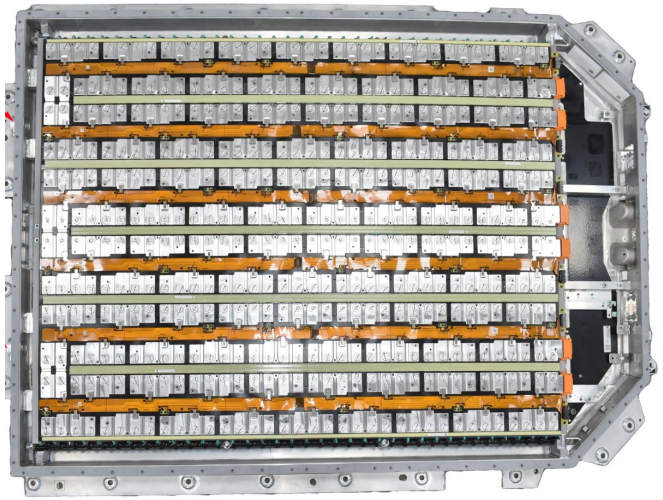
McKinsey & Company

Why so many have been wrong on critical metals

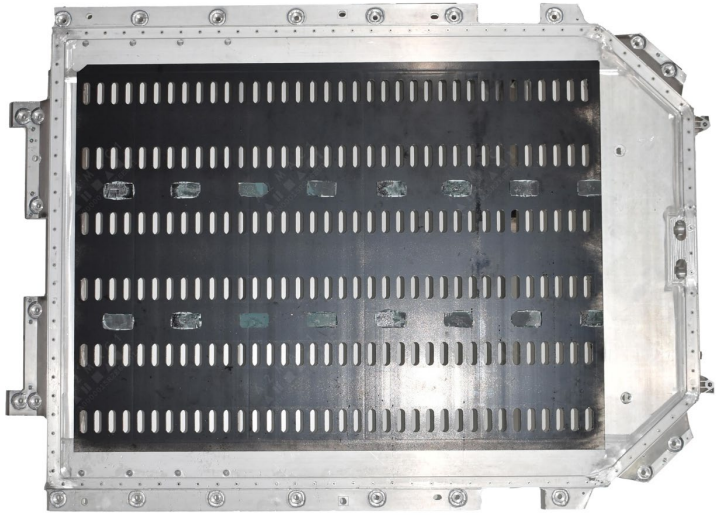
LME Week Asia

June 2024

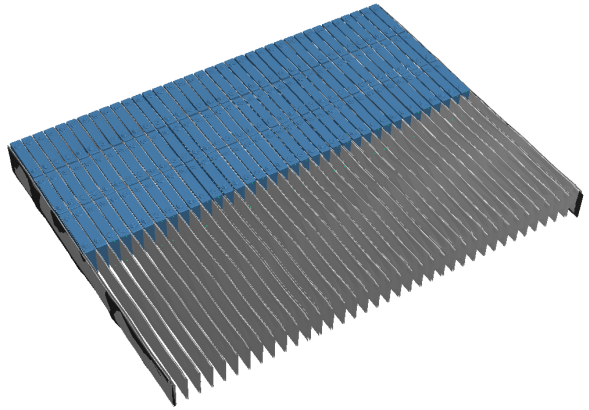
Vehicles are getting close to 1,000 km range and sub 5 min recharge times, ending the need for ICE



140kWh Qilin pack from Zeekr 009, cells connections are top welded



Battery housing is absent of crossmembers, venting channels pictured



Cooling plate configuration

Detail of venting channels with “blow out panels” that allow gasses to escape while providing protection to neighboring cells from hot gasses

KPI assessment

	Announced	Zeekr 009
Range, km	1000+	855
Pack energy density, Wh/kg	250+	200
Cell energy density, Wh/kg	255	285
VCTPR, %	72	86
Charging speed, 10-80% @ 23C, minutes	>10	TBC
Cycles to 80%, cycles	TBC	TBC

Design highlights

Despite missing initial claims, 200Wh/kg energy density is best in class at pack level, due to absence of cross members and cell-to-pack concept

Side cooling with slightly less efficient thermal path is used to minimize additional thermal runaway features

Downward venting thermal management system featuring “blow out panels”

Source: A2Mac1, MCFM EV Insights

Why did so many get the high volatility of metal markets wrong?

1) The markets are relatively thinly traded (cobalt, nickel, even to some extent nickel)

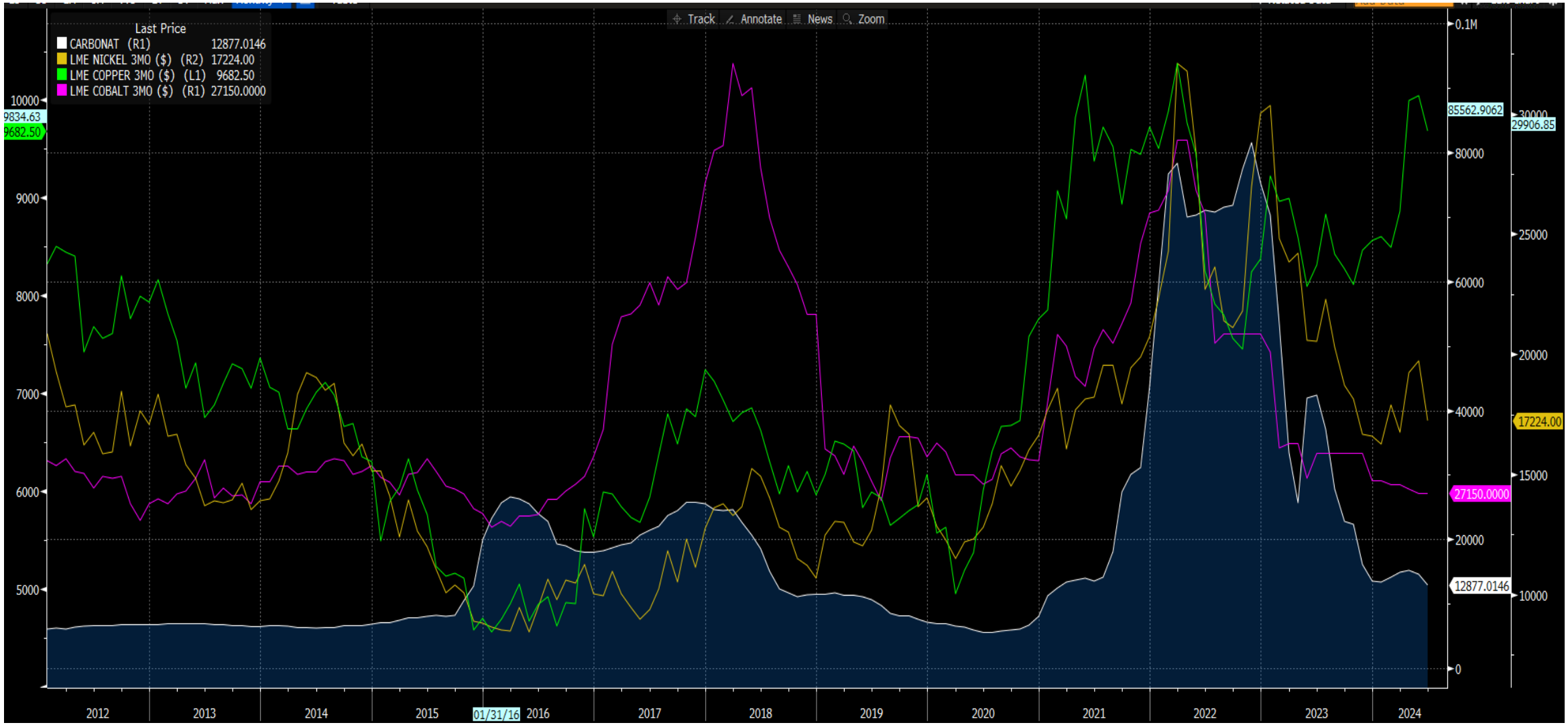
2) Analyst like linear models and they trend t o track either supply OR demand (do not adjust changed in demand matrix quickly enough)

- **Copper demand per unit of vehicle vs infrastructure**
- **Battery chemistry changes**

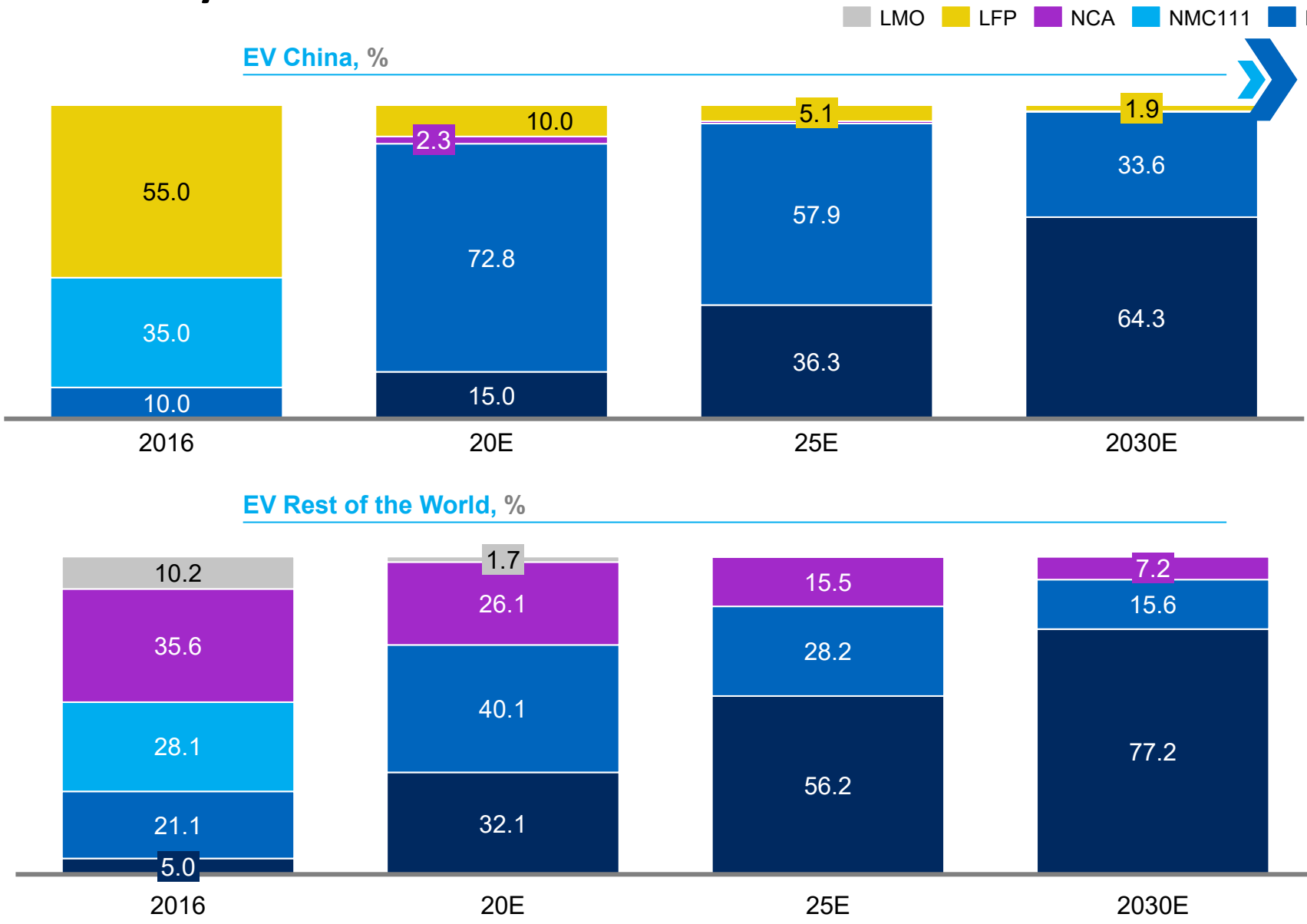
3) Demand has been unprecedented

4) Supply reactions have been incredibly rapid

Expect high volatility to continue, but know that there is no "bottleneck" metal as innovations can alter chemistries



Our view of the battery market in 2017 was quite different from today

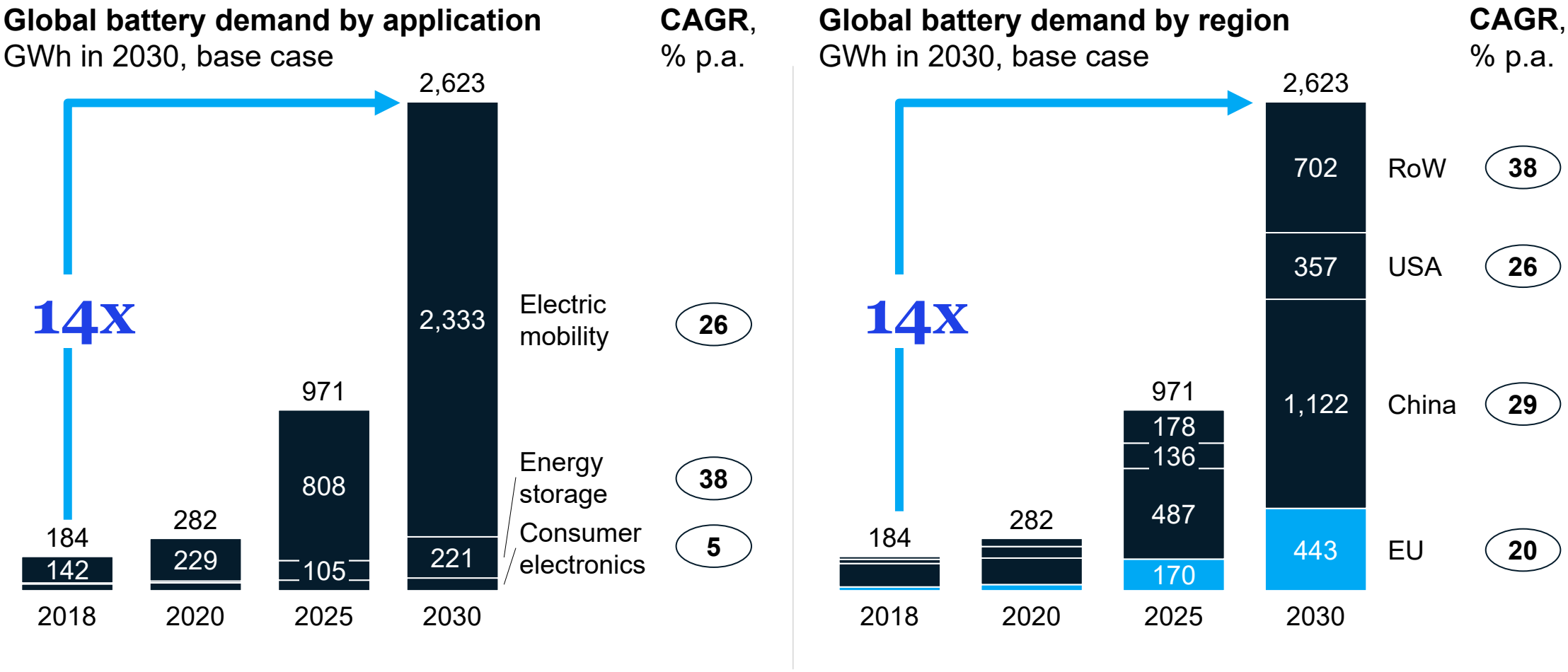


Comments

- Chinese battery demand transitioning from LFP to NMC in order to increase EV performances
- Rest of the World is going to phase out NMC111 and LMO due to low performance vs other battery chemistry
- Overall increasing adoption of NMC811 due to good balance between high performance and cost
- NCA is the chemistry of choice of Tesla (sales volume will continue to increase but declining market share unless Panasonic will partner with an additional OEM)

SOURCE: Battery raw materials demand model

Our view of the market in 2019…showed global battery demand to reach ~2,600 GWh in 2030, we now see nearly triple this



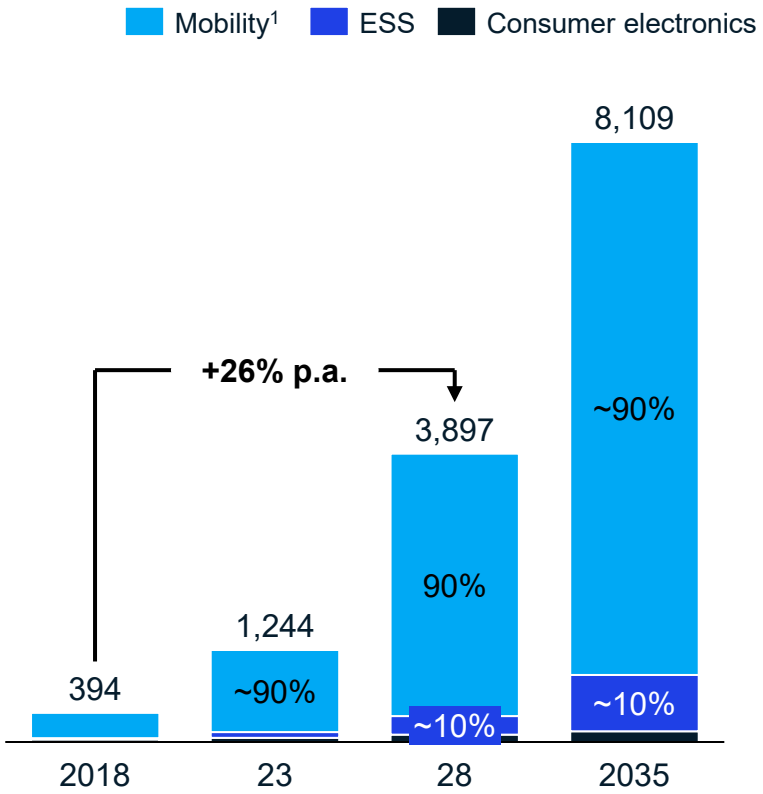
Source: McKinsey and Global Battery Alliance

Battery demand is projected to reach 8.1 TWh by 2035, mostly concentrated in China

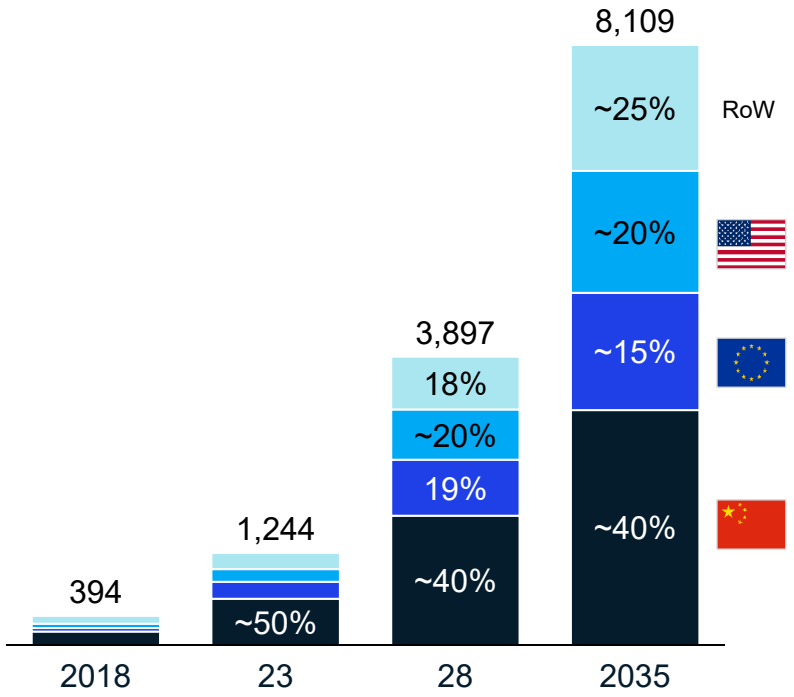
2023 Q3 | Current trajectory Scenario

Li-ion | Na-ion | Li-S | Pb-a | V-RF | Ni-MH

Global battery cell demand by sector, 2020-2035, GWh



Global battery cell demand by region, 2020-2035, GWh



1. Incl. Passenger cars, Commercial vehicles, 2-3 wheelers, off highway vehicles, maritime, drones and aviation

Source: McKinsey Battery Insights Demand Model

Key insights

- ~ 90% of demand driven by the mobility sector
- ~40% of demand to come from the China market
- Significant growth globally due to regulation

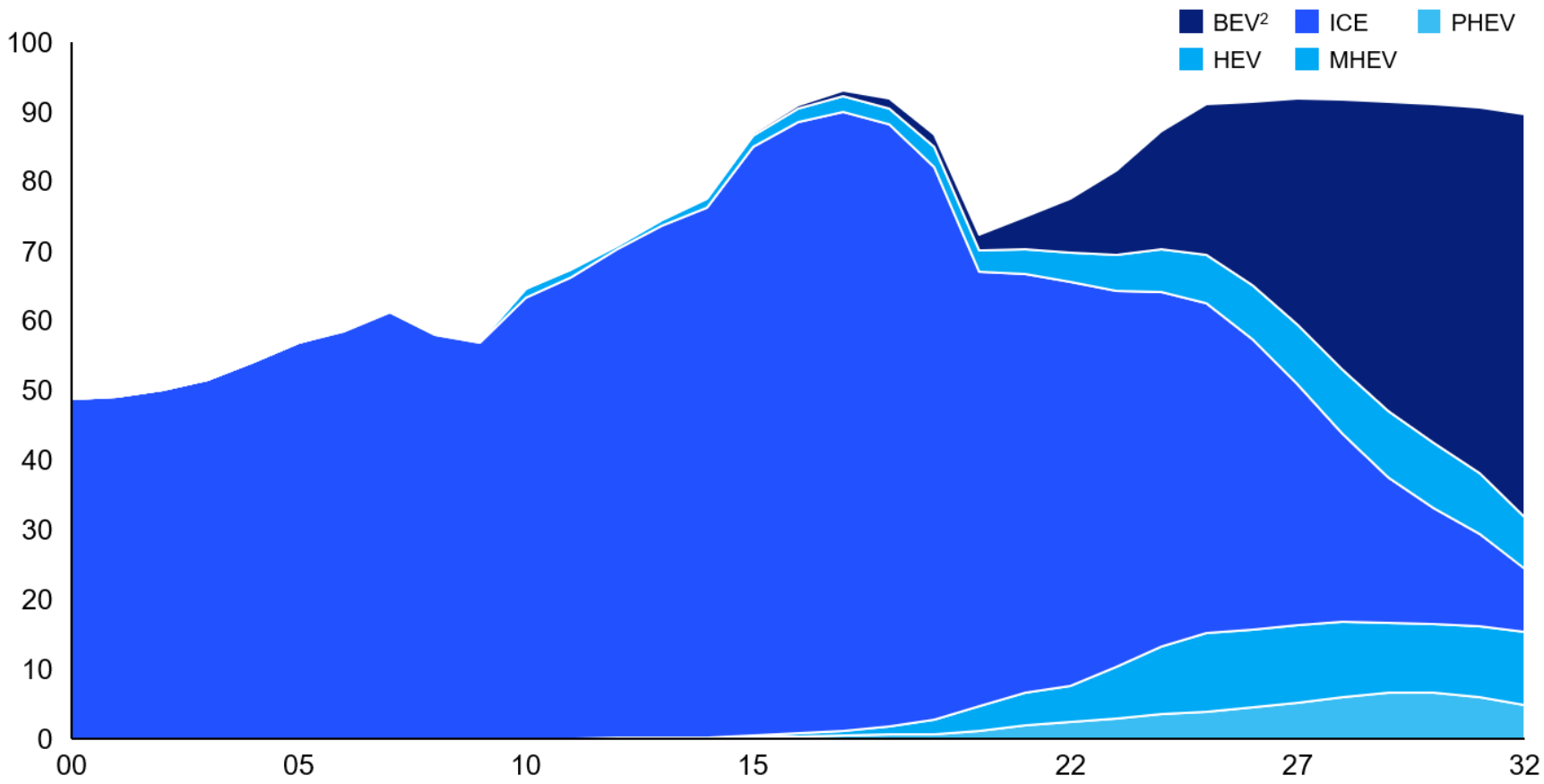
20 x

growth in GWh battery demand from 2018 to 2035

BEV adoption continues to accelerate – could reach over 60% of global passenger vehicle sales within the next 8 years

Further Acceleration

Passenger cars production by powertrain[1], million units



1. BEV – Battery Electric Vehicle; HEV – Hybrid Electric Vehicle; PHEV – Plug-in Hybrid Electric Vehicle, MHEV – Mild Hybrid Electric Vehicle; ICE – Internal Combustion Engine Vehicle
2. Include FCEV - Fuel Cell Electric Vehicle

Source: McKinsey Center of Future Mobility

BEV adoption driven by:

Regulation and incentives

- Regional/national regulations and local laws (e.g., UK moving ICE ban forward to 2030) are the key driver of electric vehicle adoption globally and often combined with incentives

Technology & charging infrastructure

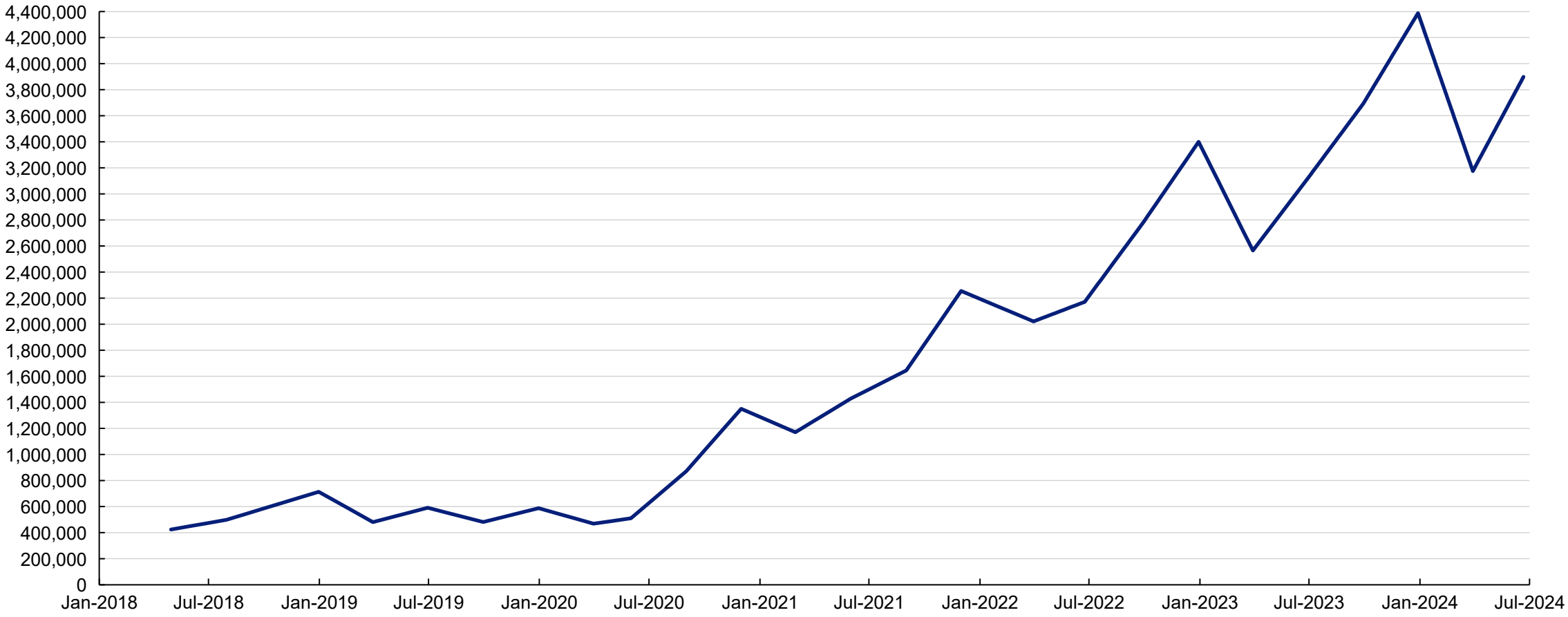
- Further reduction in battery costs and technology cost will reduce price difference between EVs and ICE vehicles
- Public fast-charging infrastructure is growing in early EV markets. First generation of EV buyers has access to private charging (often subsidized)

Consumer preferences

- Consumer mind is shifting towards sustainable mobility and purchase consideration of EVs is growing

Demand for pure EV's has continued to grow at a rapid pace, chemistries have changed

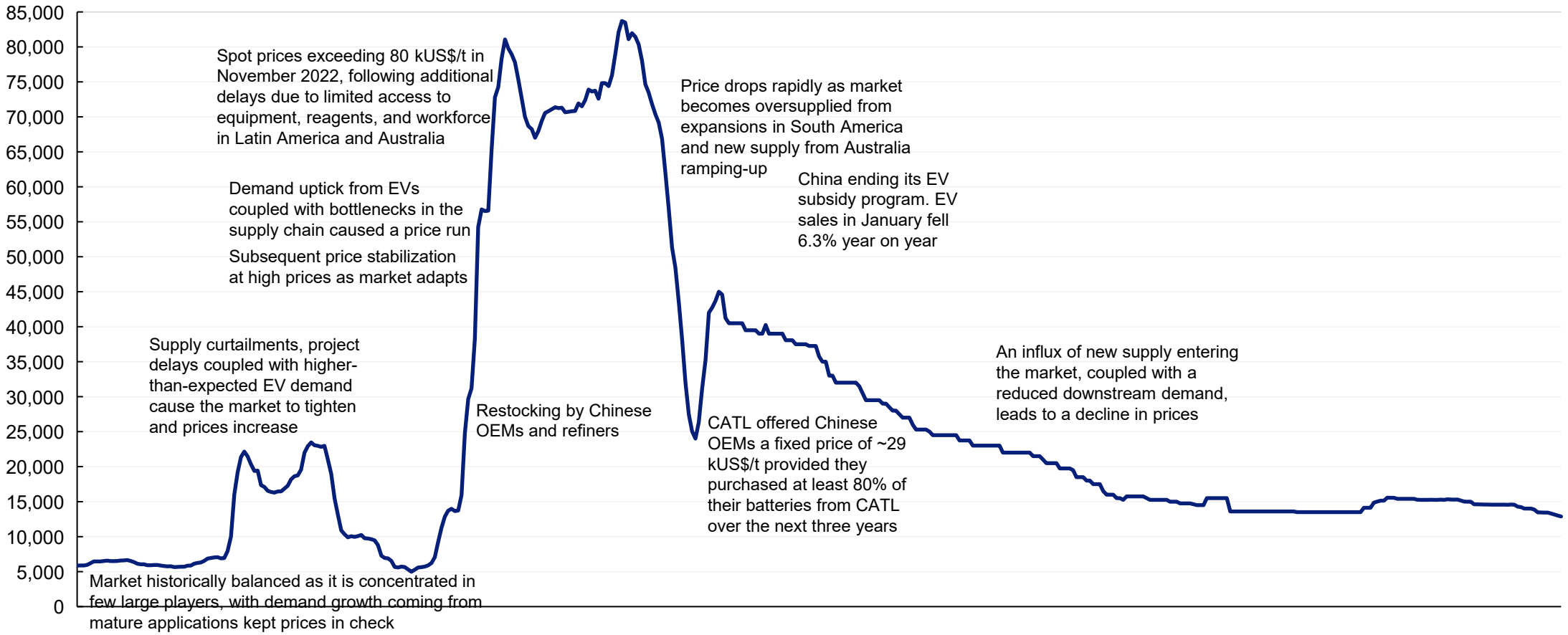
Global Quarterly BEV Sales



Lithium prices have gone through periods of sharp spikes and drops over the past five years, driven by imbalances in the market

2024 Q1

Lithium Carbonate price in China, US$/tonne

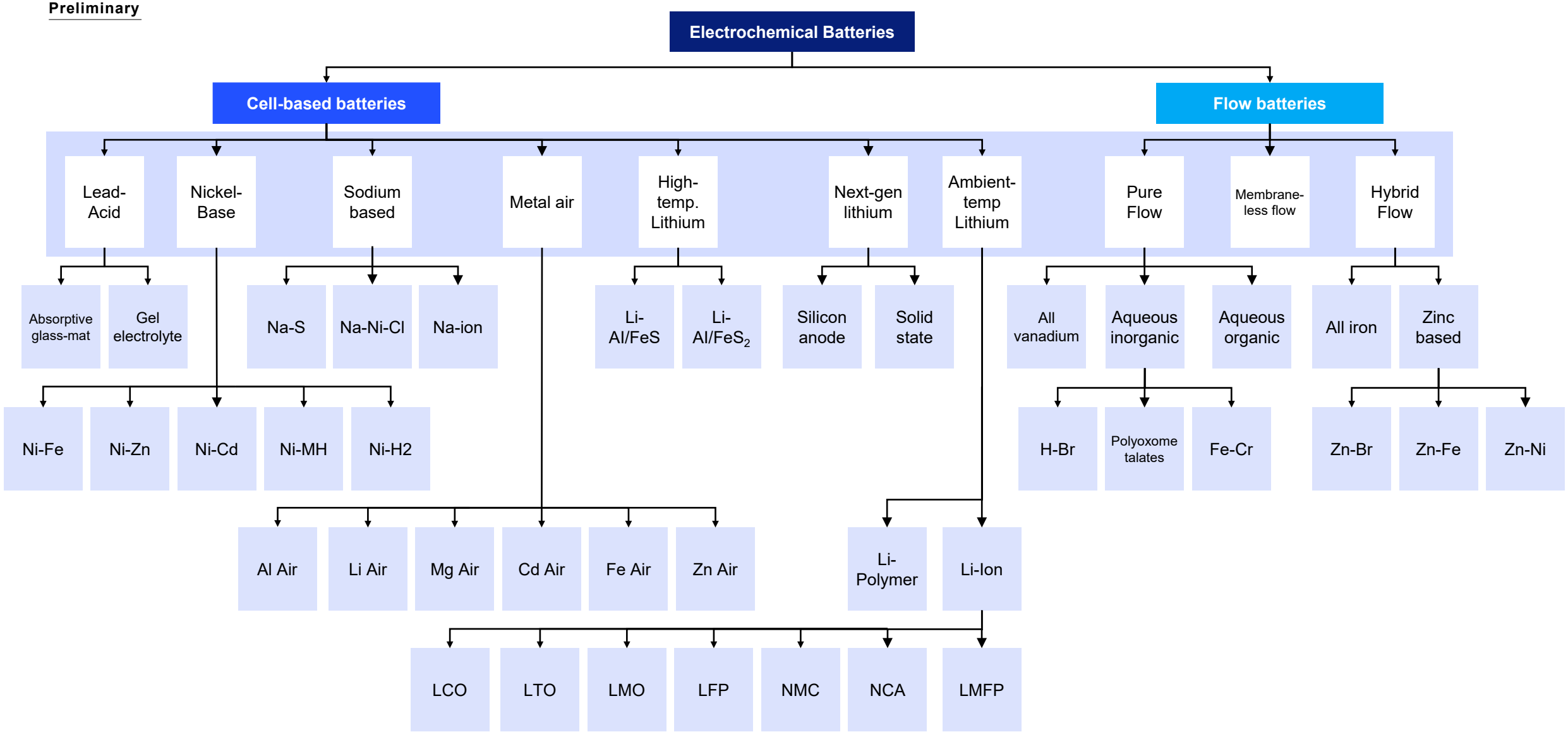


1. Prices until June 23rd, 2024

Source: Fastmarkets MB, MineSpans

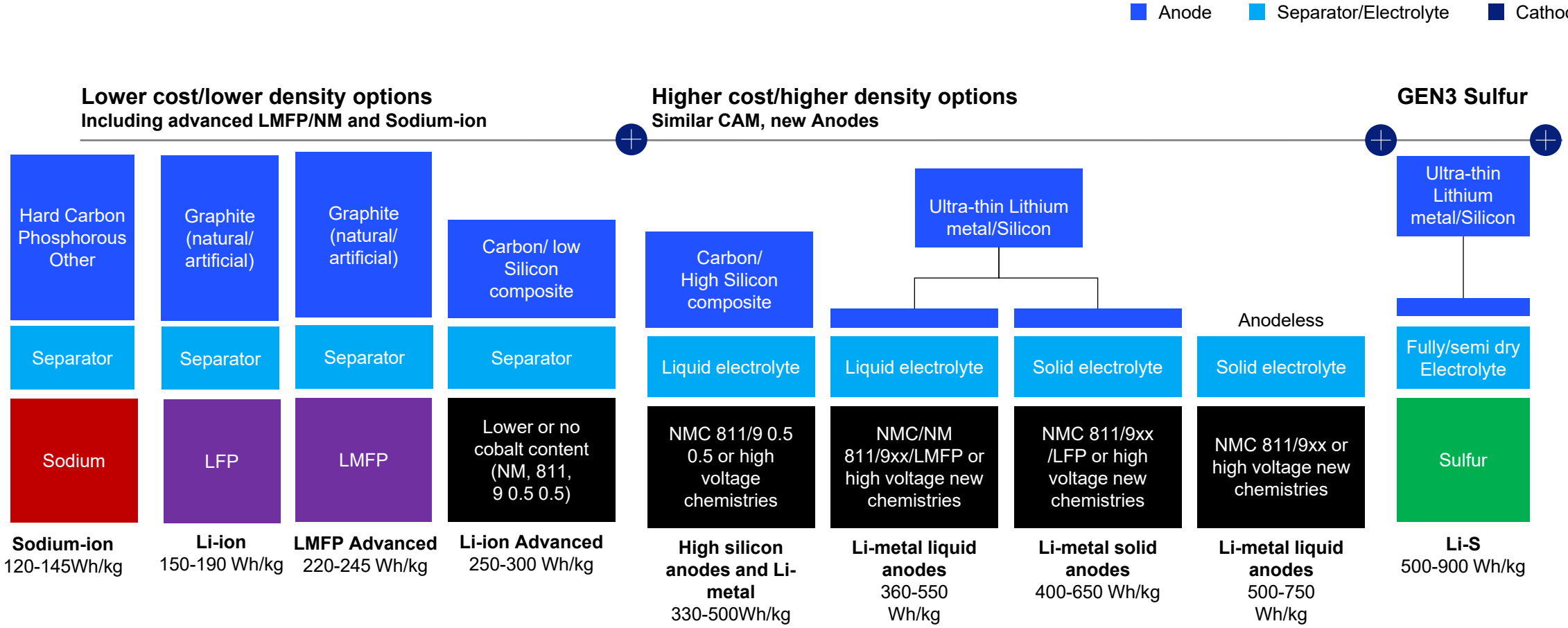
Cell Technology is very diverse--The type of potential solutions to the world's battery needs is vast and changing every day

Preliminary



We see battery chemistry evolving rapidly and not in a straight line, OEM's focus on density, charging speed, costs, and durability

Understand cathode AND anode material qualities and implications



1. Very early stage reflexion
2. Based on 7-year contracts in average, last known supply order signed with Volkswagen in March 2021

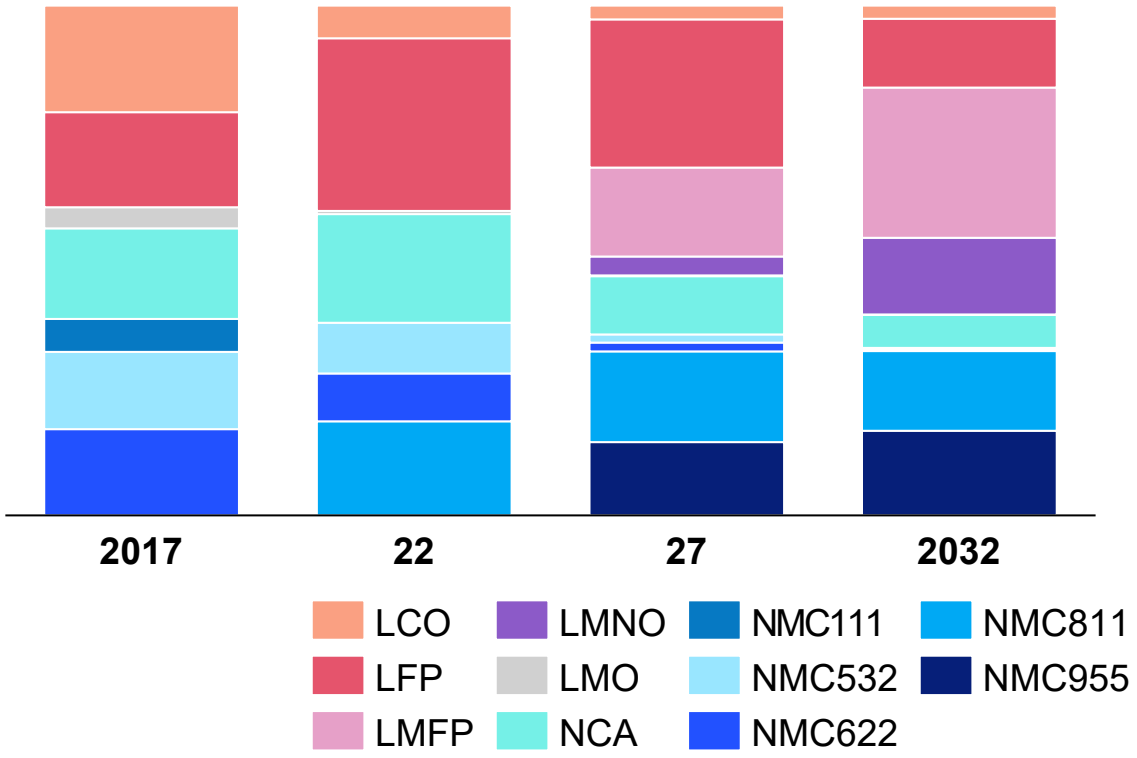
Source: Team analysis, Bernstein

Our 2023 chemistry view has changed vastly, and expect this change to continue, causing issues for those estimating demand

Further Acceleration Scenario

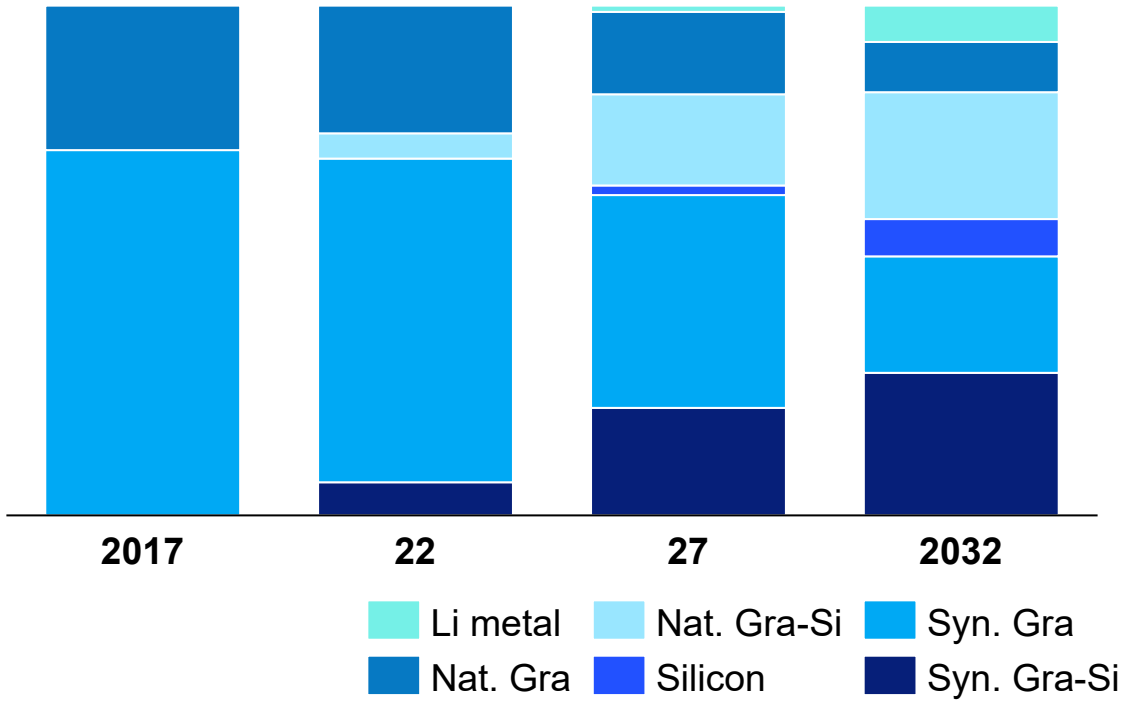
Cathode technology split[1]

GWh



Anode technology split[2]

GWh



1. Lithium Ions batteries only. LCO: Lithium Cobalt Oxide; NMC: Lithium Nickel Manganese Cobalt Oxide; NCA: Lithium Nickel Cobalt Aluminum Oxide; LFP: Lithium Iron Phosphate; LMFP: Lithium Manganese Iron Phosphate; LMO: Lithium Manganese Oxide;
2. Lithium Ions batteries only. LTO: Lithium Titanate Oxide;

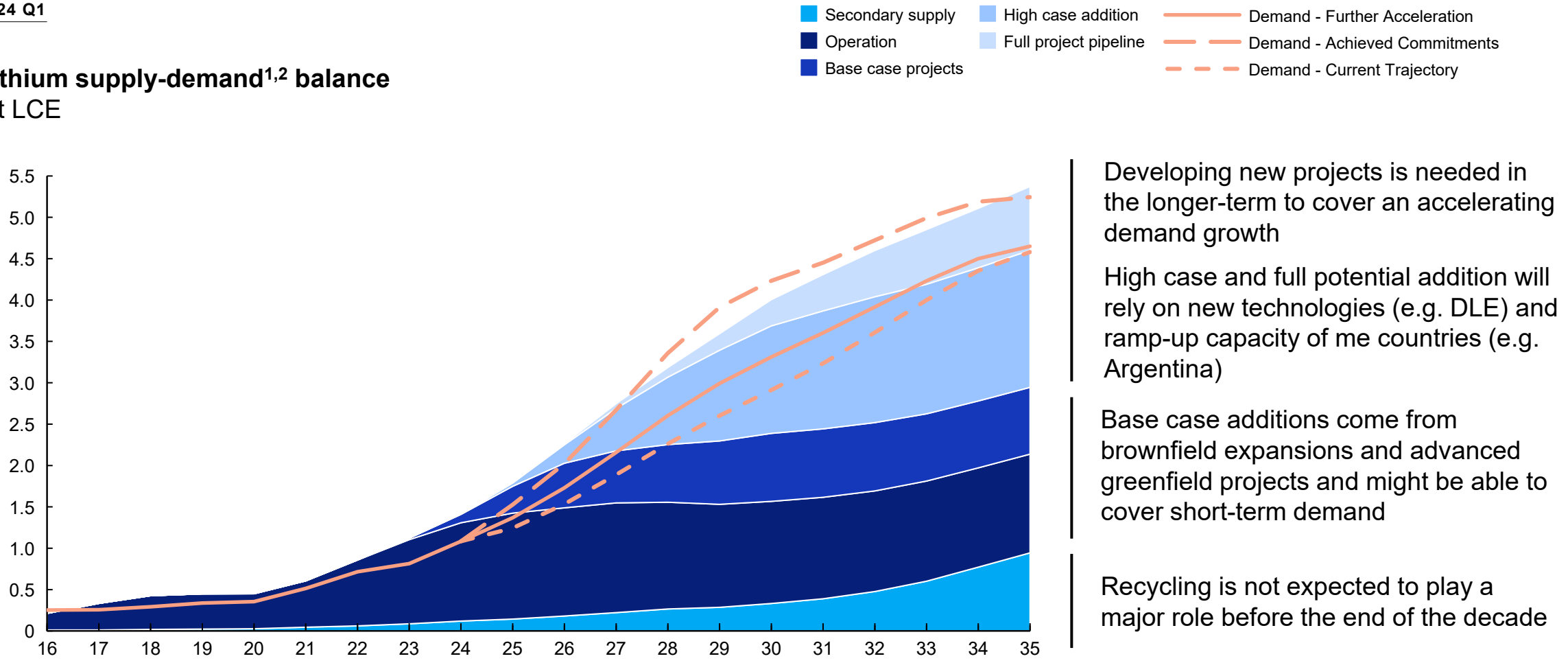
Source: McKinsey Battery Insights

Current base pipeline of lithium projects expected to cover demand until 2026, but early-stage projects needed to cover demand to 2035

Investments in new deposits development will be required over the next decade

2024 Q1

Lithium supply-demand[1,2] balance
Mt LCE



Developing new projects is needed in the longer-term to cover an accelerating demand growth

High case and full potential addition will rely on new technologies (e.g. DLE) and ramp-up capacity of me countries (e.g. Argentina)

Base case additions come from brownfield expansions and advanced greenfield projects and might be able to cover short-term demand

Recycling is not expected to play a major role before the end of the decade

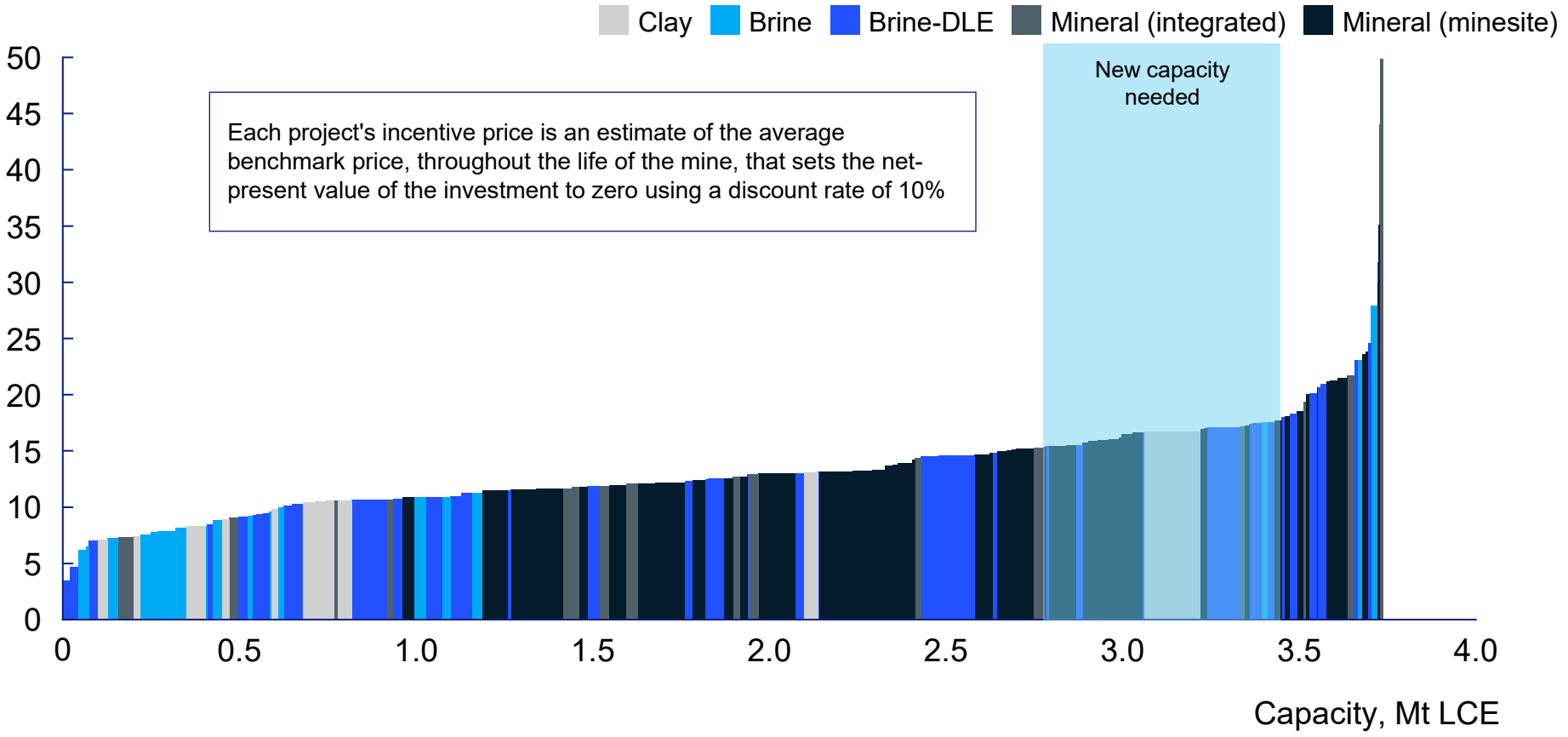
1. Mined production volume. Forecast potential production accounts for historic utilization rates as a result of external disruptions and economic curtailments (7%) – modelled at 93% of the available capacity
2. Production includes volumes which may not have been refined. These include stockpiling of DSO and Spodumene concentrate

Source: MineSpans

Marginal lithium mining projects require a price of at least 17,000 USD/t LCE over their mine life

2024 Q1 **Full potential**

Incentive price for finished lithium projects, k US$/ kg LCE



Takeaways

Most of the lithium mining projects have an incentive price varying between 7 and 18 USD/kg LCE

Clay mining projects require theoretically the lowest lithium price, with an incentive price varying between 4.6 and 10.0 USD/kg LCE.

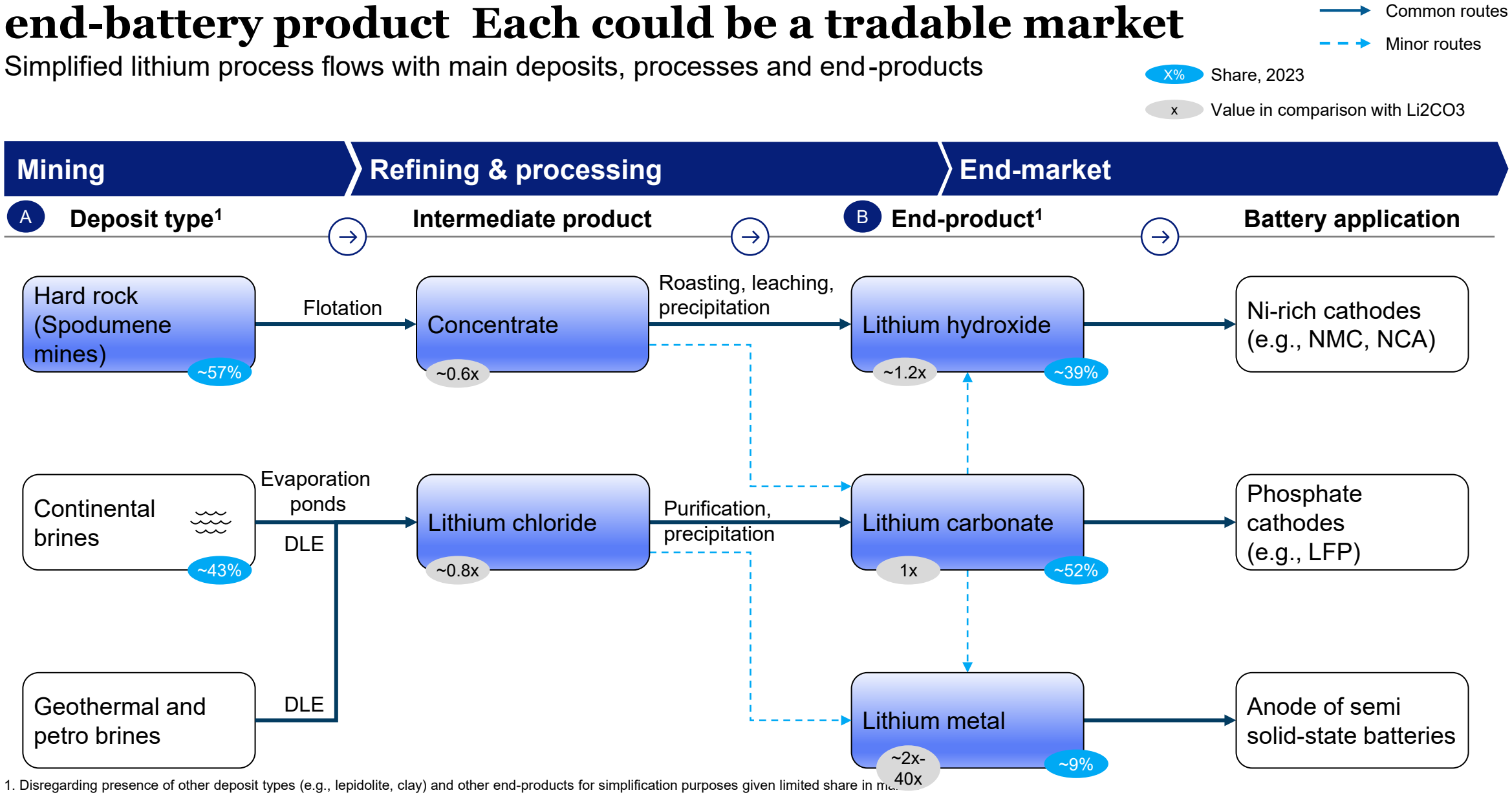
Most of the conventional brine projects are in the first half of the incentive price curve.

Many DLE methods are being tested and depends on the local conditions. As a results DLE projects are spread across the incentive price curve.

Source: MineSpans

Lithium value chain follows two routes, each having a preferential end-battery product Each could be a tradable market

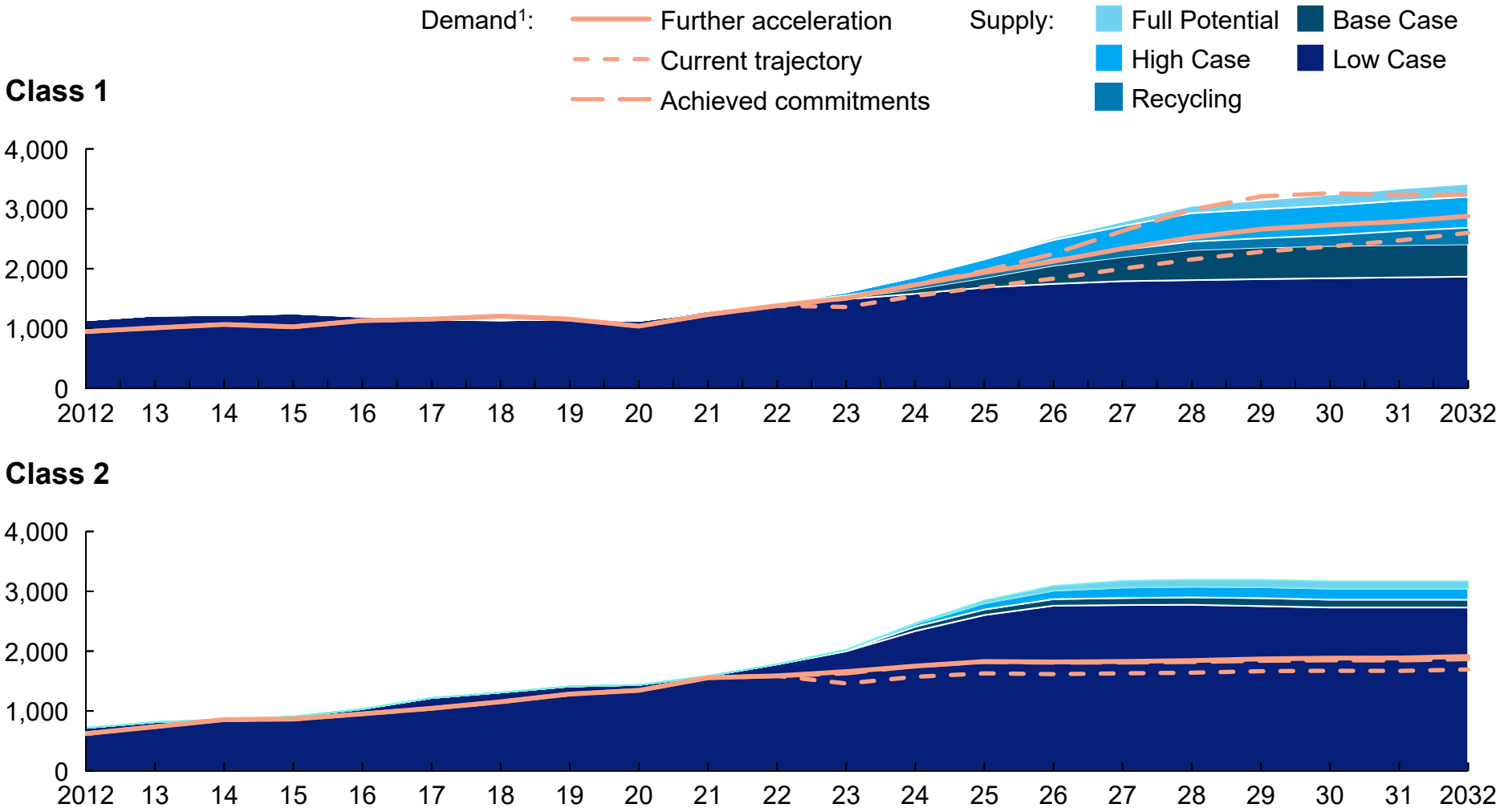
Simplified lithium process flows with main deposits, processes and end-products



1. Disregarding presence of other deposit types (e.g., lepidolite, clay) and other end-products for simplification purposes given limited share in ma

Class 1 tightness is likely to endure, potentially relieved by NPI conversion increasing supply or nickel substitution reducing demand

Refined nickel supply capacity and demand by class of nickel, in kt Ni



Fast-growing EV batteries using NMC/NM/LMNO etc expected to drive class 1 demand

The bulk of supply growth is expected from laterites in Indonesia , will this supply last?

The nickel pig iron (NPI) supply, particularly in Indonesia, in excess of the flat stainless steel demand is expected to be available for class 1 intermediate production (matte)

1. Class demand based on the current demand profile. Shifts in demand are likely to happen with evolving technology and price dynamics

Source: MineSpans

How to do your best are understanding metal markets in this unprecedented age of energy transition

1) Know that battery technology and battery chemistry will evolve depending upon

- **A) Cost**
- **B) Performance**

2) Track all demand trends, not just EV's but stationary, infrastructure etc. to understand true demand delta

3) Never underestimate the mining industry for bringing new capacity to market

4) Buy when prices are low and sell when prices are high