

Modelling the Electricity Market

European Summer School
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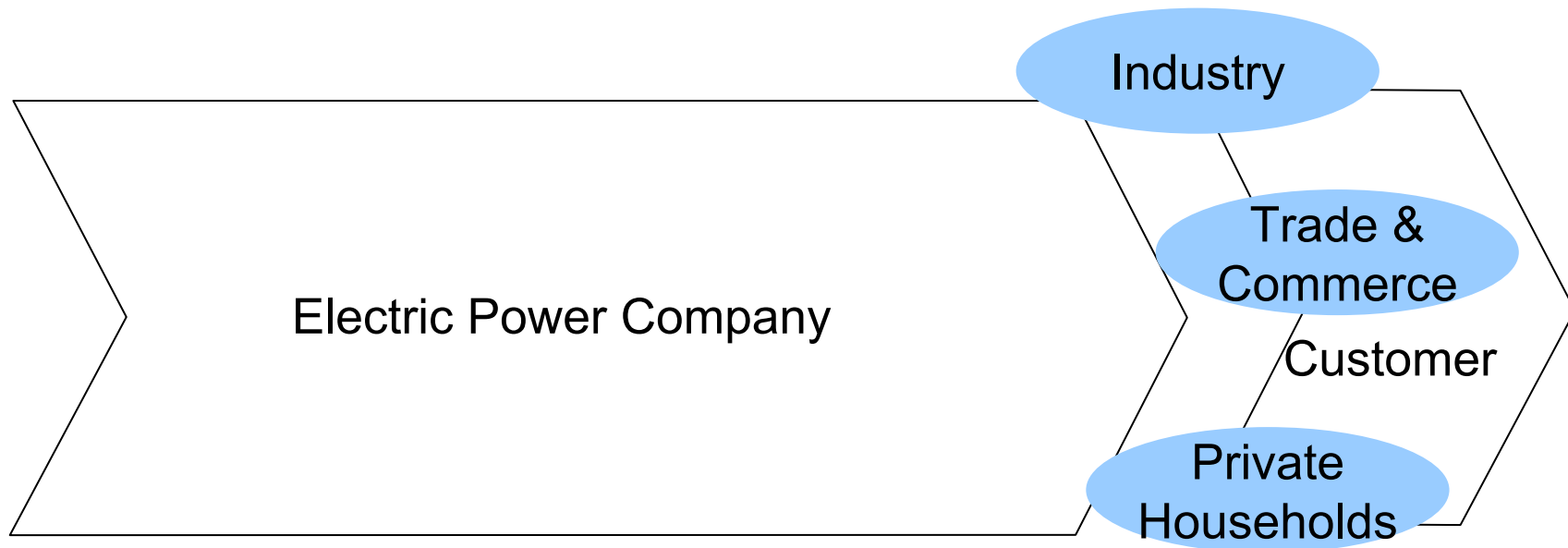
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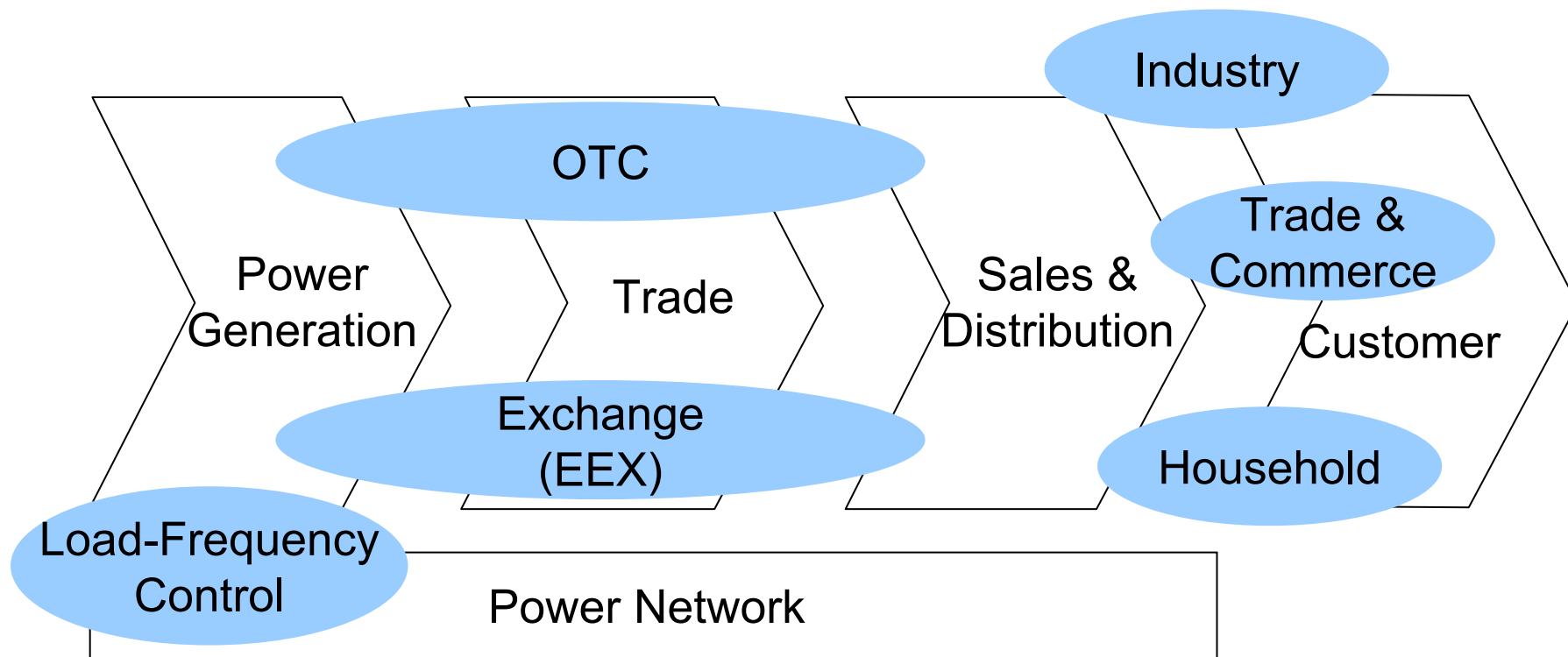
Agenda

- Overview over Electricity Markets
- Different Models of Pricing
- Approaches of Modelling Electricity Prices
- Results and Comparison of two different Approaches

Overview over Electricity Markets before Liberalisation and Unbundling



Overview over Electricity Markets since Liberalisation and Unbundling

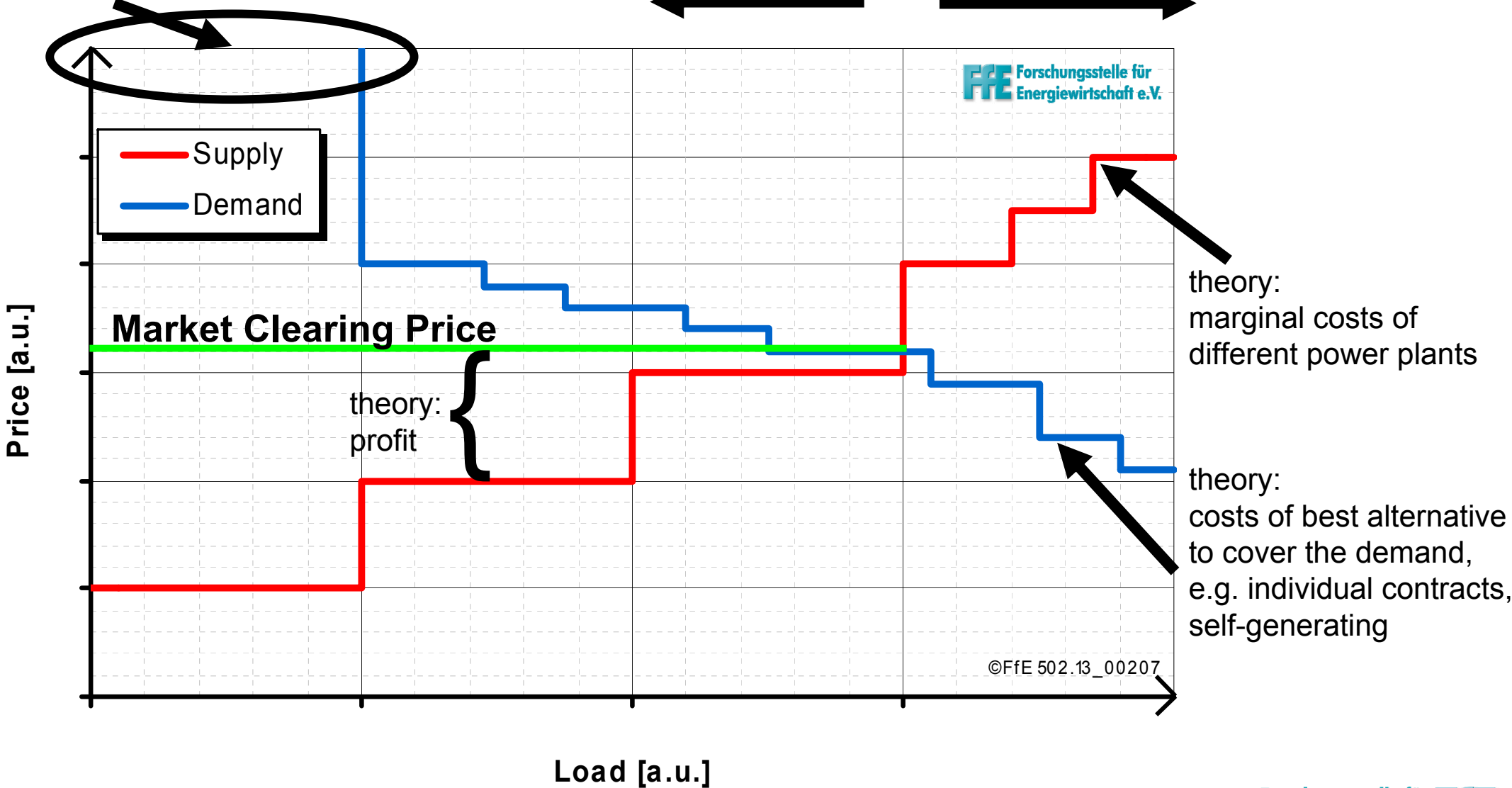


EEX:
Derivatives;
Day-ahead;
Intra-day

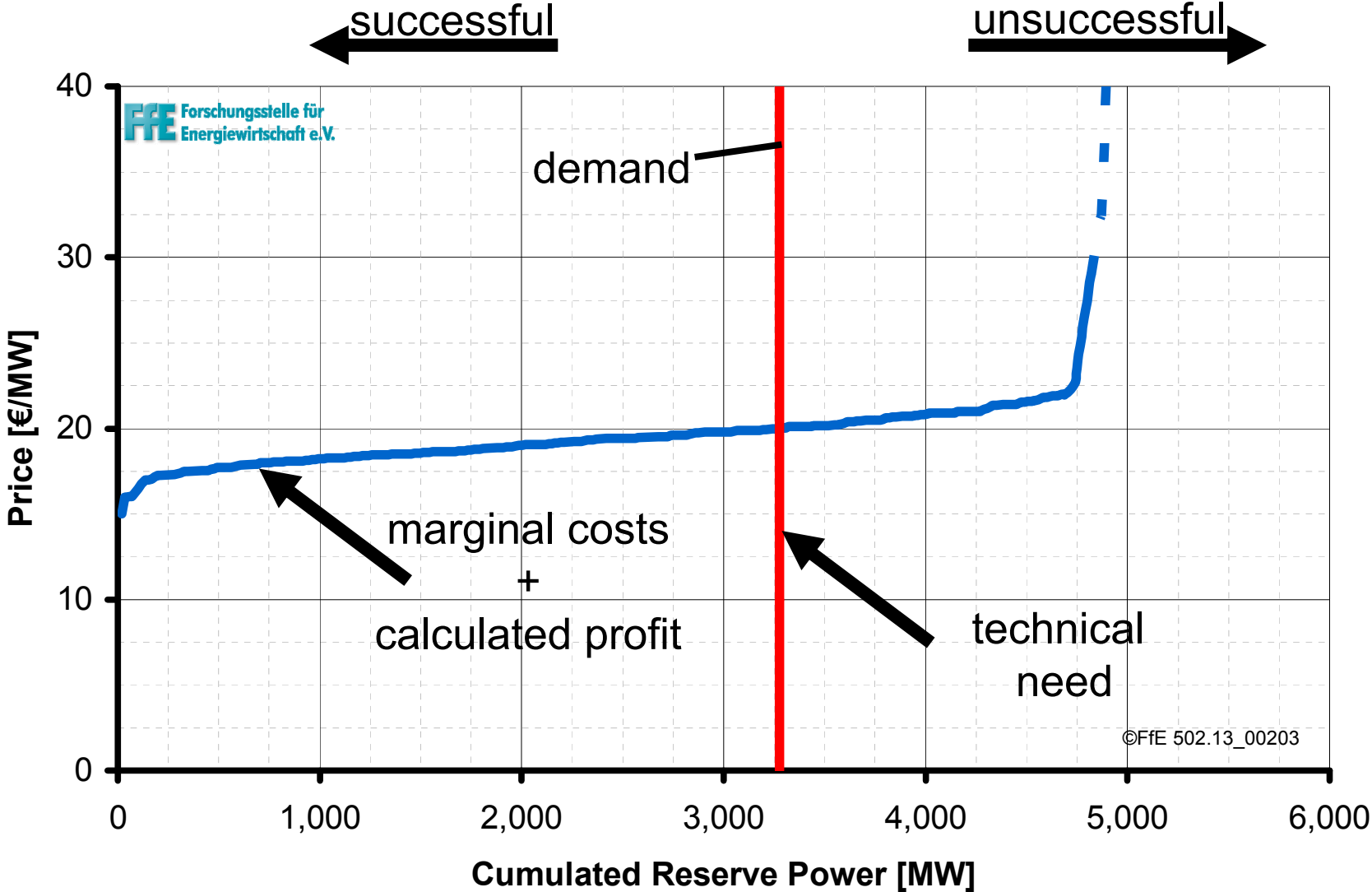
Pricing: European Energy Exchange (EEX)

without a price (no alternative),
demand must be covered

← successful → → unsuccessful ←



Pricing: Load Frequency Control Power

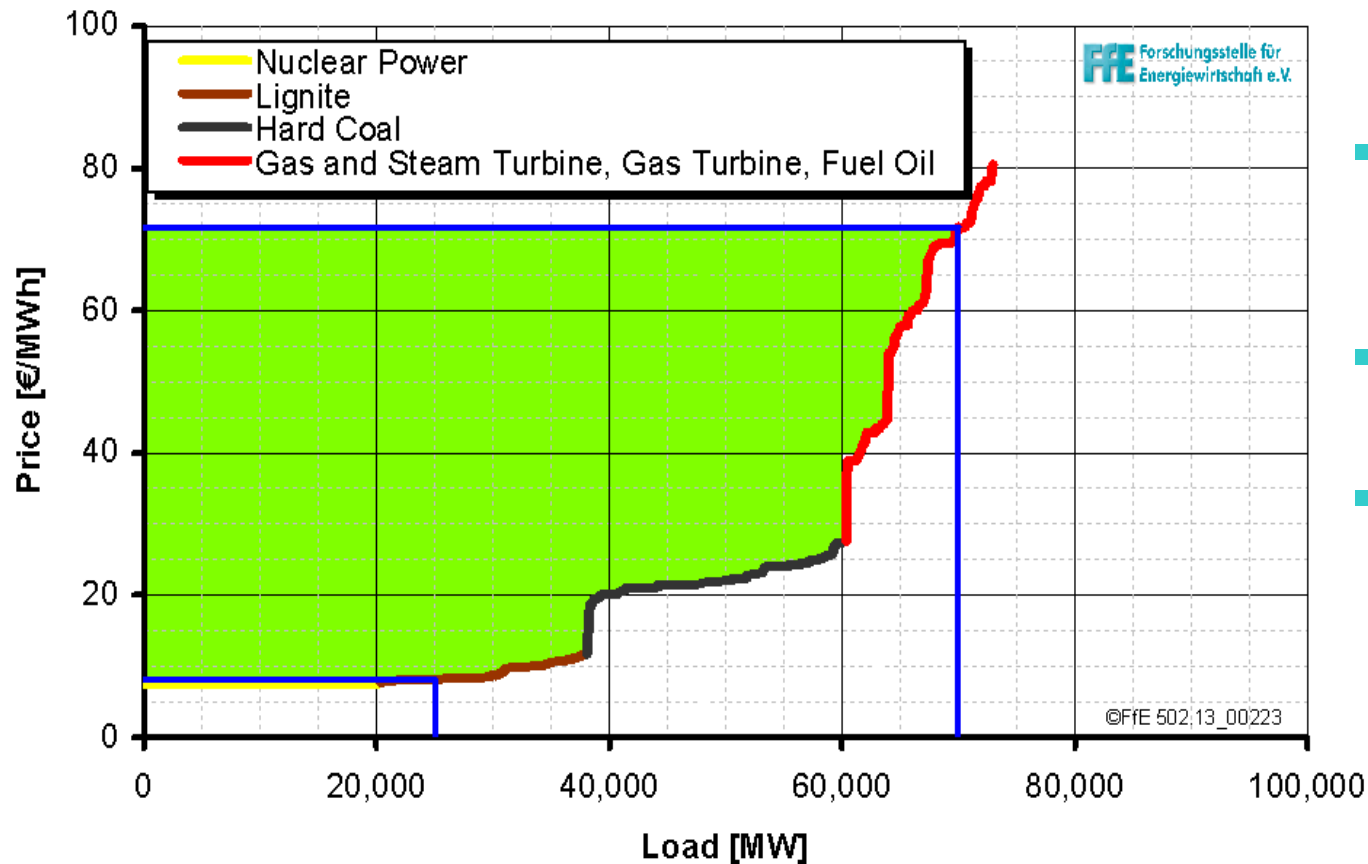


Approaches of Modelling Electricity Prices

Approach	Essential Factors
Fundamental	costs of generation of electricity
	technical conditions
	consumer load profile
by Neural Networks	historic data of correlations of input and output
	modelling correlation function with least error
Statistical	historic data of the energy market
Agent-based	individual optimisation
	agents improve their strategies based on experience

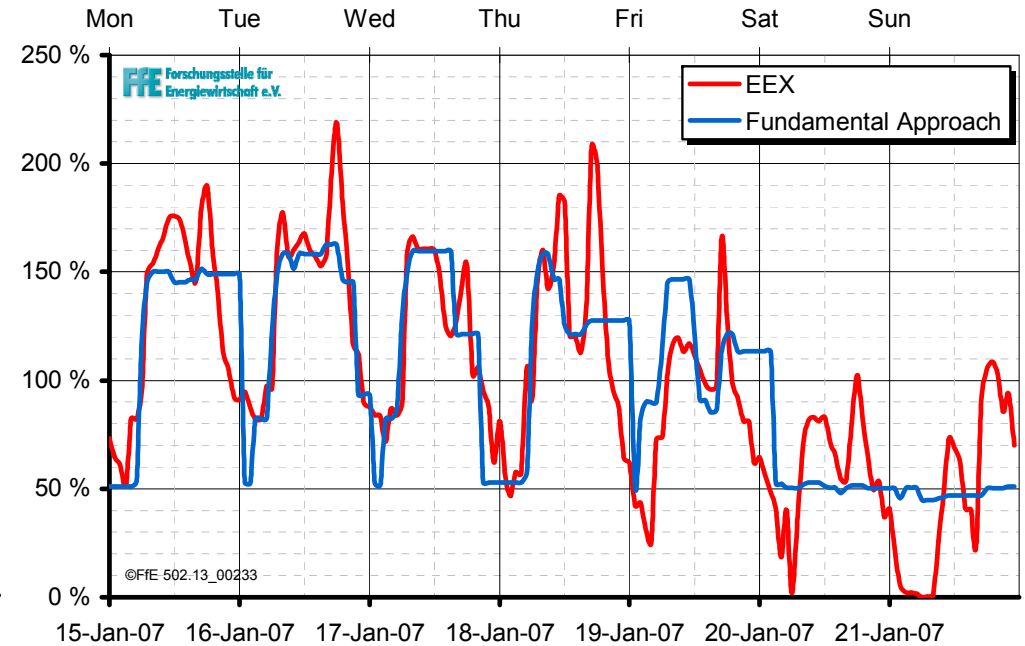
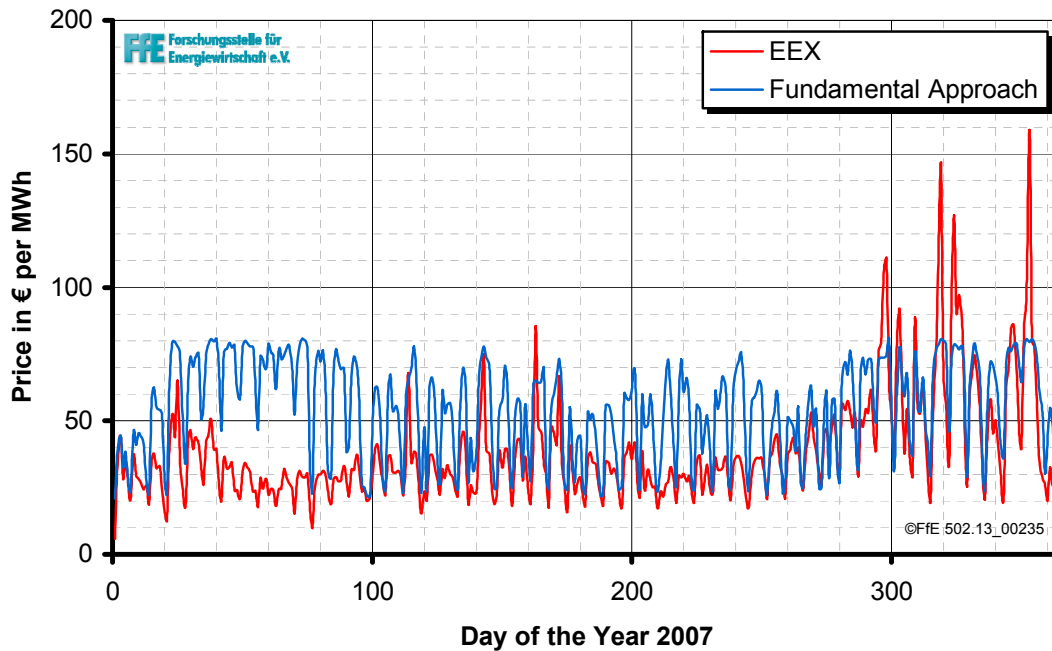
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Fundamental Approach - Methodology



- based on the load profile that has to be covered by conventional power plants
- the merit order is a result of the power plant data base
- For each hour there we get a certain price according to the load needed to be provided

Fundamental Approach - Results

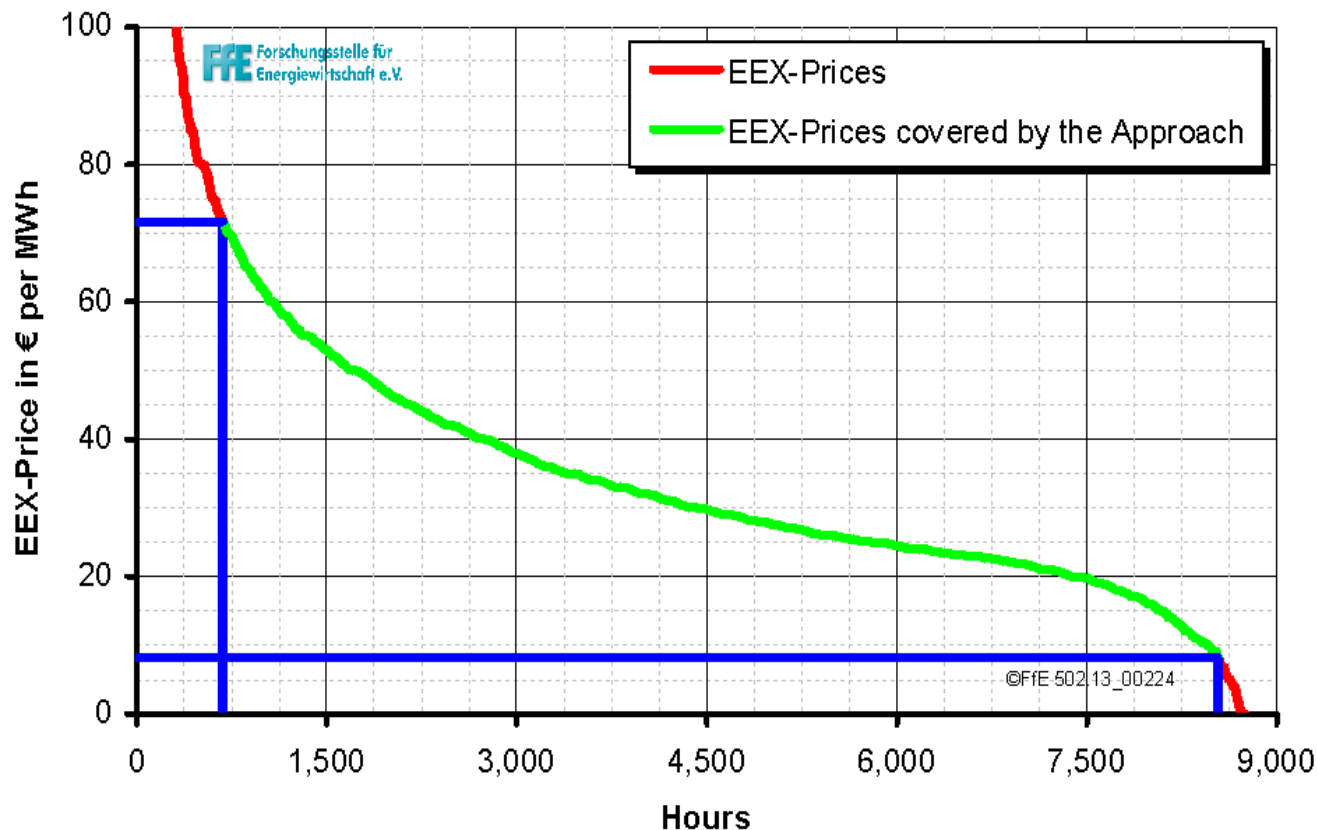


2007	EEX	Fundamental Approach
average price in € per MWh	37.98	54.76

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- The two graphs show the characteristic of a whole year and an exemplary week (normalised with the week mean price).
- The left graph shows that the fundamental approach mostly overestimates the real price for electricity, this is also proved by the data.
- The other graph illustrates that the characteristic on weekdays is achieved pretty well while the weekend price fluctuations can hardly be recognised.


Fundamental Approach - Weaknesses

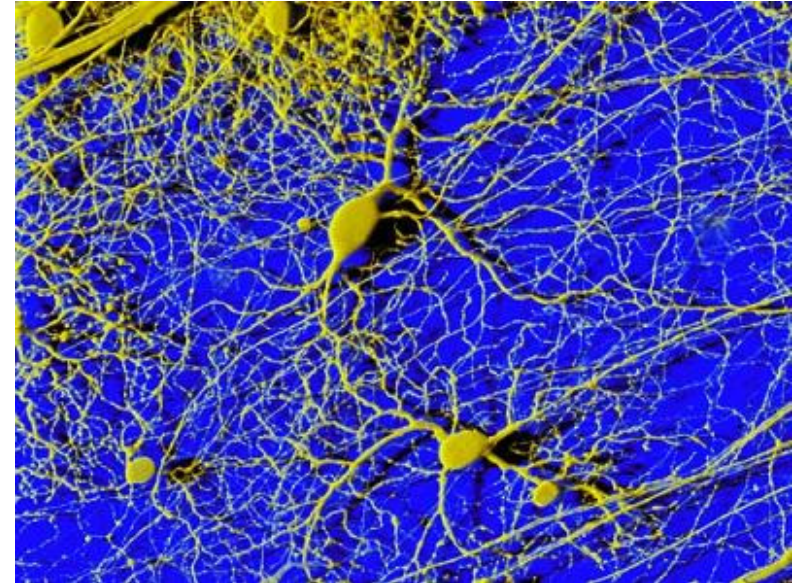


weaknesses of this approach:

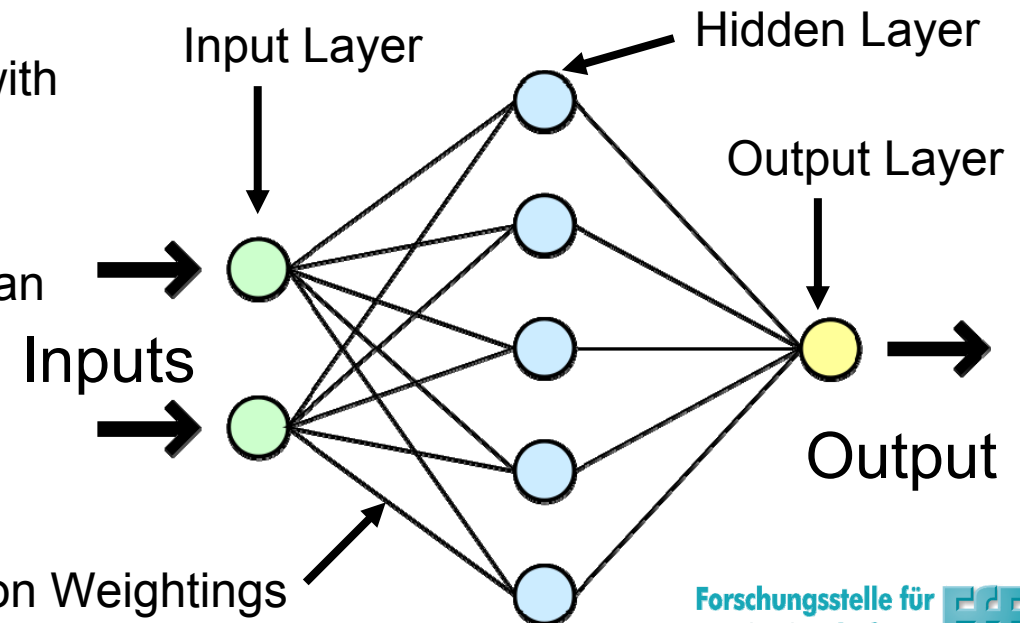
- In this calculation the model is too static, changing costs for fuel or CO₂-certificates are not regarded
- extreme weather conditions are not taken into account
- as the graph shows about 800 hours - which equals almost 10 % of the year's prices - cannot be reached by the model, especially high prices do not occur

Design of Synthetic Neural Networks

- background is the composition of the human brain (real neural network) 
- neurons are stimulated by input signals; depending on processing functions in neurons output signals will result
- by repeating correlations of input and output signals (training) the connections to the neurons will increase (learning)
- synthetic neural networks consist of layers with synthetic neurons
- by entering input parameters and defining associated output parameters the network can be trained \Rightarrow backpropagation algorithm (change of the connection weightings)



Source: Westdeutscher Rundfunk, Köln, 2009



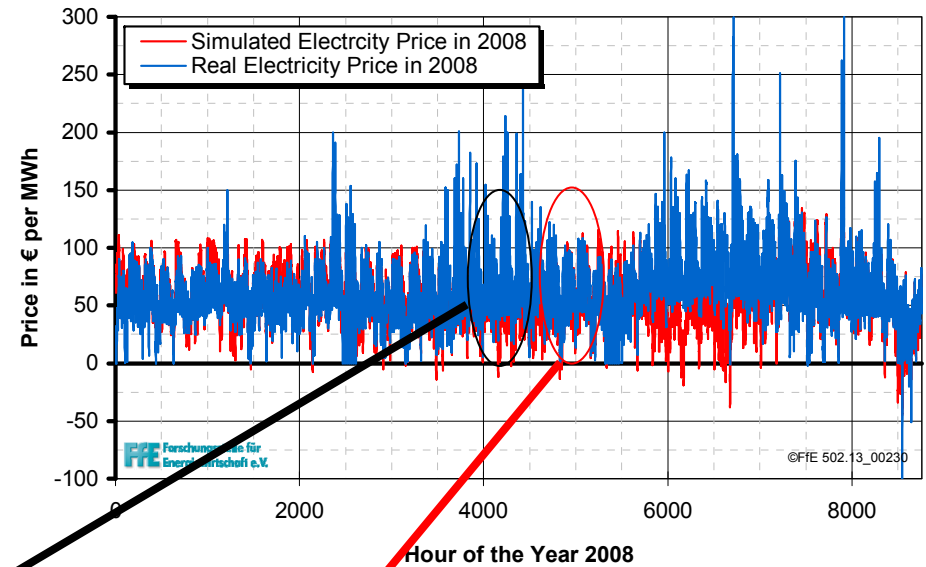
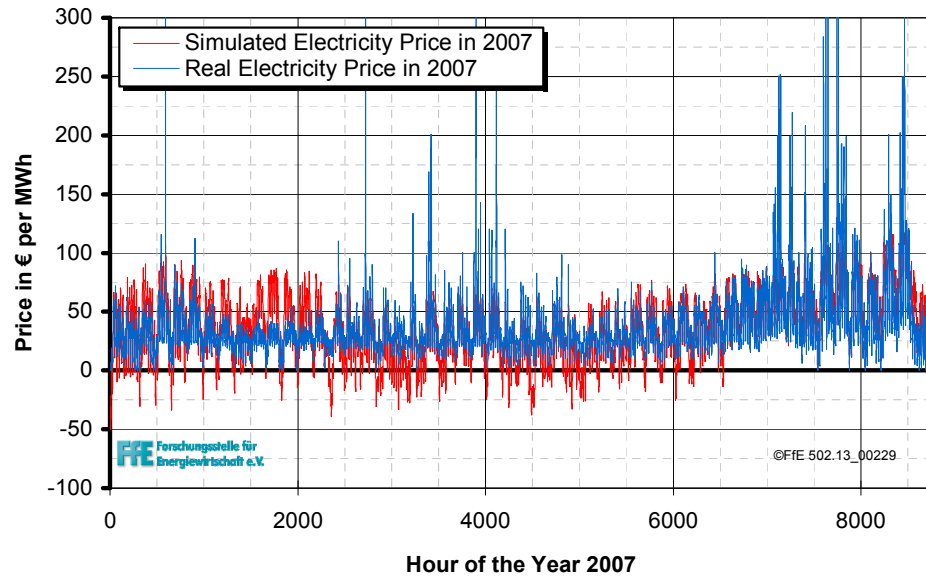
Implementation of a Synthetic Neural Network for Modelling Electricity Prices

- training network with influencing factors on the electricity price in 2007

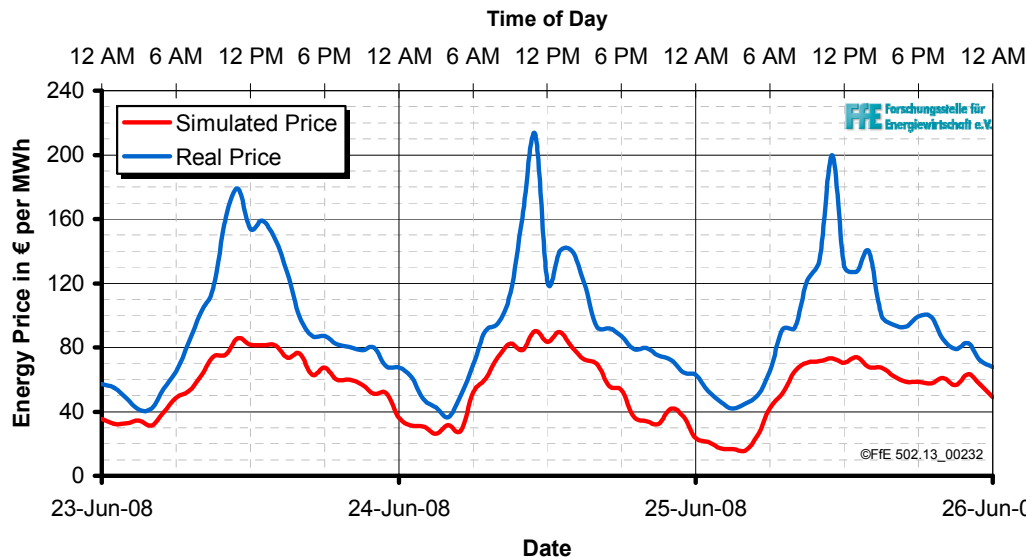
⇒ input parameters in resolution of one hour

- consumer load
 - wind load
 - coal price
 - gas price
 - oil price
 - price of CO₂ emission certificates
 - temperature
 - atmospheric fallout
- input parameters with a resolution lower than one hour are approximated (e. g. coal with quarterly prices)
 - modelling electricity prices for 2007 and 2008 by entering associated input parameters to the 2007-trained network

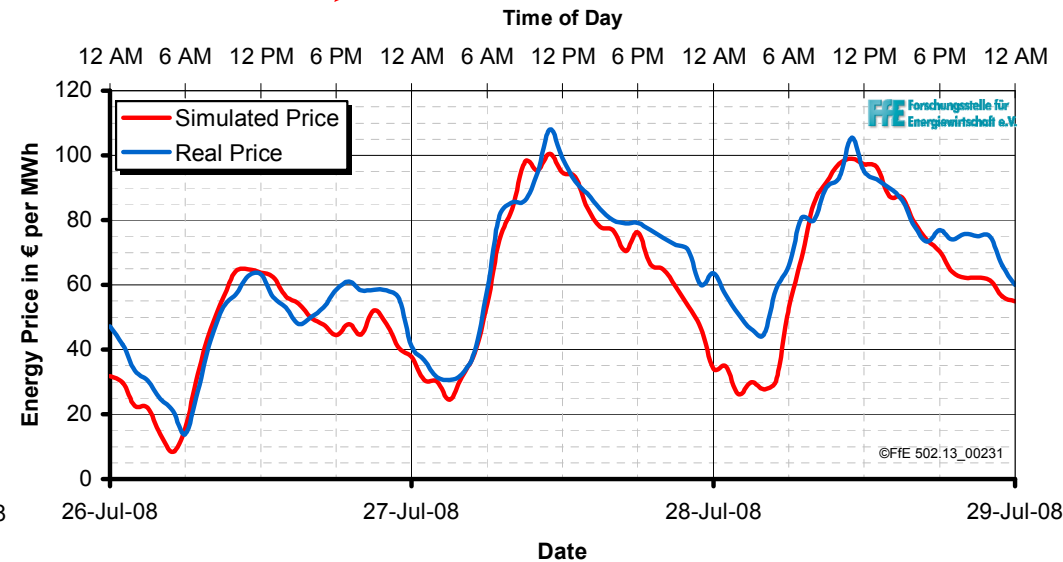
Results of Modelling Electricity Prices for 2007 and 2008



comparison over a time period of 3 days:

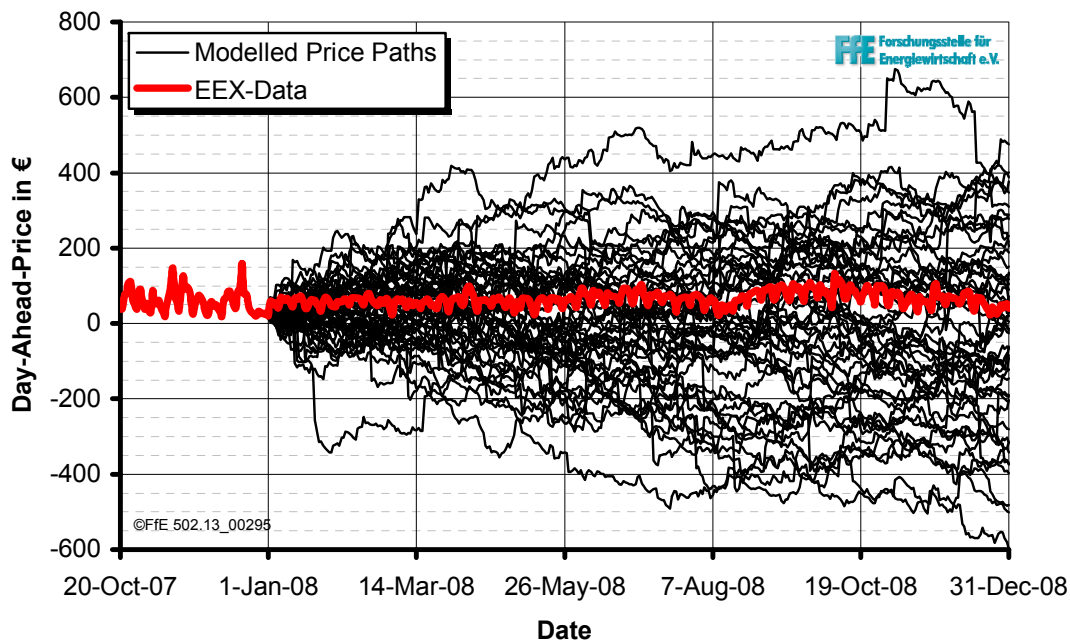
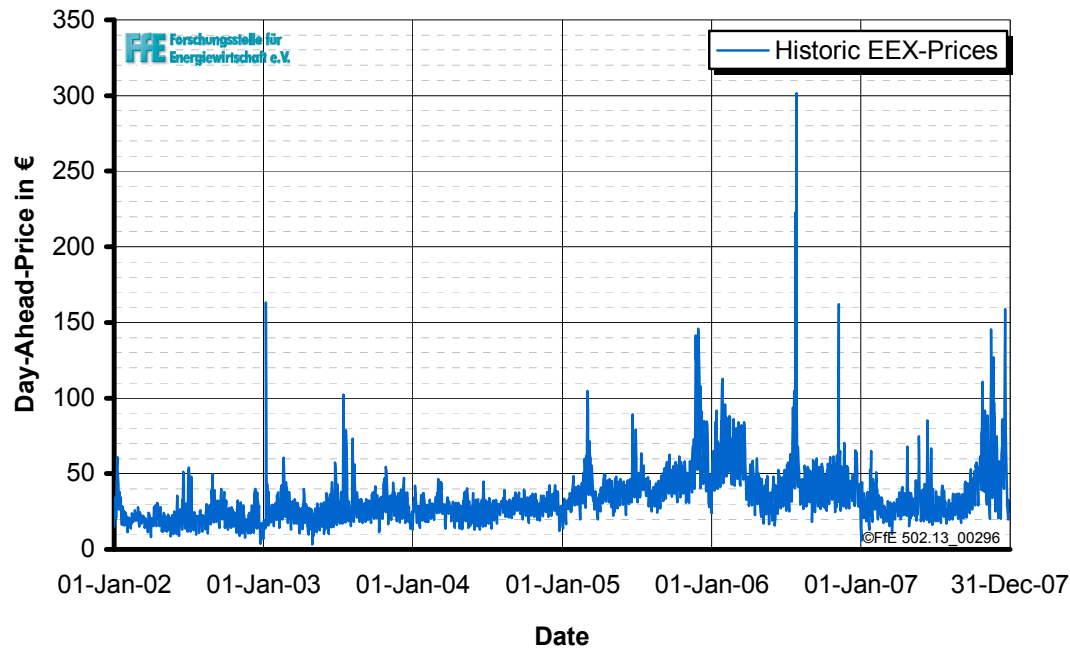


some days match bad



some days match well

Statistical Approach



- The data base for the statistical approach are the years 2002 - 2007. The changes of the daily mean prices are evaluated and are the basis of the model. The model does not reproduce the course of 2008's prices at all. Instead the price reach extreme values and are not realistic. Therefore this model is not very useful.

Agent-based computational Economics (ACE)

supply side

agent 1

agent 2

agent ..

apply their
strategies

market 1

market 2

market ..

demand side

time variable fixed
demand **or**
consumer agents

next time step

agents "learn" and
adopt their strategies

pricing according to
supply and demand

profit
payout

agents offer products
on different markets

Agent-based computational Economics (ACE)

- application to electricity markets:
 - agents can be: utilities, renewable energy producers, governments/regulators, consumers, traders, grid operators, etc.
 - according to the research question and abstraction level the agents for the models are chosen
 - the markets can be: spot market, balancing market, CO₂ market
- advantages:
 - realistic behaviour of individual agents can be simulated
 - the effects of a wide range of influences on the pricing can be tested
- disadvantages:
 - high complexity of the model, difficult to comprehend and implement
 - parameters can be set in order to achieve desired results

Summary and Conclusion

- There are different markets for electricity with individual pricing
- In Germany the most important market is the Spot market at the European Energy Exchange. These prices are reference prices for other markets
- There are different approaches to model electricity markets
- The presented approaches have difficulties to reproduce the historic extreme prices
- Predicting future electricity prices – not only mean prices but also the temporally price structure - is a challenge

Thank you for the attention!