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High-resolution inventory of technologies, activities, and emissions of coal-fired power plants in China from 1990 to 2010

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Table S1 Probability distributions of the national emission estimation-related parameters of coal-fired power plants in China

Category	Subcategory	Value in 1990	Distribution in 1990	Value in 2010	Distribution in 2010	Rating[a]
Activity	Coal Consumption (Tg)	272	Normal (CV: 10%)	1576	Normal (CV: 5%)	B
Boiler Type	Pulverized Boiler Ratio	79% (84%–74%)	Triangular	82% (79%–84%)	Triangular	C
	Circulating Fluidized Bed Ratio	NIP[b]		NIP[b]		
	Grate Furnace Ratio	8% (3%–13%)	Triangular	4% (2%–7%)	Triangular	C
Coal Type	Bituminous Coal Ratio	98% (88%–100%)	Triangular	98% (93%–100%)	Triangular	C
	Anthracite Coal Ratio	NIP[b]		NIP[b]		
Unabated SO_2 Emission Factor	Sulfur Content of Coal (%)	1.01	Normal (CV: 20%)	0.95	Normal (CV: 5%)	C
	Sulfur Retention in Ash (%)	15 (12–18)	Beta	same[c]		B
Unabated NO_x Emission Factor (g/kg)	$\text{Large Units}_{\text{Advanced LNB\_Bituminous}}$	4.06	Logistic (Scale: 0.16)	same[c]		A
	$\text{Large Units}_{\text{Advanced LNB\_Anthracite}}$	6.50 (4.34–8.23)	Triangular	same[c]		A
	$\text{Large Units}_{\text{LNB\_Bituminous}}$	5.08	Logistic (Scale: 0.71)	same[c]		A
	$\text{Large Units}_{\text{LNB\_Anthracite}}$	8.04	Logistic (Scale: 1.29)	same[c]		A
	$\text{Medium Units}_{\text{LNB\_Bituminous}}$	6.78	Logistic (Scale: 0.32)	same[c]		A
	$\text{Medium Units}_{\text{LNB\_Anthracite}}$	7.29 (6.58–7.88)	Triangular	same[c]		A
	$\text{Medium Units}_{\text{Non-LNB\_Bituminous}}$	7.63 (3.59–12.17)	Triangular	same[c]		A
	$\text{Medium Units}_{\text{Non-LNB\_Anthracite}}$	10.46	Logistic (Scale: 1.31)	same[c]		A
	$\text{Small Units}_{\text{Non-LNB\_Bituminous}}$	6.66 (6.17–6.93)	Triangular	same[c]		A
	$\text{Small Units}_{\text{Non-LNB\_Anthracite}}$	10.50 (9.36–11.50)	Triangular	same[c]		A

	Ash Content of Coal (%)	27.7	Normal (CV: 20%)	25.90	Normal (CV: 5%)	C
	$ar_{\text{Pulverized Boilers}}$[d]	20% (13%–28%)	Beta	same[c]		B
Unabated $PM_{2.5}$ Emission Factor	$ar_{\text{Circulating fluidized beds}}$[d]	44% (40%–52%)	Uniform	same[c]		B
	$ar_{\text{Grate furnaces}}$[d]	85%	Logistic (Scale: 0.05)	same[c]		B
	$f_{\text{Pulverized boilers}}$[d]	6%	Lognormal (GSD: 1.19%)	same[c]		B
	$f_{\text{Circulating fluidized beds}}$[d]	7% (5%–10%)	Uniform	same[c]		B
	$f_{\text{Grate furnaces}}$[d]	14% (3%–25%)	Uniform	same[c]		B
	Carbon $\text{Content}_{\text{Bituminous}}$ (kg-C/GJ)	25.8	Lognormal (GSD: 1.5%)	same[c]		B
Unabated CO_2 Emission Factor	Carbon $\text{Content}_{\text{Anthracite}}$ (kg-C/GJ)	26.7	Lognormal (GSD: 1.5%)	same[c]		B
	Oxidization Rate	100%	Lognormal (GSD: 0.2%)	same[c]		B
	Heating Value (kJ/g-coal)	20.1	Normal (CV: 10%)	18.8	Normal (CV: 5%)	C
	FGD	0% (0%–5%)	Triangular	1% (0%–3%)	Triangular	C
	FGD+Wet Scrubbers	0% (0%–5%)	Triangular	86% (83%–88%)	Triangular	C
	$\text{Non-LNB}_{\text{Large Units}}$	NIP[b]		–		
Control Technology Penetration	$\text{LNB}_{\text{Large Units}}$	100% (90%–100%)	Uniform	40% (30%–50%)	Uniform	C
	Advanced $\text{LNB}_{\text{Large Units}}$	–		NIP[b]		
	$\text{Non-LNB}_{\text{Medium Units}}$	100% (90%–100%)	Uniform	38% (28%–48%)	Uniform	C
	$\text{LNB}_{\text{Medium Units}}$	NIP[b]		NIP[b]		
	$\text{Non-LNB}_{\text{Small Units}}$	100% (90%–	Uniform	100% (90%–	Uniform	C

		100%)		100%)		
	$LNB_{Small\ Units}$	NIP[b]		NIP[b]		
	$Cyclones_{Pulverized\ boilers}$	5% (2%–7%)	Uniform	0% (0%–1%)	Uniform	C
	$Wet\ Scrubbers_{Pulverized\ boilers}$	43% (41%–46%)	Uniform	1% (0%–2%)	Uniform	C
	$Electrostatic\ Precipitators_{Pulverized\ boilers}$	NIP[b]		NIP[b]		
	$Bag\ Filters_{Pulverized\ boilers}$	2% (0%–5%)	Uniform	3% (2%–4%)	Uniform	C
	$Cyclones_{Circulating\ fluidized\ beds}$	25% (22%–27%)	Uniform	0% (0%–1%)	Uniform	C
	$Wet\ Scrubbers_{Circulating\ fluidized\ beds}$	47% (44%-49%)	Uniform	3% (2%–4%)	Uniform	C
	$Electrostatic\ Precipitators_{Circulating\ fluidized\ beds}$	NIP[b]		NIP[b]		
	$Bag\ Filters_{Circulating\ fluidized\ beds}$	0% (0%–3%)	Uniform	11% (10%–12%)	Uniform	C
	$Cyclones_{Grate\ furnaces}$	8% (6%–11%)	Uniform	5% (4%–6%)	Uniform	C
	$Wet\ Scrubbers_{Grate\ furnaces}$	75% (72%–77%)	Uniform	27% (26%–28%)	Uniform	C
	$Electrostatic\ Precipitators_{Grate\ furnaces}$	NIP[b]		NIP[b]		
	$Bag\ Filters_{Grate\ furnaces}$	0% (0%–3%)	Uniform	3% (2%–4%)	Uniform	C
Removal Efficiency	$Wet\ Scrubbers_{SO2}$	20%	Normal (CV: 10%)	same[c]		B
	FGD_{SO2}	78%	Normal (CV: 10%)	78%	Normal (CV: 5%)	C
	$Cyclones_{PM2.5}$	10% (5%–15%)	Triangular	same[c]		B
	$Wet\ Scrubbers_{PM2.5}$	50% (38%–72%)	Triangular	same[c]		B
	$Electrostatic\ Precipitators_{PM2.5}$	93%	Lognormal (GSD: 1.0%)	same[c]		B
	$wet\text{-}FGD_{PM2.5}$	50%	Normal (CV: 2.5%)	same[c]		B

Bag Filters$_{PM2.5}$	99% (98.7%–99.4%)	Triangular	same[c]		B

[a]A: the distribution is obtained via data fitting based on field measurements / CPED; B: the distribution is determined from extant studies; C: the distribution is subjectively provided.

[b]Non-independent parameter, calculated as 1 minus the penetrations of other boiler types / coal types / control technologies.

[c]The distribution is the same as that in 1990.

[d]*ar*: the mass fraction of retention ash; *f*: the mass fraction of $PM_{2.5}$ to the total particulate matter in fly ash.

Table S2 Probability distributions of emission estimation-related parameters for a large coal-fired generation unit in China[a]

Category	Subcategory	Value in 2000	Distribution in 2000[b]	Value in 2010	Distribution in 2010[b]
Activity	Coal Consumption Rate (gce/kW·h^{-1})	328	Normal (CV: 10%)	328	Normal (CV: 5%)
	Annual Operation Hours (hours)	4118	Normal (CV: 20%)	4699	Normal (CV: 5%)
Coal Quality	Probability of Bituminous Coal	95%	Yes-No	99%	Yes-No
	Probability of Anthracite Coal	NIP[c]		NIP[c]	
	Ash Content of Coal (%)	25.1	Normal (CV: 10%)	25.1	Normal (CV: 5%)
	Heating Value (kJ/g-coal)	21.5	Normal (CV: 10%)	19.3	Normal (CV: 5%)
	Sulfur Content of Coal (%)	1.13	Normal (CV: 10%)	0.98	Normal (CV: 5%)
Control Technology	FGD	50%	Yes-No	99%	Yes-No
	Removal Efficiency of FGD on SO_2	42% (0%–84%)	Triangular	84% (81%–86%)	Triangular
	LNB	50%	Yes-No	50%	Yes-No

[a]The selected unit is a 600 MW, pulverized boiler, equipped with FGD, LNB, and an electrostatic precipitator. The uncertainties of the unlisted emission-related parameters are the same as those given in Table S1.

[b]The distribution is subjectively provided.

[c]Non-independent parameter, calculated as 1 minus the ratio of bituminous coal.