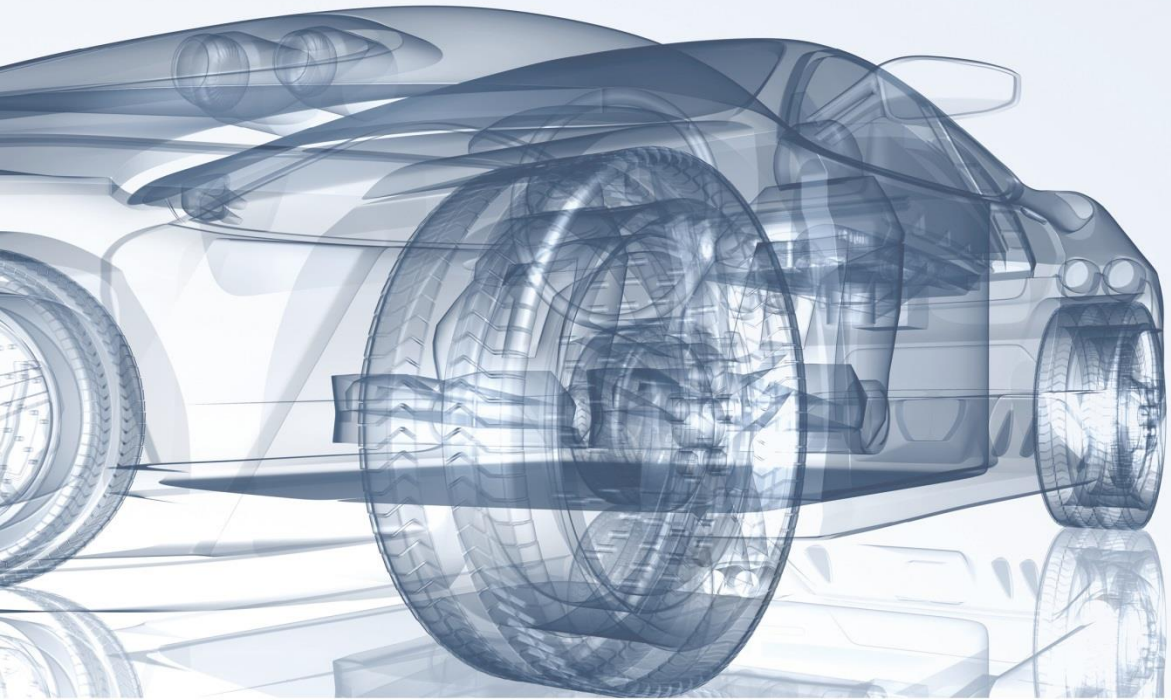
evs 30



The 30th International
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Messe Stuttgart, Germany

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Battery Ageing • Battery Models • Battery Diagnostics • Battery Pack Design • Electromobility • Stationary Energy Storage • Energy System Analysis

Dimensioning and Optimization of (Hybrid) Li-Ionen Batteries

22.09.2017

Jan Becker

Chair for Electrochemical Energy Conversion
and Storage Systems

iSEA Power Electronics and Electrical Drives | RWTH AACHEN UNIVERSITY

Motivation

- Battery is essential component of electric drive train
  - Currently made of **one type** of Li-ion cells (connected in series / parallel)
- Many different cell products on the market, characterized by…
  - housing / format
  - costs
  - safety concept
  - predicted life time
  - energy- and power density

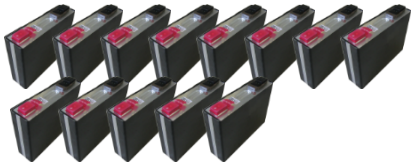
Source: bmwusa.com

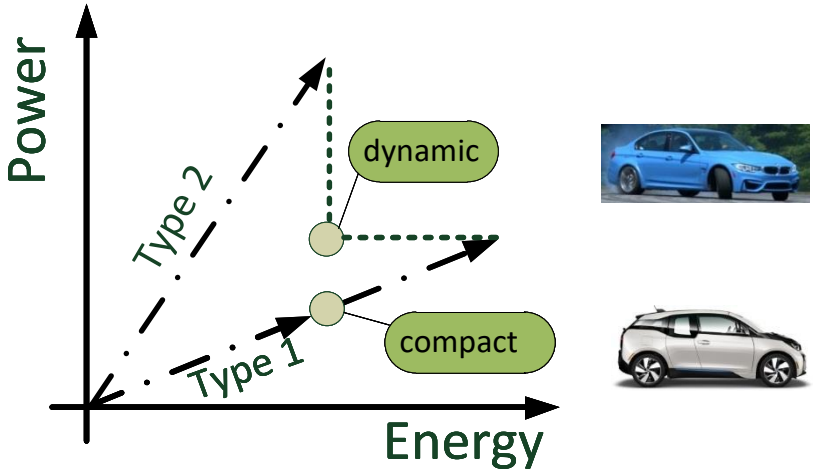
Motivation Hybrid Battery Storage: Requirement optimized Dimensioning

More compact?
Cost efficient?
Less cell types?

Cell type 1

Cell type 2

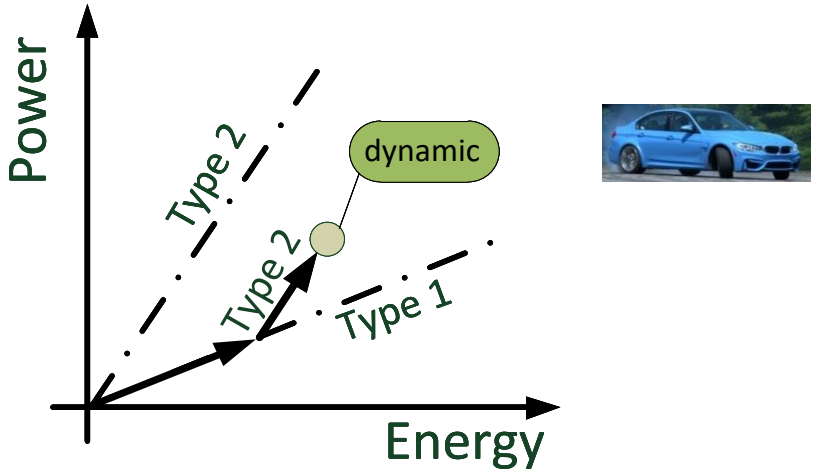




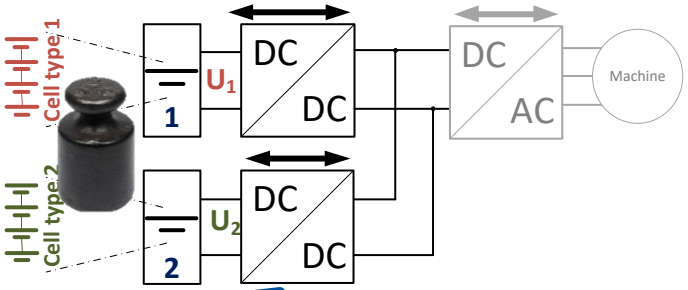
Hybrid battery storage

Cell type 1

Cell type 2

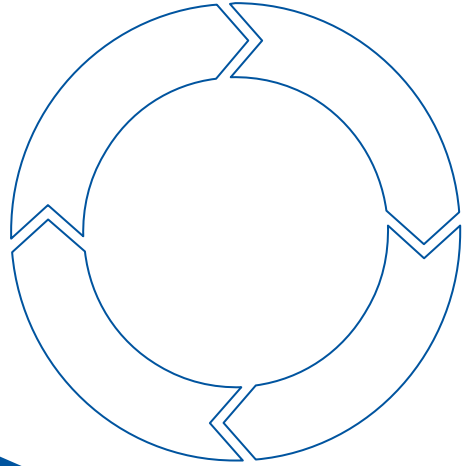


Hybrid Energy Storage - Dimensioning



Influence of „Performance“

Evalutation in vehicle (model)



Dimensioning of storage

E_1 E_2 E_3 E_4 E_5

Modify dimensioning

Optimization: time consuming

Optimization Tool Box - Overview

Matlab
Optimization

1) Parameter definition

2) Automated Evaluation
→ Penalty points

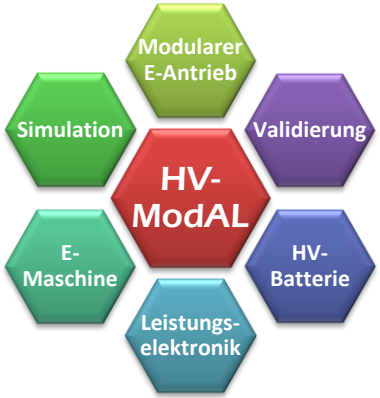
3) Automated Adaption of Parameters (Optimization)

Parameter-set 1

Hybrid-Battery-Optimization

Simulink
Vehicle Model

Research project



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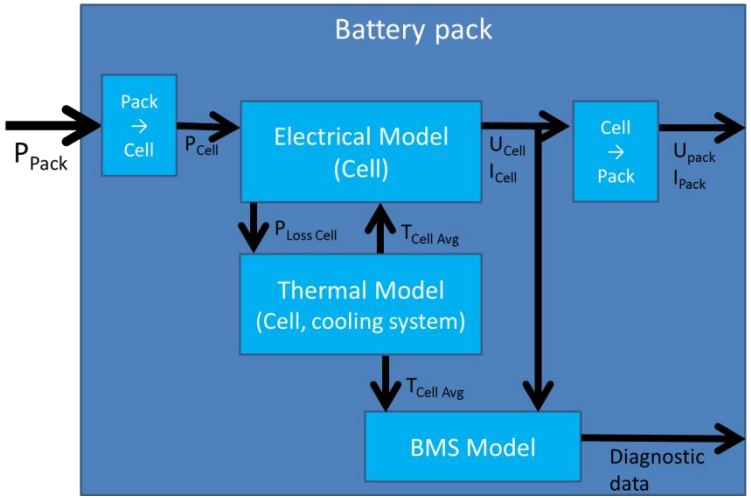
Battery model

- Matlab
  - Battery costs model
    - Based on literature
  - Aging model
    - Based on data and model by Ecker[1] & Schmalstieg[2]
    - Prediction of degradation through usage and standstill
    - Evaluation of vehicle performance after (simulated) 8 years / 160.000 km usage
- Simulink
  - Electrical R-RC-model
  - Thermal model for different cooling approaches
  - Battery Management
    - Interaction with power distribution

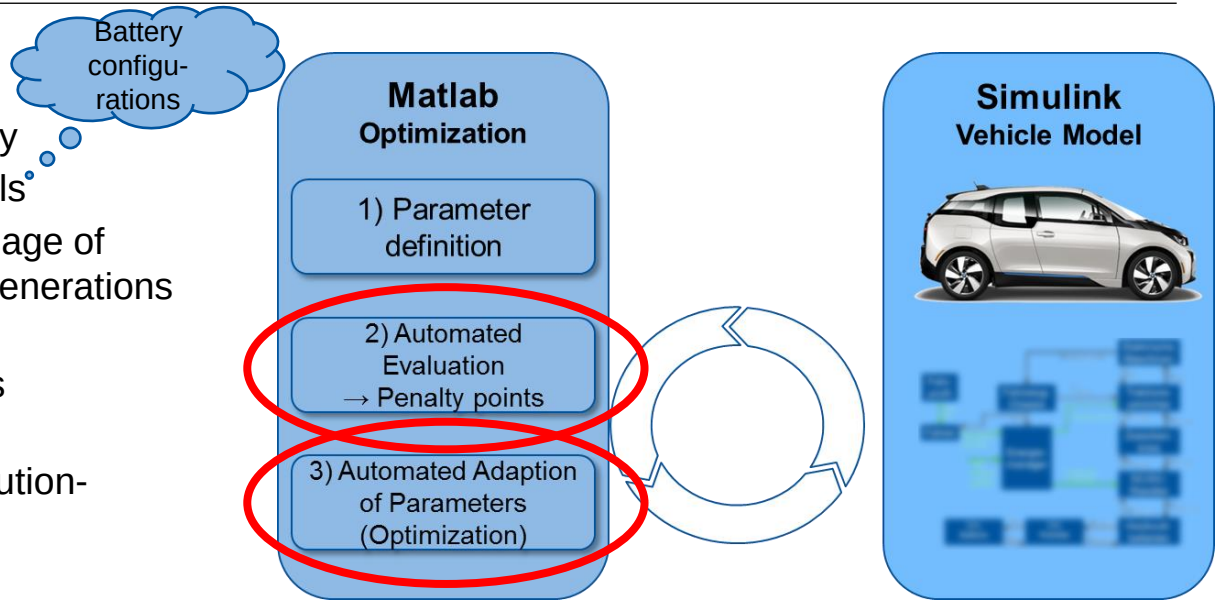


[1] Ecker et al. Calendar and cycle life study of Li(NiMnCo)O2-based 18650 lithium-ion batteries, *Journal of Power Sources* , **2014**

[2] Schmalstieg et al. A holistic aging model for Li(NiMnCo)O2 based 18650 lithium-ion batteries, *Journal of Power Sources* , **2014**

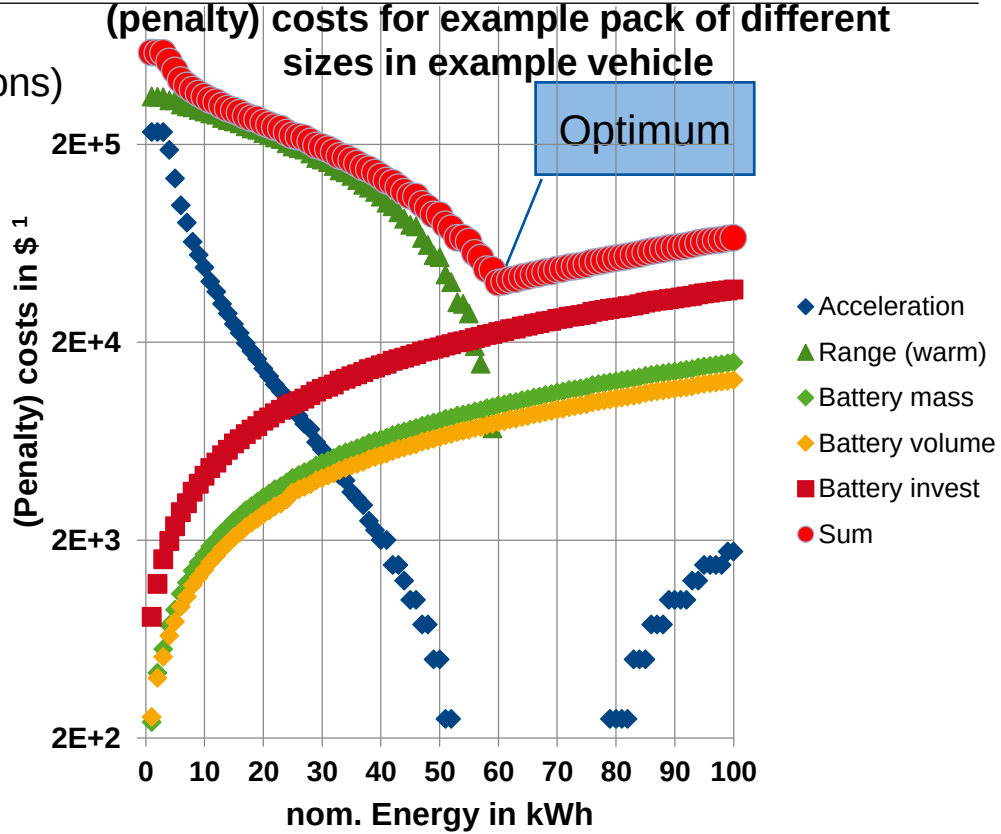
Battery Dimensioning & Optimization Framework

- Optimization
  - Evolutionary Optimization Strategy
    - generations consist of individuals
    - Evaluation of individuals and usage of genetic operators lead to new generations with better individuals
    - Convergence to better solutions
  - Here: CMAES (Hansen et al.) **C**ovariance-**M**atrix-**A**daption-**E**volution-**S**trategy
    - Compared to other strategies: less parameter tuning to gain good convergence



Evaluation criteria & cost function

- Evaluation of individuals (battery configurations) based on several criteria
  - Acceleration
  - Driving at v_{max}
  - Range
  - Battery mass
  - Battery volume
  - Invest costs
- Conversion of all results to comparable currency
  - actual and penalty costs



[1] price model based on publically available sources by ISEA

Analysed Vehicle- and Cell Portfolio

	Compact (150km)	Compact (300km)	Medium-sport	High class	SUV
Requirements (excerpt)					
a 0..100km/h	7.3 s	7.3 s	3.9 s	5.1 s	5.1 s
Range	150 km	300 km	350 km	400 km	500 km

- Chassis- and further parameters in model

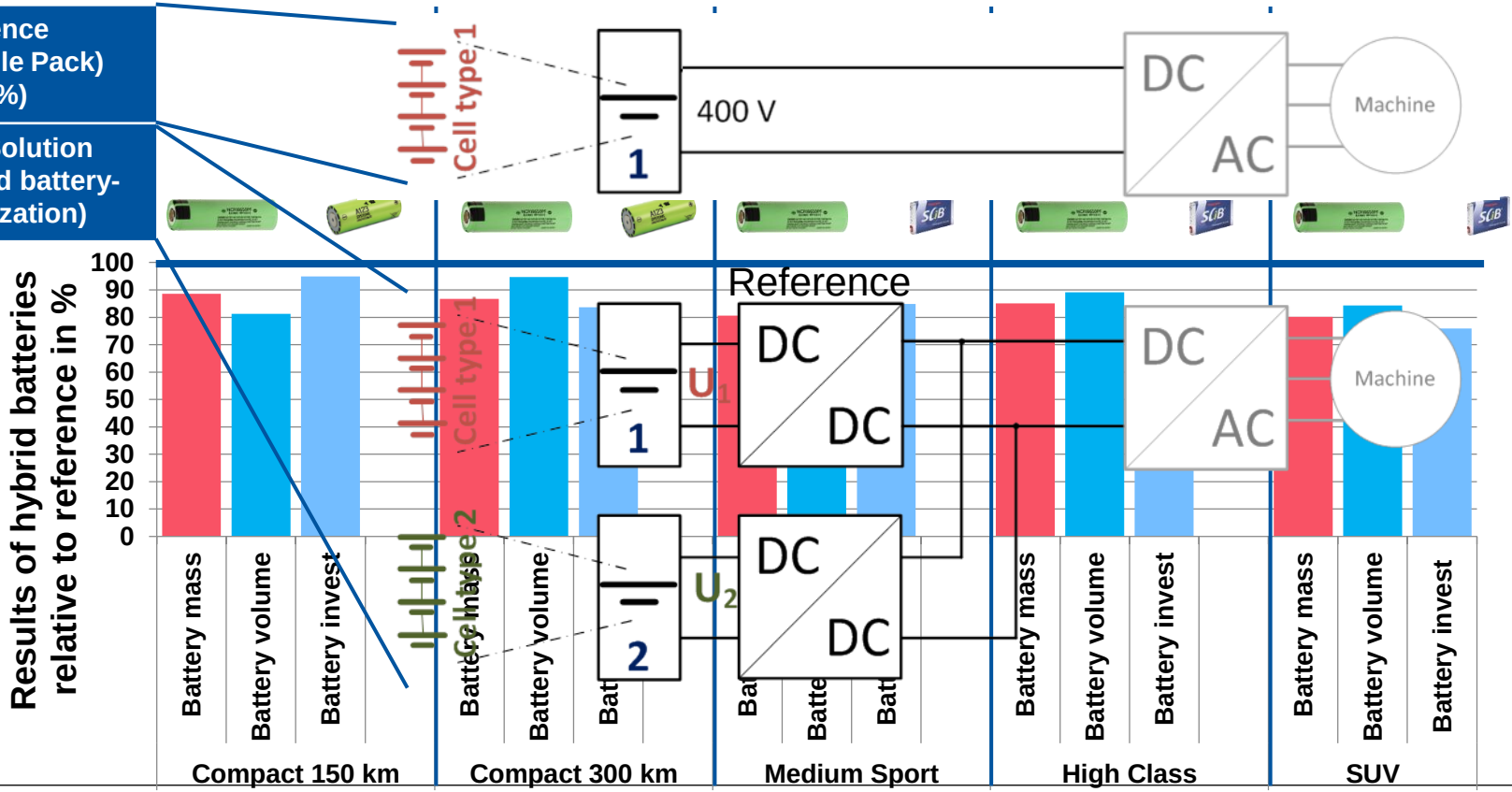
	SB LiMotive	Kokam HR2 46Ah	Panasonic NCR18650B	A123 26650 M1B	Toshiba SCiB 2,9Ah
					
Power vs. Energy	Power, Energy	Energy	Energy!!	Power	Power!!

Results

„how good are hybrid batteries?“

Reference (=Single Pack) (= 100%)

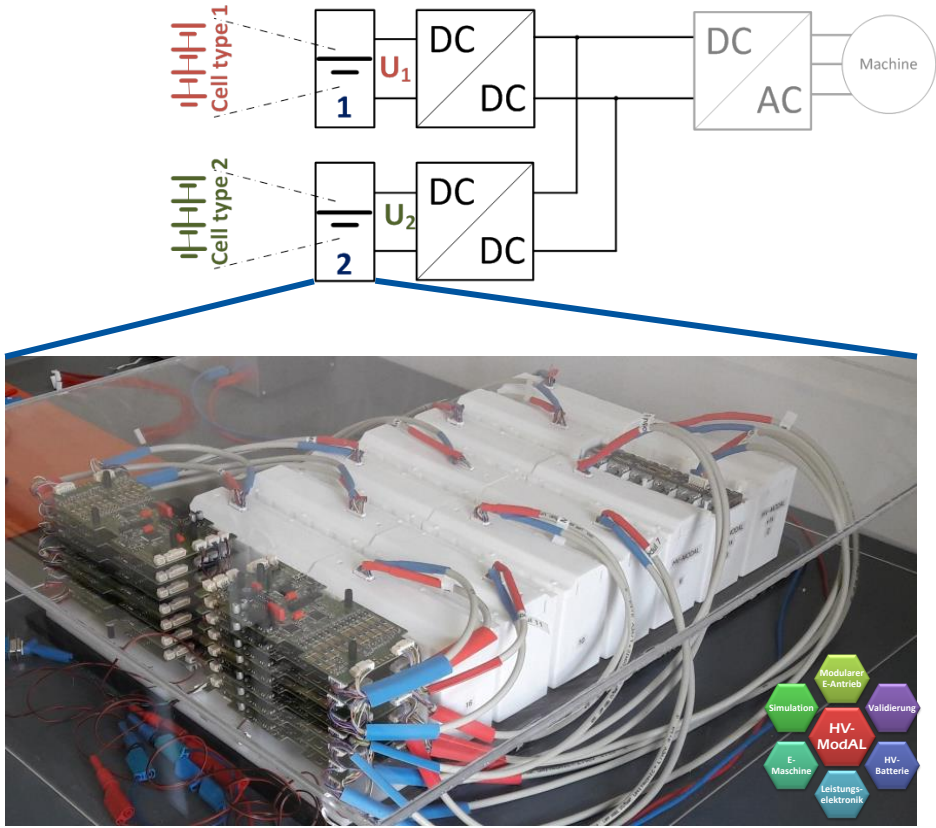
Best Solution (Hybrid battery-optimization)



All results including suitable dc/dc converters

Summary & Outlook

- Hybrid Battery Systems show potential for improvements on system level…
- …however require more complex management
- Building a hybrid battery demonstrator
  - High Energy Pack from com. EV
  - High Power Pack developed in project
    - LTO cell technology
    - Modular, scalable concept
  - DC/DC converter based on Si-C semiconductors



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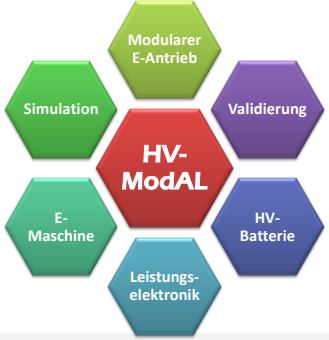
for your attention



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Contact

Jan Becker
Tel.: +49 241 80 49412
Jan.Becker@isea.rwth-aachen.de
batteries@isea.rwth-aachen.de

Chair for Electrochemical Energy Conversion
and Storage Systems
Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
RWTH Aachen University

Jaegerstrasse 17/19
52066 Aachen
GERMANY
www.isea.rwth-aachen.de

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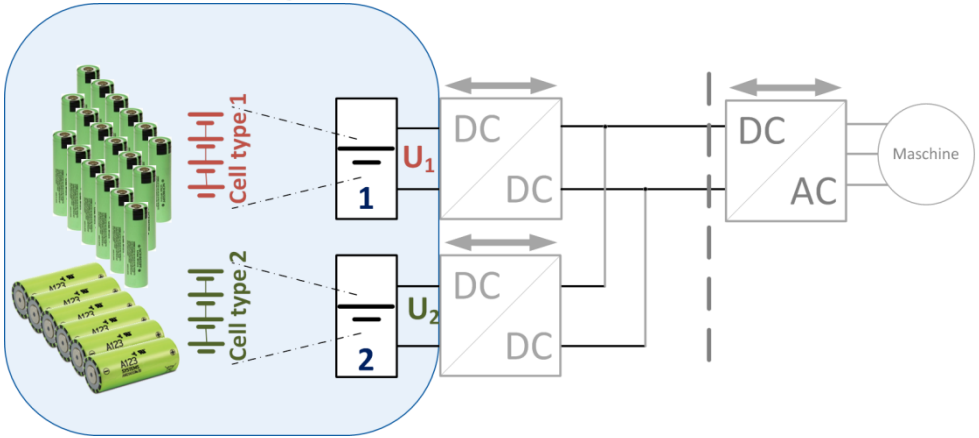

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