Mid- to long-term modeling of electricity market prices

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25. Workshop des Student Chapters
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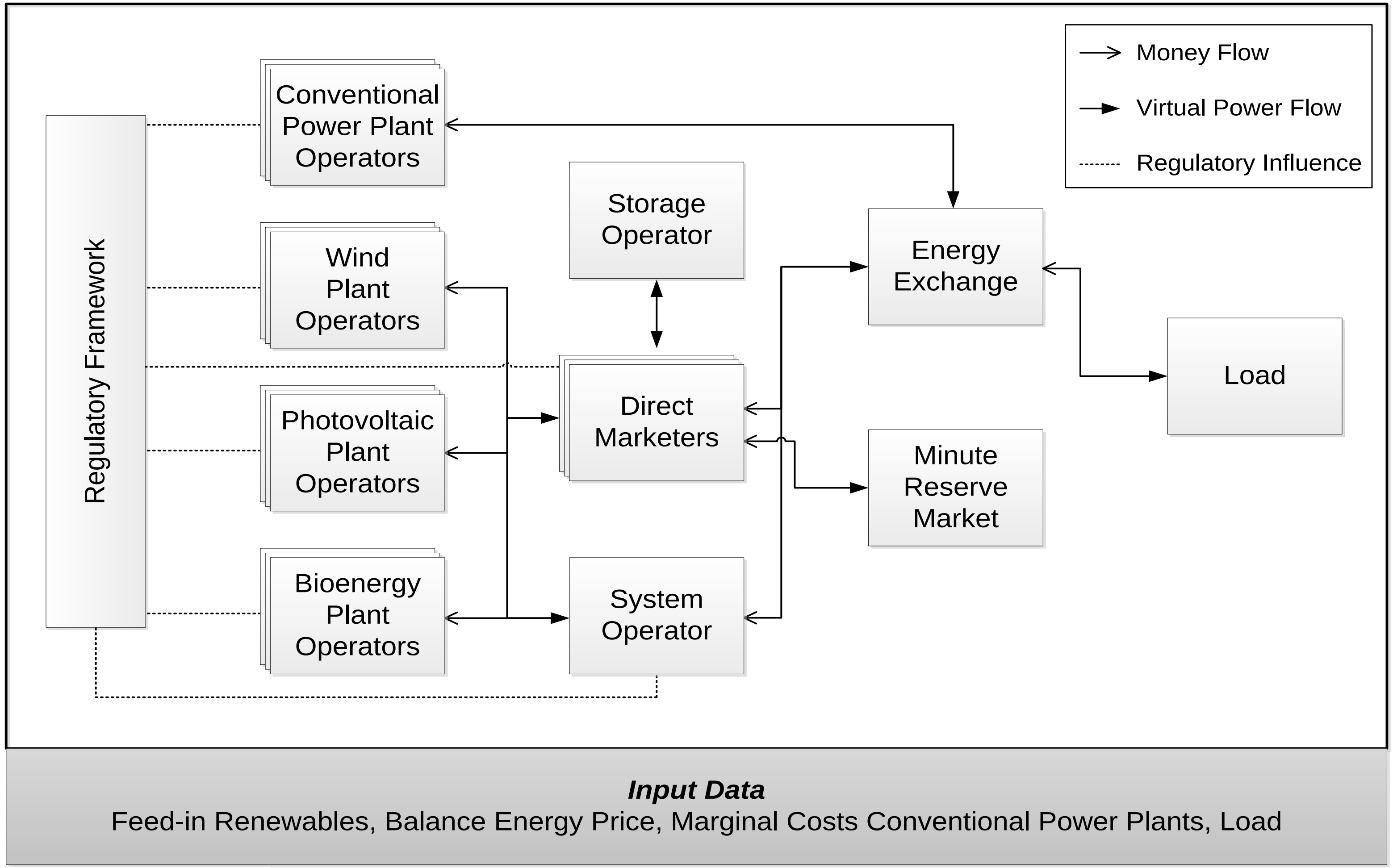
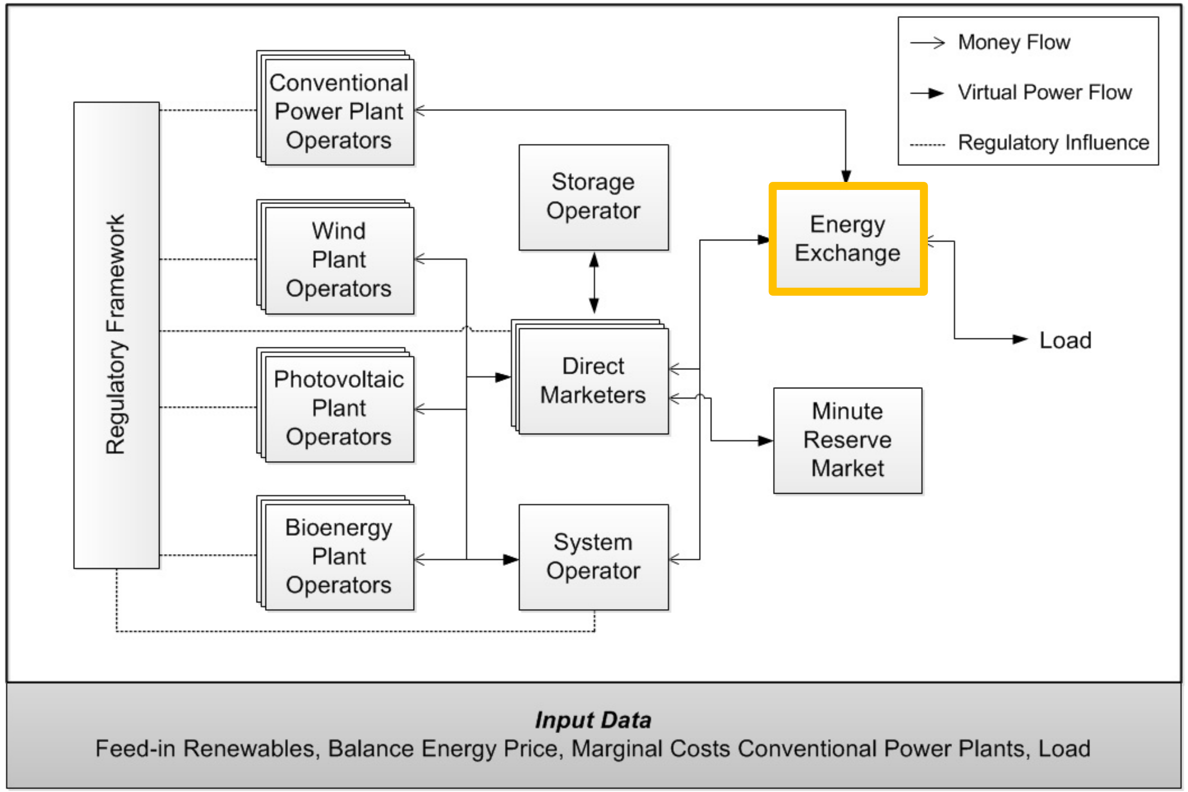
AMIRIS – An Agent-Based Model of the German Electricity System

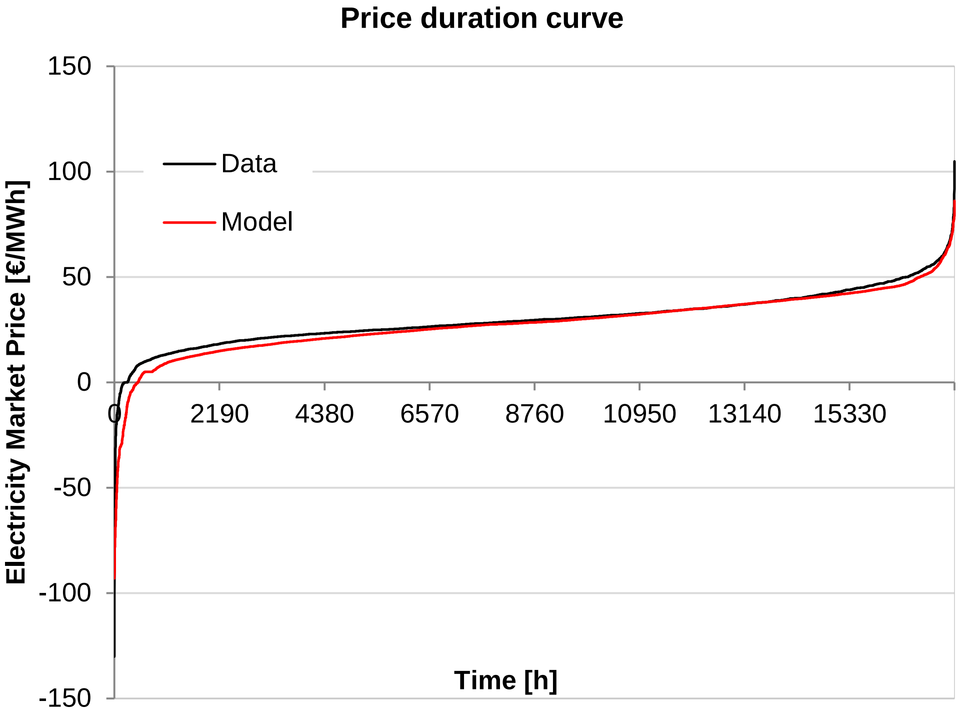


Deissenroth et al. 2017 - Assessing the Plurality of Actors and Policy Interactions - Agent-based Modelling of Renewable Energy Market Integration, *Complexity*, 1-24

Agent-based model as a container framework

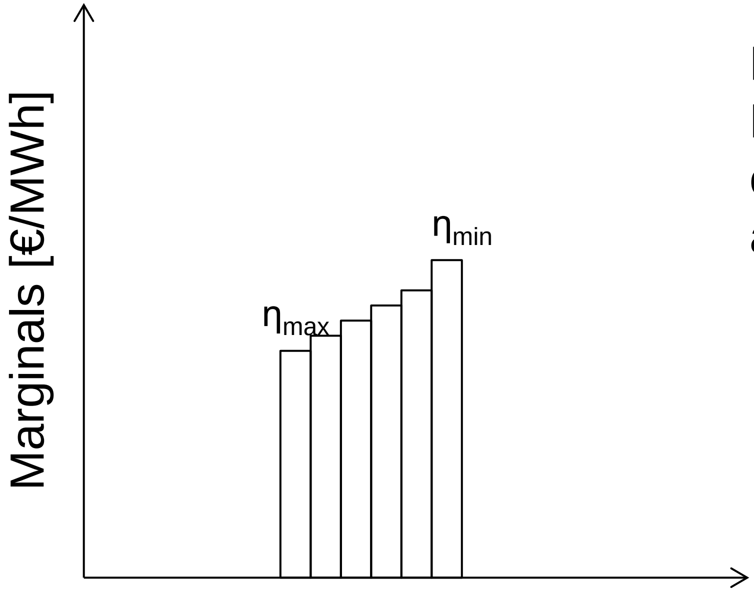
Example of model within model // explicit internal model coupling



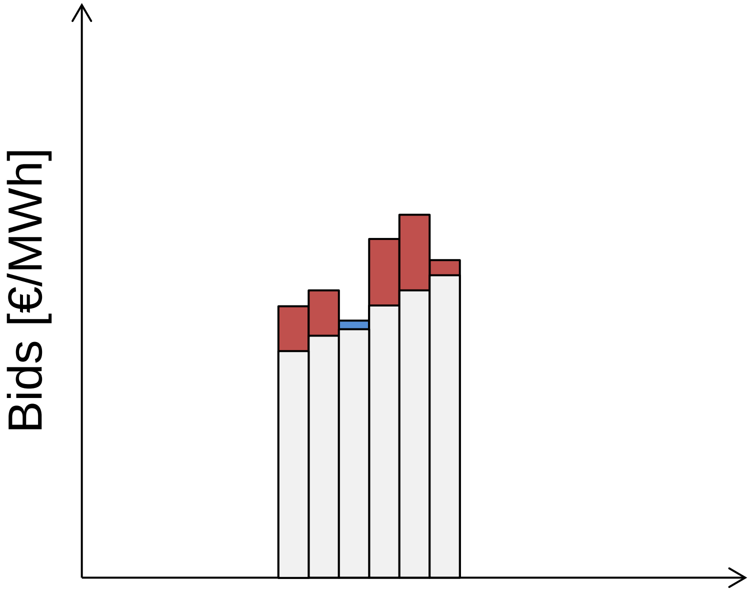


= internal model

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
- *minimum and maximum markups/markdowns* 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: $\begin{array}{cl} \begin{array}{cc} \textit{min} & \textit{max} \end{array} & \\ \begin{pmatrix} -200 & -10 \\ -30 & 10 \\ -50 & 30 \end{pmatrix} & \begin{array}{l} \textit{Nuclear} \\ \textit{Coal} \\ \textit{Gas CC} \end{array} \end{array}$

- *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

Genetic algorithm to determine markups

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- *Pseudo-Code:*
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- Multi-objective Fitness Evalution:

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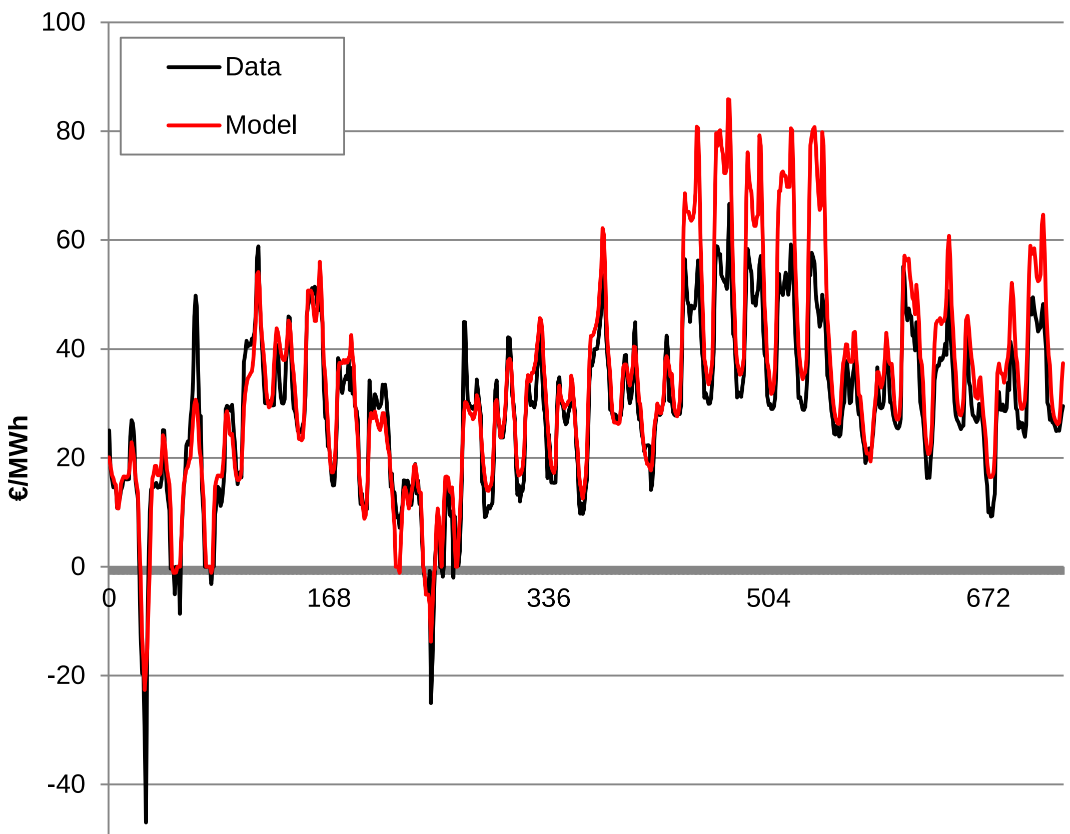
- Make new children with random crossover
- $\begin{pmatrix} -200 & -10 \\ -30 & 10 \\ -50 & 30 \end{pmatrix} + \begin{pmatrix} -300 & -30 \\ -70 & 30 \\ -20 & 60 \end{pmatrix} \rightarrow \begin{pmatrix} -200 & -10 \\ -30 & 10 \\ -20 & 60 \end{pmatrix}$

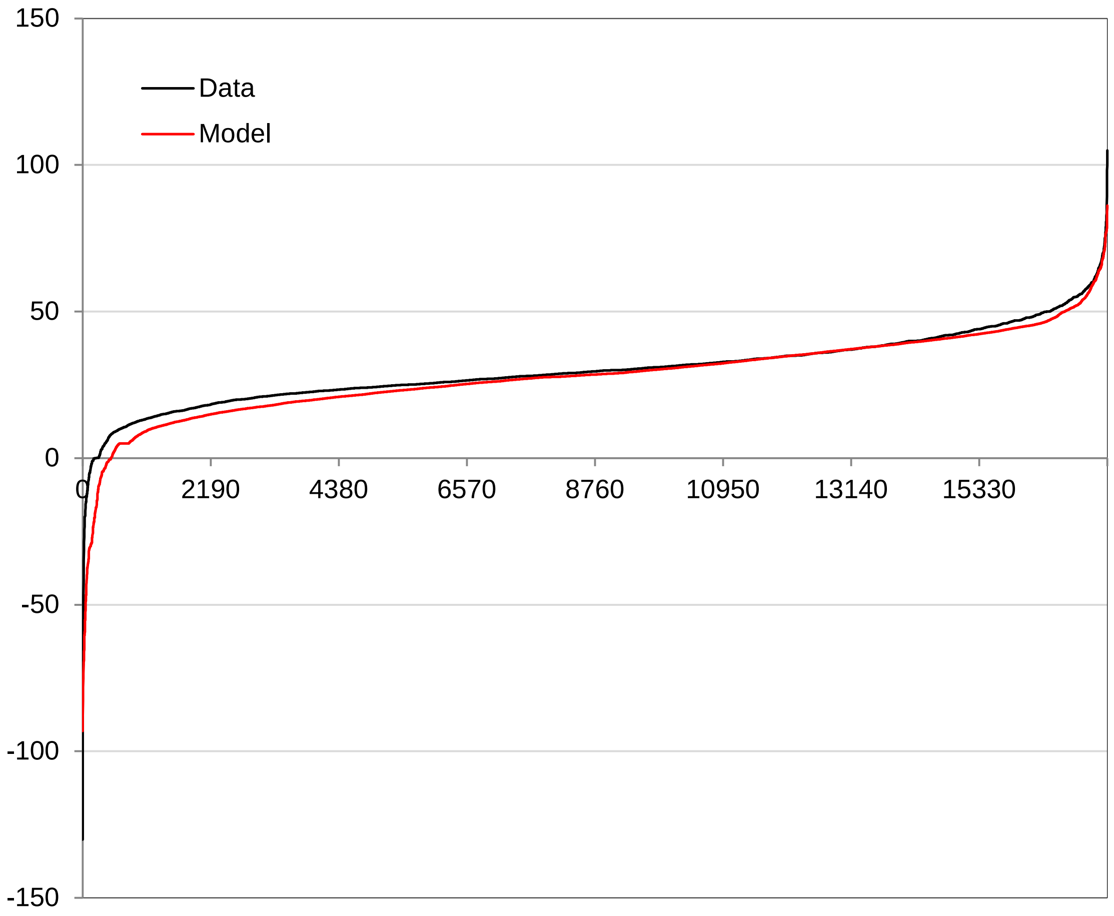
Validation - Descriptive statistics

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

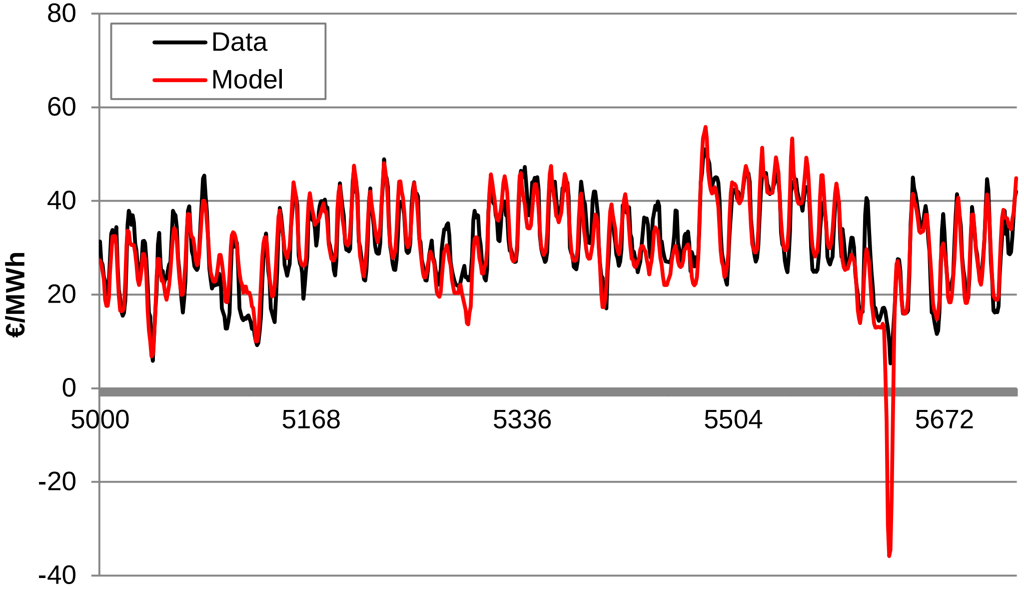
SHAPE PARAMETERS	DATA	MODEL
Mean [€/MWh]	30.30	28.73
Std.D. [€/MWh]	12.64	13.10
# Hours < 0€/MWh	223	446
Min [€/MWh]	-130.09	-57.93
Max [€/MWh]	104.96	85.90

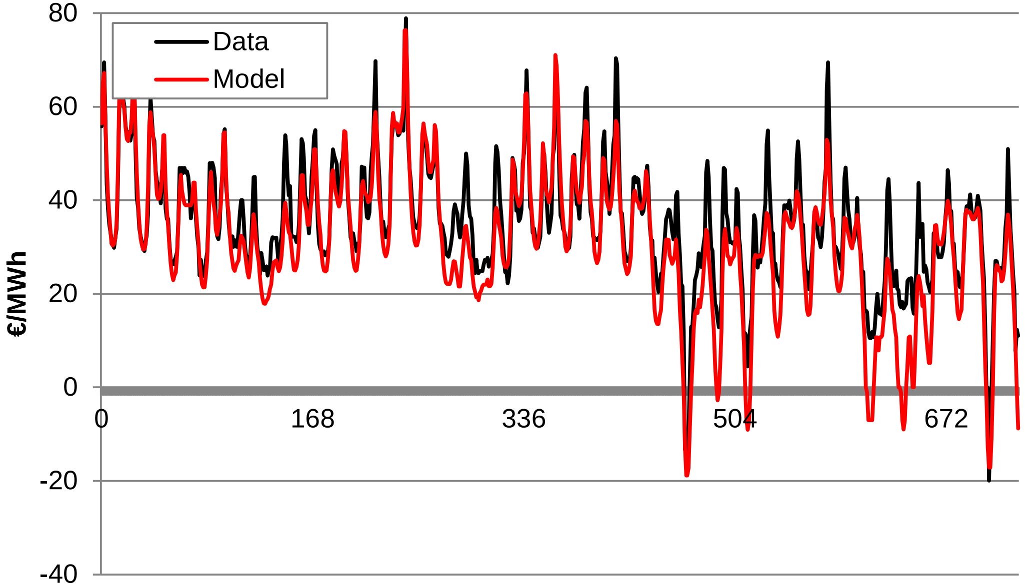
Electricity spot market price modeling
Results

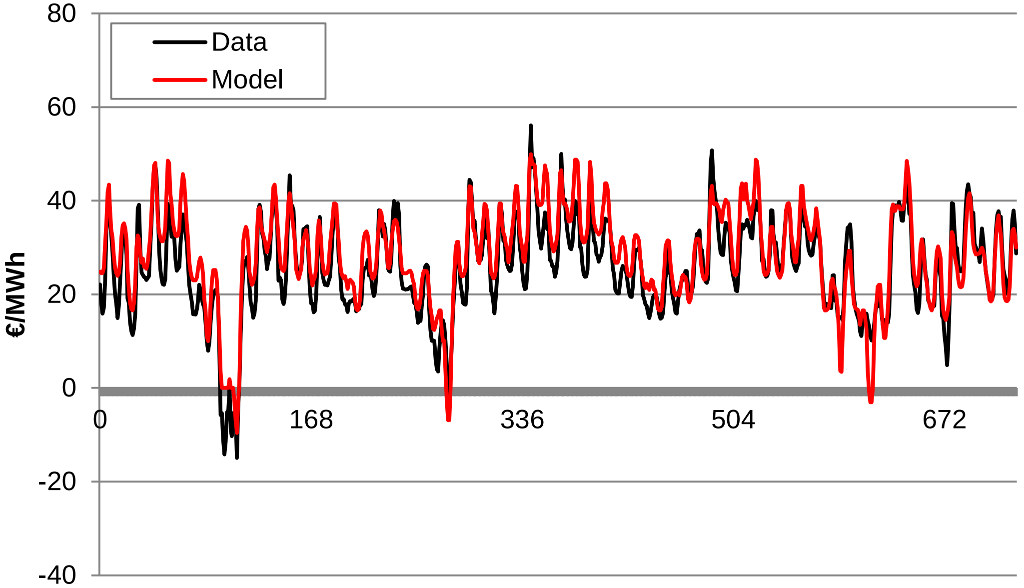


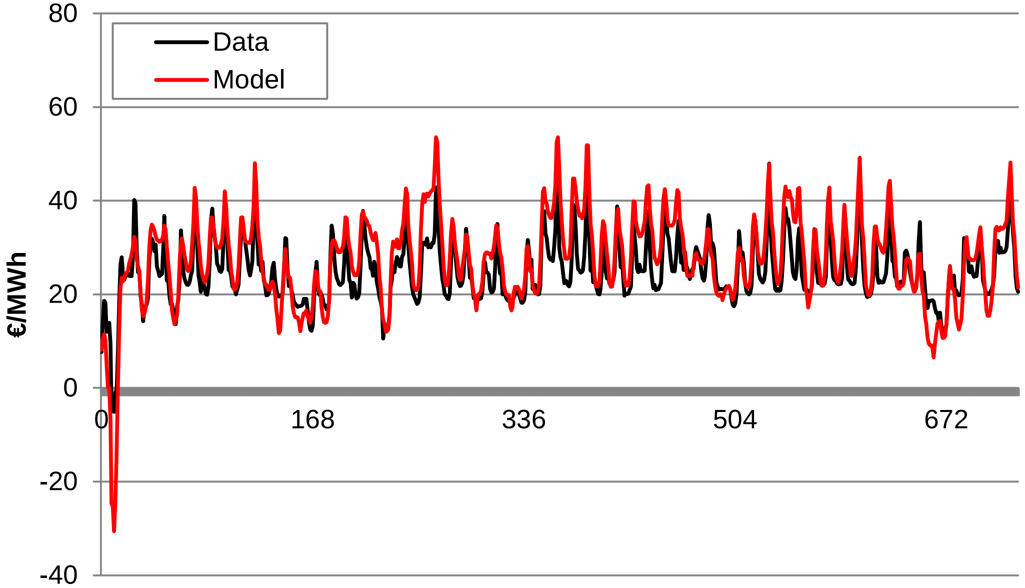


Further randomized examples





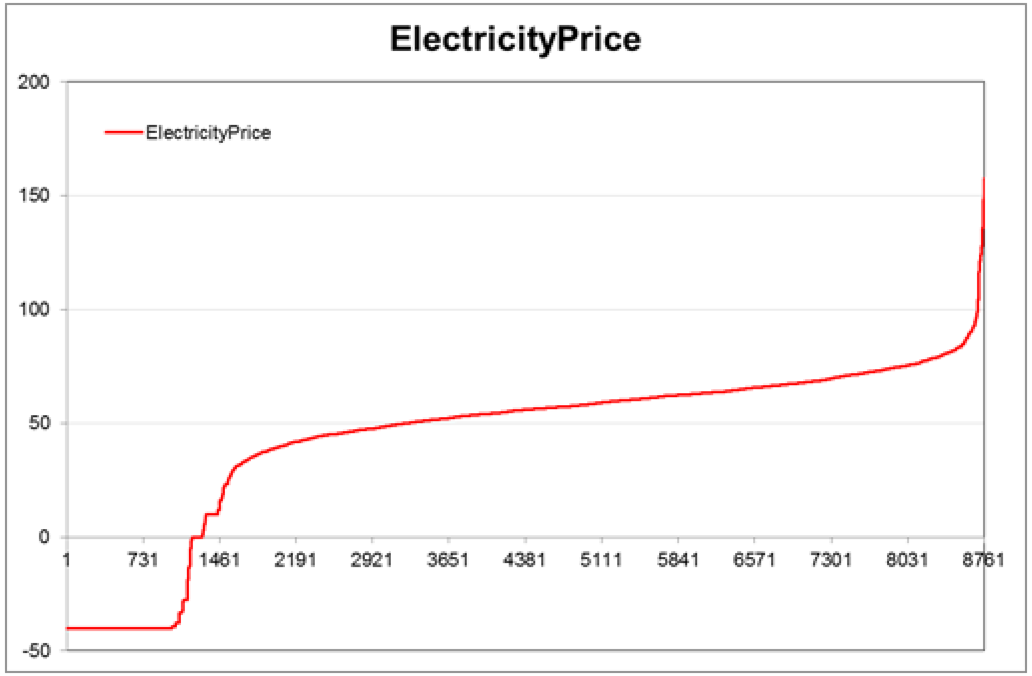




Discussion and outlook

- 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

energy
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