Quality assurance to support the bankability of renewable energy + storage applications

Matthias Vetter

Fraunhofer Institute for
Solar Energy Systems ISE

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Agenda

- Introduction to Fraunhofer ISE and VDE Renewables battery storage services
- Motivation and applications of larger PV battery systems
- Quality assurance for PV power plants with battery storage
- Quality assurance for PV battery systems in commercial applications and mini-grids
- Example of a commercial PV battery system
- Example of a district storage
- Examples of mini-grid applications
- Conclusions

Services for stationary energy storage systems
From product development to project implementation

Strategic partnership of Fraunhofer ISE and VDE Renewables

PRODUCT DESIGN & PROJECT PLANING

- Analyses of load profiles
- Technical advice with focus on product design and optimization
- Simulation-based system design and component dimensioning
- Yield prediction
- Recommendations on component selection

TESTING & PROJECT DEVELOPMENT

- Economic feasibility studies using simulation-based system analyses
- Characterization of components
- Performance testing
- Lifecycle testing
- Conformity testing
- Electrical safety & EMC testing
- Benchmark tests
- Environmental simulation
- Abuse tests
- United Nations Transport Test

CERTIFICATION & IMPLEMENTATION

- Certification of whole Energy Storage Systems
- System testing
- Ongoing quality monitoring

Motivation and applications of larger photovoltaic battery systems

- Integration of battery storage in PV power plants
  - → Feeding-in of PV power according to the needs of the grid
  - → But: Battery storage increases the LCOE
- Integration of battery storage in commercial grid connected PV applications
  - → Increasing PV self consumption and reducing electricity bill
  - → But: Reasonable usage depends on specific boundary conditions and system performance
- Integration of battery storage in hybrid PV Diesel mini-grids
  - → Increasing the solar share and decreasing Diesel cost
  - → But: Economic benefits depend on project life-time and proper system design

Quality assurance for photovoltaic power plants with battery storage

From project planning to system monitoring

TECHNICAL ADVICE ON STORAGE SELECTION AND DIMENSIONING

CHARACTERIZATION OF BATTERY SYSTEMS

YIELD PREDICTION FOR THE OVERALL SYSTEM

SYSTEM TESTING

QUALITY MONITORING

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Quality assurance for photovoltaic power plants with battery storage

From project planning to system monitoring

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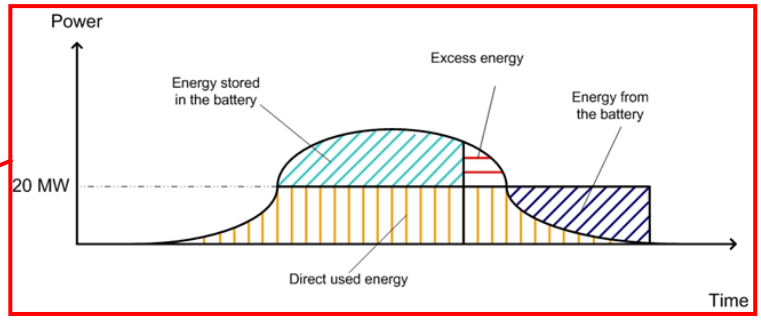

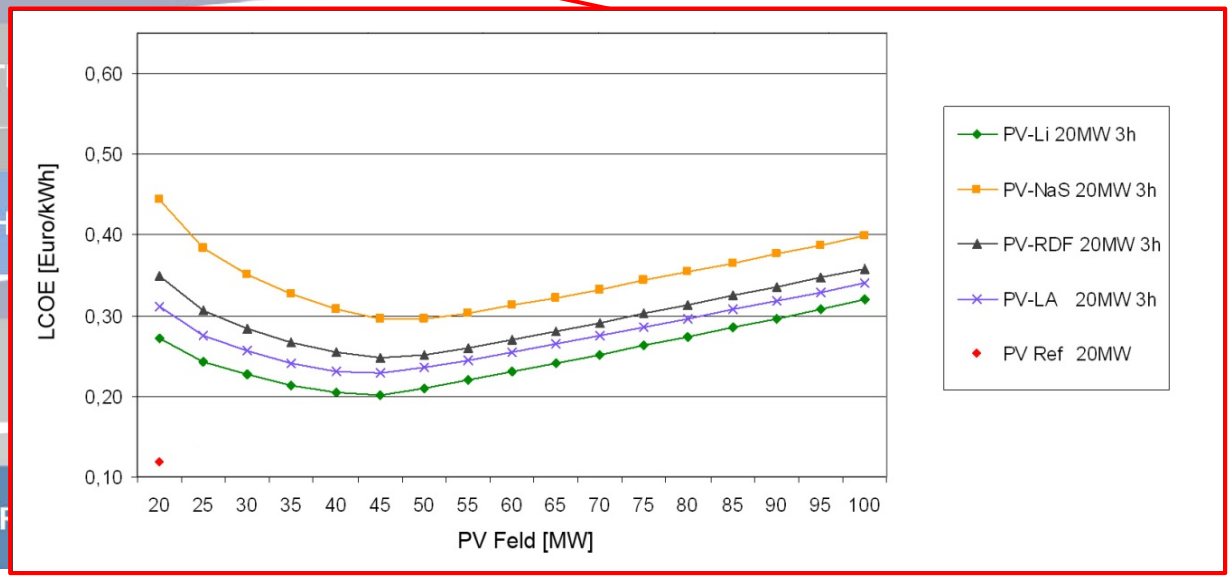

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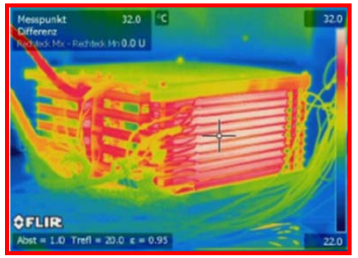
From project planning to system monitoring



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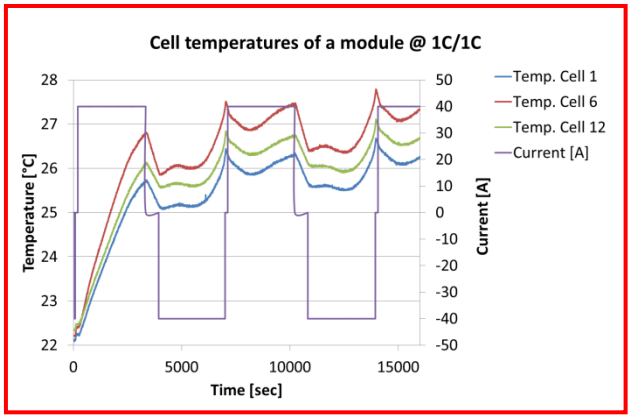

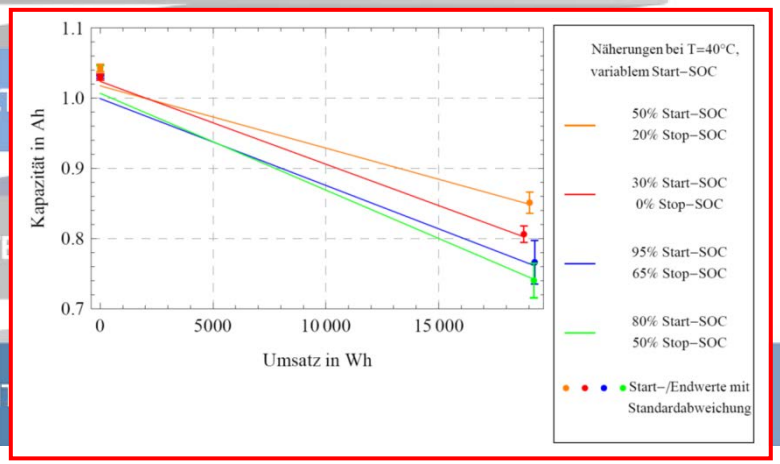

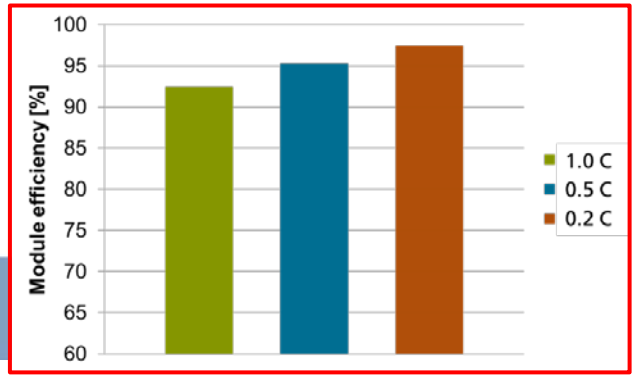

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From project planning to system monitoring

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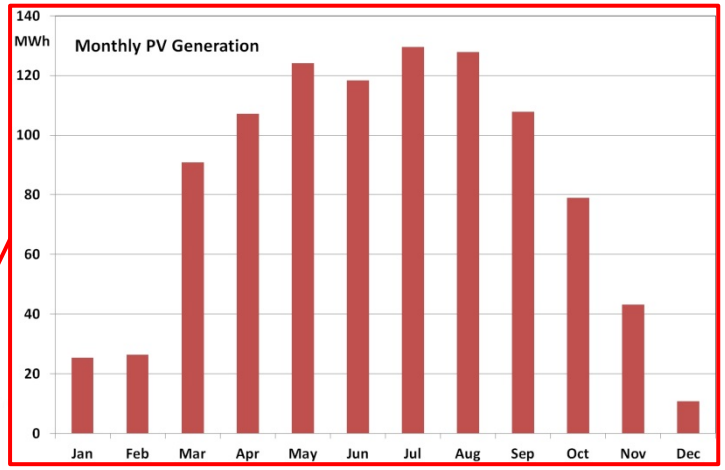

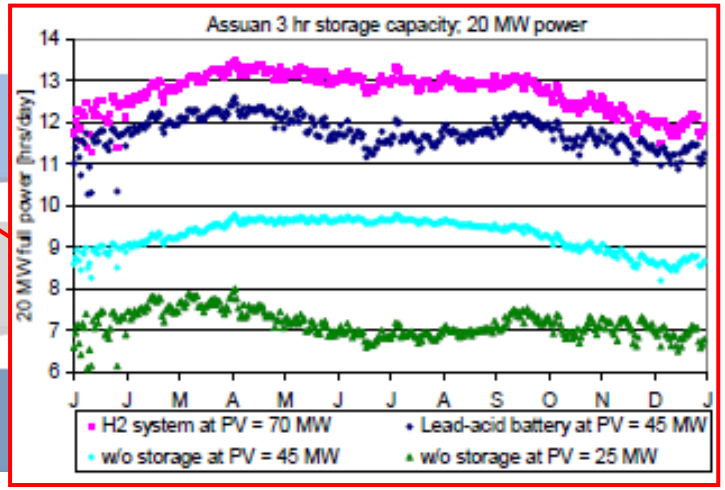

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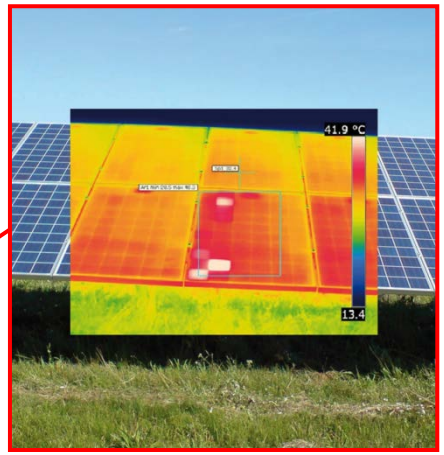

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Quality assurance for photovoltaic battery systems in commercial applications and mini-grids

From project planning to system monitoring

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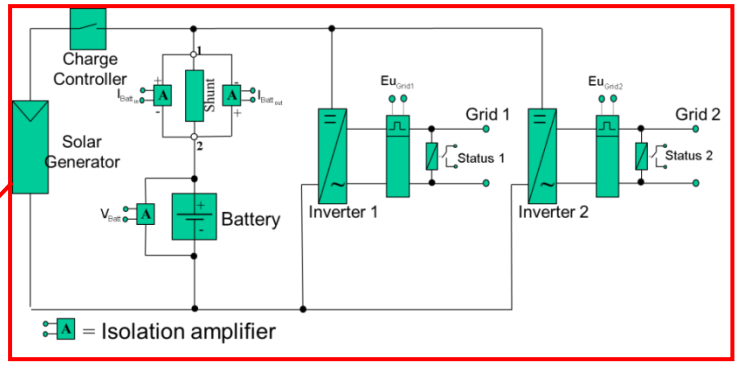

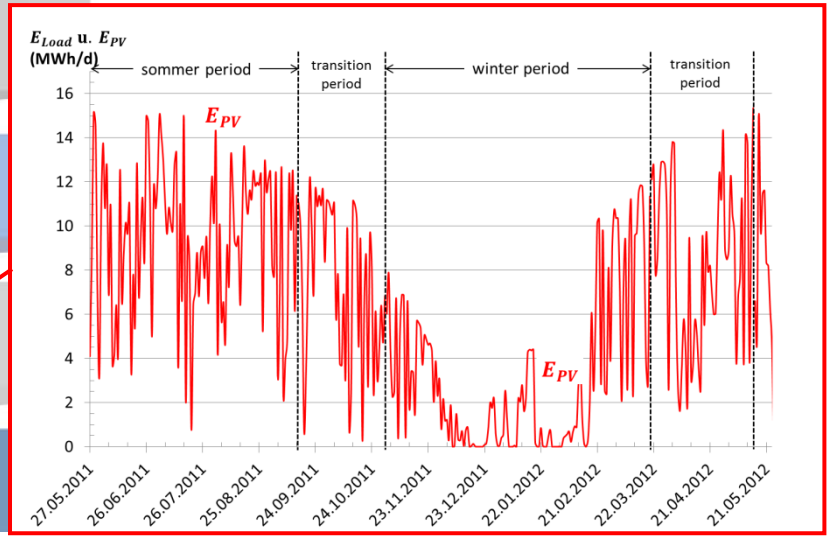

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Quality assurance for photovoltaic battery systems in commercial applications and mini-grids

From project planning to system monitoring

- ANALYSES OF LOAD PROFILES
- SYSTEM DIMENSIONING & COMPONENT SELECTION
- CHARACTERIZATION OF SYSTEM COMPONENTS
- YIELD PREDICTION FOR THE PV SUBSYSTEM
- SYSTEM TESTING
- QUALITY MONITORING


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Example: Commercial PV battery system

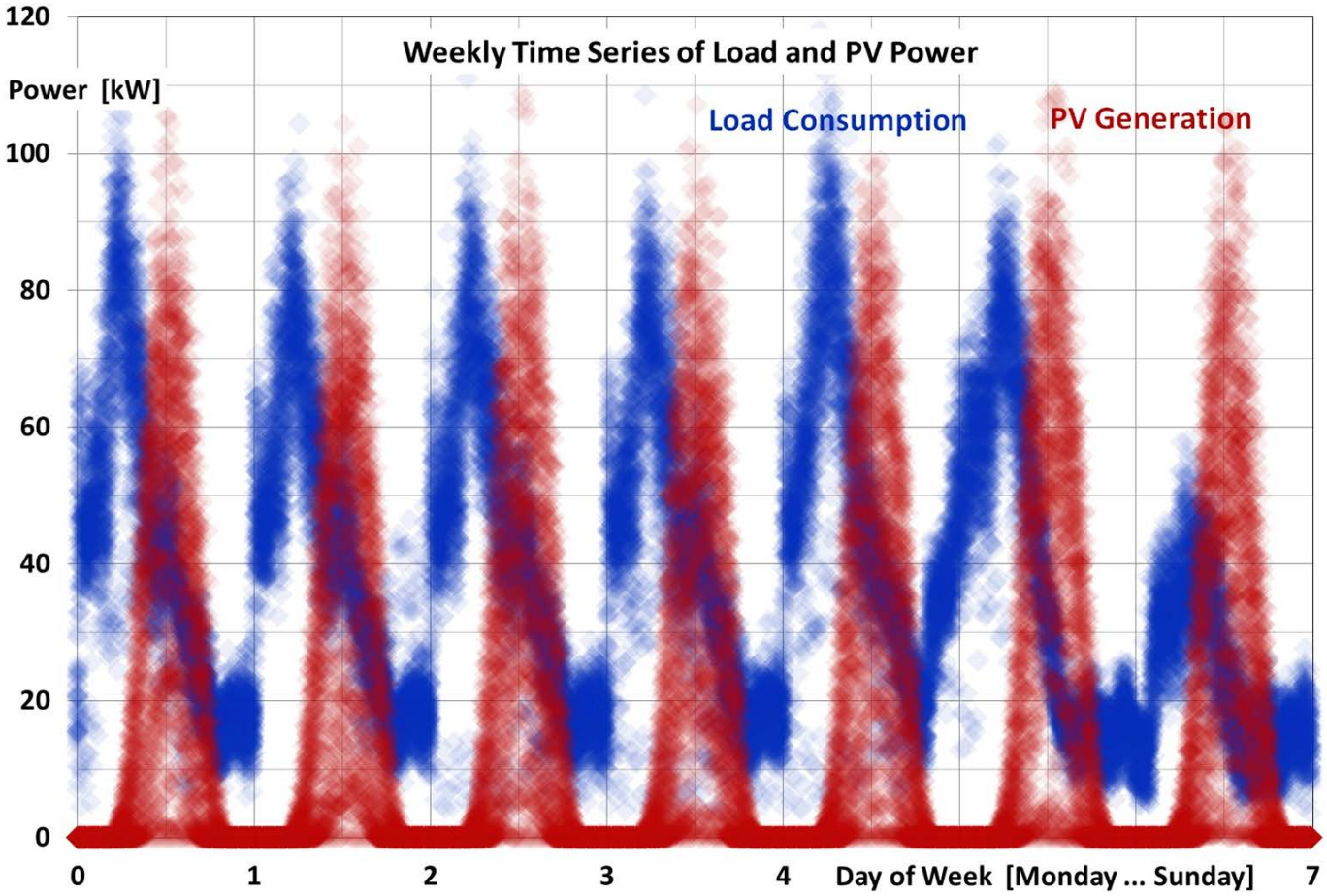
Analysis of load profile and PV generation profile

Load (bakery):

- Consumption: 335 MWh/a
- Max. power: 118 kW

PV example:

- Size: 150 kWp
- Production: 135 MWh



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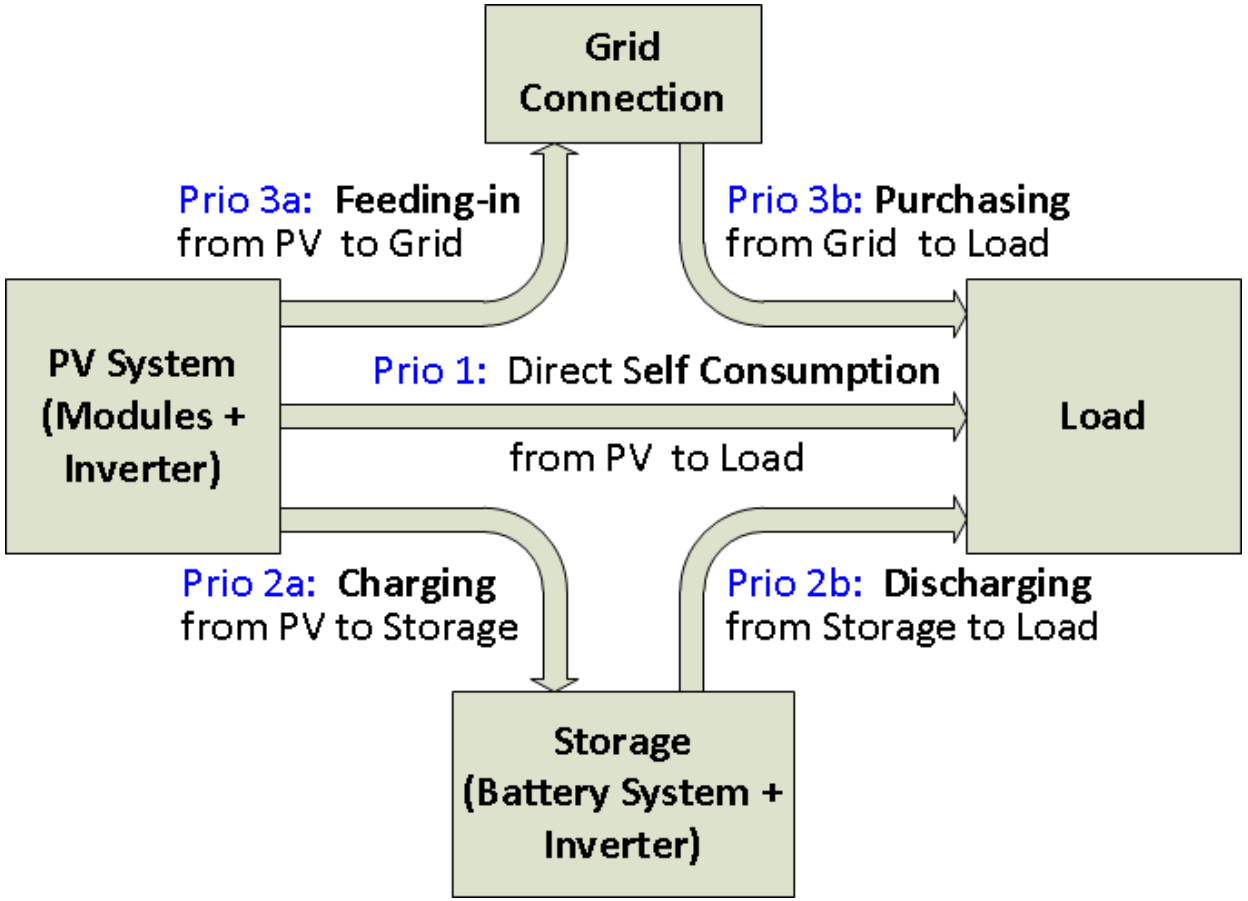
Example: Commercial PV battery system
Simulation based system analysis and design

Load (bakery):

- Consumption: 335 MWh/a
- Max. power: 118 kW

Integration of a PV system and a lithium-ion battery storage:

- Variation of PV system size
- Variation of battery storage size



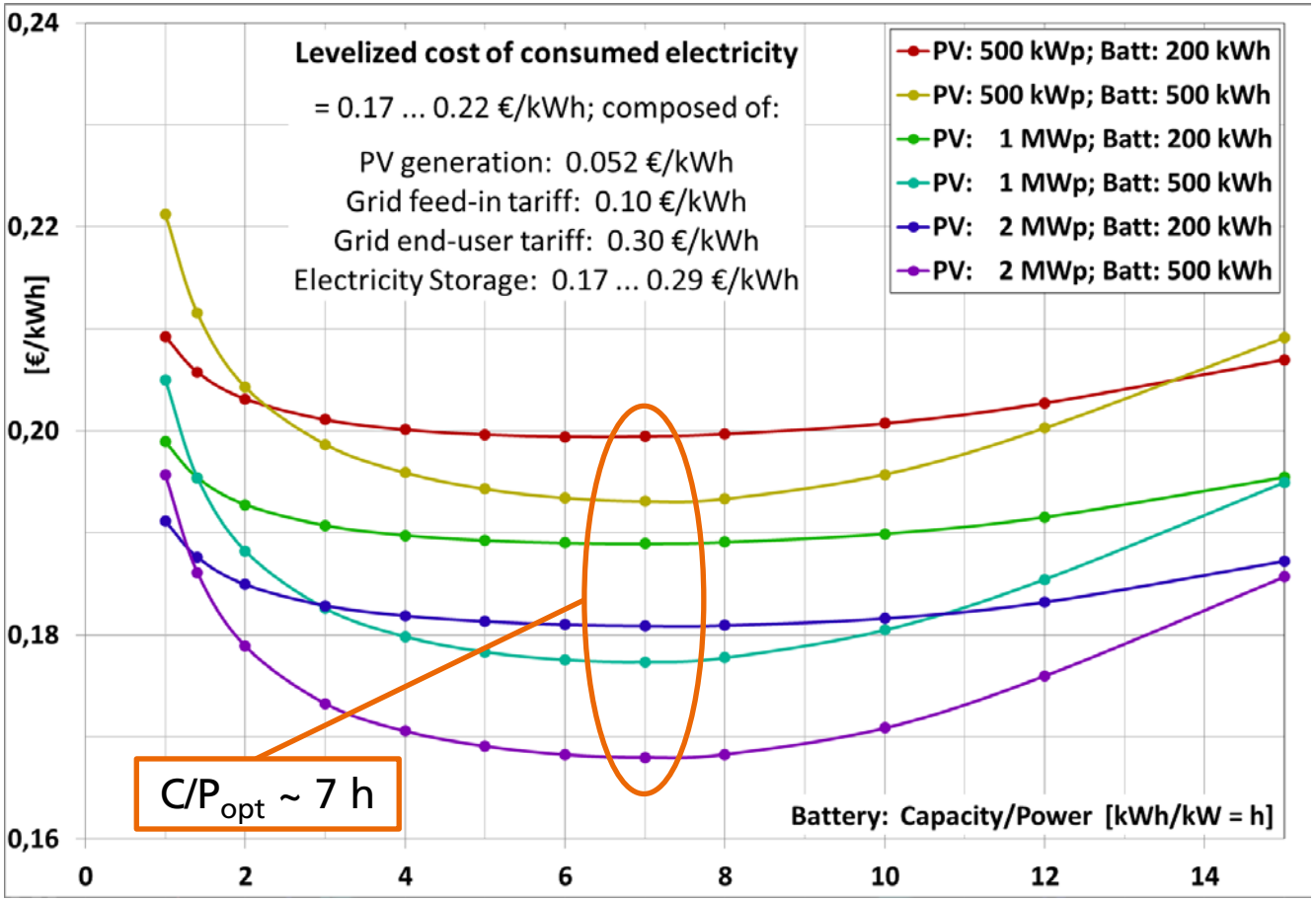
Example: Commercial PV battery system

Simulation based system analysis and design

Levelized cost of energy

Main parameters:

- PV system: 840 €/kWp
- Battery system: 600 €/kWh
- Battery inverter: 215 €/kW
- Interest rate: 3 %/a



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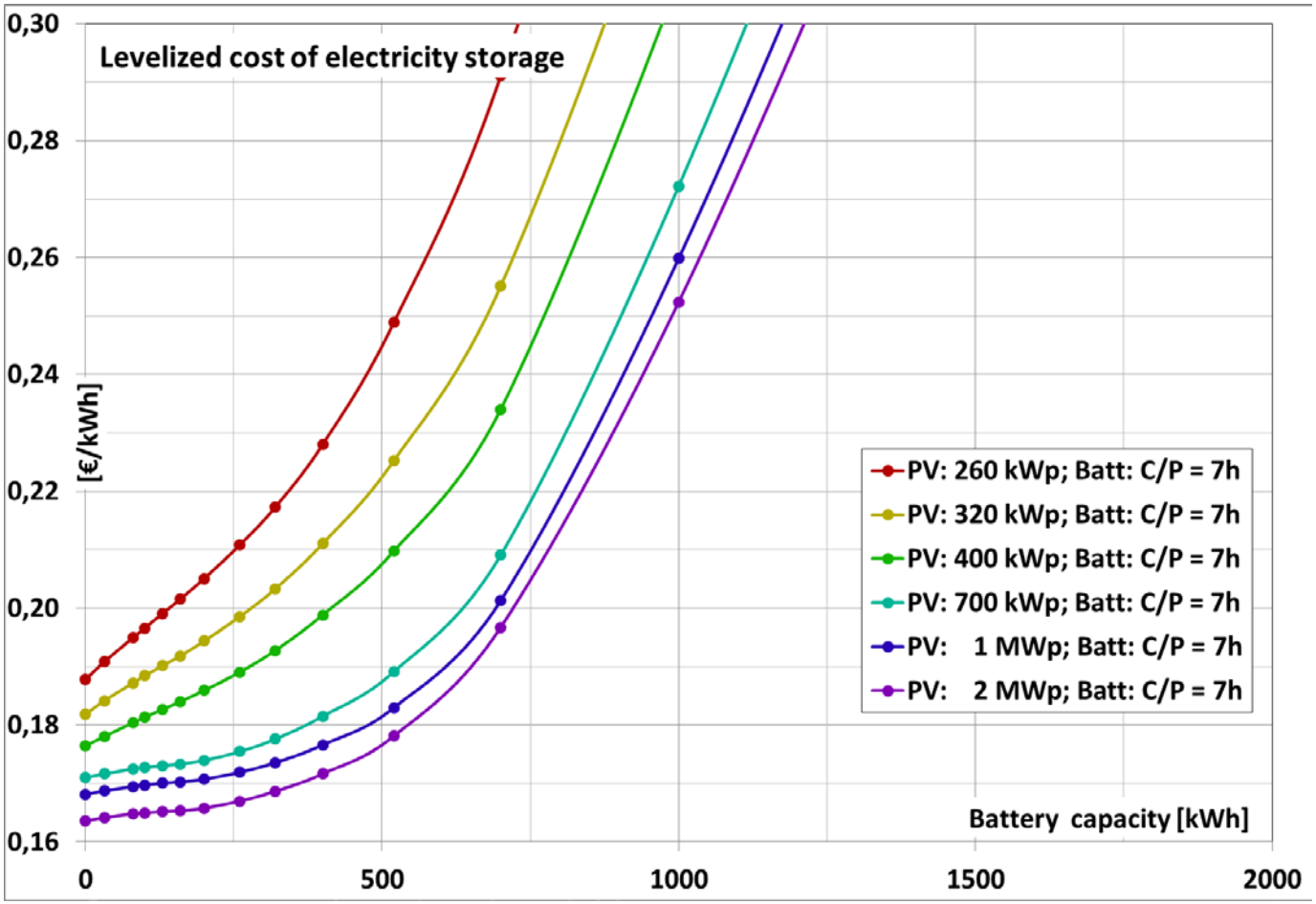
Example: Commercial PV battery system

Simulation based system analysis and design

Levelized cost of electricity storage



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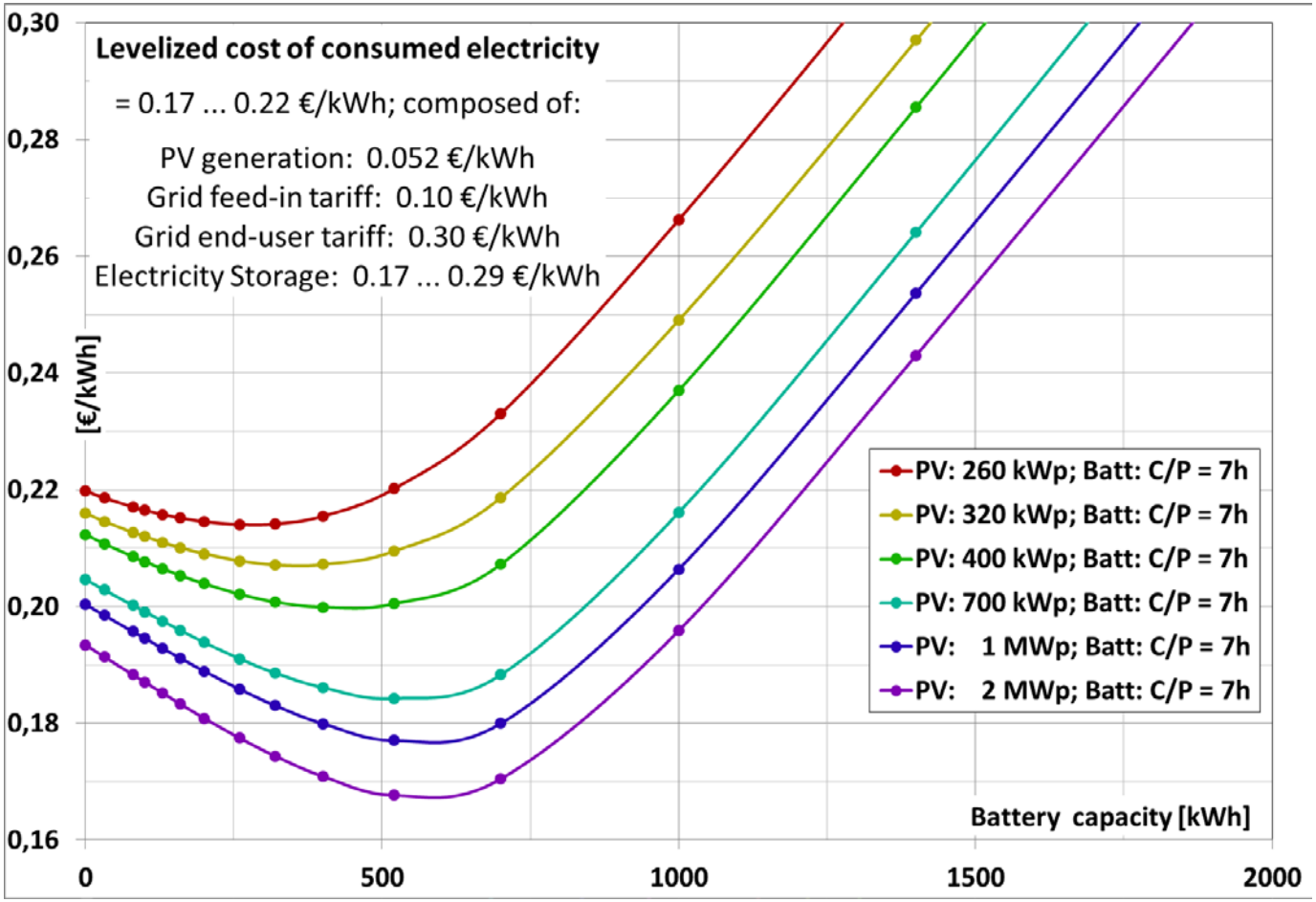
Example: Commercial PV battery system

Simulation based system analysis and design

Levelized cost of consumed electricity



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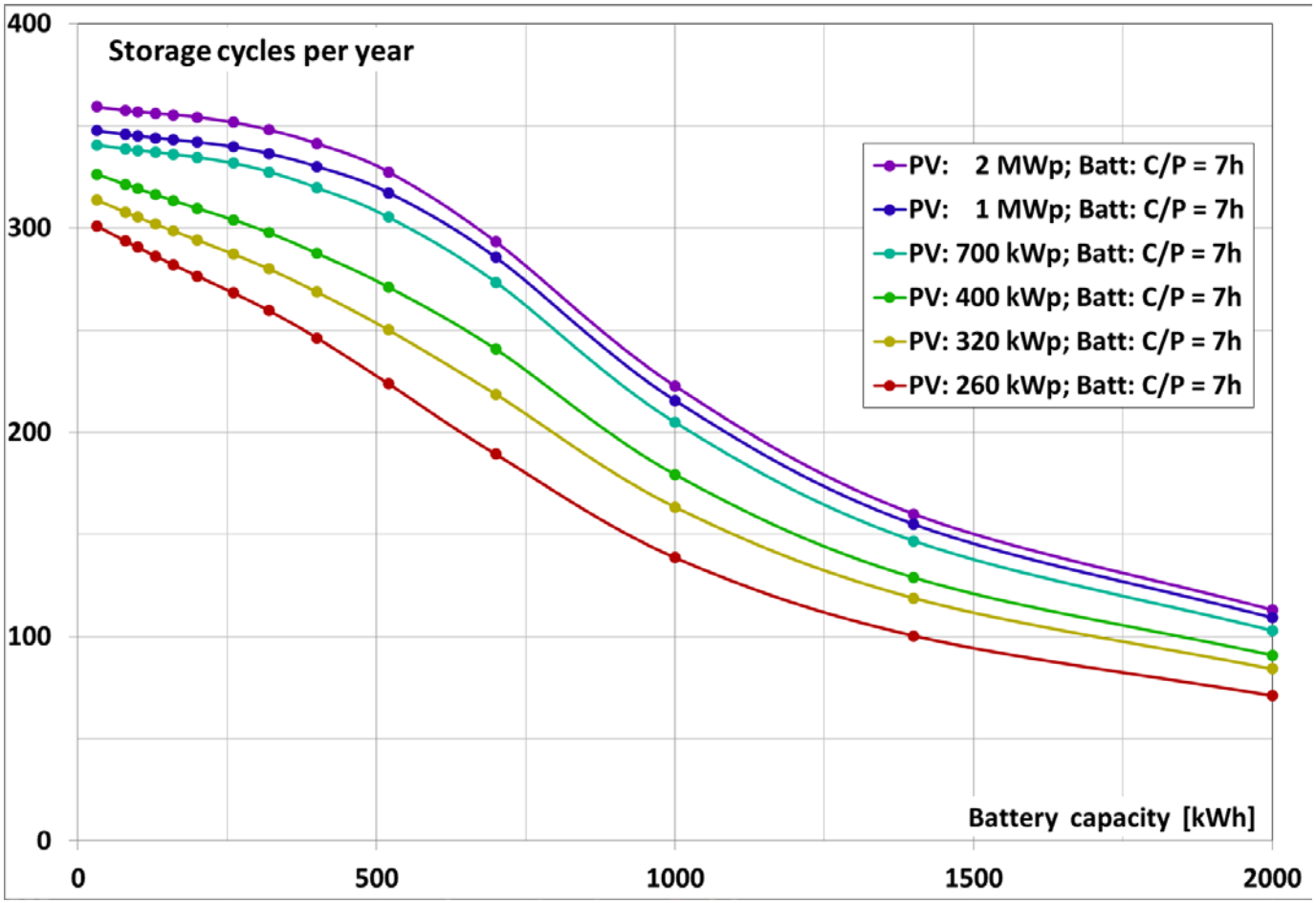
Example: Commercial PV battery system

Simulation based system analysis and design

Battery storage: Equivalent full cycles as a function of usable capacity and power



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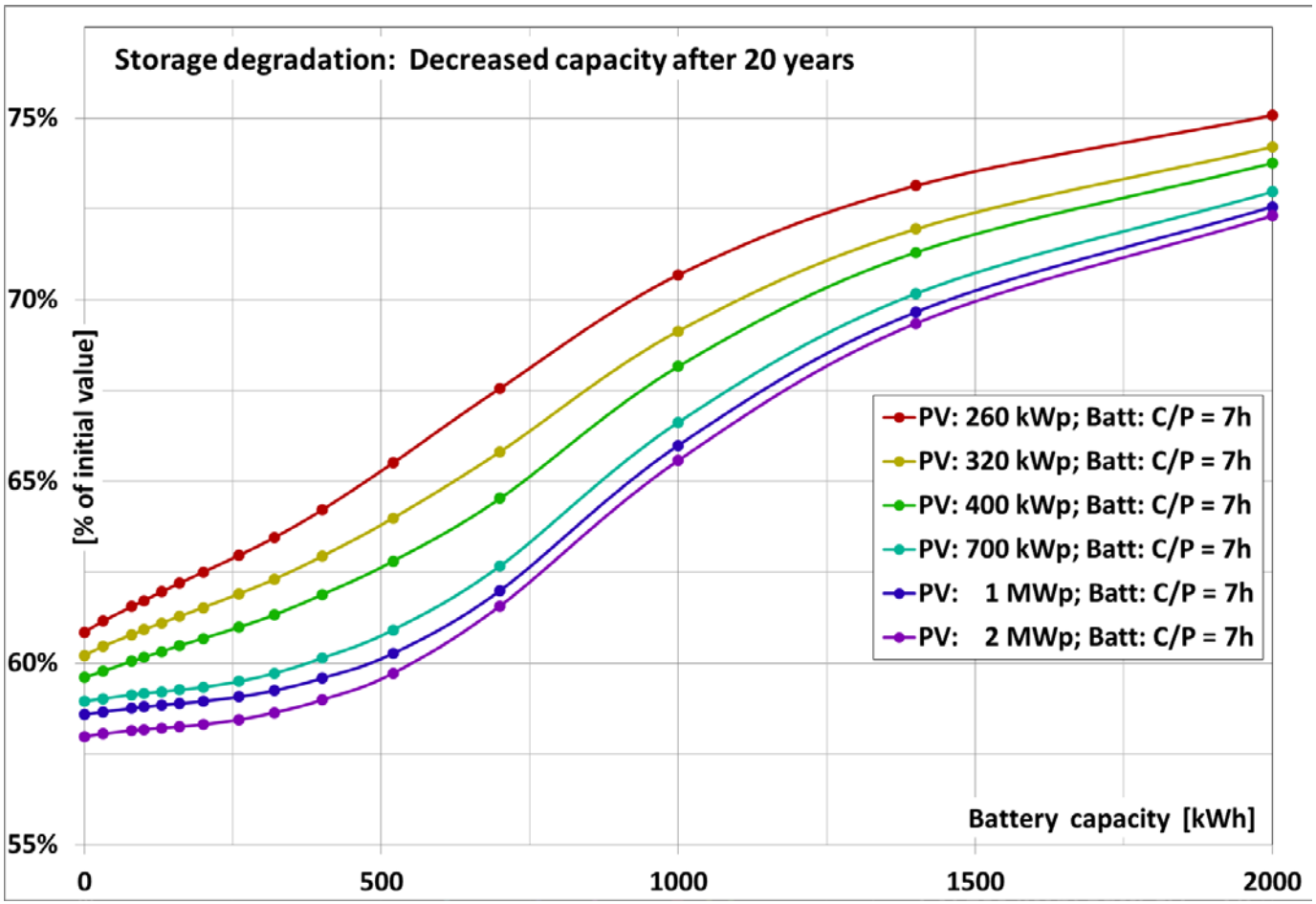
Example: Commercial PV battery system

Simulation based system analysis and design

Battery storage: Aging as a function of usable storage capacity and PV power



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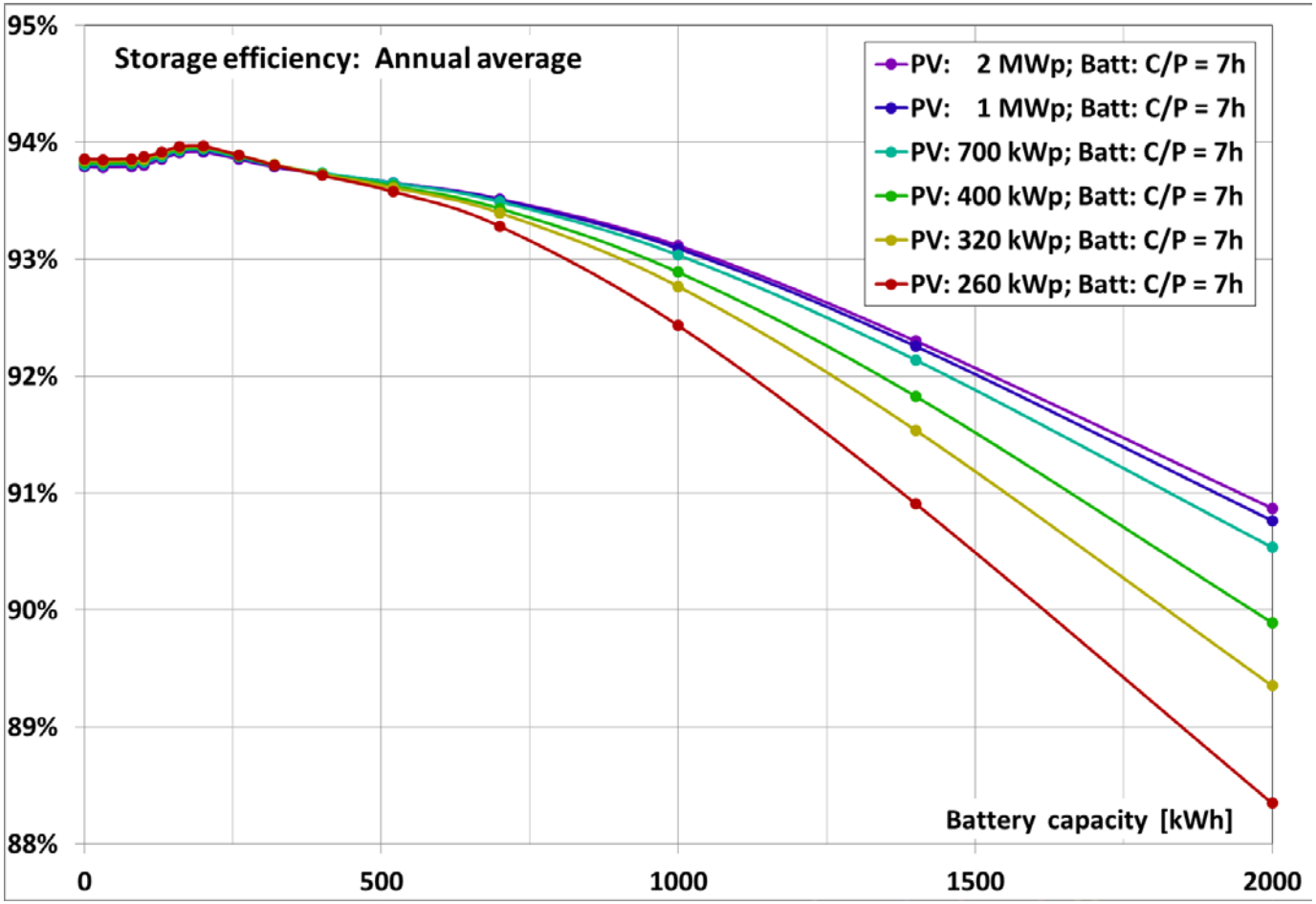
Example: Commercial PV battery system

Simulation based system analysis and design

Battery storage: Annual average storage efficiencies



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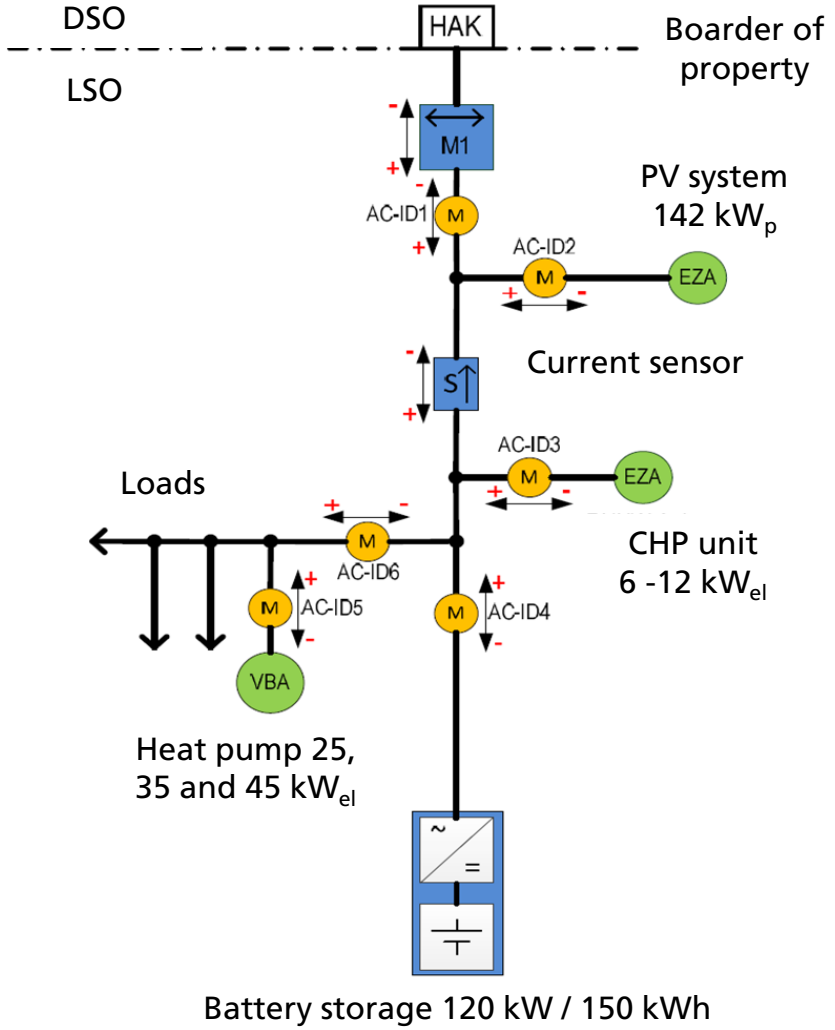
Example: District storage system – “Weinsberg”

Simulation based system design

Optimization criteria:

Minimization of grid dependency –

Physically not only accumulated



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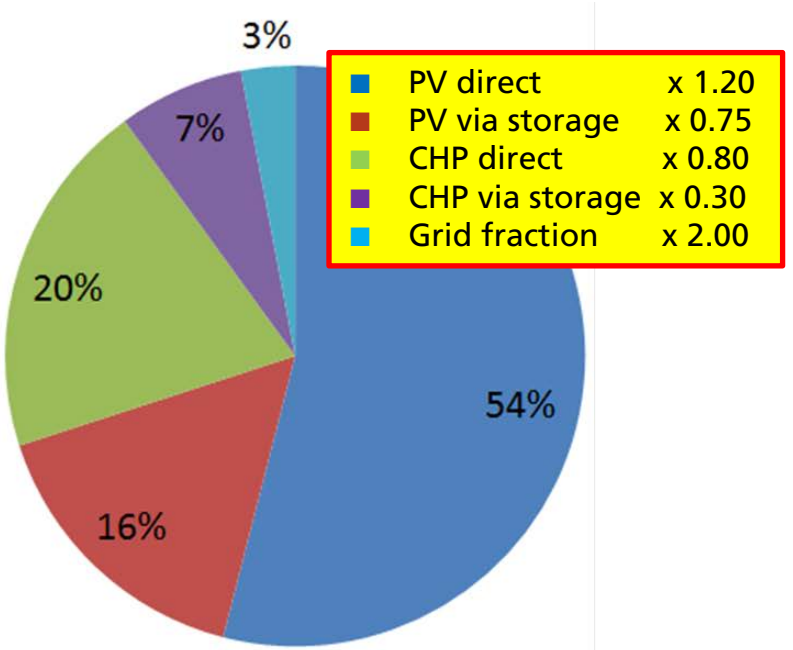
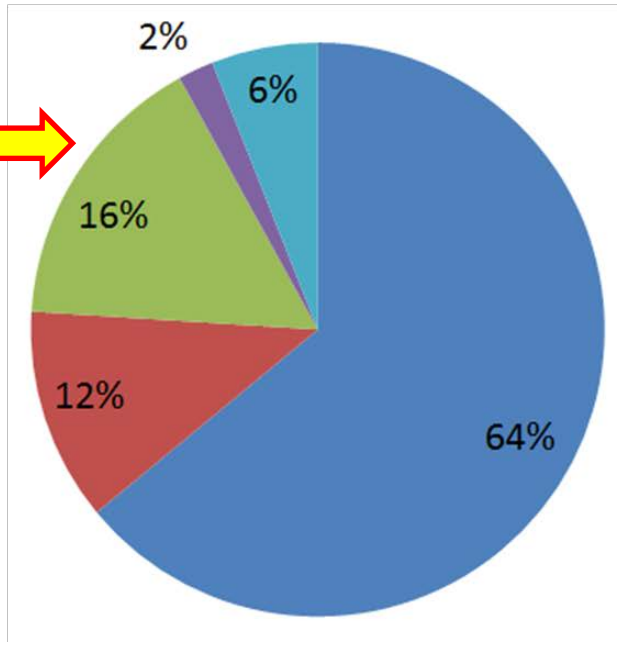
Example: District storage system – “Weinsberg”

Monitoring: Accumulated annual electrical energies

Simulation



Monitoring 2015 / 2016



Reasons for differences:

- Problems with air conditioning → To high temperatures in operation room → Shut-down of CHP unit and battery inverter
- Necessary maintenance interval of CHP unit in winter (!)
- End-users do not behave 100 % as predicted (!)

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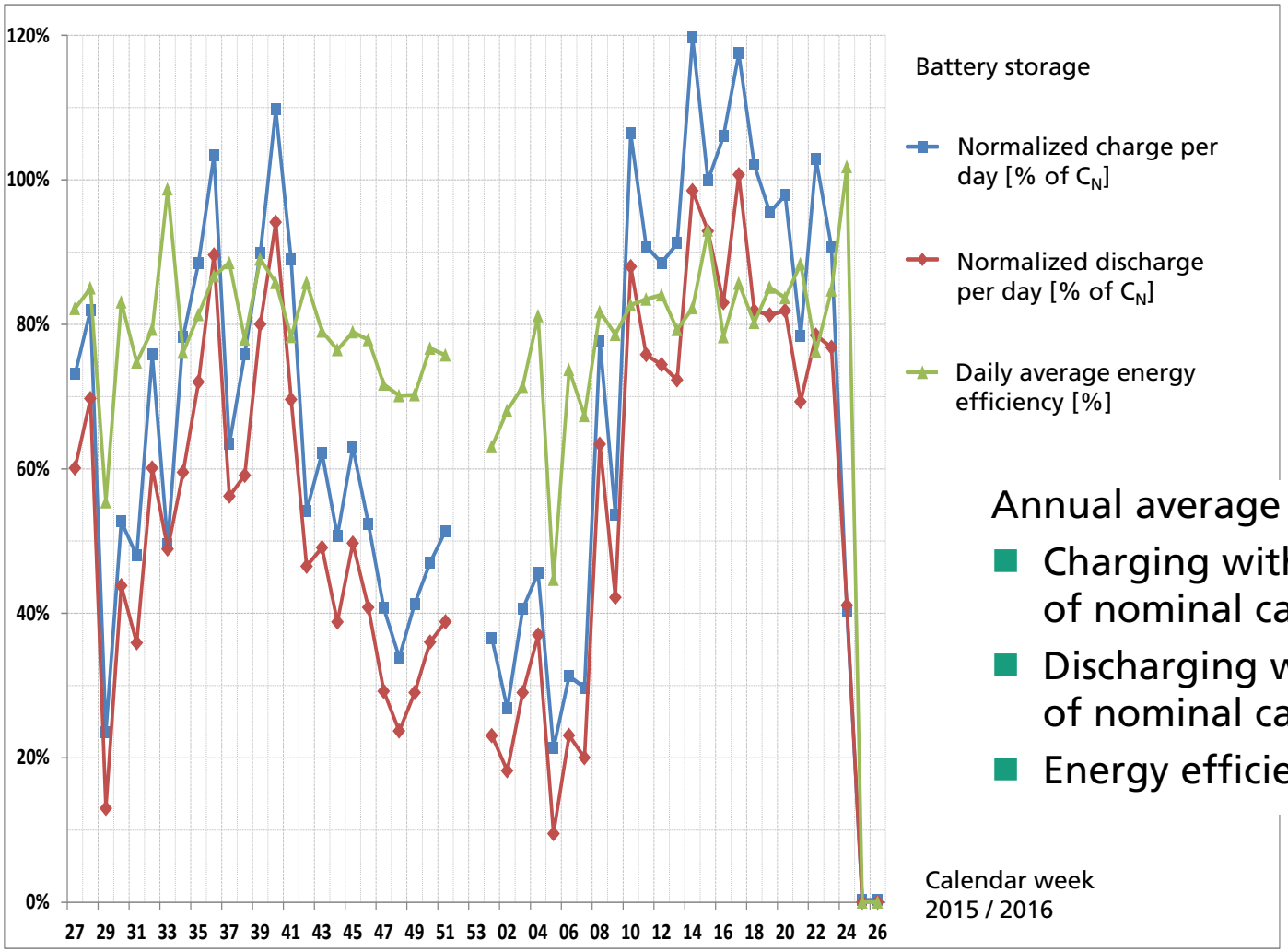
Example: District storage system – “Weinsberg”

Monitoring: Analysis of storage operation



Annual average values:

- Charging with 67 % of nominal capacity
- Discharging with 54 % of nominal capacity
- Energy efficiency: 81 %

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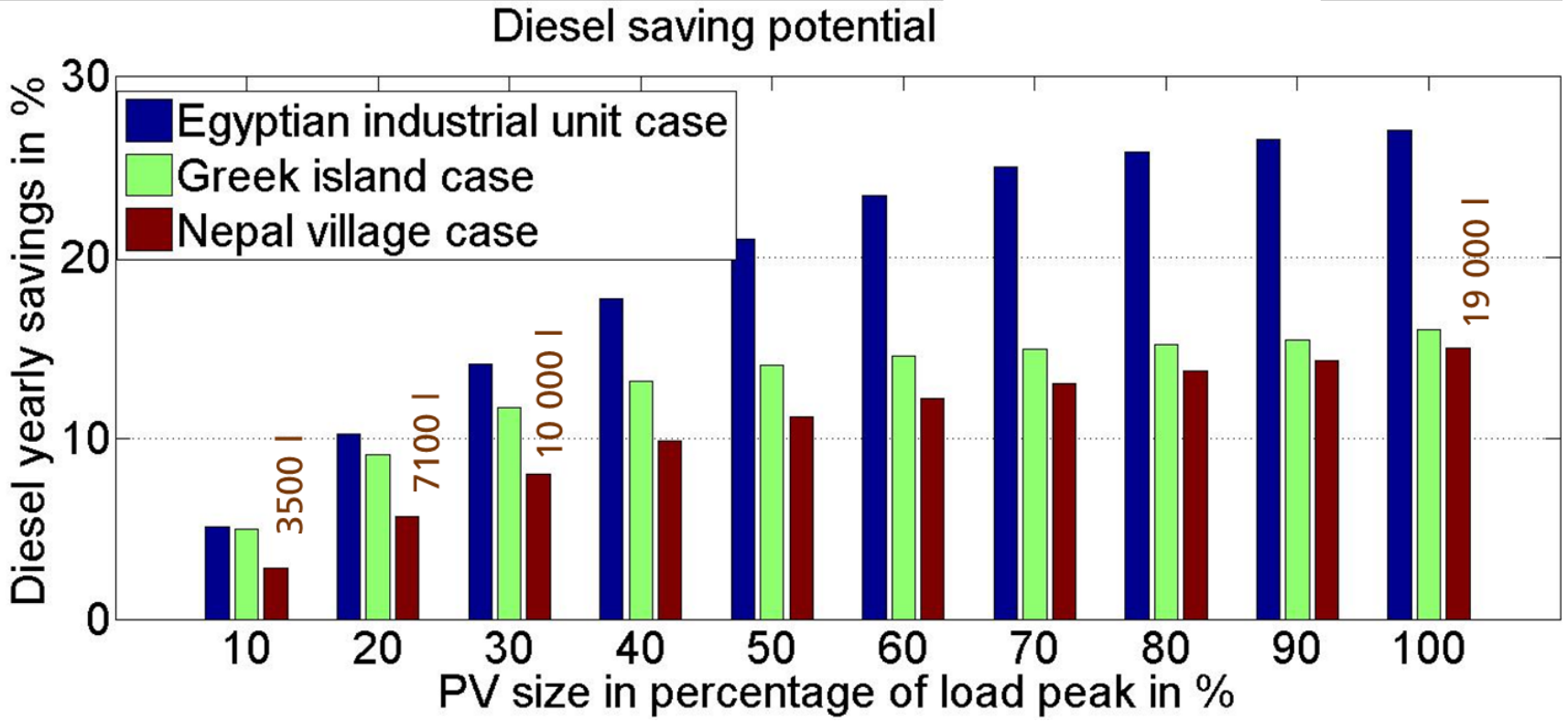
Example: PV mini-grids without storage

Simulation based system analysis and design

- 3 cases with varying load profiles
- Diesel consumption: Saturation at an application specific PV system size



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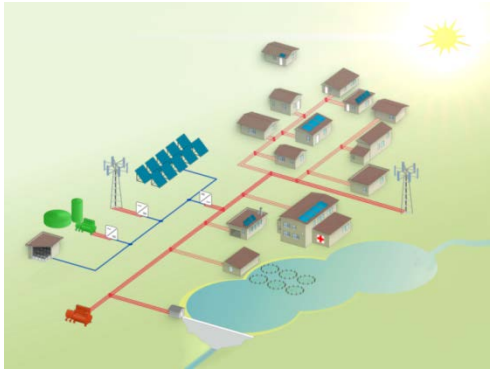
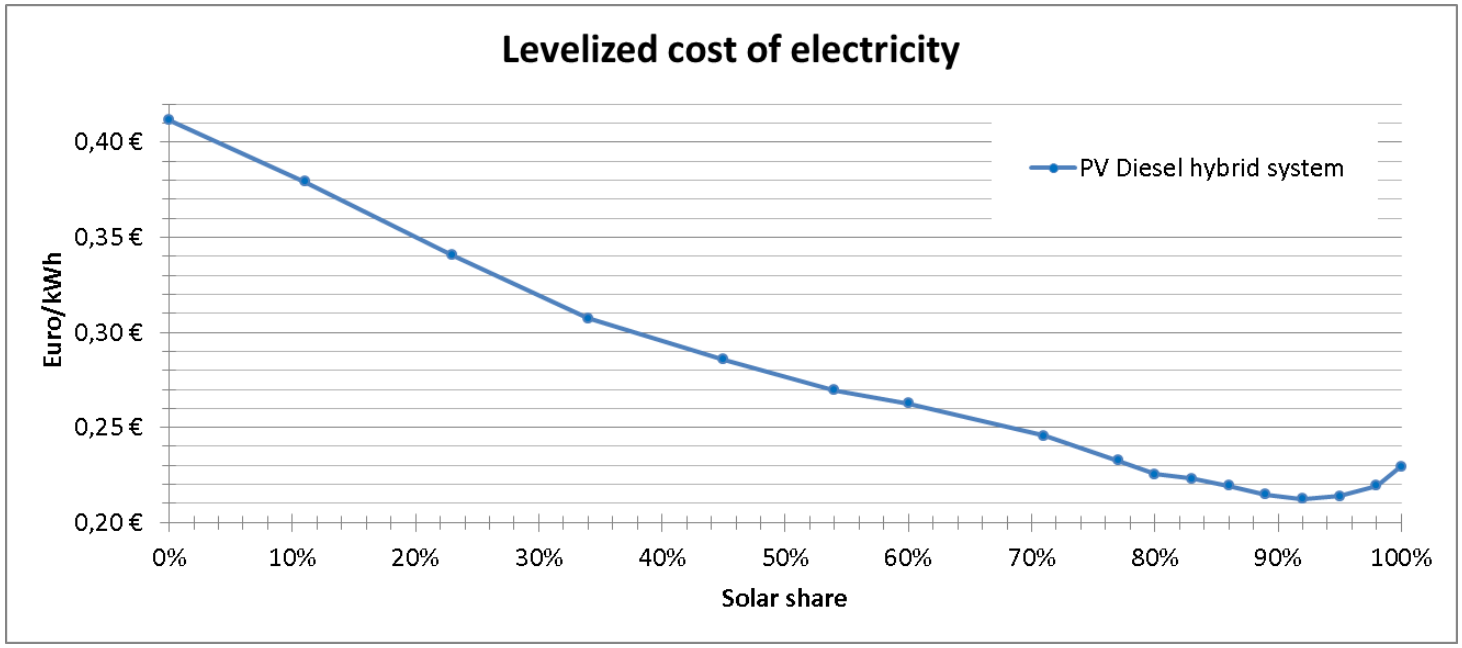
Example: PV mini-grids without storage

Simulation based system analysis and design



- Example Uganda
- Load:
  - Peak load: 200 kW
  - Annual consumption: 574 MWh
- PV Diesel hybrid system:
  - PV system (incl. power electronics): 1.5 Euro/Wp
  - Battery system: 220 Euro/kWh
  - Diesel: Invest 273 $/kW; Fuel 1$/l; Maintenance: 0.7 $/h



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Conclusions

- Integration of battery storage in PV power plants, commercial PV systems and hybrid PV mini-grids requires several steps of **quality assurance**:
  - From detailed load profile analyses to application specific system design and yield prediction
  - From characterization of components in the laboratory to system testing in the field and quality monitoring of the entire power plant
- Detailed **simulation based system analysis**:
  - Enables an "early" identification of application specific operating conditions of a battery storage
  - Enables life time predictions and determination of levelized cost of energy storage and levelized cost of consumed energy by using aging models
  - Enables an application specific optimization of the entire system design
  - Enables an application specific optimization of the operating control strategies
- **Monitoring** of battery storage systems:
  - Very important as no long-term field experience exists with new technologies
  - Enables an early identification of component and system failures
  - Enables a verification of the system design and an early identification of optimization potential (component and system level)

Thanks for your attention !!!

Fraunhofer Institute for Solar Energy Systems ISE

Dr. Matthias Vetter

www.ise.fraunhofer.de
matthias.vetter@ise.fraunhofer.de