IEEJ: March 2004

Coal and Environmental Issues in Northeast Asia[1]

Atsushi Fukushima,
General Manager, International Corporation Department

Introduction

The region of Northeast Asia has abundant coal resources and also produces and makes use of coal in massive quantities among various kinds of energy sources. For the future as well, it is anticipated to have a steadily increasing demand for coal. As used here, the term "Northeast Asia" consists of the countries situated in the southeast region of the Eastern Siberian territory of the Russian Federation, i.e., Mongolia, the People's Republic of China, the Democratic People's Republic of Korea (hereinafter referred to as "North Korea"), the Republic of Korea (hereinafter referred to as "South Korea"), and Japan. As for Russia, this study took up the Eastern Siberia and the Russian Far East categorized as economic zones in Russia.

Nowadays coal issues cannot be discussed without considering the related environmental concerns. The flue gas treatment technologies at present enable to resolve the air pollution problems originated from fuel burning, conspicuously SOx, NOx and soot/dust emissions. It is technically possible to improve the air quality in urban areas in the Region. In addition, China, North and South Korea, and Japan are all in the same boat under the influence of acid rain, which is a typical atmospheric problem affecting wide areas across the border.

1. Current Situation in Northeast Asia

1.1 Socioeconomic and Energy Indicators

Spanning Eastern Siberia, the Russian Far East, Mongolia, China, North Korea, South Korea, and Japan, the region of Northeast Asia supports an immense population over its vast area and is situated in the different stages in respect of economic development and energy supply and demand structure. Table 1.1 shows the main social, economic, and energy indicators for the Region in 2000. The Region excluding Japan and South Korea shows extremely high values of energy intensities with respect to GDP, and it indicates energy waste or energy consuming industrial structure in general.

---

[1] This report is summarized two installments of the same title (Japanese) represented on the IEEJ website, 1st report in October 2003, and 2nd report in January 2004.

According to statistics from the International Monetary Fund (IMF) and other sources, in U.S. dollar terms, the 2001 nominal gross domestic product (GDP) came to 310 billion dollars in Russia (and an estimated 21.1 billion dollars in Eastern Siberia and 18.6 billion dollars in the Russian Far East), 1,191.5 billion dollars in China, 1 billion dollars in Mongolia, 427.2 billion dollars in South Korea, and 4,141.4 billion dollars in Japan. These translate into real economic growth rates of 5.0 percent in Russia, 7.3 percent in China, 1.4 percent in Mongolia, 3.0 percent in South Korea, and 0.4 percent in Japan. As for North Korea, estimates made by the Bank of Korea put the 2001 GDP at 15.7 billion dollars. The country's economic growth rate made an upturn in 2000 and reached 1.3 percent in that year and 3.7 percent in 2001.

The 2001 figures for nominal GDP per capita amounted to 2,147 dollars in Russia (and 2,340 dollars in Eastern Siberia and 2,550 dollars in the Russian Far East), 940 dollars in China, 413 dollars in Mongolia, 706 dollars in North Korea, 9,025 dollars in South Korea, and 32,522 dollars in Japan. In China, however, the figure varies substantially depending on the region, from 3,400 dollars in Shanghai and 2,300 dollars in Beijing to 460 dollars in Gansu Province and 320 dollars in Guizhou Province.

Table 1.1 Main Socioeconomic and Energy Indicators in Northeast Asia (2000)

		Russia	Eastern Siberia	Russian Far East	Mongolia	China	North Korea	South Korea	Japan
Area	Thousands of km^2	17,075.4	4,094.7	6,191.5	1,566.5	9,558.0	122.8	99.5	378.9
Population	Millions of people	145.5	9.0	7.3	2.4	1275.1	22.3	47.3	126.9
Population density	People/km^2	8.5	2.2	1.2	1.5	133.4	181.7	475.0	334.8
Nominal GDP	Billions of dollars	259.7	17.7	15.6	1.0	1,079.4	16.0	461.5	4,765.1
Exchange rate	Dollar-based rates	28.13 (Ruble)			1,076.67 (Togrog)	8.28 (RMB)	2.20 (Won)	1,130.96 (Won)	107.77 (Yen)
TPES	ktoe	613,969	50,179	27,382	2,102	1,142,438	46,112	191,160	524,230
Power consumption	GWh	863,711	123,000	41,600	2,066	1,347,268	31,636	266,400	1,091,500
GDP/Capita	Dollars/person	1,785	1,962	2,135	406	847	717	9,761	37,559
TPES/GDP	toe/millions of dollars	2,364	2,841	1,757	2,167	1,058	2,882	414	110
TPES/Capita	toe/person	4.22	5.58	3.75	0.88	0.90	2.07	4.04	4.13
Power consumption/GDP	Wh/dollar	3,326	6,965	2,670	2,130	1,248	1,977	577	229
Power consumption/capita	kWh/person	5,937	13,667	5,699	864	1,057	1,419	5,635	8,603

Note: TPES = Total primary energy supply; ktoe = thousand tons of oil-equivalent

(Source) "International Financial Statistics" IMF,
"Country Profile Table", WB
"Key Indicators of Developing Asian and Pacific Countries", ADB
"Energy Balances of Non-OECD Countries" (2002 Edition), IEA
SEI (Energy System Institute, Russian Academy of Science, Siberian Branch)

1.2 Energy Supply and Demand Structure

1.2.1 Primary Energy

Northeast Asia is a net energy importer. According to statistics of the International Energy Agency (IEA), yearly energy trade worked out to a net import of 30 million toe (tons of oil equivalent) in China, 425 million toe in Japan, 168 million toe in South Korea, and 3.5 million toe in North Korea. Mongolia, too, is a net importer of petroleum products; the surplus import comes to about 0.5 million toe per year. Looking at by energy source, China is a coal exporter, and the coal productions of North Korea and Mongolia are essentially directed only to the domestic market.

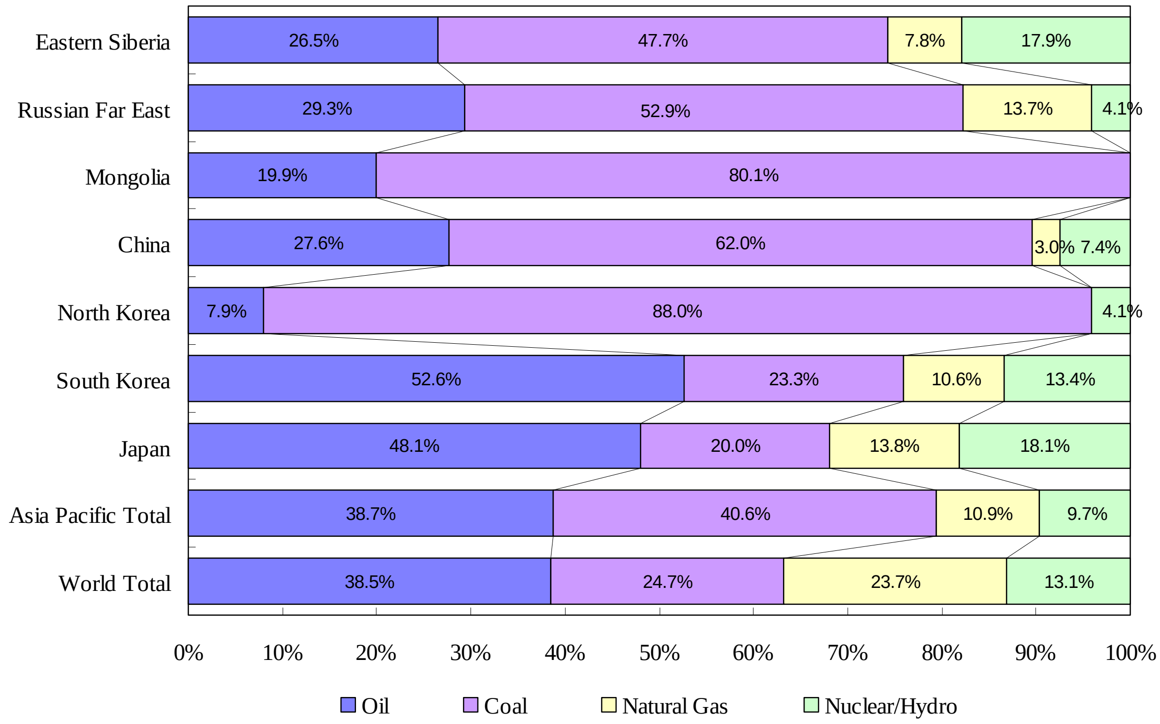
At present, Eastern Siberia and the Russian Far East are net receivers of energy. In 1999, the former had a net input (inbound shipments) amounting to 5.8 million toe, and the latter, one of 9.4 million toe. However, although Eastern Siberia has a net input of oil and natural gas, it had a net output (outbound shipment) of 5.5 million toe in coal, 4.6 million toe in petroleum products, and 13,990 gigawatt-hours (1.2 million toe) in electric power.

Figure 1.1 shows the structure of the primary energy demand in Northeast Asia. In Asia as a whole, the share of coal in the primary energy consumption is high, due to the presence of China and India, which are big coal producers and consumers. In the entire Asian Pacific as well, the coal’s share is 40.6 percent, much higher than the global average of 24.7 percent.

Excluding the resource-poor countries of Japan and South Korea, the countries and territories of Northeast Asia have energy supply and demand structure depending fairly heavily on coal. The share of coal in the primary energy supply is above the 50-percent mark; in North Korea at 88 percent, followed by Mongolia at 80 percent, China at 62 percent, and the Russian Far East at 53 percent. In Eastern Siberia as well, it is close to that mark, at 48 percent. These figures derive fundamentally from the abundant reserves of coal in these countries and territories.

In contrast, the share of natural gas is lower than the global average. It does not even appear in the statistics for Mongolia and North Korea. The oil’s share reflects circumstances prevailing in each country or territory. It is high in Japan and South Korea, which have high levels of oil import and consumption. The Russian Far East, which produces crude oil, nevertheless ships in about twice of the production to meet its domestic energy demand. Mongolia and North Korea import all of their oil requirements.

Figure 1.1 Primary Energy Demand Structure (2001)



(Source) Eastern Siberia and the Russian Far East: SEI data,
North Korea (2000 value): "Energy Balances of Non-OECD Countries, 2002 Edition", IEA
Mongolia (1999 value): "Energy Statistics Yearbook", UN
Others: "BP Statistics 2002"

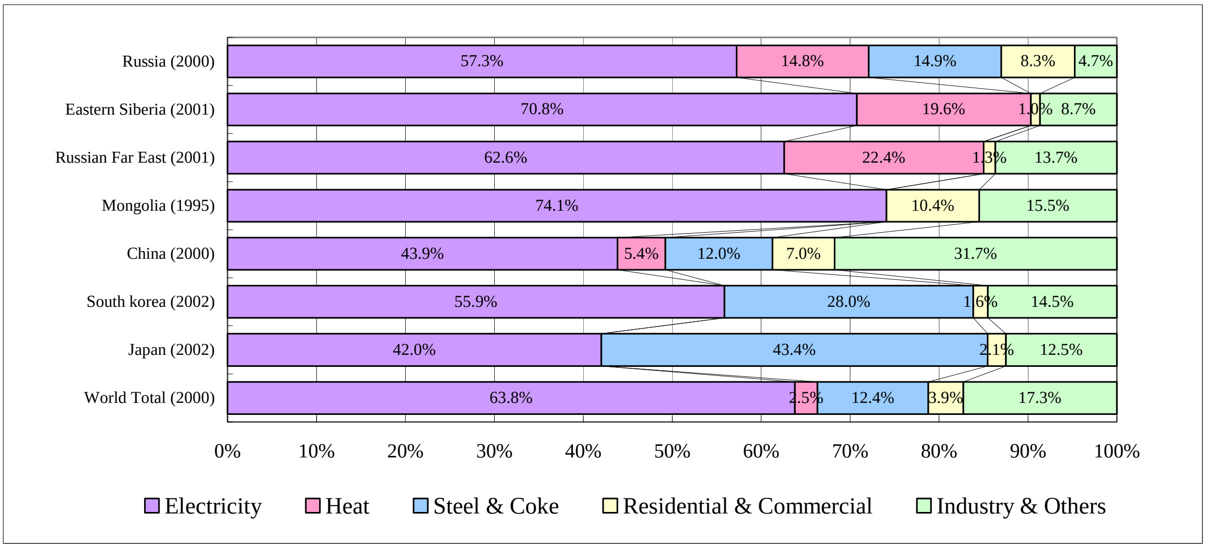
In the Figure 1.1, nuclear power and hydropower are lumped as one category together. The share of nuclear power in the primary energy supply accounts for 0.1 percent in the Russian Far East, 0.5 percent in China, 13 percent in South Korea, 14 percent in Japan, 4.6 percent in the Asian Pacific as a whole, and 6.6 percent worldwide. In Eastern Siberia, Mongolia, and North Korea, the primary electric power supply depends entirely on hydropower.

1.2.2 Coal

Figure 1.2 shows the structure of the coal demand in Northeast Asia (the observation year varies somewhat depending on the country or territory). In each country/territory, coal demand is mainly for power generation. More specifically, the share of the coal supply for the power sector was 71 percent in Eastern Siberia, 63 percent in the Russian Far East, 74 percent in Mongolia, 44 percent in China, 56 percent in Korea, and 42 percent in Japan. Furthermore, in Chinese statistics, captive power generation is classified into the industrial energy demand, and the share of the coal for power generation in China is therefore even higher. The share for the iron and steel industry is by far highest in Japan, followed in order by South Korea, Russia, and China. Coal demand for steel making is scarce in Eastern Siberia and the Russian Far East, which is different from the Russian average.

In Russia and China, coal demand is in large for combined heat and power plants (CHP) and boilers for district heat and hot water supply. The coal demand exclusively for supply of heat and hot water (i.e., excluding power generation plants and CHP plants) accounts for about 20 percent of the coal supply in Eastern Siberia and 22 percent in the Russian Far East (as compared to the average of about 15 percent in Russia as a whole). In China, the corresponding average value is about 5 percent.

Figure 1.2 Coal Demand Structure in Northeast Asia



(Source) Russia and the world: "Energy Balances of Non-OECD Countries, 2002 Edition", IEA

Eastern Siberia and the Russian Far East: SEI data

China: "China Statistical Yearbook 2002", China Statistics Press

Mongolia: "Mongolian Economy and Society in 1995"

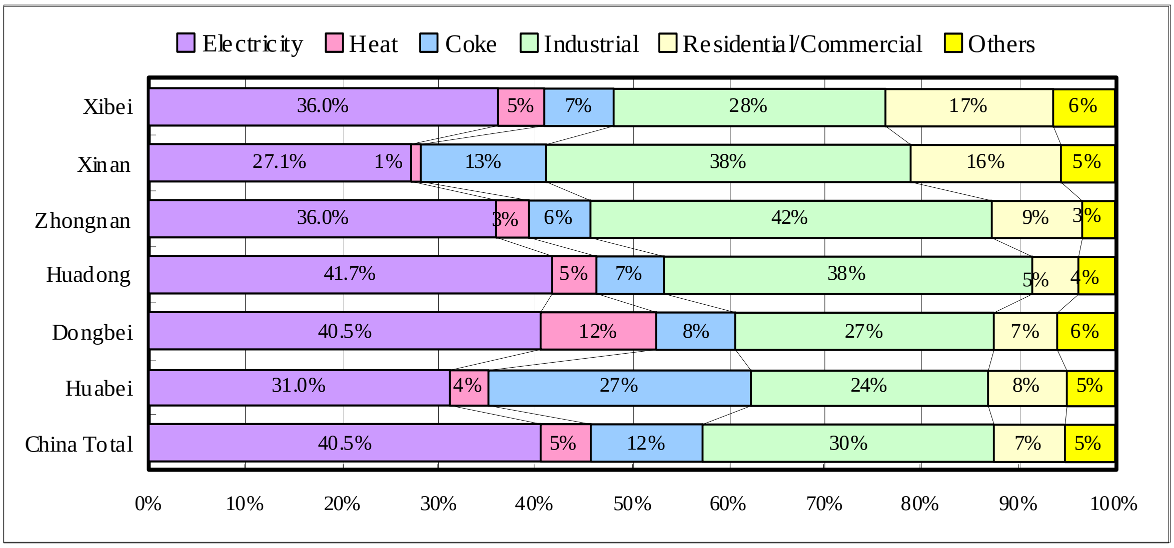
The coal demand structure in China varies by province. Figure 1.3 shows the demand structure by administrative region. The share of the industrial and power sector accounts for 80 percent in the Huadong (Eastern) Region. In the Dongbei (Northeastern) Region, the share for heat supply is higher than the other regions. The Huabei (Northern) Region has a high share of coke due to the yearly coke production of some 64 million tons in the Shanxi Province and 15 million tons in Hebei Province. More of the coke produced in the Shanxi is shipped out to other provinces.

In China, coal is produced over many regions, but provinces with surplus potential for shipment to other regions are limited. The biggest shipper is the Shanxi Province, which shipped 211 million tons to other regions in 2000. The main coal producing area consisting of Shanxi, Inner Mongolia and Shannxi shipped out or exported 257 million tons. The other major provinces supplying coal to other provinces or to other countries were Heilongjiang Province in the Dongbei Region, which had an ex-province shipment of 23 million tons, Shandong Province in the Huadong Region, and Guizhou Province in the Xinan (Southwest) Region, both of which had one of 14 million tons.

As for coal demand, main consuming provinces are to the east of Shanxi Province. In 2000, the provinces with a consumption of at least 70 million tons were Shanxi (109 million tons), Heibei (101 million tons), Liaoning (82 million tons), Jiangsu (81 million tons), Shandong (75 million tons), and Henan (73 million tons). The coal consumption in Shanxi Province is mostly for the coke production for shipment to other provinces. Excluding this shipment, the province's domestic consumption is around 45 million tons.

Within Northeast Asia, the eastern coastal zone of China combines with Japan and South Korea to form a coal-consuming region of 800 million tons yearly, which account just over 20 percent of the global coal consumption. The region above is also expected to increase the coal demand into the future.

Figure 1.3 Coal Demand Structure by Province in China (1999)



(Source) "China Energy Statistical Yearbook 1997-1999" (July 2000), China Statistics Press

2. Energy Supply and Demand Forecasting

2.1 Premises

Table 2.1 shows the premises for energy supply and demand forecasting. In the case of South Korea and Japan, officially announced figures are quoted. And for the other countries, the forecasting results are obtained by use of some simulation models. The observation years in the Table mean the scope of time-series data that were both available and applied for the model building. Data sources related to economic indicators and energy supply-demand data are as follows.

Russia as a whole: "Energy Balances of Non-OECD Countries", IEA
"International Financial Statistics", IMF
Eastern Siberia and the Russian Far East: SEI (Energy System Institute)
"Russian Energy Strategy in the 21st Century" (Tozai Boeki Tsushinnsha)
Mongolia: "Key Indicators of Developing Asian and Pacific Countries", ADB
"UN Energy Statistics", UN
China: "China Statistical Yearbook", "China Energy Statistical Yearbook", China Statistics Press
North Korea: IEA Statistics, IMF Statistics and "Country Profile Table", WB

Table 2.1 Premises for Energy Supply and Demand Forecasting

	Base year	Target year	Scenario
Russia	2000	2020	Average annual GDP growth rate: 5.4% (2002 - 2005), 5.0% (2006 - 2020); Observation years: 1992 - 2000
Eastern Siberia & Far East	2000	2020	Average annual GDP growth rate: 5.9% (2002 - 2005), 5.5% (2006 - 2020); Observation years: 1995 - 2000
Mongolia	2000	2020	Average annual GDP growth rate: 3% (2002 - 2020); Observation years: 1985 - 2000
China	2000	2020	Average annual GDP growth rate: 6.5% (2002 - 2010), 5.9% (2010 - 2020) Energy prices: real price constant; Observation years 1980 - 2000
North Korea	2000	2020	Average annual GDP growth rate: 3% (2003 - 2020); Observation years 1990 - 2000
South Korea	2001	2021	Outlook figures from the Korea Energy Economics Institute
Japan	FY2000	FY2020	Outlook figures from the IEEJ (released in November 2002), base case

The economic growth rate for Russia as a whole was set in the range of 5.0 - 5.4 percent, lower than that of 5.4 - 6.4 percent in the Energy System Institute (SEI)'s outlook. The actual growth rate over the last few years has been in the range of 3 - 8 percent. Owing to the connection with the nationwide economy, the corresponding figures for the Eastern Siberia and the Far East territories were put at 5.9 percent to 2005 and 5.5 percent thereafter.

The reasoning was that the GDP shares of these territories in 2000 (6.8 and 6.0 percent, respectively) would return to the levels in the early 1990s, and consequently hit a respective 7.1 and 6.3 percent in 2010, and 7.5 and 6.6 percent in 2020. For China, it was assumed that the GDP growth rate would be lower than the 7-percent level in the Chinese forecast. The corresponding rates for Mongolia and North Korea were set at a uniform pace of 3 percent.

For China, besides the base case, it was decided to consider a second case of extensive energy conservation and a third case of energy conservation plus conversion (fuel shift) from coal to natural gas. The energy conservation case applied a conservation coefficient of 1.5 percent annually beginning in 2006 for the fields and energy sources judged to be the prospective subjects of conservation. The case of energy conservation plus fuel shift from coal to natural gas assumed the conversion in sectors most likely to promote it, i.e., the power, heat supply, manufacturing, and residential / commercial sectors.

For Japan, the outlook applied the figures in the long-term outlook of the Institute of Energy Economics, Japan (IEEJ).[2]

2.2 Outlook for Primary Energy Supply and Demand

In 2000, the primary energy consumption in Northeast Asia (excluding non-commercial energy) amounted to 1,756 million toe (tons of oil-equivalent). In the Region, China recorded 888 million toe and accounted for 50.6 percent of the total, followed by Japan at 559 million toe (31.8 percent) and South Korea at 193 million tons (11.0 percent). The consumption of Eastern Siberia and the Russian Far East were a respective 46.6 and 22 million tons (2.7 and 1.3 percent, respectively), and those for North Korea and Mongolia, 45.7 and 2.1 million tons (2.6 and 0.1 percent, respectively). From 1990 to 2000, the primary energy demand increased in China, Japan, and South Korea, at annual average rates of 3.4, 1.4, and 7.6 percent, respectively. In the other countries and territories, it recorded minus growth.

Table 2.2 shows the results of the primary energy demand forecasting by country/territory. It also shows the outlook for Russia as a whole for the purpose of reference. The primary energy demand in the Region is forecast to increase from 1,756 million toe in 2000 to 2,296 million toe in 2010 and to 3,056 million toe in 2020.

---

2 More information about premises and other items are shown in "EDMC Energy and Economic Statistical Handbook 2003".

Table 2.2 Outlook for Primary Energy Demand in Northeast Asia

(Unit: millions of oil-equivalent tons)

		2000	2010	2020	Average annual growth rate	
					2010/2000	2020/2010
Russia		(639.9)	(862.0)	(1,200.1)	(3.02)	(3.36)
	Eastern Siberia	46.6	65.0	94.2	3.37	3.78
	Russian Far East	22.0	34.8	51.9	4.69	4.08
Mongolia		2.1	2.7	3.7	2.70	2.90
China (Base case)		887.8	1,297.2	1,935.4	3.86	4.08
North Korea		45.7	57.4	72.4	2.31	2.34
South Korea		192.9	263.6	311.8	3.17	1.70
Japan (Base case)		558.7	575.7	586.3	0.30	0.18
Northeast Asia total		1755.8	2296.4	3055.6	2.72	2.90

The primary energy demand in China, which came to 888 million toe in 2000, is projected to reach 1,297 million toe in 2010 and 1,935 million toe in 2020 in the base case, and 1,213 million toe in 2010 and 1,608 million toe in 2020 in the energy conservation case. As such, in the latter case, the total ratio of primary energy conservation would be about 7 percent in 2010 and 18 percent in 2020. This scenario must be termed an extreme one, in that the energy conserved as of 2020 would amount to 330 million toe (equivalent to about 60 percent of Japan's total primary energy demand).

2.3 Outlook for Coal Supply and Demand

Although the aforementioned primary energy demand treated coal in oil-equivalent terms, this section employs the original units (metric tons). The types of coal are lignite in Eastern Siberia, the Russian Far East, and Mongolia, and mainly bituminous and sub-bituminous coal with some anthracite in other countries.

In 2000, coal consumption in Northeast Asia reached 1,600 million tons, and accounted for 40 percent of the global total. In the 1990s, coal consumption increased in China, Japan, and South Korea, at average annual growth rates of 3.0, 2.2, and 5.8 percent respectively. In the other countries, the growth rates were negative. China accounted for the largest share at 77 percent, with the remaining 23 percent being divided among mainly Japan at 9.2 percent, South Korea at 4.0 percent, North Korea at 3.9 percent, Eastern Siberia at 3.9 percent, and the Russian Far East at 1.8 percent.

Table 2.3 shows the results of the coal demand forecasting in Northeast Asia. The demand is expected to increase from 1,610 million tons in 2000 to 2,200 million tons in 2010 and to 3,030 million tons in 2020. China therefore accounts for a high proportion of the Northeast

Asia total; indeed, the trend of the Region's coal demand may be said to depend on China's demand. Moreover, China's share of the regional total is forecast to expand from 77 percent in 2000 to 78 percent in 2010 and 81 percent in 2020. In 2020, the shares of Eastern Siberia and the Russian Far East are expected to expand their shares to 4.1 and 2.1 percent, respectively, which is a little bit higher than the values in 2000. However the shares of Japan, South Korea, and North Korea are projected to decline to 5.6, 3.1, and 3.4 percent, respectively, in 2020.

Table 2.3 Outlook for Coal Demand in Northeast Asia

	Millions of toe			Millions of tons of coal			Average annual growth rate (%)		Calorific value (kcal/kg)
	2000	2010	2020	2000	2010	2020			
Russia									
Eastern Siberia	22.6	30.8	44.1	63.9	87.3	124.9	3.17	3.65	3,532
Russian Far East	11.4	16.7	24.5	30.1	44.3	65.1	3.92	3.93	3,770
Mongolia	1.7	2.2	2.9	5.2	6.8	9.0	2.66	2.87	3,250
China (Base case)	616.0	861.2	1,233.4	1,232.0	1,722.4	2,466.8	3.41	3.66	5,000
North Korea	39.6	50.2	63.6	64.5	81.7	103.4	2.39	2.39	6,150
South Korea	42.9	61.5	62.6	65.5	93.6	95.2	3.64	0.17	*1
Japan (Base case)	100.2	107.8	110.9	152.0	164.1	169.7	0.77	0.34	*2
Northeast Asia total	834.4	1,130.4	1,542.0	1,613.2	2,200.1	3,034.1	3.15	3.27	

(Note) *1: Bituminous coal: 6,600 kcal/kg, Anthracite: 6,000 kcal/kg

*2: Coking coal: 6,900 kcal/kg, Steaming coal: 6,354 kcal/kg

As for the coal supply, Eastern Siberia and China will export over the domestic demand. Mongolia and North Korea will remain self-sufficient in coal, and South Korea and Japan will import to meet the domestic demand.

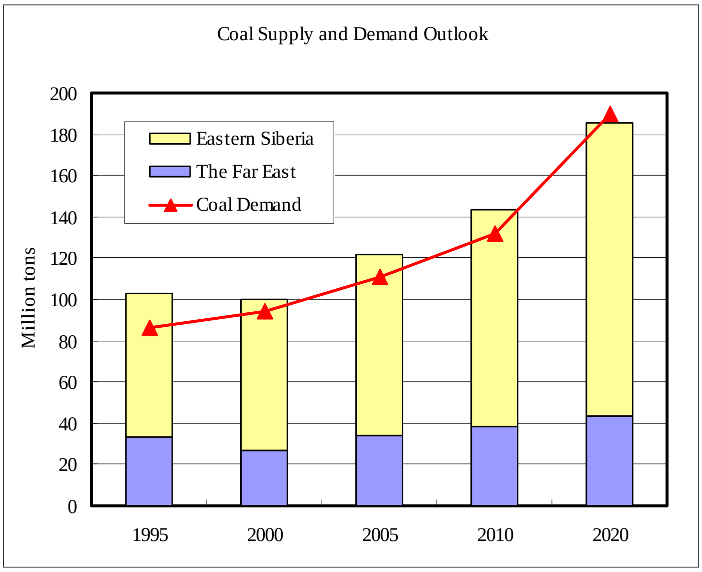
2.3.1 Eastern Siberia and the Russian Far East

Figure 2.1 shows the outlook for coal production and consumption in Eastern Siberia and the Russian Far East. In the Figure, the bar graph shows the production, and the polygonal graph shows the consumption forecasted.

Coal production is centered in Eastern Siberia, which is expected to produce 1,050 million tons in 2010 and 1,420 million tons in 2020. Eastern Siberia is also a net shipper of coal; in 1999, it shipped out 16.7 million tons and received 1.30 million tons. In 2010 and succeeding years, it could have a net outbound shipment on the order of 17 million tons. The Russian Far East, on the other hand, has a net inbound shipment of coal (in 1999, it had inbound shipments of 4.35 million tons and outbound shipments of 1 million tons). It is projected to require a net inbound shipment of about 6 million tons in 2010 and 20 million tons in 2020.

Figure 2.1
Outlook for Coal Supply and Demand in Eastern Siberia and the Russian Far East

(Source)
Coal production: SEI (Energy System Institute, Russian Academy of Science, Siberian Branch)
Demand outlook: Table 2.3, ibid.



2.3.2 Mongolia

Mongolia's coal demand depends on the power sector’s requirement. The total power supply in Mongolia is met to the domestic demand by adding the import of about 10 percents from Russia. As such, the demand for coal would vary depending on whether the power demand is supplied by the coal thermal power plants domestically or is continued to import power partially. The domestic coal production would also vary, because it meets the domestic coal demand mainly depending on power generation.

In this study, the coal demand forecasting is assumed to continue power import from Russia. Figure 2.2 shows the actual and forecast trends of the total power supply, domestic power generation, and coal demand.

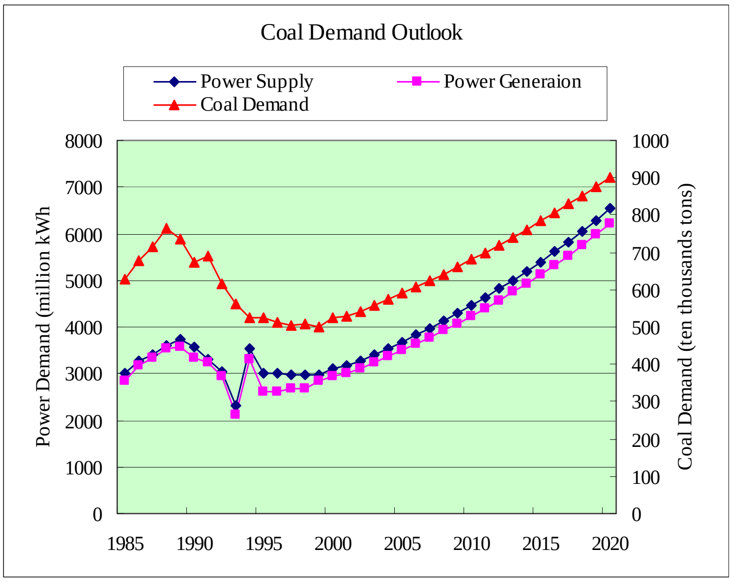


Figure 2.2
Outlook for Total Power Supply, Generated Output, and Coal Demand in Mongolia

2.3.3 China

Table 2.4 shows the outlook for China's coal demand in each sector and in each case (base, energy conservation, and energy conservation plus natural gas conversion). Figure 2.3 shows the breakdown of the forecast coal demand by sector in the base case.

Table 2.4 Outlook for Coal Demand in China

(Unit: millions of tons)

			Base case		Energy conservation		Energy conservation plus natural gas conversion	
		2000	2010	2020	2010	2020	2010	2020
Steaming coal		1,101	1,494	2,155	1,386	1,759	1,355	1,529
	Power	573	866	1,398	796	1,074	781	967
	Heat	68	104	142	104	142	99	118
	Manufacturing	333	392	480	358	415	353	385
	Others	128	131	135	129	128	123	60
Coking coal		158	229	311	212	250	212	250
Coal total		1,260	1,722	2,467	1,599	2,009	1,568	1,779

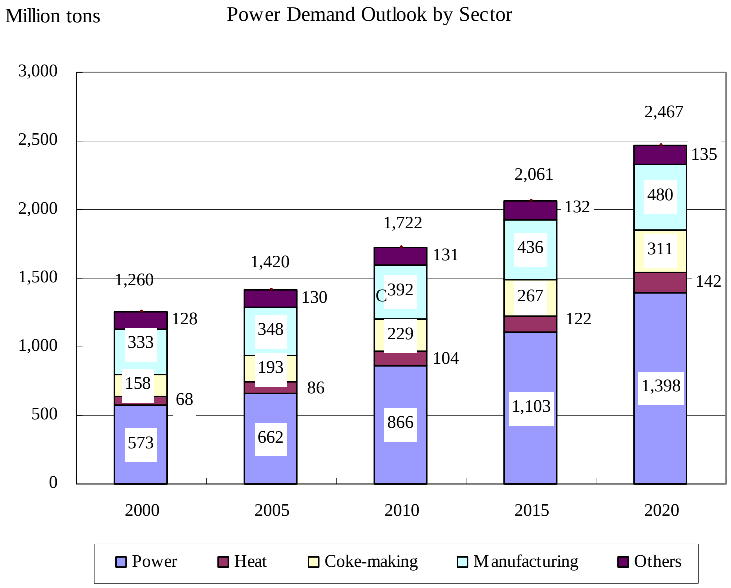
In China, the coal demand is forecast to increase from 1,260 million tons in 2000 to 1,720 million tons in 2010 and 2,470 million tons in 2020 in the base case, 1,600 million tons in 2010 and 2,010 million tons in 2020 in the energy conservation case, and 1,570 million tons in 2010 and 1,780 million tons in 2020 in the case of energy conservation plus natural gas conversion.

In the scenario except the base case, the energy conservation ratio in 2020 would be 19 percent, for a savings of 460 million tons, which is larger than the 380 million tons of consumption in Northeast Asia excluding China. This scenario expects the ambitious promotion of energy conservation by the Chinese government in light of the international environment. The ratio of energy conservation would be largest in the power sector at 23 percent in 2020, for a savings of 320 million tons. The corresponding figures in the manufacturing sector would be 13.6 percent and 65 million tons. As for the metallurgical coal, the conservation ratio in 2020 would be 19.7 percent, for savings of 61 million tons.

In the case of energy conservation plus natural gas conversion, it is assumed that the fuel shift from coal to natural gas would concern only thermal coal. The conversion ratio as of 2020 would be 13 percent, equivalent to 230 million tons of coal (or 115 million tons of oil). Of this total, the power sector would account for 110 million tons, and the residential/commercial sector, for 67 million tons.

In each of the aforementioned outlook cases, the power sector would account for the largest share in the coal demand. This share would increase from 45 percent in 2000 to 50 percent in 2010 and 57 percent in 2020 in the base case, and 50 percent in 2010 and 54 percent in 2020 even in the case of energy conservation plus natural gas conversion. The second-largest share in the coal demand would be followed by the manufacturing sector.

Figure 2.3
Outlook for Coal Demand by Sector in China
(Base Case)



2.3.4 North Korea

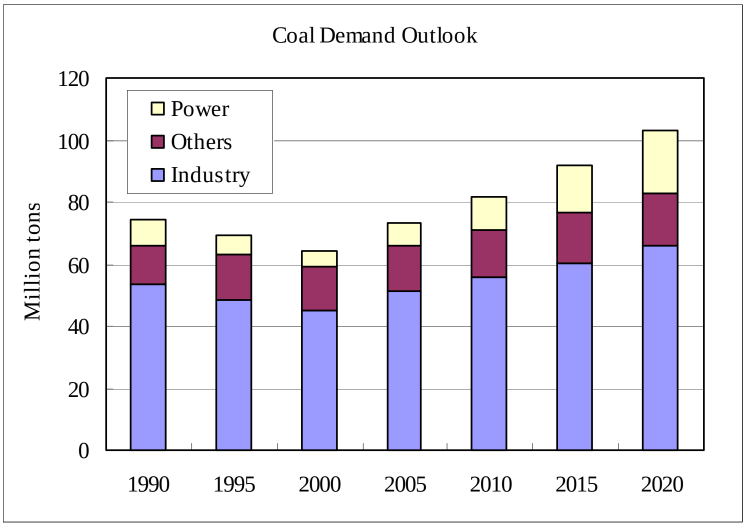
In North Korea, the coal demand (and supply) increased at an average annual rate of 5.2 percent in the 1970s and 5.8 percent in the 1980s, but had recorded minus growth since 1993. In recent years, it has begun to show the rising trend (according to IEA statistics).

Figure 2.4 shows the outlook for the coal demand in North Korea. In 2000, the demand came to 64.5 million tons (consisting of 45.1 million tons in the industrial sector, 14.2 million tons in the residential/commercial sector, and 5.2 million tons in the power sector). It is forecast to increase to 81.7 million tons (with a corresponding composition of 55.6, 15.5, and 16 million tons) in 2010 and 103.4 million tons (with one of 65.8, 16.8, and 20.8 million tons) in 2020. Over the years 2000-2020, the demand would therefore grow by annual rates averaging 1.9 percent in the industrial sector, 0.9 percent in the residential/commercial sector, and 7.2 percent in the power sector, which would have the highest growth rate.

In the current power source mix, the hydropower (21,320 gigawatt-hours) is the principal supply source over the thermal power (10,320 gigawatt-hours), which is coal-fired thermal. In the simulation result, the shares of the two would become same level in 2018. In this simulation as well, the industrial structure change and fuel switch in North Korea are not taken into consideration for the future.

At present, North Korea has a coal trade of about 300 thousand tons, but the domestic production is supplied for the home consuming. North Korea produced just under 80 million tons in the past, but it is doubtful whether it could produce the approximately 100 million tons that would be needed in the 2020 basing on the simulation result. This suggests a dependence on import from China or use of other fuels for the shortage.

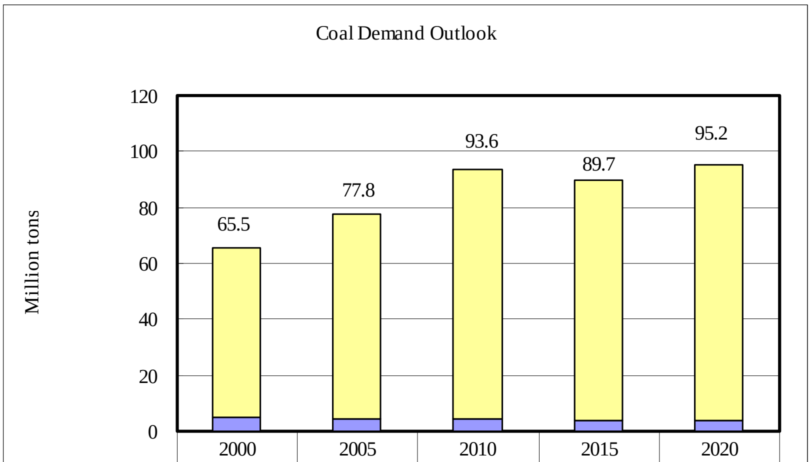
Figure 2.4
Outlook for Coal Demand in North Korea



2.3.5 South Korea

Figure 2.5 shows the outlook for the coal demand in South Korea. It is forecast to increase from 65.5 million tons in 2000 to 93.6 million tons in 2010 and 95.2 million tons in 2020. Production of coking coal is supposed to remain on the current level of 18 million tons, and that of steaming coal is expected to increase by 27 million tons, from 49 million tons in 2002 to 76 million tons in 2010. Thereafter, it is thought that coal demand will shift to LNG and nuclear power.

Figure 2.5
Outlook for Coal Demand in South Korea



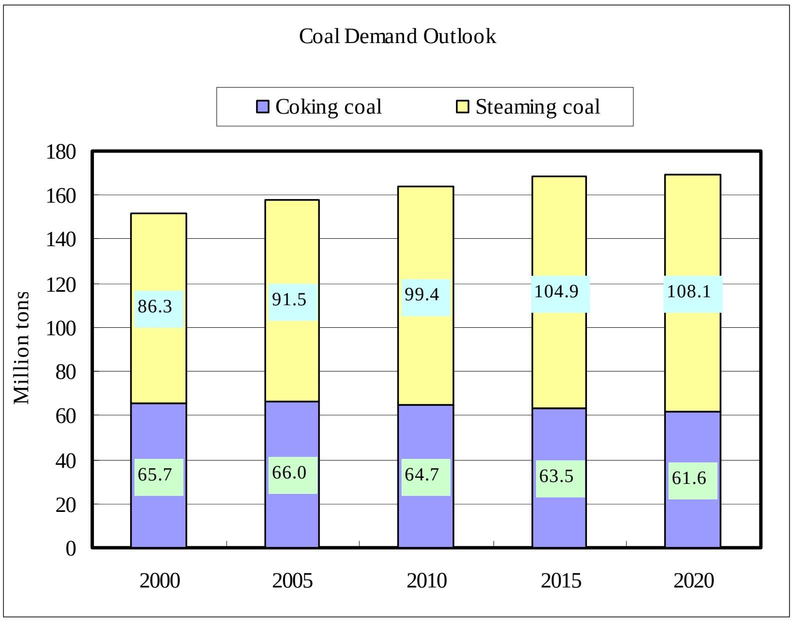
	2000	2005	2010	2015	2020
Bituminous	60.30	73.33	89.24	86.06	91.36
Anthracite	5.17	4.50	4.33	3.67	3.83

(Source)
Korean Ministry of Commerce, Industry and Energy (Website)

2.3.6 Japan

Figure 2.6 shows the coal demand outlook for Japan (the IEEJ long-term outlook released in November 2002) in the base case. The demand is expected to increase from 152 million tons in 2000 to 164 million tons in 2010 and 170 million tons in 2020. the demand for coking coal is forecast to decline only slightly from the area of 66 million tons, that for steaming coal is expected to expand steadily, from 86 million tons in 2000 to 99 million tons in 2010 and 108 million tons in 2020.

Figure 2.6
Outlook for Coal Demand in Japan



(Source)
IEEJ long-term outlook
(Base case)

The long-term energy supply-demand outlook released by the Advisory Committee for Natural Resources and Energy in July 2001 envisions a coal demand of 180 million tons (including 120 million tons of steaming coal) in the base case and 151 million tons (including 90 million tons of steaming coal) in the target case.

3. Environmental Issues in Northeast Asia

Whereas environmental problems in energy sector formerly meant ordinary water and air pollution, they have generally been viewed from a global standpoint more recently, due to concern about global warming as a phenomenon apart from air pollution. In reality, however, most parts of Northeast Asia are confronted with the ordinary types of environmental problem. Excessive emission levels of dust and soot affect the health of local inhabitants. Emissions of sulfur oxides (SOx) and nitrogen oxides (NOx) have an influence on a wide regional area, and can cause problems of acid rain that cross national borders.

3.1 CO_2 Emissions - Current Situation and Future Outlook

Table 3.1 shows emission coefficients used in the calculation of emission levels for carbon dioxide (CO_2). Table 3.2 shows the resulting future outlook (estimates) for CO_2 emissions in the countries of Northeast Asia. The emission coefficients indicate the emission intensities on the calorie basis (tons of carbon per toe). The CO_2 emissions were obtained by multiplying the domestic or regional fuel consumption by the respective coefficients.

Table 3.1 CO_2 Emission Factors

(Unit: ton-C/toe)

Coal 1.08, Natural gas 0.641, Crude oil 0.837, LPG 0.723, Gasoline 0.791, Jet fuel 0.816, Kerosene 0.821, Gas oil 0.846, Heavy oil 0.883, Other petroleum products 0.837

In the Northeast Asian region as a whole, the CO_2 emission (carbon-equivalent) in the base case are projected to increase from 1,400 million tons in 2000 to 1,880 million tons in 2010 and 2,540 million tons in 2020. In 2000, China accounted for the largest share at 61 percent, and was followed by Japan at 23 percent, South Korea at 8 percent, and Eastern Siberia and the Russian Far East at 4 percent. China's share would expand to 66 percent in 2010 and 72 percent in 2020 in the base case, and 65 percent in 2010 and 67 percent in 2020 even in the case of energy conservation plus natural gas conversion. By 2020, the emission in China is therefore anticipated to be five or six times as high as in Japan.

As shown in Table 3.3, China's CO_2 emission per capita in 2000 could be termed relatively low. In terms of the total emission volume, nevertheless, China currently is the second-largest emission country in the world, and could be likely to replace the United States at the No. 1 position, according to the scenario (in 2000, U.S. emission amounted to 1,580 million carbon-equivalent tons). As for the emission level per GDP, China has a considerable potential for the improvement of energy efficiency comparing with South Korea and Japan. China will be asked to strengthen its energy conservation policy over the coming years.

Table 3.2 Outlook for CO_2 Emissions in Northeast Asia

(Unit: millions of carbon-equivalent tons)

		1999 (A)	2000 (B)	2010 (C)	2020 (D)	Multiplier (B/A)	(C/A)	(D/A)
Russia		643.6	424.7	573.8	797.7	0.66	0.89	1.24
	Eastern Siberia	56.9	35.2	49.2	71.4	0.62	0.86	1.25
	Russian Far East	39.9	22.7	33.7	50.2	0.57	0.84	1.26
Mongolia		2.8	2.2	2.8	3.8	0.79	1.03	1.36
China	(Base case)	653.0	859.2	1,245.3	1,833.5	1.32	1.91	2.81
	(Energy conservation)	653.0	859.2	1,159.6	1,503.7	1.32	1.78	2.30
	(Energy conservation plus natural gas conversion)	653.0	859.2	1,152.8	1,453.3	1.32	1.77	2.23
North Korea		53.1	46.2	58.0	72.9	0.87	1.09	1.37
South Korea		65.2	119.4	162.2	186.7	1.83	2.49	2.87
Japan (Base case)		287.1	316.3	325.2	322.9	1.10	1.13	1.12
Northeast Asia total		1,158.0	1,401.1	1,876.4	2,541.4	1.21	1.62	2.19

(Note)

- The 1990 figures for the entire Russia were taken from the "3rd National Communication of the Russian Federation" Report submitted to the UN Framework Convention on Climate Change.
- The 1990 figures for Eastern Siberia and the Russian Far East are calculated from the Energy Balance Table of the " Study on Comprehensive Energy Plan in Eastern Siberia and Far East of the Russian Federation", June 1995, IEEJ.

Table 3.3 CO_2 Emissions per Capita and per GDP (2000)

		Total emissions (millions of T-C)	/Capita (T-C/person)	/GDP (T-C/millions of dollars)
Russia		425	2.92	1,635
	Eastern Siberia	35	3.92	1,996
	Russian Far East	23	3.11	1,456
Mongolia		2	0.91	2,243
China		859	0.67	796
North Korea		46	2.07	2,885
South Korea		119	2.52	259
Japan		316	2.49	66

At an international symposium on "Energy Strategy and Reform" held on 5 November 2003, a

"Basic Vision for National Energy Strategy in China" was presented by a research group on issues in strategy and policy for total energy development. The paper presented points out as follows.

"In 2020, China's CO_2 emission should be in the range of 1,300 - 2,000 million tons, or 0.9 - 1.3 tons per person. If the United States were to sign the Kyoto Protocol, China would then find it difficult to avoid the acceptance for restriction of its GHG emissions. Along with the reduction of GHG emission, the marginal cost of CO_2 reduction would probably begin to rise. The development of energy in China would consequently be under the pressure from the global environmental concerns. As the reduction of GHG emission requires an economic input, China would presumably be compelled to modify the positioning of its energy sector."

Looking at the CO_2 emissions in Northeast Asia from the standpoint of carbon trading as shown in Table 3.2, it is cloudy whether Russia could keep the "hot air" margin for use in carbon trading from 2015 onwards. Assuming that the energy demand increases at rates in the range of 3.0 - 3.4 percent as shown in Table 2.2, Russia's CO_2 emission would reach 67.7 million tons in 2015 and 79.8 million tons in 2020. According to simulation results of this time, Russia would therefore exceed the 1990 emission level around 2014.

3.2 Current Situation of Atmospheric Environment

3.2.1 Air Quality

Table 3.4 shows the results of atmospheric measurements in cities in China, South Korea, and Japan (selected with consideration of regional spread). For concentrations of SOx and NOx, the figures of SO_2 and NO_2 were adopted from reasons of data consistency among the cities. Although statistics in Japan and South Korea express these concentrations in volume terms (ppm, parts per million), these figures are converted into weight terms (milligrams per cubic meter), which are used in Chinese statistics.

The SO_2 concentrations in Chinese cities are several times as high as those in Japanese and South Korean cities. The level in Beijing is on a par with that in Seoul in the early 1990s and in Tokyo in the early 1980s.

Regarding NO_2 concentrations, there are little differences among the cities. The trend over time indicates one of flatness or increase, because the NO_2 concentrations in urbanized areas are originated from the exhausted gas from moving emission sources.

Table 3.4 Atmospheric Environments in Cities in Northeast Asia

	SO_2 (mg/m^3)	NO_2 (mg/m^3)	TSP (mg/m^3)	PM-10 (mg/m^3)	Soot and dust fall (ton/km^2/month)
Beijing (2000)	0.071	0.071	0.353		15.1
Jilin (2000)	0.067	0.063	0.557		25.0
Lanzhou (2000)	0.060	0.053	0.668		21.1
Shanghai (2000)	0.046	0.061	0.156		8.9
Chongqing (2000)	0.126	0.044	0.261		11.5
Guangzhou (2000)	0.049	0.068	0.185		7.3
Seoul(2002)	0.014	0.074		0.076	
Busan(2002)	0.020	0.060		0.069	
Tokyo (2001)	0.000	0.000		0.042	4.6
Fukuoka (2001)	0.000	0.000		0.033	2.8

(Note) SO_2: 1ppm = 2.857 mg/m^3, NO_2: 1ppm = 2.054 mg/m^3

(Source)

- China: China Environment Press, "China Environment Yearbook 2001"
- South Korea: Korean National Statistical Office (KNSO)
- Japan: "Environmental GIS Data", National Institute for Environmental Studies

For suspended particles, statistics contain data for total suspended particles (TSP) in China and suspended particulate matter with a diameter of 10 micro millimeters or less (SPM, PM-10) in Japan and South Korea. While the two definitions above therefore cannot be compared without qualification, it appears that the concentration of suspended particles is fairly high in China. It may also be noted that the TSP values in Chinese cities are at least one digit higher than the TSP guideline of the World Health Organization (WHO; 0.04 - 0.06 milligrams per cubic meter). The amount of soot and dust fall also includes yellow sand and other particles from natural sources, and is higher in the northern part of China. In Japan, there are now only two monitoring stations remaining for long-term continuous measurement related to soot and dust falling. In Table 3.4, the measured values for Kawasaki and Omuta were therefore applied for Tokyo and Fukuoka, respectively.

The “China Environment Yearbook” contains average annual values for the atmospheric environment in about 90 cities that are subjects of observation in the northern and southern parts of the country. Table 3.5 shows yearly data for the five cities ranking as the worst (the two cities ranking as the worst and the fifth-worst) in the northern and southern parts. It can be seen that there has been improvement in the category of amount of soot and dust fall in the northern cities and in those of SO_2 and TSP in the southern ones. Previously, there were high atmospheric concentrations of SO_2 in southern provinces such as Guizhou and Sichuan due to the combustion of high sulfur content coal. The reduction in SO_2 concentrations in southern cities is thought to be due to the fuel controls limiting to the sulfur content within 3 percent, which apparently led to a decrease in use of high-sulfur coal.

In the category of NOx, in contrast, there are no signs of improvement in either the northern or the southern cities. The amount of soot and dust fall cannot be completely resolved only by countermeasures for fixed emission sources, because it includes yellow sand and other material from natural sources. It is more serious in the northern industrialized districts.

Table 3.5 Monitoring Results of the Atmospheric Environment in Chinese Cities

	Northern cities							
	SO_2 (mg/m^3)		NOx (mg/m^3)		TSP (mg/m^3)		Soot and dust fall (ton/km^2/month)	
	NO.1	NO.5	NO.1	NO.5	NO.1	NO.5	NO.1	NO.5
1994	0.216	0.182	0.147	0.091	0.815	0.538	83.5	40.6
1996	0.212	0.183	0.117	0.075	0.618	0.536	52.7	36.9
1997	0.248	0.147	0.133	0.073	0.741	0.509	53.2	33.9
1998	0.276	0.139	0.151	0.074	0.741	0.523	66.3	35.0
1999	0.272	0.135	0.140	0.075	0.655	0.494	61.6	31.1
2000	0.277	0.134	0.126	0.069	0.721	0.545	38.4	28.3

	Southern cities							
	SO_2 (mg/m^3)		NOx (mg/m^3)		TSP (mg/m^3)		Soot and dust fall (ton/km^2/month)	
	NO.1	NO.5	NO.1	NO.5	NO.1	NO.5	NO.1	NO.5
1994	0.451	0.202	0.109	0.071	0.721	0.304	19.9	13.5
1996	0.418	0.144	0.152	0.071	0.618	0.312	20.2	13.0
1997	0.216	0.138	0.140	0.067	0.529	0.278	19.2	13.8
1998	0.183	0.134	0.124	0.061	0.529	0.278	18.6	13.8
1999	0.171	0.125	0.113	0.062	0.320	0.259	19.1	12.0
2000	0.208	0.125	0.118	0.048	0.435	0.266	27.8	13.3

(Note) WHO guidelines (annual averages):

SO2: 0.04-0.06 mg/m3, Nox: 0.04-0.06 mg/m, TSP: 0.06-0.09 mg/m

(Source) prepared from editions (for the years in question) of "China Environment Yearbook"

3.2.2 Acid Rain

Table 3.6 shows the hydrogen-ion concentrations (pH) of rainfall in China, South Korea, and Japan. The figures for China are based on measurements monitored at 102 cities, and indicate the number of cities in each pH range. Those for South Korea indicate the average monthly pH range in major cities. Those for Japan are based on the results of the fourth acid rain survey (1998 - 2000), and indicate the average yearly pH values in selected cities considering its regional spread.

Table 3.6 pH Concentrations in Rainfall

China Monitoring (2000)	PH	<4.0	4.0-4.5	4.5-5.0	5.0-5.6	5.6-7.0	>7.0
	No. Cities	0	4	32	36	30	0
	Percent	0	3.9	31.4	35.3	29.4	0
South Korea (Monthly average pH)	2000	Seoul (4.3-5.5), Busan (4.7-5.7), Daegu (4.3-5.8), Inchon (4.3-5.8), Jeju (4.1-6.2)					
	2001	Seoul (4.4-7.3), Busan (4.7-6.6), Daegu (5.4-6.6), Inchon (4.4-7.4), Jeju (3.8-5.4)					
	2002	Seoul (4.4-6.8), Busan (5.6-6.8), Daegu (5.1-6.6), Inchon (4.3-5.8), Jeju (4.2-5.2)					
Japan (Yearly average pH)	1998	Sapporo 5.2, Niigata 4.6, Matsue 4.7, Kitakyushu 5.0, Sendai 5.1, Kawasaki 4.7, Osaka 4.5					
	1999	Sapporo 4.7, Niigata 4.6, Matsue 4.8, Kitakyushu 5.1, Sendai 5.2, Kawasaki 4.9, Osaka 4.7					
	2000	Sapporo 4.7, Niigata 4.8, Matsue 4.8, Kitakyushu 5.0, Sendai 5.1, Kawasaki 4.7, Osaka 4.8					

(Source)

- China: "China Environment Yearbook 2001"
- South Korea: KNSO (Korean National Statistical Office)
- Japan: "FY2003 Environmental White Paper" edited by the Ministry of Environment

To judge from Table 3.6, there are no significant differences among the three countries in this respect. In most Japanese cities, the pH ranges from 4.5 to 5.0, on a par with or lower than the averages in the Chinese cities designated under acid rain controls. Seeing that the data for South Korea are average monthly values, Japan could be considered to rank below South Korea as regards acid rain. More significant, however, is the absence of signs of improvement in the pH level in both Japan and South Korea over the long term. In Japan, the average annual pH values in each year of the fourth survey (1998 - 2000) are in the range of 4.72 - 4.90, and this is basically the same as the corresponding range of 4.7 - 4.9 in the third survey (1993 - 1997). Moreover, the 2003 edition of the Environmental White Paper ("Quality of the Environment in Japan") edited by the Ministry of Environment notes that monitoring stations on the Sea of Japan coast confirmed a trend toward increase in sulfuric ions and nitric acid deposition in the winter, and that the findings of the third survey suggested an influence from the mainland. The observation data for the major Korean cities since 1990 also exhibit no sign of improvement in the pH value.

3.3 Emissions of Atmospheric Pollutants - Current Situation and Future Outlook

3.3.1 Current Situation

Table 3.7 shows the past trends of SO_2 emissions in China, South Korea, and Japan based on official published data. It indicates a trend of increase in China and significant decrease in South Korea. In Japan, SO_2 emissions decreased from the order of 1.3 million tons in the late 1970s and have been in the range of 600 – 700 thousand tons since the late 1980s. It should be noted that, in the case of Japan and South Korea, the value in the 2000 column is actually for 1999. NO_2 emissions from fixed emission sources have remained on roughly the same level in Japan, and are likely to decline in South Korea. No data are available for NO_2 emissions in China.

Table 3.7 Historical Trends of SO_2 and NO_2 Emissions

(unit: thousand tons)

		1980	1985	1990	1995	2000 (1999)
SO_2	China	n.a	13,250	14,990	18,900	19,927
	South Korea	n.a	n.a	1,611	1,532	951
	Japan (fixed sources)	1,158	795	615	708	629
NO_2	South Korea	n.a	n.a	926	1,153	1,136
	Japan (fixed sources)	819	699	780	878	837

(Source) China: China Environment Yearbook, Japan: Ministry of Environment
South Korea: KNSO (Korean National Statistical Office)

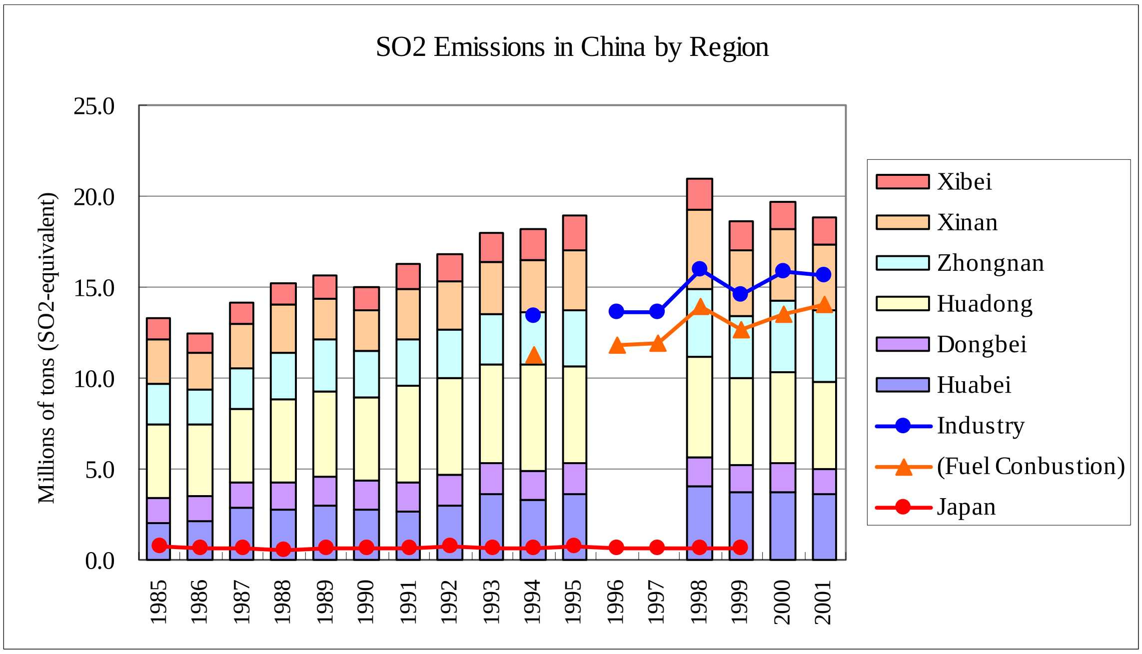
China now records the highest level of SOx emissions in the world. In 2000, China emitted 19.93 million tons (in SO_2 equivalent), which is already more than the corresponding 18.48 million SO_2 tons emitted in the United States (according to "OECD Environmental Indicators 2001").

Figure 3.1 shows the historical trends of SO_2 emissions in China by region. In the Figure, SO_2 emissions in Japan are also plotted as a reference. The emissions in China derive from both the industrial sector and the residential/commercial sector. The polygonal graph in the Figure shows those from the industrial sector. In 2001, the emission recorded 19.5 million tons, consisting of 15.7 million tons in the industrial sector and 3.8 million tons in the residential/commercial sector. The share of the industrial sector account for averaged 78 percent over the years 1998 - 2001. The emission originated from fuel combustion account for the share of averaged 87 percent in the industrial sector over the years 1996 - 2001.

Table 3.8 shows the comparison of atmospheric pollutant emissions in China and Japan in recent years. In the Table, the industrial sector enclosed parenthesis indicates the subtotals of the total emissions in China. Chinese statistics contain data for dust emissions in the industrial sector as well as soot emissions. The figures for dust emissions in the Table are for those deriving from the industrial sector. The figures for SOx emissions in Japan are from 1999, because there have not been any in-depth surveys for the same in recent years.

As shown in Table 3.8, the level of SOx emission per capita in China is about three times as high as in Japan overall and 2.5 times as high even in the case of industrial sector taken separately.

Figure 3.1 Historical Trends of SO2 Emissions in China by Region



(Note) For the years 1996 and 1997, figures were announced only for emissions from the industrial sector ("China Environment Yearbook").

(Source) prepared from editions (for the years in question) of "China Statistical Yearbook" and " China Environment Yearbook"

Table 3.8 Comparisons of Atmospheric Pollutant Emissions in Japan and China

		SO_2 emissions			Soot emissions			fall of soot and dust
		Total emissions (thousands of tons)	/Capita (kg/person)	/area (tons/km)	Total emissions (thousands of tons)	/Capita (kg/person)	/area (tons/km^2)	(tons/km^2/month)
China (2001)	Total emissions	19,472	15.36	2.04	10,700	8.44	1.12	14.21
	(Industrial sector)	15,660	12.35	1.64	8,619	6.80	0.90	
	Dust emissions				8,175	6.45	0.86	
Japan (1999)	Fixed emission sources	629	4.97	1.66	75	0.59	0.20	3.60

(Note) Figures for soot and dust fall are averages for 44 Chinese cities and seven Japanese cities.

(Source) China: "China Environment Yearbook 2002"

Japan: "FY2003 Environmental White Paper and "FY2002 Survey of Fixed Emission Sources Related to the Atmospheric Environment", Ministry of Environment

The level of soot emission in China is about 14 times as high per capita and about six times as high per square kilometer as compared to that in Japan. In China, dust emissions are about on the same level as soot emission. Taken together, they came to some 19 million tons in 2001.

3.3.2 Outlook for SO_2 and NO_2 Emissions

Table 3.9 shows the emission factors and sulfur contents applied for the estimation of SOx (in SO_2-equivalent) and NOx (in NO_2-equivalent) emissions. For sulfur contents, analytical data are adopted if available and applied assumed figures in the absence of such data. As for emissions from lignite, it was decided to subtract the total moisture from the amount of input and to multiply the remainder by the emission factor, considering that the analytical figures are on the air-dried basis and that the lignite has high moisture content on the received basis.

Table 3.9 SO_2 and NO_2 Emission Factors

SO_2	Emission factors (SO_2 kg/ton)		Sulfur contents (S%)					
	Coal		Coal		Oil			
	Power sector	19.5*S	(Received basis)		China		Russia	
	Industrial sector	15.5*S	China	1.08%	Gas oil	0.20%	Gas oil	0.20%
	Residential sector	12.0*S	North Korea	0.70%	Heavy oil	1.50%	Heavy oil	1.10%
	Coke		Lignite		LPG	0.12%	Gasoline	0.05%
	Industrial sector	17.7*S	(Air-dried basis)	0.70%	Kerosene	0.08%	Crude oil, other	0.60%
			Lignite total moisture		Gasoline	0.05%		
	Petroleum products	20.0*S	Eastern Siberia	30%	Other	0.12%	North Korea	
	Crude oil		Russian Far East	30%	Crude combustion	1.00%	Industrial	1.50%
	(Crude combustion)	20.0*S	Mongolia	25%			Transport	0.12%
	Oil refining	0.46*S			Mongolia	0.14%	Other	0.08%

NO_2	Emission factors (NO_2 kg/ton)						
	Coal	Power sector	9.95 kg/ton	Industrial sector	7.50 kg/ton	Residential sector	2.00 kg/ton
	Lignite	Power sector	8.48 kg/ton	Industrial sector	6.38 kg/ton		
	Coke	Industrial sector	9.00 kg/ton				
	Natural gas	Power sector	4.40 kg/toe	Industrial sector	2.24 kg/toe		
	Crude oil	Power sector	7.24 kg/ton	Industrial sector	5.09 kg/ton	Oil refining	0.24 kg/ton
	LPG	Industrial sector	2.63 kg/ton				
	Gasoline	Transport sector	31.70 kg/ton	Other sectors	16.71 kg/ton		
	Kerosene	Transport sector	27.40 kg/ton	Industrial sector	7.46 kg/ton	Residentialsector	2.49 kg/ton
	Gas oil	Power sector	27.37 kg/ton	Industrial sector	9.62 kg/ton	Transport sector	27.40 kg/ton
	Heavy oil	Power sector	10.00 kg/ton	Industrial sector	5.84 kg/ton	Transport sector	54.13 kg/ton

(Source) Emission factors: "Energy Utilization in Asia and the Global Environment", edited by the National Institute of Science and Technology Policy, Science and Technology Agency

Table 3.10 shows the estimated results of SO_2 and NO_2 emissions without flue gas treatment by additional desulfurizers and denitrizers. Figures for Japan and South Korea are excluded from the Table, because their emissions have already leveled off or are in decline. In the case of China, the difference of 4.5 million tons from the 2000 figure of 19.93 million tons reported in the "China Environment Yearbook" was handled as the amount of removal. According to the annual editions for the years in question, the amount of SO_2 removal over the years 1996 - 2001 was in the range of 4.0 - 5.5 million tons (for a removal ratio of about 20 percent), with removal of emissions from fuel combustion accounting for 1.2 - 1.5 million tons of this (for a removal ratio of about 10 percent). Therefore, the figures for China in Table 3-10 indicate the amount of SO_2 derivation.

Table 3.10 Outlook for SO_2 and NO_2 Emissions

		SO_2 emissions (thousands of tons of SO_2-equivalent)					NO_2 emissions (thousands of tons of NO_2-equivalent)				
		2000	2010	2020	Multiplier		2000	2010	2020	Multiplier	
		(A)	(B)	(C)	(B/A)	(C/A)	(A)	(B)	(C)	(B/A)	(C/A)
Russia											
	Eastern Siberia	660	902	1,290	1.37	1.95	469	661	970	1.41	2.07
	Russian Far East	361	527	774	1.46	2.14	281	421	637	1.50	2.26
Mongolia		55	71	94	1.30	1.73	44	58	77	1.31	1.74
China	(Base case)	23,966	34,411	50,442	1.44	2.10	13,719	20,414	30,904	1.49	2.25
	(Energy conservation)	23,966	31,976	41,055	1.33	1.71	13,719	18,974	25,056	1.38	1.83
	(Energy conservation plus natural gas conversion)	23,968	31,530	37,823	1.32	1.58	13,720	18,750	23,411	1.37	1.71
North Korea		910	1,148	1,449	1.26	1.59	553	702	898	1.27	1.62

Emissions of SO_2 and NO_2 in China are incomparably higher than those in other countries and territories in the Region. At present China is the highest emitted country of SO_2 in the world, and is likely to get ahead of the United States as the world's top emitter of NO_2 (U.S. NO_2 emissions is 21.4 million tons). Atmospheric environmental problems in China are not the concern of that country alone; they are having an effect on many other areas of Northeast Asia. More specifically, the Region (and particularly China, the Korean peninsula, and Japan) could very well come to have a worse acid rain problem than North America and Europe - indeed, the worst in the world. Such problems cannot be resolved without the installation of desulfurizers and denitrizers.

4. Environmental Problems in China

4.1 Tasks for Environmental Improvement

The aforementioned "Basic Vision for National Energy Strategy" in China also contains a passage on constraints on environmental capacity, which might be translated as follows.

"Considering SO_2 capacity based on acid rain controls, the acceptable amount of SO_2 emission nationwide would be about 16.2 million tons at the most. Considering the capacity based on atmospheric conditions, the total emission ceiling would be about 12 million tons. With emissions below this ceiling, most of the cities across the country could meet the national environmental standard Class 2. The environmental capacity for NOx emissions must be put at no higher than 18.9 million tons." In addition, it posts the targets shown in Table 4.1.

The "Basic Vision" differs from previous reports, and deserves favorable ratings, in respect of its stance of calling for formidable policy leadership. However, it is not clear what parties should assume the related responsibilities. This section therefore presents a simple description of the importance of the leadership role to be played by China's coastal area, which is the most economically advanced part of the country, and the role of the power sector (and particularly coal-fired thermal power) as the producer of some 45 - 50 percent of the country's total SO_2 emission.

Table 4.1 Environmental Targets

Indicator	Unit	2000	2010	2020
SO_2 emission control target	Tens of thousands of tons	1,995	1,600	1,300
NO_2 emission control target	Tens of thousands of tons	1,890	1,800	1,600
Soot and dust emission control target	Tens of thousands of tons	2,257	1,600	1,000
SO_2 reduction ratio (combustion)	%	10	50	70
Ratio of thermal power generation facilities with desulfurizers	%	2	38	80
Environmental protection investment as percentage of GDP	%	1.1	1.5	2

(Note) The grounds of the SO2 and NO2 estimations are not clear. The base year for the forecast is 1998.

(Source) "Basic Vision for National Energy Strategy", presented at an international symposium held on 5 November 2003 under the title "Energy Strategy and Reform"

4.1.1 Role of the Coastal Area

Formerly, extensive installation of desulfurizers and denitrizers was regarded as requiring a rise in the economic scale (e.g., GDP) or level (GDP per capita) to a certain line. These days, however, even the Mae Mo lignite-fired thermal power plants (with a single-unit capacity of 300 megawatts) in a rural district of northern Thailand have been installed with desulfurizers since 1995. There is presumably enough economic margin for the installation of such environmental protection equipment not only in Shanghai and Beijing, where the gross regional domestic product per capita is above 30,000 and 20,000 RMB, respectively, but also in the city of Tianjin and the provinces of Liaoning, Jiangsu, Zhejiang, Fujian, Shandong, and Guangdong, where it is over 10,000 RMB.

Environmental measures in China are now going beyond the stage of fuel controls, and fundamental solutions cannot be found with the recent steps on the order of relocating plants from cities to locations on their outskirts. Acid rain cannot be overcome without the reduction measures in the total emissions.

4.1.2 Role of the Power Sector

The additional installation of environmental facilities must be applied with an order of sector priority. More specifically, its installation must begin with the power sector, and then proceed to energy-intensified industries. The biggest problem in the power sector, and particularly in the case of coal-fired thermal power, is the extremely small size of capacity per unit and the large number of units. As shown in Table 4.2, facilities with a capacity of less than 100,000 kilowatts account for about 30 percent (70 million kilowatts) of the total capacity and about 80 percent of the total number of units. Similarly, those with a capacity of less than 200,000 kilowatts account for a corresponding 46 percent (103.3 million kilowatts) and 88 percent. In China, small-scale coal-fired thermal power plants consume an average of about 550 grams of coal per kilowatt-hour (at a thermal efficiency of 25 percent). These small-scale facilities must be consolidated for an increase in scale. This in itself would bring a considerable reduction in the volume of coal consumption and emission of atmospheric pollutants. As part of its program for power sector reorganization, China itself is planning to abolish small-scale coal-fired plants and replace them with large-scale ones in the capacity class of 500,000 kilowatts.

Table 4.2 Coal Thermal Power Plants by Capacity in China

Power generation capacity	Number of units (Units)	Installed capacity (MW)	Schare (%)	Steam pressure/ temperature
Less than 100 MW	2,800	70,000	31.0	
100 MW	144	14,400	6.4	8.8Mpa/535°C
110 - 125 MW	152	18,915	8.5	8.8Mpa/535°C
200 - 220 MW	195	39,140	17.5	12.2Mpa/535°C
250 - 300 MW	170	51,136	22.3	16.6Mpa/538°C
320 - 362.5 MW	50	17,252	7.7	16.6Mpa/538°C
500 - 660 MW	23	13,300	5.9	16.6Mpa/538°C
Total	About 3,500	223,434	100.0	

(Source) Zhao Zongrang, 8th APEC Coal Flow Seminar (2002)

Another problem is the extremely limited installation of desulfurizers, which have been installed at only 17 units with a combined capacity of 3.47 million kilowatts, or just 1.6 percent of the total installed capacity. Desulfurizers must be installed not only on newly constructed facilities but also on existing ones.

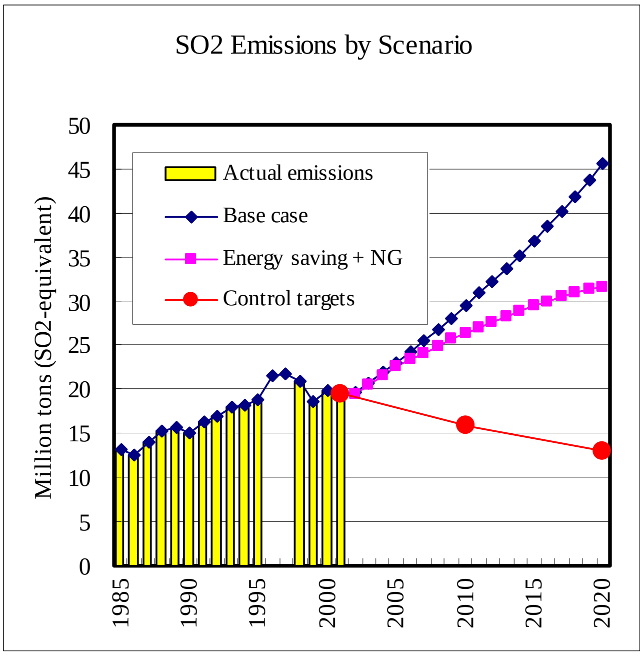
4.2 Scenario for Reduction of SOx and NOx Emissions

4.2.1 SOx Emissions

Figure 4.1 shows the levels of SO_2 emissions in each scenario. The levels were obtained by subtracting the current amount of removal from the calculation results for emissions shown in Table 3.10. The control target scenario indicates the total emission targets in Table 4.1.

If the amount of removal stays on the current level (5.33 million tons in 2001), SO_2 emissions in the base case would rise from 19.93 million tons in 2000 to 29.5 million tons in 2010 and 45.6 million tons in 2020, for respective 1.5- and 2.3-fold increases relative to 2000. Even in the case of energy conservation plus conversion (fuel shift) from coal to natural gas, emissions would rise to 26.4 million tons in 2010 and 31.6 million tons in 2020, for respective 1.3- and 1.6-fold increases relative to 2000. In all cases, from 90 to 93 percent of the SO_2 emissions would come from coal-fired sources.

Figure 4.1
SO_2 Emissions by Scenario



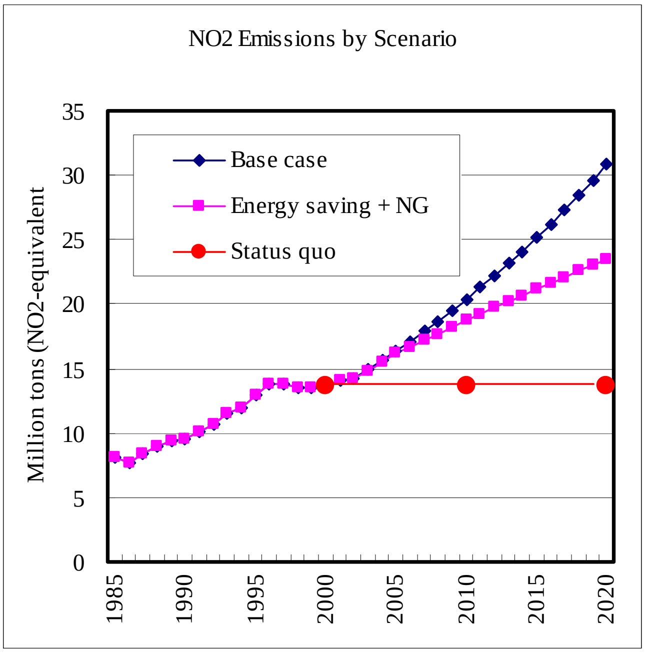
(Note)
“Energy saving + NG” means “Energy conservation plus natural gas conversion case”.

In the base case, achievement of the control targets for total emissions shown in Table 4.1 (16 million tons in 2010 and 13 million tons in 2020) would require the removal of 19 million tons in 2010 and 38 million tons in 2020, for respective removal ratios of 54 and 75 percent. In the case of energy conservation plus natural gas conversion, it would require the removal of 16 million tons in 2010 and 24 million tons in 2020, for respective removal ratios of 50 and 65 percent.

4.2.2 NOx Emissions

Figure 4.2 shows the levels of NO_2 emissions in each scenario. Because data are not available on these emissions, the levels are based on the figures in Table 3.10. In the base case, it is estimated that NO_2 emissions would rise from 13.7 million tons in 2000 to 20.4 million tons in 2010 and 30.9 million tons in 2020, for respective 1.5- and 2.3-fold increases relative to 2000. In the case of energy conservation plus natural gas conversion, the corresponding levels are 18.8 million tons in 2010 and 23.5 million tons in 2020, for respective 1.4- and 1.7-fold increases relative to 2000. In 2020, the share of all NO_2 emissions deriving from coal-fired sources, which is currently estimated at 75 percent, would decrease to about 70 percent in the base case and 65 percent in the case of energy conservation plus natural gas conversion.

Figure 4.2
NO_2 Emissions by Scenario



(Note)
"Energy saving + NG" means "Energy conservation plus natural gas conversion case".
"Status quo" means "maintaining case of the current emission level".

In the base case, curtailment of emissions to the level in 2000 (maintenance of the status quo) would require removal of 6.7 million tons in 2010 and 17.2 million tons in 2020, for respective removal ratios of 33 and 56 percent. In the case of energy conservation plus natural gas conversion, it would require removal of 5 million tons in 2010 and 9.8 million tons in 2020, for respective removal ratios of 27 and 42 percent.

4.2.3 Countermeasures for Fixed Emission Sources

In China, SOx and NOx emissions come mainly from fixed emission sources, i.e., power, industry (manufacturing), and heat supply sectors. Without countermeasures for fixed emission sources, it would be impossible even to maintain the status quo, not to mention attaining the environmental targets in the “Basic Vision”. This points to a need for the installation of desulfurizers and denitrizers. The power sector, and particularly coal-fired thermal power, has a vital role to play. The key items on the agenda for conserving energy and protecting the atmospheric environment are the successive and systematic consolidation of small- and medium-scale facilities to expand the scale of and modernize coal-fired thermal power, and the installation of desulfurizers and denitrizers.

Putting aside dispersed, independent sources in remote communities, the major conceivable options for reconstruction of the power supply system are as follows: 1) abolition of small-scale sources and supply of power from the grid system, 2) consolidation (coal- or gas-fired sources), and 3) re-powering and other adjustment. Each of these options would require the construction of thermal power plants as replacements for existing facilities. Replacement of all facilities that have a capacity of no more than 100,000 kilowatts with coal-fired thermal power plants would demand an investment of about 73.5 billion dollars. Even assuming replacement with gas combined cycle plants for 20 percent of above replacement, the cost would still be about 67.9 billion dollars.

As new (additional) power sources would be constructed simultaneously with replacements of existing plants. Table 4.3 shows the outlook for power capacity commensurate with demand. The total installed capacity is forecast to rise from 315 million kilowatts in 2000 to 838 million kilowatts (a 2.7-fold increase) in 2020 in the base case, and a corresponding 695 million kilowatts (a 2.2-fold increase) in the case of energy conservation plus natural gas conversion. The installed capacity of coal-fired thermal power is forecast to rise from 218 million kilowatts in 2000 to 621 million kilowatts (a 2.8-fold increase) in 2020 in the base case and a corresponding 390 million kilowatts (a 1.8-fold increase) in the case of energy conservation plus natural gas conversion. The funding required for construction of additional thermal power plants over the years 2000 - 2020 is estimated at 338.6 billion dollars in the base case and 235.8 billion dollars in the case of energy conservation plus natural gas conversion. Aside from those for coal-fired thermal power, the cost figures for thermal power construction in Table 4-3 are premised on gas-fired thermal plants.

Table 4.3 Outlook for Power Source Capacity

(Unit: millions of kW, billions of dollars)

	Installed capacity			Additional capacity		Requisite funding	
	2000	2010	2020	2010/2000	2020/2010	2010/2000	2020/2010
Base case							
Total capacity	315	525	867	210	342		
Thermal power	236	378	621	143	242	143	246
(Coal-fired)	218	344	564	126	220	132	231
Share of coal-fired							
to total capacity	69.3%	65.5%	65.1%	59.9%	64.4%		
to thermal power	92.5%	90.9%	90.9%	88.2%	90.9%		
Energy conservation plus natural gas conversion							
Total capacity	315	494	723	179	229		
Thermal power	236	348	477	112	129	109	116
(Coal-fired)	218	310	390	92	80	96	84
Share of coal-fired							
to total capacity	69.3%	62.7%	54.0%	51.2%	35.1%		
to thermal power	92.5%	89.2%	81.8%	82.1%	62.2%		

(Note) Assumptions;

1. Capacity factor: 63% for all thermal power (average), 68% for coal-fired thermal power, 40% for hydropower, and 85% for nuclear power

2. Construction cost: US$1,050/kW for coal-fired thermal power (with desulfurizers and denitrizers costing 150/kW) and US$650/kW for gas combined cycle facilities

Nevertheless, the SOx and NOx emission targets cannot be attained on the strength of efforts in the power sector alone. As the sector with the highest emission levels after the power sector, industry must promote the installation of desulfurizers and denitrizers. In 2000, China's GDP amounted to about 1.080 billion US dollars (see Table 1.1), and about 0.5 percent of this could be directed to the consolidation of small-scale facilities and installation of desulfurizers and denitrizers. The “Basic Vision” posits total environmental expenditures in the range of 1.5 - 2.0 percent of the GDP (see Table 4.1). China is fully capable of bearing the environmental cost burden. The need for expenditures would also present an opportunity to actively promote the growth of the environmental industry.

Conclusion

Northeast Asia is a vast region spanning (from the northwest) Eastern Siberia, the Russian Far East, Mongolia, China, North and South Korea, and Japan. These countries and territories represent diversity in respect of economic circumstances and energy utilization. In light of their geopolitical situation, however, they should cooperate with each other in aspects including energy trade. With the exception of Japan and South Korea, they also have a high dependency on energy resources, and particularly coal, within their own borders. Furthermore, the Region is expected to exhibit continued economic growth and an accompanying increase in the energy demand. Within the Region, the eastern coastal area of China, Japan, and South Korea together constitute a huge center of coal consumption on the order of 800 million tons per year. This accounts for about 20 percent of the total global consumption. Furthermore, the Region's demand for coal is forecast to expand into the future.

China has serious environmental problems. Combustion of coal is the source of about 75 percent of the CO_2 emissions, 90 percent of the SOx emissions, and 75 percent of the NOx emissions. Although this report included scenarios of formidable policy direction for conservation of energy and conversion to natural gas in addition to the base case, there is a limit to reduction of emissions of CO_2 as well as SOx, NOx, and other pollutants causing acid rain. In other words, it will be impossible to curtail emissions of pollutants causing acid rain to the current level or below solely by policy measures to promote energy conservation, fuel conversion, fuel controls, and new energy development. The circumstances demand the installation of flue gas desulfurizers and denitrizers in line with exacting controls for total emissions. In this connection, there are important roles to be played by the coastal area, which is the most economically advanced, as well as the power (especially coal-fired thermal power) and industrial (manufacturing) sectors as the sources of about 50 and 35 percent, respectively, of the SO_2 emissions.

China now emits more SO_2 than any other country in the world, and more NO_2 and CO_2 than any other except the United States. If its emissions continue in the current trend, it could become the world's biggest source of the latter emissions as well. In the process, China, North and South Korea, and Japan could replace North America and Europe as the region with the world's worst acid rain and atmospheric pollution.

The simulation results in this study indicate that desulfurizers and denitrizers could be installed in China's power and industrial sectors for a cost of about 0.5 percent of the GDP. The “Basic Vision for National Energy Strategy” posits expenditures in the range of 1.5 - 2.0 percent of the GDP for environmental measures nationwide. This environmental cost is fully capable of being borne by China. These expenditures would also constitute an opportunity for actively promoting the growth of the environmental industry.

Viewing Northeast Asia from the standpoint of CO_2 emission trading, Russia might lose its margin for carbon trading (hot air) after 2015. The simple simulation conducted for this study found that, if Russia's demand for primary energy grows at annual rates in the range of 3.0 - 3.4 percent, its CO_2 emissions could top the 1990 level around 2014.

In closing, the author would like to express his gratitude to his colleagues in the International Cooperation Department for their valuable comments, and to Dr. Yonghun Jung, Vise-President of the Asia Pacific Energy Research Center, for so kindly providing energy supply and demand outlooks for South Korea.

Contact: ieej-info@tky.ieej.or.jp