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CREATING IDEAS &
DRIVING INNOVATIONS

FUTURE REQUIREMENTS AND CHALLENGES FOR AUTOMOTIVE BATTERY SYSTEMS

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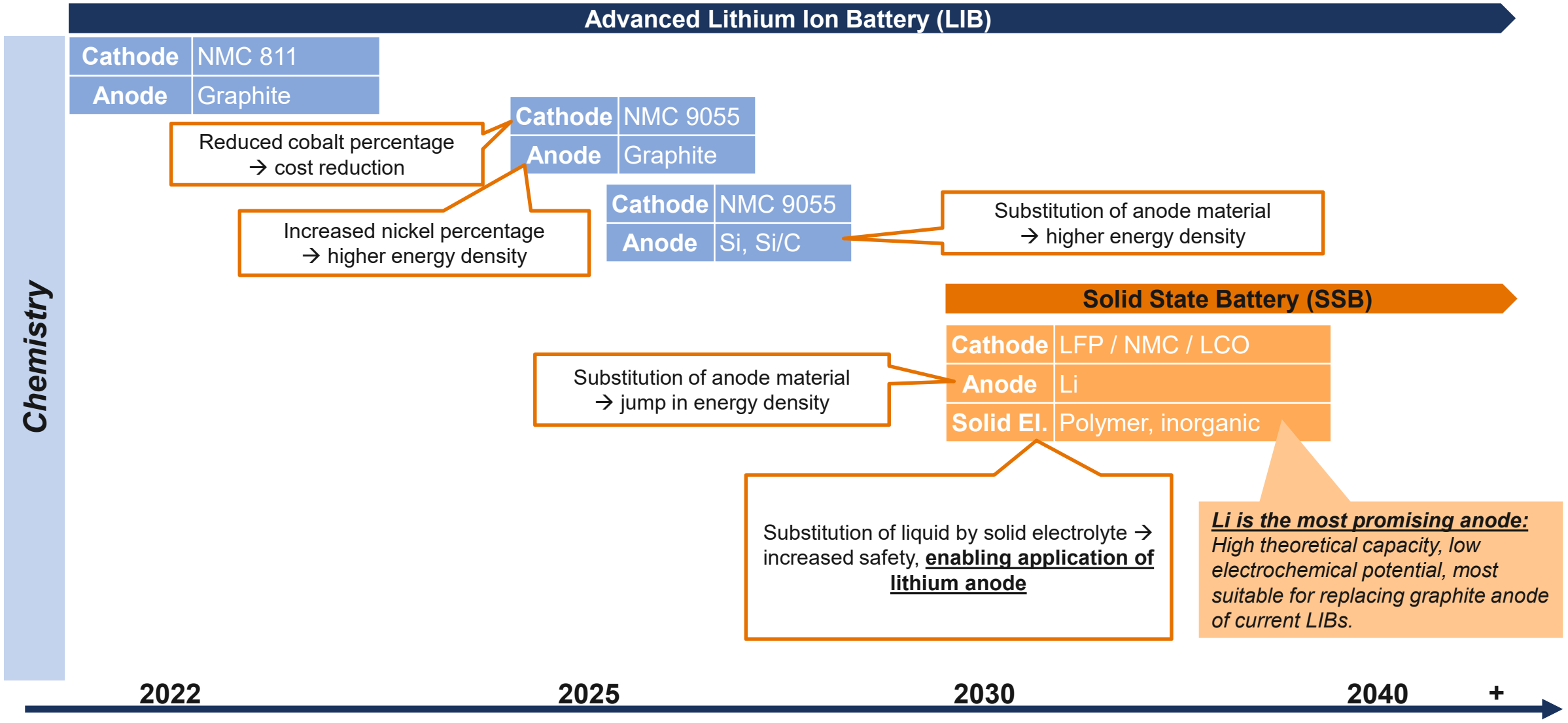
Coexistence of different cell chemistries expected - according to the respective requirement profile in automotive applications.



Source Fraunhoer

NMC: Nickel Manganese Cobalt
LFP: Lithium Iron Phosphate

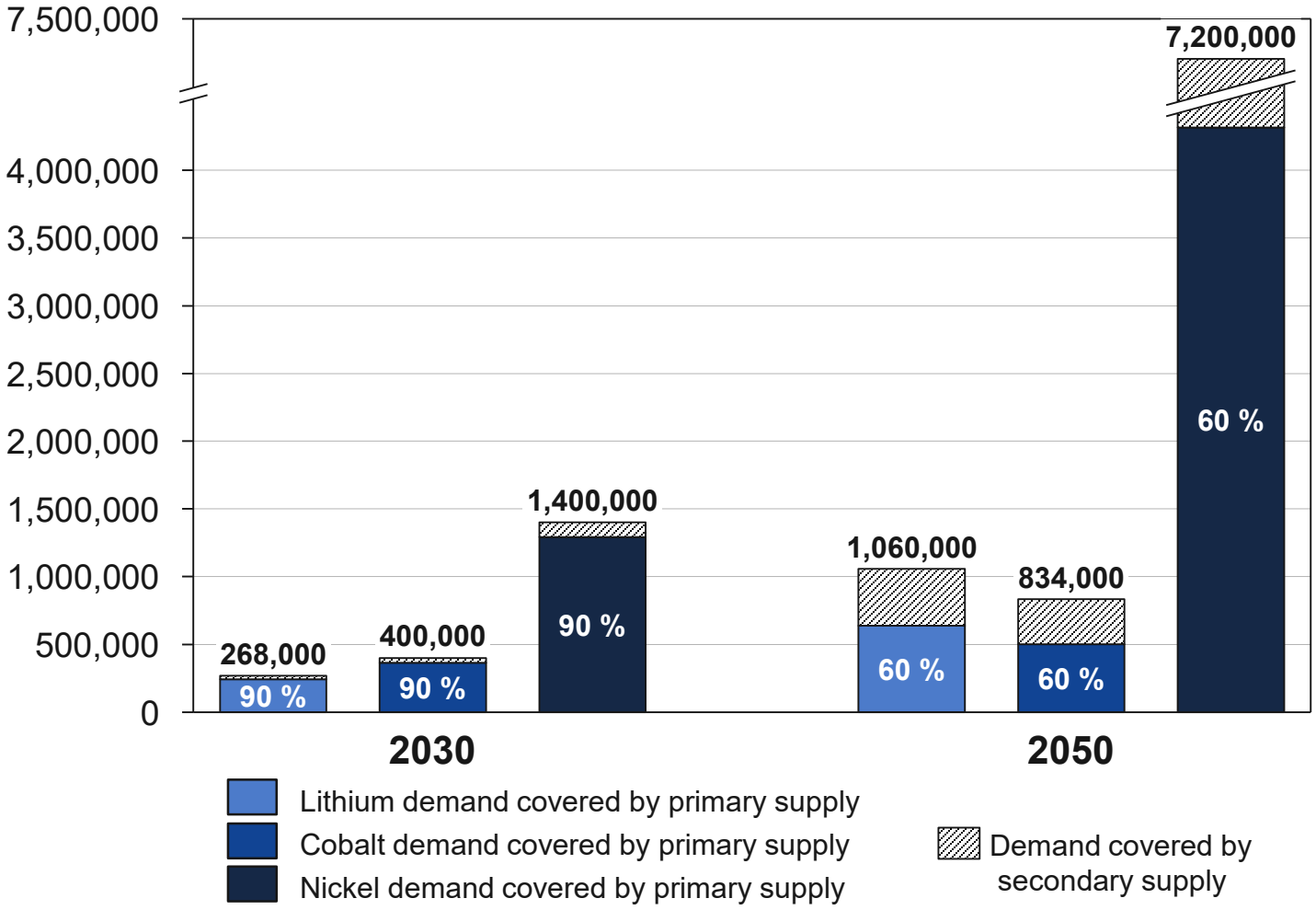
In this context, the availability of resources to meet the growing demand is of crucial importance.

Assumption Base

- Results of calculated global battery demand in GWh
- Li-Ion remains leading battery technology
  - Progress of NMC 6:2:2 about 8:1:1 to 90:5:5
  - Decreasing cobalt ratio
  - Increasing nickel* ratio
- Increasing recycling capacity (secondary supply)
  - Trend from 10 % in 2030 to 40 % in 2050 (optimistic assumption based on present aspirations)

**Nickel is a highly sensitive resource, especially in regard to the current political situation, as Russia is one of the largest nickel producers.*

Raw Material Demand in tonnes

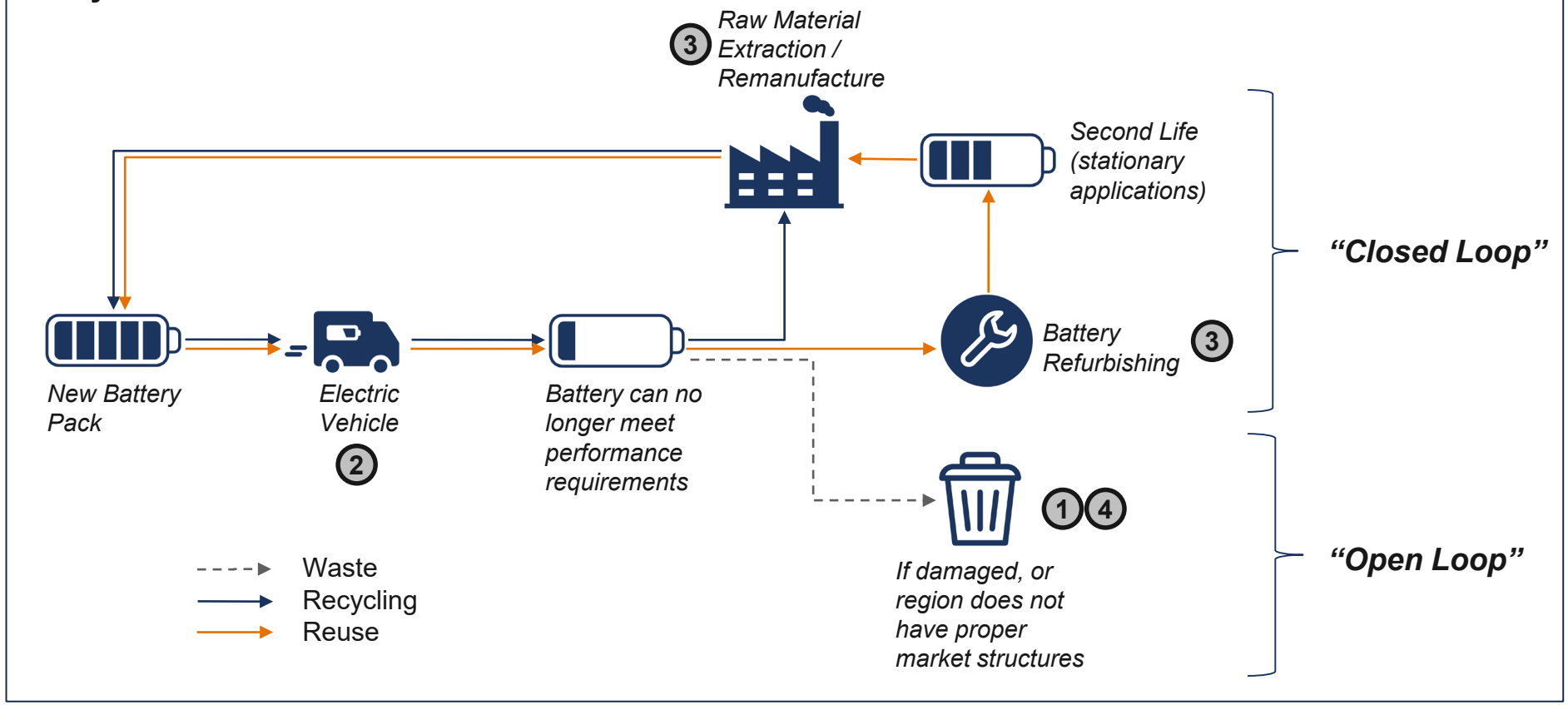


Therefore, recycling is highly gaining importance to sustainably meet the increasing demand.

Regulations

1. ELV Directive 2000/53/EC
2. TA RRR* Directive 2005/64/EC
3. Battery Directive 2006/66/EC
4. Shipment Directive 2006/1013

Life Cycle



Source: McKinsey

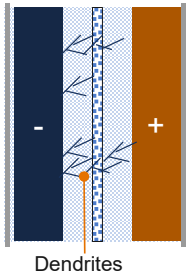
Design for recyclability of components and systems is key to realize an efficient and sustainable recycling loop.

When integrating the battery into the vehicle, consideration of existing safety risks is crucial.

Lithium Plating

» Inhomogeneous metallic depositions at anode during charging (esp. fast charging)

Dendrite Growth



» Formations during charging

» Possible cause for **short circuit**, when growing through the separator/solid electrolyte to the cathode

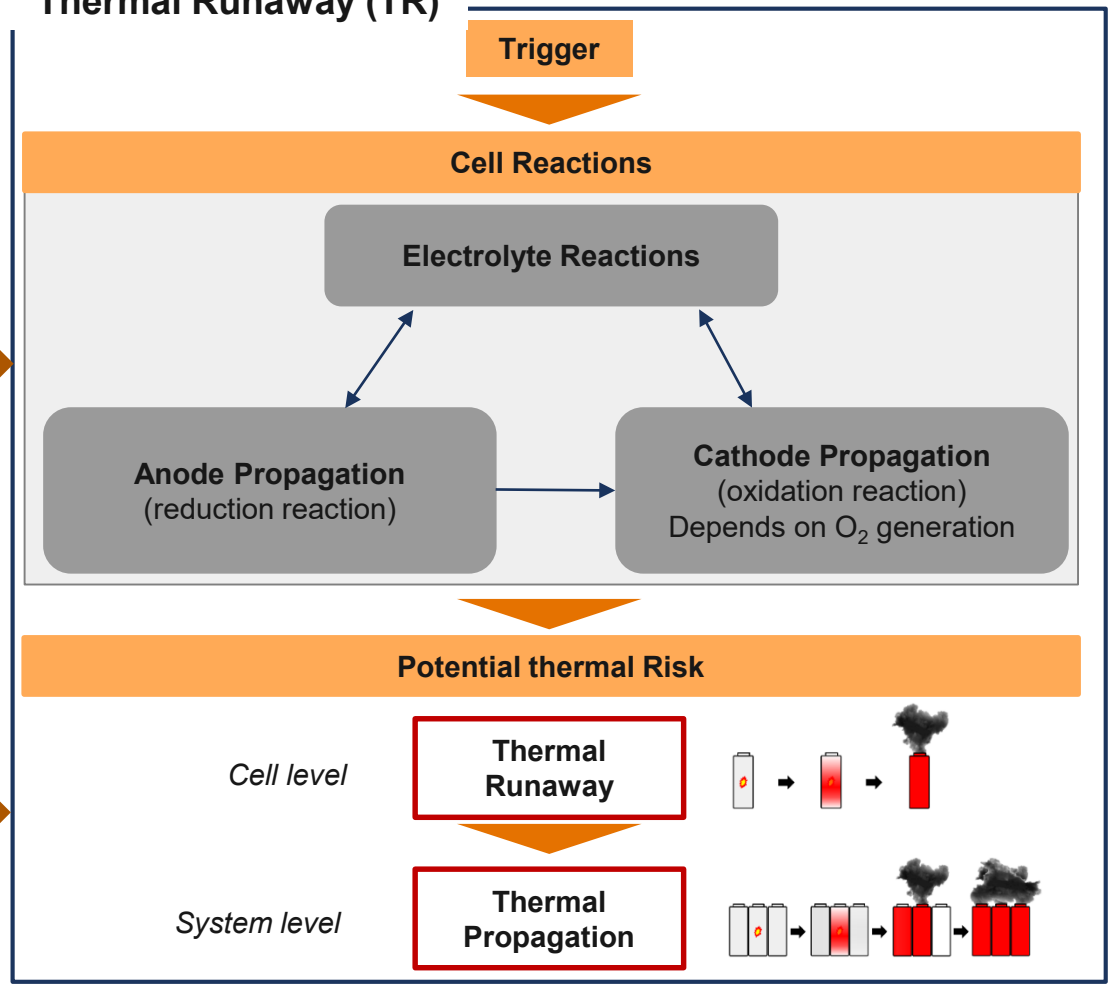
Short Circuit

» Uncontrolled cell reactions occur. This process expands and culminates in a **thermal runaway**

Overcharge/ Deep Discharge

» Occur if the control electronics of the charging station or the battery pack (BMS) malfunction

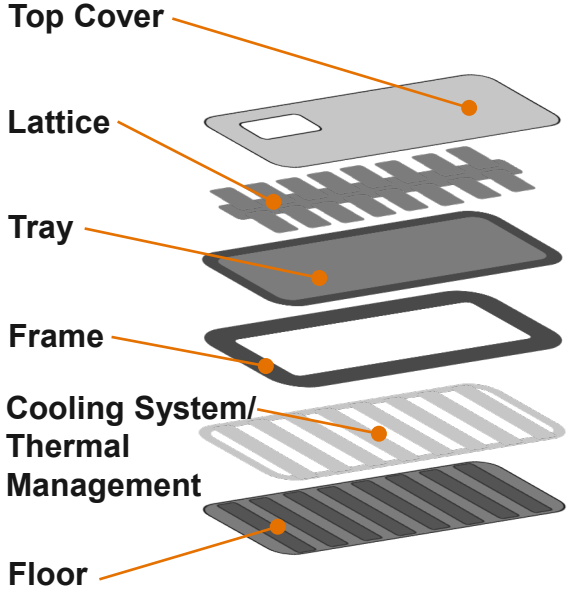
Thermal Runaway (TR)



Various complex cell reactions that may trigger a thermal runaway.

Source: MDPI, batteris

In example, battery housing has a key role in meeting the safety as well as customer requirements.



Example of Battery Housing	Components	Requirements	Most Applied Materials
	Top Cover	» Corrosion protection (tightness) » EMC » Thermal safety	» Aluminum » Steel » Al / St Sandwich » Plastic
	Lattice	» Crash performance » Underbody Protection	» Steel » Aluminum » Hybrid
	Tray (may be integrated in frame)	» Corrosion protection » EMC » Underbody Protection	» Steel » Aluminum » Hybrid » Plastic
	Frame (may be integrated in tray)	» Crash performance (force absorption)	» Steel » Aluminum » Hybrid » Plastic
	Cooling System / Thermal Management	» Homogeneous as possible	
	Floor	» Underbody Protection » Cooling	» Steel » Aluminum » Hybrid » Plastic (incl. FRP) » Titan layer

High level of materiel competition with a general differentiation by vehicle segment (volume vs. premium)

Summary and Typical Questions for Businesses

Summary

- **Cell level:**
  - Co-existence of different cell chemistries expected: LFP, NMC
  - Further research on new cell chemistries:
    - LIB: Innovation in cathode chemistry
    - SSB expected before 2030
    - SSB potentially safer, however still thermal risk
- **System level:**
  - High level of material competition to meet safety as well as customer requirements
  - Trend towards structural role of cells within the battery system: Cell to Pack → Cell to Chassis
  - General trend towards high production volumes and scalable platforms

Potential Questions for Businesses

- ***What is the status quo and future perspective regarding cell chemistry and raw materials?***
  - Market intelligence
- ***Which requirements for components & systems exist at vehicle level?***
  - Technology assessment
  - Strategic portfolio analysis
- ***How might requirements change in the future?***
  - Technology trend analysis and market intelligence
- ***How do legal policy targets for carbon reduction affect battery development and integration?***
  - Status quo assessment
  - Strategic scenario analysis
  - Life Cycle Assessment (LCA)

SSB: Solid State Battery
LIB: Lithium Ion Battery

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