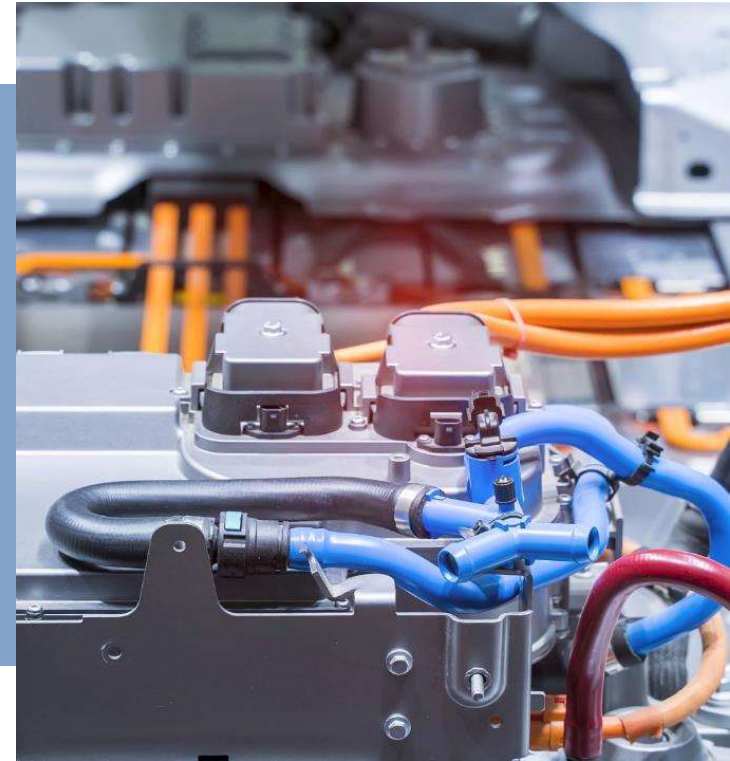


# Cells, Modules and Battery Pack Economics and evolution



# Agenda



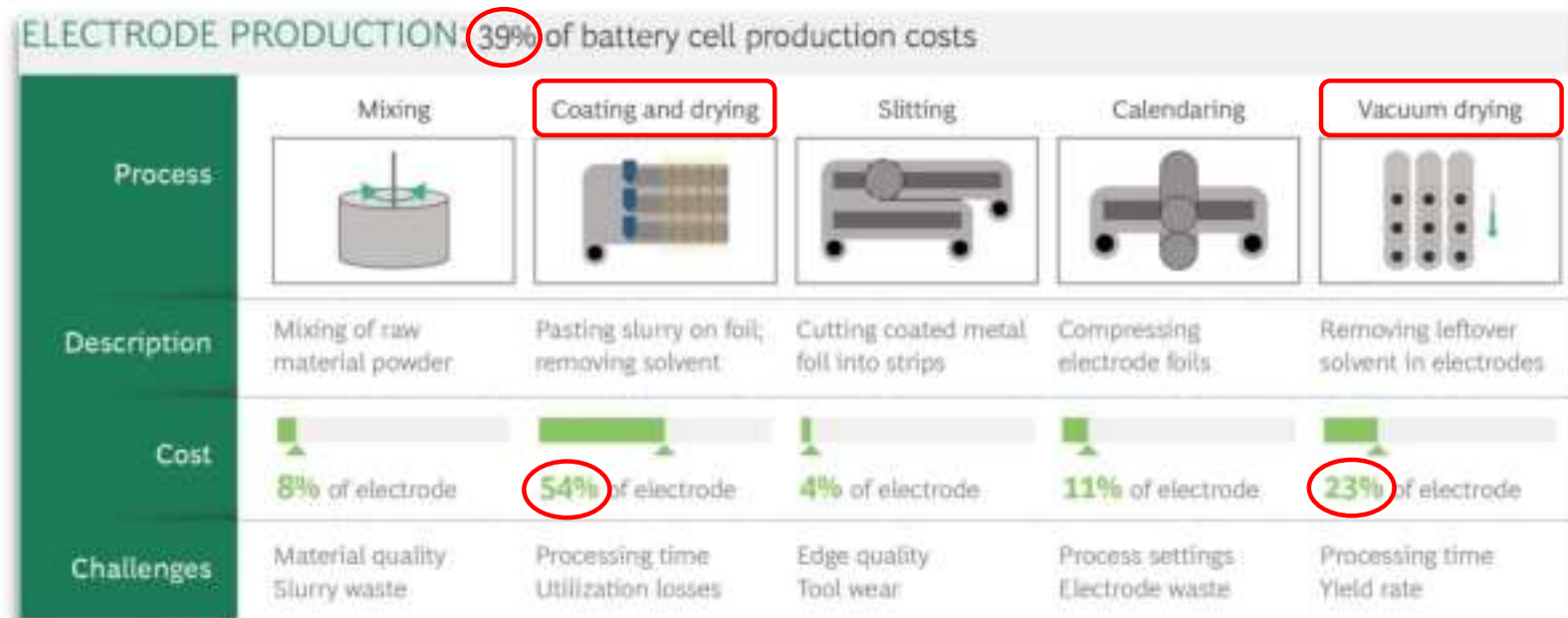
- Process Bottlenecks and Challenges
- The evolutions

# Process Bottlenecks and Challenge

Boston Consulting Group conducted a techno-economic analysis by battery manufacturing process step, summarizing key process steps, costs and challenges commonly faced by manufacturers

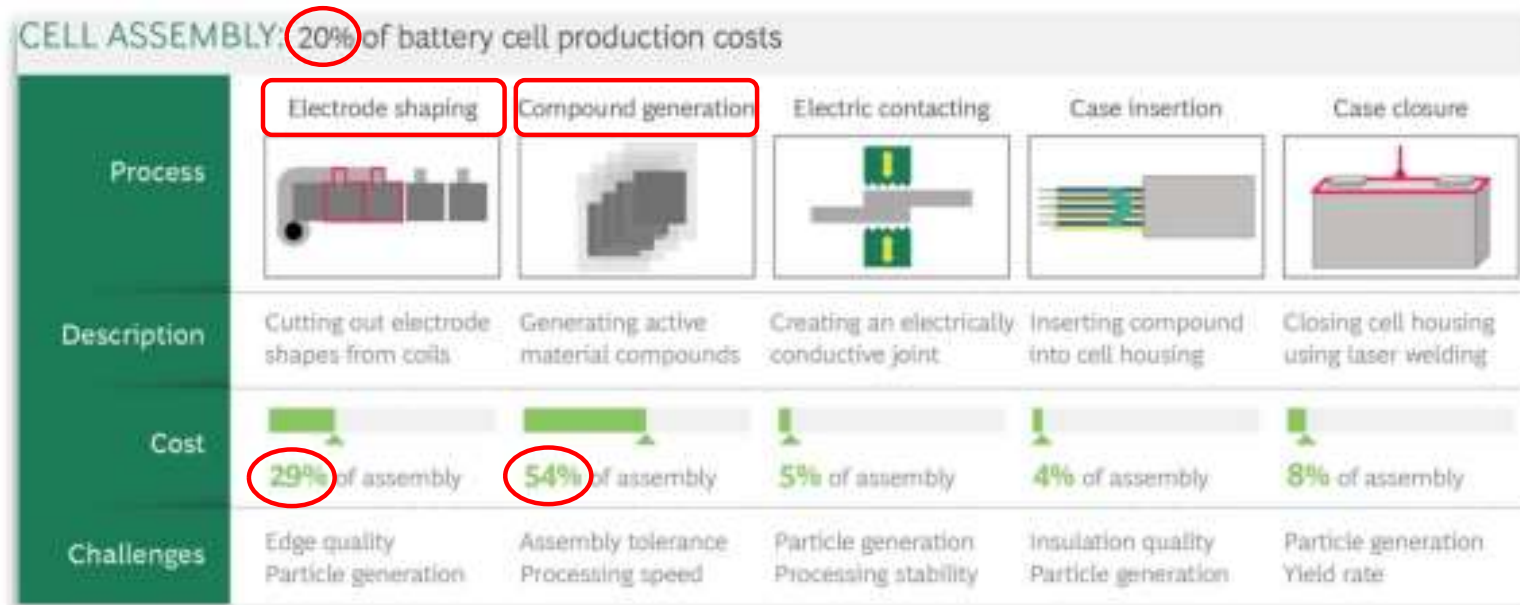
## 1. ELECTRODE (Step 4 and 5):

Source: Boston Consulting



# Process Bottlenecks and Challenge

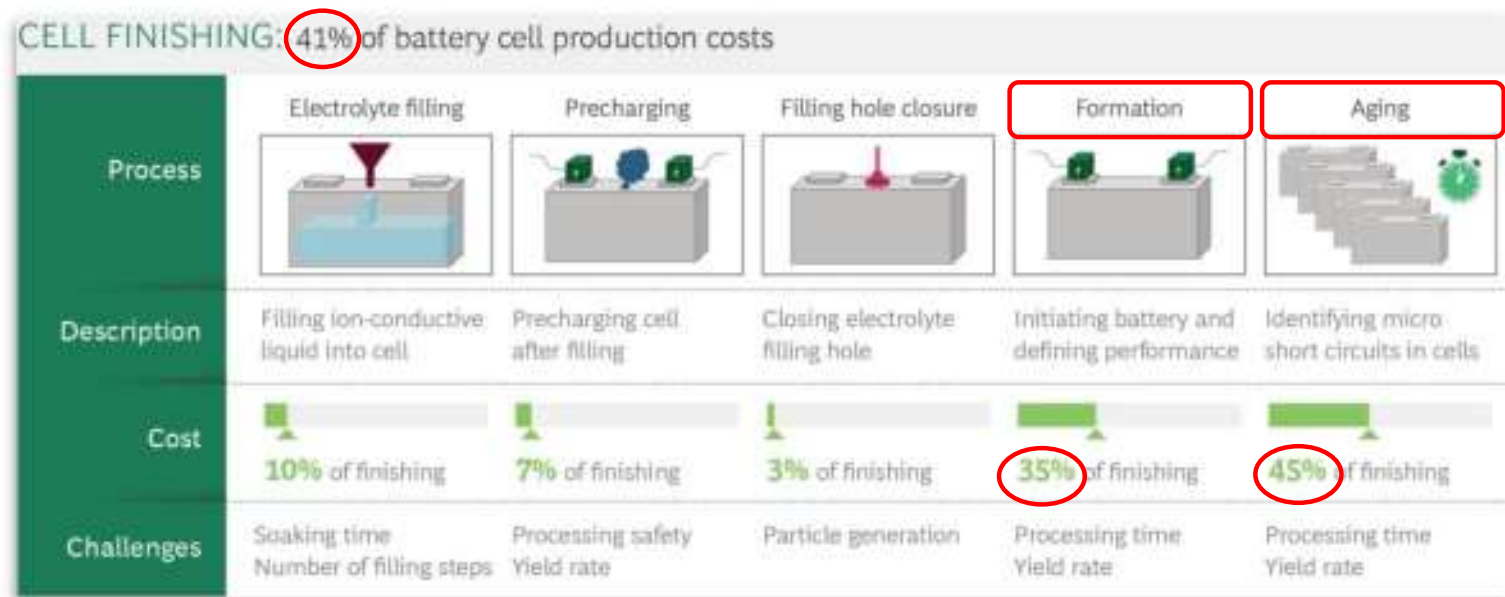
## 2. ASSEMBLY (Step 6 to 8):



Source: Boston Consulting

# Process Bottlenecks and Challenge

## 3. CELL FINISHING (Step 9 and 10):



Source: Boston Consulting

# Cell-to-Pack (CTP) Evolution

Pack designs are evolving, with a move towards monolithic designs, intended to eliminate dead weight, enable higher packing efficiency and lower costs

## Advantages

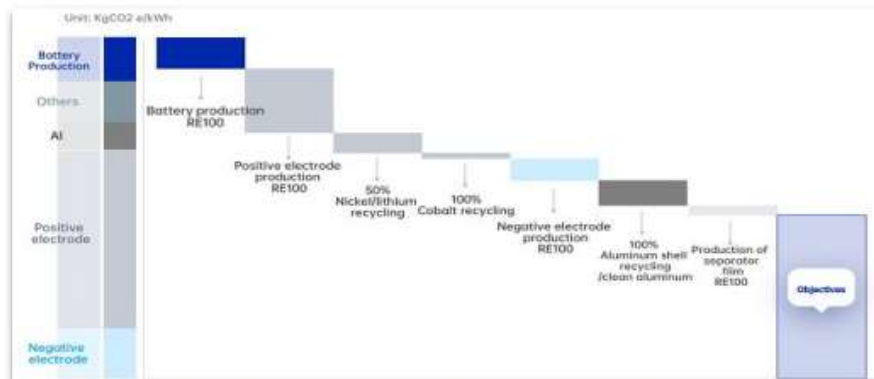
Elimination of the module assembly level reduces number of components and battery assembly costs, and increases packing efficiency. CTP concepts generally employ larger cell form factors, resulting in fewer cells. These advantages are also projected to reduce carbon intensity (kg-CO<sub>2</sub>/kWh).

## Challenges

But engineering challenges such as [safety and thermal propagation](#) remain before CTP can achieve the claimed cost reductions. Safety challenges still remain, indicated by the recent [recall of BYD Blade batteries](#).

## What companies are doing

[CATL Qilin Structural Battery](#)  
[BYD Blade Structural Battery](#)  
[Tesla 4680 Structural Battery](#)



[Contribution of different materials and processes to CO<sub>2</sub> emissions](#)

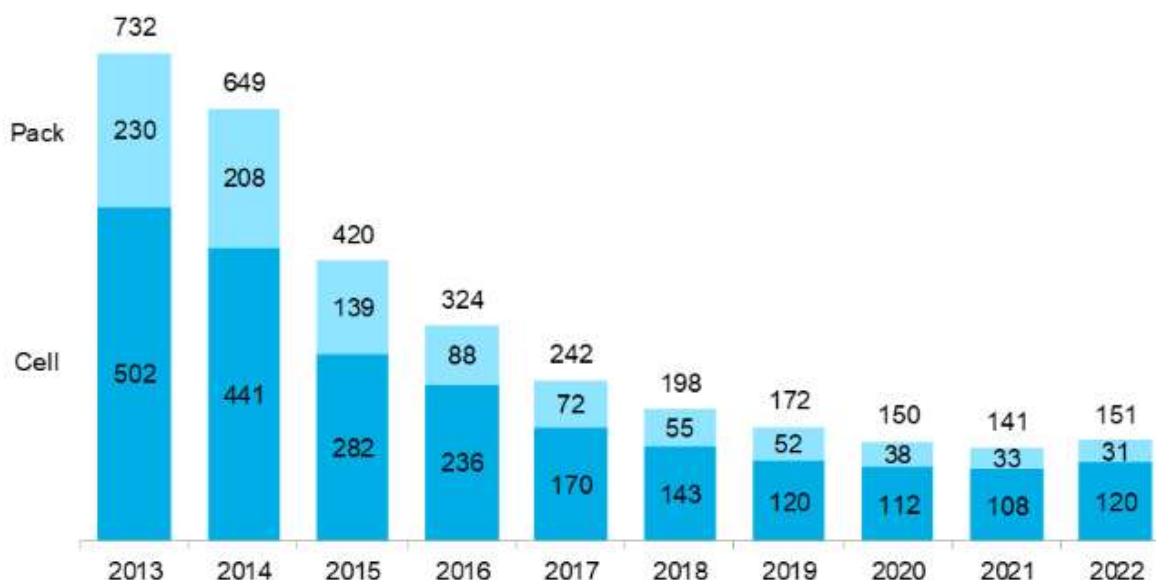


Source: Boston Consulting



# Lithium-ion Battery Pack Prices

**Volume-weighted average lithium-ion battery pack and cell price split, 2013-2022**  
real 2022 \$/kWh



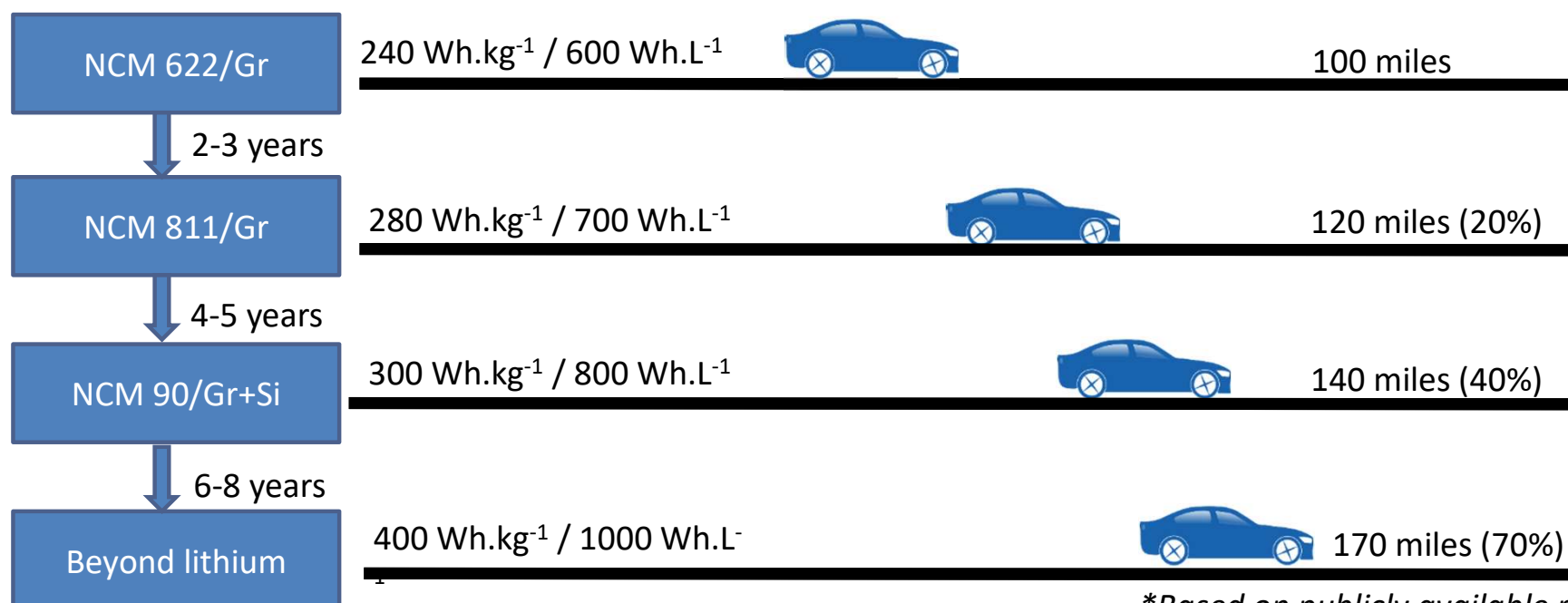
*Source: BloombergNEF. All values in real 2022 dollars. Weighted average survey value includes 178 data points from passenger cars, buses, commercial vehicles and stationary storage.*

Source: IEA Global Electrical Vehicle Outlook 2022

# Range Improvement Strategies

Driving range depends on the active lithium inventory in the cell. Out of all the components, range directly depends on electrode capacity

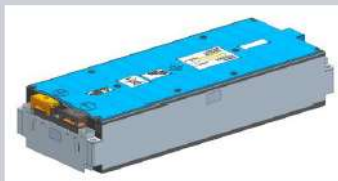
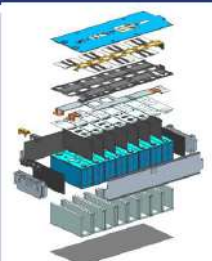
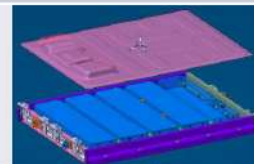
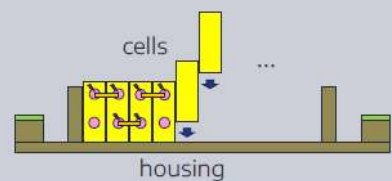



- Reduction in vehicle / battery pack weight
- Increase in usable on-board energy



*\*Based on publicly available roadmaps*



# Product evolution (forecast)

	Definition	exemple
Module	<p>Cells assembled together :</p> <ul style="list-style-type: none"> <li>- Mechanically (cell swelling, mechanical requirements, abuse test)</li> <li>- Electrically (internal busbars and terminals : welded )</li> <li>- With sensors (voltage, temperature)</li> <li>- Insulated (electrically and thermic)</li> </ul> <p>Initially for logistics and pre-assembly for mounting, Regulations apply on module. Can be put in different orientations in a pack → complex shapes (like eCMP) Classical sizes = VDA (390), MEB (590)</p>	 
Cell block (sometime called CTP abusively, or for "marketing")	<p>Similar than modules, but bigger, with specific size adapted to the pack, specific number of cells, of specific dimensions. Increases volumetric efficiency ratio from modules. Target to reduce the sizing of mechanical parts</p>	
(real) Cell To Pack (=CTP) Only BYD Han today	<p>Cells are directly integrated in the battery pack without a pre-assembly level. (module or cellblock) Cells are put 1 by 1 in the pack. glued. Mechanical functions of a module are transferred to the housing And then need welding of busbar and sensors under high voltage.  Permits a gap in volumetric efficiency ratio.</p>	 
Cell to body (or cell to car, cell to chassis)	<p>Different integration axis than CTP. Integration between pack housing and vehicle body in white, communalization of</p> <ul style="list-style-type: none"> <li>- Pack cover and car floor,</li> <li>- Rocker and pack side profile</li> </ul> <p>Inside, could be done with cellblocks or real CTP.</p>	 

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