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NTNU
Norwegian University of Science and Technology

Forecasting and Market Design for Multi-area Energy Balancing: A European Perspective

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EU: Internal electricity market
Day-ahead
Intraday
Balancing
Reserve replacement
Frequency restoration
Frequency containment
TERRE platform
MARI platform (mFRR)
PICASSO platform (aFRR)

Multiple balancing processes

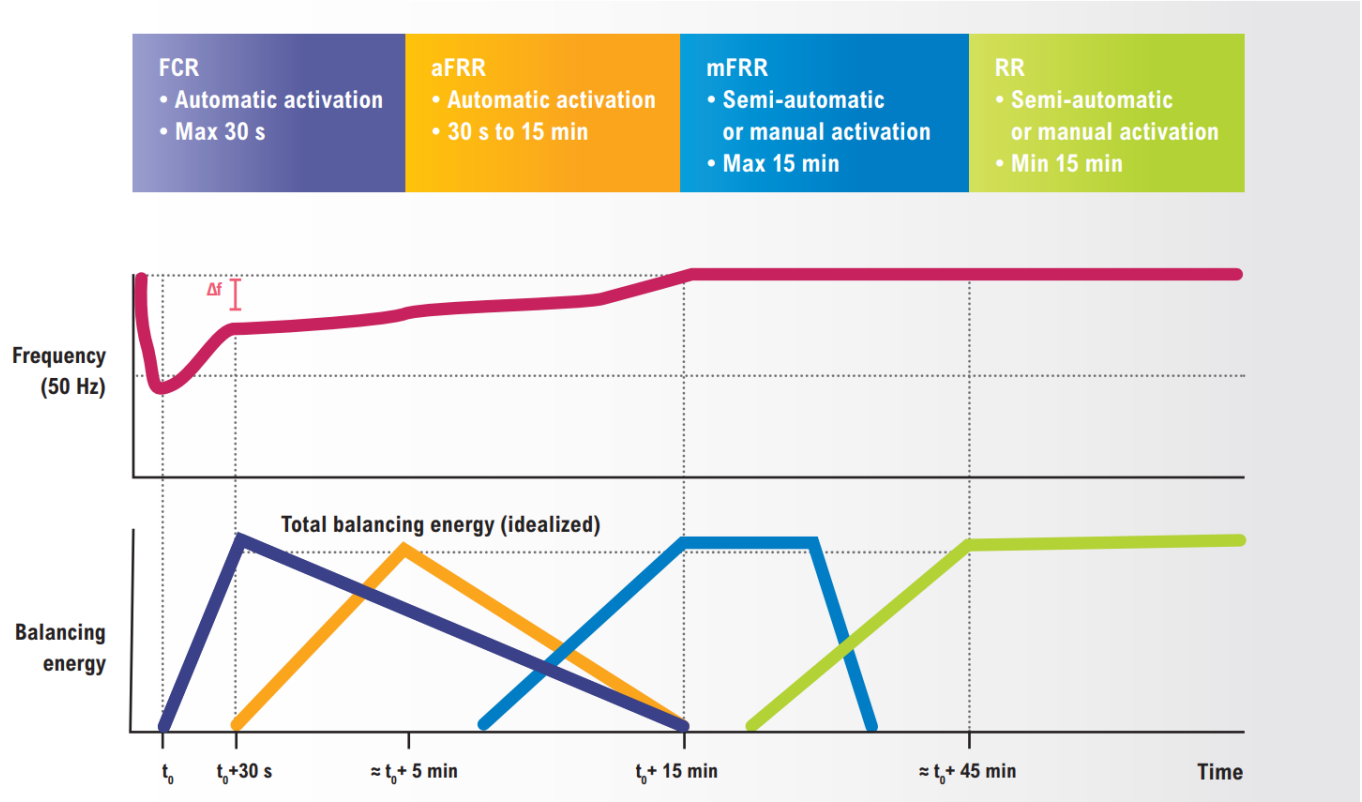


Figure: ENTSO-E

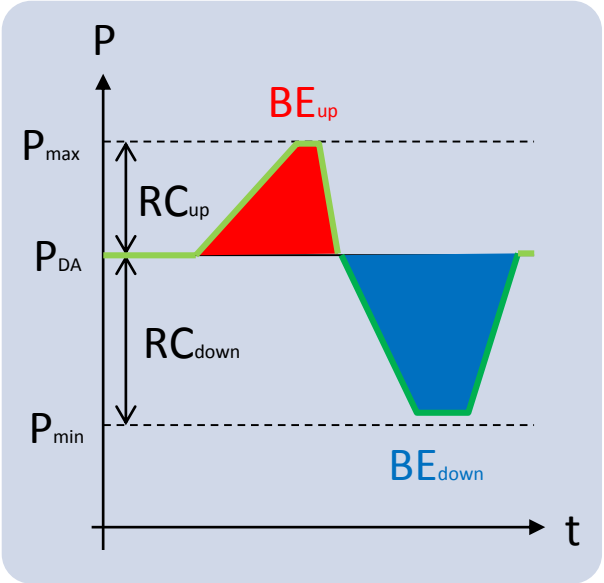
Balancing Reserve Capacity vs Energy

Reserve procurement

- Reserve capacity (RC) [EUR/MW]
- TSOs ensure sufficient reserves in the system during operation

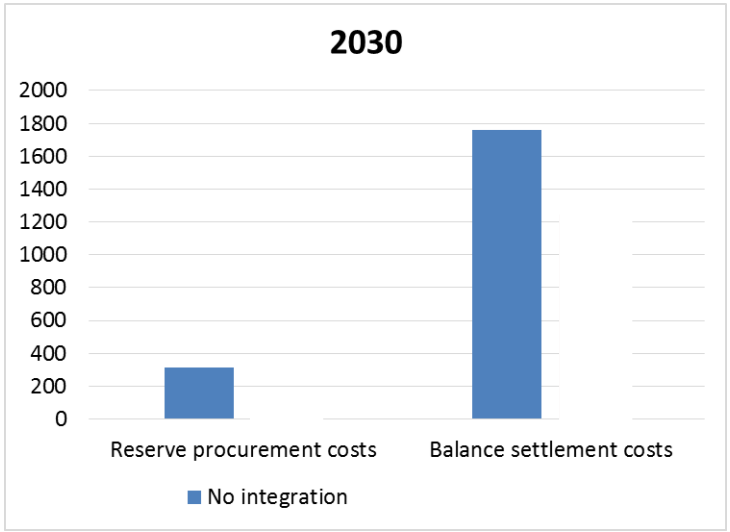
System balancing

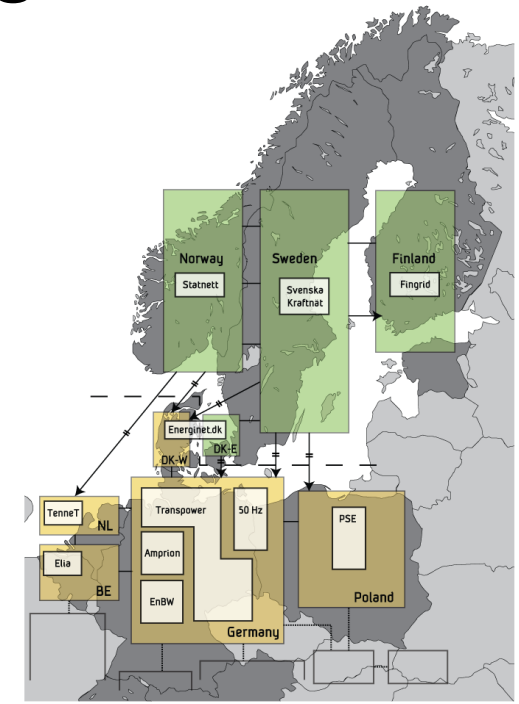
- Balancing energy (BE) [EUR/MWh]
- TSOs activate reserves to counteract system imbalances



Large benefits of integrating the Northern and continental balancing markets

Total annual balancing costs (Mill.EURO)

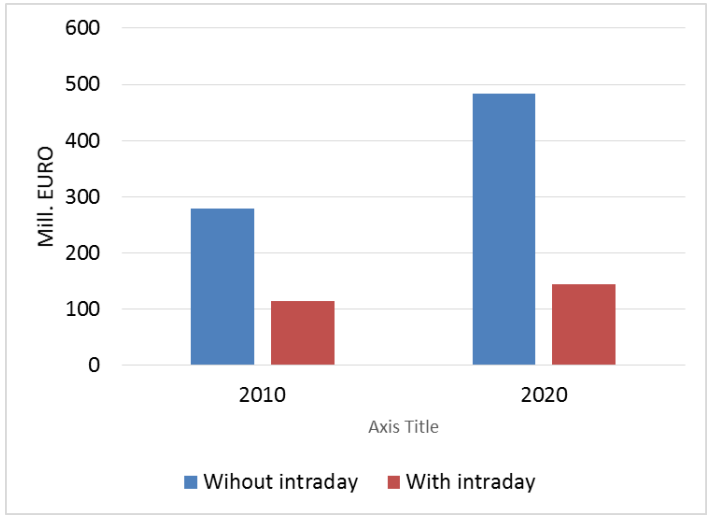




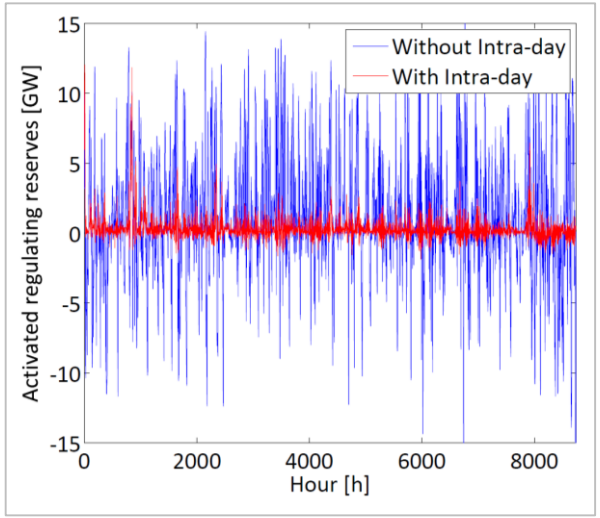
H. Farahmand, «Integrated Power System Balancing in Northern Europe», PhD Thesis, NTNU, 2012

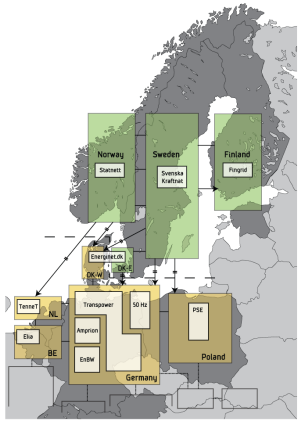
Large benefits of integrating the Northern and continental intraday markets

Total annual balancing costs



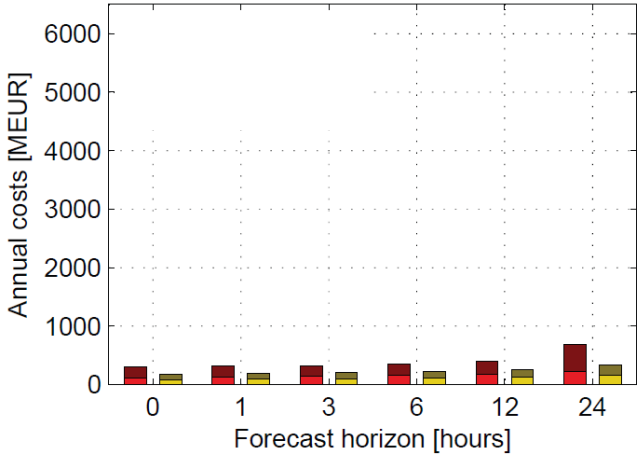
Activated reserves





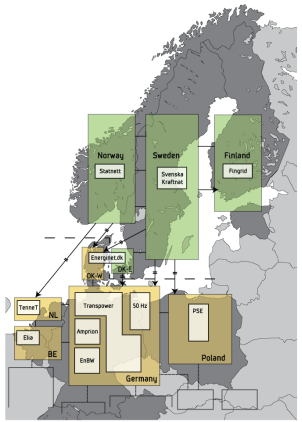
Source: T. Aigner, «System Impacts from Large Scale Wind Power», PhD Thesis, NTNU, 2013

Total balancing market costs for different wind forecast horizons



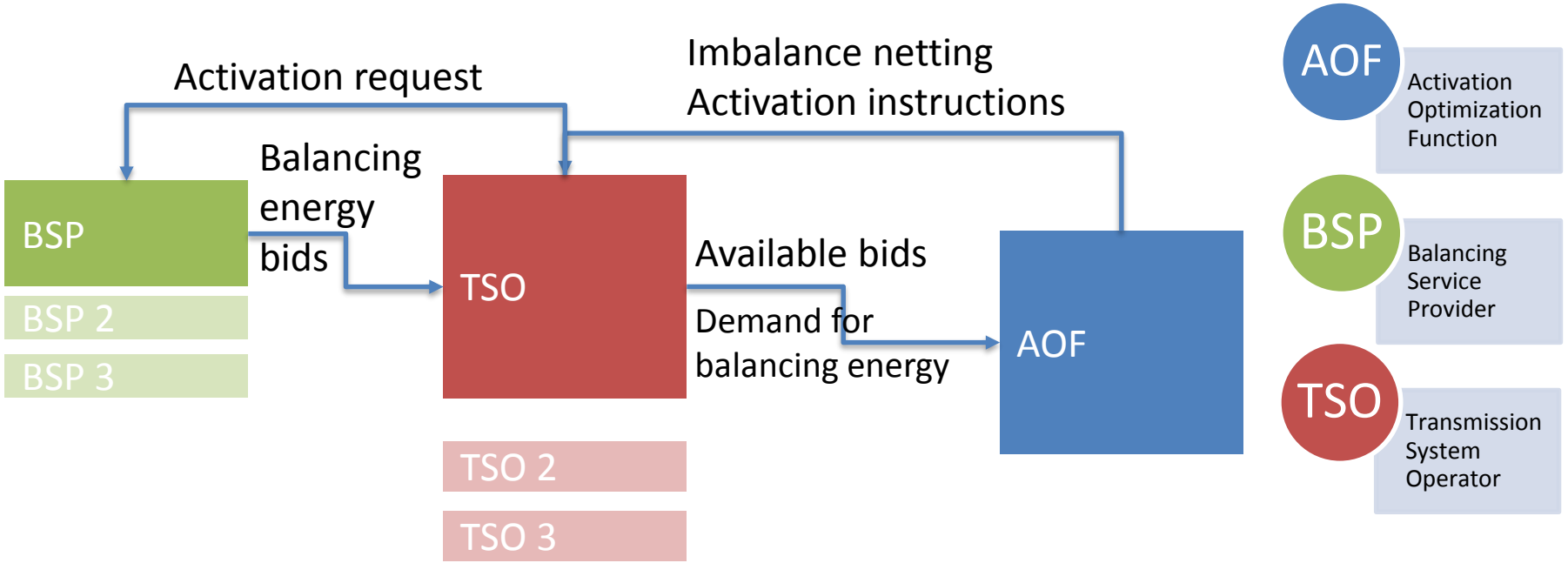
(a) 2010

No integration : Reserve procurement
No integration : System balancing
Full integration: Reserve procurement
Full integration: System balancing

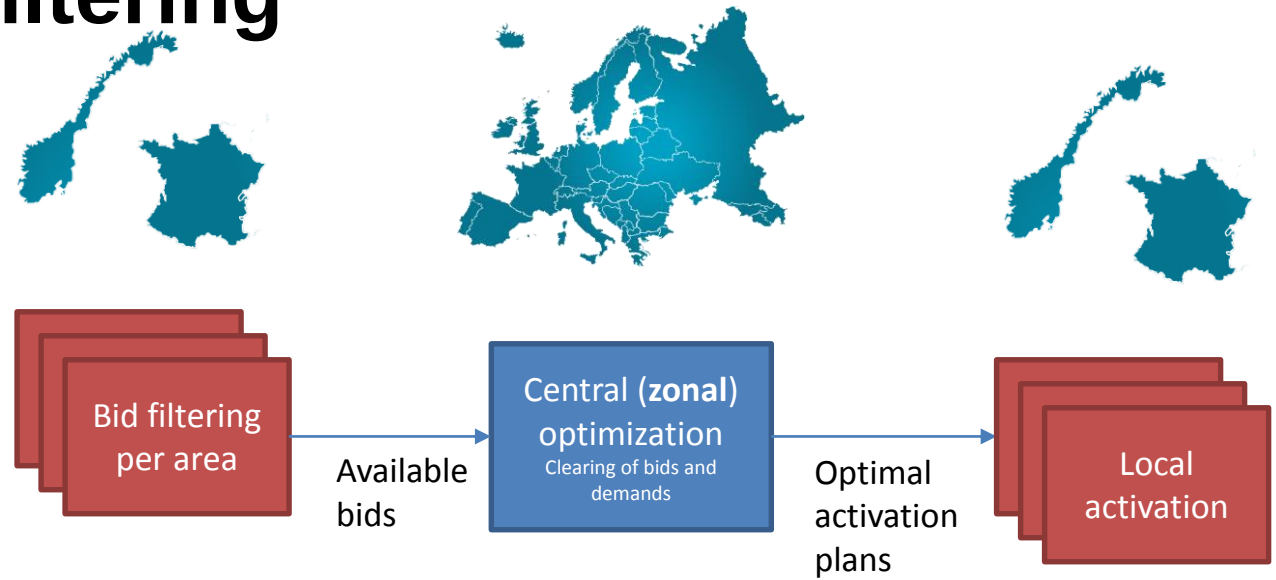


NTNU S. Jaehnert, «Integration of Regulating Power Markets in Northern Europe», PhD Thesis, NTNU, 2012

Generalized Pan-European Balancing Process

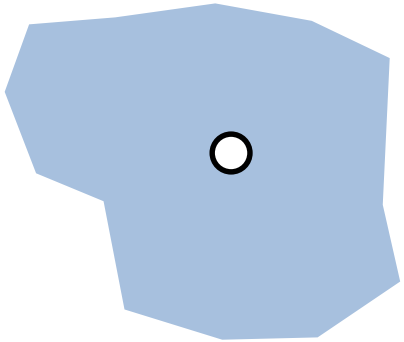


Congestion management based on bid filtering

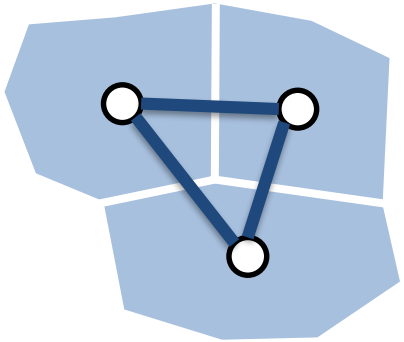


Transmission network representation

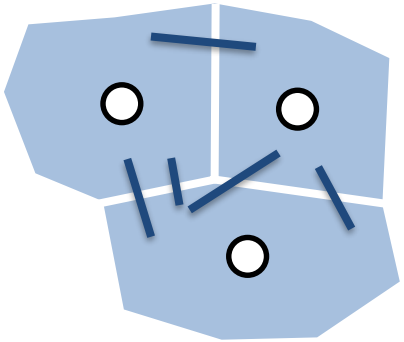
Copper plate



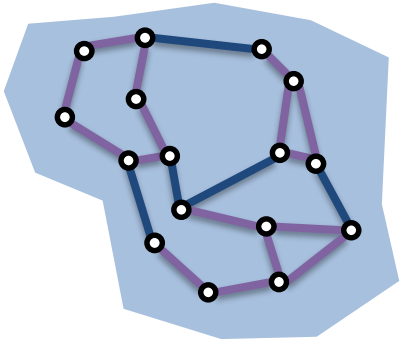
Zonal ATC



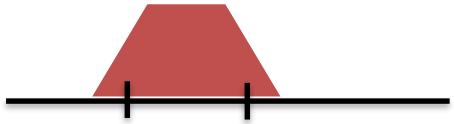
Flow-based



Nodal

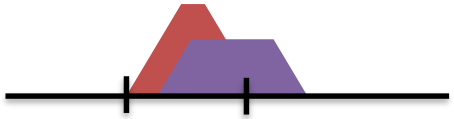


Scheduled products



Simple market clearing
Pooling and netting
Elegant settlement

Direct activated products



Optimization?
Emergencies?

Flexible

Balancing philosophy: Proactive vs Reactive?

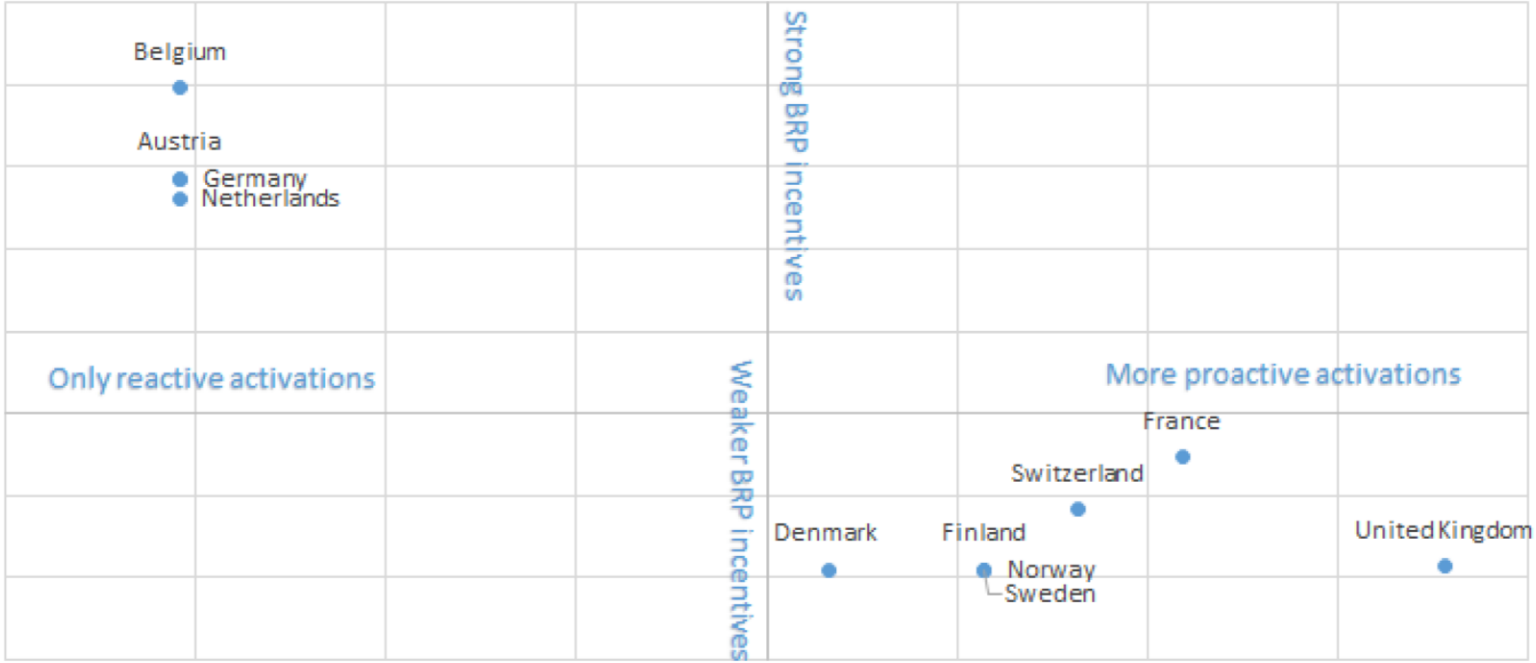
Proactive

- TSO estimates balancing needs in advance
- Relies on good forecasts
- Needs optimization
- Must reschedule closer to real-time
- TSO takes care of the imbalance netting. BRP pays TSO

Reactive

- Let the market handle the imbalance to a larger extent
- Needs fast balancing products
- Incentive for BRP to contribute to balancing without bidding actively
- Participation from more market players
- Only if no or limited congestion

Balancing philosophy: Proactive or Reactive?



NTNU

Håberg, Doorman: Classification of Balancing Markets Based on Different Activation Philosophies: Proactive and Reactive Designs, IEEE EEM Conf., 2016

Forecasting for multi-area balancing

- Different balancing philosophies give different needs for forecasts
- ENTSO-E Transparency Platform for exchange of data
  - Publiciation of wind and solar forecasts (and other power system data)
  - Day-ahead and Intraday
  - Some countries updates wind forecasts
  - Very limited solar forecasts have been published (yet..)
- Impression is that different countries initiate own forecasting projects
  - No harmonization of forecasting methods at EU level (yet..)
  - New collaborative EU research projects (H2020) focus more on the technology or grid integration of renewables than forecasting per se

entsoe Transparency Platform

Central collection and publication of electricity generation, transportation and consumption data and information for the pan-European market.

Generation Forecasts for Wind and Solar

Day-ahead Generation Forecasts for Wind and Solar [14.1.D]
Intraday Generation Forecasts for Wind and Solar [14.1.D]
Current Generation Forecasts for Wind and Solar [14.1.D]

Day and Time Range: 05.06.2019

Control area | Bidding zone | Country

Area

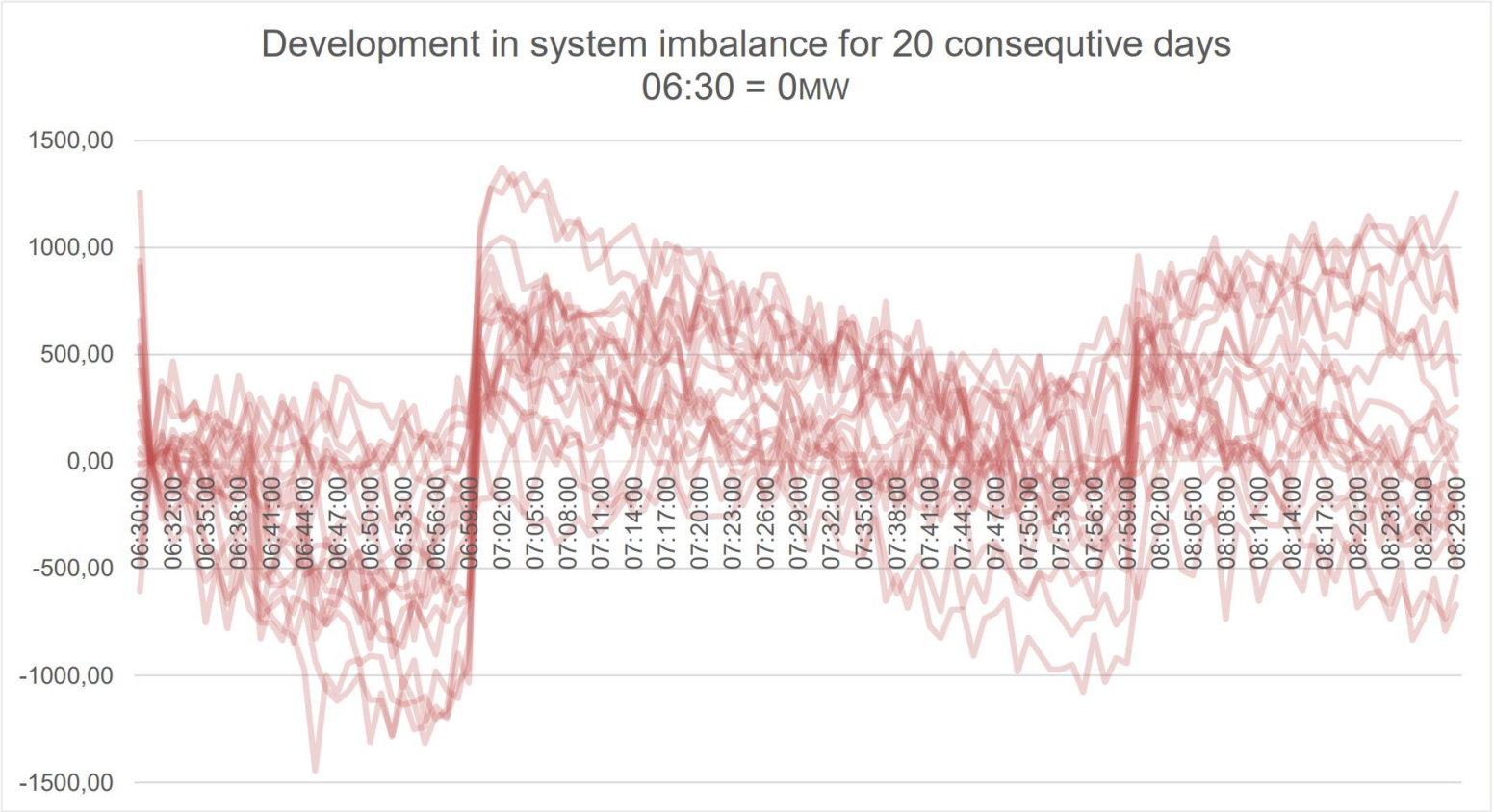
- [x] Germany (DE)
- [x] Germany (DE)
- [ ] Greece (GR)
- [ ] Hungary (HU)
- [ ] Iceland (IS)
- [ ] Ireland (IE)
- [ ] Italy (IT)
- [ ] Latvia (LV)
- [ ] Lithuania (LT)
- [ ] Luxembourg (LU)

Show fullscreen | Export Data | CET (UTC+1) / CEST (UTC+2)

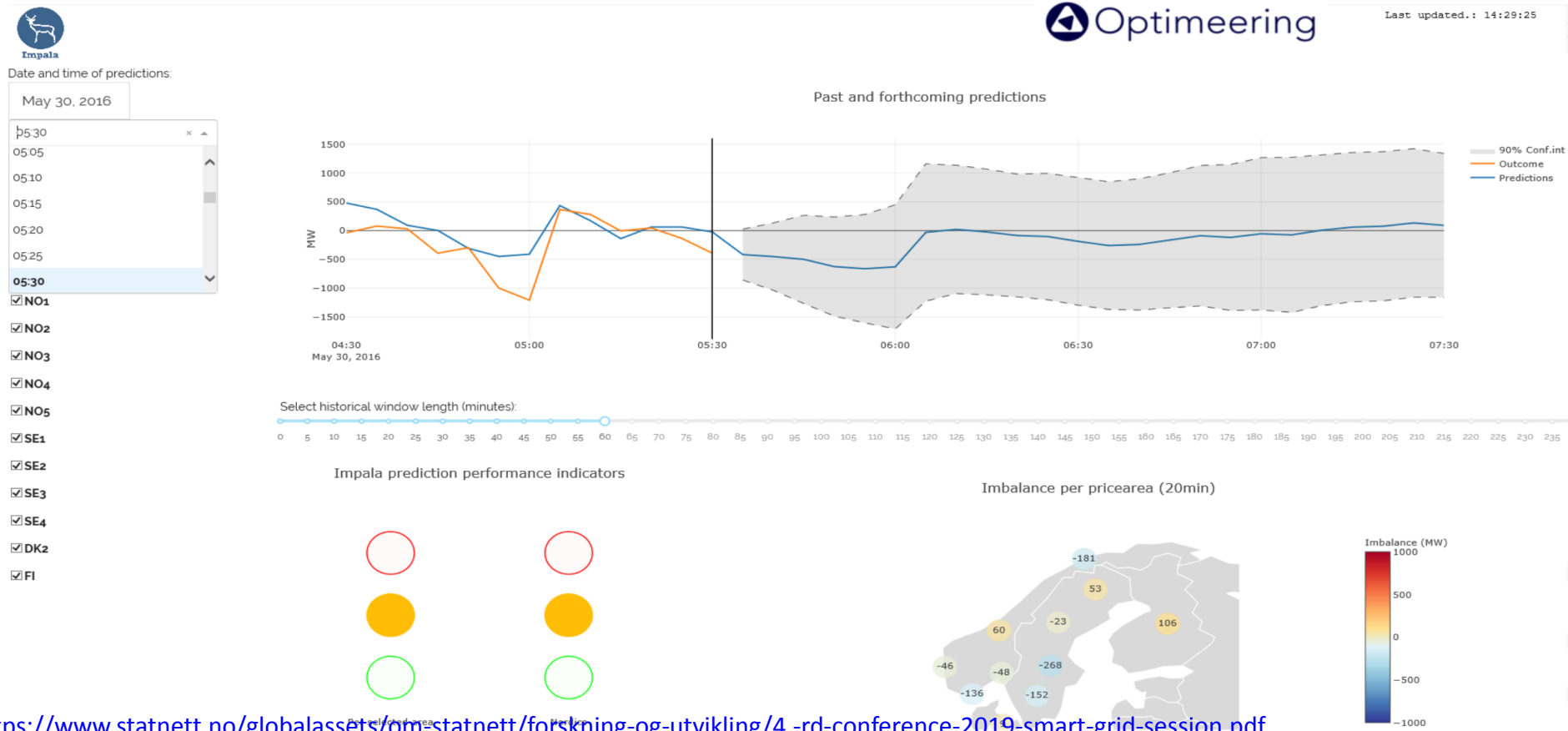
MTU	Germany (DE) Generation Forecast					
	Wind Onshore [MW]			Solar [MW]		
	Day ahead	Intraday	Current	Day ahead	Intraday	Current
00:00 - 00:15	17961	18646	n/e	0	0	n/e
00:15 - 00:30	17775	18597	n/e	0	0	n/e
00:30 - 00:45	17598	18388	n/e	0	0	n/e
00:45 - 01:00	17361	18180	n/e	0	0	n/e
01:00 - 01:15	17058	17754	n/e	0	0	n/e
01:15 - 01:30	16714	17391	n/e	0	0	n/e

IMPALA: Imbalance Predictions with Advanced Machine Learning

Optimeering Statnett



IMPALA: Imbalance Predictions with Advanced Machine Learning



https://www.statnett.no/globalassets/om-statnett/forskning-og-utvikling/4.-rd-conference-2019-smart-grid-session.pdf

IMPALA: Imbalance Predictions with Advanced Machine Learning

- Collaborators: Norwegian TSO Statnett, NTNU and Optimeering
- Partly funded by the Norwegian Research Council
- Results so far:
  - Up to **50 per cent more accurate imbalance forecasts** than current system
  - Can **reduce system imbalances by 25 per cent**
  - Planned implementation by Statnett this year
- More details:
  - T. S. Salem, K. Kathuria, H. Ramampiaro, H. Langseth, “Forecasting Intra-Hour Imbalances in Electric Power Systems”, Jan. 2019: https://www.researchgate.net/publication/330871332_Forecasting_Intra-Hour_Imbalances_in_Electric_Power_Systems
  - E. Lindeberg, presentation at Statnet R&D conference, 2019: https://www.statnett.no/globalassets/om-statnett/forskning-og-utvikling/4.-rd-conference-2019-smart-grid-session.pdf

European balancing market harmonisation in brief

- Integrating balancing markets across borders is beneficial
  - Reduces costs and emissions
  - Makes it easier to increase the renewable energy share
- A pan-European set of rules for balancing is in place
  - Electricity Balancing Guideline (EBGL), developed by ENTSO-E, was approved by the European Commision (EC) in Nov. 2017
  - One single market for all balancing enery products (Mandatory)
  - Not mandatory for balancing capacity
- Main goal: Common solutions for all countries
  - One platform and one standard product for each type of reserve
  - At May 15 this year, ENTSO-E released its proposal on standard products for balancing capacity
- Limited harmonisation of forecasting (so far)
  - ENTSO-E Transparency Platform for data sharing
  - Most forecasting projects are presently done within each country/TSO