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FUTURE VEHICLE AND BATTERY STRUCTURE – CELL TO X (CTX) APPROACHES

Dr. Michael Funcke
Senior Engineer Battery Systems

Motivation for new battery structure approaches for battery electric vehicles

The modular approach “cell to module” (**CTM**) is currently state of the art in automotive industry

- » Cells are grouped in modules, which are mounted in an enclosed battery systems
- » Battery systems are attached in vehicle floor area

CTM design requires numerous parts

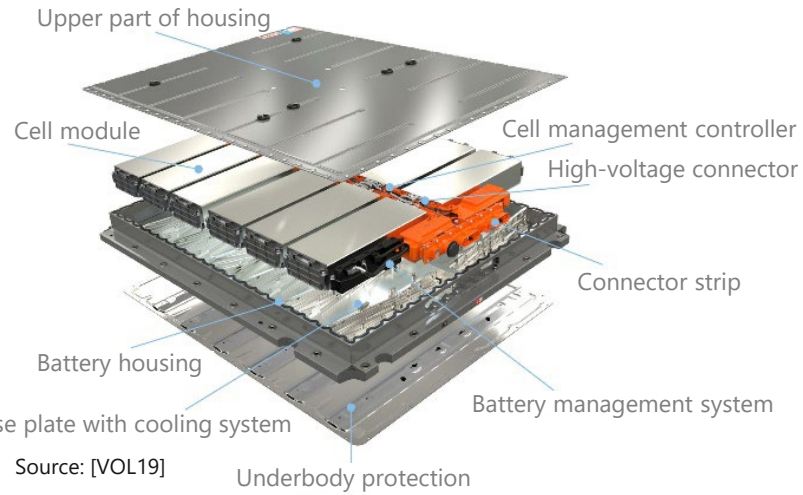
- » High mechanical, electrical and thermal complexity

Not the entire enclosed design space can be used for cells

- » Limited volumetric energy density
- » Large and heavy battery system to achieve requested driving ranges

Cells contribution to the structural properties of battery system is limited

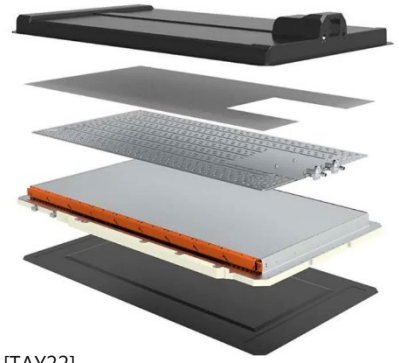
High optimization potential in terms of
… space utilization, weight, complexity, and more
through the introduction of advanced battery structures



Source: [VOL19]

Modular (traditional)

Cell to pack

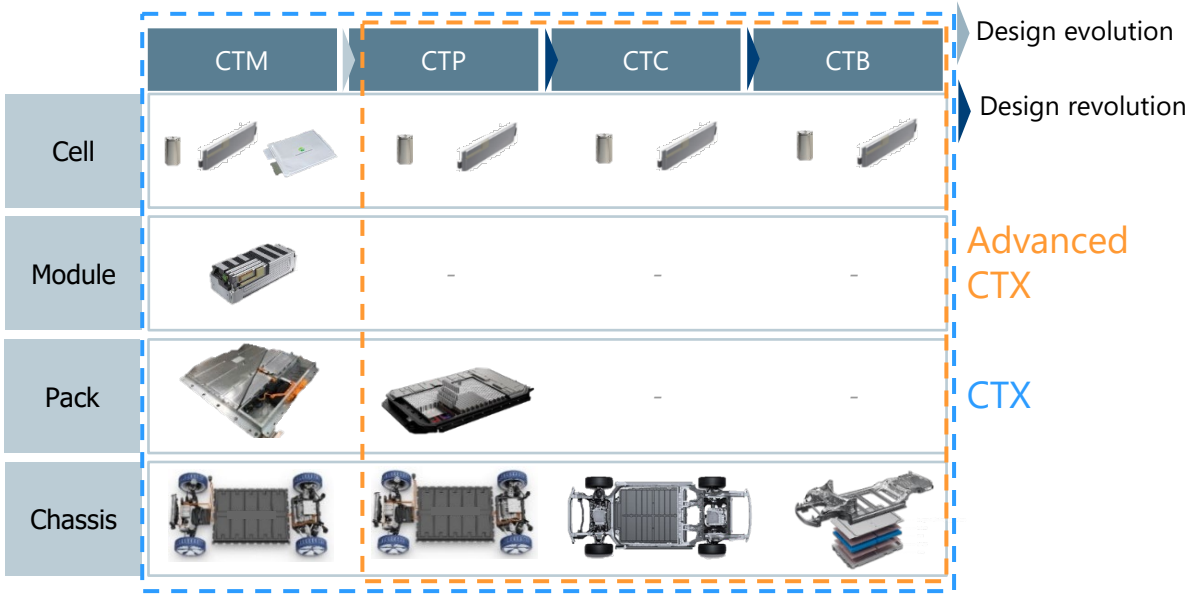


Source: [TAY22]

Improvement through advanced battery structure designs

In order to reduce the number of parts and the system complexity as well as to increase the space utilization the modular grouping of cells in the battery housing is skipped

- The cells are directly mounted in the battery pack -> cell to pack **(CTP)** design
- CTP introduced by CATL, BYD & SVOLT
- Volkswagen, GM, Toyota, Nio, et al. intend to implement or have already included CTP design



Further improvements possible by dispensing with a separate battery system → cells directly mounted to chassis (**CTC**) or to vehicle body (**CTB**)

- First CTP designs by Tesla, Volvo, Leapmotor et. al.

Source: [LEI22, REP22]

Impact of advanced CTX designs

Improved space utilization CTM < CTP < CTC & CTB

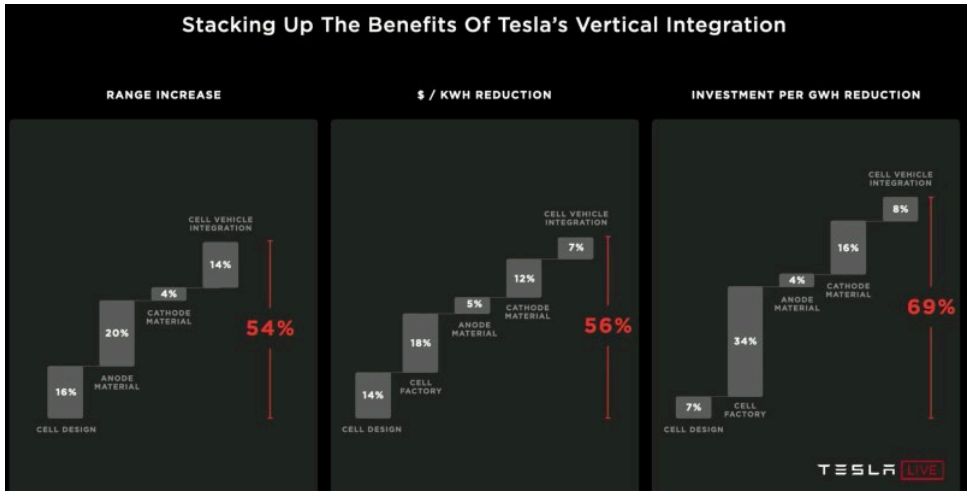
- » Space utilization of > 70 % possible
- » Higher range or lower required space
- » **Tesla claims a range increase of 14% (change CTP → CTC)**

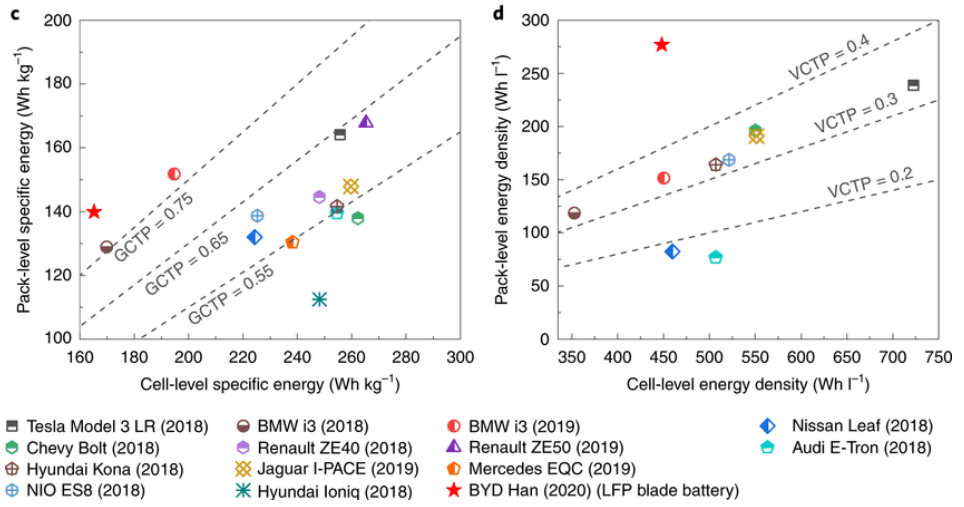
Reduced number of components

- » Simplification of bodywork design
- » Reduction of electrical, mechanical and thermal complexity

Advanced CTX (CTP, CTC, CTB) approaches allow batteries to fulfil a structural role in the vehicle

- » Reduced costs per kWh
  → 7 % according to Tesla (CTP → CTC)
- » Alternative and more effective cooling strategies can be applied (e.g. immersion cooling)





Source: [YAN21, REP22, TES20]

Are advanced CTX technologies the future of battery electric vehicles?

Challenges

- With increasing cell integration level
  - Knowledge about structural behaviour of cells is crucial
  - Holistic development approach is required
- Higher maintenance cost compared to CTM
- High risk of thermal propagation between cells
- Encapsuling of cells to passenger compartment is necessary (fire / gases / heat)
- Recycling / disassembling of cells in CTC and CTB approach is more complex compared to CTM and CTP
- Sophisticated vehicle assembling process required
  - In-line integration of cells and wiring

Potential questions for businesses

Market Intelligence

- Which OEMs use or are currently looking at advanced CTX (vehicle models, platforms)?
- How is the value chain structure impacted?

Cell Integration

- Which part reduction ratios can be achieved?
- How is the vehicle design process implicated?
- How can the structural cell performance be integrated in the virtual design process?

Production:

- How is the assembly process impacted and which process changes are necessary?

Performance:

- Lightweight and CO2 reduction potential compared to other designs?
- What are the advantages in battery cooling?

Dr. Michael Funcke

fka GmbH
Steinbachstraße 7
52074 Aachen
Germany

phone +49 241 8861 132
e-mail michael.funcke@fka.de
web www.fka.de

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