# Effects of price-making and portfolio size in stochastic optimization of trading in sequential electricity markets

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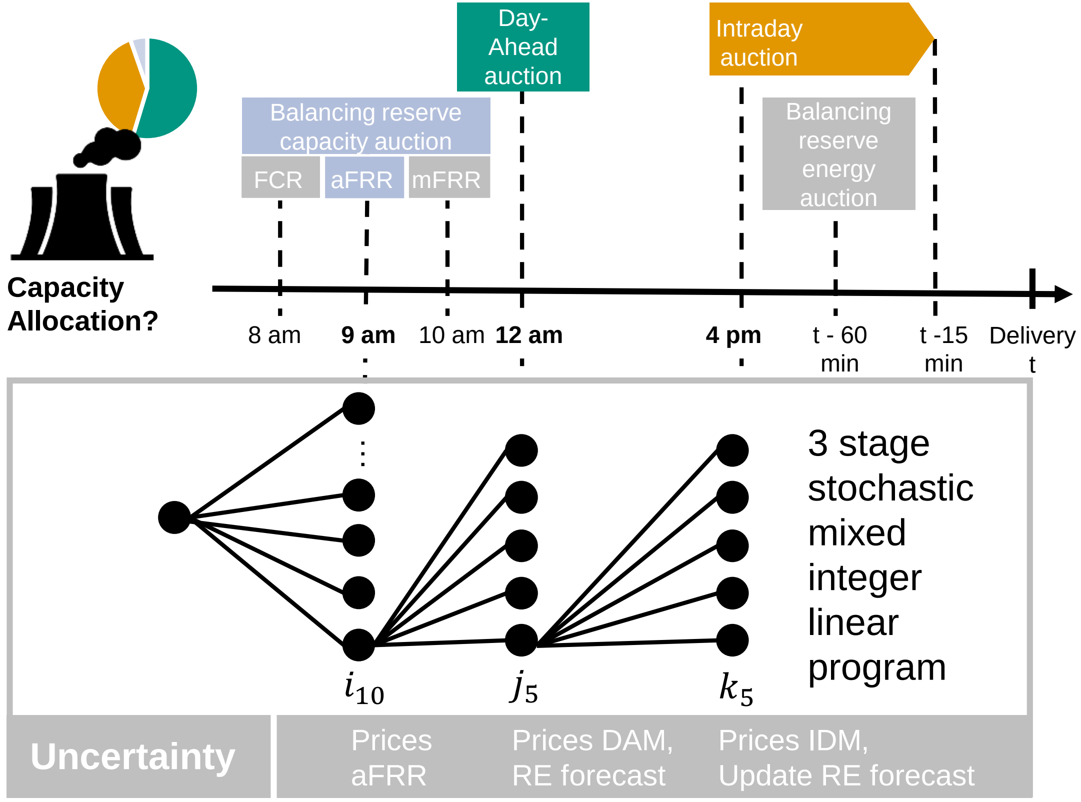
# Motivation




## Research Gap

- Increasing importance of products with short lead time [1, 2]
- Currently trading decisions often made deterministic [3, 4]
- ➢ Large value of coordination of bids?
- ➢ Dependency on portfolio composition?
- ➢ Effect of price making?

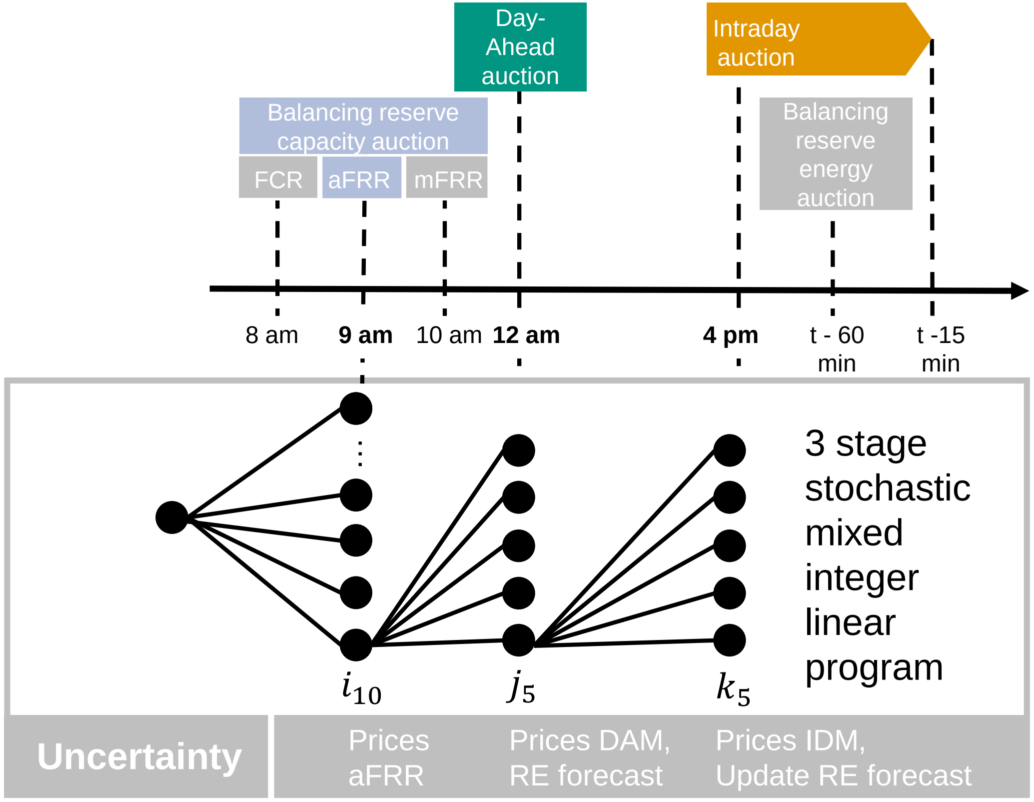
Flexibility [3]
Price impact [3]
Portfolio size [4]
Risk aversion [1]

Price maker



FCR- Frequency Containment Reserve, aFRR- automatic Frequency Restoration Reserve, mFRR- manual FRR, DAM- Day-ahead market, IDM –Intraday market, RE- Renewable Energies

# Stochastic optimization model




## Profit maximisation with risk consideration

$$max \ \ (1-\lambda)\cdot\mathbb{E}(\pi_{i,j,k}) + \lambda\cdot\mathrm{CVaR}_\alpha(\pi_{i,j,k})$$
$$\forall\ \alpha \in (0,1), \lambda \in [0,1]$$

$\lambda = 0$ risk neutral

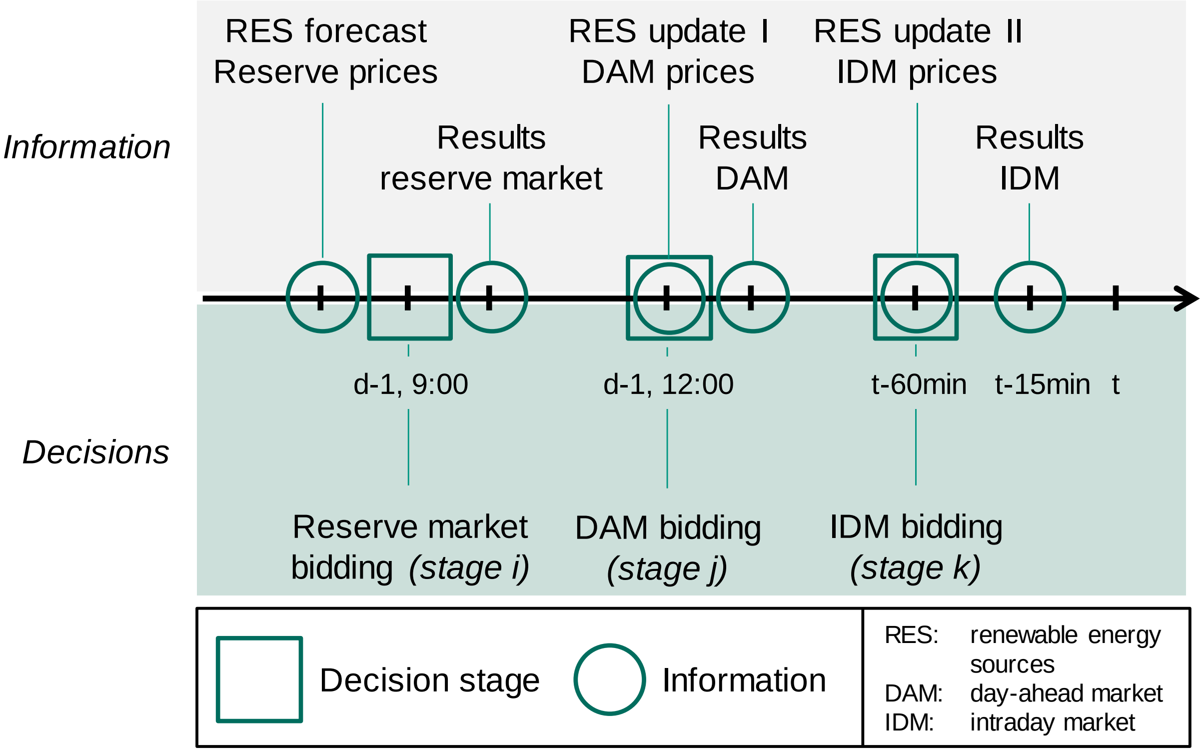
$\lambda = 1$ very risk averse

100 MW Biomass
100 MW PV

German market data and setting
July 2019 – March 2020
1 day = 96 quarter hours

18 type days
Work day, season,
low/medium/high residual load

# Decision structure




Kraft et al. (2022)

# Extensions

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| Start Point | **Multi-stage stochastic model & derived scenarios**<br>Kraft et al. (2022) |
| --- | --- |

**1. Implement Price Impact**

$$Revenue = \left(\hat{y}^{ID}_{j,k,qh} - b_{qh} * x^{ID,trade}_{i,j,k,qh}\right) * x^{ID,trade}_{i,j,k,qh}$$

- IDM with limited liquidity
- Continuous trading ≈ one uniform auction with ID3 price
- Impact derived from historical data following [3,6,7]
- Accepted bids from last 3 h
- Ordered and linear regression fitted → $b_{qh} = slope$
- Linearized following [6]

**2. Formulate Bidding Heuristic**

**3. Sensitivity Analysis**

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## 2. Formulate Bidding Heuristic

Optimizing market stages separately [3,6,8] → Myopic bidding heuristic

**Stage 1:**
Maximise profit aFRR & DAM assuming average realizations of DAM scenarios

$x_i^{aFRR}$

**Stage2:**
Maximize profit DAM

$x^{DA}_{i,j,k,qh}$

**Stage 3:**
Maximize profit IDM

## 3. Sensitivity Analysis

# Extensions

1. Price Impact | 2. Bidding Heuristic | 3. Sensitivity Analysis

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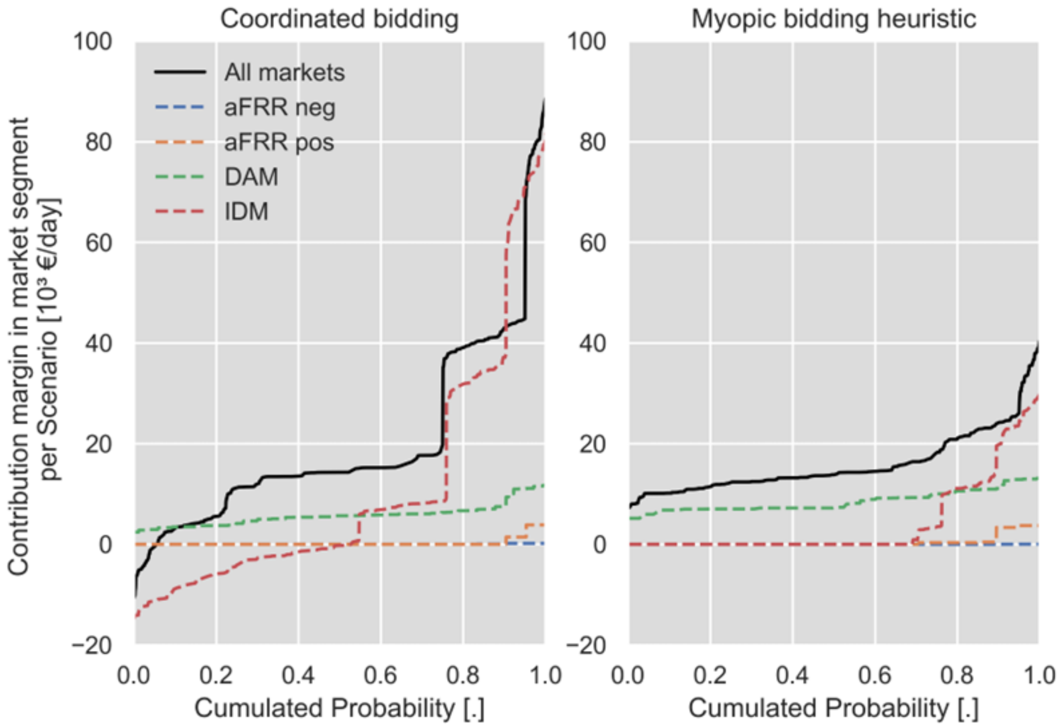


## Comparison

- Maximise immediate revenue – greedy approach
- Shift volume to earlier market stages
- Less volume left for Intra-day
- No negative revenue in myopic bidding

➢ Significant difference in head and tail

CM - Contribution Margin, IDM – intraday market, DAM – day-ahead market

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## 1. Implement Price Impact

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## 3. Sensitivity Analysis

- Follow up on interdependencies in literature
- Analyse spread of average contribution margin = value of coordination

# Extensions

1. Price Impact | 2. Bidding Heuristic | 3. Sensitivity Analysis

**Base Case:**

100 MW Biomass
100 MW PV

- Risk neutral trading
- Technical parameters taken from [1]
- One type day (transition, medium load, weekday)

**Risk aversion [1]**

1. $\lambda = 0.1$
2. $\lambda = 0.5$

$$(1-\lambda) \cdot \mathbb{E}(\pi_{i,j,k}) + \lambda \cdot \mathrm{CVaR}_{\alpha}(\pi_{i,j,k})$$

**Portfolio size [4]**

1. 500 MW Biomass, 500 MW PV
2. 1GW Biomass, 1GW PV → similar size to other portfolios analysed

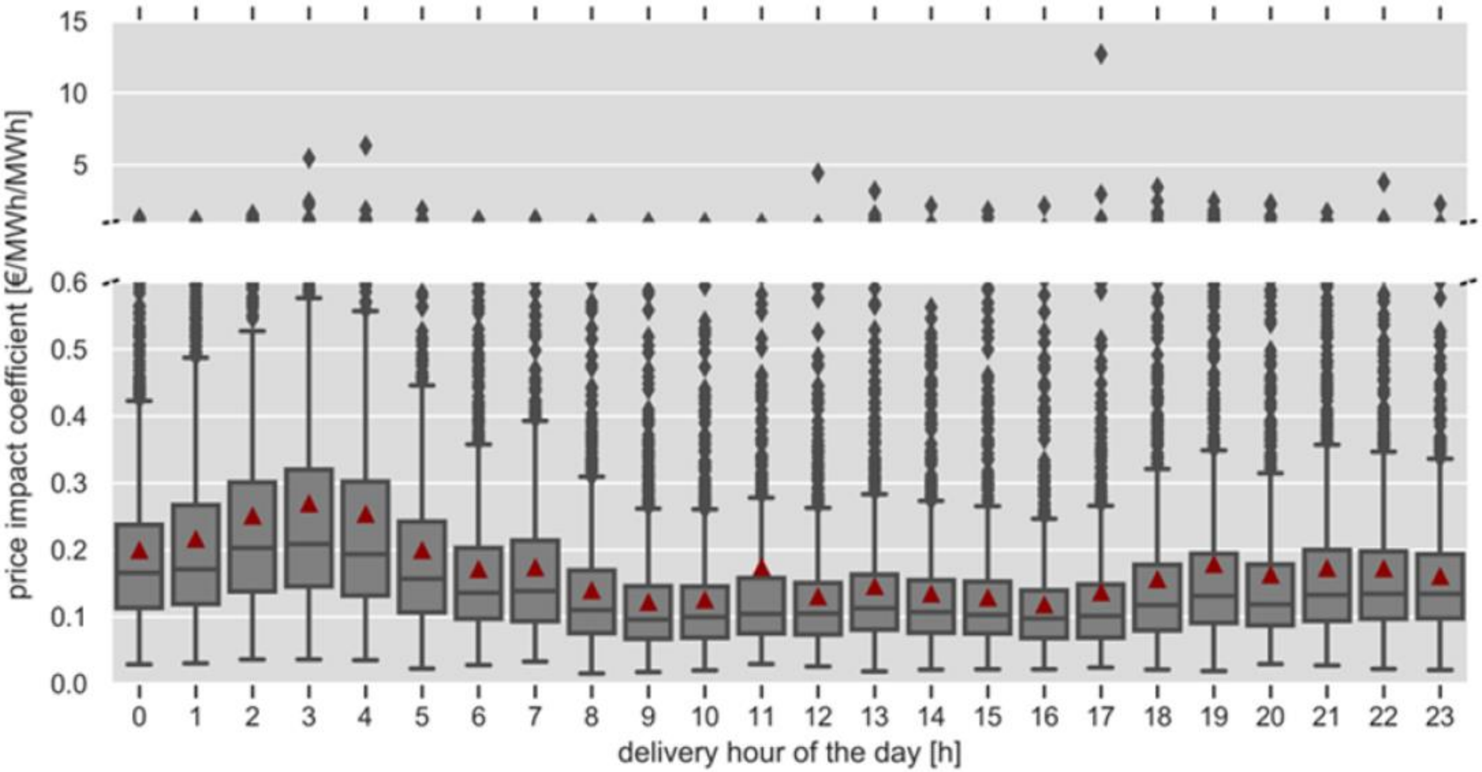
**Price impact [3]**

1. Average price impact in each hour
2. 0.25 quartile of price impact factor
3. 0.75 quartile of price impact factor

**Flexibility parameter variation [3]**

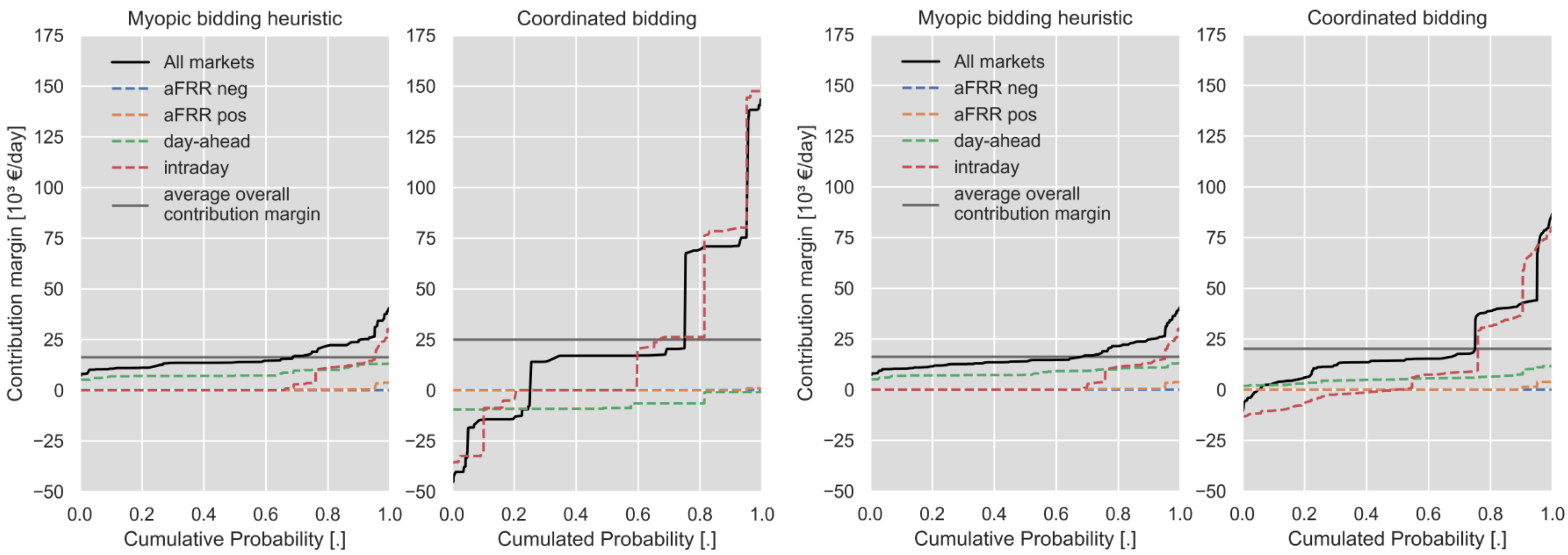
**Share of renewables in portfolio [5]**

# Largest price impact during night and smallest in the peak hours



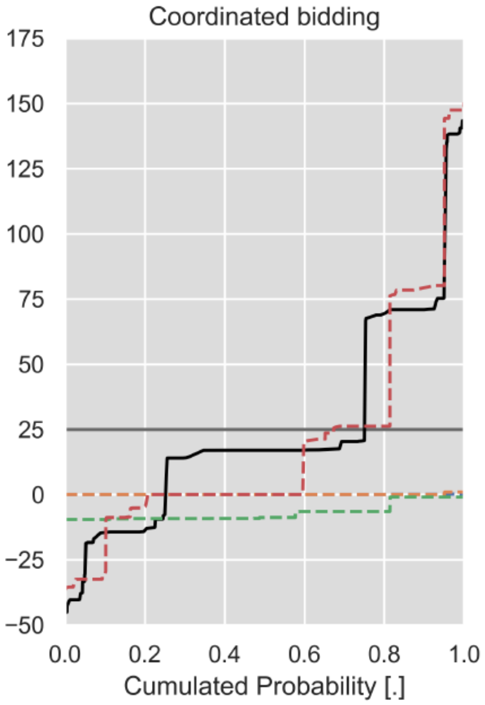
# Price making has little impact on heuristic, but large impact on coordinated trading strategy

*Price taking* *Price making*

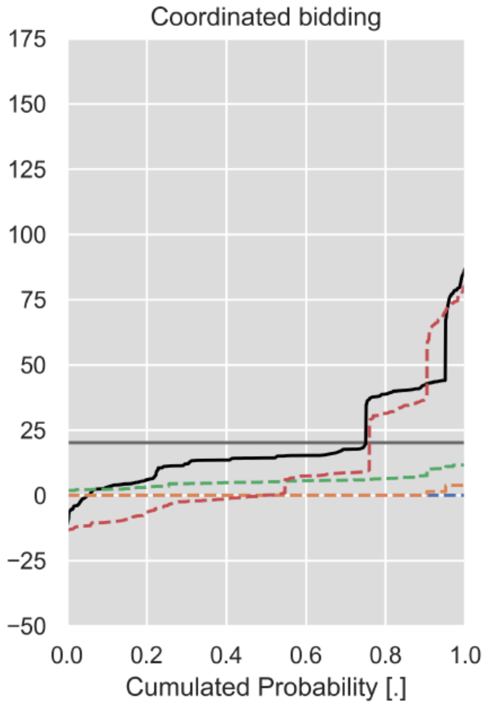


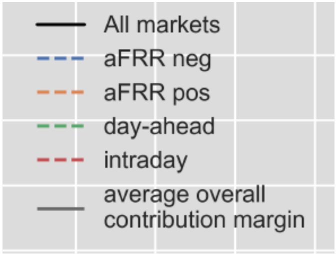
# Less speculation on high intraday prices

*Price taking*




*Price making*



# High variance across type days complicates drawing general conclusions

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- Gain of coordination for portfolio depends on:
  - Price relations and steepness of supply curve in market segments
  - Inframarginal / extramarginal power plant
  - Share of renewable generation
  - Flexibility of portfolio / degrees of freedom in dispatch
- For case study:
  - In summer lower than in transition and winter
  - Weighted relative value of coordination ~18%
  - Pay attention when comparing relative values!

# Conclusion

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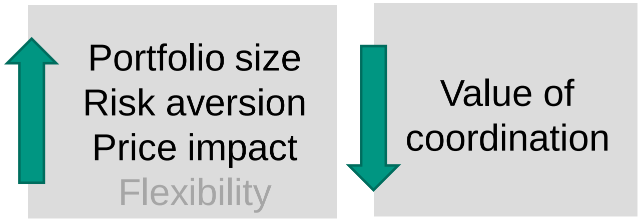
## Summary

- Price impact depiction
  - Price impact for IDM modelled
  - Price impact estimation through empirical data (2019-2020)
  - Extension of stochastic optimization model computationally expensive but feasible through piece-wise linearization
- Benefit of coordinated bidding
  - Overestimation of IDM profitability by neglecting price making (Kraft et al. 2022)
  - Lower but robust value of coordination across markets
  - Large impact of uncertainty modelling and portfolio configuration on value of coordination (no one-size-fits-it-all conclusion)
  - Given an increase in renewables and the importance of IDM, further increase in importance can be expected for coordinated bidding




## Outlook

# Conclusion

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## Summary

## Outlook

- Updating of scenarios to more recent data
- Evaluation of advantages of stochastic approach regarding risk exposure
- Scalability of model
- Interdependencies of influencing factors
  - Which situations require which degree of coordination?
  - How do sensitivities interact with each other?
- Add further technologies, e.g. storages of different time scales
- Translate principles to long-term energy markets

# Thanks for your attention!