# Mid-to long-term modeling of electricity market prices

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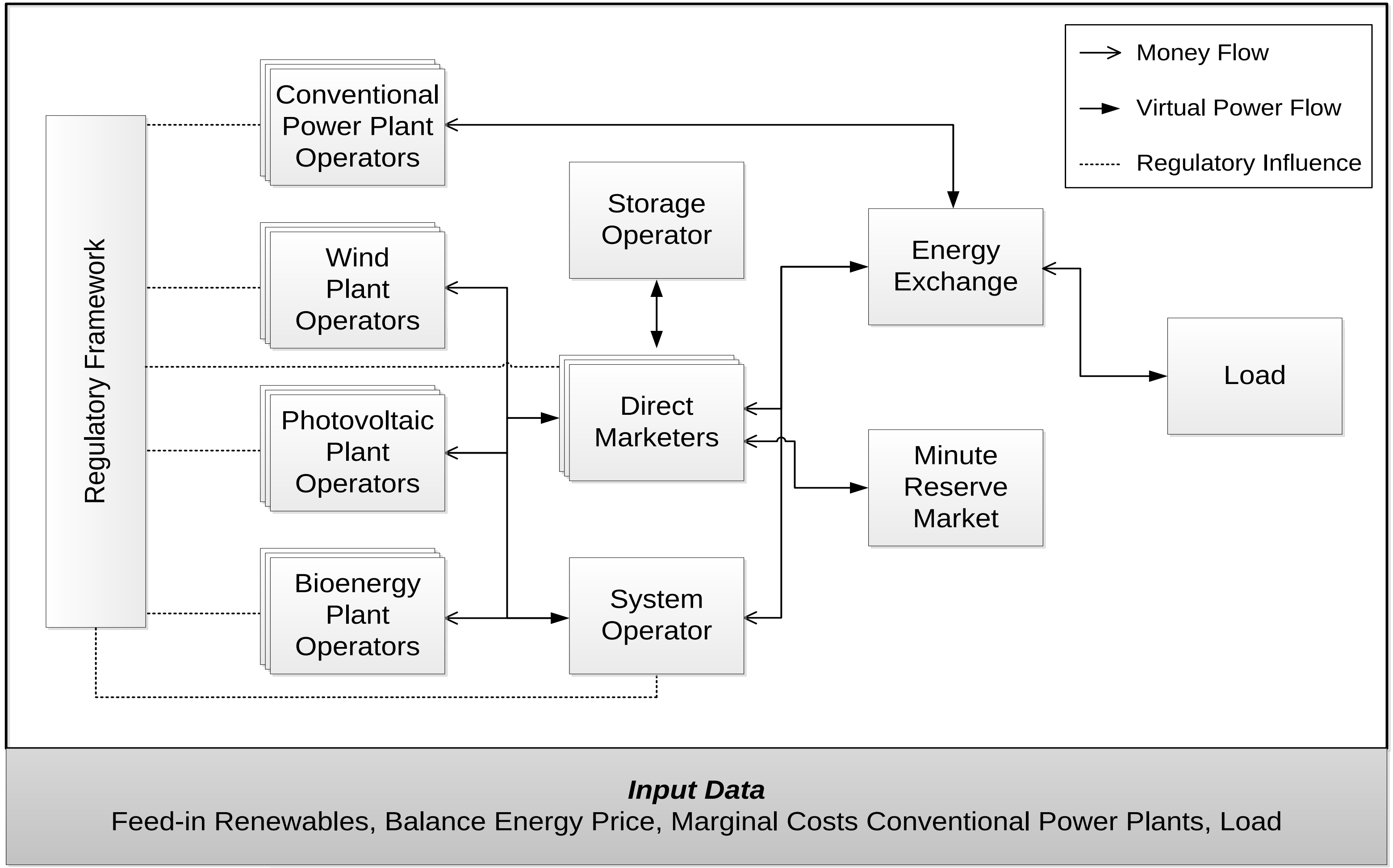
Gesellschaft für Energiewissenschaft und Energiepolitik e.V.
25. Workshop des Student Chapters
EWI, Köln, 04th May 2018

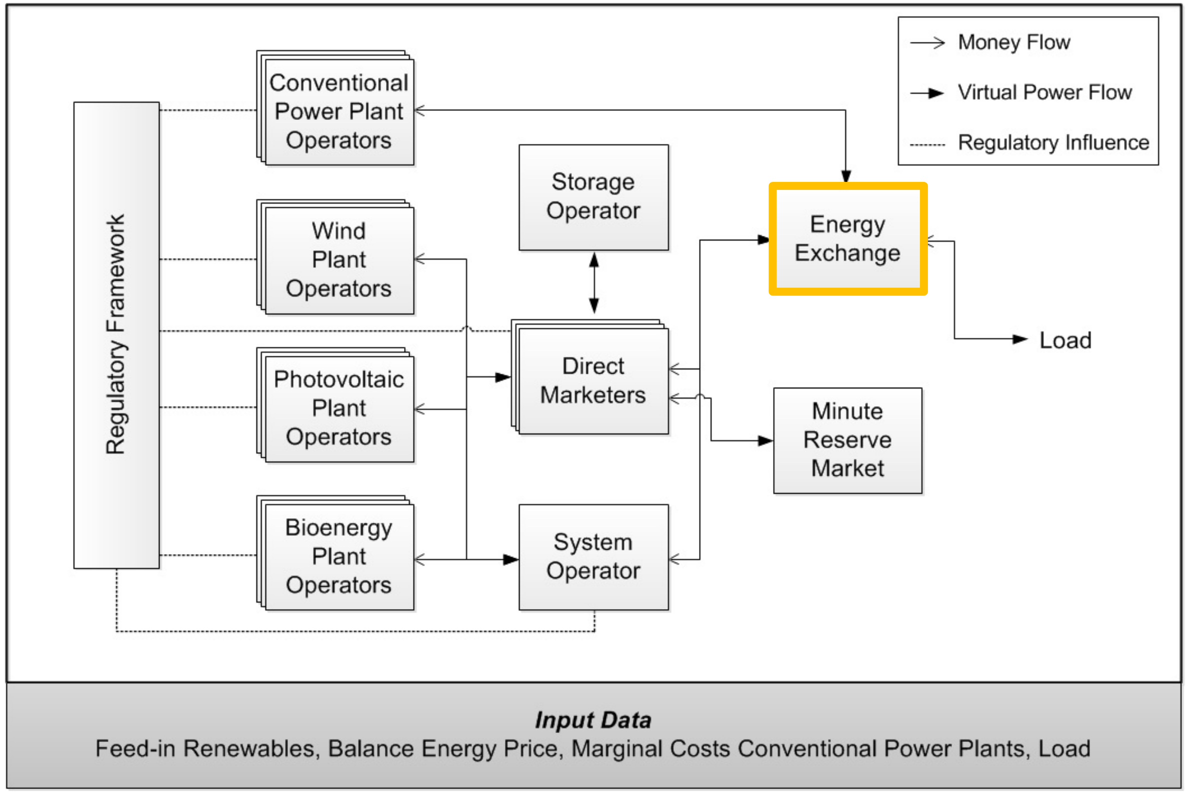
# AMIRIS – An Agent-Based Model of the German Electricity System

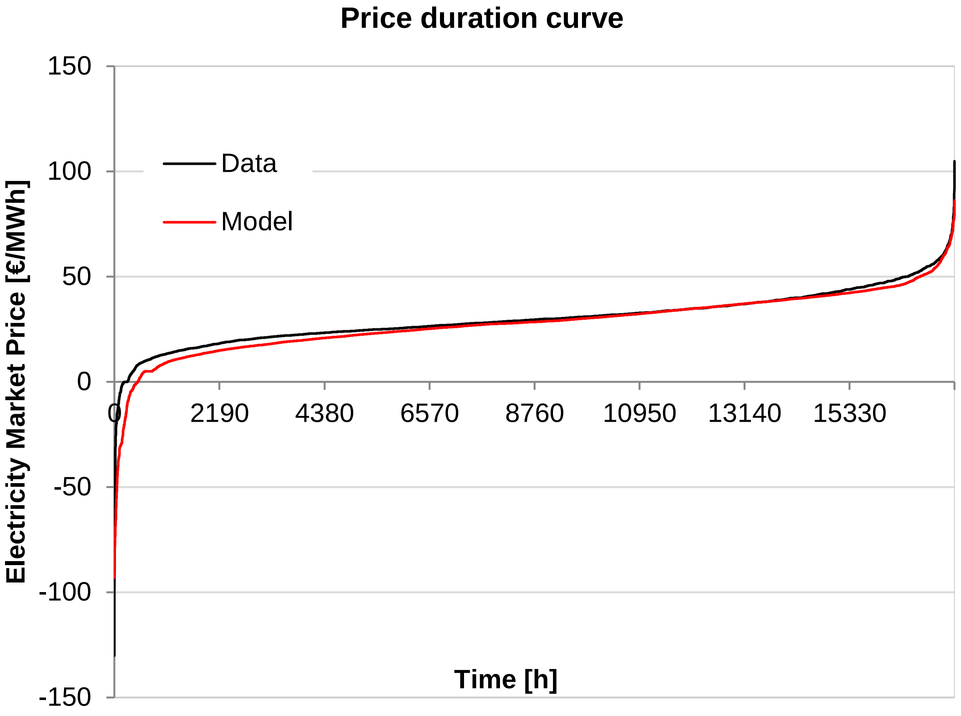



Deissenroth et al. 2017 - Assessing the Plurality of Actors and Policy Interactions - Agent-based Modelling of Renewable Energy Market Integration, *Complexity*, 1-24

# Agent-based model as a container framework

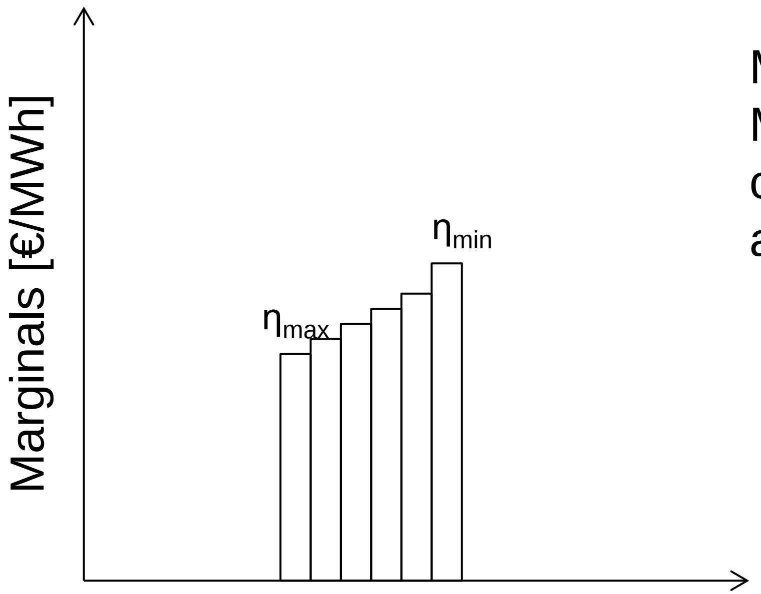
Example of model within model // explicit internal model coupling



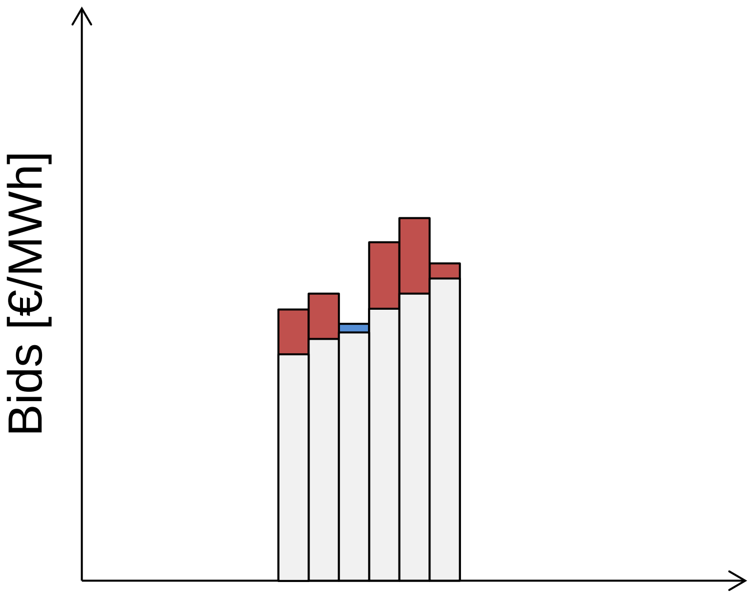




= internal model

# Electricity spot market price modeling
## Hybrid fundamental and econometric approach




Markups and Markdows by conventional traders and direct marketers



# Electricity spot market price modeling
## Input and output

*Time series:*

- **demand** curve (hourly)
- **generation potentials** for PV and wind (hourly)
- **fuel prices** for coal, gas and oil (daily)
- power plant **unavailabilities** (planned) (monthly)
- **capacities** for all power plant classes (nuclear, lignite, hard coal, gas combined cycle, gas turbine, oil, PV, wind onshore, wind offshore, hydro, biomass, import DRE, storage) (yearly)
- power plant **efficiencies** (min and max) (yearly)

*Constants:*

- power plant unavailabilities (unplanned)
- Average block sizes of power plants
- <u>*minimum and maximum markups/markdowns*</u> on top of the marginal bid of each block

***Output:*** **Hourly electricity market prices in €/MWh**

# Data

*Sources:*

| | |
|---|---|
| Power Plant Capacities and Efficiencies: | Open Power System Data |
| Demand, Spot Prices: | SMARD, BMWi |
| Planned Unavailabilities: | EEX Transparency |
| Fuel Prices: | Quandl / Destatis |

We investigate the wholesale electricity market price curve of Germany for the years **2012-2016**

- **Training:** Genetic algorithm works on first half of data set (2012 – 2014)
- **Validation:** on an *independent* data set which was not used for fitting (2015 – 2016)

# Genetic algorithm to determine markups

- One gene = one set of possible markups
- Example: $\begin{array}{cc} \textit{min} \qquad \textit{max} & \\ \begin{pmatrix} -200 & -10 \\ -30 & 10 \\ -50 & 30 \end{pmatrix} & \begin{array}{l} \textit{Nuclear} \\ \textit{Coal} \\ \textit{Gas CC} \end{array} \end{array}$
- *Pseudo-Code:*
  - Evaluate Fitness Of Genepool
  - Remove Low Fitness Solutions
  - Calculate Selection Probabilities
  - For generationSize :
    - Make new Children

# Genetic algorithm to determine markups

## Multi-objective fitness criteria

| Optimization Criteria | Unit | target $t_i$ | weight $w_i$ |
|---|---|---|---|
| Pearson Correlation | 1 | 1.0 | 3 |
| Mean Average Error | €/MWh | 0.00 | 5 |
| Standard Deviation | €/MWh | 16.63 | 3 |
| Mean | €/MWh | 37.74 | 3 |
| Minimum | €/MWh | -221.99 | 1 |
| Maximum | €/MWh | 210.00 | 1 |
| Number of hours with negative prices | 1 | 178 | 2 |

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- Multi-objective Fitness Evalution:

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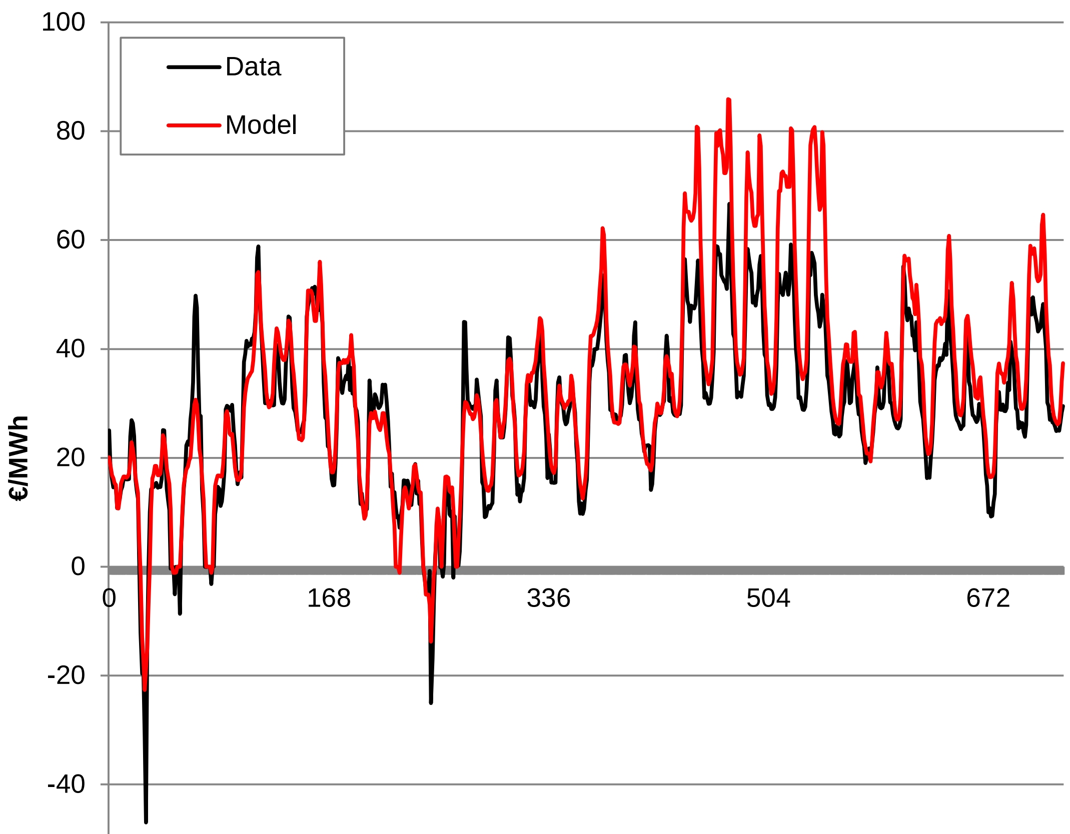
- Make new children with random crossover
- $\begin{pmatrix} -200 & -10 \\ -30 & 10 \\ -50 & 30 \end{pmatrix} + \begin{pmatrix} -300 & -30 \\ -70 & 30 \\ -20 & 60 \end{pmatrix} \rightarrow \begin{pmatrix} -200 & -10 \\ -30 & 10 \\ -20 & 60 \end{pmatrix}$

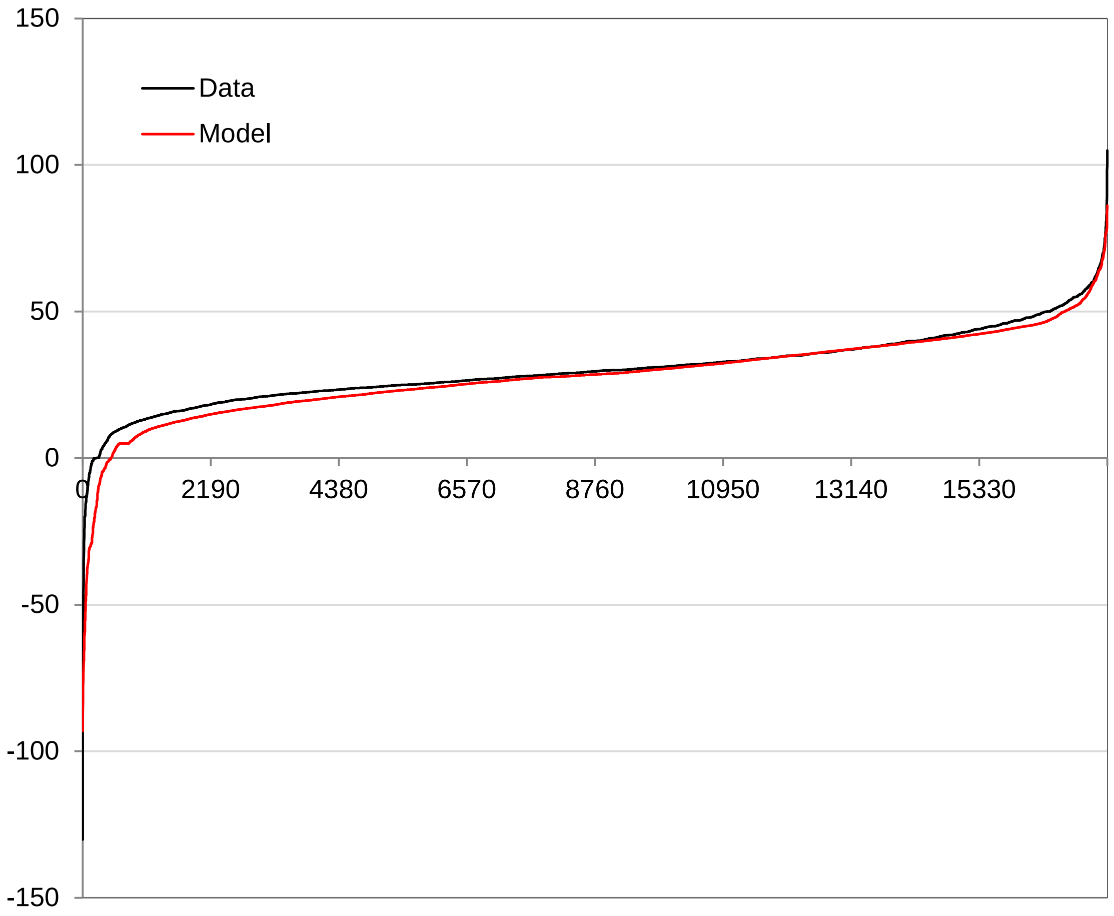
# Validation - Descriptive statistics

| DESCRIPTIVE STATISTICS Model vs. Data (2015 – 2016) | |
|---|---|
| Pearson Correlation | 0.87 |
| Rank Correlation | 0.89 |
| MAE [€/MWh] | 4.79 |
| RMSE [€/MWh] | 6.78 |

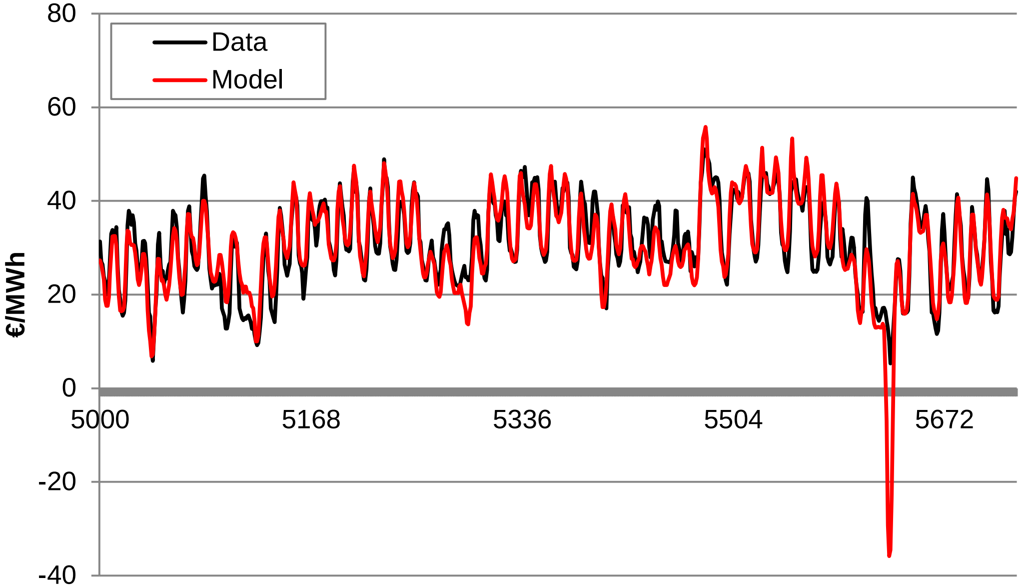
| SHAPE PARAMETERS | DATA | MODEL |
|---|---|---|
| Mean [€/MWh] | 30.30 | 28.73 |
| Std.D. [€/MWh] | 12.64 | 13.10 |
| # Hours < 0€/MWh | 223 | 446 |
| Min [€/MWh] | -130.09 | -57.93 |
| Max [€/MWh] | 104.96 | 85.90 |

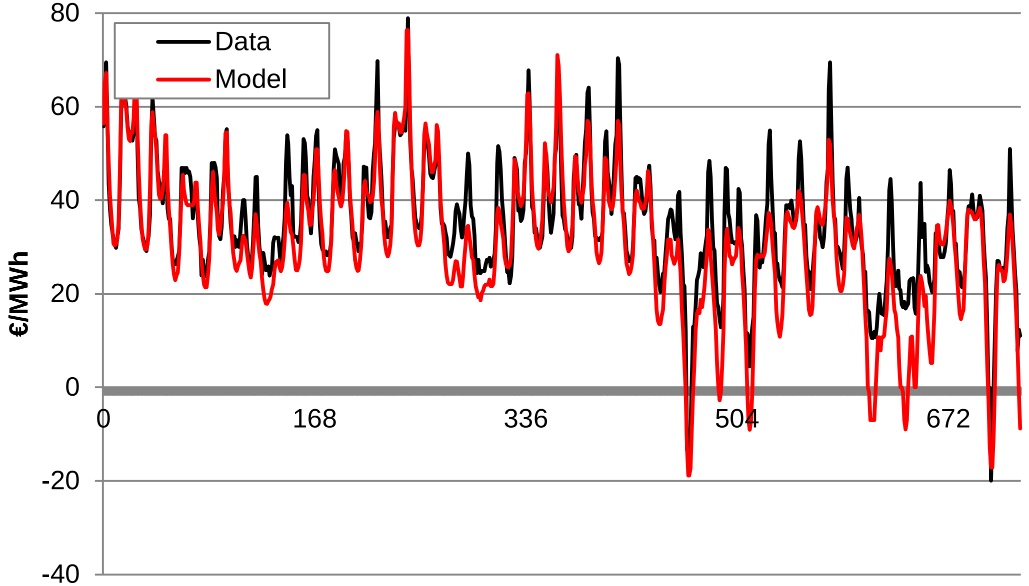
# Electricity spot market price modeling
## Results

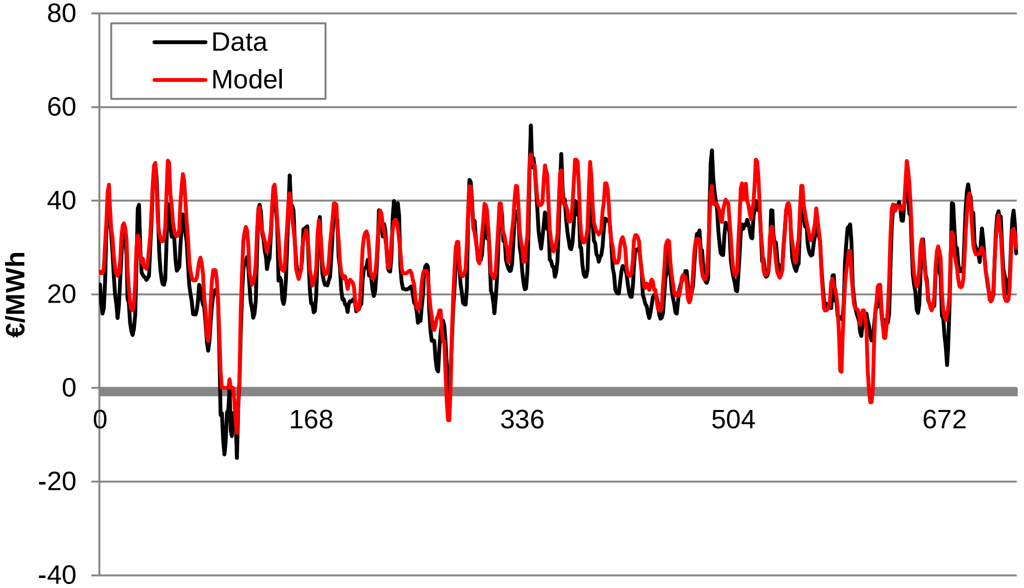


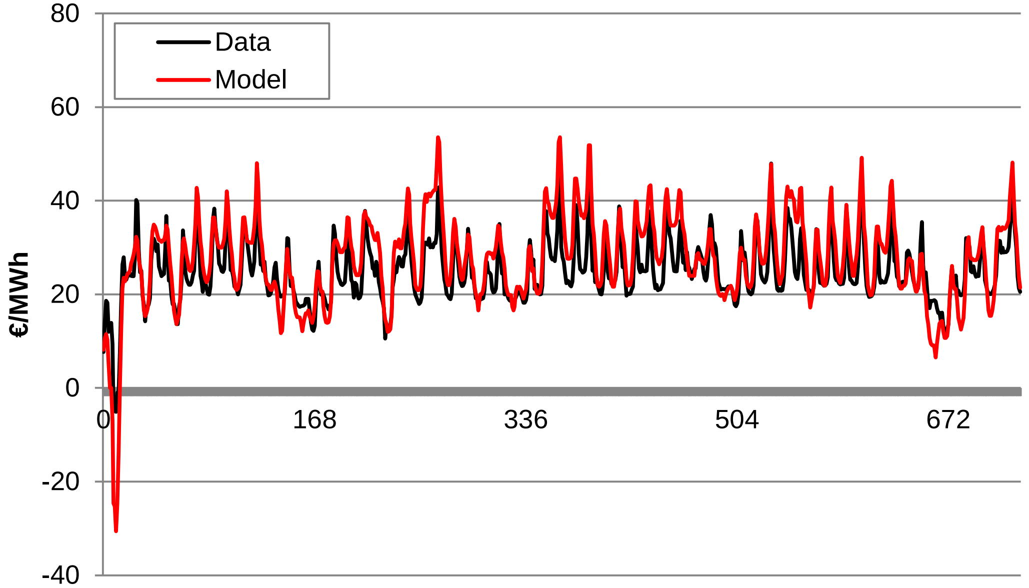



# Further randomized examples



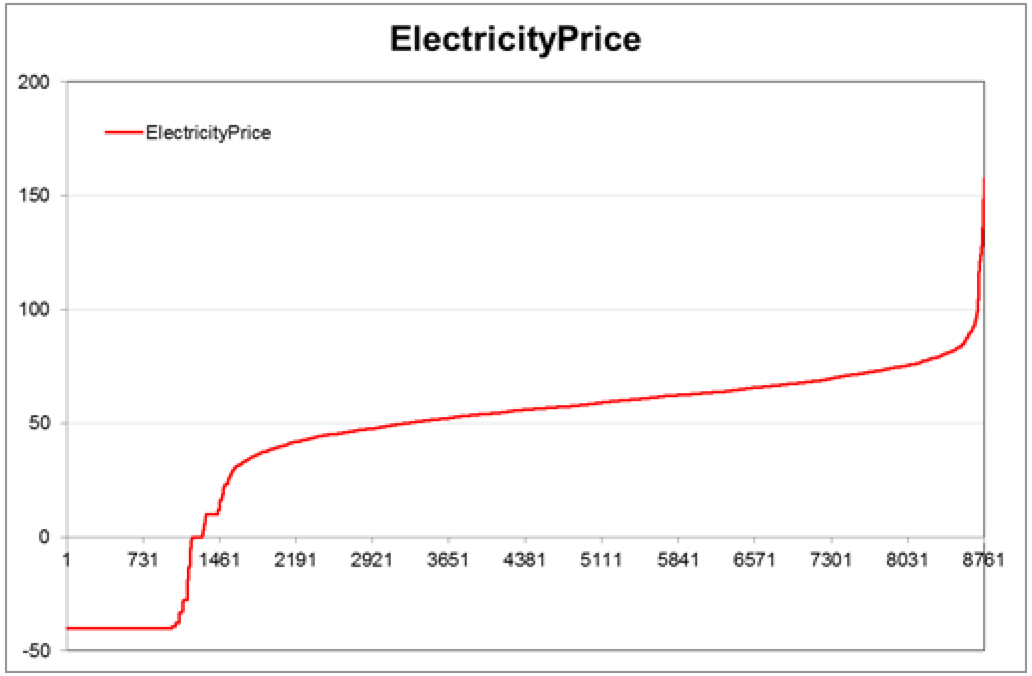



# Discussion and outlook

- Novel hybrid method to model electricity market prices is presented
- Combines fundamental bidding mechanism with a machine learning algorithm
- Very good agreement with validation data set (high correlation, low mean average error)
- Capable of reproducing the stylized facts of spot market prices including negative prices, high volatility and kurtosis
- Open Question: To what extent are the markup values characteristic for the technology class and to what extent to the „whole“ power plant park?
- Can this approach be used for long-term energy scenarios?

**Example Scenario 2035:** VRE 50%, RES 60%; less coal, security of supply ensured with gas power plants and some dispatchable imports, demand increase 1%/a, fossil fuel prices on same level as of today,



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Contact


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