Grid Stabilization by the Battery Energy Storage System at Wunsiedel-Energy-Park: A Case Study and Model Simulation

Patrick Mößle[1,2,3], Michael A. Danzer[1,2,3]

[1]Chair of Electrical Energy Systems (EES), University of Bayreuth, Germany
[2]Bavarian Center for Battery Technology (BayBatt), Germany
[3]Center of Energy Technology (ZET), Germany

Electrical Energy Systems

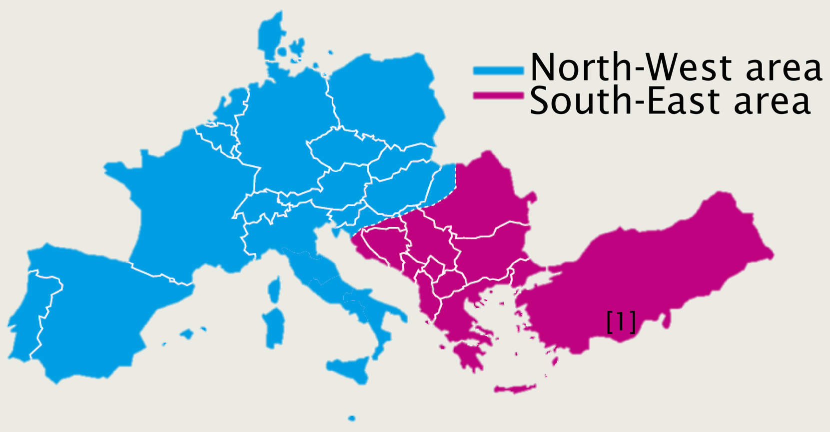
BayBatt Bayerisches Zentrum für Batterietechnik

ZET Zentrum für Energietechnik

Motivation

Scenario 08 January 2021 at 14:05 (CET)

- Continental synchronous area (ENTSO-E) in Europe separated into two areas due to the tripping of several transmission network elements



- Deficit of power in the north-west area and surplus of power in the south-east area
- Frequency decrease in the north-west area
- Frequency increase in the south-east area

Source: Siemens AG

- Contribution to frequency stabilization by BESS
- Stabilized local grid by increased effective power of BESS
- Behavior of BESS simulated using energy flow model

Battery energy storage systems (BESS)

- Located in Wunsiedel energy park
- Entire region supplied by green energy
- Siestorage provided by Siemens AG
- One of Bavarias's largest BESS
- Use case 1: Primary frequency response market
- Use case 2: Regional energy management

System Parameter	Value
Nominal Storage Capacity	9 MWh
Rated Power	8.4 MW
Inverter	12x833 kVA
Transformers	4x2000 kVA
Battery Cells	Graphite | NCM

Modeling of Battery Energy Storage

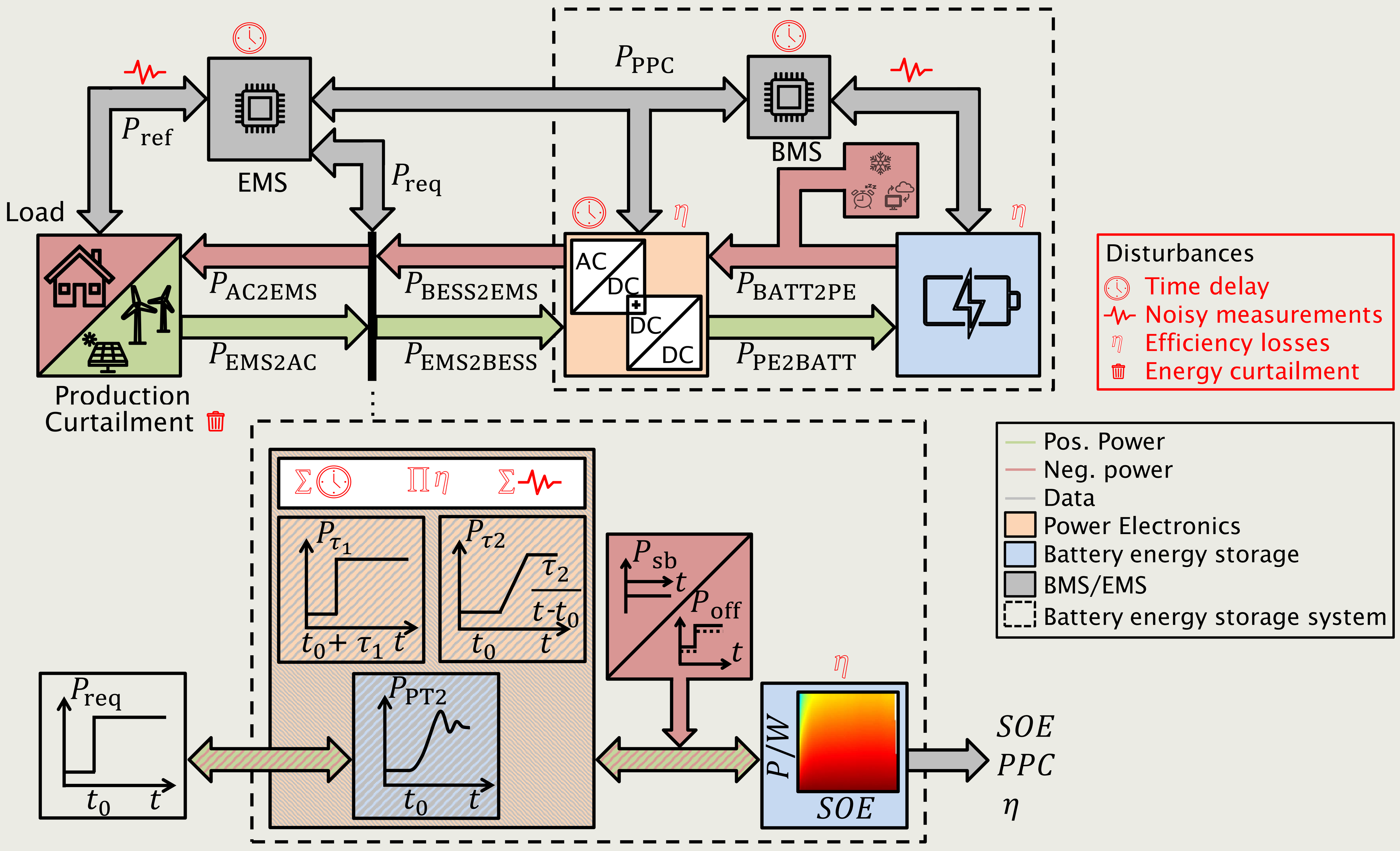
Battery Model

- Modeling of system components
- Approach based on control technology modeling methods and efficiency maps
- Difference equations simulate dynamic system behavior
- Uses energy flow as input
- No information about current or voltage needed
- Low model complexity and fast computation times

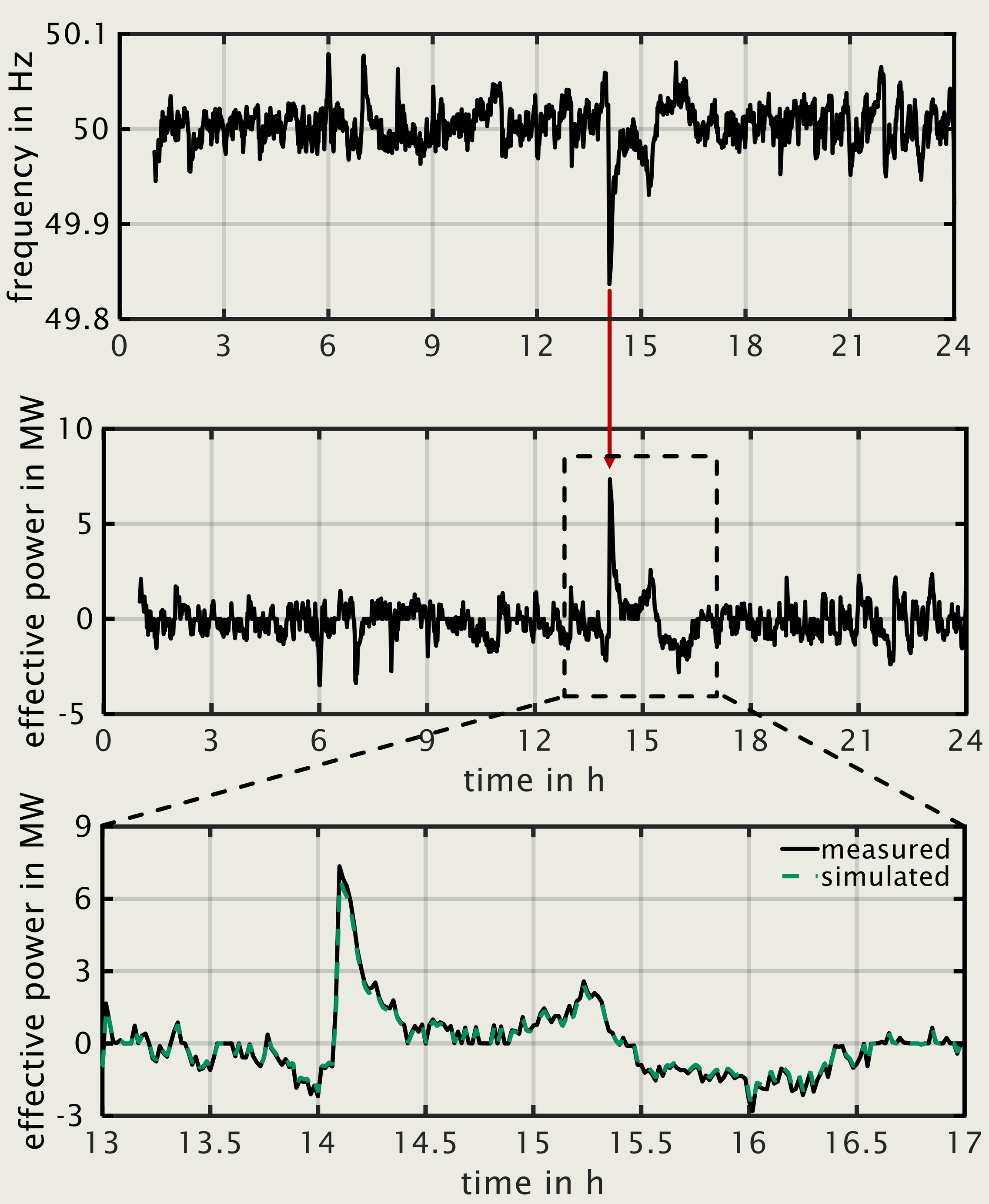
Modeled internal states

- Model simulated at discrete time steps Δt
- At each iteration step update of internal states
- Information of non measurable system states for operation strategies

Three internal states	Equation
State of energy (*SOE*)	$SOE = \frac{E_t}{E_{nom}} = \frac{\int P\,dt}{E_{nom}}$
Pulse power capability (*PPC*)	$\min_P \{PPC_{SOE,t}\ PPC_{lim,t}\ PPC_{U,t}\}$
System efficiency η	$\prod \eta$



Real and modeled System Response

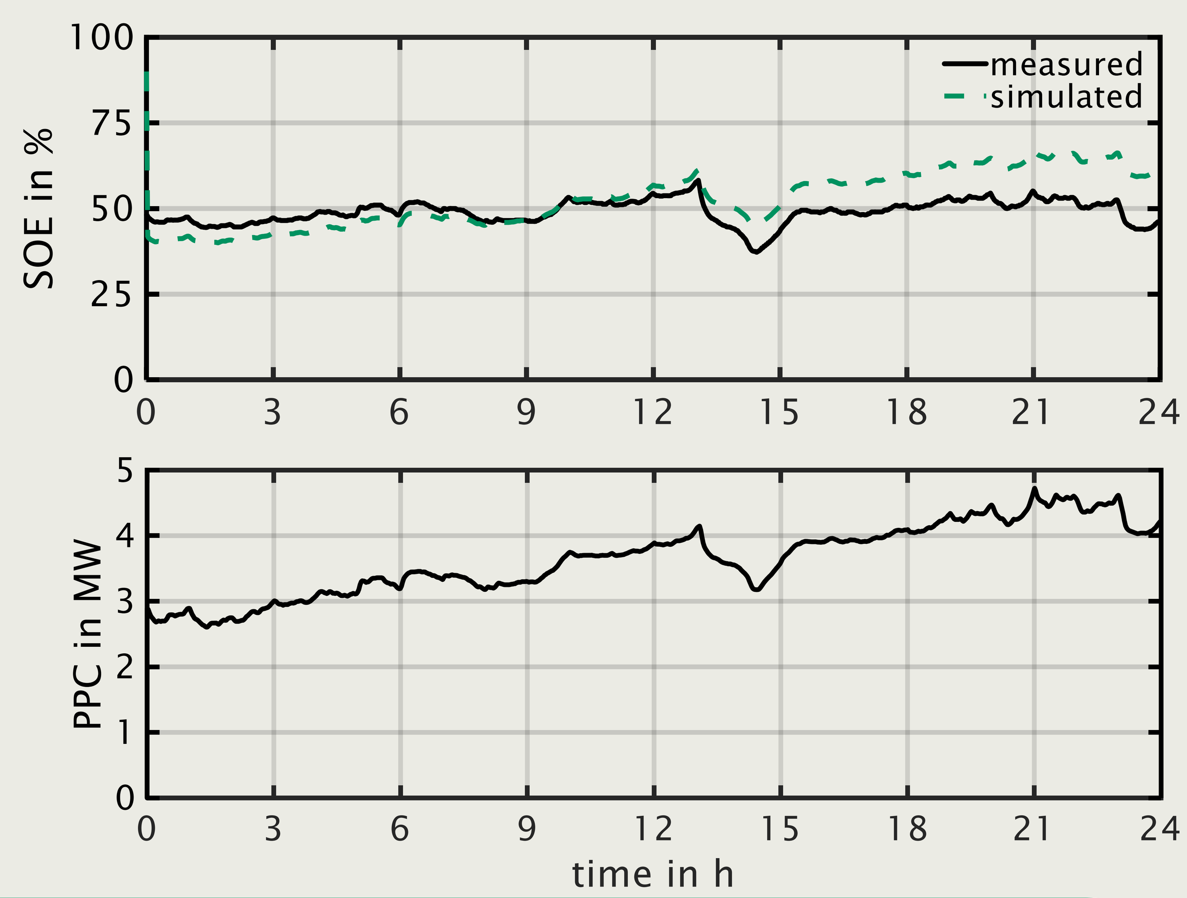


Situation in Wunsiedel

- Frequency collapse measurable without delay from source event
- Neutralized by the on-site battery storage
- Slight increase in frequency shortly before collapse
- BESS briefly absorbing power from the grid
- Frequency drop to well below 49,9 Hz at event
- Rapid increase of active power within seconds from -3 MW to 7.21 MW

Simulation

- Model fitted to real BESS
- Measured control signal of BESS as model input
- Modeled effective power follows measured data dynamics
- Mean deviation of simulated and measured power: 0.007 MW
- *PPC* curve follows *SOE*
- Modeled *SOE* with higher deviations due to parameterization



Summary

- Grid failure in south-east Europe measurable in northern Bavaria
- BESS dynamically able to provide high effective power
- Dynamic models required for simulating BESS behavior in frequency response market
- Model able to simulate system dynamics and effective power output of BESS

Sources:
[1] ENTSO-E Continental Europe Synchronous Area Separation 08 January 2021