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What can we learn from Battery Benchmarking?

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What can we learn from Battery Benchmarking?

We don't have the resources to take batteries apart, but there are lots out there who do and they share lots of data.



Data => Estimations / Limit Cases => Calculations

Tesla 2022 Model Y 4680

Early model teardown and weight of pack + interior trim and seats.

- \Rightarrow Create parts list => estimate mass => estimate 4680 pack mass
- \Rightarrow Compare to Model 3 21700 based pack

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Cell to pack mass ratio 66%	Cell to pack mass ratio	669	6									
5/kwh \$ 69,90	\$/kWh	\$ 69.90										

Pack capacity from declared cycle testing. Cell configuration from teardown.





Capacity tests from a number of cells [7]:

- Capacity: 22.31Ah at C/20 discharge
- Capacity: 22.41Ah at C/20 charge
- Capacity: 22.08Ah at C/3 discharge

Ank, Manuel, Sommer, Alessandro, Abo Gamra, Kareem, Schöberl, Jan, Leeb, Matthias, Schachtl, Johannes, Streidel, Noah, Stock, Sandro, Schreiber, Markus, Bilfinger, Philip, Allgäuer, Christian, Rosner, Philipp, Hagemeister, Jan, Rößle, Matti, Daub, Rüdiger, Lienkamp, Markus, <u>Lithium-Ion Cells in Automotive Applications: Tesla 4680 Cylindrical Cell</u> <u>Teardown and Characterization, Journal of The Electrochemical Society</u>, Volume 170, Number 12

Tesla 4680 Cell

How does this cell compare?



This was an early cell and we know that it is all about lowering the cost.



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UC San Diego analysis, <u>The Limiting Factor</u> & <u>Laboratory for</u> <u>Energy Storage and Conversion</u>, UC San Diego, <u>Ying Shirley</u> <u>Meng</u>, UC San Diego

DCIR ~5.4m Ω to 7m Ω @50% SoC

Ank, Manuel, Sommer, Alessandro, Abo Gamra, Kareem, Schöberl, Jan, Leeb, Matthias, Schachtl, Johannes, Streidel, Noah, Stock, Sandro, Schreiber, Markus, Bilfinger, Philip, Allgäuer, Christian, Rosner, Philipp, Hagemeister, Jan, Rößle, Matti, Daub, Rüdiger, Lienkamp, Markus, <u>Lithium-Ion Cells in Automotive Applications:</u> <u>Tesla 4680 Cylindrical Cell Teardown and Characterization,</u> <u>Journal of The Electrochemical Society</u>, Volume 170, Number 12

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If we know the cell DCIR we have the ability to then look at discharge limits and to estimate heat rejection requirements.

What can we learn from Battery Benchmarking?



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Battery Pack Weight



Lots of data >400 values in database.

A spread of ~200kg @100kWh in pack mass across the various applications.

Battery Pack Weight



- modules
- thermal
- HV electrical
- LV harness sensors
- SensorBMS
- BMS
- HV control
- connectors
- case
- mounts



On average: 31.2kg for the BMS, connectors, fuses, contactors.

Module, case, cooling, busbars ~2x Total kWh

https://www.batterydesign.net/battery-pack-mass-estimation/

Pack Mass Estimation



How big are battery packs?



We can see a range and the trend of those limits.

Pack volume data is much harder to acquire and a lot of variation in how it is measured => lower confidence and the need for more data.

Busbar Sizing



Copper busbars in battery packs sized at around 5.9A/mm²

Pouch Cell Cooling Development

Top Tabs Lower DCIR More uniform discharge Improved underfloor package More robust wrap Lower module height Lower ΔT One piece outer wrap, electrical tabs closer to cooling plate

Opposing Tabs, reduced height to suit automotive underfloor

Innovations: engineering design

Some innovations are subtle and an amalgamation of good engineering, eg Hyundai Ioniq 5, Kia EV6, Genesis GV60 (E-GMP).



Plastic module case with no base.



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Pouch Cell Cooling Development



Innovations: engineering detail

Let's look at a section through the module and cell Hyundai Ioniq 5 / Kia EV6 / Genesis GV60 (E-GMP)



Pouch Cell Cooling Development





- Opposing tabs
- Reduced cell height
- Module case wrap around cells
- Heat transfer material in • base of the module

- Single outer cell wrap reduces distance to cooling plate
- Open module base removes ٠ need for second layer of TIM



Closer to coolant Simpler cell wrap Less TIM



What can we learn from Battery Benchmarking?

