Model-based system design for 2nd-life usage scenarios of mobile battery systems

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Project motivation

- The goal of the project is to reduce the costs and ecological footprint of traction batteries by **extending their lifetime**.
- This is to be achieved through the use of second-hand **vehicle batteries in 2nd-life applications**.
- However, the reuse rate of batteries is low.
- To facilitate the reuse of batteries in 2nd-life, **suitable methods are lacking** to consider the requirements of both phases of use in battery development.
- The **complex development of multi-life battery systems** is to be supported by the method developed in the project.

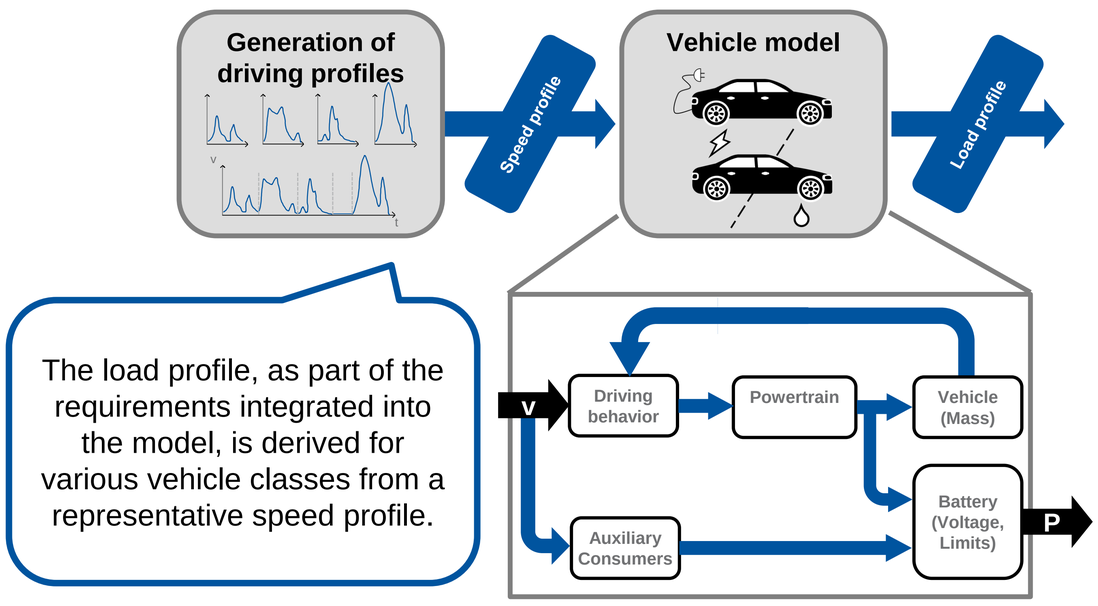
Approach

- In the Model2Life project, a model structure was developed that allows the user to consider **1st- and 2nd-life requirements** during the development process.
- With the help of **model-based systems engineering (MBSE)**, batteries can be optimized for potential 2nd-life applications.
- This involves linking models from different technical domains.
- In a **case study**, the 2nd-life suitability of battery configurations created with the MBSE approach was investigated.
- Additionally, work was conducted on **lifetime prediction models** that enable the selection of suitable 2nd-life systems in the field.

Project results

Case study

Requirements (e.g., Load Profile)

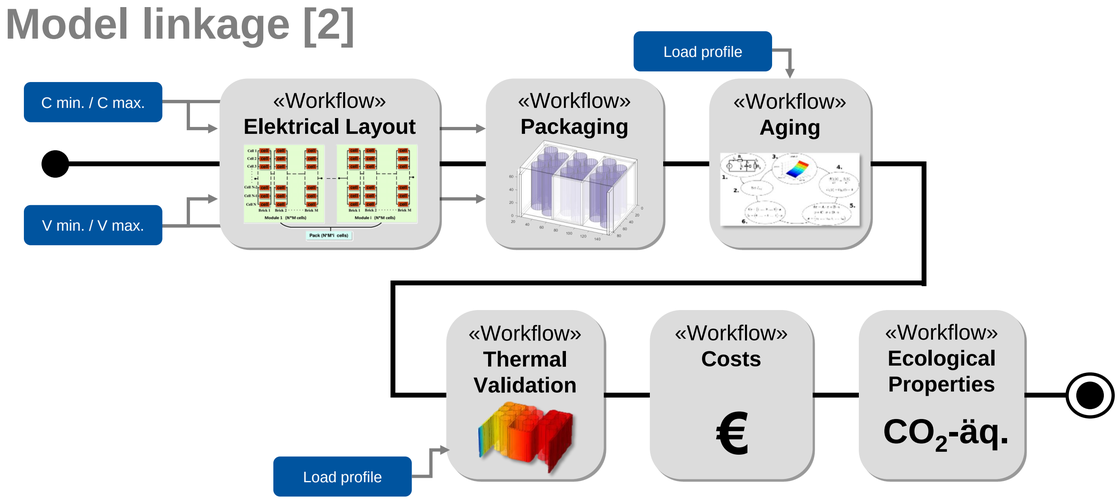


Model2Life system model

Results

- Batteries from small cars are less suitable than those from luxury class (Confirmation of paper at the beginning of the project) [1].
- However: In the chosen use case and the selected cell, calendar aging dominates → the difference is not significant, and the possibility to influence by oversizing is limited.
- Configuration: 14s70p modules, 8 modules in series
  Energy content: 100,16 kWh
- SOH_C and SOH_R at the end of the 1st-life (10 years): 0,71 and 1,51
- Potential lifetime in 2nd-life: about 3 years (60% SOH_C)

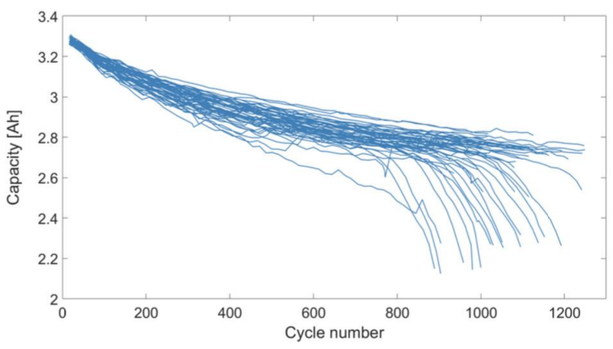
Model linkage [2]



The **representation** and **validation** of a life cycle phase can be automated through the workflow presented.

Data based lifetime prediction

- Cyclic aging tests for data acquisition with changes in usage profile
- Adaptation of algorithms for lifetime prediction [3]
- Further development of fast, non-dismantling diagnostic methods [4]



References and own publications

[1] Börner et al.: „Challenges of second-life concepts for retired electric vehicle batteries", Cell Reports Physical Science 2022, http://dx.doi.org/10.1016/j.xcrp.2022.101095
[2] Berges et al.: „Model-based Systems Engineering für 2nd-Life-Nutzungsszenarien von mobilen Batteriesystemen", Tag des Systems Engineering 2023
[3] Li et al.: „Forecasting battery capacity and power degradation with multi-task learning", Energy Storage Materials 2022, http://dx.doi.org/10.1016/j.ensm.2022.09.013
[4] Yang et al.: „Fast screening of lithium-ion batteries for second use with pack-level testing and machine learning", eTransportation 2023, http://dx.doi.org/10.1016/j.etran.2023.100255

Acknowledgements

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