Risk mitigation and quality assurance for PV battery storage applications

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Fraunhofer Institute for
Solar Energy Systems ISE

Asia Clean Energy Summit

Singapore, 25th – 27th of October 2016

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Agenda

- Introduction to Fraunhofer ISE battery activities
- Motivation and applications of larger PV battery systems
- Quality assurance for PV power plants with battery storage
- Quality assurance for commercial PV battery systems and PV Diesel grids
- Example of a commercial PV battery system
  - Analysis of load profile
  - Simulation based system design and cost analyses
- Perspective: Multiple use of storage
- Conclusions

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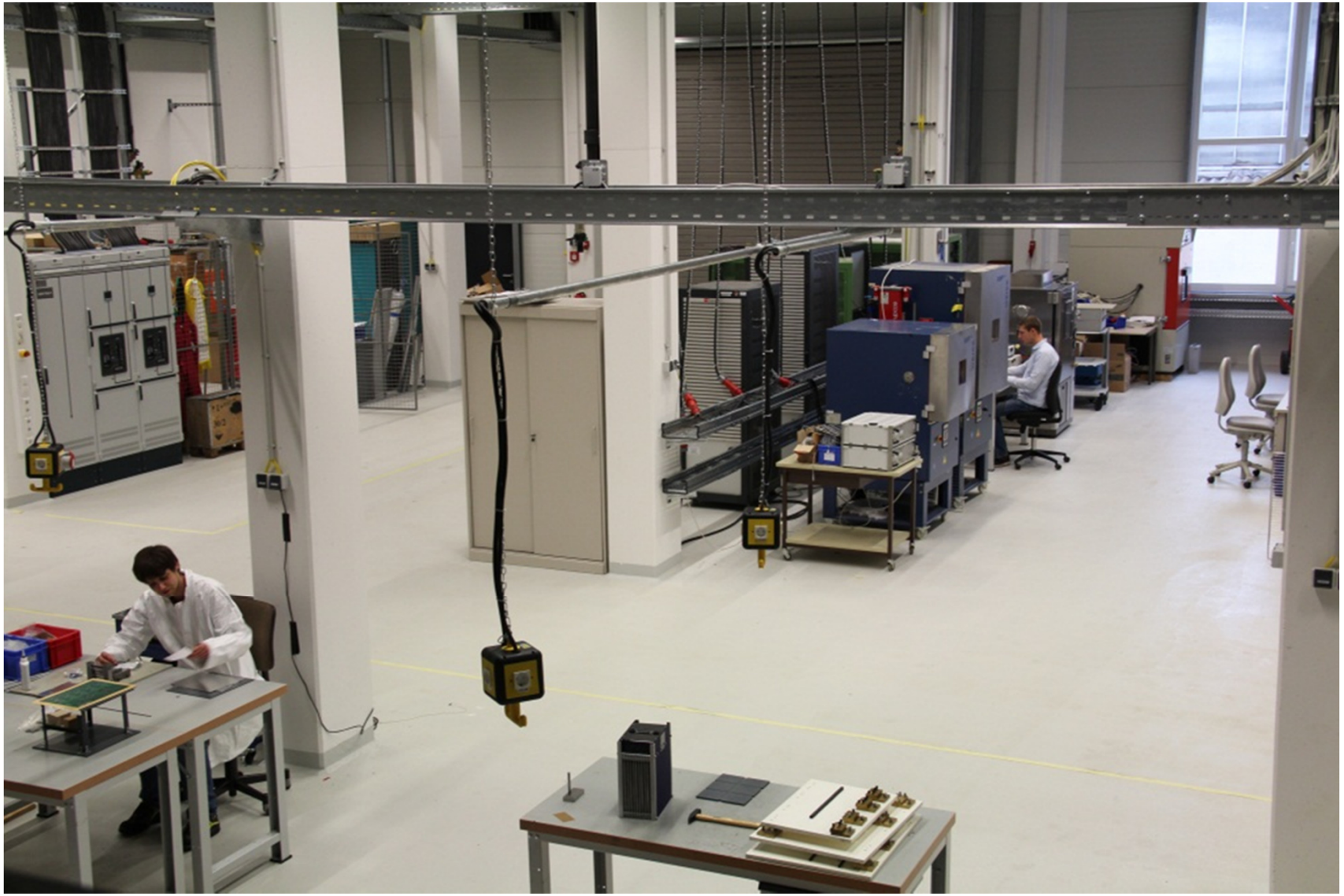
Battery system technology
R&D at Fraunhofer ISE

- **Formation of battery cells:** Last production step, essential for performance and life time of lithium-ion cells
- **Cell / module / system tests and analyses:** Performance, aging, reliability, functional safety, post mortem
- **Modeling and simulation:** From detailed aging and thermal models for life time prediction to performance models for system analyses
- **Battery module and system development:** From small home storage applications to large hybrid systems
- **Battery management:** From algorithms for state estimation and operating control strategies to hardware implementation
- **Thermal management:** From passive to high efficient active methods with model predictive control for optimized operation
- **Integration in energy systems:** From interface specification and energy management systems to implementation
- **Quality assurance, safety and certification:** Accompanying of product developments and implementation projects (e.g. commercial PV battery systems) via cooperation with renowned partners

Battery laboratory



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Cell and system characterization

max. current	10 A	30 .. 300 A	1000 A
max. voltage	up to 18 V	5 .. 500 V	600 V
Channels	84	94	1
Cell example	2 Ah (18650)	20 Ah (pouch)	System test

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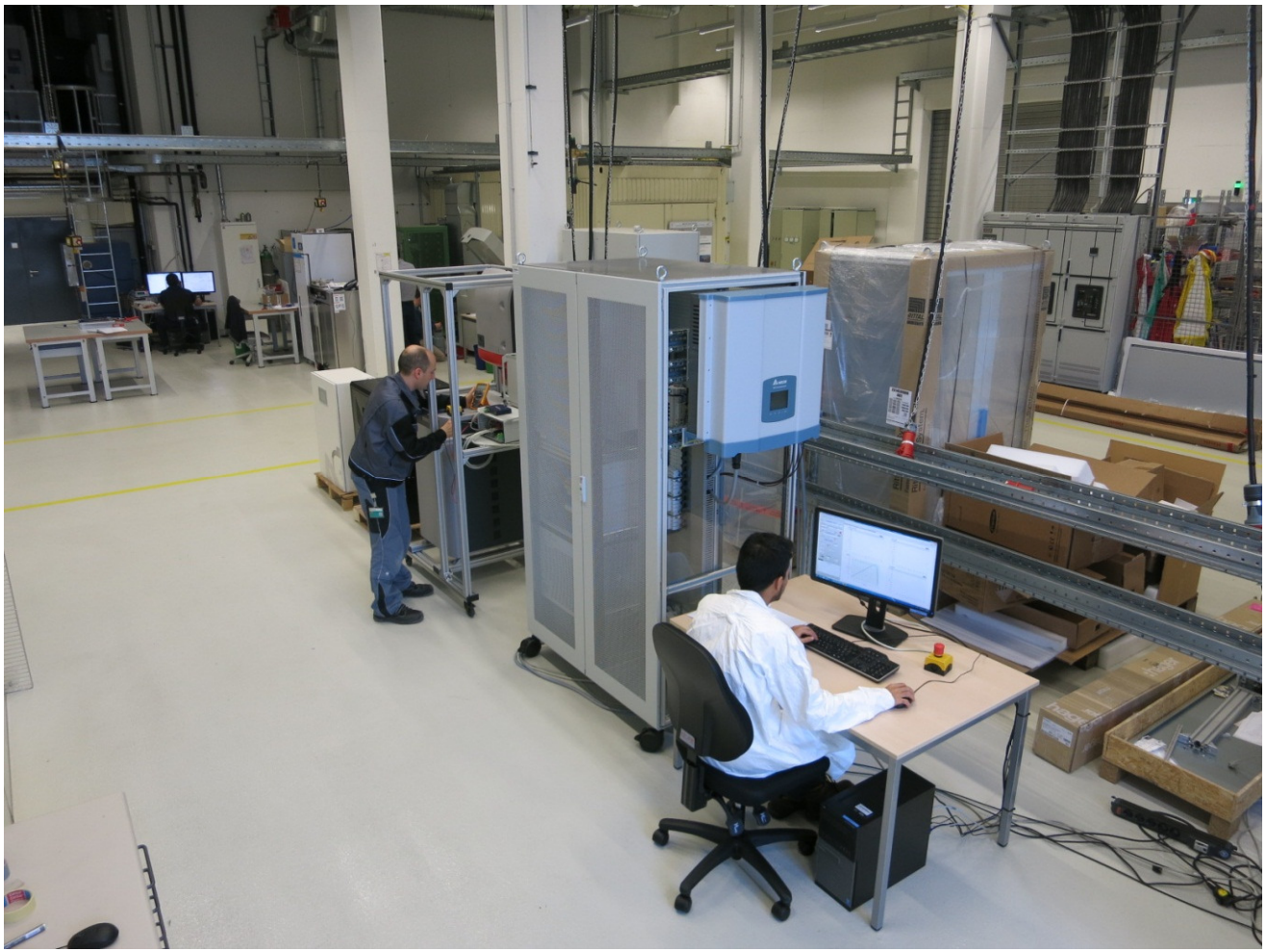
Test and characterization of PV home storage systems

- DC coupled systems
- AC coupled systems
- Max. power: 15 kW
- PV simulator
- Load simulator



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Climate chambers and Calorimeter IBC 284

300 A cycler

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Motivation and applications of larger PV 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

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Quality assurance for PV 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 PV power plants with battery storage

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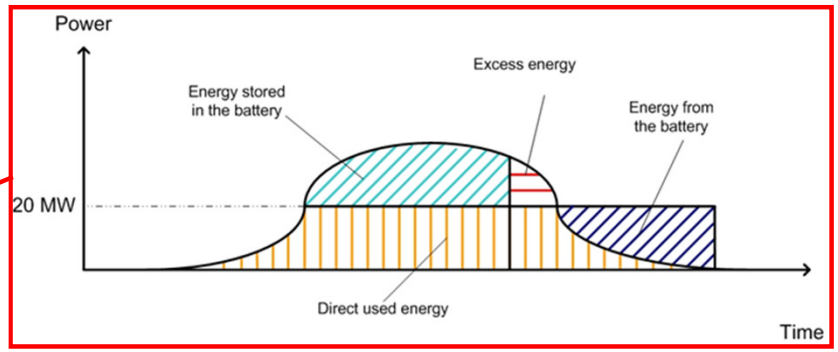

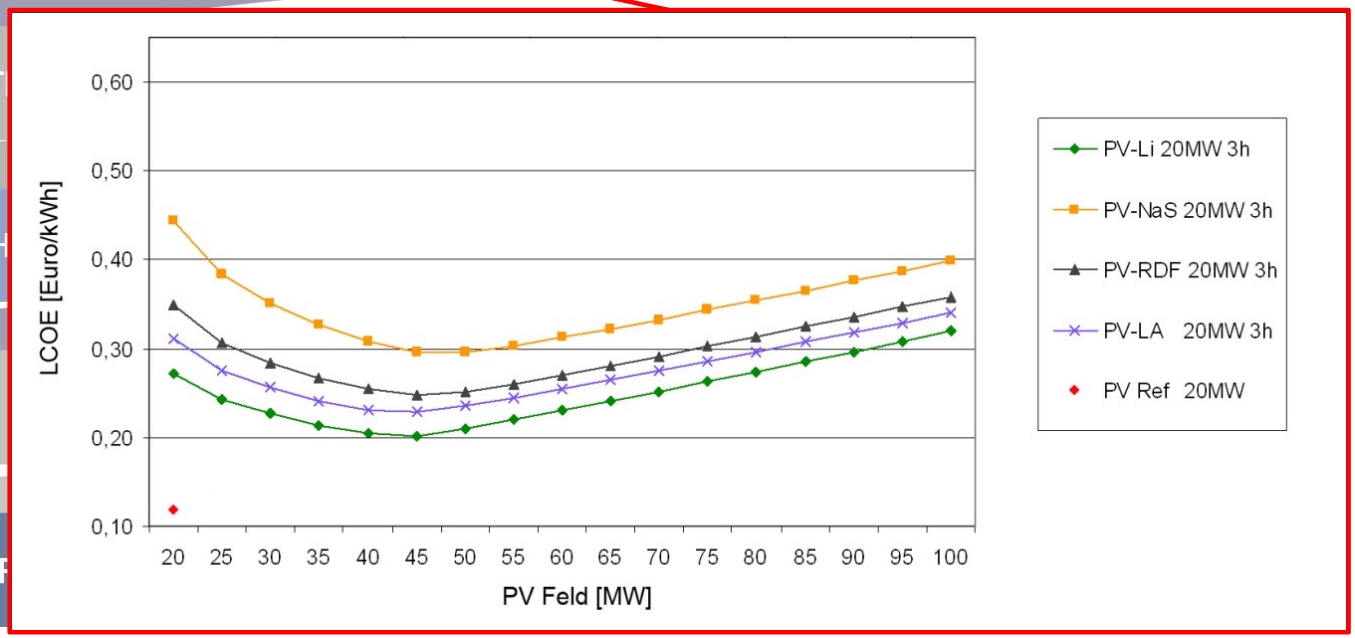

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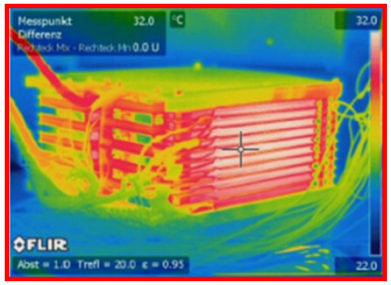
Quality assurance for PV power plants with battery storage

From project planning to system monitoring



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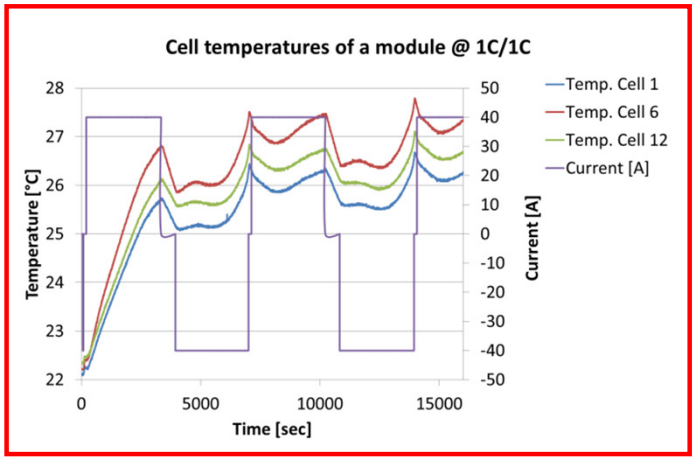

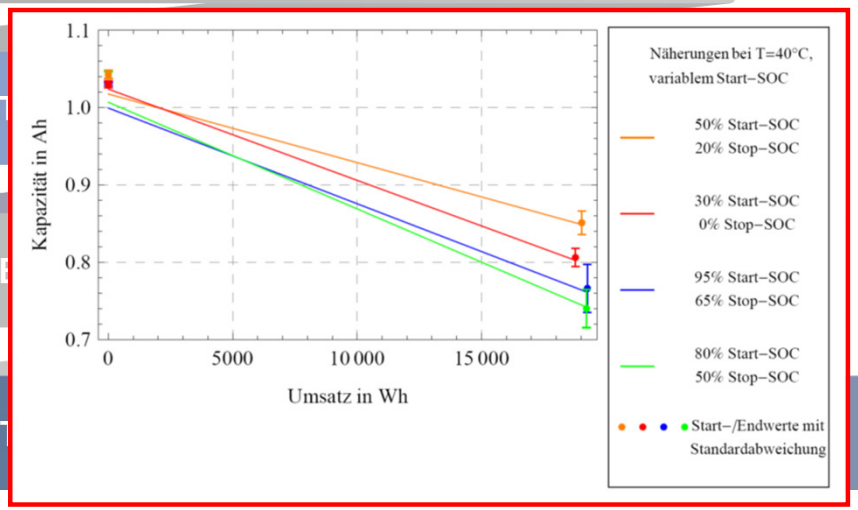

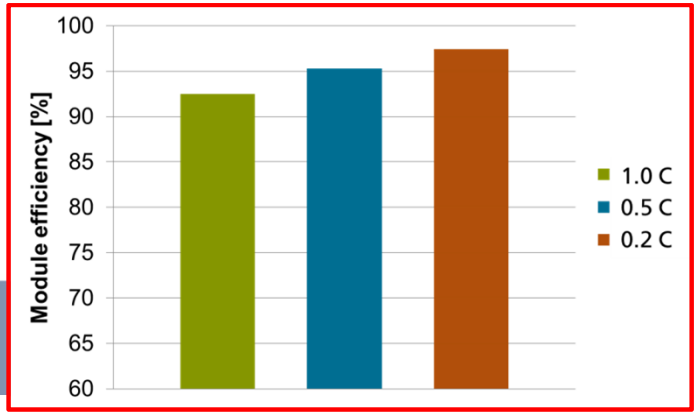

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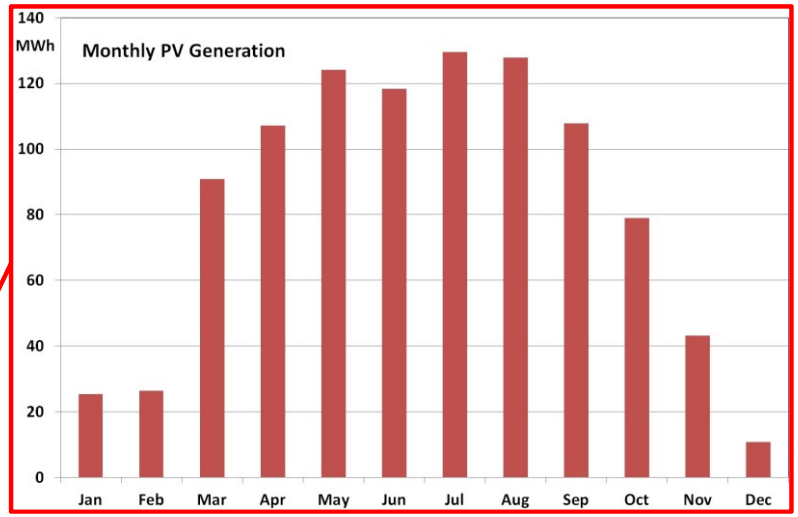

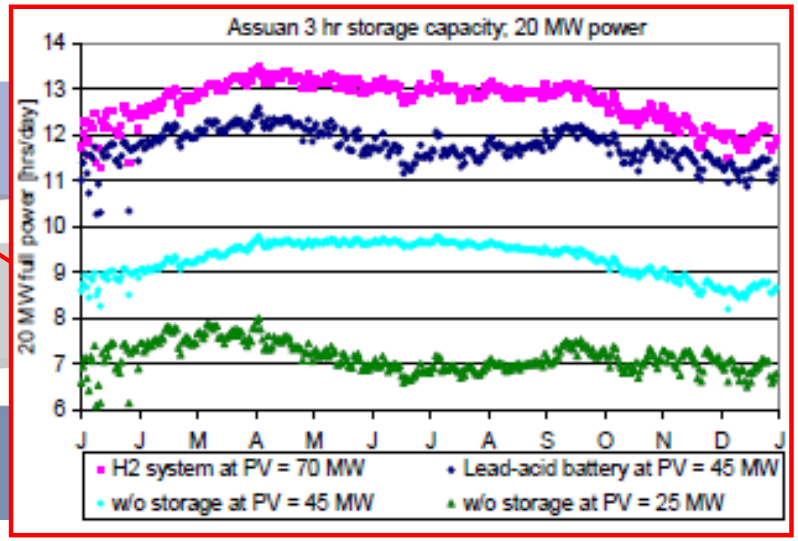

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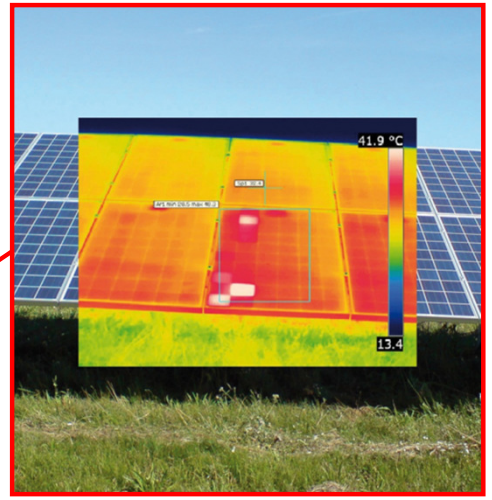

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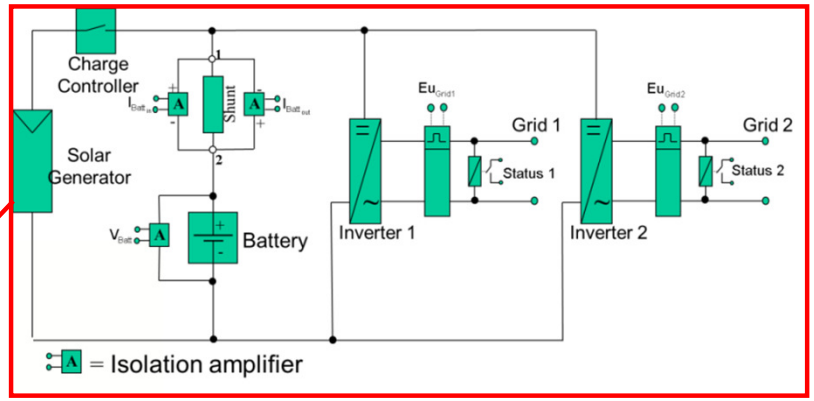

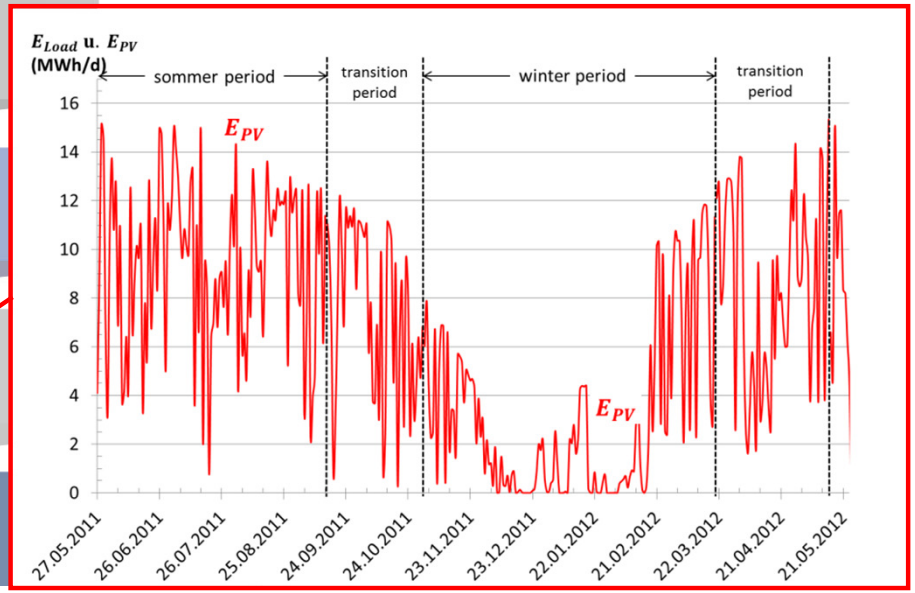

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Quality assurance for commercial PV battery systems and PV Diesel grids

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

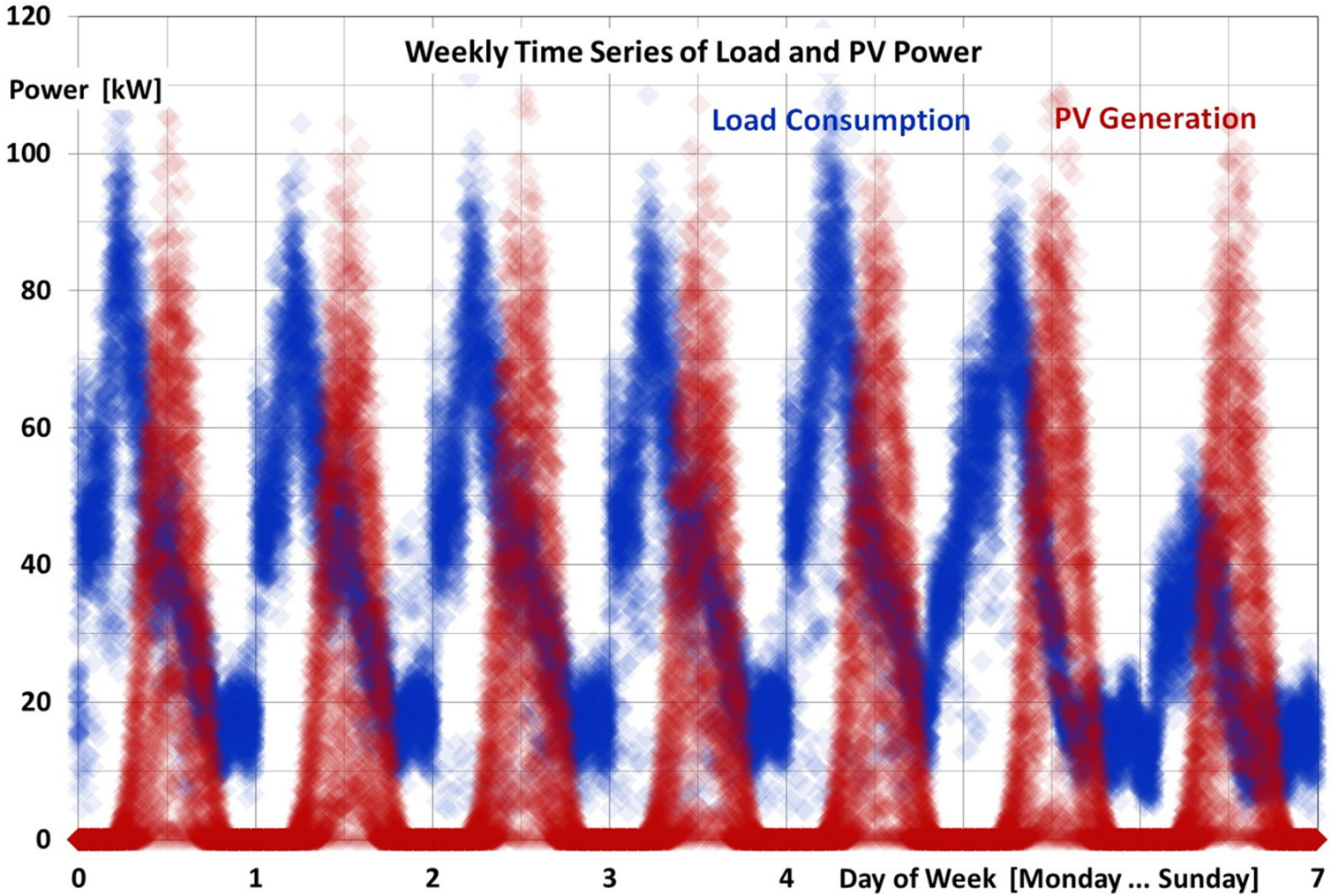
Analyses of load profile and PV generation profile

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

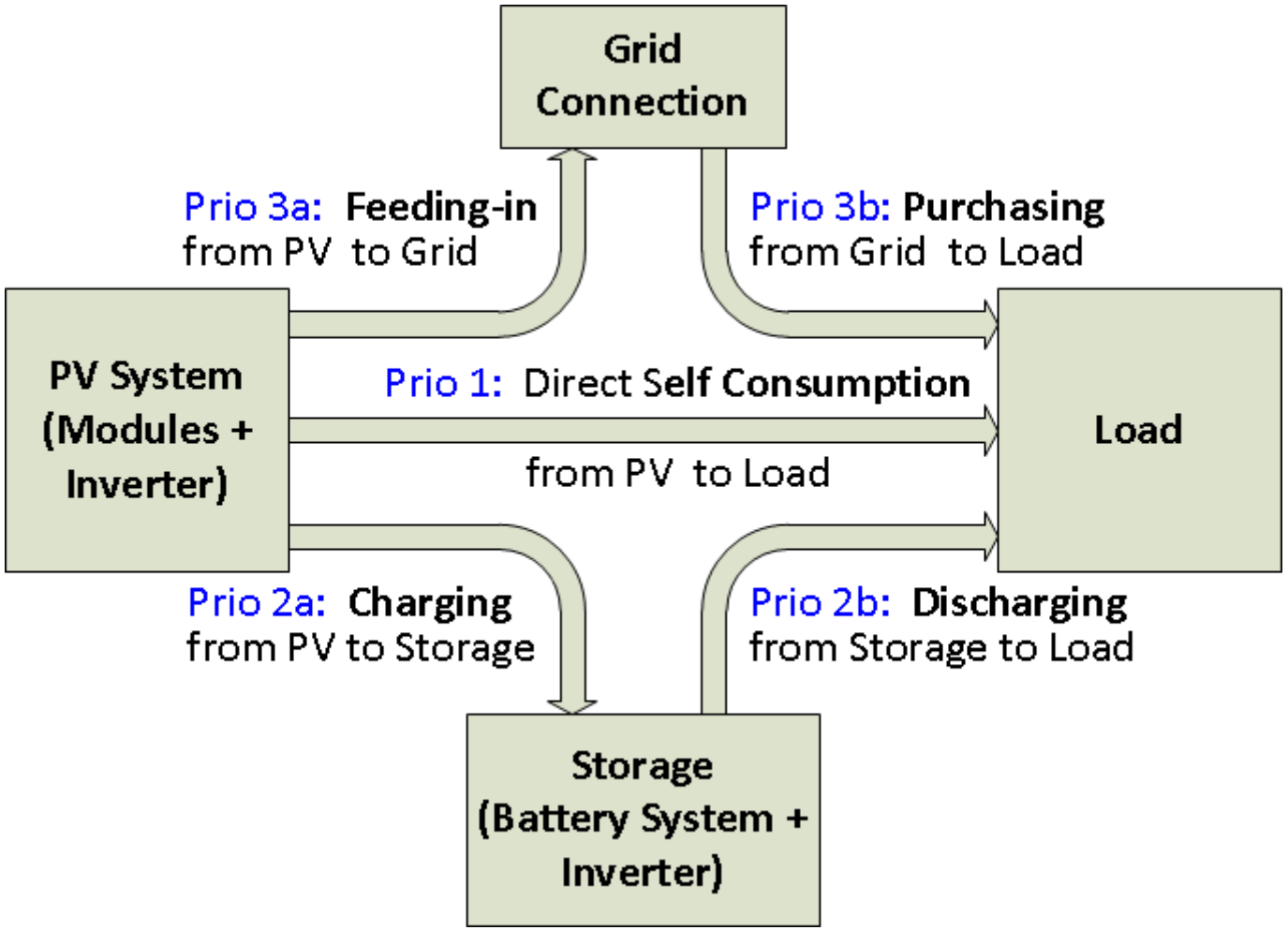
Simulation based system analyses and dimensioning

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



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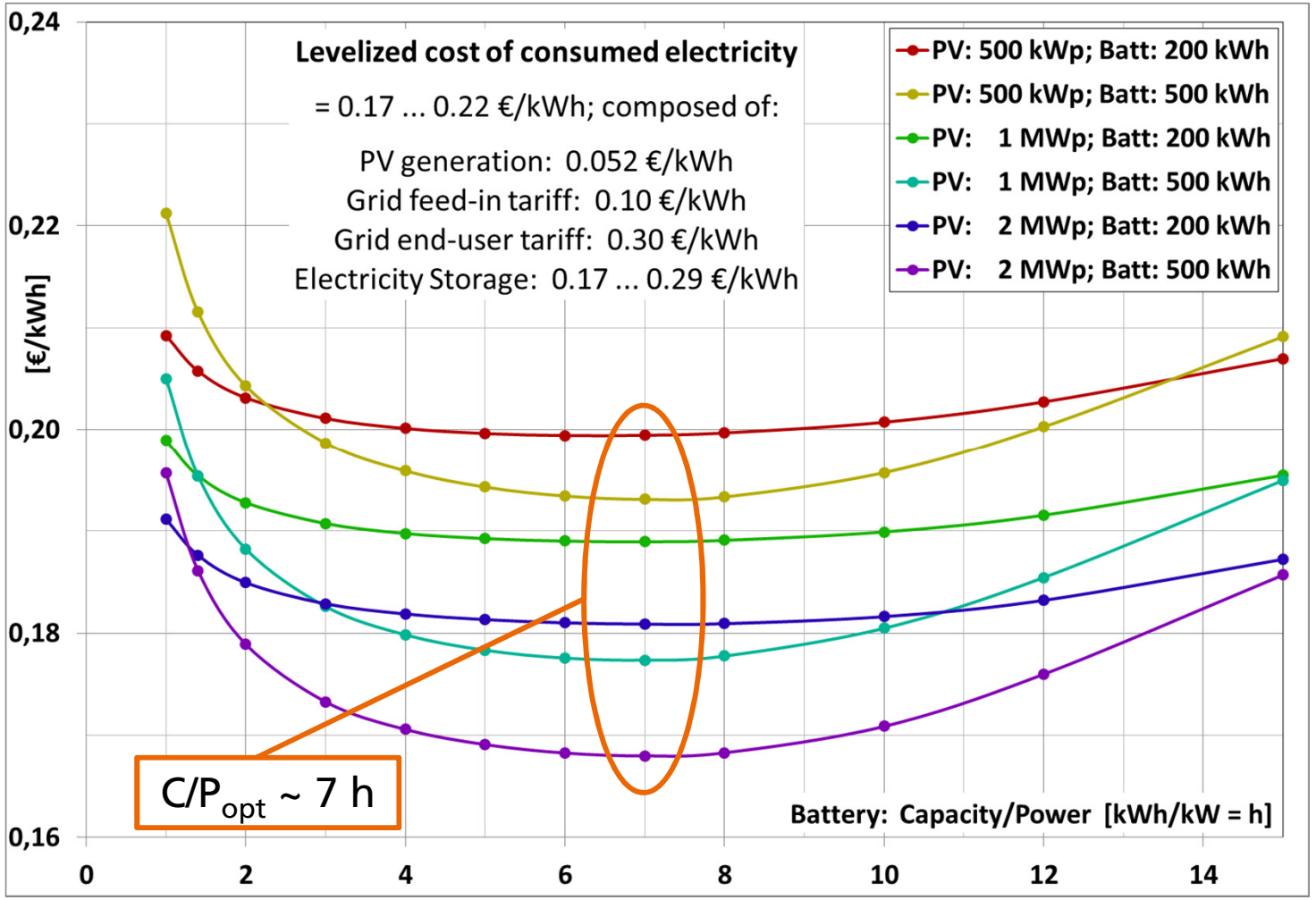
Example: Commercial PV battery system

Simulation based system analyses and dimensioning

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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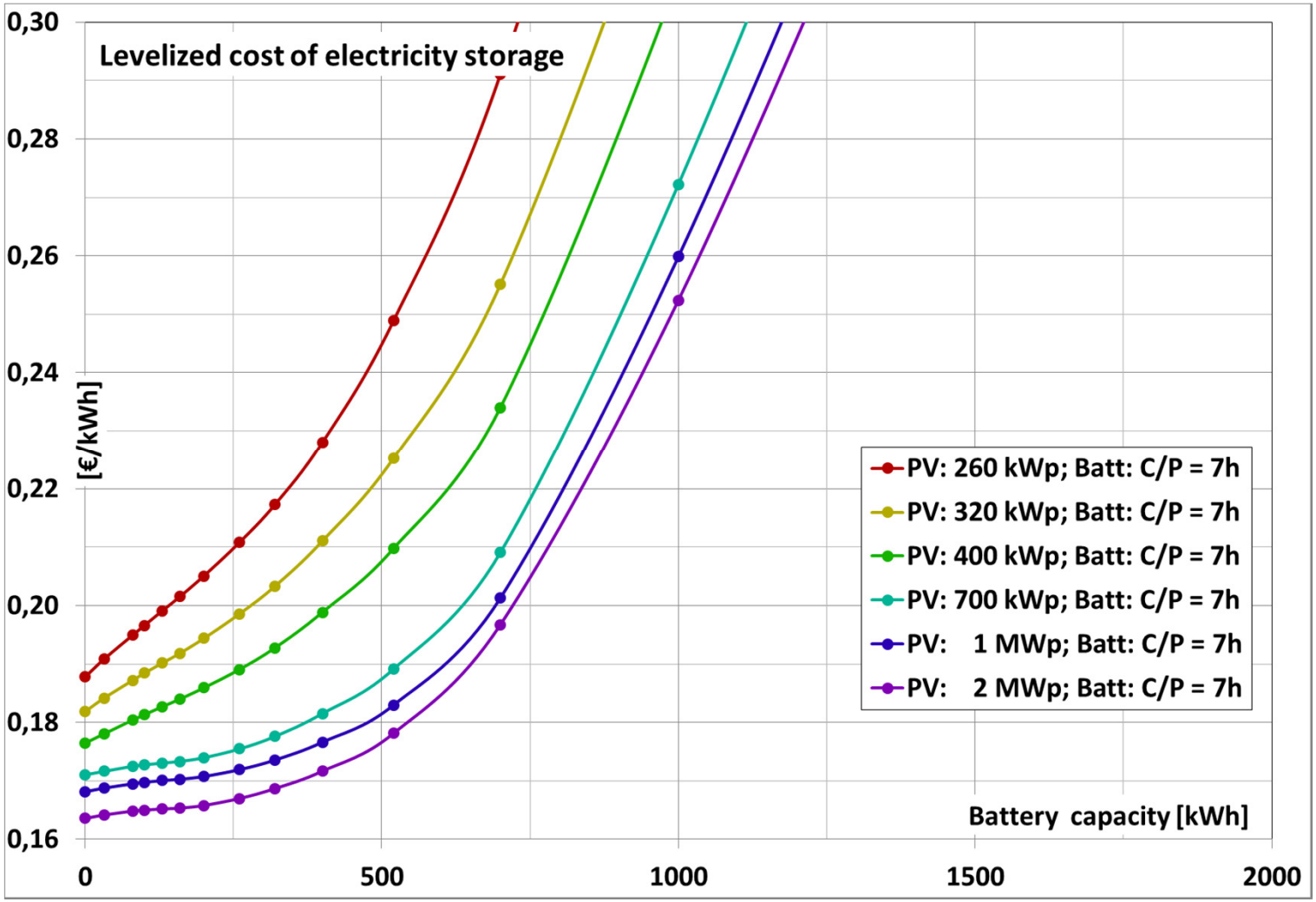
Example: Commercial PV battery system

Simulation based system analyses and dimensioning

Levelized cost of electricity storage



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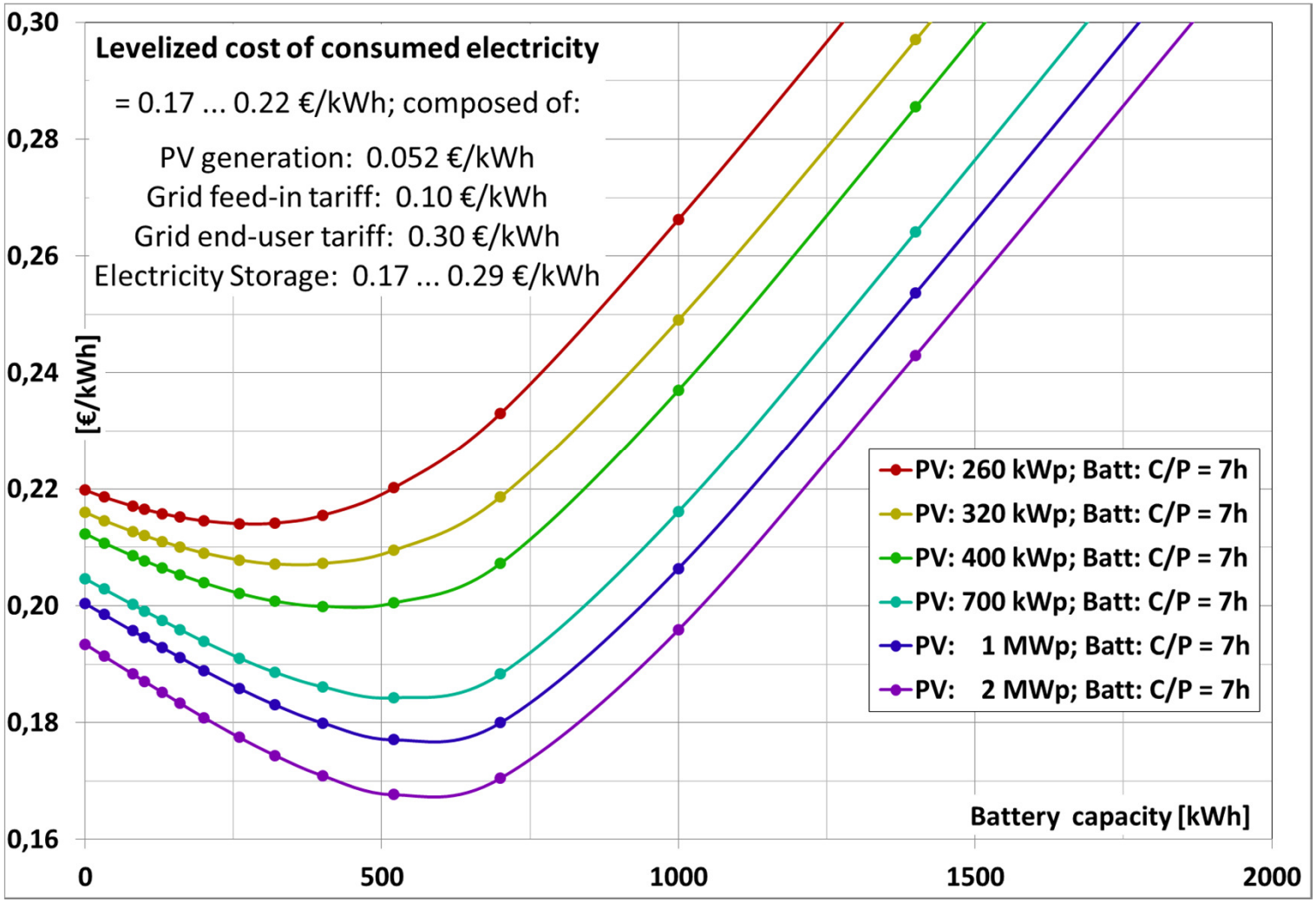
Example: Commercial PV battery system

Simulation based system analyses and dimensioning

Levelized cost of consumed electricity



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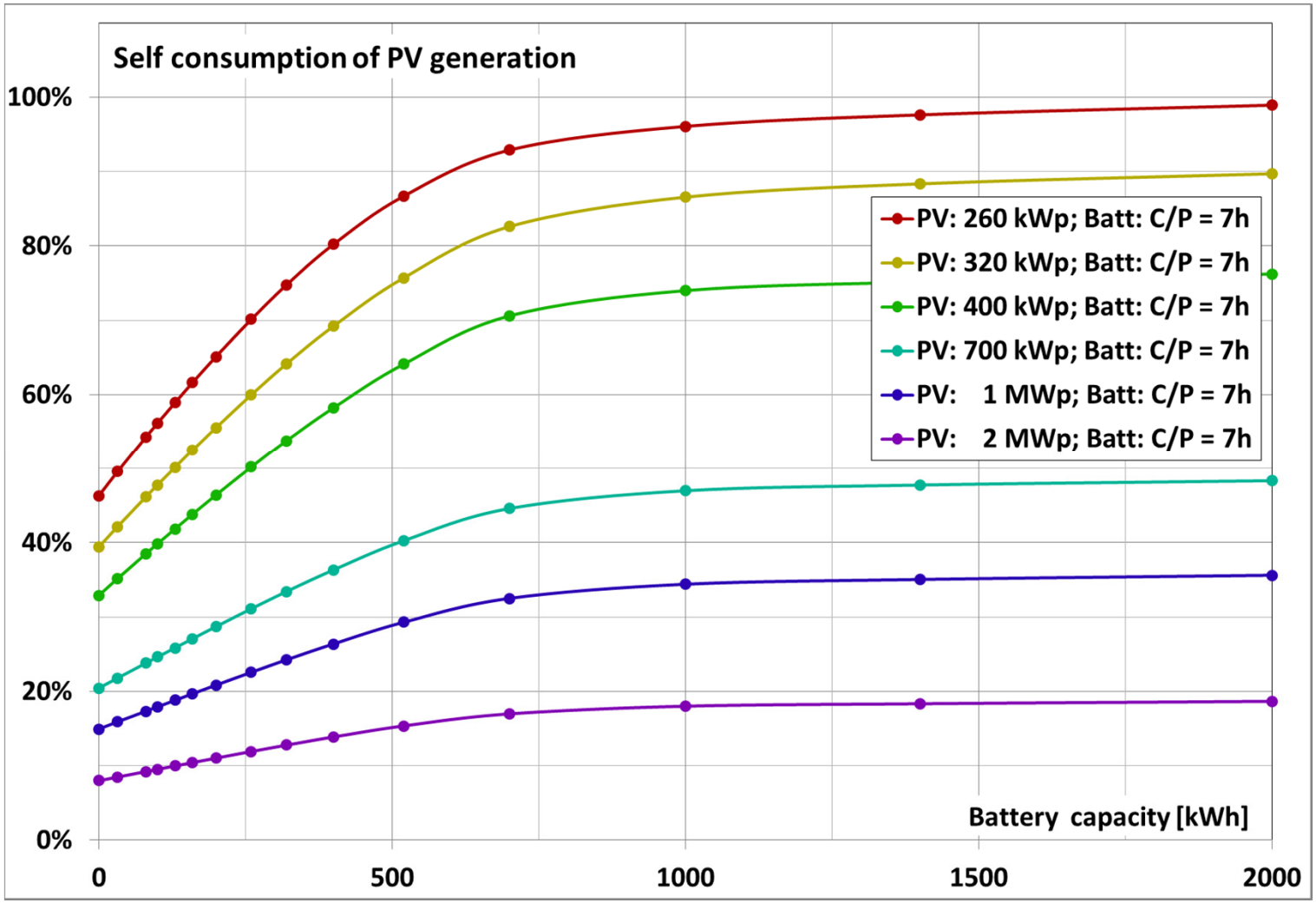
Example: Commercial PV battery system

Simulation based system analyses and dimensioning

Self consumption as a function of usable storage capacity and PV power



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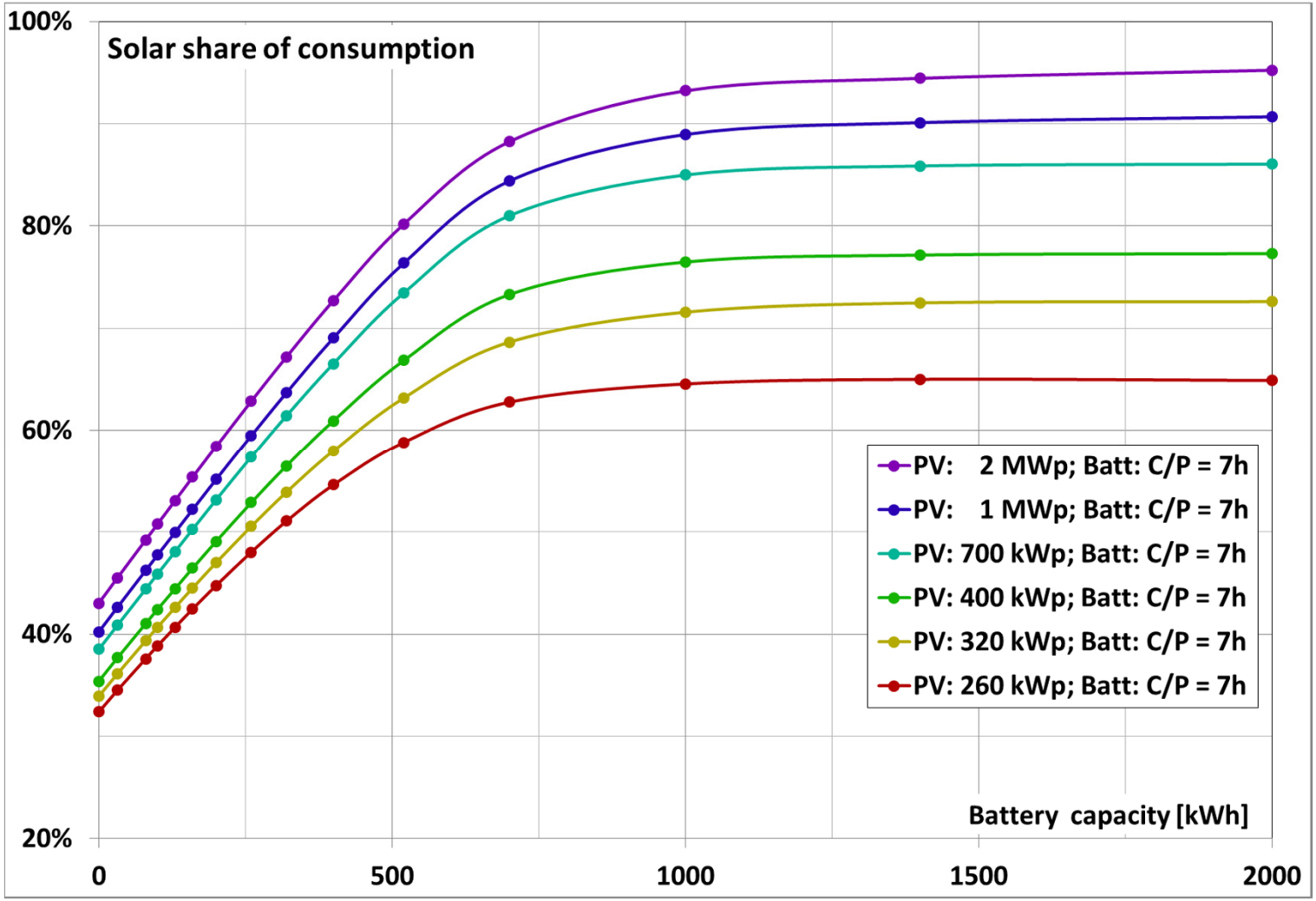
Example: Commercial PV battery system

Simulation based system analyses and dimensioning

Solar share as a function of usable storage capacity and PV power



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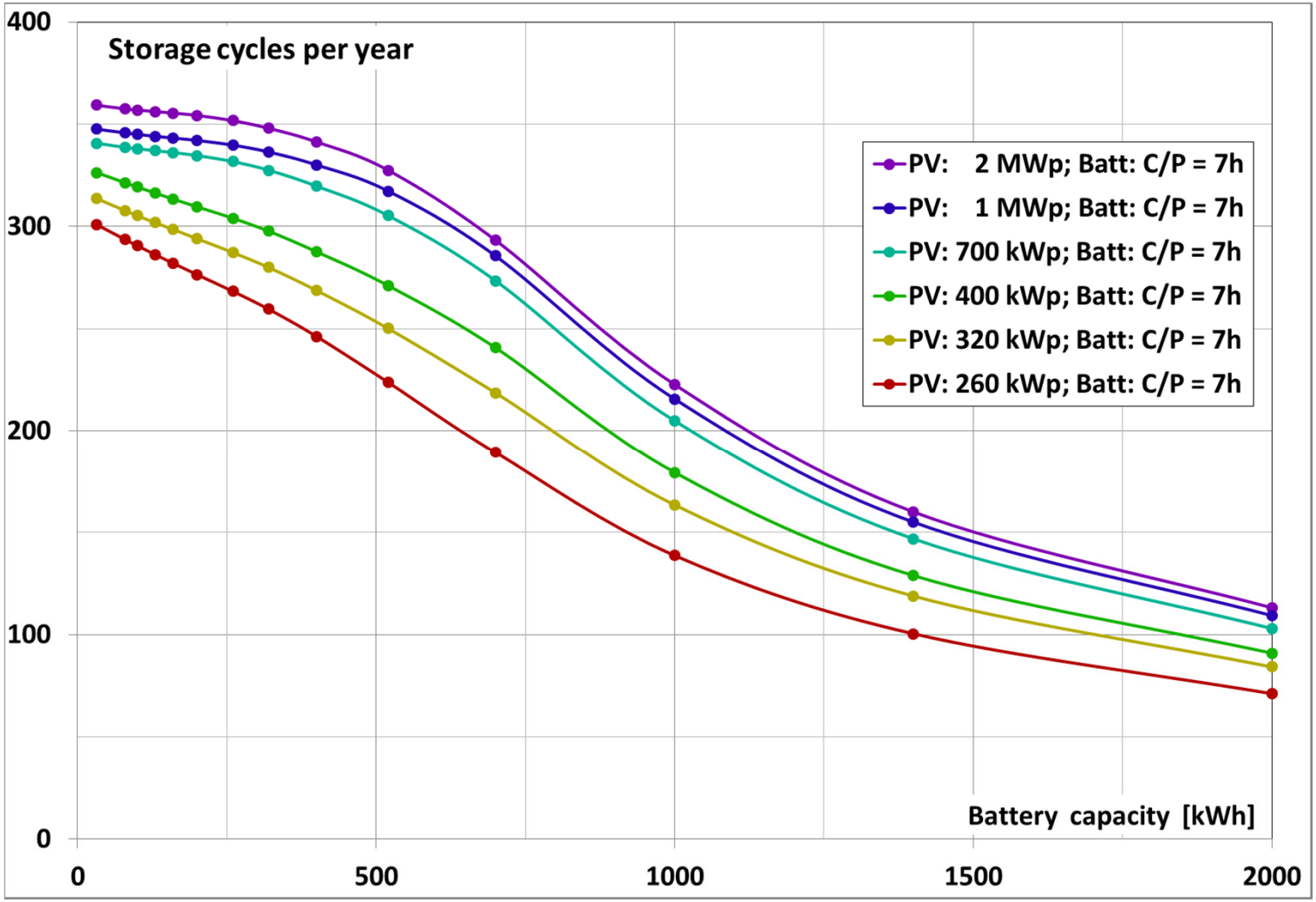
Example: Commercial PV battery system

Simulation based system analyses and dimensioning

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



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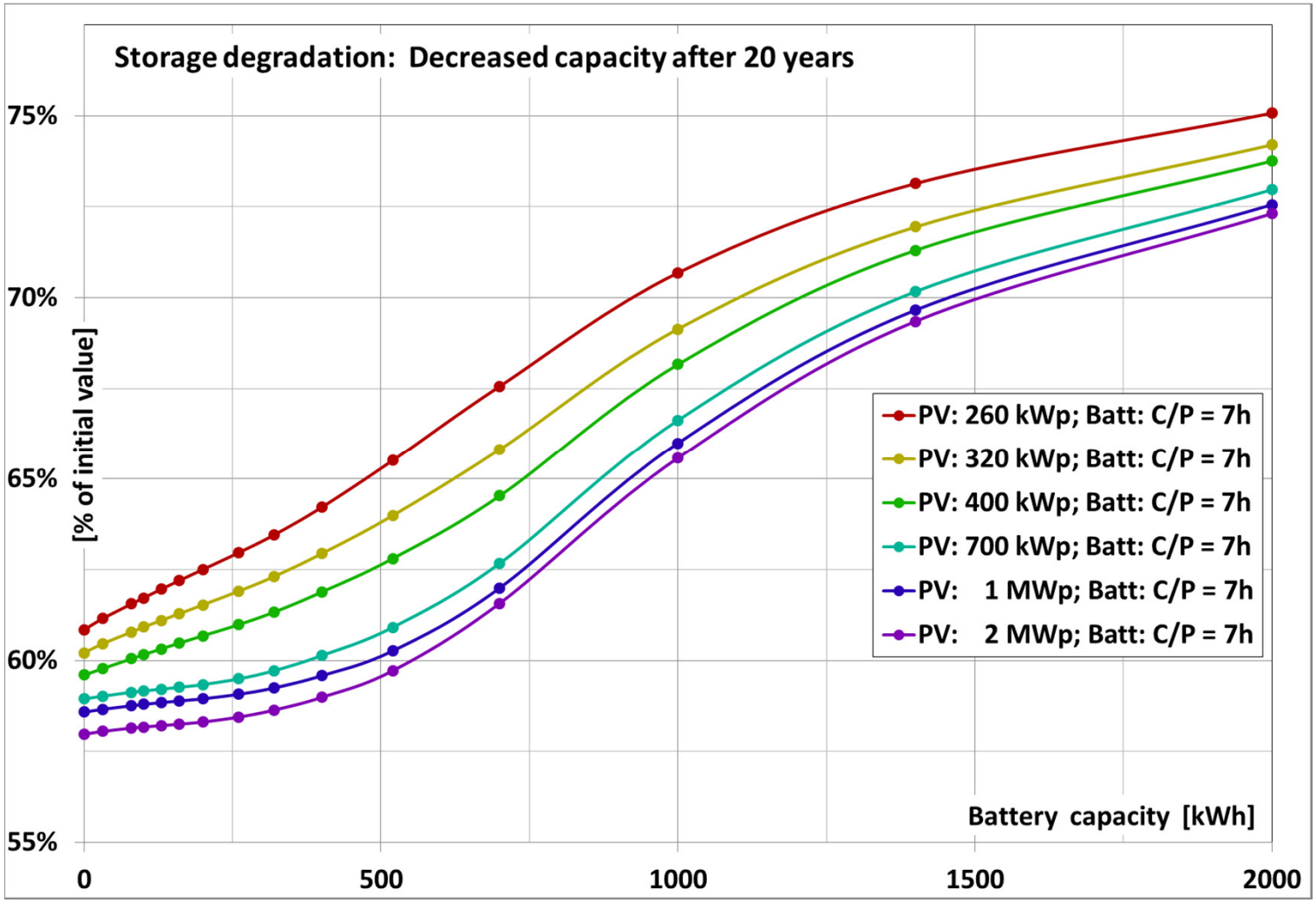
Example: Commercial PV battery system

Simulation based system analyses and dimensioning

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



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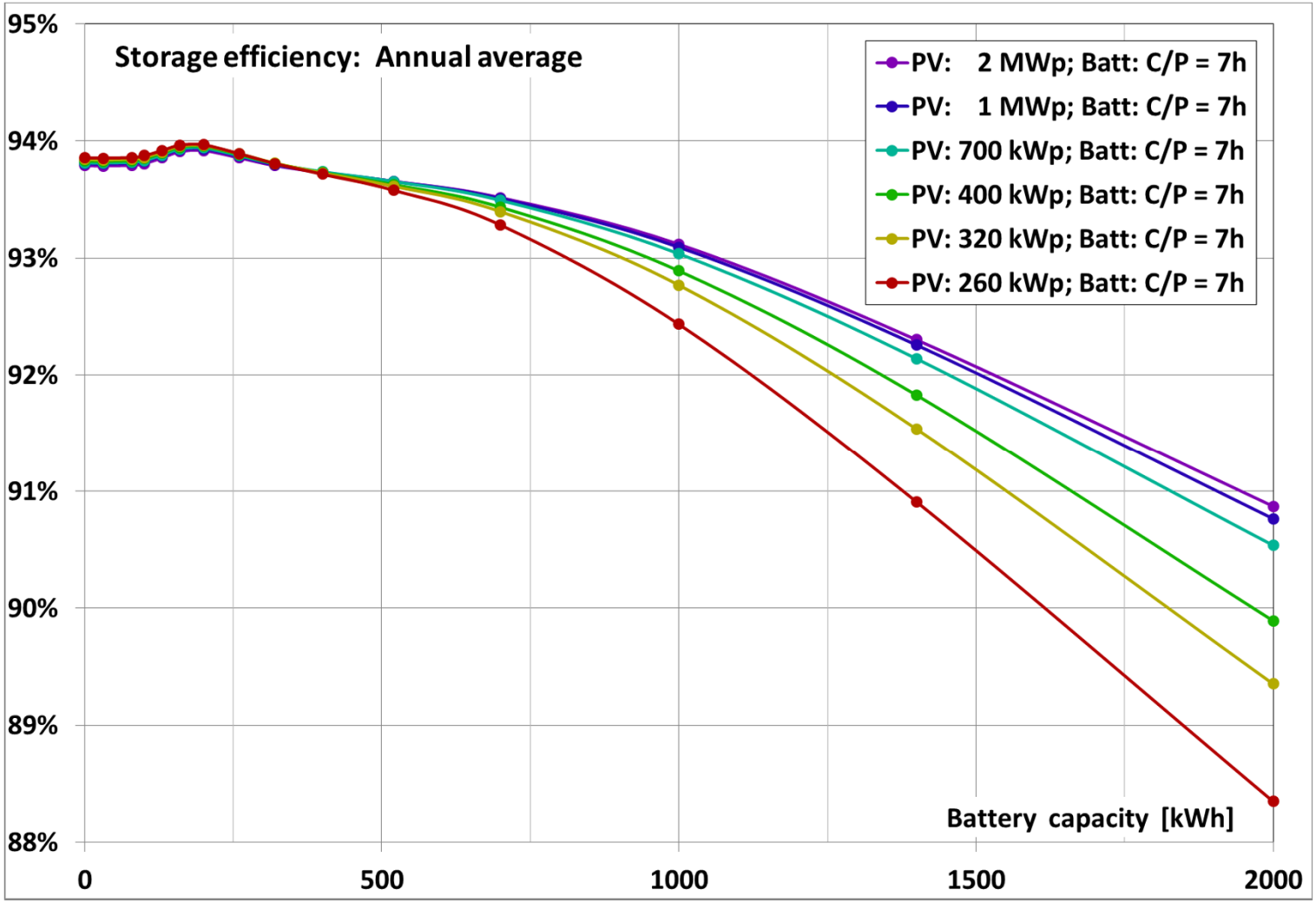
Example: Commercial PV battery system

Simulation based system analyses and dimensioning

Battery storage: Annual average storage efficiencies



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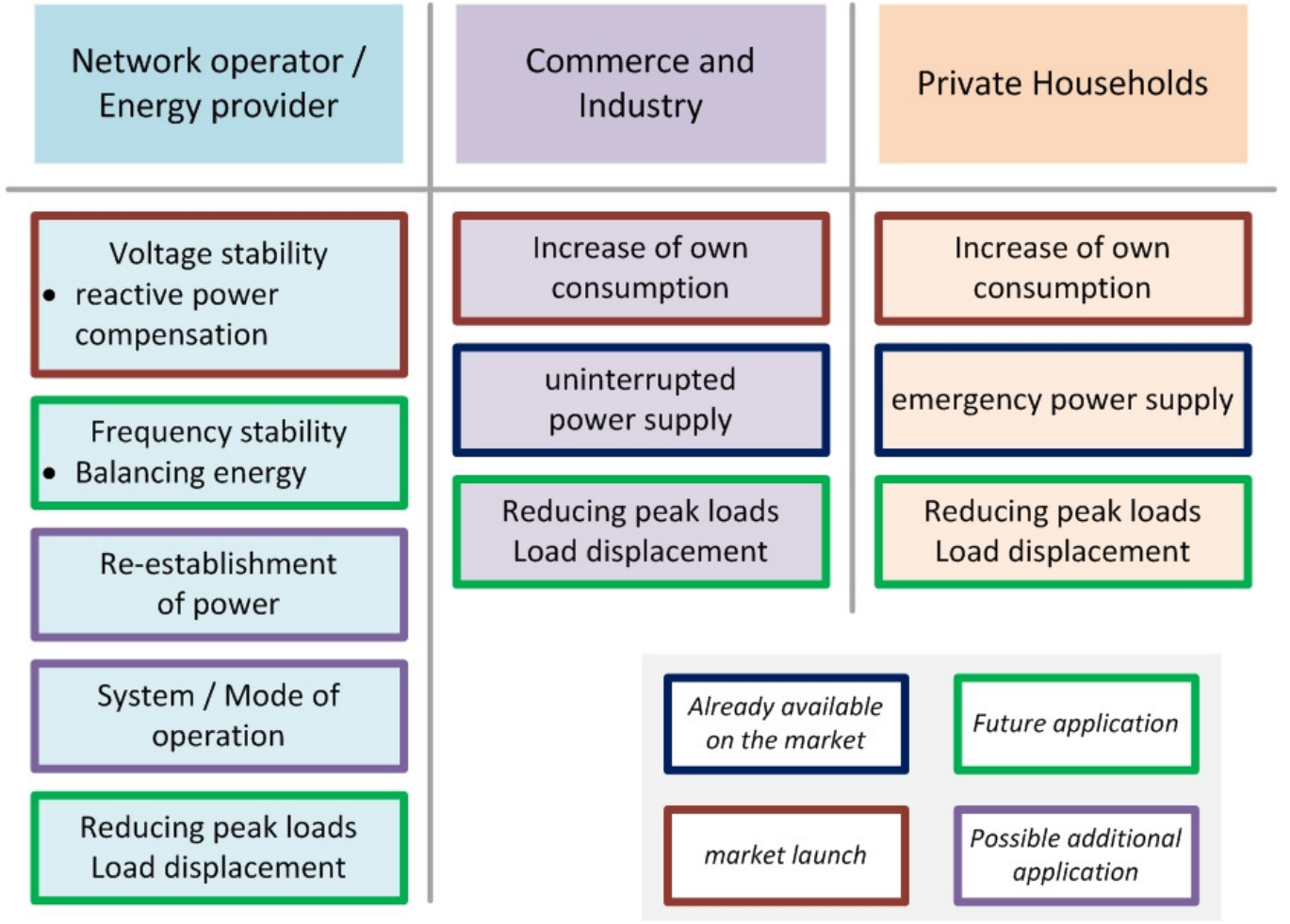
Perspective for (commercial) PV battery systems

Additional business cases beyond PV self consumption

- Multiple use of storage device
  - → Additional services, e.g. grid support
  - → Additional revenues



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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 dimensioning 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 analyses:
  - Enable an “early” identification of application specific operating conditions of a battery storage
  - Enable life time predictions and determination of levelized cost of energy storage and levelized cost of consumed energy by using aging models
  - Enable an application specific optimization of the entire system design
  - Enable an application specific optimization of the operating control strategies
- Cost analyses: Multiple use of battery systems may improve the economics

Thanks for your attention !!!

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