Eco-design WorkShop
Ideas from Brainstorming Implementation

General Assembly

16/02/2023

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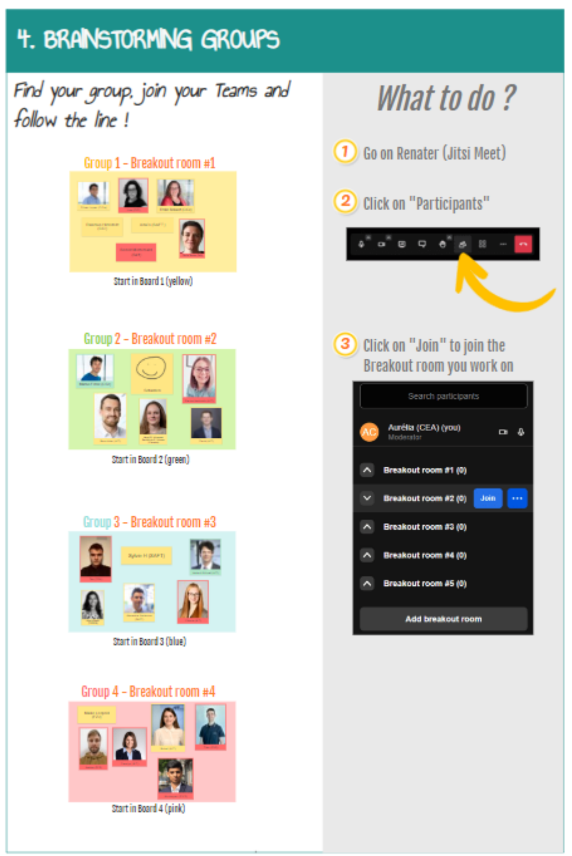
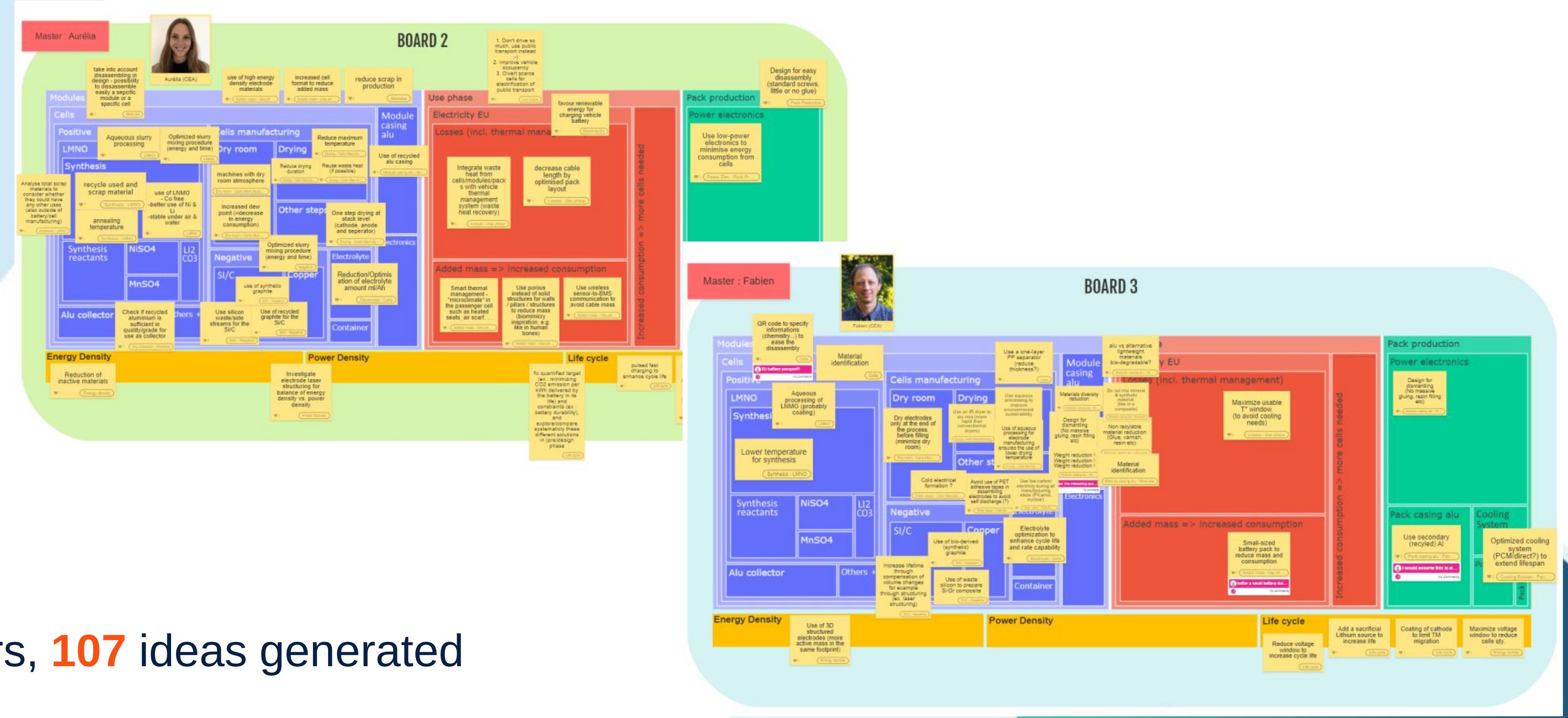
About the Brainstorming

- Context: Achievement of an eco-design approach from the beginning of the project (T0+3 months)
- Brainstorming on positive impactful ideas starting from a representative treemap organized in subgroups and two rounds.





→ **25** participants, **5** facilitators, **107** ideas generated

About the implementation

- Context: Implementation of the impactful ideas from the brainstorming with the WP Leaders.
- Decision-making about the ideas : To be followed, to be tested, already planned, to be evaluated, not feasible.

→ **4** participants (WP Leaders), **1** facilitators, **41** reviews

Impactful ideas : Recycling

Design for easier dismantling (pack-module)

Design for dismantling (no massive gluing, resin filling etc.) ❤❤❤❤❤❤❤
Design for easy disassembly (standard screws, little or no glue) ❤❤❤❤❤❤
Take into account disassembling in design - possibility to disassemble easily a specific module or a specific cell ❤❤❤❤❤
Fasteners instead of glue for easier recycle ❤❤
External BMS ❤
Non recyclable material reduction (glue, varnish, resin etc.)

Already planned – WP5 | Already planned – WP1 in D1.3 | To be evaluated – WP4

Recycle or reuse our scraps and used materials

Recycle used and scrap material (LMNO) ❤❤❤❤❤❤❤
Investigate quality of recovered materials from cell recycling to determine if it can be reused for new cells ❤❤❤❤❤❤
Try to recycle the different materials used in a battery pack (active materials, copper/aluminum) ❤❤❤❤
Analyze total scrap materials to consider whether they could have any other uses (also outside of battery/cell manufacturing) (LMNO) ❤❤❤
Reduce scrap in production ❤❤

Already planned – WP6

Fix targets

Fix quantified target (ex : minimizing CO_2 emission per kWh delivered by the battery in its life) and constraints (ex : battery durability), and explore/compare systematically these different solutions in (pre)design phase

Material diversity reduction (pack-module)

Materials diversity reduction ❤❤
Do not mix mineral & synthetic materials (like in a composite)

Already planned – WP5 | To be evaluated – WP4

Impactful ideas : Sustainable sourcing

Use recycled aluminum

- Check if recycled aluminum is sufficient in quality/grade for use as collector ❤❤❤❤❤
- Use of recycled alu casing (pack) ❤❤❤❤❤
- Use secondary (recycled) Al (pack) ❤❤
- Use recycled material (pack) ❤❤
- Use of recycled alu casing (module) ❤

Already planned – WP5

To be evaluated – WP4

Material identification

- QR code to specify information (chemistry...) to ease the disassembly ❤❤❤❤
- Adhesion to battery passport regulation (information about composition, chemistry, etc) ❤❤
- Material identification (Cells)
- Material identification (Modules)

Already planned – WP5

To be evaluated – WP4

Use recycled silicon / graphite

- Use of recycled graphite for the Si/C ❤❤❤❤❤
- Use silicon waste/side streams for the Si/C ❤❤❤❤
- Use of waste silicon to prepare Si/Gr composite

To be followed – WP2

Use recycled copper

- Use Cu current collectors recycled from waste Cu ❤❤❤

Already planned – WP5

Impactful ideas : Materials

High energy density active materials

- Increase active materials capacity ♥♥♥♥♥♥♥
- Use of LNMO (Co free, better use of Ni & Li, stable under air & water) ♥♥♥♥
- Use of high energy density electrode materials ♥♥
- Use boosting additives for increase the capacity (LMNO synthesis)

Already planned – WP2

To be tested – WP3

Alternative to natural graphite

- Use of bio-derived (synthetic) graphite ♥♥♥♥
- Use of synthetic graphite ♥♥♥

Already planned – WP2

Alternative to aluminum for casing

- Alu vs alternative lightweight materials (bio-degradable?) ♥♥
- Stainless steel case + metallic cover for High Voltage ♥
- Use polymeric materials for casing

To be evaluated – WP4

To be evaluated – WP5

Active material coating to improve cycle life

- Stabilize electrodes/electrolyte interface with additives/coatings ♥♥♥
- Coating of cathode to limit TM migration ♥

To be tested – WP2

Already planned – WP3

Electrolyte optimization

- Electrolyte optimization to enhance cycle life and rate capability ♥♥
- Consider aqueous electrolytes? stable to 5.0 V

Already planned – WP2

Sacrificial lithium source

- Add a sacrificial Lithium source to increase life ♥

Already planned – WP2

To be tested – WP3

One-layer PP separator

- Use a one-layer PP separator (reduce thickness?) ♥

To be evaluated – WP4

Impactful ideas : Energy saving

Aqueous processing

- Aqueous slurry processing ❤❤❤❤❤❤❤❤❤
- Aqueous processing of the electrodes ❤❤❤❤
- Aqueous processing of LMNO ❤
- Use of aqueous processing for electrode manufacturing ensures the use of lower drying temperature ❤
- Use aqueous processing to improve environmental sustainability

Already planned – WP3

Optimize drying

- Reuse waste heat (if possible) ❤❤❤❤
- Reduce maximum temperature ❤❤
- Reduce the drying rate (drying temperature) to reduce the amount of energy needed for this step ❤❤
- Reduce drying duration ❤❤
- Use an IR dryer to dry inks (more rapid than conventional dryers)
- Effect of drying conditions in the surface properties

To be tested – WP3

Decrease synthesis temperature (LMNO)

- Annealing temperature ❤❤
- Decrease synthesis T and heat treatment duration
- Lower temperature for synthesis

Slurry mixing optimization

- Optimize slurry mixing procedure (energy and time) (Negative) ❤❤❤
- Optimize slurry mixing procedure (energy and time) (Positive) ❤❤

Already planned – WP3

Low carbon electricity

- Use low carbon electricity during all manufacturing steps (PV, wind, nuclear) ❤❤❤

Not feasible – WP4

Cold electrical formation

- Cold electrical formation

Minimize dry room

- Avoid use of dry room (besides electrolyte filling) by choosing binders and materials that are less sensitive to air/moisture ❤❤❤
- Increased dew point (=decrease in energy consumption) ❤
- One step drying at stack level (cathode, anode and separator) ❤
- Dry electrodes only at the end of the process, before filling (minimize dry room)
- Machines with dry room atmosphere

To be evaluated – WP4

To be evaluated – WP3 ? Small scale

Impactful ideas : Mass reduction

Lightweight structures (module & pack)

Light-weight structures for pack casing with better thermal resistance ❤ ❤ ❤
Use porous instead of solid structures for walls / pillars / structures to reduce mass (biomimicry inspiration, e.g. like in human bones) ❤
Weight reduction ! ❤

Already planned – WP5

Small battery pack

Small-sized battery pack to reduce mass and consumption ❤ ❤

Swappable batteries

Swappable batteries to only take the amount of batteries you need to save weight and thus improve efficiency ❤ ❤

Avoid cable mass

Decrease cable length by optimized pack layout ❤
Use wireless sensor-to-BMS communication to avoid cable mass ❤

Already planned – WP5

Large cell format

Increased cell format to reduce added mass ❤

To be evaluated – WP5

Not feasible – WP4

Impactful ideas : Design optimization

Higher loading (e.g. laser structuration)

Enhance the lifetime of the Si-C anode by laser structuring (compensation of the volume expansion) ❤ ❤ ❤ ❤
Investigate electrode laser structuring for balance of energy density vs. power density ❤ ❤
Use of 3D structured electrodes (more active mass in the same footprint) ❤ ❤
Increase lifetime through compensation of volume changes for example through structuring (ex. laser structuring)
Increase loading to minimize Cu use ❤
Increase electrodes loading

Already planned – WP3

To be tested – WP3

Low power electronics

Use low-power electronics to minimize energy consumption from cells ❤ ❤ ❤

Increase energy density by cell design

Reduction/Optimization of electrolyte amount ml/Ah ❤ ❤ ❤ ❤
Reduction of inactive materials ❤ ❤ ❤ ❤ ❤ ❤ ❤
Decrease void volume in cell
Increase energy level
Decrease volume of inactive components (foil/separator, ..)
Decrease electrodes porosity

Already planned – WP3

To be evaluated – WP4

Avoid PET adhesives

Avoid use of PET adhesive tapes in assembling electrodes to avoid self discharge (?) ❤

Optimize pressure

Effect of the used pressure in the cell performance

To be tested – WP3

To be evaluated – WP4

Impactful ideas : Thermal and electrical management

Trade-off : cycle life <-> energy (voltage window)

Reducing DoD to improve cycle life ❤ ❤ ❤
Maximize voltage window to reduce cells qty. ❤
Reduce voltage window to increase cycle life
< DoD vs. > battery and vehicle (aircraft) weight or < payload(economic question)

Already planned – WP1 in D1.3

Trade-off : passive <-> active thermal management

Passive cooling methods ❤ ❤ ❤ ❤
Optimized cooling system (PCM/direct?) to extend lifespan ❤ ❤
Maximize usable T° window. (to avoid cooling needs) ❤ ❤
Adding insulation to the packs/modules to reduce the need of heating/cooling in extreme temperatures

To be evaluated – WP5

Pulse charging

Pulsed fast charging to enhance cycle life ❤

Optimize BMS

BMS properly "trained" for our battery chemistry ❤ ❤ ❤

Impactful ideas : Usage (out of scope)

Reduce demand

Improve vehicle occupancy ❤ ❤ ❤ ❤
Decrease in vehicle weight -> decrease vehicle power -> decrease C-rate on cell level -> increased cycle life ❤ ❤
High utilization of aircraft/car to maximize usage of spent materials

Modal shift

Don't drive so much, use public transport instead ;-) ❤ ❤ ❤ ❤
Divert scarce cells for electrification of public transport ❤ ❤ ❤ ❤

Reuse

Reuse the cells after EOL. For example, a 100kWh car at 80 SoH still has more capacity than a small 45 kWh car at BOL ❤ ❤ ❤ ❤
2nd life of "spent" batteries (mainly pack) ❤

Waste heat recovery

Integrate waste heat from cells/modules/packs with vehicle thermal management system (waste heat recovery) ❤ ❤ ❤ ❤
Smart thermal management - "microclimate" in the passenger cell such as heated seats, air scarf, ... ❤ ❤

Low carbon electricity

Favor renewable energy for charging vehicle battery ❤ ❤