



Performance, Degradation and Lifetime

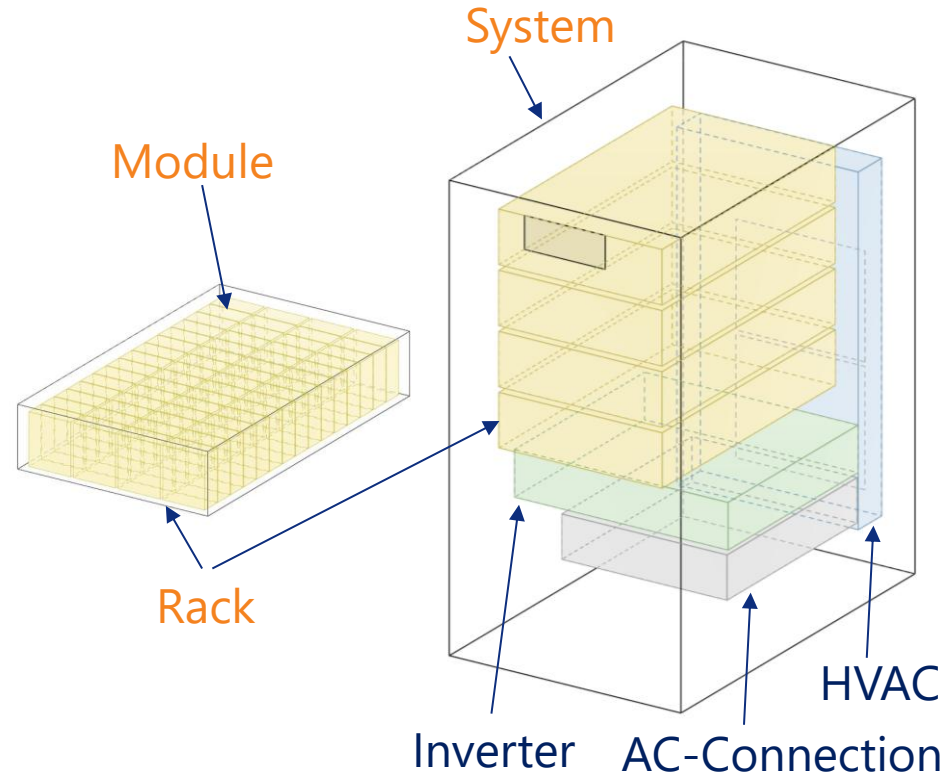
Alexander Erber, Christian Messner, AIT Austrian Institute Of Technology

EUPVSEC 2026, Rotterdam, 17th September 2026

Performance analysis



- When and where?
 - Factory Acceptance Tests
 - Site Acceptance Test
 - Time-series based analysis
 - Use-case specific PI
- Hierarchy level
 - Cell, module (DC)
 - Pack, rack (DC)
 - System, Container (DC/AC)

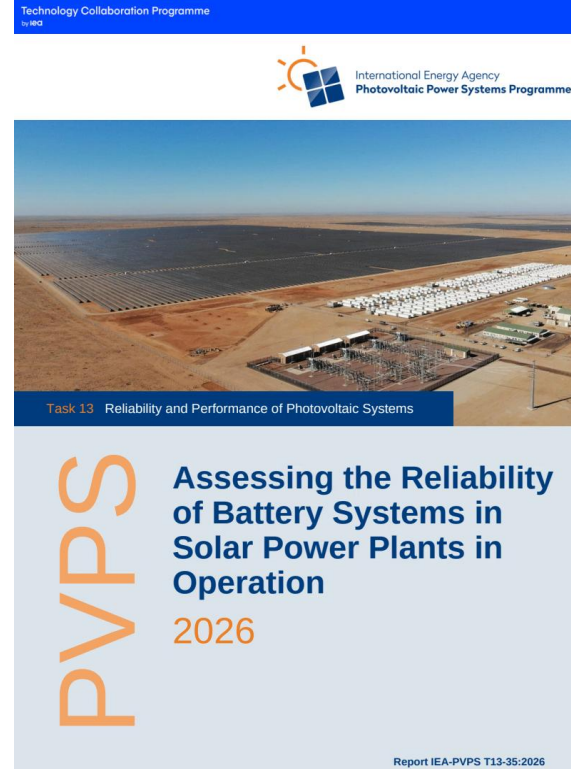


Performance indicators



Indicator for understanding BESS state

1. Energy storage capacity
2. Power capacity and tolerance
3. Standby losses
4. Round-trip efficiency
5. Response time
6. Internal resistance



Performance Tests – Residential Systems



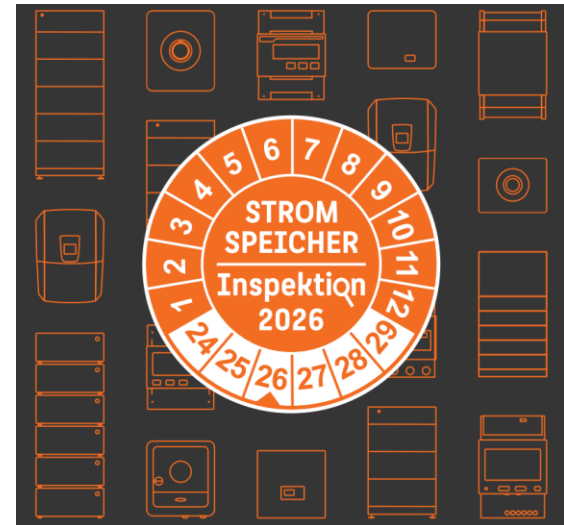
- **Test procedures**

- 2019-2026 BVES/BSW efficiency guideline
- 2026 ... DIN VDE V 0510-200 Pre-Standard

- **Benchmark – System comparison**

- HTW-Berlin / aquu storage inspection
- every year
- From laboratory measurements to one System performance index (SPI) by means of simulation

Latest inspection results: <https://solar.htw-berlin.de/studien/stromspeicher-inspektion-2026/>

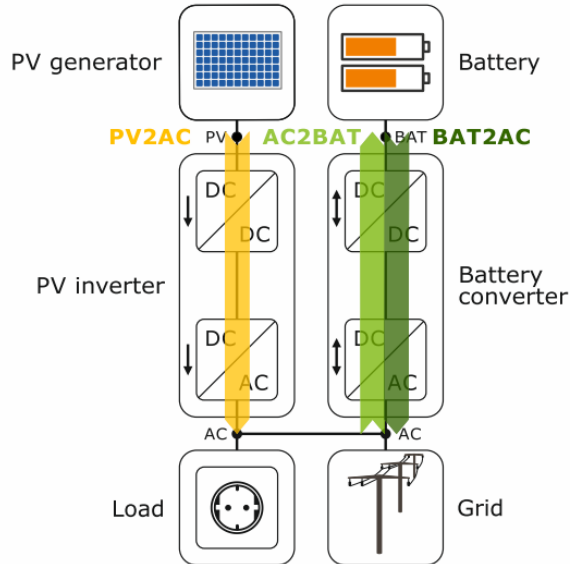


Inverter efficiency

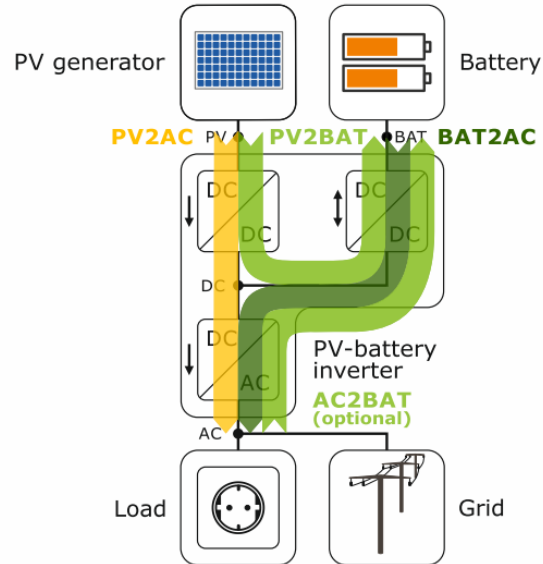


- Inverter efficiency for multiple energy conversion pathways

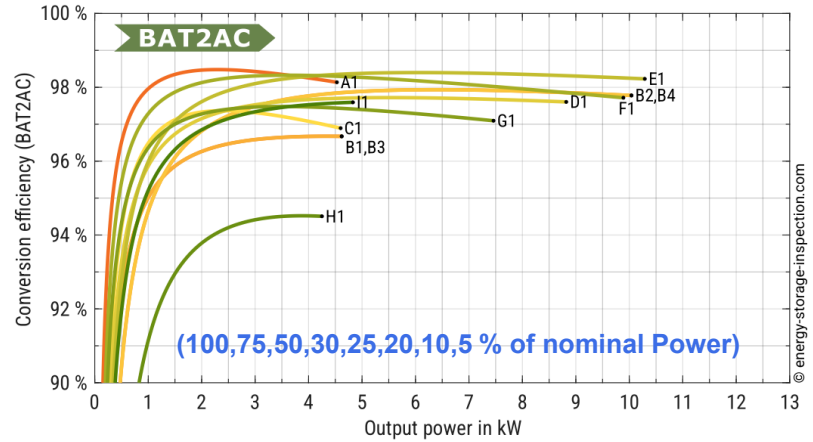
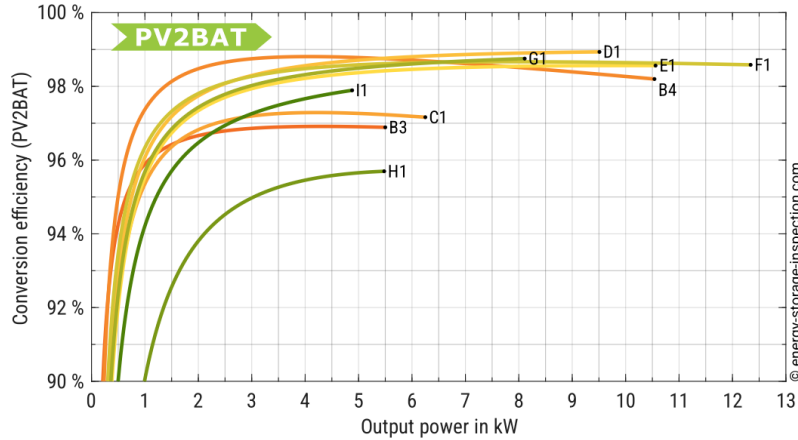
AC-coupled systems



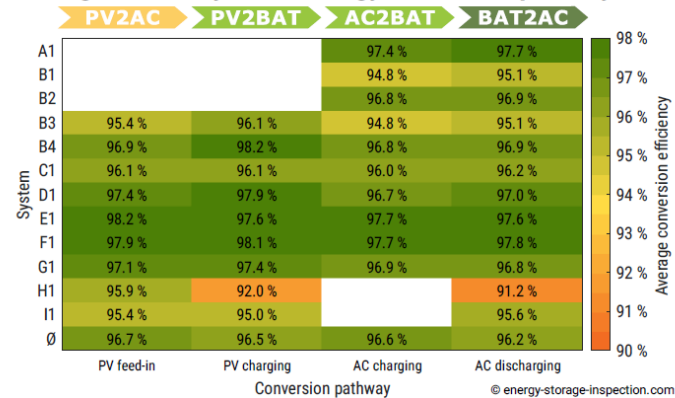
DC-coupled systems



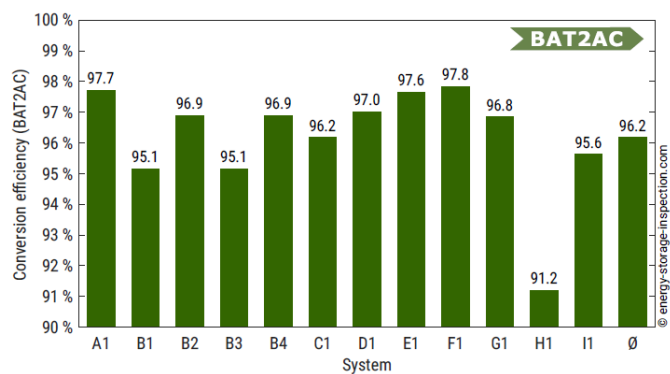
Inverter conversion efficiency



Average efficiency of the energy conversion pathways



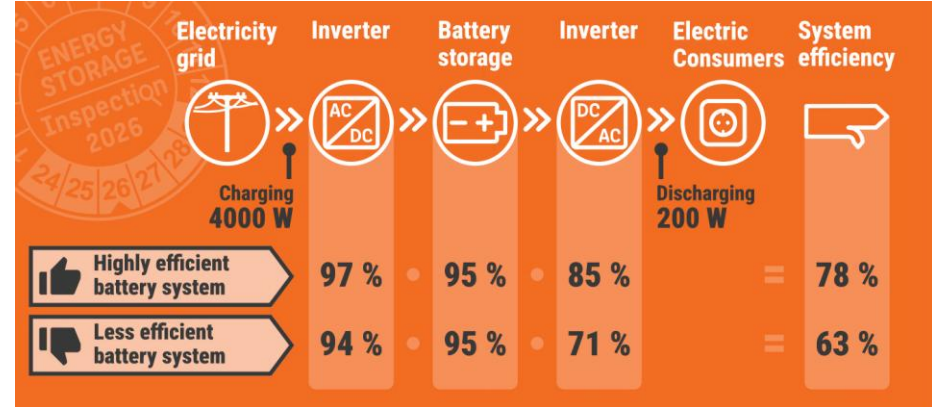
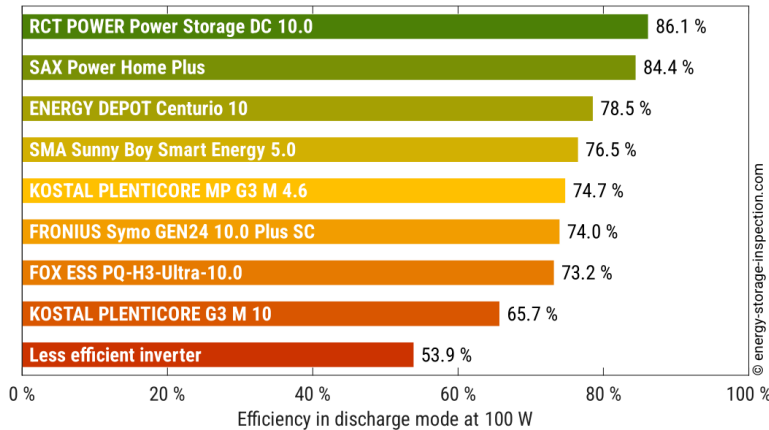
Average conversion efficiency of AC battery discharging



Test portfolio – Inverter efficiency



- Low power load consumption during evening / night
- Efficiency of tested 5-10kW products at 100W BAT2AC

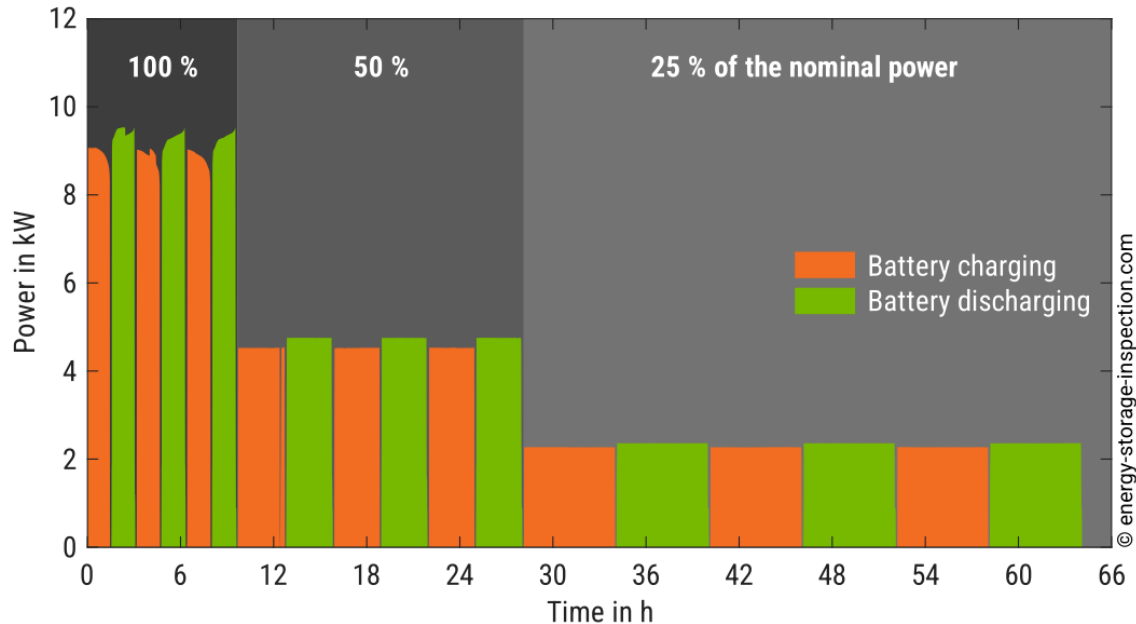


ntw aquu°

Battery efficiency



- Roundtrip efficiency (DC) as energy output / energy input
- Cycle testing at 100%, 50%, 25% of nominal power

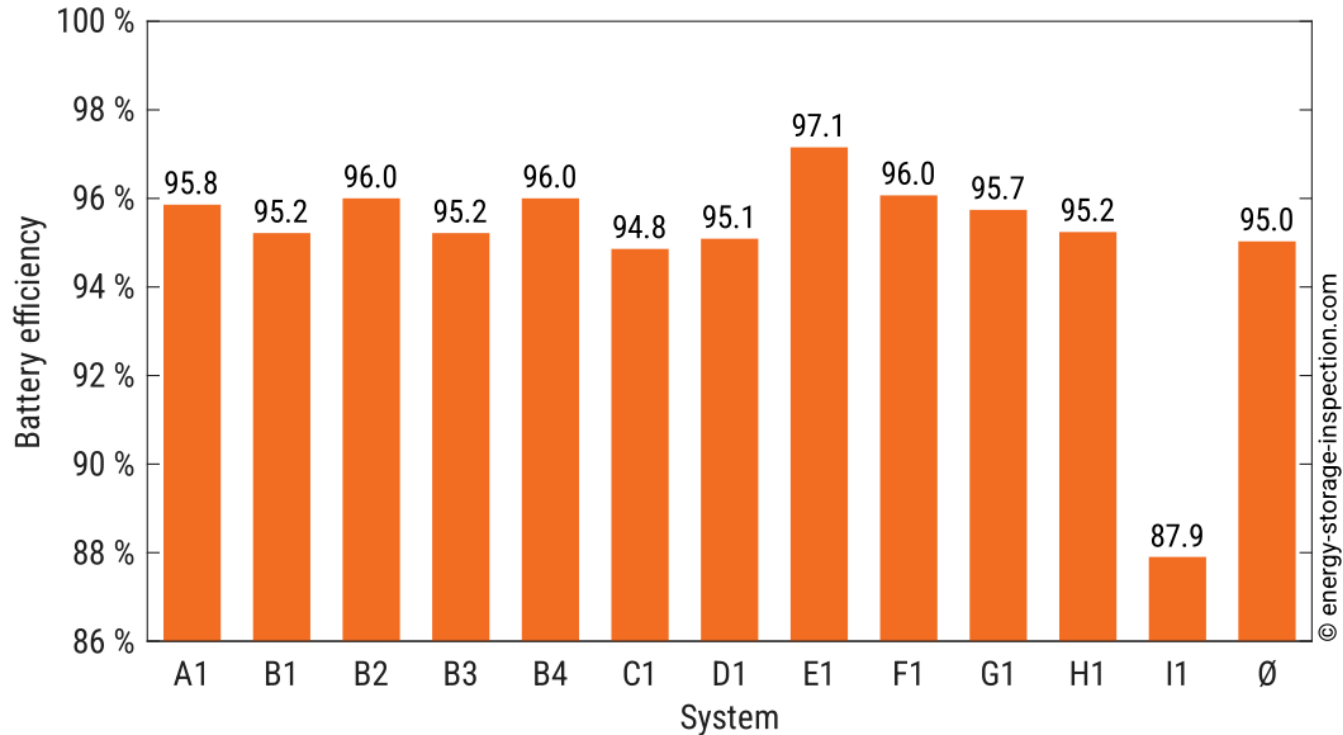


Example: FRONIUS Symo GEN24 10.0 Plus SC and Reserva 12.6, Data: AIT

Test portfolio – Battery efficiency (RTE)



Average battery efficiencies

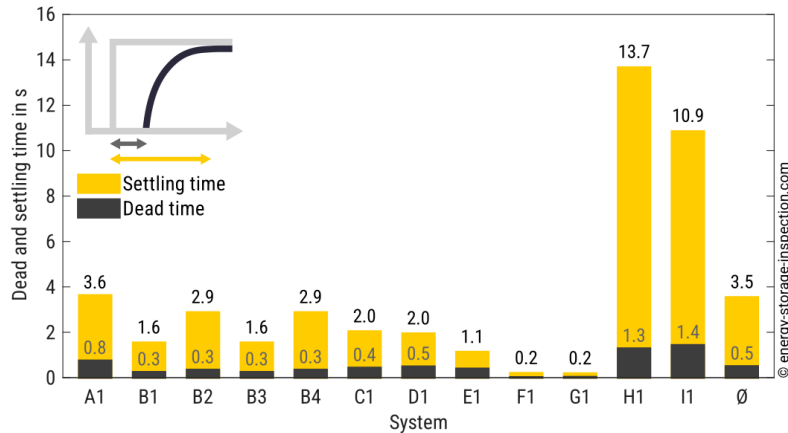


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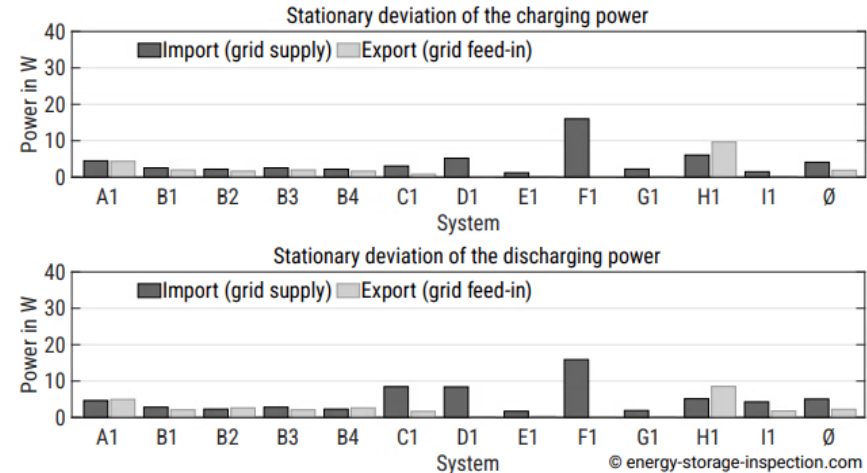
Control Speed and Accuracy



- **Step response (Dead time) and settling time for 10x14 load steps (~10s)**
 - Load > PV: system starts discharging
 - PV > Load: system starts charging
- **Control Accuracy as steady state deviation of 160s steps**



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C&I and Utility Scale BESS – Main Pls



- **Roundtrip Efficiency and usable Energy content**

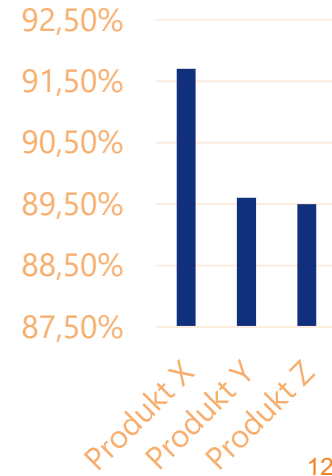
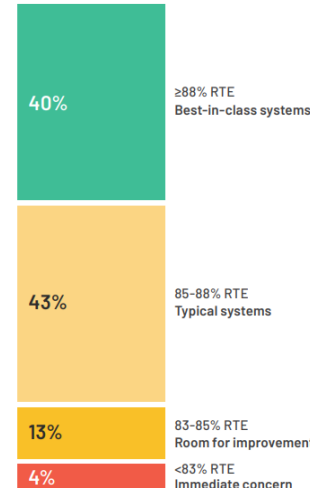
- Full charging/discharging cycles – energy output / energy input

- POC Medium or Low Voltage

- Co-Location BESS may only be chargeable from PV

- **Additional Information during test**

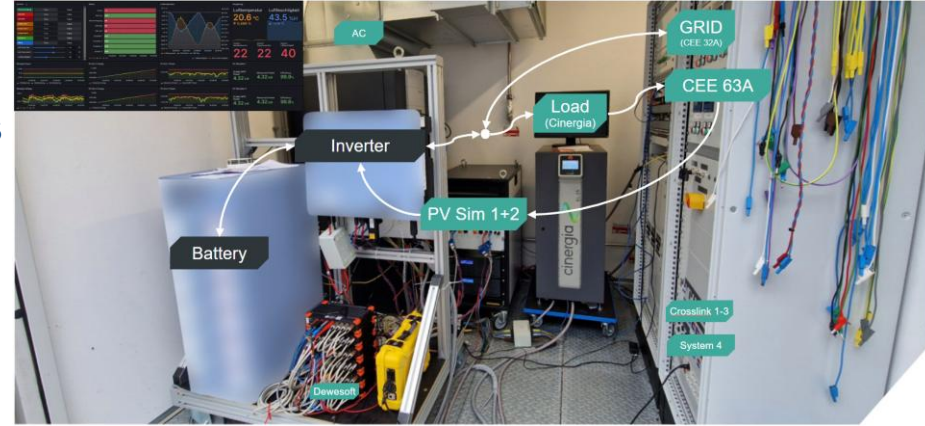
- Quality of temperature management
- SOC accuracy and cell voltage drifts



Data acquisition and infrastructure



- In the laboratory
 - Data crawler for measurement devices
 - Central control of sources and sinks
 - Builds up on the AIT RDP (Core OSS)
- In the field
 - Measurement case – scalable hardware for 40+ cases
 - Reading local data sources
 - Currently only AC measurements



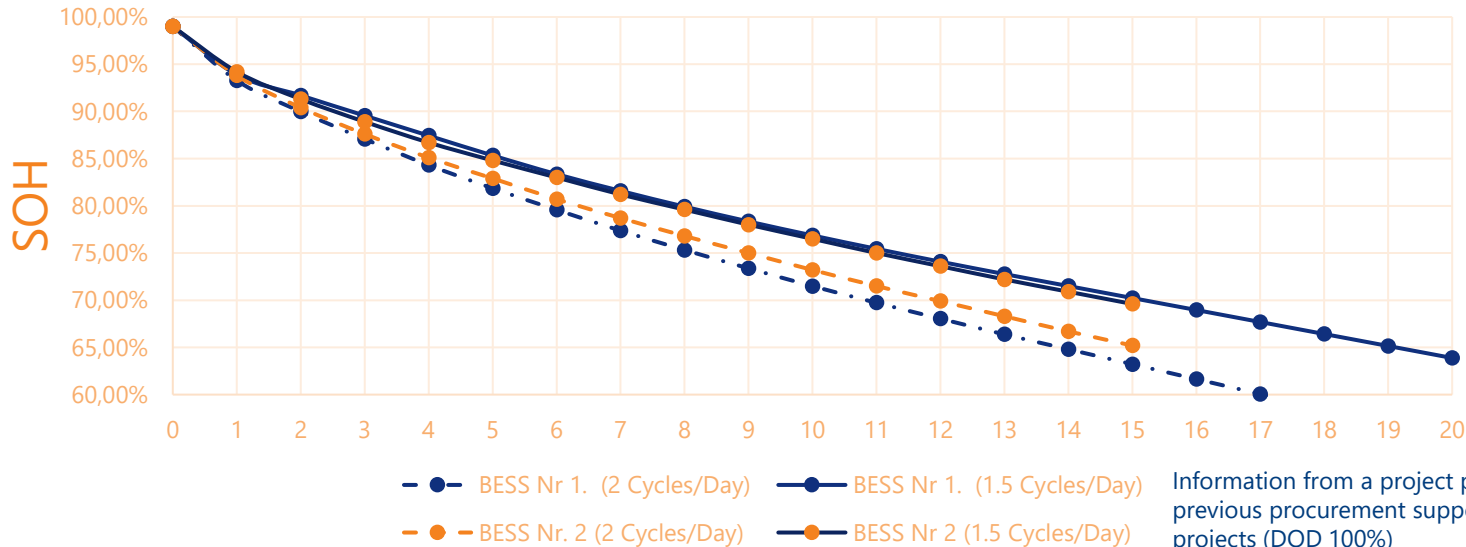
<https://github.com/AIT-RDP>

RDP = Rapid Deployment Plattform

Degradation and Lifetime



- Options for contractual values – remaining capacity, SOH, Energy Throughput
- Energy Storage Capacity test shall be repeated every year
- Internal SOH from BESS should not be used for contractual evaluation

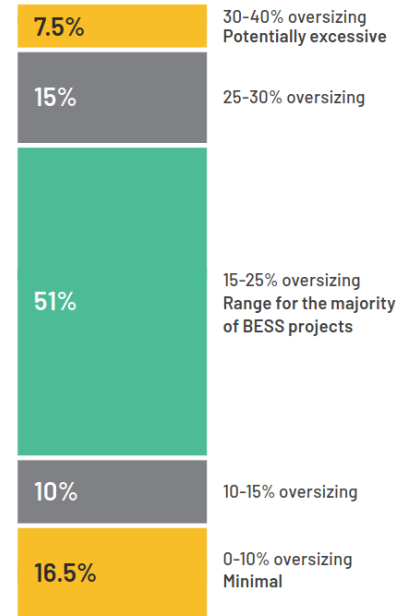


Information from a project proposal based on previous procurement support for battery storage projects (DOD 100%)

Degradation and Lifetime



- Internal resistance could be a fast measurable degradation indicator
 - Current spike necessary -> hard to measure, Q: possible with BMS & BESS control?
- Availability
 - Definition on the contractual level
 - System vs component failure?
- Warranty conditions
 - Analysis for residential systems
 - > HTW/aqqu storage inspection



Source: ACCURE
ESS Health and
Performance
Report 2025

Thank you!

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