Appendix I Data on Activity Levels and Emission Factors

The data on activity levels are taken from the following sources: (ADB, 2000; China Coal and Urban Development Society, 1992; China Production Safety Supervision Bureau and China Coal Mine Safety Supervision Bureau, 2001; China Statistics Administration, 2000; China Statistics Administration, 2001; China Urban Development Society, 2001; CRSI, 2001; Department of Investment and Construction Statistics of National Bureau of Statistics, 2001; Editorial Board of China Electric Power Yearbook, 2001; National Bureau of Statistics of China, 1999; National Quality and Technical Supervision Bureau of China, 1999; People's Government of Hebei, 2001; People's Government of Henan, 2001; People's Government of Jiangsu, 2001; People's Government of Shandong, 2001; People's Government of Shanxi, 2001; Shandong Statistics Bureau, 2001; SRSY, 2001; State Environmental Protection Agency of China, 2002; Statistical Bureau of Anhui, 2001; Statistical Bureau of Hebei, 2001; Statistical Bureau of Henan, 2001; Statistical Bureau of Jiangsu, 2001; Statistical Bureau of Shanxi, 2001).

The emission factors by species and coded source categories are listed in Tables A1, A2 and A7. The sulfur and ash contents of coal are listed in Tables A4 and A5. The sulfur content for other fuels are listed in Table A3.

Table A1 Emission Factors for Highway Vehicles (Fu et al., 2001; Streets et al., 2001; Zheng et al., 2003)

Source Category	Speed: 24 km hr^{-1}			Speed: 45 km hr^{-1}		
(vehicle type, fuel type)	CO	NOx	BC	CO	NOx	BC
Large passenger vehicle, gasoline	163.3	11.9	0.08	98.2	14.1	0.08
Large passenger vehicle, M5	146.97	10.71	0.08	88.38	12.69	0.08
Large passenger vehicle, M100	130.64	9.52	0.08	78.56	11.28	0.08
Large passenger vehicle, diesel	24.6	24.9	1.1	13.5	22.7	1.1
Large passenger vehicle, DME	7.38	7.47	0.08	4.05	6.81	0.08
Small passenger vehicle, gasoline	51.8	1.8	0.08	29.8	1.9	0.08
Small passenger vehicle, M5	46.62	1.62	0.08	26.82	1.71	0.08
Small passenger vehicle, M100	41.44	1.44	0.08	23.84	1.52	0.08
Small passenger vehicle, diesel	24.6	24.9	1.1	13.5	22.7	1.1
Small passenger vehicle, DME	7.38	7.47	0.08	4.05	6.81	0.08
Heavy truck, diesel	24.6	24.9	1.1	13.5	22.7	1.1
Heavy truck, DME	7.38	7.47	0.08	4.05	6.81	0.08
Large truck, gasoline	81.9	4.8	0.08	50.7	4.8	0.08
Large truck, M5	73.71	4.32	0.08	45.63	4.32	0.08
Large truck, M100	65.52	3.84	0.08	40.56	3.84	0.08
Large truck, diesel	24.6	24.9	1.1	13.5	22.7	1.1
Large truck, DME	7.38	7.47	0.08	4.05	6.81	0.08
Medium truck, gasoline	81.9	4.8	0.08	50.7	4.8	0.08
Medium truck, M5	73.71	4.32	0.08	45.63	4.32	0.08
Medium truck, M100	65.52	3.84	0.08	40.56	3.84	0.08
Medium truck, diesel	24.6	24.9	1.1	13.5	22.7	1.1
Medium truck, DME	7.38	7.47	0.08	4.05	6.81	0.08
Small truck, gasoline	43.6	2.8	0.08	26.2	2.8	0.08
Small truck, M5	39.24	2.52	0.08	23.58	2.52	0.08
Small truck, M100	34.88	2.24	0.08	20.96	2.24	0.08
Small truck, diesel	24.6	24.9	1.1	13.5	22.7	1.1
Small truck, DME	7.38	7.47	0.08	4.05	6.81	0.08
Specialized truck, diesel	24.6	24.9	1.1	13.5	22.7	1.1
Specialized truck, DME	7.38	7.47	0.08	4.05	6.81	0.08
Other specialized auto, diesel	24.6	24.9	1.1	13.5	22.7	1.1
Other specialized auto, DME	7.38	7.47	0.08	4.05	6.81	0.08
Wheeled tractor, diesel	24.6	24.9	1.1	13.5	22.7	1.1
Wheeled tractor, DME	7.38	7.47	0.08	4.05	6.81	0.08
Trailer, diesel	24.6	24.9	1.1	13.5	22.7	1.1
Trailer, DME	7.38	7.47	0.08	4.05	6.81	0.08
Motorcycle, gasoline	16.3	0.1	0.08	9	0.1	0.08
Motorcycle, M5	14.7	0.09	0.08	8.1	0.09	0.08
Motorcycle, M100	13.0	0.08	0.08	7.2	0.08	0.08
Other motor vehicle, gasoline	163.3	11.9	0.08	98.2	14.1	0.08
Other motor vehicle, M5	147.0	10.7	0.08	88.4	12.7	0.08

Source Category (vehicle type, fuel type)	Speed: 24 km hr^{-1}			Speed: 45 km hr^{-1}		
	CO	NOx	BC	CO	NOx	BC
Other motor vehicle, M100	130.6	9.5	0.08	78.6	11.3	0.08

Notes:

1. The unit for CO and NOx emission factors is g km^{-1} traveled and the unit for BC is g kg^{-1} fuel.
2. Large passenger vehicles have 4 seats or more in each row, and 31 seats or more in total. Medium-sized passenger vehicles have a maximum of 4 seats in each row, and 16-30 seats in total. Small-sized passenger vehicles have a maximum of 3 seats in each row, and 15 seats or less in total. Heavy freight vehicles include trucks with a rated capacity of 8 tons or more and trailers with a rated capacity of 15 tons or more. Large-sized freight vehicles refer to trucks with a rated capacity of 4 tons or more. Medium-sized freight vehicles refer to trucks with a rated capacity between 2-4 tons. Small-sized freight vehicles refer to trucks with a rated capacity of 2 tons or less. Source: Circular No. 839 issued by Ministry of Transport of China on 7 October 1996.
3. M5 = a mixture of 5% methanol and 95% gasoline by molar fraction, M100 = transportation fuel grade methanol and DME = dimethyl ether.

Table A2 Emission factors for area sources (g kg^{-1} solid or liquid fuel or g m^{-3} gaseous fuel unless indicated otherwise)

Source Category	SO_2	CO	NOx	NH_3	PM_{10}	$PM_{2.5}$	CO_2
Stationary Source Fuel Combustion, residential, urban, LPG	0.01		0.88		0.26	0.16	2640.5
Stationary Source Fuel Combustion, residential, urban, natural gas	0.01		1.57				2187.9
Stationary Source Fuel Combustion, residential, urban, residential coal	1.2Sa	71.3	1.88		0.65	0.39	2280.0
Stationary Source Fuel Combustion, residential, urban, residential Oil	2.0Sh		1.95				3109.4
Stationary Source Fuel Combustion, residential, urban, Biogas	1.00		1.57				2980.0
Stationary Source Fuel Combustion, residential, urban, syngas	0.01		1.57				2980.0
Stationary Source Fuel Combustion, residential, urban, crop residuals	0.40	86.3	2.5	0.00152	4.03	2.42	1130.0
Stationary Source Fuel Combustion, residential, urban, kerosene		7.39	2.49				3130.0
Stationary Source Fuel Combustion, residential, urban, fuelwood	0.86	69.2	0.6		2.80	1.68	1520.0
Stationary Source Fuel Combustion, residential, urban, DME			0.88				2640.5
Stationary Source Fuel Combustion, residential, rural, LPG	0.01		0.88		0.26	0.16	2640.5
Stationary Source Fuel Combustion, residential, rural, natural gas	0.01		1.57				2187.9
Stationary Source Fuel Combustion, residential, rural, residential coal	1.2Sa	71.3	1.88		0.65	0.39	2280.0
Stationary Source Fuel Combustion, residential, rural, residential Oil	2.0Sh		1.95				3109.4
Stationary Source Fuel Combustion, residential, rural, biogas	1.0		1.57				2980.0

Source Category	SO_2	CO	NOx	NH_3	PM_{10}	$PM_{2.5}$	CO_2
Stationary Source Fuel Combustion, residential, rural, syngas	0.01		1.57				2980.0
Stationary Source Fuel Combustion, residential, rural, crop residuals	0.40	86.30	2.50	0.00152	4.03	2.42	1130.0
Stationary Source Fuel Combustion, residential, rural, kerosene		7.39	2.49				3130.0
Stationary Source Fuel Combustion, residential, rural, fuelwood	0.86	69.20	0.60		2.80	1.68	1520.0
Stationary Source Fuel Combustion, residential, rural, DME			0.88				2640.5
Stationary Source Fuel Combustion, electric power, steam and hot water, raw coal	1.95Sa		9.95		2.32	1.230	1998.8
Stationary Source Fuel Combustion, electric power, steam and hot water, clean coal	1.95Sb		9.95		1.74	0.92	2406.8
Stationary Source Fuel Combustion, electric power, steam and hot water, other washed coal	1.95Sb		9.95		1.74	0.92	2406.8
Stationary Source Fuel Combustion, electric power, steam and hot water, coke			0.00				4686.9
Stationary Source Fuel Combustion, electric power, steam and hot water, coke oven gas	0.38Sb		4.40				1531.5
Stationary Source Fuel Combustion, electric power, steam and hot water, other gas	0.01		10.00				1531.5
Stationary Source Fuel Combustion, electric power, steam and hot water, crude oil	2.0Sh	0.00	7.24000				3070.3
Stationary Source Fuel Combustion, electric power, steam and hot water,	2.0Sc		16.7				3104.

Source Category	SO_2	CO	NOx	NH_3	PM_{10}	$PM_{2.5}$	CO_2
gasoline							
Stationary Source Fuel Combustion, electric power, steam and hot water, kerosene	2.0Sd		21.2				3216.0
Stationary Source Fuel Combustion, electric power, steam and hot water, diesel oil	2.0Se		27.4				3209.3
Stationary Source Fuel Combustion, electric power, steam and hot water, fuel oil	2.0Sh		10.0		1.22	0.89	3109.4
Stationary Source Fuel Combustion, electric power, steam and hot water, LPG	0.0108		3.74				2640.5
Stationary Source Fuel Combustion, electric power, steam and hot water, refinery gas	0.013		0.75				1531.5
Stationary Source Fuel Combustion, electric power, steam and hot water, natural gas	0.0092		4.4				2187.9
Stationary Source Fuel Combustion, electric power, steam and hot water, other petroleum products	1		16.0				3281.7
Stationary Source Fuel Combustion, electric power, steam and hot water, others			10.0				
Stationary Source Fuel Combustion, electric power, steam and hot water, gasification, polygeneration coal							1776.3
Stationary Source Fuel Combustion, industrial, coal gasified syngas ($g\ MJ^{-1}$)			0.041				1998.8
Stationary Source Fuel Combustion,	1.55Sa	37.60	7.50		13.55	3.20	2406.9

Source Category	SO_2	CO	NOx	NH_3	PM_{10}	$PM_{2.5}$	CO_2
industrial, raw coal							
Stationary Source Fuel Combustion, industrial, clean coal	1.55Sb	37.6	7.5		10.16	2.4	2406.8
Stationary Source Fuel Combustion, industrial, other washed coal	1.55Sb	37.6	7.5		10.16	2.4	4686.9
Stationary Source Fuel Combustion, industrial, coke	1.77Sb		9.0				1531.5
Stationary Source Fuel Combustion, industrial, coke oven gas	0.38Sb		2.29				1531.5
Stationary Source Fuel Combustion, industrial, other gas	0.1		0.31				3070.3
Stationary Source Fuel Combustion, industrial, crude oil	2.0Sh		5.09				3104.6
Stationary Source Fuel Combustion, industrial, gasoline	2.0Sc		16.7				3216.0
Stationary Source Fuel Combustion, industrial, kerosene	2.0Sd		7.46				3209.3
Stationary Source Fuel Combustion, industrial, diesel oil	2.0Se		9.62				3109.4
Stationary Source Fuel Combustion, industrial, fuel oil	2.0Sh		5.84		1.48	0.96	2640.5
Stationary Source Fuel Combustion, industrial, LPG	0.0108		2.63				1531.5
Stationary Source Fuel Combustion, industrial, refinery gas	0.013		0.53				2187.9
Stationary Source Fuel Combustion, industrial, natural gas	0.013		2.24				3281.7
Stationary Source Fuel Combustion, industrial, other petroleum products	1		5.84				
Stationary Source Fuel Combustion, industrial, others	1		5.84				2640.5

Source Category	SO_2	CO	NOx	NH_3	PM_{10}	$PM_{2.5}$	CO_2
Stationary Source Fuel Combustion, industrial, DME	0		0.88				1998.8
Stationary Source Fuel Combustion, Commercial/Institutional, raw coal	1.2Sa	37.6	7.5		13.55	3.20	2406.8
Stationary Source Fuel Combustion, Commercial/Institutional, clean coal	1.2Sb	37.6	7.5		10.16	2.40	2406.8
Stationary Source Fuel Combustion, Commercial/Institutional, other washed coal	1.2Sb	37.6	7.5		10.16	2.40	4686.9
Stationary Source Fuel Combustion, Commercial/Institutional, coke	1.77Sb		9.00				1531.5
Stationary Source Fuel Combustion, Commercial/Institutional, coke oven gas	0.38Sb		2.29000				1531.5
Stationary Source Fuel Combustion, Commercial/Institutional, other gas	0.1		0.31000				3070.3
Stationary Source Fuel Combustion, Commercial/Institutional, crude oil	2.0Sh	0.00	5.09				3104.6
Stationary Source Fuel Combustion, Commercial/Institutional, gasoline	2.0Sc	0.00	16.7				3216.0
Stationary Source Fuel Combustion, Commercial/Institutional, kerosene	2.0Sd	0.00	7.46				3209.3
Stationary Source Fuel Combustion, Commercial/Institutional, diesel oil	2.0Se	0.00	9.62				3109.4
Stationary Source Fuel Combustion, Commercial/Institutional, fuel oil	2.0Sh	0.00	5.84		0.00326	0.00251	2640.5
Stationary Source Fuel Combustion, Commercial/Institutional, LPG	0.0108		2.63				1531.5
Stationary Source Fuel Combustion, Commercial/Institutional, refinery gas	0.013		0.53				2187.9
Stationary Source Fuel Combustion, Commercial/Institutional, natural gas	0.013		2.24				3281.7

Source Category	SO_2	CO	NOx	NH_3	PM_{10}	$PM_{2.5}$	CO_2
Stationary Source Fuel Combustion, Commercial/Institutional, other petroleum products	1		5.84				
Stationary Source Fuel Combustion, Commercial/Institutional, others	1		5.84				2640.47520
Stationary Source Fuel Combustion, Commercial/Institutional, DME	0	0.00	0.88				
Industrial processes, oil refinery	0.046Sh						
Industrial processes, Coke oven							232.1
Industrial processes, synthetic ammonia				800.0			
Industrial processes, nitric acid production				41.0			
Industrial processes, sugar making			0.33				
Industrial processes, cement							509.1
Industrial processes, plywood making		5.10	0.24				
Industrial processes, N fertilizer manufacture				1647.0			
Fuel storage, handling, sale and transport, gasoline	2.0Sc						3104.6
Fuel storage, handling, sale and transport, kerosene	2.0Sd						3188.2
Fuel storage, handling, sale and transport, diesel	2.0Se						3209.3
Fuel storage, handling, sale and transport, DME							
Fuel storage, handling, sale and transport, M5							2949.4
Fuel storage, handling, sale and transport, M100							
Waste Disposal, Treatment, and Recovery, medical waste		1.48	1.78				

Source Category	SO_2	CO	NOx	NH_3	PM_{10}	$PM_{2.5}$	CO_2
Waste Disposal, Treatment, and Recovery, municipal waste		3.0	0.25				
Waste Disposal, Treatment, and Recovery, agri waste burning	1	92.0	0.50	0.00152	11.0	6.6	1130.0

Notes:

1. Sa-Sh denote the sulfur content in the fuels. The values of Sa (for commercial raw coal) and Sb (for washed coal) are shown in Table A8; the values of Sc to Sh are shown in Table A3.
2. The unit for NH_3 emissions from industrial processes (N fertilizer, synthetic ammonia and nitric acid production) is kg N/Gg N in the product.

Table A3 Sulfur content for fuels other than coal in China (Kato and Akimoto, 1992)

Fuel Type	Symbol used in Table A4	Sulfur content (% by weight)
Motor gasoline	Sc	0.12
Kerosene	Sd	0.032
Industrial diesel	Se	0.4
Road diesel	Sf	0.16
Residual oil	Sh	1.5

Table A4 Ash content (%) of coal in China

Province	Commercial coal	Washed coal
Hebei	20.49	10.37
Shandong	19.12	8.83
Shanxi	14.54	10.04
Jiangsu	19.98	9.66
Anhui	23.90	11.34
Henan	17.01	11.04

Notes:

1. Source: (China Coal and Urban Development Society, 1992)

2. Ash content is a coal output weighted average based on major coal mines in 1990.

Table A5 Sulfur content (%) of coal in China

Province	Commercial coal[1]	Washed coal[2]
Hebei	0.92	0.46
Shandong	1.12	0.56
Shanxi	0.92	0.46
Jiangsu	1.12	0.56
Anhui	1.12	0.56
Henan	1.18	0.59

[1]Source: (China Coal and Urban Development Society, 1992)

[2] Based on (Fridley, 2001).

In addition we make the following assumptions in the emission estimates, but are not able to verify them due to lack of relevant information:

1) Sulfur content of coke is assumed to be same as that of washed coal.

2) All residential coal is produced locally. We might underestimate the ash content of residential coal when it is produced by local small coal mines and is of inferior quality.

3) Coal imported from Shanxi Province is of the same quality as Shanxi coal. The amount of coal imported from Shanxi is seen in Table A6. The rest of the coal consumed is assumed to be of the average quality in respective provinces.

Table A6 Coal imported from Shanxi Province (ton) in 2000

Province	Coal Imported
Hebei	58,377,300
Shandong	27,651,600
Jiangsu	17,260,100
Anhui	2,813,900
Henan	16,147,500
Shanxi	--

Table A7 NH_3 emission factors for agricultural production activities and human

Source Category	EF	Unit
Application of N fertilizers, ammonium sulfate	8.0	% of N content
Application of N fertilizers, urea, temperate zones	15.0	% of N content
Application of N fertilizers, urea, tropical zones	25.0	% of N content
Application of N fertilizers, ammonium nitrate	2.0	% of N content
Application of N fertilizers, calcium ammonium nitrate	2.0	% of N content
Application of N fertilizers, anhydrous ammonia, direct application	4.0	% of N content
Application of N fertilizers, nitrogen solutions	2.5	% of N content
Application of N fertilizers, other straight nitrogen, ammonium bicarbonate, temperate zones	20.0	% of N content
Application of N fertilizers, other straight nitrogen, china, ammonium bicarbonate, tropical zones	30.0	% of N content
Application of N fertilizers, other straight nitrogen when fertilizer consumption for individual categories not available	4.0	% of N content
Application of N fertilizers, mono-ammonium phosphate,	5.0	% of N content
Application of N fertilizers, bi-ammonium phosphate,	3.0	% of N content
Application of N fertilizers, other compound nitrogen-phosphorous fertilizers	2.0	% of N content
Application of N fertilizers, compound nitrogen-potassium fertilizer	4.0	% of N content
Application of N fertilizers, compound nitrogen-phosphorous-potassium fertilizer	4.0	% of N content
Crops	2.5	KgN ha^{-1} $year^{-1}$
Domestic animal, dairy cattle	17.4	KgN $animal^{-1}$ $year^{-1}$
Domestic animal, nondairy cattle	8.1	KgN $animal^{-1}$ $year^{-1}$
Domestic animal, buffalo	8.7	KgN $animal^{-1}$ $year^{-1}$
Domestic animal, camels	10.6	KgN $animal^{-1}$ $year^{-1}$
Domestic animal, horses	8.7	KgN $animal^{-1}$ $year^{-1}$
Domestic animal, all big animals	8.7	KgN $animal^{-1}$ $year^{-1}$
Domestic animal, sheep and goat	0.95	KgN $animal^{-1}$ $year^{-1}$
Domestic animal, pigs	4.0	KgN $animal^{-1}$ $year^{-1}$
Domestic animal, poultry	0.2	KgN $animal^{-1}$ $year^{-1}$
Human	0.5	KgN $person^{-1}$ $year^{-1}$

Appendix II Air Pollution Reporting in China

Air quality data in China is reported as an air pollution index (API) on a daily basis using measurements of ambient concentrations at pre-designated non-background sites in a municipality. The measurements are made of three species: SO_2, NO_2 and inhalable particulates (PM_{10}). However, it is not clear how often the measurements are made on a given day. The daily average concentrations of a municipality for individual species are calculated as arithmetic means of the measurements made at all qualified monitoring stations in the municipality over the period from 12pm of the previous day to 11:59am of the current day (Equation A1).

$$C_i = \sum_{j=1}^{J}\sum_{k=1}^{K} c_{i,j,k} /(\text{J*K}) \qquad \text{(A1)}$$

where C_i is the average daily concentration of the i^{th} municipality, $c_{i,j,k}$ is the concentration measured at the j^{th} monitoring site and the k^{th} time in the i^{th} municipality, J is the total number of monitoring sites in the municipality and K is the total number of measurements made during the 24-hour period at a given monitoring station. The municipal average concentrations are then converted to APIs based on the following formula (Equation A2) (China National Environmental Monitoring Center, 2003):

$$\text{API}_i = \frac{API_{upper} - API_{lower}}{C_{upper} - C_{lower}}(C_i - C_{lower}) + API_{lower} \qquad \text{(A2)}$$

where C_{upper} and C_{lower} are the concentrations listed in Table A8 in between which the actual concentration C_i falls, and API_{upper} and API_{lower} are the API values listed in Table A9 that correspond to C_{upper} and C_{lower}. Only the highest API value together with the pollutant name on a given day is reported (Equation A3).

$$\text{API (reported)} = max\ (\text{API}_1, \text{API}_2, \ldots \text{API}_n) \qquad \text{(A3)}$$

where n is the number of pollutants that are measured in each municipality and for which API is calculated.

We have managed to collect the reported daily API data for 37 municipalities within the 12 km domain (Anhui Provincial Environmental Protection Bureau, 2003; China National Environmental Monitoring Center, 2003; Hebei Provincial Environmental Protection Bureau, 2003; Henan Provincial Environmental Protection Bureau, 2003; Jiangsu Provincial Environmental Protection Bureau, 2003; Shandong Provincial Environmental Protection Bureau, 2003).

Table A8 The API values and corresponding pollutant concentrations

	Pollutant Concentrations (mg m^{-3})				
API	SO_2 (daily average)	NO_2 (daily average)	PM_{10} (daily average)	CO (hourly average)	O_3 (hourly average)
50	0.050	0.080	0.050	5	0.120
100	0.150	0.120	0.150	10	0.200
200	0.800	0.280	0.350	60	0.400
300	1.600	0.565	0.420	90	0.800
400	2.100	0.750	0.500	120	1.000
500	2.620	0.940	0.600	150	1.200

Source: (China National Environmental Monitoring Center, 2003)

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