

SUPPLEMENTARY

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Title: Analysis of Reduction Potential of Primary Air Pollutant Emissions from Coking Industry in China

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Table S1. Coke production by province in China, 2015.

Province	Coke production Mt	Province	Coke production Mt
National total	447.78	Henan	29.42
Beijing	0.00	Hubei	9.20
Tianjin	1.96	Hunan	6.57
Hebei	54.81	Guangdong	2.00
Shanxi	80.35	Guangxi	6.26
Inner Mongolia	30.41	Hainan	0.00
Liaoning	20.97	Chongqing	2.17
Jilin	3.72	Sichuan	13.04
Heilongjiang	6.87	Guizhou	7.29
Shanghai	5.34	Yunnan	11.50
Jiangsu	24.33	Xizang	0.00
Zhejiang	2.94	Shaanxi	36.44
Anhui	9.58	Gansu	5.25
Fujian	1.52	Qinghai	0.00
Jiangxi	8.15	Ningxia	7.57
Shandong	43.65	Xinjiang	16.44

Data sources: CCIA, 2016; NBSC, 2016.

Table S2. The uncertainties of activity data and emission factors.

Parameters	Parameters	Data distribution
Activity data	Coke production	Normal (CV ^a : 30%)
	Coal charging	Triangular (CV: 100%)
	Coke pushing	Triangular (CV: 100%)
	Coke transport	Triangular (CV: 100%)
Emission Factors	Coke quenching	Triangular (CV: 100%)
	Chimney exhaust	Triangular (CV: 100%)
	Whole process	Triangular (CV: 130%)

CV: confidence interval

Table S3. The contrast of current status and the planning targets of the 13th five-year-plan.

Current status	Plan targets
The backward production capacity of coking enterprises with the heights of the coke oven's carbonization chamber lower than 4.3 m was nearly 20 Mt, and most of which were located in remote areas.	All the backward production capacity will be banned.
Until the end of 2015, the production capacity with admission conditions of coking industry accounted for about 50.0% of the totals.	The production capacity with admission conditions of coking industry will reach more than 70.0% of totals.
The production capacity was 687 Mt in 2015, but the actual coke production is approximately 450 Mt.	50 Mt of the surplus production capacity will be cut down.
Since January 1 st , 2015, a new version of the Emission Standard of Pollutants should be in effect for existing and new coking enterprises.	All the enterprises meeting the coking industry admission conditions should reach at the new Emission Standard of Pollutants.
Coke consumption had reached at 438 Mt in 2015.	Keep the coke consumption at 400 Mt per year until 2020.

Sources: MEP, 2012; MIIT, 2014; NDRC and NEA, 2016

Table S4. The projection of emission factors of primary air pollutants from coking industry under the control scenarios, kg t⁻¹.

Coke oven types	Year	TSP					SO ₂	NO _x
		Coal charging	Coke pushing	Transportation	Coke quenching	Chimneys		
Top-charging coke oven (<4.3m)	2015	1.98	2.05	1.46	0.08	3.70E-03	0.94	0.23
	2020	—	—	—	—	—	—	—
Top-charging coke oven(4.3–6.0m)	2015	0.12	0.13	0.12	0.08	0.02	0.83	0.40
	2020	0.02	0.03	0.02	0.04	0.04	0.05	0.50
Top-charging coke oven(>6.0m)	2015	0.1	0.13	0.11	0.07	0.01	0.08	0.36
	2020	0.02	0.03	0.02	0.04	0.04	0.05	0.15
Stamp-charging coke oven	2015	0.12	0.13	0.12	0.06	0.02	0.88	0.41
	2020	0.02	0.03	0.02	0.01	0.05	0.05	0.50
Heat recovery coke oven	2015	1.98	2.05	1.46	0.08	0.26	3.04	0.29
	2020	0.03	—	—	0.02	0.12	0.10	0.20

Data sources: (MEP, 2012; NDRC and NEA, 2016)

Table S5. The flue gas volume of different coke processes and coke oven types.

Coke oven type	Coking processes				Chimneys
	Coal charging	Coke pushing	Transportation	Coke quenching	
Top-charging coke oven (4.3-6.0m)	352	665	641	727	1416
Top-charging coke oven (>6.0m)	326	647	623	706	1275
Stamp-charging coke oven	347	682	655	286	1501
Heat recovery coke oven	-	-	-	433	4096

Data sources: (FNPSCD, 2010)

Table S6. Provincial emission characteristics of air pollutants from coking industry.

Province	TSP	PM _{2.5}	SO ₂	NO _x	VOCs	PAHs	CO	CH ₄
Beijing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tianjin	1.61	0.10	1.76	0.76	5.80	0.12	8.91	0.31
Hebei	45.09	2.85	49.27	21.35	162.23	3.46	249.25	8.77
Shanxi	66.10	4.18	72.23	31.30	237.83	5.07	365.41	12.86
Inner Mongolia	25.02	1.58	27.34	11.85	90.01	1.92	138.30	4.87
Liaoning	17.25	1.09	18.85	8.17	62.08	1.32	95.38	3.36
Jilin	3.06	0.19	3.35	1.45	11.02	0.23	16.92	0.60
Heilongjiang	5.66	0.36	6.18	2.68	20.35	0.43	31.26	1.10
Shanghai	4.40	0.28	4.80	2.08	15.82	0.34	24.31	0.86
Jiangsu	20.02	1.27	21.88	9.48	72.03	1.53	110.67	3.90
Zhejiang	2.42	0.15	2.64	1.14	8.70	0.19	13.37	0.47
Anhui	7.89	0.50	8.62	3.73	28.37	0.60	43.59	1.53
Fujian	1.25	0.08	1.37	0.59	4.51	0.10	6.92	0.24
Jiangxi	6.71	0.42	7.33	3.18	24.14	0.51	37.09	1.31
Shandong	35.91	2.27	39.24	17.00	129.19	2.75	198.49	6.99
Henan	24.21	1.53	26.45	11.46	87.10	1.86	133.82	4.71
Hubei	7.57	0.48	8.27	3.58	27.23	0.58	41.84	1.47
Hunan	5.41	0.34	5.91	2.56	19.46	0.41	29.89	1.05
Guangdong	1.65	0.10	1.80	0.78	5.92	0.13	9.10	0.32
Guangxi	5.15	0.33	5.63	2.44	18.53	0.39	28.47	1.00
Hainan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chongqing	1.79	0.11	1.95	0.85	6.43	0.14	9.88	0.35
Sichuan	10.73	0.68	11.73	5.08	38.61	0.82	59.32	2.09
Guizhou	6.00	0.38	6.56	2.84	21.59	0.46	33.17	1.17
Yunnan	9.46	0.60	10.34	4.48	34.03	0.73	52.29	1.84
Xizang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shaanxi	29.98	1.90	32.76	14.20	107.87	2.30	165.74	5.83
Gansu	4.32	0.27	4.72	2.05	15.54	0.33	23.88	0.84
Qinghai	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ningxia	6.22	0.39	6.80	2.95	22.39	0.48	34.41	1.21
Xinjiang	13.52	0.85	14.77	6.40	48.65	1.04	74.75	2.63
Total	368.36	23.28	402.54	174.43	1325.42	28.24	2036.43	71.68

Table S7. Specific control technologies and corresponding control effect of different coking procedures.

Coking procedures	Air pollutants	Control technologies	Emission concentration, mg/m ³
Coal charging	TSP	<ul style="list-style-type: none"> ● Side catheter ● Dry ground station 	≤50
	SO ₂	<ul style="list-style-type: none"> ● Dust removing vehicles 	≤100
Coke pushing	TSP	<ul style="list-style-type: none"> ● Coke cleaning system with thermal buoyancy cover 	≤50
	SO ₂	<ul style="list-style-type: none"> ● Dry ground station ● Wet dust removal ground station 	≤100
Transportation	TSP	Fabric filter	≤30
Coke quenching	TSP	Fabric filter	≤50
	SO ₂		≤100
Chimneys	TSP		≤30
	SO ₂	Burning purified gas	≤50
	NO _x		≤500

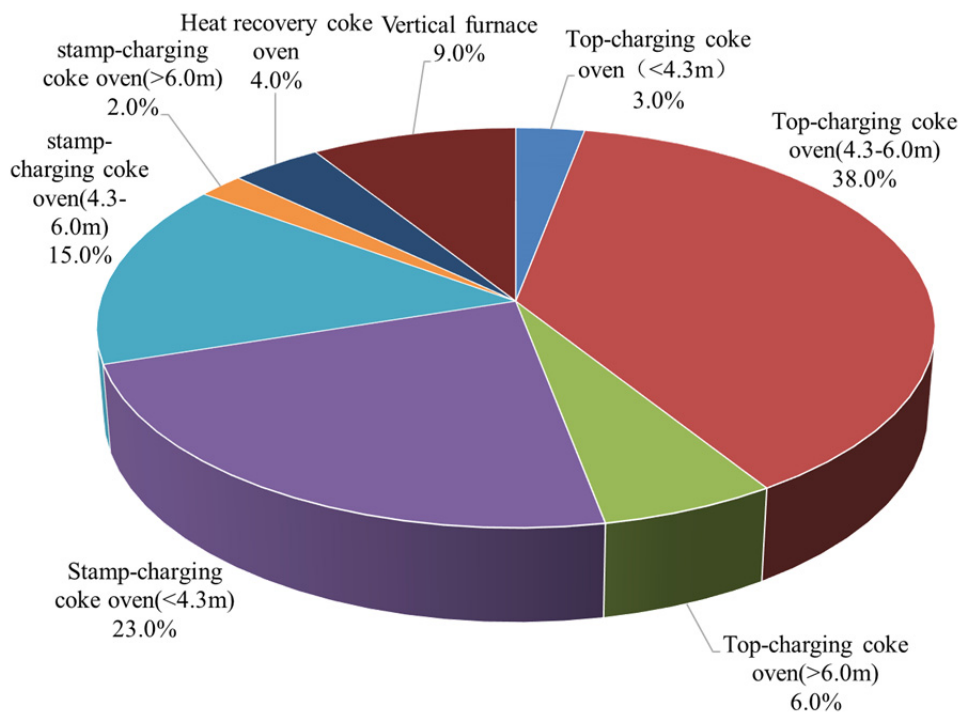


Fig. S1. The respective percentages of all coke ovens that used various technologies.

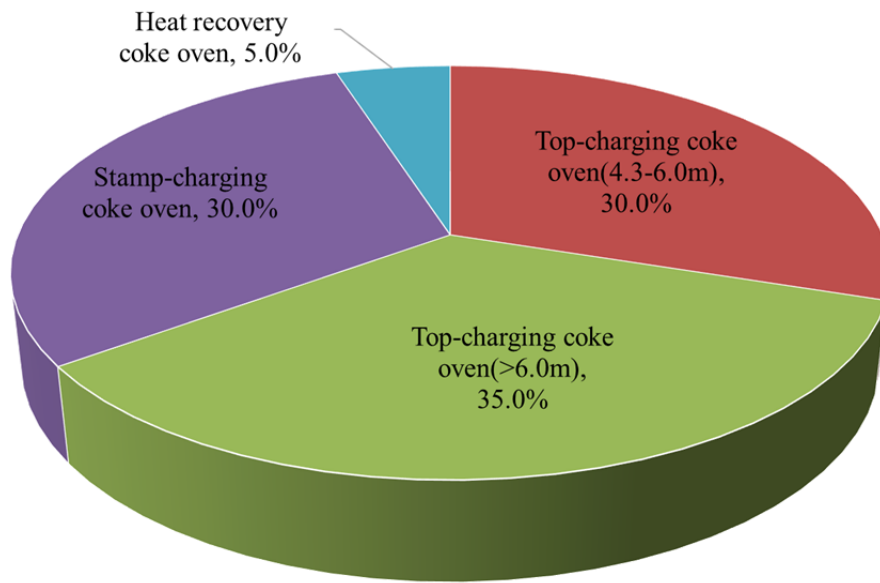


Fig. S2. The projection of different type of coke ovens until the end of the 13th five-year-plan.

REFERENCES

- China Coking Industry Association (CCIA). (2016). *Annual report of coke market development of China 2016*. China Economic Press, Beijing, China (in Chinese).
- Compilation Committee of the First National Pollution Source Census Data (FNPSCD). (2010). *The handbook of emission factors of industrial pollution sources of the first national pollution source census*. China Environmental Science Press, Beijing, China (in Chinese).
- Ministry of Environmental Protection of the People's Republic of China (MEP). (2012). Emission standard of pollutants for coking chemical industry. http://kjs.mep.gov.cn/hjbhzbz/bzwb/shjbh/swrwpfbz/201207/t20120731_234146.shtml (in Chinese).
- Ministry of Industry and Information Technology of the People's Republic of China (MIIT). (2014). Access conditions of Coking industry (revised in 2014). <http://www.miit.gov.cn/n1146290/n1146397/c4231310/content.html> (in Chinese).
- National Bureau of Statistics of China (NBSC). *China Statistical Yearbook 2016*, China Statistics Press: Beijing, China, 2016 (in Chinese).
- National Development and Reform Commission (NDRC) and National Energy Administration (NEA). (2016). Notice on Issuing the coal industry development in "13th Five-Year-Plan". http://www.sdpc.gov.cn/gzdt/201612/t20161230_833726.html (in Chinese).