

# Flexibility Provision through European Balancing Power Markets

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**CEEM Conference**  
**THE MARKET ARCHITECTURE FOR ENHANCING FLEXIBILITY PROVISION  
IN THE EUROPEAN ELECTRICITY SECTOR**

**Tuesday, 16 April 2019, 14h30 to 19h00**  
**Université Paris-Dauphine, Room Raymond Aron, 2<sup>nd</sup> Floor**

The decarbonisation of the European power sector, to the extent that it is pursued primarily by introducing variable renewables, requires increasing amounts of flexibility over different geographic areas and different timeframes to match supply with demand. New technologies and behavioral changes offer some potential to respond to that need. There is, however, an open question whether this flexibility potential is best leveraged through decentralised competition in homogenous European markets, centralised competition *for* certain markets, e.g. auctions, or local energy markets with yet to be developed coordination mechanisms. This conference organised by the Chaire European Electricity Markets (CEEM) brings together leading experts to discuss how the first of these three options, European-wide markets **with marginal cost pricing**, can best respond to the flexibility challenge.

# Outline of the talk

- 1 Introduction to balancing power
- 2 Future European market design
- 3 Theoretical analysis: Uniform pricing
- 4 Discussion

# Volatility in the power system

## Why do we need balancing power?

- **Power supply and demand** are volatile because they are mostly based on forecasts.
- Growing share of power production from **renewable energy sources** increases the volatility of the supply side.
- Principles of an AC power system require a **constant grid frequency** (50 Hertz), i.e. power supply and demand must match at any time.
- **Balancing power** is the most important short-term ancillary service of the power system by balancing instantaneously discrepancies of supply and demand.

# Balancing power markets

## Procurement of balancing power

In most liberalised power markets worldwide, markets for balancing power are organised as **procurement auctions**, i.e. the TSO(s), ISO(s), etc. “purchase” balancing power from suppliers (bidders).

## Characteristics of bidders

- Market participation demands a prior **prequalification**.
- Bidders face two cost types: **Capacity** and **activation cost**.

## Types of balancing power

- **Direction**: Positive and negative balancing power.
  - Positive: Reservation and needs-based upward regulation.
  - Negative: Reservation and needs-based downward regulation.
- **Quality**: Primary, Secondary and Tertiary balancing power.

# Recent developments

- „German paradox” (Hirth & Ziegenhagen, 2015):
  - Increasing production from renewable energy sources, but
  - demand for balancing power decreased continuously.
- Extreme prices (Heim & Götz, 2013) and evidence for collusion (Ocker et al., 2018) lead to a general re-consideration of the “appropriate” market design for balancing markets.
- Future harmonisation of European markets (Electricity Balancing Guideline, 2017) sets out common design elements such as:
  - product harmonisation, i.e. FCR, aFRR and mFRR,
  - auction rules, e.g. time-frames and frequency,
  - pricing rule, i.e. uniform pricing (marginal pricing).

# Important design elements

	Frequency Containment Reserve	Frequency Restoration Reserve (automatic)	Frequency Restoration Reserve (manual)
<b>Auction frequency</b>	Weekly	Daily	Daily
<b>Time-frame</b>	Minimum weekly	Minimum daily	Minimum daily
<b>Direction</b>	Positive <u>and</u> negative	Positive <u>or</u> negative	Positive <u>or</u> negative
<b>Activation time</b>	$\leq 30s$	$\leq 5min$	$\leq 15min$
<b>Bid components</b>	Capacity bid	Energy bid (+ Capacity bid)	Energy bid (+ Capacity bid)
<b>Activation strategy</b>	Pro-rata	Merit-order	Merit-order
<b>Price rule</b>	Uniform pricing	Uniform pricing	Uniform pricing
<b>Cooperation(s)</b>	AT, BE, CH, FR, GER & NL	DE & AT, PICASSO	DE & AT, MARI

# Major challenges to target model

## Short gate-closure-time

- Shifting gate-closure-time of energy bids closer to real-time.
- **Rationale:** Efficient pricing and increased market liquidity, e.g. from demand-side-response, intermittent generation, etc.

## Voluntary energy bids

- Bidders may submit energy bids without capacity bids.
- **Rationale:** Increased market liquidity (no reservation required).

## Uniform pricing

- Bidders are remunerated with a uniform price.
- **Rationale:** Truthful cost revelation (efficient auction outcome).



# Balancing power markets and game theory

## Previous research to balancing power markets

- Empirical analyses (e.g. Rammerstorfer and Wagner, 2009),
- Decision-theoretic analyses (e.g. Bushnell and Oren, 1995) or
- Macroeconomic model (Müsgens, Ockenfels and Peek, 2014).

**Observation:** Bidders' **strategic interaction & strategy spaces** in the balancing power auctions are mostly neglected.

## Research method: Game theory

- Game theory analyses decision-making of players with **interdependent payoffs**.
- Result of game-theoretical analysis is **solution of a game**.
- Solution concept for auctions: **Bayes-Nash equilibrium**, i.e. a set of “best responses” (no incentive to deviate unilaterally).

# Effects of uniform pricing on bidding behavior

## Game-theoretical solution

- The **procurement costs are identical** as with pay-as-bid.
- **But:** Uniform pricing does **not induce bidders** to truthfully report their costs in their bids.
- **On the contrary:** Bidders are **incentivized to underbid** costs!

## Interpretation of solution

- “Goods” in the merit-order are **inhomogeneous**:
  - Underbidding secures **“better” rank** in merit-order.
  - This results in a **higher probability to deliver balancing power** and, thus, in higher profits.
- However, the **uniform price** is set by last activated bidder, i.e. underbidding is “safe” in many instances.

# Strategic considerations

The rationale for uniform pricing is to increase the auction efficiency by inducing **incentive compatible** bidding:

- It is a bidder's best response to report her true cost to the auction mechanism.
- The mechanism allocates the bidder in the best possible way.

## Evaluation of uniform pricing

- Uniform pricing sets **counter-intuitive incentives** for bidders.
- It is highly **doubtful** that bidders actually underbid their costs.
- If there are no clear incentives ... **bidders get creative!**

**Bottom line:** Theoretical properties of uniform pricing are **not desirable** in the specific case of balancing power markets.

# Strategic considerations

## Collusion and the price rule

- In Germany, there is empirical evidence that bidders abused their **market power** and **colluded implicitly**.
- Such **strategic behavior** is generally independent of the price rule because it is grounded on other factors:
  - The **regular repetition** of the auction and
  - the **limited and stable** set of suppliers.

Increasing the **market liquidity** within the European harmonisation

- by common markets,
- by common products and
- by more flexible market participation,

is a **key element** for efficient auction outcomes.

# Thanks for your attention!

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