial areas (annual average third grade)	0.10 (mg/m ³)	
WHO recommended value (annual average concentration)	0.05 (mg/m ³)	

Table1.3 SO₂ concentration statistics by grade in 'two control zones' in 1998

SO ₂ concentration	SO ₂ control zone	Acid rain control zone
Over third grade	37.5%	15.7%
Meet third grade	29.7%	13.7%
Meet second grade	32.8%	70.6%

Table1.4 NO_x pollution statistics by grade in China

Percentage of the cities (%)	1998	1997
air quality		
Meet second grade (%)	81.68	80.44
Over second grade (%)	18.32	19.56
Over third grade (%)	0.62	0.95
Average urban NO _x concentration (mg/m ³)	0.037	0.038

Air quality standard in residential areas (annual average second grade)	0.05 (mg/m ³)
Air quality standard in industrial areas (annual average third grade)	0.10 (mg/m ³)
WHO recommended value (annual average concentration)	0.05 (mg/m ³)

On the whole, air pollution did not deteriorate continuously, see figure 1.1. However, we can not be optimistic with the status of air quality, since 3 quarters of the cities can not meet the standard. The average concentration of TSP、SO₂ and NO_x of the 322 cities is 0.389 mg/m³、0.056 mg/m³、0.037 mg/m³ respectively in 1998. The concentration of TSP and SO₂ decreased 3% and 12.5% respectively compared to that in 1997 and decreased 6.4% and 15.2% compared to 1995. The average concentration of NO_x is almost the same, only fluctuated during the different time of the year. The pollution in a few of the metropolises is very serious.

Among the 322 cities, only 27.64% met the national air quality standard second grade, more 40% is over the third grade, see figure 1.2.

Figure 1-1 Air quality change trend of 88 cities in the national monitoring network

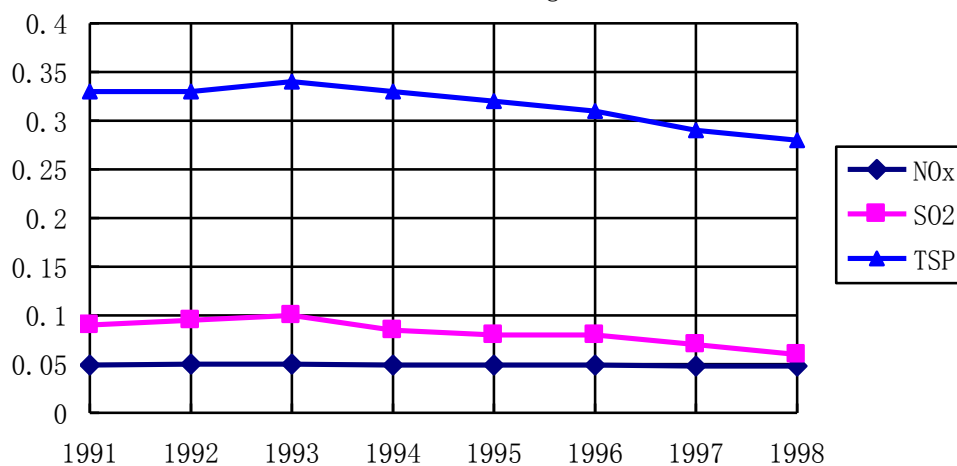


Figure 1.2 The share of cities by air quality in China

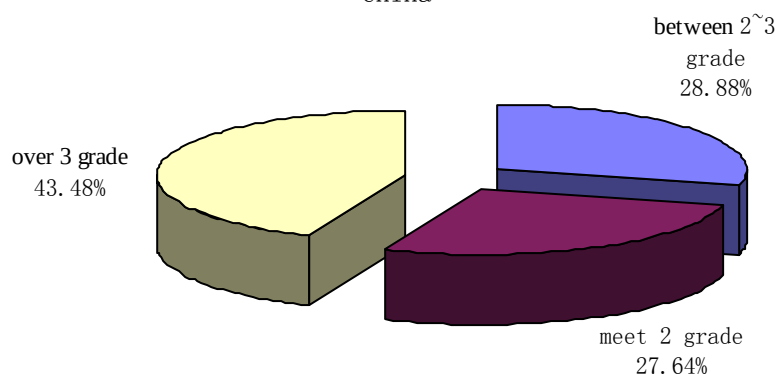


Table 1.5 Urban air quality statistics by grade in 1998 in China

Grade	city		Key city	
	City number	Share, %	City number	Share, %
Over 3 grade*	140	43.48	20	42.55
Between 2~3 grade	93	28.88	14	29.79
Meet 2 grade**	89	27.64	13	27.66
Total city number	322		47	

* at least one of the monitored items is over 3 grade of national air quality standard

** all of the 3 items meet the 2 grade

1.2 Air quality of provinces, municipalities and autonomous regions

Table 1.6 shows the top 10 regions in terms of the pollution of TSP, SO₂ and NO_x. For TSP, the order from most seriously polluted to less polluted is : Ningxia, Gansu, Shanxi, Qinghai, Shaaxi, Xinjiang, Inner Mongolia, Beijing, Hebei and Tianjin. For SO₂, the order is: Chongqing, Guizhou, Shanxi, Beijing, Hebei, Tianjin, Sichuan, Ningxia, Shaanxi and Shandong. For NO_x, the order is: Beijing, Shanghai, Chongqing, Tianjin, Shanxi, Hebei, Henan, Jilin, Guangdong and Shandong. The order of integrated pollution index is: Beijing, Shanxi, Chongqing, Guizhou, Ningxia, Shaaxi,, Gansu, Hebei, Tianjin and Shanghai.

Table 1.6 Top 10 regions in terms of 3 pollutants index

Items No.	Region	TSP	Region	SO ₂	Region	NO _x
1	Ningxia	2.820	Chongqing	3.050	Beijing	3.040
2	Gansu	2.605	Guizhou	2.867	Shanghai	2.000
3	Shanxi	2.530	Shanxi	2.433	Chongqing	1.120
4	Qinghai	2.485	Beijing	2.000	Tianjin	1.060
5	Shaaxi	2.430	Hebei	1.517	Shanxi	0.980
6	Xinjiang	2.070	Tianjin	1.367	Hebei	0.920
7	Inner Mongolia	1.960	Sichuan	1.283	Henan	0.880
8	Beijing	1.890	Ningxia	1.233	Jilin	0.860
9	Hebei	1.795	Shaaxi	1.183	Guangdong	0.820
10	Tianjin	1.700	Shandong	1.167	Shandong	0.803

1.3 Acid rain

Acidic precipitation mainly induced by coal consumption takes place over an area of around 30% of the total territorial area of China. Acid rain shows a regional characteristic.

The scope of PH of precipitation ranged from 4.13 to 7.79 in China in 1998. The annual average PH of 52.8% of the key cities was lower than 5.6. The PH of 73% of the cities in South China was lower than 5.6. The cities with a PH less than 4.5 included Linan, Zhuzhou, Yiyang, Shaoguan, Qingyuan, Nanchang, Yintan and Changsha. The PH of 4 North cities, namely Tumen, Qingdao, Xian and Tongchuan was less than 5.6.

Pollution of acid rain region in Central China was mitigated, however, the PH of central areas was still less than 5.0, and the frequency of acid rain was still over 70%.

The general situation of acid rain region in South China did not change, but a few of costal cities' PH decreased year by year, and the frequency of acid rain increased year by year.

The situation of acid rain regions in East China and Southwest China almost kept at the same level of the previous year, but some areas' situation improved with a PH over 5.6, such as Wuyishan at west Fujian, some areas located at west Yunnan and west Guizhou.

The situation of acid rain pollution of two regions in North China, Qingdao and Tumen was stable.

2. The development of the world's natural gas

Taking natural gas as the most important alternative energy in the 21st century is based on its abundant reserves. It is estimated that the global total resources of natural gas are about 400~600 trillion cubic meters, which can be exploited for two or three centuries. By the end of 1998, the remaining proved recoverable reserves of natural gas in the world was about 146.4 trillion cubic meters. The ratio of reserve to production is 63.4. The reserves in the former Soviet Union and the Middle East, the regions most abounding in natural gas, amounted to about 38.8% and 33.8% of the world's total.

Natural gas is becoming an increasingly important source of energy in the world's primary energy consumption mix. Between 1950 and 1970, the proportion of natural gas in the world's total primary energy consumption increased from 4.8% to 19.9%. That proportion had kept increasing since 1970 and reached 23.7%. In 1998, some energy experts predicted that the consumption of natural gas will exceed that of petroleum after 2020.

3. It is necessary to develop natural gas for China

Since reforming and opening to the world China's energy industry kept rapid growth. In 1998, the primary energy production was 1242.5Mtce. Raw coal production in China hit 1250 million tons, ranking first in the world. Electricity generation reached 1167TWh, only less than that of USA, ranking second in the world. Crude oil production was 161 million tons, ranking fifth in the world, natural gas production was 23.28 billion cubic meters, ranking 18th in the world. When China entered 21st century, she had owned the big energy production system which ranking third in the world.

Primary energy consumption mix of China in 1998 was: coal 69.6%, oil 21.5%, natural gas 2.2%, hydro and nuclear power 6.7%. The mix of world was: coal 26.3%, oil 40.0%, natural gas 23.7%, hydro (2.6%) and nuclear (7.4%) power 10.0%. The mix of OECD countries is: coal 21.7%, oil 43%, natural gas 22.7%, power 13.2%. Compared with the mix of the world and OECD countries', it is clear that the primary energy consumption depends too much on coal, and it is inevitable to be low efficient, low benefits and serious pollution because of the huge consumption of coal.

During the previous half century, most of the countries achieved the switching of fuel from coal to oil and are entering into oil and natural gas age. The share of coal in primary energy mix reached 57.5% in 1950, which decreased to 30.5% in 1970 and further to 27.5% in 1993 and to 26.3% in 1998, while the share of oil (40%) and gas (23.7%) reached 63.7%.

In views of the trend of different countries, all of the industrialized countries' energy mix is dominated by oil and gas. Gradual reduction of solid fuel is the inexorable choice to improve energy efficiency, reduce the cost of energy system and provide high quality energy service. The share of coal in primary energy mix of OECD countries is less than 30%, of which the index of French, Italy and Japan is less, only 6.6%, 7.0% and 16.6% respectively in 1998.

In views of energy consumption, energy technologies and mix shows a cleaner, higher quality and higher efficient trend. However, total energy demand is huge in China, it is difficult to improve the energy mix only by a kind of energy carry. It is necessary to develop more power and increase the supply of liquid and gas fuel.

China has rich natural gas resource while China is lagged behind in development and utilization. The production ration and the consumption rations of oil to gas were 1:0.13 and 1:0.1 in 1998 while the two indexes of the world average were 1:0.58 and 1:0.59. It is clear that the development and utilization of natural gas in China is far less than the level of the world average and further less than that of OECD countries'. To reach the level of middle developed country by the middle of the century, it is necessary for China to change the situations at early time.

4 China has resource base for natural gas development

4.1 Natural gas resources

The second assessment of oil and gas resources of China was done in 1994. This assessment used the documents before 1993, and the resource of natural gas was 38 trillion cubic meters. In this paper, Chinese experts use the latest documents of 2000 to revise the second assessment, and the new geological resource and recoverable source of natural gas are 47.23 and 9.3 trillion cubic meters.

4.2 Natural gas reserve

Natural gas can be divided into unassociated gas and dissolved gas in terms of phase. Condensate oil is a kind of specific unassociated gas. Accumulated reserve of unassociated gas was 1943.028 billion cubic meters, and that of dissolved gas was 955.533 billion cubic meters, condensate was 107.72 billion cubic meters (equivalent). The sum of former two was 2938.561 billion cubic meters and the total of three was 3046.281 billion cubic meters.

In 1998, the remaining recoverable reserves were: unassociated gas 961.927 billion cubic meters, dissolved gas 158.686 billion cubic meters, and condensate 32.704 billion cubic meters. The total was 1153.717 billion cubic meters.

Previous analysis shows that the total geological reserve of natural gas was 47.23 trillion cubic meters in 1998. The proved reserve was 3.05 trillion cubic meters, so the proved ratio was 6.5%. There is large resource potential in China. In light of the analysis of Chinese experts, China is in a rapid increasing phase in terms of natural gas reserve and annual increased reserve will be over 200 billion cubic meters. Therefore China has the resource base for developing natural gas by large scale.

5 Natural gas consumption

Since the percentage of natural gas rose to 2% in China's primary energy production and consumption structure in 1973, the figure has been lingering around 2%, with few exceptions, in more than two decades. In 1998, China produced 23.3 billion cubic meters of natural gas.

The consumption of natural gas was 20.2 billion cubic meters, of which 53% of industry, 25.9% of self-consumption by gas fields, 12.7% of power generation, 48.5% of chemical industry (of

which 88% of chemical fertilizer), and 10.9% of residential consumption, 4.8% of commercial, transportation and other sectors. And in the global natural gas consumption structure in 1998, 25.7% of industrial consumption, and 4.1% of chemical raw material were accounted for.

Based on the structure comparison above, some conclusions can be drawn out. 1) The percentage of natural gas for chemical raw material is big, and the internal structure is irrational, in which, the gas consumption for chemical fertilizer production shares 88%, and for other chemical products, such as ethane, methanol, share very little percentage, resulting in insufficient depth of processing with single products. 2) The over percentage of self-consumption of gas and the low commercial rate of outside gas supply. At present, the percentage of gas consumption for oil and gas exploitation holds 25.9% of total natural gas consumption, therefore, the truly out-transporting commercial gas only shares 74.1% of the total natural gas production. And the average natural gas commercial rate in the world is about 88%. 3) The low share of natural gas for residential use. 4) The percentage of natural gas for power generation is very low. 5) The natural gas consumption, still under the start-up phase.

According to the experience from the developed countries, the natural gas utilization in China will be mainly toward power generation, residential use, chemical industry and natural gas car.

6 Natural gas demand forecast

Based on the analysis the increase of demand for natural gas will be faster than that of coal and oil in China. It is estimated that the ratio of natural gas in the total energy demand will be increased from 2.2% of 1997 to 6% of 2010 and to 10% of 2020, the demand for natural gas will reach 96 billion cubic meters in 2010 and 203.7 billion cubic meters in 2020. In China's natural gas demand by sectors, the demand for natural gas in power generation and residential sectors will have great development and their ratios in the total natural gas demand are greater than other sectors. During the 23 years from 1998 to 2020, the yearly increase rate of natural gas demand in power sector will reach 17%; 14.7% for residential sector; 8% for industry sector and 6% for chemical industry. By the end of 2020, natural gas used for power generation will account for 40% of the total demand, 24.5% for residential sector; 16% for chemical industry and 19.6% for industry and other sectors (see table 6.1)

Table 6.1 Forecast of natural gas demand in China unit: billion cubic meters

	1997		2010		2020	
	demand	%	demand	%	demand	%
Power generation	2.19	11.2	35.0	36.4	81.2	39.9
Residential use	2.12	10.8	22.0	22.9	50.0	24.5
Chemical industry	8.43	43.1	19.0	19.9	32.5	16.0
Industry and others	6.82	34.9	20.0	20.8	40.0	19.6
total	19.56	100	96.0	100	203.7	100

7 Natural gas supply

China produced 26.5 billion cubic meters natural gas in 2000, of which 18.3, 3.9 and 4.3 billion cubic meters are produced by CNPC, SINOPEC and CNOOC respectively, accounting for 69%, 14.7% and 16.3% respectively. At present, the shares of proved reserve of CNPC, SINOPEC and CNOOC are 80%, 10% and 10% respectively.

Table 7.1 shows the forecast of natural gas production made by CNPC in four regions.

Table 7.1 Forecast natural gas production in four regions.

	2010			2020		
	Remaining recoverable reserve	production	R/P	Remaining recoverable reserve	production	R/P
Tarilmu	5143.3	180	28.6	7343.3	300	24.5
Changqing	4084	180	22.7	5934	350	17.0
Qinghai	1932.2	50	38.6	2442.2	100	24.4
Chuanyu	3671.7	150	24.5	4471.7	250	17.9
Total	14831.2	560	26.5	20191.2	1000	20.2

Based on the above analysis, China has rich natural gas resource and is in the phase of rapid exploration and development. It is estimated that the natural gas production will be 50, 95~100 and 150 billion cubic meters in 2005, 2010 and 2020 respectively. Domestic production can basically meet the demand before 2010 while it is necessary to import after 2010 to keep balance.

Conclusions:

- Air pollution is serious in China, since 3/4 of the cities can't meet the national standard in 1998.
- Serious air pollution connected with that mix of primary energy consumption. It depends too much on coal.
- Natural gas is a clean fossil energy, in order to improve air quality, China should be to development NG.
- China has rich NG resources and has the resource base for developing natural gas by large scale.
- The natural gas utilization in China will be mainly toward power generation, residential use, chemical industry and NG car.
- It is estimated the NG production will be 50, 95-100 and 150 billion cubic meters in 2005, 2010 and 2020 respectively.

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