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REGIONAL EMISSIONS OF AIR POLLUTANTS IN CHINA

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Abstract

As part of the China-MAP program, sponsored by the U.S. National Aeronautics and Space Administration, regional inventories of air pollutants emitted in China are being characterized, in order that the atmospheric chemistry over China can be more fully understood and the resulting ambient concentrations in Chinese cities and the deposition levels to Chinese ecosystems be determined with better confidence. In addition, the contributions of greenhouse gases from China and of acidic aerosols that counteract global warming are being quantified. This paper presents preliminary estimates of the emissions of some of the major air pollutants in China: sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), and black carbon (C). Emissions are estimated for each of the 27 regions of China included in the RAINS-Asia simulation model and are subsequently distributed to a 1° x 1° grid using appropriate disaggregation factors. Emissions from all sectors of the Chinese economy are considered, including the combustion of biofuels in rural homes. Emissions from larger power plants are calculated individually and allocated to the grid accordingly. Data for the period 1990-1995 are being developed, as well as projections for the future under alternative assumptions about economic growth and environmental control.

Background

In order for transport and deposition models to be accurate, it is necessary to have reliable input data on emissions. Accuracy depends both on detailed fuel consumption data and the application of appropriate emission factors. In addition, in order for emissions data to be meaningful when gridded for input to atmospheric models, the fuel consumption data must be collected on a disaggregated geographic basis and apportioned using appropriate surrogate measures, i.e., population or production. For example, Chinese national data gridded by population are less accurate than Chinese provincial data gridded by population. To this end, energy consumption data have been gathered by RAINS-Asia regions, and, when possible, regional emission factors have been used. Emissions from both fossil-fuel and biofuel combustion are examined here.

Acid Precursors

A need was identified in the China-MAP project to develop emissions profiles for China for 1995, for the purpose of comparing calculated deposition with observed data for sulfate and nitrate deposition in Chinese monitoring data sets. The RAINS-Asia model generates sulfur dioxide emissions estimates for the years 1990 and 2000 (nitrogen oxide emissions estimates were determined by multiplying energy data from the RAINS-Asia model by appropriate emission factors). It was decided that interpolating between the RAINS-Asia emission values for 1990 and 2000 would provide results consistent with other parts of the China-MAP project [1]. A methodology is being developed for a different project which would involve extrapolation from 1990 to 1995 using fuel-use proxies. For the present, however, interpolation is considered a reasonable method that relies on real data for 1990 and anticipated growth rates by region and sector for the period 1990-2000.

Five sectors were examined in this project: industry, power, domestic, transportation, and non-commercial (includes biofuels that are collected and burned for energy, such as wood, crop residues, and animal waste). The two sectors that contributed the most sulfur dioxide and nitrogen oxides in 1990 were the industrial and power sectors, which were responsible for 50.8% and 28.1% of the SO_2 emissions and 43.6% and 35.5% of the NO_x emissions, respectively. By the year 2000, the industrial sector will be contributing more than one-half of the SO_2 emissions in China (54.5%). The percent share of NO_x emissions will decrease in all sectors over this period except for the transportation sector, which will double its contribution, from 6.6% in 1990 to 13.6% in 2000.

For each of the 27 regions in China, a fixed rate of growth between 1990 and 2000 was assumed for each sector. This allowed the interpolation of values for 1992/93 and 1995 from the 1990 and 2000 values generated by the RAINS-Asia model. The formula for fixed annual growth in this period is:

$$E_{2000} = E_{1990}\,(1 + r)^{10}$$

where E represents the emissions, in Gg, of pollutant and r is the annual rate of growth. By manipulating this function algebraically, we find that:

$$E_{1995} = (E_{1990} * E_{2000})^{½}$$

For three of the sectors–industry, domestic, and transportation–1995 values were interpolated by applying this formula. Slightly different methods were used for the power and non-commercial sectors.

The power sector was examined in greater detail. Because RAINS-Asia makes available information about two parts of the power sector, small utility generators (< 500 MW) and individual large point sources (LPS, ≥ 500 MW), it was decided that it would be more accurate to estimate values for individual LPS rather than to interpolate the total power sector values. (This is a more accurate method because we know that the square of the sums is not necessarily equal to the sum of the squares, or $(P_1 + P_2 + P_3 + \ldots + P_n)^{½} \neq P_1^{\,½} + P_2^{\,½} + P_3^{\,½} + \ldots + P_n^{\,½}$.) Values for 1995 were interpolated for each LPS as above. The 1995 values for the total power sector were similarly calculated, then the LPS totals were subtracted to yield values for the small sources. In some cases, however, the LPS was not yet on line in 1990, but is predicted to be in operation by 2000. This presents a problem for the above method, because assuming a fixed rate of growth does not work if the original value is zero (i.e., let $E_{1990} = 0 \Rightarrow E_{2000} = 0$ because $0\,(1 + r)^{10} = 0$). For these LPS's, literature sources [2-5] were consulted to determine when the power plant went on line. If the LPS went on line in 1991, the emissions from this date were used in place of the zero value for 1990 and 1995 value were interpolated accordingly. If it was found that the LPS was not yet on line in 1995, it was assigned a zero value for 1995. Correct information regarding LPS's is important for accurately representing the geographical patterns of emissions, against which monitored deposition is to be compared.

Data for the non-commercial (biofuel) sector are not part of the RAINS-Asia model. Data for 1990 were collected for a different project [6] and will be added to future versions of RAINS-Asia. Because only 1990 data were available, a different method, extrapolation for future years based on trend data, had to be developed for this sector. A few literature sources [7,8] had data for several years on *per capita* rates of energy consumption for different non-commercial fuels. Trends were extrapolated from these data for each type of biofuel (wood, crop residue, and animal waste) and were assumed to remain constant through 2000. In each case it was found that the *per capita* rate of consumption was decreasing over time. However, the rural population (the primary consumers of non-commercial energy) was growing at a faster rate, so total use of non-commercial energy increased slightly over this period. Appropriate conversion factors for each fuel and pollutant were then applied to the energy values projected for 1995.

Tables 1 and 2 show the SO_2 and NO_x emissions by sector for each of the 27 regions in China. Figures 1 and 2 illustrate the total SO_2 and NO_x emissions in China by sector and year. Results for four time periods are shown for comparison.

Carbon Monoxide

Carbon monoxide (CO) is an important atmospheric pollutant from many perspectives. It is a greenhouse gas with a global warming potential (GWP) on a 20-year time scale of 4.5, i.e., over the next twenty years each CO molecule released today is equivalent to approximately 4.5 CO_2 molecules [9]. In addition to being an important greenhouse gas, CO is toxic to humans and is a critical component of many photochemical reactions in the atmosphere. It is a scavenger of hydroxyl radicals and thereby influences the production of tropospheric and stratospheric ozone [10]. There are many relatively easy ways to reduce CO emissions–catalytic converters for automobiles and boilers, household stoves that combust fuels more completely, and reuse of CO gas in industry–but in order to implement the most cost-effective controls, the sectors that have the greatest impact on CO emissions must be determined.

Five sectors were judged to have the greatest influence on CO emissions in China in 1995. These sectors are domestic (direct combustion of fossil fuels and biofuels for household use), industry (both fossil-fuel combustion and processes such as iron and steel manufacture), transportation (primarily passenger and freight highway traffic), field combustion (disposal of crop residues by direct combustion in fields), and electric power generation. Emissions from these sectors have been estimated for China at the regional level using the 27 RAINS-Asia regions (Fig. 3). The largest point sources are also identified.

Our preliminary estimate is that approximately 116 mt (million metric tonnes) of CO were released in China in 1995. This figure is nearly 40% greater than 1995 CO emissions in the United States of 83.5 mt. Sectoral distribution is also significantly different, with the majority of U.S. emissions coming from the transportation sector, while in China the transportation sector is responsible for less than 20% of total CO in 1995 (Table 2). The domestic sector was by far the largest contributor in China, emitting approximately 73.3 mt, or 63% of all the CO emissions in China for 1995 (Figure 3). Within the domestic sector, direct burning of biofuels (wood, crop residues, and animal waste) was the primary contributor. The transportation, industrial, and agricultural sectors were also large emitters, releasing 23.0 mt, 10.1 mt, and 9.8 mt of CO, respectively. In order to estimate CO emissions for China in 1995, activity levels and emission factors for each sector and fuel were determined.

In 1995, the domestic sector emitted 73.3 mt of CO, or 63% of the total CO emissions in China (Table 2). This sector contributed more than three times as much CO as the next highest emitting sector. There are a variety of reasons that domestic emissions are so high. Biofuels are a large portion of the energy consumed in this sector. When these fuels are burned in inefficient stoves which do not burn at high enough temperatures to fully combust the fuel, CO emissions can be quite high. CO emissions from biofuels amounted to approximately 62.6 mt in 1995. This is over 85% of the CO from the domestic sector, and nearly 54% of the total CO emitted in China. Approximately 9% of total CO emitted comes from the use of fossil fuels (particularly coal) in the domestic sector. This is due, again, to incomplete combustion in typical Chinese stoves. Another factor that affects the emission factor for domestic coal consumption is the prevalence of unwashed, poor quality coal in this sector, especially in rural areas.

The industrial sector, including iron and steel manufacture and combustion in industrial boilers, contributed 8.7% of total CO emissions in 1995. This makes it the third highest CO emitting sector in China. Approximately one-half of the emissions from industrial processes (iron and steel making) came from the 14 largest steel manufacturing plants. Coal-burning boilers are responsible for 98% of the industrial combustion emissions.

Over 8% of the CO emitted in China came from the open burning of crop residues in fields. This practice is used mainly to prevent the spread of crop diseases and for ease in disposal of residues. The most effective way to reduce CO emissions in the agricultural sector is to encourage farmers to plow under crop residues instead of burning them. Plowing under crop residues also contributes to greater organic content in the soil and decreases erosion [11]. This practice has been growing in recent years, but with nearly 25% of crop residues still being burned in fields, there is clearly room for improvement.

The transportation sector was the second largest CO emitter, contributing nearly 20% of total CO emissions in 1995. Trucks contributed the bulk of the emissions with 17 mt. Personal transportation, cars and motorcycles, contributed about one-third of that amount, with 4 and 2 mt, respectively. Rail transport had very low emissions, only 0.2% of total transportation emissions. Rail transportation tends to have lower CO emissions due to the high quality of coal used for this sub-sector and the efficiency of combustion. As personal cars become more commonplace, emissions from passenger cars are expected to rise rapidly over the next decade and beyond. With 19.8% of total CO emissions coming from the transportation sector, and knowing that its percent contribution is likely to grow in the coming years, it would be wise to institute controls such as catalytic converters to prevent rapid growth in CO emissions from this sector.

Electric power generation contributed an almost insignificant amount of CO emissions in 1995. Emitting only 180 thousand tonnes of CO, it was the smallest contributing sector with 0.15% of the total emissions. Typically, power-sector boilers are large and operate at high temperatures, leading to relatively complete combustion.

The total 1995 CO emissions estimated in this study compare favorably with the EDGAR [12] estimate for 1990. However, at the sector level, there are some obvious discrepancies. Our estimate of field burning of crop residues was 9.8 mt, while the EDGAR estimate was 25.9 mt (Table 2). This difference can perhaps be partially explained by comparing total biofuel emissions from the domestic and field combustion sectors. The percent contribution of biofuels from both sectors is similar in the two studies; domestic and field combustion in our study contribute 62.1%, with the EDGAR study estimates these categories at 62.7% of total emissions. Thus, different ways of classifying biofuel combustion may be partly responsible for this discrepancy. A similar problem is found within the domestic sector, with the EDGAR estimate of fossil-fuel emissions being significantly higher, and biofuel emissions lower, than found for this study. Again, there appears to be a variance in distribution, but the percent contribution for the entire sector is comparable.

CO emissions are concentrated primarily in the eastern third of China. The three regions with the highest total emissions were HEHE (Henan, Hebei, and Anhui), NEPL (Heilongjiang, Jilin, and Liaoning), and SICH (Sichuan) with 17.1 mt, 11.8 mt, and 10.5 mt, respectively. As expected (since these are also the three most populated regions in China), these regions also had the greatest emission levels from the domestic sector, emitting 10.3 mt, 6.4 mt, and 7.8 mt, respectively. Industrial CO emissions in HEHE and NEPL, at 1.9 mt and 1.8 mt, contributed over 35% of the total industrial emissions in China. CO emissions from transportation were also greatest in HEHE and NEPL (3.3 mt and 2.4 mt), contributing more than the third, fourth, and fifth highest emitting regions combined.

The sectoral distribution of CO emissions in Beijing (*Beij*) and Shanghai (*Shan*), the two largest cities in China with similar populations, differed significantly in two main sectors, domestic and industry. Although the population of Shanghai is slightly greater than Beijing, domestic emissions in Beijing were nearly one-third greater than in Shanghai. This difference is probably primarily due to the greater heating needs in the northern climates. However, industrial emissions were much greater in Shanghai (0.91 mt compared to 0.62 mt in Beijing) due to the larger number of iron and steel manufacturing plants located there. Emissions from passenger vehicles were also 60% greater in Beijing (1.01 mt) than in Shanghai (0.63 mt).

Black Carbon

Carbon aerosols are currently being calculated, also. There are two components to carbon aerosols: organic carbon and black carbon. We are primarily concerned with the latter, black carbon (also known as elemental carbon or soot). Black carbon (BC) emissions result primarily from incomplete combustion of carbon based fuels, such as coal, diesel, and fuelwood. Although the data presented here are still preliminary, it is believed that the domestic and industrial sectors are the primary contributors, with agricultural burning, power generation, and transportation together contributing less than 8% of total BC emissions.

Black carbon emissions were determined by applying appropriate emission factors [13-15] to the energy data used in calculating SO_2 and NO_x emissions. Total BC emissions in China in 1995 were approximately 4.1 mt-C (Table 3, Figure 4). This is a 50% increase over the BC estimate of 2.7 mt-C for China in 1980 [14]. The domestic sector was the largest contributor with 2.9 mt-C, or 71% of total emissions. The large share of BC from the domestic sector is due largely to the poor rate of combustion common to most household stoves. These stoves tend to allow too little mixing between air and the carbon in the fuel, thus not allowing for the carbon to be completely oxidized (combusted) to form CO_2. Industry accounted for another 876 kt-C (21.5%), primarily due to coal combustion. Field combustion, power generation, and transportation together accounted for only 7.5% of total emissions (304 kt-C).

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Table 1 - Chinese SO_2 an NO_x Emissions - 1995

	SO2 (kt) - 1995								NOx (kt) - 1995							
	Industry		Power						Industry		Power					
Region	Conv.	Comb.	LPS	Small	Domestic	Transport	Non-Com	Total	Conv.	Comb.	LPS	Small	Domestic	Transport	Non-Com	Total
Beij	13.5	157.5	77.0	12.5	75.7	5.4	1.5	343.0	7.7	100.9	63.2	9.6	21.6	38.2	2.1	243.3
Chon	51.9	623.6	184.1	1.4	348.5	19.6	0.1	1229.2	6.9	44.2	39.9	0.5	21.6	17.2	0.1	130.5
FUJI	13.7	148.0	19.2	21.5	166.4	0.5	11.8	381.0	7.3	55.4	20.1	17.6	42.0	9.4	14.9	166.7
GUAH	18.9	587.8	73.8	111.9	107.1	12.6	15.6	927.5	8.0	171.8	37.8	68.4	24.2	82.9	20.2	413.3
GUAX	31.6	395.8	289.7	136.2	129.8	32.6	19.8	1035.6	6.6	71.7	28.6	13.6	16.6	18.9	25.8	181.7
Guaz	17.5	147.7	89.3	10.9	15.7	0.9	0.5	282.4	7.3	46.1	60.2	6.7	3.0	13.9	0.7	137.9
Guiy	47.8	151.9	0.0	112.6	47.1	0.1	0.0	359.5	6.6	12.9	0.0	30.4	3.2	1.0	0.1	54.1
GUIZ	36.9	229.4	105.7	110.9	445.0	2.4	15.1	945.3	6.6	22.9	24.1	21.7	38.8	23.0	18.7	155.6
HEHE	14.8	2303.1	659.0	314.1	532.0	26.8	48.2	3898.0	11.3	845.5	417.1	213.6	158.9	124.9	64.0	1835.3
HUBE	17.4	206.1	52.9	76.2	164.8	27.1	17.1	561.6	7.6	69.6	31.9	27.3	39.8	94.9	22.4	293.4
HUNA	16.2	161.3	57.6	44.6	203.8	12.4	23.1	519.1	6.6	43.4	53.1	38.4	43.1	43.7	29.8	258.2
IMON	9.4	232.7	155.3	206.1	90.4	30.0	63.5	787.6	8.0	107.5	68.5	94.5	36.5	25.3	19.5	359.9
JINU	16.8	1605.4	326.1	162.4	331.4	74.0	15.4	2531.3	8.0	488.0	181.5	96.7	72.3	60.8	20.9	928.1
JINX	16.4	174.3	27.5	104.4	96.2	12.9	17.0	448.8	6.9	43.9	24.3	49.5	21.5	34.1	21.8	202.0
NEPL	12.9	2400.6	435.7	174.1	154.1	32.0	32.5	3241.9	12.4	1149.7	389.5	181.6	61.4	57.3	43.4	1895.1
Shan	19.0	191.6	343.2	7.2	49.7	2.9	1.6	615.1	7.7	115.4	178.8	5.8	9.8	32.3	2.2	352.0
Shen	13.8	90.8	0.0	2.5	15.9	11.2	0.4	134.7	8.9	32.7	0.0	1.7	4.5	11.4	0.6	59.7
SHGA	15.8	513.5	254.8	174.7	112.3	7.3	18.2	1096.7	10.0	186.6	76.9	87.0	28.8	25.5	24.0	438.7
SHND	24.2	234.3	611.0	172.1	228.5	23.5	26.1	1319.6	9.3	120.8	224.5	69.1	37.2	49.5	34.4	544.8
SHNX	11.0	272.0	260.9	168.6	52.6	5.7	6.5	777.3	6.6	170.2	162.9	86.4	20.0	16.1	8.6	470.8
SICH	33.3	1617.9	242.0	288.4	798.2	5.9	41.8	3027.4	7.3	222.9	49.7	70.4	81.8	40.5	54.1	526.7
Taiy	11.6	150.1	32.7	25.9	68.0	2.5	0.2	291.0	6.6	49.4	24.7	12.9	24.1	28.9	0.3	146.8
Tian	13.0	103.1	95.5	29.0	47.1	12.8	1.2	301.7	7.6	60.0	67.0	21.0	15.2	43.5	1.6	215.8
WEST	17.7	239.0	0.0	50.2	133.6	5.4	44.0	489.8	12.8	90.7	0.0	44.9	35.6	36.1	11.5	231.5
Wuha	11.7	106.4	39.0	118.5	43.7	1.4	0.8	321.4	7.3	81.5	16.5	66.9	12.9	11.3	1.0	197.4
YUNN	28.9	671.8	140.6	51.3	281.3	3.0	18.0	1194.9	6.6	138.3	22.9	17.6	36.5	38.6	22.5	283.0
ZHEJ	21.8	352.5	210.1	26.4	63.5	4.9	18.3	697.4	6.9	78.4	113.2	15.8	10.5	57.4	23.6	305.8
WHOL	557.2	14068.2	4782.9	2714.4	4802.6	375.6	458.2	27759.1	215.3	4620.2	2376.6	1369.6	921.3	1036.5	488.7	11028.2

Table 2 - CO Emissions (kt CO) in China - 1995

I.D. No.	Region	1995 CO Emissions (kt CO) Domestic Coal	Domestic Oil	Domestic Biofuels	Iron & Steel Ind. LPS	Iron & Steel Ind. Area	Industry Comb. Coal	Industry Comb. Oil	Field Comb. Crop Res.	Transportation Rail	Transportation Trucks	Transportation Cars	Transportation M/C	Power Coal	Total
9	*Beij*	240	3	282	584	0	32	1	63	1	610	352	43	3	2215
28	*Chon*	271	0	18	66	6	33	0	0	1	24	84	28	2	533
23	FUJI	520	1	1830	0	53	31	0	196	1	332	78	66	2	3112
24	GUAH	226	6	2563	0	112	86	3	396	1	1948	344	187	5	5877
26	GUAX	163	11	3291	0	69	33	7	512	1	383	102	112	2	4686
25	*Guaz*	38	0	84	0	11	20	2	0	0	109	136	51	3	454
30	*Guiy*	40	0	6	0	3	9	0	0	0	14	10	16	2	99
29	GUIZ	487	0	2246	0	64	17	0	172	1	267	41	72	2	3369
8	HEHE	1961	7	8354	335	945	570	4	1549	13	2445	503	353	31	17068
16	HUBE	368	8	2876	0	85	27	4	511	2	498	103	95	3	4580
18	HUNA	509	6	3770	0	134	26	1	541	3	639	120	92	4	5846
15	IMON	451	2	2476	241	19	80	0	255	3	471	98	11	8	4115
20	JINU	751	7	2799	0	209	280	5	606	2	808	210	116	14	5808
19	JINX	232	1	2747	0	104	29	1	376	1	274	59	50	4	3876
6	NEPL	722	7	5701	781	321	718	16	1121	9	1924	421	64	27	11833
21	*Shan*	111	0	291	599	285	28	1	65	0	345	162	121	9	2017
7	*Shen*	45	0	75	0	19	20	0	0	0	104	46	16	0	326
14	SHGA	344	2	3090	42	117	106	2	524	3	665	142	37	8	5080
11	SHND	415	5	4459	0	339	28	2	778	3	1399	242	107	14	7792
12	SHNX	240	1	1132	0	516	71	0	226	2	566	64	25	12	2856
27	SICH	979	6	6863	190	204	136	1	1019	2	765	150	162	6	10482
13	*Taiy*	299	0	35	168	58	37	0	0	0	49	38	8	2	693
10	*Tian*	145	4	219	125	0	22	1	48	1	495	85	37	4	1186
32	WEST	412	6	1473	0	61	48	2	150	1	564	121	10	2	2850
17	*Wuha*	162	0	141	394	13	26	0	0	0	41	40	26	4	848
31	YUNN	390	17	2747	0	121	65	1	258	0	610	112	25	2	4348
22	ZHEJ	118	2	2987	0	75	44	1	432	1	631	130	71	6	4498
	China	**10640**	**101**	**62558**	**3525**	**3942**	**2623**	**57**	**9799**	**52**	**16978**	**3994**	**2000**	**180**	**116449**
		10741		**62558**	**7467**		**2680**		**9799**	**23024**				**180**	**116449**
	EDGAR*	22500		39500	4700		1600		25900	10000				100	104300

* CO estimates for 1990 from the RIVM EDGAR project (Olivier et al., 1996)

Table 3 - BC Emissions (kt-C) in China - 1995

Black Carbon Emissions in China - 1995 (kt-C)

Region	Domestic HC2	Domestic DC	Domestic Fuelwood	Domestic Crop Res.	Domestic An. Waste	Domestic MD	Industry HC2	Field Combust.	Power HC2	Transport MD	Total All Sect.
Beij	48.00	0.00	0.25	2.81	0.00	0.37	10.78	1.14	1.82	0.47	65.63
Chon	54.20	0.00	0.19	0.05	0.00	0.00	26.34	0.00	1.17	0.35	82.30
FUJI	103.82	0.01	14.67	8.79	0.00	0.09	5.40	3.57	1.08	0.20	137.62
GUAH	45.14	0.05	14.00	17.05	0.00	0.79	20.46	7.20	2.82	1.61	109.11
GUAX	32.64	0.00	16.55	22.92	0.00	0.00	7.10	9.32	1.19	0.76	90.49
Guaz	7.58	0.00	0.33	0.65	0.00	0.00	10.70	0.00	1.71	0.05	21.02
Guiy	7.91	0.01	0.09	0.01	0.00	0.00	5.83	0.00	0.88	0.02	14.74
GUIZ	97.24	0.00	22.31	7.67	0.00	0.00	10.23	3.12	1.32	0.42	142.32
HEHE	391.75	0.05	26.61	69.33	0.00	0.39	162.44	28.18	18.20	2.88	699.83
HUBE	73.49	0.00	12.61	21.37	0.00	0.54	5.43	9.30	1.69	1.22	125.64
HUNA	101.76	0.00	21.82	24.20	0.00	0.60	9.96	9.83	2.63	0.92	171.72
IMON	90.15	0.00	9.78	11.43	8.28	0.10	32.84	4.64	4.70	0.58	162.51
JINU	146.48	12.52	3.51	27.14	0.00	0.79	41.02	11.03	7.99	0.41	250.87
JINX	46.41	0.00	17.01	16.82	0.00	0.00	15.20	6.84	2.12	0.62	105.01
NEPL	144.14	0.53	15.31	49.38	0.00	0.96	266.07	20.39	15.79	1.42	513.98
Shan	22.26	0.00	0.25	2.90	0.00	0.00	7.82	1.18	4.99	0.69	40.10
Shen	8.88	0.46	0.00	0.79	0.00	0.04	8.39	0.00	0.05	0.22	18.83
SHGA	68.66	0.00	12.87	23.45	0.00	0.18	20.57	9.53	4.72	0.44	140.42
SHND	82.86	0.00	17.26	34.80	0.00	0.34	16.10	14.14	8.17	0.85	174.52
SHNX	47.87	0.08	3.12	9.75	0.00	0.01	17.55	4.11	7.20	0.38	90.07
SICH	195.48	0.20	37.80	45.43	0.00	0.50	99.75	18.53	3.41	0.87	401.97
Taiy	59.69	0.00	0.00	0.37	0.00	0.00	6.99	0.00	1.08	0.62	68.75
Tian	29.01	0.09	0.22	2.16	0.00	0.27	5.01	0.88	2.24	0.89	40.78
WEST	82.25	0.08	4.57	6.70	6.00	0.61	16.22	2.72	1.29	0.86	121.29
Wuha	32.41	0.00	0.00	1.50	0.00	0.00	5.55	0.00	2.37	0.27	42.09
YUNN	77.93	0.14	24.28	11.56	0.00	0.00	32.15	4.70	1.17	0.74	152.67
ZHEJ	23.50	0.01	17.09	19.31	0.00	0.21	10.02	7.85	3.64	2.30	83.92
China	**2121.51**	**14.20**	**292.49**	**438.36**	**14.27**	**6.77**	**875.90**	**178.22**	**105.44**	**21.07**	**4068.22**
% of Total	52.1	0.3	7.2	10.8	0.4	0.2	21.5	4.4	2.6	0.5	100.0
Sector %			71.0				21.5	4.4	2.6	0.5	

Figure 1 - Chinese SO2 Emissions, by Sector - 1995

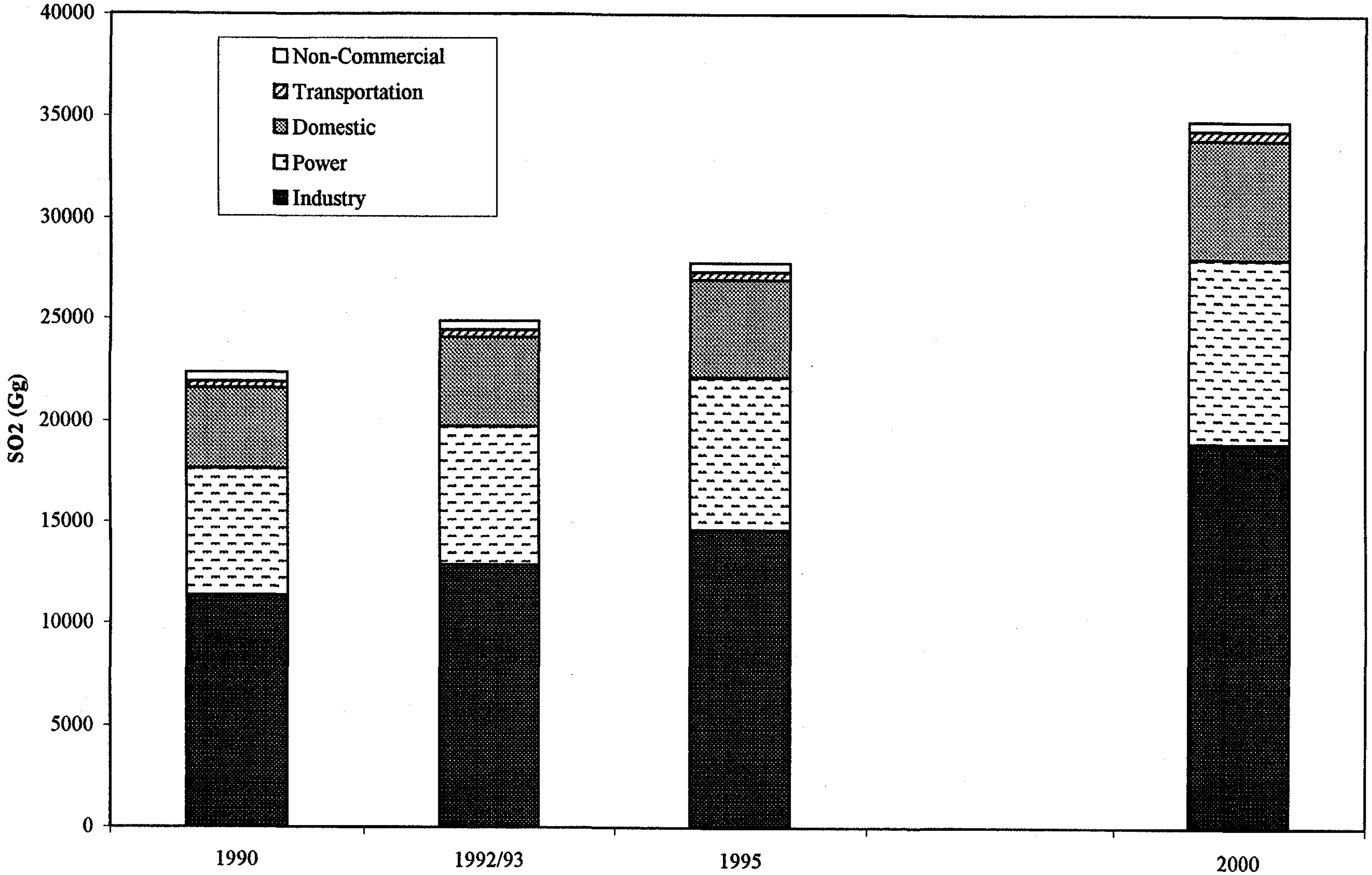

Figure 2 - Chinese NOx Emissions, by Sector - 1995

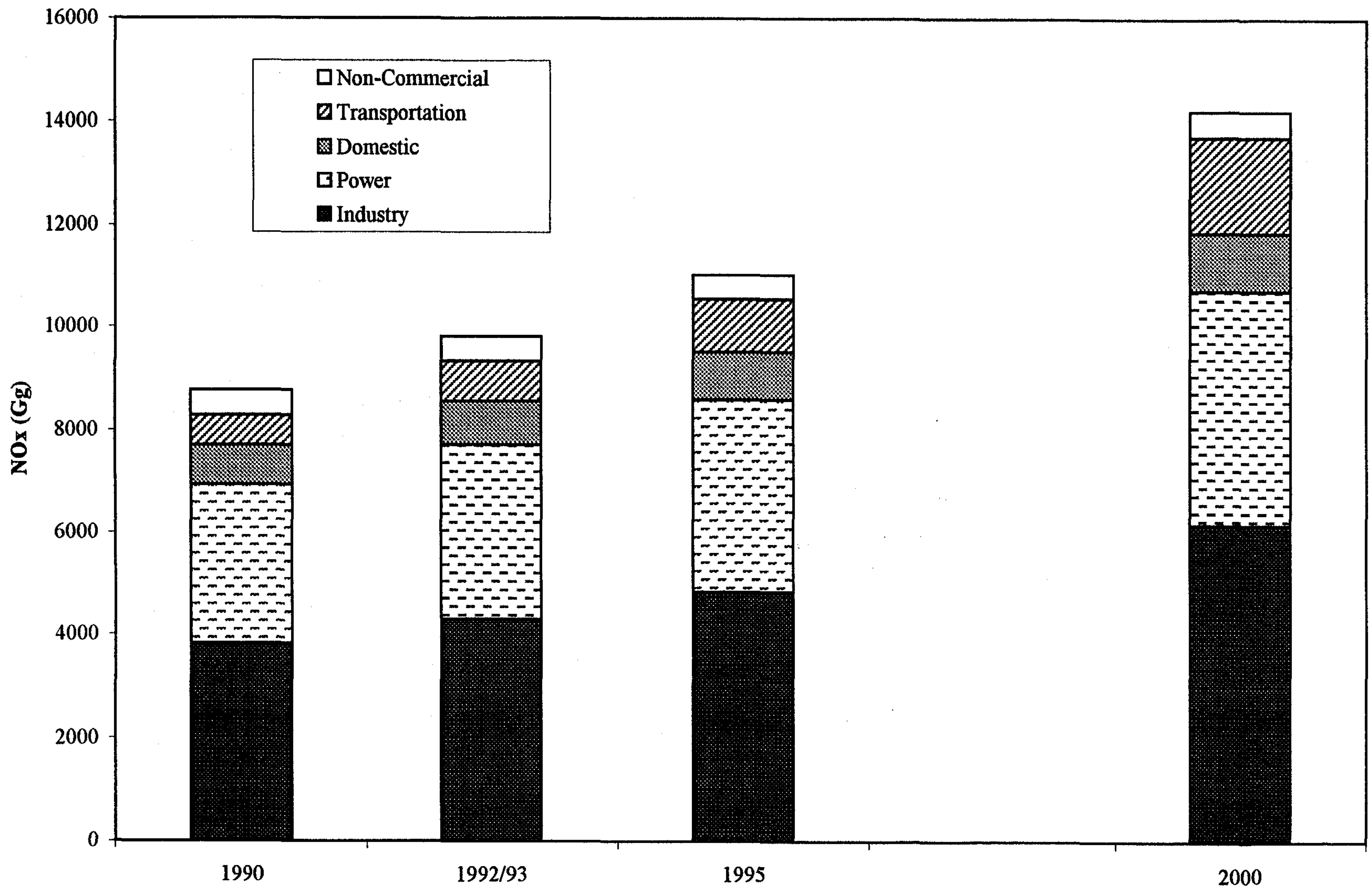

Figure 3 - Chinese CO Emissions, by Sector - 1995

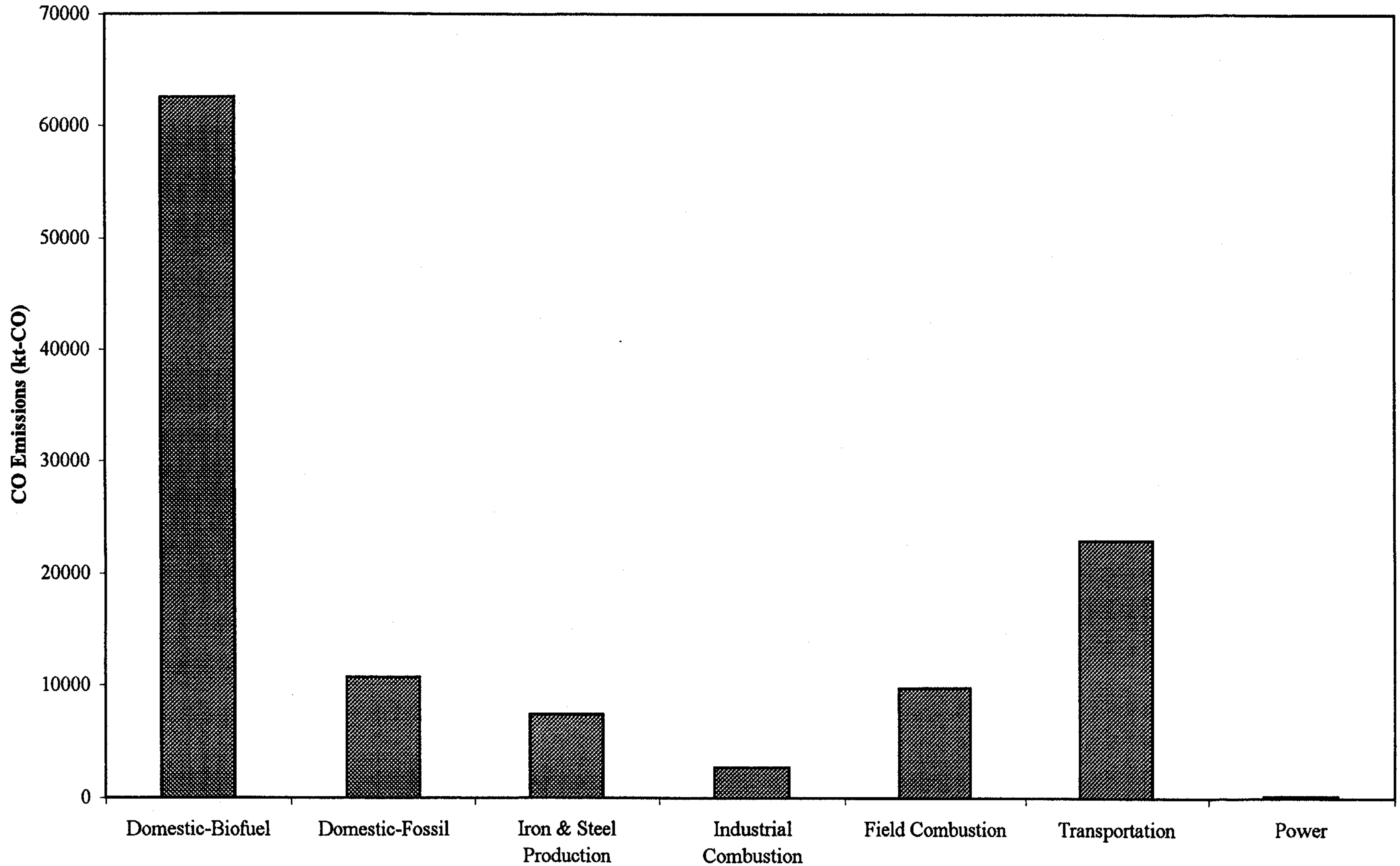

Figure 4 - Chinese BC Emissions, by Sector - 1995