Supplementary material 1: The recycling rate of LiB materials published by the Chinese government (Ministry of Industry and Information Technology of the People's Republic of China, 2019)

	Nickel	Cobalt	Manganese	Lithium	Rare metal and others
Recycling rate	98%	98%	98%	85%	97%

Ministry of Industry and Information Technology of the People's Republic of China, 2019. Standards to utilize waste driving battery from new energy vehicle (2019) [WWW Document]. URL http://www.miit.gov.cn/n1146295/n1652858/n1652930/n4509607/c7595282/content.html

Supplementary material 2: LiB’s composition estimated by previous studies.

Affiliation (Cell)	Material	Subsititute material	Battery type and research object																			
			Battery	Battery	Battery	Battery	Battery	Battery	-	Battery	Battery	Cell	Electrode	Electrode	Electrode	Cell	Cell	Battery	Battery	Battery	Moduel	Electrode
			NCA	LFP	NCA	NCM			-	-	-	NCM										
						NCM111	NCM622	NCM811				-	NCM 111	NCM622	NCM811	NCM 523	-	-	NCM111	NCM111	NCM111	Waste battery
Cathode	-	Nickel	12.10%	23.75%	21.64%	25.17%	23.07%	22.15%	22.00%	20.00%	40.00%	9.64%	20.13%	36.07%	47.93%	12.00%	12.00%	23.20%	25.17%	13.50%	5.30%	21.90%
		Cobalt	2.30%									9.67%	20.21%	12.07%	6.02%	5.00%	3.00%				5.60%	15%
		Manganese	0.00%									9.03%	18.84%	11.26%	5.61%	7.00%	5.00%				4.60%	17%
		Lithium	1.90%									1.14%	7.86%	7.82%	7.79%	1.20%	2.00%				1.90%	5.75%
Graphite	-	-	16.50%	12.24%	15.62%	14.05%	14.98%	14.68%	-	10.00%		17.20%	19.00%	20.70%	20.60%	-	-	9.40%	14.05%	12.50%	12.40%	-
Carbon	-	-	2.40%	1.60%	1.46%	1.70%	1.56%	1.23%	-			6.04%	2.30%	2.10%	1.70%	-	-	-	1.70%	1.00%		3.04%
Bonding material	Polyvinylidene fluoride（PVDF）	-	3.80%	1.98%	2.04%	2.15%	2.08%	2.54%	25.00%		-	2.42%	2.90%	2.90%	3.60%	-	-		2.15%	1.00%	8.30%	-
Copper	-	-	13.30%	10.10%	11.79%	11.42%	11.45%	11.19%	-	8-13%	-	7.80%	16.40%	16.80%	15.70%	-	13.00%	8.30%	11.42%	5.30%	11%	0.05%
Aluminum	-	-	0.30%	5.48%	6.09%	5.94%	5.95%	5.87%	33.00%	2-3%	3.00%	5.26%	8.20%	8.40%	8.00%	-	12.00%	3.60%	5.94%	4.80%	10.50%	10.80%
Electrolyte	Lithium hexafluorophosphate（LiPF6）	-	11.70%	2.45%	1.60%	1.61%	1.60%	1.83%	-	9-12%	12.00%	4.86%	2.20%	2.20%	2.60%	-	-	12.00%	1.61%	1.20%	16.60%	-
Electrolyte	Ethylene carbonate	-		6.84%	4.45%	4.50%	4.47%	5.12%	-			1.21%	6.20%	6.30%	7.20%	-	-		4.50%	10.50%		-
Electrolyte	Dimethyl carbonate	-		6.84%	4.45%	4.50%	4.47%	5.12%	-			-	6.20%	6.30%	7.20%	-	-		4.50%			-
Plastic	Polypropylene	-	4.20%	0.97%	1.13%	1.10%	1.09%	1.07%	-	1-3%		3.15%	1.90%	1.90%	1.80%	-	-	3.80%	1.10%	2.20%	6.60%	-
Plastic	Polyethylene	-		0.22%	0.26%	0.25%	0.25%	0.25%	-				0.30%	0.30%	0.30%	-	-		0.25%			-
Plastic	Polyethylene terephthalate	-		0.22%	0.21%	0.21%	0.21%	0.22%	-				0.30%	0.30%	0.40%	-	-		0.21%			-
Total			68.50%	48.96%	49.09%	47.44%	48.12%	49.11%	-	63.00%	15.00%	47.94%	67.04%	67.22%	67.35%	25.20%	47.00%	44.50%	72.61%	52.00%	82.80%	73.44%
Affiliation（Module）																						
Copper	-	-	-	0.25%	0.29%	0.26%	0.28%	0.28%	-	-	-	-	-	-	-	-	-	17.00%	0.26%	1.00%	-	-
Aluminum	-	-	12.70%	4.63%	4.47%	4.38%	4.46%	4.53%	-	-	-	-	-	-	-	-	-		4.38%	-	16.60%	-
Plastic	Polyethylene	-	-	0.09%	0.12%	0.11%	0.12%	0.11%	-	-	-	-	-	-	-	-	-		0.11%	17.00%	0.70%	-
Heat insulating material	-	Fiber	1.20%	0.06%	0.07%	0.07%	0.07%	0.07%	-	4.00%	-	-	-	-	-	-	-		0.07%	-	-	-
Electronic part	-		0.30%	0.55%	0.75%	0.68%	0.74%	0.71%	-	3.00%	1.00%	-	-	-	-	-	-		0.68%	0.20%	-	-
Total			14.20%	5.58%	5.72%	5.49%	5.67%	5.71%	-	7.00%	1.00%	-	-	-	-	-	-	-	5.49%	18.20%	17.30%	-
Affiliation（pack）																						
Copper	-	-	-	0.05%	0.06%	0.05%	0.06%	0.06%	-	30.00%	-	-	-	-	-	-	-	20.10%	0.05%	-	-	-
Aluminum	-	-	8.90%	12.98%	14.36%	13.53%	14.17%	14.14%	-		10.50%	-	-	-	-	-	-		13.53%	28.50%	-	-
Steel	-	-	0.10%	0.71%	0.62%	0.62%	0.62%	0.64%	-		30.00%	17.32%	-	-	-	-	-		0.62%	1.30%	-	-
Heat insulating material	-	Fiber	-	0.40%	0.44%	0.42%	0.44%	0.44%	-		-	-	-	-	-	-	-		0.42%	-	-	-
Coolant	Glycol	-	-	5.10%	4.76%	4.30%	4.63%	4.63%	-		-	-	-	-	-	-	-		4.30%	-	-	-
Electronic part	-	-	-	2.48%	3.31%	2.98%	3.23%	3.13%	-		3.00%	-	-	-	-	-	-	3.00%	2.98%	-	-	-
Others	-	-	8.30%	-	-	-	-	-	20.00%	-	-	-	-	-	-	-	-	-	-	-	-	-
Total			17.30%	21.72%	23.56%	21.91%	23.14%	23.03%	-	30.00%	43.50%	17.32%	0.00%	0.00%	0.00%	-	-	-	21.91%	29.80%	-	-
Total			100.00%	100.01%	100.01%	100.01%	100.00%	100.00%	-	-	99.50%	94.74%	-	-	-	-	-	100.40%	100.01%	100.00%	100.10%	-
Number			[1]	[2]					[3]	[4]	[5]	[6]	[7]			[8]	[9]	[10]	[11]	[12]	[13]	[14]

Supplementary material 2 is made by reference to (Ambrose and Kendall, 2016; Chen, 2017; China Automotive Technology and Research Center and Panasonic Automotive Systems DaLian, 2018; Chubu Electric Power, 2019; Dai et al., 2018, 2019; Gaines et al., 2011, 2018; Kim et al., 2016; Li et al., 2014; Majeau-Bettez et al., 2011; Richa et al., 2014; Romare et al., 2017; Zhang et al., 2018).

Among all the references, No.1 was referenced from (Gaines et al., 2011), No.2 was referenced from (Dai et al., 2018), No.3 was referenced from (Ambrose and Kendall, 2016), No.4 was referenced from (Romare et al., 2017), No.5 was referenced from (Kim et al., 2016), No.6 was referenced from (Richa et al., 2014), No.7 was referenced from (Gaines et al., 2018), No.8 was referenced from (Chen, 2017), No.9 was referenced from (China Automotive Technology and Research Center and Panasonic Automotive Systems DaLian, 2018), No.10 was referenced from (Majeau-Bettez et al., 2011), No.11 was referenced from (Dai et al., 2019), No.12 was referenced from (Li et al., 2014), which demonstrated that during the manufacturing of cathode material for NCM 111, the input of nickel, cobalt and manganese is around 27% respectively compared to the input amount of nickel, cobalt, manganese and lithium, while the input of lithium equals to around 19% of the input of nickel, cobalt, manganese and lithium. No.13 was referenced from (Chubu Electric Power, 2019), No.14 was referenced from (Zhang et al., 2018). It is clear to see that No.2 shows the most detailed composition of LiBs.

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Supplementary material 3: Selected 16 EV dealers in China

	EV sales number in 2017	EV dealer name	Transportation distance between EV dealer to battery maker（km）
Zhejiang Province	56,545	Hangzhou Jinfeng Rongyue	180
Shandong Province	56,218	Shandong Shangrong Shangqirongwei	738
Beijing	55,532	Beijing Bolehengtong	1,122
Guangdong Province	43,320	Dongguan Weimingrongwei	1,357
Henan Province	31,105	Henan Mingwei Rongwei Gongchangdian	769
Tianjin	28,140	Tianjin Rongxintongrongwei	967
Shanghai	24,857	Shanghai Pujiangjinrongrongwei	257
Jiangsu Province	19,462	Hupeng Rongsheng	452
Fujian Province	18,238	Fuzhou Zhongyangrongwei	830
Hunan Province	16,601	Hunan Yujianrongwei	935

Anhui Province	16,080	Hefei Zhongguohongweirongwei	252
Jiangxi Province	15,371	Guanghui Yuntonghonggutanrongwei	590
Guangxi Zhuang Autonomous Region	14,526	Guanghui Rongweihongwei	1,791
Hebei Province	13,541	Handan Rongweinanhuan	902
Hubei Province	13,087	Wuhan Rongjue	631
Chongqing	12,782	Chongqing Junweishangqirongwei	1,482

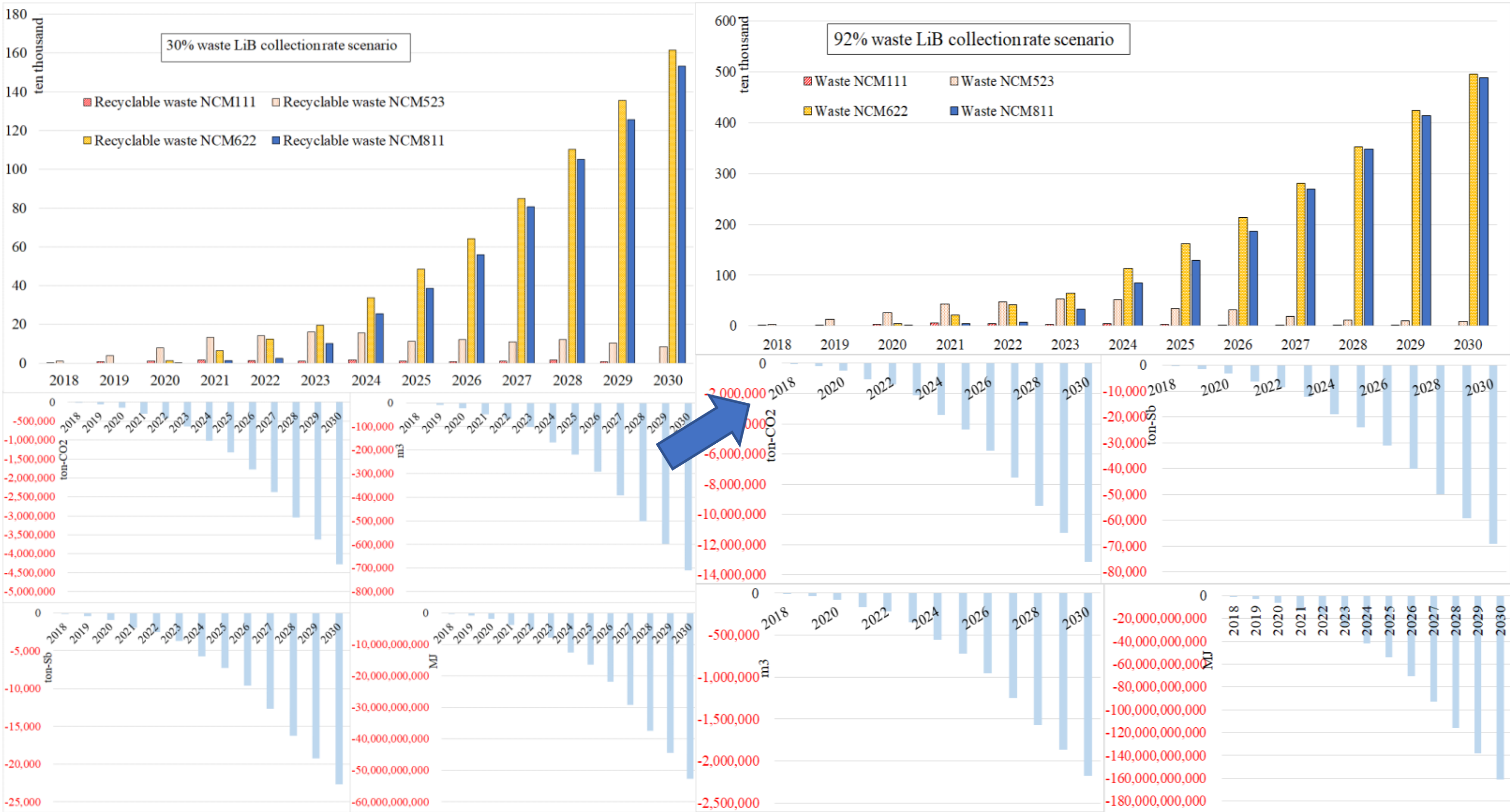
Total EV sales in China in 2017 is 486,897 (China Automotive Technology and Research Center and China Association of Automobile Manufacturers., 2018).

China Automotive Technology and Research Center, China Association of Automobile Manufacturers., 2018. China Automotive Industry Yearbook, Yu, K., Dong, Y., Gao, H., Cheng, K. (Eds.), . ISBN: 9787807528548. Automotive Technology Information Research Institute, Tianjin, p. 148.

Supplementary material 4: Resource input and output during waste LiB cell material recycling process (example on NCM111)

Resource input	Weight (kg)	Resource output	Weight (kg)
Electrode material	218	Nickel	20
1mol/L Sodium hydroxide solution	20	Cobalt	20
3mol/L Acetic acid solution	294	Lithium	12
5mol/L Acetone solution	125	Manganese	20
Sum	657	Aluminum	17
		Copper	33
		Building materials	47
		Industrial waste acid	471
		Industrial solid	10.5
		Waste plastic	6.5
		Sum	657

Supplementary material 5: Result of fleet-based sensitive analysis focusing on the collection rate of waste LiBs



The number and type of waste LiBs in China until 2030 was estimated by Wang and Yu (2020) (Wang and Yu, 2020).

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