Specification and Assessment of Electric Energy Storage Systems based on Generic Storage Load Profile

Dipl.-Ing. Hendrik Schaede

Maximilian Schneider, M.Sc.

Prof. Dr.-Ing. Stephan Rinderknecht

Agenda

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- Motivation
- SDA-Methodology
- Specification Process
- Application Example: Industrian Plant
- Discussion and Conclusion

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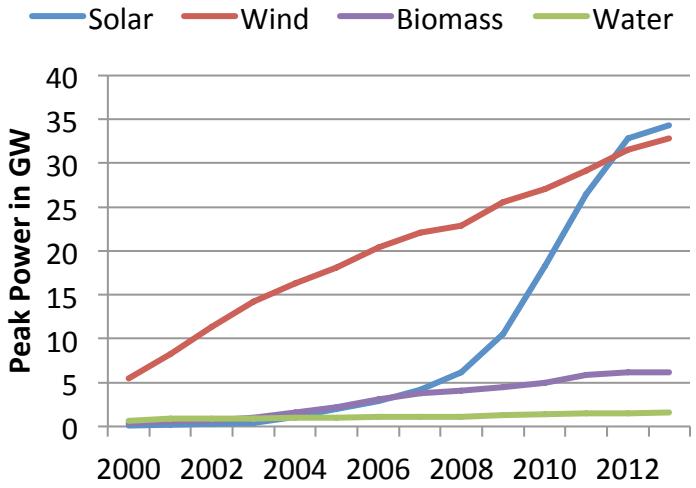
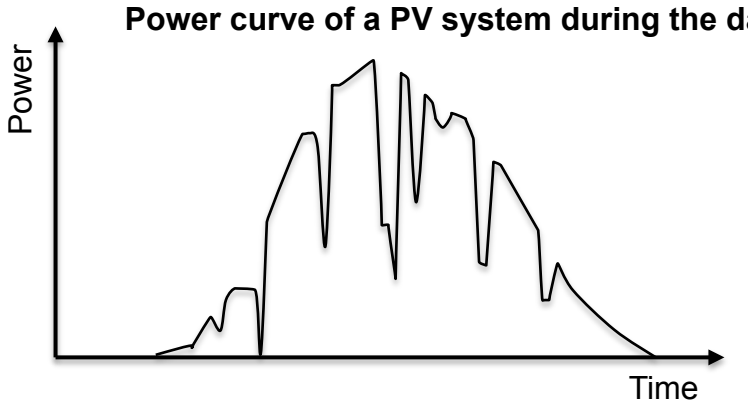
Motivation



Quelle: www.bz-bildung.de



- Rapid increase of renewable energies in the grid
- Renewable energies are highly volatile
- Energy consumption is hard to predict

Electical Energy Storage Systems (EESS) serve as intermediates between consumption and renewable production

Motivation

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- Depending on task different storage types and properties are necessary:
  - Type of storage technology
  - Capacity
  - Maximum charge and discharge power
  - Cycle-life and energetic losses
- Decisions are crucial for the profitability of the energy storage system

- **Properties of the energy storage system must be thoroughly determined**
- **No general methods availabe for this task**

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SDA-Methodology

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Object:

Find the optimal energy storage system for the application

Challenge:

- No methodologies
- Documented procedures for specific applications

Approach:

- Development of a technologically neutral process
- Analysis of the Process
- Definition of four standardized steps:
  1. ***S**pecification*
  2. ***D**esign*
  3. ***A**ssessment*
  4. Optimisation

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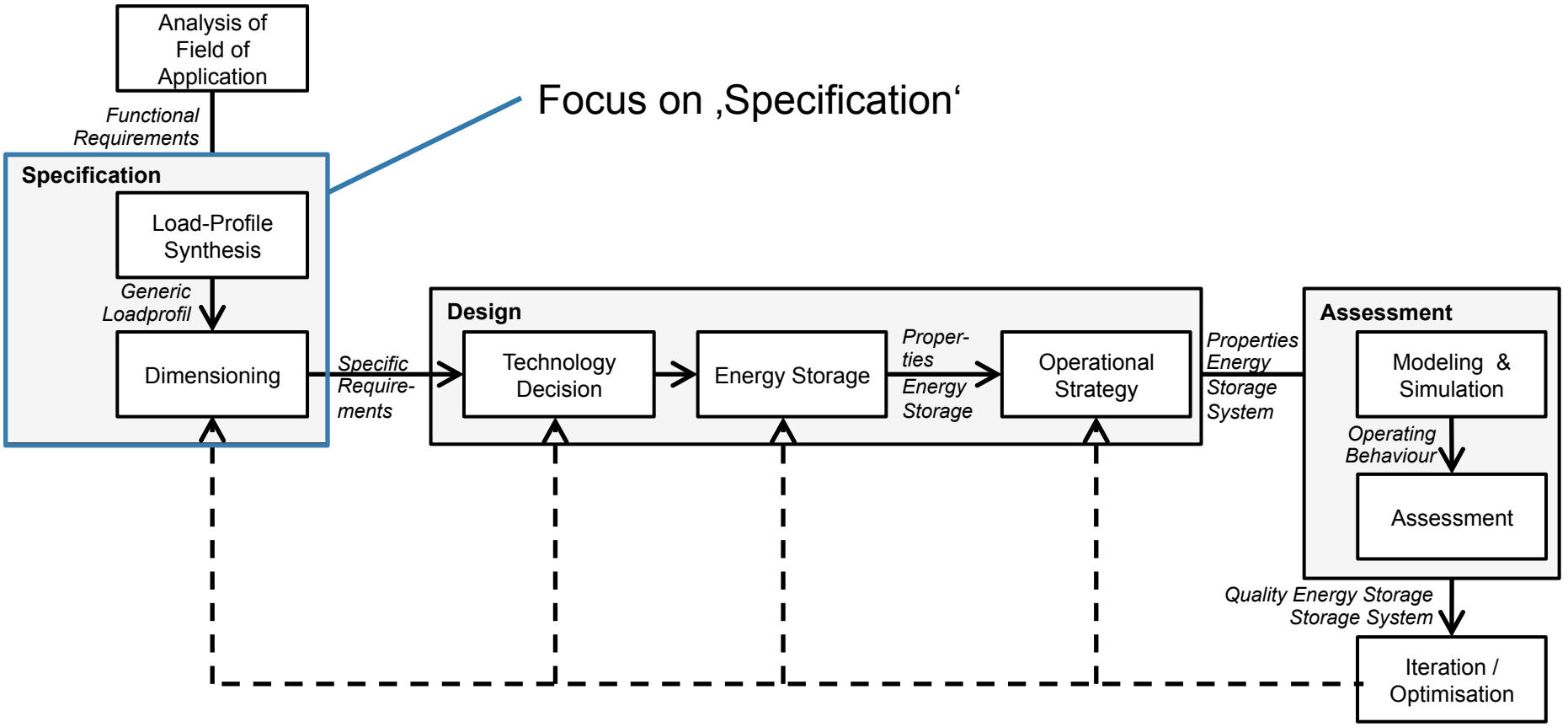
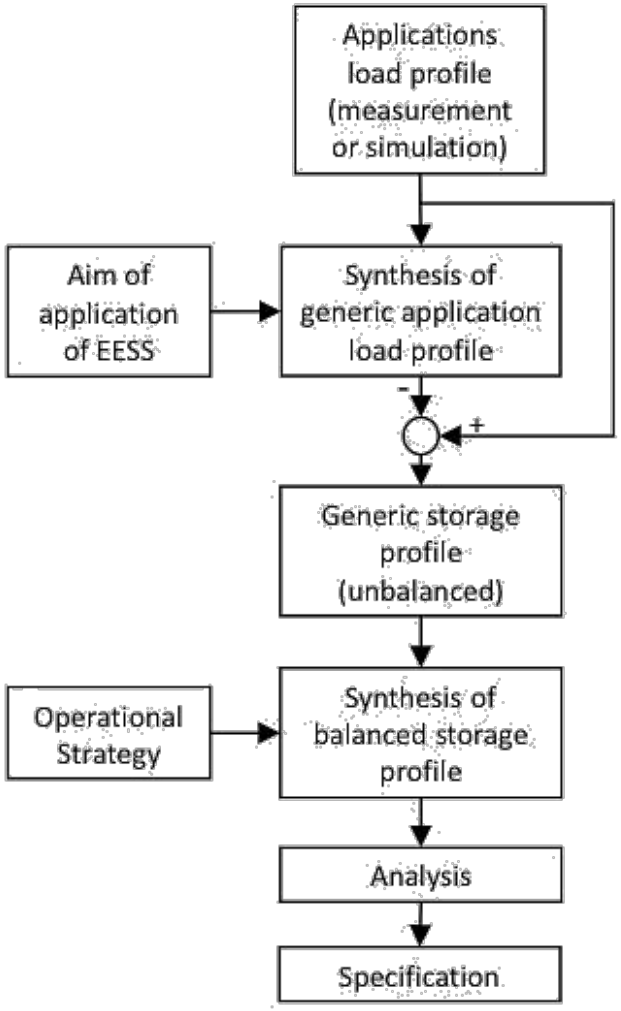
SDA-Methodology



Specification Process



‘Specification’:

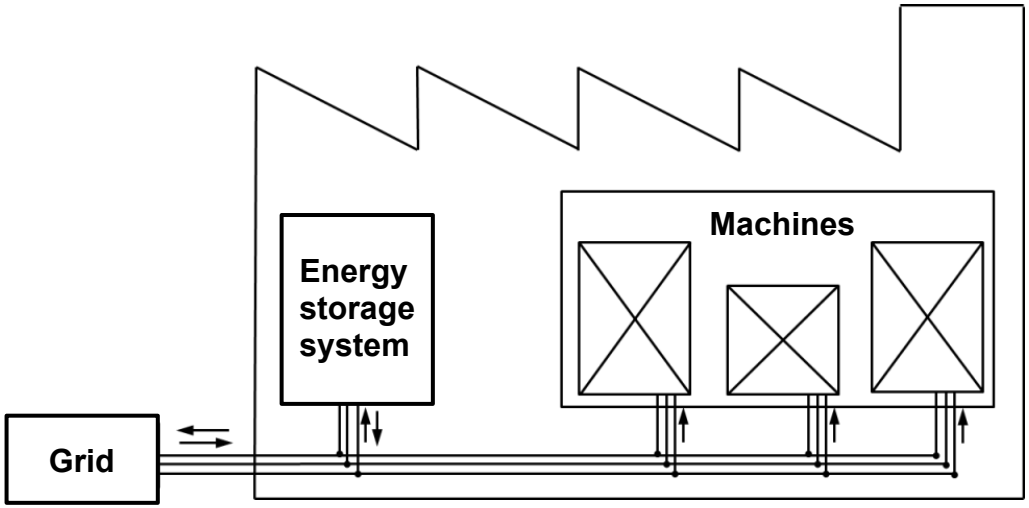
- In-depth analysis of the field of application
- Identification of storage operator needs
- Assumption of ideal storage

Results from ‘Specification’:

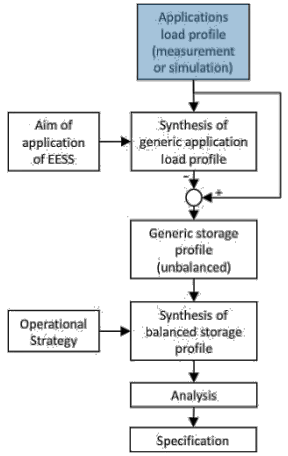
- Nominal electrical power
- Usable storage capacity
- Goals for the ‘Design’ process
  - Efficiencies
  - Cycle life
  - Safety
  - Total costs
  - Specific energy and power densities

Criteria also basis for the ‘Assessment’ and ‘Optimization’

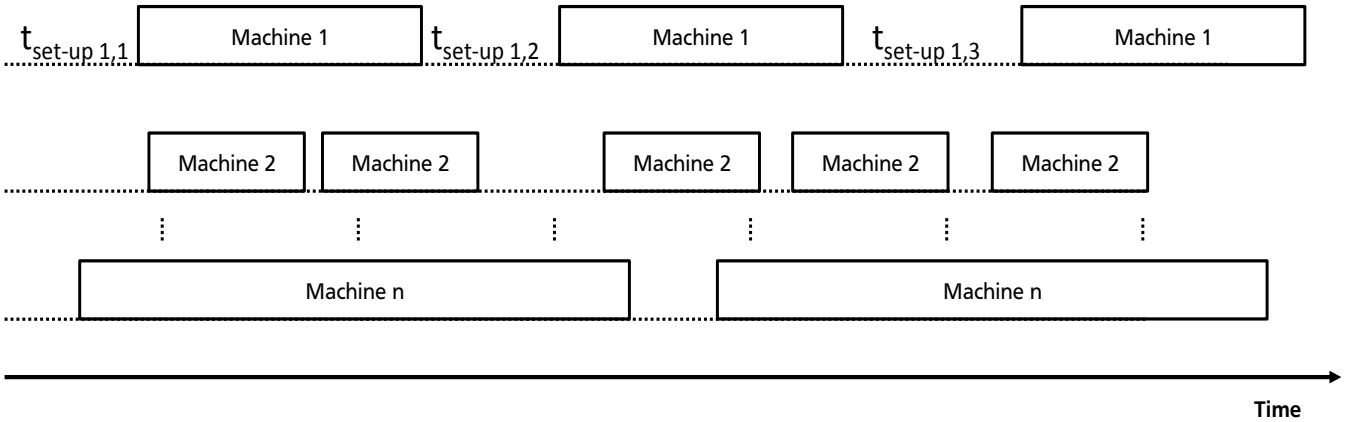
Application Example: Industrian Plant
Application load profile



ENERGIEEFFIZIENZ TECHNOLOGIE-UND ANWENDUNGSZENTRUM



Generating an **application load profile**



Application Example: Industrian Plant

Synthesis of gernic application load profile

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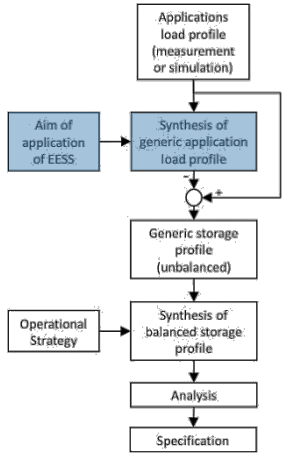
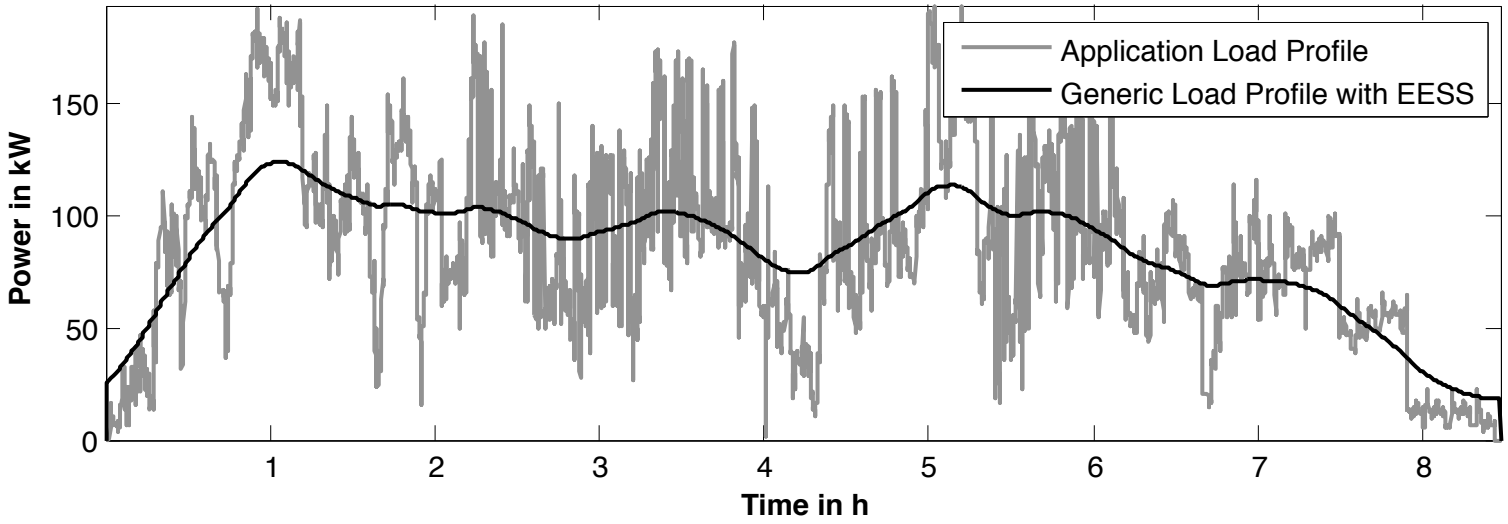
Aim of the EESS: smoothen the load profile

Determination of ideal Generic Load Profile with EESS: zero-phase digital low-pass filter





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Application Example: Industrian Plant

Synthesis of gerenic application load profile

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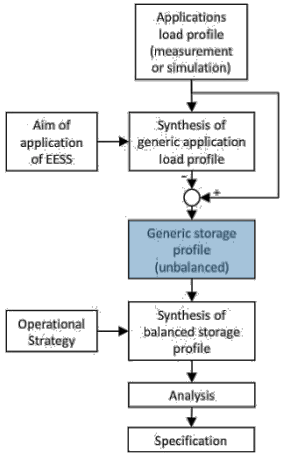
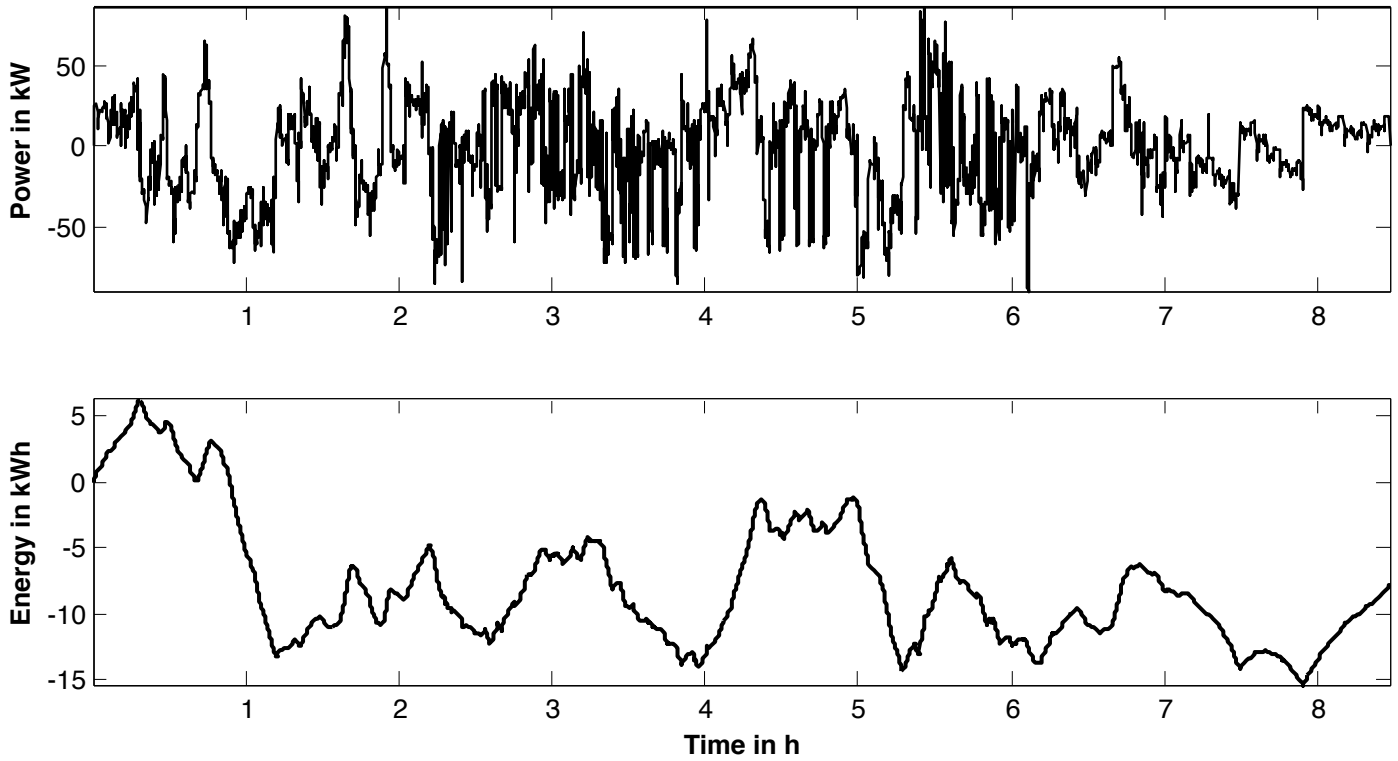
Calculation of the generic storage profile (unbalanced):

$$P_{st,gen,ub} = P_{load,gen} - P_{app}$$

$$E_{st}(\tau) = \sum_{t=1}^{\tau} P_t \cdot \Delta t$$





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Application Example: Industrian Plant
Operational Strategy

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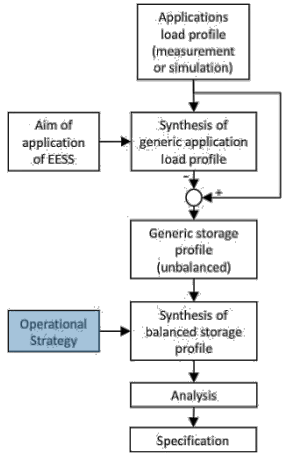
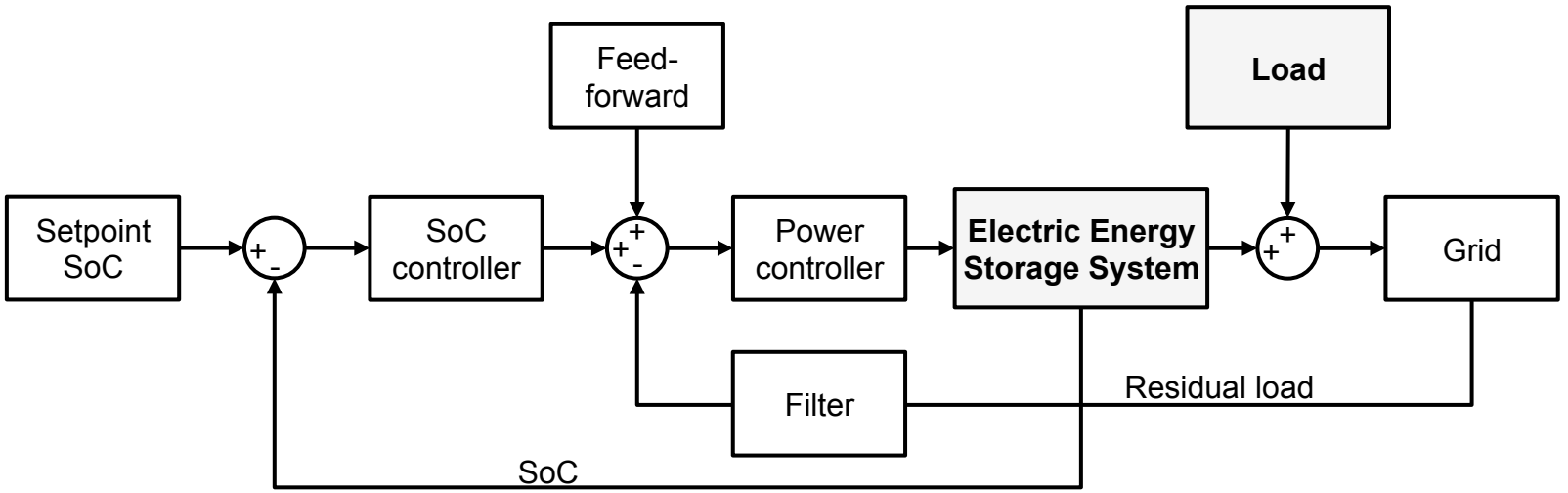
- Operational strategy is necessary to balance the EESS
- Power and SoC controller parameters must be set





Source Schneider, M., Boras, P., Schaede, H., Quurck, L., Rinderknecht, S.; Effects of Operational Strategies on Performance and Costs of Electric Energy Storage Systems; In: Energy Procedia, Vol. 46, 2014, pp. 271-280.

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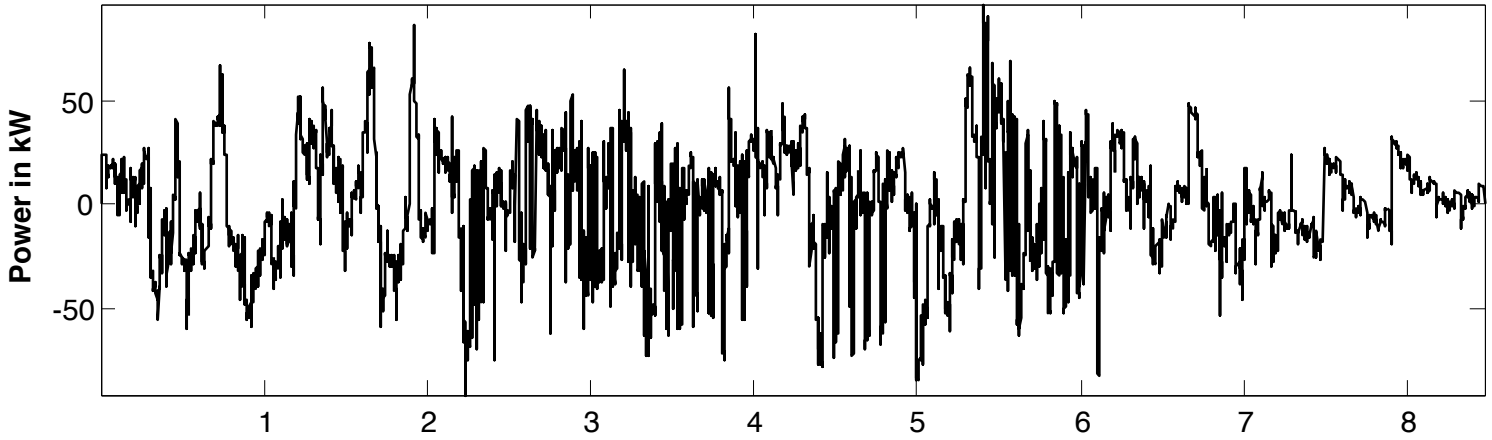
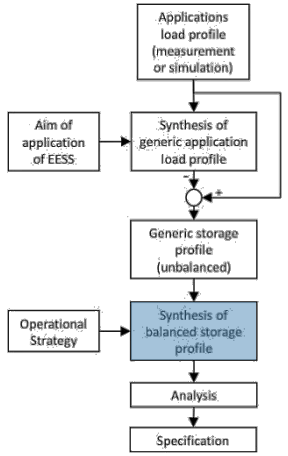
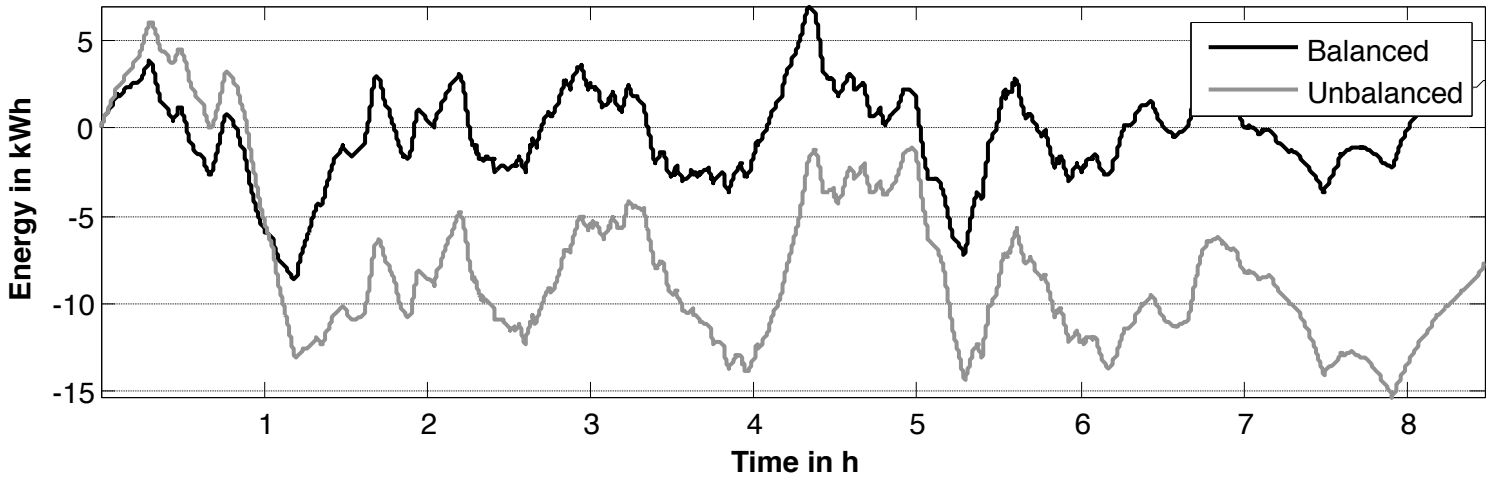
Application Example: Industrian Plant

Synthesis of balanced storage profile







Application Example: Industrian Plant
Analysis and Specification

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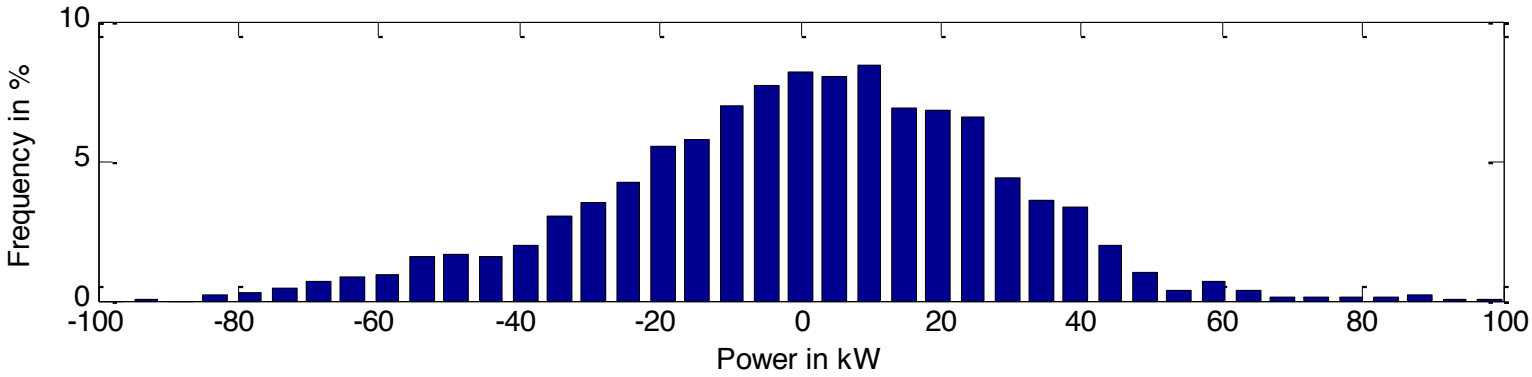
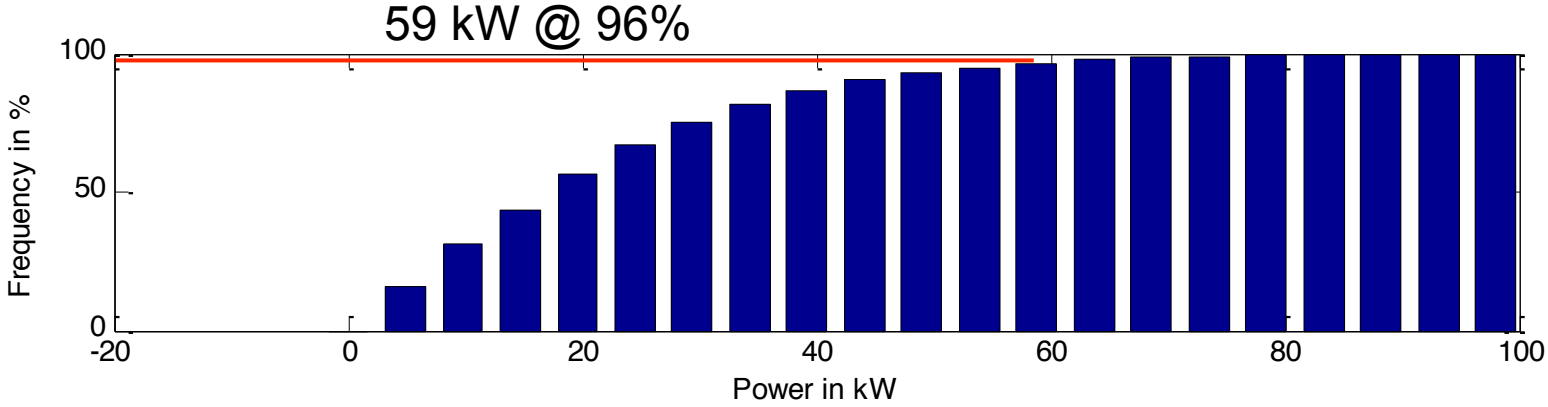
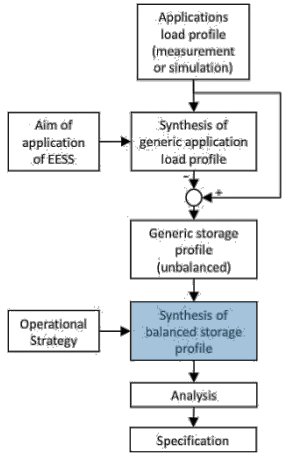
Power distribution







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Application Example: Industrian Plant
Analysis and Specification

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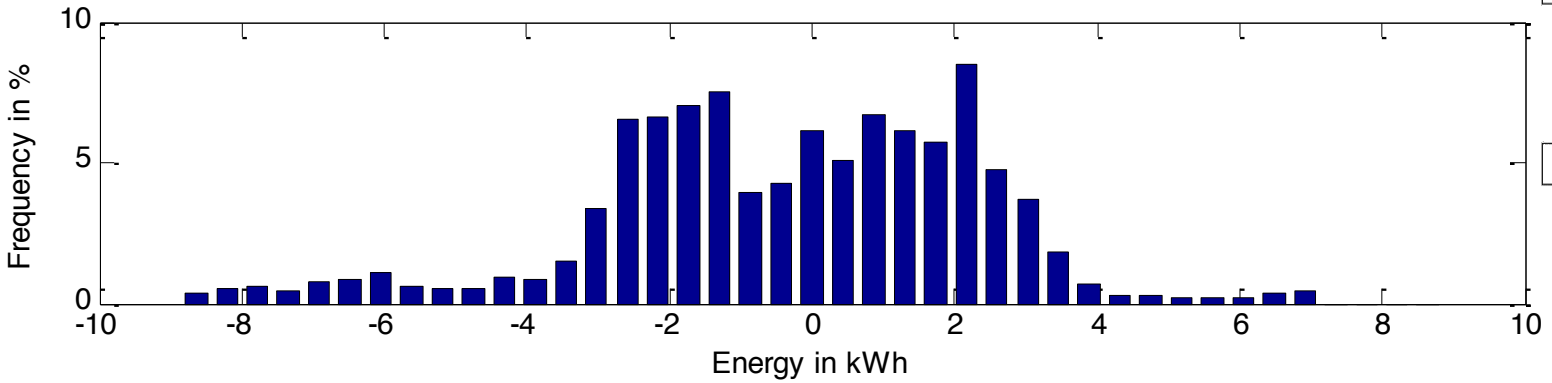
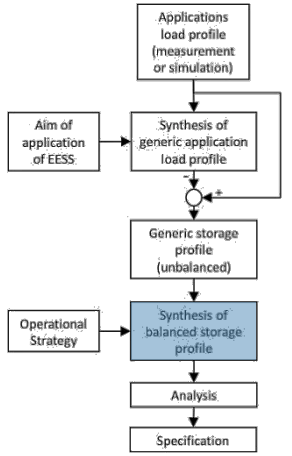
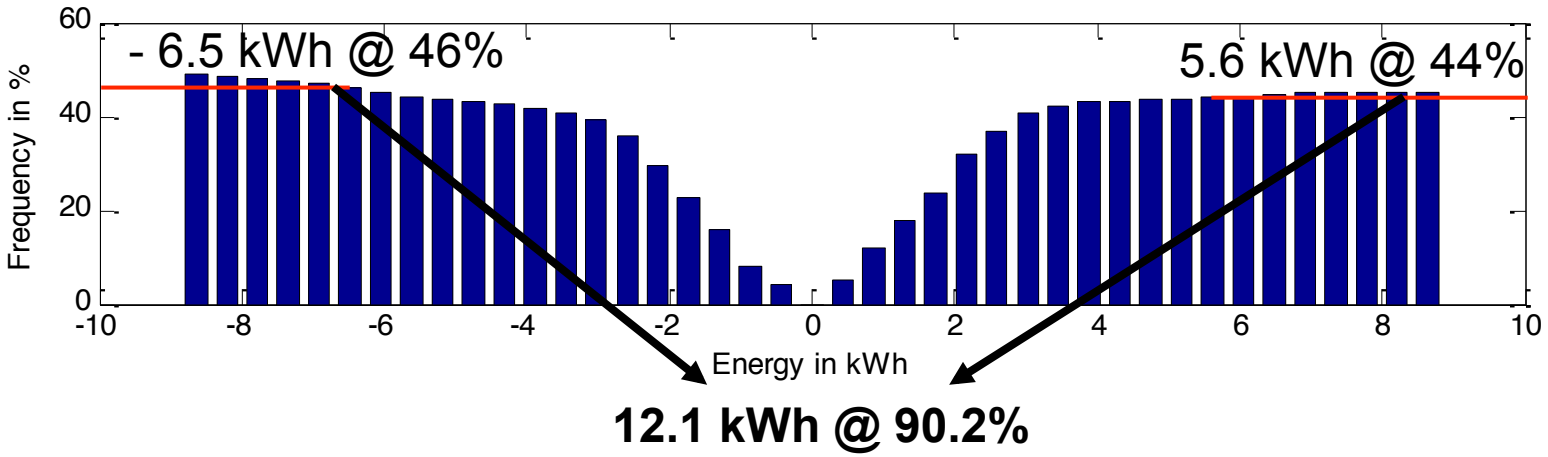
Energy distribution







12.1 kWh @ 90.2%

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Application Example: Industrian Plant
Analysis and Specification

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Additional information can be gained from the balanced storage profile:

	Per Profile (≈8 h)	Per Year (200 workdays)
Power ramp rate	71.8 kW/s	71.8 kW/s
Number of load reversals	17,415	3,483,000
Number of load cycles (100% DoD and 100 % Capacity)	10.7	2,133

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Discussion and Conclusion

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- Sizing of EESS is important
- No standardized methods available
- SDA Methodology as overall approach to size, design and optimize energy storage systems
- ‚Specification' process allows for technology neutral definition of requirements

- Detailed information about the field of application necessary
- Consideration of losses later in the process can affect the storage performance

- Uncertainties should be integrated into the procedure

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Thank you very much for your attention!

Maximilian Schneider
schneider@ims.tu-darmstadt.de