Technische Universität München

Modeling Framework for Simulating Energy Storage Systems in Grid Applications

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Motivation

The imminent coupling of the transport sector with the electricity sector and the possibilities of grid integrated energy storages are creating new potentials and challenges.

With open_BEA (open battery models for electrical grid applications), the following open questions are addressed:

- Which storage technology is cost-optimal for a given application?
- How must stationary storage systems optimally positioned, dimensioned and operated in order to provide grid-related services?
- To which extend are battery electric vehicles capable to serve as a flexibility option in a future power grid?
- Which potential has an energy storage system performing active peak-shaving for future grid planning?

Model Overview

In open_BEA (open battery models for electrical grid applications), a holistic open-source modeling tool, which will be made open-source accessible is developed.

The simulation platform allows connects the open-source tools SimSES for simulation storage systems and eDisGo, a toolbox to analyze distribution grids [1]. Figure 1 shows the open_BEA model overview of as well as its key functionalities.

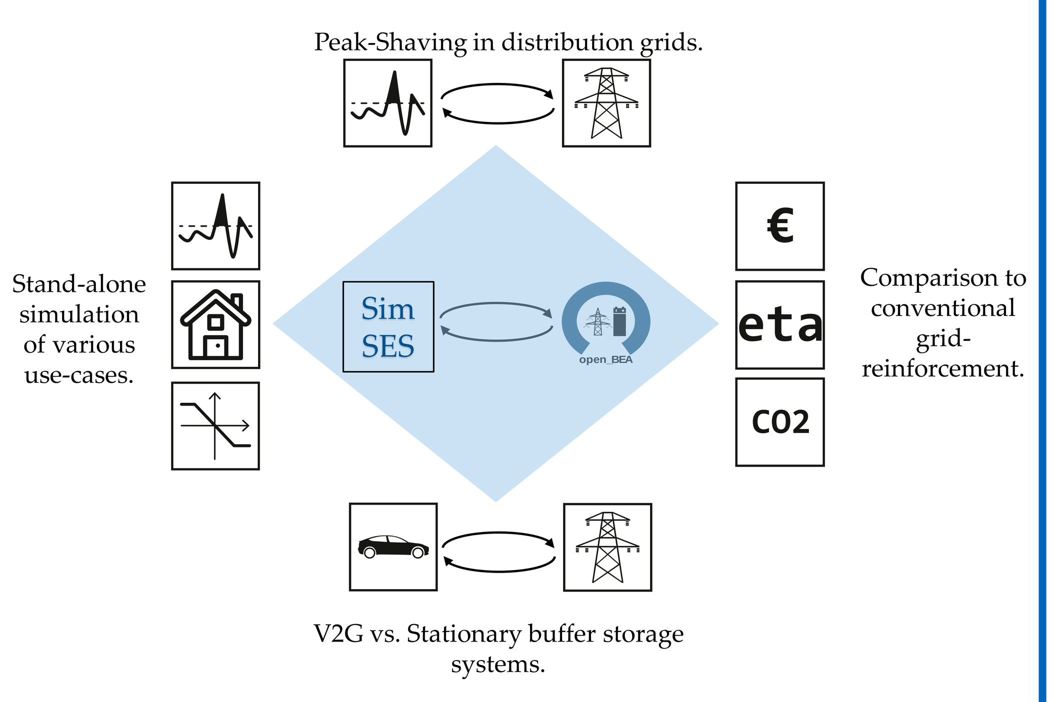

Figure 1: Model Overview of open_BEA

SimSES

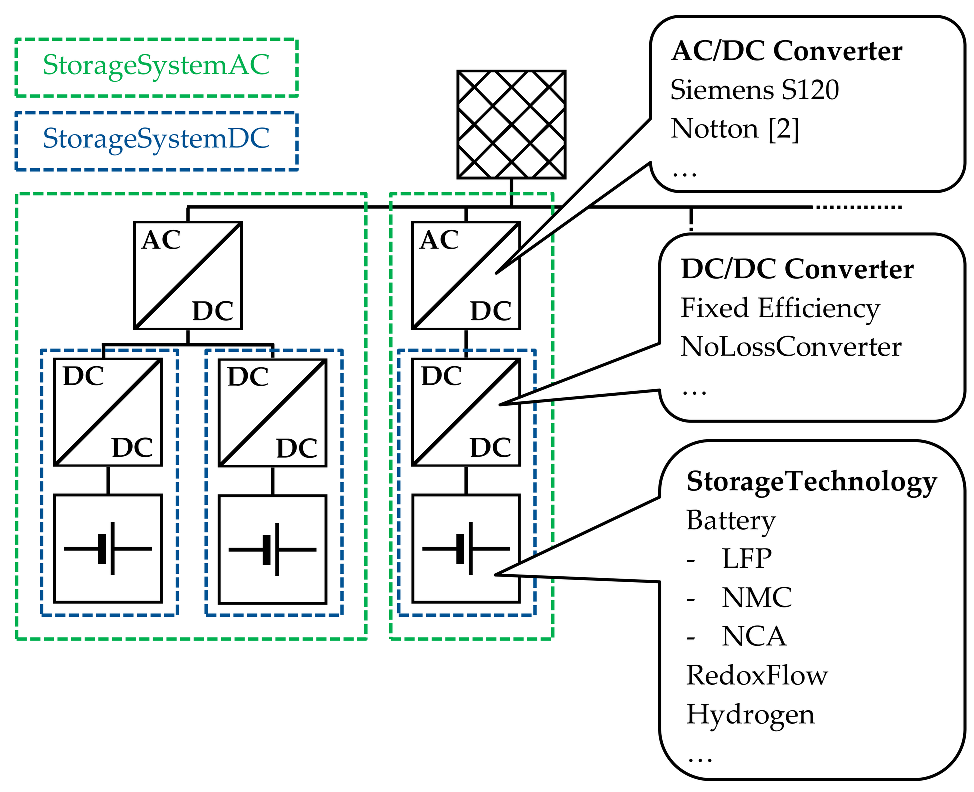

Figure 2: Modular Topology in SimSES

SimSES (Simulation of stationary energy storage systems) is a modeling framework for stand-alone simulations stationary energy storage systems. The open-source tool is developed at the Institute for Electrical Energy Storage Technology. SimSES enables:

- A detailed simulation and evaluation of stationary energy storage systems with the current main focus on lithium-ion batteries, redox-flow batteries and hydrogen based storage systems.
- A modular and flexible structure (see Figure 2), which allows the variation of storage technologies, technical sub-components, such as power electronic units, and aging models.

SimSES is available as an open source version and can be found here: www.simses.org. The simulation loop (flow-chart) is shown in Figure 3.

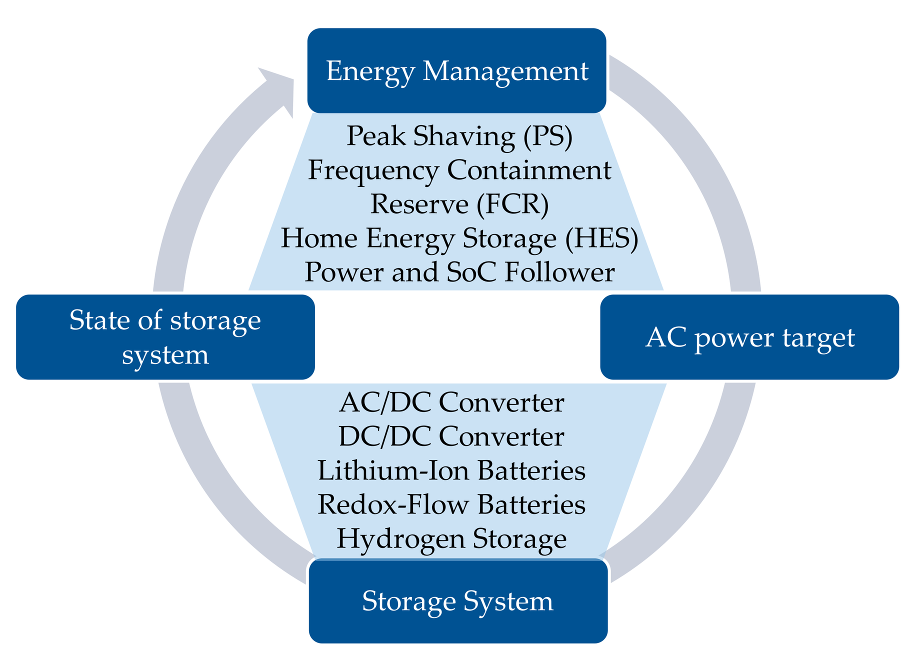

Figure 3: Simulation Loop of SimSES

Results SimSES

In order to analyze three stand-alone applications, the tool was used to transform input profiles into storage profiles including power and SoC.

The results are post-processed with a profile analyzer tool in order to identify six key characteristics as shown in Figure 4.

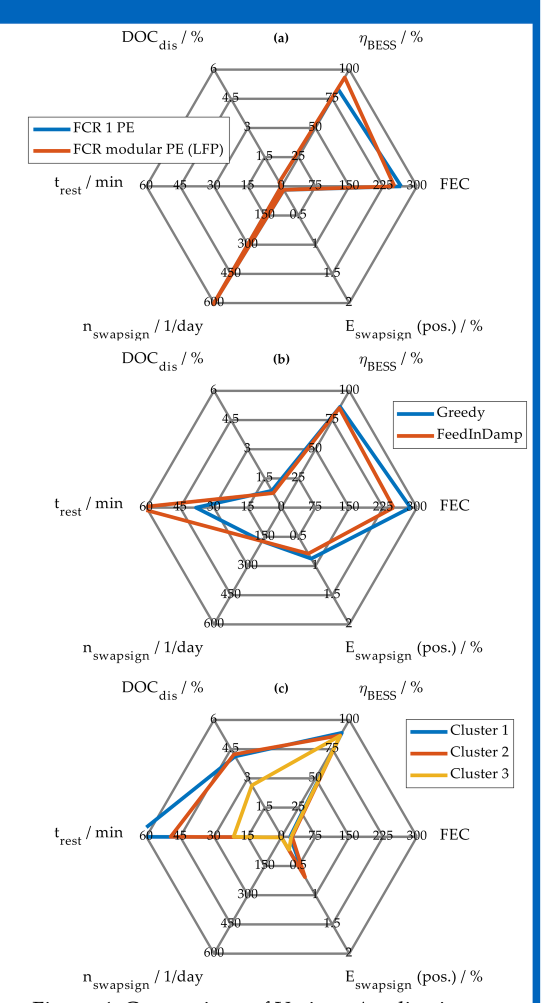

Figure 4: Comparison of Various Applications: (a) FCR, (b) HES and (c) PS

Results open_BEA

The open_BEA framework was used to analyze the effect of storage systems performing PS in an active role.

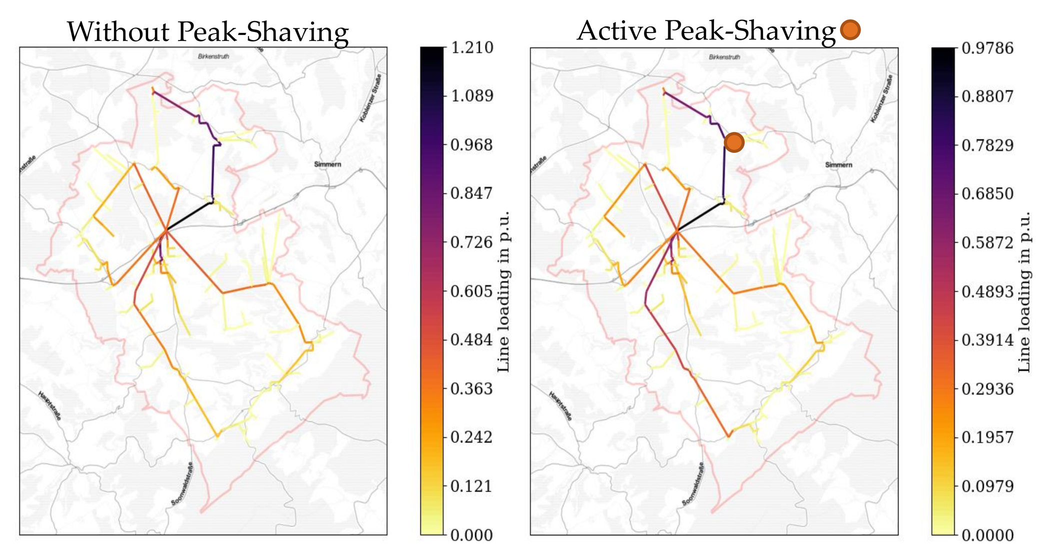

Figure 5: Peak-Shaving in an Example Grid.

Outlook

In the future the open_BEA framework will include:

- A holistic techno-economic analysis to fully compare stationary storage systems based on lithium-ion batteries with redox-flow batteries and hydrogen based storage systems.
- The possibility to simulate and analyze buffer storage systems at (fast-) charging stations.
- Real-life examples by simulating storage systems in existing grid topologies.

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[2] G. Notton, V. Lazarov, and L. Stoyanov, "Optimal sizing of a grid-connected PV system for various PV module technologies and inclinations, inverter efficiency characteristics and locations," Renewable Energy, vol. 35, no. 2, pp. 541–554, 2010.

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