Utility-scale batteries in the power system

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9 September 2025

Welfare effects of utility-scale batteries

Added value on the market

- Charge when prices are low and discharge when prices are high
- Economic added value: Lower electricity generation costs through cheaper generators

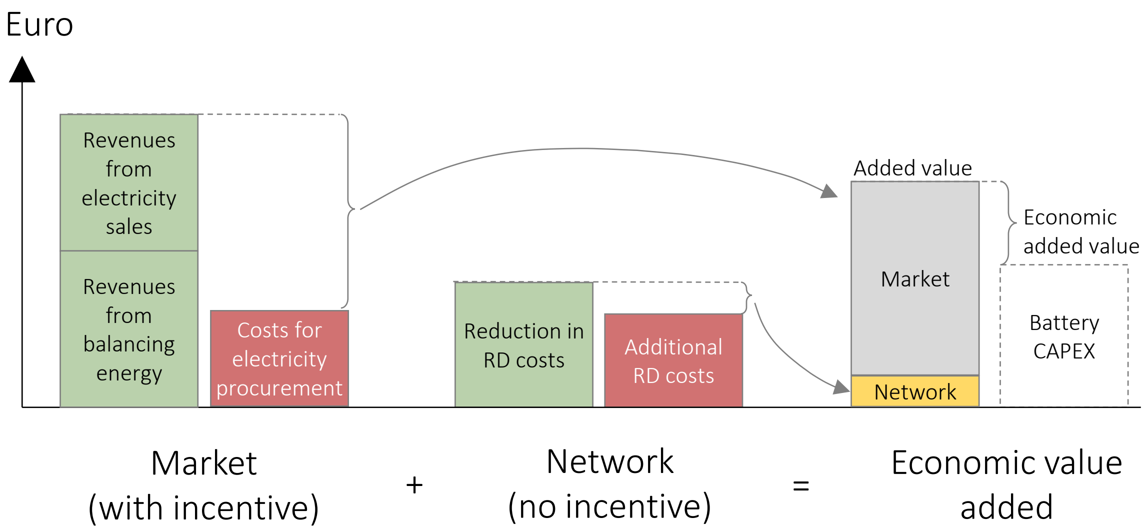
Added value for the grid

- Charge when there is a local electricity surplus and discharge when there are no bottlenecks
- Economic added value: Avoidance of redispatch and, in the long term, grid expansion

Economic value added = market + grid

- Electricity market-optimized battery operation maximizes added value on the market
- Added value in the grid is one (of several) external effect of battery operation

Welfare effect of a large battery (illustrative)



Effect of utility-scale batteries on redispatch needs

A recent Neon study

- Published last week
- Commissioned by ECO STOR

Network effect of batteries

- In this study: impact of batteries on redispatch needs
- Focus: Battery in Bollingstedt with 103 MW / 220 MWh
- Based on historical data from 2024
- Battery participation in all markets (DA, ID-Auction, ID-continuous, aFRR, FCR)

KURZSTUDIE

Netzdienlichkeit von Großbatterien

Netzwirkung von Großbatterien heute und Instrumente zur Entlastung der Stromnetze

1. September 2025

Im Auftrag der ECO STOR GmbH

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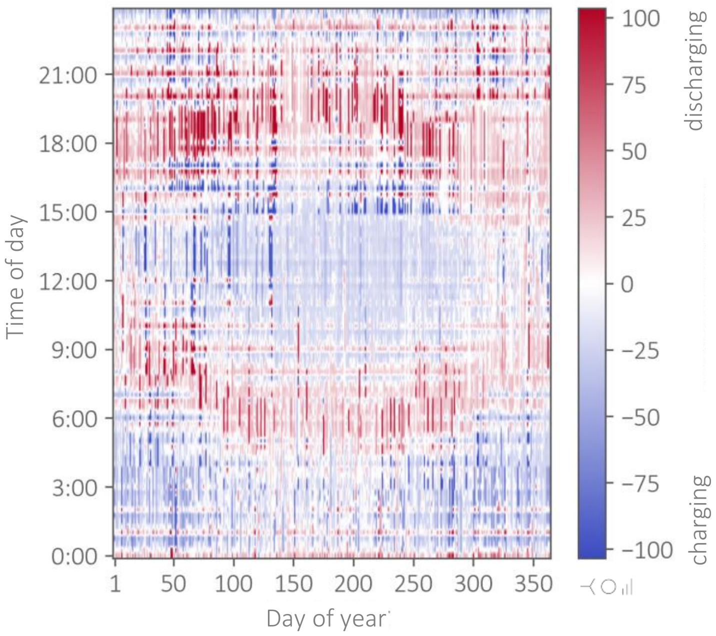
Comparing battery dispatch and redispatch needs

Battery operation



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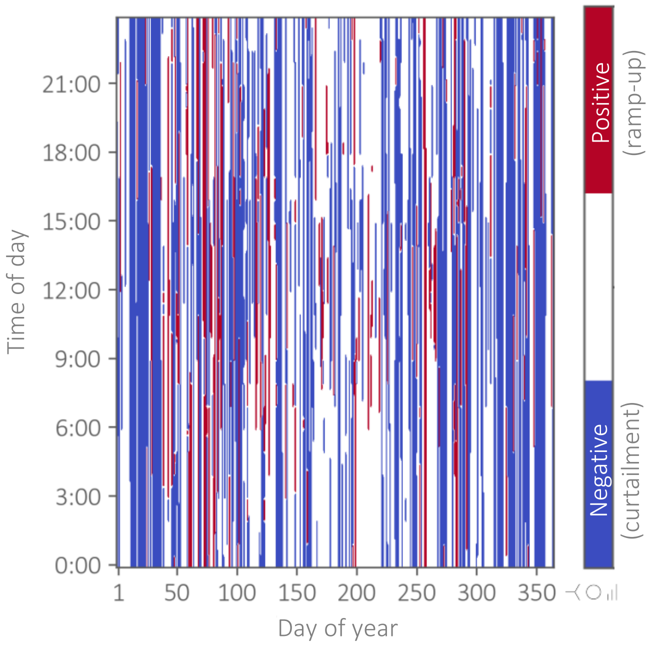
Regional redispatch needs
in northwest Germany



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Effect of battery on Redispatch needs
in northwest Germany

	charging	idle	discharging
Positive RD (ramp-up)	5% network-stressing	1%	4% network-friendly
No RD	24%	8%	20%
Negative RD (curtailment)	20% network-friendly	5%	15% network-stressing

Battery operation

Added value for the network and the market

Small additional value for the network

- Large batteries relieve and burden the network: the net effect is small but slightly positive
- There is no location for batteries that is systematically beneficial to the network

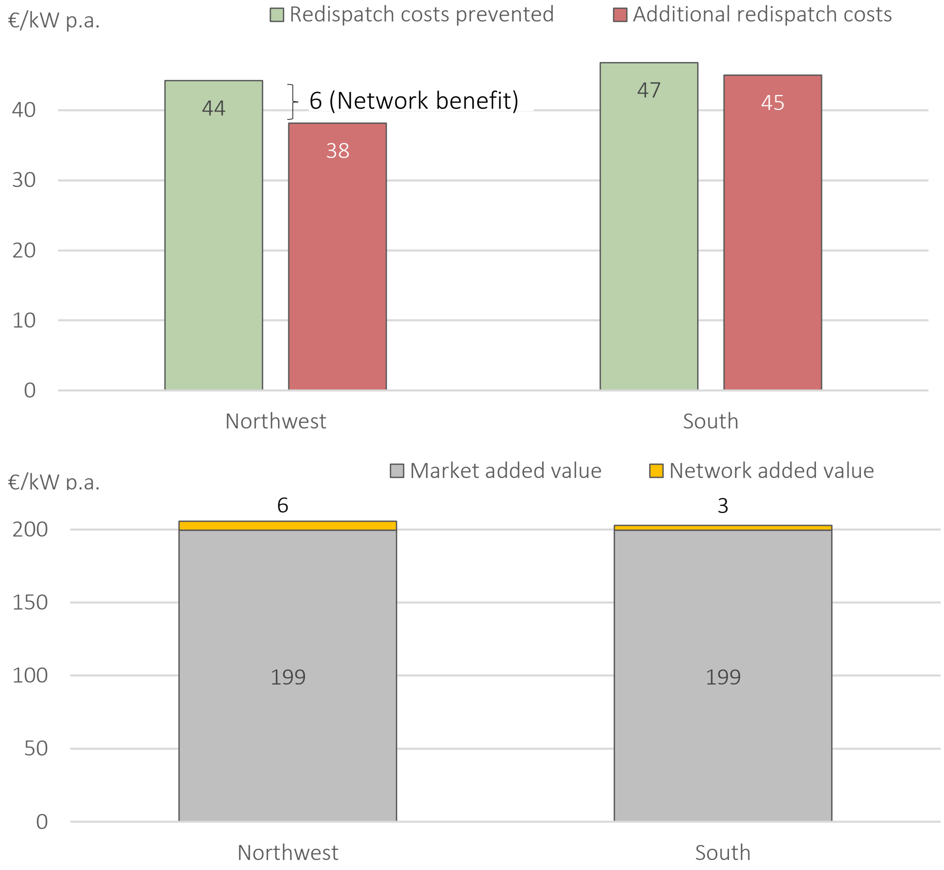
Most value creation on the market

- Revenues from wholesale trading and balancing reserves
- Much higher than value for the network

Network benefit of batteries is far below its potential

- No incentive for a network-friendly operation in current market design

Redispatch change and added value



Instruments to improve the network value

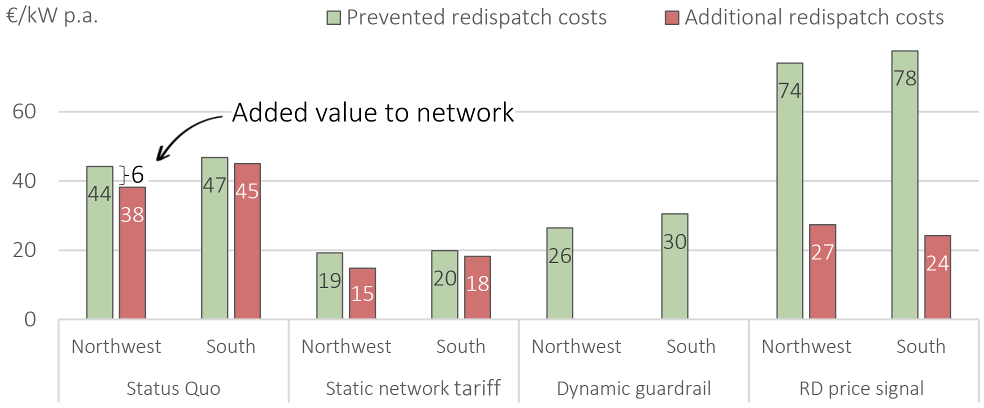
Three instruments studied

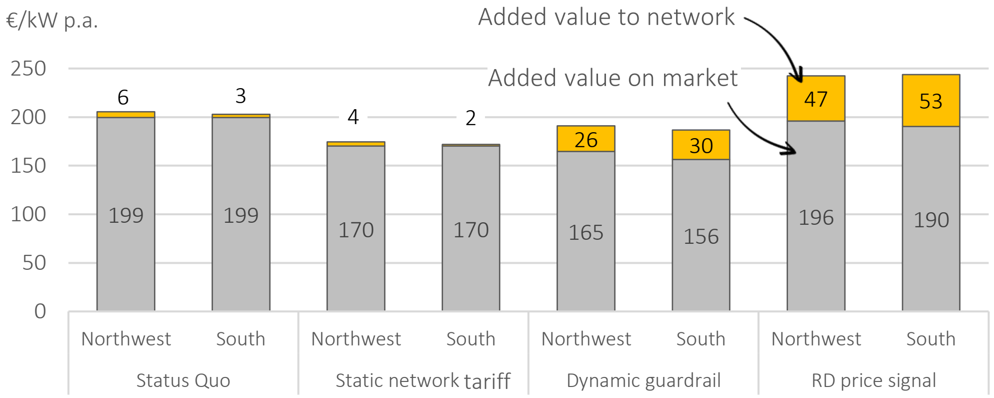
- Static network tariff
- Dynamic guard rail („Leitplanke“)
- Dynamic redispatch price signal

Impact on redispatch needs

- Operation with pure market optimization ("status quo") and static network tariff hardly beneficial to the network
- Dynamic guard rail does not reap potential network benefits of batteries and reduces market benefit
- Dynamic redispatch price signal increases network benefit strongly (8x – 13x)

Redispatch needs and value creation





Network-friendliness (“Netzdienlichkeit”)

No uniform definition

- Network-friendliness hard to defined in economic terms (gray area between market and network)
- Also no deeper analytical value of the term
- In a scientific context, we would simply dispense with the term altogether
- But the term has become established in the energy policy debate and is also crutial in law and regulation (building law, network fee reform, etc.)

Market	... gray area ...	Network
• Day-ahead • Intraday	• Balancing reserves • Imbalance energy • Instantaneous reserve • Black start capability • Dispatch within the billing period	• Network bottlenecks / redispatch • Voltage control / Reactive power

A possible definition of network-friendliness

The effect of the battery on total grid costs

- "The network-friendliness of a large battery is its effect on the total costs of the German electricity grid; a battery is therefore network-friendly if it reduces overall grid fees."
- Explicitly across network levels (not only on the connection network level)
- Includes effects on grid expansion/redispatch, voltage maintenance, etc., but also the more cost-effective provision of system services such as balancing power
- For example: total grid fees, “Erlösobergrenze”

Neon Neue Energieökonomik is an energy consulting firm based in Berlin. As a boutique firm, we have specialized in sophisticated quantitative and economic-theoretical analyses of the electricity market since 2014. Through consulting projects, studies, and training courses, we support decision-makers in addressing the current challenges and future issues of the energy transition. Our clients include governments, regulatory authorities, grid operators, energy suppliers, and electricity traders from Germany and Europe.

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More important: internal vs. external effects

External effects („externalities“)

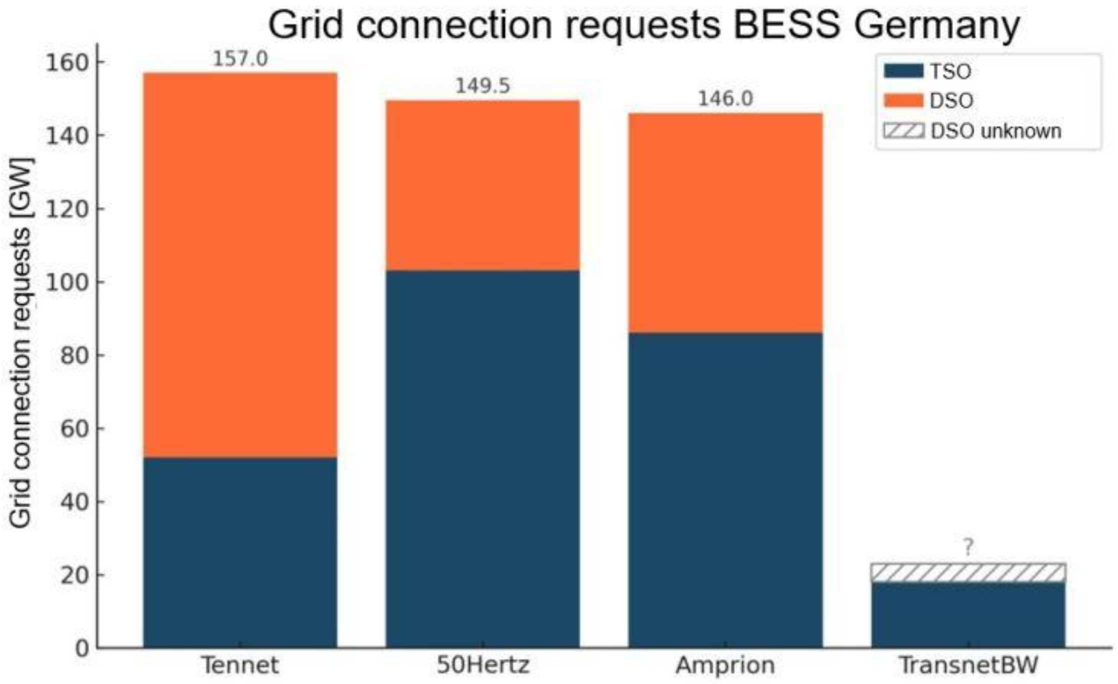
- Batteries have real effects on the power system without being visible
- Consequence: „you don‘t get the most out of the battery"
- Externalities can have positive or negative effects

	Market	... Gray area ...	Network
Internalized ("sees the battery")	• Day-ahead • Intraday	• Balancing reserves • Imbalance energy • Instantaneous reserve • Black start capability	
External effect (“invisible for battery”)		• Dispatch within the billing period	• Network bottlenecks / redispatch • Voltage / Reactive power

Background

Background

- Strong growth and expansion plans for large batteries
- Currently the only technology without government subsidies
- Cautious stance of grid operators and BNetzA towards large batteries
- Main point of criticism: impact of batteries on the power grid



(2025)

Impact of batteries on load flow / congestion

Effect of battery use on redispatch

- Charging the battery in surplus regions reduces curtailment, while discharging increases curtailment
- The opposite is true in regions with shortages
- Only applies to trading transactions up to approx. 2 hours before delivery, because redispatch processes require lead time

Effect of *short-term* trading transactions on grid bottlenecks

- Trading transactions shorter than approx. 2 hours before delivery do not affect (time-consuming) redispatch
- *Spontaneous* charging in surplus regions therefore does not reduce curtailment
- *Spontaneous* discharging in surplus regions causes grid congestion that cannot be resolved by redispatch

Further external effects of large batteries

Misguided incentives within the 15-minute balancing period

- Requirement for balancing group equilibrium only in the 15-minute average
- Batteries can balance their own balancing group on average through short-term but significant deviations from the schedule or take on a system-supporting position on average
- High imbalances within the quarter hour can cause large ACE → requires high FRR deployment
- Applies to all market participants in principle, but particularly relevant for batteries due to their high flexibility

Influence on voltage stability

- Frequent switching between grid consumption and feed-in causes local voltage fluctuations
- Causes additional work for grid operators in grid strings with regulating transformers
- Overall effect very small compared to other aspects