

IEB AutoTech 2022

Global Battery Technology Trends and Challenges

S&P Global
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Agenda

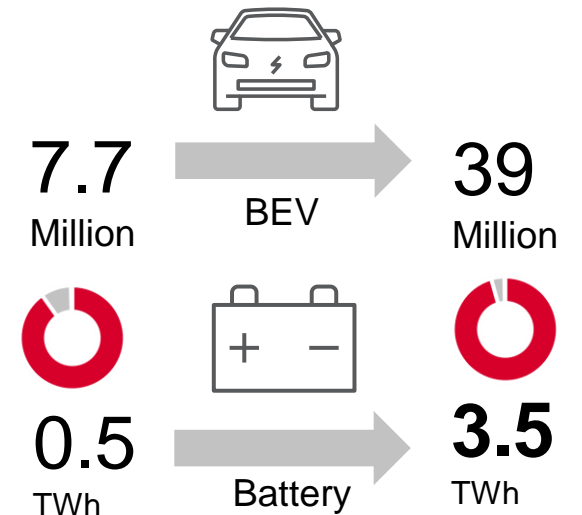
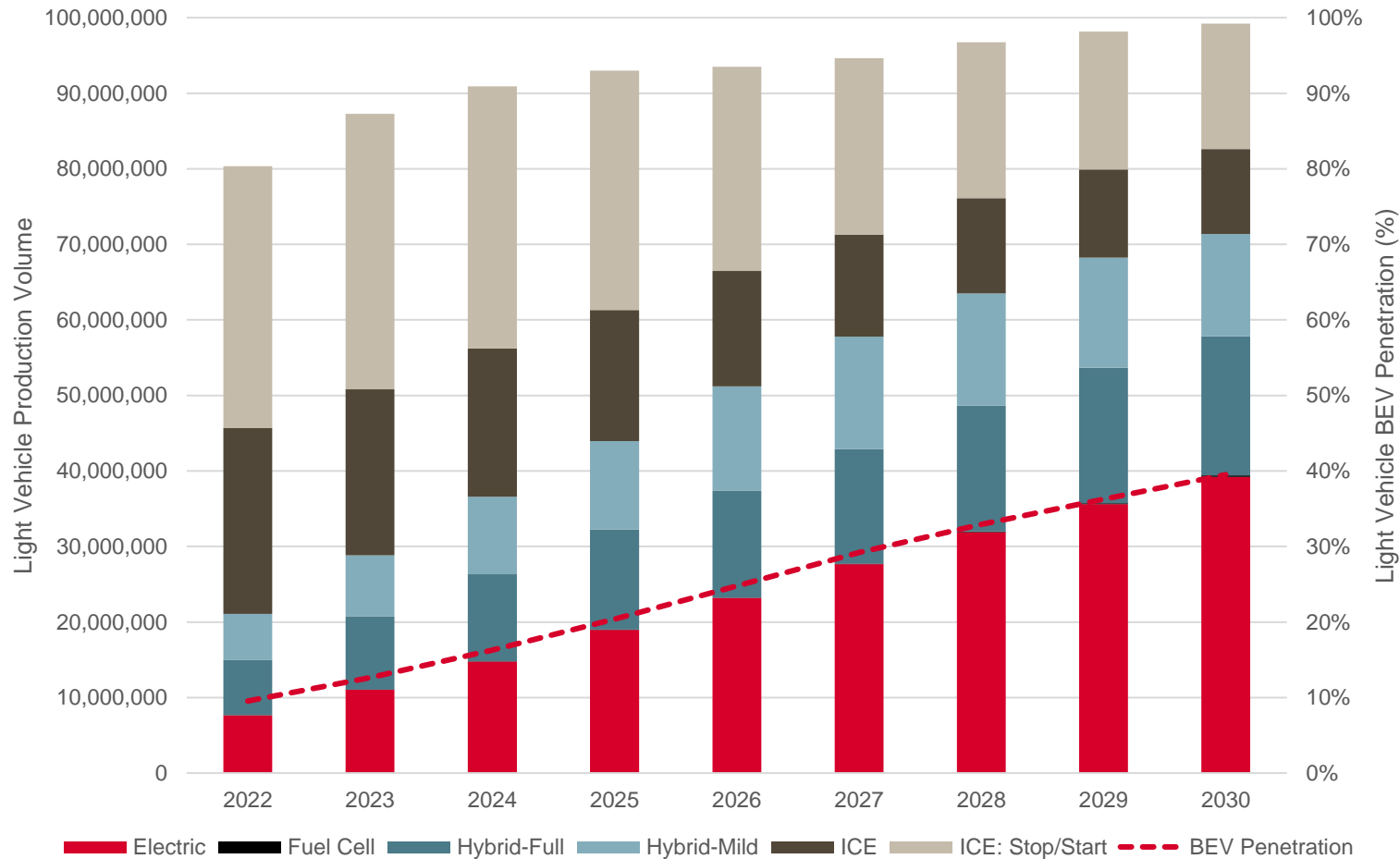
Evolving Battery Technology for Mobility

- Global EV Battery Market Overview
- Battery Cell/Pack Design to Boost Energy Density
- Chemistry to Leverage Supply Shortage



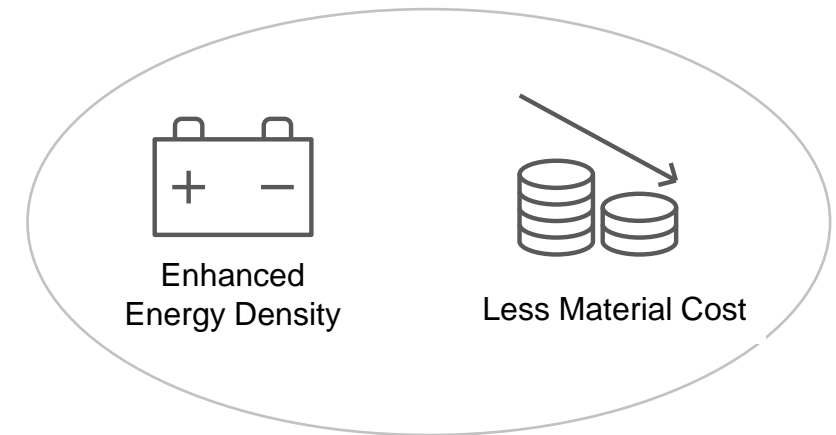
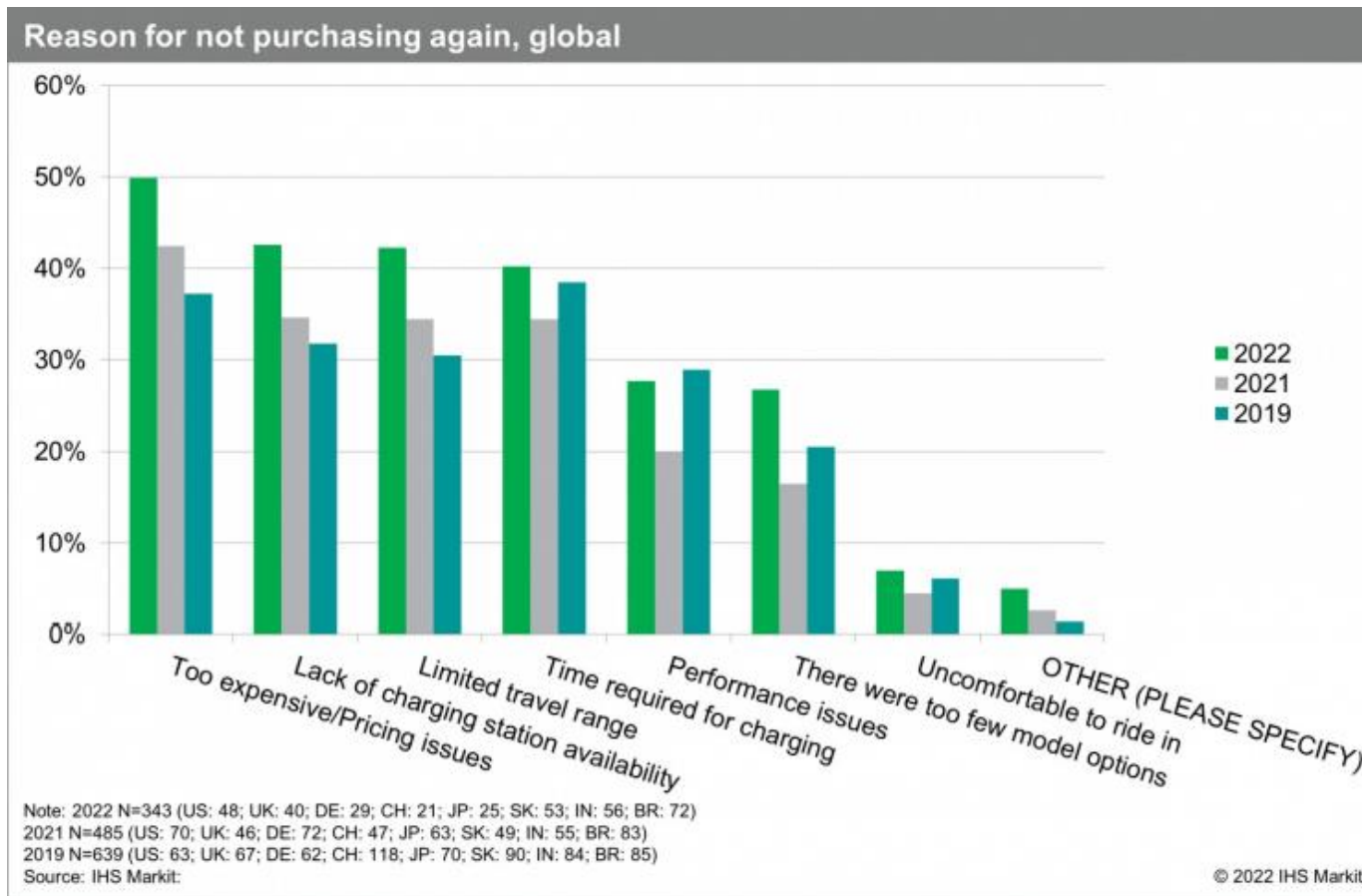
Growing Electrification despite of Slow Down Vehicle Production

40% BEV Penetration by 2030



Drivers for Battery Technology Development

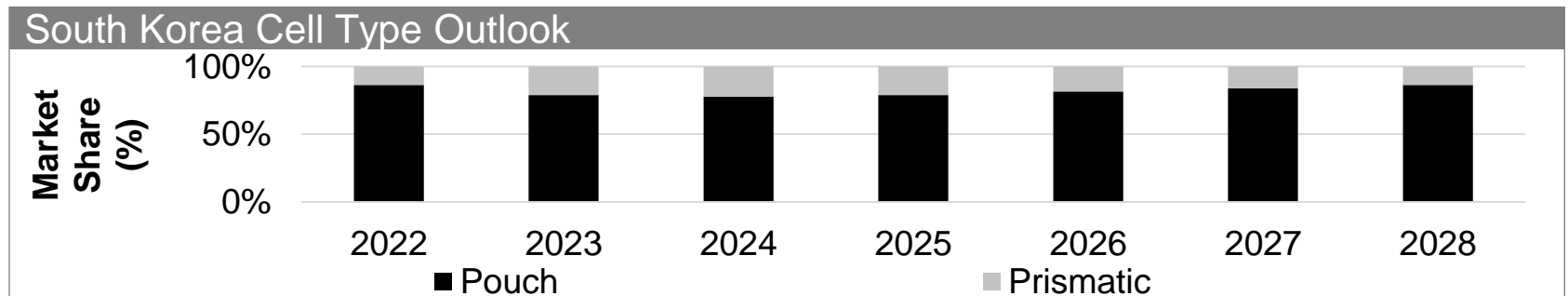
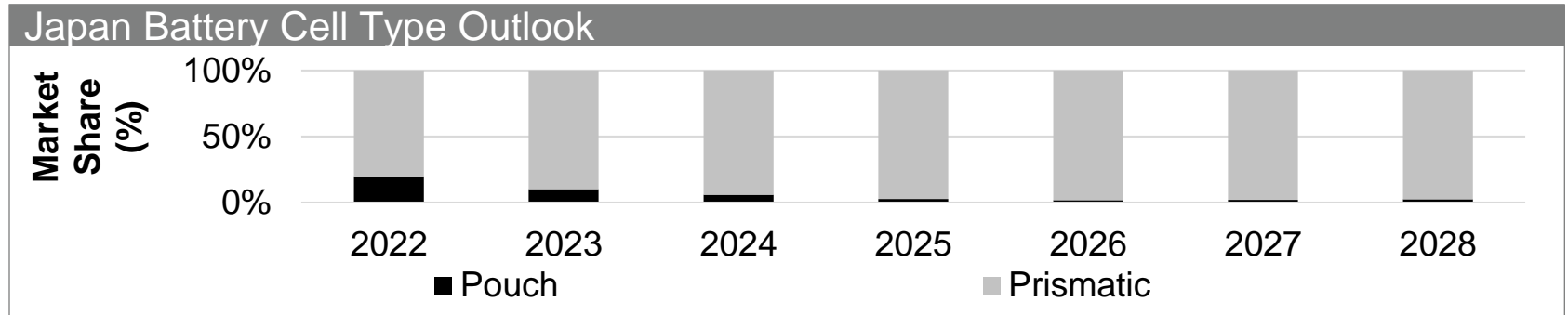
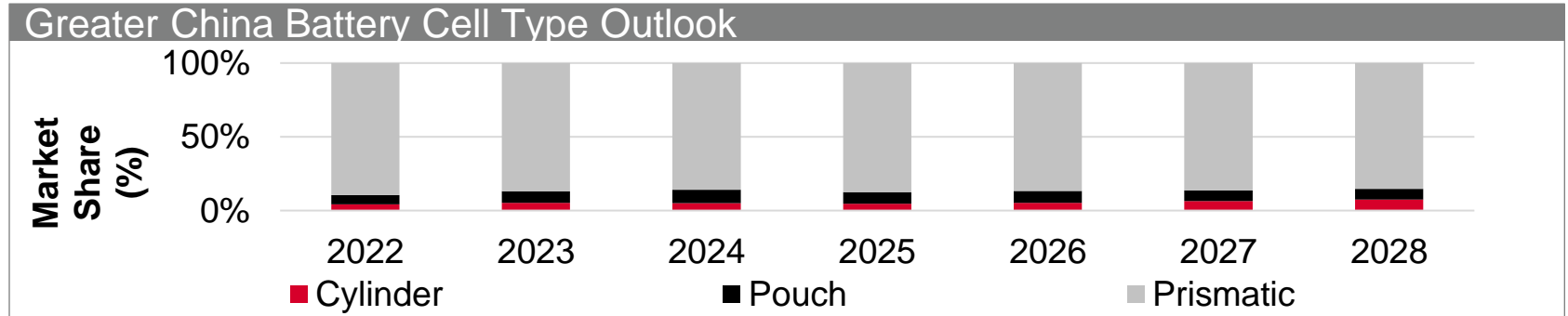
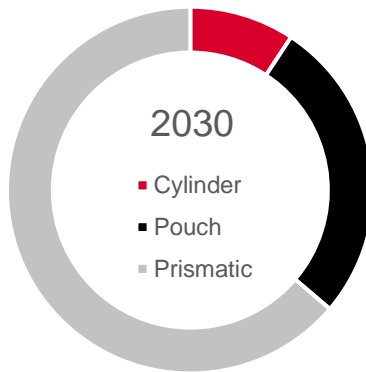
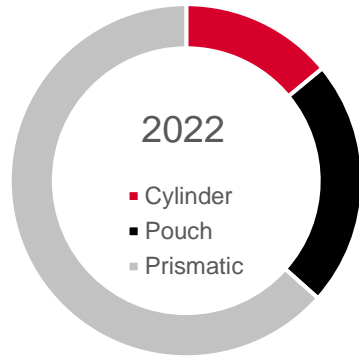
Cost, Travel Range



- | | |
|--|---|
| Compact Battery Design <ul style="list-style-type: none"> • Cell Type • Pack Design | Alternative Chemistry <ul style="list-style-type: none"> • Cost Reduction • Energy Density |
|--|---|

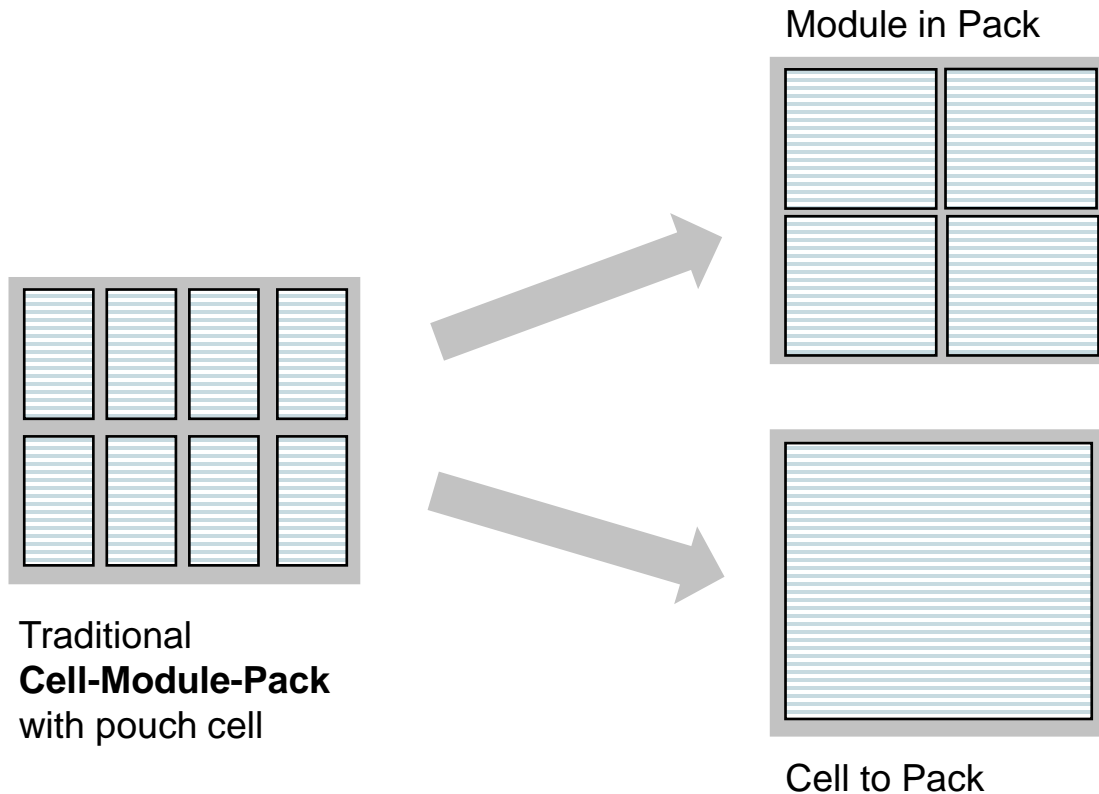
Global Battery Cell Type Outlook

Prismatic cell will be leading cell type in the future



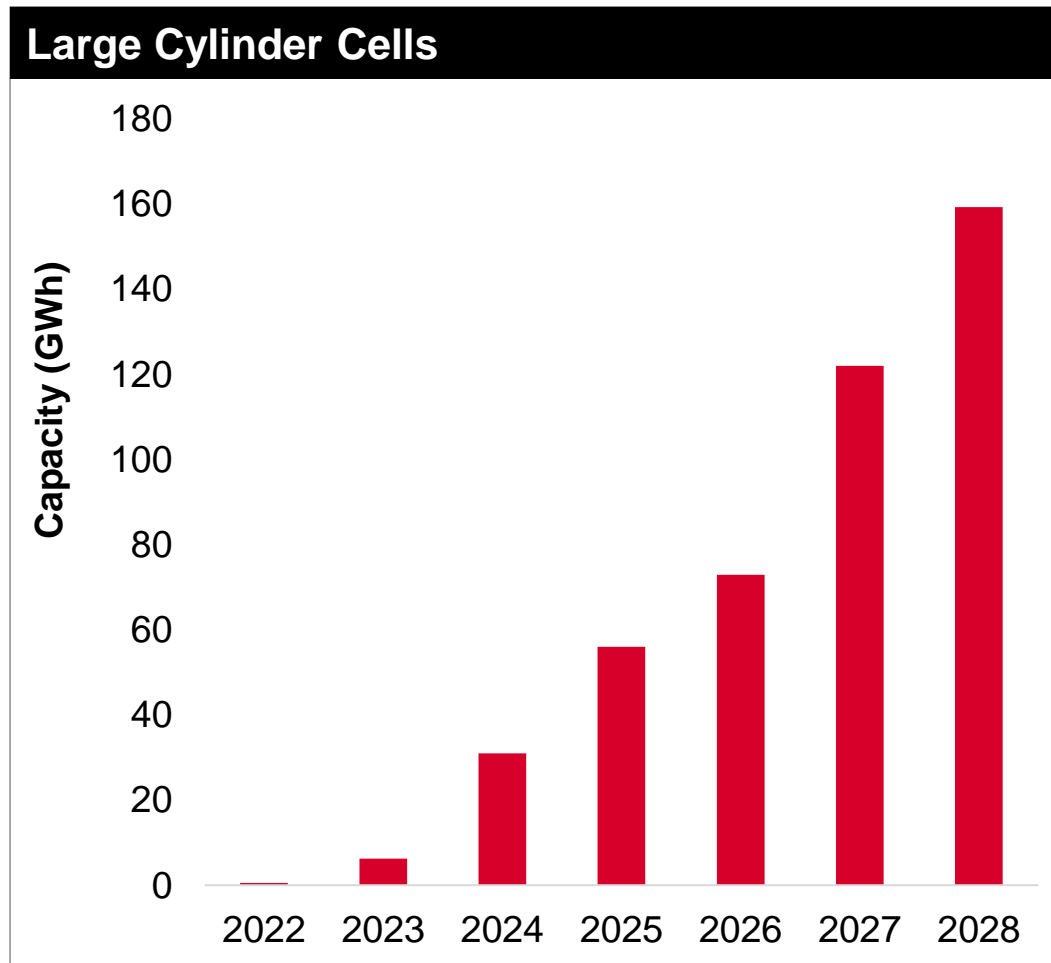
Source: S&P Global, AutoTechInsight, OCT 2022

The Future of Pouch Cell CTP and “Module in Pack”



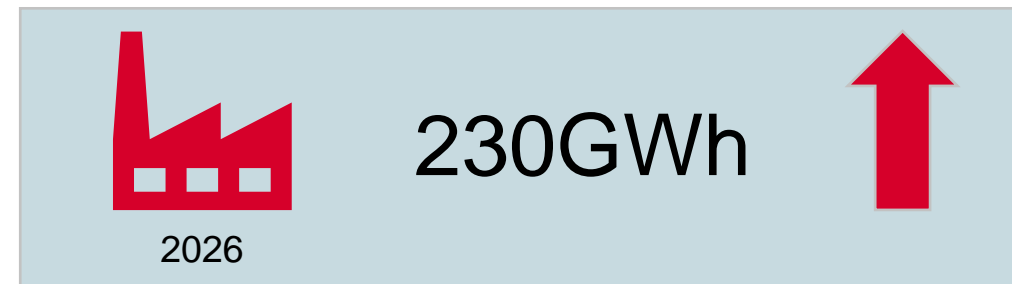
- Pouch cell makers are developing highly compact pack system with stacked pouch cells
- CTP and “Module in Pack” concept could boost pack volumetric utilization rate to **50%~75%**
- Technology expected to be SOP by 2025
 - LG CTP (Pouch cell) SoP 2025
 - Up to **70%** volume utilization rate
 - SK on “S Pack”
 - Farasis “Super Pouch Solution”
 - Adjustable cell thickness
- Similar design concept to be adopted by hybrid solid state/solid state battery cell makers

2022 Marks the Year of Large Cylindrical Cells



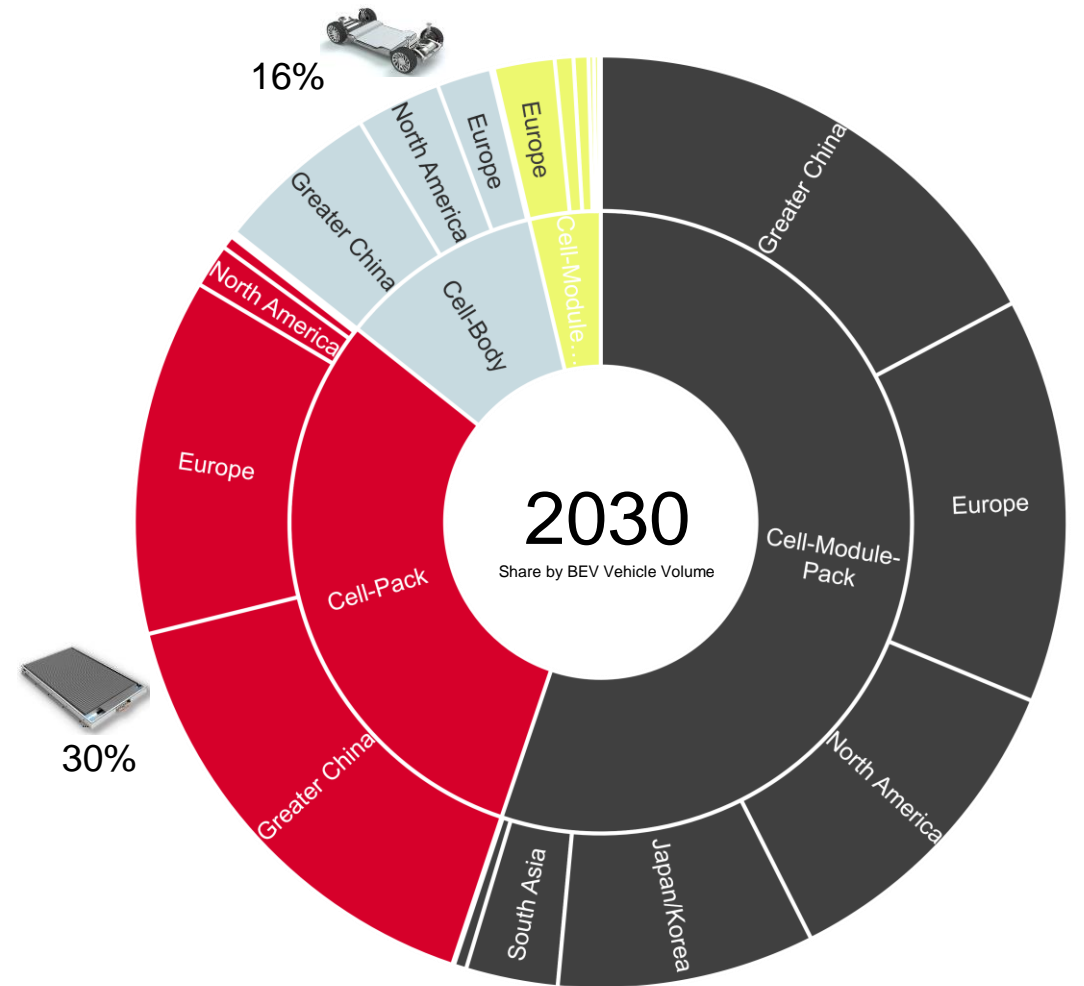
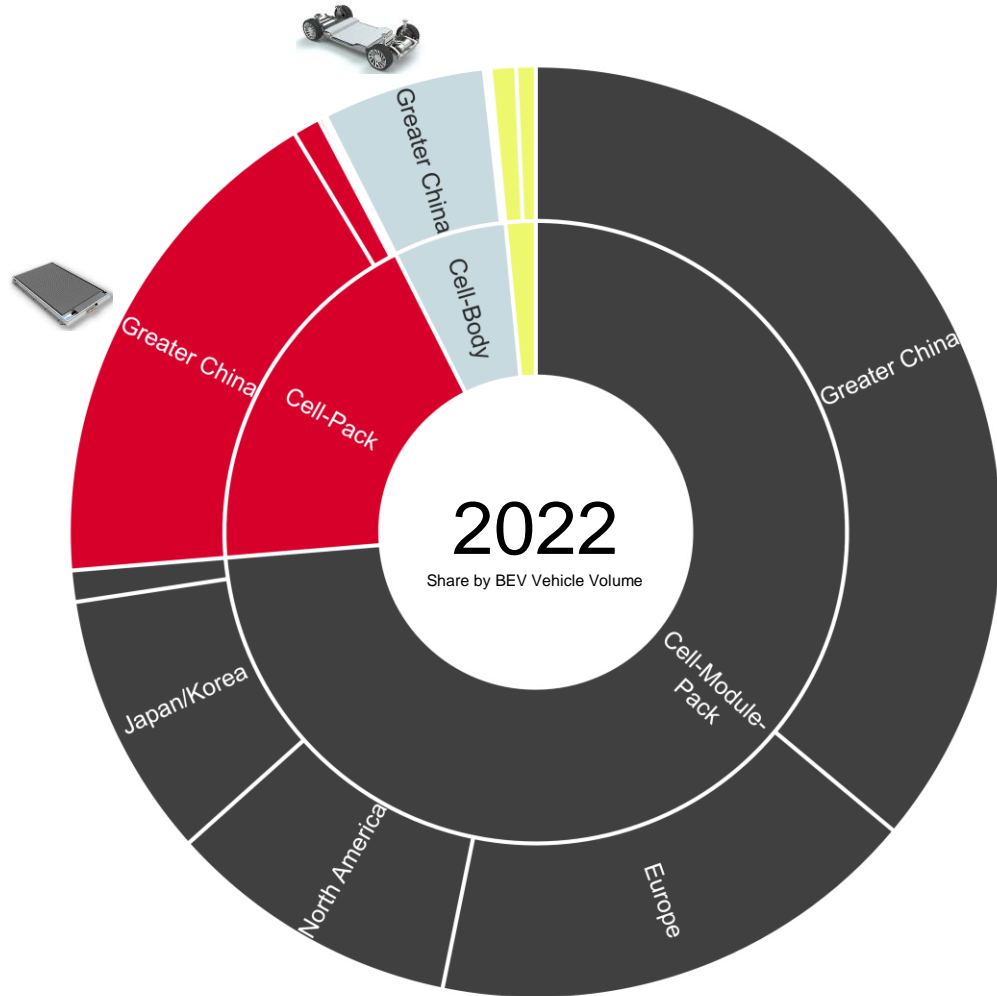
Source: S&P Global, AutoTechInsight, OCT 2022

- 2022 marks the year of beginning of large cylindrical cells while market demand continue to grow as more OEMs launch their next-gen platform from 2025
 - Tesla Model Y (2022)
 - BMW NK platform (2024/2025)
 - NIO
- Expecting production capacity expansion



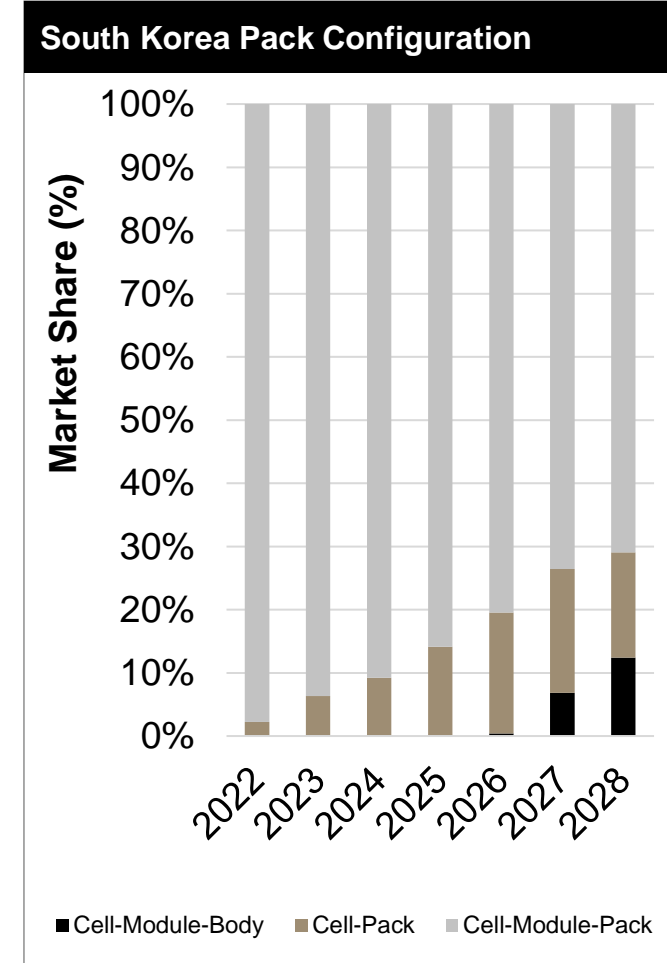
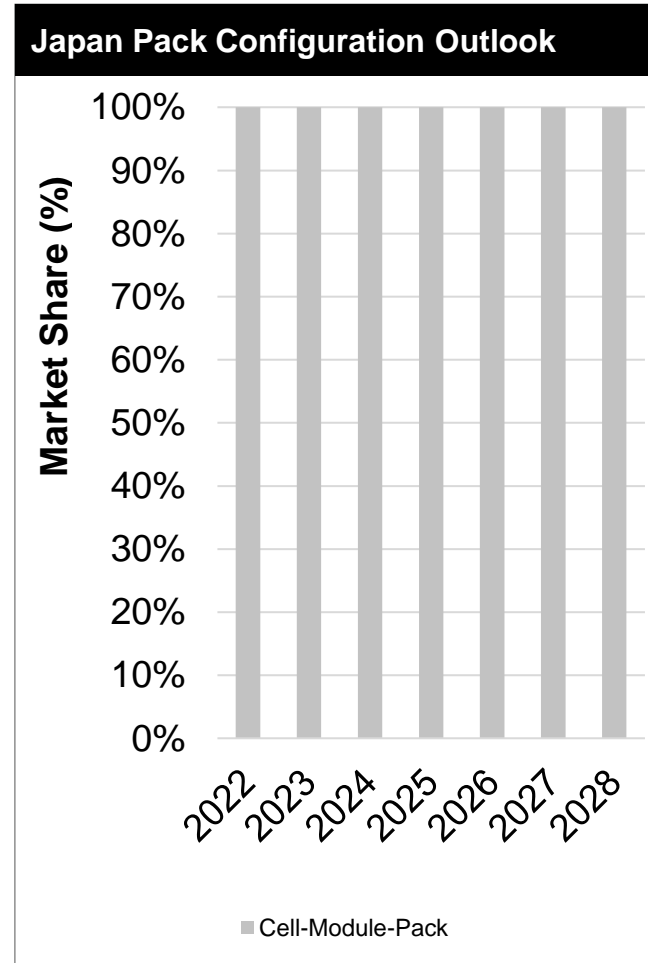
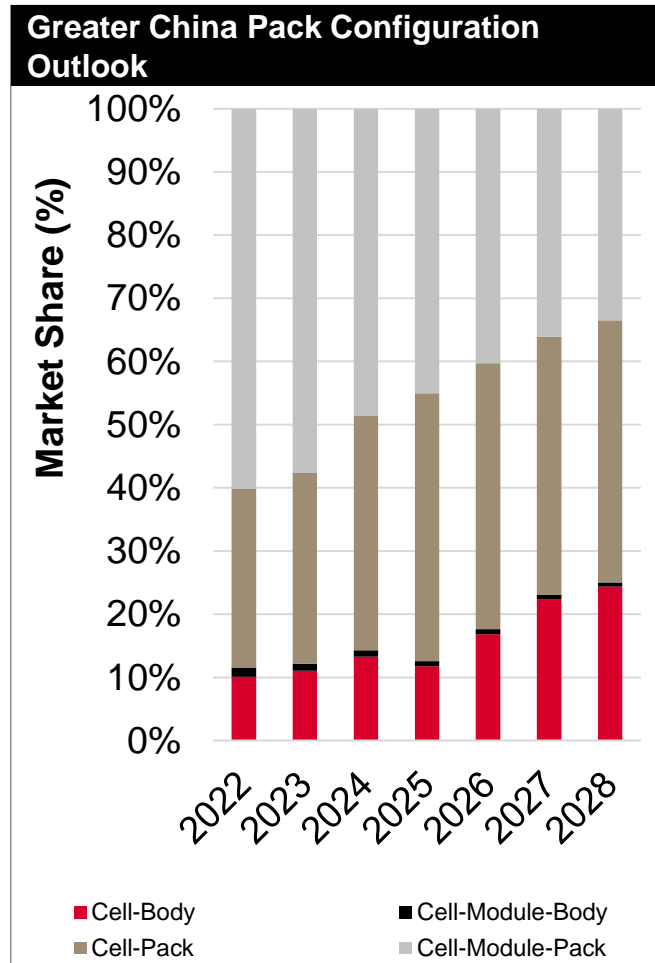
BEV Battery Configuration

Cell to Pack Penetration increased to 30% by 2030



Source: S&P Global, AutoTechInsight



High Growth of CTP in Greater China Driven by CATL and BYD



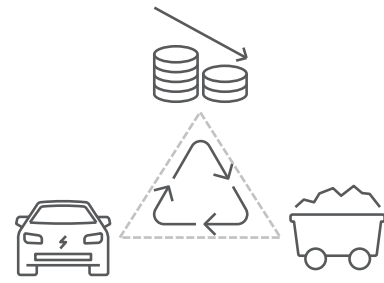
Source: S&P Global, AutoTechInsight, OCT 2022

Standardized CTP Battery Pack for Battery Swapping

OEMs have different approaches on Battery Swappable Packs

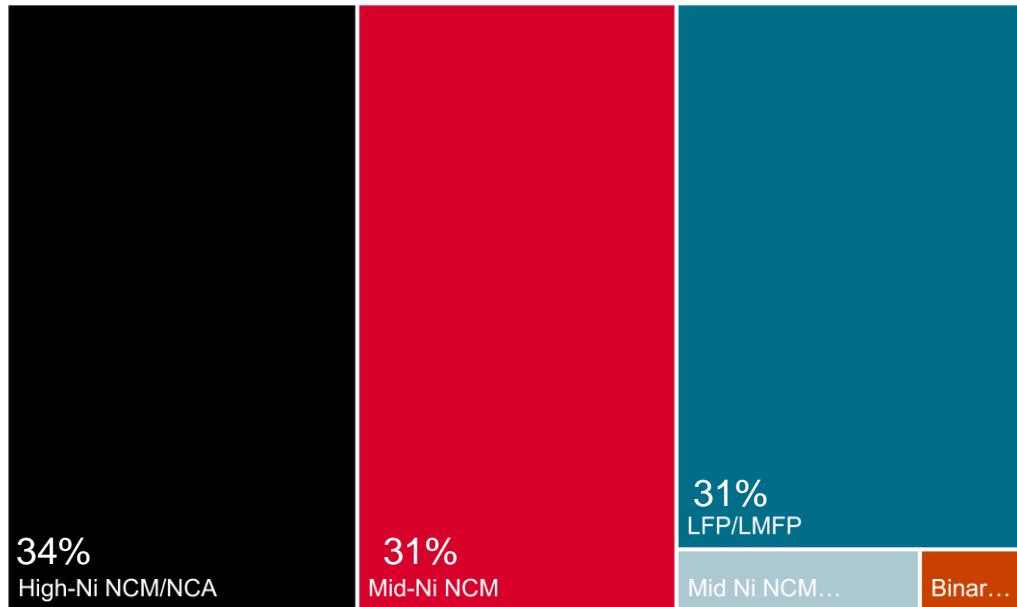
NIO	SAIC	CATL
<ul style="list-style-type: none"> Unified battery pack for multiple vehicle models <div> <p>One Pack Size</p> <p>Different Cell Chemistry</p> <ul style="list-style-type: none"> 75kWh/100kWh/150kWh (LFP/NCM)/NCM/semi-solid-state </div>	<ul style="list-style-type: none"> Adjustable battery pack height while keeping same width and length for multiple brands/models <div>  <p>Different capacity reached by</p> <ul style="list-style-type: none"> Prismatic cell thickness Chemistry(LFP/NCM..) </div>	<ul style="list-style-type: none"> Adjustable modules to be installed in vehicle <div>  <p>Flexibility in swapping different numbers of modules</p> <ul style="list-style-type: none"> Unified CTP module (26.5kWh) 26.5/53/79.5 kWh installation </div>
<p>Impossible for cross-OEM battery swapping</p>		<p>One step further to “real” battery swapping?</p>

Diversified Cathode Materials Driven by Performance, Cost Competitiveness, Raw Material Availability



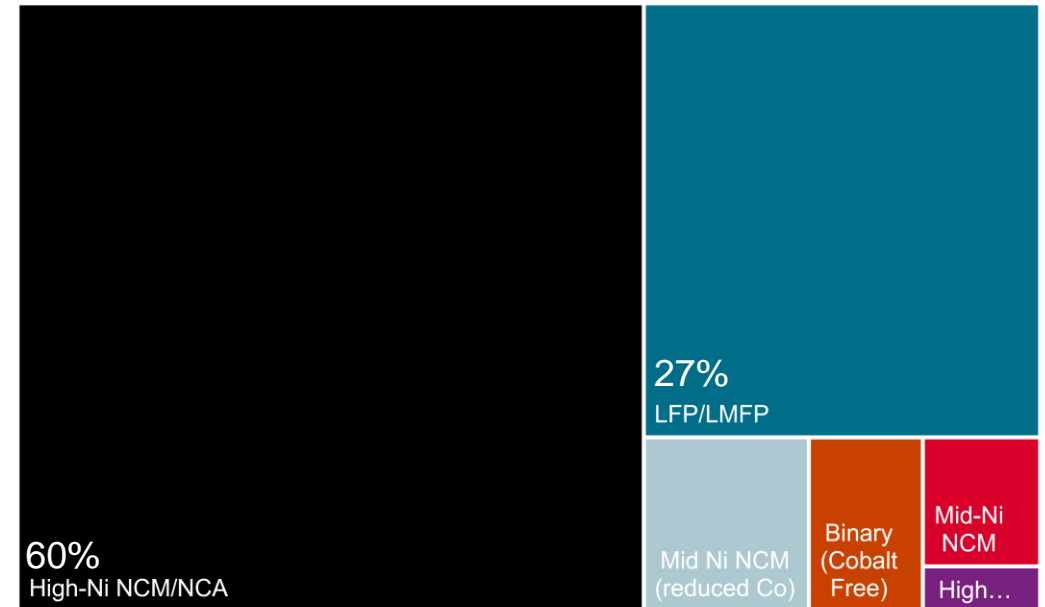
• Market Share of Cathode Materials (2022)

- Binary (Cobalt Free) ■ High-Mn NCM
- High-Ni NCM/NCA ■ LFP/LMFP
- Mid Ni NCM (reduced Co) ■ Mid-Ni NCM



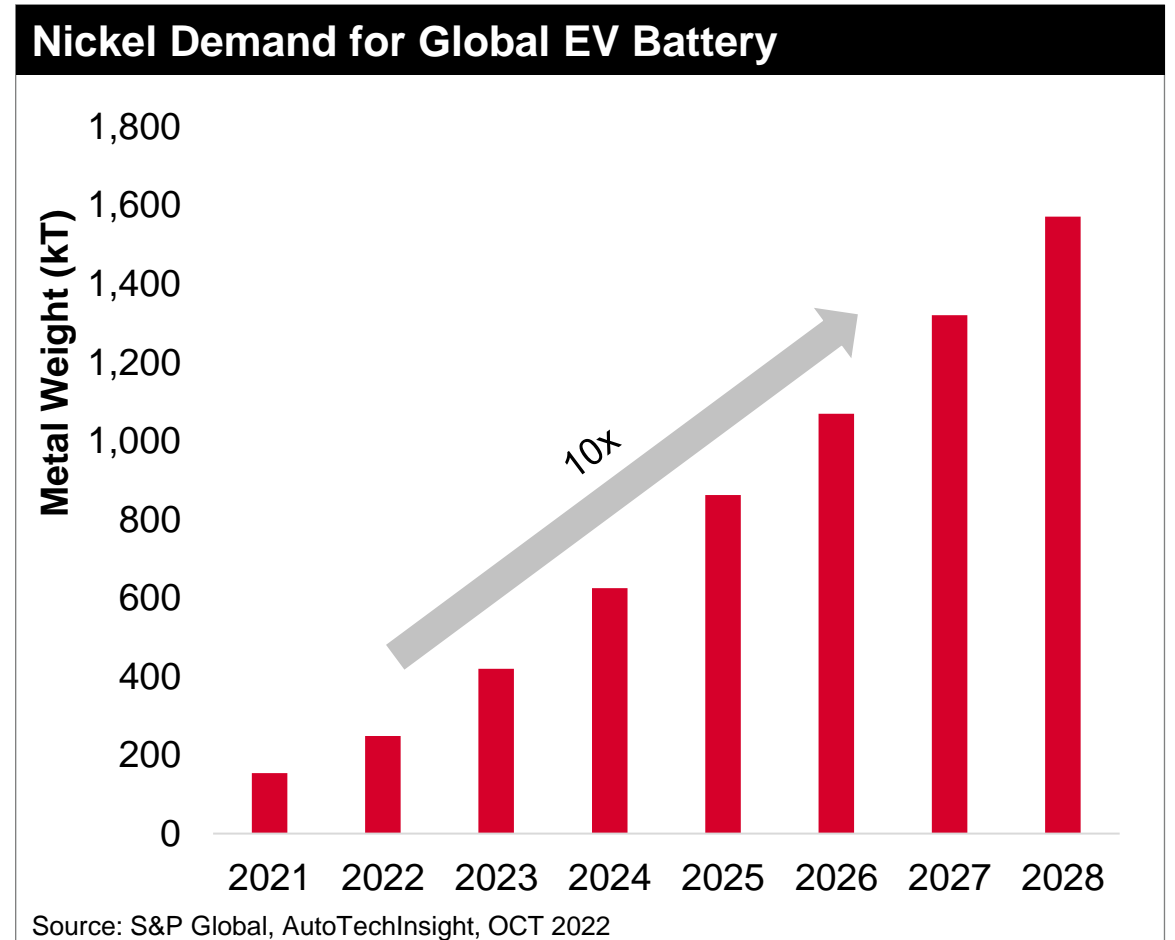
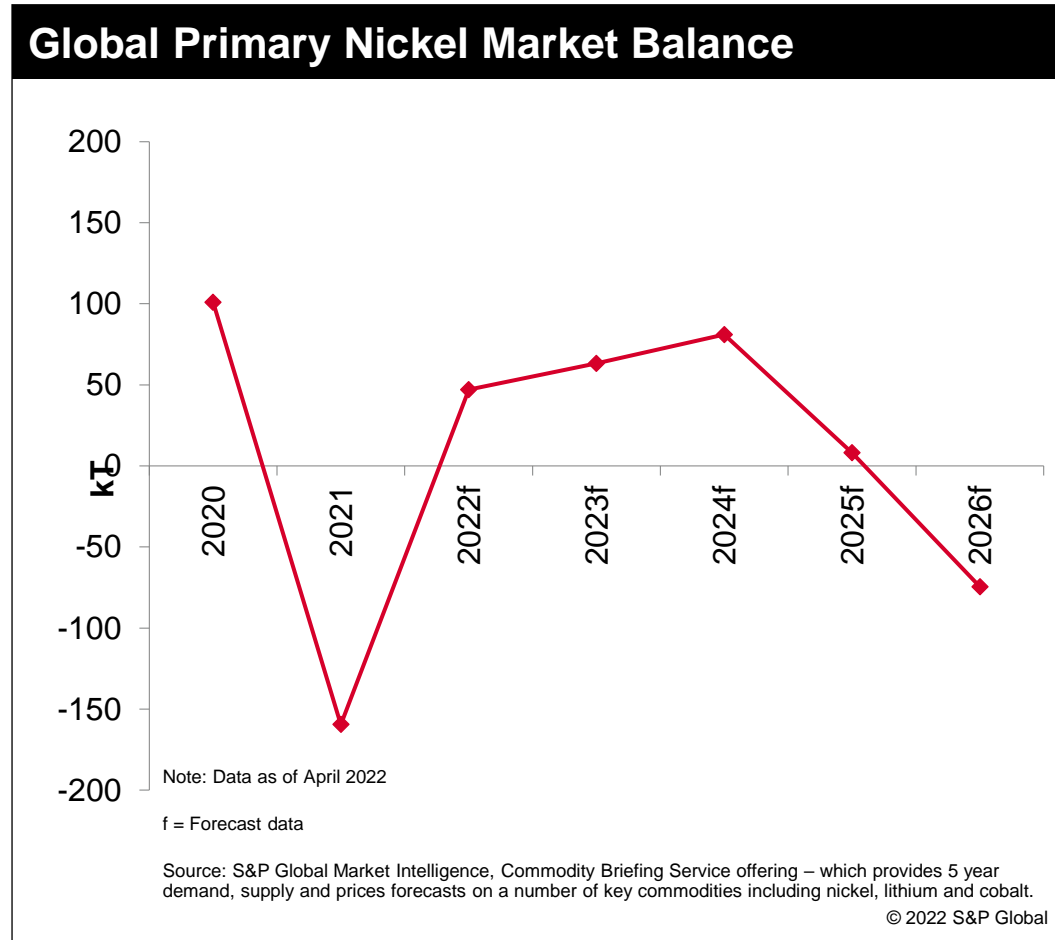
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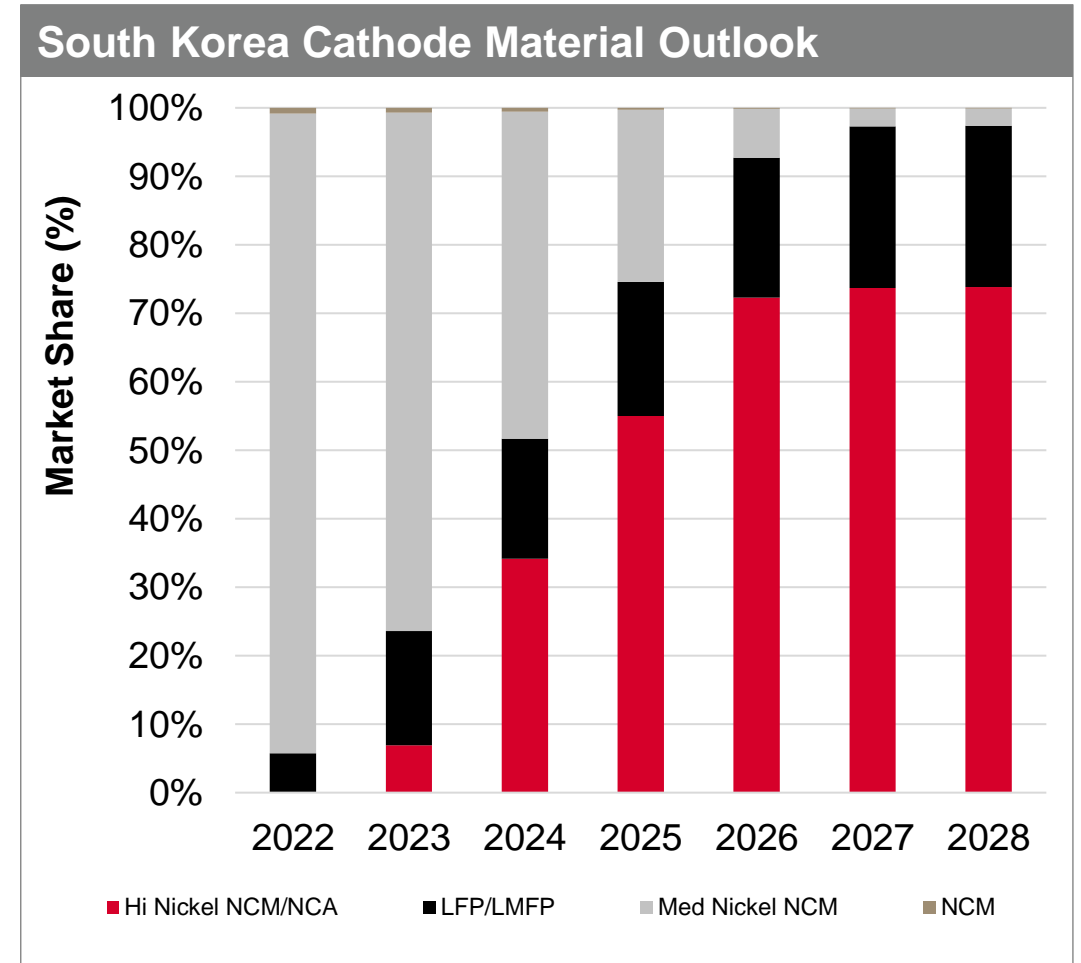
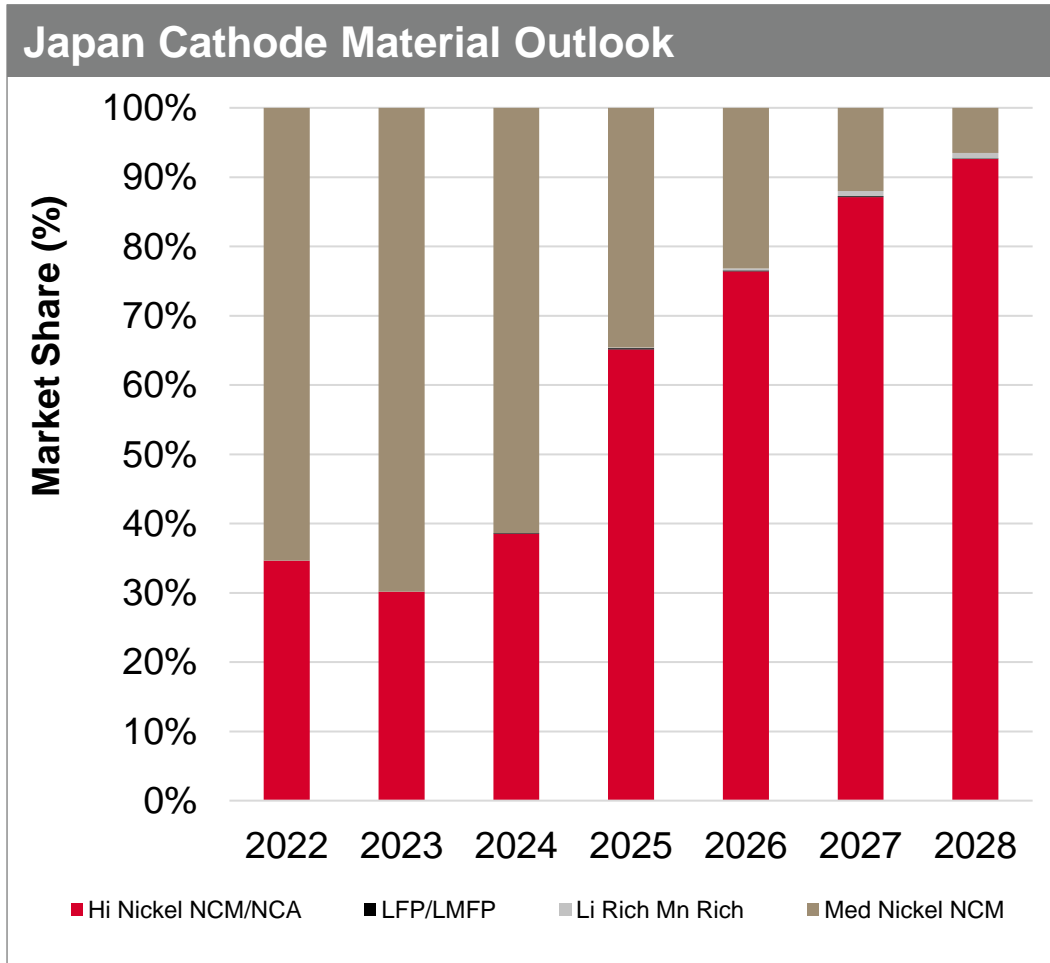


Source: S&P Global, AutoTechInsight, OCT 2022

Expecting Nickel Shortage in Short-term

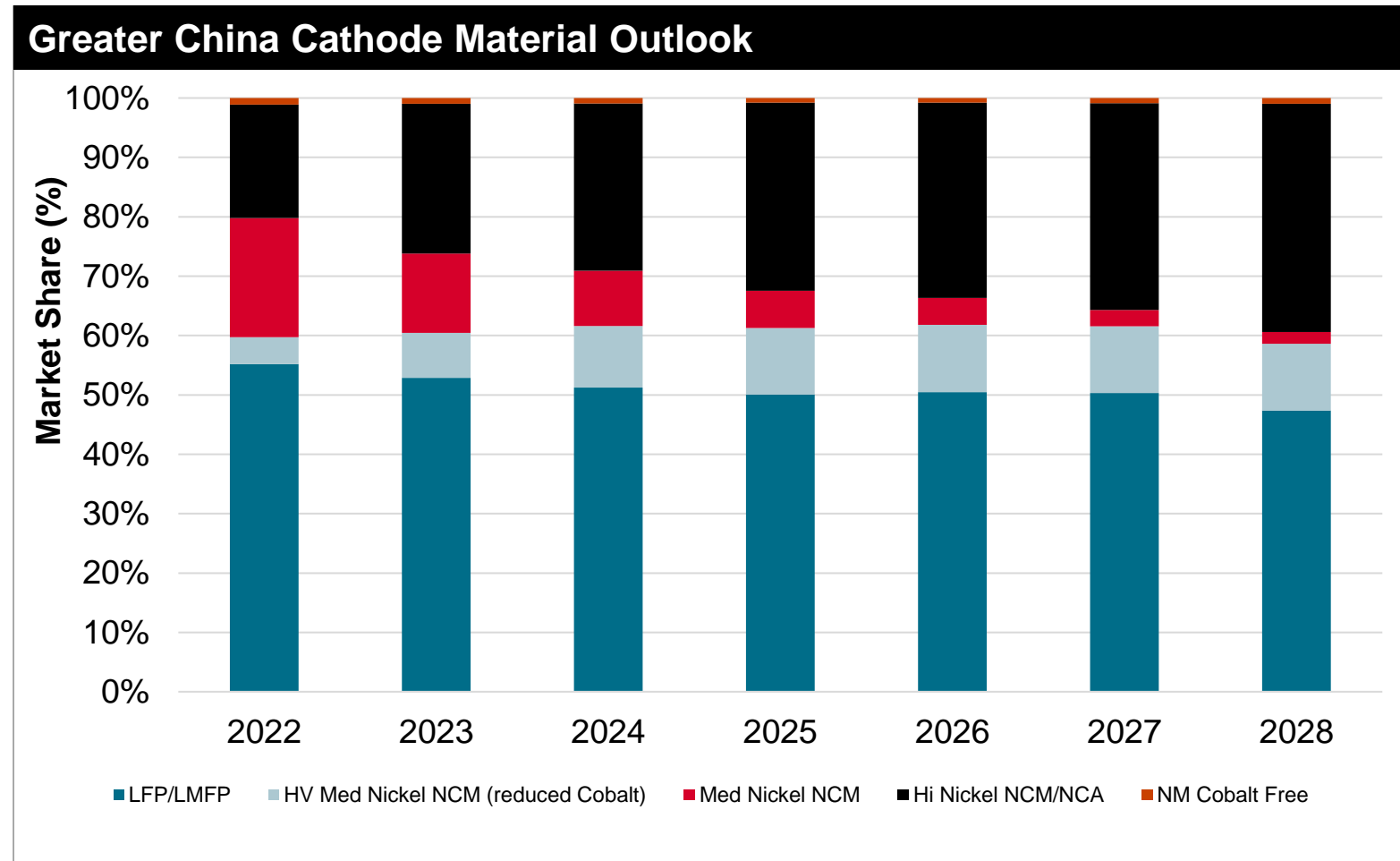


Japan and South Korea: Shifting Towards High Nickel Chemistry

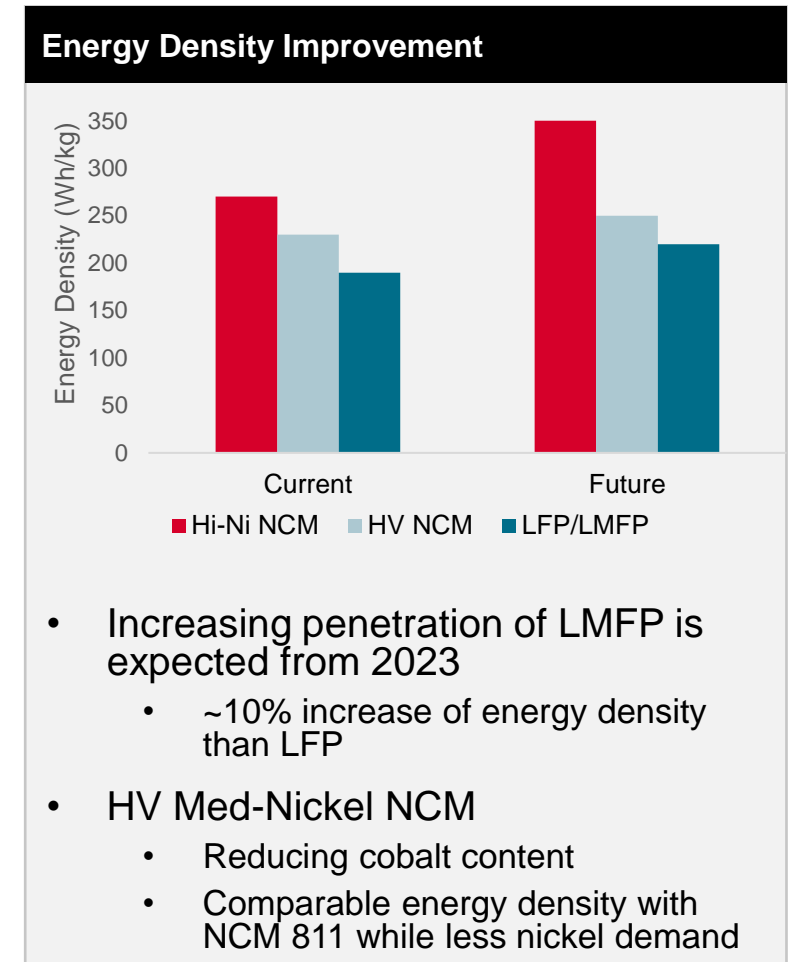


Source: S&P Global, AutoTechInsight, OCT 2022

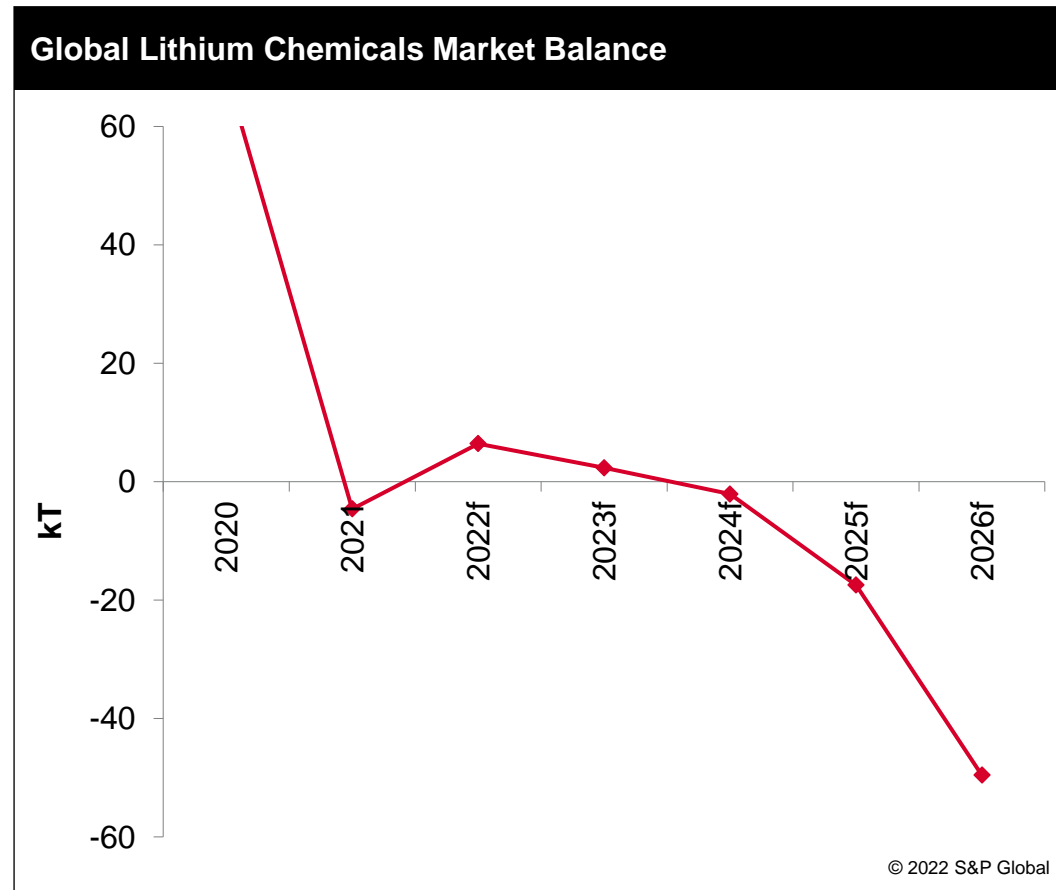
Greater China: Strong LFP market position Reducing demand for Nickel and Cobalt



Source: S&P Global, AutoTechInsight, OCT 2022



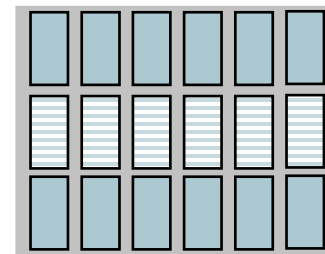
Sodium Batteries to Leverage Lithium Shortage



Note: Data as of April 2022
 f = Forecast data
 Source: S&P Global Market Intelligence, Commodity Briefing Service offering – which provides 5 year demand, supply and prices forecasts on a number of key commodities including nickel, lithium and cobalt.

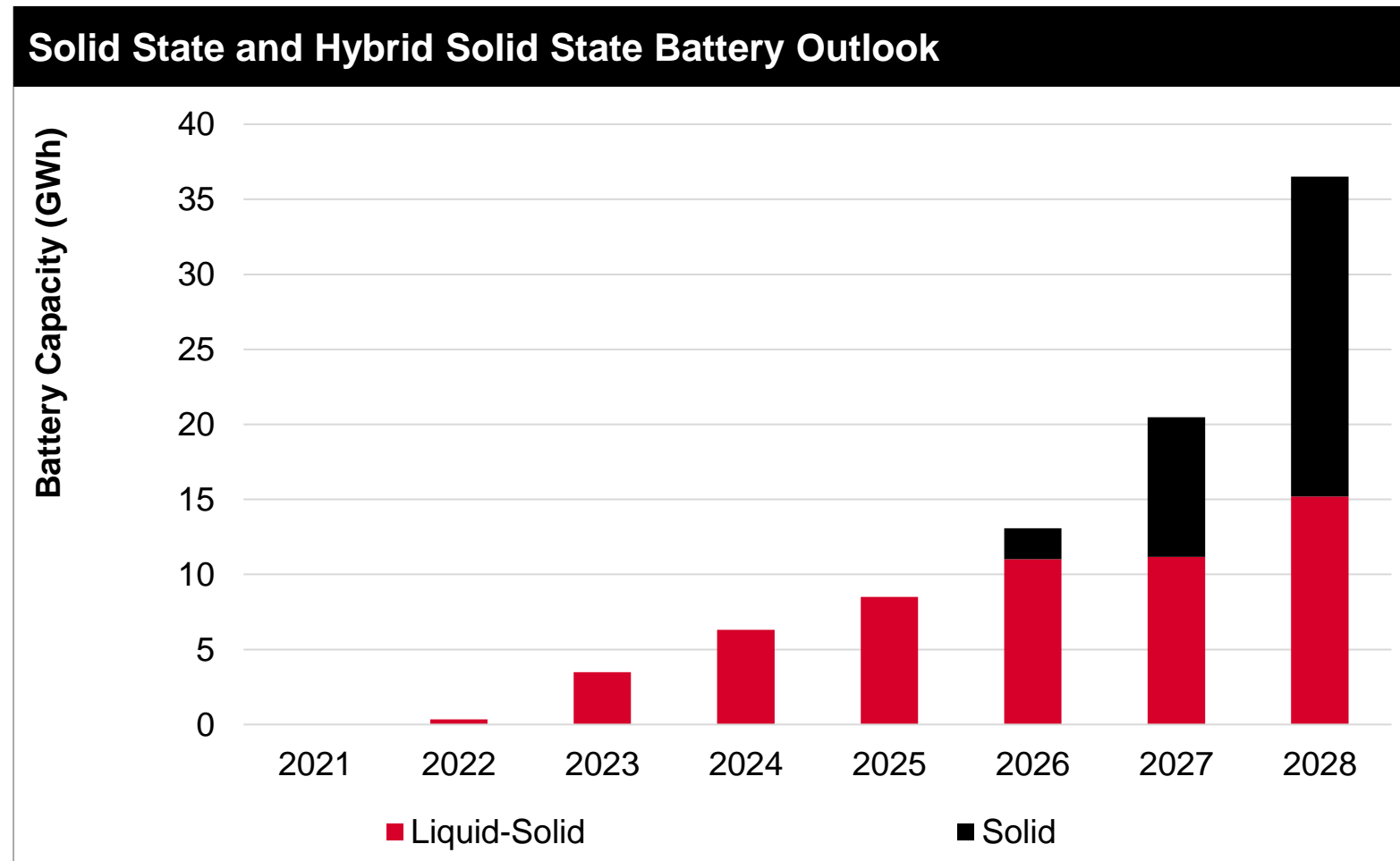
	LiB	SiB
Raw Material Availability	/	+
Cost	/	+
Low Temperature Performance	/	+
Energy Density	/	-
Cyclability	/	-
Safety	/	+

- Solution for Mini-EVs
 - Non-energy density sensitive application
 - “A/B” battery pack concept



CATL introduced one pack consisting of two different battery system of Sodium and Lithium cells

Next-Gen Battery Technology



Source: S&P Global, AutoTechInsight, OCT 2022

- **Hybrid-Solid State** (Liquid-Solid)
 - Battery from We-lion applied in NIO models (150KWh battery pack) to reach 1000 km driving range
 - Dongfeng E70 pilot program for semi - solid-state battery from Ganfeng Lithium
 - Gotion 160kWh battery pack SOP 2023
- **Solid State Battery**
 - Prologium co-develops solid-state battery with Mercedes
 - BMW and Ford planned to purchase battery from Solid Power for vehicle test
 - Nissan and Toyota are actively testing solid state battery

Summary

Sustainable growth of global EV market is dependent on battery technology evolution

- Compact battery cell and pack design to achieve higher energy density
- Innovation in battery chemistry to leverage raw material shortage



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