Solid State Battery Market

Shanghai Metals Market

Initial Research Framework

Module 1 Solid State Battery Route and Application

- **Study of solid-state battery types and definitions**
  - Based on the definition and classification of different solid-state batteries
  - Based on liquid electrolyte content, liquid 25wt%, semi-solid (5-10wt%), quasi-solid (0-5wt%), all-solid (0w%) (to be verified)
- **Solid State Battery Technology Route Analysis**
  - Major technology routes for polymers, sulfides, and oxides, mainstream players， also rationale for selecting technology routes
  - Comparison of application areas and advantages and disadvantages of the three technology routes (cost, conductivity, mass production feasibility, high temperature performance, etc
- **Study of Solid State Battery Product and Application Matrix**
  - Product performance (Model, ED, charge multiplier, cycle life, safety)
  - Downstream application segmentation and ratio study of different solid state batteries
  - Comparison of performance and application competitiveness between solid state batteries and traditional lithium batteries

Module 2 Market Potential and Product Economic Analysis

- **Product Economy Measurement**
  - Simulation(simulation of maximum upper limit of total cell cost) of cell cost for mass production of different solid state batteries (form, technology)
  - Cost simulation prediction of solid state battery main material (electrolyte powder) for mass production (maximum value simulation)
  - Cost comparison between solid-state batteries (limit value) and conventional lithium batteries (under different material cost scenarios)
- **Global Target Market Share Forecast** (Y2023E-Y30E), Split into China, U.S., Japan, Others
  - Cost Comparison of Solid State and Conventional Lithium Batteries
  - Future Growth in Solid State Battery Applications
- **Next Generation Battery Analysis**
  - Upper and Lower Bounds on Energy Density of Coalescent Batteries
  - Analyzing potential drivers of condensed matter battery releases
- **Supportive policies for solid-state batteries, and the review and outlook for the regulation of the industry**

Module 3 Leading Player Tracking

- **Solid State Industry Chain Overview**
  - Profiles of upstream and downstream mainstream players in the three global technology routes
  - Potential new player entry
- **Global Solid-state Cell Player Tracking**
  - Technology routes of different players and the basis for the choice of route
  - Tracking pilot stages for the players
  - Major suppliers and customers
  - Feedback on usage by customers
- **Global tracking of head solids (electrolytes, lithium sulfide)**
  - Tracking of Solid State Battery Technology Route and Mass Production of Head Supplier (Small Pilot, Medium Pilot, Mass Production)
  - Major Customers
  - Researching order signing method and pricing mechanism

Sample enterprise suggestions: solid state battery enterprise, lithium sulfide enterprise, electrolyte enterprise

Alternative List of Research Enterprises				
Enterprise Category	Enterprise Name	Country	Major product	Technology Route
Cell	BYD	China	solid-state lithium battery、solid electrolyte	polymer
	Hydro-Québec	Canada	solid-state lithium battery、solid electrolyte	polymer
	Qingtao (KunShan) Energy Development	China	solid-state lithium battery、solid electrolyte	Oxide
	Ganfeng Lithium Group	China	solid-state lithium battery、solid electrolyte、lithium sulfide	Oxide
	Solid Power	U.S	solid-state lithium battery、solid electrolyte	sulfide
	CATL	China	solid-state lithium battery、solid electrolyte	sulfide
	Maxell	Japan	solid-state lithium battery、solid electrolyte	sulfide
	Toyota	Japan	solid-state lithium battery、solid electrolyte	sulfide
Lithium Sulfide	Ganfeng Lithium Group	China	solid-state lithium battery、solid electrolyte、lithium sulfide	Oxide
	Chengdu Hanpu High Tech Materials	China	Solid state battery material、lithium sulfide	-
	Hangzhou Kaiyada Semiconductor Materials	China	Solid state battery material、lithium sulfide	-
	Hubei XinRunde Chemical	China	Solid state battery material、lithium sulfide	-
	ALB	U.S	Solid state battery material、lithium sulfide	-
	Lorad Chemical	U.S	Solid state battery material、lithium sulfide	-
	AMG lithium	Germany	solid-state lithium battery、lithium sulfide	-
Electrolyte	BYD	China	solid-state lithium battery、solid electrolyte	polymer
	Hydro-Québec	Canada	solid-state lithium battery、solid electrolyte	polymer
	Ionic Materials	U.S	solid electrolyte	polymer
	Qingtao (KunShan) Energy Development	China	solid-state lithium battery、solid electrolyte	Oxide
	Ganfeng Lithium Group	China	solid-state lithium battery、solid electrolyte、lithium sulfide	Oxide
	Solid Power	U.S	solid-state lithium battery、solid electrolyte	sulfide
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Solid-State Battery – Next Generation Technology

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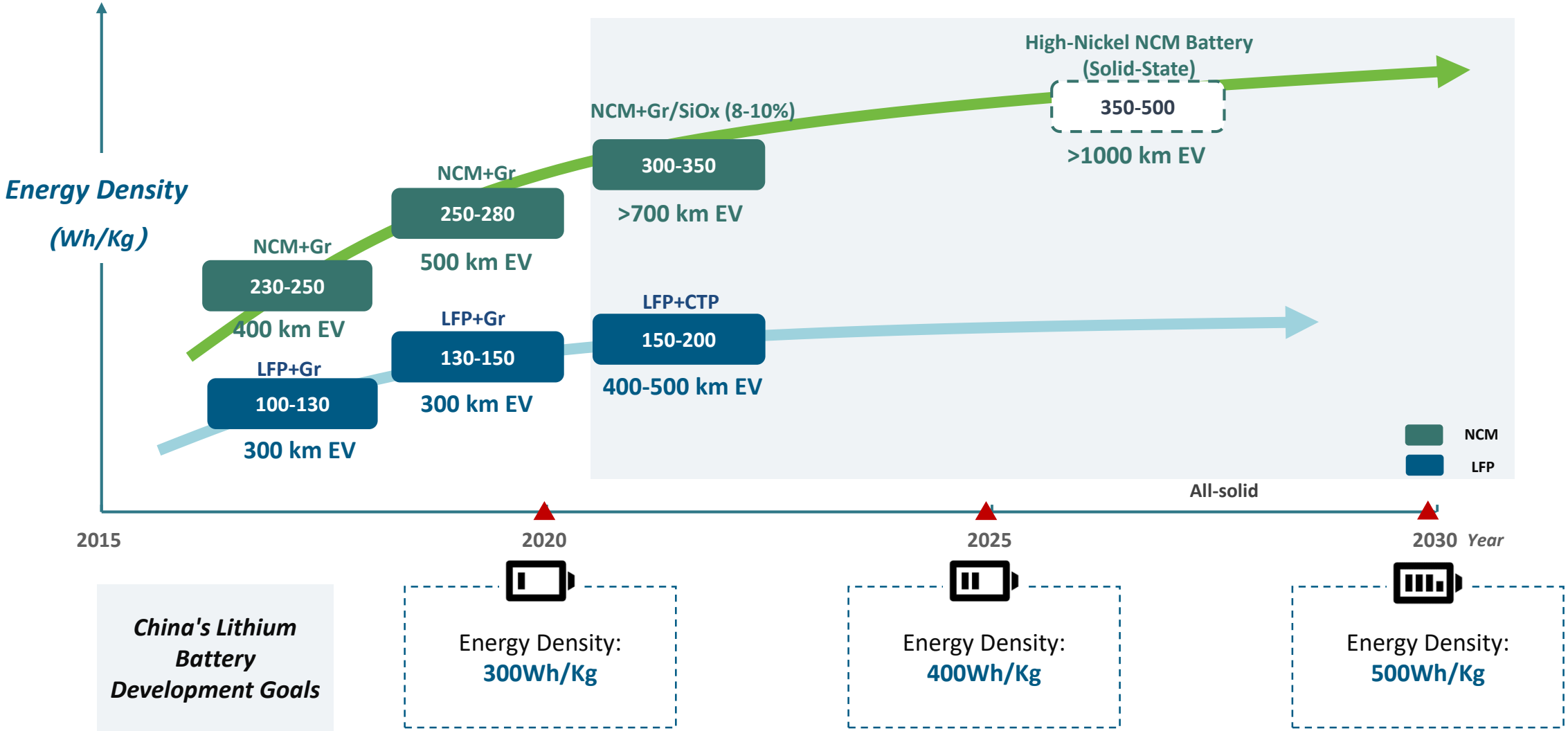
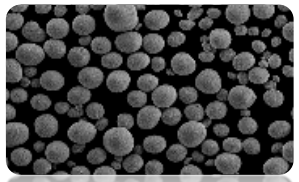


Solid-state Battery Value Chain

ORE

- **Increasing demand for lithium raw material** given the lithium used in anode

BATTERY MATERIAL



- **No separator** in solid-state battery era
- **New solid-state electrolytes** players

BATTERY

- New LIB players which **focus on solid-state battery** (e.g. Quantum Scape, Qingtao)

OEM

- Nearly all mainstream & leading OEMs are **actively develop solid-state battery**

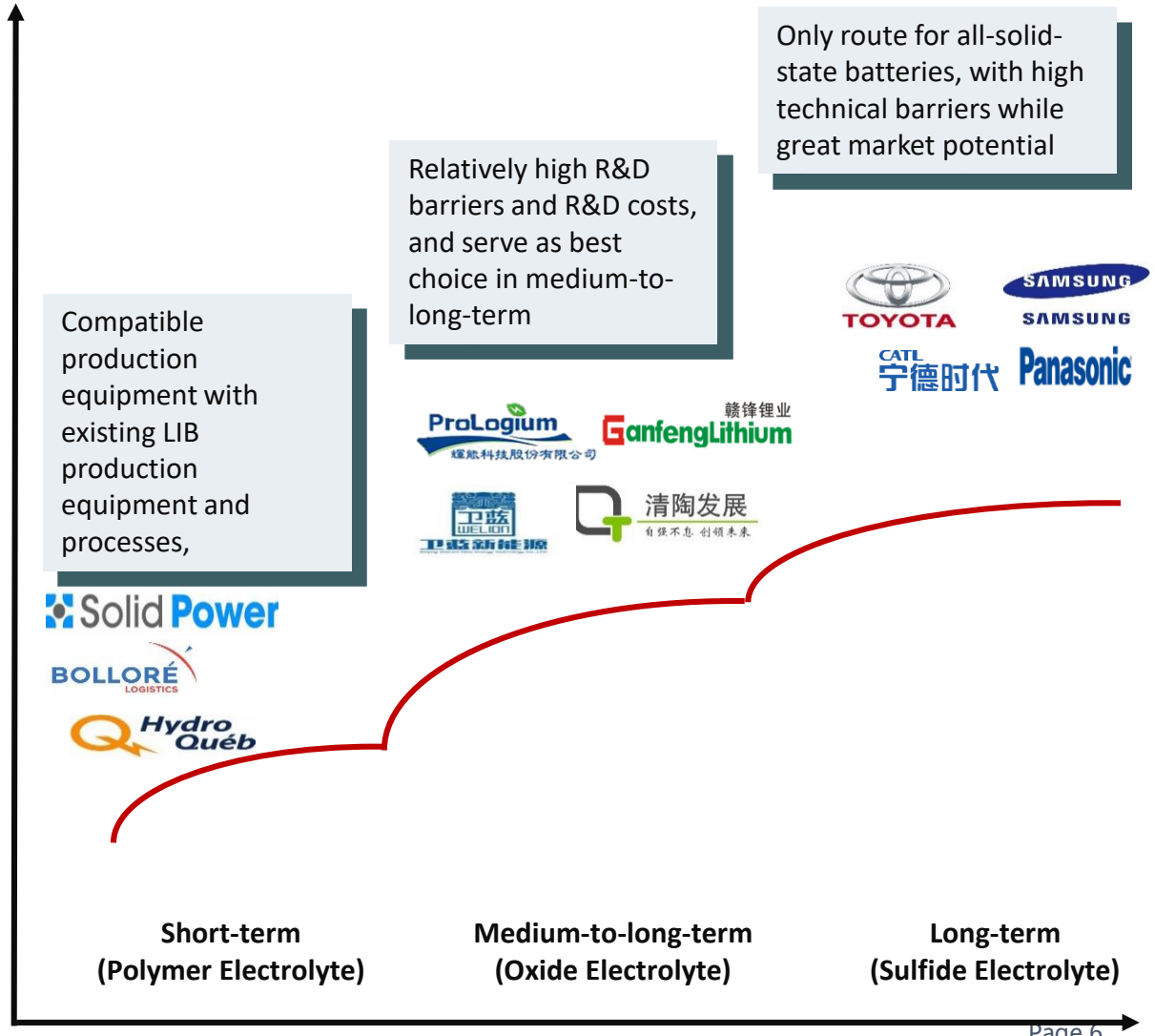
New players compared with traditional LIB

Solid-state Battery Competitive Landscape

Solid-state Battery Competitive Landscape

Polymer Electrolyte	BOLLORÉ LOGISTICS, Hydro Québec, Solid Power	⊕ • Good performance at high temperature ⊖ • **Low conductivity** at room temperature
Oxide Electrolyte	清陶发展, 卫蓝新能源, ProLogium, GanfengLithium 赣锋锂业	⊕ • **Good cycle performance** • **High electrochemical stability** ⊖ • **Low conductivity** • Poor interface contact
Sulfide Electrolyte	CATL 宁德时代, Panasonic, TOYOTA, SAMSUNG	⊕ • **High conductivity** and performance ⊖ • Easy to oxidize • **Poor interface stability**

Who are wining in different periods?



Solid-state Battery Technology Route Deep-dive Analysis

	Polymer Electrolyte	Oxide Electrolyte	Sulfide Electrolyte
	PEO, PAN, PVDF, PPC, PVC, PMMA	LiPON, NASICON	LiGPS, LiSnPS, LiSiPS
Cost Effectiveness	◔ Low	◑ High	◕ Relatively high
Ionic Conductivity	○ 10^{-5}S/cm	◑ 10^{-4}S/cm	● 10^{-3}S/cm
Production Feasibility	● Easy to process	◔ Fragile, difficult to process	◕ Easy to process with suitable technology
Thermal Stability	◑ <120°C	● <500°C	◕ <450°C

○ Unsatisfied Performance ● Ideal Performance

Solid-state Battery - Battery Material Deployment

	Liquid	Gal	Semi-Solid	Solid
Cathode	High-Ni Cathode	Ultra-High-Ni Cathode (Cobalt Free)		Ultra-High Ni Cathode + Coating Material (Ceramic)
Anode	Graphite Anode	Pre-lithiated Anode	Li-rich Composite Anode	Lithium Metal Anode
Electrolyte	Organic Electrolyte		Inorganic Electrolyte	
Separator	Coated Separator	Mixed-coated Separator		No Separator

Back-up - Solid-state Battery Supplier Roadmap

Back-up

	Company	R&D	Small Sample Pilot Production	Production Line Construction	Mass Production Date (Announced)	Potential End-customer
Oxide Supplier	清陶发展	Mass Production Achieved at Jul.2020			2020	北京汽车, 上汽集团 SAIC MOTOR, 蔚来 NIO, DFM, 广汽集团 GAC GROUP, HiPhi 高合
	卫蓝新能源	Mass Production Achieved at Jun. 2022			2022	
	赣锋锂业 GanfengLithium	Pilot Production Ac			2023	
	国轩高科 GUOXUAN HIGH-TECH	Trial production has been accomplished			2023	
Polymer Supplier	Solid Power, Hydro Québec, BOLLORÉ	Trial production has been accomplished			TBA	N/A
Sulfide Supplier	SAMSUNG, TOYOTA, Panasonic, CATL 宁德时代	R&D			TBA	N/A

202x: Target Mass Production Year