Ex-ante trade of balancing power reserves in German electricity markets
The cure to the missing money or a new disease?*

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Motivational background

- Reserves auctions provide an additional source of income for producers
- Imbalance minimization is incentivized through imbalance prices
- Long-run equilibrium & capacity adequacy are a product of expected total income, including spot market and reserves provision incomes

Do the current rules in German electricity markets
1. provide efficient signals for long-run decision-making, and
2. what does the available data have to tell about it?
The change of pattern: from missing money to missing flexibility

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**Scarcity ↔ peak load situation**

- Missing money?
  - Capacity adequacy
  - Full load hours
  - Unit commitment
  - Predictability
  - Weather = ambient temperature
  - Hourly intervals

**Scarcity ↔ net load variation**

- Missing flexibility?
  - Service reliability
  - Ramping capabilities
  - Dynamic optimization
  - Intermittency
  - Weather = wind, solar radiation, temperature
  - 15-minute intervals

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Focus shift from day-ahead to real time market

Evolving role of different markets and players

Implications to suitability of analytical approaches
The change of pattern: the continuum of subsequent markets

- **Imbalance pricing**
- **Ancillary services**
- **Balancing power**
- **Intra-day**
- **Day-ahead**
- **Forward markets**

Linear dependency
Adjust
Hedge

Primary control by all TSOs (reserve provision) within the time frame of seconds
Secondary control and minutes reserve by TSO affected
Compensation through the balancing group affected

Decision parameter, “price signal”
Real-time market, “marginal system price”
Traditional focus, “spot market”
Unbiased imbalance prices prerequisite for efficient market outcome → system balance error a random process

Efficient equilibrium between energy market and control power reserves markets exists, when:
1. **Scoring rule** = based on capacity price bids;
2. **Settlement rule** = marginal cost price bids;
3. **Parallel bidding** of up & down regulation; and
4. Day-ahead price is an unbiased predictor of real-time prices.

(Chao & Wilson, 2002)

Demand for control power random → implies stochastic balancing prices  
(e.g. Klæboe et al, 2013)
Some controversial design aspects of the balancing power markets in Germany, …

<table>
<thead>
<tr>
<th>TSOs’ role</th>
<th>Market</th>
<th>Capacity payment</th>
<th>Energy payment</th>
<th>Pricing rule</th>
<th>Auction interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average balancing cost basis for price</td>
<td>Imbalance pricing</td>
<td>No</td>
<td>Yes</td>
<td>Single price</td>
<td>Ex-post</td>
</tr>
<tr>
<td>Single buyer</td>
<td>Primary control</td>
<td>Yes</td>
<td>No</td>
<td>Pay-as-bid</td>
<td>Weekly</td>
</tr>
<tr>
<td>Single buyer</td>
<td>Secondary control</td>
<td>Yes</td>
<td>Yes</td>
<td>Pay-as-bid</td>
<td>Weekly</td>
</tr>
<tr>
<td>Single buyer</td>
<td>Minute reserve</td>
<td>Yes</td>
<td>Yes</td>
<td>Pay-as-bid</td>
<td>Daily</td>
</tr>
<tr>
<td>Trading as balance responsible party</td>
<td>Intra-day</td>
<td>No</td>
<td>Yes</td>
<td>Per contract</td>
<td>Cont 45 min ahead</td>
</tr>
</tbody>
</table>

- Focus of our research

- Other controversial features
... and how they potentially undermine long-run price signals

- Implicit price premia in reserves pricing
- Reserve auctions week ahead
- Correct long-run signals!
- TSO trade in intra-day market
  - Biased incentives (private information)
- No arbitrage: day-ahead ↔ balancing prices
- Stochastic system balancing volumes
- Random balancing prices
- Average cost imbalance price
  - Insufficient penalty for imbalances
  - Illiquid intra-day market

Marginal imbalance price
From market design aspects to research hypothesis

**Market feature**

- Week-ahead auction for reserves
- TSO trade in intra-day market
- Imbalance price based on average costs

**Hypothesis**

- Given the TSOs important role in intra-day markets, TSO’s estimates of the imbalance costs constitute a cap for intra-day prices
- TSO incentives to trade in intra-day market are biased by private information of cost and availability of control reserves
- Due to insufficient incentives to self-balancing, the TSOs actually dominate the intra-day market
Assuming positive confirmation of the 3 hypothesis, the distraction to the hedging role of intra-day and day-ahead markets would be confirmed.

Research aim: Econometric modeling of intra-day prices & intra-day–day-ahead price differences

Variables to be used:
- Control dependent for auto-regression, seasonality, balancing state (up/down)
- Volumes in 15 min granularity
  - Control power auction results
  - TSO Intra-day transactions (related to RES forecasts)
  - Control area & RES balance group forecasts: 24h & 8:00am
  - Actual RES in-feed
- Prices
  - Energy and capacity prices of subsequent physical markets (secondary reserve … day-ahead markets)
The more there is **physical volatility** related to balancing power demand, the more important it is to maintain **unbiased link** between real time prices and day-ahead market.

Should the model imply any significant explanatory power, the efficiency of price signals should be closely examined.

Next steps: model specification and testing of hypothesis.

Final comment: the latest amendments in German market rules encourage indeed RES self-balancing decreasing the TSO involvement.


Thank you for your attention!

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SCRAP
The imbalance pricing system applied to balance responsible parties' imbalances has the following characteristics:

- Imbalance prices are calculated for each balancing interval (equivalent to the scheduling interval of ¼ hour). Since 01/06/2010, a uniform balancing energy price (reBAP) applies for the whole of Germany.
- The balancing energy prices are based on the TSO's payments or proceeds for the activated control energy (secondary and minute reserve).
- Symmetric price per ¼ hour, i.e. no price spread between positive and negative balance group deviations.
- Due to the introduction of negative energy prices for minute and secondary control reserves, the balancing energy price can also be negative and therefore also cause costs for balancing groups with a positive imbalance.

Source:
https://www.regelleistung.net
Operational targets of a TSO

- Provision of system services in order to ensure secure system operation
  - Frequency stability
  - Voltage stability
  - Rebuilding of supply
  - System operation

- Three reserve qualities for frequency stability of Transmission System Operators (TSOs)
  - Primary control reserve (PCR)
  - Secondary control reserve (SCR)
  - Tertiary reserve (TR)

Source: DR.-ING. ULF / Transnet BW Dresden Enerday, April 11th, 2014
the German TSOs procure the following types of control reserve:

- **Primary control reserve**: (= frequency containment reserves)
  - Provided according to the solidarity principle by all TSOs synchronously connected within the ENTSO-E area
  - Automatic and complete activation of primary control reserve within 30 seconds
  - Period per incident to be covered: \(0 < t < 15\) min

- **Secondary control reserve**: (= frequency restoration reserves)
  - Energy balance of the control area and frequency control
  - Immediate automatic activation by the concerned TSO
  - Complete activation within five minutes (at most)

- **Minute reserve (tertiary control reserve)**: (= replacement reserves)
  - The activation is based on MOLS by a Merit-Order-List (electronic activation)
  - Complete activation within fifteen minutes
  - Period per incident to be covered \(t > 15\) min to 4 quarter hours or up to several hours in case of several incidents

Source: https://www.regelleistung.net
The stylized facts observed on electricity prices:

- long term trend,
- Mean reversion,
- different sources of seasonality,
- presence of spikes,
- High volatility
Outline

1. Introduction
2. The framework
3. The propositions