

## Global Electric Vehicle Battery (H/A)

## Growth moderated in '23 YTD; challenging outlook; 4Q earnings miss likely overall

Industry Overview

## Robust BEV sales in Nov, yet see looming downside risk

Global BEV sales in Nov reached 1mn units (+9% MoM/+25% YoY), driven by strong sales in China/ US (+41%/ +26% YoY), while EU sales remain lacklustre (+11% YoY). However, our global Auto team (see [EV tracker](#)) believes the situation is unlikely to improve as German EV subsidies were abruptly cancelled (see [Sudden stop of German subsidies](#)) with some potential downside risk to BEV penetration given risks related to the upcoming US presidential elections (see [US Auto Year Ahead](#)).

## Battery growth moderated; LFP gained share in '23 YTD

Global EV battery cumulative sales in '23 YTD reached 623GWh (+42% YoY), but at a much moderate pace vs. the previous years (+106%/+67% YoY in 2021/22). The market share of K-trio (LGES, SK On, SDI; NCM battery chemistries) largely remained flattish at 23% with sales growth of +19% YoY vs. a year ago. On the other hand, LFP battery (China EV producers) gained market share by c.2ppt to 38% 2023 YTD due to higher sales growth of +30% YoY (see Battery wars: diverse technologies race to be winners).

## EV battery op. rates pressure; capacity build-out delays

Our global EV battery supply-demand model suggests that the global operating rates (demand over supply) for EV battery will reach 65%/70%/76% in 2024/25/26 (down 2-3ppt from 67%/71%/78% earlier). This is mainly attributed to our revised EV outlook resulting in lower EV battery demand forecasts, which coincided with lower battery supply forecasts amid the recent announcements of capacity expansion delays by several battery producers/OEMs (see Global EV Battery YA report).

## Cathodes 4Q: likely large miss; downward spiral to ASPs

Four major Korea cathode producers are likely to report 4Q EBIT miss (c.20% below the consensus on average) in the coming weeks, due mainly to: (1) sharp ASP declines in cathodes (-12% QoQ); (2) inventory loss on falling metal prices; and (3) weaker-than-expected volume (c.-20% QoQ decline). We see further downside to ASPs on declining metal prices (Li/Ni: -12%/-9% QoQ in 4Q vs. 3Q) on the lagging impact (c.3 months). In January so far, 1Q24 QTD Korea NCM/NCA cathode export prices have declined 11%/8% QoQ to US\$33/US\$38, after the 4Q decline (-10%/-14% QoQ), according to TRASS.

## Maintain Buy: LGES, LGC, Panasonic, SKIET, and CATL

We maintain our Buy ratings on: (1) LGES (policy tailwinds, 46 series cylindrical expansion, No.1 share in NA by '25E); (2) LG Chem (cathode share gainer in LGES, vertical integration); (3) CATL (fast-charging LFP, share gainer); (4) Panasonic (see report) (restructuring, 4680); and (5) SK IET (non-captive customer expansion, investment in NA). In contrast, we maintain our Underperform ratings on cathode names such as: (1) Ecopro BM; (2) Umicore; and (3) Shenzhen Dynanonic, given the expected oversupply from 2024.

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BEV/EV: battery electric vehicle/electric vehicle

YTD/QTD: year to date/quarter to date

JV: joint venture

NA: North America

ASP: average selling price

Li: Lithium

Ni: Nickel

NCA/NCM: nickel-cobalt-aluminum/manganese oxide

TRASS: Trade Statistics Service

OEM: original equipment manufacturer

# Key data for EV sales & battery shipments

## Exhibit 1: EV sales by region (units)

EV sales increased 29% YoY/8% MoM in Nov'23

	Type	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	MoM	YoY
EU	BEV	290,434	103,514	130,767	237,594	140,019	184,172	227,501	165,817	216,778	210,658	180,831	208,366	15%	11%
	PHEV	138,300	65,579	65,461	100,258	71,440	82,679	100,213	81,864	68,719	92,362	89,825	91,023	1%	-15%
	FCEV	137	38	60	44	28	98	231	91	60	47	38	58	53%	-57%
	Total	428,871	169,131	196,288	337,896	211,487	266,949	327,945	247,772	285,557	303,067	270,694	299,447	11%	2%
China	BEV	495,569	226,247	316,876	429,153	402,842	438,270	497,922	471,550	531,575	536,561	558,152	599,993	7%	26%
	PHEV	200,441	125,383	149,903	170,464	175,133	201,942	232,630	224,382	245,847	261,043	284,258	301,830	6%	75%
	Total	696,010	351,630	466,779	599,617	577,975	640,212	730,552	695,932	777,422	797,604	842,410	901,823	7%	39%
US	BEV	99,320	84,117	84,947	86,492	86,922	91,956	109,022	100,401	103,718	104,614	100,640	101,531	1%	41%
	PHEV	21,107	15,087	17,877	22,802	23,257	25,699	26,805	23,250	24,375	28,257	19,216	20,402	6%	2%
	FCEV	328	232	272	229	212	411	460	508	305	148	81	72	-11%	-67%
	Total	120,755	99,436	103,096	109,523	110,391	118,066	136,287	124,159	128,398	133,019	119,937	122,005	2%	32%
Global	BEV	945,423	454,770	593,266	834,770	692,447	786,874	921,471	805,193	923,466	931,456	919,127	999,152	9%	25%
	PHEV	370,754	219,997	246,437	311,064	283,070	325,841	378,422	345,761	355,799	400,215	409,667	432,553	6%	40%
	FCEV	1,097	389	1,272	1,182	669	977	1,355	1,195	1,012	481	339	394	16%	-76%
	Total	1,317,274	675,156	840,975	1,147,016	976,186	1,113,692	1,301,248	1,152,149	1,280,277	1,332,152	1,329,133	1,432,099	8%	29%

Source: EV-Volume, BofA Global Research

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## Exhibit 2: Top-10 OEMs sales

BYD was the top selling OEM for the month of Nov'23

Rank	OEMs	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	MoM	YoY
1	BYD	234,645	150,563	191,637	191,637	205,900	209,909	239,767	252,148	260,884	273,468	287,268	301,151	5%	31%
2	Tesla Inc.	173,619	94,829	119,573	119,573	208,345	116,289	138,388	211,337	113,610	167,471	154,095	114,954	-25%	-25%
3	VW Group	128,549	50,571	57,641	57,641	83,553	68,380	79,977	91,442	85,567	86,760	90,323	99,577	10%	13%
4	Stellantis	63,076	36,143	42,846	42,846	62,421	46,814	59,574	70,517	47,848	54,258	63,706	45,775	-28%	-10%
5	BMW Group	63,732	31,973	32,011	32,011	47,934	38,615	48,730	51,807	40,105	48,344	48,825	49,354	1%	-2%
6	GM	54,740	28,662	45,116	45,116	44,958	44,684	49,993	45,306	51,719	48,872	59,898	71,073	19%	44%
7	Hyundai Motor	42,688	24,543	40,628	40,628	53,280	45,678	47,620	51,778	51,659	54,282	46,450	47,222	2%	14%
8	Geely Auto Group	47,061	20,540	31,205	31,205	40,106	39,081	36,729	51,465	51,427	54,774	57,055	69,573	22%	83%
9	GAC	33,189	11,424	31,404	31,404	40,109	44,057	49,055	49,979	48,356	56,151	54,492	44,176	-19%	41%
10	Changan Automobile Group	41,076	20,330	18,824	18,824	29,727	21,824	25,254	31,501	32,916	35,170	40,647	43,926	8%	45%

Source: EV-Volume, BofA Global Research

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## Exhibit 3: Battery sales by regions (MWh)

China battery sales increased 30% YoY

Region	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	MoM	YoY
EU	21,088	7,552	9,298	17,091	9,924	13,097	16,321	11,905	14,999	15,426	13,091	13,951	7%	3%
China	35,796	14,988	20,117	27,970	25,642	28,428	34,470	31,741	35,682	38,943	39,969	43,569	9%	30%
US	8,017	6,742	7,107	6,958	7,522	8,114	8,763	8,422	8,939	8,920	8,336	9,493	14%	57%
Global	68,721	31,740	40,666	57,479	47,587	54,061	65,120	56,741	64,349	68,691	66,362	69,931	5%	23%

Source: SNE research, BofA Global Research

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## Exhibit 4: Top-10 battery makers sales (MWh)

CATL was the largest battery manufacturer for the month of Nov'23

Rank	Maker	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	MoM	YoY
1	CATL	26,993	10,849	13,656	21,203	16,978	18,959	24,633	20,136	24,100	27,385	26,261	28,945	10%	28%
2	BYD	9,217	5,449	6,953	7,917	7,756	8,946	9,847	9,557	10,161	10,163	10,766	10,765	0%	23%
3	LGES	11,790	4,337	5,790	9,921	5,982	7,775	10,080	7,102	9,014	9,044	6,811	8,158	20%	0%
4	CALB	1,728	741	1,711	2,512	2,126	2,090	2,868	3,260	3,540	3,608	3,446	3,225	-6%	67%
5	Panasonic	3,992	3,341	3,680	3,549	3,785	3,882	4,371	3,757	3,902	3,578	3,470	3,504	1%	12%
6	SDI	3,560	1,704	1,777	2,671	2,096	2,595	3,061	2,634	2,797	3,079	2,753	2,880	5%	7%
7	SK On	2,819	1,690	2,819	3,364	2,657	2,807	3,045	3,050	2,854	2,720	3,012	2,874	-5%	5%
8	Guoxuan	1,343	582	761	1,397	1,365	1,078	1,295	1,487	1,353	1,826	1,902	1,857	-2%	30%
9	EVE	1,276	620	672	1,024	943	1,737	1,487	1,180	1,116	1,254	1,693	1,652	-2%	157%
10	Sunwoda	1,308	502	508	757	875	770	912	815	862	836	888	938	6%	5%

Source: EV-Volume, BofA Global Research

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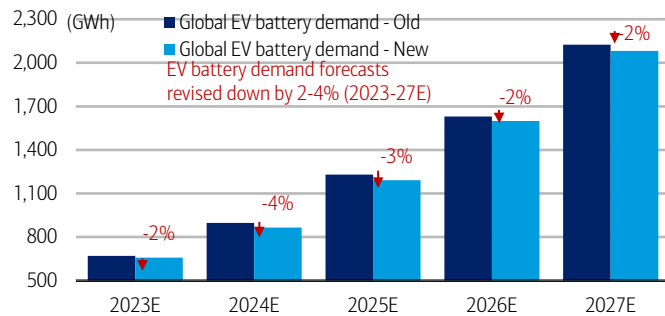
# Global EV battery outlook

## 2024E demand up 32% YoY, much moderated, vs 2022/23

We expect global EV battery demand to likely reach 865GWh/1,192GWh/1,599GWh (+32%/38%/34% YoY) in 2024-26E (see Global EV battery YA 2024 report), much moderated than the previous years' growth (+112%/86%/34% YoY in 2021-23). This is due to the slower BEV sales growth globally in 2024/25E (+25%/26% YoY vs +112%/60%/25% YoY in 2021/22/23), with BEV penetration in China/Europe moderating to 25%/15% in 2024E, according to our global auto team (see [US Auto YA 2024 report](#)). In the medium term, we expect a 24% CAGR in the global EV battery demand in 2025-30E vs ~57% in 2020-25E. We assume EV battery energy density for BEV will steadily rise to 58KWh in 2025E from 48KWh in 2020.

### Exhibit 5: Global EV battery demand (New vs Old)

EV battery demand forecasts revised down by 2-4% in 2023-27E (vs estimates as of Dec-2023)

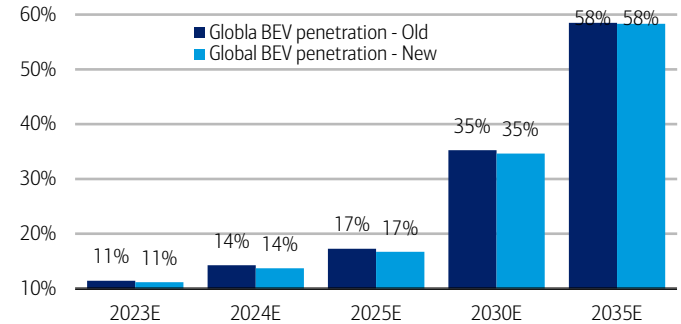


Source: BofA Global Research

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### Exhibit 6: Global BEV penetration (New vs Old)

BEV penetration forecasts lowered by 1ppt in 2023-30E (vs estimates as of Dec-2023), mainly due to NA penetration revision



Source: BofA Global Research

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### Exhibit 7: Global BEV penetration

We expect North America to exhibit the highest growth rate among major regions, while we remain cautious on the EU outlook

BEV Sales by Region	2019	2020	2021	2022	2023E	2024E	2025E	2030E	2035E	2040E
Europe	389,491	783,557	1,297,298	1,683,639	2,198,599	2,694,770	3,513,762	9,372,766	14,084,230	15,828,274
West & Central Europe	388,119	781,043	1,291,586	1,675,077	2,147,142	2,618,804	3,420,634	9,023,946	13,200,176	14,763,020
Eastern Europe	1,372	2,514	5,712	8,562	51,457	75,966	93,128	348,820	884,054	1,065,254
North America	266,292	290,949	542,470	888,501	1,328,429	1,893,737	2,472,202	6,862,866	14,057,134	16,036,281
Greater China	973,245	1,103,507	2,790,046	4,698,871	5,591,656	6,582,200	7,806,258	12,112,755	16,756,681	22,776,477
Japan	23,648	16,418	20,248	56,432	78,952	145,578	321,298	1,049,247	2,465,195	3,080,614
Korea	32,659	45,501	96,395	159,129	190,771	244,675	329,806	692,361	883,294	1,085,929
<b>Total</b>	<b>1,698,349</b>	<b>2,257,259</b>	<b>4,789,373</b>	<b>7,684,401</b>	<b>9,590,865</b>	<b>11,970,573</b>	<b>15,076,326</b>	<b>33,208,280</b>	<b>55,583,379</b>	<b>68,857,727</b>
BEV as % of LV sales	2019	2020	2021	2022	2023E	2024E	2025E	2030E	2035E	2040E
Europe	1.9%	4.7%	7.7%	11.3%	12.5%	15.4%	19.8%	53.7%	74.5%	83.4%
West & Central Europe	2.1%	5.6%	9.3%	12.9%	14.5%	17.7%	22.7%	62.0%	85.2%	94.9%
Eastern Europe	0.1%	0.1%	0.2%	0.4%	1.8%	2.9%	3.5%	12.0%	25.8%	31.1%
North America	1.4%	1.6%	3.1%	5.4%	7.2%	9.8%	12.2%	32.8%	72.2%	82.2%
Greater China	3.9%	4.6%	11.4%	19.1%	21.5%	25.0%	28.6%	40.9%	68.7%	88.8%
Japan	0.4%	0.4%	1.4%	1.4%	1.7%	3.1%	6.7%	24.3%	59.1%	73.7%
Korea	1.9%	2.4%	5.7%	9.6%	11.1%	14.4%	20.0%	45.1%	59.2%	72.7%
<b>Total</b>	<b>1.9%</b>	<b>2.9%</b>	<b>6.0%</b>	<b>9.7%</b>	<b>11.2%</b>	<b>13.7%</b>	<b>16.7%</b>	<b>34.6%</b>	<b>58.3%</b>	<b>71.2%</b>
BEV unit sales y/y change %	2019	2020	2021	2022	2023E	2024E	2025E	2030E	2035E	2040E
Europe	69%	101%	66%	30%	31%	23%	30%			
West & Central Europe	70%	101%	65%	30%	28%	22%	31%			
Eastern Europe	-9%	83%	127%	50%	501%	48%	23%			
North America	3%	9%	86%	64%	50%	43%	31%			
Greater China	10%	13%	153%	68%	19%	19%	19%			
Japan	-14%	-31%	23%	179%	40%	84%	121%			
Korea	2%	39%	112%	65%	20%	28%	35%			
<b>Total</b>	<b>18%</b>	<b>33%</b>	<b>112%</b>	<b>60%</b>	<b>25%</b>	<b>25%</b>	<b>26%</b>			

Source: BofA Global Research estimates, S&P

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## Some EV battery projects pushed, but most on schedule

From the EV-battery supply-side, there have been a series of announcements recently:

(1) capacity expansion delays by several battery producers/JVs, including GM-LGES JV, Stellantis-LGES JV, Ford-SK On JV, Panasonic by 0.5-1 year; as well as (2) a pause in new capacity builds (ie, Ford-CATL JV in Michigan) as we highlighted in our [US Industrials/Multi-Industry report](#).

### Exhibit 8: A summary of the delays in major battery capacity expansion projects

We find delays in major 5 battery capacity expansion projects in North America, as well as a delay in mass production schedule of 4680 cylindrical battery at Panasonic

Company/Project	Region	Capacity	SOP (original)	SOP (updated)	Comment
BO SK (Ford-SK On JV)	KY, USA	43GWh	2026		n/a BO SK has delayed production at its 2nd plant in Kentucky.
Ford-CATL JV	MI, USA	35GWh	2026		n/a The construction is paused on concerns over Chinese technology.
Ultium Cells (GM-LGES JV #2)	TN, USA	50GWh	2H23	1H24	The JV capacity delayed due to slower demand & yields at JV #1.
Ultium Cells (GM-LGES JV #3)	MI, USA	50GWh	2H24	2H25	The JV capacity delayed due to slower demand & yields at JV #1.
Stellantis-LGES JV	Ontario, Canada	45GWh	2024	2H25	Mass production likely to start in late 2025 postponed vs 2024 earlier.
Panasonic (4680)	Japan	3GWh	2H23	2024	Panasonic postponed mass production of 4680 cylindrical.

Source: Industry sources, BofA Global Research

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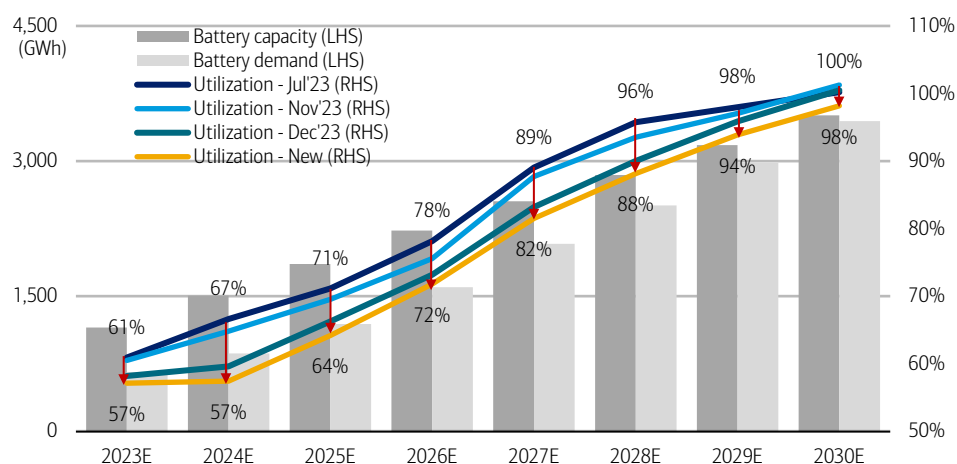
## Global EV battery operating rates: down 1-2ppt in '24-26E

Our updated EV battery supply-demand model suggests that the global EV battery operating rates (demand over supply) for 2024/25/26E expected to be 57%/64%/72%, down by 2ppt/2ppt/1ppt, from 60%/66%/73% earlier. This could be attributed to our revised EV outlook (see [US Auto YA 2024 report](#)) resulting in lower EV battery demand forecasts, which coincided with a sudden stoppage of EV subsidies by the German government (see [EU automobiles report](#)).

We expect the global EV battery market size or total addressable market (TAM) at the pack level to reach US\$146bn/US\$194bn in 2024/25E vs US\$89bn in 2022, delivering a 57% CAGR (2020-25E), supported by secular EV-battery demand growth amid rising EV sales despite the anticipated battery prices declines (c. mid-single % YoY decline sequentially through 2025E) post the high base in 2022 on metal price hikes.

### Exhibit 9: Global battery supply-demand (New vs Old)

The demand-supply utilization ratios in 2024-26E revised down by 6-9ppt (vs estimates as of Jul-2023)

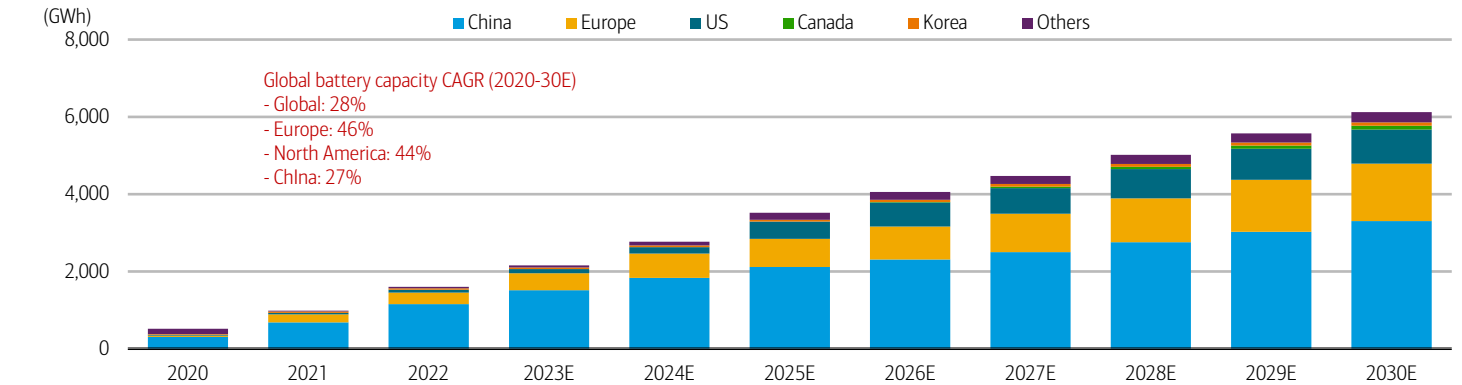


Source: BofA Global Research

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**Exhibit 10: Global EV battery capacity growth forecast**

We project global EV battery capacity will deliver a 28% CAGR (2020-30E)

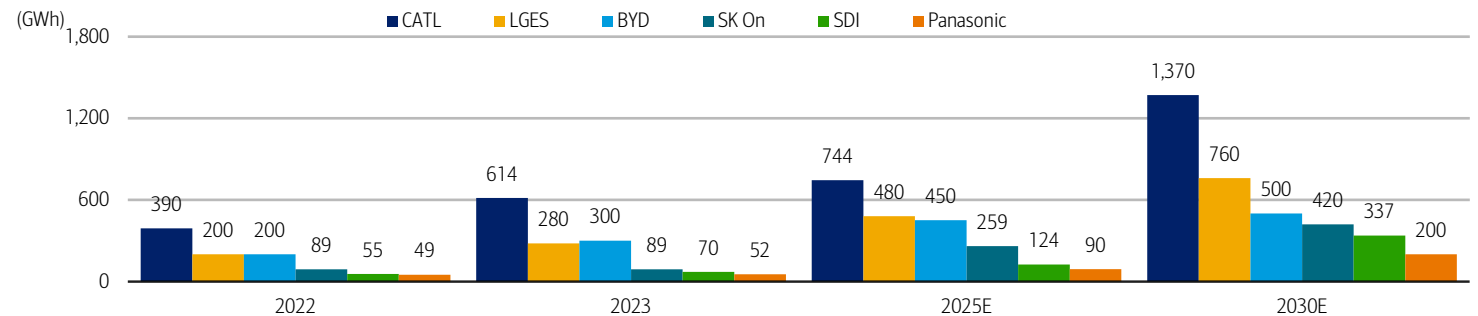


Source: BofA Global Research

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**Exhibit 11: EV battery capacity expansion by major global producers**

CATL/LGES to continue leading in battery capacity expansion by 2030E



Source: Company data, BofA Global Research

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**Exhibit 12: Global EV battery supply-demand, TAM projection**

Global EV battery demand/supply ratios to reach 57%/64%/72% in 2024-26E (1-2ppt lower vs estimates as of Dec-2023)

	2020	2021	2022	2023E	2024E	2025E	2026E	2027E	2028E	2029E	2030E
<b>BEV sales</b>											
Global BEV production (mn units)	2.3	4.7	8.2	10.4	13.8	18.5	24.2	29.9	34.7	39.4	43.7
YoY	23%	108%	74%	27%	32%	35%	30%	24%	16%	13%	11%
BEV as % of LV production	3%	6%	10%	12%	15%	20%	26%	32%	36%	41%	45%
<b>EV battery energy density</b>											
BEV battery density (KWh/unit)	48	49	53	56	56	58	61	65	68	72	76
YoY	6%	3%	9%	4%	0%	5%	5%	7%	5%	6%	5%
<b>EV battery supply</b>											
Global battery capacity - EOP (GWh)	514	982	1,628	2,210	2,810	3,380	4,045	4,467	5,018	5,571	6,123
Global battery capacity - AOP (GWh)	441	748	1,305	1,919	2,510	3,095	3,713	4,256	4,742	5,294	5,847
Utilization rate x yield (%)	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
Global EV battery supply (GWh)	265	449	783	1,151	1,506	1,857	2,228	2,554	2,845	3,177	3,508
<b>EV battery demand</b>											
Global EV battery demand (GWh)	125	264	491	658	865	1,192	1,599	2,082	2,508	2,982	3,444
YoY	36%	112%	86%	34%	32%	38%	34%	30%	20%	19%	16%
Global EV battery demand/supply balance	47%	59%	63%	57%	57%	64%	72%	82%	88%	94%	98%
<b>EV battery TAM</b>											
Global EV battery TAM - cell (US\$bn)	17	36	74	97	124	165	211	260	297	346	391
Global EV battery TAM - pack (US\$bn)	20	43	89	116	146	194	246	302	344	399	449

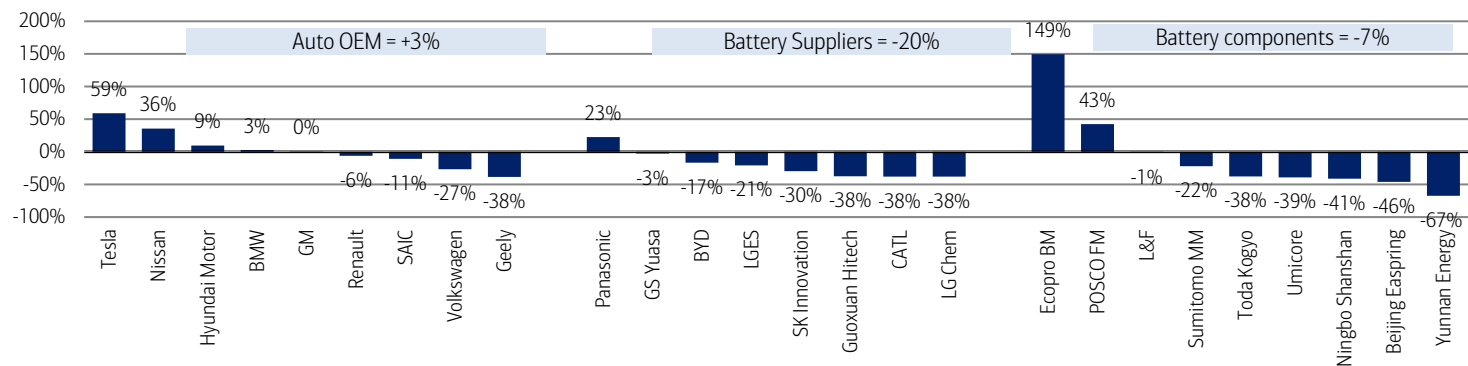
Source: BofA Global Research

BofA GLOBAL RESEARCH

# Share price performance and valuation

## Exhibit 13: 12M share price performance

12M share price performance

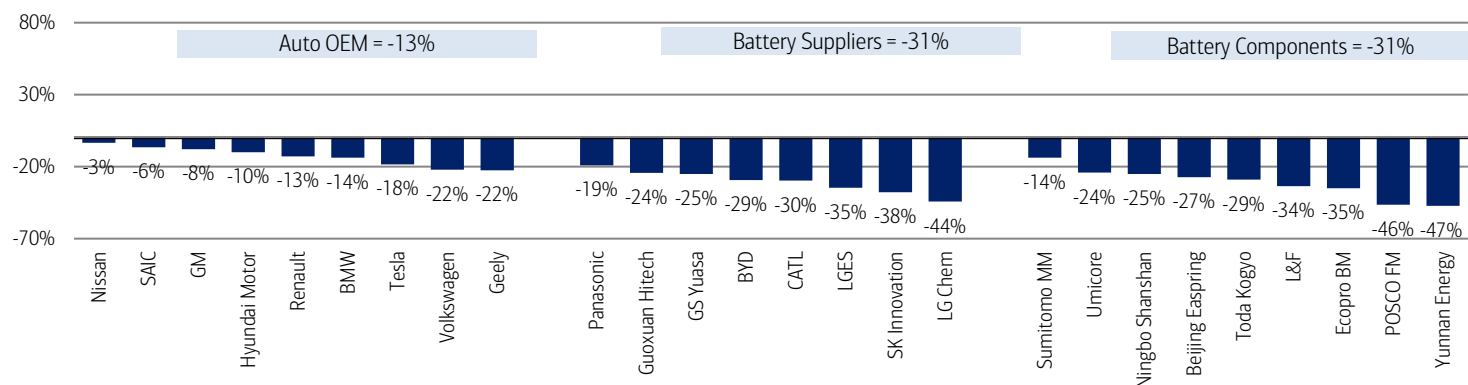


Source: Bloomberg, BofA Global Research

BofA GLOBAL RESEARCH

## Exhibit 14: 6M share price performance

6M share price performance

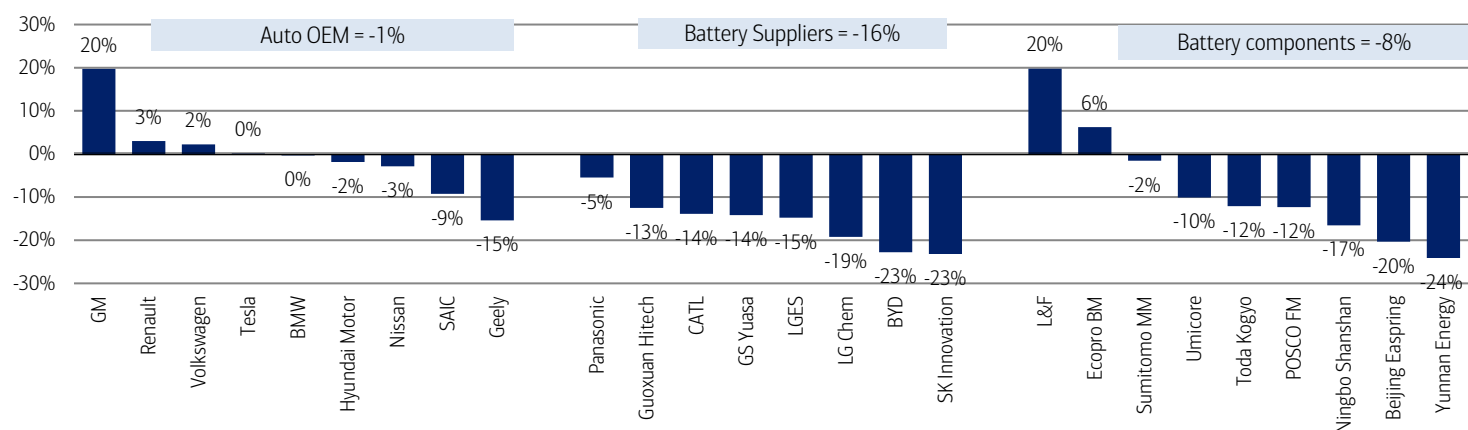


Source: Bloomberg, BofA Global Research

BofA GLOBAL RESEARCH

## Exhibit 15: 3M share price performance

The shares of battery suppliers rose 2% over the past 3 months



Source: Bloomberg, BofA Global Research

BofA GLOBAL RESEARCH



# Global valuation comparison

## Exhibit 16: Valuation comparison – Battery, Auto, Chemical materials, & Raw materials

Valuation comparison – Battery, Auto, Chemical materials, &amp; Raw materials

	Country	Mcap (US\$bn)	P/E		P/B		EV/EBITDA		EV/Sales		ROE		Div. yield		EPS Growth		EBITDA Growth	
			FY24E	FY25E	FY24E	FY25E	FY24E	FY25E	FY24E	FY25E	FY24E	FY25E	FY24E	FY25E	FY24E	FY25E	FY24E	FY25E
EV Battery suppliers																		
LG ES	Korea	71.0	44.0x	28.5x	3.9x	3.3x	14.2x	10.8x	2.6x	1.9x	9.6%	12.6%	0.0%	0.0%	48%	54%	55%	32%
Samsung SDI	Korea	20.6	11.6x	10.2x	1.3x	1.2x	8.5x	7.5x	1.4x	1.2x	11.4%	11.4%	0.3%	0.3%	8%	13%	19%	14%
BYD	China	78.7	14.9x	13.1x	3.3x	2.7x	6.7x	5.8x	0.7x	0.6x	24.3%	22.7%	0.7%	0.8%	19%	13%	19%	15%
Panasonic	Japan	23.4	7.8x	6.4x	0.7x	0.6x	3.8x	3.4x	0.4x	0.4x	9.1%	10.3%	2.9%	2.9%	-6%	23%	23%	14%
SK Innovation	Korea	9.3	7.4x	4.6x	0.5x	0.4x	5.6x	4.4x	0.4x	0.4x	6.8%	9.9%	4.9%	4.9%	70%	61%	19%	28%
CATL*	China	95.2	12.6x	10.1x	2.7x	2.2x	7.9x	6.5x	1.4x	1.1x	22.7%	23.0%	1.3%	1.7%	24%	25%	26%	23%
EVE	China	11.6	15.3x	11.6x	2.1x	1.8x	14.4x	11.0x	1.8x	1.5x	14.9%	17.0%	0.7%	0.9%	23%	31%	38%	31%
Guoxuan Hitech*	China	4.9	33.0x	22.2x	1.4x	1.3x	17.5x	13.4x	1.5x	1.2x	4.3%	6.0%	0.0%	0.1%	86.9%	48.8%	48.8%	30.7%
Sunwoda*	China	3.3	15.3x	11.2x	1.0x	0.9x	9.3x	8.1x	0.6x	0.5x	6.9%	8.7%	1.0%	1.2%	40.0%	37.3%	31.5%	15.2%
GS Yuasa*	Japan	1.4	10.9x	10.2x	0.7x	0.7x	5.6x	5.2x	0.6x	0.6x	7.0%	7.0%	2.6%	2.8%	16.3%	6.3%	26.2%	8.4%
Auto OEM																		
Tesla	US	695.8	53.4x	44.7x	10.7x	8.7x	37.4x	31.8x	6.4x	5.8x	22.4%	21.5%	0.0%	0.0%	37%	22%	39%	19%
Nissan	Japan	15.7	4.7x	4.6x	0.4x	0.4x	6.5x	6.4x	0.6x	0.6x	8.4%	8.2%	6.3%	6.5%	1%	3%	7%	2%
Renault	France	11.2	2.3x	2.4x	0.2x	0.2x	1.1x	1.1x	0.1x	0.1x	11.5%	9.9%	5.3%	5.3%	2%	-6%	0%	-5%
GM	US	48.3	4.5x	4.0x	0.7x	0.6x	1.9x	1.8x	0.3x	0.3x	15.0%	14.6%	1.0%	1.0%	9%	13%	7%	5%
BMW	Germany	66.3	5.3x	5.7x	0.6x	0.6x	1.5x	1.5x	0.2x	0.2x	11.6%	10.1%	6.1%	5.4%	-10%	-8%	-8%	-5%
Volkswagen	Germany	61.6	4.0x	3.7x	0.3x	0.3x	1.0x	1.0x	0.2x	0.1x	7.9%	8.0%	7.5%	7.8%	-3%	7%	-1%	3%
Hyundai Motor	Korea	28.4	3.9x	4.0x	0.5x	0.4x	5.4x	5.4x	0.8x	0.8x	11.5%	10.6%	6.1%	6.2%	-7%	-1%	29%	0%
SAIC	China	21.6	9.9x	8.7x	0.5x	0.5x	5.2x	4.5x	0.3x	0.3x	5.4%	5.9%	3.5%	4.0%	4%	13%	24%	14%
NIO	China	14.9	NM	NM	6.5x	14.6x	NM	NM	1.4x	0.9x	-113.3%	-77.0%	0.0%	0.0%	NA	NA	NA	NA
XPeng	China	11.1	NM	NM	3.8x	4.0x	NM	219.3x	0.9x	0.6x	-28.5%	-3.2%	0.0%	0.0%	NA	NA	NA	NA
Li Auto*	China	30.0	19.0x	12.2x	3.9x	3.0x	9.6x	6.1x	0.7x	0.5x	20.8%	24.7%	0.0%	0.0%	56%	55%	72%	57%
Battery Components																		
Cathode																		
Umicore	Belgium	5.8	13.4x	14.4x	1.2x	1.2x	7.2x	7.1x	1.6x	1.4x	9.3%	8.2%	3.7%	3.7%	-8%	-7%	-4%	1%
Ningbo Shanshan*	China	3.5	9.5x	7.8x	0.9x	0.8x	7.4x	6.5x	1.5x	1.3x	9.8%	9.8%	2.7%	3.4%	24%	21%	16%	13%
Beijing Easpring*	China	2.4	7.4x	6.3x	1.1x	1.0x	4.3x	3.6x	0.6x	0.5x	15.9%	15.7%	2.7%	2.7%	10%	16%	11%	17%
Toda Kogyo*	Japan	0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cosmo AM&T*	Japan	3.2	79.3x	28.1x	9.8x	7.3x	43.0x	17.6x	3.8x	1.4x	14.2%	32.1%	0.0%	0.0%	139%	182%	104%	144%
Sumitomo MM	Japan	8.3	8.9x	5.8x	0.6x	0.6x	12.6x	9.2x	1.3x	1.2x	7.6%	10.5%	3.9%	6.1%	NA	NA	21%	38%
L&F	Korea	5.6	20.3x	13.4x	5.0x	3.7x	14.6x	9.2x	1.1x	0.7x	26.1%	29.8%	0.4%	0.5%	NA	52%	NA	59%
LG Chem	Korea	23.1	8.8x	7.0x	0.5x	0.4x	4.2x	3.0x	0.6x	0.5x	6.5%	6.2%	2.8%	2.8%	105%	26%	28%	37%
Ecopro BM	Korea	22.0	67.9x	41.9x	15.1x	11.3x	40.5x	24.7x	3.5x	2.1x	24.8%	30.7%	0.1%	0.1%	142%	62%	86%	64%
Shenzhen Dynanonic	China	1.9	9.0x	7.4x	1.4x	1.1x	7.8x	5.5x	1.0x	0.8x	15.0%	18.5%	0.7%	1.7%	NA	23%	499%	41%
Ningbo Rongbay	China	2.2	11.1x	8.7x	1.6x	1.4x	9.1x	7.4x	0.8x	0.7x	15.5%	16.2%	1.1%	1.3%	47%	27%	31%	24%
Hunan Changyuan	China	1.6	22.2x	18.2x	1.5x	1.4x	22.6x	16.9x	1.0x	0.9x	6.5%	7.5%	NA	NA	350%	22%	235%	34%
Guizhou Zhenhua	China	1.2	17.3x	9.9x	1.6x	1.4x	11.8x	8.9x	1.0x	0.8x	11.5%	13.9%	0.8%	1.2%	181%	75%	59%	33%
Anode																		
Mitsubishi Chem	Japan	9.3	12.0x	10.0x	0.8x	0.7x	7.5x	6.9x	0.9x	0.9x	6.4%	7.6%	3.6%	3.8%	-17%	21%	-3%	8%
Showa Denko	Japan	3.8	67.3x	43.1x	1.0x	1.0x	11.9x	10.1x	1.2x	1.2x	1.5%	2.4%	2.2%	2.2%	NA	56%	35%	17%
Posco Future M	Korea	17.8	62.6x	34.9x	8.0x	6.6x	34.4x	17.8x	3.6x	1.9x	13.6%	20.7%	0.1%	0.1%	132%	80%	119%	93%
Daejoo Electronic Materials*	Korea	0.9	74.3x	19.9x	8.3x	5.7x	29.1x	12.1x	4.6x	2.4x	11.7%	36.8%	0.1%	0.1%	508%	274%	149%	141%
Advanced Nano Products*	Korea	0.9	58.4x	27.7x	5.0x	4.3x	29.1x	17.5x	6.5x	3.4x	9.1%	16.7%	0.3%	0.3%	22%	111%	134%	66%
Shanghai Putailai	China	5.6	10.3x	9.0x	1.9x	1.6x	8.3x	6.8x	2.1x	1.7x	18.9%	18.9%	1.6%	1.9%	45%	14%	29%	23%
Separator																		
SK IE Technology	Korea	4.3	44.1x	23.2x	2.5x	2.2x	18.1x	10.1x	5.7x	3.9x	5.8%	10.1%	0.0%	0.0%	1151%	90%	109%	79%
W-Scope Chungju*	Korea	1.0	29.0x	16.1x	1.3x	1.2x	10.9x	6.6x	4.2x	2.4x	4.7%	8.0%	0.0%	0.0%	-14%	80%	32%	66%
Asahi Kasei	Japan	10.6	13.3x	11.5x	0.9x	0.8x	7.7x	7.1x	0.9x	0.9x	6.6%	7.3%	3.3%	3.4%	31%	16%	12%	9%
Toray	Japan	8.1	13.6x	11.2x	0.7x	0.7x	7.8x	7.0x	0.8x	0.8x	5.4%	6.3%	2.5%	2.5%	23%	22%	6%	12%
W-Scope*	Japan	0.3	25.6x	9.8x	0.8x	0.7x	6.2x	4.3x	2.5x	1.8x	3.5%	8.4%	0.0%	0.1%	NA	161%	NA	44%
Ube Industries	Japan	1.7	10.7x	9.2x	0.6x	0.6x	10.4x	8.7x	0.9x	0.9x	6.0%	6.6%	4.1%	4.3%	NA	16%	0%	19%
Teijin	Japan	1.8	27.6x	12.6x	0.6x	0.6x	6.4x	5.6x	0.7x	0.6x	2.8%	4.6%	2.2%	2.5%	NA	119%	20%	13%
Yunnan Energy*	China	6.6	12.1x	9.8x	1.7x	1.5x	8.1x	6.4x	3.6x	2.9x	14.6%	15.2%	1.1%	1.2%	21%	23%	22%	26%
Shenzhen Senior*	China	2.3	12.0x	9.0x	1.5x	1.3x	7.5x	5.7x	3.3x	2.5x	12.6%	14.5%	1.4%	1.8%	37%	32%	41%	33%
Electrolyte																		
Central Glass*	Japan	0.5	6.8x	6.2x	0.6x	0.6x	5.2x	4.6x	0.7x	0.6x	11.1%	6.9%	4.2%	4.3%	-68%	10%	-12%	13%
Soulbrain*	Korea	0.6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Foosung*	Korea	0.7	110.8x	35.7x	2.7x	2.6x	15.1x	11.2x	2.1x	1.7x	2.5%	7.4%	0.2%	0.2%	NA	210%	199%	34%
Guangzhou Tinci*	China	5.9	15.2x	12.4x	2.8x	2.4x	12.5x	9.9x	2.5x	1.9x	17.3%	18.6%	1.2%	1.7%	12%	22%	2%	26%
Shenzhen Capchem*	China	4.3	17.6x	13.1x	2.9x	2.4x	13.2x	9.6x	2.7x	2.1x	15.7%	18.1%	1.0%	1.5%	40%	35%	36%	38%
Chunbo*	China	0.7	60.4x	16.8x	2.6x	2.3x	16.0x	8.3x	3.7x	2.1x	5.1%	15.1%	0.5%	0.5%	NA	259%	122%	93%
Enchem*	Korea	1.3	NA	NA	NA	NA	NA	NA	NA	NA	24.8%	39.0%	NA	NA	NA	NA	NA	NA
Solvay	EU	2.9	6.8x	6.3x	0.4x	0.4x	6.8x	6.4x	1.6x	1.5x	5.8%	6.2%	9.9%	10.2%	-40%	8%	-19%	5%
Fuchs	EU	5.6	16.6x	14.9x	2.7x	2.4x	10.0x	9.2x	1.5x	1.4x	16.4%	17.0%	2.7%	2.8%	13%	11%	8%	9%
Arkema	EU	8.1	10.5x	9.5x	1.0x	0.9x	6.6x	6.2x	1.1x	1.1x	9.9%	10.3%	3.9%	4.1%	13%	11%	10%	7%
Copper foil																		
SKC	Korea	2.3	38.1x	14.2x	1.8x	1.7x	14.7x	10.3x	2.3x	1.8x	4.6%	11.7%	1.4%	1.4%	NA	168%	445%	43%

**Exhibit 16: Valuation comparison – Battery, Auto, Chemical materials, & Raw materials**

Valuation comparison – Battery, Auto, Chemical materials, &amp; Raw materials

	Country	Mcap	P/E		P/B		EV/EBITDA		EV/Sales		ROE		Div. yield		EPS Growth		EBITDA Growth	
Solus	Korea	0.8	29.9x	20.1x	0.7x	0.6x	8.3x	6.4x	1.3x	0.9x	2.9%	4.3%	0.7%	0.7%	-89%	49%	NA	29%
Lotte Energy Materials*	Korea	1.1	26.0x	16.0x	1.0x	0.9x	9.5x	6.4x	1.4x	1.1x	3.7%	5.7%	0.9%	1.0%	NA	62%	74%	47%
Furukawa Electric	Japan	1.1	12.1x	9.3x	0.6x	0.6x	9.0x	8.2x	0.5x	0.5x	4.7%	6.0%	2.6%	3.4%	6653%	30%	33%	10%
Nippon Denkai*	Japan	0.1	NA	NA	1.6x	1.7x	NA	NA	1.2x	0.9x	-17.5%	-1.6%	0.0%	0.0%	NA	NA	NA	NA
Nuode*	China	1.2	24.0x	60.0x	1.3x	1.3x	22.3x	18.6x	2.2x	2.0x	1.3%	2.1%	NA	NA	54%	-60%	33%	20%
<b>Binder</b>																		
Kureha	Japan	1.2	9.9x	8.8x	0.8x	0.7x	4.8x	4.4x	0.9x	0.8x	7.8%	8.5%	3.8%	4.3%	1%	12%	0%	11%
Zeon	Japan	2.0	10.6x	9.8x	0.7x	0.7x	6.7x	6.1x	0.9x	0.9x	7.1%	7.3%	3.3%	3.4%	14%	7%	15%	10%
<b>Metals</b>																		
<b>Lithium</b>																		
SQM	Chile	14.0	9.4x	7.2x	2.2x	1.8x	5.5x	4.3x	2.2x	1.9x	25.1%	27.6%	4.9%	6.0%	-35%	30%	-28%	29%
Albemarle	US	14.8	19.2x	9.0x	1.3x	1.1x	12.6x	6.3x	2.8x	2.2x	7.5%	14.5%	1.3%	1.4%	-67%	113%	-62%	382%
FMC	US	7.3	13.5x	11.0x	2.0x	1.8x	11.6x	10.3x	2.6x	2.5x	15.3%	17.2%	4.0%	4.0%	48%	23%	6%	12%
Tianqi Lithium*	China	12.1	11.9x	11.4x	1.5x	1.3x	5.3x	5.8x	3.8x	3.8x	12.6%	11.8%	1.6%	1.6%	-27%	4%	-50%	-8%
Ganfeng Lithium *	China	10.1	11.4x	8.6x	1.4x	1.2x	12.7x	8.7x	3.0x	2.4x	12.6%	14.1%	0.8%	0.9%	-9%	32%	3%	46%
<b>Nickel</b>																		
Vale	Brazil	65.6	5.0x	7.5x	1.5x	1.3x	5.2x	6.8x	2.3x	2.6x	28.9%	17.3%	7.8%	6.3%	26%	-33%	13%	-23%
BHP Billiton	Australia	157.0	9.1x	11.4x	3.0x	2.7x	4.9x	5.6x	2.7x	3.0x	35.3%	24.7%	6.0%	4.8%	33%	-20%	20%	-12%
<b>Cobalt</b>																		
Glencore	Switzerland	69.1	13.3x	11.4x	1.5x	1.4x	5.6x	5.0x	0.4x	0.4x	11.1%	12.4%	4.6%	4.6%	-2%	17%	-1%	12%
China Molybdenum*	China	14.3	8.4x	6.3x	1.2x	1.1x	5.4x	4.4x	0.7x	0.6x	19.6%	19.3%	3.2%	5.9%	41%	34%	30%	23%
Huayou Cobalt*	China	6.6	8.1x	6.5x	1.3x	1.1x	7.3x	5.9x	1.1x	0.9x	15.1%	16.4%	0.9%	1.2%	32%	24%	22%	22%
<b>Manganese</b>																		
Eramet	France	2.0	7.4x	4.1x	0.9x	0.7x	3.1x	2.0x	0.7x	0.6x	12.2%	18.7%	0.0%	0.0%	166%	79%	36%	64%
Anglo American	UK	28.5	9.8x	12.5x	1.0x	0.9x	4.3x	5.0x	1.6x	1.7x	10.2%	7.6%	4.1%	3.2%	13%	-22%	6%	-13%
<b>Manufacturing equipment</b>																		
Wuxi Lead Intelligent *	China	4.9	8.0x	6.9x	2.0x	1.7x	7.9x	6.6x	1.5x	1.3x	26.1%	24.8%	3.7%	4.3%	27%	15%	19%	20%
Zhejiang Hangke*	China	1.7	9.4x	7.5x	2.0x	1.6x	6.6x	5.5x	1.7x	1.4x	24.1%	25.3%	3.0%	3.7%	33%	25%	28%	21%
Yinghe Technology*	China	1.5	13.2x	9.3x	1.5x	1.3x	8.1x	6.7x	1.0x	0.9x	9.2%	13.0%	1.6%	1.7%	14%	42%	6%	21%
CKD Corp*	Japan	1.2	19.6x	12.9x	1.4x	1.3x	8.5x	6.2x	1.2x	1.1x	7.1%	10.2%	2.1%	3.1%	-41%	51%	-29%	36%
Hirano Tecseed*	Japan	0.2	16.5x	10.2x	NA	NA	NA	NA	0.6x	0.6x	4.4%	NA	3.2%	3.2%	-40%	62%	NA	NA
Shin Heung Energy*	Korea	0.3	9.0x	7.6x	1.1x	0.9x	5.7x	4.6x	0.9x	0.7x	10.4%	12.2%	0.8%	0.8%	23%	18%	19%	23%
People & Technology*	Korea	0.7	10.3x	8.5x	2.8x	2.1x	7.7x	6.4x	1.3x	1.1x	32.0%	28.7%	0.2%	0.2%	87%	21%	122%	20%
<b>Infrastructure</b>																		
Delta Electronics	Taiwan	24.1	18.0x	15.8x	2.9x	2.6x	10.4x	9.1x	1.6x	1.4x	17.0%	17.5%	2.8%	3.2%	23%	14%	24%	15%
NARI Tech*	China	23.3	19.5x	17.0x	3.1x	2.8x	14.3x	12.6x	2.7x	2.4x	16.7%	16.9%	2.1%	2.4%	16%	15%	12%	14%
Qingdao Tgood*	China	2.6	32.4x	24.3x	2.6x	2.4x	16.7x	13.3x	1.4x	1.1x	8.3%	10.3%	0.6%	0.9%	34%	34%	27%	25%
Engie	France	42.9	8.7x	9.7x	1.3x	1.2x	6.1x	6.3x	0.9x	0.9x	15.1%	12.7%	8.2%	7.2%	-15%	-12%	-3%	-3%
TDK	Japan	19.0	15.7x	13.4x	1.7x	1.7x	7.0x	6.4x	1.3x	1.2x	11.6%	13.0%	1.8%	2.1%	42%	17%	15%	11%

Source: BofA Global Research, Note: \* Bloomberg consensus for Not Covered/ China listed companies

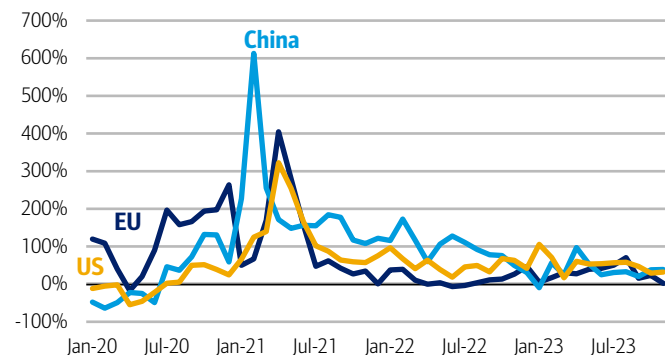
BofA GLOBAL RESEARCH



# Global EV sales data

## Exhibit 17: Global BEV+PHEV YoY changes

Global BEV+PHEV sales moderating YoY

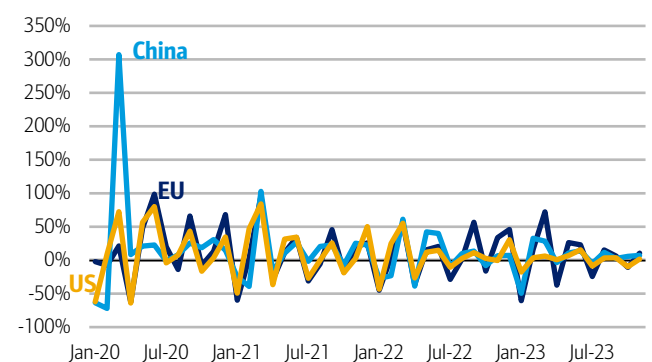


Source: EV-volumes, BofA Global Research

BofA GLOBAL RESEARCH

## Exhibit 18: Global BEV+PHEV MoM changes

Global BEV+PHEV sales moderating MoM

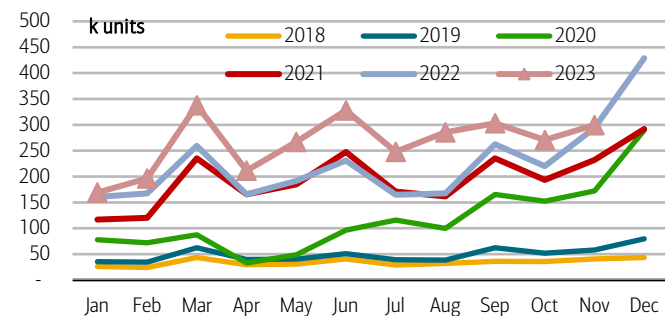


Source: EV-volumes, BofA Global Research

BofA GLOBAL RESEARCH

## Exhibit 19: EU sales volume (BEV+PHEV)

EU sales volume (BEV+PHEV) increased slightly MoM

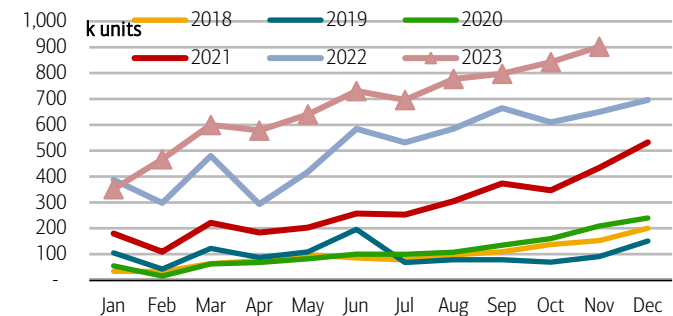


Source: EV-volumes, BofA Global Research

BofA GLOBAL RESEARCH

## Exhibit 20: China sales volume

China sales volume (BEV+PHEV) increased MoM

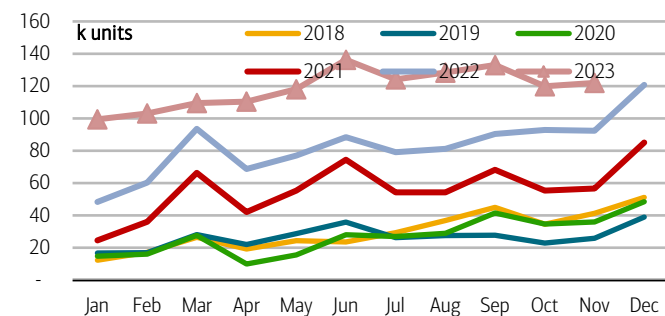


Source: EV-volumes, BofA Global Research

BofA GLOBAL RESEARCH

## Exhibit 21: US sales volume

US sales volume (BEV+PHEV) increased slightly MoM

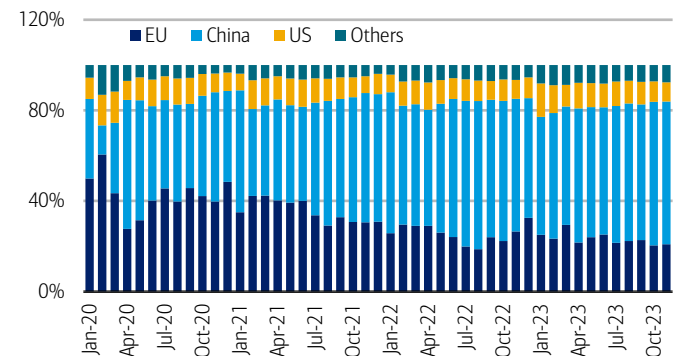


Source: EV-volumes, BofA Global Research

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## Exhibit 22: Global BEV+PHEV sales by regions

Global BEV+PHEV sales by regions



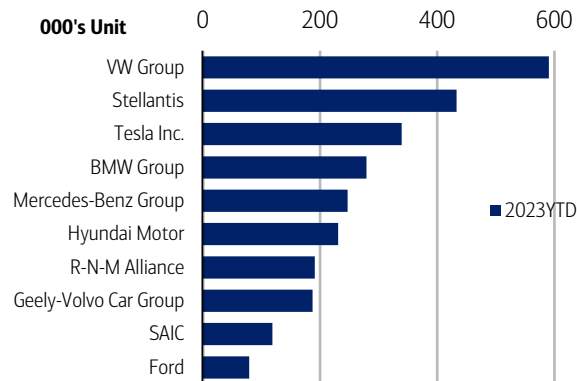
Source: EV-volumes, BofA Global Research

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# Top-10 EV OEMs/models sales by regions

## Exhibit 23: EU Top-10 sales OEMs

VW was the top selling OEM in EU

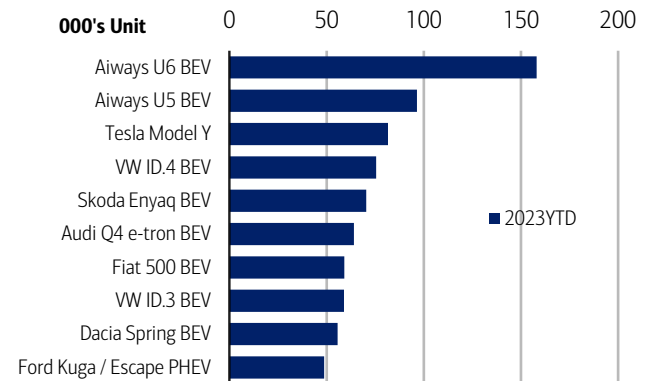


Source: EV-volumes, BofA Global Research

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## Exhibit 24: EU Top-10 sales models

Aiways U6 was the top selling model in EU

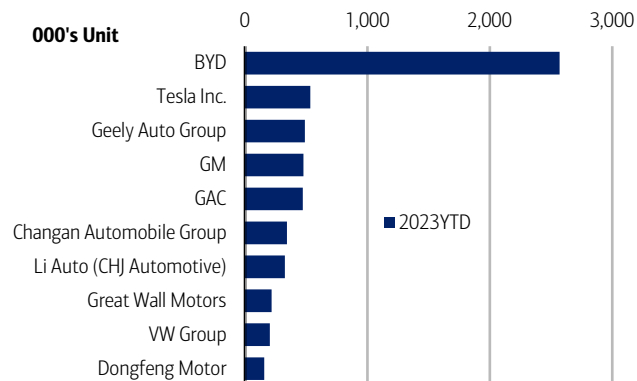


Source: EV-volumes, BofA Global Research

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## Exhibit 25: China Top-10 sales OEMs

BYD was the top selling OEM in China

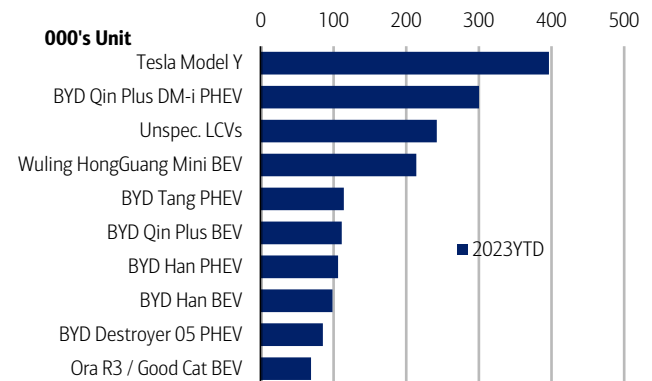


Source: EV-volumes, BofA Global Research

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## Exhibit 26: China Top-10 sales models

Tesla model Y was the top selling model in China

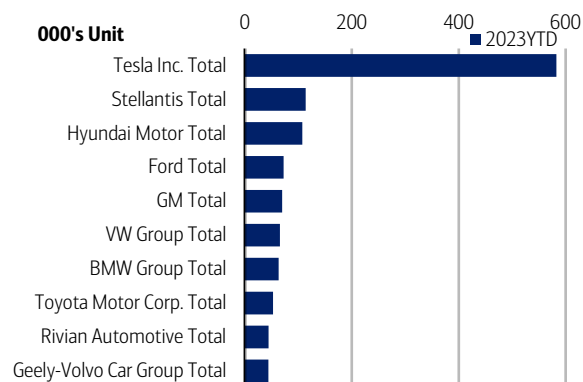


Source: EV-volumes, BofA Global Research

BofA GLOBAL RESEARCH

## Exhibit 27: US Top-10 sales OEMs

Tesla was the top selling OEM in US

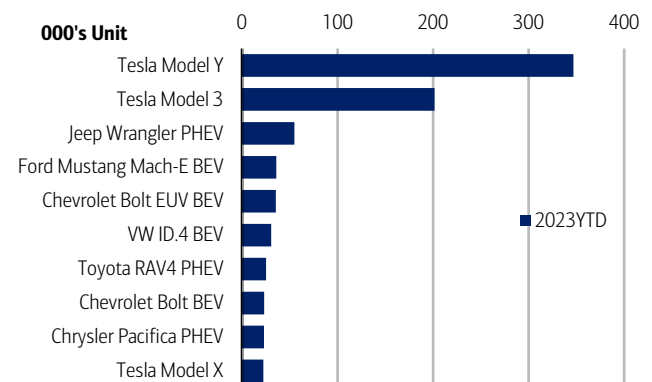


Source: EV-volumes, BofA Global Research

BofA GLOBAL RESEARCH

## Exhibit 28: US Top-10 sales models

Tesla model Y was the top selling model in US



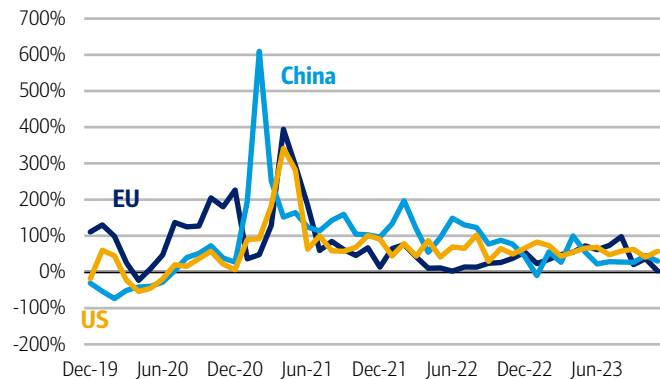
Source: EV-volumes, BofA Global Research

BofA GLOBAL RESEARCH

# Global EV battery shipment by region

## Exhibit 29: Global battery sales YoY changes

Global battery sales YoY growth moderated in Nov '23

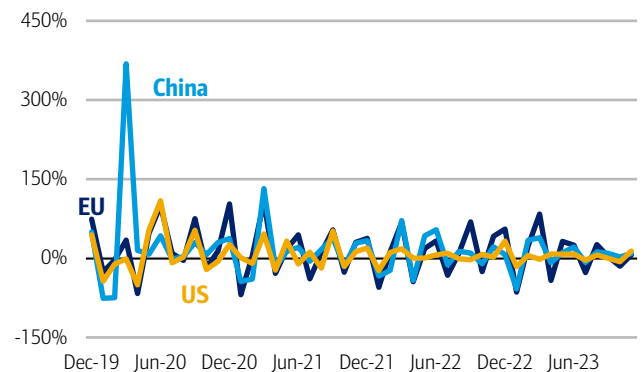


Source: SNE Research, BofA Global Research

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## Exhibit 30: Global battery sales mom changes

Global battery sales mom growth was almost flat in Nov '23

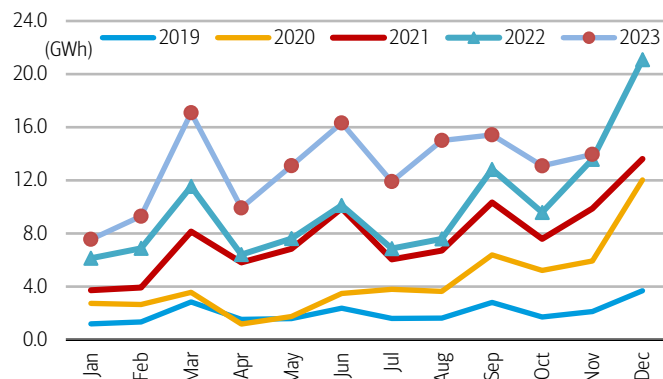


Source: SNE Research, BofA Global Research

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## Exhibit 31: EU Battery sales volume

EU Battery sales volume increased 7% MoM/3% YoY

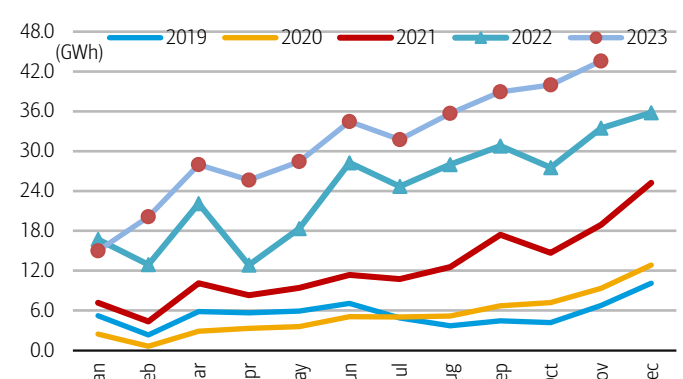


Source: SNE Research, BofA Global Research

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## Exhibit 32: China Battery sales volume

China Battery sales volume increased 9% MoM/30% YoY

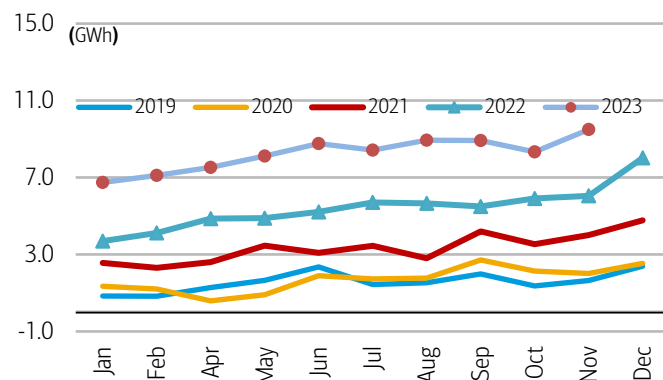


Source: SNE Research, BofA Global Research

BofA GLOBAL RESEARCH

## Exhibit 33: US Battery sales volume

US Battery sales volume increased 14% MoM/57% YoY

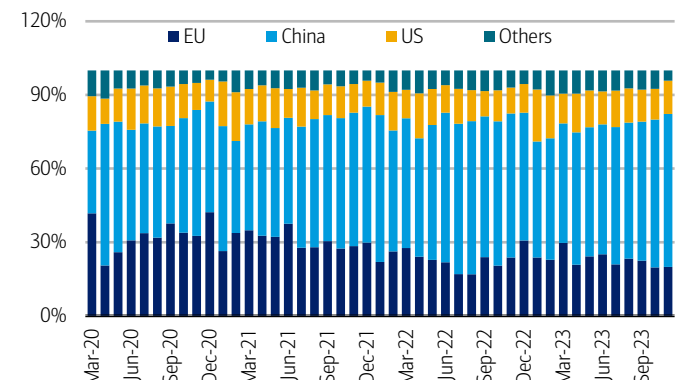


Source: SNE Research, BofA Global Research

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## Exhibit 34: Global battery sales by regions

China battery market share increased MoM in Nov by 2%



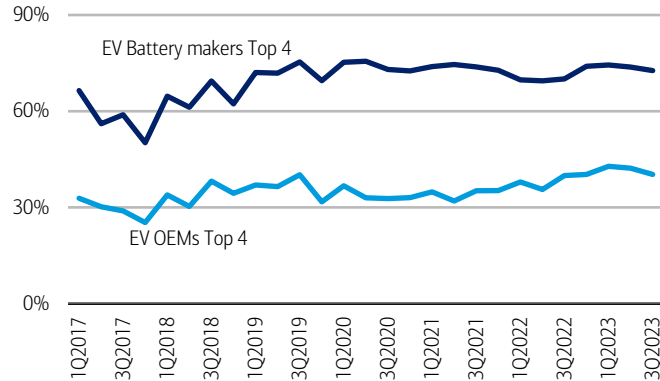
Source: SNE Research, BofA Global Research

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# Global EV battery M/S by region

## Exhibit 35: EV battery Top 4 market share

Top 4 EV battery makers control 73% market share

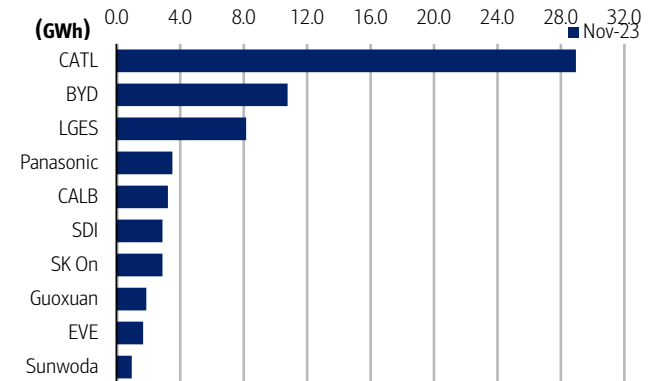


Source: SNE Research, BofA Global Research

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## Exhibit 36: Top 10 battery makers sales

CATL had No.1 market share in Nov'23

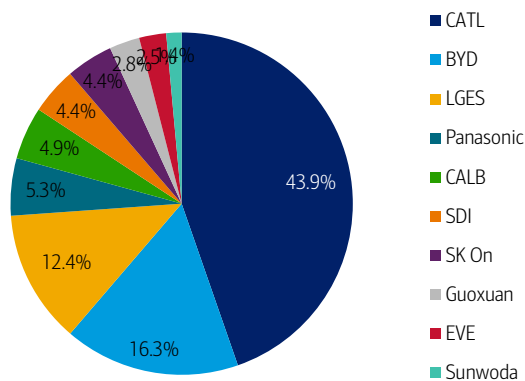


Source: SNE Research, BofA Global Research

BofA GLOBAL RESEARCH

## Exhibit 37: Top 10 battery makers market share

CATL retains No.1 market share in Nov

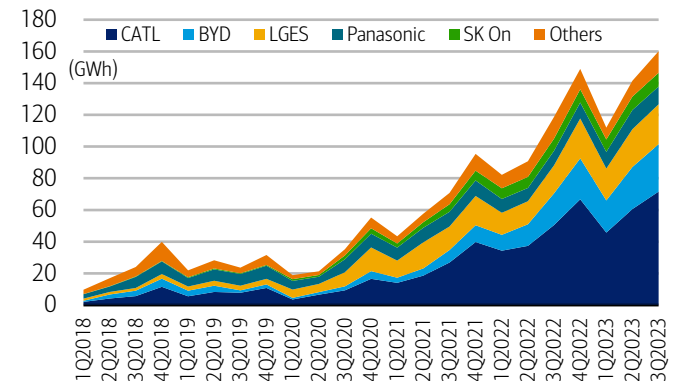


Source: SNE Research, BofA Global Research

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## Exhibit 38: Global: Top 5 EV battery maker's sales

Top-5 EV battery producers' sales increased in 3Q23

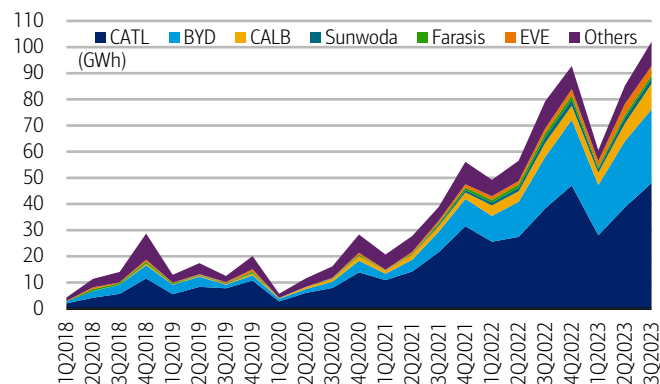


Source: SNE Research, BofA Global Research

BofA GLOBAL RESEARCH

## Exhibit 39: China: Top 6 EV battery makers' sales

Top-5 battery producers' sales increased in 3Q23

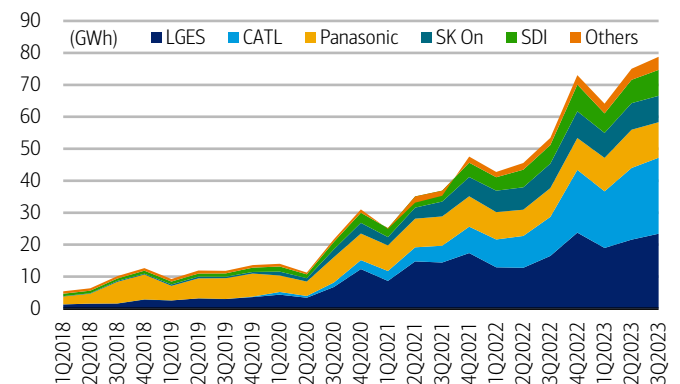


Source: SNE Research, BofA Global Research

BofA GLOBAL RESEARCH

## Exhibit 40: Global (ex-China) Top 5 EV battery maker's sales

Top-5 battery producers' sales increased in 3Q23



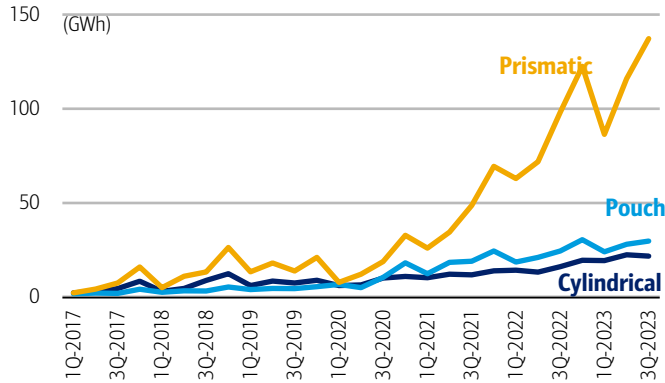
Source: SNE Research, BofA Global Research

BofA GLOBAL RESEARCH

# Global EV battery M/S by form factor

**Exhibit 41: Global EV battery sales volume by form factor**

Prismatic battery showed QoQ increase in sales volume

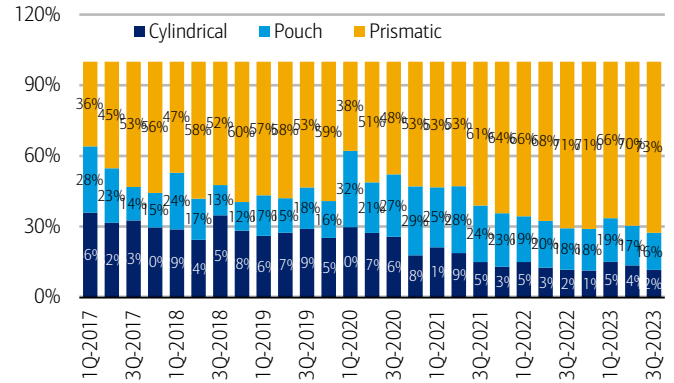


Source: SNE Research, BofA Global Research

BofA GLOBAL RESEARCH

**Exhibit 42: Global EV battery sales volume by form factor**

Prismatic battery showed QoQ increase in sales volume

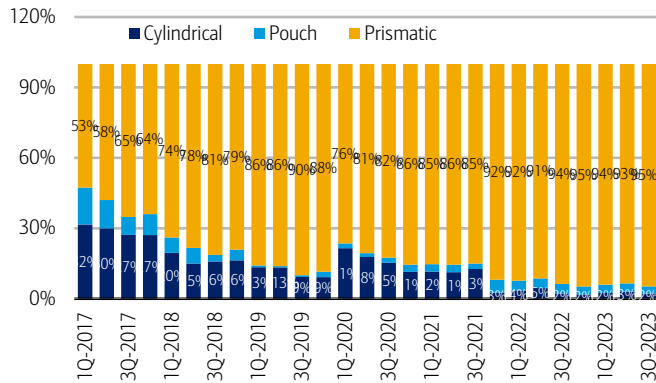


Source: SNE Research, BofA Global Research

BofA GLOBAL RESEARCH

**Exhibit 43: China EV battery sales volume share by form factor**

Prismatic still dominating with &gt;90% market share in 3Q23

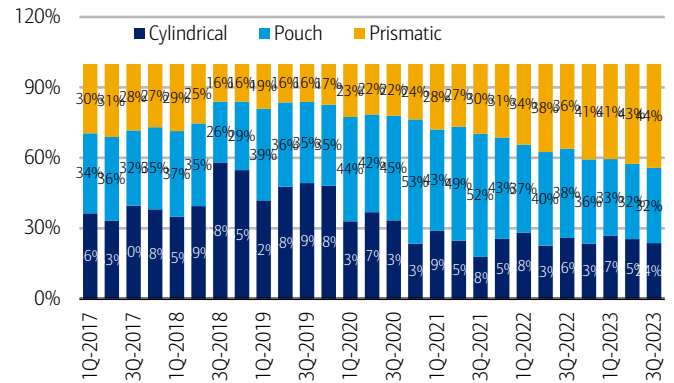


Source: SNE Research, BofA Global Research

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**Exhibit 44: Global ex. China EV battery volume share by form factor**

Prismatic still dominating with &gt;40% market share in 3Q23

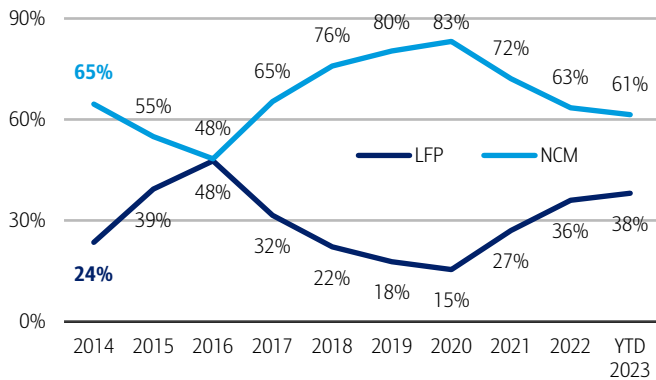


Source: SNE Research, BofA Global Research

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**Exhibit 45: Global LFP and NCM market share**

LFP battery has been gaining market share vs NCM

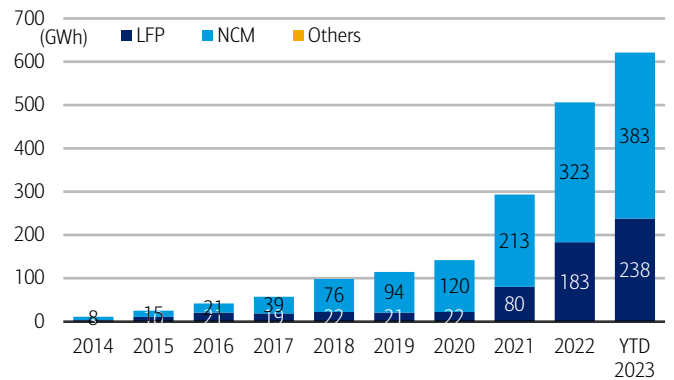


Source: SNE Research, BofA Global Research

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**Exhibit 46: Global battery chemical trend**

LFP sales have been steadily catching up with NCM



Source: SNE Research, BofA Global Research

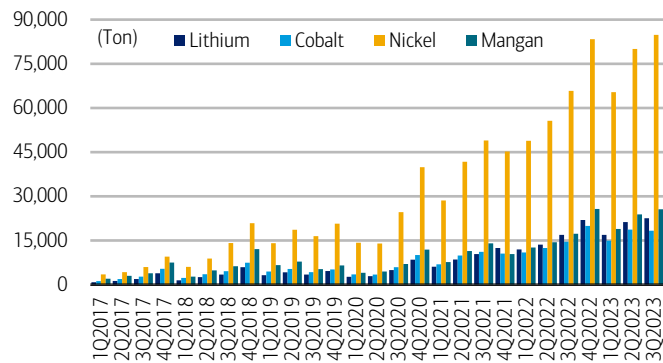
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# Global battery materials & metals shipments

## Battery materials & metals volumes

**Exhibit 47: Global material trend - Quarterly**

Ni consumption increased 29% YoY

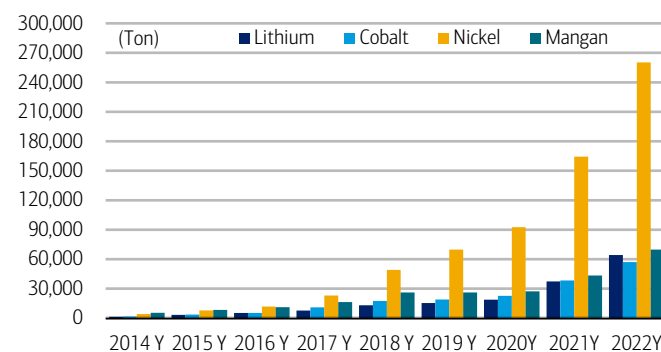


Source: SNE Research, BofA Global Research

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**Exhibit 48: Global material trend - Annually**

Nickel continued to show the highest growth (up 76% YoY) in 2022

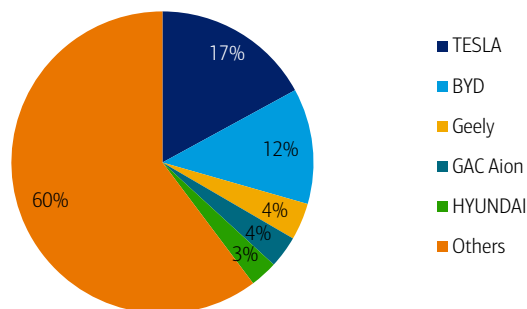


Source: SNE Research, BofA Global Research

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**Exhibit 49: Market share of top 5 lithium consuming OEMs**

TSLA tops Lithium consumption (17% M/S)

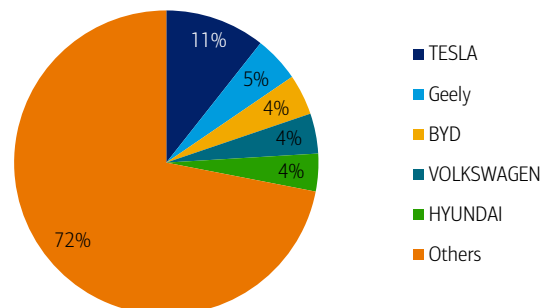


Source: SNE Research, BofA Global Research

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**Exhibit 50: Market share of top 5 cobalt consuming OEMs**

TSLA tops Cobalt consumption (11% M/S)

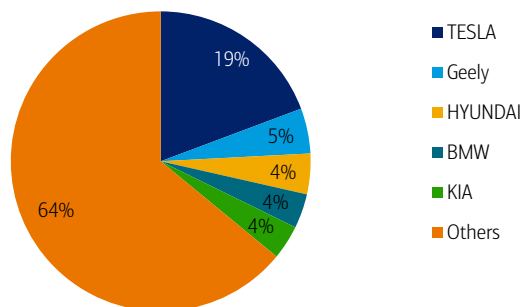


Source: SNE Research, BofA Global Research

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**Exhibit 51: Market share of top 5 nickel consuming OEMs**

TSLA tops Ni consumption (19% M/S)

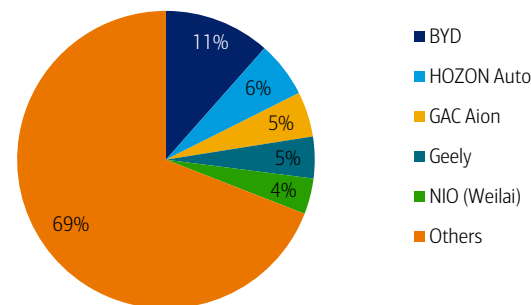


Source: SNE Research, BofA Global Research

BofA GLOBAL RESEARCH

**Exhibit 52: Market share of top 5 mangan consuming OEMs**

BYD tops Mn consumption (11% M/S)



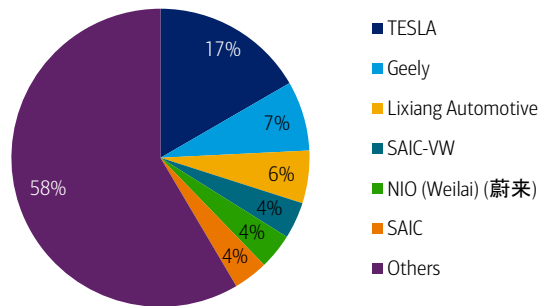
Source: SNE Research, BofA Global Research

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# EV battery shipments by OEM customers

## Exhibit 53: CATL top 6 OEMs (Nov'23)

CATL top 6 OEMs: Tesla was the largest client for CATL

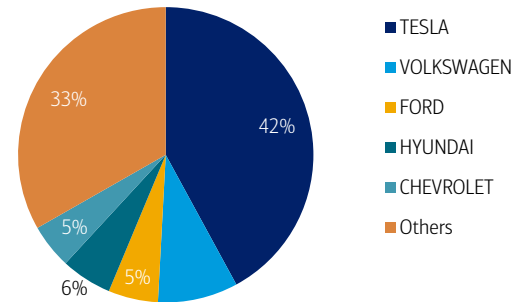


Source: SNE Research, BofA Global Research

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## Exhibit 54: LGES top 5 OEMs (Nov'23)

LGES top 5 OEMs: Most of LGES's sales are to Tesla

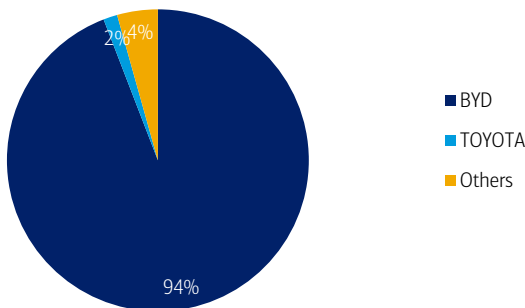


Source: SNE Research, BofA Global Research

BofA GLOBAL RESEARCH

## Exhibit 55: BYD top 2 OEMs (Nov'23)

BYD top 2 OEMs: Almost all of BYD's sales are consumed internally

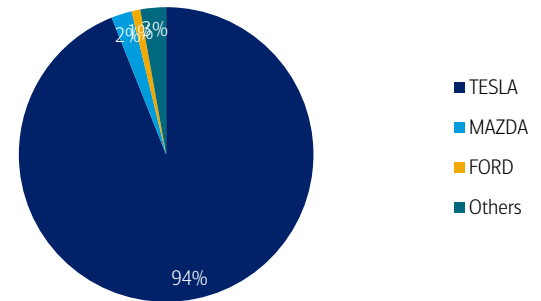


Source: SNE Research, BofA Global Research

BofA GLOBAL RESEARCH

## Exhibit 56: Panasonic top 3 OEMs (Nov'23)

Panasonic top 5 OEMs: almost all of Panasonic's sales are to Tesla

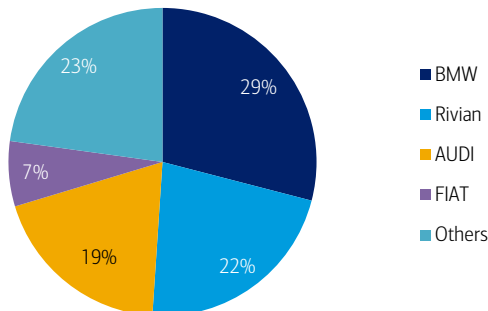


Source: SNE Research, BofA Global Research

BofA GLOBAL RESEARCH

## Exhibit 57: Samsung SDI top 4 OEMs (Nov'23)

SDI top 5 OEMs: SDI's sales are diversified amongst top OEMs

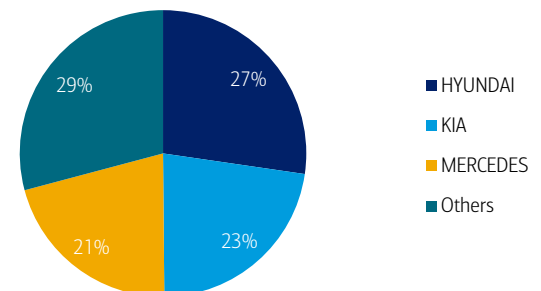


Source: SNE Research, BofA Global Research

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## Exhibit 58: SK On top 3 OEMs (Nov'23)

SK On top 3 OEMs: (Hyundai+Kia) make up half of SK On's sales



Source: SNE Research, BofA Global Research

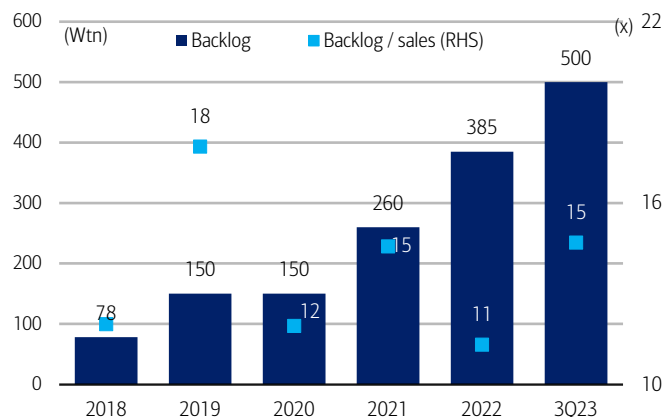
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# EV battery capacity of major players

## Exhibit 59: LGES backlog

LGES' order backlog increased to W500tn (15x 23E sales) as of 3Q23

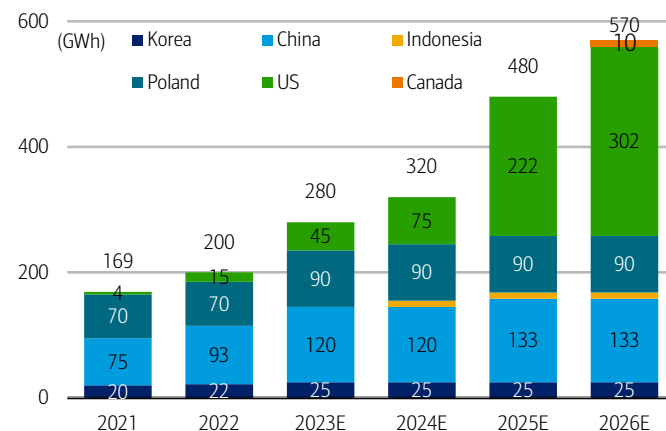


Source: Company data, BofA Global Research

BofA GLOBAL RESEARCH

## Exhibit 60: LGES' EV battery capacity

LGES to expand its capacity to 570GWh by '26E (US taking up >50% of total)

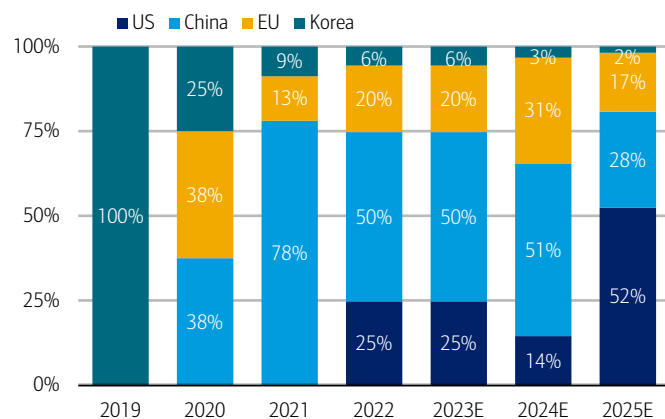


Source: Company data, BofA Global Research

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## Exhibit 61: Regional breakdown of SKI's EV battery capacity

Future expansions center on the US and China

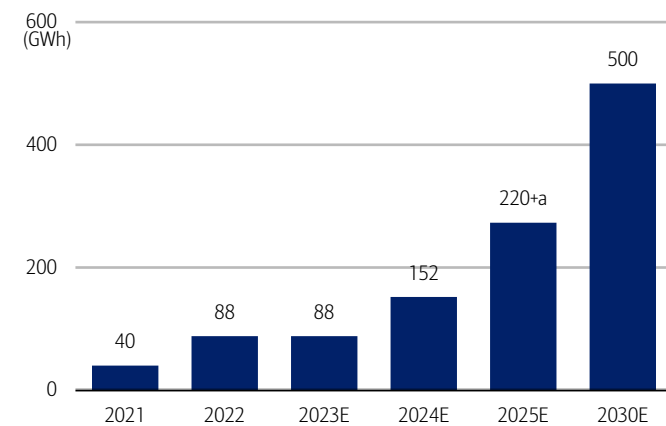


Source: Company data, BofA Global Research

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## Exhibit 62: SKI's EV battery capacity

SKI will increase the battery capacity to 500GWh+ by 2025E



Source: Company data, BofA Global Research

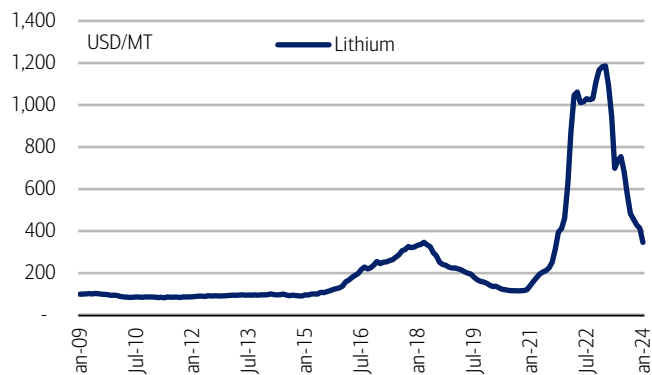
BofA GLOBAL RESEARCH

# Battery metals & component pricing data

## Battery metals price trends

### Exhibit 63: Lithium price

Lithium price has dropped since its peak in 2022

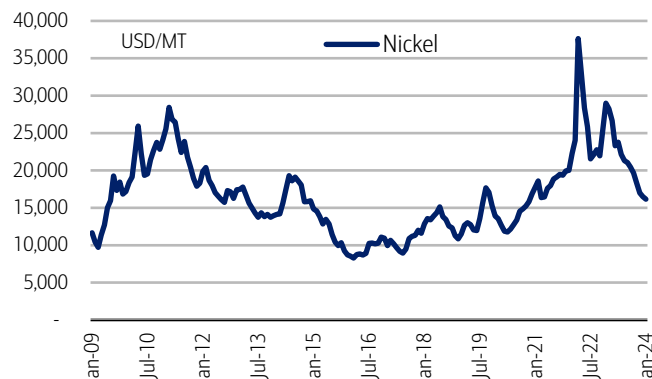


Source: Bloomberg, BofA Global Research

BofA GLOBAL RESEARCH

### Exhibit 64: Nickel price

Nickel price has decreased from its recent peak

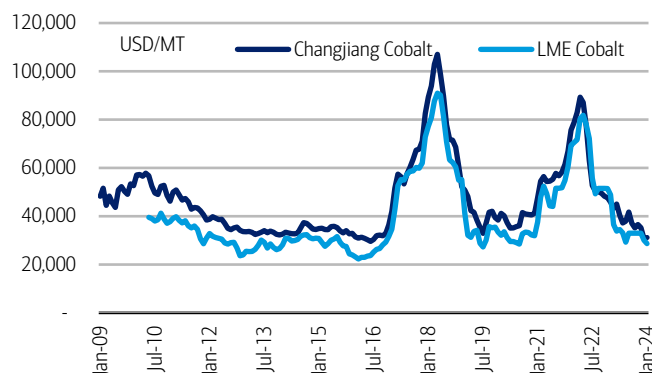


Source: Bloomberg, BofA Global Research

BofA GLOBAL RESEARCH

### Exhibit 65: Changjiang cobalt and LME cobalt prices

Changjiang cobalt and LME cobalt prices have dropped since 2022

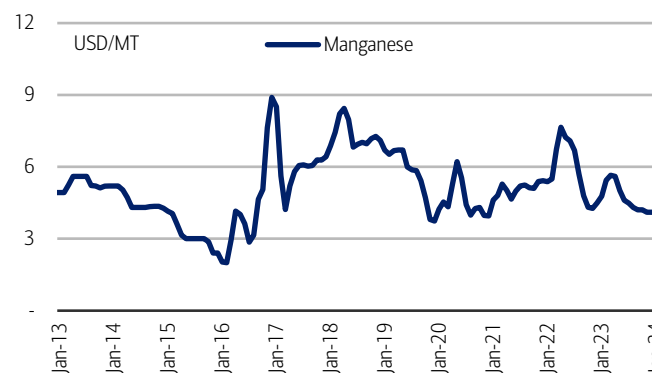


Source: Bloomberg, BofA Global Research

BofA GLOBAL RESEARCH

### Exhibit 66: Manganese price

Manganese price has been declining

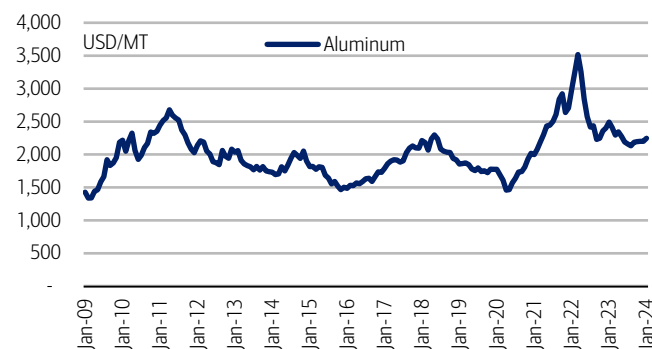


Source: Bloomberg, BofA Global Research

BofA GLOBAL RESEARCH

### Exhibit 67: Aluminum price

Aluminum price have moderated since its peak in 2022

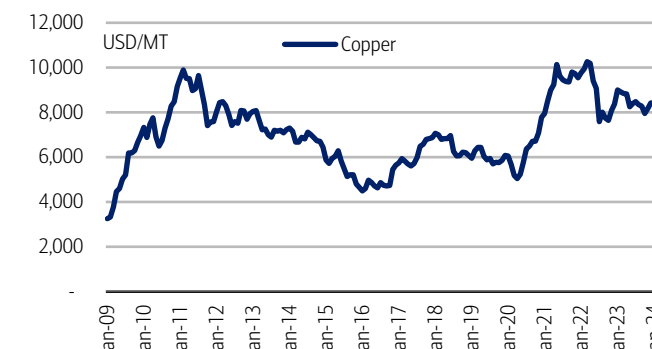


Source: Bloomberg, BofA Global Research

BofA GLOBAL RESEARCH

### Exhibit 68: Copper price

Copper price has been moderating recently



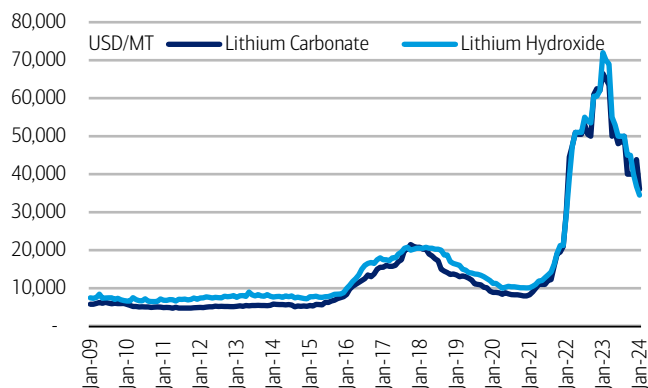
Source: Bloomberg, BofA Global Research

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## Battery chemical compounds price trends

### Exhibit 69: Lithium carbonate and hydroxide prices

Lithium hydroxide prices have been falling

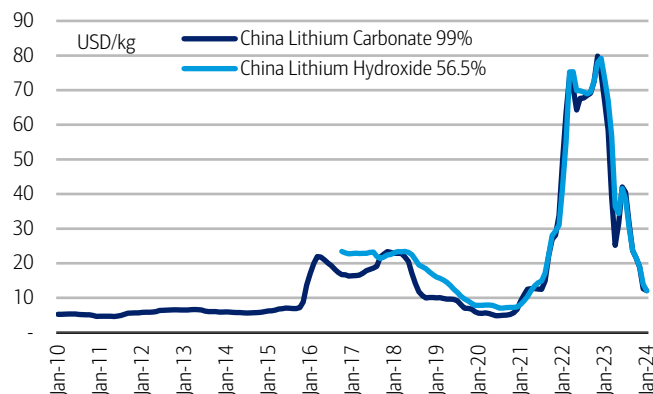


Source: Bloomberg, BofA Global Research

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### Exhibit 70: China Lithium carbonate 99%, hydroxide 56.5% prices

China Lithium carbonate and hydroxide prices have been falling

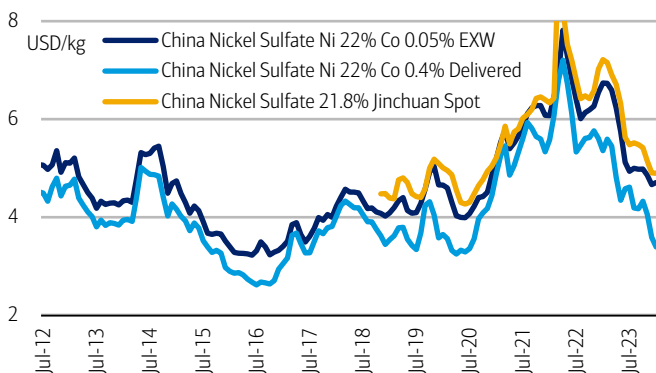


Source: Bloomberg, BofA Global Research

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### Exhibit 71: China nickel sulfate prices

China nickel sulfate prices have been falling

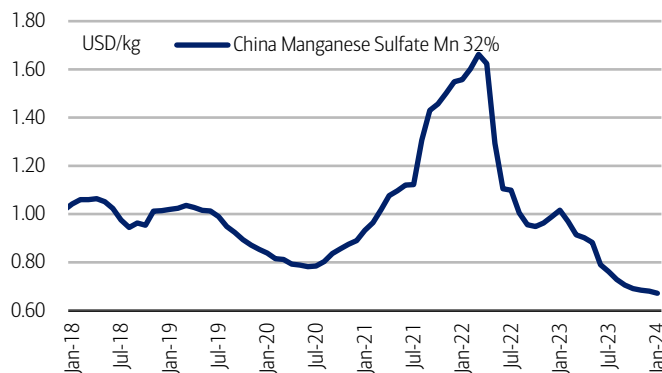


Source: Bloomberg, BofA Global Research

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### Exhibit 72: China manganese sulfate Mn price

China manganese sulfate Mn price continues a downtrend

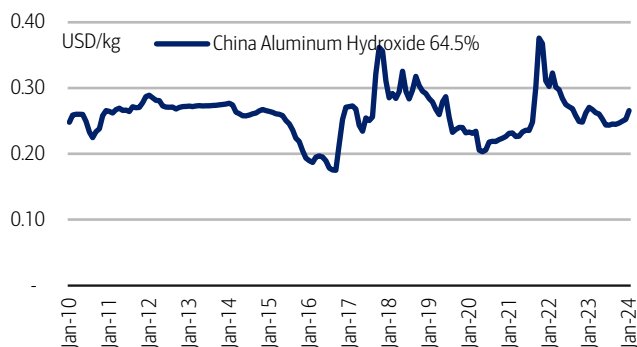


Source: Wind, BofA Global Research

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### Exhibit 73: China aluminum hydroxide 64.5% price

China aluminum hydroxide 64.5% price remained flattish QoQ

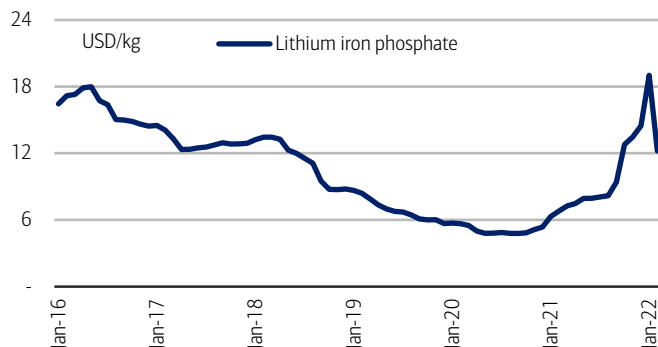


Source: Wind, BofA Global Research

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### Exhibit 74: Lithium iron phosphate price

Lithium iron phosphate price sharply decreased



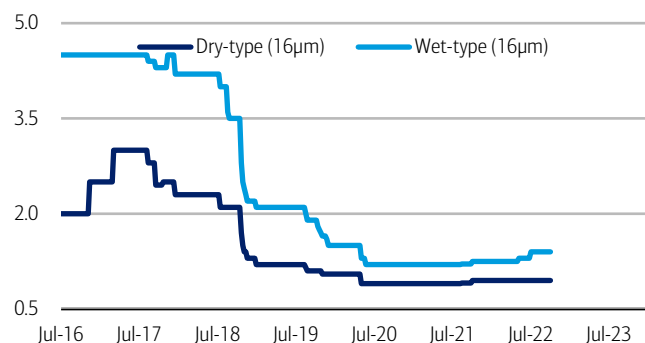
Source: Wind, BofA Global Research

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## Battery components price trends

### Exhibit 75: Separator price (RMB/m<sup>2</sup>)

Wet-type prices continue to have premium over dry type

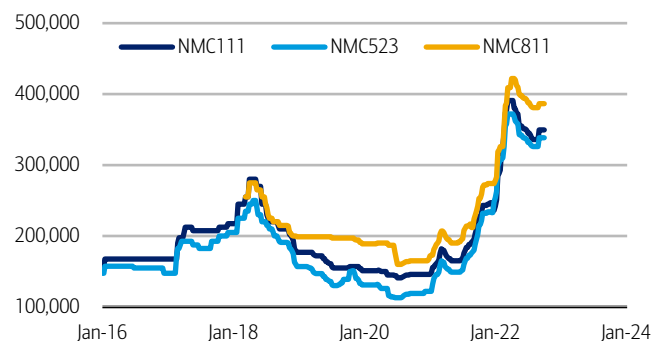


Source: Baiinfo

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### Exhibit 76: Cathode material price (Ternary, RMB/ton)

Cathode material price (Ternary, RMB/ton)

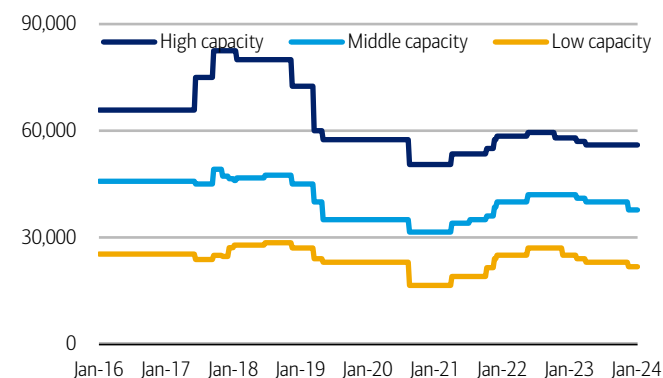


Source: Baiinfo

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### Exhibit 77: Anode material price (Natural graphite, RMB/ton)

Anode material price (Natural graphite, RMB/ton) remained flat MoM

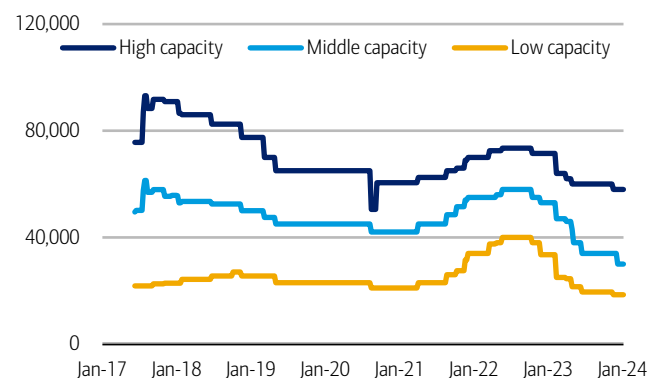


Source: Baiinfo

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### Exhibit 78: Anode material price (Artificial graphite, RMB/ton)

Anode material price (Artificial graphite, RMB/ton) stayed flat MoM

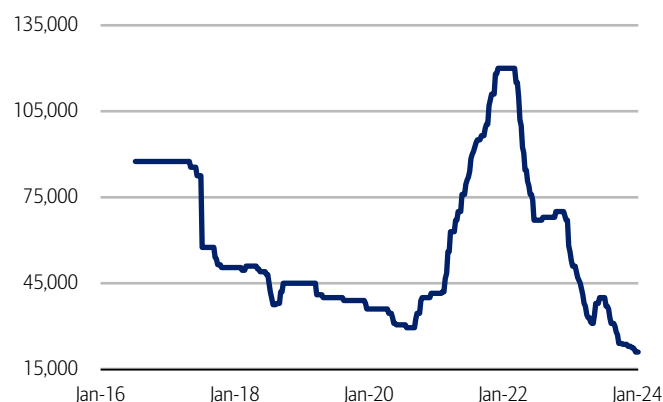


Source: Baiinfo

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### Exhibit 79: Electrolyte price (RMB/ton)

Electrolyte price (RMB/ton) decreased to recent low

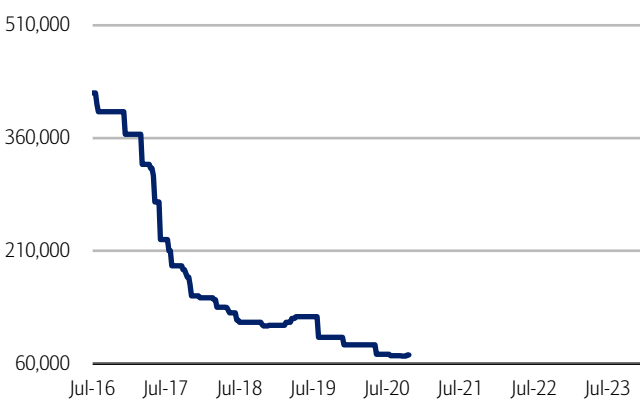


Source: Baiinfo

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### Exhibit 80: LiPF6 price (RMB/ton)

LiPF6 price (RMB/ton)



Source: Baiinfo

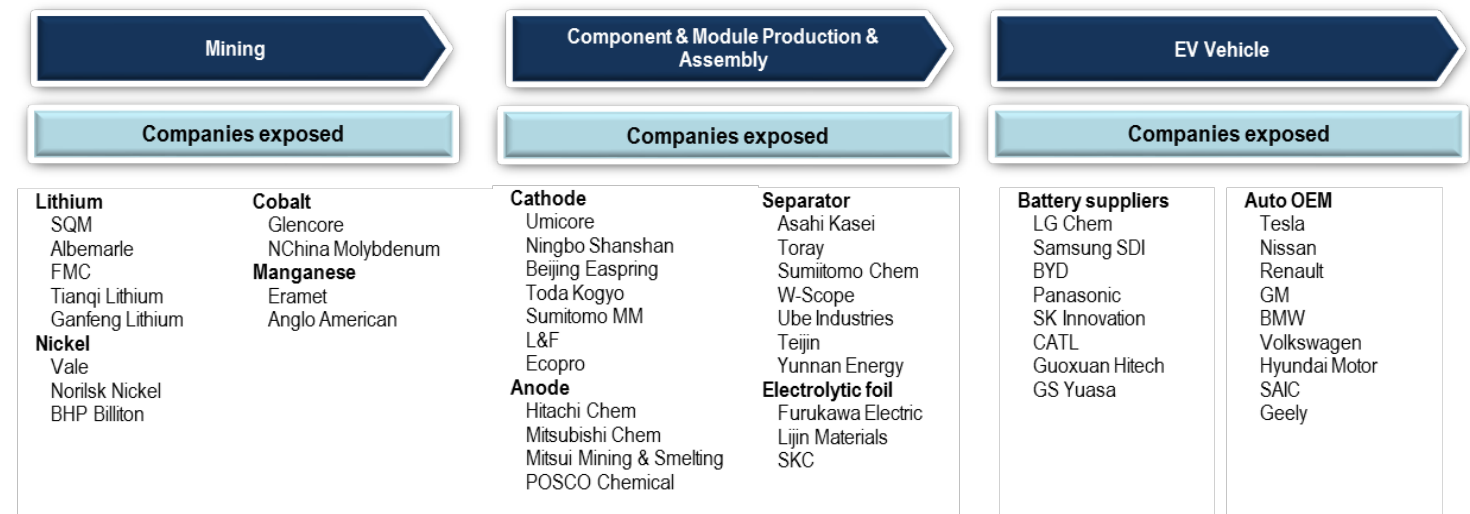
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# Appendices

## Main companies exposed to the EV battery value chain

### Exhibit 81: Main companies exposed to the EV battery value chain

We identified major companies in the global EV battery value chains from metals through EV OEMs

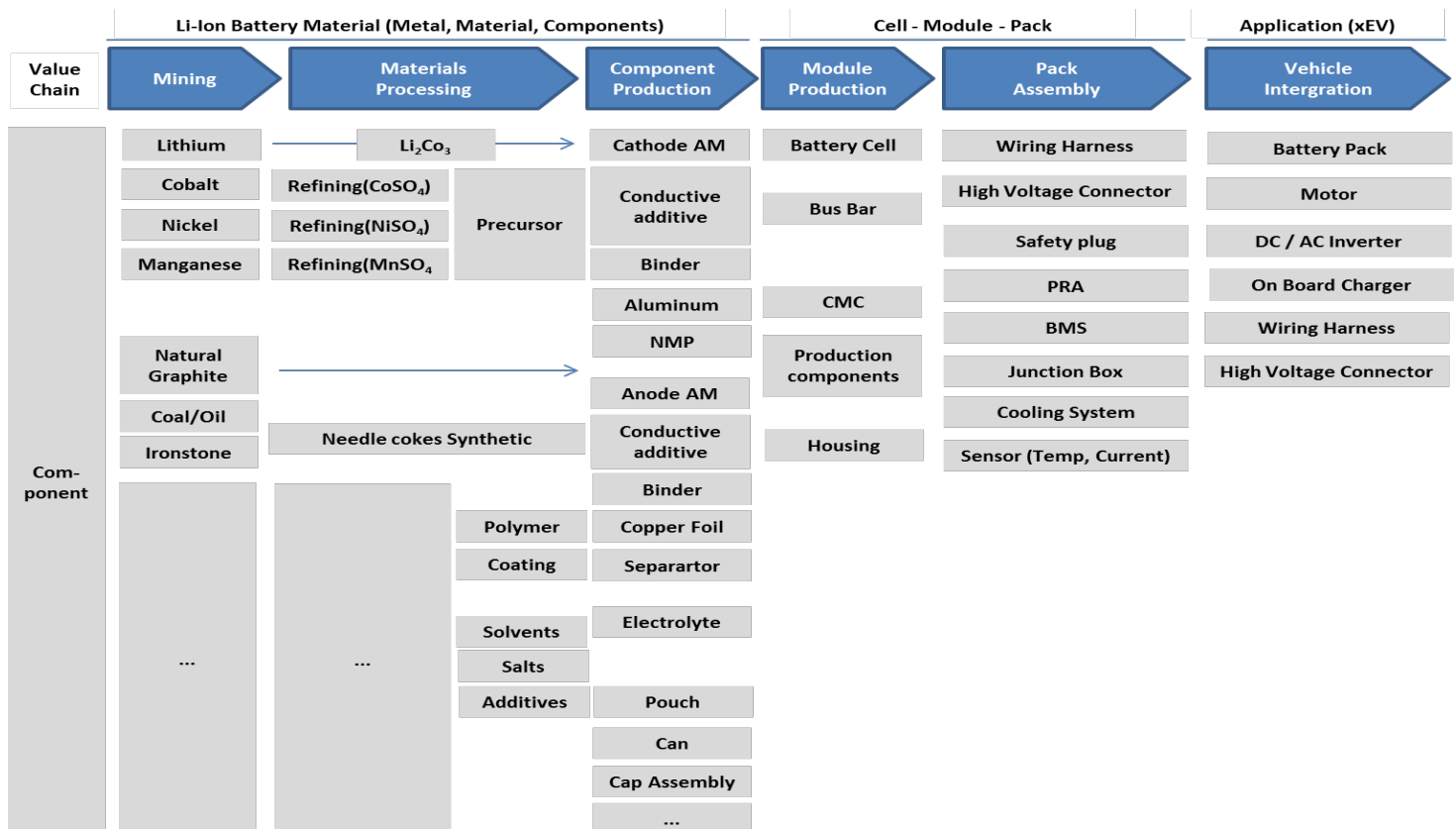


Source: BofA Global Research

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### Exhibit 82: Li-Ion battery supply chain from metal to EVs

Li-Ion battery supply chain from metal to EVs



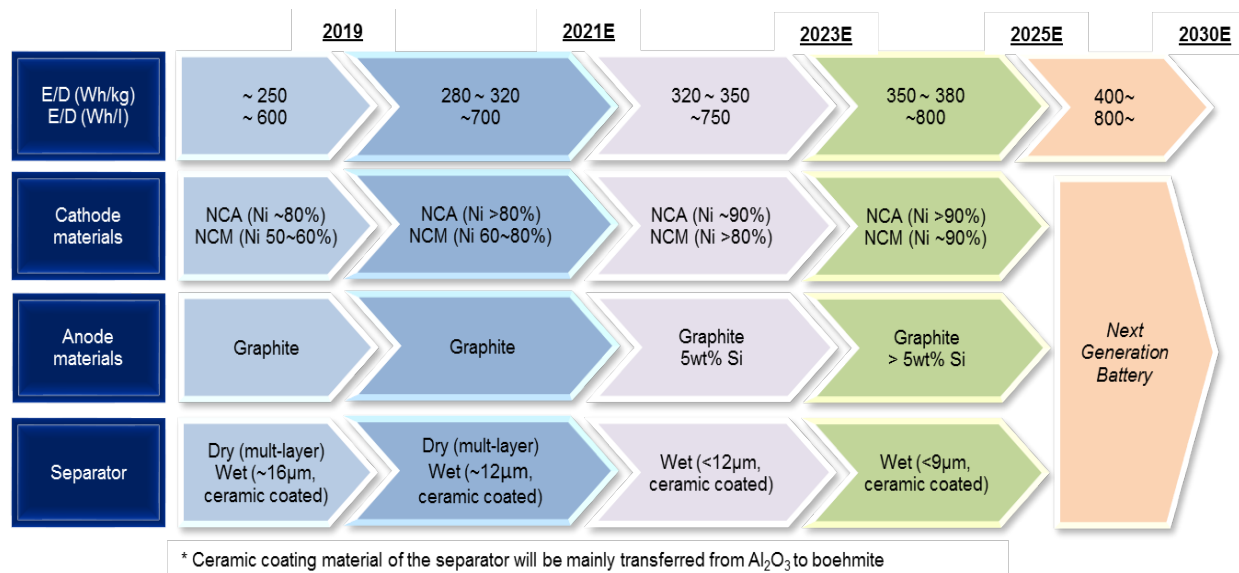
Source: SNE Research, BofA Global Research

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## Global battery materials suppliers

### Exhibit 83: Roadmap for EV battery technology through 2030E (major battery components and technologies)

Roadmap for EV battery technology through 2030E (major battery components and technologies)

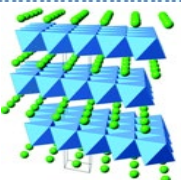
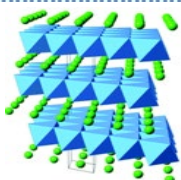
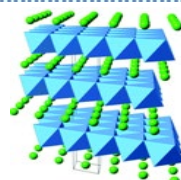
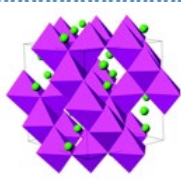
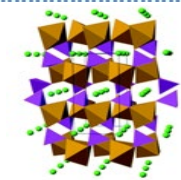
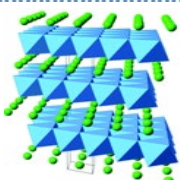


Source: SNE Research, industry data, BofA Global Research

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### Exhibit 84: Types of cathode materials for lithium ion batteries

Types of cathode materials for lithium ion batteries

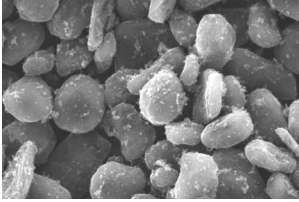
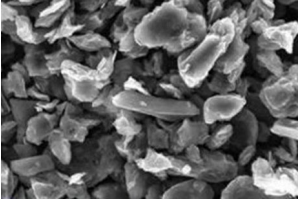
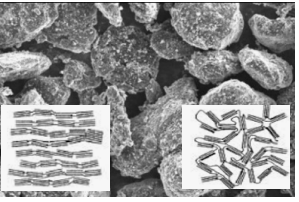
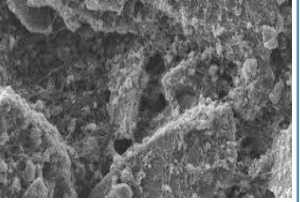
Types	LCO	NCM	NCA	LMO	LFP	NCMA
Molecular formula	LiCoO <sub>2</sub>	Li[Ni,Co,Mn]O <sub>2</sub>	Li[Ni,Co,Al]O <sub>2</sub>	LiMn <sub>2</sub> O <sub>4</sub>	LiFePO <sub>4</sub>	Li[Ni,Co,Mn,Al]O <sub>2</sub>
Structure						
	Layered	Layered	Layered	Spinel	Olivine	Layered
Energy density	145 mAh/g	140-220mAh/g	180-220 mAh/g	100 mAh/g	150 mAh/g	228 mAh/g
Voltage	3.8V	3.7V	3.7V	4.0V	3.2V	3.7V
Stability	High	Medium	Low	High	Very high	Very high
Life cycles	High	Medium	High	Low	High	High
Difficulties	Easy	Difficult	Difficult	Difficult	Difficult	Difficult
Applications	Small size	Small / large size	Small / large size	Mid-large size	Mid-large size	Small / large size
Major producers	L&F, Cosmo AM&T, Shanshan, Umicore, Nichia	L&F, EcoPro BM, Cosmo AM&T, POSCO Chemical, Umicore, Nichia	EcoPro BM, Sumitomo, Toda, Nichia	POSCO Chemical, Nichia, BYD	Shanshan, BYD, A123	L&F, POSCO Chemical, LG Chem, SVOLT

Source: BofA Global Research

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**Exhibit 85: Types of anode materials for lithium ion batteries**

Types of anode materials for lithium ion batteries

Types	Natural graphite	Synthetic graphite	Carbon-based	Silicon-based
Structure				
Raw materials	Natural graphite	Pitch/Cokes	Pitch/Cokes, resins	SiOx, Si carbon complex
Energy density (mAh/g)	350-370	270-360	200-300	800-1600
Power	Low	Medium	High	Medium
Life cycle	High	High	Medium	Low
Price (US\$/kg)	7-12	4-10	8-12	40-150
Advantages	High energy density	Longer life cycle	High power	High energy density
Major producers	POSCO Chemical, Aekyung Petrochemical, BTR, Shanshan, Hitachi, Nippon Carbon	POSCO Chemical, Hitachi, JFE, Mitsubishi, BTR, Nippon Carbon, Showa Denko, Tokai Carbon	Aekyung Petrochemical, Nippon Carbon, Hitachi Chemical, JFE, Kureha	Daejoo Electronic Materials, BTR, Shinetsu Chemical, OTC, Hitachi Chemical

Source: BofA Global Research

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**Exhibit 86: Global cathode material suppliers**

Global cathode material suppliers

Company	Ticker	EV battery materials	Core business
<b>China</b>			
Ningbo Shanshan	600844 CH	Cathode material	Men's fashion textile, advanced materials
Beijing Easpring	300073 CH	NCM cathode material (NCM532/622), lithium cobalt oxide	Lithium battery materials
Xiamen Tungsten	600549 CH	Cobalt oxide	Tungsten carbide manufacturing
China Zhenhua	000733 CH	NCM-type cathode materials	Battery materials, electric components
Pulead Tech	Private	LFP-type cathode materials	Lithium battery materials
Guoxuan High tech	Private	LFP-type cathode materials	Li ion battery materials, motors, switchgears
Shenghua	Private	LFP-type cathode materials	Agricultural chemicals, real estate
Ningbo Jinhe	Private	Cobalt oxide	Lithium battery materials
<b>Europe</b>			
Umicore	UMI BB	Cobalt oxide for NCM cathode, nickel sulfate	Advanced material and technology
BASF	BAS GR	NCM cathode material (NCM111/424/523)	Chemical producer (agri, construction, pharma etc)
Johnson Matthey	JMAT LN	LFP to Chinese buses, eLNO	Automotive and industrial catalysts
<b>Japan</b>			
Toda Kogyo	4100 JP	Lithium cobaltate, Lithium-nickel oxide, Lithium manganate	Electronic printing, EMC, digital media materials
Sumitomo MM	5713 JP	Nickel hydroxide and lithium nickelite	Mining mineral
Tanaka Chem	4080 JP	Nickel hydroxide, cobalt carbonate	Lithium ion battery materials
Mitsui M&S	5706 JP	LMO and NCM, battery-use zinc powder	Engineered materials, metals, auto parts
Nippon Denko	5563 JP	Lithium manganese oxide	Ferro alloys, metals
Nikkasan	4094 JP	NCA cathode material, Nickel compounds	Chemical materials, construction materials
Sumitomo Chem	4005 JP	Cathode material	Petrochemical and plastics, PI film
Sumitomo Osaka	5232 JP	Lithium iron phosphate	Cement, advanced materials, optoelectronics
Nichia	Private	Lithium manganate, LMO and NCM cathode materials	UV LED, semi materials, chemical engineering
<b>Korea</b>			
L&F	066970 KQ	Lithium cobaltate, lithium nickel manganese cobaltate	EV battery material
Ecopro	086520 KQ	NCA, NCM cathode material, lithium carbonate	Environmental materials, battery materials
LG Chem	051910 KS	NCM cathode material, separator, battery cell	Polymer petrochemicals, electronic materials

Source: BofA Global Research, Bloomberg,

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**Exhibit 87: Global anode materials suppliers**

Global anode materials suppliers

Company	Ticker	EV battery materials	Core business
<b>Japan</b>			
Hitachi Chem (RSTR)	4217 JP	Artificial graphite, anode material	Semi/display materials, films, resins
Mitsubishi Chem	4188 JP	Natural and artificial based graphite material	Industrial products, semis/display materials, films
Showa Denko	4004 JP	Anode, graphite electrode	Petrochemicals, resins, industrial gases
Nippon Carbon	5302 JP	Anode, graphite electrode	Carbon fiber products
Kureha	4023 JP	Anode material	Specialty chemicals/plastics/materials
Tokai Carbon	5301 JP	Graphite electrode	Graphite materials
Mitsui M&S	5706 JP	Hydrogen storage alloy for nickel hydride battery anodes	Engineered materials, metals, auto parts
<b>China</b>			
China Baoan	000009 CH	Silicon oxide anode material, natural graphite	Heat conductive materials, advanced materials
Shan shan Tech	Private	Artificial graphite electrodes, silicon oxide	Anode materials, (subsidiary of Ningbo Shanshan)
BTR New Energy	Private	Anode, graphite electrode	Carbon and graphite materials
<b>Korea</b>			
Posco Future M	003670 KS	Natural graphite anode material	Coal chemicals
Iljin Materials	020150 KS	Graphite composite electrode	Electric foil for PCB
Power Carbon Technology	Private	Anode material	JV of GS-Caltex and JX NOE
<b>US/Europe</b>			
SGL Carbon	SGL SE	Graphite anode materials, carbon composite anode materials	Carbon-related products, graphite products
Graftech Intl	Private	Artificial graphite electrodes	Global leader in graphite electrodes

Source: BofA Global Research, Bloomberg. RSTR = Restricted.

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**Exhibit 88: Global separator material suppliers**

Global separator material suppliers

Company	Ticker	EV battery materials	Core business
<b>Japan</b>			
Asahi Kasei	3407 JP	Separator (polyolefin flat-film membrane)	Fibers, electronic materials, construction materials
Toray	3402 JP	Separator film	Industrial products
Sumitomo Chem	4005 JP	Separator tape	Petrochemical and plastics, PI film
W-Scope	6619 JP	Separator film	Li-ion battery materials
Ube Industries	4208 JP	Separator film	Various chems incl. OLED
Teijin	3401 JP	Separator	High-performance fibers, carbon fibers
<b>US</b>			
Polypore	Private	Separator, membrane	(Acquired by Asahi Kasei) Li batteries
<b>Korea</b>			
SK Innovation	096770 KS	Separator	Refining, chemicals (aromatics), E&P, lubricants
<b>China</b>			
Cangzhou Mingzhu	002108 CH	Separator	Polyethylene gas and pipes
Suzhou Victory Precision	002426 CH	Separator	Structure modules, precision plastic components
Yunnan Yuntianhua	600096 CH	Separator	Fertilizer products, chemical products
Zhejiang Great SE	002263 CH	Separator	Polypropylene, PE plastic, capacitor, solar PV cells
Zhejiang Nanyang Tech	002389 CH	Separator	Capacitor film, solar cell backing films
Sinoma S&T	002080 CH	Separator	Specialty fiber composites
Jiangsu Jiujiujiu Tech	Private	Separator	Pesticides and fertilizers

Source: BofA Global Research, Bloomberg

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**Exhibit 89: Global electrolyte and electrolyte solution suppliers**

Global electrolyte and electrolyte solution suppliers

Company	Ticker	EV battery materials	Core business
<b>Japan</b>			
Mitsubishi Chem	4188 JP	Formulated electrolyte for lithium ion batteries	Industrial products, semis/display materials
Ube Industries	4208 JP	Dimethyl carbonate-based electrolyte for batteries	Various chems incl. OLED
Nippon Shokubai	4114 JP	Lithium bis (fluorosulfonyl) imide electrolyte	Acrylics, performance chemicals
Central Glass	4044 JP	Additives for electrolytes	Glass products, fine chem
Kanto Denka	4047 JP	Electrolyte (lithium hexafluorophosphate)	Semi/display materials, optical fibers
<b>Korea</b>			
Soulbrain	036830 KQ	Electrolytes and electrolyte solution	Etchants for semis/display/battery
Foosung	093370 KS	Electrolyte (LiPF <sub>6</sub> , LiBF <sub>4</sub> , LiPO <sub>2</sub> F <sub>2</sub> )	Coolants, refrigerants
SK Chemicals	006120 KS	Electrolyte additives	Green chemicals, life science, LPG gas

**Exhibit 89: Global electrolyte and electrolyte solution suppliers**

Global electrolyte and electrolyte solution suppliers

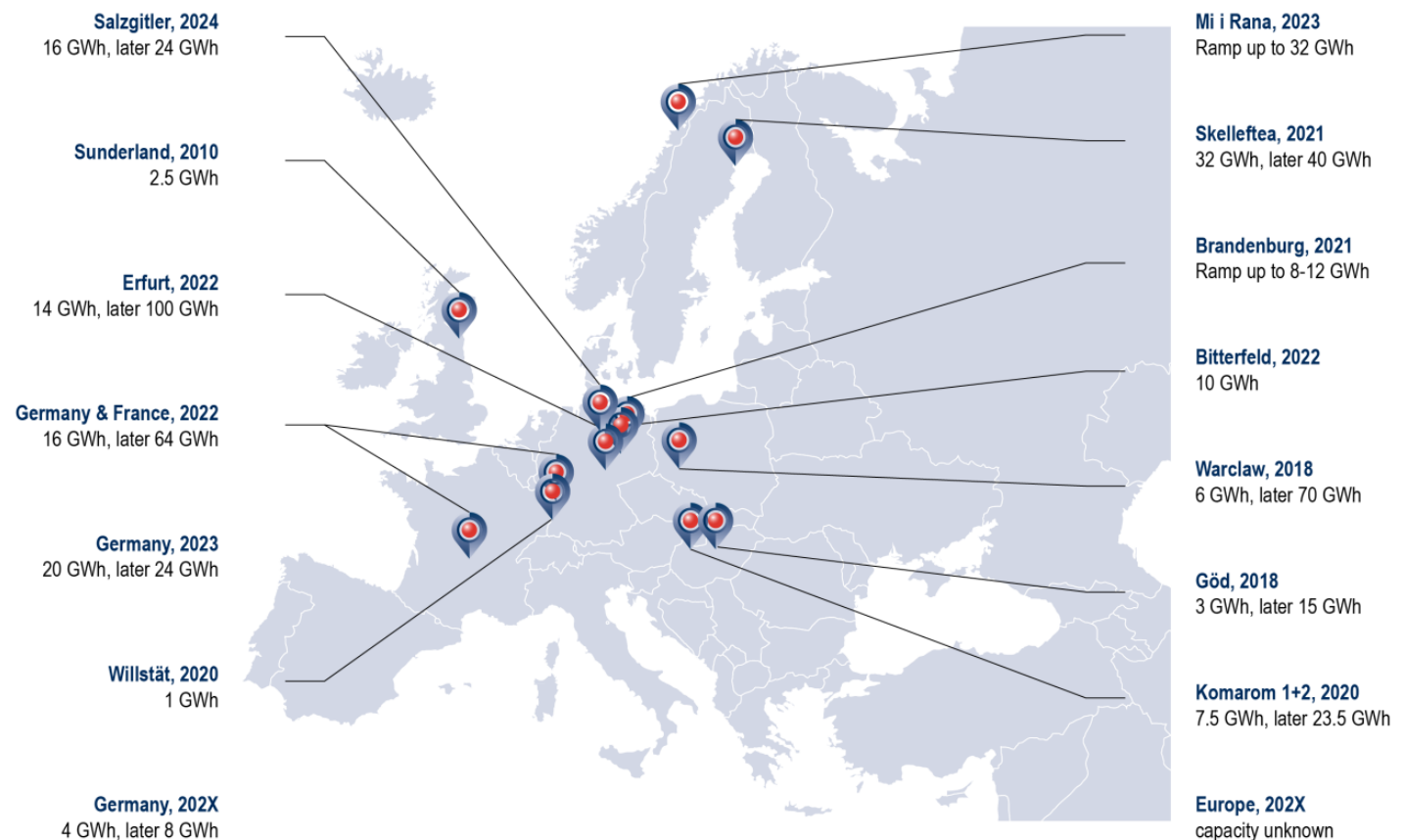
Company	Ticker	EV battery materials	Core business
<b>US</b>			
UDC	OLED US	Electrolyte	OLED emitter materials and patents
Stella Pharma	Private	Electrolyte	Pharmaceuticals
Novolyte Tech	Private	Electrolyte formulations for lithium ion batteries	subsidiary of BASF
<b>China</b>			
Shenzhen Capchem Tech	300037 CH	Electrolyte solution	Li-ion battery, organic chem, semi materials
Guangzhou Tinci	002709 CH	Electrolyte solution	Fine chem and new materials
Do-Fluoride Chem	002407 CH	Electrolyte (LiPF <sub>6</sub> )	Inorganic fluoride products
Huzhou Chuangya Power	Private	Cathode, anode, electrolyte materials	Electrolyte (subsidiary of Ningbo Shanshan)
Jiangsu Jiujiju Tech	Private	Electrolyte salt maker	Pesticides and fertilizers

Source: BofA Global Research, Bloomberg

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**Exhibit 90: Europe battery production plan by major EV battery producers/OEMs**

Europe battery production plan by major EV battery producers/OEMs



Source: Electrios, BofA Global Research

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# Disclosures

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Investment rating	Total return expectation (within 12-month period of date of initial rating)	Ratings dispersion guidelines for coverage cluster <sup>R1</sup>
Buy	≥ 10%	≤ 70%
Neutral	≥ 0%	≤ 30%
Underperform	N/A	≥ 20%

<sup>R1</sup> Ratings dispersions may vary from time to time where BofA Global Research believes it better reflects the investment prospects of stocks in a Coverage Cluster.

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