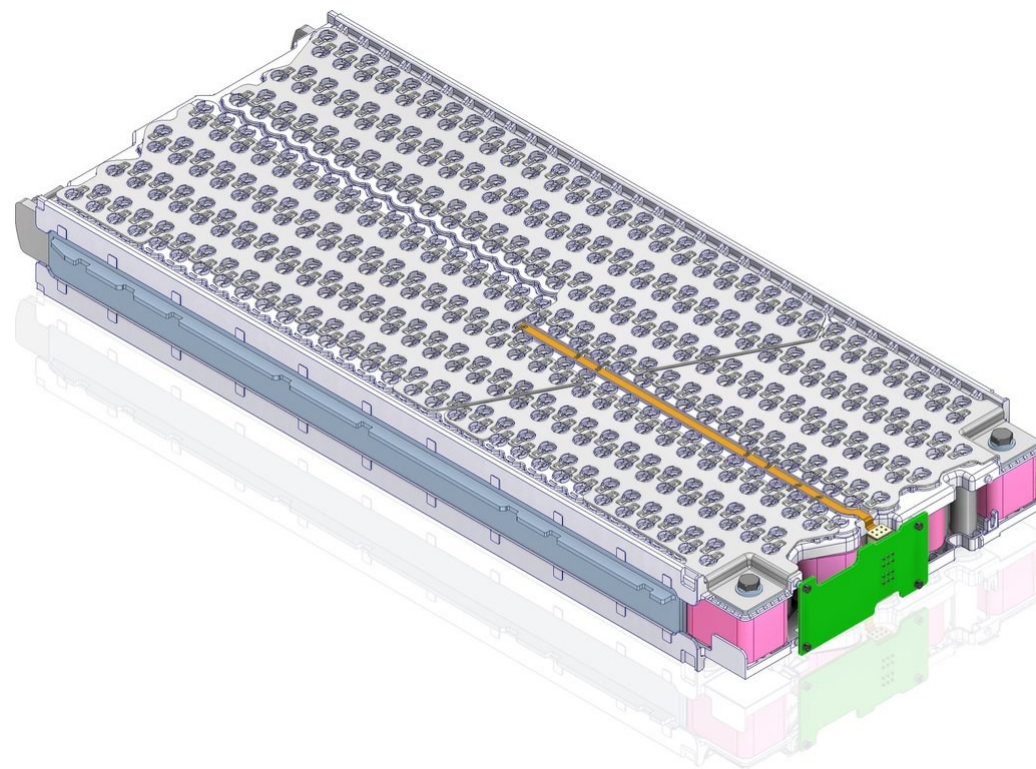


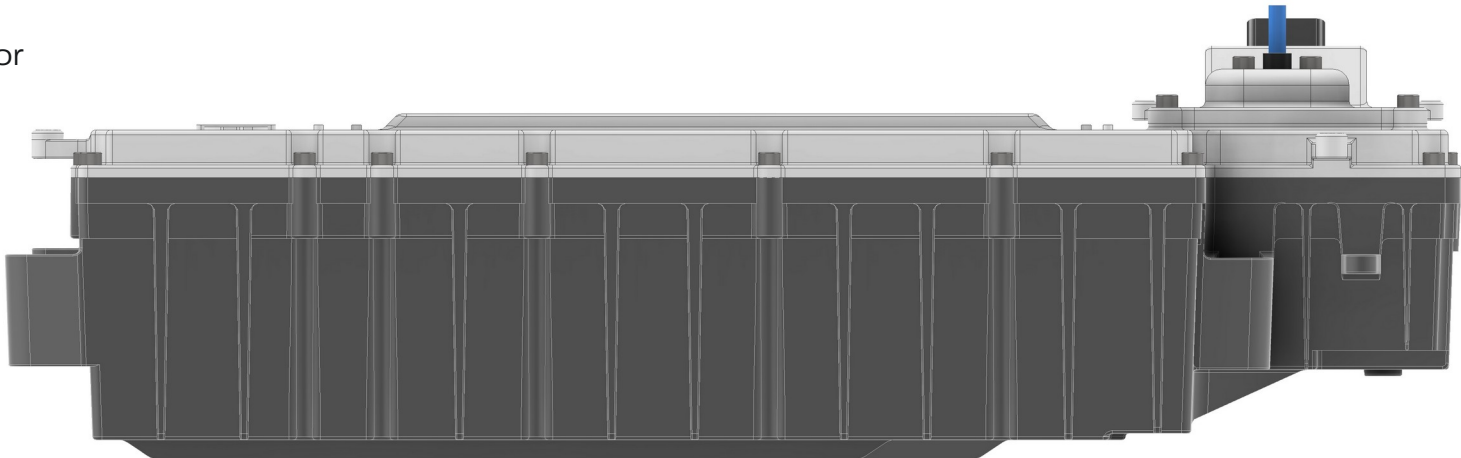
BATTERY STUDIES

TESLA MODEL S · Ather 450



Two battery packs, studied from reference photos and modeled part by part: **a car module built from hundreds of small cells, and a scooter pack built around one casting.**

Built using Autodesk Inventor



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Two battery packs, studied from reference photos **and modeled part by part in CAD.**

01 INSPECT

Reference photographs of each system, including a real pack seen up close. Neither was taken apart.

02 SCALE

Known parts, such as the cylindrical cells, set the scale for every other dimension.

03 MODEL

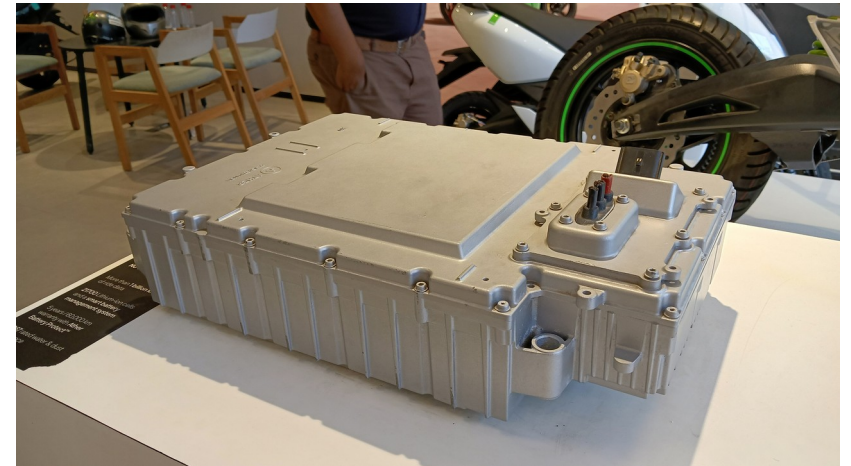
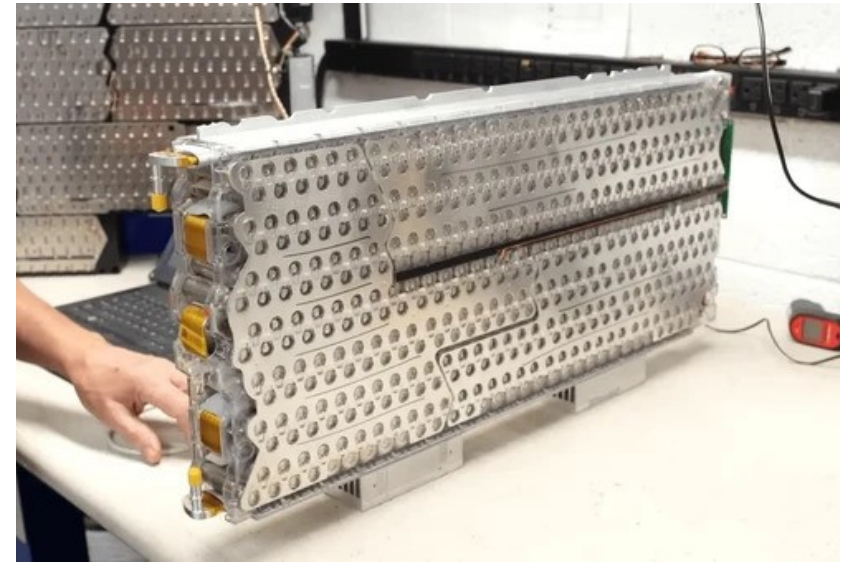
Every part modeled as it would be made: molded, cast, stamped or laid out on a circuit board.

04 ASSEMBLE

Parts assembled and exploded to show how each system goes together and why.

05 CHECK

The finished models were reviewed for fit, assembly and manufacture (DFMA).

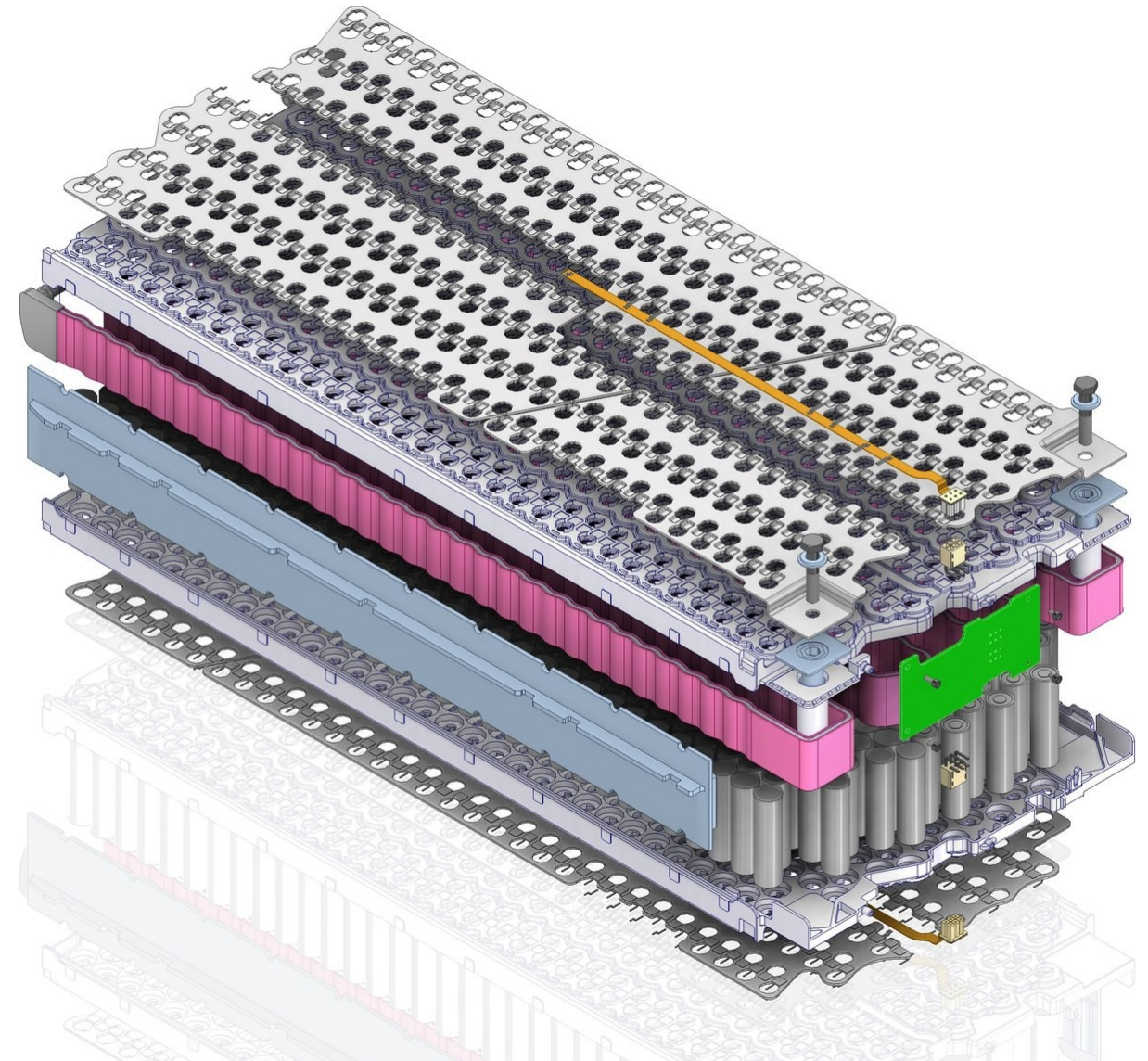


TESLA MODEL S

BATTERY MODULE STUDY

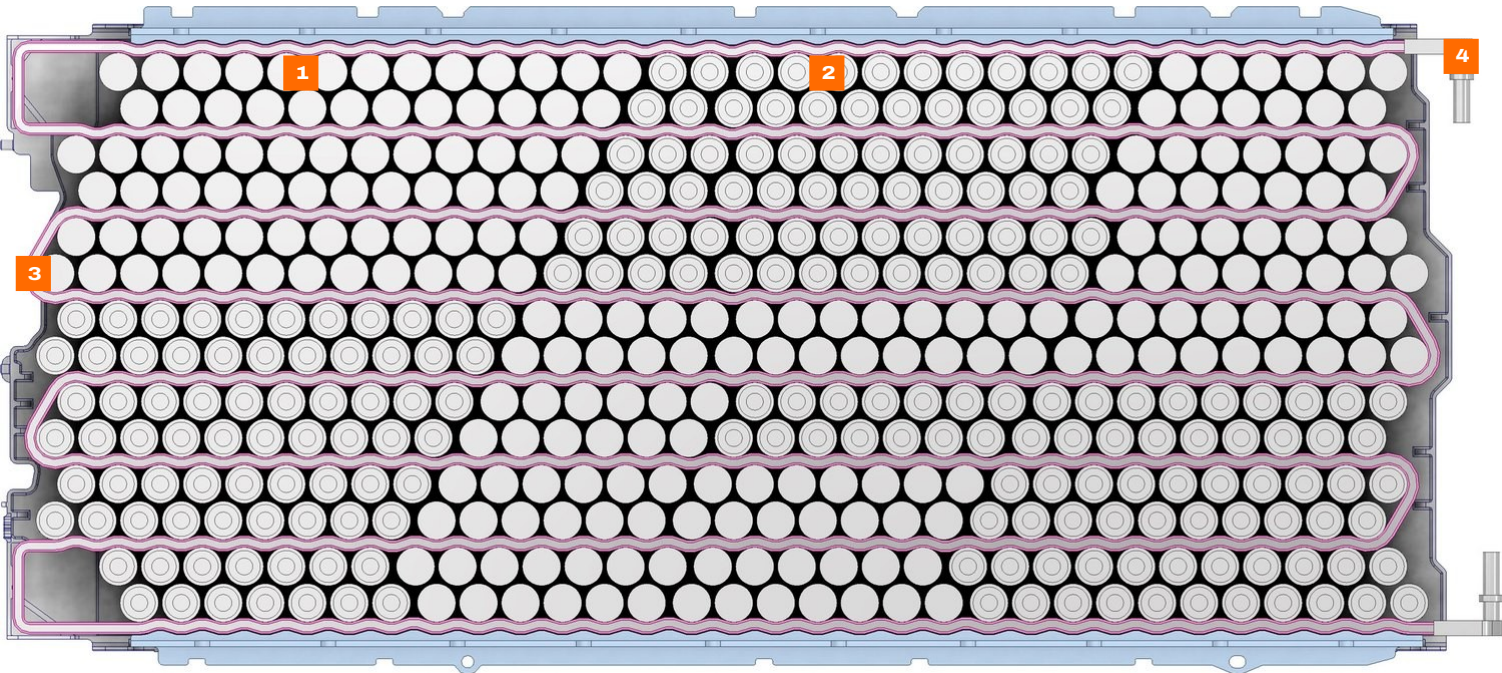
The Model S pack is made up of modules like this one. Each holds hundreds of small cylindrical cells, is liquid cooled and has its own monitoring board that reports to the pack's main controller. This study models one module in full.

- 1 Top busbar plates
- 2 Sense ribbon
- 3 Top carrier
- 4 Coolant ribbon
- 5 Side cover
- 6 Bottom carrier
- 7 Bottom busbar plate
- 8 Cells
- 9 Monitoring board



CELL LAYOUT AND COOLING

The 18650 cells are arranged in groups. Cells within a group are joined in parallel, and the groups are joined in series. Neighboring groups sit end to end, so one busbar plate can link them. A flat coolant ribbon winds between the rows and touches every cell along its side. With the cells potted in place, the whole block is rigid.



1 Group, negative ends up

2 Group, positive ends up

3 Coolant jacket

4 Coolant inlet and outlet

444

Cells in the module

6

Groups in series

74

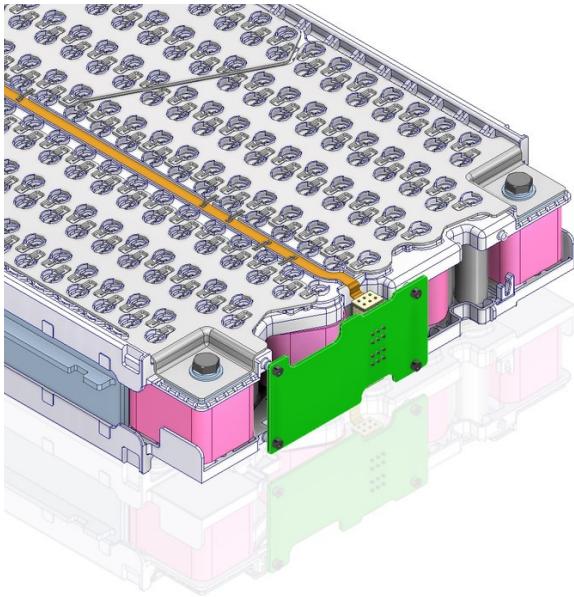
Cells per group

16

Modules in the pack

MONITORING BOARD

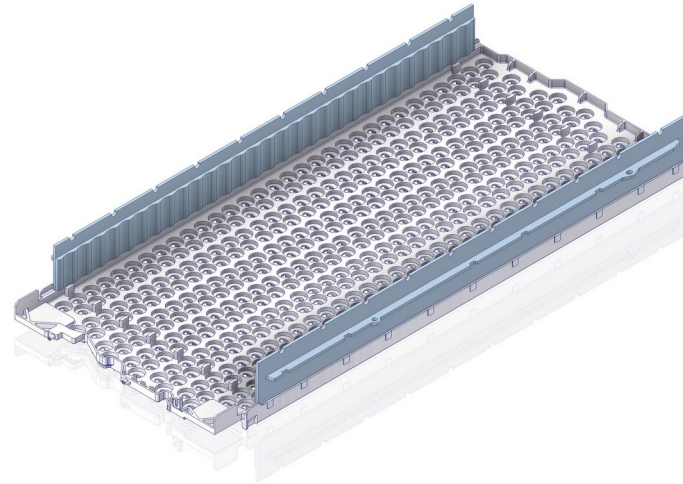
A slave monitoring board is mounted on the end of the module. It reads the voltage of each of the six groups and the temperature of the module, and balances the groups so they stay level. It reports to the battery management system of the whole pack.



MONITORING BOARD ON THE MODULE END

TWO MOLDED CARRIERS

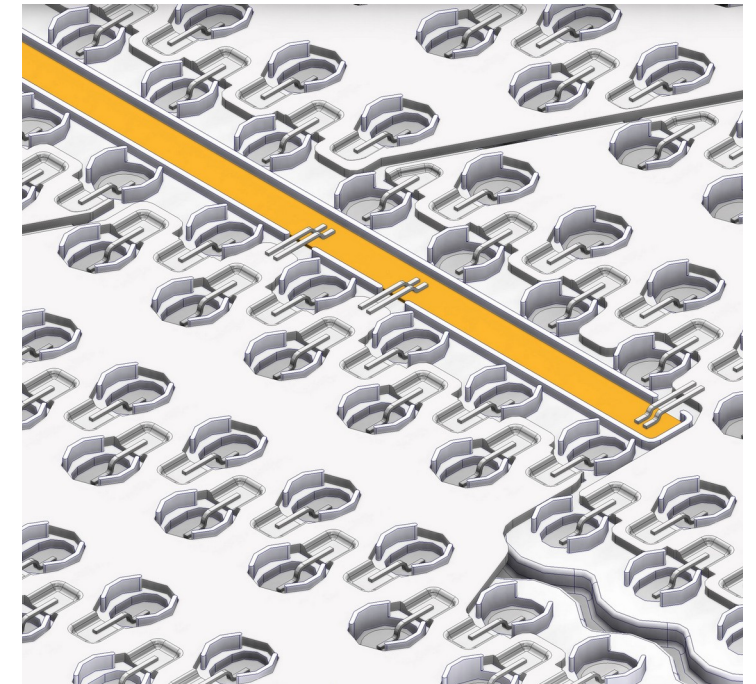
The cells are held between two injection-molded carriers, one at each end. Every cell sits in its own pocket, so the spacing is exact and nothing can move. The carriers also hold the coolant ribbon, the busbar plates and the side covers, and follow plastic part design rules so they can be tooled.



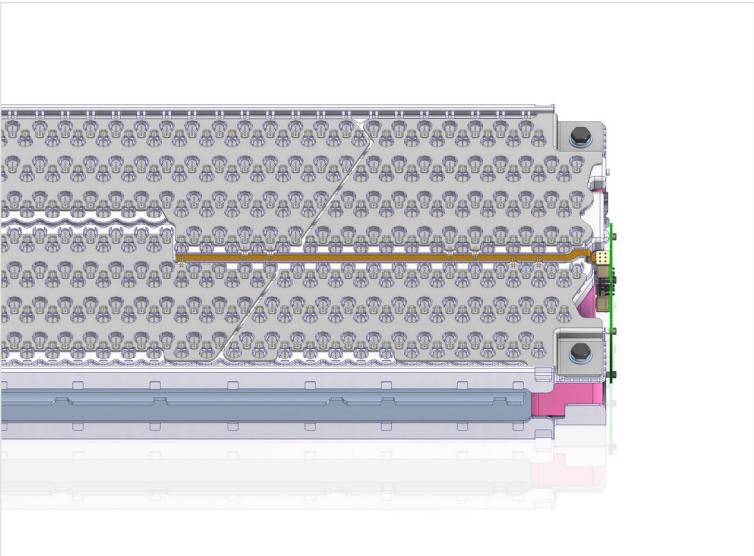
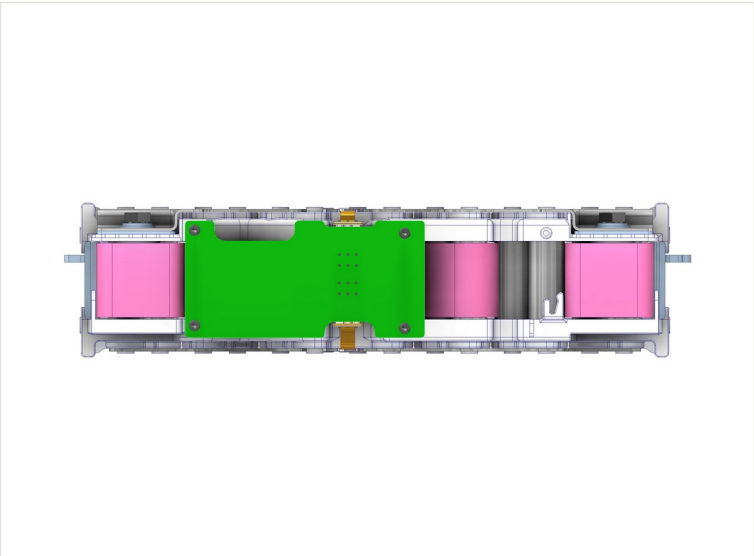
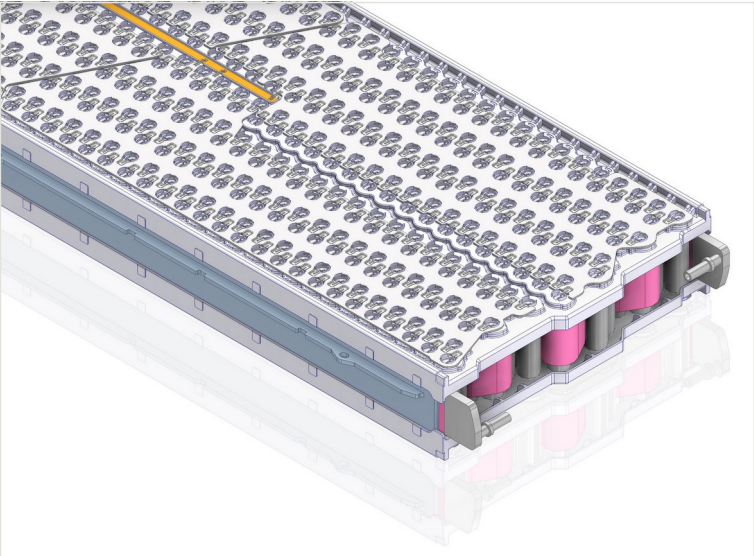
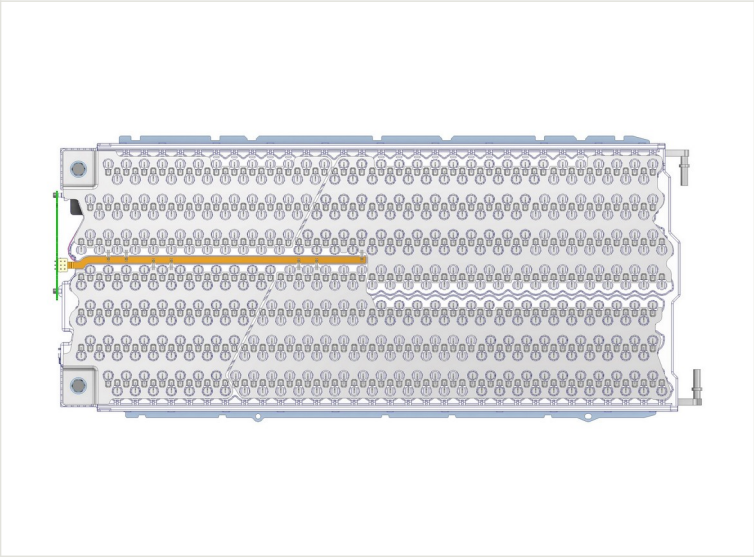
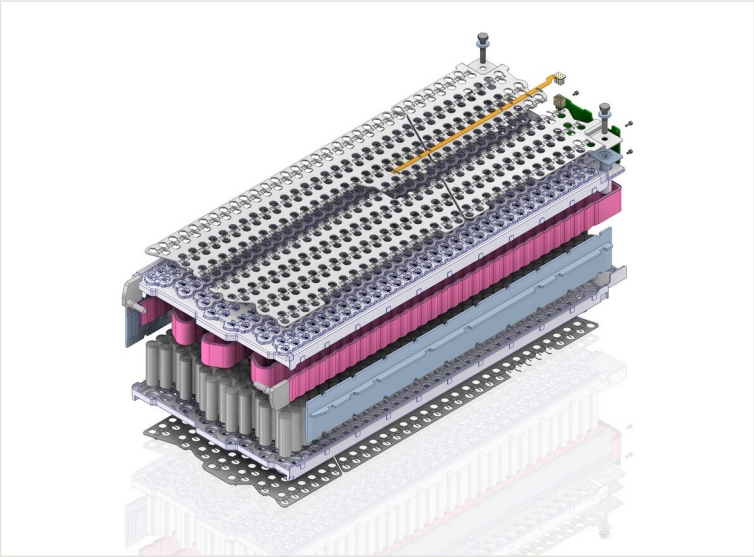
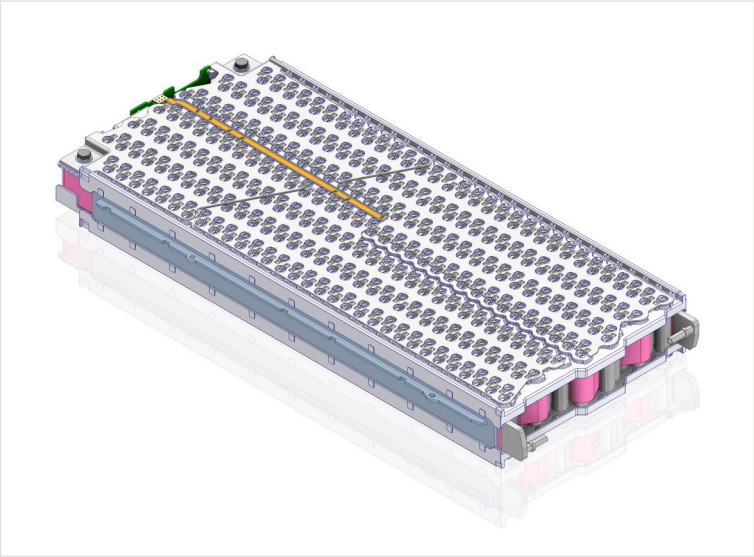
BOTTOM CARRIER WITH ITS SIDE WALLS

WIRE-BONDED CELLS

Each cell is joined to an aluminum busbar plate by its own thin wire bond. The bond also acts as a fuse: if a cell fails, its bond burns open and the rest of the group carries on. A flexible ribbon cable runs over the busbars and picks up the voltage of every group.



WIRE BONDS AND THE SENSE RIBBON

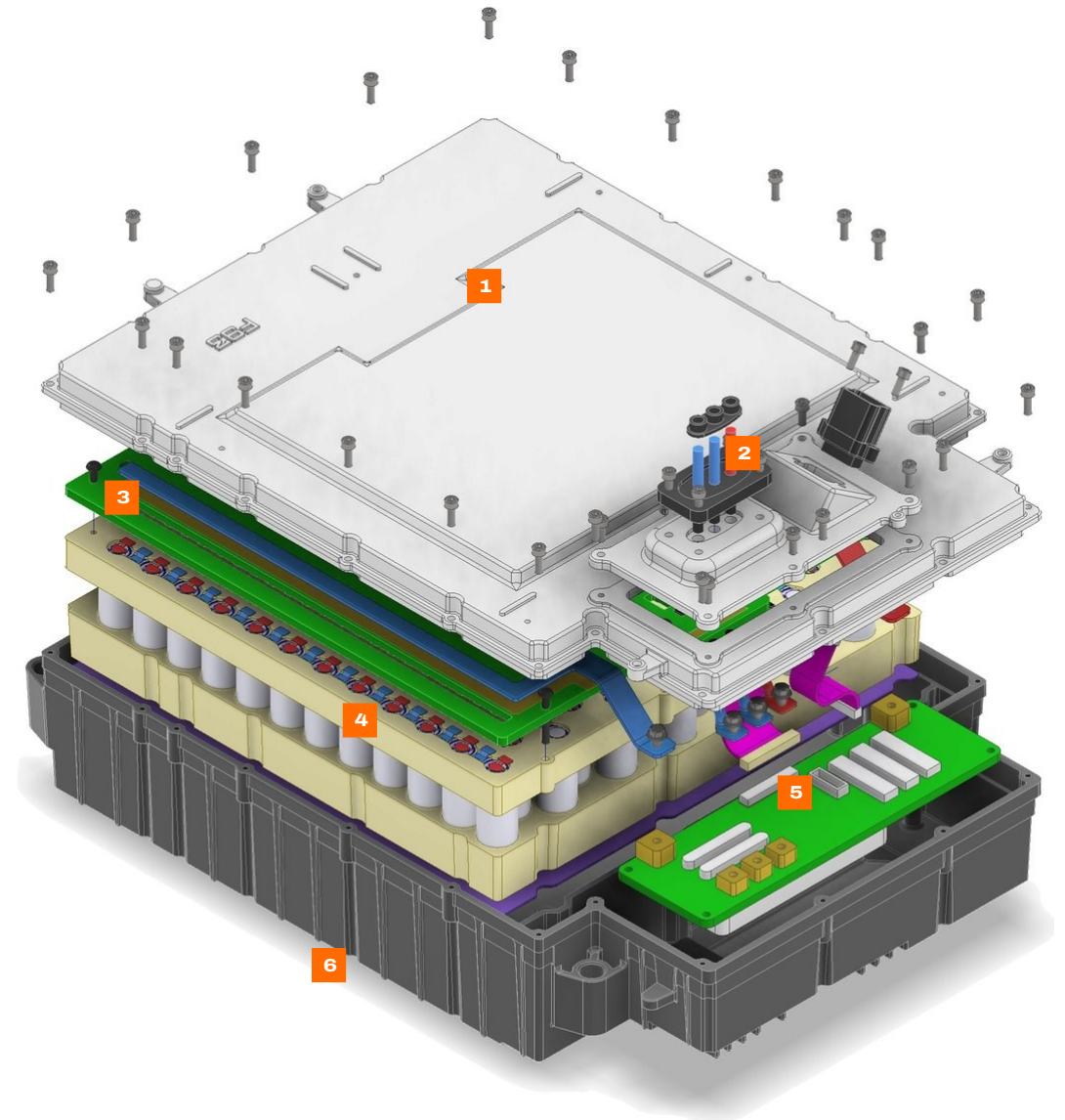


ATHER 450

BATTERY PACK STUDY

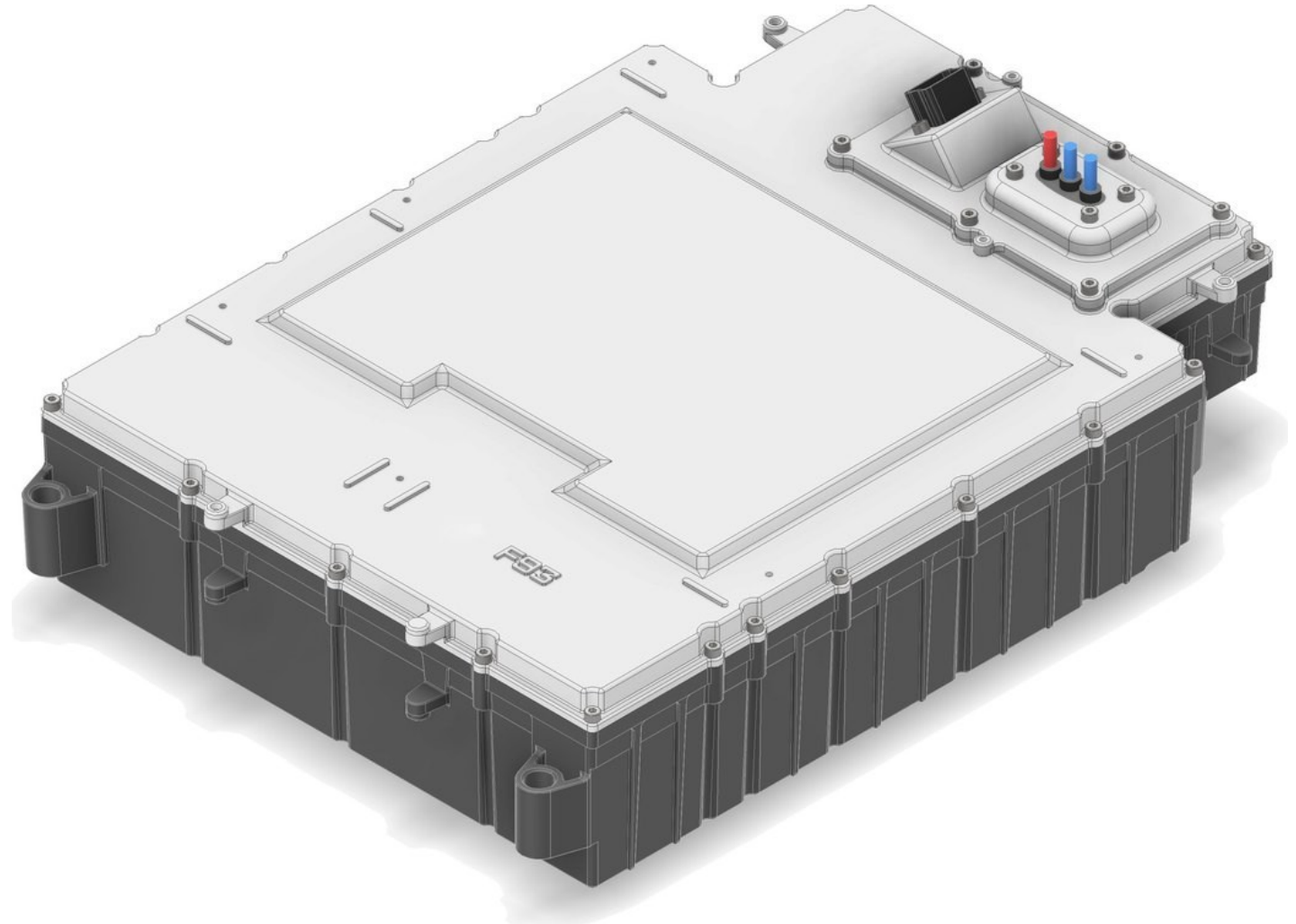
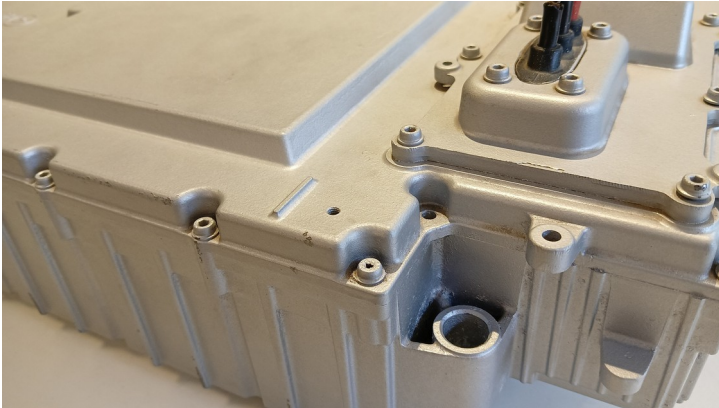
The cells sit in holders inside a single aluminum casting, set in a phase-change material. One circuit board on top acts as the busbar: copper layers in the board carry the pack current and the balance paths in place of separate busbars. The battery management board sits in its own bay at the end.

- 1 Cast lid
- 2 Port plate, power and signal
- 3 PCB busbar
- 4 Cells set in holders
- 5 Battery management board
- 6 Cast base with fins



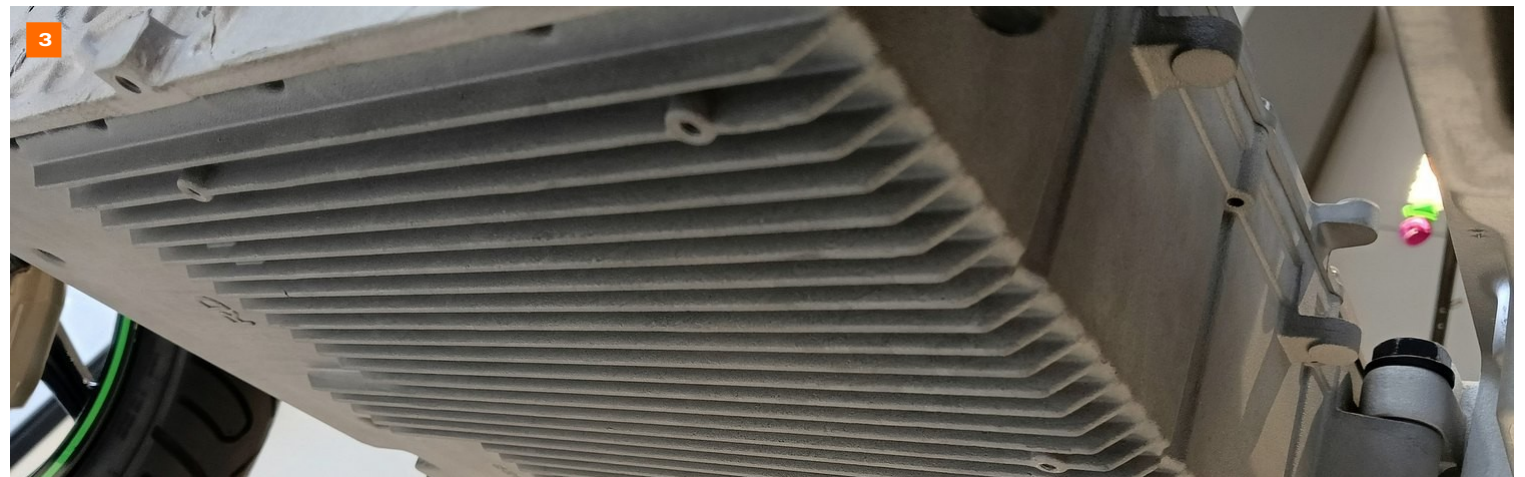
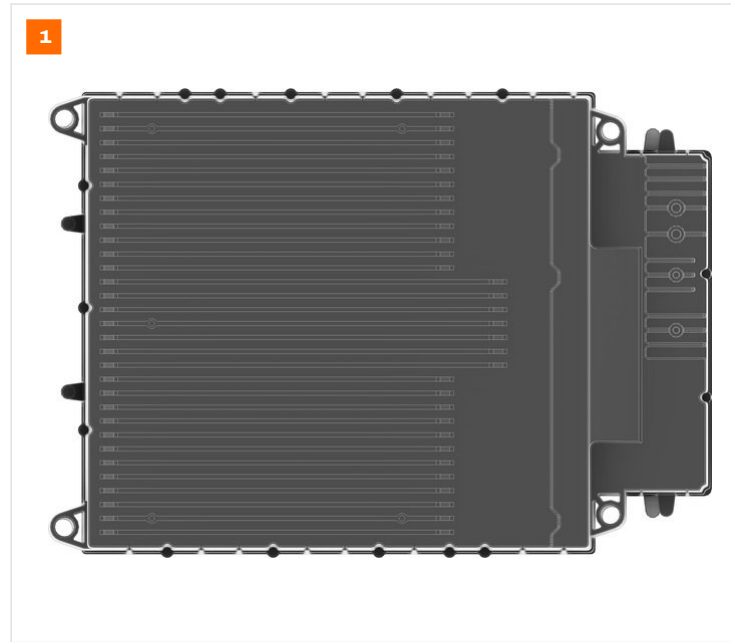
A DIE-CAST ENCLOSURE

The base is a single high-pressure aluminum die casting. Its walls, ribs, mounting lugs and fins are formed in one shot, so the pack needs no separate frame. A cast lid closes it along a flanged edge, held down by a ring of screws and sealed to hold the PCM.



PASSIVE COOLING

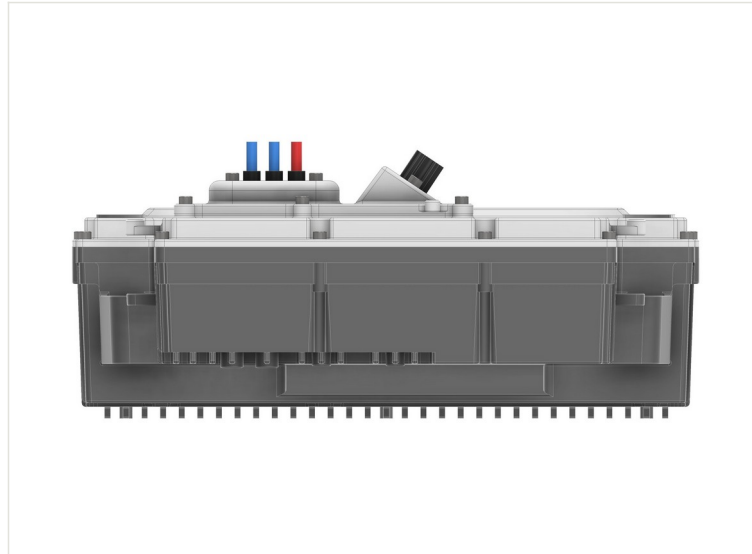
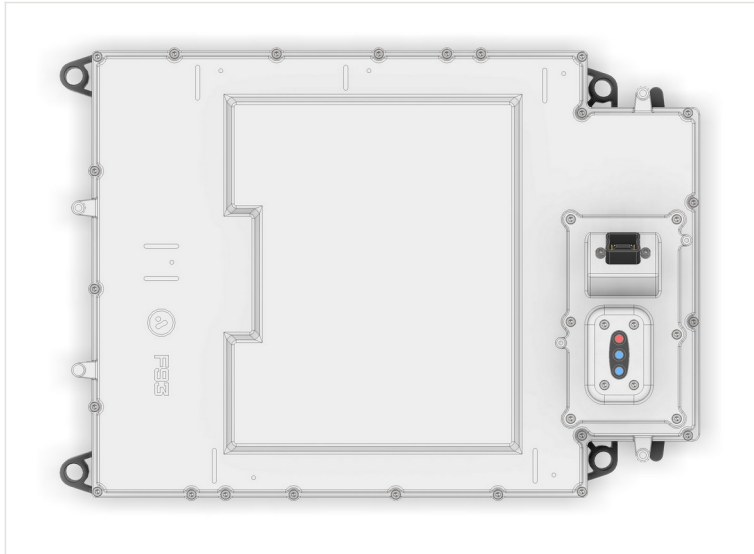
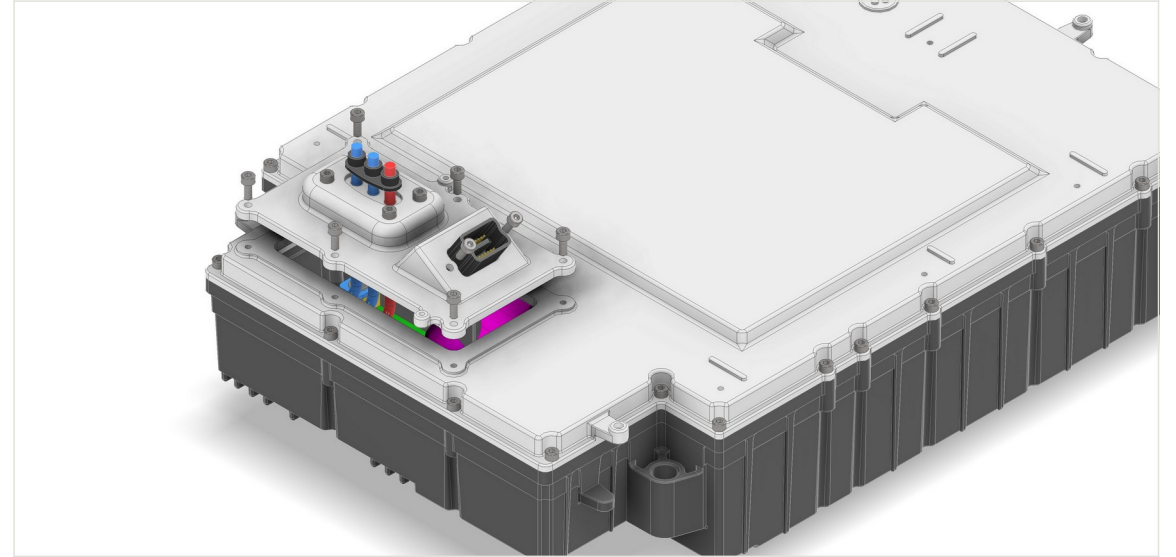
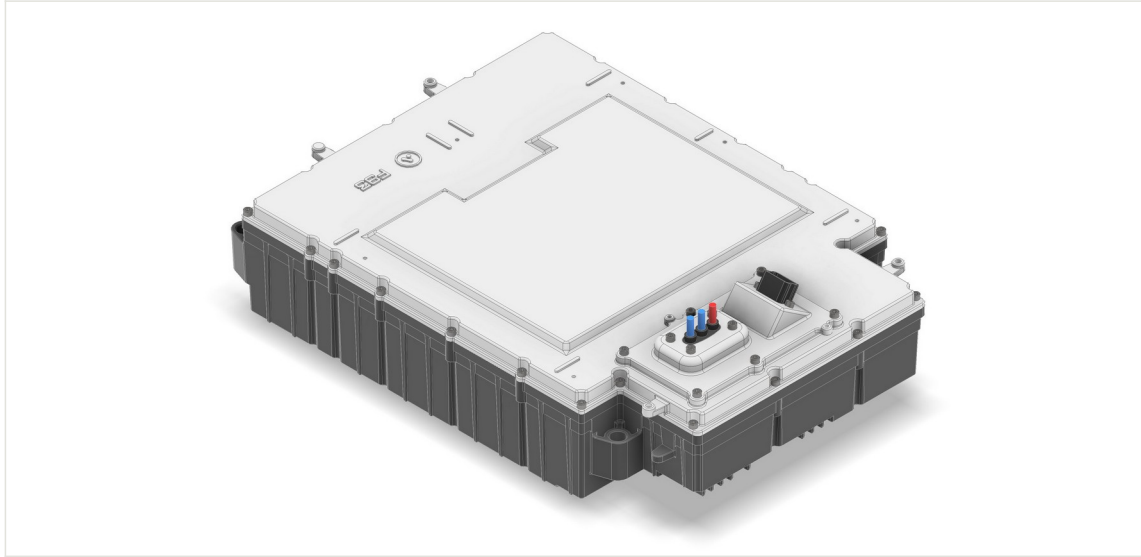
When the cells heat up under sustained riding or charging, the phase-change material absorbs the heat as it melts and keeps the cells at an even temperature. The heat then passes into the casting and out through fins on its underside, in the airflow under the scooter. There are no pumps, fans or coolant.



1 Finned underside

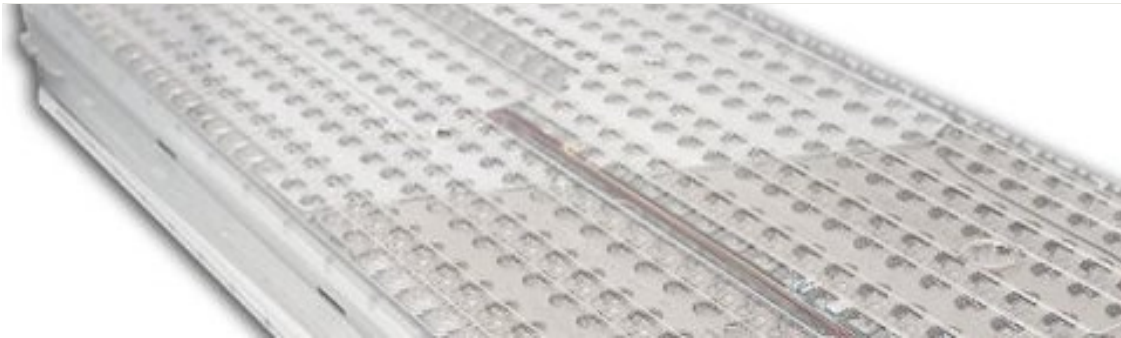
2 Fins, close up

3 The real pack, from below



A car module and a scooter pack solve the same problem in different ways.

TESLA MODEL S MODULE



01 FUSE EVERY CELL

With hundreds of small cells, one weak cell must never take down the module.

02 COOL EVERY CELL ALIKE

Cells age with heat. Even cooling keeps them wearing evenly.

03 LET THE TOOL LOCATE

Precision comes from hard tooling, not from careful assembly.

ATHER 450 PACK



01 ONE PART, THREE JOBS

Structure, seal and heat sink in one casting: fewer parts and fewer joints.

02 PASSIVE CAN BE ENOUGH

At scooter power, a heat store and fins replace pumps and fans.

03 A BOARD FOR WIRES

One circuit board replaces strips and wires, and is made and tested by machine.

LET'S BUILD THE NEXT ONE

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