QUALITY ASSURANCE FOR PV BATTERY SYSTEMS IN MICRO-GRID APPLICATIONS

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Future Energy Asia

Bangkok, 12.-14. December 2018

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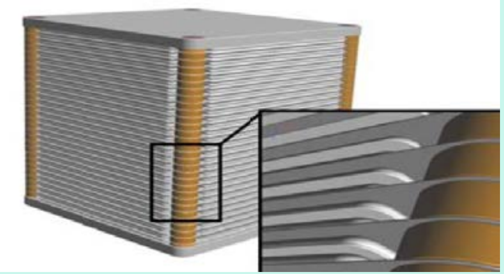
AGENDA

- Introduction to battery R&D and services of Fraunhofer ISE
- Overview of global electrical energy storage trends
- Key factors affecting bankability of energy storage projects
- Quality assurance for larger PV battery systems –
  Concept and range of services
- Project examples
- Conclusions

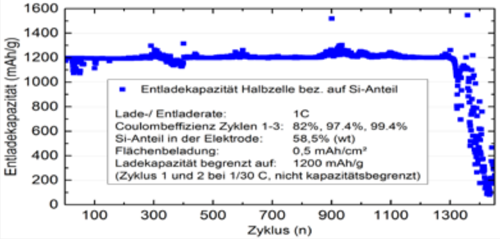
Battery cells

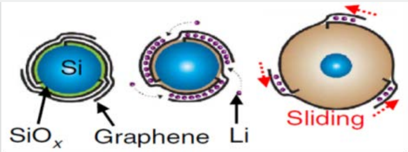
Current focus topics of Fraunhofer ISE

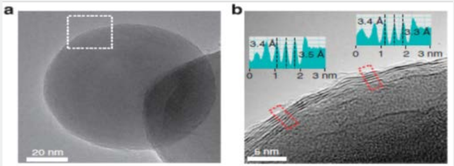
Aqueous batteries for stationary applications



Silicon based anodes as *drop-in replacement* for lithium-ion battery cells

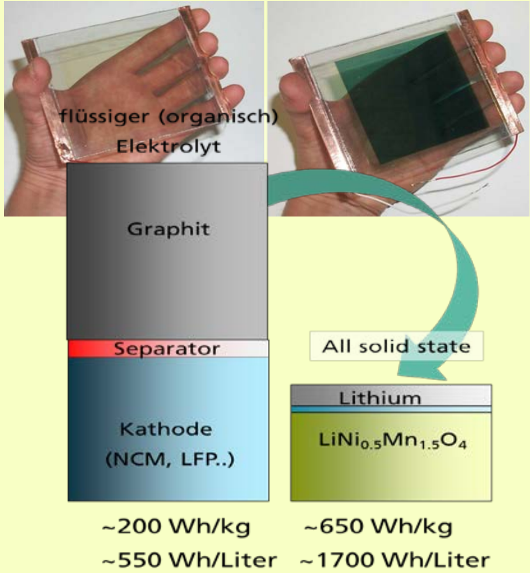






From DOI: 10.1038/ncomms8393

New materials and process technology for *solid state* batteries



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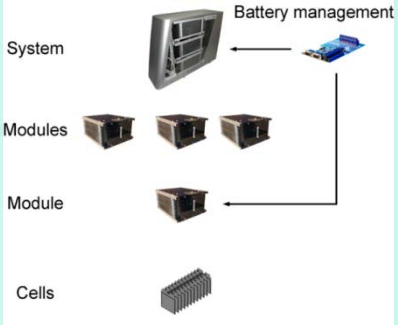
Battery systems and applications
R&D and services of Fraunhofer ISE

Battery system technology
From cells to systems



- Cell characterization
- Module and system design
- Battery management
- Thermal management
- Algorithms for state estimation and life time prediction
- Optimized charging and operating control strategies

Storage applications
System design, integration and quality assurance


Photo: CSIRO. Off-grid power supply for SKA1 low radio telescope

- Consultancy during planning phase
- System design and analysis
- Simulation based storage sizing
- Elaboration of specifications
- Energy management systems
- Site inspections and testing
- Monitoring

Testing
Electrical, thermal, mechanical

- Safety: Components, systems including functional safety
- Aging: Calendric, cyclic
- Performance: Efficiency and effectiveness
- Reliability: Consideration of operating conditions and system performance with aged components

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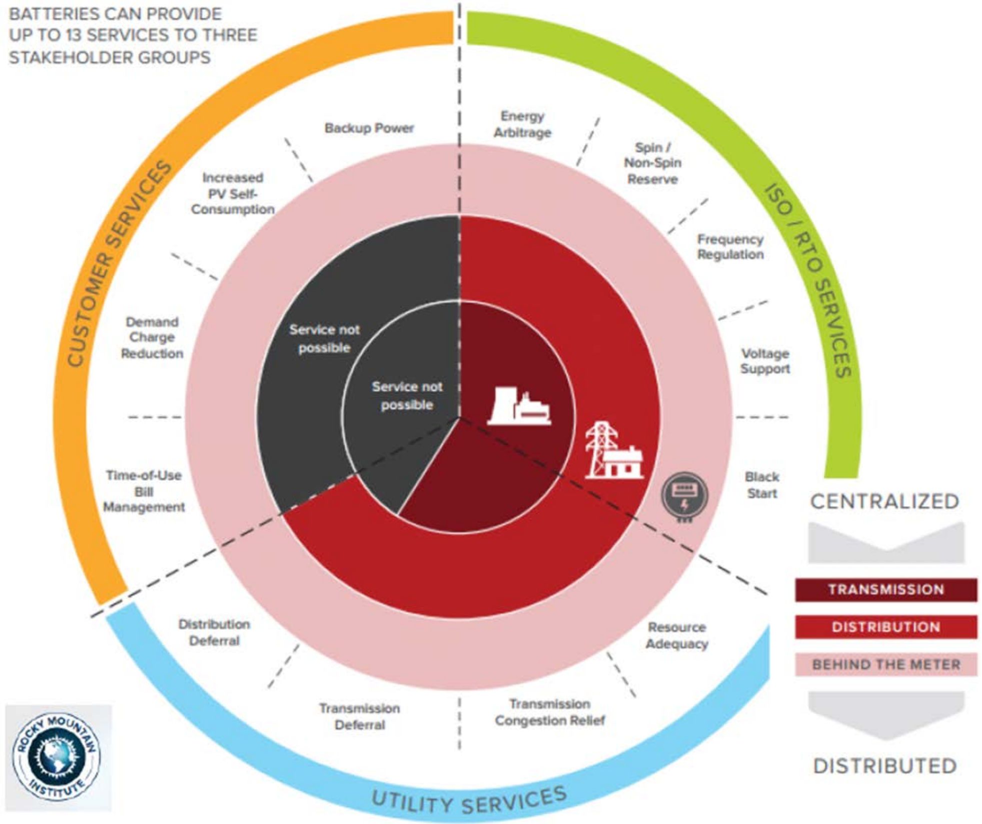
Overview of global electrical energy storage trends

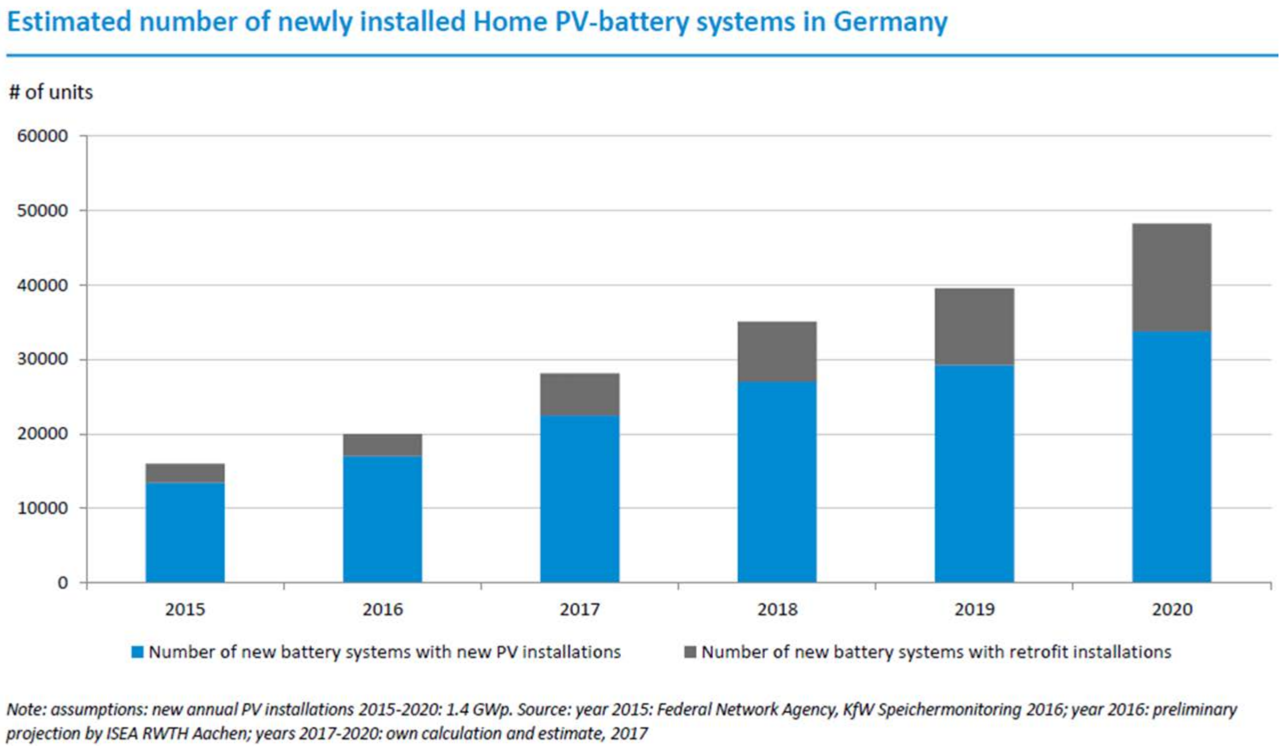
Services and benefits



Source: F. Gattiglio: Battery energy storage in the EU, ees conference, Munich 2017.

Overview of global electrical energy storage trends

Example Germany: PV self consumption / self sufficiency

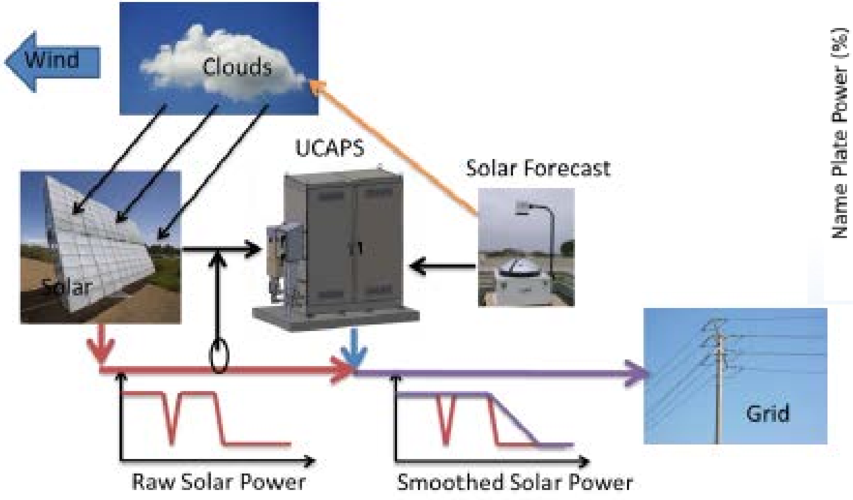


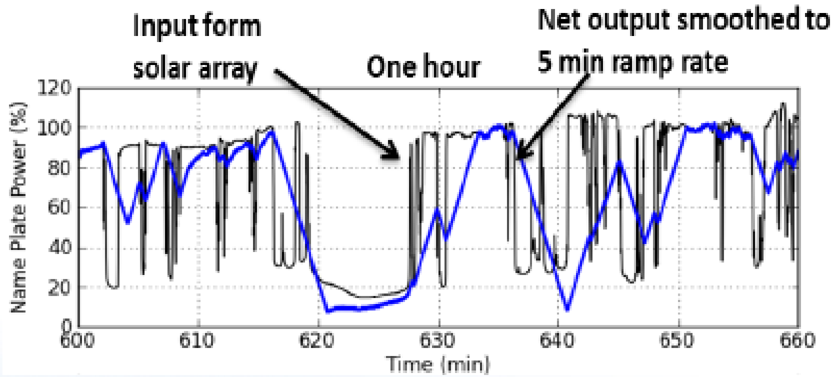
Source: A. Bräutigam: Business models for energy storage in Germany and hot spot markets, ees conference, Munich 2017.

Overview of global electrical energy storage trends

Example USA: Solar firming (PV power plants)

- Stabilization of solar output for 5 min ramp rate grid regulation
- Approach with ultracapacitors



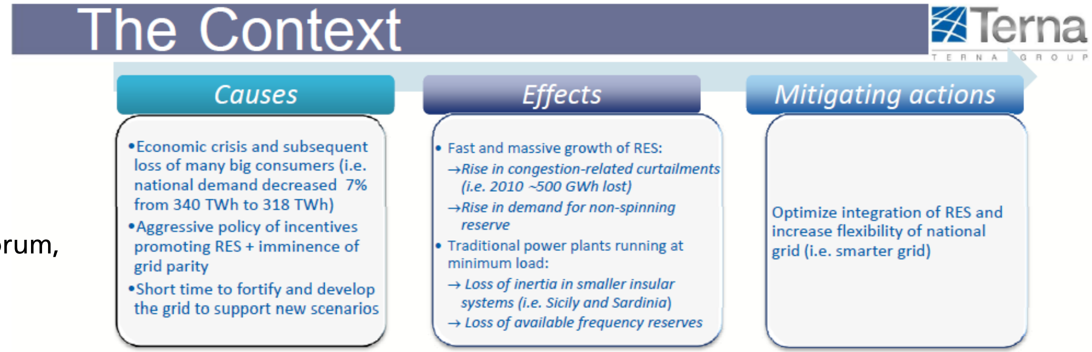


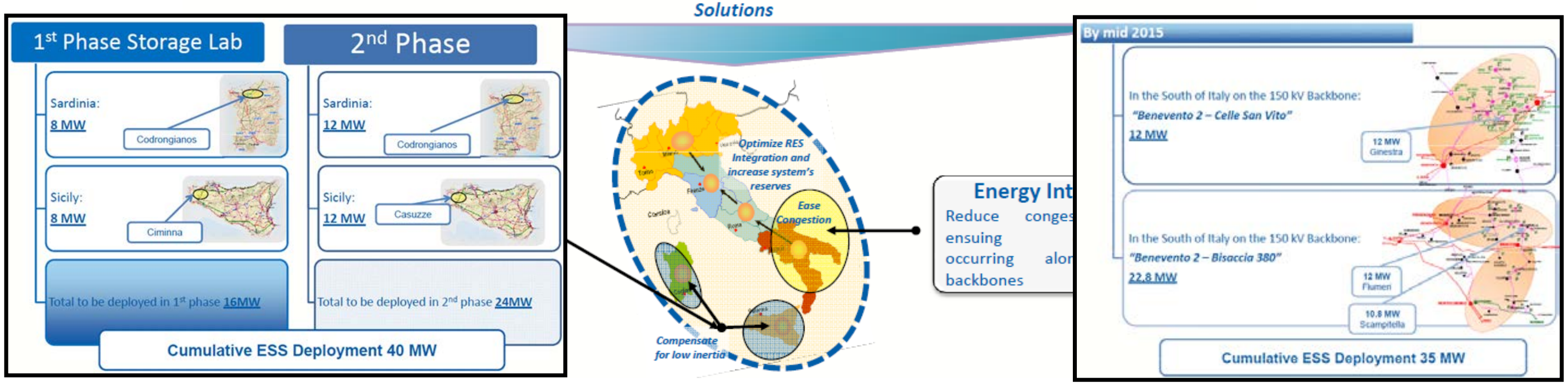
Source: K. McGrath: Increasing the value of PV: Integration ultracapacitors with renewables, NAATBatt storage workshop July 10, 2014.

Overview of global electrical energy storage trends

Example Italy: Batteries for grid support

Source: : A. Tortora,
Terna Group,
Energy Storage World Forum,
Rome, 2015.





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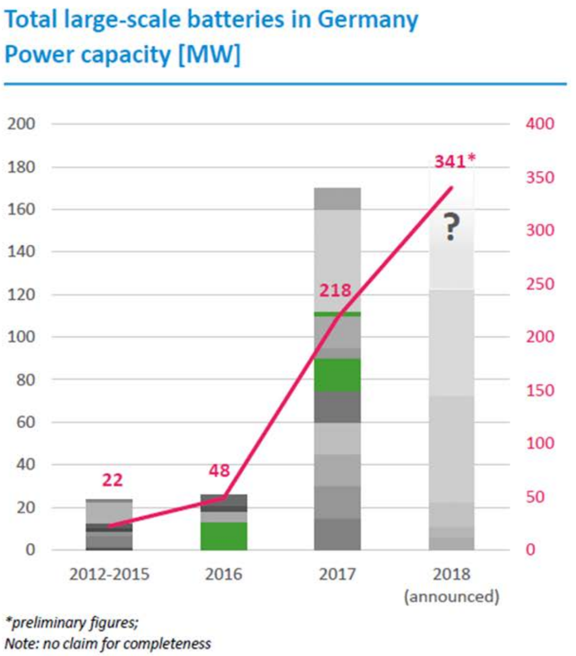
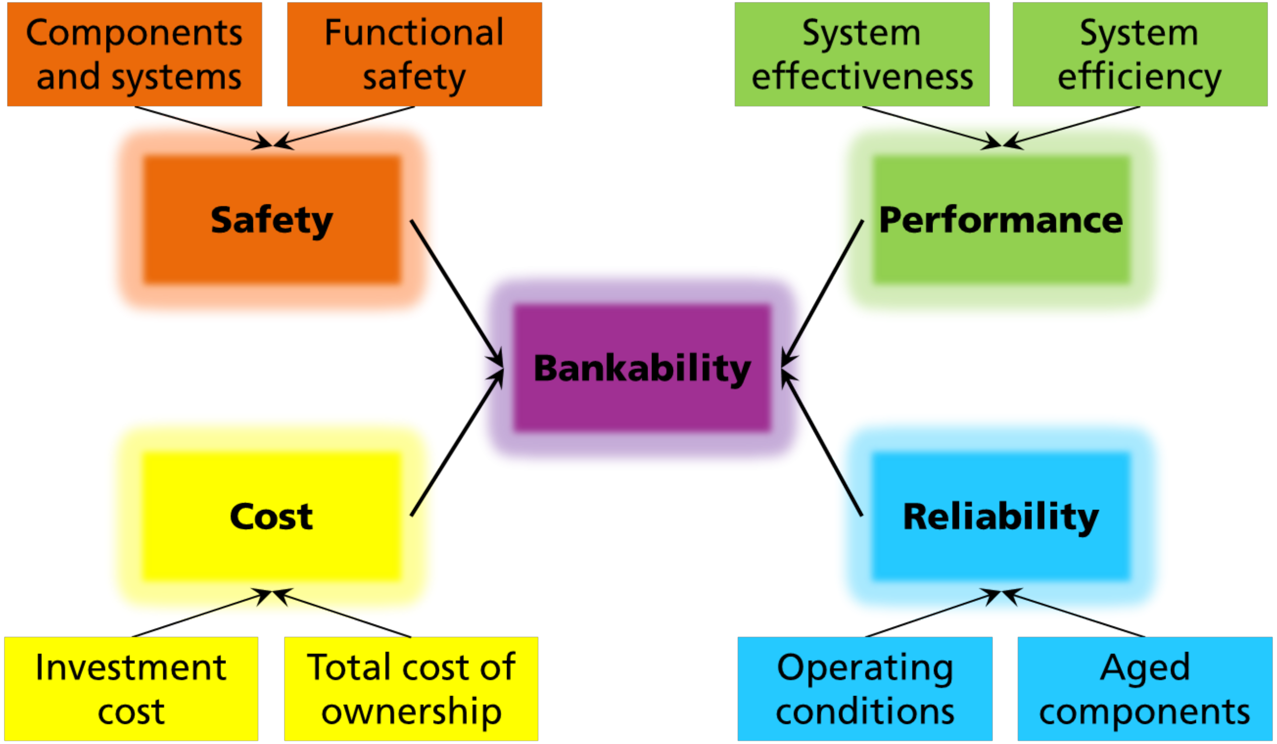
Overview of global electrical energy storage trends
Example Germany: Primary control power



Source: A. Bräutigam: Business models for energy storage in Germany and hot spot markets, ees conference, Munich 2017.

Key factors affecting bankability of renewable energy + storage projects



Quality assurance for larger PV battery systems

Power plants, commercial applications and mini-grids

Concept and range of services

- 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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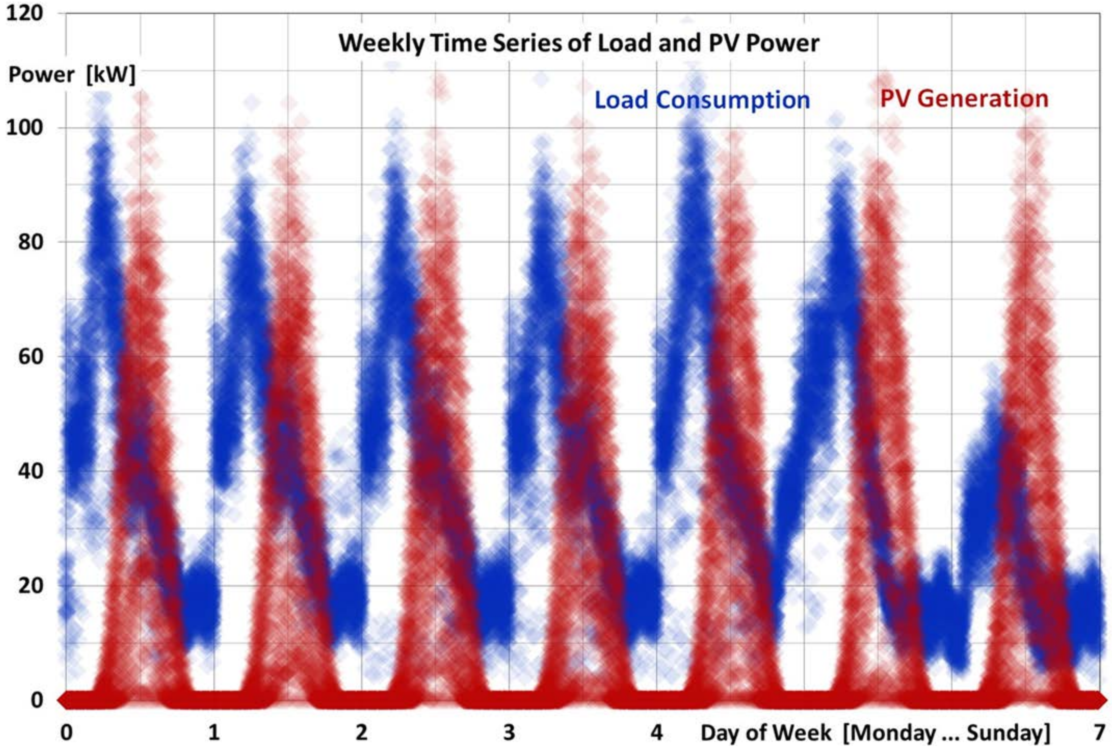
Project examples – System simulation and analyses
Commercial PV battery system – Load and PV generation

Load (bakery production line):

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

PV example:

- Size: 150 kWp
- Production: 135 MWh



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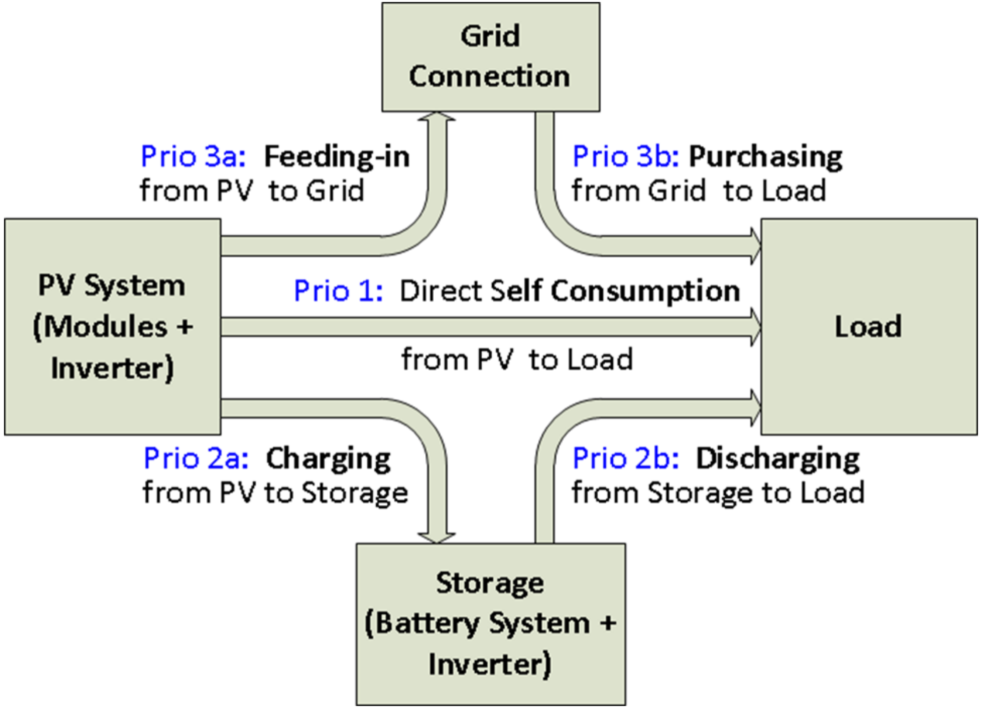
Project examples – System simulation and analyses
Commercial PV battery system – Control strategy

Load (bakery production line):

- 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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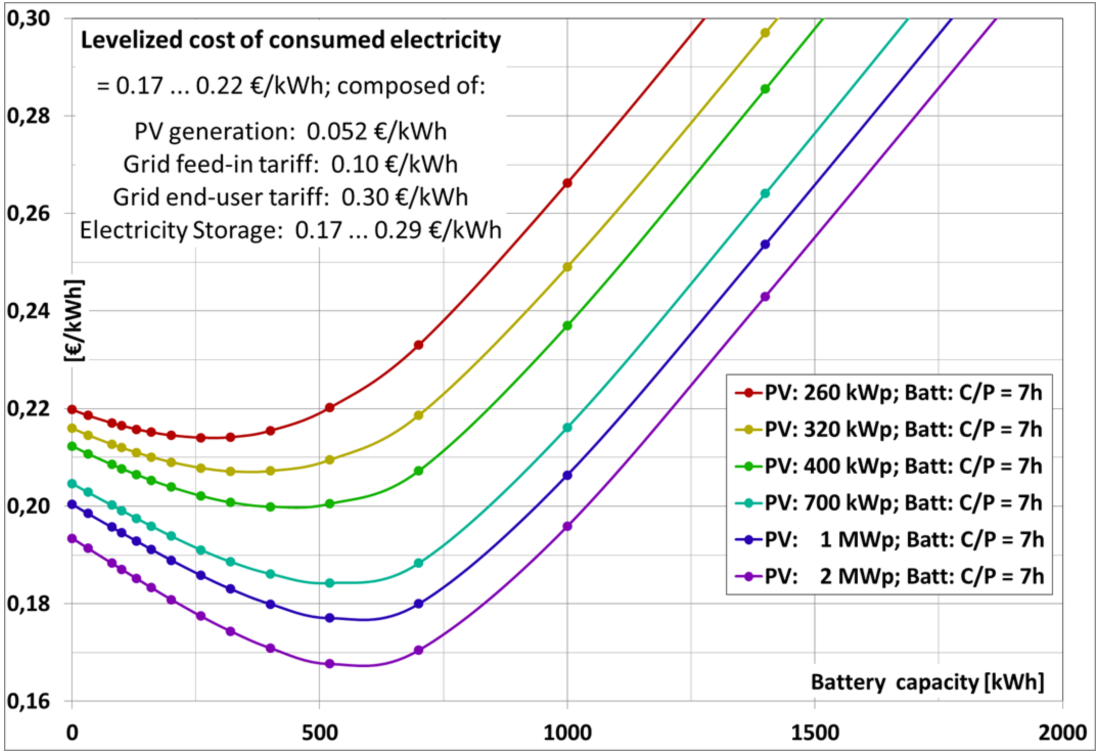
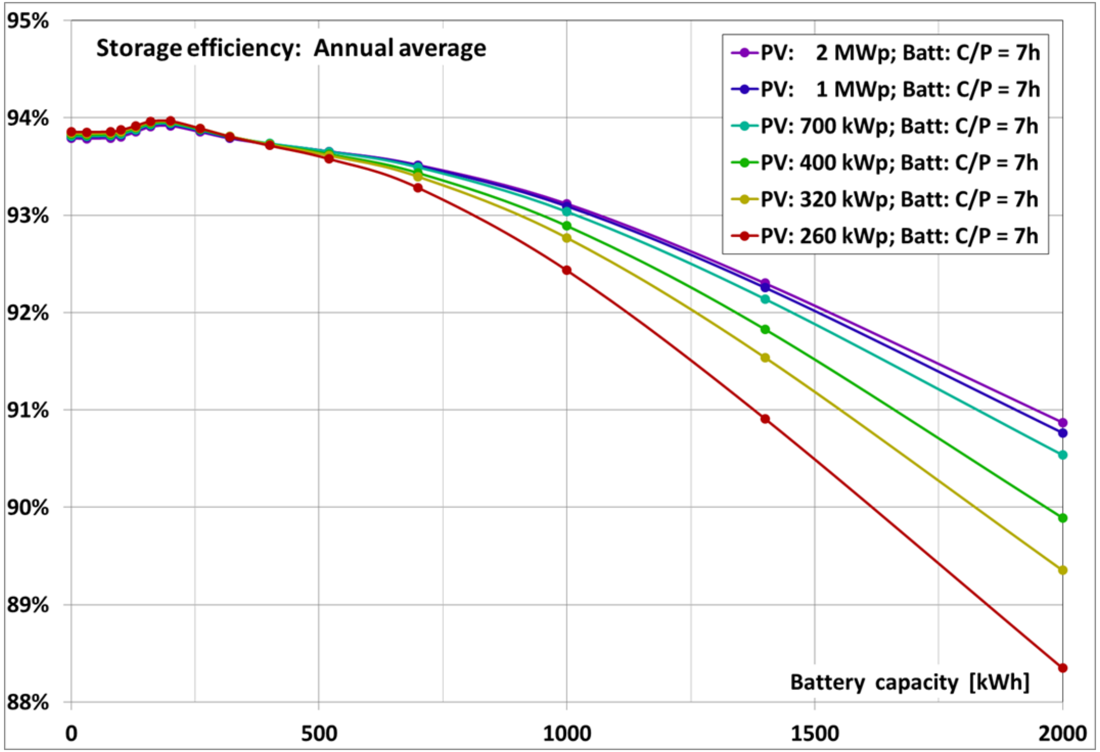
Project examples – System simulation and analyses
Commercial PV battery system – Results

Levelized cost of consumed electricity



Project examples – System simulation and analyses
Commercial PV battery system – Results

Battery storage:
Annual average storage efficiencies



Project examples – System simulation and analyses

Layout and sizing of a PV mini-grid for SKA1 low radio telescope

Design proposal

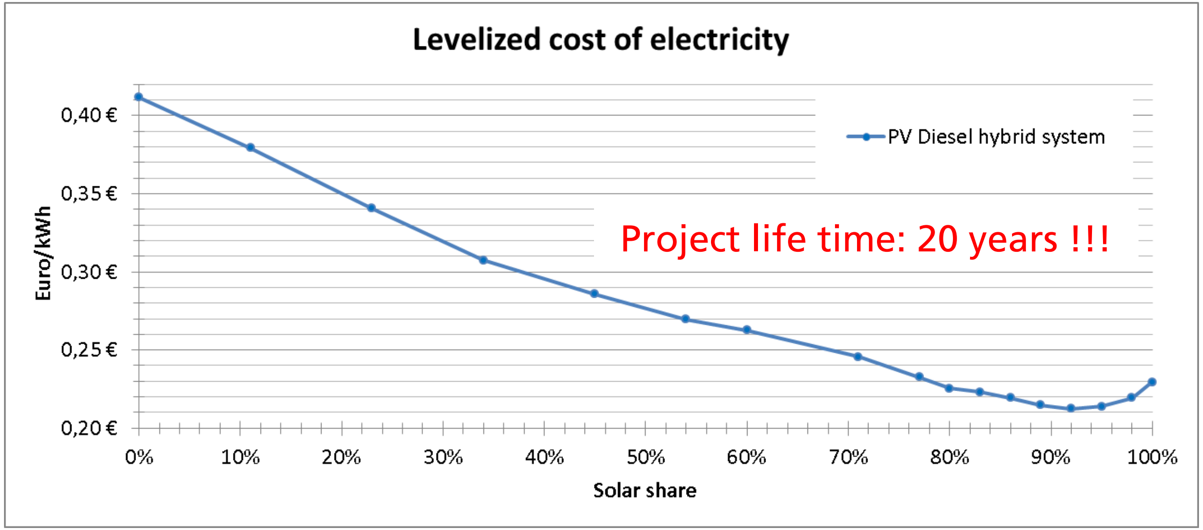
- Central power plant powering 80 % of total telescope load (2.4 MW in average)
  - PV system: 17 MW_p
  - Lithium-ion battery storage: 40 MWh / 5.5 MW
  - Diesel genset: 3.2 MW
- 20 % outermost antenna clusters
  - Powered locally
  - 15 RPFs (distance from CPF > 10 km)
- LCOE: ~ 0.307 €/kWh

CSIRO SKA Fraunhofer ISE

Project examples – System simulation and analyses

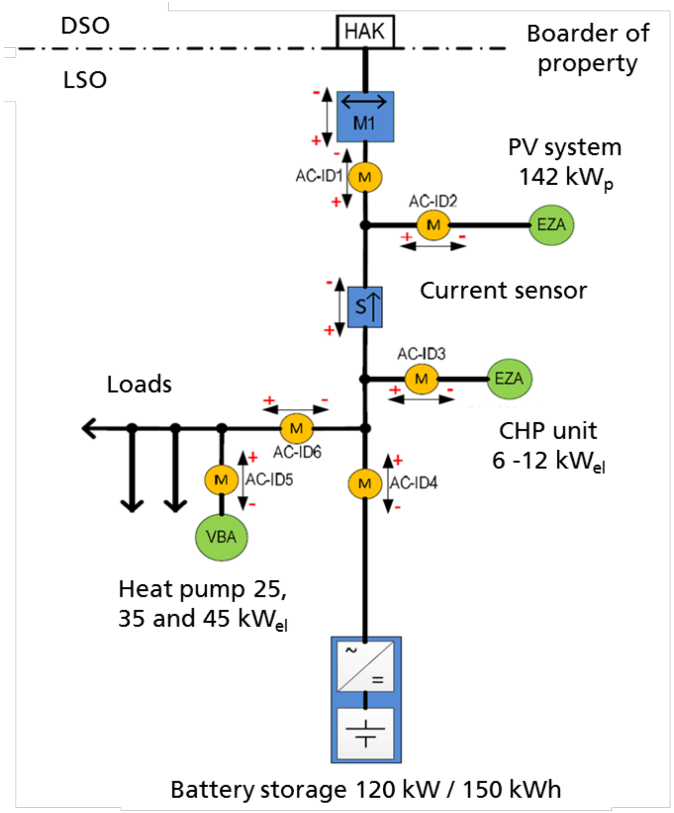
Techno-economical evaluation of a mini-grid in Uganda

- Example Uganda
- Load:
  - Peak load: 200 kW
  - Annual consumpt.: 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



Project examples – Monitoring and system evaluation

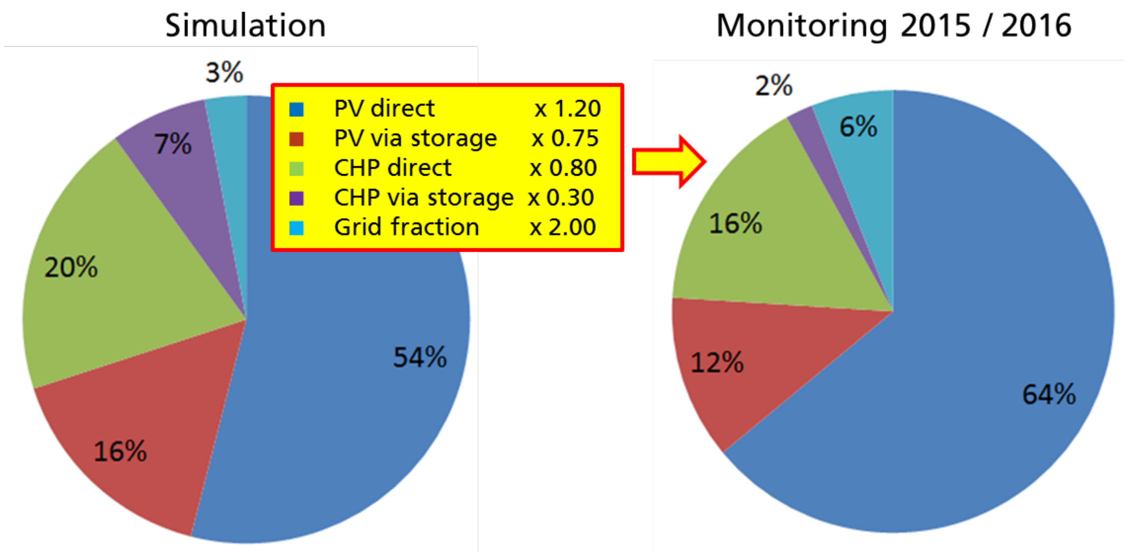
District storage system – "Weinsberg"



Project examples – Monitoring and system evaluation

District storage system – “Weinsberg”

Accumulated annual electrical energy quantities



Reasons for differences:

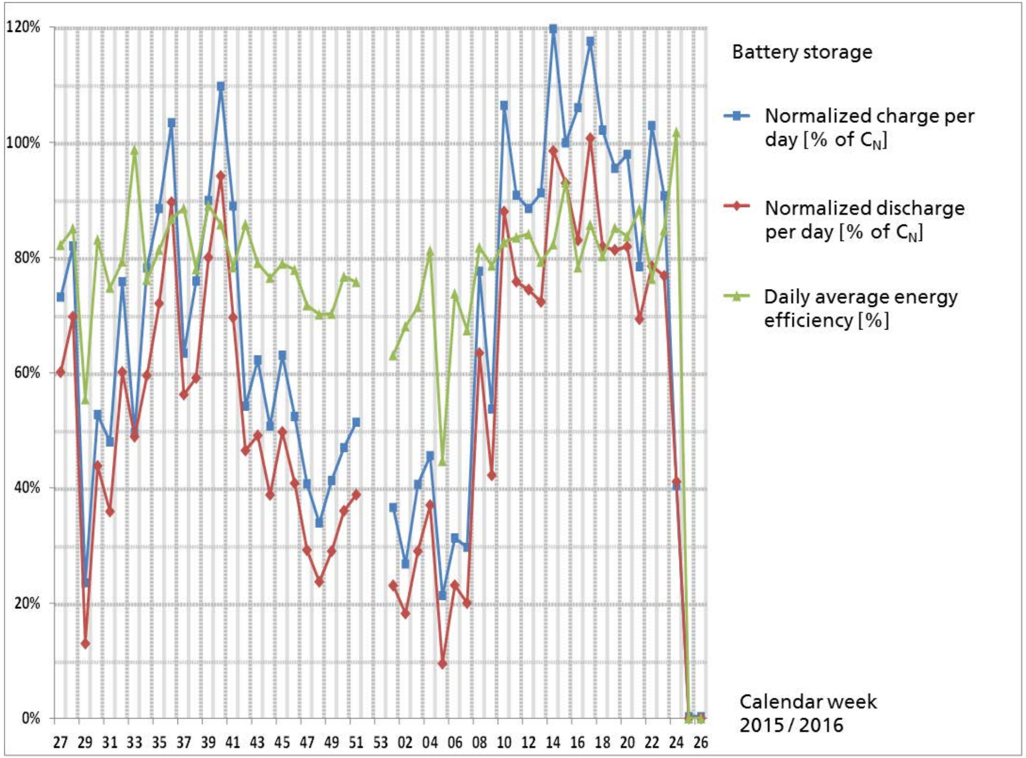
- Problems with air conditioning → To high temperatures in operation room → Shut-down of CHP unit and battery inverter
- Necessary maintenance interval of CHP unit in winter (!)
- End-users do not behave 100 % as predicted (!)

Project examples – Monitoring and system evaluation

District storage system – “Weinsberg”

Annual average values:

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

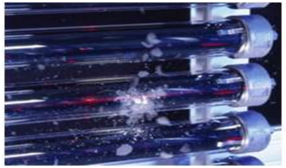


Conclusions

- Large-scale integration of fluctuating renewable energies in power supply systems require storage (grid-connected and isolated mini-grid applications)
- Integration of battery storage requires several steps of quality assurance enabling bankable projects:
  - From detailed analyses of load pattern to system simulation and application specific system design
  - From characterization of components and systems in the laboratory to system testing in the field as well as quality monitoring
- Field experiences with “new” battery technologies still show huge optimization potential – Component and system level
- Renewable energy shares in power supply systems, e.g. mini-grids:
  - Economic optimum strongly depends on the considered project life-time (Levelized cost of energy computation)

Thanks for your attention !!!



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