Table S1

The production data of China’s Al cycle.

Unit: Mt	Production Stage										Manufacturing and Fabrication Stage				Waste Management and Recycling Stage		
	Bauxite		Aluminum				Primary Aluminum				Aluminum Semi-products		Aluminum Products		Secondary Aluminum	Aluminum Scraps	
	Production	Import	Production	Non-metallurgical	Import	Export	Production	Import	Export	consumption	Import	Export	Import	Export	Production	Import	Export
2000	7.90	0.40	4.33	0.43	1.88	0.01	2.99	0.91	0.21	3.53	0.46	0.13	0.02	0.14	0.75	0.80	0.01
2001	7.90	0.32	4.75	0.53	3.35	0.03	3.58	0.53	0.41	3.49	0.40	0.14	0.02	0.20	0.65	0.37	0.01
2002	13.77	0.40	5.45	0.65	4.57	0.02	4.51	0.58	0.79	4.12	0.48	0.19	0.03	0.26	0.75	0.45	0.01
2003	14.57	0.62	6.11	0.68	5.61	0.06	5.87	0.88	1.25	5.18	0.53	0.27	0.03	0.33	1.05	0.65	0.01
2004	17.52	0.88	6.98	0.71	5.87	0.02	6.69	1.03	1.68	6.19	0.61	0.43	0.03	0.42	1.39	1.20	0.00
2005	17.41	2.17	8.54	0.70	7.02	0.02	7.79	0.64	1.32	7.12	0.65	0.71	0.03	0.55	1.73	1.69	0.00
2006	18.00	9.68	13.70	0.77	6.91	0.02	9.27	0.51	1.21	8.65	0.69	1.24	0.04	0.70	2.19	1.77	0.00
2007	20.45	23.26	19.47	0.50	5.12	0.03	12.34	0.28	0.55	12.35	0.69	1.85	0.03	1.11	2.75	2.09	0.00
2008	25.18	25.79	22.78	0.52	4.59	0.04	13.17	0.26	0.84	12.41	0.62	1.90	0.03	1.31	2.75	2.15	0.00
2009	29.21	19.69	23.80	0.37	5.14	0.07	12.89	1.74	0.31	13.15	0.58	1.39	0.03	1.03	3.11	2.63	0.00
2010	36.84	30.07	28.96	0.63	4.31	0.06	15.77	0.36	0.75	16.50	0.59	2.18	0.03	1.24	4.00	2.85	0.00
2011	36.00	44.84	34.08	0.60	1.88	0.08	19.61	0.33	0.77	17.70	0.58	3.00	0.04	1.40	4.40	2.69	0.00
2012	44.05	40.07	37.70	0.57	5.02	0.04	23.14	0.64	0.63	20.26	0.54	3.32	0.04	1.54	4.83	2.59	0.00
2013	50.34	70.70	43.38	0.63	3.83	0.19	25.44	0.48	0.57	21.96	0.50	3.64	0.04	1.66	5.27	2.50	0.00
2014	59.21	36.28	47.12	0.57	2.31	0.00	28.86	0.35	0.67	28.00	0.52	4.57	0.04	1.84	5.65	5.28	0.12
2015	60.79	56.10	58.98	0.94	4.65	0.29	31.41	0.22	0.57	31.07	0.54	5.37	0.04	1.98	5.78	2.09	0.00
2016	68.62	52.05	61.03	1.30	3.03	0.11	32.65	0.26	0.51	32.56	0.43	4.82	0.04	1.95	6.30	1.92	0.00
2017	68.39	68.76	69.06	1.66	2.87	0.06	33.29	0.19	0.55	31.91	0.45	5.08	0.04	2.14	6.90	2.17	0.00
2018	79.00	82.57	69.62	2.02	0.51	1.46	36.83	0.20	0.56	35.80	0.45	6.34	0.04	2.30	6.95	1.57	0.00
2019	75.00	100.66	72.83	2.39	1.65	0.27	35.13	0.29	0.58	35.04	0.35	5.15	0.05	2.43	7.25	1.39	0.00
2020	75.75	111.59	72.56	2.75	3.81	0.15	37.08	1.06	0.28	36.89	0.58	4.86	0.05	2.43	7.55	0.82	0.00

Sources:

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Ministry of Commerce (MOFCOM)
NBSC (National Bureau of Statistic of China)
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General Administration of Customs
Sixty Years of Nonferrous Metal Industry in New China
East Money Net
China Report Net
UN Comtrade Database
Research Report on the development of China's nonferrous metals industry
China Nonferrous Metals Net (CNMN)
Zhang Chao (2017). Comprehensive material flow analysis of Chinese aluminum (Master's thesis, Northeastern University)
Estimating by expert working on the China's biggest non-metallurgical alumina company, Aluminum Corporation of China Limited (CHINALCO)
Extrapolation method

Table S2

The Parameter data of China’s Al cycle.

	Al Content %					Loss Rate (%)				Internal Circulation (Primary Aluminum Consumption)			Sector Shares of Aluminum Market						
	Bauxite Production	Bauxite Import	Red Mud	Alumia	Carbon Slag	Aluminum Casting Yield	Loss Rate of Alumina Refining	Loss Rate of Aluminum Products	Loss Rate of Secondary Aluminum Production	Dross Recycling ratio	Collection ratio	Reuse ratio	BC	EE	TR	CD	ME	CP	OT
2000	32.20	26.74	6.35	52.94	1.88	91.80	3.00	1.80	6.58	2.32	63.20	20.19	40.04	10.50	11.42	6.57	15.59	5.23	10.65
2001	32.20	26.54	6.35	52.94	1.88	92.28	3.00	1.80	6.65	2.35	63.80	20.65	34.62	14.64	15.47	6.61	13.56	5.83	9.27
2002	33.43	27.56	6.35	52.94	1.88	92.53	3.00	1.80	6.67	2.33	63.52	20.42	31.08	15.12	15.24	7.62	14.81	6.01	10.12
2003	33.24	26.95	6.35	52.94	1.88	92.03	3.00	1.80	6.67	2.31	63.10	20.13	31.25	16.15	15.07	6.99	14.14	6.05	10.35
2004	33.79	27.25	6.35	52.94	1.88	91.81	3.00	1.80	8.32	2.28	62.84	20.03	30.45	12.66	15.14	7.92	14.64	6.33	12.86
2005	32.42	26.85	6.35	52.94	1.88	91.94	3.00	1.80	8.27	2.26	62.66	19.79	32.08	14.93	15.40	9.51	13.52	7.22	7.34
2006	32.01	25.88	6.35	52.94	1.88	93.58	3.00	1.80	8.27	2.23	61.99	19.47	32.61	14.18	18.68	7.77	13.23	6.85	6.68
2007	31.51	25.48	6.35	52.94	1.88	91.53	3.00	1.80	8.21	2.19	61.30	19.28	31.91	14.10	19.41	7.96	12.75	7.08	6.77
2008	31.51	25.94	6.35	52.94	1.88	91.12	3.00	1.80	8.27	2.28	62.78	19.66	28.31	13.36	26.92	6.85	11.55	6.67	6.34
2009	30.96	25.95	6.35	52.94	1.88	91.52	3.00	1.80	8.23	2.39	63.97	20.35	27.63	13.46	22.96	8.05	12.73	6.46	8.71
2010	30.44	26.14	6.35	52.94	1.88	93.03	3.00	1.80	8.38	2.27	62.25	19.39	27.50	13.62	24.24	7.68	12.25	6.94	7.77
2011	30.11	26.34	6.35	52.94	1.88	93.82	3.00	1.80	8.32	2.26	62.20	19.14	27.73	14.21	23.60	7.78	12.26	6.83	7.60
2012	30.11	26.21	6.35	52.94	1.88	90.45	3.00	1.80	8.38	2.21	61.03	18.66	27.55	14.37	23.45	7.78	11.94	6.99	7.92
2013	29.69	26.84	6.35	52.94	1.88	90.45	3.00	1.80	8.41	2.19	60.80	18.49	28.49	14.07	23.33	7.63	11.61	7.35	7.52
2014	29.26	25.86	6.35	52.94	1.88	90.85	3.00	1.80	8.43	2.21	61.13	18.62	28.84	14.09	22.94	7.27	11.17	8.41	7.29
2015	29.45	26.53	6.35	52.94	1.88	90.31	3.00	1.80	8.46	2.21	61.10	18.84	28.75	14.00	22.60	7.05	11.19	9.11	7.30
2016	28.94	26.53	6.35	52.94	1.88	90.83	3.00	1.80	8.48	2.18	60.81	18.54	28.26	13.97	23.68	7.40	11.12	8.75	6.82
2017	28.57	26.53	6.35	52.94	1.88	92.69	3.00	1.80	8.57	2.20	61.12	18.62	27.95	12.53	22.81	9.12	12.37	9.05	6.18
2018	28.21	26.53	6.35	52.94	1.88	92.69	3.00	1.80	8.59	2.20	61.12	18.62	36.78	16.09	16.09	12.64	9.20	5.75	3.45
2019	27.84	26.53	6.35	52.94	1.88	92.69	3.00	1.80	8.62	2.20	61.12	18.62	33.33	17.86	22.62	5.95	7.14	9.52	3.57
2020	27.48	26.53	6.35	52.94	1.88	92.69	3.00	1.80	8.65	2.20	61.12	18.62	33.33	17.86	22.62	5.95	7.14	9.52	3.57

Note: BC (Building & Construction); EE (Electrical Engineering); TR (Transportation); CD (Consumer Durables); ME (Machinery Equipment); CP (Container & Packaging); OT (Others)

Source:

Zhang Chao (2017). Comprehensive material flow analysis of Chinese aluminum (Master's thesis, Northeastern University).

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Adopting the global average value. Global Aluminium Flow Model (2017).International Aluminum Institute (IAI).

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There are fluctuations in historical data and no obvious upward or downward trend, so it's the same as the last year.

There is obvious upward or downward trend, so it uses extrapolation method.

Table S3: The material flow of China's Al cycle.

Unit: Mt			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Production Stage	Bauxite Production	Quality	7.90	7.90	13.77	14.57	17.52	17.41	18.00	20.45	25.18	29.21	36.84	36.00	44.05	50.34	59.21	60.79	68.62	68.39	79.00	75.00	75.75
		Al Content	2.54	2.54	4.60	4.84	5.92	5.64	5.76	6.44	7.93	9.04	11.21	10.84	13.26	14.95	17.33	17.90	19.85	19.54	22.28	20.88	20.82
	Bauxite Import	Quality	0.40	0.32	0.40	0.62	0.88	2.17	9.68	23.26	25.79	19.69	30.07	44.84	40.07	70.70	36.28	56.10	52.05	68.76	82.57	100.66	111.59
		Al Content	0.11	0.09	0.11	0.17	0.24	0.58	2.51	5.93	6.69	5.11	7.86	11.81	10.50	18.98	9.38	14.88	13.81	18.24	21.90	26.70	29.60
	Red Mud	Quality	3.55	2.94	8.08	8.39	10.71	10.34	13.22	23.73	27.66	24.73	37.31	46.17	45.85	77.03	47.80	56.97	58.34	66.44	89.92	100.45	112.03
		Al Content	0.23	0.19	0.51	0.53	0.68	0.66	0.84	1.51	1.76	1.57	2.37	2.93	2.91	4.89	3.03	3.62	3.70	4.22	5.71	6.38	7.11
	Alumia Production	Quality	4.33	4.75	5.45	6.11	6.98	8.54	13.70	19.47	22.78	23.80	28.96	34.08	37.70	43.38	47.12	58.98	61.03	69.06	69.62	72.83	72.56
		Al Content	2.29	2.51	2.89	3.24	3.70	4.52	7.25	10.31	12.06	12.60	15.33	18.04	19.96	22.97	24.95	31.22	32.31	36.56	36.86	38.56	38.41
	Non-metallurgical Alumina	Quality	0.43	0.53	0.65	0.68	0.71	0.70	0.77	0.50	0.52	0.37	0.63	0.60	0.57	0.63	0.57	0.94	1.30	1.66	2.02	2.39	2.75
		Al Content	0.23	0.28	0.34	0.36	0.37	0.37	0.41	0.26	0.28	0.20	0.33	0.32	0.30	0.33	0.30	0.50	0.69	0.88	1.07	1.26	1.46
	Alumia Import	Quality	1.88	3.35	4.57	5.61	5.87	7.02	6.91	5.12	4.59	5.14	4.31	1.88	5.02	3.83	2.31	4.65	3.03	2.87	0.51	1.65	3.81
		Al Content	1.00	1.77	2.42	2.97	3.11	3.71	3.66	2.71	2.43	2.72	2.28	1.00	2.66	2.03	1.22	2.46	1.60	1.52	0.27	0.87	2.02
	Alumia Export	Quality	0.01	0.03	0.02	0.06	0.02	0.02	0.02	0.03	0.04	0.07	0.06	0.08	0.04	0.19	0.00	0.29	0.11	0.06	1.46	0.27	0.15
		Al Content	0.01	0.01	0.01	0.03	0.01	0.01	0.01	0.02	0.02	0.04	0.03	0.04	0.02	0.10	0.00	0.15	0.06	0.03	0.77	0.15	0.08
	Carbon Slag	Quality	5.24	6.82	8.45	9.85	10.84	13.12	17.39	20.75	23.09	24.39	28.06	30.31	36.05	39.73	41.76	53.51	54.03	60.71	58.01	62.69	64.39
		Al Content	0.10	0.13	0.16	0.19	0.20	0.25	0.33	0.39	0.43	0.46	0.53	0.57	0.68	0.75	0.79	1.01	1.02	1.14	1.09	1.18	1.21
	Primary Aluminum Production		2.99	3.58	4.51	5.87	6.69	7.79	9.27	12.34	13.17	12.89	15.77	19.61	23.14	25.44	28.86	31.41	32.65	33.29	36.83	35.13	37.08
Manufacturing and Fabrication Stage	Primary Aluminum Import		0.91	0.53	0.58	0.88	1.03	0.64	0.51	0.28	0.26	1.74	0.36	0.33	0.64	0.48	0.35	0.22	0.26	0.19	0.20	0.29	1.06
	Primary Aluminum Export		0.21	0.41	0.79	1.25	1.68	1.32	1.21	0.55	0.84	0.31	0.75	0.77	0.63	0.57	0.67	0.57	0.51	0.55	0.56	0.58	0.28
	Primary Aluminum Consumption		3.53	3.49	4.12	5.18	6.19	7.12	8.65	12.35	12.41	13.15	16.50	17.70	20.26	21.96	28.00	31.07	32.56	31.91	35.80	35.04	36.89
	Aluminum Semi-products Loss		0.25	0.23	0.27	0.35	0.43	0.49	0.46	0.87	0.93	0.97	0.96	0.91	1.58	1.71	2.10	2.47	2.43	1.91	2.14	2.10	2.21
	Aluminum Semi-products Production		3.28	3.26	3.85	4.82	5.76	6.63	8.18	11.48	11.48	12.18	15.54	16.79	18.67	20.25	25.90	28.60	30.13	30.00	33.66	32.94	34.68
	Aluminum Semi-products Import		0.46	0.40	0.48	0.53	0.61	0.65	0.69	0.69	0.62	0.58	0.59	0.58	0.54	0.50	0.52	0.54	0.43	0.45	0.45	0.35	0.58
	Aluminum Semi-products Export		0.13	0.14	0.19	0.27	0.43	0.71	1.24	1.85	1.90	1.39	2.18	3.00	3.32	3.64	4.57	5.37	4.82	5.08	6.34	5.15	4.86
	Aluminum Products Loss		0.07	0.06	0.07	0.09	0.11	0.12	0.14	0.19	0.18	0.20	0.25	0.26	0.29	0.31	0.39	0.43	0.46	0.46	0.50	0.51	0.55
	Aluminum Products Production		4.30	4.11	4.81	6.04	7.22	8.18	9.68	12.88	12.77	14.27	17.70	18.51	20.43	22.07	27.11	29.11	31.57	31.82	34.22	34.89	37.40
	Aluminum Products Import		0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05
	Aluminum Products Export		0.14	0.20	0.26	0.33	0.42	0.55	0.70	1.11	1.31	1.03	1.24	1.40	1.54	1.66	1.84	1.98	1.95	2.14	2.30	2.43	2.43
Use Stage	Aluminum Products		4.18	3.94	4.58	5.74	6.84	7.66	9.01	11.80	11.49	13.27	16.49	17.15	18.93	20.44	25.31	27.17	29.66	29.73	31.97	32.51	35.01
Waste Management and Recycling Stage	Aluminum Scraps Production		0.22	0.23	0.28	0.35	0.43	0.55	0.62	0.84	0.77	1.30	1.51	1.91	2.18	2.73	3.57	4.23	4.82	4.98	4.97	7.43	8.50
	Aluminum Scraps Import		0.80	0.37	0.45	0.65	1.20	1.69	1.77	2.09	2.15	2.63	2.85	2.69	2.59	2.50	5.28	2.09	1.92	2.17	1.57	1.39	0.82
	Secondary Aluminum Loss		0.07	0.04	0.05	0.07	0.14	0.19	0.20	0.24	0.24	0.32	0.37	0.38	0.40	0.44	0.75	0.53	0.57	0.61	0.56	0.76	0.81
	Secondary Aluminum Production		0.75	0.65	0.75	1.05	1.39	1.73	2.19	2.75	2.75	3.11	4.00	4.40	4.83	5.27	5.65	5.78	6.30	6.90	6.95	7.25	7.55
	Stock	Bauxite	-0.09	-0.35	0.98	0.88	1.41	0.68	-0.23	0.29	0.53	-0.21	1.04	1.36	0.59	5.73	-1.58	-2.55	-3.04	-3.88	0.55	1.39	3.43
		Alumina	0.19	0.57	0.62	0.12	-0.10	0.19	1.31	0.28	0.87	1.94	1.29	-1.19	-1.23	-1.29	-3.47	1.12	0.20	3.62	-1.57	2.97	2.06
		Primary Aluminum	0.16	0.20	0.19	0.32	-0.15	-0.01	-0.08	-0.27	0.17	1.17	-1.12	1.48	2.89	3.39	0.54	0.00	-0.17	1.02	0.67	-0.20	0.97
		In-use Stock	3.96	3.71	4.31	5.39	6.41	7.11	8.40	10.97	10.72	11.97	14.98	15.24	16.75	17.71	21.74	22.94	24.84	24.75	27.00	25.07	26.51
		Aluminum Scraps	0.21	-0.09	-0.08	-0.12	0.11	0.33	0.00	-0.06	-0.07	0.50	0.00	-0.19	-0.45	-0.48	2.45	0.01	-0.13	-0.36	-0.98	0.81	0.97
	In-use Stock	Building & Construction	1.67	1.36	1.42	1.79	2.08	2.46	2.94	3.77	3.25	3.67	4.53	4.75	5.22	5.82	7.30	7.81	8.38	8.31	11.76	10.84	11.67
		Electrical Engineering	0.44	0.58	0.69	0.93	0.87	1.14	1.28	1.66	1.53	1.79	2.25	2.44	2.72	2.88	3.57	3.80	4.14	3.73	5.14	5.80	6.25
		Transportation	0.48	0.61	0.70	0.87	1.04	1.18	1.68	2.29	3.09	3.05	4.00	4.05	4.44	4.77	5.81	6.14	7.02	6.78	5.14	7.35	7.92
		Consumer Durables	0.27	0.26	0.35	0.40	0.54	0.73	0.70	0.94	0.79	1.07	1.27	1.33	1.47	1.56	1.84	1.92	2.20	2.71	4.04	1.93	2.08
		Machinery Equipment	0.65	0.53	0.68	0.81	1.00	1.04	1.19	1.51	1.33	1.69	2.02	2.10	2.26	2.37	2.83	3.04	3.30	3.68	2.94	2.32	2.50
		Container & Packaging	0.22	0.23	0.28	0.35	0.43	0.55	0.62	0.84	0.77	0.86	1.14	1.17	1.32	1.50	2.13	2.48	2.60	2.69	1.84	3.10	3.33
		Others	0.45	0.37	0.46	0.59	0.88	0.56	0.60	0.80	0.73	1.16	1.28	1.30	1.50	1.54	1.84	1.98	2.02	1.84	1.10	1.16	1.25
	Scraps Generation	Building & Construction																					
		Electrical Engineering																				0.44	0.58
		Transportation															0.48	0.61	0.70	0.87	1.04	1.18	1.68
		Consumer Durables												0.27	0.26	0.35	0.40	0.54	0.73	0.70	0.94	0.79	1.07
		Machinery Equipment																				0.65	0.53
		Container & Packaging	0.22	0.23	0.28	0.35	0.43	0.55	0.62	0.84	0.77	0.86	1.14	1.17	1.32	1.50	2.13	2.48	2.60	2.69	1.84	3.10	3.33
		Others										0.45	0.37	0.46	0.59	0.88	0.56	0.60	0.80	0.73	1.16	1.28	1.30

Table S4

The GEF of electricity among provinces from 2000 to 2020.

g CO_2/kwh	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Beijing	1143	1123	1105	830	883	906	864	864	841	800	775	784	751	721	651	551	526	494	502	496	522
Tianjin	1027	914	883	728	901	966	983	973	1040	1005	960	1042	1077	1014	967	884	832	824	751	714	702
Hebei	1151	1784	1124	1129	1107	1096	1044	1043	1082	1009	1024	998	928	898	839	831	822	742	767	726	757
Shanxi	1180	1161	1118	1086	1120	1191	1036	990	1042	1027	1048	1072	1050	1088	1025	1002	986	1036	989	843	851
Inner Mongolia	1368	1443	1410	1349	1311	1264	1291	1184	1278	1260	1268	1476	1478	1210	1153	1166	1167	1197	1200	1209	1192
Liaoning	1259	1121	1122	1122	1193	1137	1138	1099	1119	1146	1162	1220	1112	1055	987	956	913	932	890	847	865
Jilin	1130	1246	1482	1321	1307	1210	1340	1274	1263	1245	1135	1198	1235	1098	1161	1153	1065	1235	1096	1064	1077
Heilongjiang	1400	1337	1263	1264	1363	1217	1232	1223	1201	1172	1198	1221	1190	959	1082	1091	1064	1022	878	986	1023
Shanghai	884	888	884	843	856	826	820	813	846	821	883	884	887	869	840	829	835	841	820	801	813
Jiangsu	1244	1195	1146	1063	1062	993	943	939	894	855	864	928	923	885	846	847	837	792	749	731	756
Zhejiang	927	900	847	691	706	702	740	837	848	755	727	744	712	688	667	624	621	656	641	597	634
Anhui	1095	1065	981	1060	1039	1012	1020	989	966	987	1023	1014	1024	994	951	933	907	900	912	882	960
Fujian	517	454	566	636	704	576	565	651	639	675	562	747	642	637	622	554	430	493	545	526	540
Jiangxi	1043	1051	972	986	1096	1065	946	956	819	916	902	965	842	811	773	732	695	740	771	745	786
Shandong	722	872	988	1151	1141	1175	1075	1027	1094	1059	1062	1050	1109	951	745	956	917	793	891	841	909
Henan	1236	1190	1211	1197	1196	1170	1104	1074	1068	1022	1079	1083	1011	990	993	986	982	976	926	879	933
Hubei	608	590	636	588	497	451	524	478	344	355	385	447	357	405	367	372	354	346	396	453	466
Hunan	587	606	590	678	733	565	703	681	626	612	612	714	535	609	530	491	473	486	545	533	561
Guangdong	631	588	609	528	610	625	650	678	675	665	694	721	694	703	645	616	584	624	616	553	563
Guangxi	533	543	521	507	748	685	613	559	385	429	511	618	540	574	431	353	374	386	472	557	550
Hainan	700	679	0	630	623	593	568	644	648	660	697	803	804	806	770	783	638	662	660	604	662
Chongqing	627	864	792	949	798	809	939	960	737	730	757	760	598	679	616	603	585	589	616	633	670
Sichuan	657	553	637	633	638	627	577	559	435	413	351	335	284	265	191	136	92	88	81	108	107
Guizhou	813	677	604	761	797	860	878	808	753	799	797	922	771	797	669	676	765	837	794	775	795
Yunnan	585	657	700	665	691	685	795	768	578	641	561	521	411	293	201	128	101	97	115	110	111
Tibet																					
Shaanxi	1154	763	1056	1057	1058	974	1044	1022	939	973	988	1045	980	946	905	881	839	812	816	824	801
Gansu	712	643	767	809	761	671	675	694	702	661	791	763	723	667	634	611	610	593	607	558	574
Qinghai	266	463	451	561	406	340	323	334	361	276	234	275	239	253	266	244	303	285	165	131	137
Ningxia				761	1175	1068	1080	1103	1117	1120	1140	1241	1141	1099	997	1017	936	986	947	994	972
Xinjiang	1091	1067	1133	1013	1029	939	939	933	873	971	833	881	931	906	924	917	924	910	910	899	827
National Level	923	933	911	903	927	903	896	886	863	848	848	900	853	808	747	741	721	719	721	701	716

Source: Calculated from China energy statistical yearbook (2000-2020)

Table S5
GHG emissions factor of primary Al production in China (g-CO2/g-Al)

Year	GEF of PAP		Eorrer (%)	Source
	This study	Other		
2000	16.09			
2001	17.62			
2002	18.07			
2003	17.59	16.85	4.21	[1]
2004	18.78			
2005	18.59	15.38	17.29	[2]
2006	17.12	14.38	16.02	[1]
2007	16.95			
2008	16.03	13.26	17.32	[1]
2009	14.98	13.80	7.87	[3]
2010	15.29			
2011	15.78	14.70	6.83	[4]
2012	14.50			
2013	14.03	15.69	11.85	[5]
2014	14.45			
2015	13.14			
2016	13.47			
2017	13.53			
2018	13.95			
2019	12.07	14.77	22.42	[6]
2020	12.11			

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Table S6
The GHG emission contribution of PAS in PAP and Al life cycle

	In PAP (%)				In Al life cycle* (%)
Year	This study	Previous studies	Error	Source	This study
2000	67.74				52.32
2001	72.69				59.27
2002	75.22				61.54
2003	79.40	74.07	6.71	[1]	66.53
2004	81.29	84.62	4.09	[2]	68.41
2005	80.44	85.71	6.56	[3]	70.14
2006	79.27				71.26
2007	76.60				69.74
2008	75.94	78.75	3.70	[4]	70.34
2009	78.50				71.38
2010	79.86	80.60	0.92	[2]	72.54
2011	80.03				73.29
2012	79.62				72.88
2013	79.26	73.97	6.67	[5]	72.92
2014	82.42				75.20
2015	82.62	80.01	3.15	[6]	76.60
2016	83.78				77.43
2017	82.29				76.36
2018	83.22				77.03
2019	80.97				74.56
2020	81.74				75.18

*Note: Seldom previous studies discuss PAS stage when concerning GHG emission of Al life cycle.

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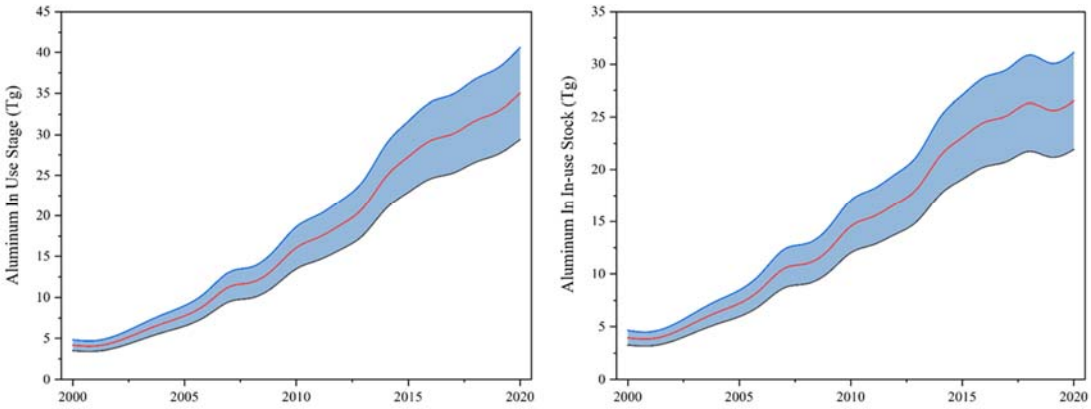

Fig. S1 Uncertainty analysis results of aluminum in Use stage and In-use stock