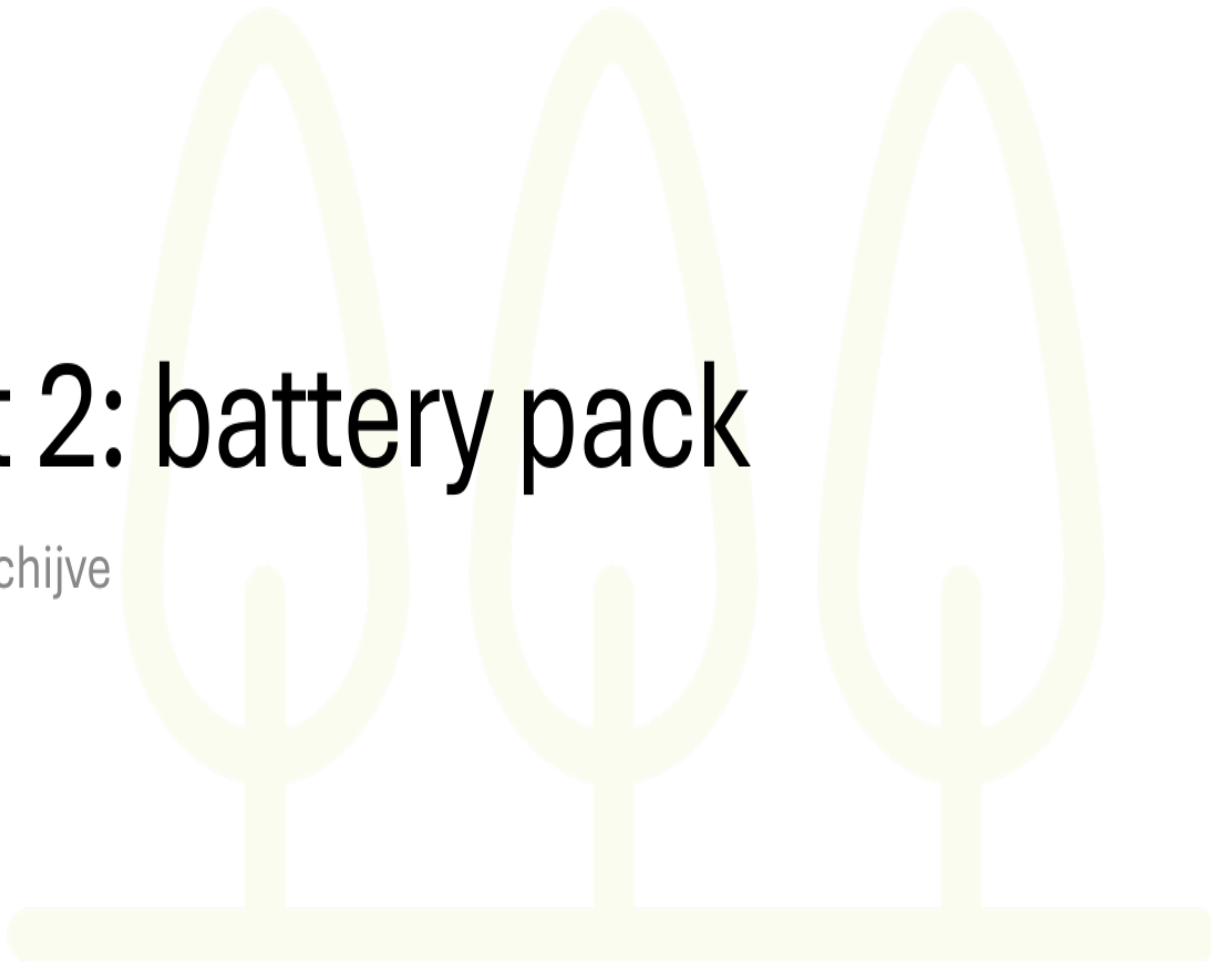


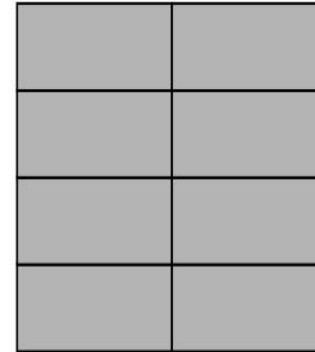
Pilot 2: battery pack

Warden Schijve





6 kWh



24 kWh

CYPRESS Project: Circular Modular Battery Casing

Warden Schijve, November 5th 2025, Helmond

Project partners



"Client"
Boundary conditions



Project organisation support



Project lead
Design



General support



Thermal analysis



Materials for Cell holders



Requirements



Materials & Cell holder design



General support



Circularity evaluation

Scope

- Development of a ~3 kWh battery casing, for modular use in KERV and Carver vehicles, with high degree of circularity
- Non-cooled with the option to add cell cooling in a later stage in the same casing component
- Future proof for new cell chemistries, although with the same cell format (cylindrical 21700) current version NMC or NCA, 5Ah, 3.6V (18Wh).

In scope:

- Definition of geometry and materials for battery casing, cell holders, thermal protection materials, venting valves, tray & lid structure, fixations, seal. Design to allow later inclusion of cooling plate or similar cooling device. Definition of the principles of that cooling device (material, dimensions).
- Mechanical and thermal CAE optimisations. Study on alternative materials and production processes.

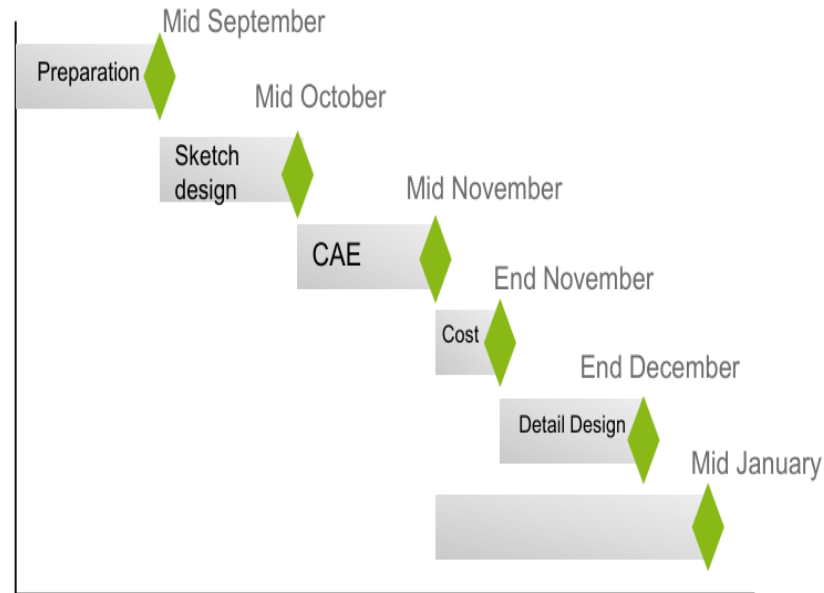
Out of scope:

- Electrical design, busbars*, BMC, and electrical connectors. It is supposed that the BMC electronics are kept in a separate EMI shielded housing, as would be logical for a modular casing design, so no EMI shielding for the modular battery casing. (interfaces between casing and electrical connections are in scope)

* Busbars to be discussed, might integrate with cell holders

Work packages

1. Project preparation
 2. Sketch design
 3. CAE simulation and analysis
 4. Evaluation on cost and circularity
 5. Detail design
- Grant request for physical proto line



Bi-weekly online progress meetings

Modular Battery Pack for two different 3-wheel vehicles



CARVER

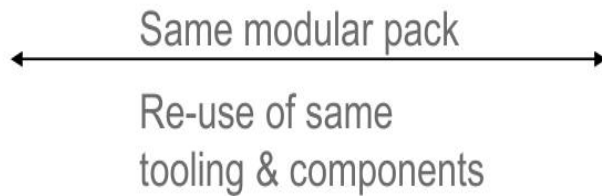


KERV



6 kWh (nett)

2 packs in parallel ~50V



24 kWh (nett)

8 packs in series ~400V

And same 3 kWh pack to be sold for other vehicles or other use case

Prediction: 5 years: ~ 50.000 modular packs

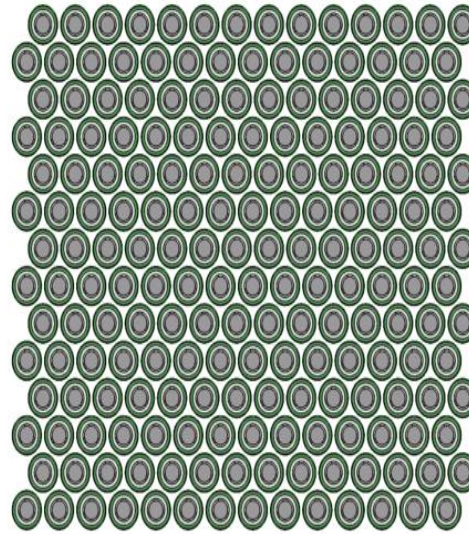
Battery cells for one modular pack

3 kWh

Nett capacity.
Gross ~ 3.5 kWh

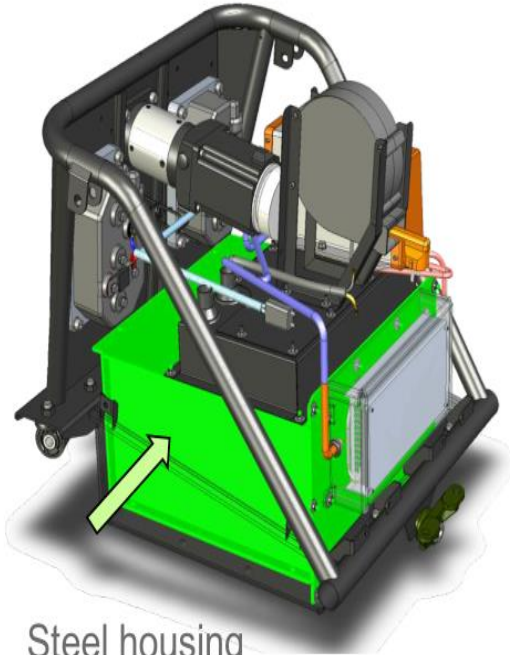


21700 NCA Cells
14p14s configuration
196 total



Reference, existing pack

CARVER



Steel housing

10.3 kg steel housing only, not taking into account cell holders.

No active cooling in this pack

KERV

New vehicle, no reference pack available

Typical state of the art:

Housing, made from aluminium extrusions

Example:



This pack will need active cooling
(high performance vehicle, fast charging)

Design requirements and strategy

- High level of circularity.

In case of conflict circularity is preference above reduced CO₂ footprint.

Target is to look for using recycled content materials in the design, while at the same time design for recycling/disassembly, and ability to recycle the used materials for the same or new applications.

Disassembly should be easy, at relatively low cost, enabling cost effective repair and recycling chains.

- Casing shall include cell fixation and optional cooling, using a cooling plate.

Same moulding tool for both options with/without cooling. Re-use of same components.

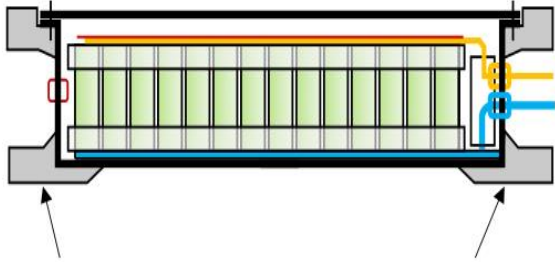
- Low risk design. Use of existing technologies, but be prepared for future cell chemistries, still enabling the use of the same components in future.

- Safe design, "non-propagating" in case of thermal runaway of a battery cell

- Cost & Weight not more than current design

One example of a pack layout: Folded or press formed box

Active cooling for KERV vehicle only



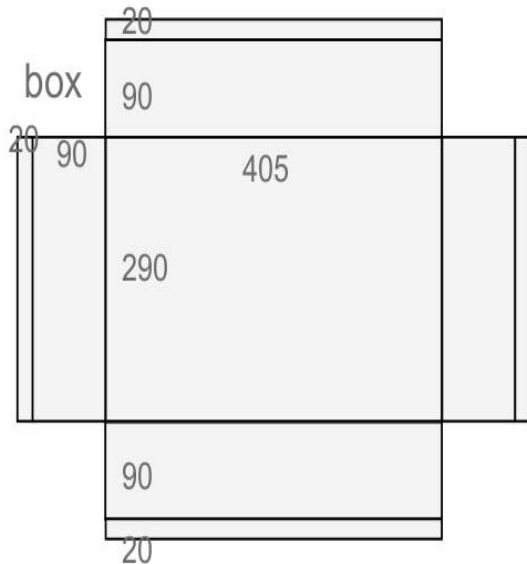
Overmoulded mounting provisions at corners and fold lines to close the box. PP-LFT

Lid: flat plate, fabric or cross-ply glass UD laminate, $t = 2 \text{ mm}$, glass-PP

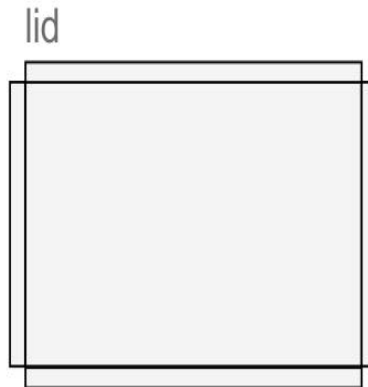
Box: folded or hot press formed from flat plate blanks, fabric or cross-ply glass UD laminate, $t = 2 \text{ mm}$

Also doable in recyclable thermoset, RTM

Thicknesses to be confirmed by CAE analysis

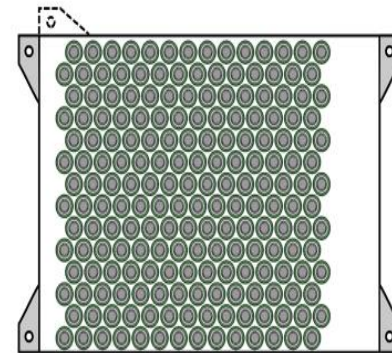


2700 cm²



1470 cm²

Mounting provisions on short or long side



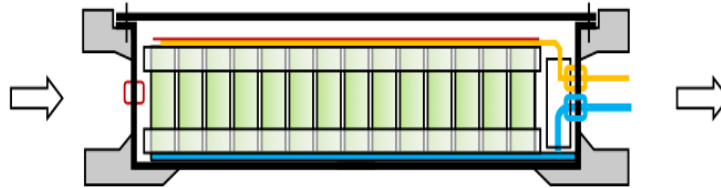
→ 1.4 kg laminate per box (nett)

Circularity

Before use:

High recycled content for

- Casing materials
- Cell holder materials



Use, long life ~10 - 15 year:

Easy repair: opening of lid
Easy separation of cells as a unit,
but using debonding on demand.
Easy replacement of single cells.

End of life:



2nd life as static energy storage.
Long life ~10 - 15 year



End of 2nd life:

Separation of cells and housing.
Debonding-on-demand adhesive
allows easy separation.

Housing to new
housing material

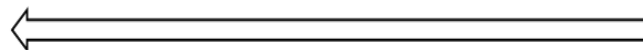


Reuse casing with new cells,
Updated chemistry

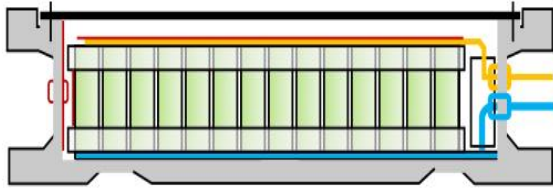


or

Cells to new battery cells



Alternative: injection overmoulded



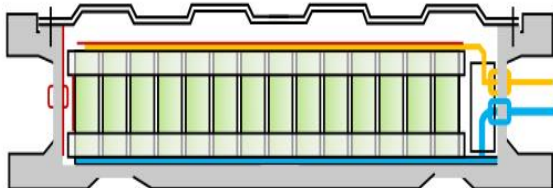
Lid: flat plate, fabric or cross-ply glass UD laminate, $t = 2 \text{ mm}$

Box: Injection overmoulded, ribbed for stiffness $t = 3 \text{ mm}$

Extra fire protection material at exhaust location

Thicknesses to be confirmed by CAE analysis

Or also do the lid hybrid overmoulded



Example Injection moulded concept
Without over moulded busbar connections

Cypress: Battery casing 3.5 kWh 14S14P cell module

Flow diagram of an EV's battery system

EV Battery System

Battery pack

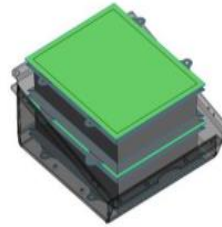
- Mechanical structures
- Fire and electrical insulation
- BMS
- Power electronics
- Cooling system
- Pack bus bar
- EMI shielding

Battery module

- Cells
- Module bus bar/connectors
- Module controller
- Cell holders/spacers
- Cooling plate
- Potting and structural adhesives

CARVER

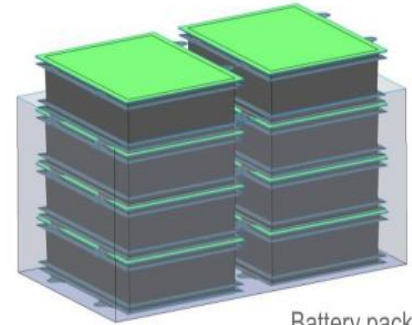
2 Module Pack 3.46 kWh 50.4 V
1 X 2 layout : 6.92 kWh



Battery pack

KERV

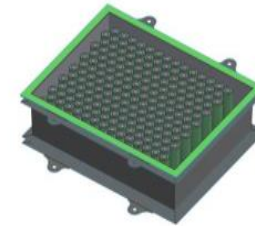
8 Module Pack 3.46 kWh 50.4 V
2 X 4 layout : 27.68 kWh



Battery pack

No cooling

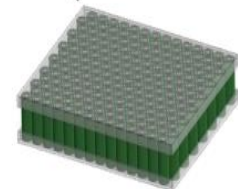
Cooling



Battery module



Cell

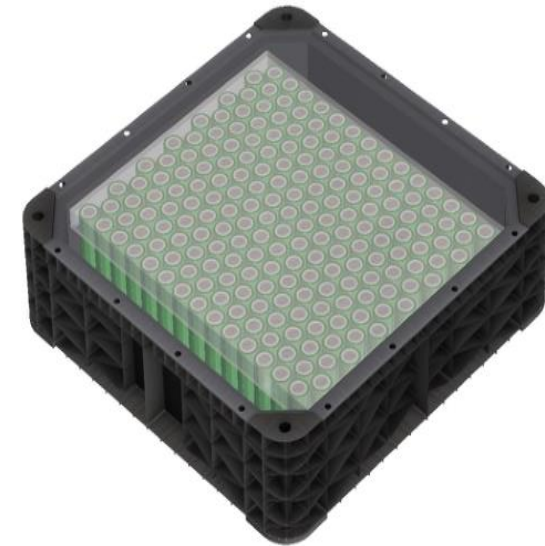
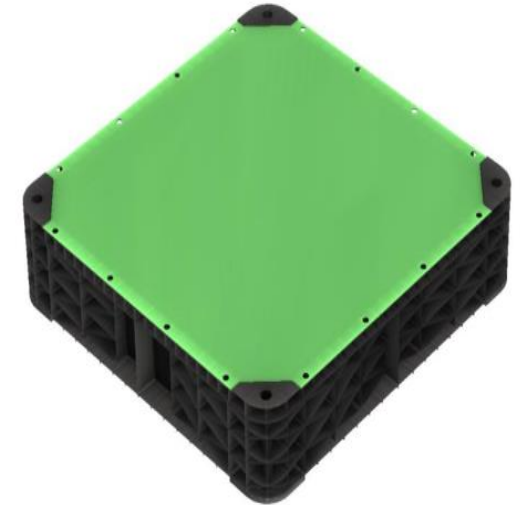
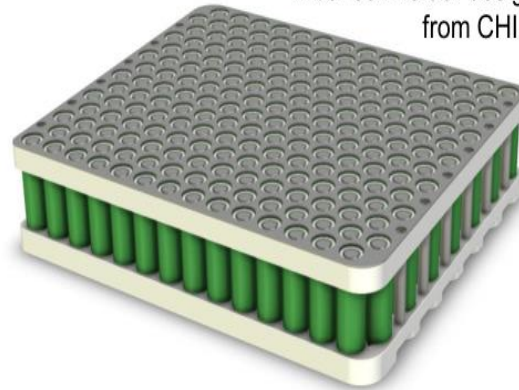


Cell module with connectors and holder

Stage 1: Design Study of Reference Battery Module

- Manufacturing type: Injection moulding

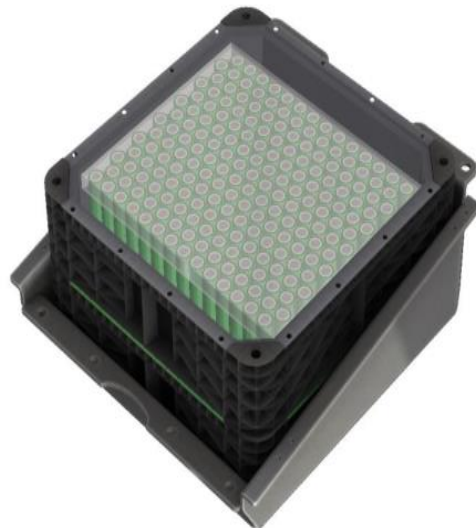
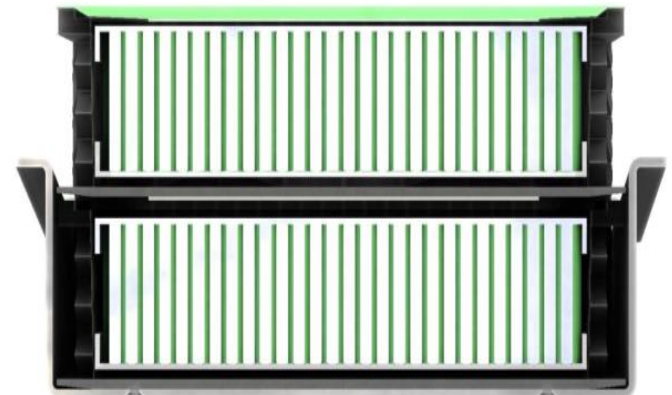
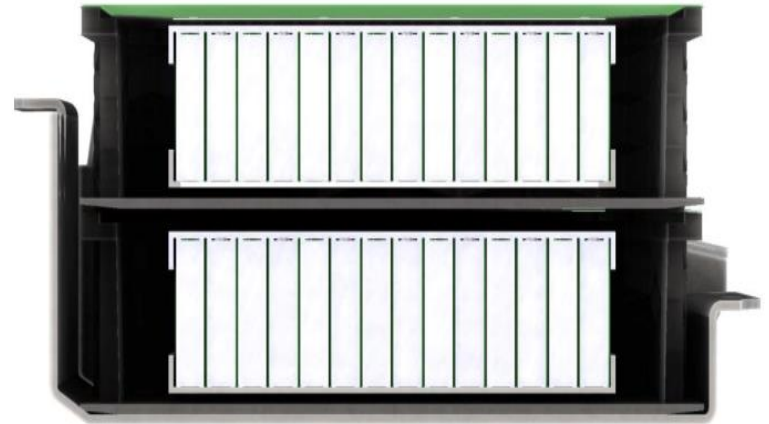
Initial cell holder design,
from CHILL



Note: ribbing pattern still under discussion

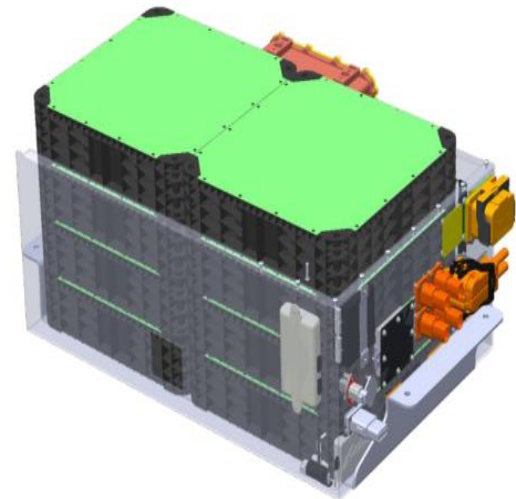
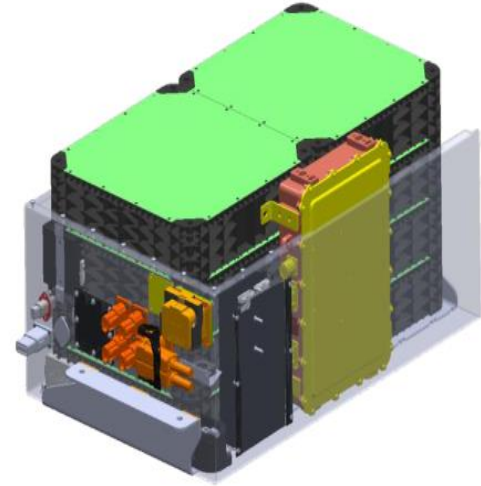
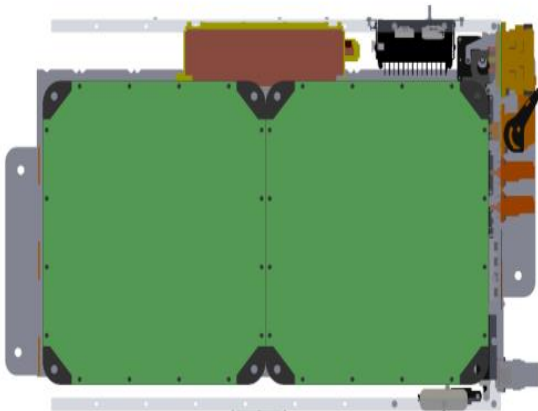
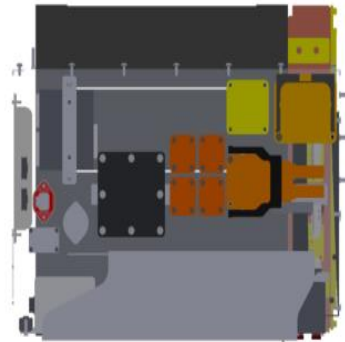
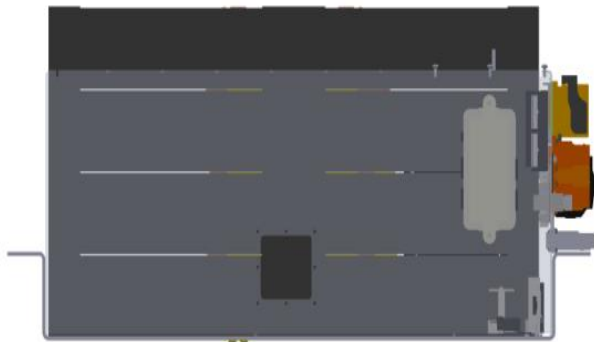
Stage 1: Design Study of Reference Battery Module

- Manufacturing type: Injection moulding
- Assembly of 2 battery modules
- Vehicle: CARVER



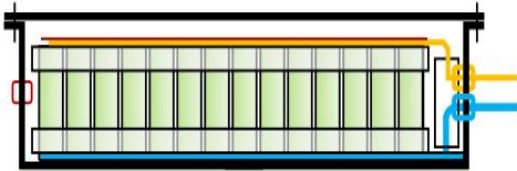
Stage 1: Design Study of Reference Battery Module

- Manufacturing type: Injection moulding
- Assembly of 8 battery modules
- Vehicle: KERV



Design space still under evaluation

Example of optional cooling plate, for KERV vehicle



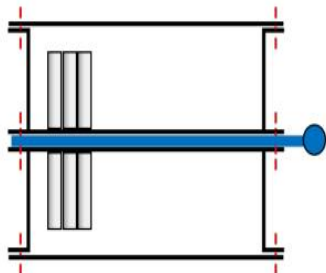
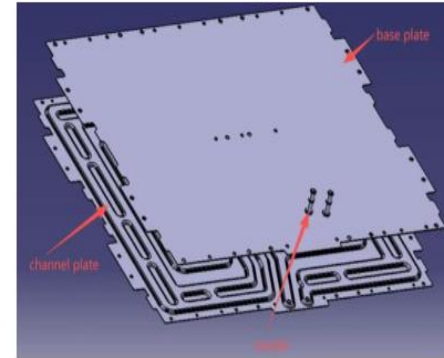
This is standard for a brazed 3D formed cooling plate, but needs tooling



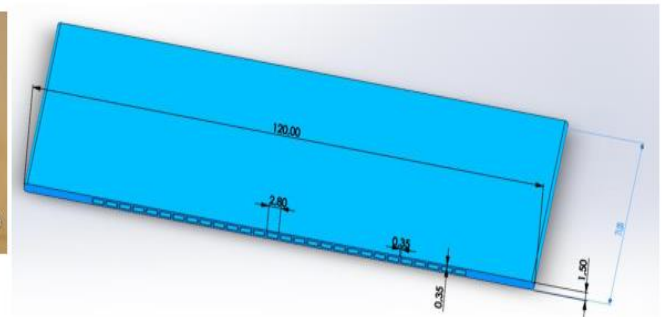
Cheaper, use standard extrusions and braze/weld tube connectors, but this adds thickness, cannot easily place on bottom. Option for two story layout.



Cooling extrusions can be very thin (picture WKW)



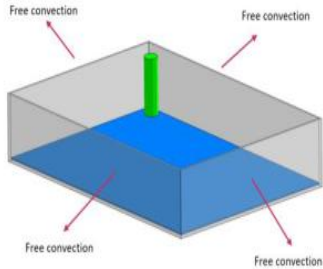
Outside cooling, efficiency checked by GD Tech



Notes

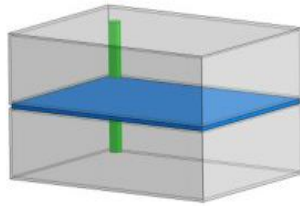
Comparison between Config. A and B

- Slightly higher temperature at the end of each charge has seen in config. B
- Nearly no cooling has observed in config. A
- Slow cooling has observed in config. B of about 0.5 to 1.5 °C



Configuration A

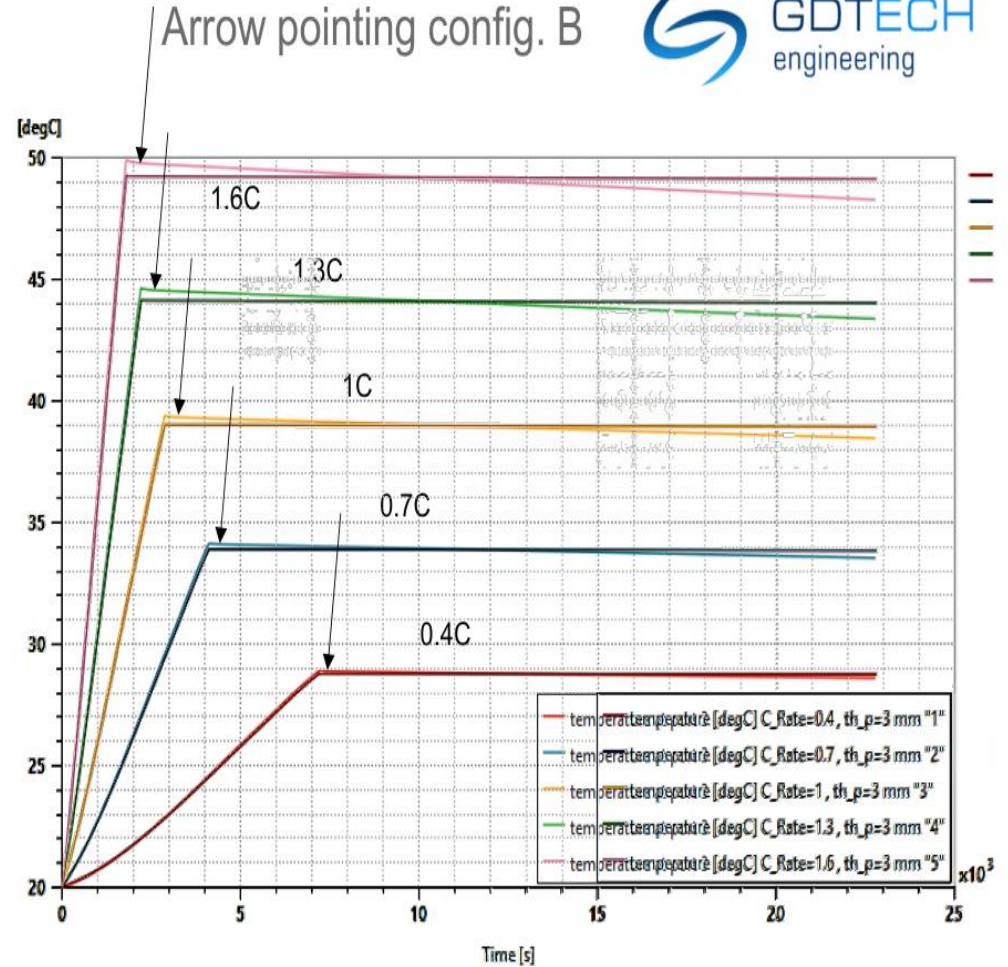
Direct cooling



Configuration B

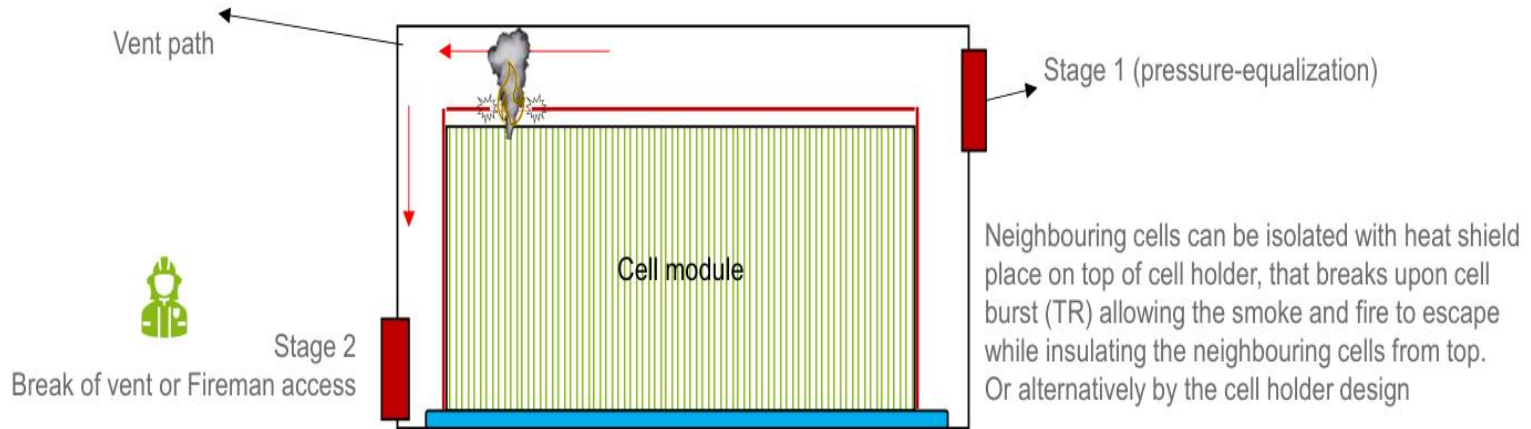
Cooling through plastic tray of 3 mm

Driving simulations have also been performed and require choices on required cooling versus max speed/time and charging rates



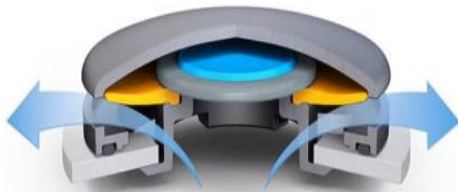
Overlap of config. A and config. B

Thermal runaway venting path



Combined or separate stage vents still under discussion

Combined



Freudenberg

Separate rupture disk



Next steps

- CAE verification (shock loads)
- Detail Design
- Cost, weight & circularity evaluation

Many thanks! Your AZL – Lightweight Center and One-stop Shop for Business and Technology Development



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Mobile: +49 1775129780

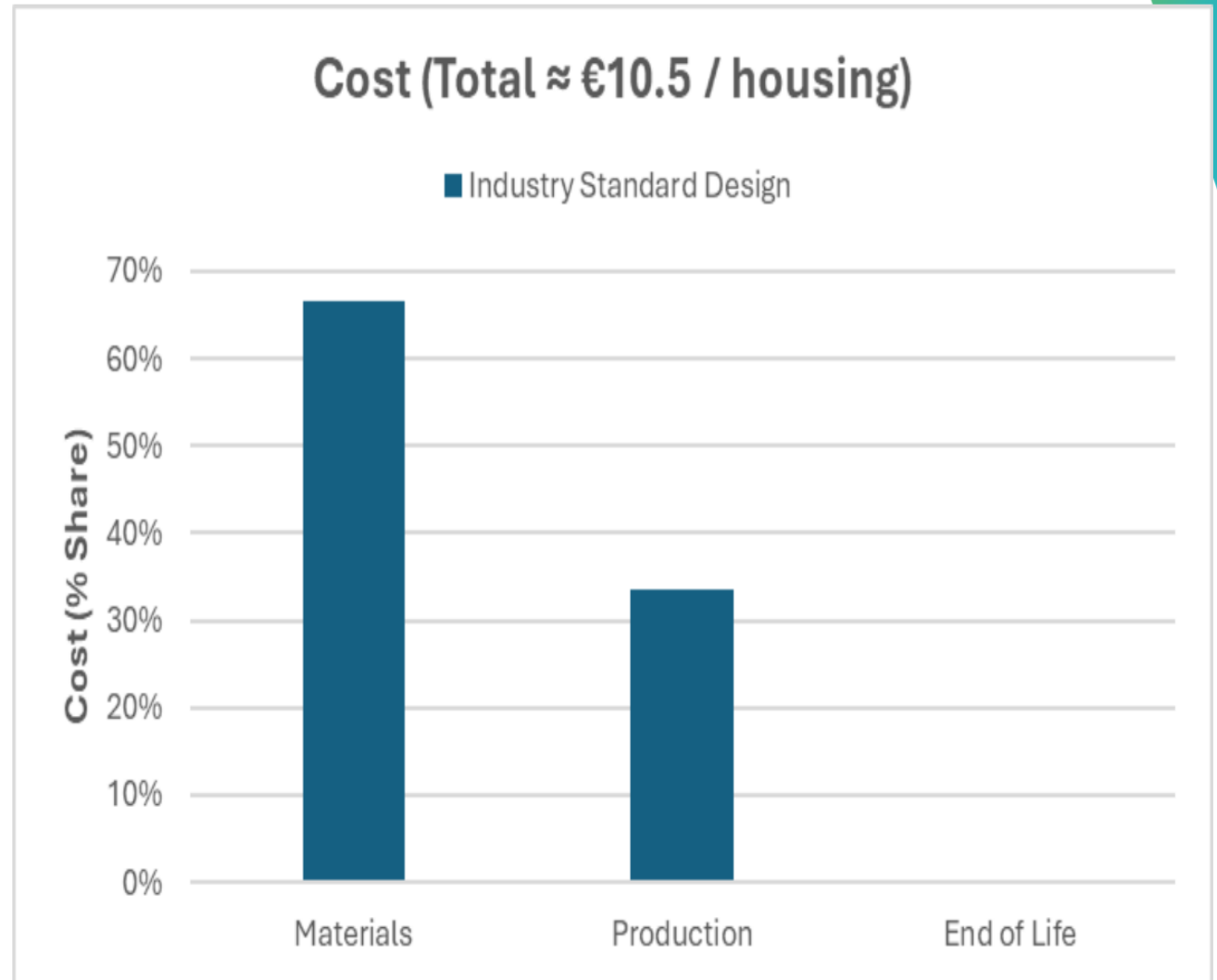
In cooperation with:

Circularity assessment of the pilot

Three pilot scenarios were assessed;

1. Industry standard battery housing, acting as the baseline scenario.
2. Pilot innovation model

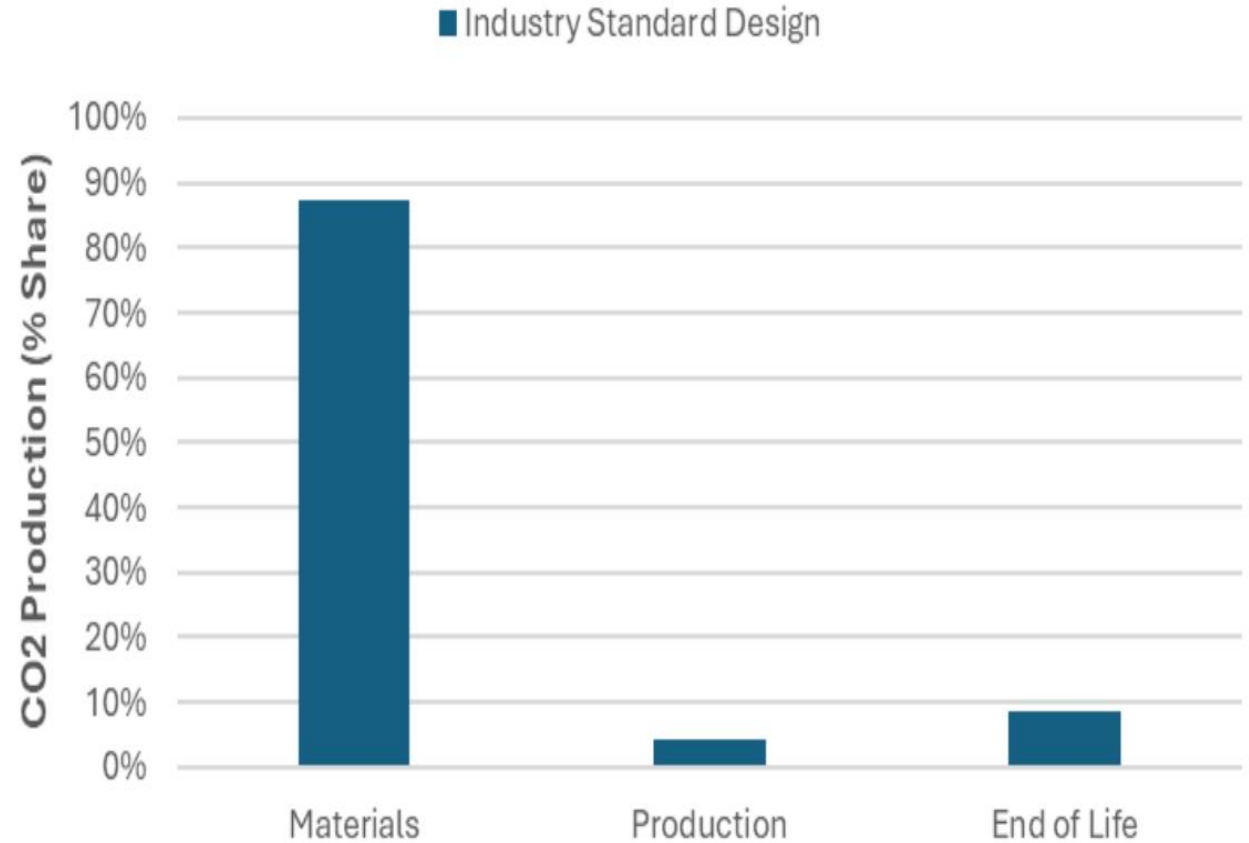
Percentage share
of the cost across
the baseline



Ecological Impact

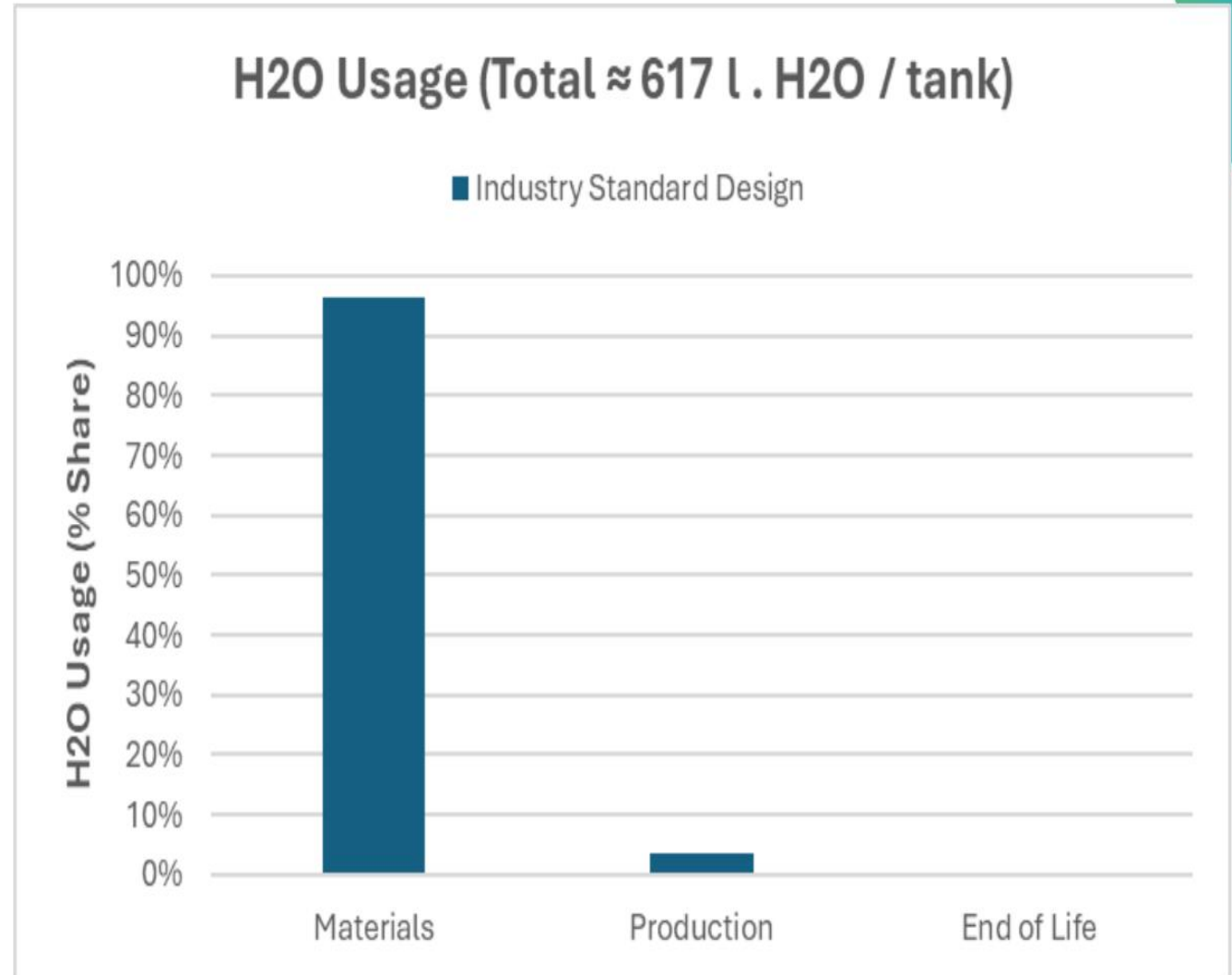
-
CO2 production share across the baseline

CO2 Production (Total ≈ 26 kg.CO2 / housing)



Ecological Impact

-
H2O usage share
across the
baseline



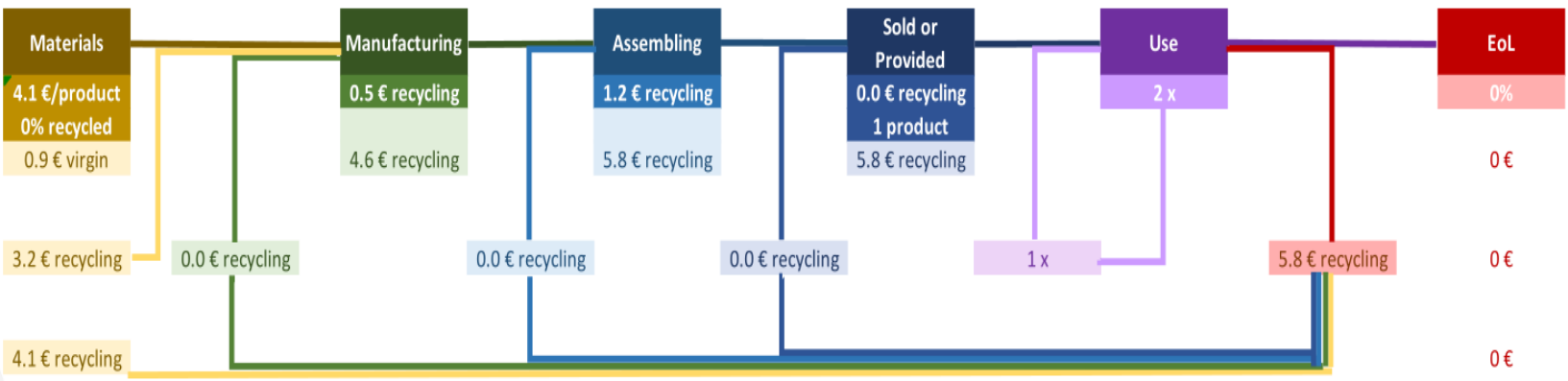
Battery Pilot - Forming Circular Strategies CYPRESS

The battery housing pilot production line considers the following R-strategies:

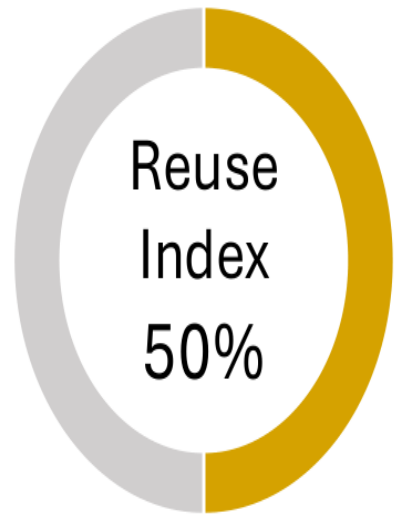
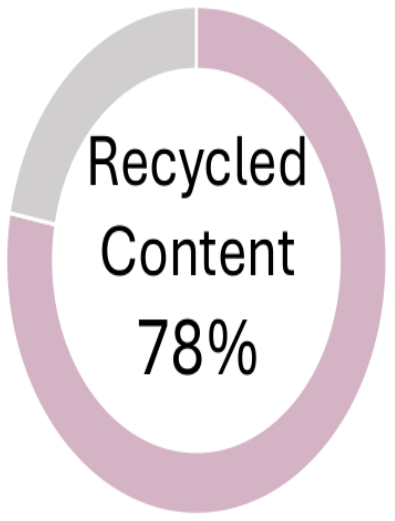
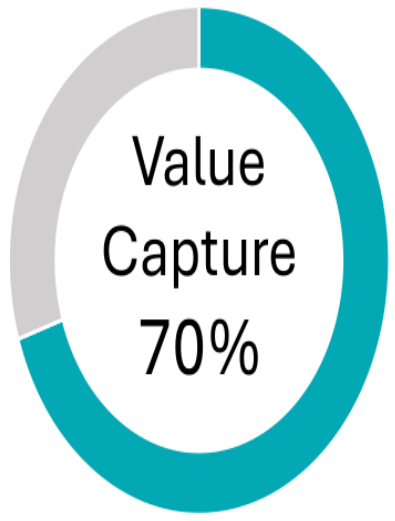
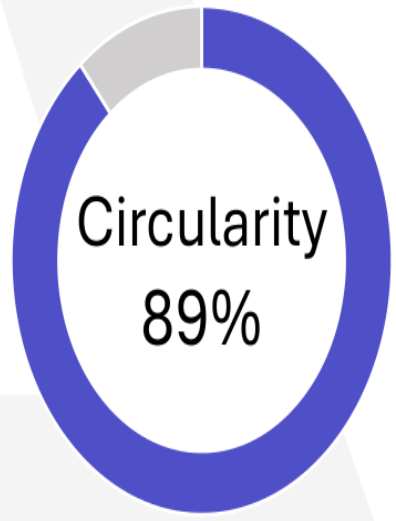
- Replace virgin material by recycled materials to reduce the carbon footprint of the product (**Refuse & substitute strategy**).
- **Reduce**: Optimization of the design process to use a minimal material amount.
- **Rethink** the manufacturing process to utilise common tooling.
- **Redesign** the housing to enable efficient repair or reuse.

The Circularity Score

CYPRESS



100% Open Loop Recycling	0% Closed Loop Recycling	0% Re manufacturing	0% Refurbishment	100% Selectively collected
--------------------------------	--------------------------------	---------------------------	---------------------	----------------------------------



Ecological Impact

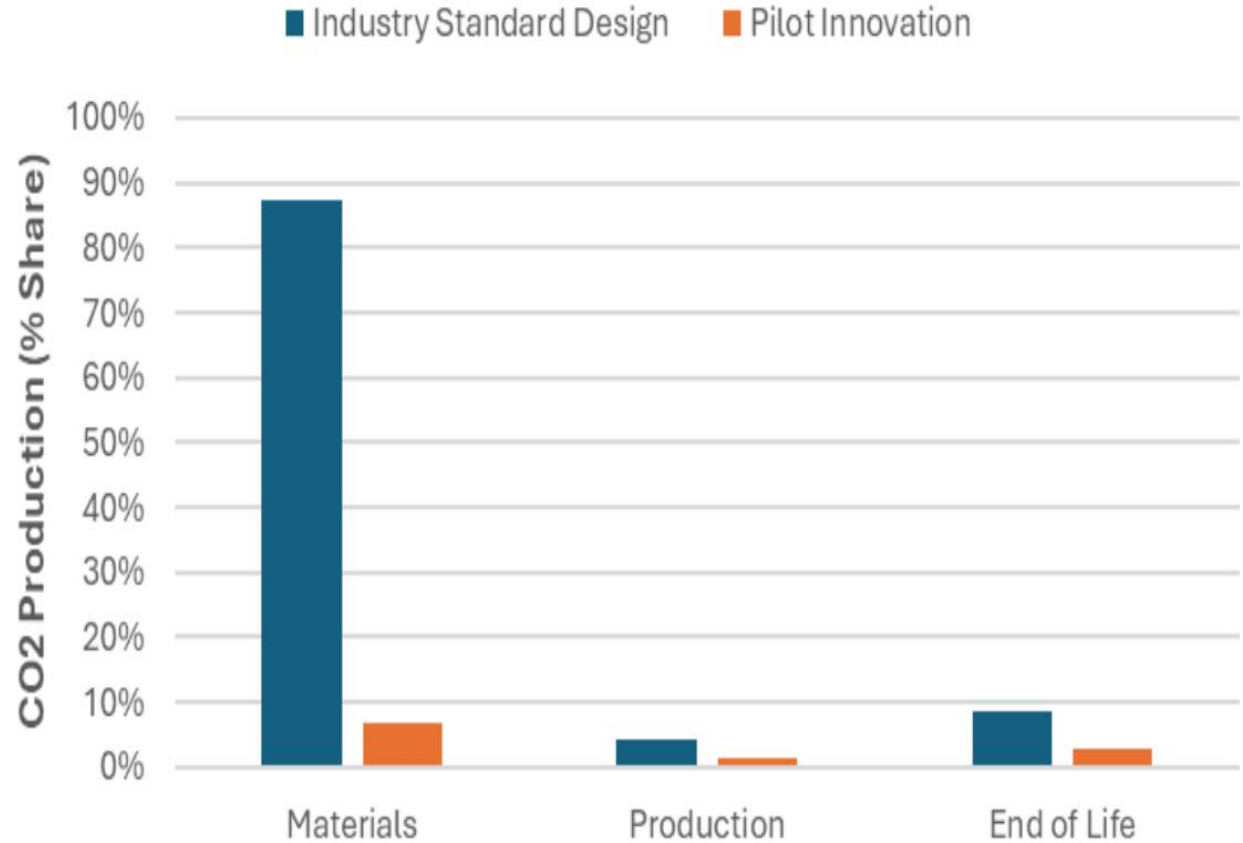
-

CO2 production share across both scenarios

-

≈ 88.5% saving of CO2

CO2 Production (Pilot ≈ 3 kg.CO2 / housing)



Strategies being explored

- Increase value capture by working on EoL strategies
 - Refurbishment (complete housing)
 - Remanufacturing (certain components)
 - Recycle (certain materials)
- Increase recycled content share by investigating CL materials