Supported by:

Federal Ministry
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and Climate Action

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Co-funded by
the European Union

Cet Partnership

Simulating market competition of heterogeneous flexibility options

Christoph Schimeczek, Felix Nitsch, Johannes Kochems, Kristina Nienhaus

11th September 2025

DLR

Motivation
Market modelling

Transformation of energy systems

- Rising shares of fluctuating renewables
- More and more investments in energy storages
- But: Will these investments be recovered?

➔ Bottom-up modelling of long-term electricity prices!

Complexity of price dynamics

- Strategic bidding
- Actor uncertainty, e.g. from competition
- Market distortions, e.g. from policies

➔ Consider that & vary dozens of other parameters!

Requirement

A bottom-up model of
complex market decisions,
with dozens of competing actors,
that delivers 1000 simulations a day.

AMIRIS

Agent-Based Market Model for the Investigation of Renewable and Integrated Energy Systems

DLR

- **Agent-based** model for power markets
- Models **business-oriented** dispatch decisions under different regulatory framework conditions
- Focus on **renewable** energy sources and **flexibility** options
- Developed **open source** without copyleft

https://wonderl.ink/@amiris

AMIRIS

Agent-Based Market Model for the Investigation of Renewable and Integrated Energy Systems

DLR

- Simulates trading of supply and demand
- Considers uncertainty and market distortions
- Resolution: hourly (temporal) – market zones (spatial)
- Runs yearly simulations on laptops in less than a minute

AMIRIS
Input & Output

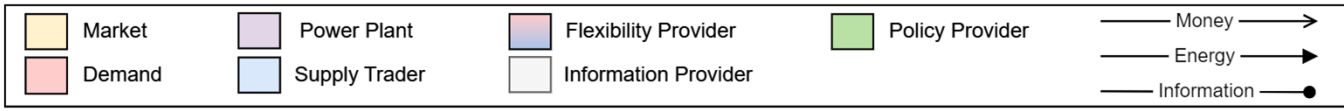
Input

- Power plant park
  - Efficiencies
  - Availabilities
  - Feed-in potential
- Demand
- Fuel prices
- CO_2 prices

Output

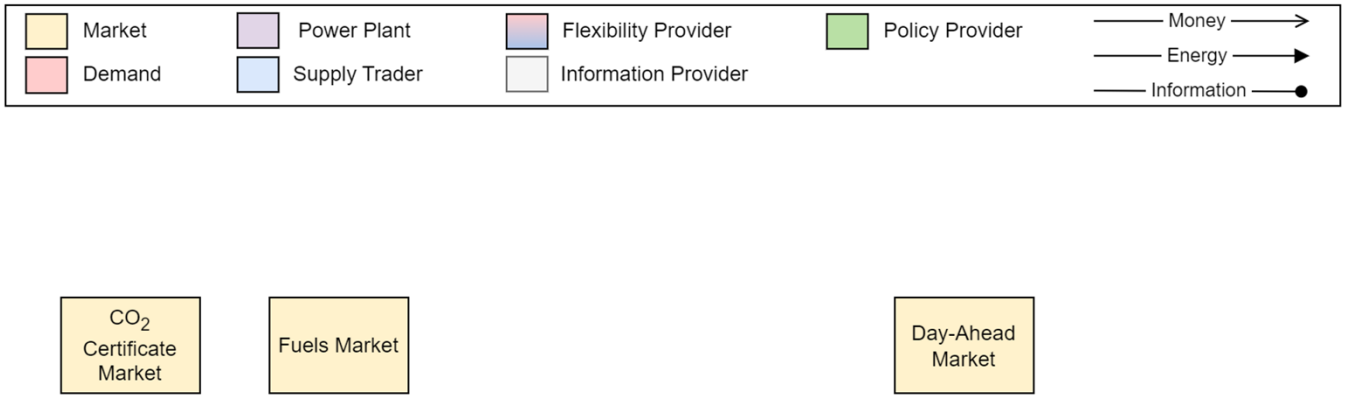
- Electricity prices
- Plant dispatch
- Market values
- CO_2 emissions
- System costs
- Costs for support instruments

AMIRIS
Agent types



AMIRIS
Agent types

Markets
- Determine prices



AMIRIS
Agent types

Markets
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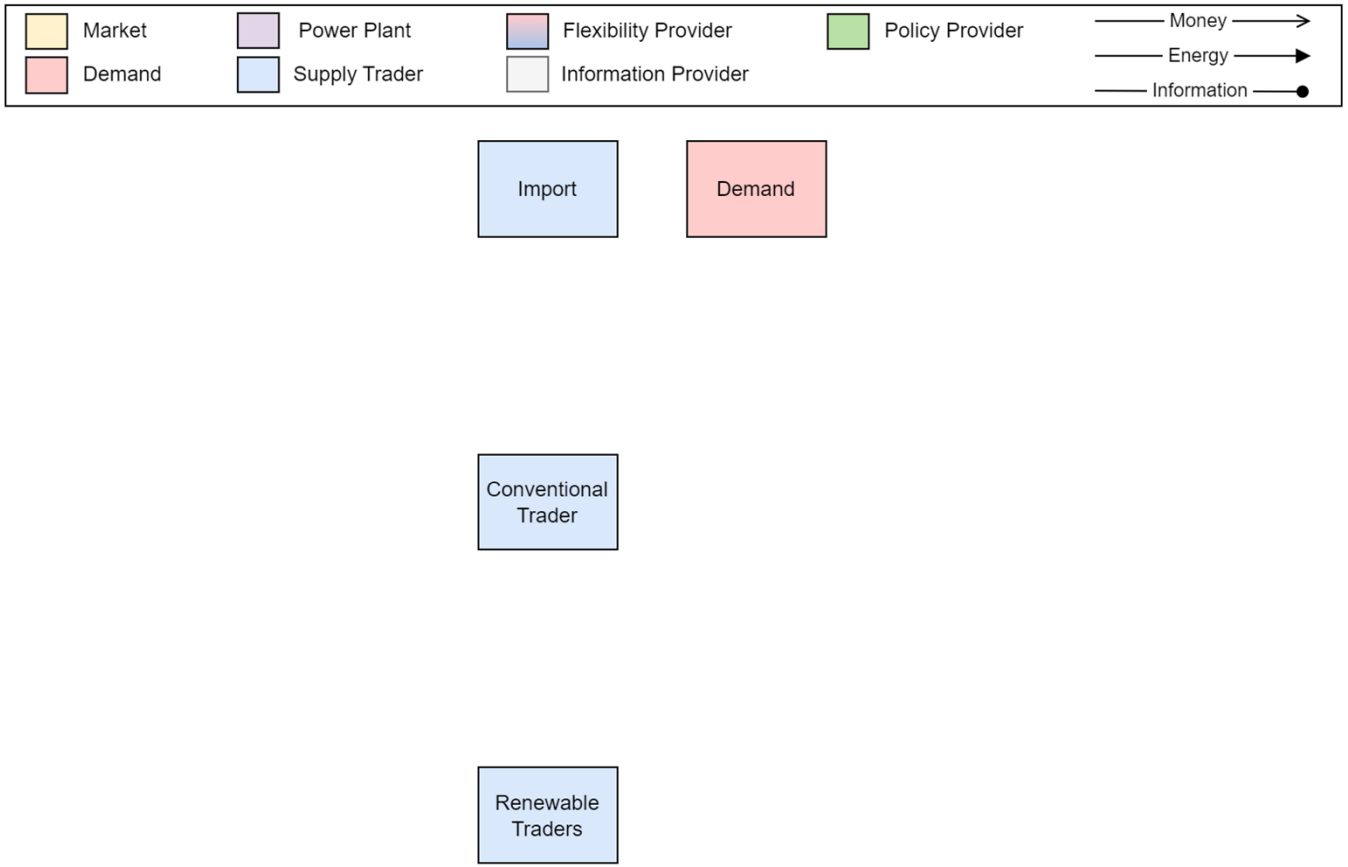
Traders
- Fulfil marketing strategies



AMIRIS
Agent types

Markets
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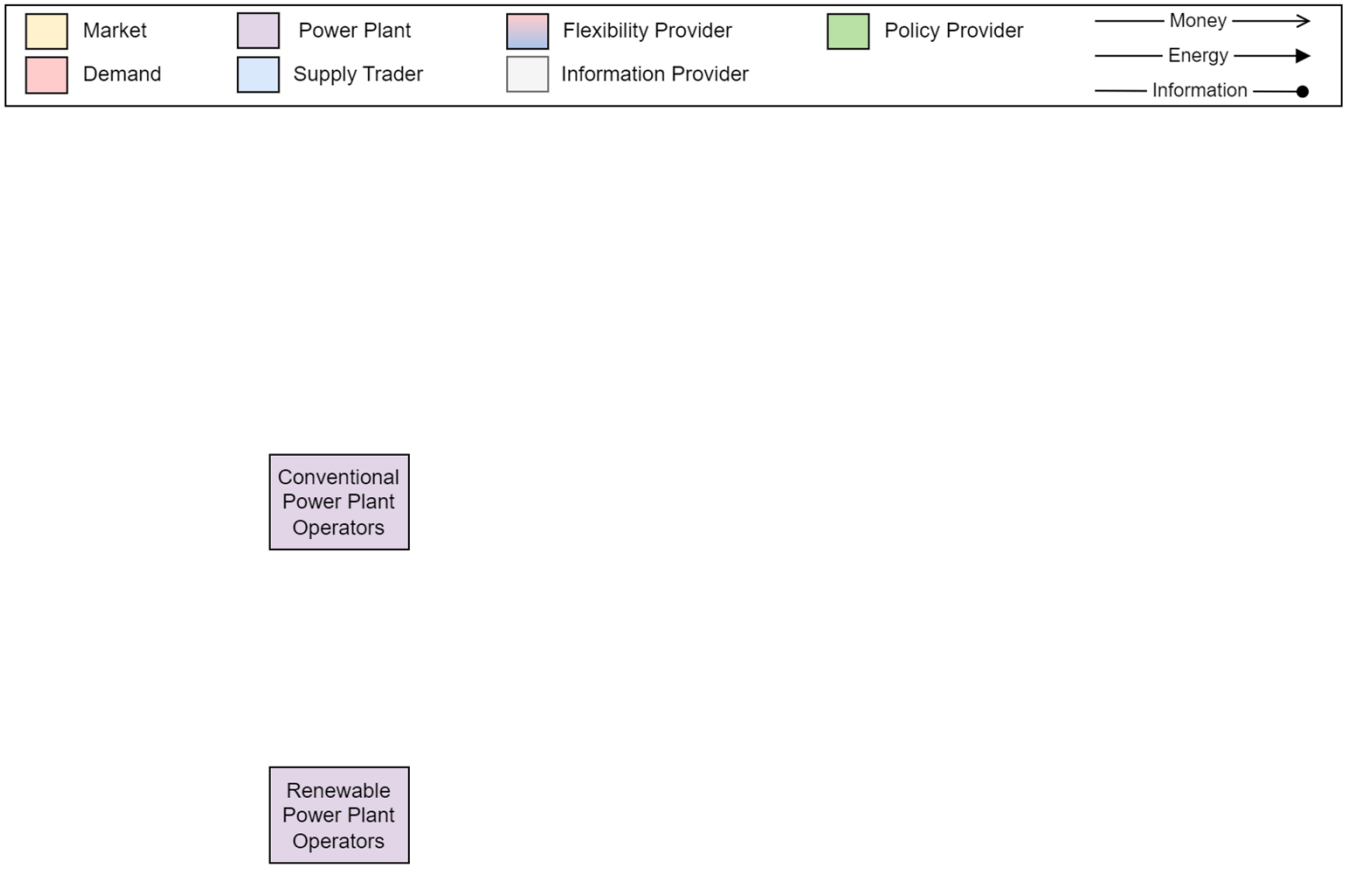
Plant operators
- Control power plants



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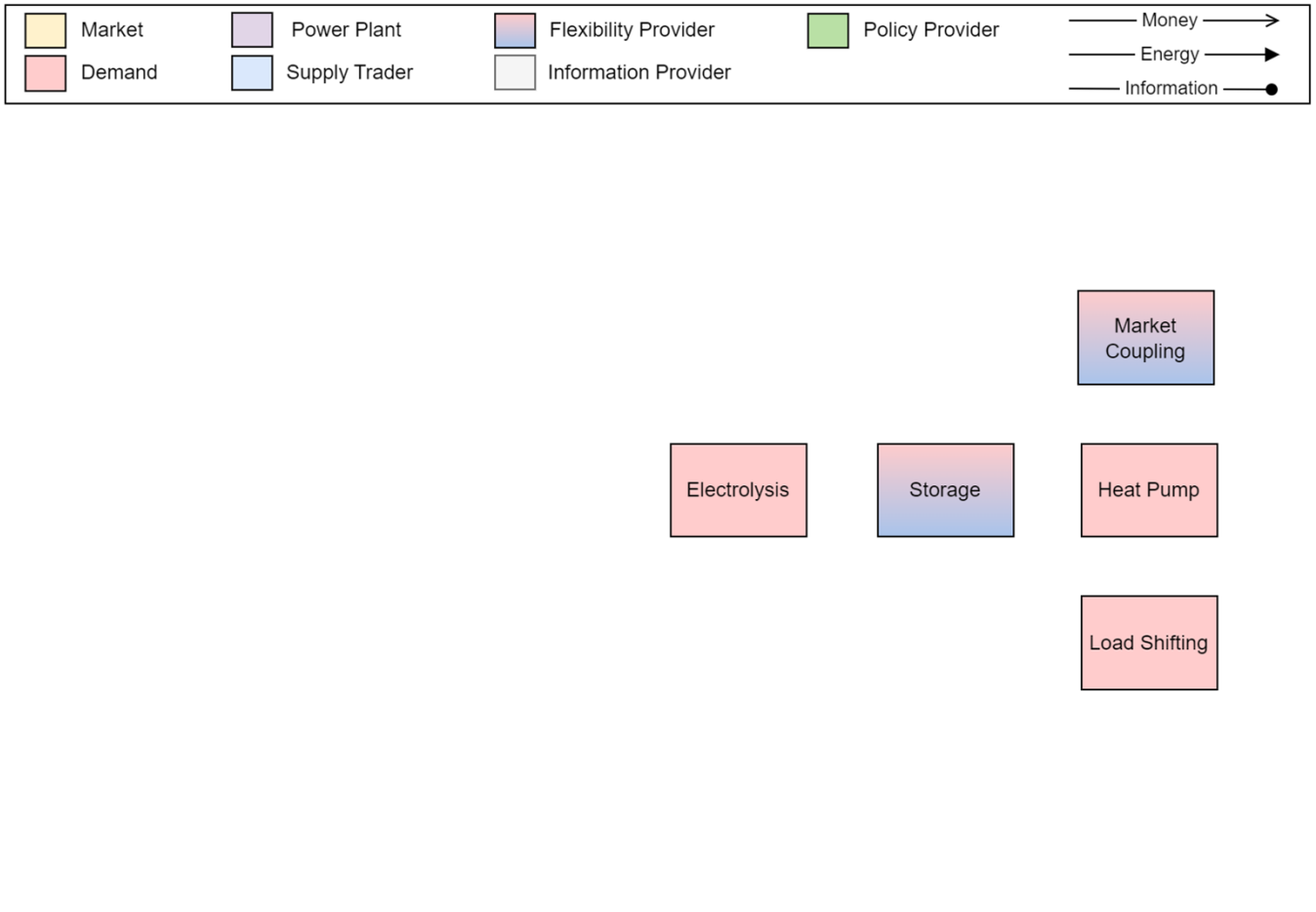
Flexibility providers
- Optimise dispatch



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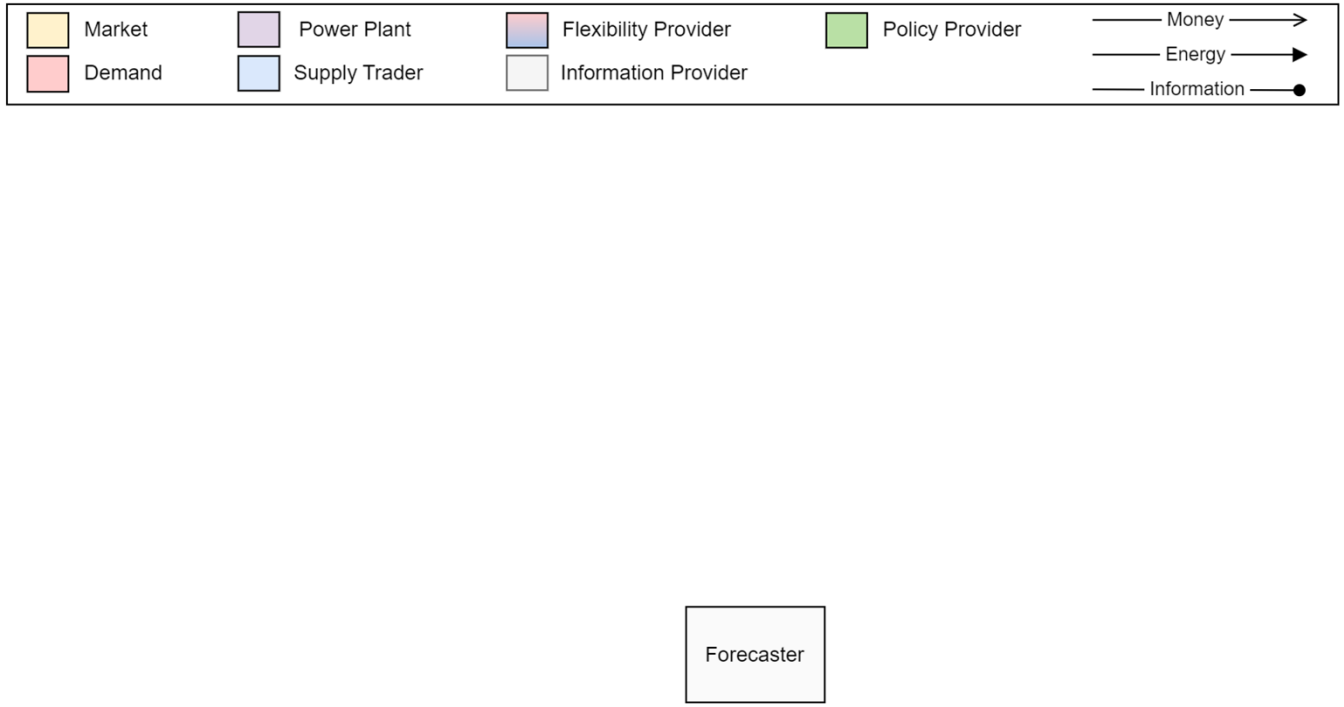
Information provider
- Create forecasts



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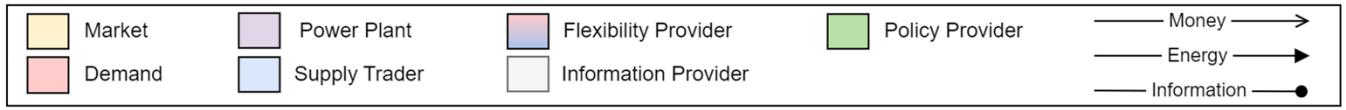
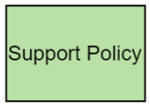
Policy
- Provide support





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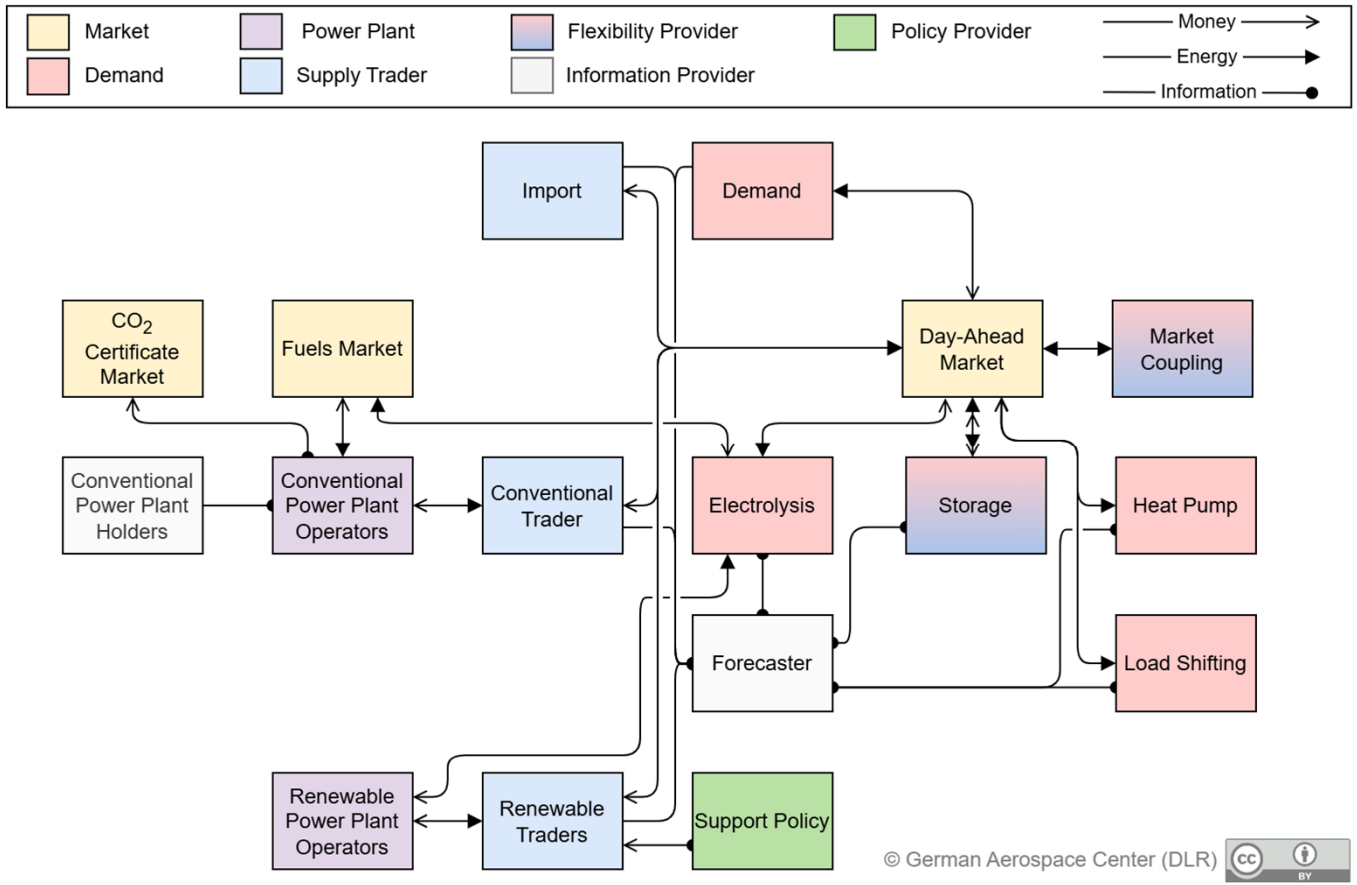

Modelling Competing Flexibilities

Image source: DLR e.V.

Modelling Competing Flexibilities

The Question

To charge or to discharge…

Modelling Competing Flexibilities

The Question

To charge or to discharge…

→ Use electricity price forecast, maximise profits with *dynamic programming*

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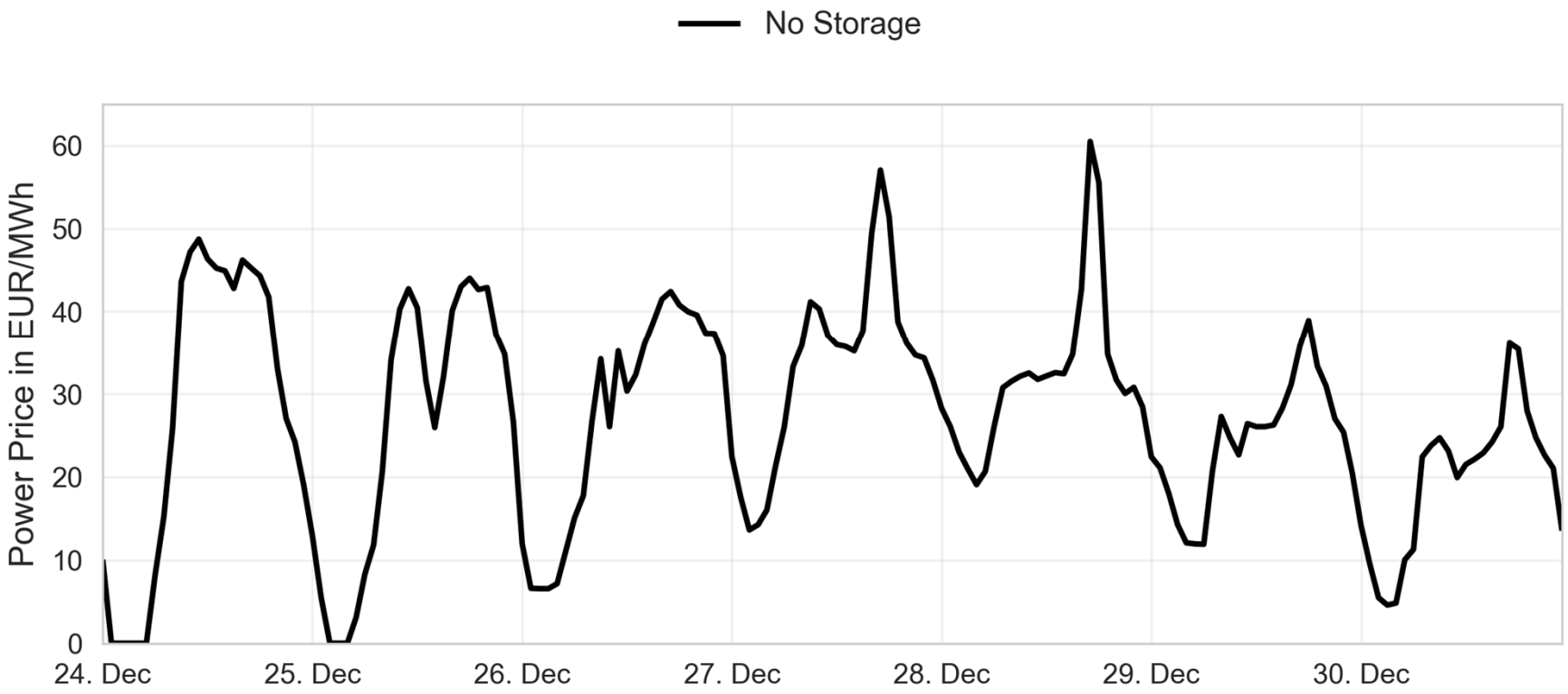

Schimeczek et al., German Aerospace Center

Modelling Competing Flexibilities

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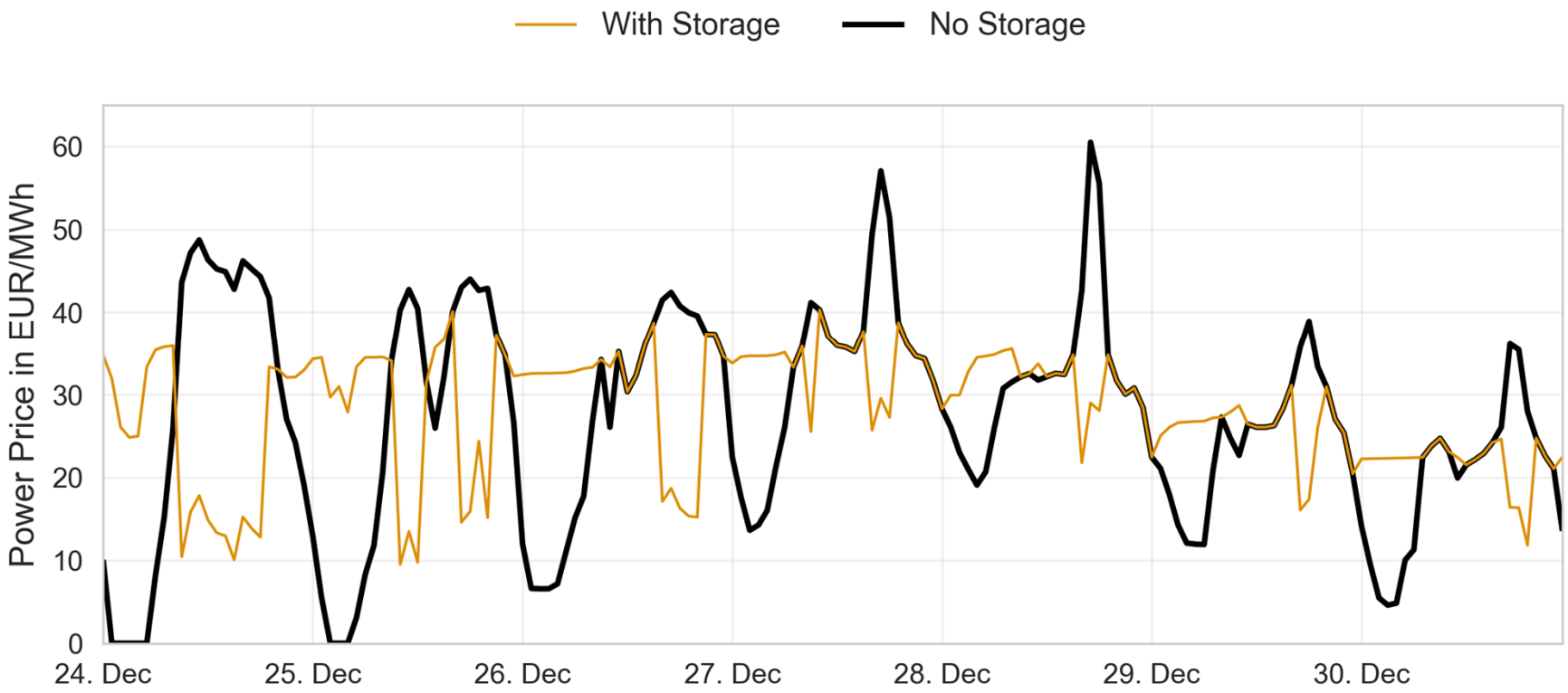

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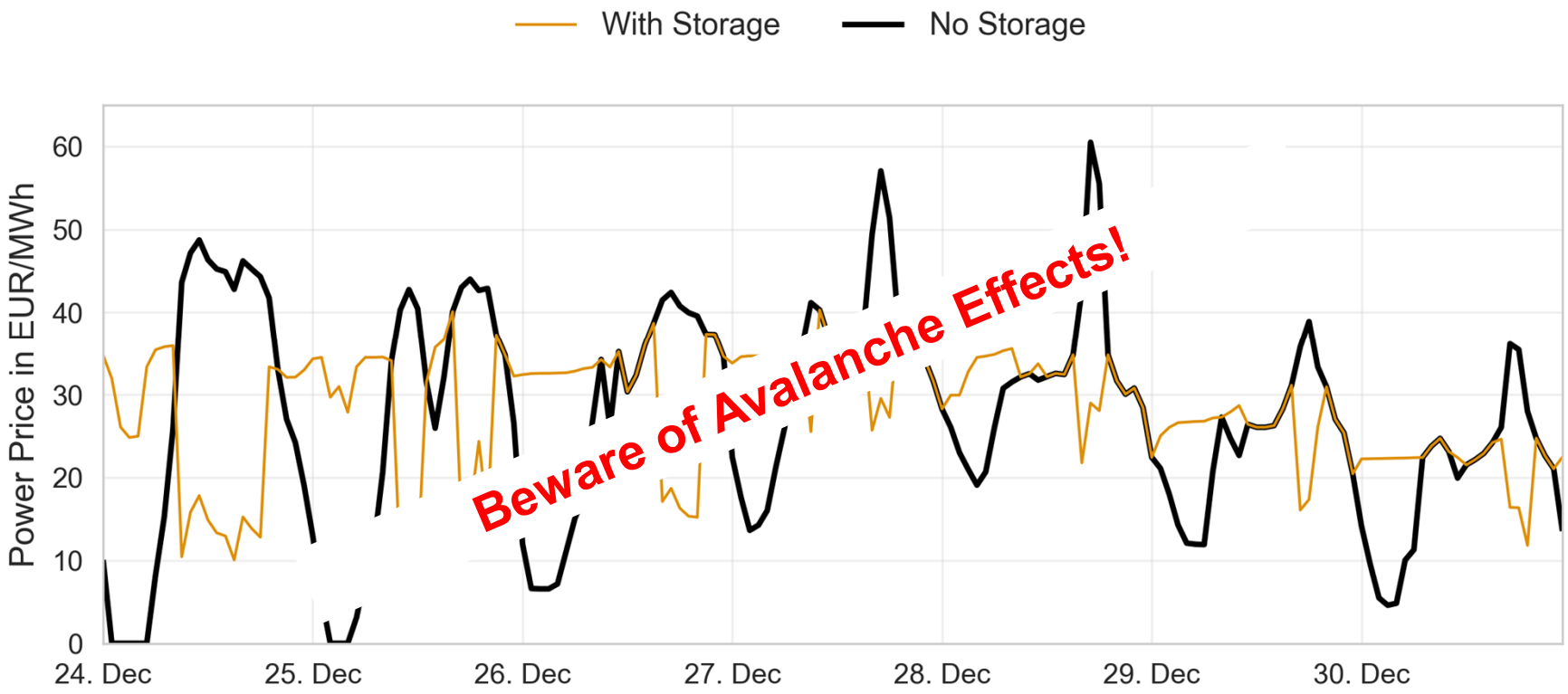
Modelling Competing Flexibilities

The Question

To charge or to discharge…

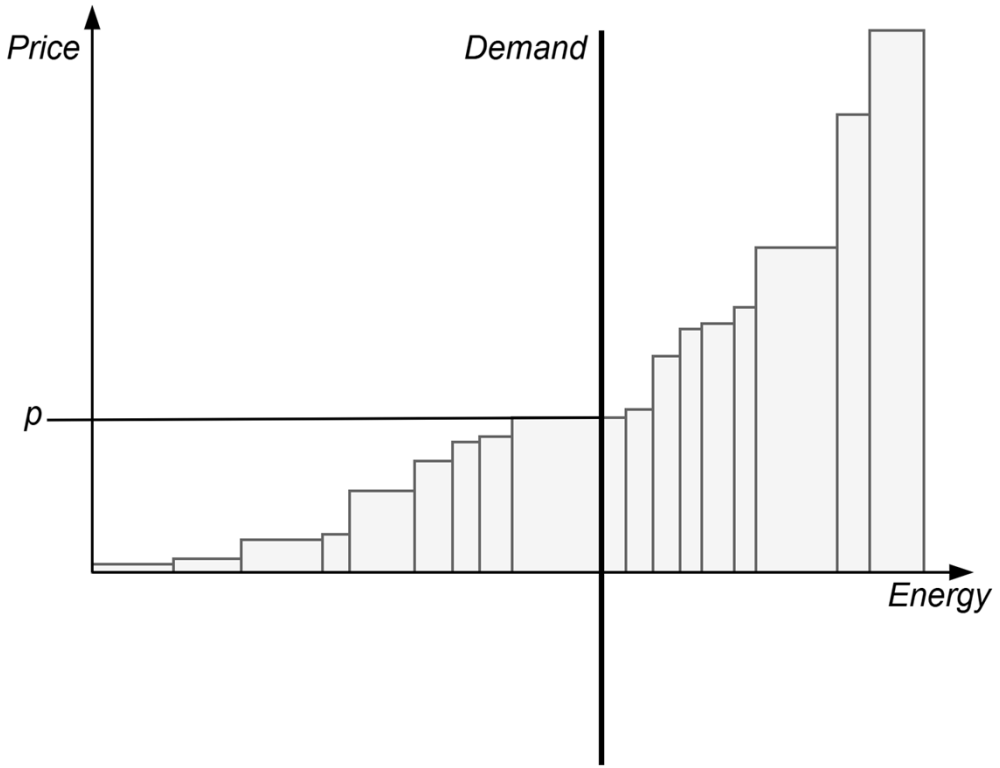
→ Use electricity price forecast, maximise profits with *dynamic programming*



Schimeczek et al., German Aerospace Center

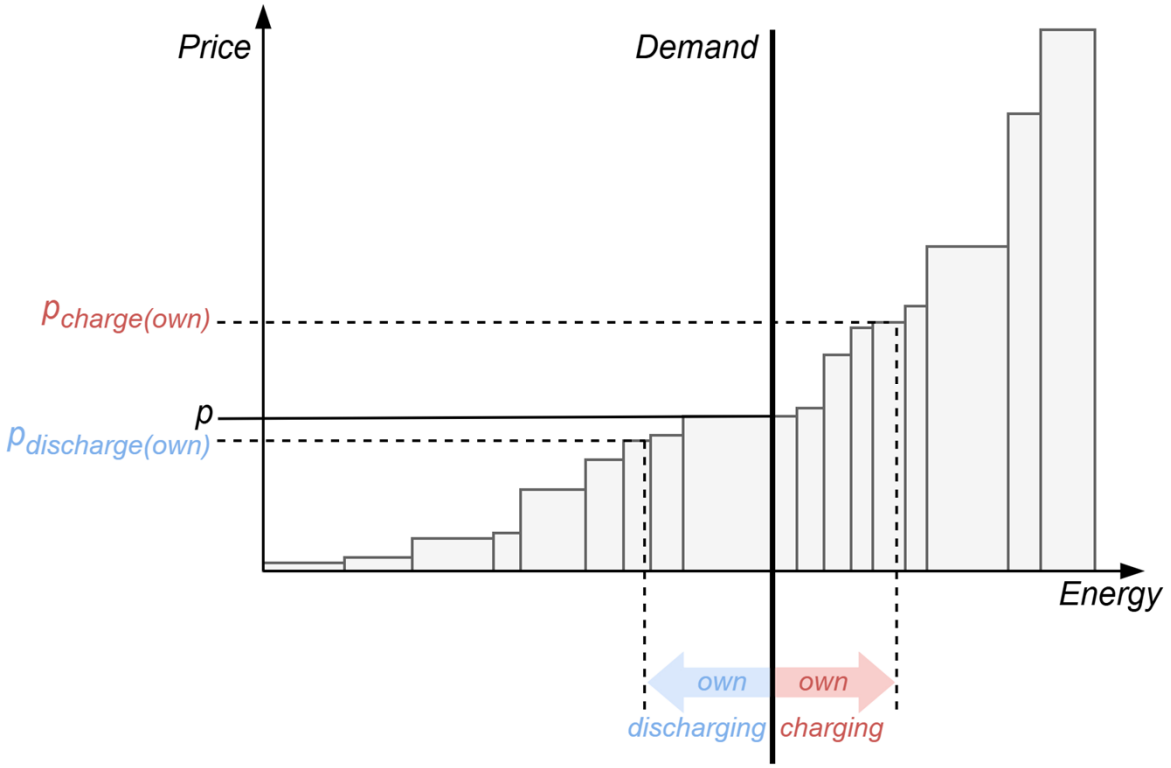
Modelling Competing Flexibilities
Idea

Use Merit Order in Forecast



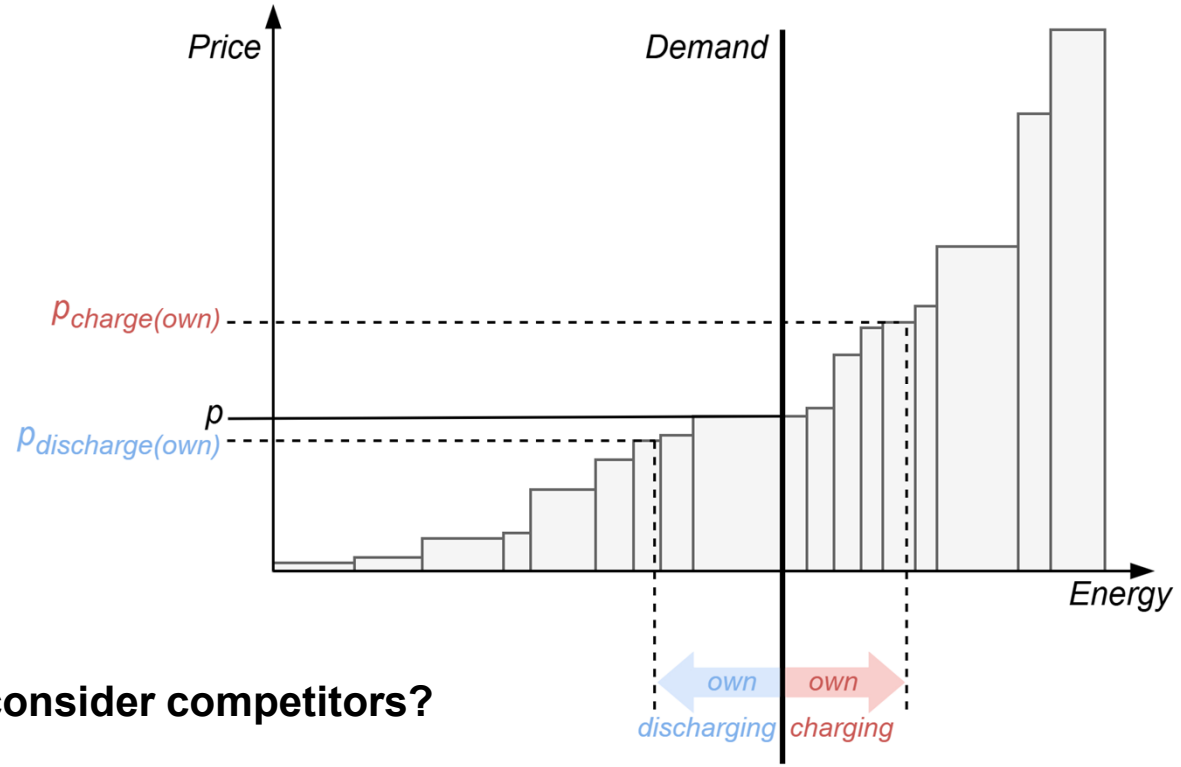
Modelling Competing Flexibilities
Idea

→ Account for price changes due to storage dispatch



Modelling Competing Flexibilities
Idea

→ **Account for price changes due to storage dispatch**

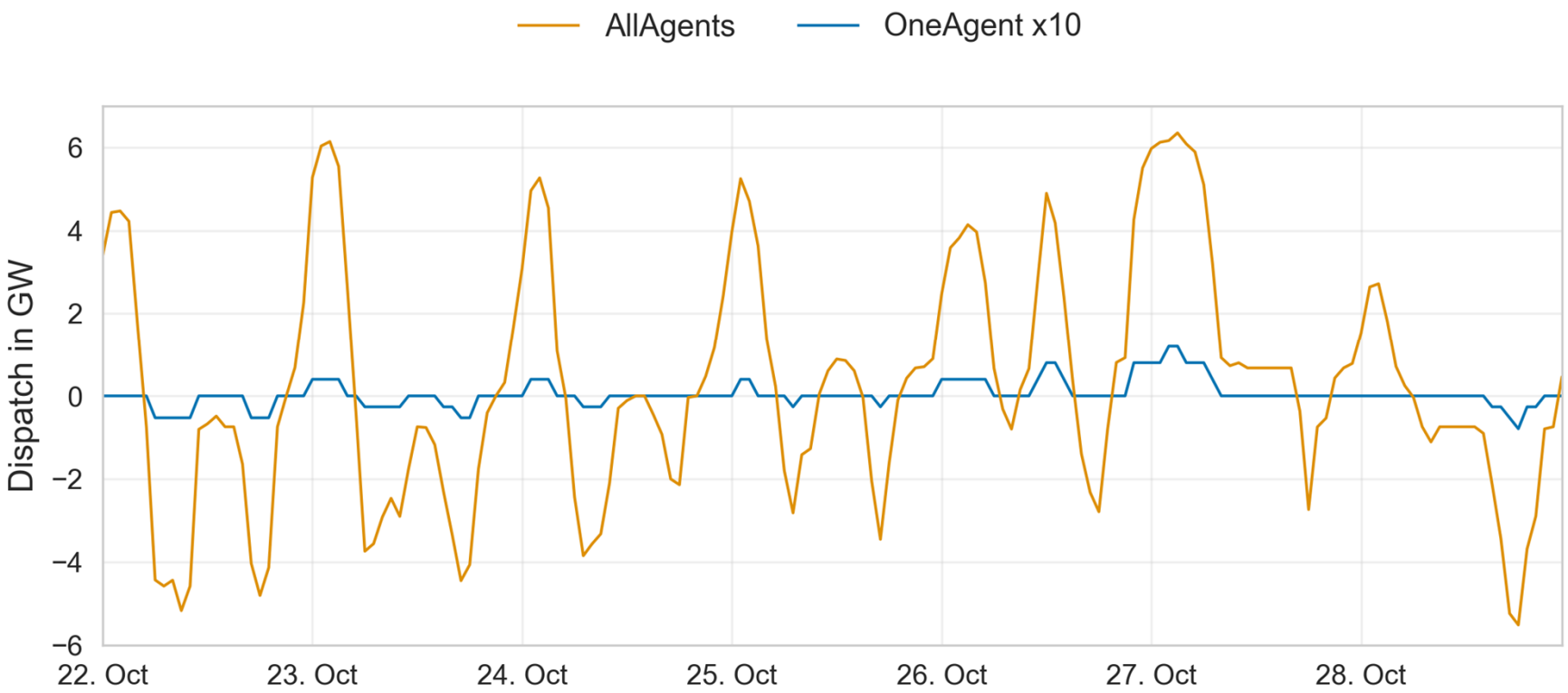


But how consider competitors?

Modelling Competing Flexibilities

Observe Dispatch

→ Compare own dispatch to that of competitors

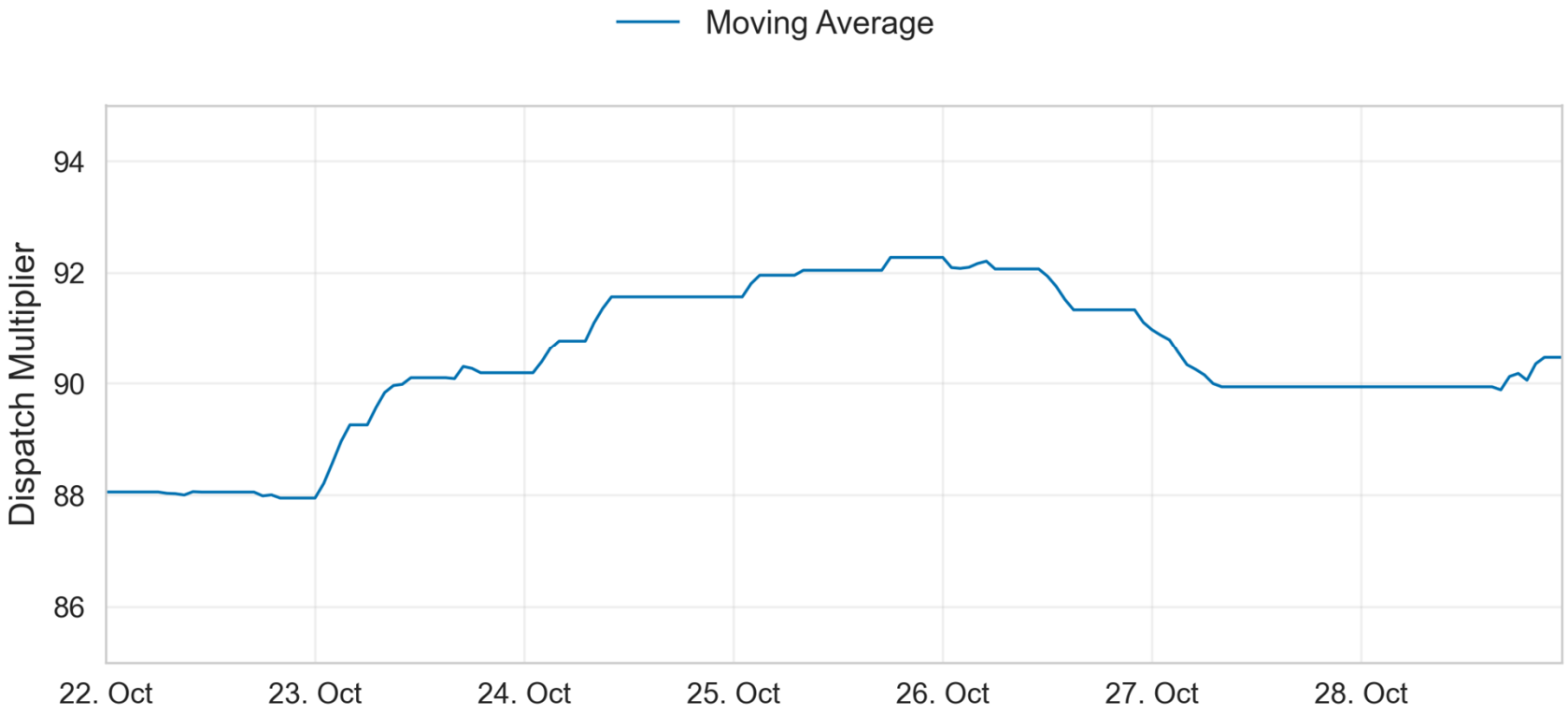


Modelling Competing Flexibilities

Observe Dispatch

→ Compare own dispatch to that of competitors

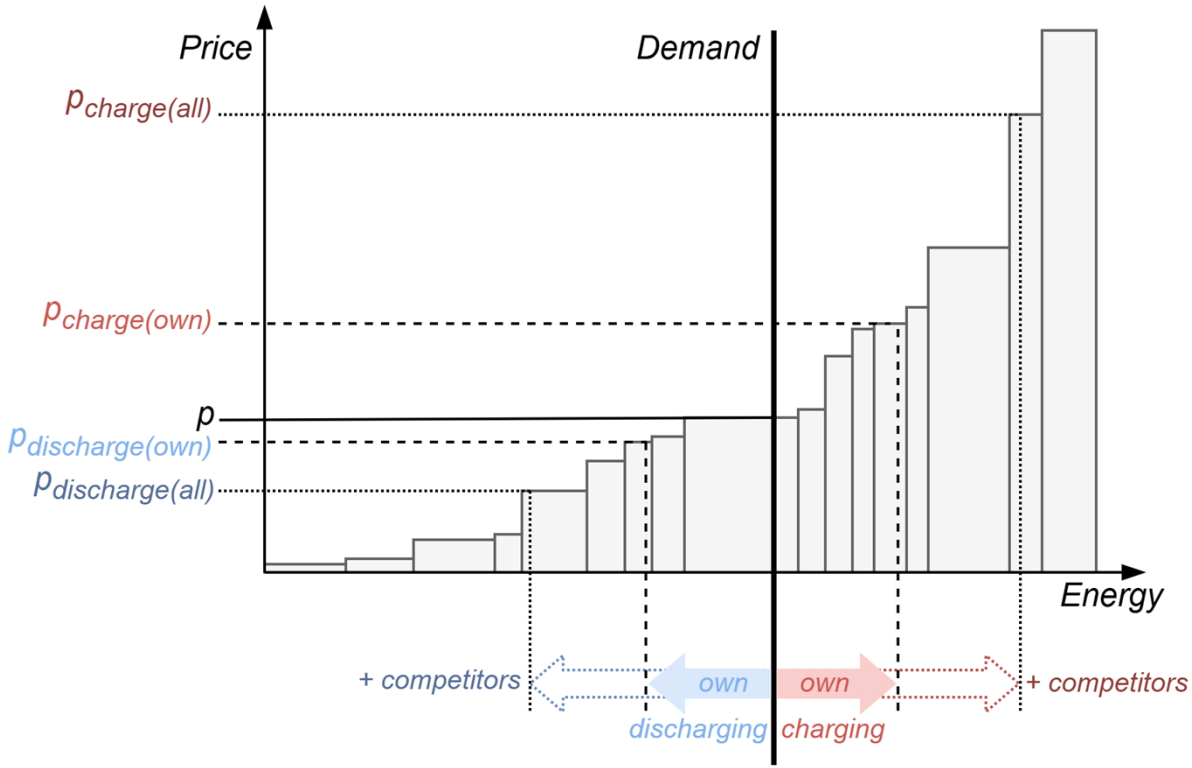
→ Represent as “**multiplier**” relative to own dispatch



Modelling Competing Flexibilities

Apply Multiplier

→ Account for price changes of **all flexibilities**



Modelling Competing Flexibilities

Apply Multiplier

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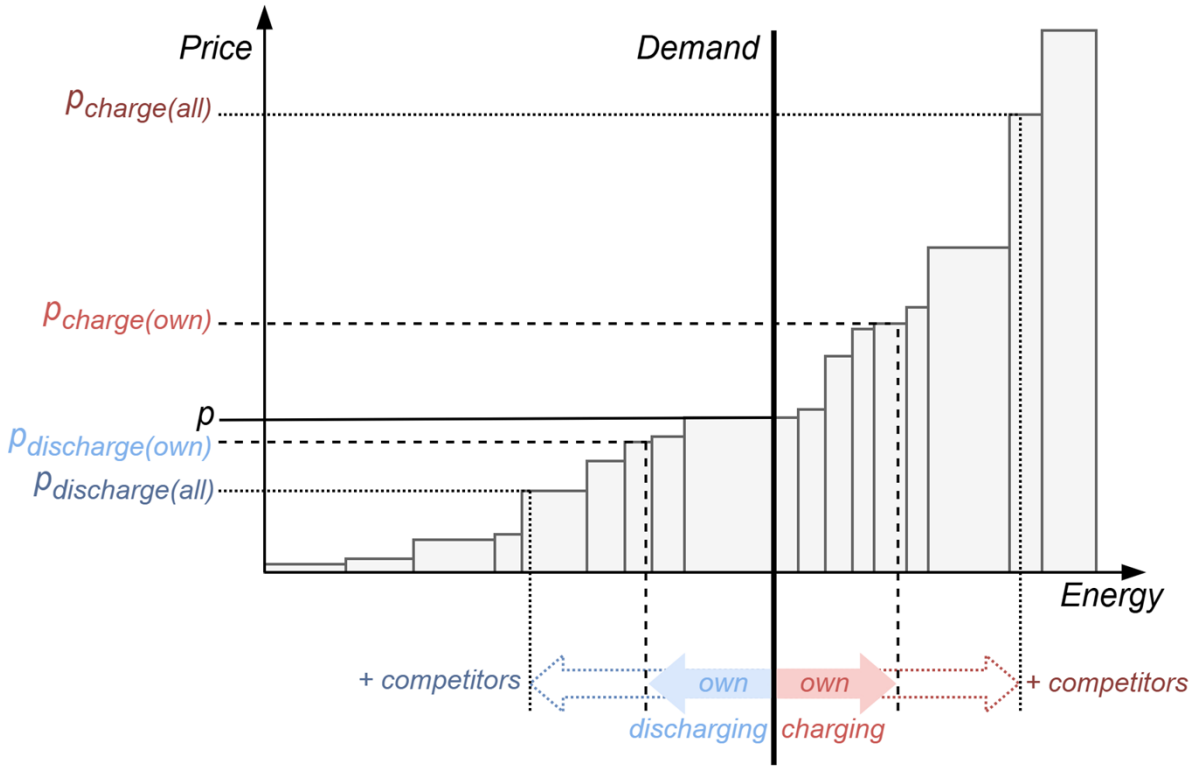
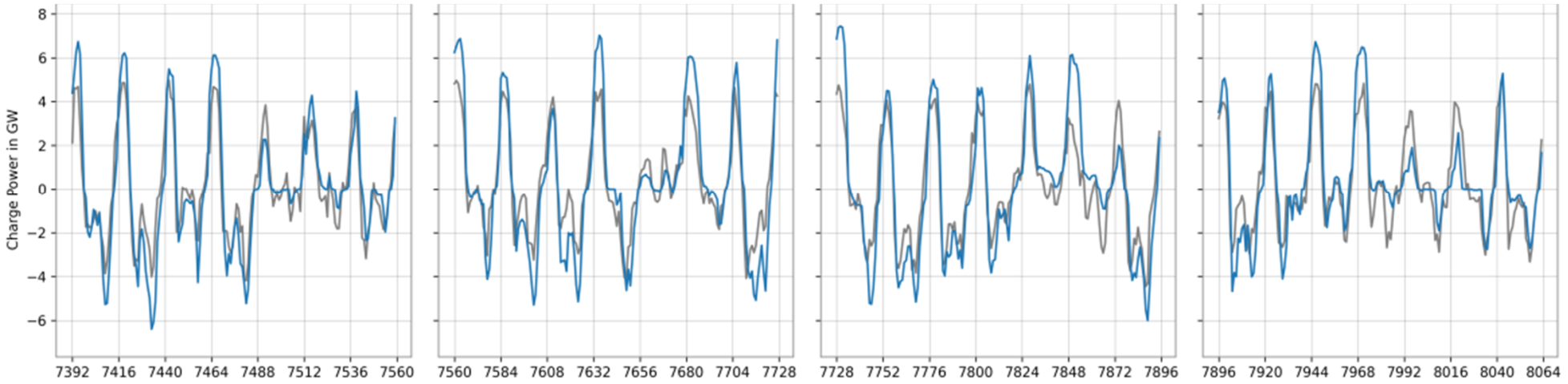


→ Avoids Avalanches

Backtesting: 18 Competing Storages

Storage Dispatch



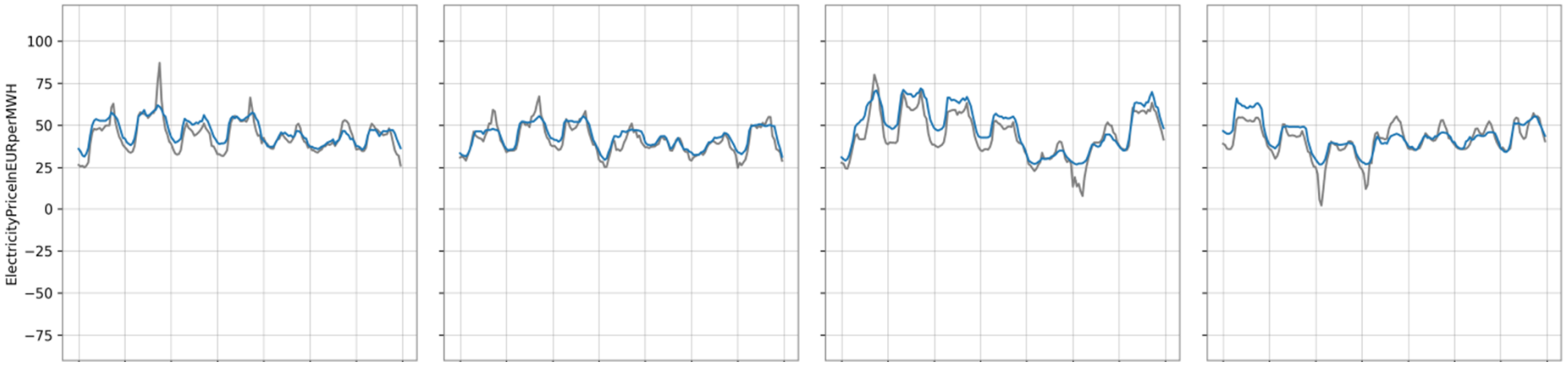
→ Accurate storage dispatch simulation

Pearson Correlation	0.86
MAE	1.02 GW

Schimeczek et al. (2025). 10.5281/zenodo.16978510

Backtesting: 18 Competing Storages

Electricity prices



→ Accurate electricity price simulation

Pearson Correlation	0.85
MAE	5.37 €/MWh

Schimeczek et al. (2025). 10.5281/zenodo.16978510

Summary

AMIRIS	agent-based model for power markets
Fast	1 year with 18 competing units takes ~30s
Accurate	convincing backtesting performance
Open	Apache 2.0
Easy setup	*We owe you a* 🍺 if you can't get it to run in 15 minutes

Model

Paper

Imprint

Topic	**Simulating market competition of heterogeneous flexibility options**
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