

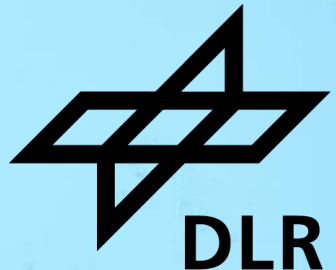
Evaluating the value of probabilistic forecasts in power systems

Lueder von Bremen, Bruno Schyska, Hauke Bents, Clara Buller

DLR, Institute of Networked Energy Systems, Oldenburg

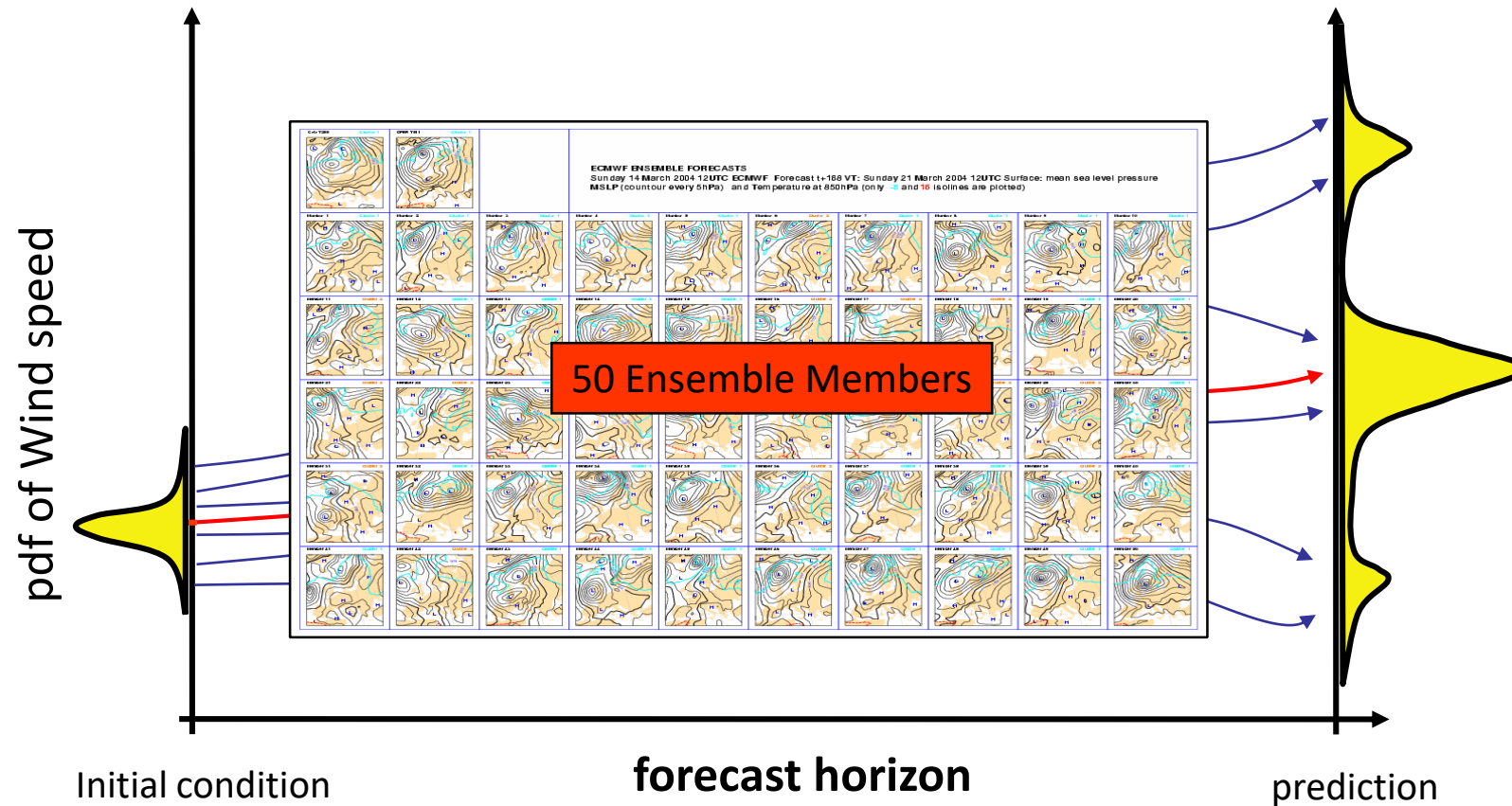
7th International Conference Energy&Meteorology 2023

Padova, 28.06.2023



How to evaluate the value of uncertain weather forecasts?

Solution from Numerical Weather Forecasting: Ensemble Prediction



Source: European Centre for Medium-Range Weather Forecasts (ECMWF)

- Lorenz Paradigm: Numerical Weather Forecasting is an initial state problem
- Quantify the uncertainty in the forecast to be aware of forecast errors
- **Major task: Combine probabilistic forecasts with power dispatch model**

How to evaluate the value of uncertain weather forecasts ?

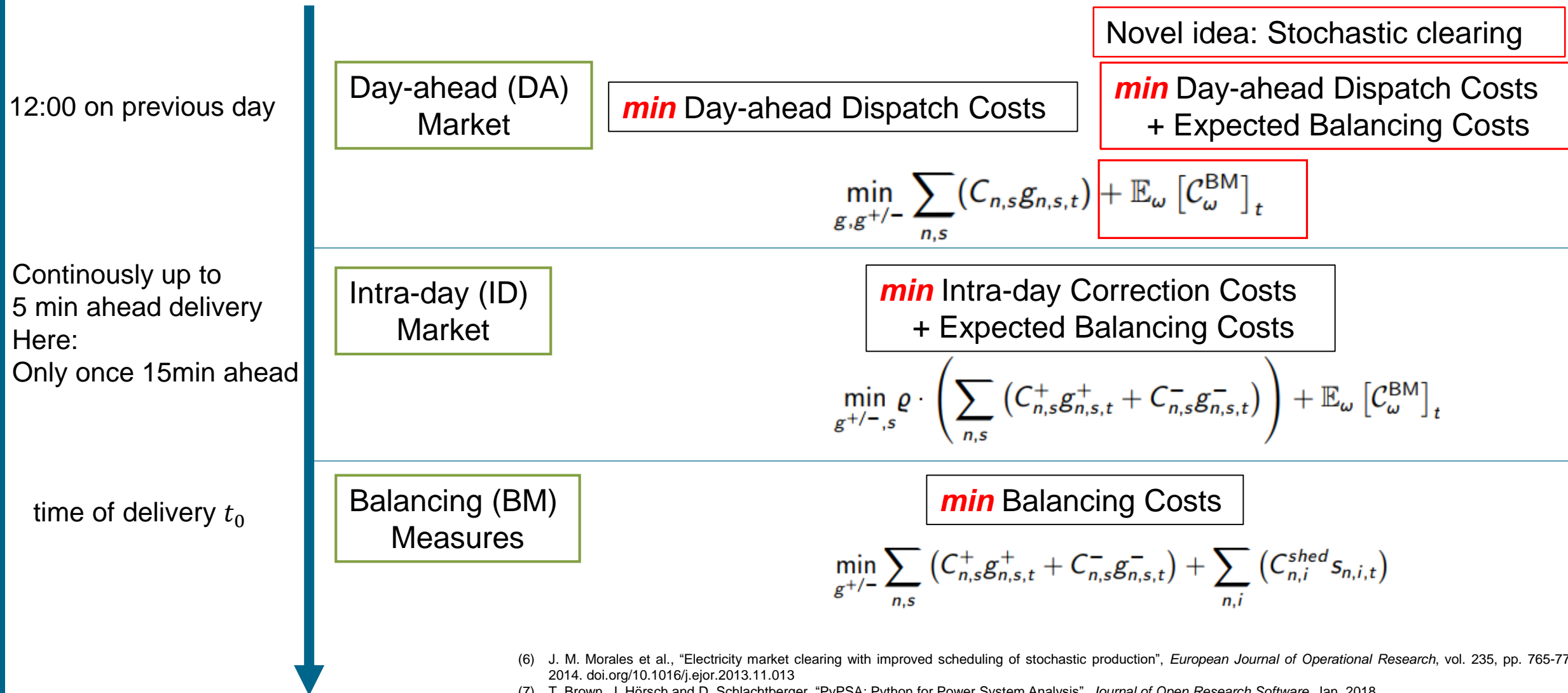
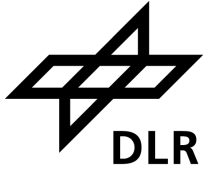


- **Solution from power system modelling: Stochastic Dispatch modelling including optimal power flow with transmission restrictions, ramping constraints and prices**

| Current practise: Conventional/Deterministic Clearing | Novel idea: Stochastic clearing |
|--|--|
| Without forecast uncertainty | Forecast uncertainty is considered by implementing expected balancing costs in optimization problem |
| Deterministic (best) forecast is used | 50 ensemble member are used as potential occuring weather scenarios |
| Potentially high system costs due to expensive balancing and expensive load shedding | System improves dispatch using uncertainty information. Less balancing is needed |

Optimization problem

Current practise: Conventional clearing at the stock exchange



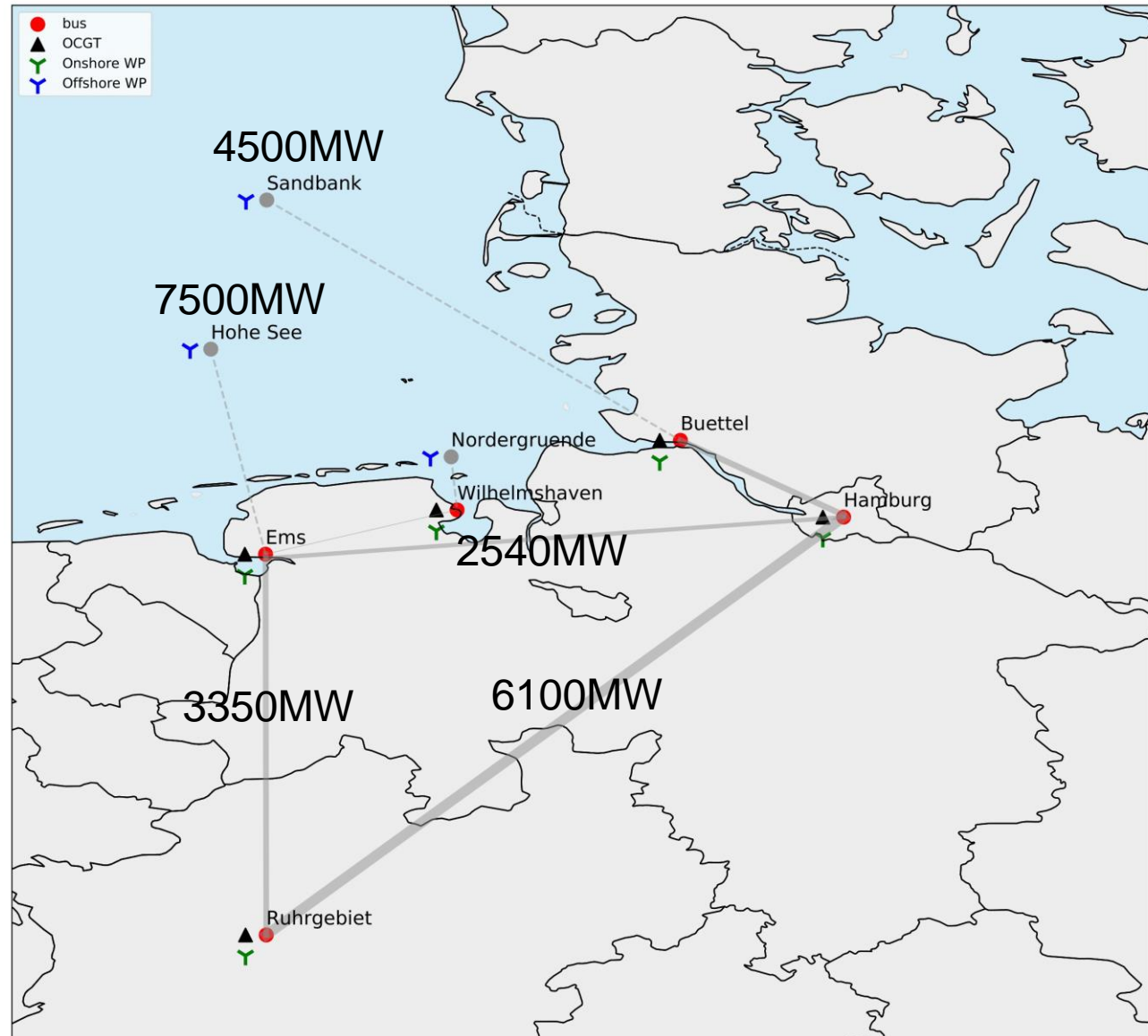
(6) J. M. Morales et al., "Electricity market clearing with improved scheduling of stochastic production", *European Journal of Operational Research*, vol. 235, pp. 765-774, 2014. doi.org/10.1016/j.ejor.2013.11.013

(7) T. Brown, J. Hörsch and D. Schlachtberger, "PyPSA: Python for Power System Analysis", *Journal of Open Research Software*, Jan. 2018.

Studying Network

Properties:

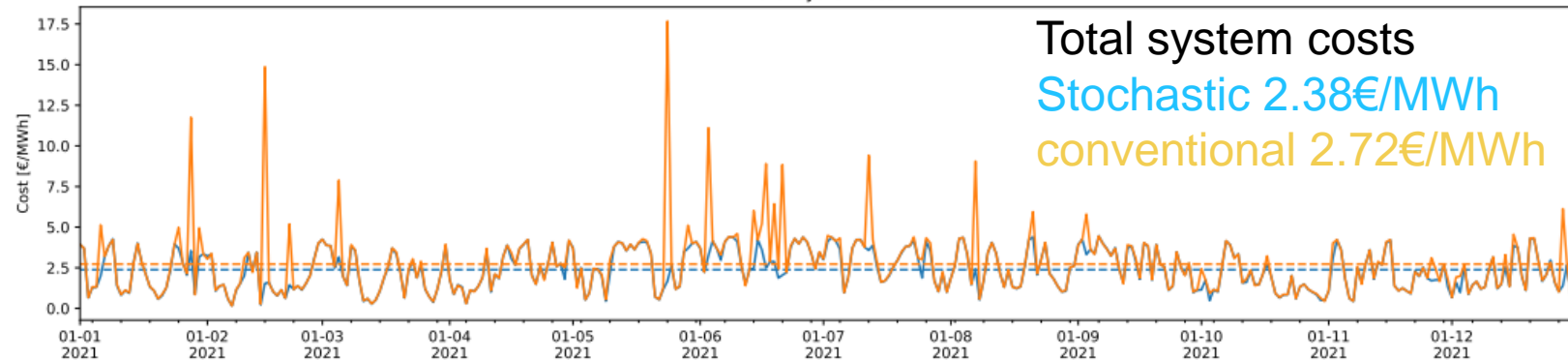
- 3 generator types:
 - 5xOCGT (flexible open-circle gas turbines)
 - 5xOnshore wind parks
 - 3xOffshore wind parks
- 5 Buses:
 - Load profile for each sector (Industry, CTS, Households)
 - Load shedding up to 200€/MWh
- 13 Generators:
 - Nominal generator capacity
 - Marginal costs (0€/MWh for Wind, 4.50€/MWh for OCGT)
 - Flexibility/balancing premium up↑: +14%
 - Flexibility/balancing premium down↓: +3%
- 5 Links:
 - Nominal link capacity



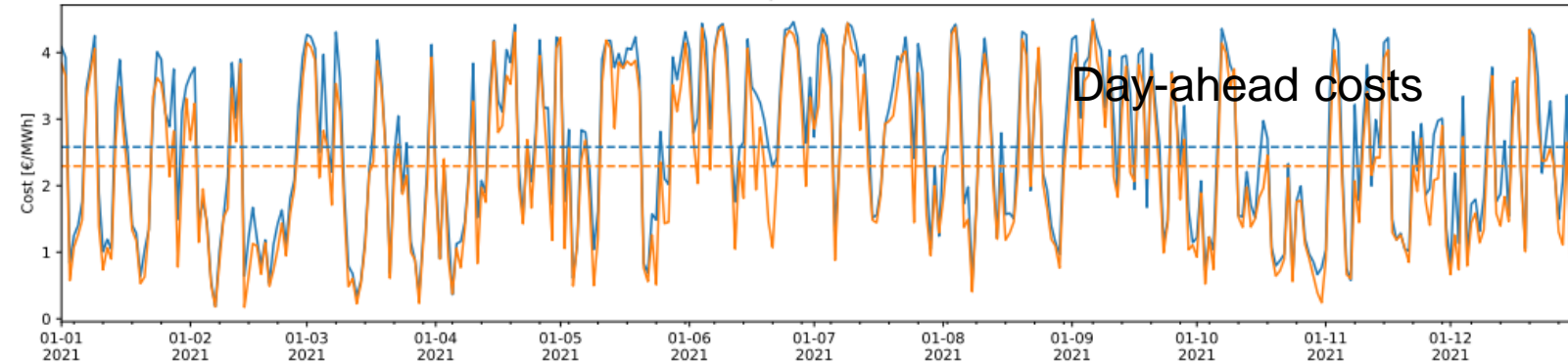
Results: Comparison of system costs

- Total system costs = day-ahead costs + balancing costs
- Stochastic model yields overall price reduction
- Higher day-ahead market costs for stoch. model as more OCGT is dispatched than in conventional clearing
- Hence, very low balancing costs at time of delivery

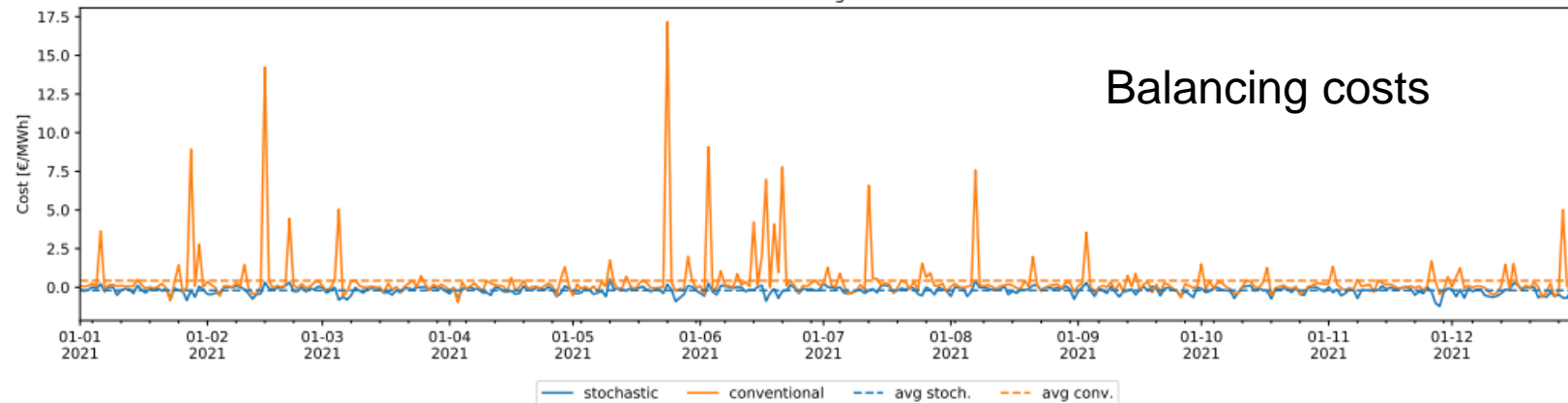
Comparison of system costs
Total system costs



Day-ahead costs

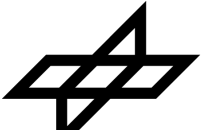


Balancing costs

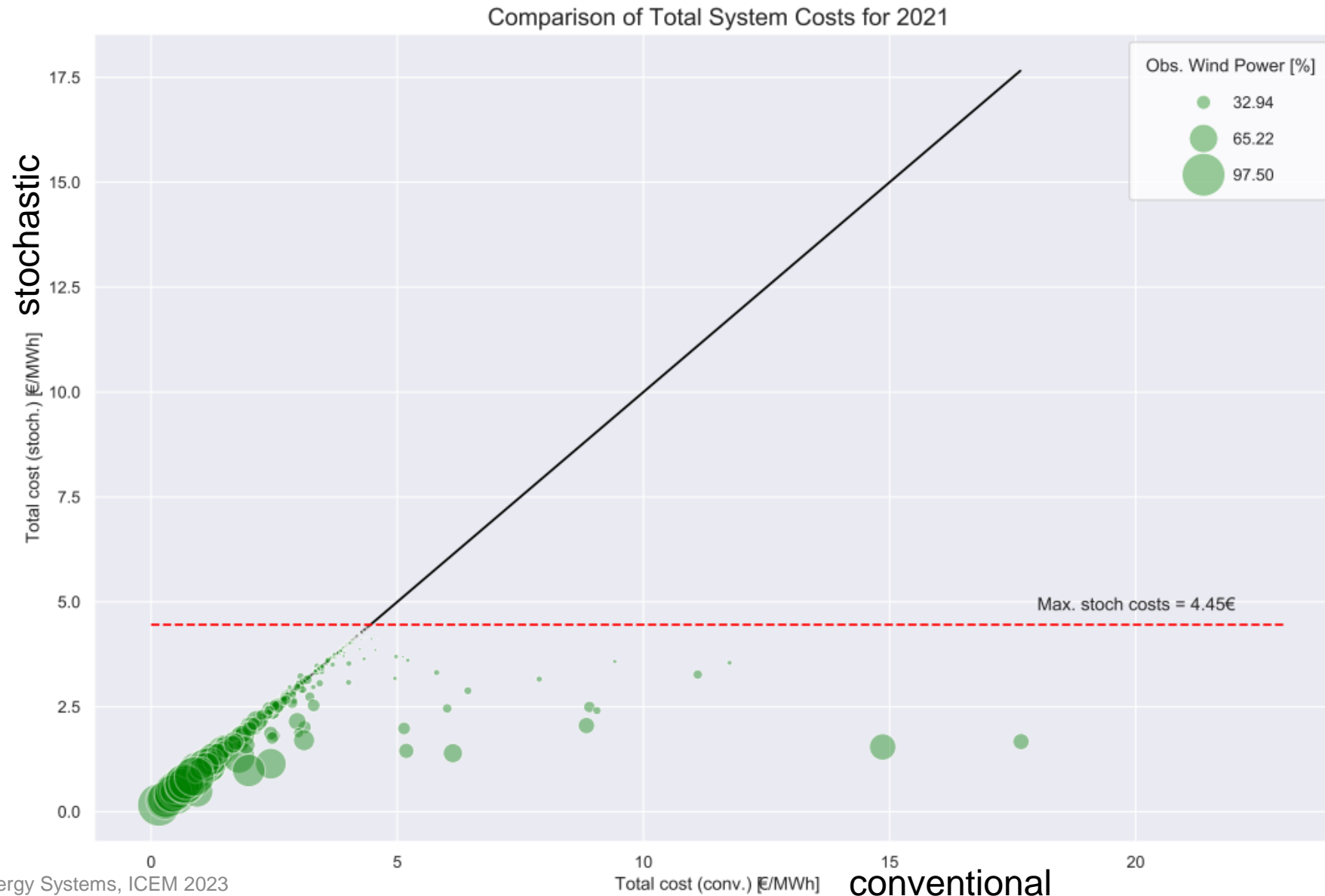


Half of balancing costs due to shedding, half due to higher balancing energy usage

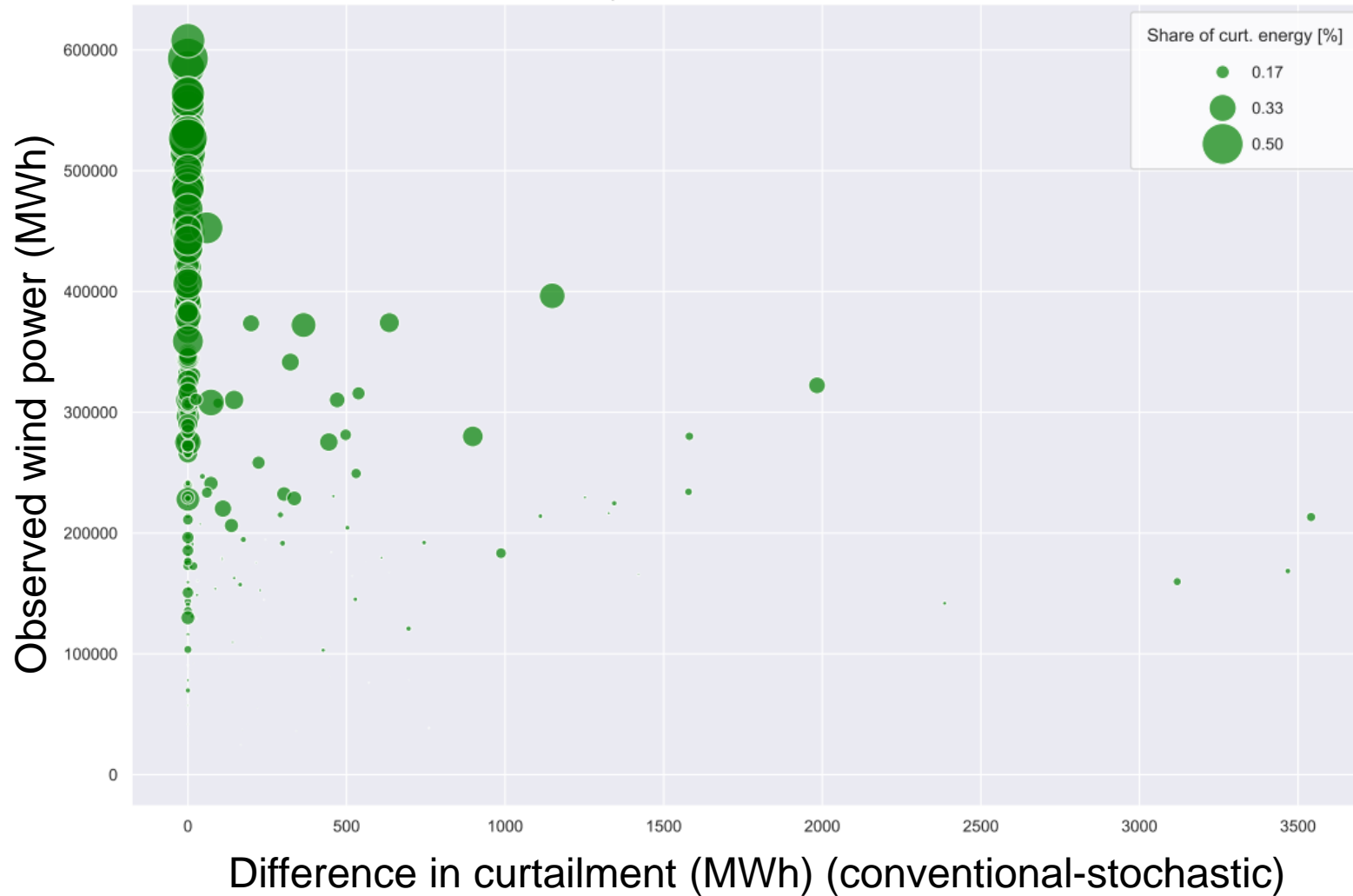
Comparison of total average daily total system costs



- Negative correlation between total system costs and observed wind power
- Cap of costs in stochastic model of 4.46€ ~ marginal costs of conventional generators

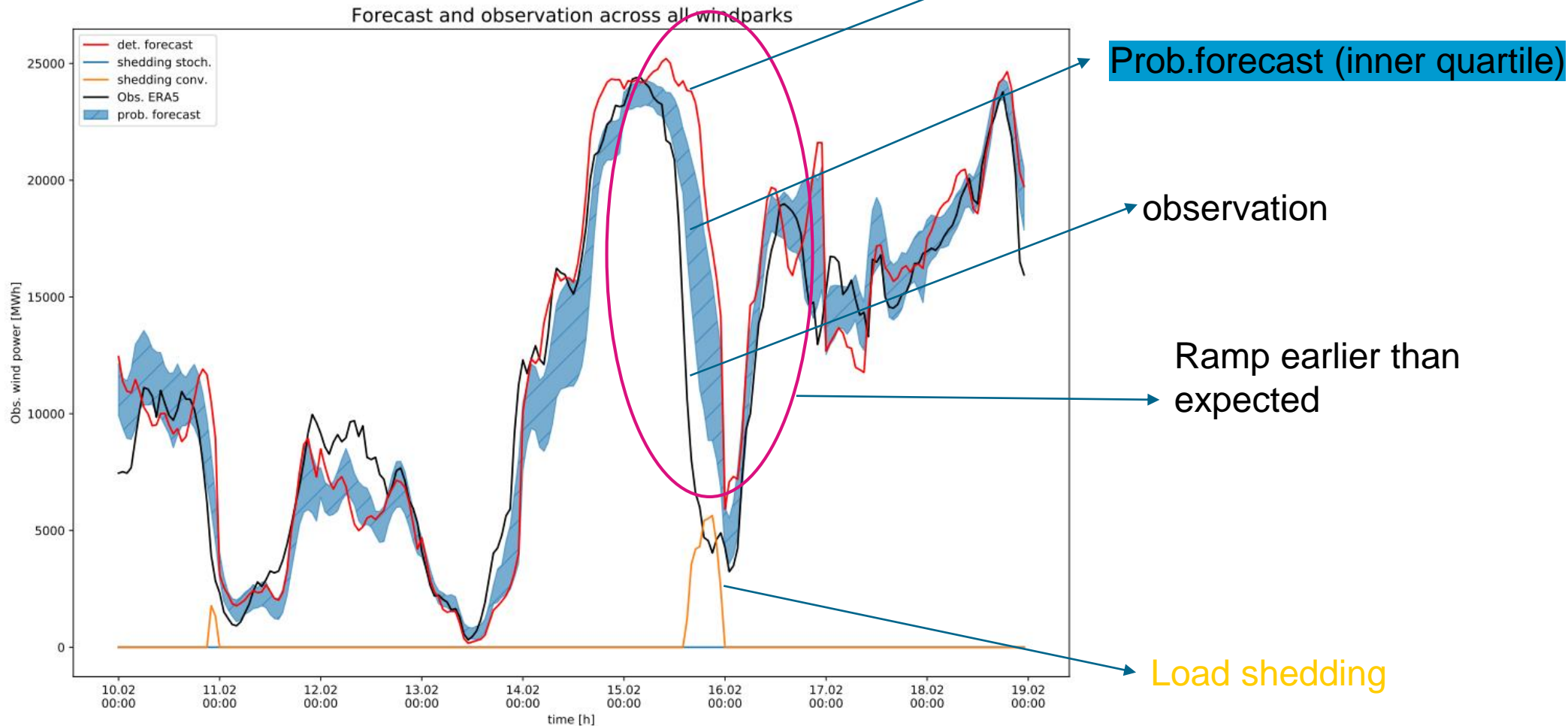


Comparison of daily wind curtailment



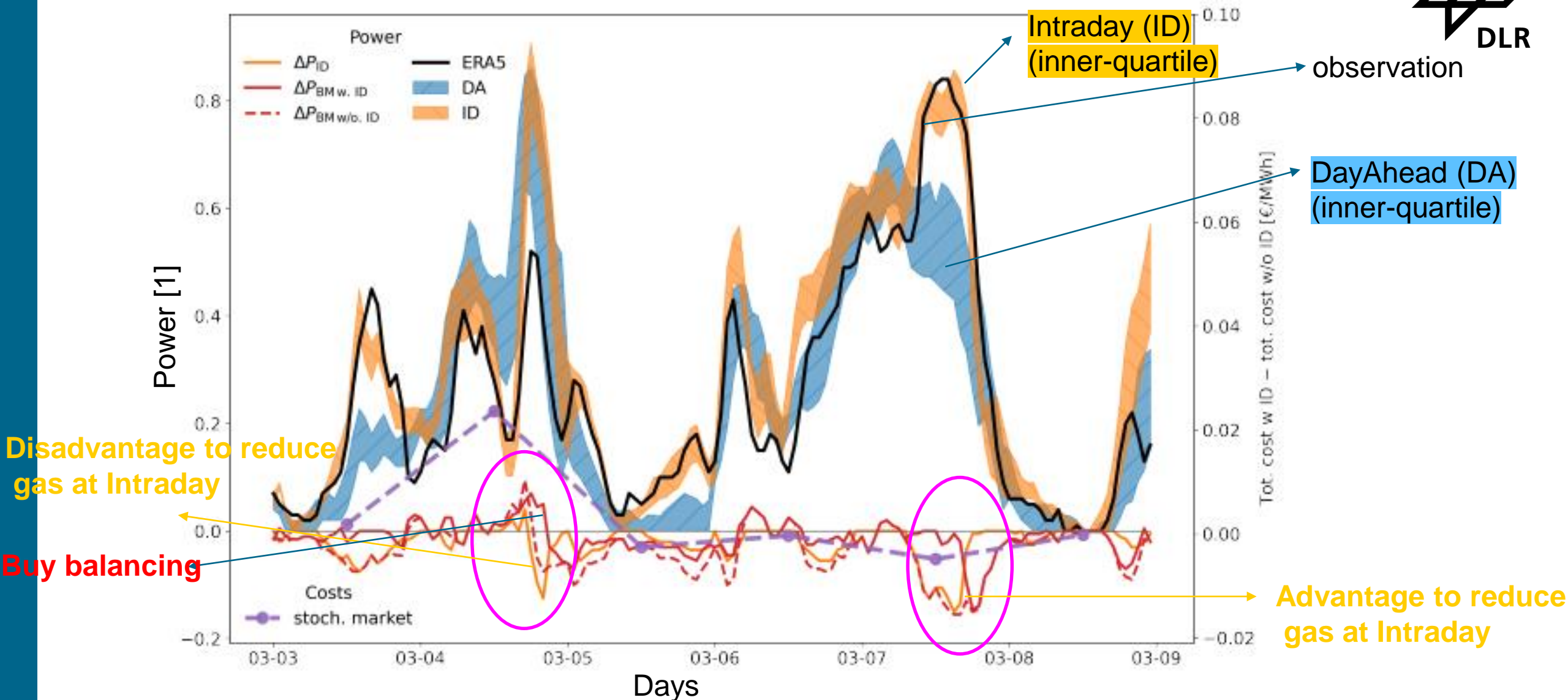
With obs. wind power the share of curtailed wind energy increases.
 Slightly more curtailment in conventional clearing for medium obs. wind power due to „unplanned“ congested lines
 Grid strengthening reduces curtailment by ~30%. But more shedding occurs.

Avoid load shedding when considering forecast uncertainty



Ramping constraints are too strict to balance the sudden lack of wind power in the conventional clearing
2021: Shedding reduction from 318GWh (conventional) to 1.5GWh (stochastic). Total load: 140 TWh

Include updated forecast for intraday (ID) clearing

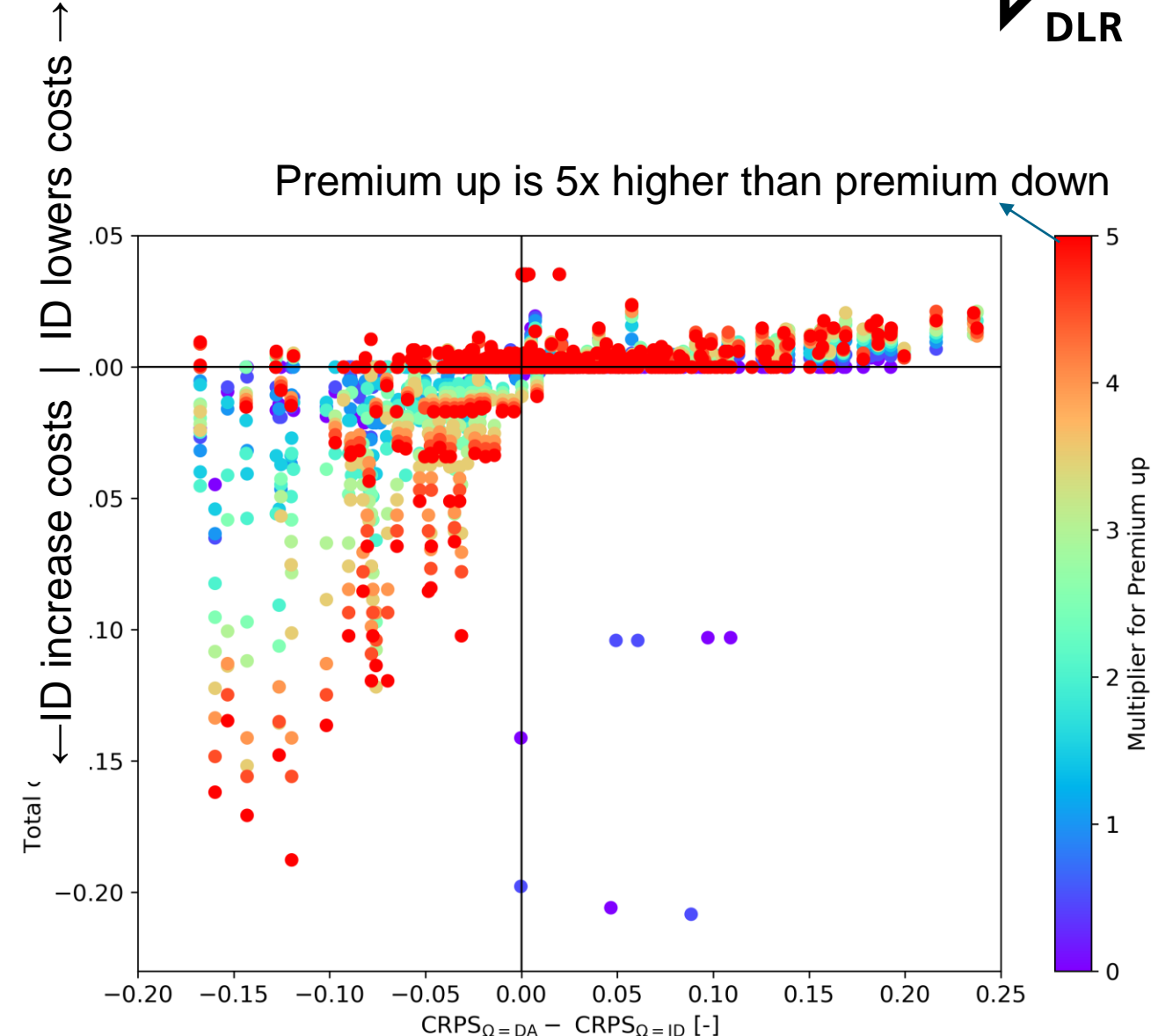


It is expensive when intraday forecast is even slightly worse than day-ahead forecast

Sensitivity of Intraday (ID) corrections to forecast skill and to premium up/down price spread



- CRPS as skill measure
- High premium spread lead to high extra costs in case Intraday is worse than DayAhead forecast
- Overestimation of wind power at Intraday is most expensive



← Intraday has less skill | Intraday has more skill →

Take home messages



- Impact of forecast uncertainty can be modelled in an (idealized) power system including power flow optimization, prices and ramping constraints
- Total system costs decrease when considering weather forecast uncertainty due to reduced curtailment, load shedding and balancing costs
- Updated forecasts at the intraday-market can reduce costs further, but premiums and forecast skill play an important role
- Next steps: expand the network for higher realism, include storages, investigate complementarity between storage and forecast skill

THANK YOU FOR YOUR ATTENTION.

Contact: lueder.von.bremen@dlr.de

Supported by:



on the basis of a decision
by the German Bundestag

We acknowledge and thank
WindRamp, FKZ 03EE3027C

