SUEID 2019
Swiss-U.S. Energy Innovation Days
Oct. 8th, 2019

Influencing the Bulk Power System Reserve by Dispatching Power Distribution Networks using Local Energy Storage

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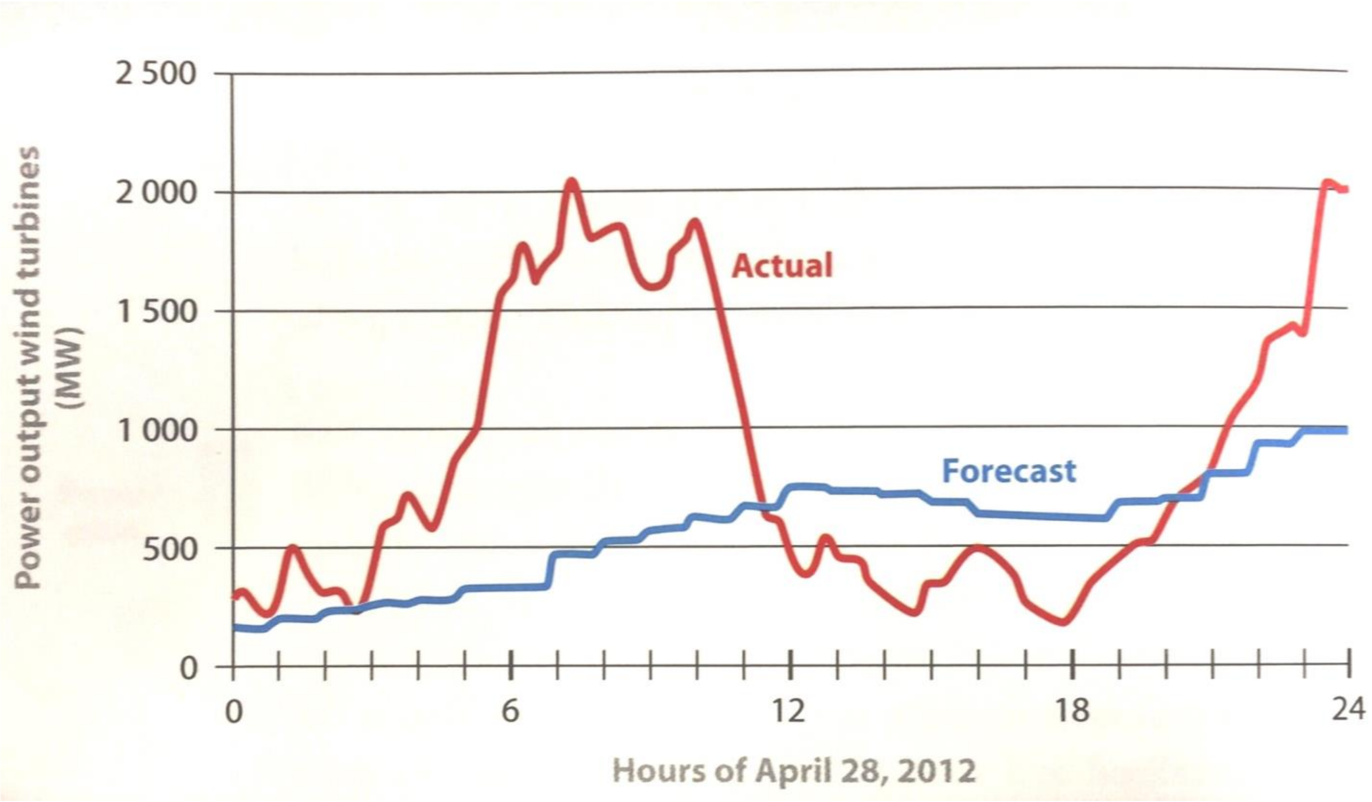
Motivations – Renewables forecasting uncertainties

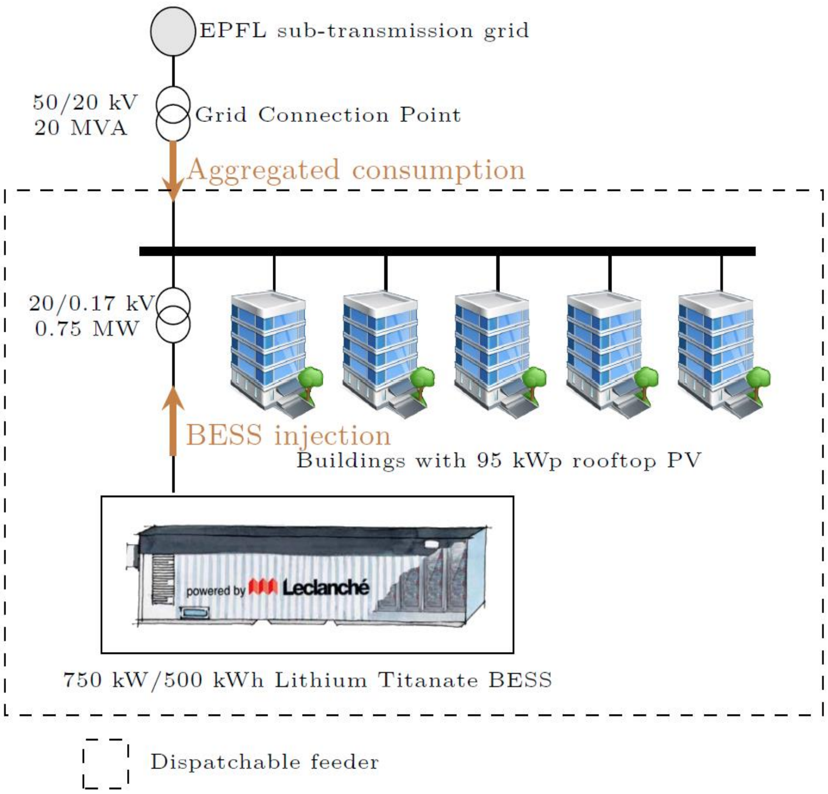


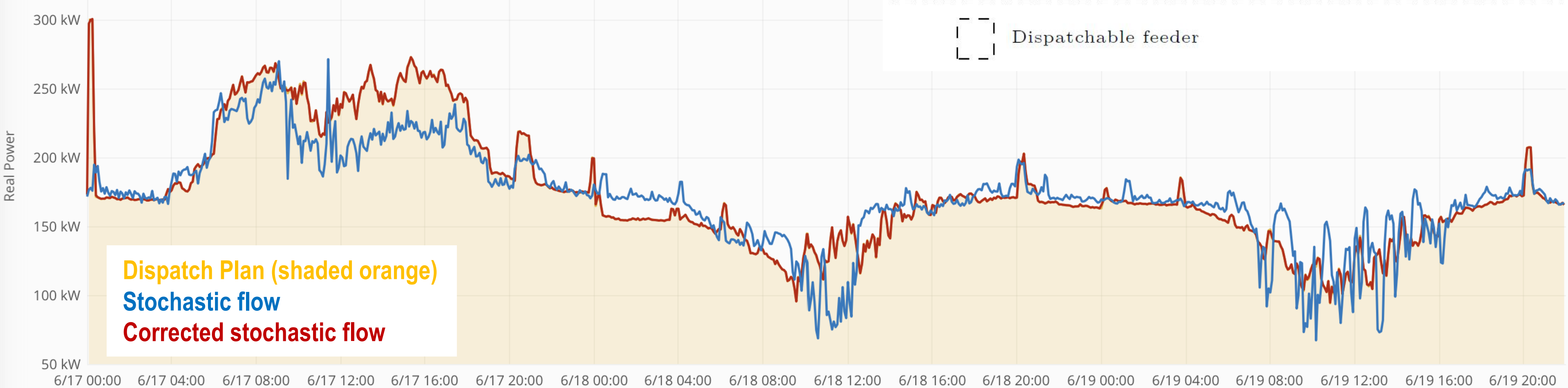
Example of deviation from predicted (24h-ahead) and actual power output from wind turbines in the German Amprion TSO region, April 28, 2012.

Dispatching heterogeneous resources via local storage

Problem Statement

- Compute a **dispatch plan** for a set of heterogeneous resources at the grid connection point (GCP) accounting for local grid constraints and local storage capacity (see also [Stai et al., 2017]).
- Control storage devices in real-time to track the dispatch plan.



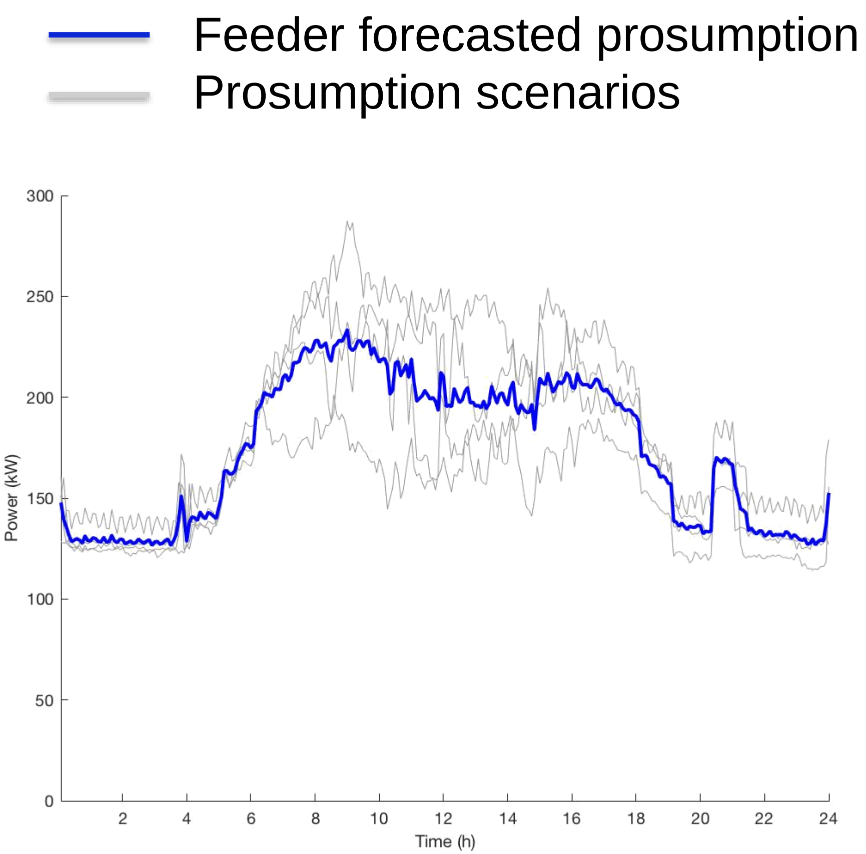


Dispatching heterogeneous resources via local storage

1. **Objective**: control an energy storage asset (for instance, a battery energy storage system - **BESS**) in order to dispatch the operation of a MV network hosting non-controllable stochastic generation and demand.

2. **Stochastic aspects**: determine a set of possible consumption/generation scenarios for the stochastic resources (prosumption).

3. **Problem**: maximize the exploitation of the ESSs capacities subject to energy and power constraints, to the uncertainty due to the stochastic nature of the resources (PV generation, loads) as well as local grid constraints.



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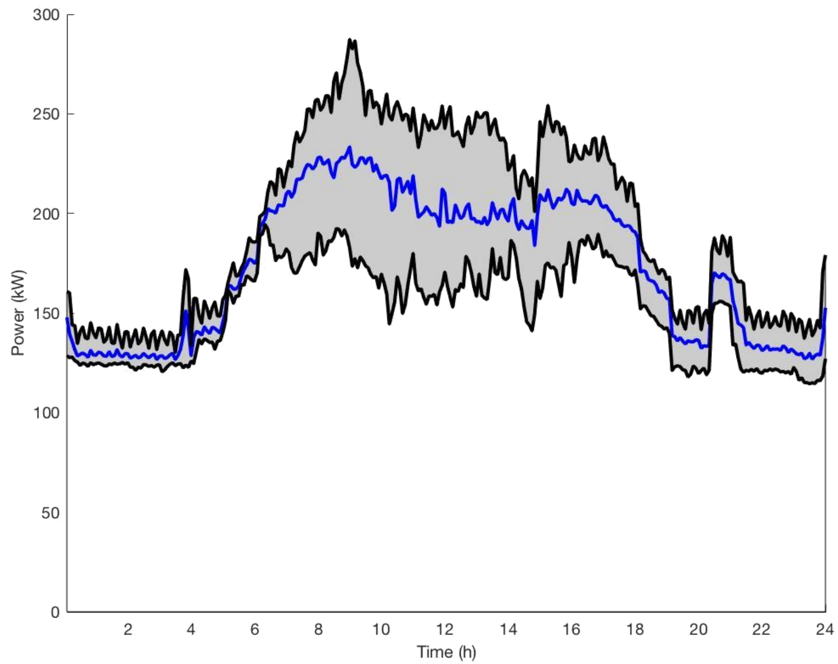
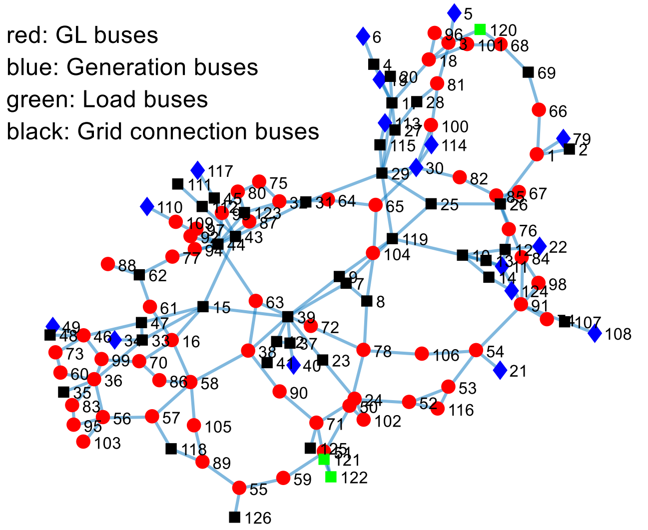
Feeder forecasted presumption

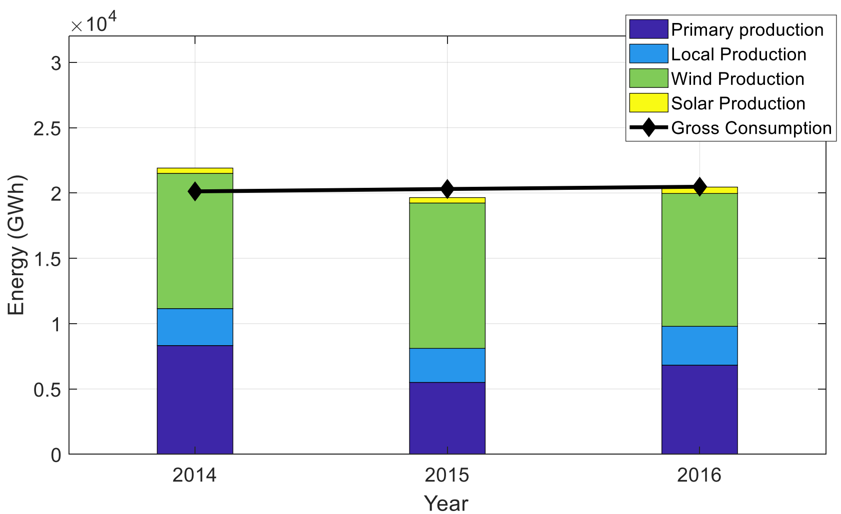
$L^{\uparrow}$ and $L^{\downarrow}$ min-max scenarios



Case Study – West Denmark power system

- 126 buses at 400 kV and 165 kV connected by 147 transmission lines and 41 high voltage transformer.
- 227 power generation units with overall capacity of 7323,1 MW. Stochastic generation (wind) penetration is 50%.
- Order of magnitude of hourly total load (electric energy demand) 2000 MWh.





Generation mix in terms of annual energy production

Note

- Technical details of system components are considered based on realistic data sets provided by ENTSO-E and Energinet.dk.
- Interconnections with neighbouring countries is not considered as the system is balanced in terms of overall generation and consumption.

Conclusions

- The effect of dispatched-by-design power distribution systems on the amount of reserve required to operate the bulk grid with a certain level of reliability has been investigated.
- We considered as a case study the Danish transmission grid and the associated fleet of conventional power plants. The two following cases were considered:
  - Case I the power reserve capacity is fully provided by conventional power plants;
  - Case II reduced capacity of conventional power plants to provide reserve power that is compensated for by implementing dispatched-by-design distribution networks.
- We performed a complete technical and economic assessment and the results showed that 1) **large scale deployment of BESSs under dispatch-by-design architecture of distribution network** is a **viable technical solution** to address flexibility requirements of power systems and 2) **this solution is economically viable with a pay-back time in the range of 11-14 years** (depends on deployment schemes) compared to providing flexibilities from conventional power plants.
- Full paper: Electric Power Systems Research 163 (2018), 270-279

Thank you !