A. Oudalov (ABB), M. Koller (EKZ) Smart Grid Week / Graz, May 23rd, 2014

1MW BESS in the Swiss Distribution Grid
Experience and visions

Power and productivity
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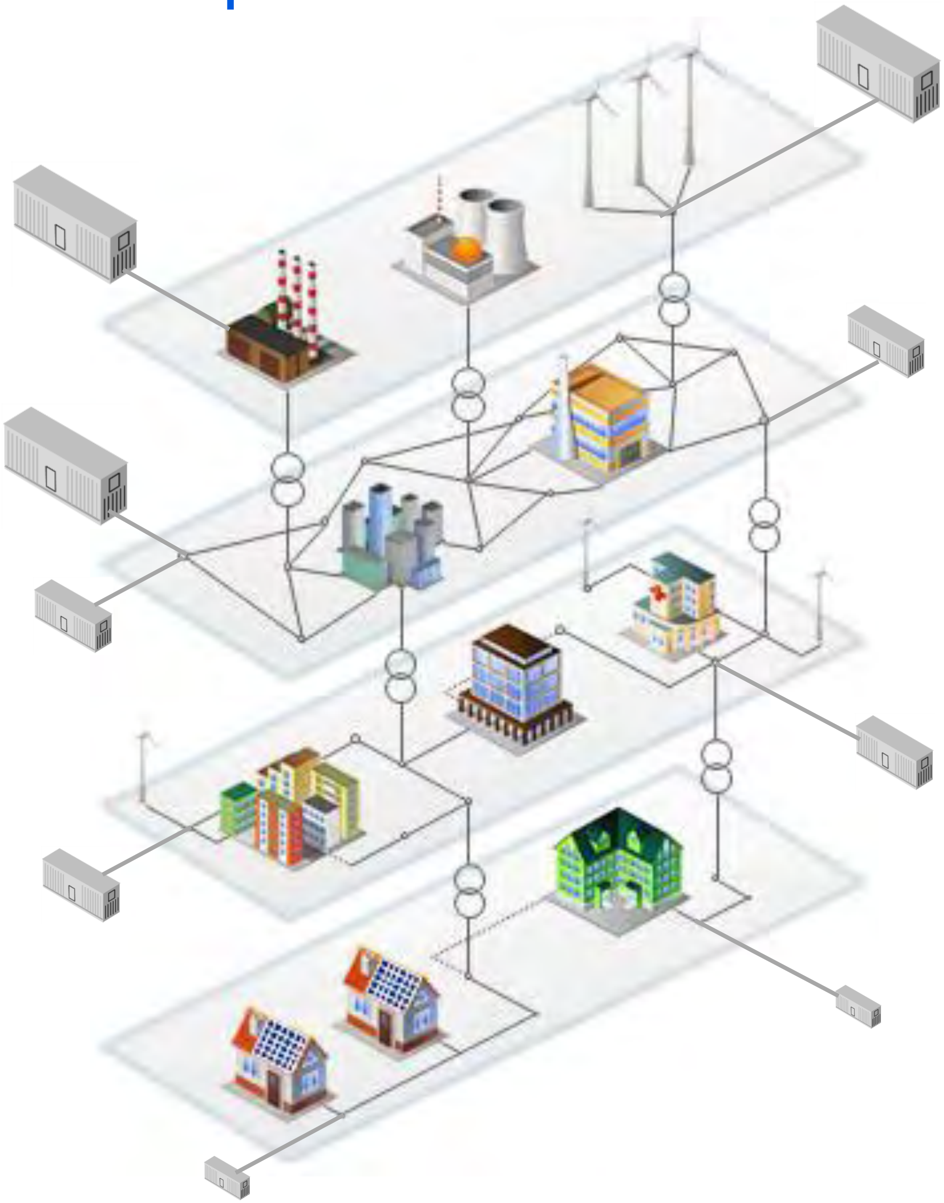
1MW BESS in the Swiss Distribution Grid
Outline



- Introduction
- EKZ’s 1 MW BESS system
- Lessons learnt
- Advanced BESS control

Place and role of energy storage in power systems
Application landscape



Integration of renewables
10-100 MW, 0.5-10 h

Load leveling for generation utilization
10-100 MW, 1-4 h

Load peak shaving
1-10 MW, 0.25-1 h

Spinning reserve in case of line outage
10-100 MW, 0.25-1 h

Frequency regulation
1-50 MW, 0.25-1 h

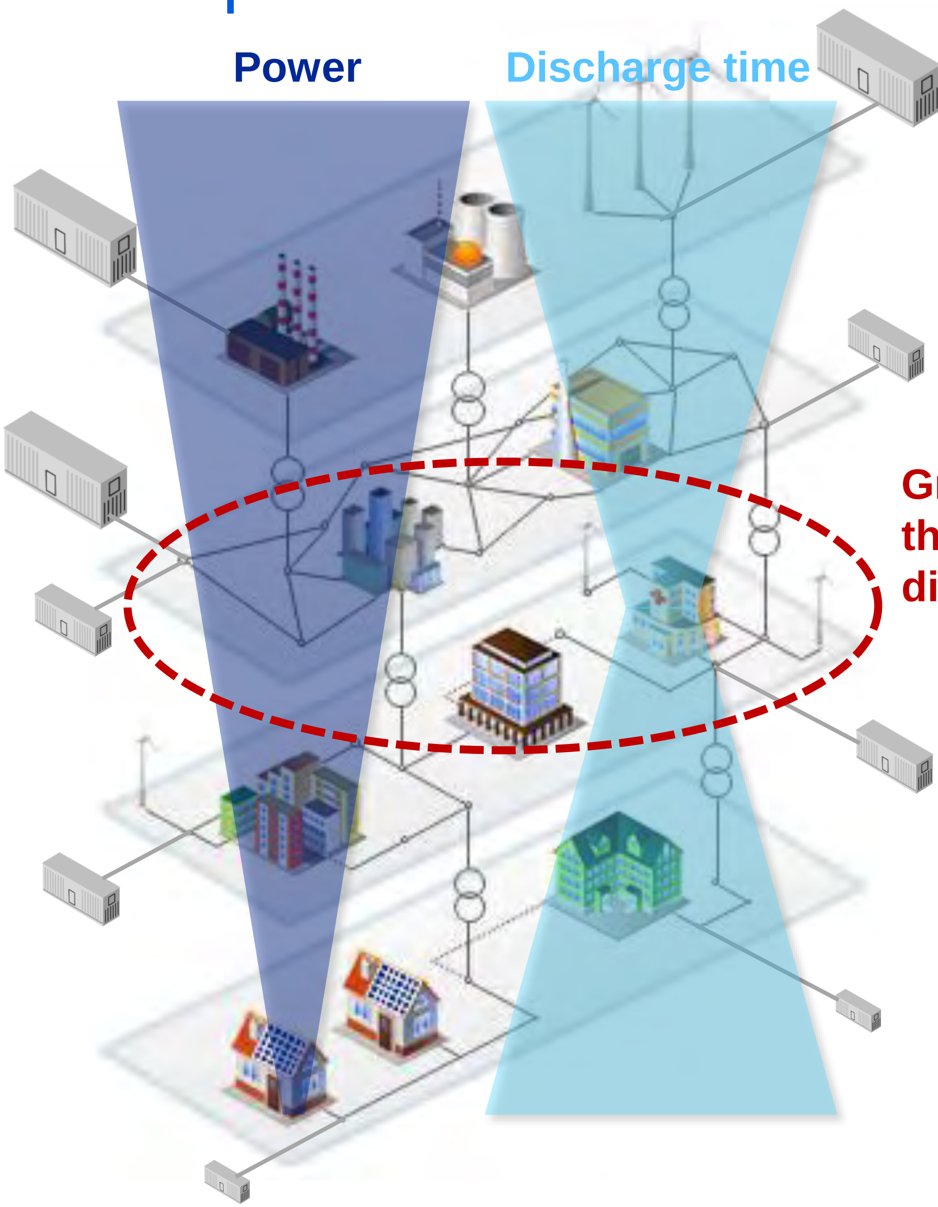
UPS and PQ for critical loads
1-10 MW, 0.1-0.25 h

Integration of renewables
1-10 MW, 0.5-10 h

Community energy mgmt
0.1-1 MW, 1-4 h

Residential energy mgmt
1-10 kW, 1-6 h

Place and role of energy storage in power systems
Application landscape



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Battery Energy Storage in a Distributioin Grid
Drivers

- EKZ is one of the largest power providers in Switzerland supplying around 10 per cent of the country's electricity consumption
- Gain experince with utility-scale energy storage and applications at the distribution grid level including business case analysis for:
  - Peak Shaving
    - Grid expansion deferral
    - Safety margin reduction in grid planning
    - Minimize demand charges
  - Voltage regulation
    - Integration of decentralized generation
    - Improvement of power quality for critical loads
  - Frequency regulation
  - Islanding capability
    - Microgrids
    - UPS for critical loads

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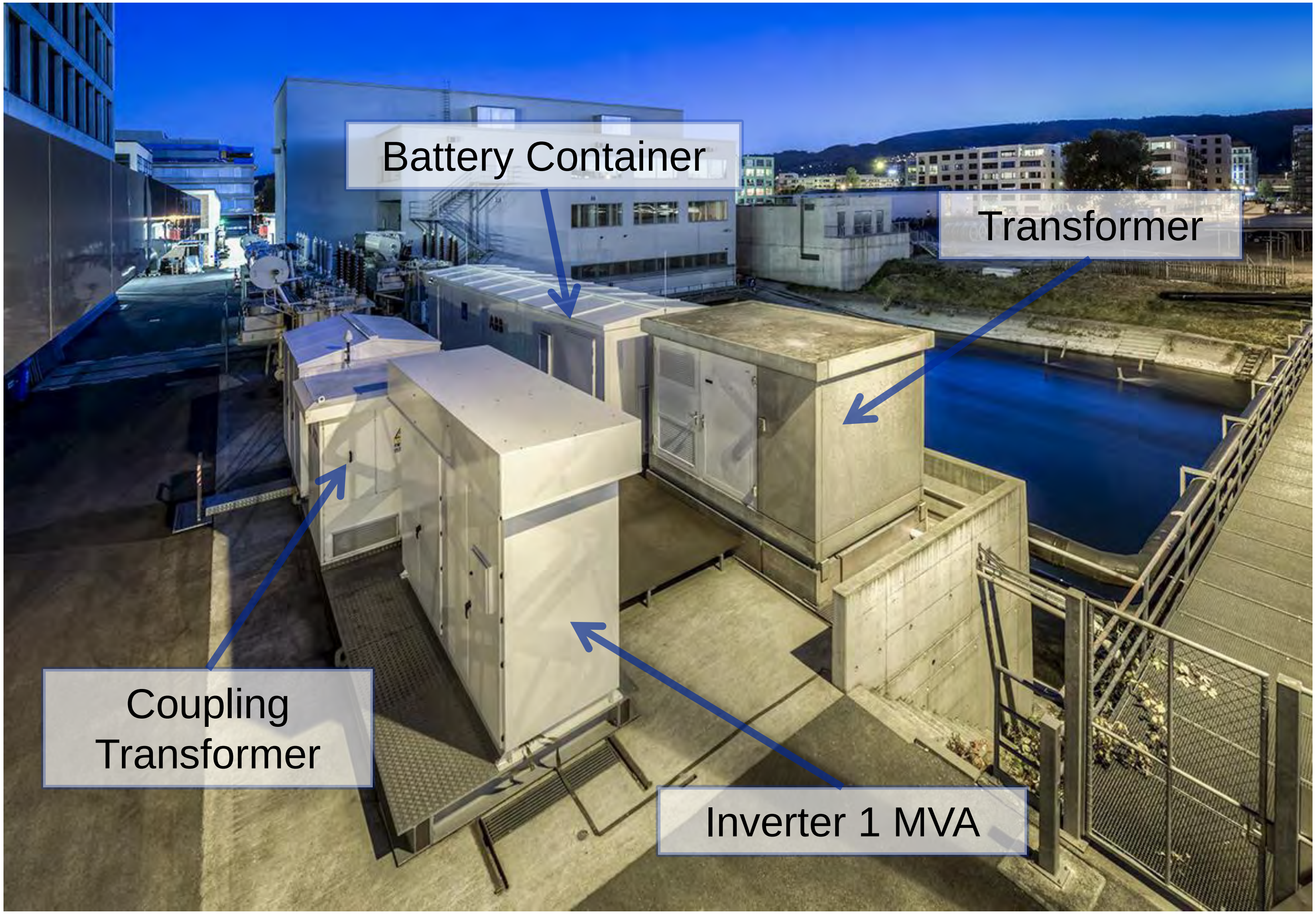
EKZ 1 MW BESS
System Overview



Source: EKZ

EKZ 1 MW BESS
System Components

Battery modules

Battery container

Inverter

SCADA

Source: EKZ

EKZ 1 MW BESS
System Properties

Property	Value	Notes
Power	1 MW	charging and discharging
Capacity	580 kWh	250 kWh @ 1 MW
System Integrator	ABB	
Battery Manufacturer	LG Chem	
Cell Type	Li-Ion	
Number of Cells	10368	
Lifetime[1]	3500 Cycles	2 Cycles/day, 250 kWh
System Costs[2]	~2 Mio EUR	~500k Battery

[1]Warranty, real lifetime most likely higher.
[2] Reflecting costs of procurement in 2011

Source: EKZ

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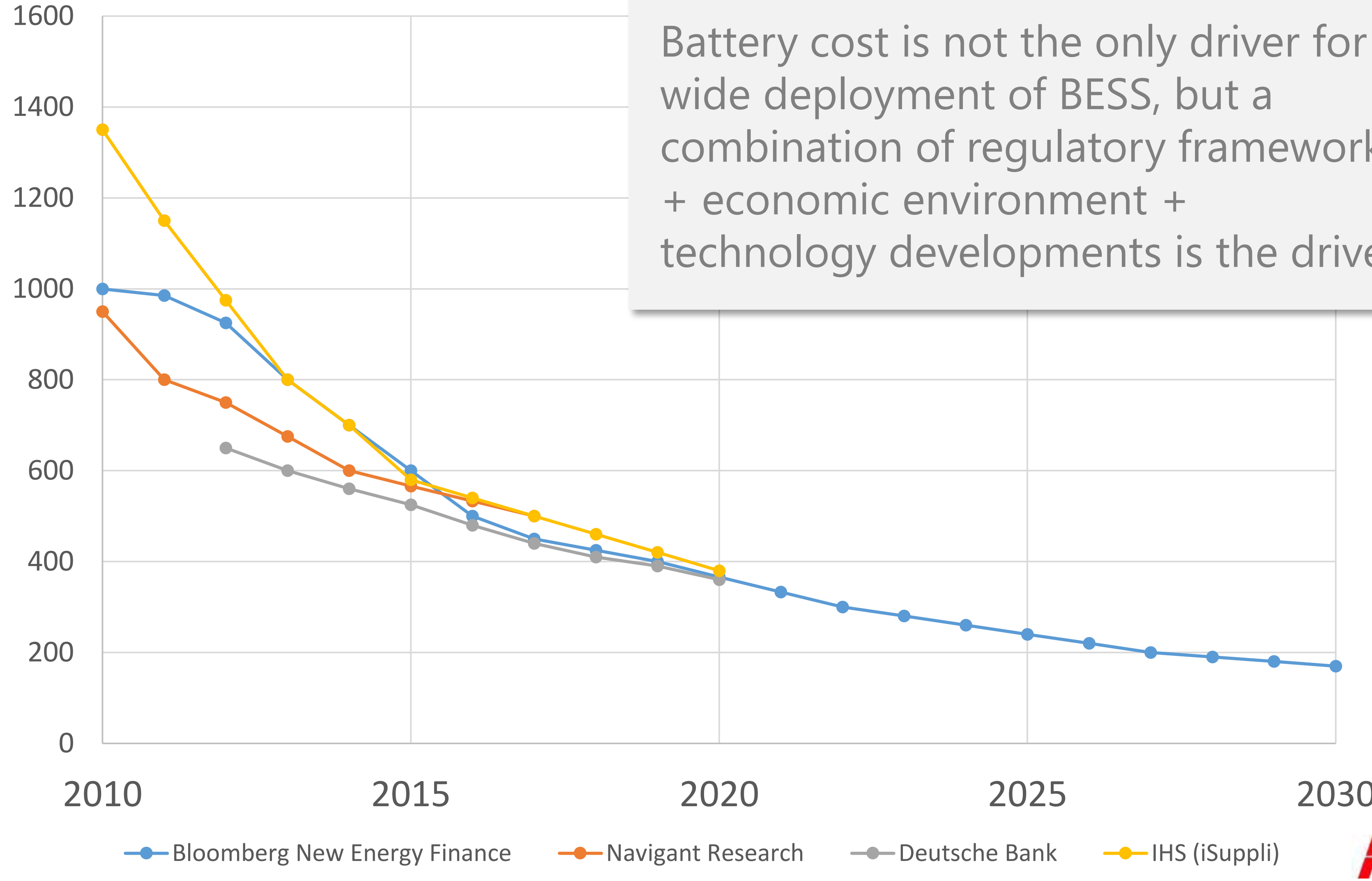
Projected Cost Reductions of Li-ion Batteries ($/kWh)



Battery cost is not the only driver for wide deployment of BESS, but a combination of regulatory framework + economic environment + technology developments is the driver

Lessons learnt
Efficiency during two years of operation


Source: EKZ

- **Components**
  - Battery: round trip 90 – 95% (higher at low power rates)
  - Inverter: one way 97% (lower at low power rates)
- **System**
  - Cycle with 50% DoD at 50% rated power (±500 kW, 30 min each)
  - Round trip w/o auxiliary: 90%
  - Round trip with auxiliary: 85%
- **Real life efficiency is strongly dependent on power profile (i.e. use case)**

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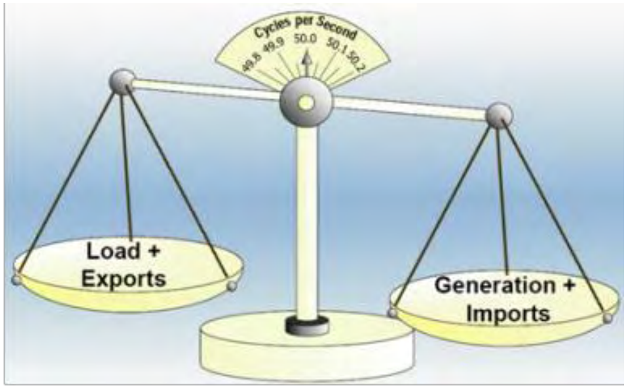
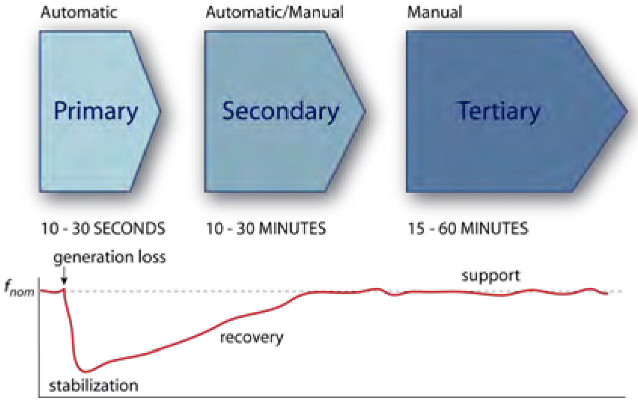
Frequency regulation
A bastion of system stability

- TSOs have the task of keeping the equilibrium between electricity generation and demand at all times
- To do so a TSO needs different types of frequency control reserve which differ according to the principle and speed of activation
- The fastest reserve is automatically called immediately after an incident of frequency deviation
  - ✓ E.g. in CE ENTSO-E zone an activation time for a full amount of primary reserve is 30 sec





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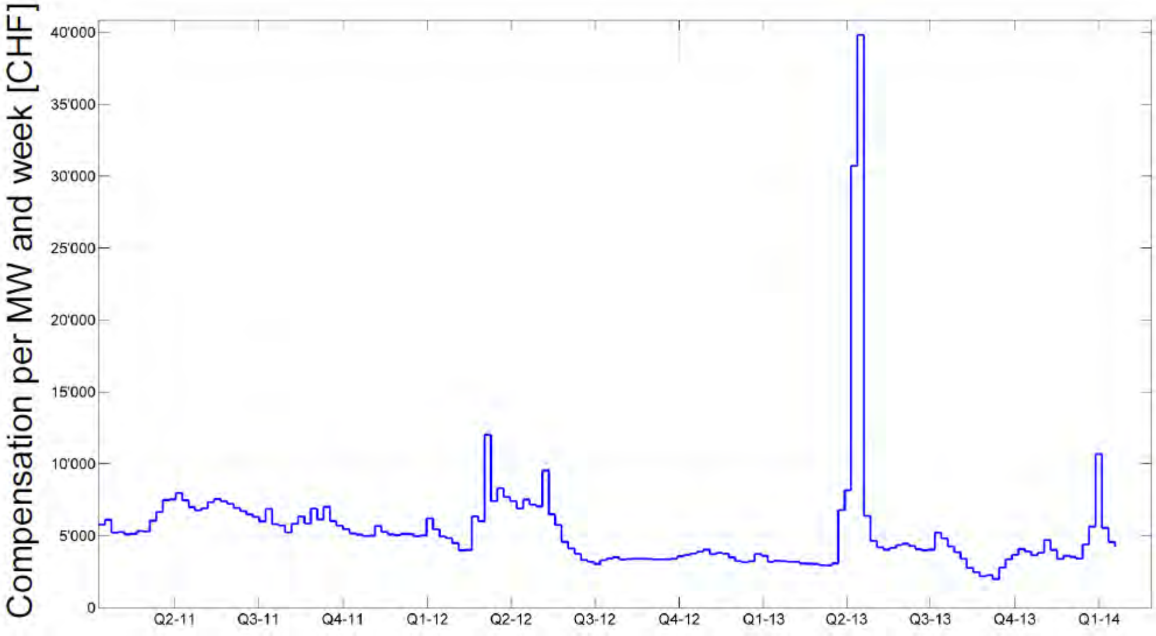
Primary Frequency Regulation in Switzerland
Ancillary service market

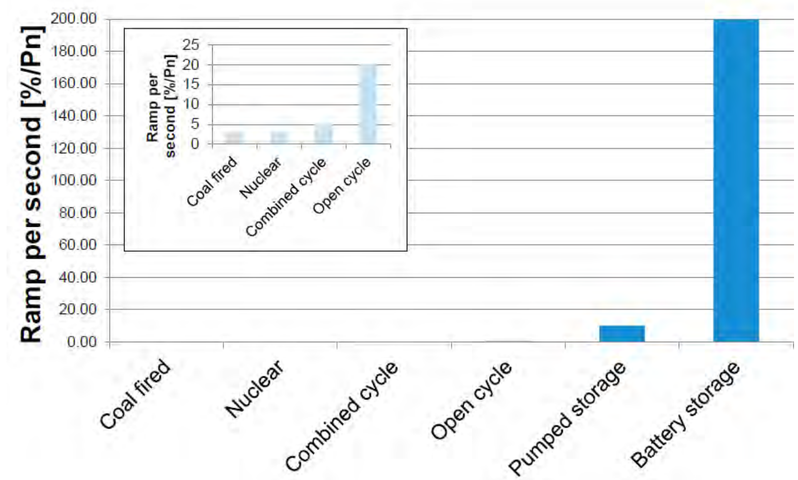
- As TSOs do not posses any power plants of their own they invite tenders from independent power suppliers
- The control power market has been created in Switzerland in 2009
- A supplier of a frequency regulation reserve is paid as bid based on provided capacity in MW

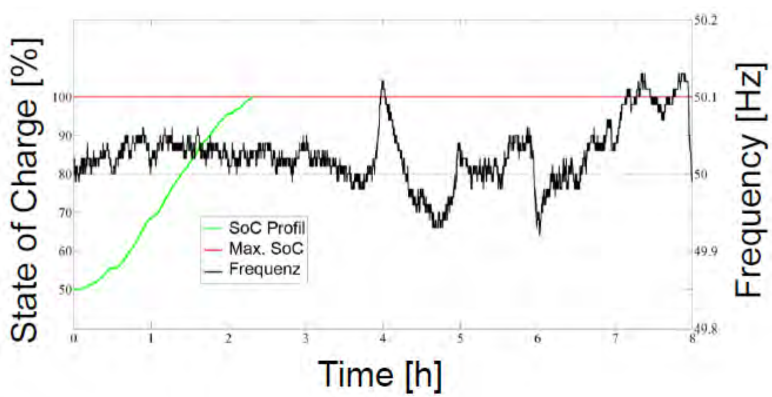


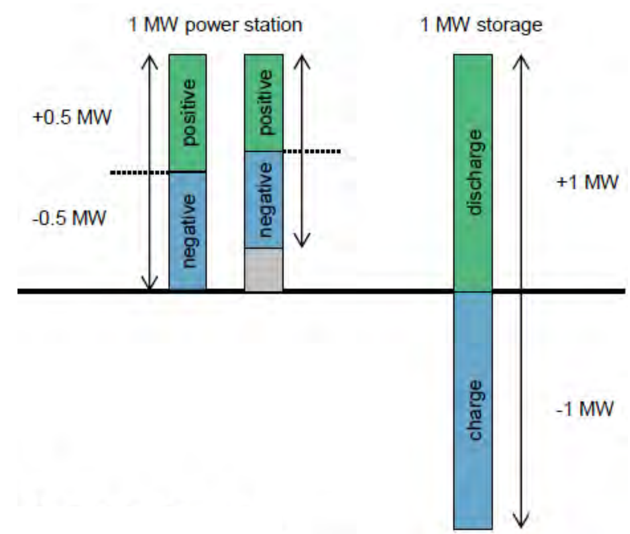
Source: swissgrid

Primary Frequency Regulation
BESS advantages and disadvantages

- BESS Advantages:
  - Fast reaction time (ramp rate)
  - Double regulation range
- BESS Disadvantage
  - Limited storage capacity for economic reasons
- Control of SoC should be made simultaneously with application control



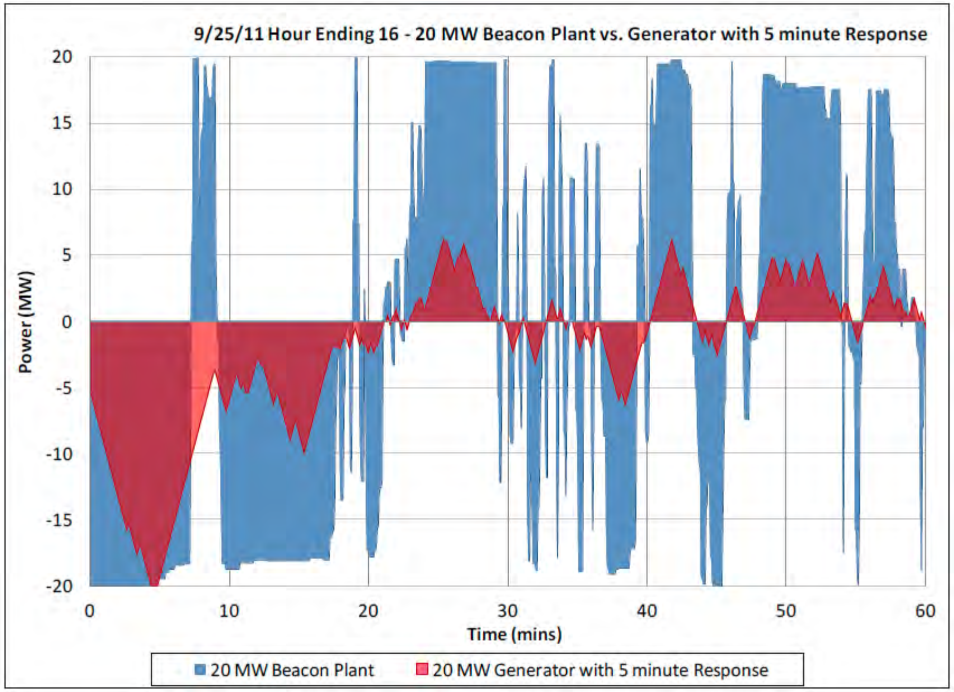




Source: EKZ

Frequency Regulation
Example of performace based reward introduction

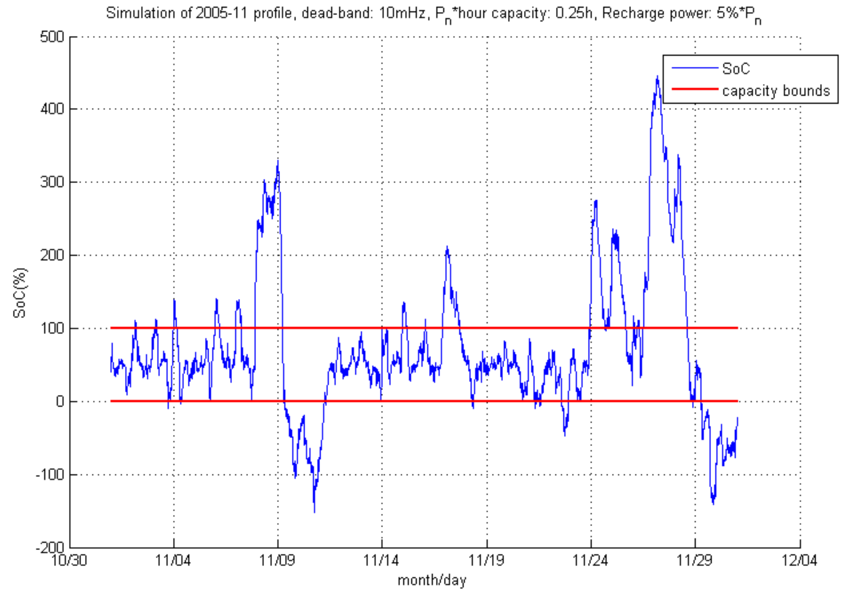
- Some stakeholders have argued about unjust and unreasonable remuneration schemes for fast ramping units
- FERC Order 755 requires RTOs and ISOs to compensate fast reacting frequency regulation resources by **adding a performance reward** (accuracy of following the dispatch signal) to the standard capacity based payment

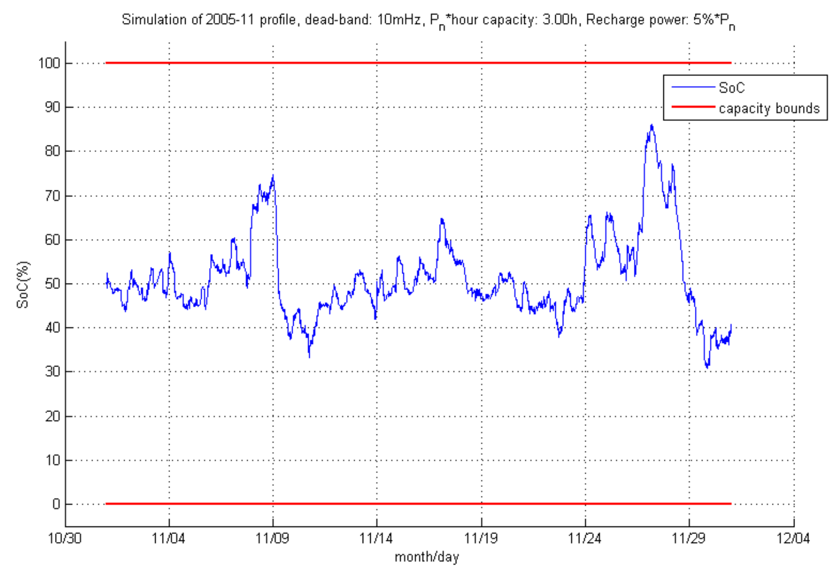


Source: Beacon Power

SoC Control
Typical «reactive» strategy

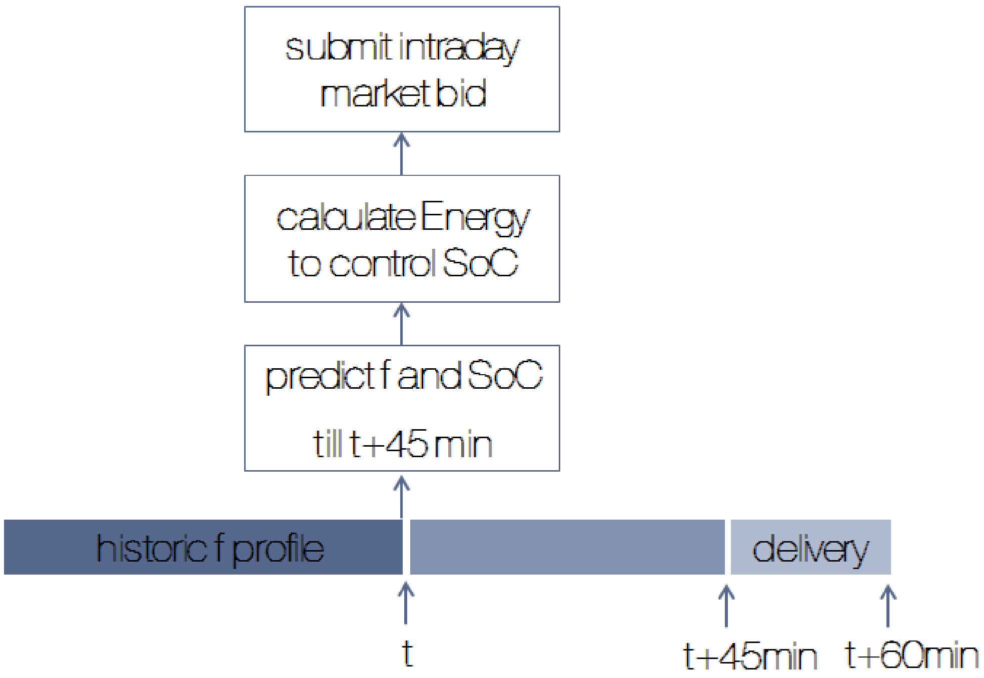
- Control strategy:
  - Battery discharge time: 15 min
  - SoC contol by additional charge/ discharge within ±10 mHz tolerance band with 5% of rated power
- Results:
  - Battery size is not sufficient to provide f control service. SoC goes out of limits several times per month
- Conclusions:
  - Low recharge power requires large battery (few hours)
  - To decresre the battery size a recharge and discharge rate must be higher



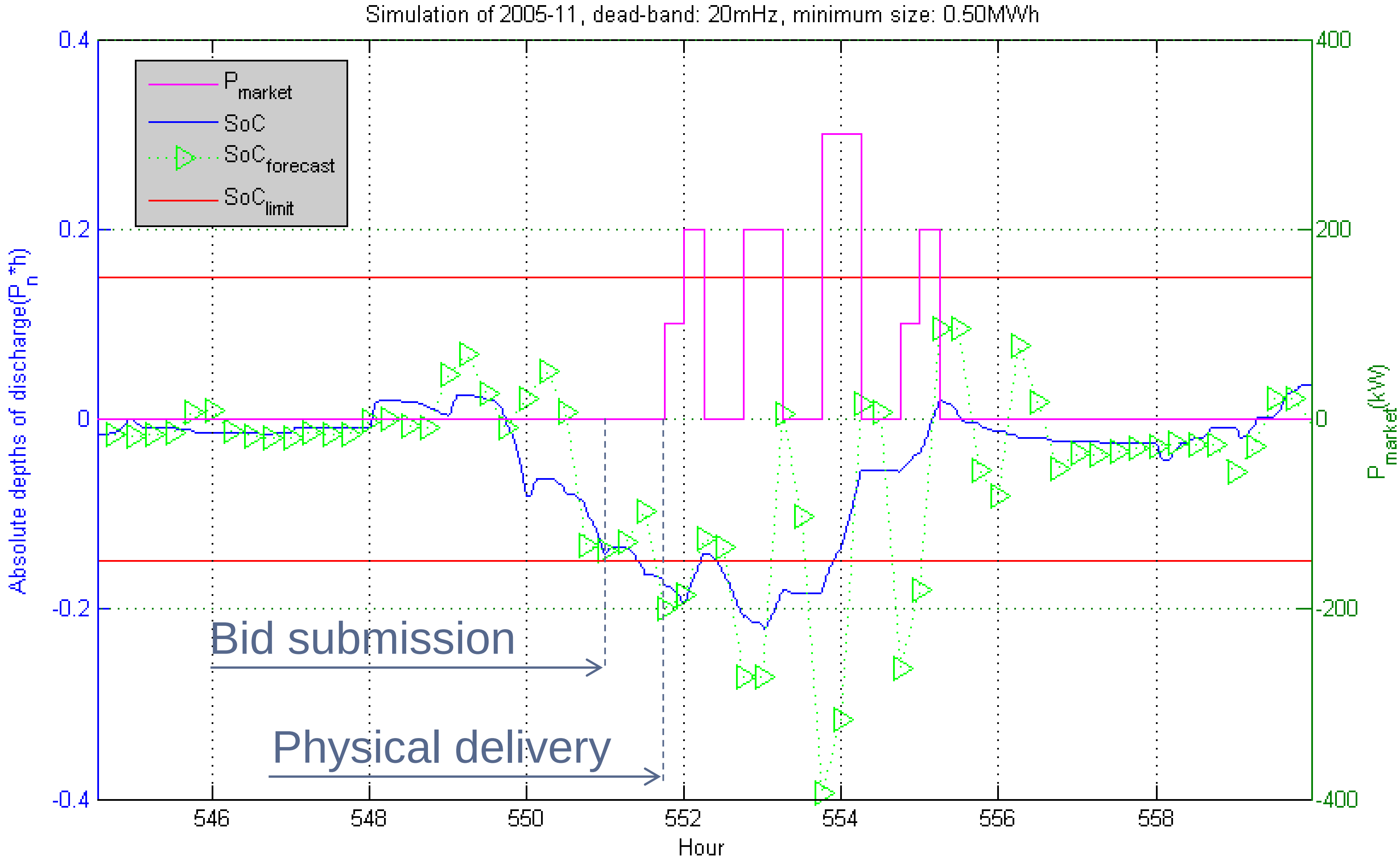


SoC Control
Potential future «pro-active» strategy

- Predict frequency behavior and estimate SoC trajectory based on historic data
- Discharge/recharge battery by selling/buying required amount of energy on the intra-day electricity market
- Current market rules in Germany:
  - bid submission latest 45 min prior the physical delivery
  - Delivery interval is 15 min or 60 min
- Not yet implenented in EKZ BESS

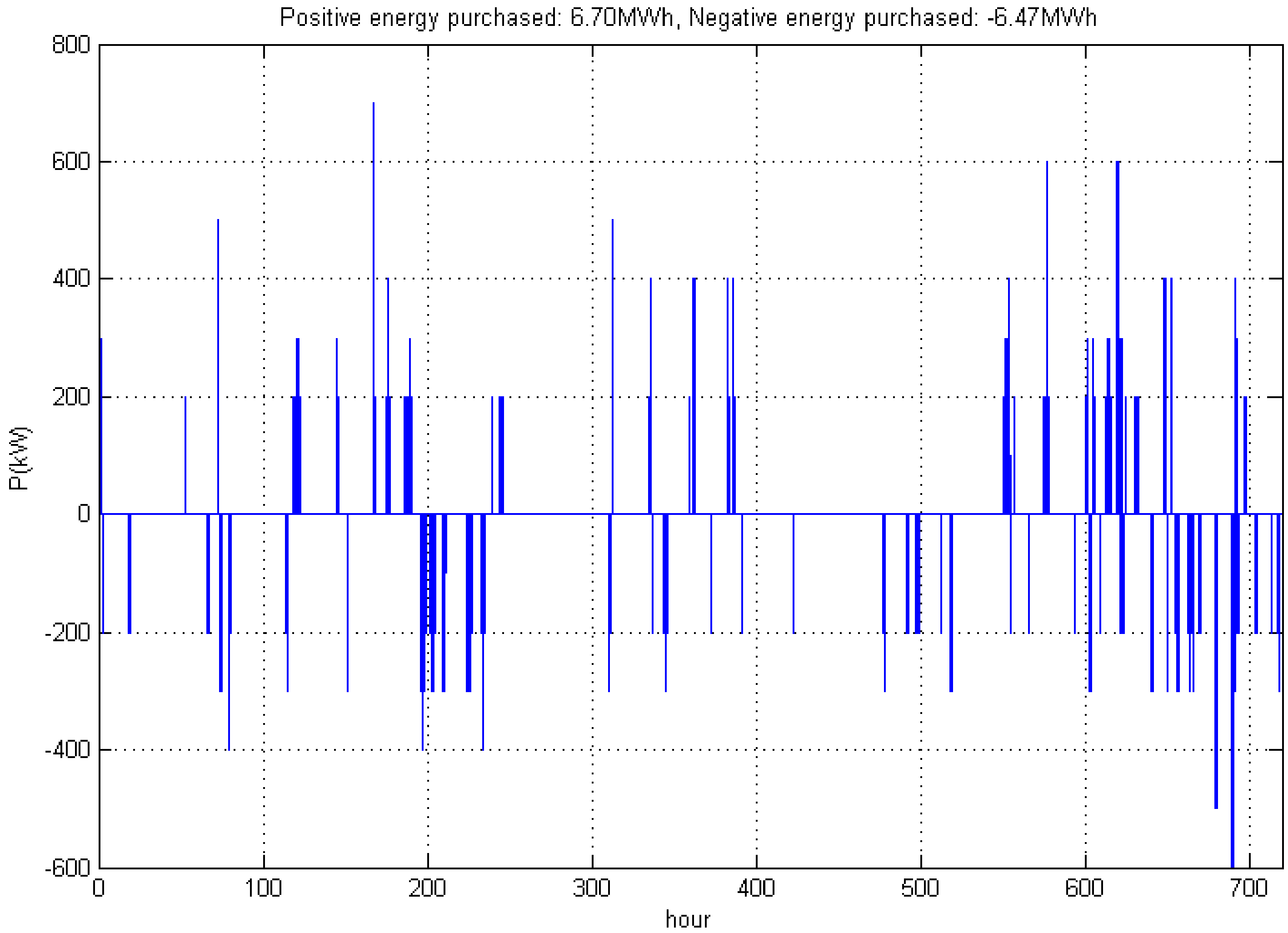


SoC Control
Example of SoC forecast

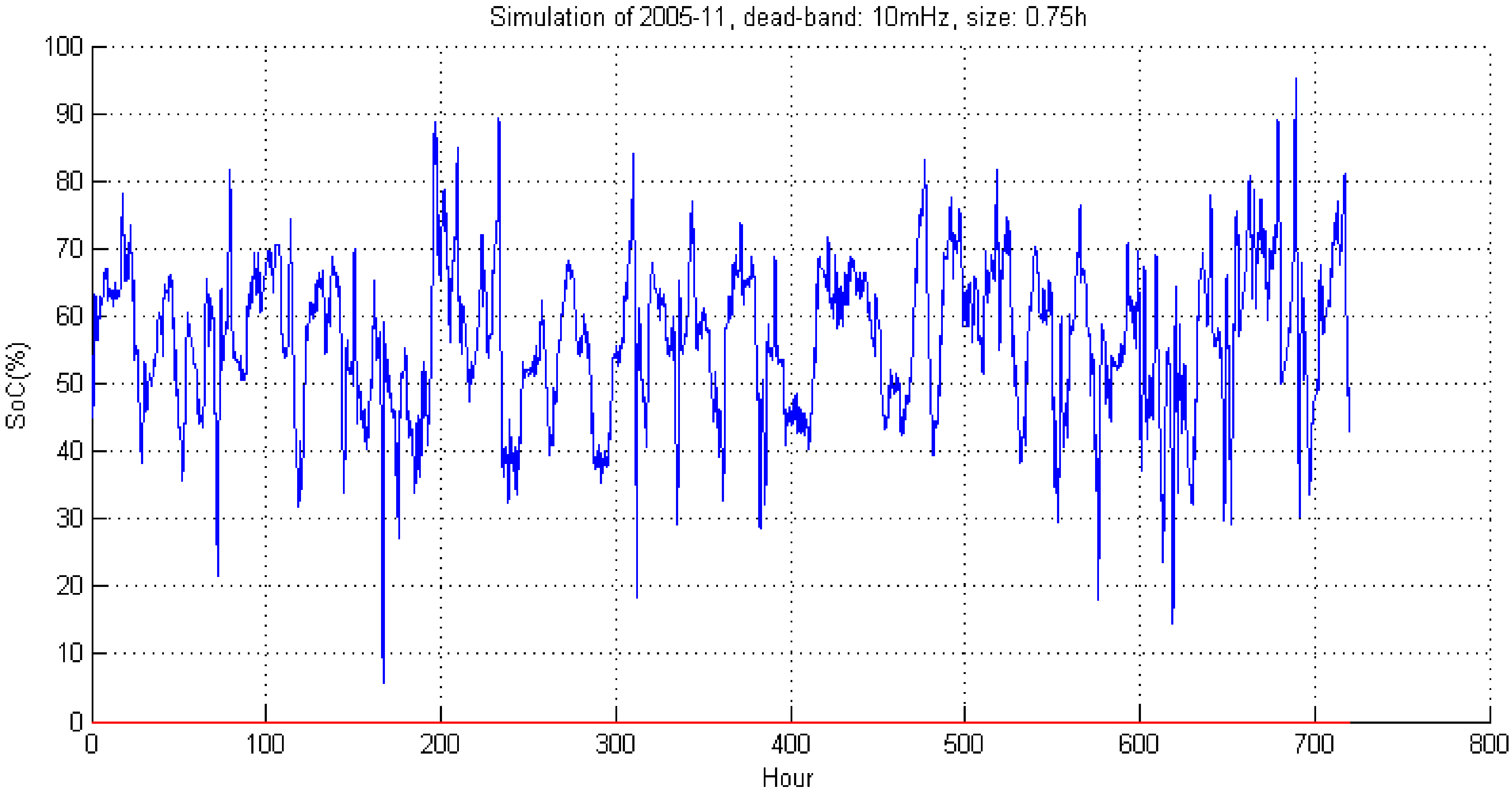


SoC predictor implemented using GM(1,1) (grey model one dimension first order)

SoC Control
Monthly intraday market energy throughput



SoC Control
Monthly SoC profile



Conclusions in a nutshell

- Different applications have been running at EKZ’s 1 MW BESS and the system was fully capable to run them
- We keep investigating and improving all applications
- We have understood a need for advanced BESS control algorithms capable to predict a future system state and pro-actively take grid friendly actions to manage optimal SoC
- Regulatory framework should be changed in order to provide an adequate reward for fast and precisely reacting units

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