SimBAS - Simulation of Battery Cells and Applications in Storage Systems

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Motivation

- Different battery applications place different demands on the battery cells and system
- Which battery cell "fits" which application?
- There is a lack of open-source tools for battery cell design, optimized system design and time series simulation of mobile storage applications
- Approach: Development of an open-source storage simulation toolchain covering the value chain from battery cell materials to various applications

Procedure

- Development of the battery cell design tool ICPD at ISEA and a cost model at PEM
- Development of the system space optimization tool BaSD at Fraunhofer IISB for optimized system space design in various applications
- Further development of the holistic storage simulation tool SimSES at TUM EES for mobile applications including Vehicle-to-X provision and characterization of mobile and stationary applications
- Development of a toolchain from the individual tools to determine the suitability of various battery cells in different applications

Results

Toolchain-Run

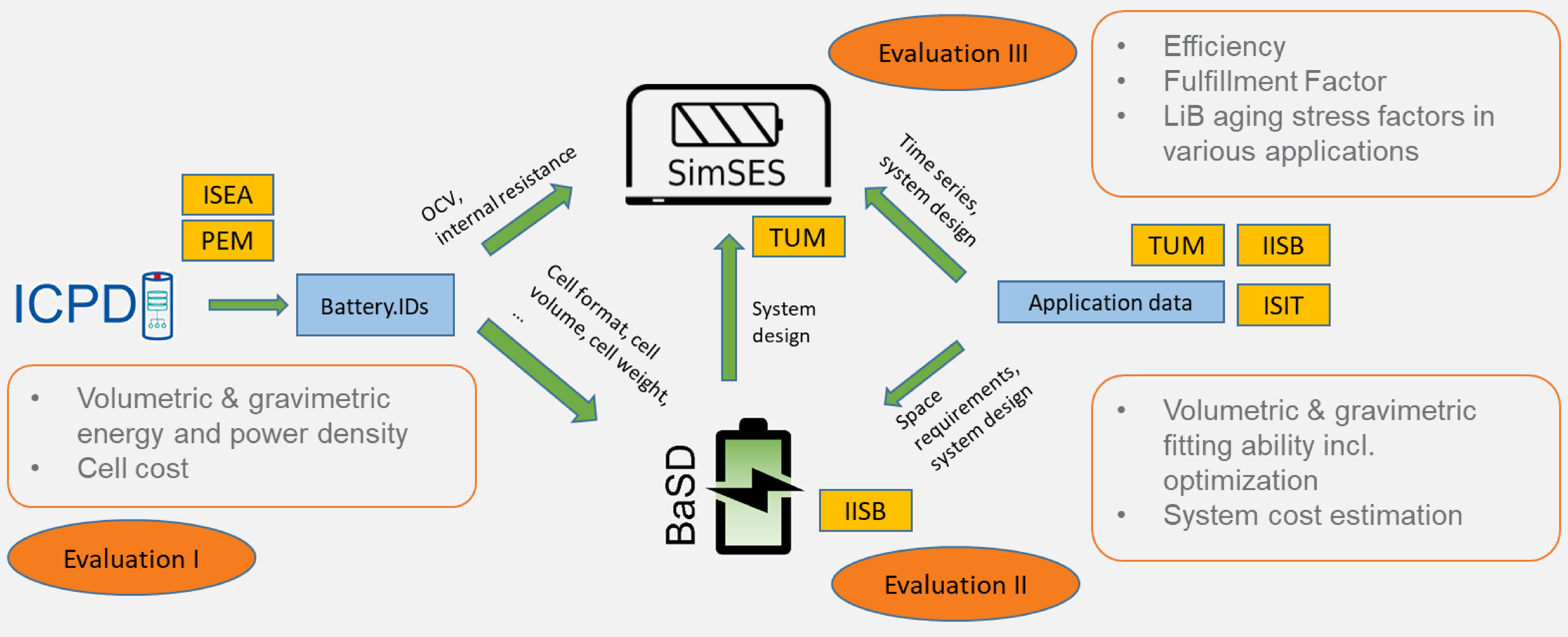

Figure 1: Toolchain with tools, interfaces, partners and evaluation areas.

Simulation of V2X-provision using E-Cars, E-Busses and E-Boats

- Simulation of V2X provision with field data from 52 E-Buses & 6 E-Boats and 60 simulated E-Cars
- Determination of battery parameters with additional provision of V2X, e.g. equivalent full cycles (Figure 4), average SOCs, average C-rates
- Open access conference paper at the International Conference on Applied Energy 2023 (see below)

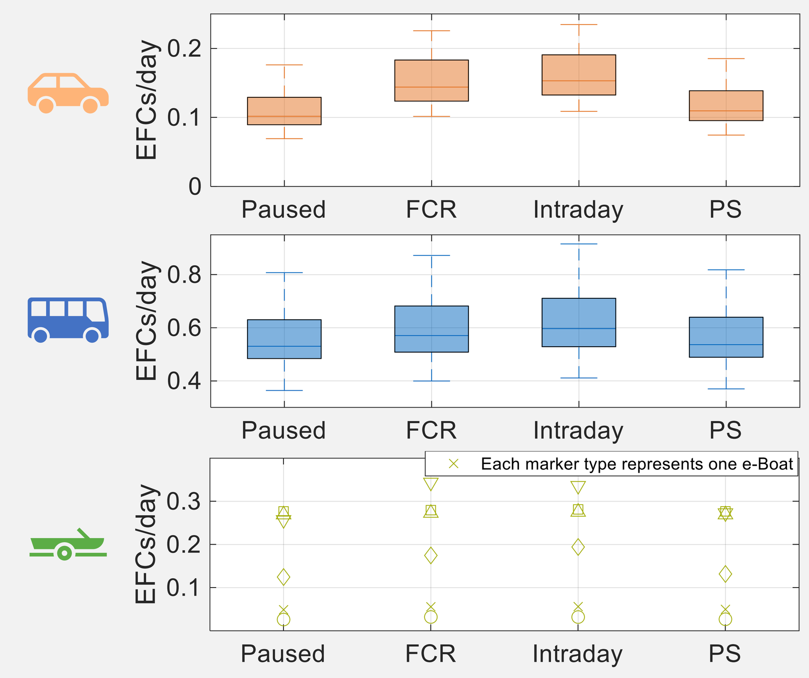

Figure 4: Daily number of equivalent full cycles (EFCs) with unidirectional charging and with additional V2X use of E-Cars (top), E-Buses (middle) and E-Boats (bottom). V2X use cases: frequency containment reserve (FCR), intraday arbitrage trading, peak shaving (PS).

ISEA Cell and Pack Database (ICPD)

- Calculation of cell parameters and cell costs from real and virtual material and design properties
- Parameter variation and combinatorics to determine optimal properties
- Example with 8 ref. cells in 11 housings with 2x6 parameter variations → 3246 cells

	Cell Name	Format	Cathode Material	Anode Material	Anode Porosity	Cathode Porosity	...	Parameter X
	Everlast_MJ1	Cylindric	NMC811	SiC	0.216	0.171		
	Kokam_11.6Ah	Pouch	NMC	C	0.32	0.3257		
	NUBase_50E	Cylindric	NCA	SiC	0.25	0.18		
	SimBAS_35E	Cylindric	NCA	SiC		0.142		
	Kokam_7.5Ah	Pouch	NCO	C	0.329	0.296		
	LTO_A-12-04-05	Pouch	NMC	LTO	0.45	0.35		
	SimBAS_FFH3H0	Prismatic	LFP	C	0.3	0.3		
	ANR26650M1B	Cylindric	LFP	C	0.25	0.25		
	...							
	Virtual Cell Y	Cylindric	NMC622	C	0.29	0.54		

U_{nom}, C_{nom}, R_i

Table 1: Morphological box to illustrate combinatorics and parameter variation with the ICPD.

Battery System Designer (BaSD)

- Software for designing, configuring and optimizing application-specific battery systems
- Possibility to map own design and system knowledge via configuration parameters
- Implementation of an open interface for integrating third-party battery models into BaSD

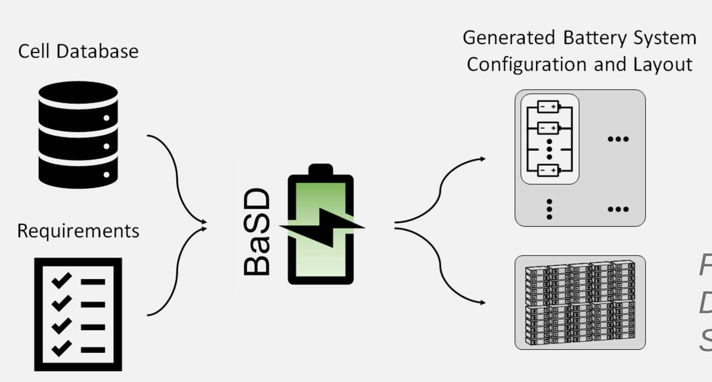

Figure 2: Battery System Designer (BaSD) Schematic.

Simulation of stationary battery storage system (SimSES)

Example: High Power Charger & BESS

- Time series simulation of the battery systems previously determined by BaSD
- Determination of KPIs depending on varied parameters
- Example with fulfillment factor and battery efficiency as a function of cell chemistry (Figure 3)

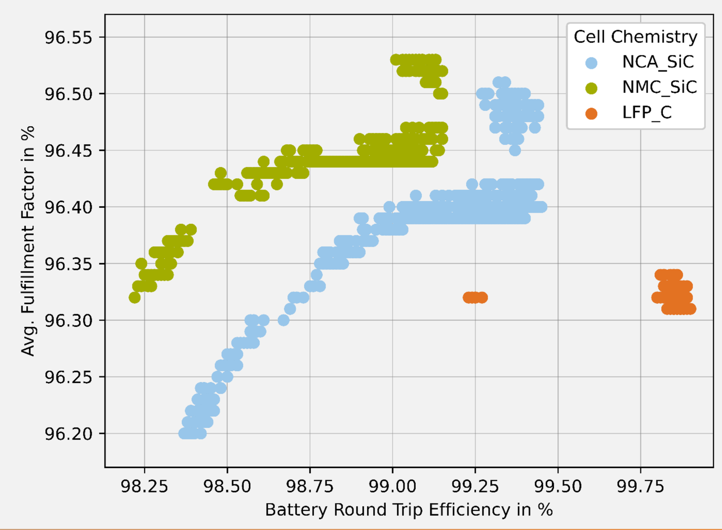

Figure 3: Energy efficiency and fulfillment factor of the battery cells as a function of the cell chemistry. Only systems possible according to BaSD were simulated.

Project-specific Publications

1. Tepe et al. „Optimal pool composition of commercial electric vehicles in V2G fleet operation of various electricity markets", Applied Energy, 2021, https://doi.org/10.1016/j.apenergy.2021.118351
2. Tepe et al. „Feature-conserving gradual anonymization of load profiles and the impact on battery storage systems", Applied Energy, 2023, https://doi.org/10.1016/j.apenergy.2023.121191
3. Tepe et al., "Lithium-ion battery utilization in various modes of e-transportation", eTransportation, 2023, https://doi.org/10.1016/j.etran.2023.100274
4. Jablonski et al., "Analysis and Characterization of the Energy Consumption in an Electric Bus Fleet", NEIS Conference, Hamburg, 2023
5. Faber et al., "A method to determine the specific heat capacity of lithium-ion battery cells using thermal insulation", Journal of Power Sources, 2023, https://doi.org/10.1016/j.jpowsour.2023.233499
6. Bihn et al., "Development of a cell design environment for bottom-up estimation of performance parameters for lithium-ion batteries and virtual cell design – ISEA Cell & Pack Database (ICPD)", Journal of Energy Storage, 2023, https://doi.org/10.1016/j.est.2023.108396
7. Tepe et al., "Vehicle-to-X Service Provision for various Modes of e-Transportation with Consideration of the Influence on Lithium-Ion Battery Utilization", 15th International Conference on Applied Energy, Qatar, 2023 https://doi.org/10.46855/energy-proceedings-10897

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