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Effective Dispatch Planning for Competing Storage Units*

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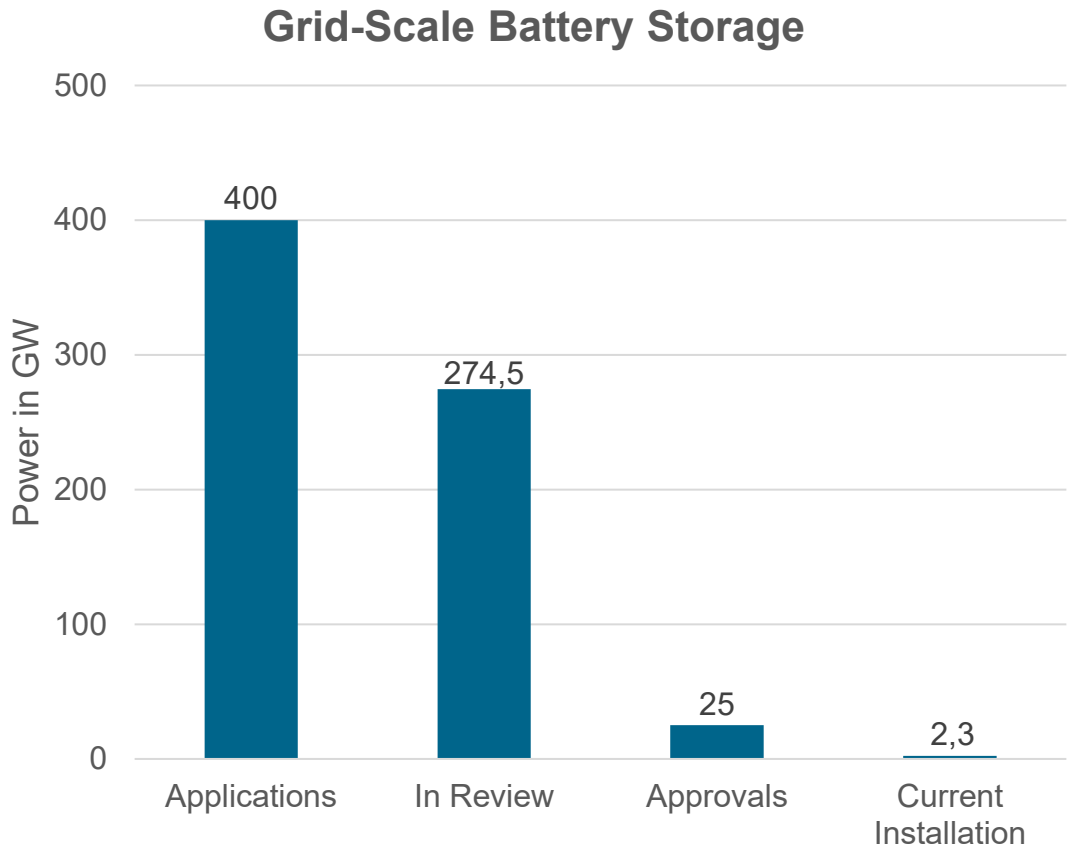
* Paper: https://doi.org/10.1016/j.est.2025.120054

Motivation



→ But how to effectively schedule dispatch in competitive environment?

Source: BNetzA (2025)

Modelling Competing Flexibilities

The Question

To charge or to discharge…

Modelling Competing Flexibilities

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

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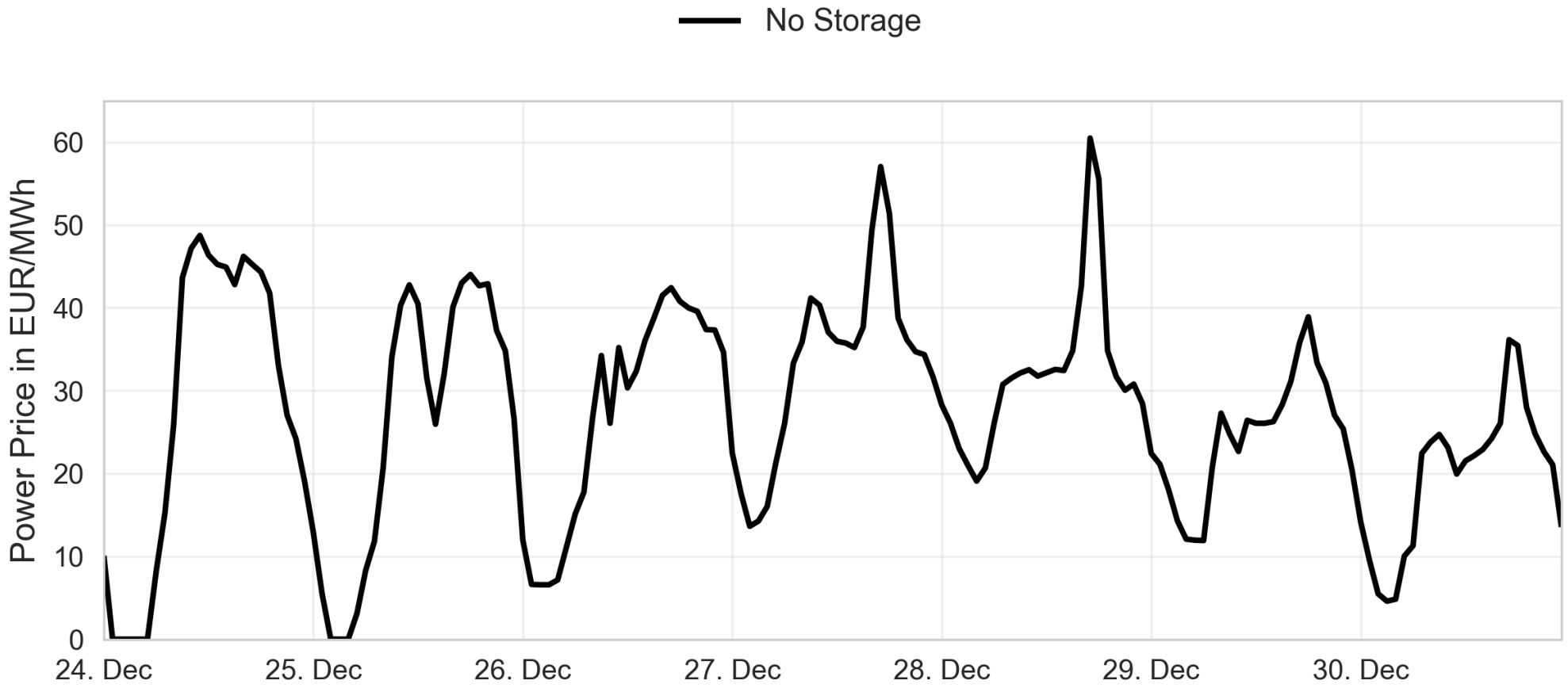

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To charge or to discharge…

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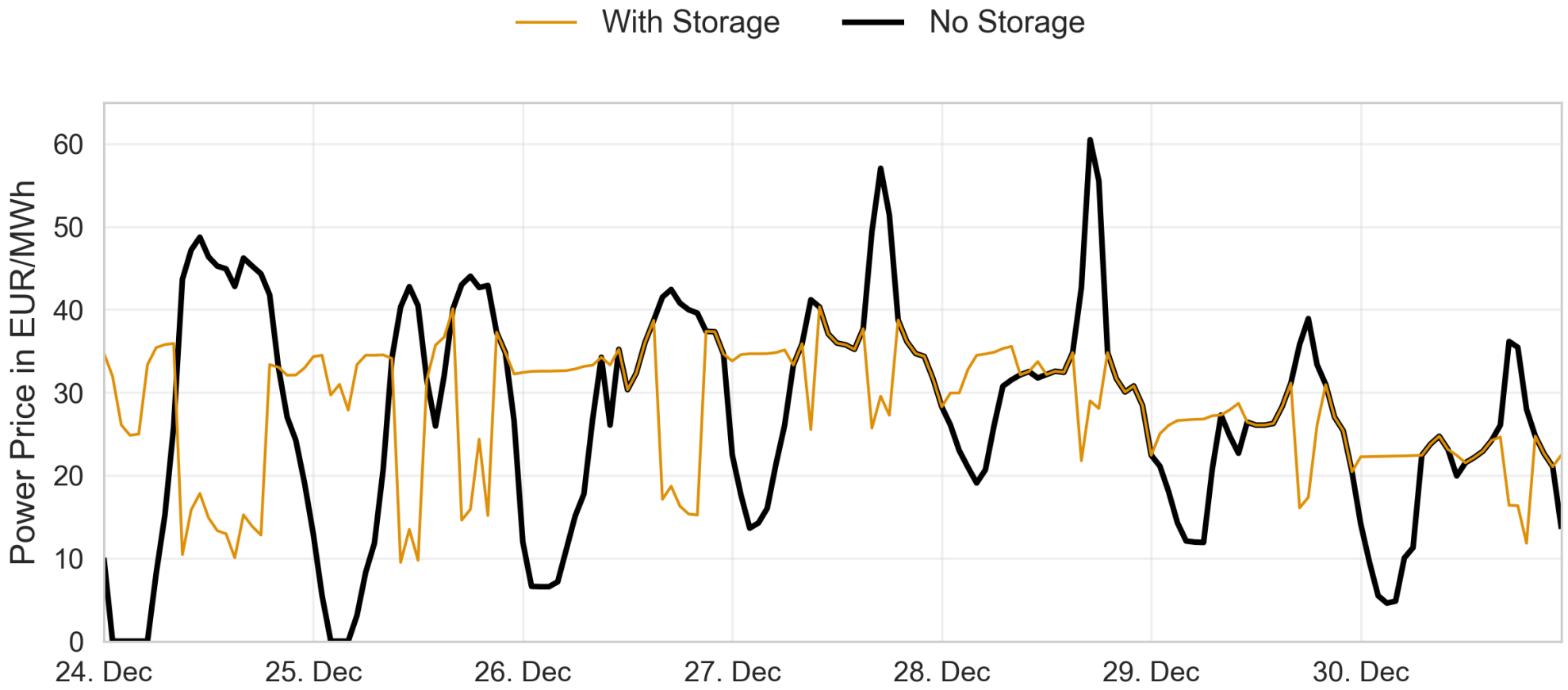

Modelling Competing Flexibilities

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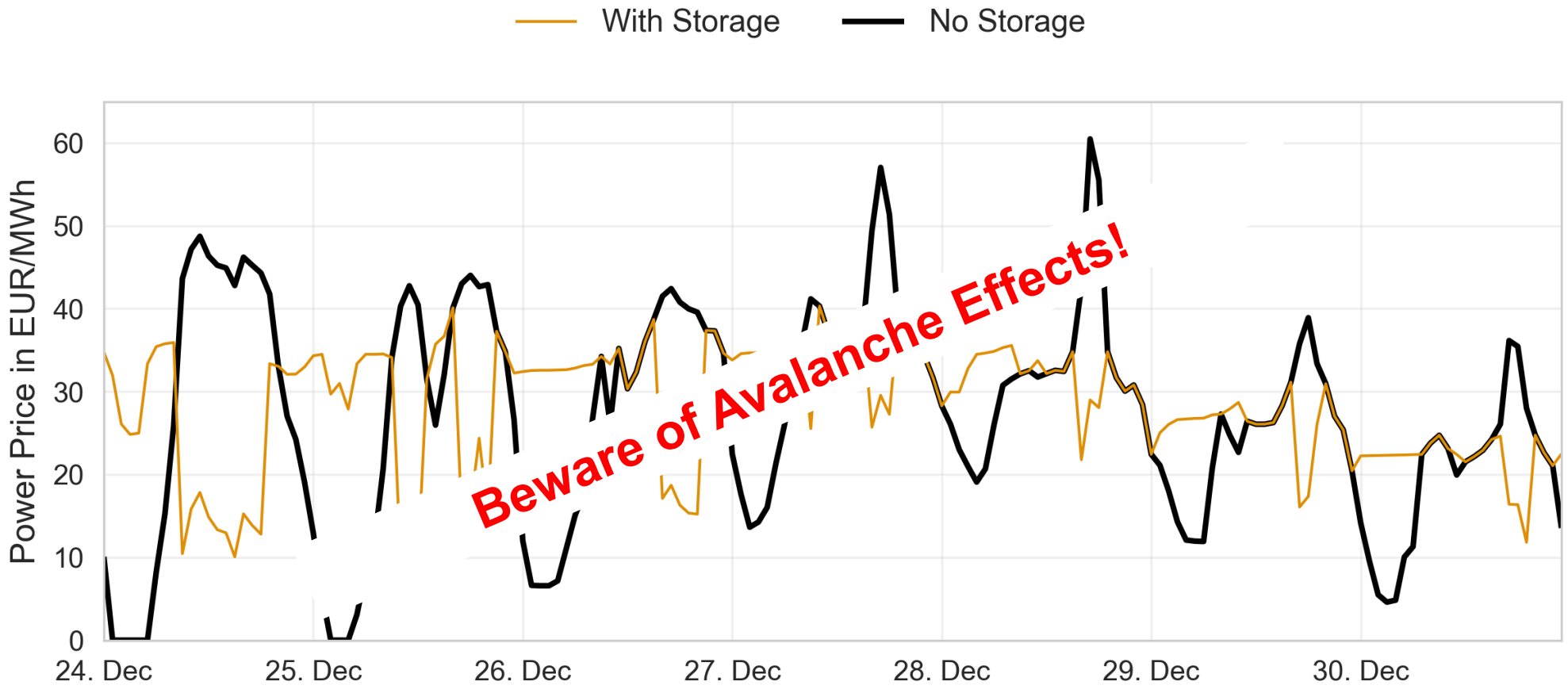
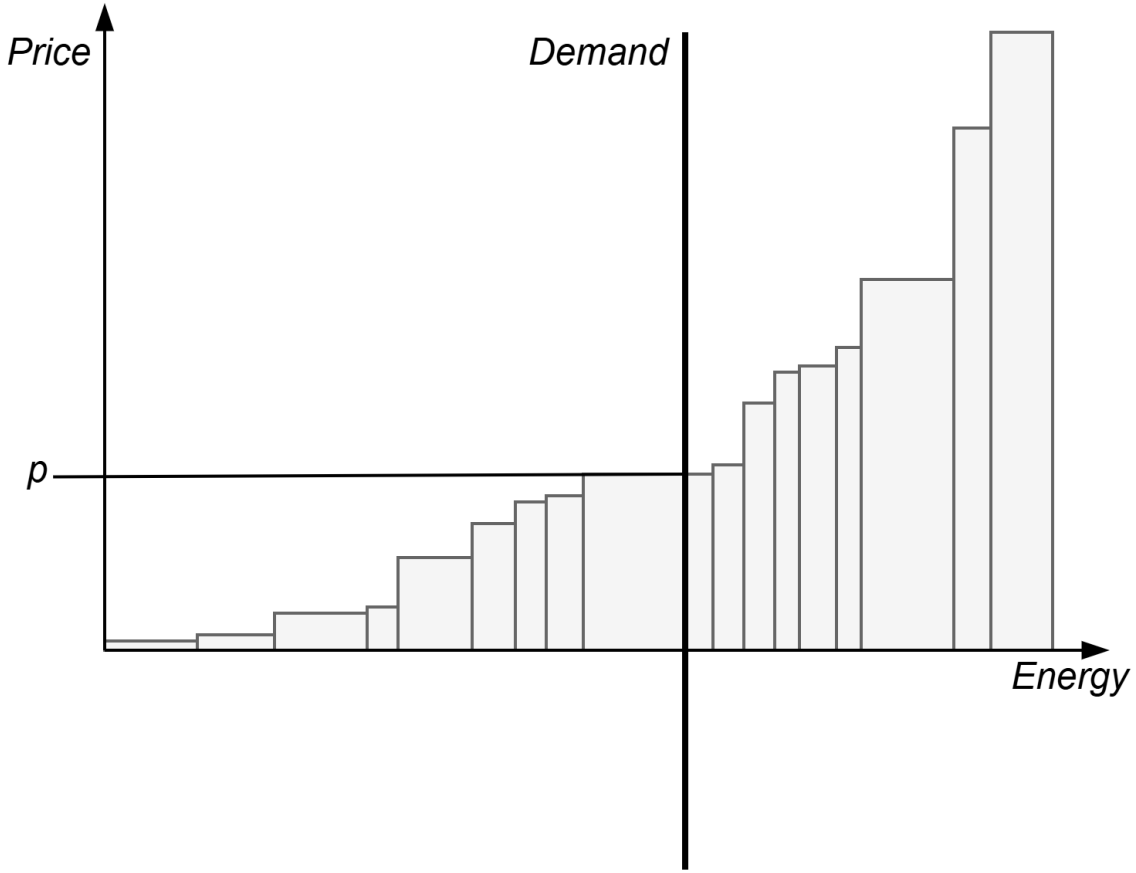
To charge or to discharge…

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



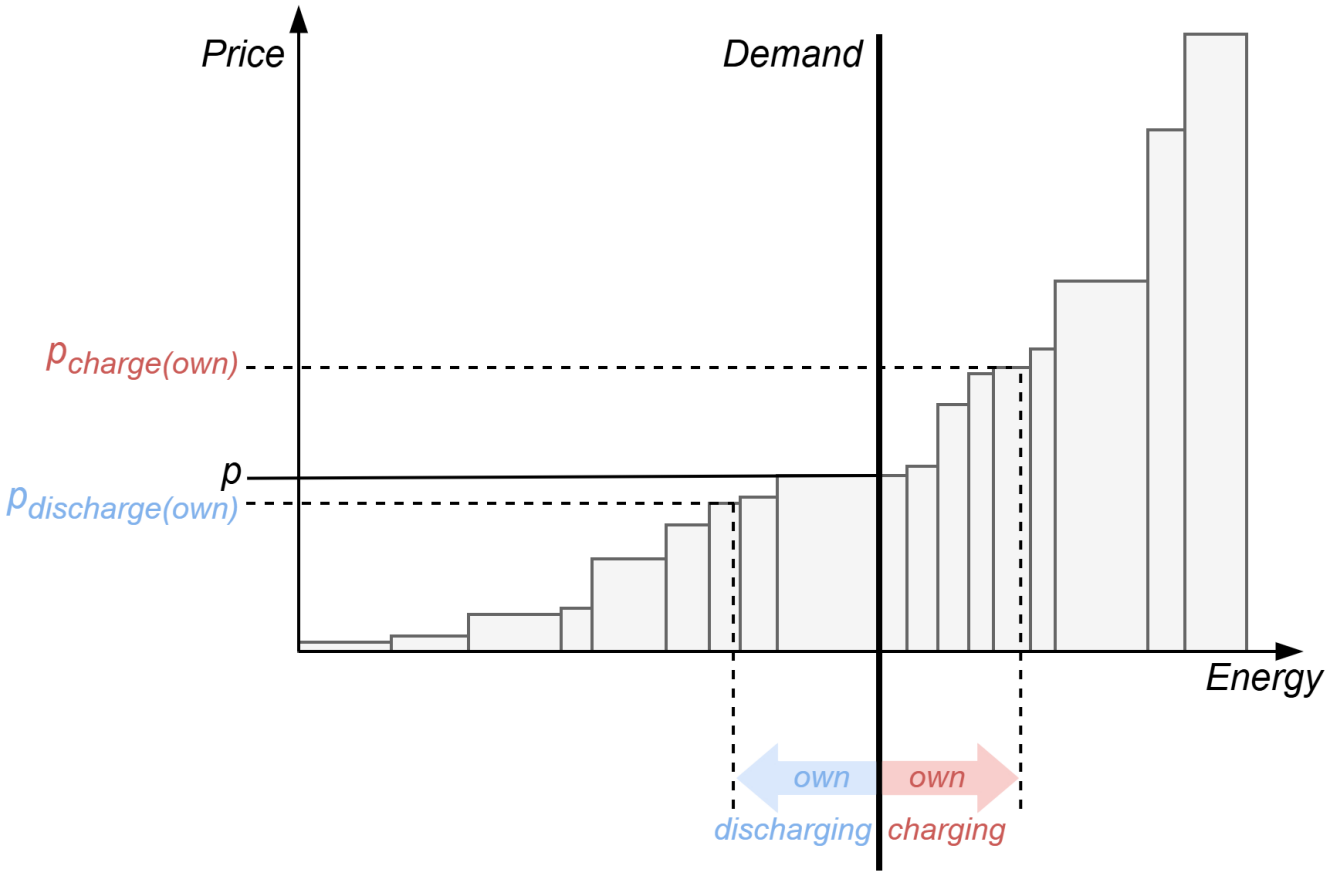
Modelling Competing Flexibilities
Idea

Use Merit Order in Forecast



Modelling Competing Flexibilities
Idea

→ Account for price changes due to storage dispatch



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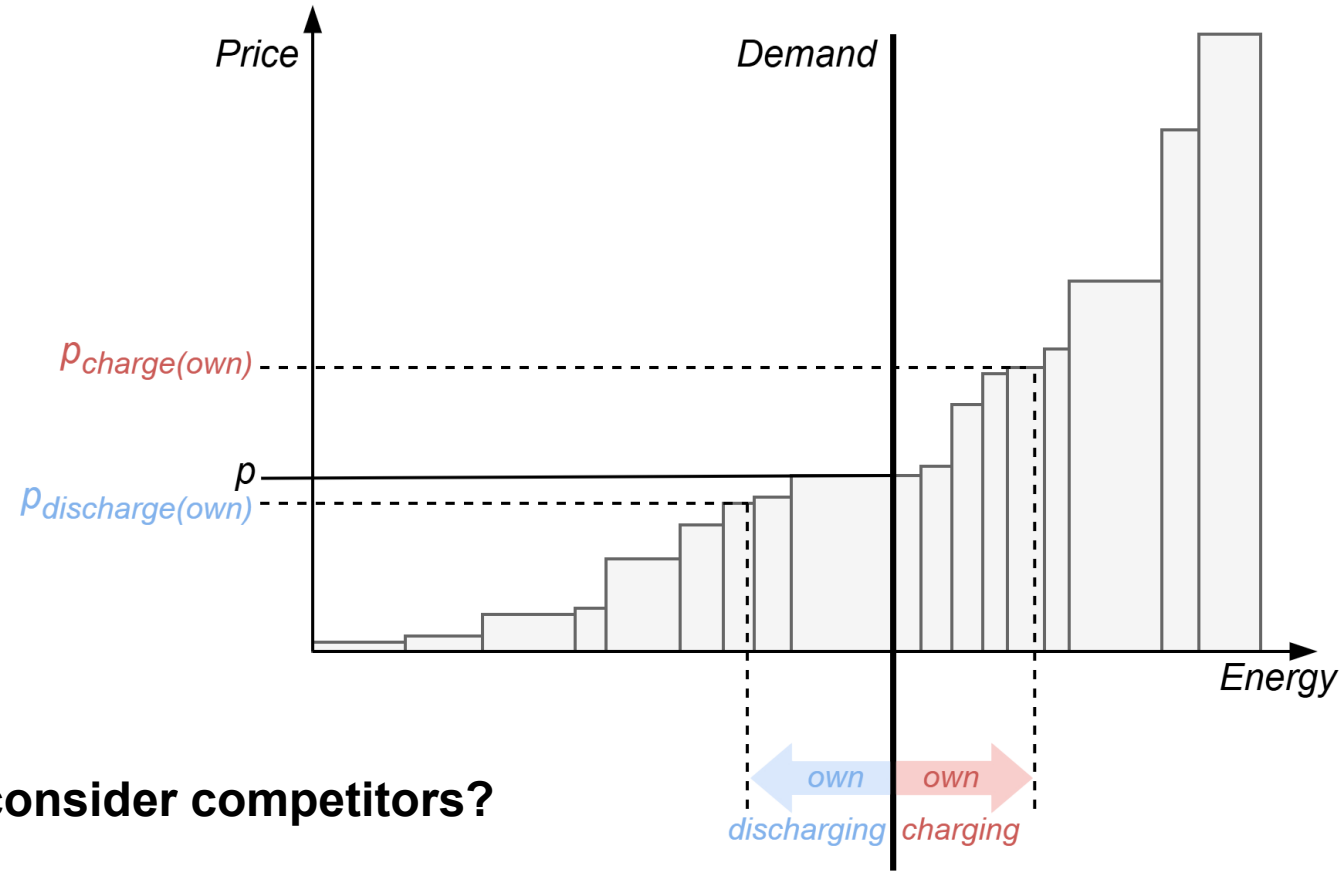
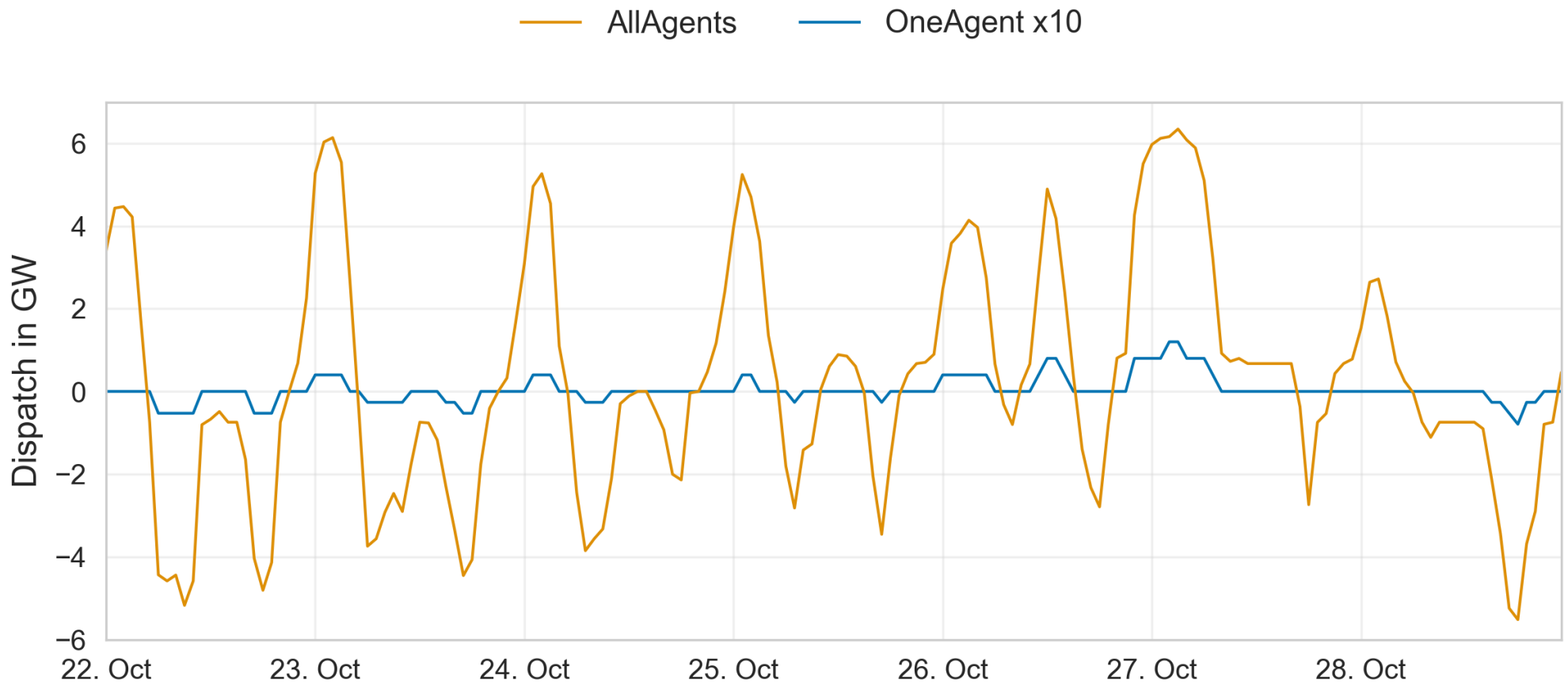


But how consider competitors?

Modelling Competing Flexibilities

Observe Dispatch

→ Compare own dispatch to that of competitors

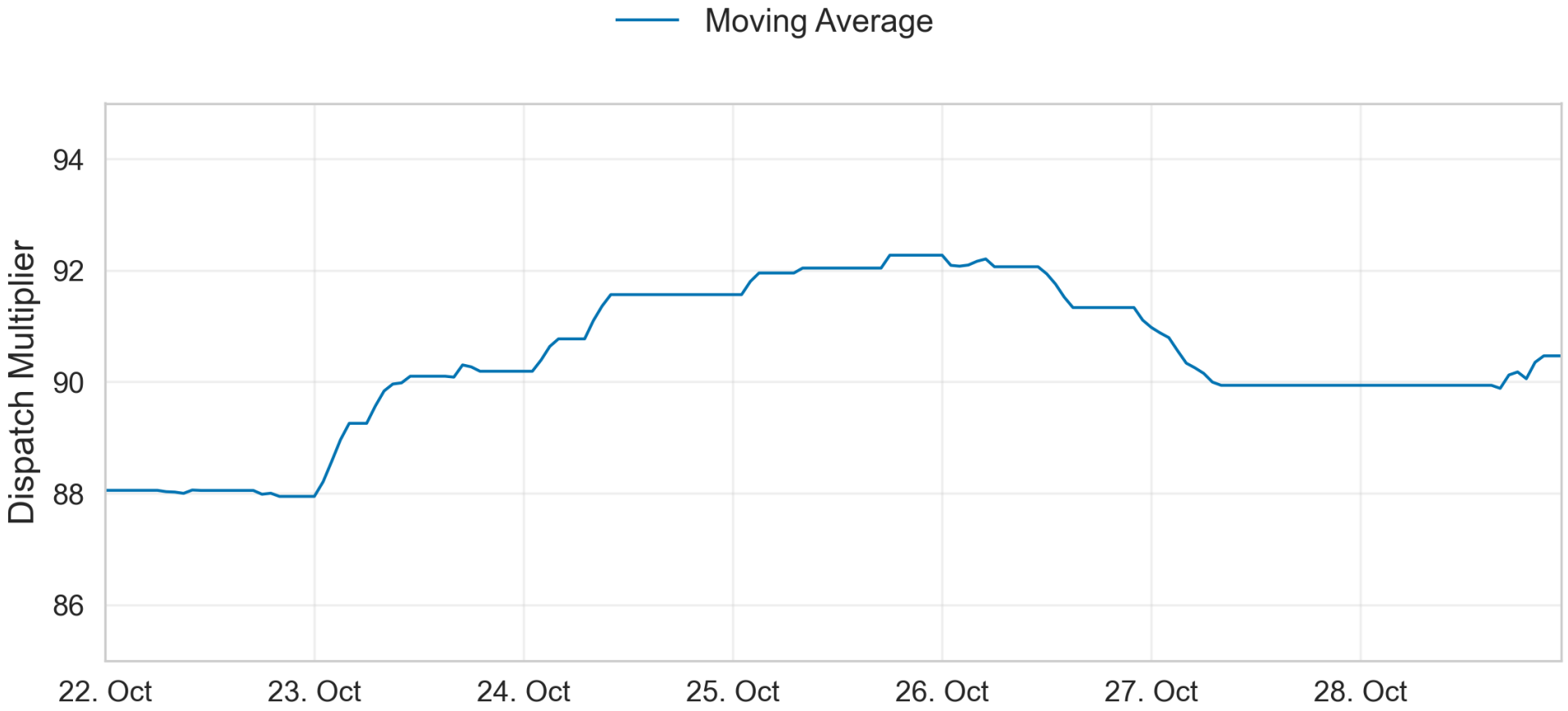


Modelling Competing Flexibilities

Observe Dispatch

→ Compare own dispatch to that of competitors

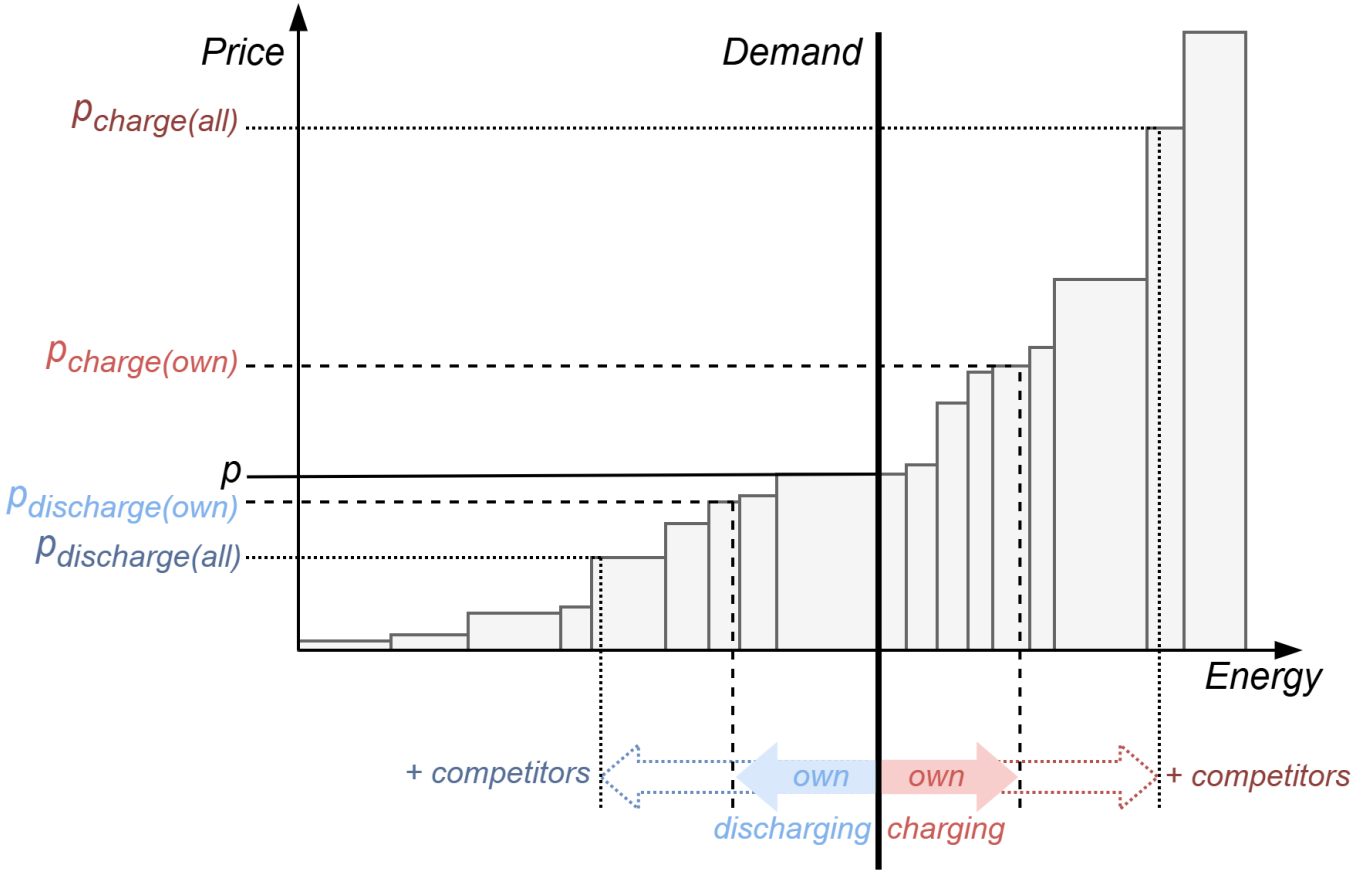
→ Represent as “**multiplier**” relative to own dispatch



Modelling Competing Flexibilities

Apply Multiplier

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



Modelling Competing Flexibilities

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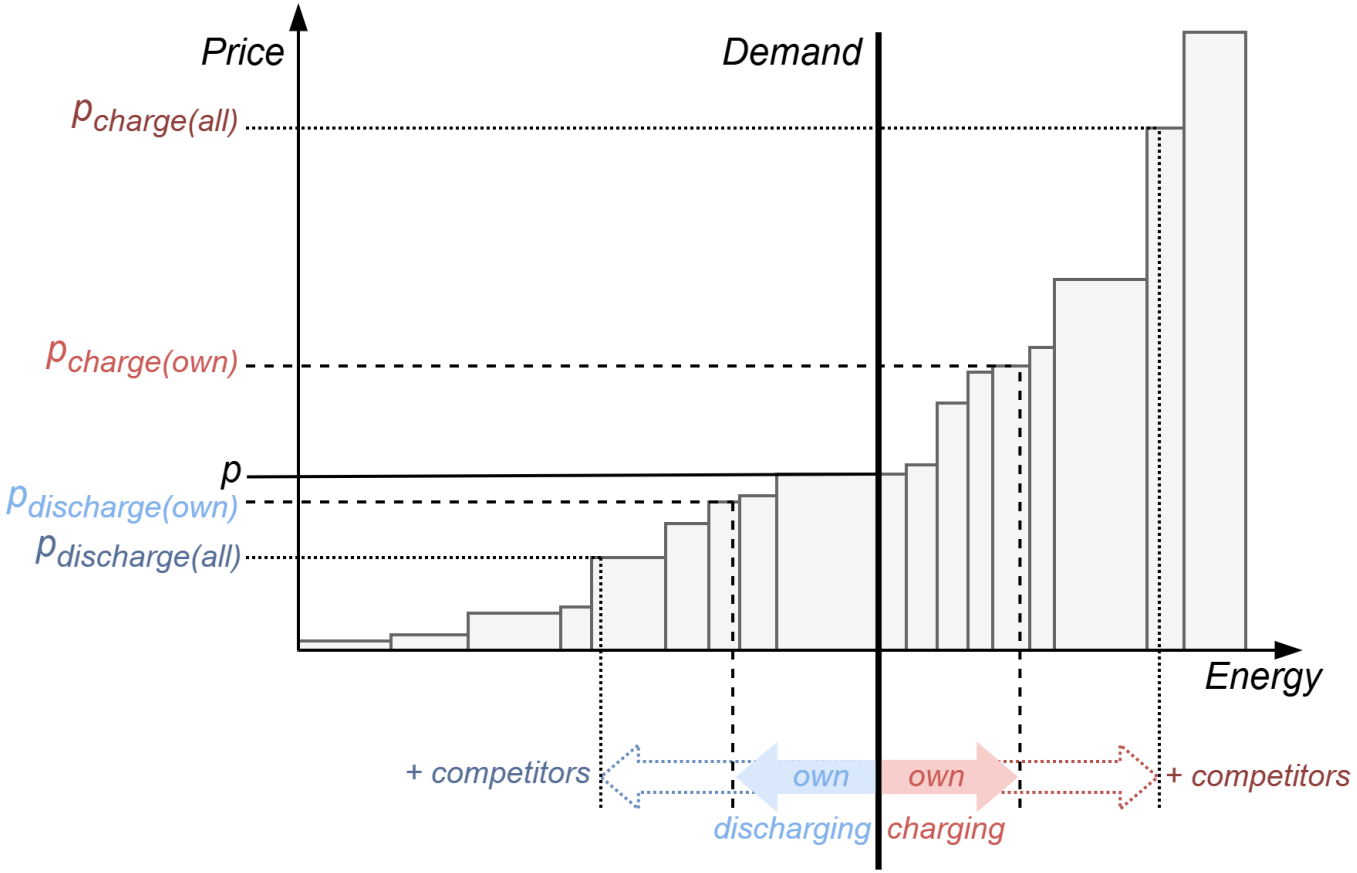
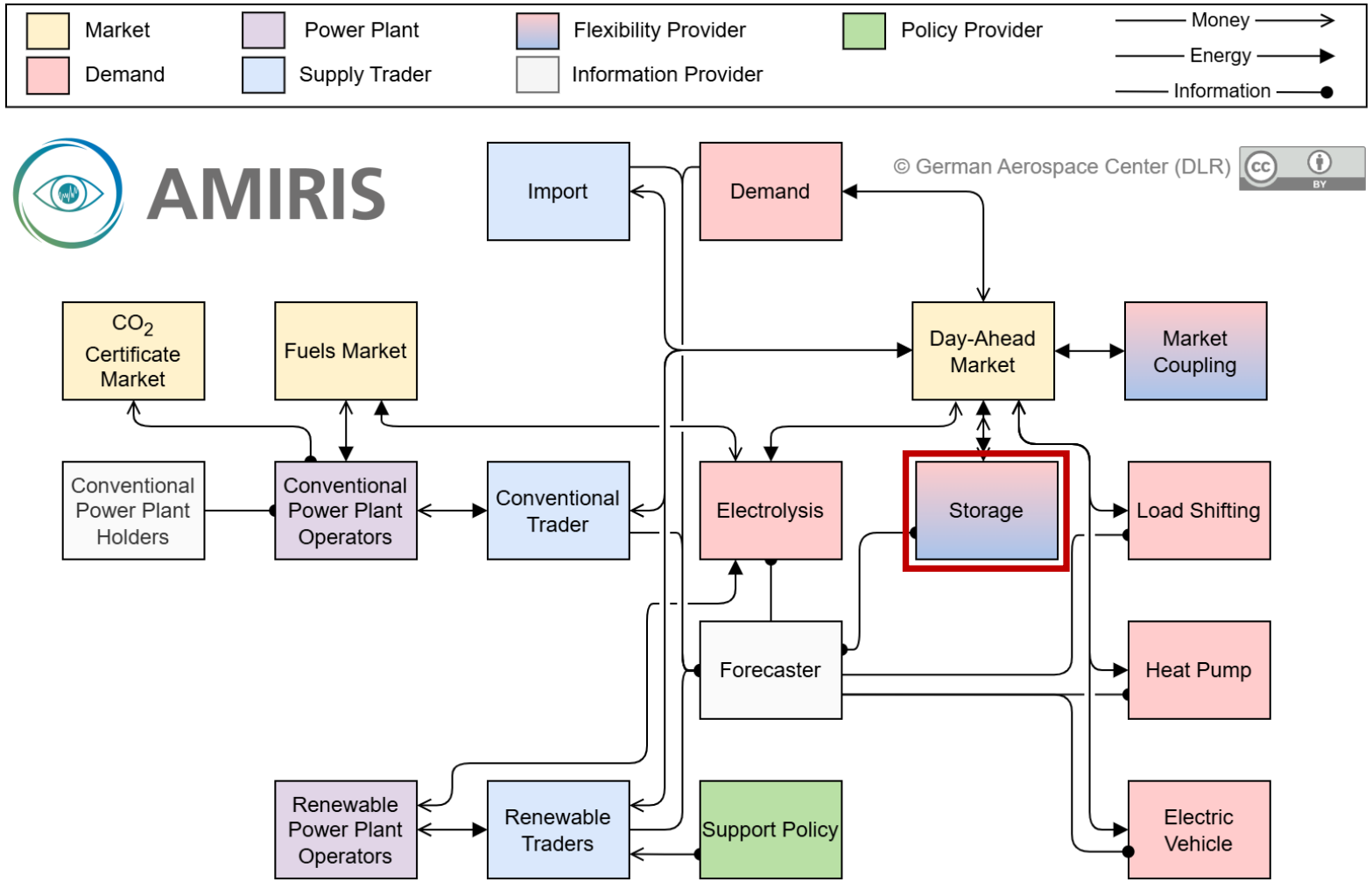


→ Avoids Avalanches

Method: Agent-based electricity market modelling



https://wonderl.ink/@amiris

Setup: Backtesting Germany 2019

3 Strategies

Price Taker

Don‘t consider own (and others‘) price effect

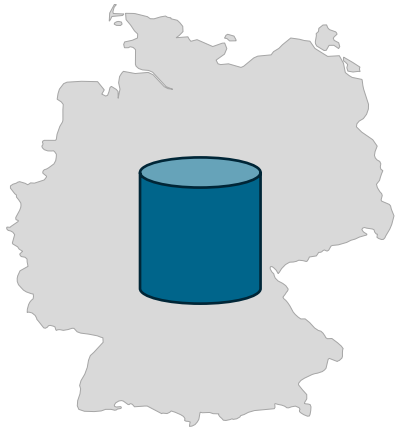
MaxProfit

Seek to maximise own profit, accounting for own (and others‘) price effect

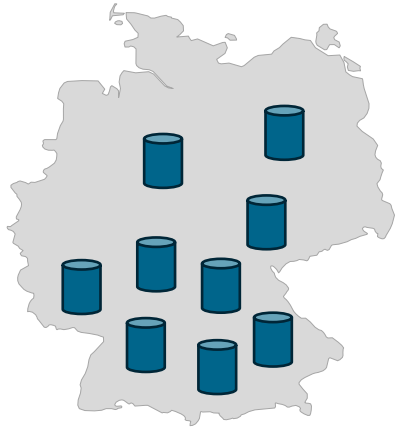
MinCost

Seek to minimise system costs, accounting for own (and others‘) price effect

2 Aggregation Levels

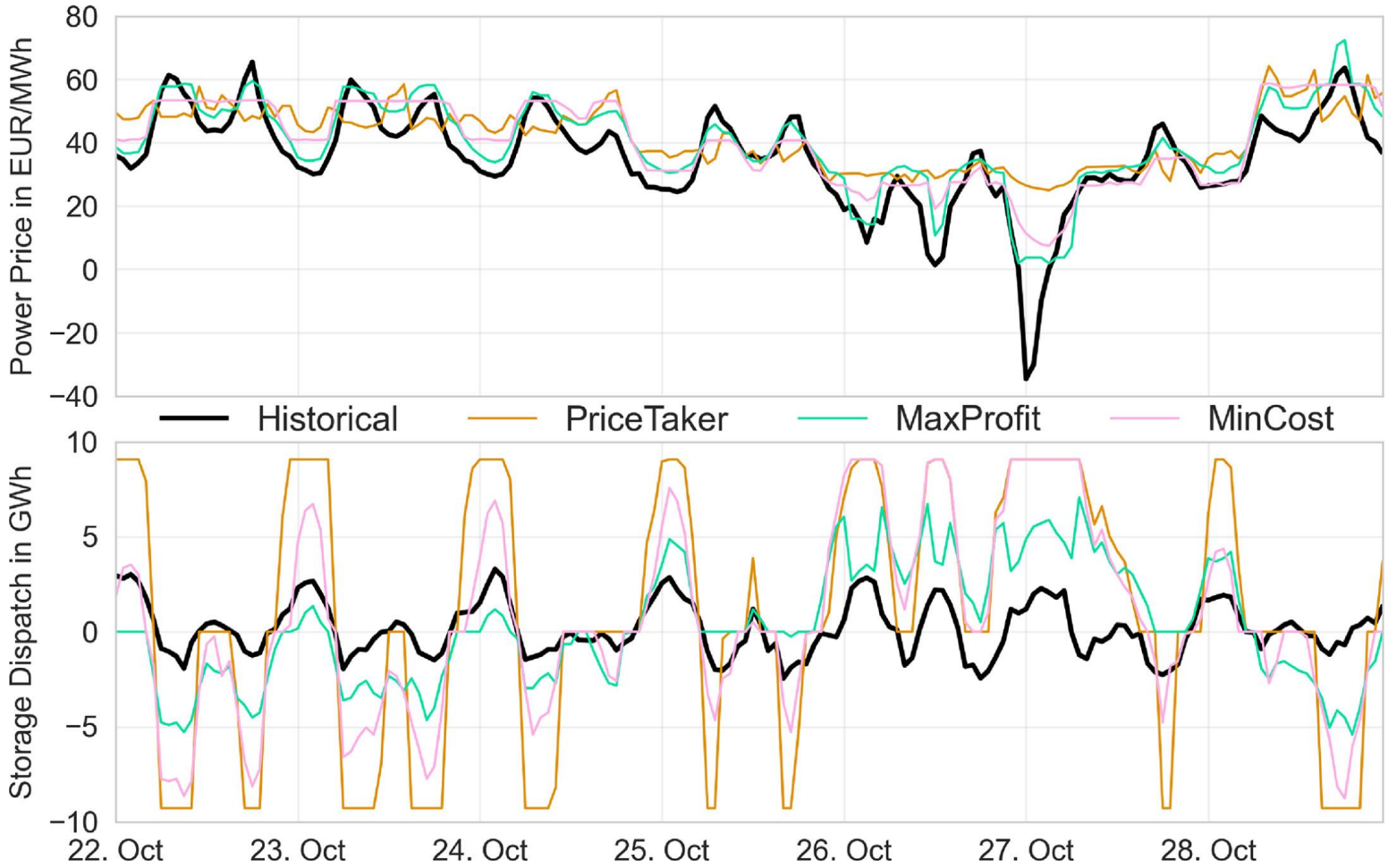


Single Storage



18 Competing Storage Units

Results: Backtesting Germany 2019 – Single Storage



Results: Backtesting Germany 2019 – Single Storage

Metric	Profit maximisation price taker	System cost minimisation price maker	Profit maximisation price maker
Price correlation	0.62	0.80	**0.87**
Mean average error in EUR/MWh	8.76	6.21	**5.09**

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Dispatch correlation	**0.80**	0.75	0.68
Relative discharged energy	245%	149%	**83%**

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Relative discharged energy	245%	149%	**83%**
Relative profits	−159%	70%	**148%**

Results: Backtesting Germany 2019 – Competing Storages

Metric	Profit maximisation price taker	System cost minimisation competition estimate	Profit maximisation competition estimate
Price correlation	0.66	0.85	**0.87** →
Mean average error in EUR/MWh	8.46	5.37	**5.24** ↗
Dispatch correlation	**0.87** ↗	0.86	0.79
Relative discharged energy	222%	**107%** ↓	72%
Relative profits	−161%	109%	**129%** ↓

Arrows: development of parameter compared to single storage case
Colors: improvement, slightly worse, worse, neutral

What if … we had more battery in the system?

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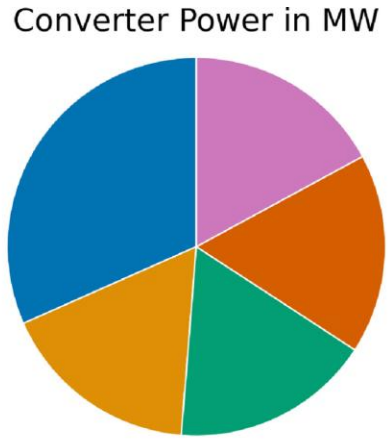
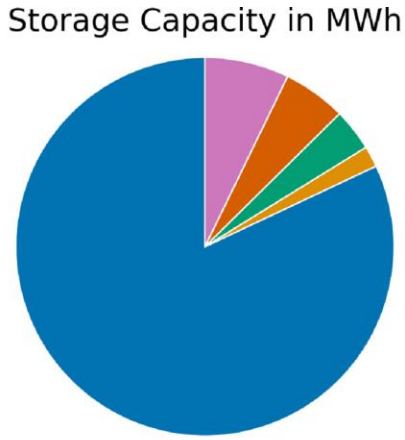
- Added 4 generic storage clusters
- Each with $P = 5\ GW$ and $\eta = 86.5\%$
- Increasing E2P ratio: 1, 2, 3, 4





Pumped Hydro Battery 1 Battery 2 Battery 3 Battery 4

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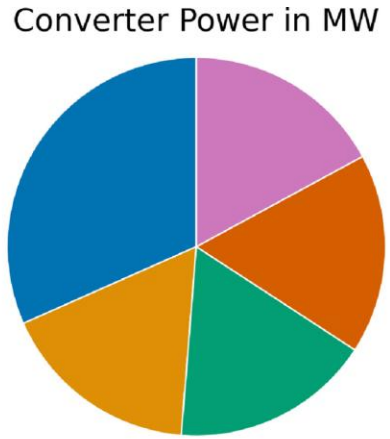

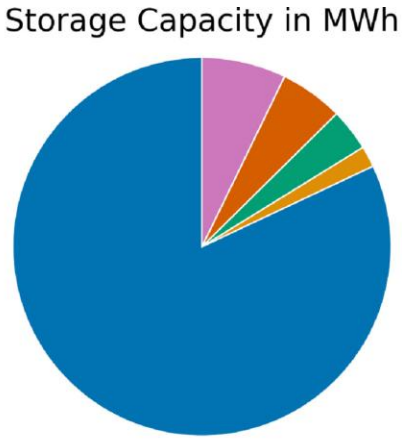

Metric	Scenario	System cost minimisation	Profit maximisation
Discharged Energy Total in TWh	Backtesting	7.32	4.95
Total Profits in M€	Backtesting	105.3	124.2

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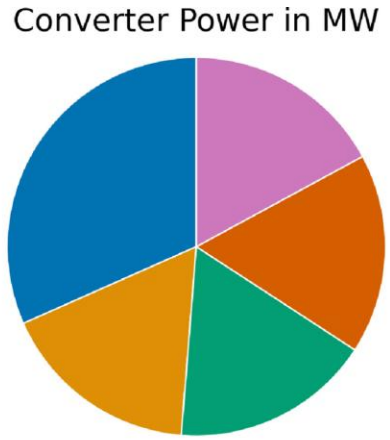

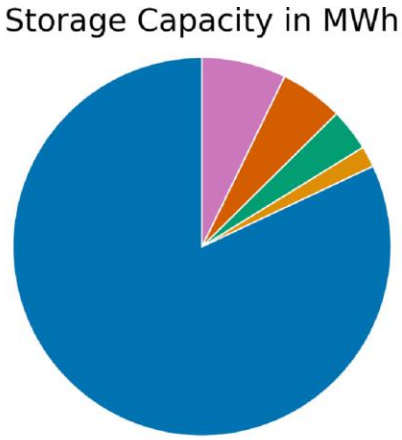

Metric	Scenario	System cost minimisation	Profit maximisation
Discharged Energy Total in TWh	Backtesting	7.32	4.95
	Increased Capacity	10.71 ↗	6.61 ↗
Total Profits in M€	Backtesting	105.3	124.2
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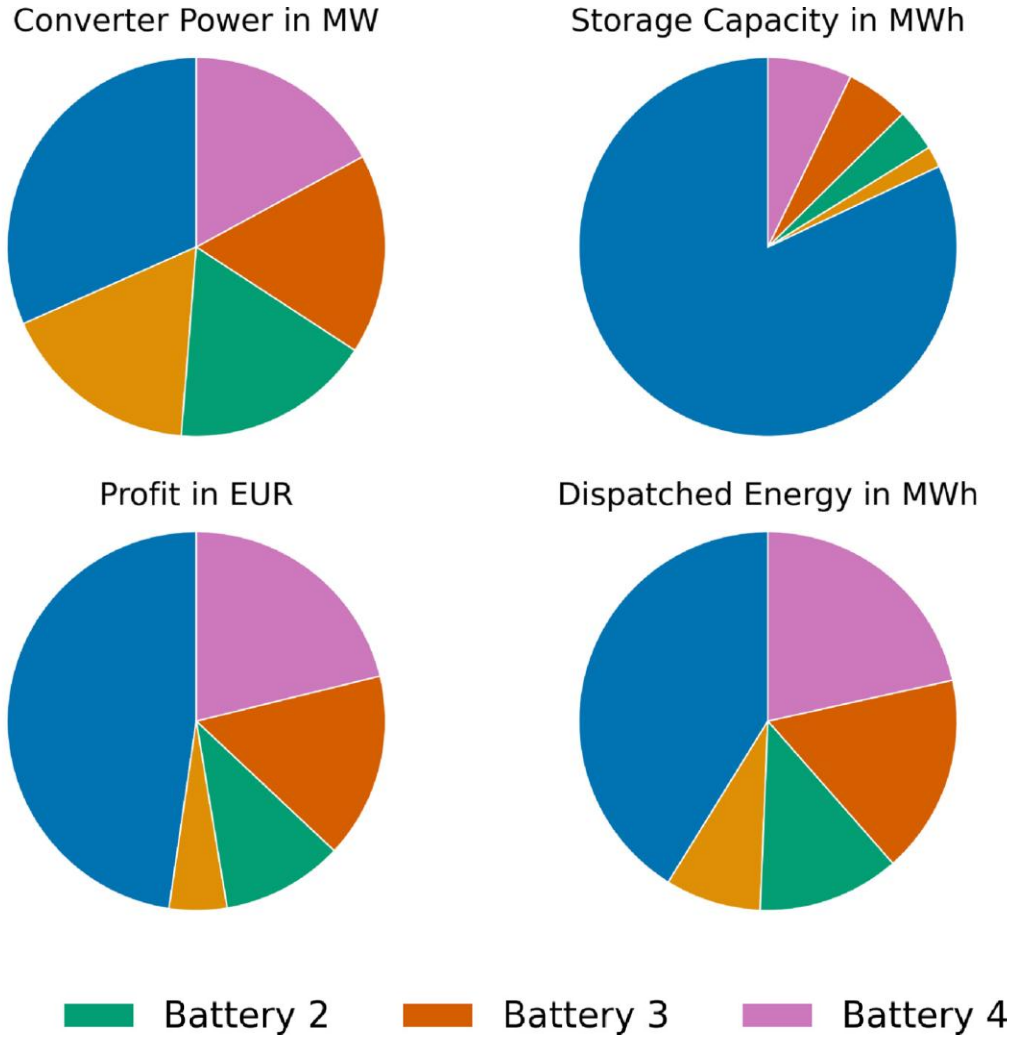

Summary and outlook

- Entire analysis **open source & open data**

Data

- Key takeaways
  - Showcased **new approach for modelling competing storages** and applied it to backtesting scenario for Germany.
  - Prices can be **resembled well**, while profit maximising storages are underused and profits higher than actual.
  - Profit **cannibalisation** is evident for increasing storage capacities.

Model

- Outlook
  - Apply for highly decarbonized scenarios
  - Apply to other kinds of flexibility options: electric vehicles, heat pumps, load shifting

Paper

Imprint

Topic:	Effective Dispatch Planning for Competing Storage Units in Day-Ahead Electricity Market Simulations
Date:	2026-02-13
Author:	Christoph Schimeczek[1], Felix Nitsch[1, 2], Johannes Kochems[1], Kristina Nienhaus[1]
DLR Institute:	[1] German Aerospace Center (DLR), Institute of Networked Energy Systems
Other Institutions:	[2] BOKU University, Institute of Sustainable Economic Development
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Sources

- BNetzA (2025): Status quo der Batteriespeicheranfragen 2024, https://www.smard.de/page/home/topic-article/216804/218412/status-quo-der-batteriespeicheranfragen-2024, accessed 03.02.2026.
- Schimeczek, C., Nitsch, F., Kochems, J. & Nienhaus, K. (2026): Avoiding avalanches: Effective dispatch planning for competing storage units in day-ahead electricity market simulations, in: *Journal of Energy Storage*, Vol. 148, 2026, 120054, ISSN 2352-152X, https://doi.org/10.1016/j.est.2025.120054.

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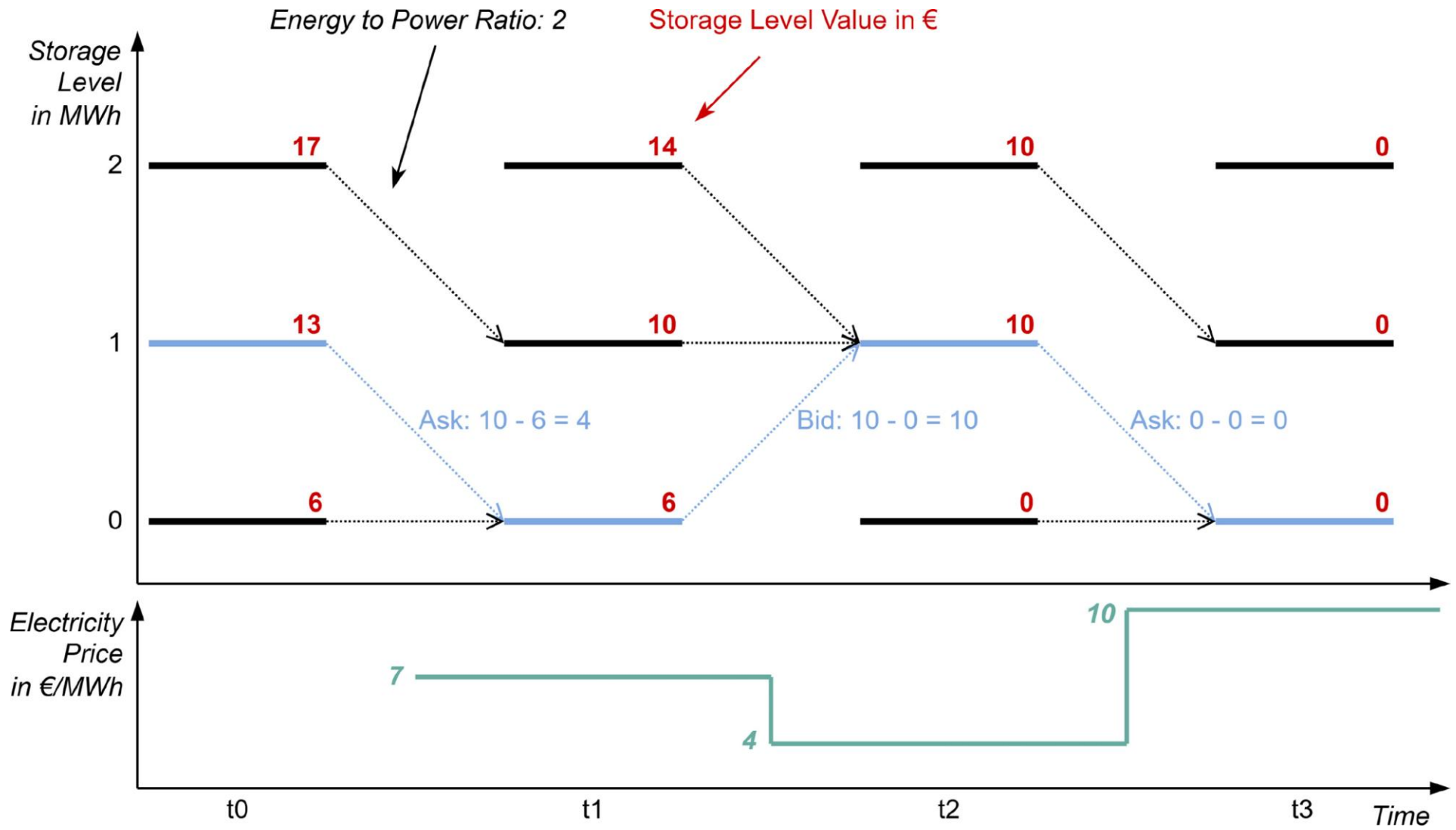
Effective Dispatch Planning for Competing Storage Units

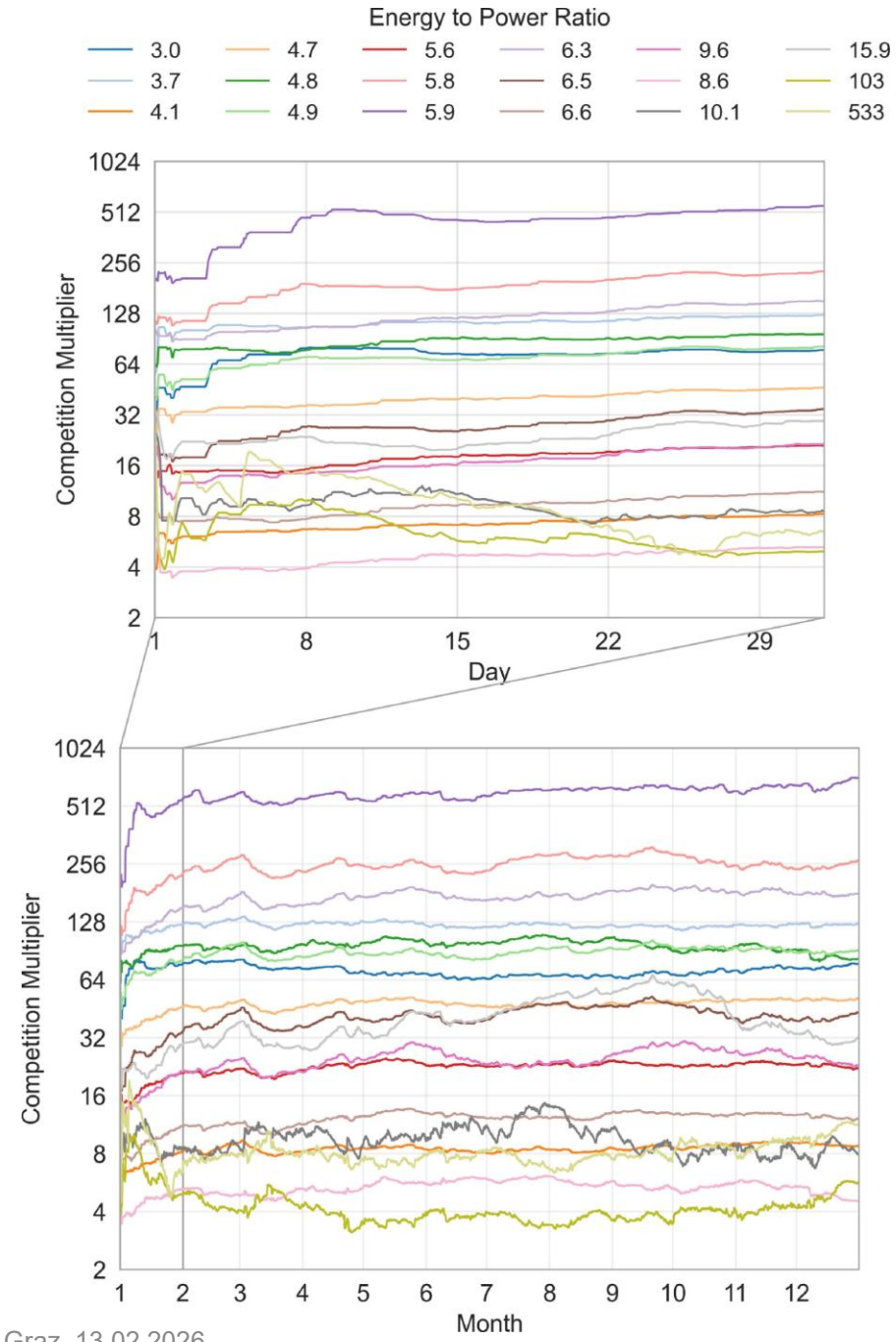
APPENDIX

DLR

Simplistic example for dynamic programming



Competition Multipliers



Determining Competition Multipliers

- Initial estimate: **capacity share** of storage k

$$m_{k,0} = \frac{\sum_{j=1}^{N}(C_j^{\mathrm{c}} + C_j^{\mathrm{d}})}{C_k^{\mathrm{c}} + C_k^{\mathrm{d}}}$$

- Updated estimate: **share** of storage k **on total net awarded capacity**

$$m_{k,t} = \frac{\sum_{j=1}^{N} A_{j,t}}{A_{k,t}}$$

- **Decay factor**: Give previous values smaller weight

$$\alpha = \exp\left(-\frac{1}{\tau}\right)$$

- **Moving average**: Blend smoothly to actual estimate

$$\bar{m}_{k,t} = \frac{m_{k,0} \cdot \omega_0 \cdot \alpha_t + \sum_{t'=1}^{t} m_{k,t} \cdot \alpha^{t-t'}}{\omega_0 \cdot \alpha_t + \sum_{t'=1}^{t} \alpha^{t-t'}}$$

$m_{k,t}$	multiplier of storage k at time t
C_k^{c}	charging capacity of storage k
C_k^{d}	discharging capacity of storage k
$A_{k,t}$	net awarded capacity of storage k at time t
α	decay factor
τ	decay time constant
ω_0	initial weight