BATTERY CELL TESTING FOR THE SIMULATIVE OPTIMISATION OF AN EV BATTERY SYSTEM

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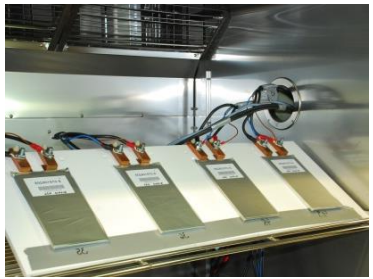
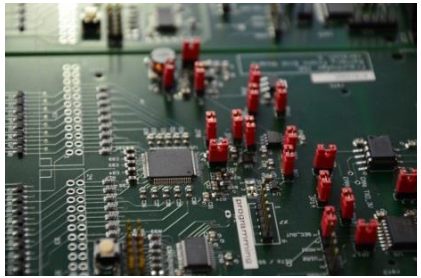
AGENDA

- Cell testing
  - Electric model
  - Thermal model
  - Aging model
- EV simulation
  - Results of the JOSPEL project



Cell testing
Motivation

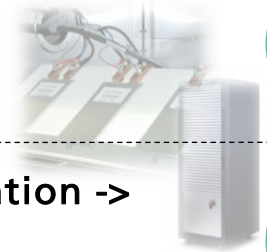
- New cell versions, short development cycles
- Need for efficient and effective cell characterization
  - Reliable
  - Automated
- Simulation of the effect of cell variation on the application and investigation of operation parameter

Cell testing
Overview

Equivalent circuit

(Temp., C-rate, SOC, SOH)

Verified by EIS, impulse tests and load profile test with battery tester



electr. model

therm. model

Temperature computation

(Temp., C-rate, SOC, R_i, dU/dT)

Joule + entropic Heat

Heat capacity

Verified by calorimeter

Fit – parameter equation ->

C-loss +R_i-increase

(Temp., C-rate, time, DOD, SOC)

Verified by cycle, calendric and load profile tests

aging model

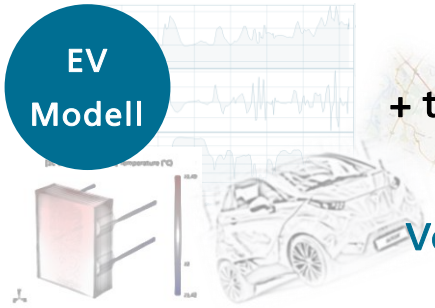
EV Modell

Load profile

+ therm. vehicle model

(Temp.$_{ambient}$, design)

Verified by test drives and CFD simulation



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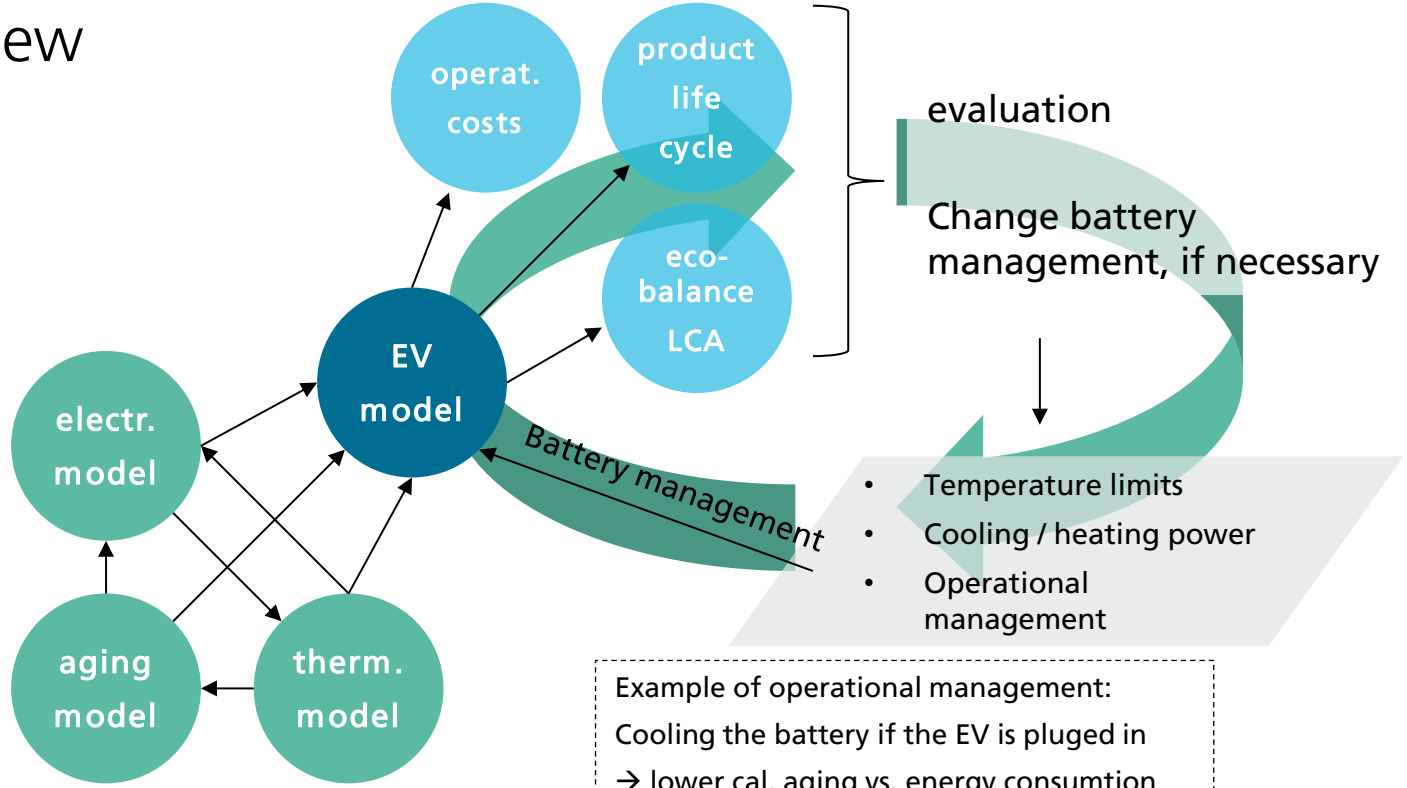
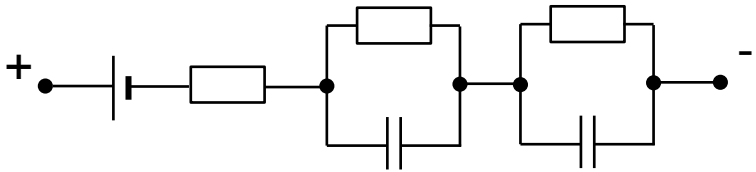
Cell testing
Overview

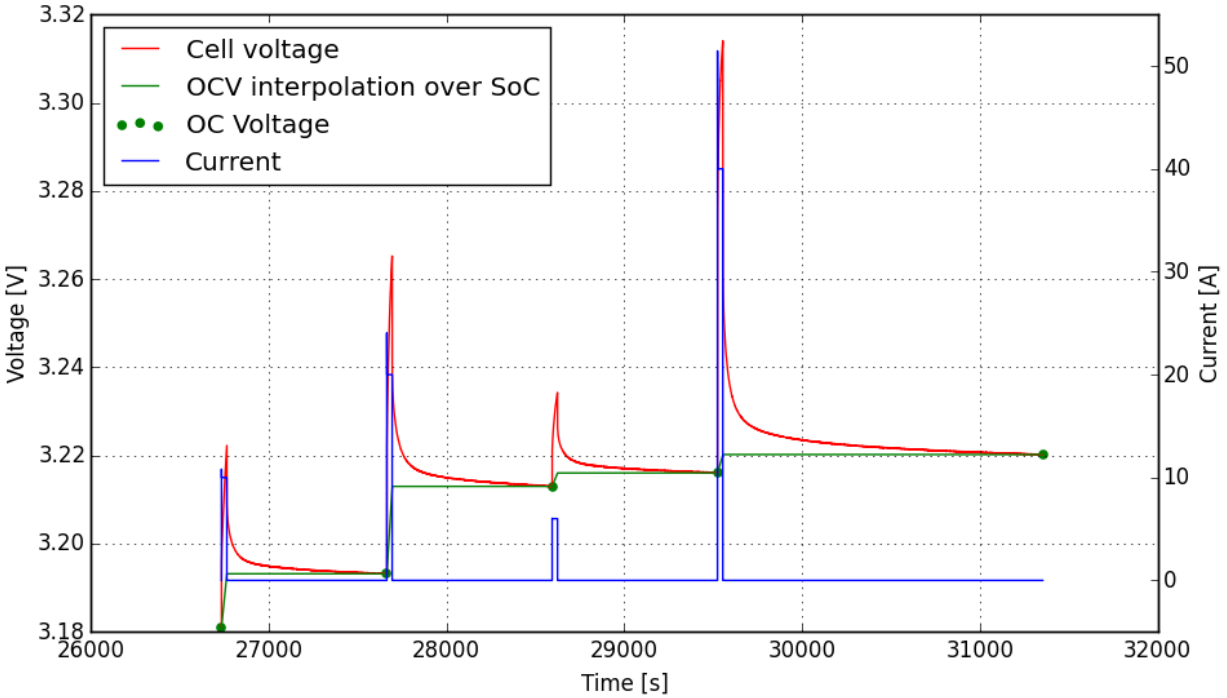


Cell testing
Electric model

- Electrochemical model
  - Plenty of material parameter are necessary
- Equivalent circuit model
  - Empirical values for circuit elements (OCV voltage, resistors, capcacitors).
  - Calculated form Pulse or EIS (Electrochemical Impedance Spectroscopy) tests

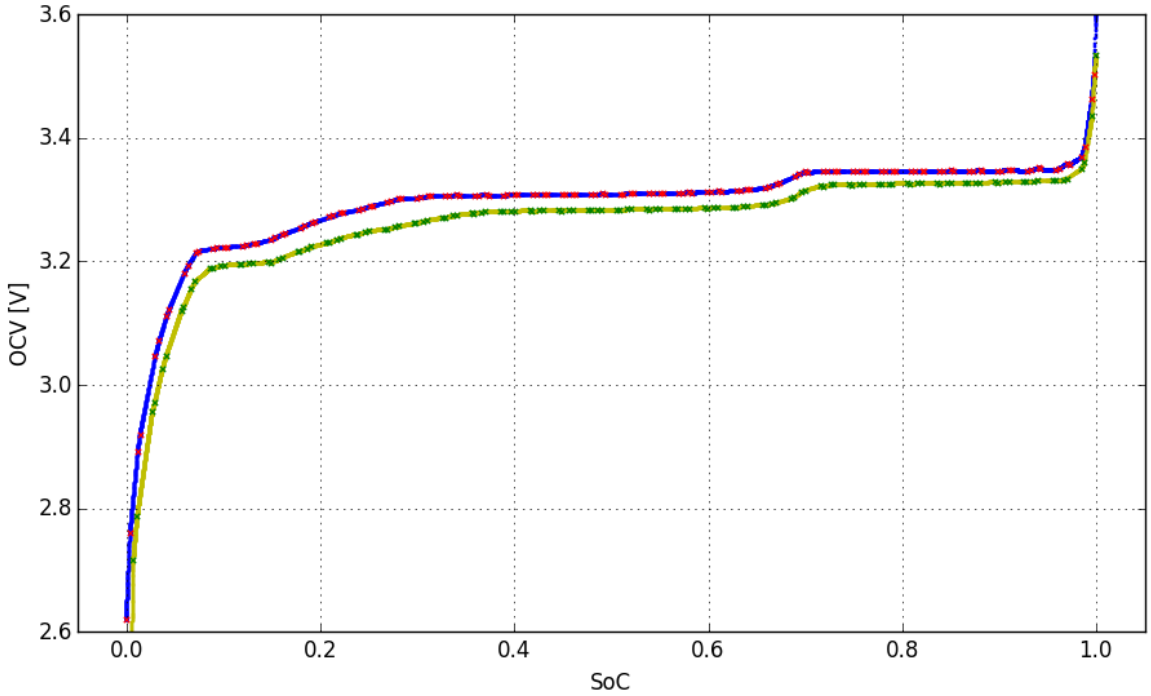


Cell testing
Electric model



Cell testing
Electric model

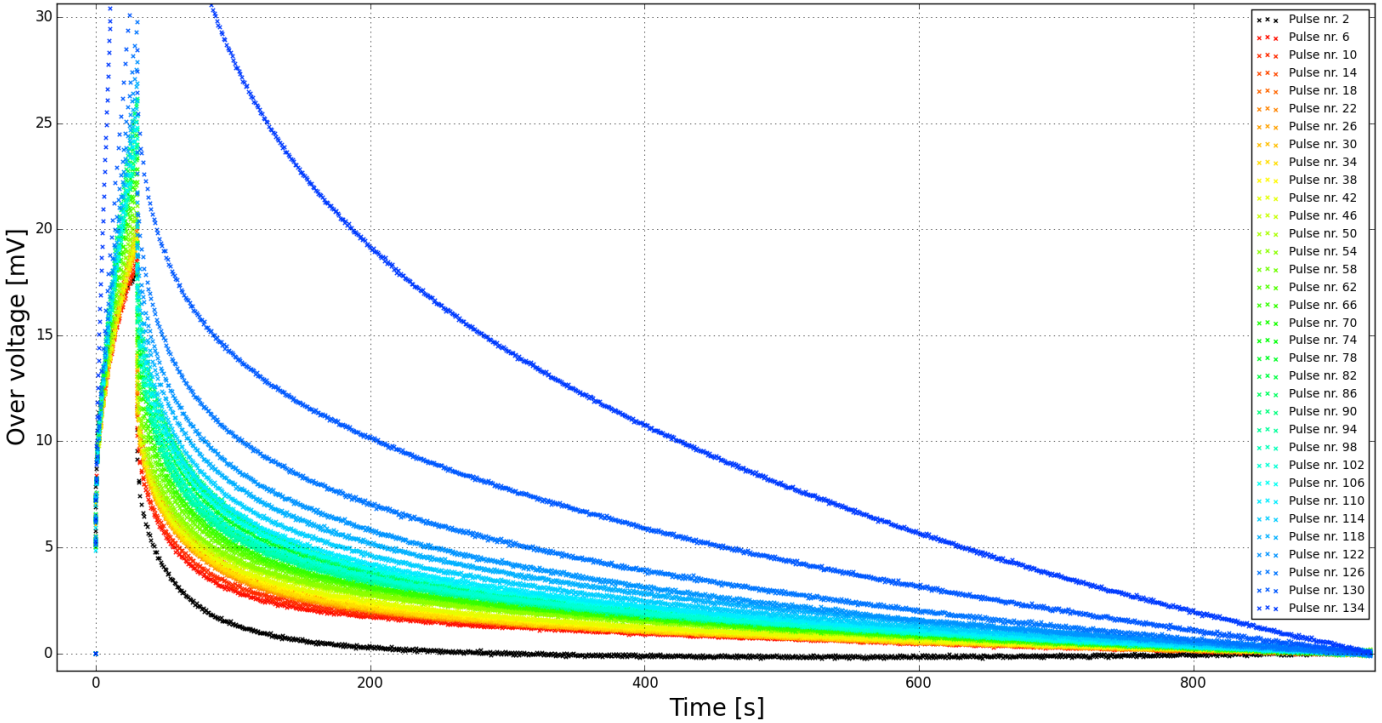
- Open Circuit Voltage (OCV)



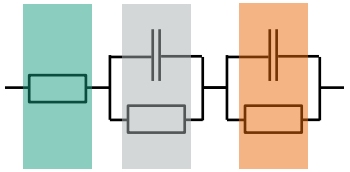
Cell testing

Electric model

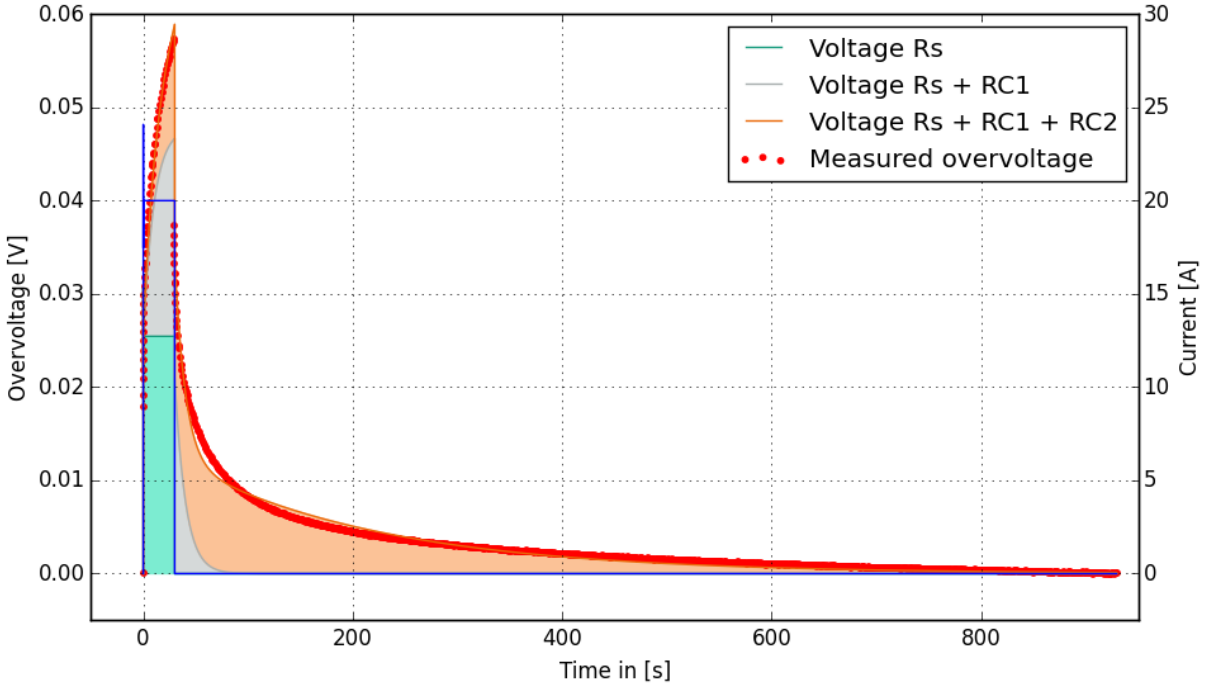
- Over-voltage
- 0.3C
- 30 sec.



Cell testing
Electric model



- Fit of model parameter
  - 1C
  - 30 sec.
  - 2 RC elements



Cell testing
Thermal model

- Equation (Bernardi et al.) :

Entropic Coefficient

$$q_{gen} = I \cdot \Delta U + I \cdot T \cdot dU/dT \quad [W]$$

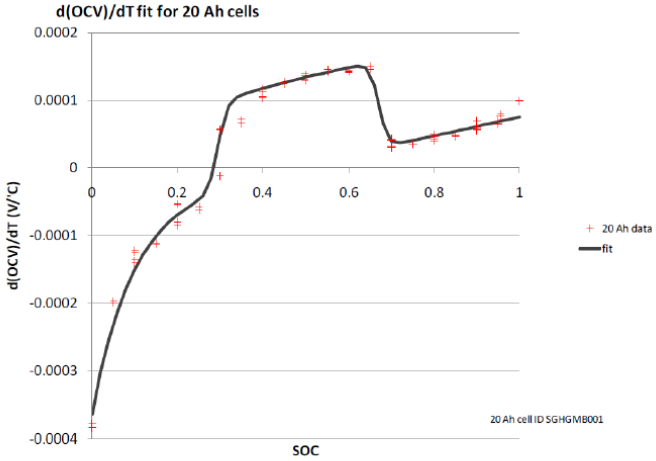
$$q_{gen} = I^2 \cdot R_{total} + I \cdot T \cdot dU/dT \quad [W]$$

irreversible heat (Joule heat)

reversible heat (Entropic heat)

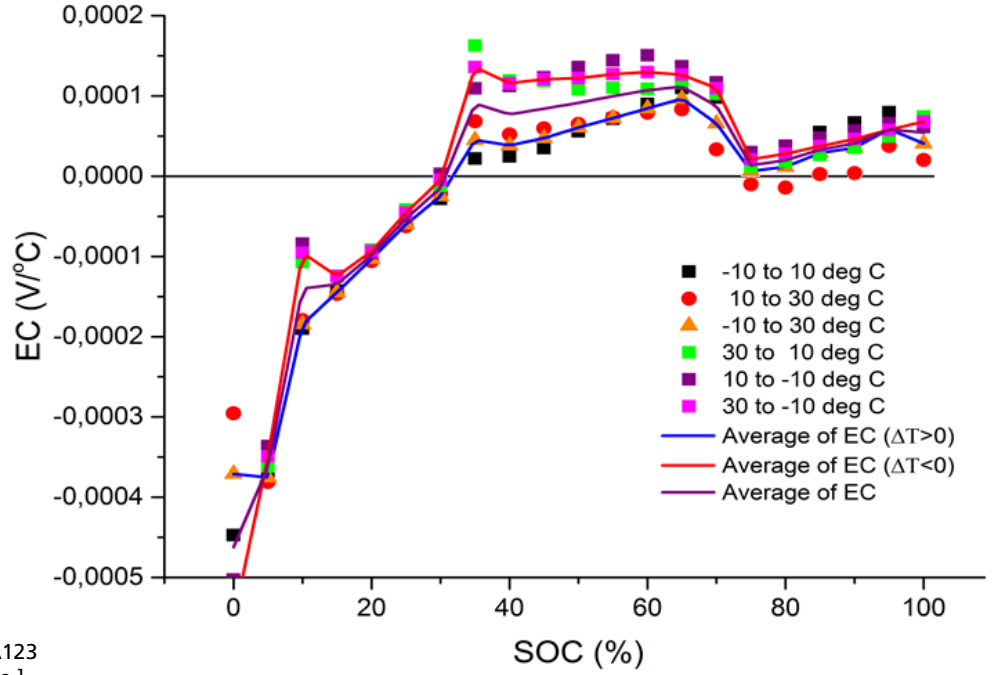
Cell testing
Thermal model

- Entropic Coefficient



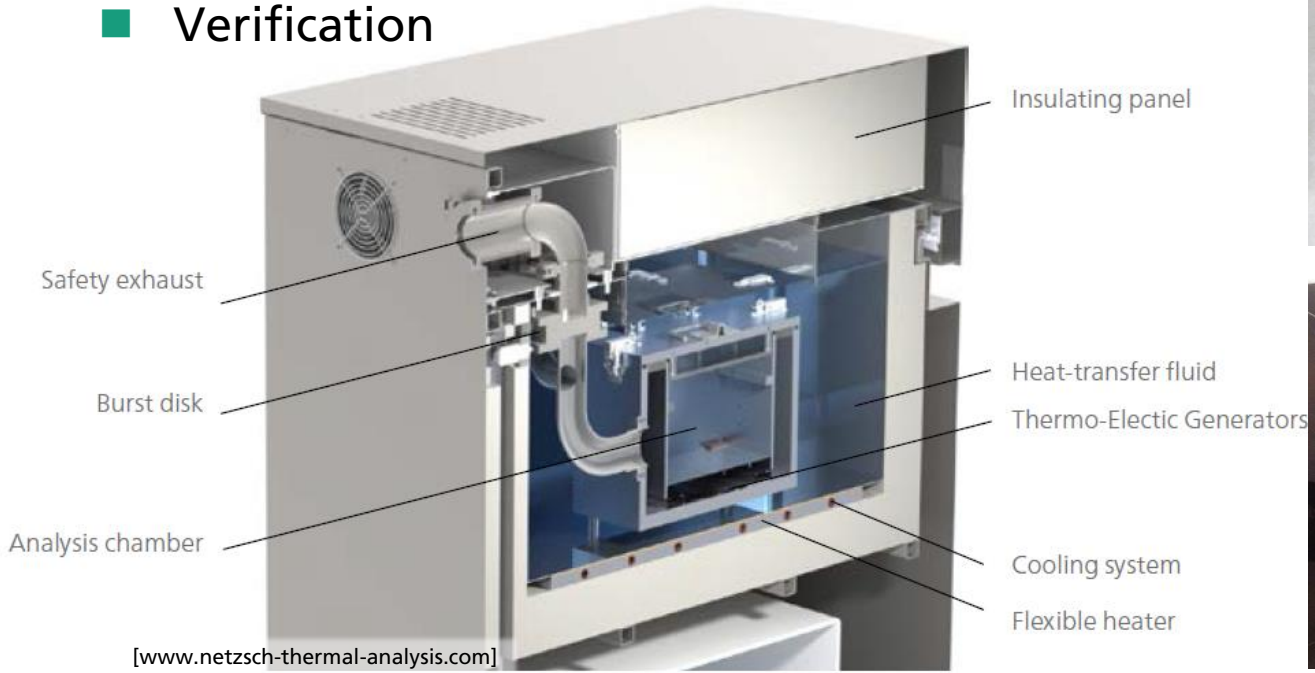
Entropic coefficient from A123 Systems data sheet.

[Battery Pack Design, Validation, and Assembly Guide using A123 Systems AMP20M1HD-A Nanophosphate Cell – A123 Systems - Online]

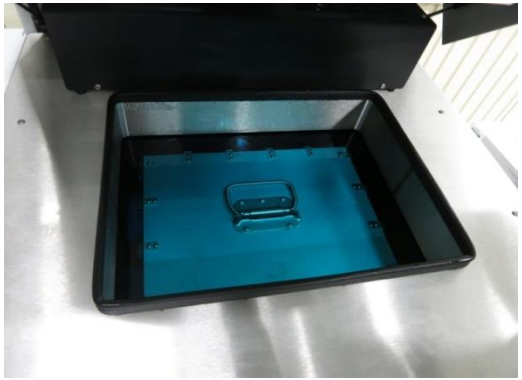


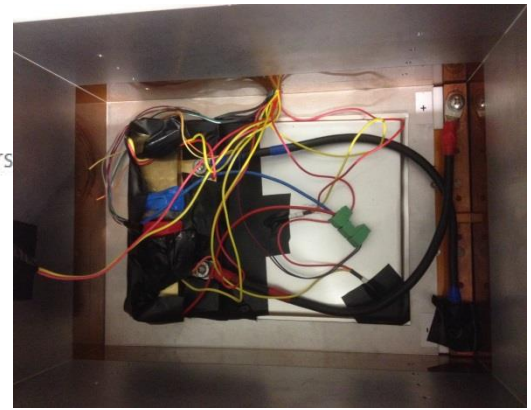
Cell testing
Thermal model

- Verification



[www.netzsch-thermal-analysis.com]





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Thermal model

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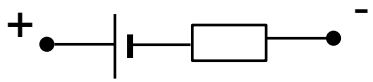
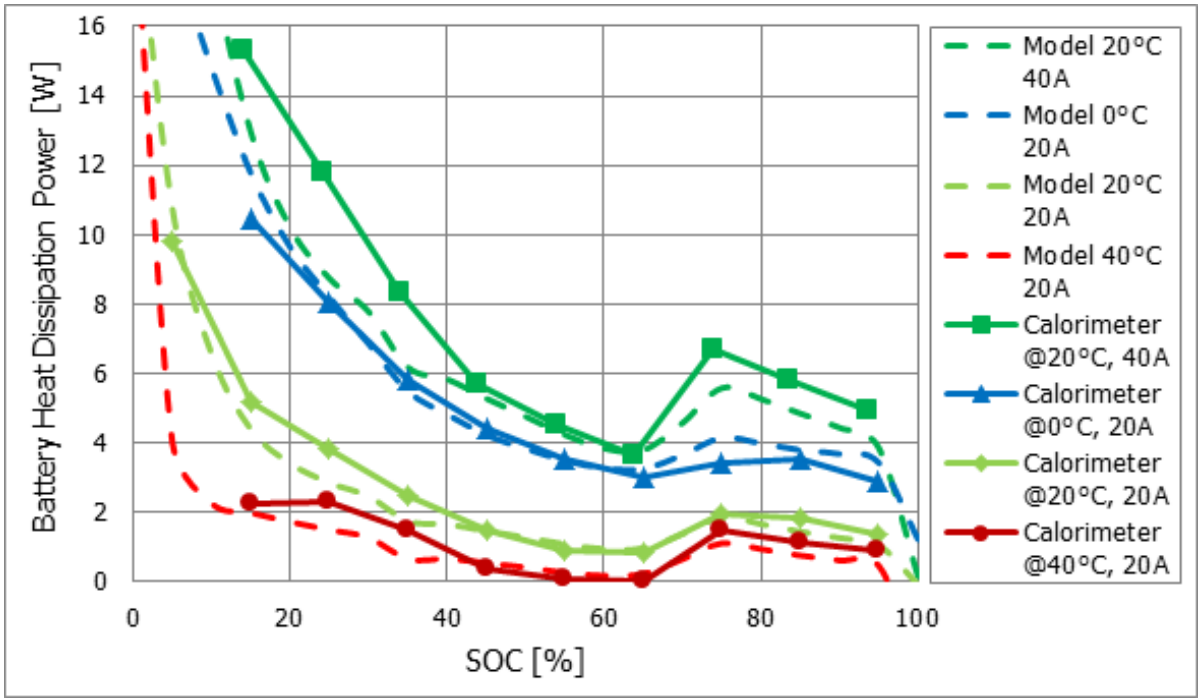
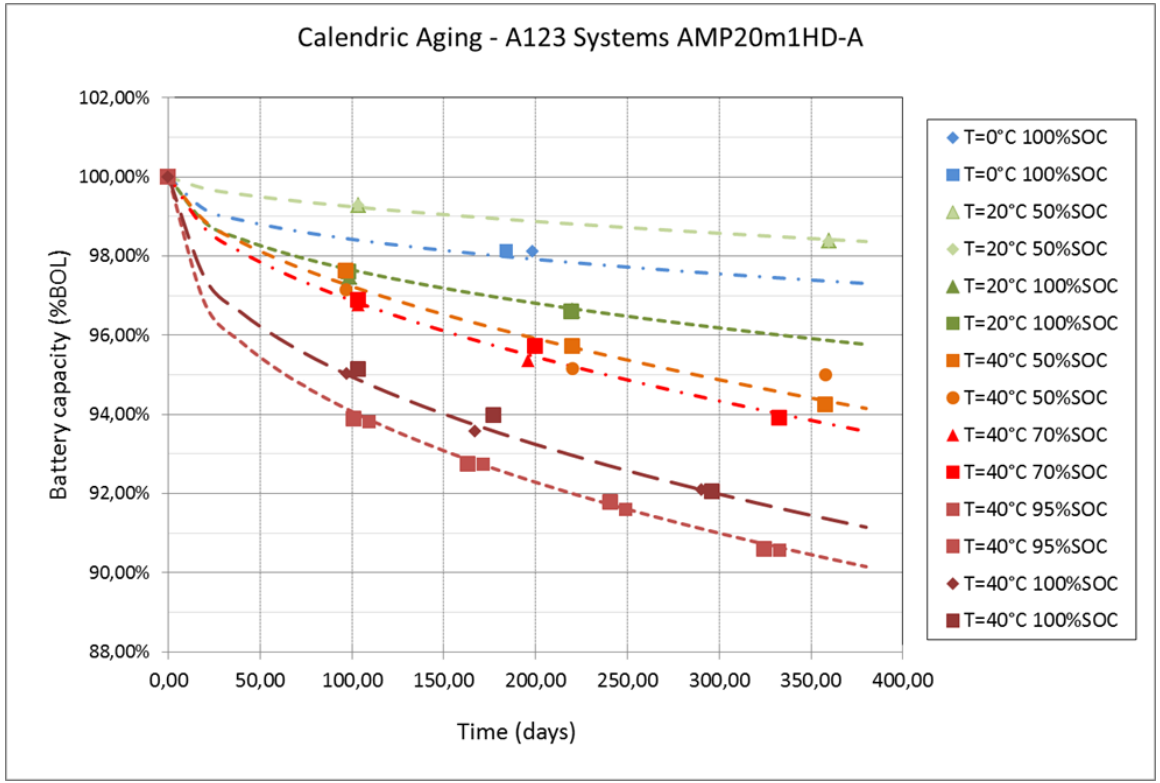




Cell testing
Aging model

- Phenomenological model

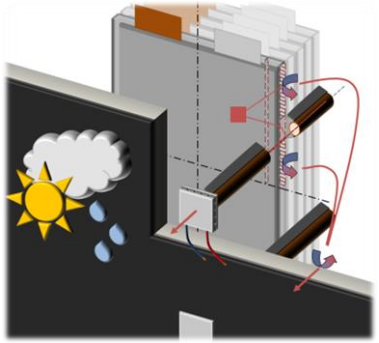


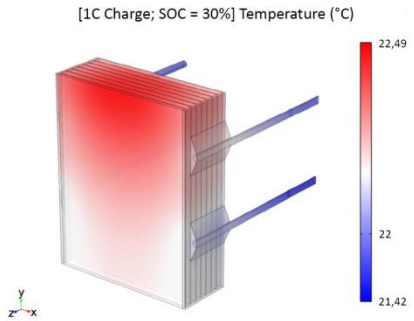
EV simulation

Results of the project

The JOSPEL project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement n° 653851.

- Load profile
- Thermal equivalent circuit
- Environmental conditions (weather)
- Operating points and strategies





EV simulation

Results of the project

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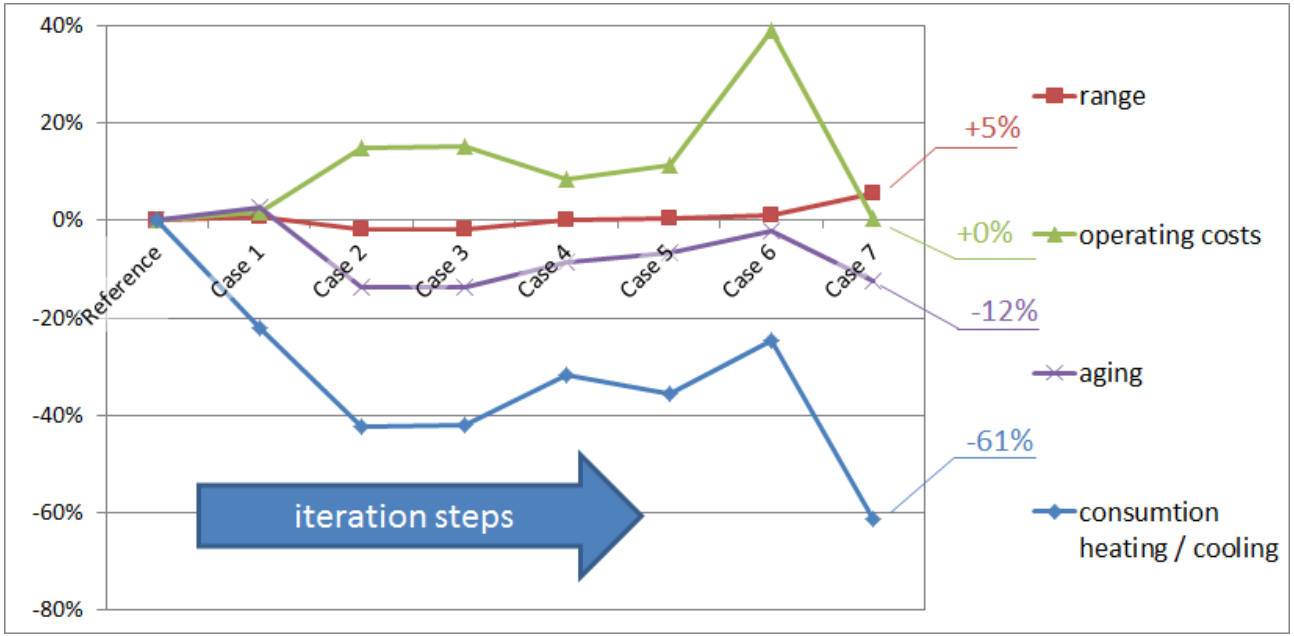
- Final Result: all target values optimized



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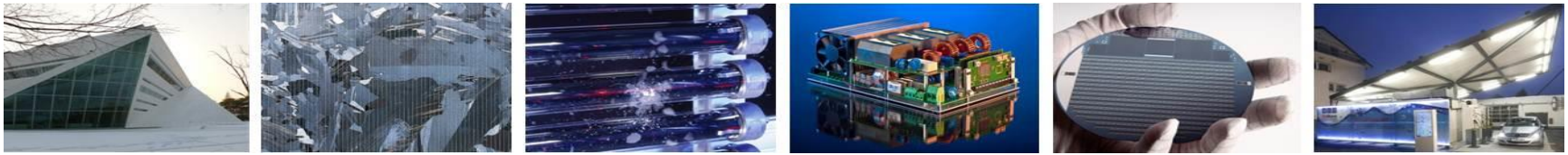
Thank you for your attention!



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