Modelling Flexible Market Participants in Distribution Grids by Coupling an Agent Based Simulation with a Fundamental Model

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- Motivation
- Model framework
- Coupling an Agent-Based Simulation with a Fundamental Model
- Exemplary Results

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Increasing vRES Extension induces Flexibility Demand
Which flexibilities do we need – and in which combination?

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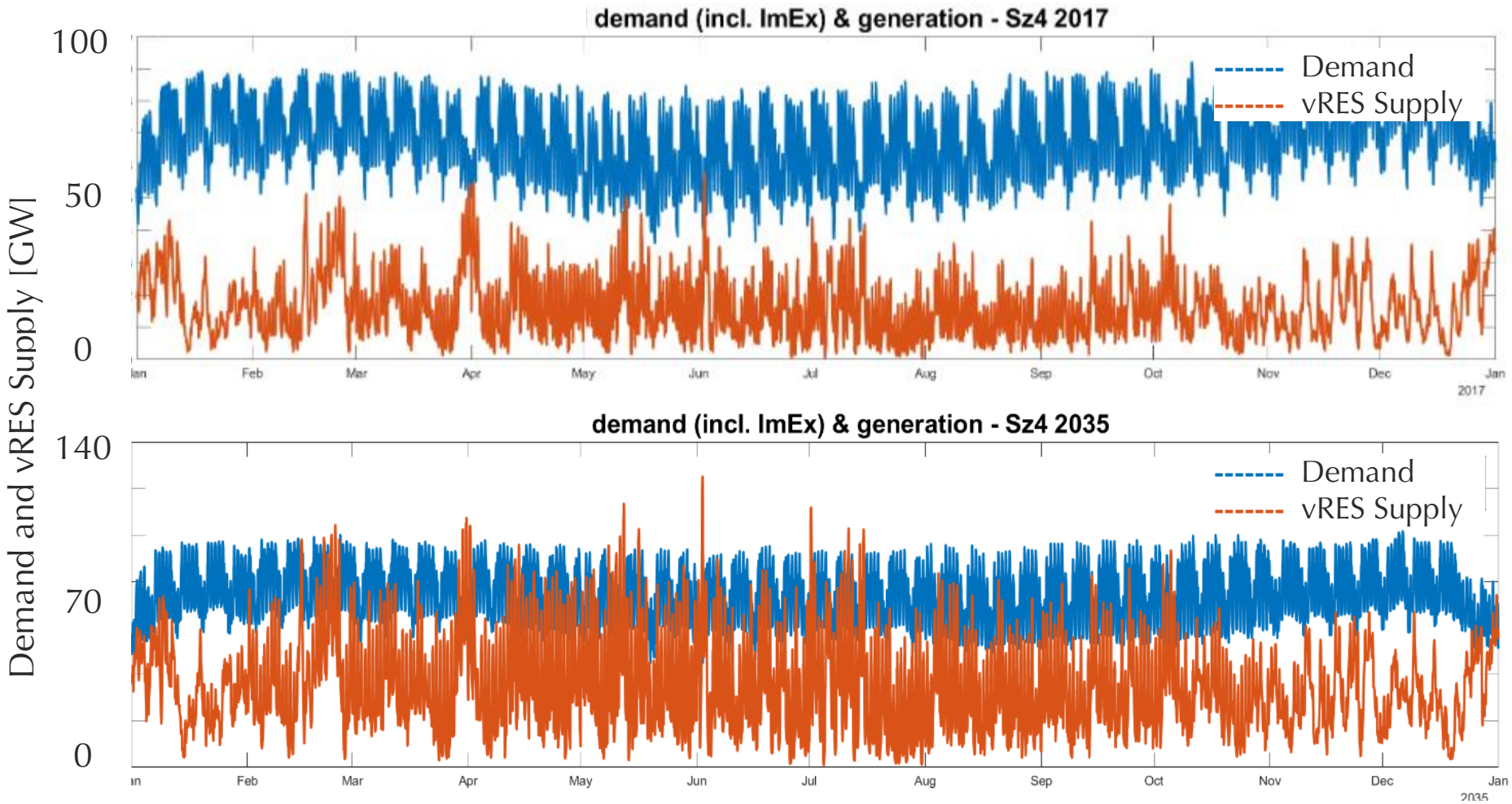
Motivation



Decarbonisation not possible without vRES extension (given parallel nuclear phase out)

Weather dependent generation leads to different load flow situations within transmission **and distribution** grid

Flexibilization Potential mainly in Distribution Grid

Flexibilization through…

- improved simulaneity of demand and supply
- temporal decoupling of demand and supply

by ...

- flexibilization of thermal plants
- network extensions
- demand side management
- storage extension
- sector coupling technolgies, e.g.
  - e-mobility (dumb/ smart charging/ V2G)
  - mini- & micro-CHPs
  - Heatpumps
  - …

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transmission system

distribution system

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transmission system

distribution system

Multiple stakeholders involved!

Many Questionmarks…

transmission system:
- profitability?
- extent? public acceptance?

distribution system:
- optimal combination?
- profitability?
- economic distributional effects?
- investment incentives?
- affordable and accepted?

Some assumptions on what's required to answer the questionmarks

1. Distribution grids will contribute massively to supply of flexibility options
   - →Coordination of multiple entities required
   - →ICT, automatization and a smart coordination required
   - →Global market integration with temporary local markets to deal with network congestions

2. Distribution network extension planning must consider multiple impacts
   - →Utilization of flexibility to limit network extensions to a cost efficient level
   - →Grid operation and extension planning become two sides of the same coin

3. Future technology mix is driven by (private and business) investment decisions
   - →Regulatory impact must be considered in detail
   - →Interactions between markets and distriution grid participants must be considerd

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Integrated Distribution Grid Analysis

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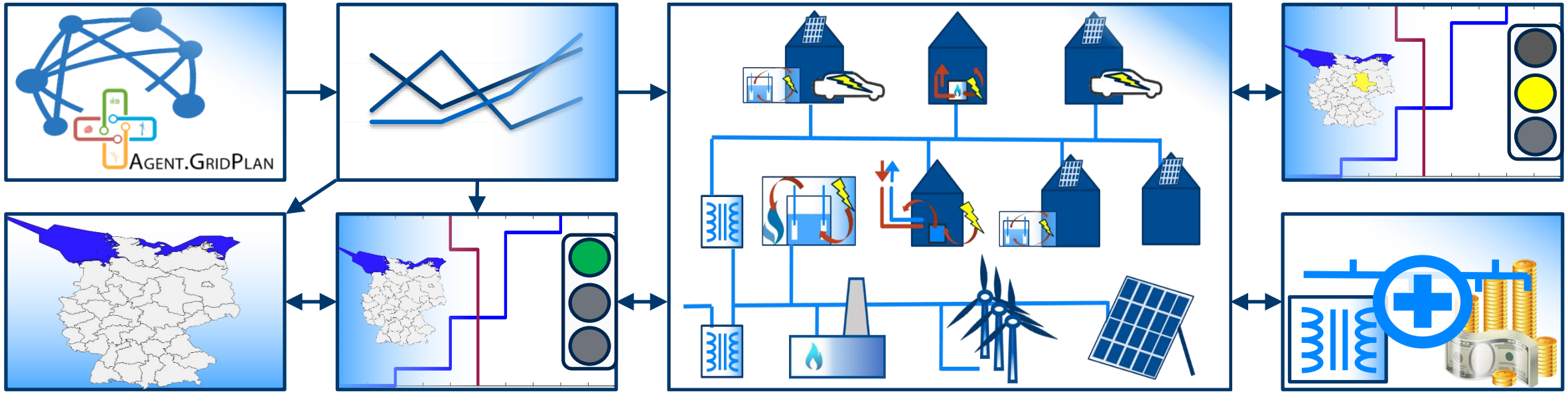
Model framework

Design of national energy scenarios within the international context

Consistent scenarios for both the considered grid and the rest of Germany

Agent-based distribution grid simulation with flexible, electricity based market participants

Temporary local market in case of distribution grid congestions



Approximized flexible agents in other areas

German electricity market influenced by all areas and conventional plants

DSO can conduct operational measures

Network extension and profitability assessment

House of Energy Markets & Finance

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Coupling an Agent-Based Simulation with a Fundamental Model

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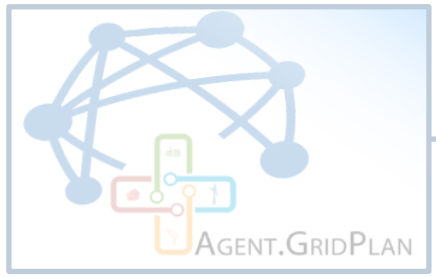

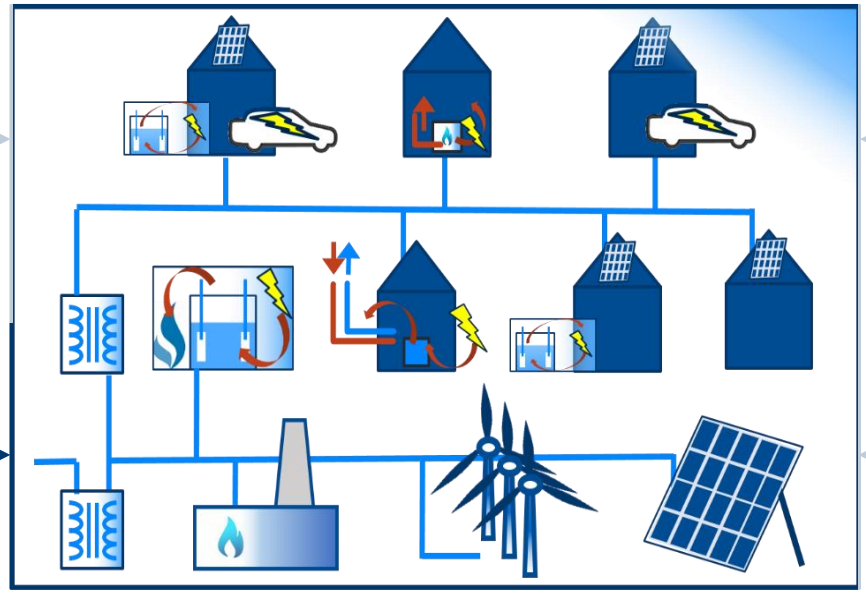

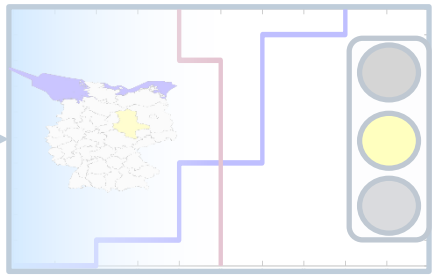

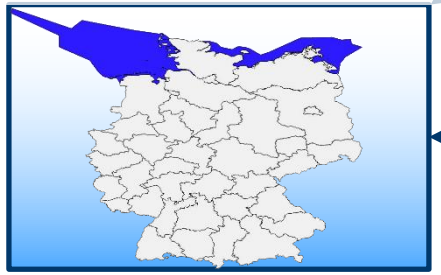

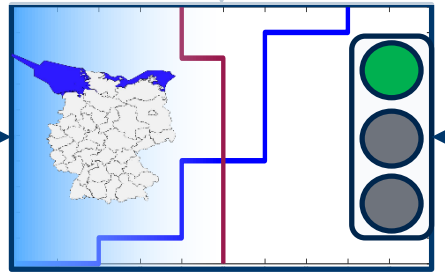

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Consecutive Model Interaction Process

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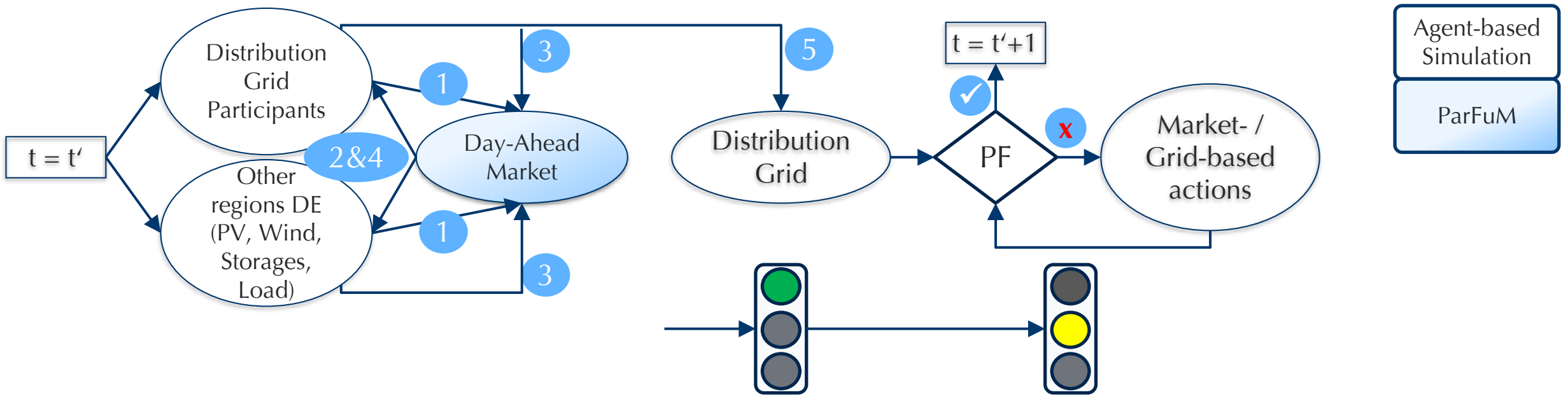

1
load and generation forecasts without any market information

2
day-ahead price forecast is calculated and sent
- conv. power plants
- availabilities
- CHP-MustRun
- …

3
(portfolio-) optimization against price forecast
- consideration of regulatory induced price components
- bids 2 market

4
day-ahead price is calculated and sendtof market values (relevant for German RES support scheme)

Parsimonious Fundamental Model – ParFuM*

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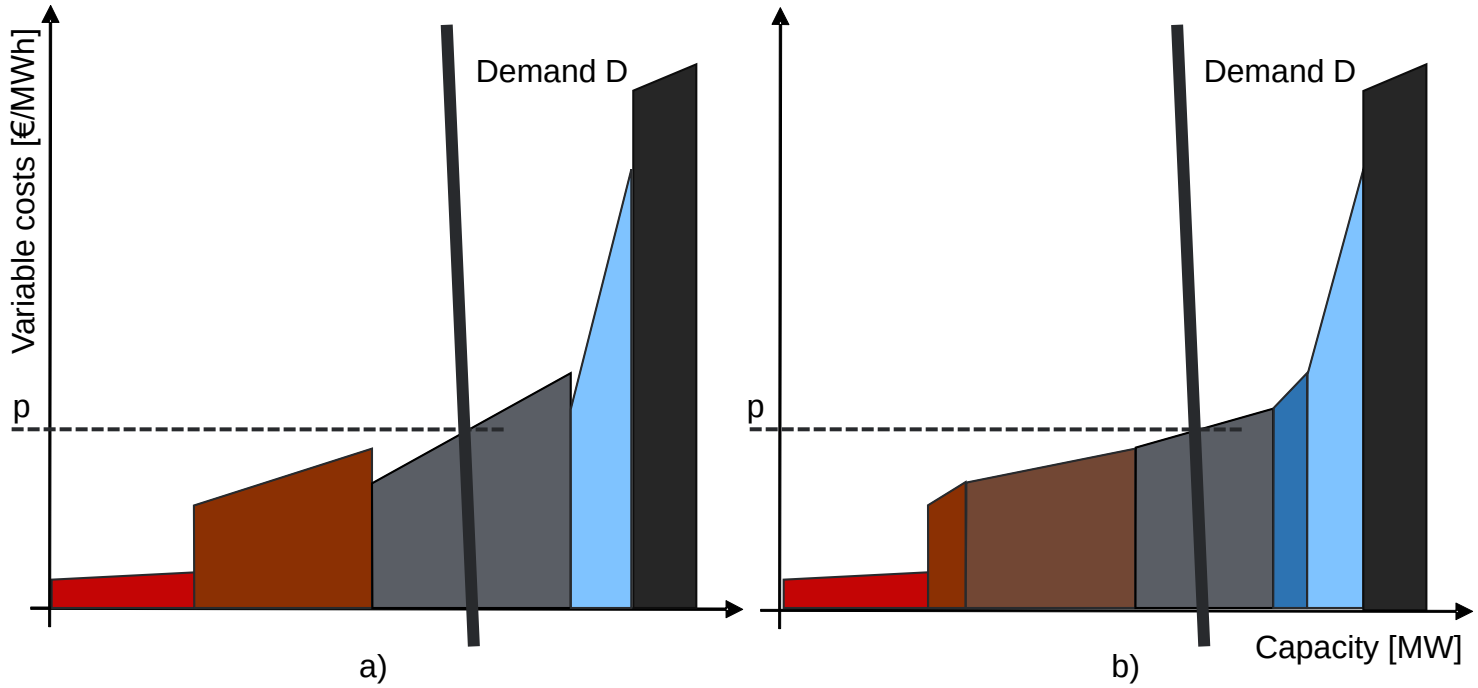

ParFuM

Basic idea: piecewise linear supply curve

a) supply stack with heterogenous costs within the technology classes

b) rearranged supply stack with mixed cost intervals.

Demand = Load (L) – CHP_mustrun – RES_infeed – TradeBalance (TB)

* P. Beran; C. Pape; C. Weber (2019): Modelling German electricity wholesale spot prices with a parsimonious fundamental model – Validation & application. In: Utilities Policy 58, S. 27–39. DOI: 10.1016/j.jup.2019.01.008

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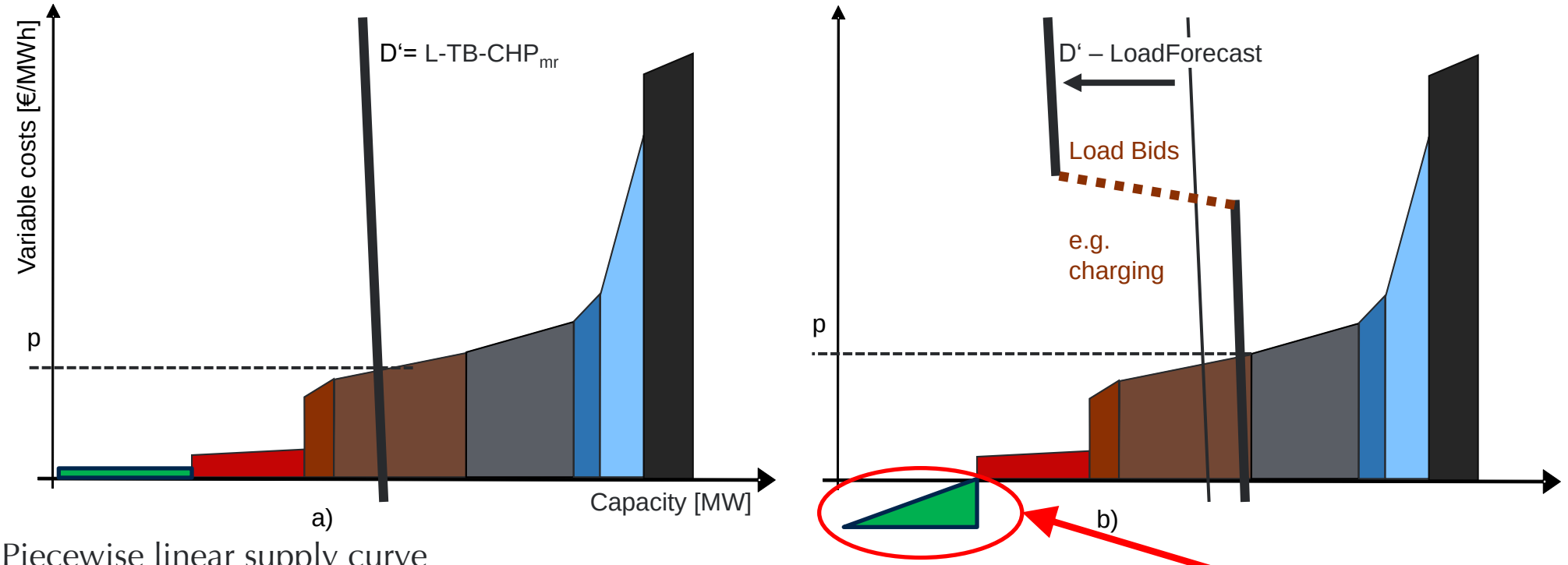

Piecewise linear supply curve

a) forecast process: generation forecasts are considered

b) price process: load forecast reduces load, generation and load bids are integrated

Demand = Load (L) – CHP_mustrun - TradeBalance (TB)

Negative through regulatory impact (RES suppport scheme)

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Price Levels in 2017 vs. historical “reference“ price

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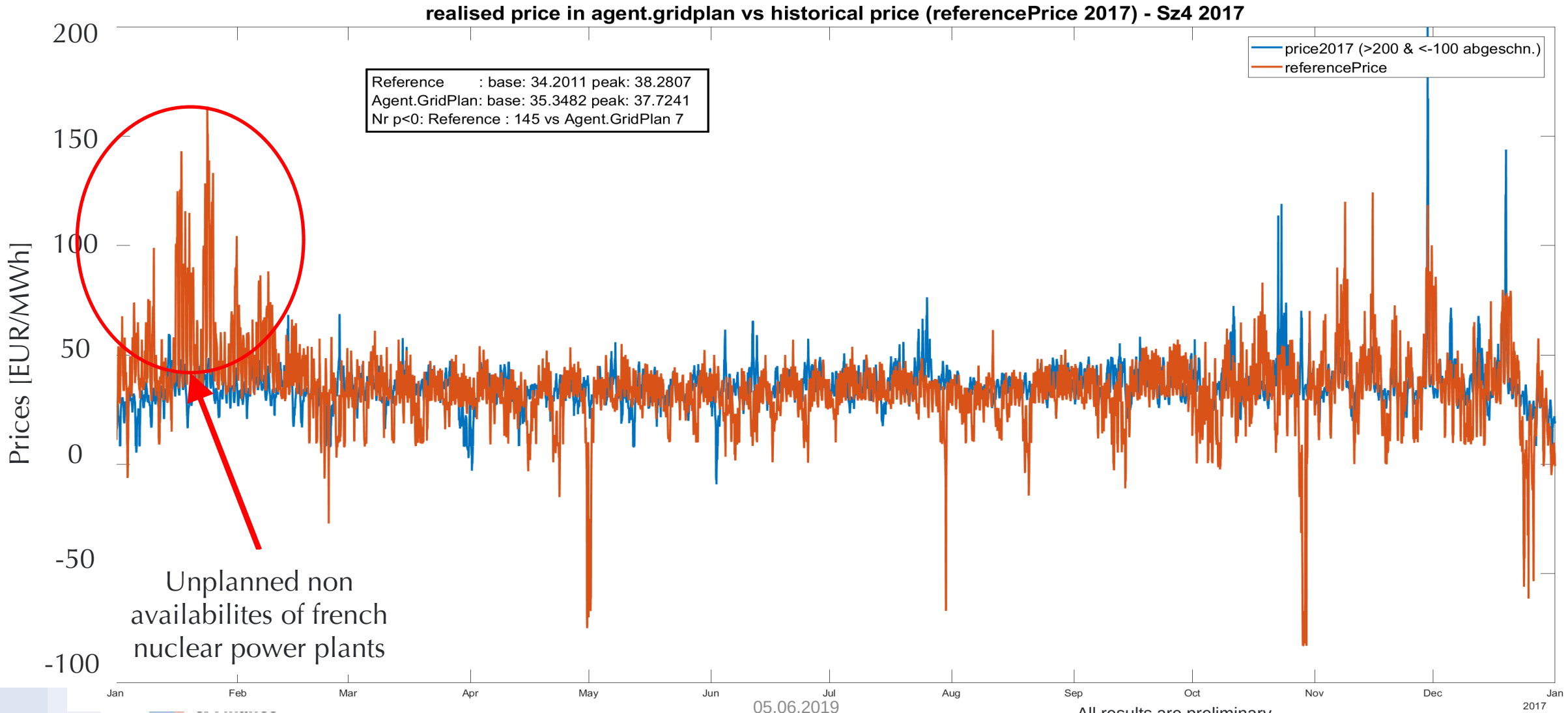
Exemplary Results



All results are preliminary

Price Levels in 2035 vs. historical “reference“ price

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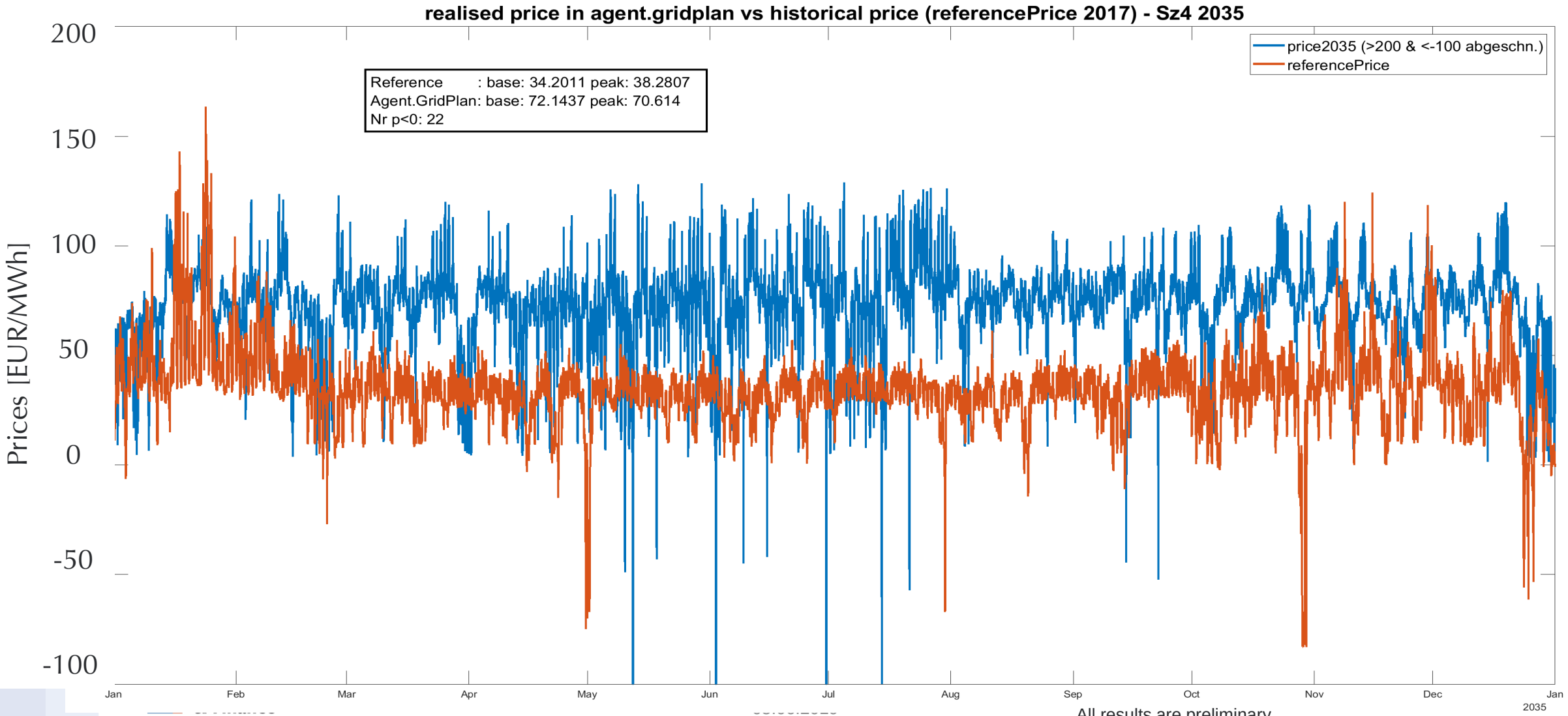
Exemplary Results



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Operator- Behaviour and regulatory impact

Exemplary Results

Operator with PV and load

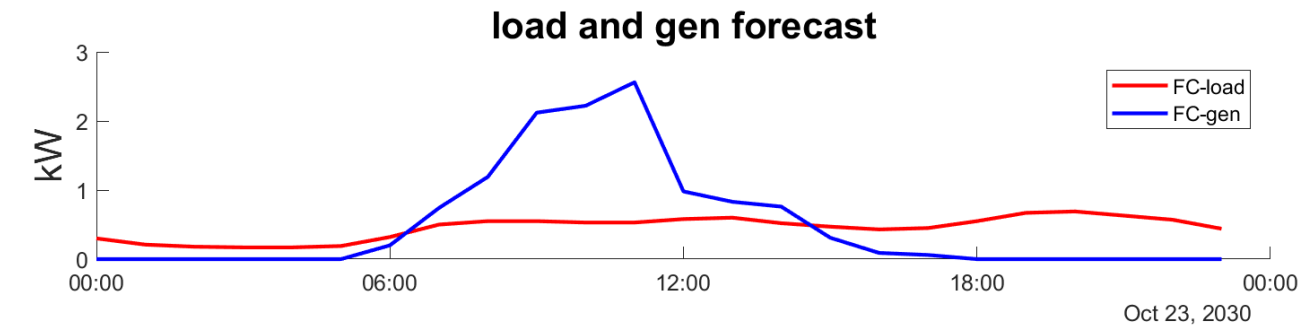
- Consumer electricity price (p^{con}) is roughly 4 times the priceforecast (regulatory price components!)
- If p^{con} > fixed-feed-in-tarif (FFIT) from PV

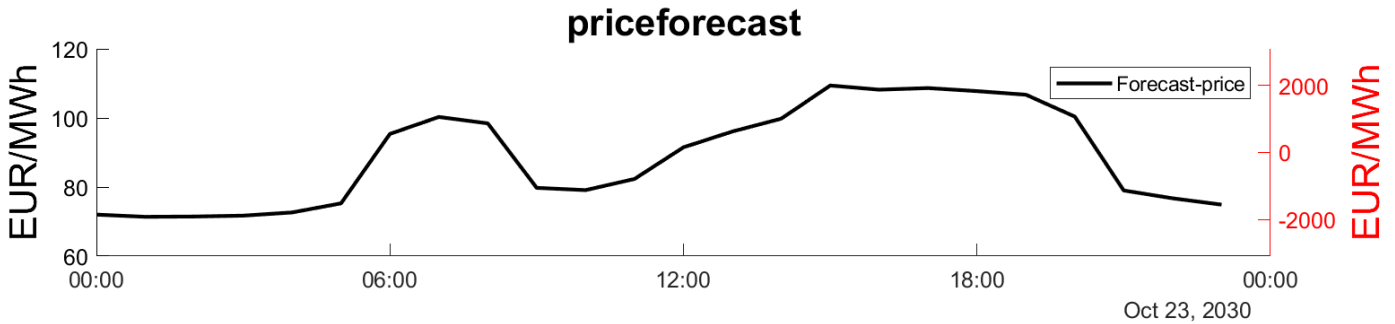
→ Maximize self-consumption

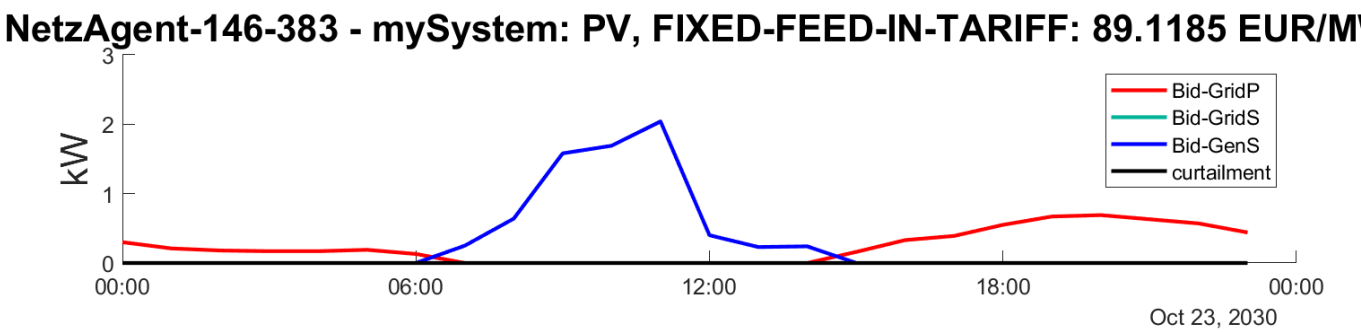
→ Here: „new“ PV with low FFIT

→ Usually: self-consumption is best

- For „older“ PVs one could observe that PV energy is sold anyway







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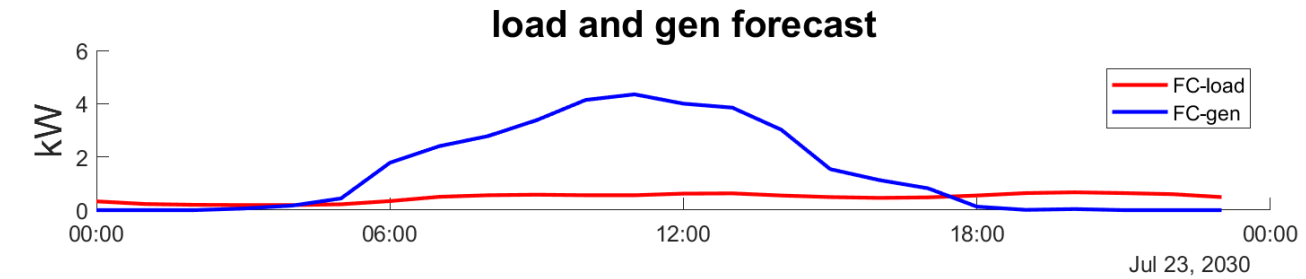
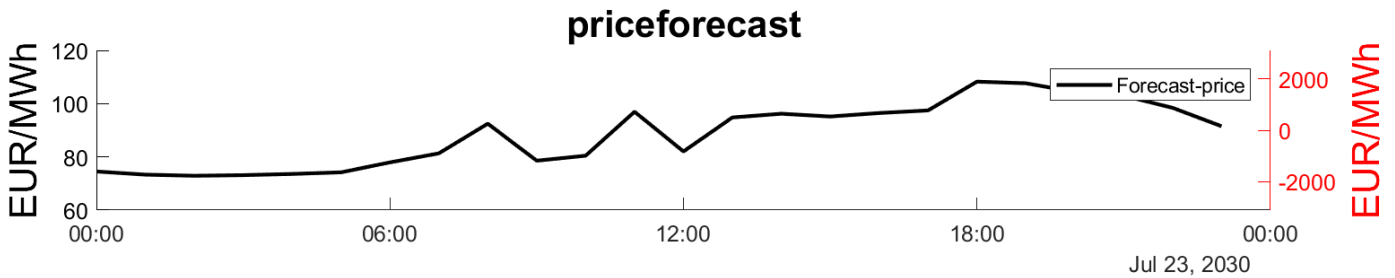
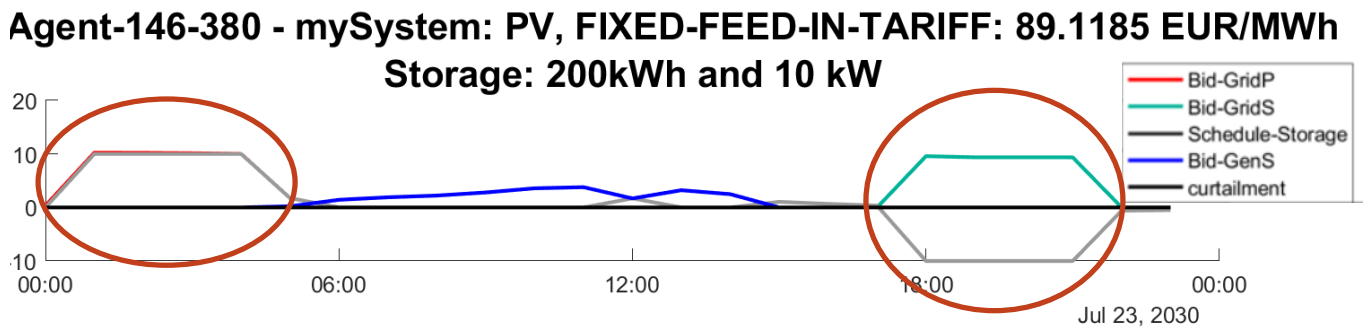
Operator- Behaviour – Market based storage utilization

Operator with PV, load and storage

- Storage is used market based





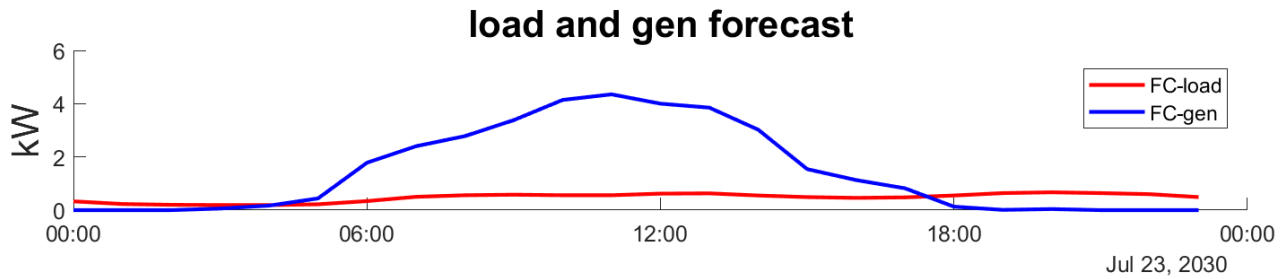


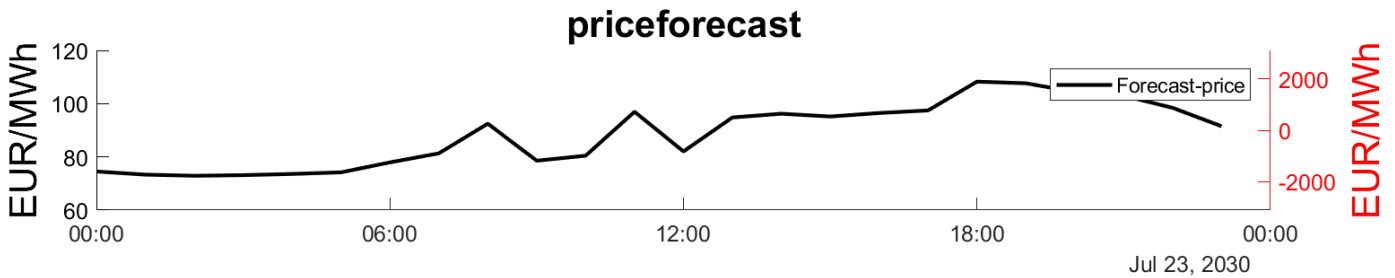
Operator- Behaviour – Market based storage utilization

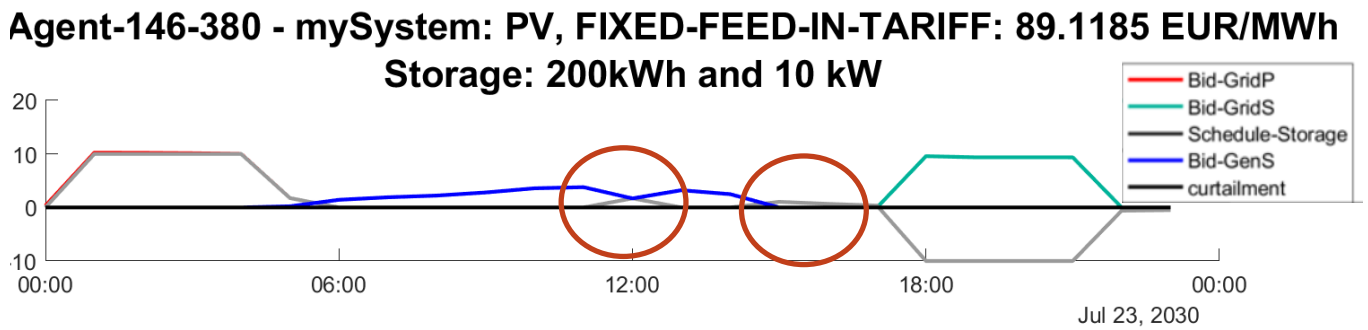
Exemplary Results

Operator with PV, load and storage

- Storage is used market based
- Storage is used to maximize self consumption







Wrap up

- Modelling approach enables
  - assessment of flexible (and static) DG participants under consideration of market interactions and regulatory induced price components
  - distribution grid specific limitations are considered in detail
  - impacts of temporary local markets can be depicted
  - with acceptable computation time (strongly depends on grid)

- Research contributions
  - trade-off between conventional network extension and „smart“ (operational) solutions
  - market integration of flexible, electricity based technologies / sector coupling
  - assessment of profitability under consideration of regulatory influence (→ investment incentives)

Acknowledgements

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