On the relevance of electricity balancing markets in Europe

A 2030 perspective

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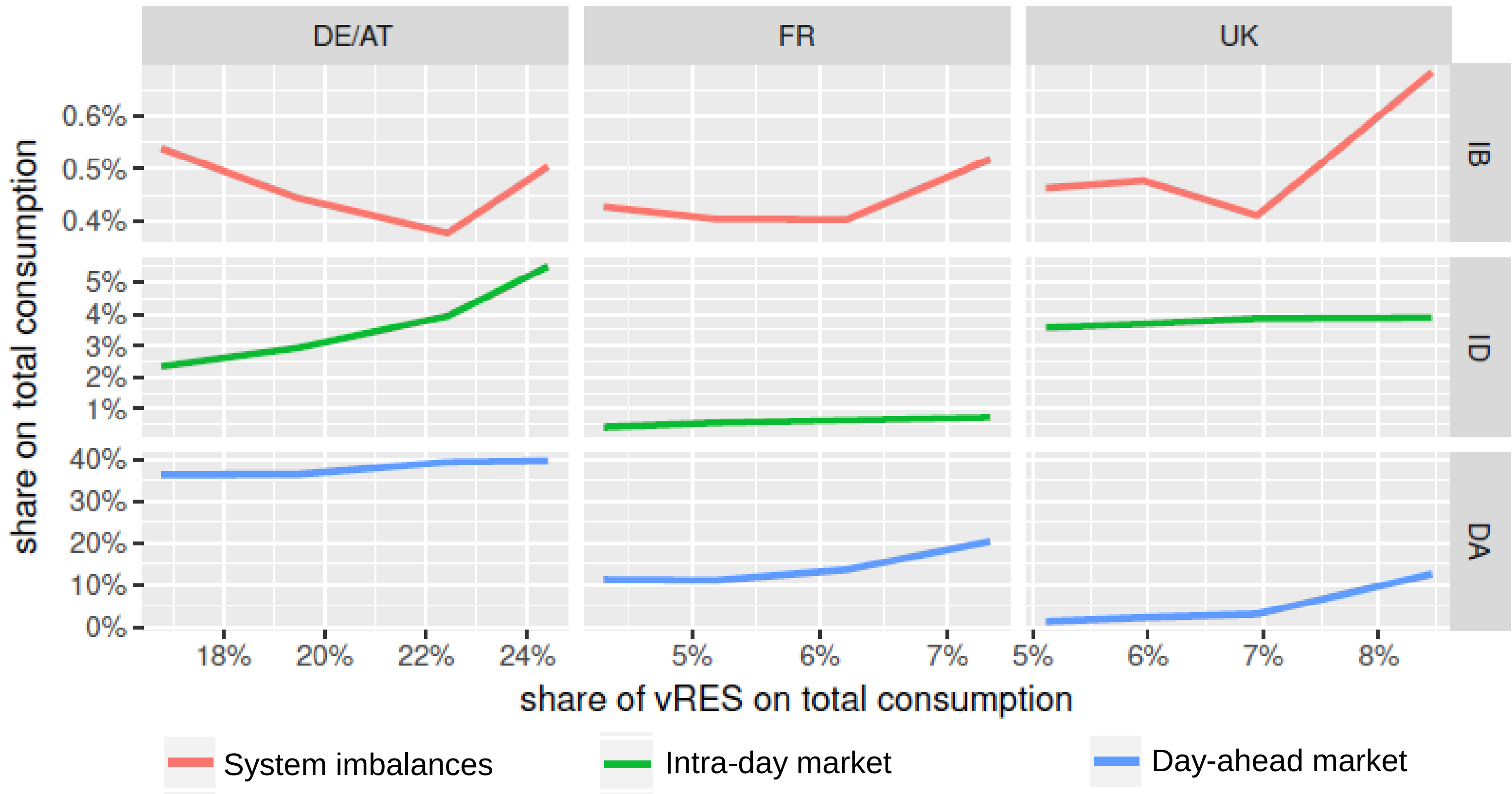
Motivation

- Short-term electricity markets gain importance
- One reason is ongoing integration of increasing shares of variable renewable electricity (vRES)



Source: EPEX and APX annual reports, ENTSO-E transparency platform

Research questions

Competing forces drive the development of balancing markets

- Pos: Additional deployment of variable RES
- Neg: Imbalance Netting, Market coupling, Flexibility, Quality of forecasts

- How large is the overall monetary market volume of electricity balancing markets as compared to day-ahead markets in various European countries with high shares of variable renewable electricity?
- How is this volume impacted by different assumptions on the level of international cooperation?
- How significant are revenues from balancing markets for different generation technologies?

Applied methodology

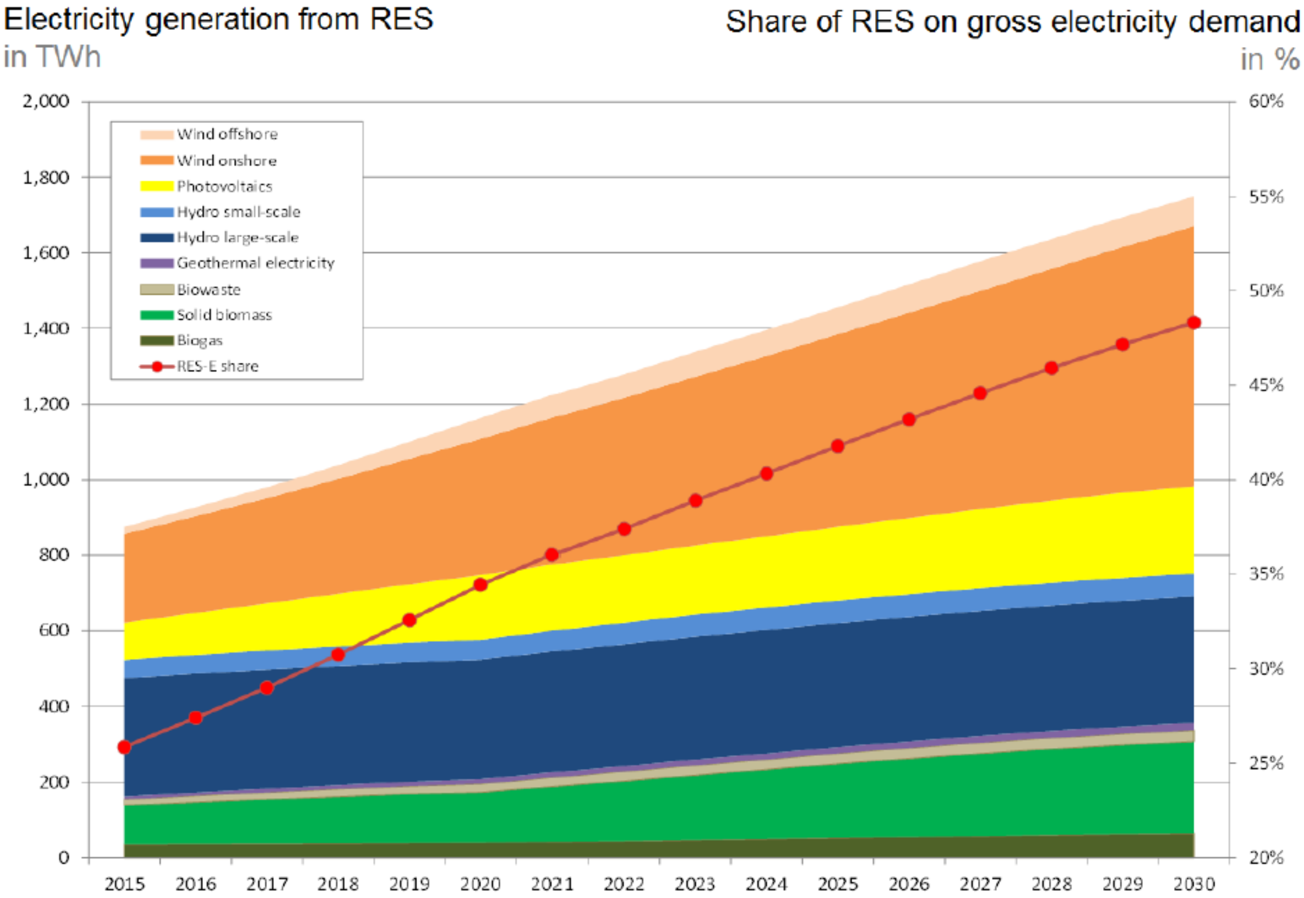
1. Balancing demand projection to 2030
   - **Variable RES**: Application of ARIMAX models to capture characteristics of historic forecast error time series
   - **Conventional generators**: Generated based on statistics of historical forced outage rates
   - **Electricity demand**: Forecast errors drawn from fitted hyperbolic distribution (Hodge 2013)

2. Development of 2x2 scenarios
   - **Dimension 1**: Textbook development of spot markets vs. currently ongoing trends
   - **Dimension 2**: EU-wide vs. national balancing markets

3. Application of EU-electricity market model *HiREPS*
   - **Method:** 3-model modes (DA, ID, IB) operated in rolling planning modus (myopic approach)
   - **Input:** Power plant database, Transmission grid model, Exogenous demand time series
   - **Output:** Real-time prices, market volume, generator revenues from electricity balancing

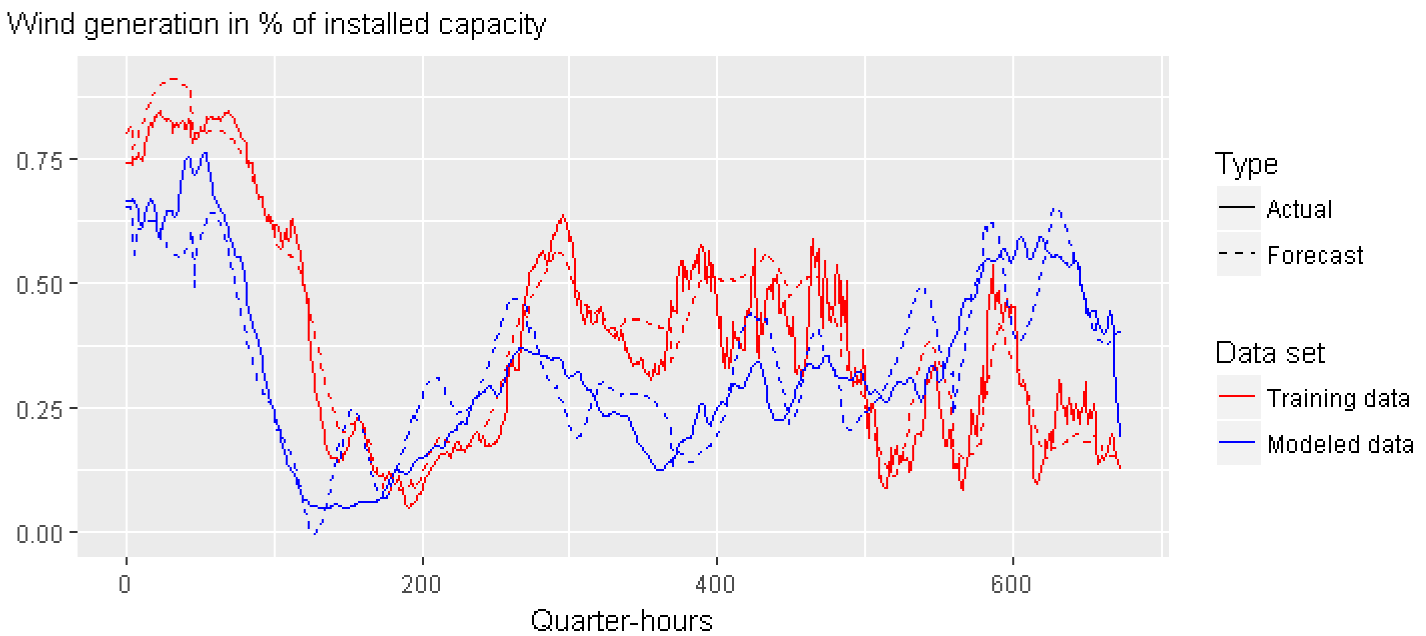
Assumptions on the future RES-E deployment

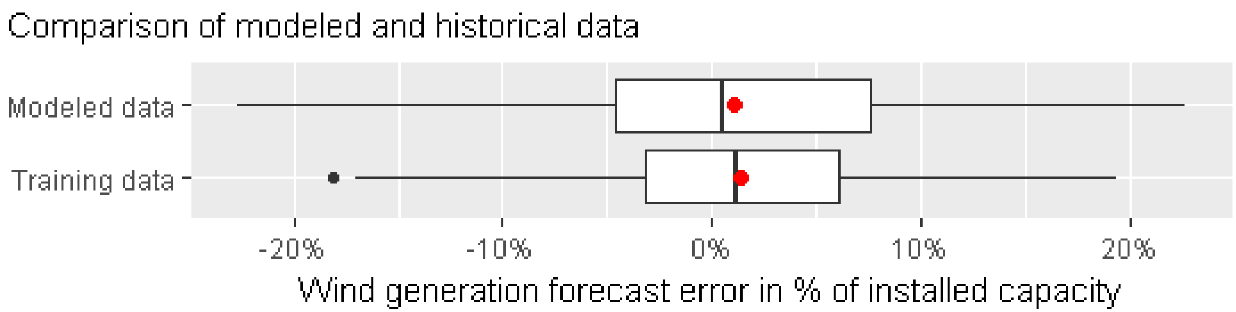
- Most likely development of RES-E in the EU until 2030 (27% target)
- Source: EU-funded project Towards2030 (www.towards2030.eu)



Application of ARIMAX models

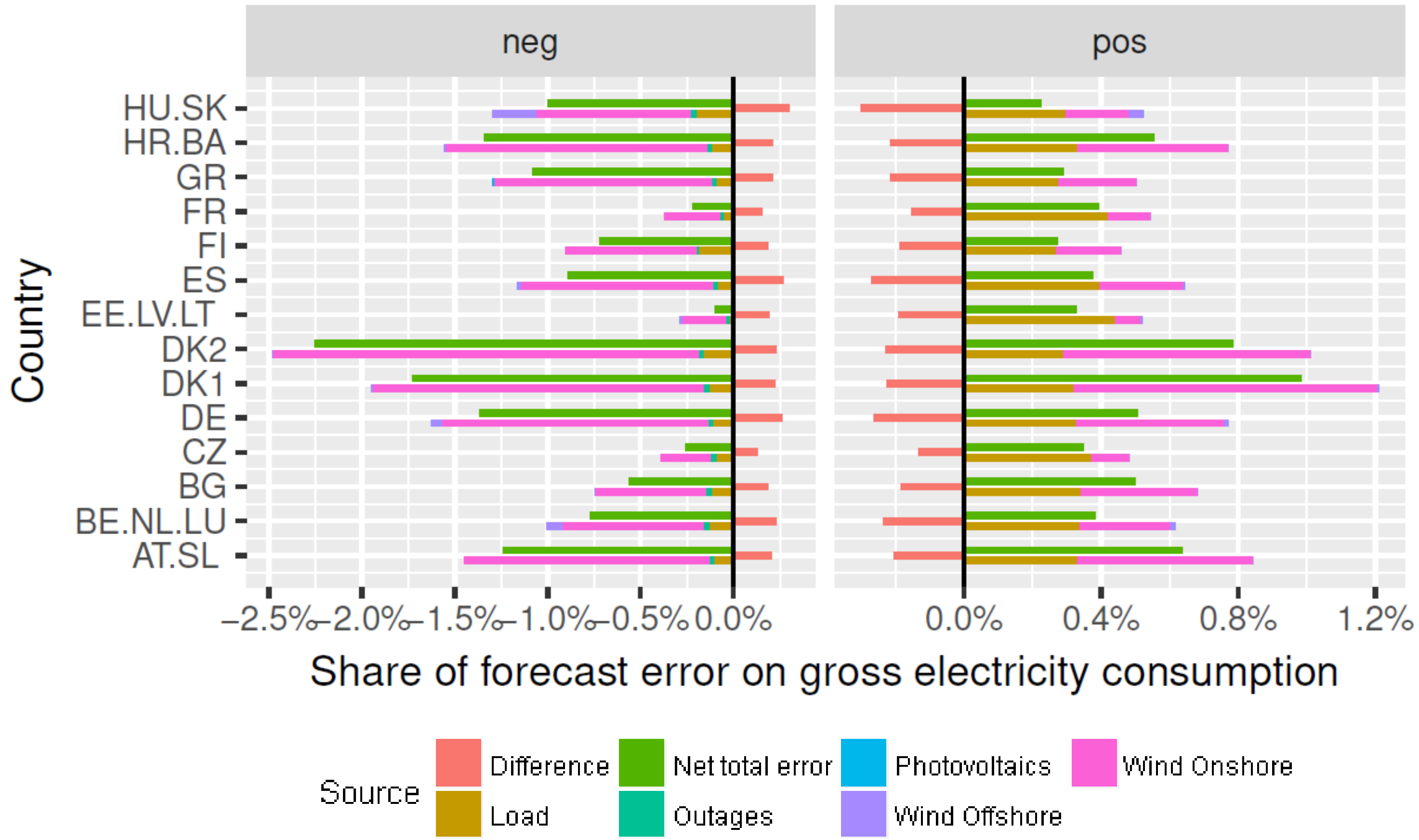
- Example: Wind forecast errors





Projecting Balancing Demand

- Application of ARIMAX models to capture characteristics of historic forecast error time series



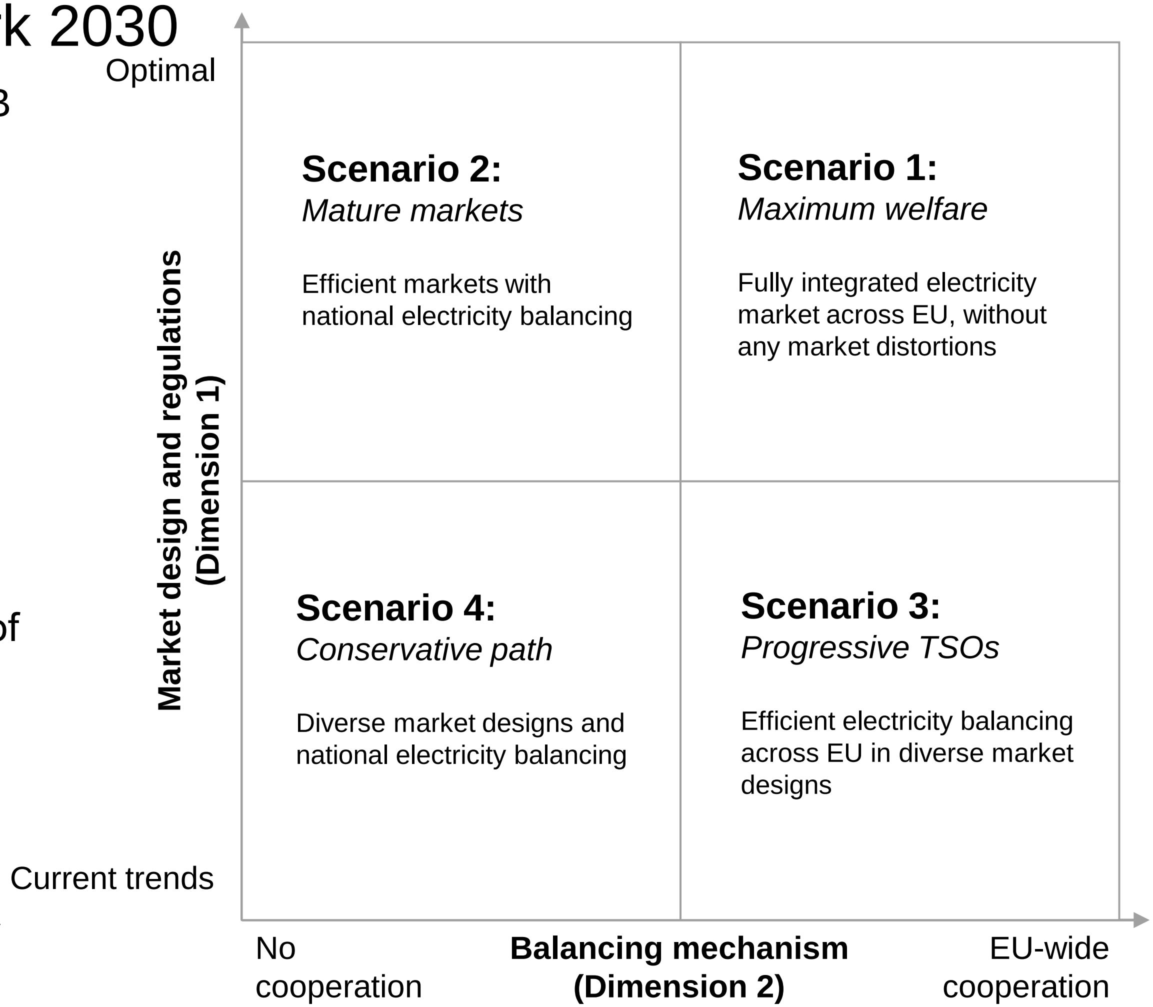
Considered scenarios

Regulatory Framework 2030

- Currently ongoing process, GLEB (ACER), EB (ENTSO-E), 3rd energy package (EC)
- Proposals of TSOs how to implement harmonized product definitions for “Coordinated Balancing Areas” (CoBAs)

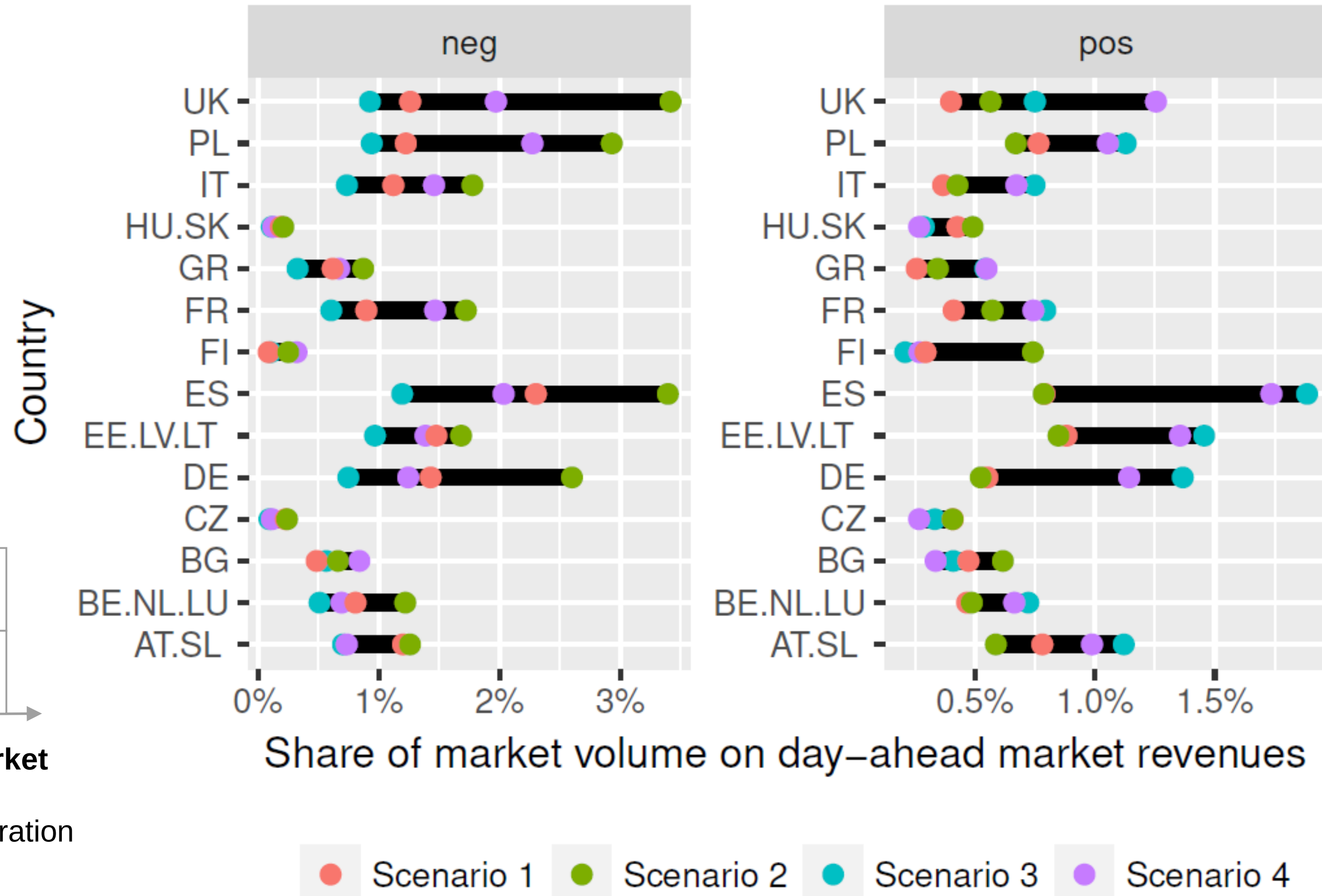
Market design

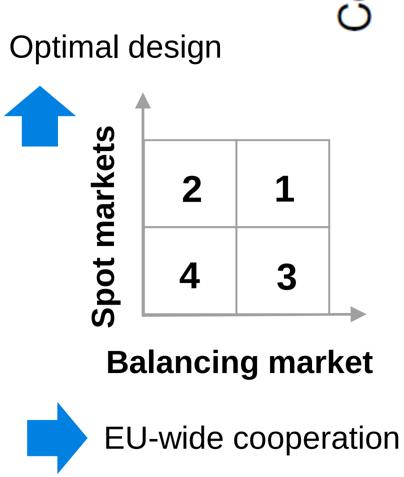
- EC urges to produce a credible “real-time price” reflecting value of flexibility and amount of ex-ante capacity reservation should be minimized
- Ongoing trends towards the EU internal electricity wholesale market (grid extensions, capacity markets, demand-side participation, …)



Results on market relevance

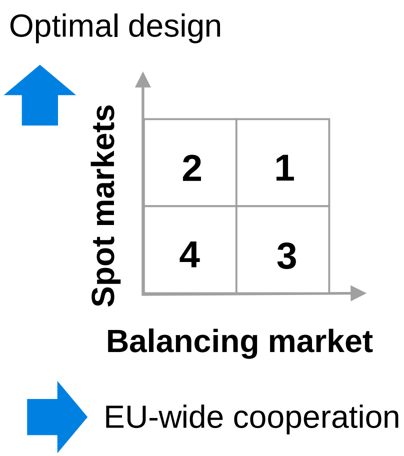
- Share of balancing market volume on day-ahead market volume in 2030

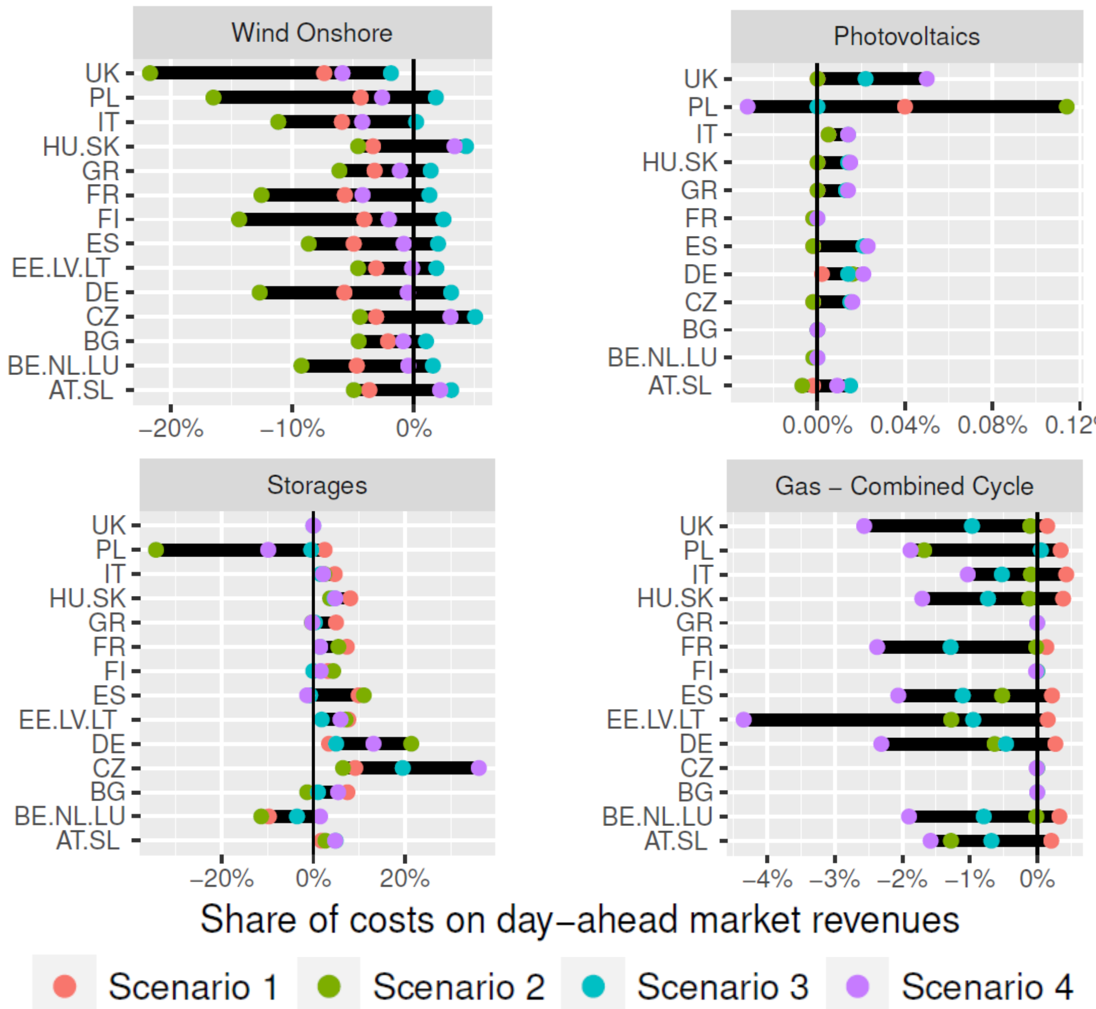




Results by technology

- Share of balancing market revenues on day-ahead market revenues in 2030





Conclusions

- Although demand for balancing energy increases up to 2030, electricity balancing will still remain a niche market
- Revenues from electricity balancing can become a relevant source of income for storages and wind power
- Market design and market coupling decisively impacts efficiency of balancing markets

Appendix

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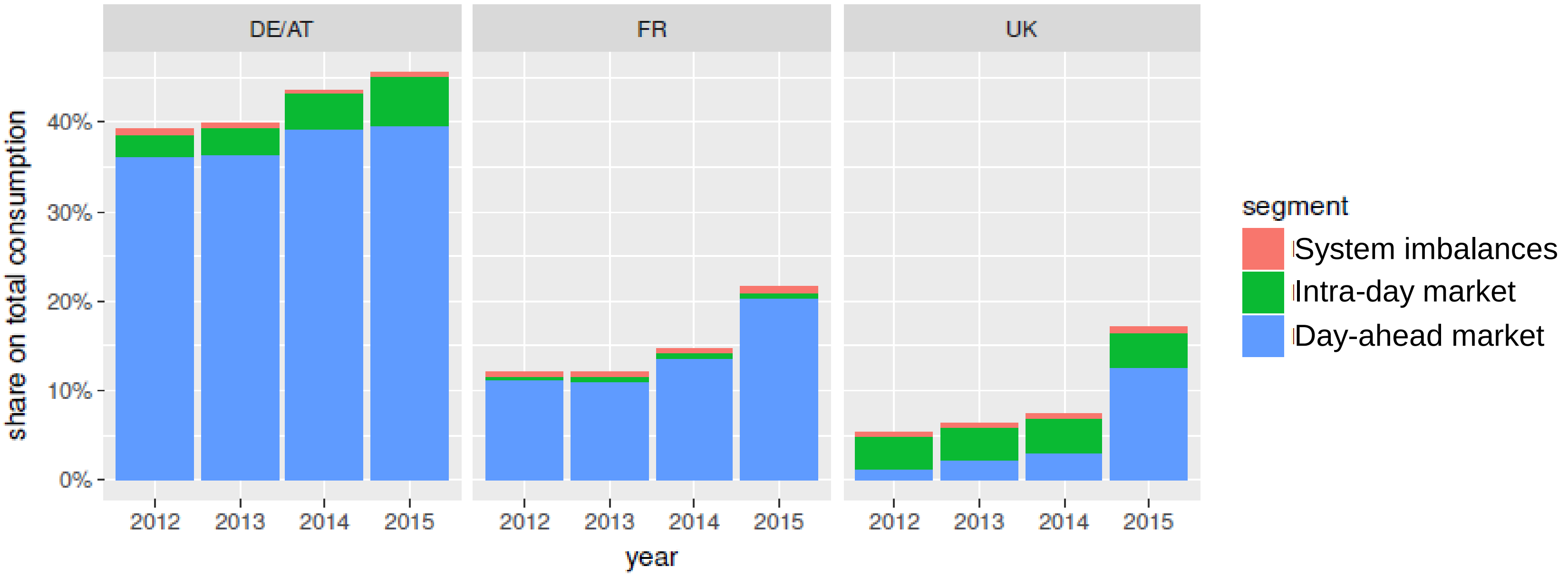
Exchange-traded electricity volumes related to gross electricity consumption



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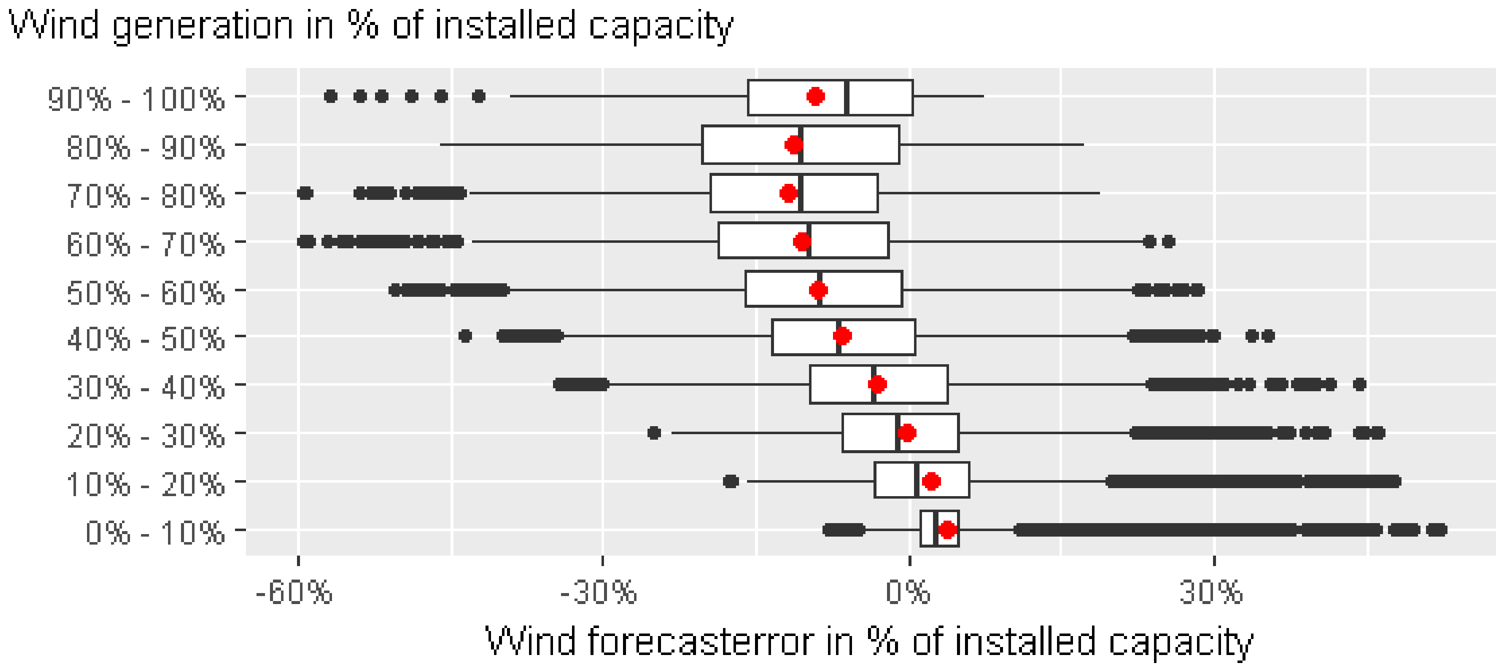
Example: Wind forecast errors

- Historic generation forecast error of wind onshore in Austria in the year 2016



Applied market model

- Operation modes of *HiREPS*

	Day-ahead market	Intra-day market	Balancing market
Design	Uniform price auction	Uniform price auction	Uniform price auction
Uncertain data input	24-hour forecasts (= day-ahead profiles)	Day-ahead profiles + difference between 24h forecasts and hourly forecasts (= intra-day profiles)	Intra-day profiles + difference between hourly forecasts and real-time profiles
Time resolution	1 hour	1 hour	5 minutes
Modeled time period	1 week for each month	1 week for each month	1 week for each month
Model approach	Representation of whole time period in 1 model run	1 model run for each hour in the time period (Rolling horizon)	1 model run for each 5min-window in the time period (Rolling horizon)
Results	• Day-ahead prices • Storage reservoir levels • Cross-border flows and remaining transmission capacity	• Intra-day prices considering unplanned outages until next day and day- ahead forecast errors • Updated cross-border flows and remaining transmission capacity	• Real-time electricity prices considering unplanned outages for 1 hour and intra-day forecast errors • Available cross-border capacity subject to scenario analysis

Outage statistics of conventional power plants

Table 4.1.: Assumptions related to unplanned outages of conventional power plants. Sources: (NERC, 2015; CEA, 2007)

Technology	[MW] Typical size	[%] FOR	[hours] MFOD
Run-of-River	100	3.96	64.97
Hydro Storage	350	3.96	64.97
Pumped Hydro Storage	350	9.22	64.97
Biomass Extraction Turbine	25	10.00	22.60
Biomass Backpressure Turbine	50	10.00	43.15
Other dispatchable RES	1	5.00	22.60
Gas Combined Cycle	300	4.71	22.60
Gas turbine	5	12.00	22.60
Oil	100	26.20	22.60
Coal	500	7.01	43.15
Lignite	600	4.20	43.15
Nuclear power	1500	2.72	518.98