

Global Energy Storage

Global Energy Storage: Can lithium supply keep pace with the relentless growth in Li-ion battery demand?



Neil Beveridge, Ph.D.
+852 2918 5741
neil.beveridge@bernstein.com



Brian Ho, CFA
+852 2918 5772
brian.ho@bernstein.com



Jenny Ku
+852 2918 5279
jenny.ku@bernstein.com

For lithium-ion battery makers, lithium supply is the biggest risk in the supply chain. While lithium capacity growth is set rise in the near term, growth in Li-ion battery demand at current rates of 70% y-o-y will keep the market balanced. Looking ahead, despite the growth in lithium supply, strong demand growth is expected to keep lithium markets tight. Battery makers with secure access to lithium supply should do better.

Lithium spot prices appear to have peaked at c. US\$70/k ton but remain at an elevated levels. In China, lithium carbonate inventories remain at trough levels.

Over NTM, there will be an increase in Li production capacity starting up. Capacity could grow at a rate at 60-80kt LCE per quarter in the next few quarters which is higher than the 50k per quarter over LTM. Assuming a utilization of 80%, supply growth could be close to 60k per quarter. Near term capacity growth comes from the ramp-up of existing projects in W. Australia, but will be dominated by Latin America in 2023 which is higher risk.

Despite the growth in supply, stronger than expected EV demand growth is keeping the lithium market tight. In the short term, we expect lithium demand to grow at c. 60kt LCE per quarter based on current 60% y-o-y EV growth. This will keep the market tight and could keep prices at current level of c. \$70k/t. On the other hand, if EV demand growth slowed to 40% then it is possible we could see a downside to lithium prices.

Over the next 3 years, lithium demand will more than double to 1,275kt LCE. In our rapid adoption case (which is more likely), rising EV penetration will drive lithium demand for EV batteries to increases from 530kt LCE in 2021 to 1,275kt LCE by 2025.

Planned capacity growth through to 2025 will struggle to keep up with demand. Over the next 3 years average global lithium capacity will grow from 702kt LCE to 1,645kt LCE. Australia will remain the largest supplier of lithium with 627kt LCE in 2025 (35% of total) followed by China which is expected to be the fastest growing supplier in the next 5 years overtaking Chile as second largest producer. Assuming an 80% utilization rate this should yield 1300kt LCE supply which is barely sufficient to cover demand.

In terms of incremental production capacity, only 50% will come from the top 5 lithium producers today with a significant component coming from 'others' which leaves a degree of uncertainty as to how much will actually be delivered on schedule.

We expect refining capacity is sufficient to meet rising lithium mining production and demand. Lithium refining capacity currently stands at 981kt LCE and is set to grow to 1949kt by 2025. This should be enough to cover the rapid case for lithium demand (1275kt LCE) and expected lithium mining capacity (1769kt LCE) in 2025.

For battery makers lithium supply remains a risk to growth and margins. CATL and LGES have been leaders in signing up lithium supply and look better positioned in the event of shortages. Ensuring however full pass through of costs will be key to maintaining margins.

BERNSTEIN TICKER TABLE

Ticker	Rating	11 Aug 2022			TTM	Reported EPS			Reported P/E (x)			
		Closing Price	Target	Rel.		2021A	2022E	2023E	2021A	2022E	2023E	
		Price	Target	Perf.								
300750.CH (CATL)	O	CNY	510.00	600.00	20.7%	CNY	6.84	5.03	12.16	74.6	101.5	41.9
051910.KS	O	KRW	658,000	1,050,000	(6.0)%	KRW	49,107	37,603	44,079	13.4	17.5	14.9
373220.KS	M	KRW	472,000	400,000	NA	KRW	3,963.00	3,460.71	6,045.71	119.1	136.4	78.1
006400.KS (SDI)	O	KRW	619,000	816,000	(5.2)%	KRW	17,855	24,154	32,213	34.7	25.6	19.2
MXAPJ			531.22				37.37	41.09	44.59	14.21	12.93	11.91

O - Outperform, M - Market-Perform, U - Underperform, N - Not Rated

Source: Bloomberg, Bernstein estimates and analysis.

INVESTMENT IMPLICATIONS

There are two very different views of the lithium market. One is that lithium is abundant and that with prices at 5x the marginal cost, prices must fall back to marginal cost as high margins incentivize new supply. The other view is that the lithium market will be structurally tight for a long period of time, which could mean it's higher for longer for lithium prices with potential shortages in supply. While it is unusual for a commodity to trade at a multiple of the marginal cost, it can happen under exceptional supply and demand scenario's. One only needs to look at spot LNG and gas prices which are trading close to 10x marginal cost as a result of Russian cuts in gas supply. What ultimately matters is supply and demand today and perceptions of how this will evolve in the future.

For lithium-ion battery makers, lithium supply is arguably the biggest risk in the supply chain and high prices have dented margins for CATL and LGES in 2022. The CEO of Albemarle this week commented 'for seven to eight years it stays pretty tight'. As with many other large capital projects, delays and shortfalls in production are not uncommon, not least when Latin America and Western Australia are the primary supply centers. As the CEO of Albemarle put it, lithium companies have historically delivered 25% less production than promised. While he may be somewhat biased, the Chairman of CATL (the largest battery maker in the world) has also raised concerns on lithium supply at NPC meetings this year. Indeed, CATL have been the pioneer in developing Na-ion batteries as an alternative to lithium, given some of the supply chain challenges.

From our review of the lithium market we make the following observations. In the short term there is certainly more supply reaching the market, although whether all of it will be delivered is another issue. But if EV demand continues to grow at 60% or more, the market will remain tight. If on the other hand, EV demand growth slows to 40% or below, then in the short term it is likely that the market will be oversupplied and there could be a chance of a pull-back in prices. Year to date, battery demand is growing at 63%. More longer term, the market remains tight and much depends on EV growth. In our rapid adoption scenario, there is little room for project delays to keep up with expected demand.

For battery makers lithium supply remains a risk to growth and margins. Most major battery makers (CATL, LGES, SDI) have taken steps to lock in upstream lithium supply, but not enough to fully cover production. We see lithium refining as less of a risk given growth in nameplate capacity, which exceeds mining capacity, although we note that much of lithium refining capacity is based in China. While battery makers and the EV industry would benefit from a material (50%) pull back in lithium price, unless there is a slowdown in EV demand, this does not seem likely in the near future.

Related notes:

[Global Energy Storage: How big a risk is lithium supply to the battery supply chain?](#)

[Global Energy Storage: Is battery cell supply enough to meet rising EV demand?](#)

[Global Energy Storage: Pedal to the metal. Which metals are poised to shine in the EV revolution](#)

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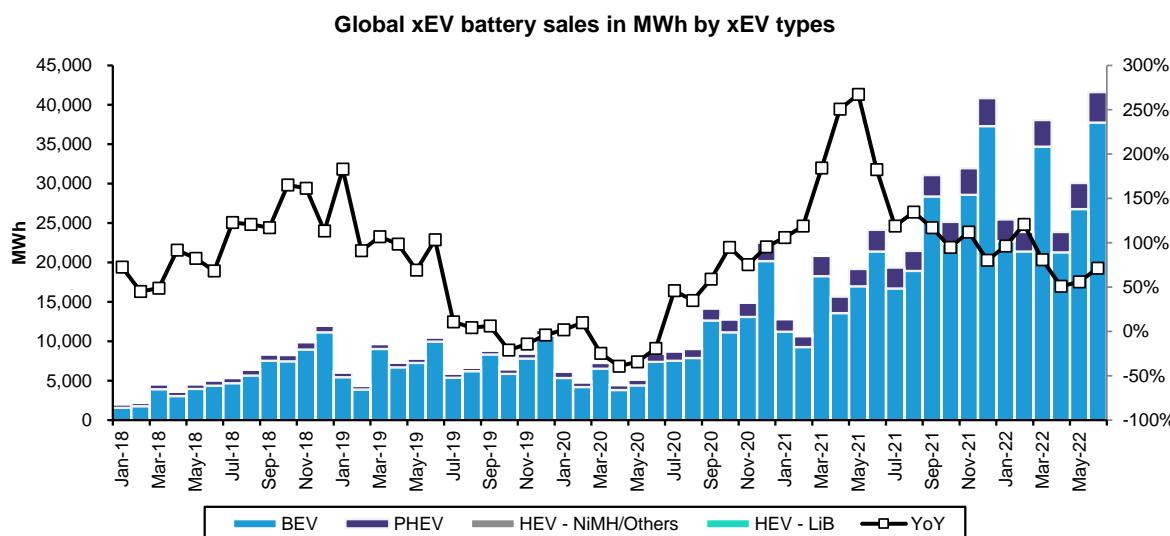
DETAILS

SHORT TERM OUTLOOK

SUPPLY AND DEMAND

The rise in demand for energy storage and lithium-ion batteries has driven up demand for mined lithium and lithium refined products at a record pace. While lithium supply has been able to keep pace with demand in previous years, the rapid development of the EV industry over the past year has led to demand outpacing supply. As a result, lithium carbonate and lithium hydroxide prices have increased from US\$15k per ton to US\$80k per ton, an increase of 500%. Prices have remained largely elevated at around \$70k/t which is well above marginal cost (c. US\$10k per ton), allowing lithium miners and refiners to generate historical high profit margins.

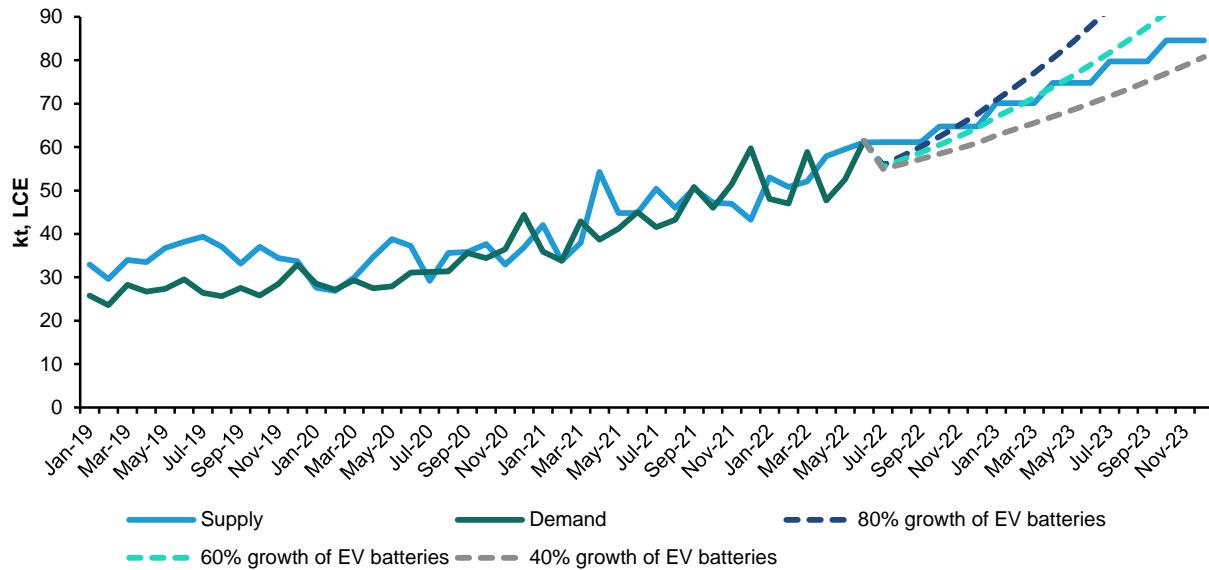
EXHIBIT 1: Total Li-ion battery sales have grown at 77% YTD which is keeping up pressure on lithium supply



Source: SNE Research, Bernstein analysis

The outlook for lithium prices is highly dependent on the supply and demand balance going forward. We project lithium demand in next 18 months based on three scenarios (40%, 60% and 80% CAGR of EV batteries growth). For perspective, EV batteries demand have grown at 77% y-o-y year to date. Based on our expected global lithium capacity expansion and utilization, lithium supply will likely remain tight if the demand growth from EV batteries comes around 60% or higher. This could keep prices at current level of \$70k/t over a longer period. On the other hand, we expect downside to lithium prices if EV growth slows to 40% as the market would seem to be in an oversupplied situation.

EXHIBIT 2 : We expect short term lithium markets to remain tight if EV demand maintains current pace (>50% growth) which will keep prices elevated. Lithium prices will see downside if demand growth slows to 40%



Source: Companies, Bloomberg, SNE, Wind, Government of Western Australia, Bernstein estimates and analysis

Exhibit 3 shows our short term lithium supply and demand outlook. Since the beginning of 2022, the total demand for lithium has increased from around 50kt LCE per month to around 60kt LCE in June. Supply has just about been able to keep up, but only just. Recent supply growth has come from Australia and China in recent quarters with the global utilization rate jumping from 70% to a record 85% in June. Assuming EV demand maintains its current pace of 60% growth in the short term, then monthly lithium demand could rise to 60-70kt LCE versus expected supply of 60-65kt LCE in coming months. This implies that lithium supply will remain tight. On the other hand, if EV demand growth falls to 40%, then we expect the lithium market to be adequately supplied.

EXHIBIT 3 : Supply and demand table (monthly, 60% growth in EV batteries)

Units	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	
Demand																			
LCE demand																			
kt LCE	19	21	28	24	29	37	25	24	36	25	30	38	31	33	45	38	46	60	
kt LCE	22	22	22	22	22	22	23	23	23	23	23	23	23	23	23	23	23	23	
Total	kt LCE	42	43	51	46	51	60	48	47	59	48	52	61	53	56	68	61	69	83
LCE demand Growth	%	97%	112%	102%	83%	95%	63%	88%	111%	76%	53%	58%	71%	60%	60%	60%	60%	60%	
LCE demand Growth																			
Capacity																			
Total																			
kt LCE	60	60	60	64	64	64	67	67	67	71	71	71	76	76	81	81	81	81	
Supply																			
Australia	22	22	22	21	21	21	22	22	22	27	27	27	27	27	27	27	27	27	
Chile	15	10	15	12	14	11	19	19	17	18	18	18	18	18	18	18	18	18	
China	9	9	7	9	7	7	7	7	8	9	10	10	12	12	12	12	12	12	
Argentina	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
RoW	3	3	3	3	2	2	3	1	1	1	1	1	1	1	1	1	1	1	
Total	kt LCE	50	46	50	47	47	43	53	51	50	57	59	60	61	61	61	65	65	65
S/D Balance																			
kt LCE	9	3	0	1	-4	-17	5	4	-9	10	6	-2	8	5	-7	4	-5	-18	
Utilization																			
%	84%	77%	84%	74%	73%	67%	79%	76%	74%	80%	82%	84%	80%	80%	80%	80%	80%	80%	

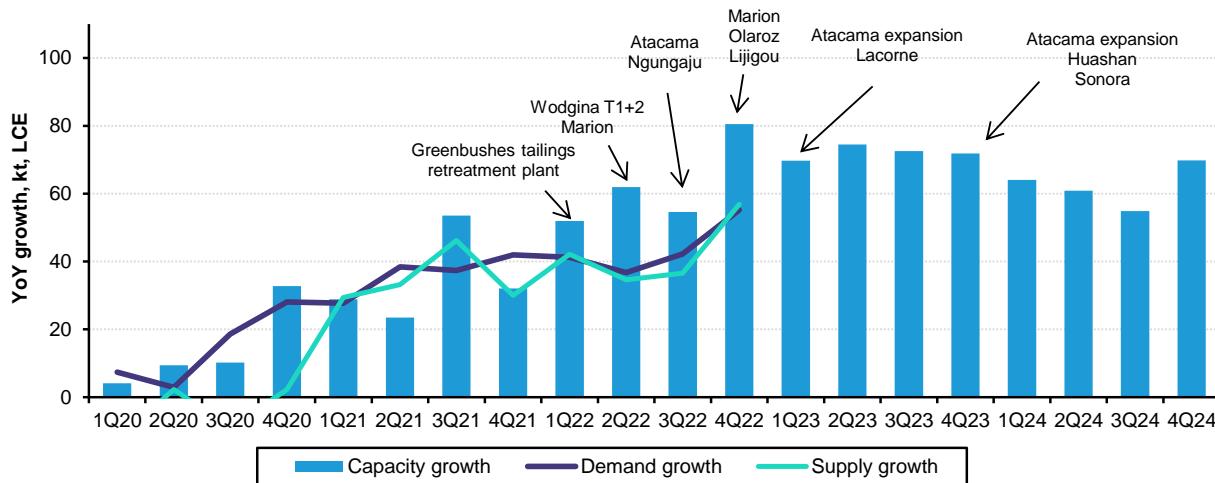
Source: Companies, Bloomberg, SNE, Wind, Government of Western Australia, Bernstein estimates and analysis

SHORT TERM CAPACITY

Over the coming quarters, we see a significant wave of new capacity coming onto the market across key lithium mines in Chile, Argentina and Australia. Most of the growth in 2022 will come from Australian spodumene mines, while salt brine deposits from Latin America will also contribute to the capacity additions in 2023.

While demand is growing at a pace of 50-60kt LCE per quarter (60% EV growth), new capacity could increase at a faster rate at around 60-80kt LCE per quarter in the next two quarters, assuming projects start up and ramp up as expected. As such, this could keep prices stable or even push them slightly lower in the next few quarters especially if demand growth slows. Again the key question becomes whether supply will come on as expected.

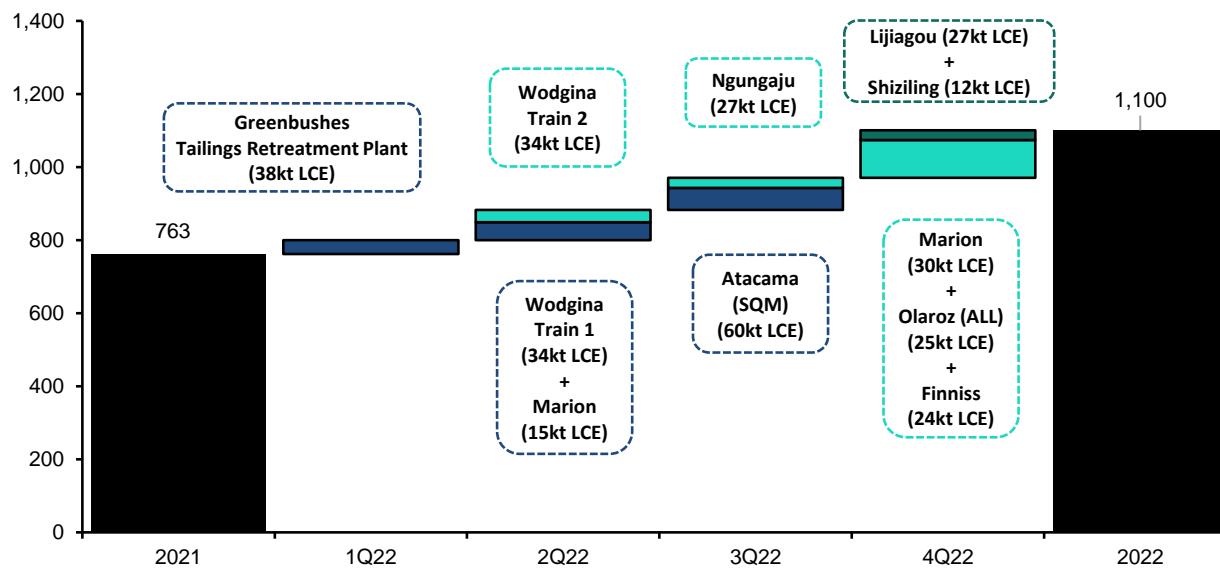
EXHIBIT 4 : We see a significant wave of new capacity coming onto the market at 60-80kt LCE which could help with the supply tightness in recent months



Source: Bloomberg, SNE, Wind, Government of Western Australia, Companies, Bernstein analysis

The majority of supply growth in 2022 comes from the ramp-up of operating projects (Greenbushes, Marion and Atacama). These projects have a fairly high level of certainty given the projects sponsors involved. Capacity expansion will also come from the restart of Mt Wodgina and Mt Ngungaju (Mt Altura), where only some plant and operational modifications are required to produce more spodumene.

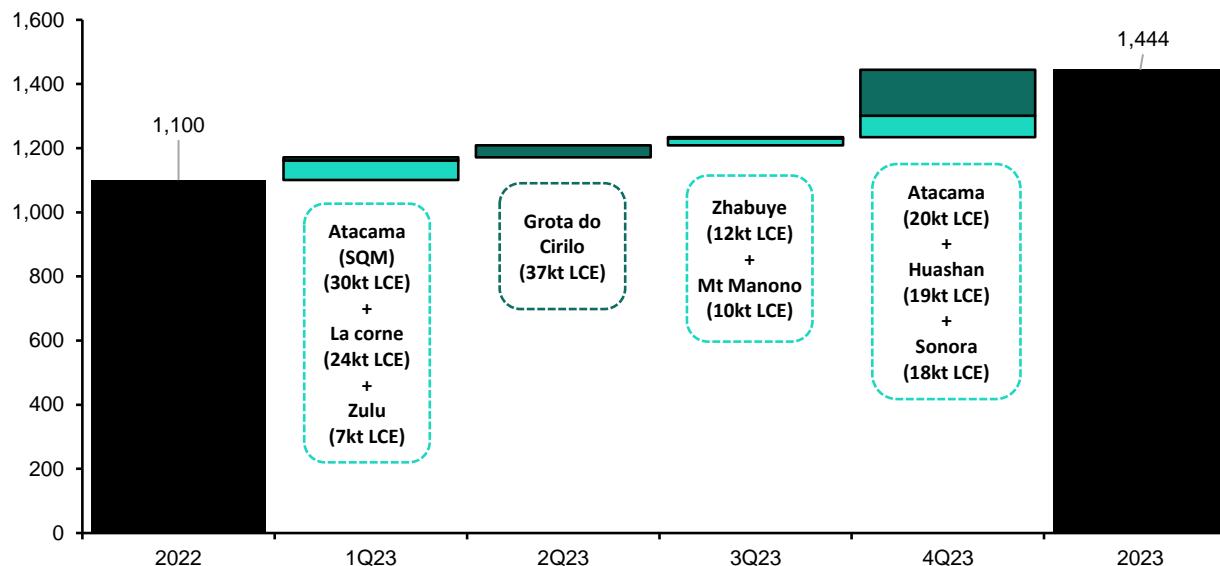
EXHIBIT 5 : 2022 nameplate capacity expansion- growth mainly comes from major mining projects which have a fairly high level of certainty coming online (in kt LCE)



Source: Companies, USGS, Bernstein estimates and analysis

Growth in 2023 will be largely driven by salt brine projects in Latin America. SQM and Albemarle are working to upgrade the capacity of their projects in Atacama, and the company's guidance of the production plan has been raised in the most recent quarter. Some other large-capacity projects like Grotto do Cirilo in Brazil and La corne in Canada will start production in 2023, increasing the lithium supply from new countries, but also leaving a degree of uncertainty as to how much will actually be delivered on schedule.

EXHIBIT 6 : 2023 nameplate capacity expansion- more projects in Salt Lakes contribute to the robust growth in 2023 although some of this are less certain (in kt LCE)



Source: Companies, USGS, Bernstein estimates and analysis

CAPACITY UTILIZATION

In 2021 lithium supply based on exports from key producers (Australia and Latin America) and production from China came in at 542kt LCE in 2021 (+34% y-o-y). Supply growth of 139kt LCE was almost sufficient to cover the lithium demand growth of 145kt LCE, but not quite. Almost all the supply growth came from established countries of Australia, China, and Chile with new projects ramping up.

EXHIBIT 7 : Lithium supply by region

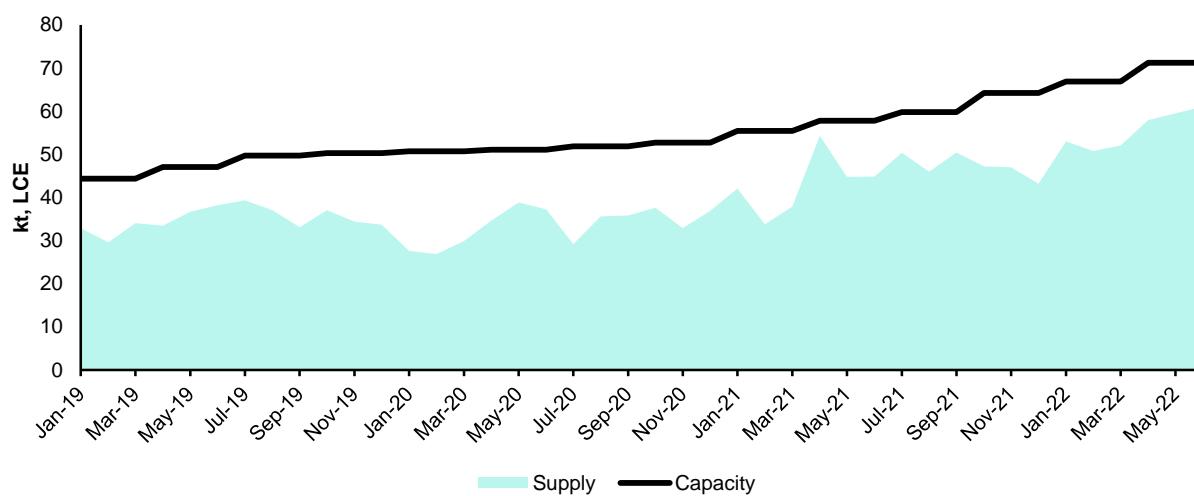
Lithium supply		2019	2020	2021	%YoY	% of 21
	kt LCE					
Australia	kt LCE	220	187	247	32%	46%
China	kt LCE	59	63	95	51%	18%
Chile	kt LCE	92	109	149	36%	27%
Argentina	kt LCE	18	17	22	29%	4%
RoW	kt LCE	30	27	29	8%	5%
Total	kt LCE	420	403	542	34%	100%

Source: Bloomberg, Government of Western Australia, Wind, Bernstein analysis

1) Southern America - exporting data, 2) Australia - operators' quarterly activity result, 3) China - SMM

Global monthly supply of lithium reached all-time high of 60kt LCE in June this year. This implies a utilization of around 85% based on our estimate of nameplate capacity.

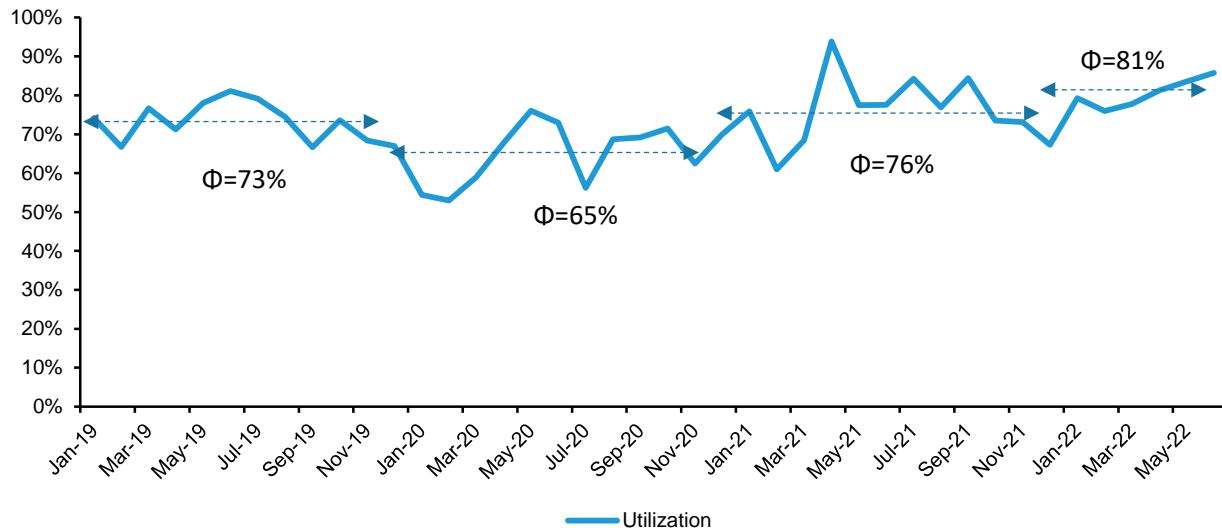
EXHIBIT 8 : Supply reached historical high of 60kt LCE in June. Utilization is increasing with supply rising faster than capacity growth



Source: Bloomberg, Government of Western Australia, Wind, Bernstein analysis

Lithium mine utilization fell to a low of 50% in April 2020 during the COVID-19 pandemic. Utilization recovered quickly since then to over 70% later in the year. With demand outpacing capacity growth, utilization has increased to above 80% and stayed at current levels in recent months in response to very high lithium prices and record gross margins.

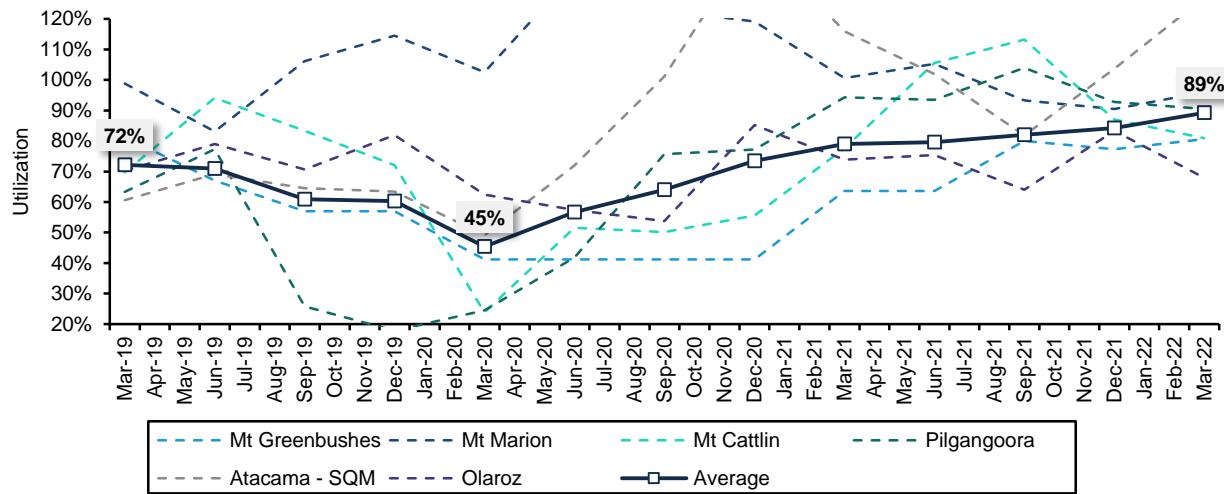
EXHIBIT 9 : Utilization levels are above 80% year to date which is an historical high



Source: Bloomberg, Government of Western Australia, Wind, Bernstein analysis

Looking more closely at the leading spodumene and brine operators, utilization reached close to 90% which is at the upper end of our estimate for global utilization, although there is variation between projects. Given the already high utilization, capacity expansion is the only solution to rebalance the market going forward.

EXHIBIT 10 : For leading suppliers, utilization bottomed in 2020 and is now at an all-time high of 89%

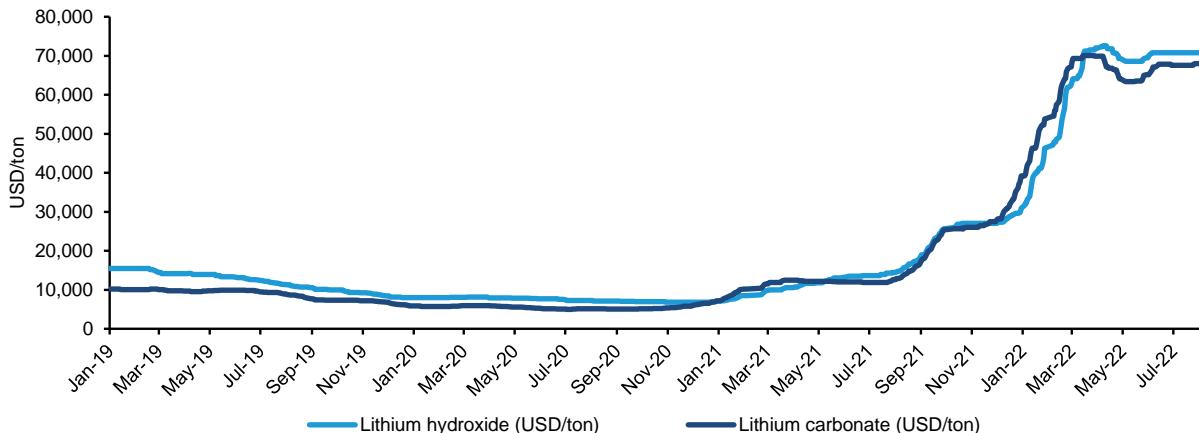


Source: Companies, Bernstein analysis

INVENTORY AND PRICES

Price of lithium carbonate and lithium hydroxide have increased sharply over the past 12 months on surging demand to US\$70/k per ton, which is significantly above cash cost of around \$10-25k/t.

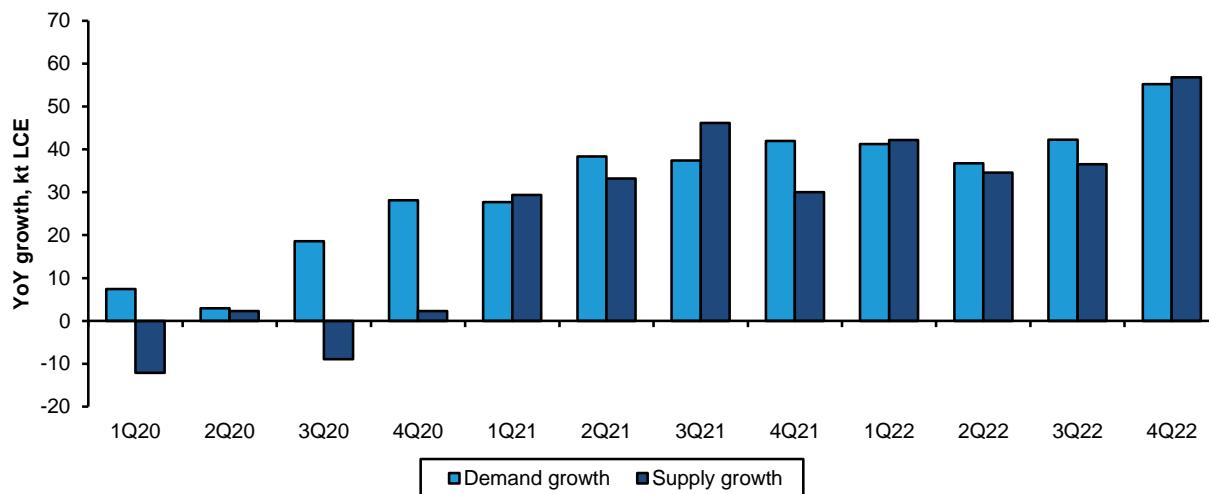
EXHIBIT 11 : Lithium prices remain elevated at around \$70k/t since the start of the year



Source: Bloomberg, Bernstein analysis

Both the quarterly supply and demand are currently growing at 40kt LCE. Adjusting for the capacity ramp up (which tends to lag for a year), markets were in deficit at the end of 2020 and again in the end of 21 driven by limited supply growth and stronger-than-expected demand growth. Based on 60% EV demand growth, it is likely that the lithium market will be more balanced given similar levels of additions in the following quarters.

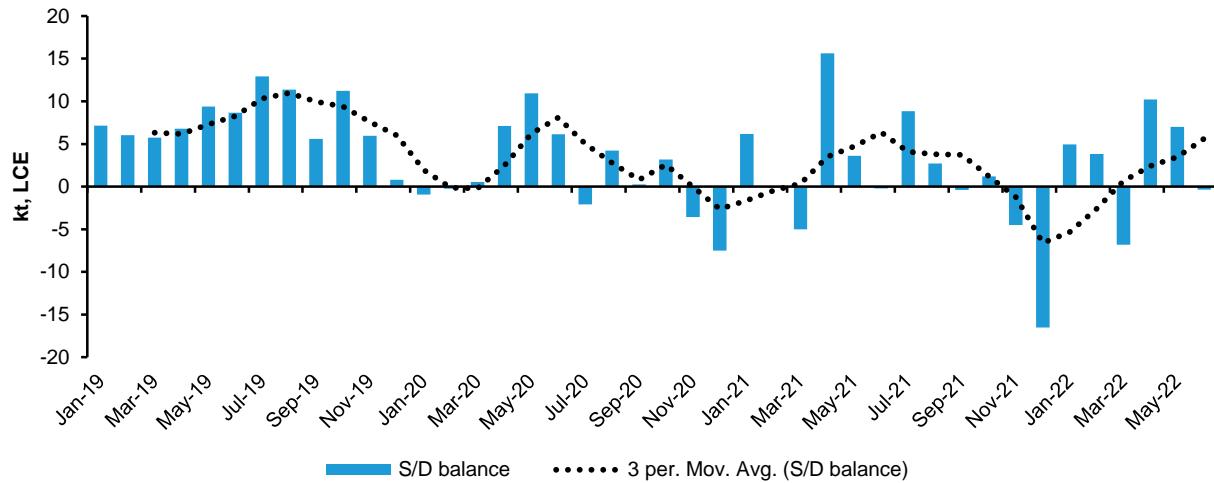
EXHIBIT 12 : Supply and demand looks more balanced in the next two quarters with slight undersupply in 3Q and oversupply in 4Q



Source: Bloomberg, SNE, Government of Western Australia, Wind, Companies, Bernstein analysis

We expect the lithium market will continue to reflect supply and demand balances in the market. Lithium prices peaked following the record supply deficits at the end of 2021. Although supply has kept pace with demand this year, our most recent data point in June, implies a market which remains finely balanced.

EXHIBIT 13 : We expect a more balanced outlook for the rest of 2022 assuming strong EV demand growth

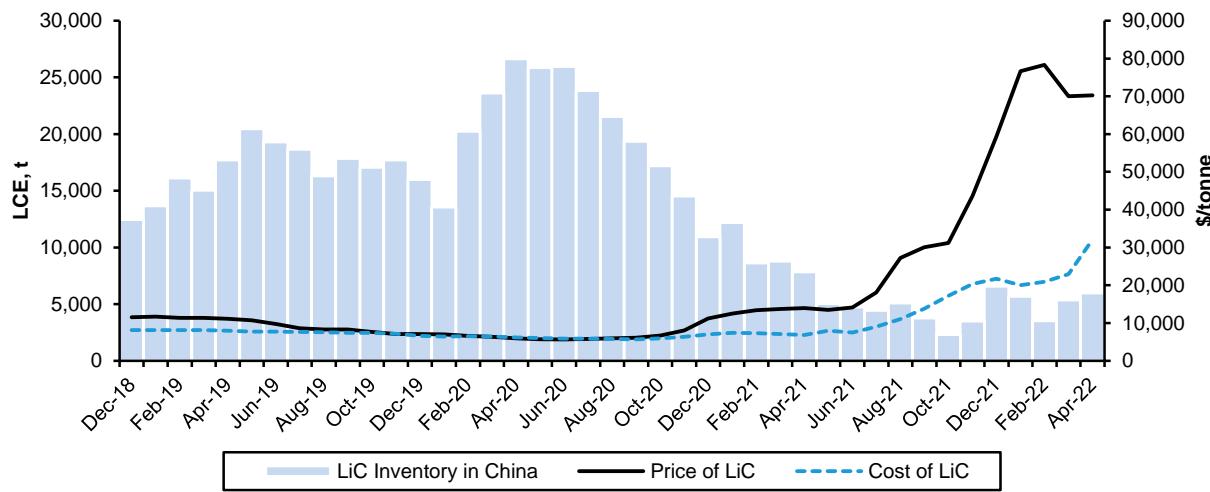


Source: Bloomberg, SNE, Government of Western Australia, Wind, Companies, Bernstein analysis

While there is no recognized lithium inventory data set, China which is the largest refiner of lithium does publish some data, although we are uncertain as to the veracity of these numbers. In China, lithium carbonate inventories fell by 20kt since peaking in mid-2020 and have remained at the current low level of around 5kt LCE in the past year.

Given low inventory levels, lithium prices have traded at a significant premium to cost. Historically prices have tended to respond to inventory declines, as would be expected. Recent data seem to suggest that inventories have bottomed with inventories increasingly sequentially in the last two months however still at a low level (May increased by 610t LCE m-o-m).

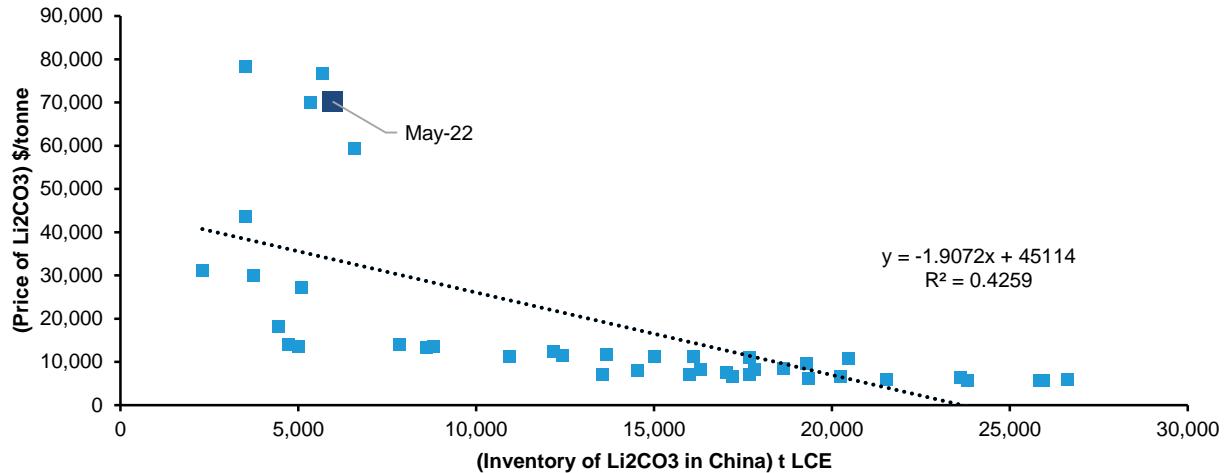
EXHIBIT 14 : Inventory in China seems to have bottomed which have seen prices start to turn



Source: Bloomberg, Asia Metals, Bernstein analysis

While markets appear more balanced in 2H22, we expect prices to remain elevated given that there is no reason to expect a significant build in lithium inventories (see Exhibit 15) without a meaningful oversupply.

EXHIBIT 15 : **Low inventory levels could keep prices at elevated levels**



Source: Bloomberg, Asia Metals, Bernstein analysis

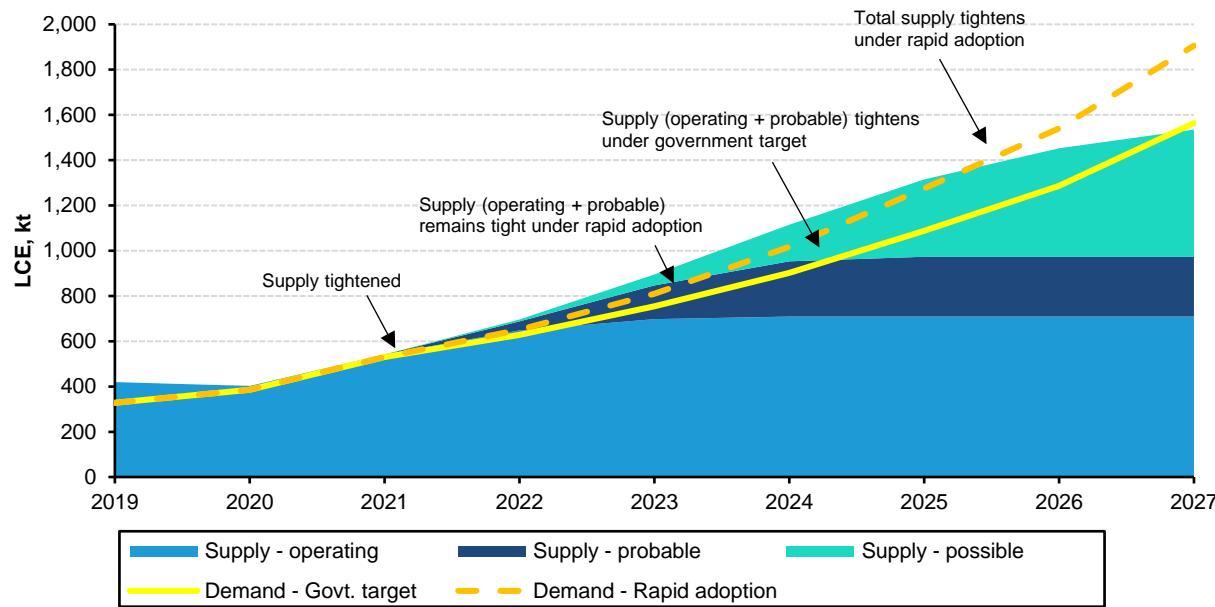
LONG TERM OUTLOOK

SUPPLY AND DEMAND

Exhibit 16 shows our long term lithium supply and demand outlook. For supply, we have tracked the operational status of individual lithium mining projects globally. We classify each project into operating, probable or possible to reflect the different stages of the projects on offtake, technical challenges, service agreements, and financing. Our demand outlook is based on our projection of battery demand for EV + ESS as well as other demand for lithium.

If lithium demand rises based on government EV targets, we expect there is likely enough lithium supply to meet demand over the medium term which could see lithium prices fall below current levels of \$70k/ton to normalized price of \$20-30k/ton. If on the other hand demand rises faster than expected following our rapid adoption case (which is currently being tracked), then we expect supply will remain extremely tight over the medium term. This will keep lithium prices at current elevated levels of \$70-80k/ton over the medium term.

EXHIBIT 16 : We expect a tight supply and demand outlook for lithium over the next several years



Source: Bloomberg, SNE, Government of Western Australia, Wind, Companies, Bernstein estimates and analysis

Over the past 18 months lithium supply and demand have been very tight. From our analysis, 2021 lithium production capacity averaged 702kt LCE (+18% y-o-y). Lithium supply based on exports from key producing regions and production from China was 542kt LCE in 2021 (+34% y-o-y) reflecting a utilization of 77%. Compared with 2021 lithium demand of 530kt LCE, we estimate a small supply surplus of 11kt LCE last year or 2% of demand.

Based our government target scenario for EV adoption, lithium demand is expected to grow by 30% CAGR between 2021-27 which will see lithium demand increase by 3x to 1,564kt MT by 2027. Based on our capacity outlook and assuming 80% utilization, we expect lithium market to remain well supplied with a supply surplus of 15-20% of demand over the next several years. As such, prices could normalize below current levels of \$70k/ton over the medium term. This obviously assumes that Lithium supply comes on as expected, although this remains a big 'if' as we will discuss later.

EXHIBIT 17 : Supply and demand outlook (Government target for demand)

Government Target	Units	2019	2020	2021	2022	2023	2024	2025	2026	2027	CAGR
Demand (Govt. Target)	kt LCE	328	385	530	628	754	902	1,087	1,286	1,564	20%
Capacity (Year end)	kt LCE	604	632	771	971	1,269	1,520	1,769	1,865	1,976	17%
Capacity (Average)	kt LCE	574	618	702	871	1,120	1,395	1,645	1,817	1,920	18%
Supply	kt LCE	420	403	542	697	896	1,116	1,316	1,454	1,536	19%
S/D Balance	kt LCE	92	18	11	69	142	213	228	168	-27	
Utilization	%	73%	65%	77%	80%	80%	80%	80%	80%	80%	
Surplus (Deficit) % of Demand	%	28%	5%	2%	11%	19%	24%	21%	13%	-2%	

Source: Bloomberg, SNE, Government of Western Australia, Wind, Companies, Bernstein estimates and analysis

Based on the rapid adoption scenario however, we expect lithium demand could increase fourfold from 530kt LCE last year to 1,906kt LCE by 2027. Under this scenario, we expect lithium markets to remain fairly tight with surplus remaining around 10% of demand in the next two years. While we currently estimate a supply deficit by mid-decade, we expect new investments will come in to fill the supply gap needed to meet the rising demand of lithium for EV batteries. Given the supply tightness, lithium prices will remain elevated out to mid-decade.

EXHIBIT 18 : Supply and demand outlook (Rapid adoption for demand)

Rapid Adoption	Units	2019	2020	2021	2022	2023	2024	2025	2026	2027	CAGR	21-27
Demand (Rapid Adoption)	kt LCE	328	385	530	650	809	1,016	1,275	1,541	1,906	24%	
Capacity (Year end)	kt LCE	604	632	771	971	1,269	1,520	1,769	1,865	1,976	17%	
Capacity (Average)	kt LCE	574	618	702	871	1,120	1,395	1,645	1,817	1,920	18%	
Supply	kt LCE	420	403	542	697	896	1,116	1,316	1,454	1,536	19%	
S/D Balance	kt LCE	92	18	11	47	87	99	41	-87	-369		
Utilization	%	73%	65%	77%	80%	80%	80%	80%	80%	80%		
Surplus (Deficit) % of Demand	%	28%	5%	2%	7%	11%	10%	3%	-6%	-19%		

Source: Bloomberg, SNE, Government of Western Australia, Wind, Companies, Bernstein estimates and analysis

LONG TERM DEMAND

Our long term battery demand is premised on our EV penetration outlook. Our government target scenario is based on central and state government announced EV related policies and targets. By 2030, global xEV sales penetration will increase from 8% in 2021 to 14% in 2025 and reaching 34% by 2030. As such, we expect lithium demand for EV batteries will increase from 261kt LCE in 2021 to 1,260kt LCE by 2027 (+30% CAGR). For "other" lithium demand (consisting of small batteries) which amounted to 270kt LCE in 2021, we assume demand will grow steadily at around 2% each year.

EXHIBIT 19 : Demand outlook (Government Target)

Government Target	Units	2019	2020	2021	2022	2023	2024	2025	2026	2027	CAGR	21-27
Demand												
Battery Lithium metal demand	kt, Li	20	24	49	66	89	116	150	186	237	30%	
LCE demand (5.31x Li demand)	kt, LCE	104	126	261	353	473	616	795	988	1,260	30%	
Other demand	kt, LCE	224	259	270	275	281	286	292	298	304	2%	
Total demand	kt, LCE	328	385	530	628	754	902	1,087	1,286	1,564	20%	
Battery Chemical												
PV	GWh	95	120	276	365	476	628	811	1,023	1,300	29%	
Bus & Truck	GWh	21	18	24	34	46	61	81	108	145	35%	
ESS LIB	GWh	12	21	33	51	76	86	110	113	145	28%	
Micro-mobility	GWh	6	5	8	14	24	34	43	54	66	43%	
Total Large Battery	GWh	134	164	340	463	622	809	1,044	1,298	1,656	30%	

Source: SNE, Bernstein estimates and analysis

In our rapid adoption scenario, we pull forward government targets to reach 100% EV sales penetration 5-10 years ahead for each region. In our rapid adoption case, EV penetration reaches 46% of sales by 2030, compared with the government target case of 34% by 2030. This will drive lithium demand for EV batteries to increases from 261kt LCE in 2021 to 1,602kt LCE by 2027 (+35% CAGR).

EXHIBIT 20 : Demand outlook (Rapid Adoption)

Rapid Adoption	Units	2019	2020	2021	2022	2023	2024	2025	2026	2027	CAGR	21-27
Demand												
Battery Lithium metal demand	kt, Li	20	24	49	71	100	138	186	235	303	35%	
LCE demand (5.31x Li demand)	kt, LCE	104	126	261	375	529	730	983	1,243	1,602	35%	
<u>Other demand</u>	<u>kt, LCE</u>	<u>224</u>	<u>259</u>	<u>270</u>	<u>275</u>	<u>281</u>	<u>286</u>	<u>292</u>	<u>298</u>	<u>304</u>	<u>2%</u>	
Total demand	kt, LCE	328	385	530	650	809	1,016	1,275	1,541	1,906	24%	
Battery Chemical												
PV	GWh	95	120	276	389	539	761	1,029	1,311	1,677	35%	
Bus & Truck	GWh	21	18	24	39	56	79	113	161	228	46%	
ESS LIB	GWh	12	21	33	51	76	86	110	113	145	28%	
Micro-mobility	GWh	6	5	8	14	24	34	43	54	66	43%	
Total Large Battery	GWh	134	164	340	493	695	961	1,295	1,639	2,116	36%	

Source: SNE, Bernstein estimates and analysis

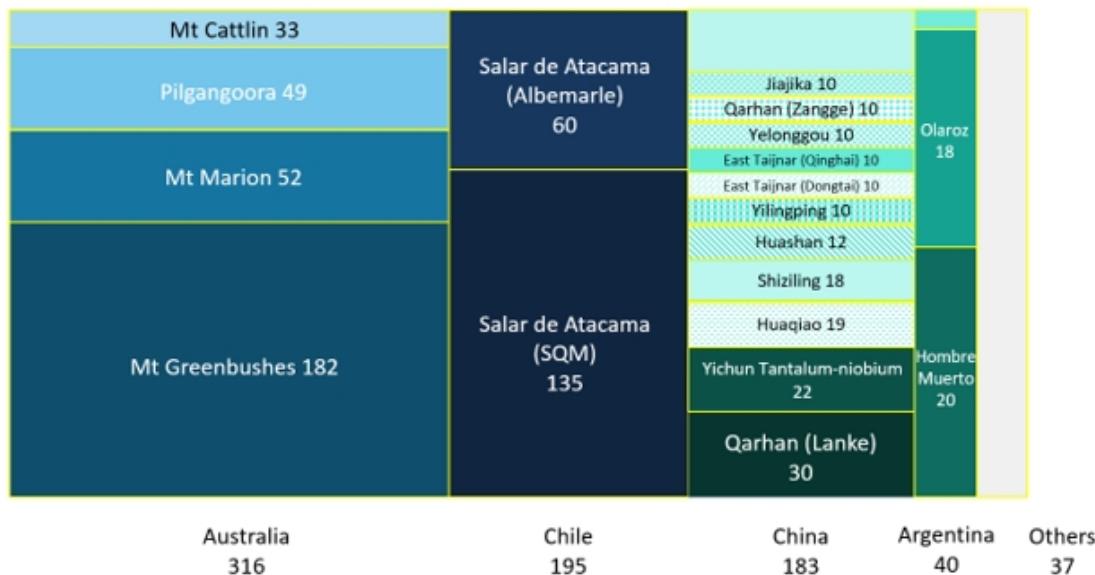
LONG TERM CAPACITY

Lithium is either produced from the extraction of lithium salts from underground brines or from the mining of lithium containing rock, such as spodumene. Australia is the largest supplier of lithium today with 47% market share, followed by Chile. Roughly half of all lithium comes from spodumene while the other half comes from brine. Processing of the ores typically involves a range of processes followed by techniques such as flotation, magnetic separation, and optical sorting to produce concentrates with 4-6% Li2O. The concentrates are then fed to roasting and leaching to extract lithium into solution.

Extraction of lithium from hard rock mines such as spodumene and other similar minerals such as lepidolite, petalite, amblygonite and eucryptite, requires a large range of processes. These minerals contain a range of lithium concentration by weight, typically between 1.5-3.5%, with spodumene having the highest lithium concentration. Some of the largest mines are shown below, Greenbushes is the highest quality mine in Australia with lithium concentrations of over 2%.

Lithium supply capacity is relatively concentrated today, with the top 3 companies (Albemarle, SQM and Tianqi) accounting for roughly 50% of capacity. Albemarle have a diversified portfolio across South America, Australia and China, with key stakes in Greenbushes and Salar La Negra and Salar de Atacama. SQM is the largest producer in Latin America with the world class Salar de Atacama deposit, while Tianqi have a major (26%) stake in Australia Greenbushes lithium project. Other notable players include Pilbara Minerals in western Australia who operate the Pilangoora Mine and Ganfeng Lithium who have a 50% share in the Mount Marion deposit together with Mineral Resources Limited.

EXHIBIT 21 : 2021 lithium capacity. Half of global lithium supply come from Atacama and Greenbushes (in kt LCE)



Source: Companies, Bernstein analysis

Over the next 4 years (2021 to 2025) global capacity is forecast to grow from 771kt LCE to 1,769kt LCE, a more than doubling of the market. Australia will continue to be the largest supplier of lithium with 627kt LCE in 2025 (35% of total). China is expected to be the fastest growing supplier in the next 5 years overtaking Chile as second largest producer with 333kt LCE in 2025 (19% of total). Chile is expected to be close third at 290kt LCE in 2025 (17% of total).

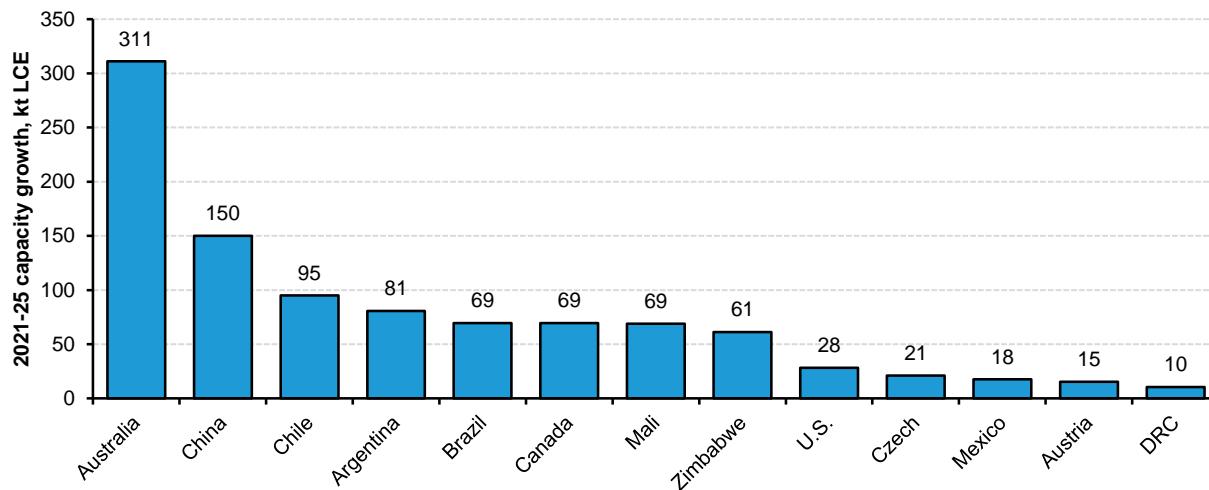
EXHIBIT 22 : Expected growth in lithium supply capacity by country, kt LCE

<i>By country, kt LCE</i>	21-25						
	2020	2021	2022	2023	2024	2025	CAGR
Australia	303	316	423	534	558	627	15%
China	163	183	202	263	282	333	13%
Chile	90	195	263	290	290	290	8%
Argentina	40	40	48	100	121	121	25%
Brazil	14	14	14	32	83	83	43%
Canada	0	0	0	18	24	69	n.a.
Mali	0	0	0	0	35	69	n.a.
Zimbabwe	5	5	5	10	66	66	68%
U.S.	6	6	6	6	6	34	42%
Czech	0	0	0	0	0	21	n.a.
Mexico	0	0	0	0	18	18	n.a.
Austria	0	0	0	0	15	15	n.a.
Germany	12	12	12	12	12	12	0%
DRC	0	0	0	3	10	10	n.a.
Total	632	771	971	1,269	1,520	1,769	18%

Source: Companies, USGS, Bernstein estimates and analysis

In terms of expansion, 70% of growth over the next 4 years will come from established countries of Australia, Chile, Argentina and China. This still leaves 30% to come from less established producers such as Brazil, Zimbabwe and Mali which carry a higher degree of risk.

EXHIBIT 23 : 2021-25 growth in lithium capacity by country (kt LCE). Australia will see the largest expansion followed by China



Source: Companies, USGS, Bernstein estimates and analysis

Looking at the capacity outlook by company, we expect SQM will remain the largest supplier at 245kt LCE capacity in 2025 (14% of total capacity) followed closely by Albemarle at 239kt LCE (14% of total). Other top lithium providers are Pilbara, Mineral Resources, Ganfeng and Tianqi. While these large lithium producers account for about 60% of total 2025 capacity, the 'others' which are comprised of smaller, independent producers are expected to dominate the remaining 40% of total capacity at 746kt LCE.

EXHIBIT 24 : Expected growth in lithium capacity by company, kt LCE

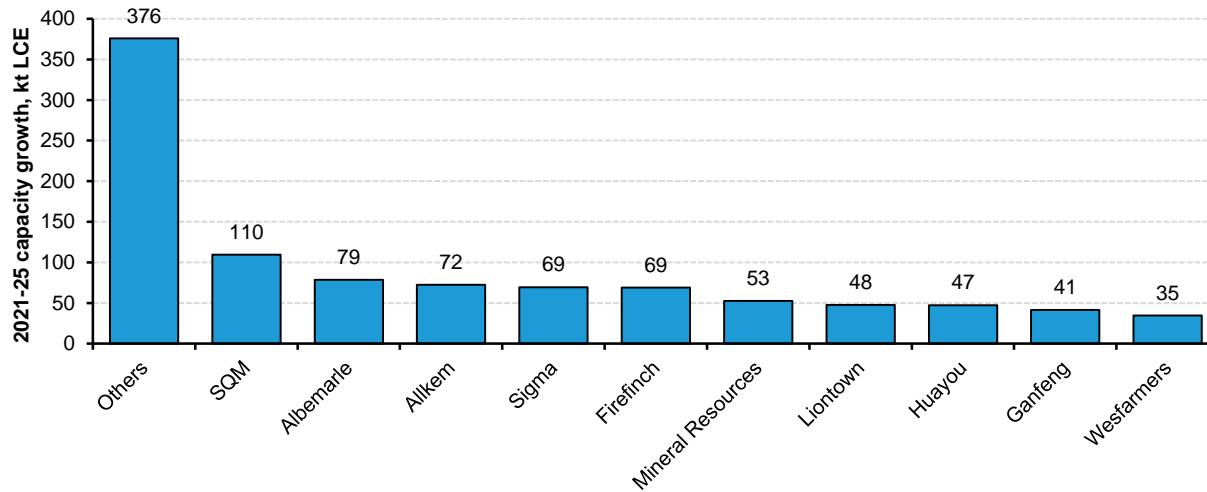
By company, kt LCE	21-25						
	2020	2021	2022	2023	2024	2025	CAGR
SQM	70	135	203	210	210	245	13%
Albemarle	120	160	192	233	233	239	8%
Allkem	44	44	44	61	72	116	21%
Mineral Resources	21	26	62	79	79	79	25%
Pilbara	45	49	56	76	76	76	9%
Ganfeng	26	31	49	61	72	72	19%
Sigma	0	0	0	19	69	69	n.a.
Firefinch	0	0	0	0	35	69	n.a.
Tianqi (excl. SQM)	47	47	55	57	57	57	4%
Others	258	278	311	473	617	746	22%
Total	632	771	971	1,269	1,520	1,769	18%

Source: Companies, USGS, Bernstein estimates and analysis

In terms of incremental production capacity by company, only 50% will come from the top 5 lithium producers today with a significant component coming from 'others' which leaves a degree of uncertainty as to how much will actually be delivered on

schedule.

EXHIBIT 25 : 2021-25 growth in lithium capacity by company (kt LCE). Most of the growth will come from "Others" lithium producers



Source: Companies, USGS, Bernstein estimates and analysis

Greenbushes is the largest and highest quality mine in Australia. Albemarle have a diversified portfolio across South America, Australia and China, with key stakes in Greenbushes and Salar La Negra and Salar de Atacama. Tianqi also has a major (26%) stake in Australia Greenbushes lithium project. SQM is the largest producer in Latin America with the world class Salar de Atacama deposit. Salar de Atacama has one of the highest concentrations of lithium brine deposit of 0.15% or 1500ppm of lithium.

EXHIBIT 26 : Expected growth in lithium capacity by mining project, kt LCE

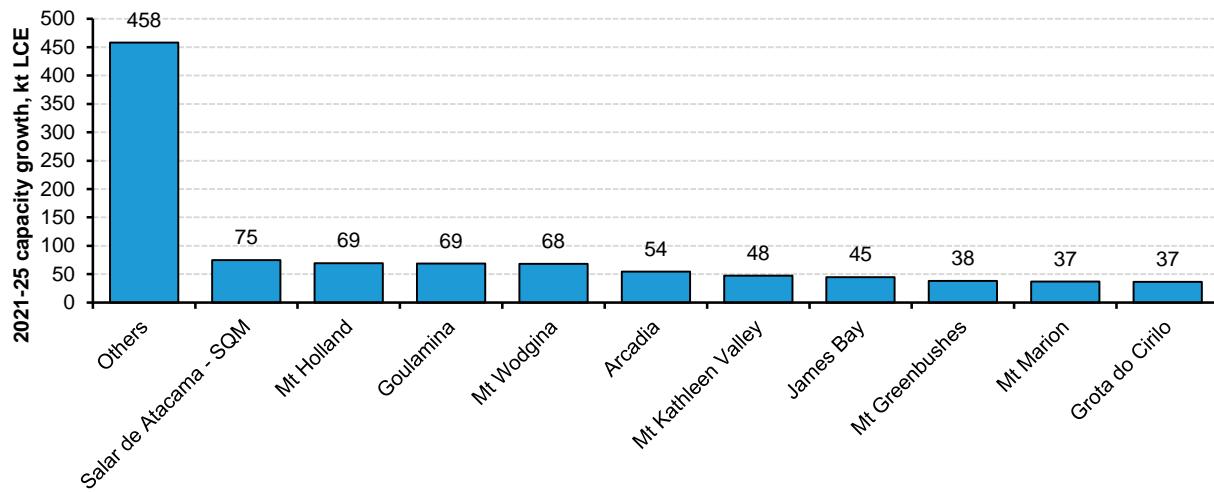
<u>By mining project, kt LCE</u>	21-25							CAGR
	2020	2021	2022	2023	2024	2025		
Mt Greenbushes	182	182	211	220	220	220	220	4%
Salar de Atacama - SQM	70	135	203	210	210	210	210	9%
Mt Marion	43	52	89	89	89	89	89	11%
Salar de Atacama - Albemarle	20	60	60	80	80	80	80	6%
Mt Holland	0	0	0	0	0	69	n.a.	
Goulamina	0	0	0	0	35	69	n.a.	
Mt Wodgina	0	0	34	68	68	68	n.a.	
Arcadia	0	0	0	0	54	54	n.a.	
Pilgangoora	45	49	49	49	49	49	49	0%
Mt Kathleen Valley	0	0	0	24	48	48	n.a.	
Others	272	292	325	528	667	812	23%	
Total	632	771	971	1,269	1,520	1,769	18%	

Source: Companies, USGS, Bernstein estimates and analysis

While significant capacity growth will come from the large lithium deposits in Australia, Chile and Argentina, we see 'other' mines from China and RoW (ie.US, Canada, Brazil, and Mexico) to grow the most in the coming years which could be more speculative

with varying quality.

EXHIBIT 27 : 2021-25 growth in lithium capacity by mining project (kt LCE). "Other" mining projects are the largest growth of capacity



Source: Companies, USGS, Bernstein estimates and analysis

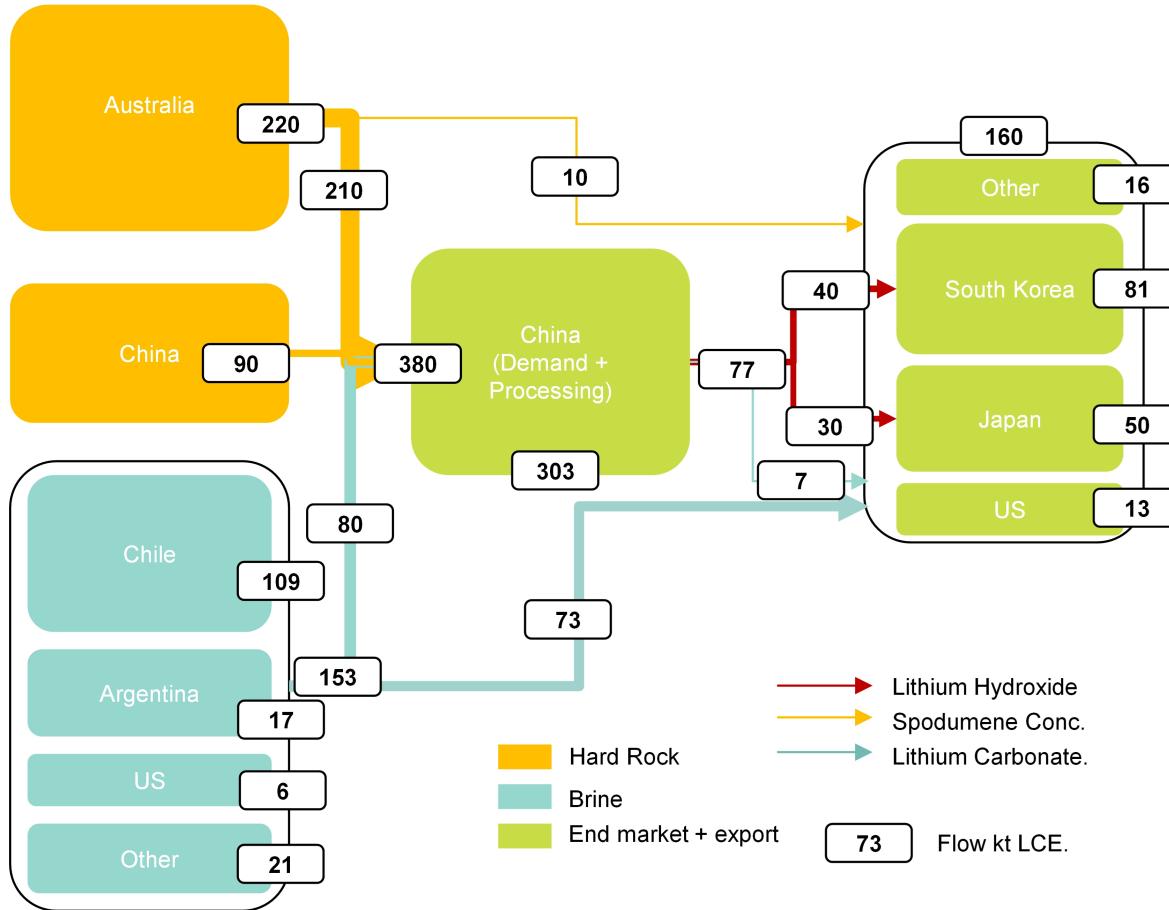
LONG TERM REFINING

Lithium refining capacity is as important as mining. There is no point in extracting lithium if there is not sufficient capacity to purify to battery grade metal.

A summary of the trade flows of lithium (LCE) is shown in the following chart. China plays a key role in the overall lithium market as both a producer of lithium in its own right and a major refiner of lithium to produce lithium carbonate and lithium hydroxide for both the domestic and export market, with exports mostly in the form of lithium hydroxide. Overall China accounts for only 20% of lithium production but around 70% of lithium processing capacity and the key supplier of lithium products to global markets.

EXHIBIT 28 : How lithium is traded around the world

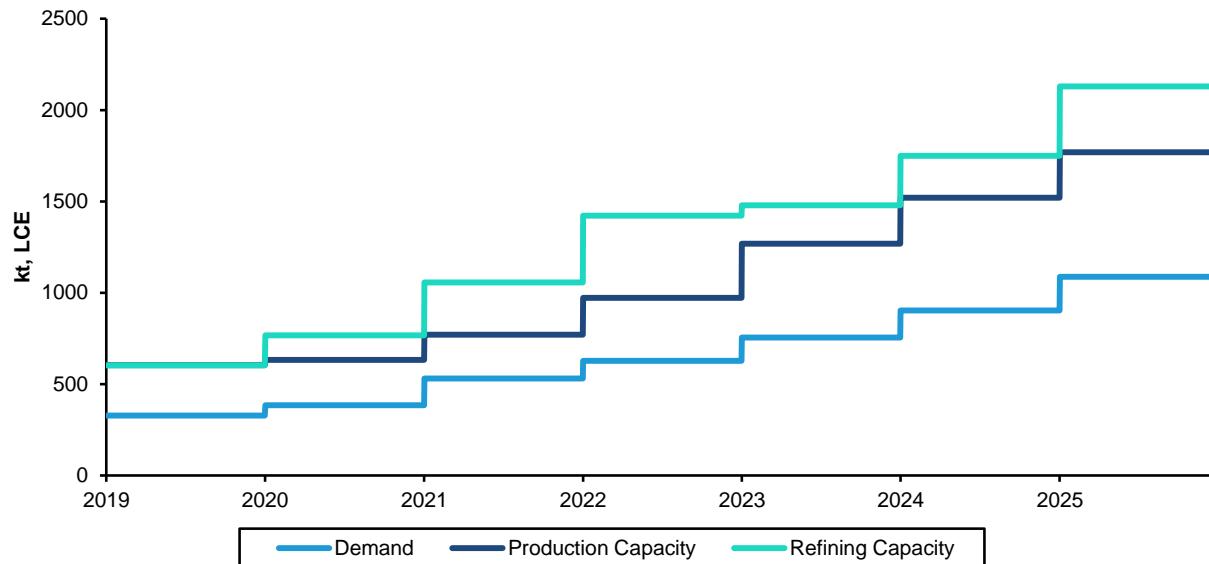
2020 Lithium Market Mass Balance



Source: USGS, Bloomberg, Government of Australia, Bernstein analysis

Going forward, we expect refining capacity is sufficient to meet rising lithium mining production and demand. Lithium refining capacity currently stands at 981kt LCE and is set to grow to 1949kt by 2025. This should be enough to cover the rapid case for lithium demand (1275kt LCE) and expected lithium mining capacity (1769kt LCE) in 2025.

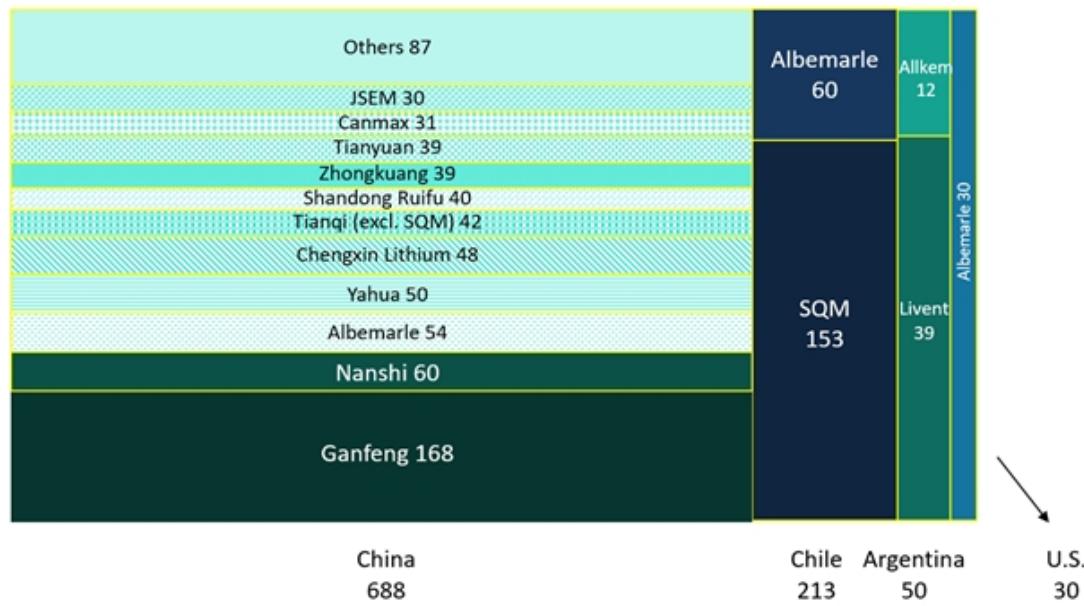
EXHIBIT 29 : The rapidly growing refining capacity keeps midstream from being a bottleneck



Source: Companies, SNE, Bernstein estimates and analysis

Companies which dominate lithium refining are mostly Chinese with the exception of Albemarle and SQM which are also the largest lithium producers. Ganfeng Lithium is the largest refiner in China and globally. China by far has the largest amount of refining capacity accounting for 70% of total refining capacity in 2021.

EXHIBIT 30 : Midstream lithium capacity is more fragmented but dominates by Chinese companies, kt LCE as of 2021



Source: Companies, USGS, Bernstein analysis

Growth in lithium refining capacity over the next 4 years will be led by China and Australia over the next 4 years. Australia is investing in greater downstream capacity to enhance the value add in Australia, although the cost of this is far higher than in China. In 2025, China is expected to continue to dominate the lithium capacity with around 60% of total lithium refining capacity. Chile is second at 17% of total refining capacity while Australis is third at 8%.

EXHIBIT 31 : Expected growth in lithium conversion capacity by country, kt LCE

<i>By country, kt LCE</i>	2020	2021	2022	2023	2024	2025	Growth 21-25
China	576	764	914	971	1,081	1,320	556
Australia	0	0	114	114	151	151	151
Chile	111	213	286	286	332	332	119
Argentina	50	50	69	69	94	133	83
Mexico	0	0	0	0	0	50	50
Indonesia	0	0	0	0	43	43	43
Canada	0	0	0	0	0	26	26
U.S.	30	30	38	38	38	48	18
North America / Europe	0	0	0	0	0	15	15
Japan	0	0	0	0	12	12	12
South Korea	0	0	0	0	0	0	0
Total	767	1,057	1,421	1,478	1,750	2,129	1,072

Source: Companies, USGS, Bernstein estimates and analysis

China will continue to grow capacity significantly led by Canmax, Tianqi, Ganfeng, Sichuan Yahua and other Chinese lithium refiners. Outside of China, the growth in capacity will come primarily from SQM, Albemarle and Livent.

EXHIBIT 32 : Expected growth in lithium conversion capacity by company, kt LCE

<i>By company, kt LCE</i>	2020	2021	2022	2023	2024	2025	Growth 21-25
Albemarle	104	144	190	229	229	277	133
SQM	91	153	226	226	272	272	119
Ganfeng	168	168	189	189	189	248	80
Canmax	0	31	77	77	77	247	216
Livent	39	39	46	69	69	141	102
Sichuan Yahua	50	50	96	96	96	127	77
Chengxin Lithium	48	48	80	80	122	122	74
Tianqi (excl. SQM)	42	42	61	61	100	100	58
Zhongkuang	6	39	39	39	74	74	35
Nanshi	15	60	60	60	60	60	0
Others	205	284	357	352	462	462	178
Total	767	1,057	1,421	1,478	1,750	2,129	1,072

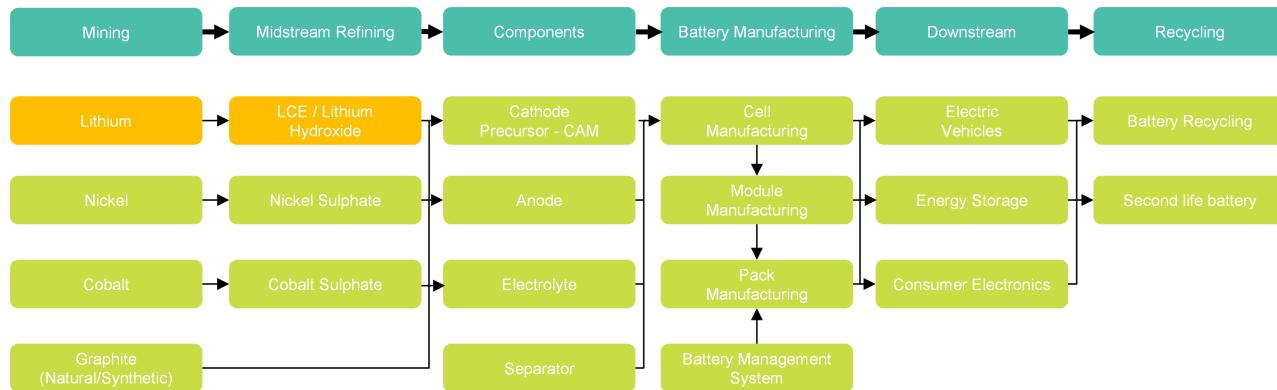
Source: Companies, USGS, Bernstein estimates and analysis

COMPANY OVERVIEW

The battery value chain includes many components. The process of lithium production and lithium refining are the key steps before the manufacture of precursor and cathode active material which is used in the production of cathodes, which are used in

battery cells.

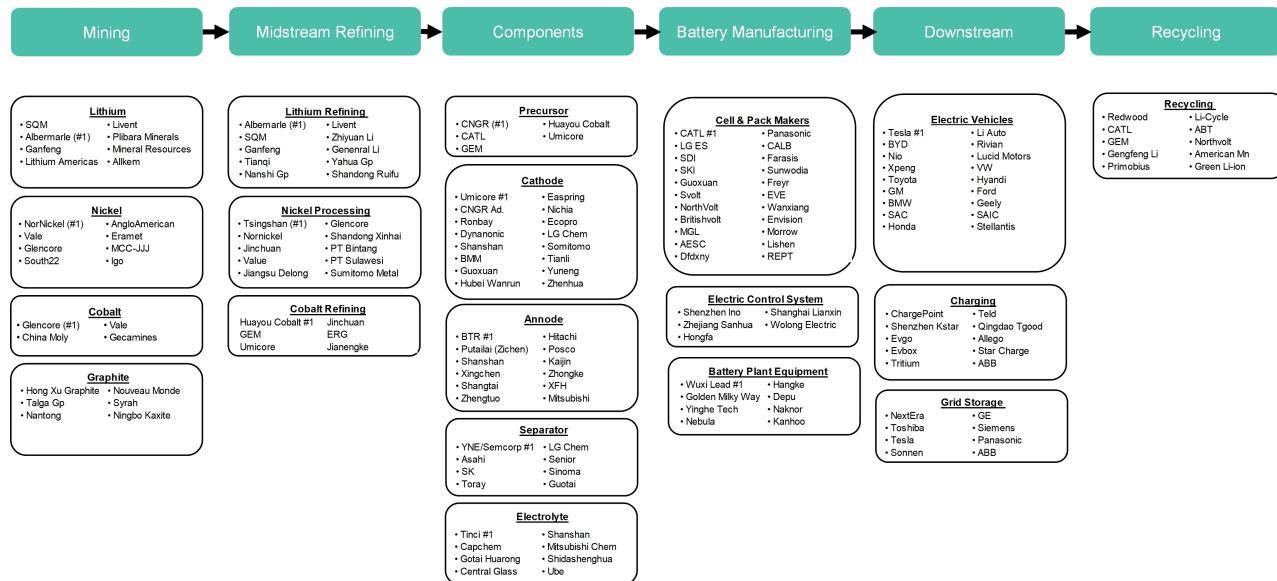
EXHIBIT 33 : Battery value chain



Source: Bernstein analysis

A summary of some of the key companies in the battery value chain are shown below. There are a number of companies to invest in both lithium upstream supply and lithium refining.

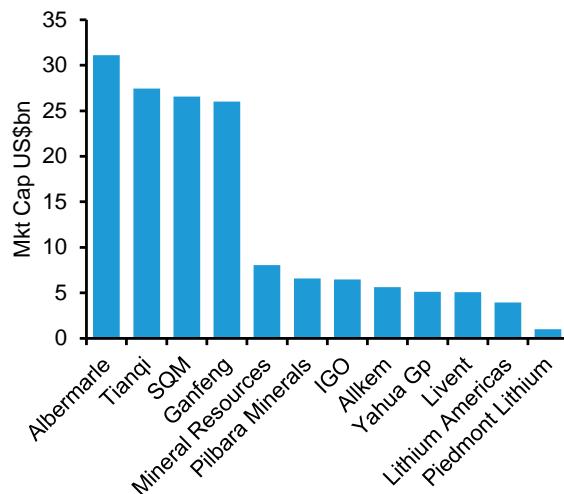
EXHIBIT 34 : Key companies along the battery value chain including lithium mining and refining



Source: Bernstein analysis

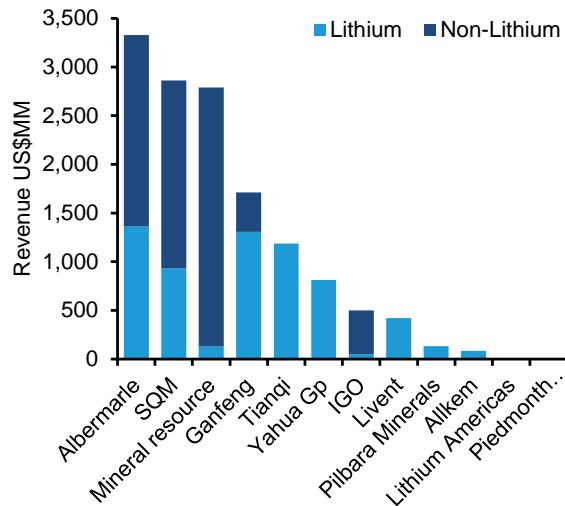
Some companies span both lithium refining and mining. Albemarle and SQM both mine and refine lithium. Most Chinese players started out as domestic lithium producers or refiners and have acquired projects internally, most notably Ganfeng Lithium (Mount Marion) and Tianqi Lithium which acquired a stake in Greenbushes. By market capitalization, Albemarle, SQM, Ganfeng and Tianqi are the largest. In revenue terms, Albemarle and SQM are also the largest, but a significant portion of their revenue is non-lithium. Mineral Resources is dominated by iron ore, leaving Ganfeng and Tianqi as the two other major lithium companies, which are vertically integrated miners and refiners.

EXHIBIT 35 : Lithium mining and refining companies by market cap



Source: Bloomberg, Bernstein analysis

EXHIBIT 36 : Annual revenue of lithium and lithium refining companies



Source: Bloomberg, Bernstein analysis

The table below shows a comparison of key financial and valuation metrics for lithium mining and refining companies based on Bloomberg consensus estimates.

EXHIBIT 37 : Comparisons of publicly-listed lithium mining and refining companies

Company	Ticker	Market cap (USD bn)	2022 P/S	2022 EV/EBITDA	2022 OPM	21-24 Rev Growth	12 month return
Albemarle Corp	ALB US Equity	31.1	4.3	10.5	36%	35%	12%
Sociedad Quimica y Minera de C	SQM US Equity	26.6	2.9	5.0	53%	44%	96%
Ganfeng Lithium Co Ltd	1772 HK Equity	25.6	4.3	10.2	42%	47%	-36%
Tianqi Lithium Corp	002466 CH Equity	27.5	5.5	8.6	78%	73%	14%
Mineral Resources Ltd	MIN AU Equity	8.0	3.3	11.8	19%	19%	0%
IGO Ltd	IGO AU Equity	6.5	10.1	12.5	53%	12%	22%
Allkem Ltd	AKE AU Equity	5.7	7.4	10.4	68%	164%	25%
Pilbara Minerals Ltd	PLS AU Equity	6.6	7.2	10.0	70%	119%	30%
Sichuan Yahua Industrial Group	002497 CH Equity	5.1	2.3	7.2	31%	55%	3%
Livent Corp	LTHM US Equity	5.1	6.0	14.6	39%	46%	10%
Lithium Americas Corp	LAC US Equity	3.9	79.6	-89.1	-115%	n.a.	53%
Piedmont Lithium Inc	PLL US Equity	1.0	n.a.	-43.6	n.a.	n.a.	-14%
Average			5.3	10.1	49%	61%	18%

Source: Bloomberg (consensus), Bernstein analysis

All companies not covered by Bernstein

DISCLOSURE APPENDIX

I. REQUIRED DISCLOSURES

Autonomous Research US is a unit within Sanford C. Bernstein & Co., LLC, a broker-dealer registered with the U.S. Securities and Exchange Commission and a member of the Financial Industry Regulatory Authority (www.finra.org) and the Securities Investor Protection Corporation (see www.sipc.org). When this report contains an analysis of debt securities, such report is intended for institutional investors and is not subject to all the independence and disclosure standards applicable to debt research for retail investors under the FINRA rules.

VALUATION METHODOLOGY

Global Energy Storage

We value Global Energy Storage companies using the sum of the parts valuation and DCF approach. Our DCF model is based on annual free cash flow forecasts until 2050, plus a terminal value estimate to capture the continuing value of the company.

Contemporary Amperex Technology Co Ltd

We value CATL using the DCF approach. Our DCF model is based on annual free cash flow forecasts until 2050, plus a terminal value estimate to capture the continuing value of the company.

LG Chem Ltd

We value LG Chem using a sum of the parts valuation methodology.

LG Energy Solution

We value LGES using the DCF approach. Our DCF model is based on annual free cash flow forecasts until 2050, plus a terminal value estimate to capture the continuing value of the company.

Samsung SDI Co Ltd

We value Samsung SDI using a sum of the parts valuation methodology.

RISKS

Global Energy Storage

Risks to Global Energy Storage companies include increasing market competition globally which could negatively impact growth and price outlook. In addition, further raw material costs increase could put additional pressure on the EV value chain. Given the industry is still in a nascent stage, positive or negative changes in government policy and subsidy programs will impact the growth outlook.

Contemporary Amperex Technology Co Ltd

Key risks include 1) stronger than expected competition in the space, 2) raw material costs increase further, putting additional pressure on the EV value chain and 3) CATL's battery costs fall slower than expected due to either poor execution or higher input costs (from suppliers).

LG Chem Ltd

Downside risks include: 1) increasing competition within the EV battery industry, 2) rising raw material costs which could put additional pressure on the EV value chain, 3) battery quality issues which could lead to battery recalls, and 4) larger than expected conglomerate discount.

LG Energy Solution

Key upside risks include 1) increasing market share with customer diversification which could increase sales, 2) rising margins with better costs control and raw material passthrough and 3) improved battery quality which could lower the risks of recalls.

Downside risks include 1) slower than expected expansion of US and European capacity, 2) lower sales due to customer switching battery suppliers, and 3) lower margins due to inability to passthrough higher raw material costs.

Samsung SDI Co Ltd

Samsung SDI's earnings growth depends on the adoption of electric vehicles and energy storage systems to boost battery revenues and profits. Any change in strategy by automakers, or lack of cost declines would reduce this upside. In addition display still plays a large role on the equity income line. Small battery profit recovery depends on utilization of their polymer lines improving, which in turn depends on orders from customers including parent Samsung Electronics. Risks to display (driving equity income) include supply/demand balance pressuring pricing and hence margins. Downside risks include lower than expected EV battery/ESS sales and slower than expected technology development.

RATINGS DEFINITIONS, BENCHMARKS AND DISTRIBUTION

Bernstein brand

The Bernstein brand rates stocks based on forecasts of relative performance for the next 6-12 months versus the S&P 500 for stocks listed on the U.S. and Canadian exchanges, versus the MSCI Europe Index (MSDLE15) for stocks listed on the European exchanges (except for Russian companies), versus the MSCI Emerging Markets Index for Russian companies and stocks listed on emerging markets exchanges outside of the Asia Pacific region, versus the MSCI Japan (MXJP) for stocks listed on the Japanese exchanges, and versus the MSCI Asia Pacific ex-Japan Index for stocks listed on the Asian (ex-Japan) exchanges - unless otherwise specified.

The Bernstein brand has three categories of ratings:

- Outperform: Stock will outpace the market index by more than 15 pp
- Market-Perform: Stock will perform in line with the market index to within +/- 15 pp
- Underperform: Stock will trail the performance of the market index by more than 15 pp

Not Rated: The stock Rating, Target Price and/or estimates (if any) have been suspended temporarily.

Autonomous brand

The Autonomous brand rates stocks as indicated below. As our benchmarks we use the SX7P and SXFP index for European banks, the SXIP for European insurers, the S&P 500 and S&P Financials for US banks coverage, S5LIFE for US Insurance, the SPSIINS for US Non-Life Insurers coverage, and IBOV for Brazil and H-FIN index for China banks and insurers. Ratings are stated relative to the sector (not the market).

The Autonomous brand has three categories of ratings:

- Outperform (OP): Stock will outpace the relevant index by more than 10 pp
- Neutral (N): Stock will perform in line with the market index to within +/- 10 pp
- Underperform (UP): Stock will trail the performance of the relevant index by more than 10 pp
- Coverage Suspended (CS) applies when coverage of a company under the Autonomous research brand has been suspended. Ratings and price targets are suspended temporarily. Previously issued ratings and price targets are no longer current and should therefore not be relied upon.

Not Rated: The stock Rating, Target Price and/or estimates (if any) have been suspended temporarily.

Those denoted as 'Feature' (e.g., Feature Outperform FOP, Feature Under Outperform FUP) are our core ideas. Not Rated (NR) is applied to companies that are not under formal coverage.

For both brands, recommendations are based on a 12-month time horizon.

DISTRIBUTION OF RATINGS/INVESTMENT BANKING SERVICES

Rating	Market Abuse Regulation (MAR) and FINRA Rule 2241 classification	Count	Percent	Count*	Percent*
Outperform	BUY	395	50.51%	0	0.00%
Market-Perform (Bernstein Brand)	HOLD	262	33.50%	1	0.38%
Neutral (Autonomous Brand)					
Underperform	SELL	122	15.60%	0	0.00%
Not Rated (Bernstein Brand)	NOT RATED	3	0.38%	0	0.00%
Coverage Suspended (Autonomous Brand)					

* These figures represent the number and percentage of companies in each category to whom Bernstein and Autonomous provided investment banking services.

As of Aug 12 2022. All figures are updated quarterly and represent the cumulative ratings over the previous 12 months.

PRICE CHARTS/ RATINGS AND PRICE TARGET HISTORY

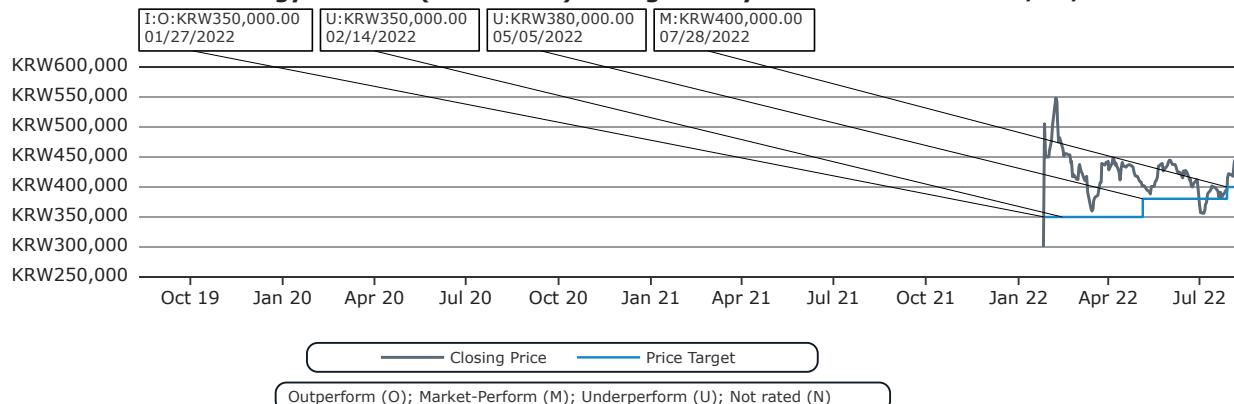
Contemporary Amperex Technology Co Ltd (300750.CH) Rating History for Bernstein as of 08/11/2022



LG Chem Ltd (051910.KS) Rating History for Bernstein as of 08/11/2022



LG Energy Solution (373220.KS) Rating History for Bernstein as of 08/11/2022



Samsung SDI Co Ltd (006400.KS) Rating History for Bernstein as of 08/11/2022



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specific recommendations or views in this publication.

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