



Market and Technology Development of Decentralized Battery Storage Systems in Germany

inspired workshop

Vienna 2022

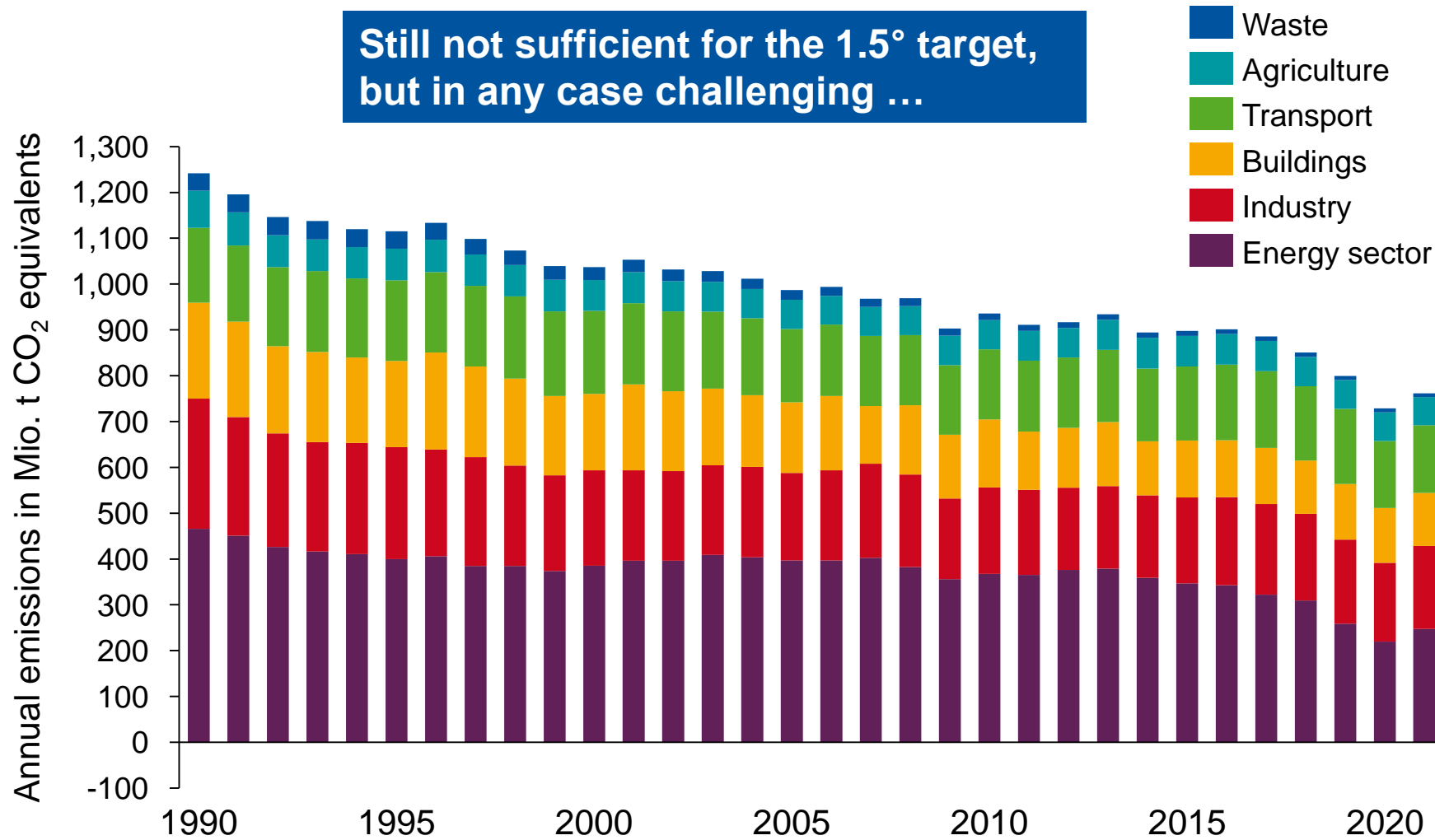
Jan Figgener, Dirk Uwe Sauer

Chair for Electrochemical Energy Conversion
and Storage Systems



CO₂ emissions (1990 – 2020) and targets (2030 – 2045) in Germany by sector

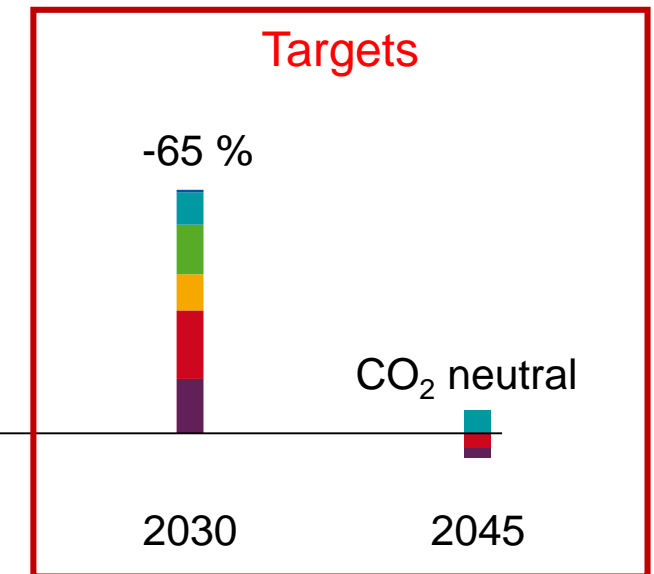
Still not sufficient for the 1.5° target, but in any case challenging ...



Cabinet decision of 12.05.2021:
Tightening of climate targets

Greenhouse gas emissions:

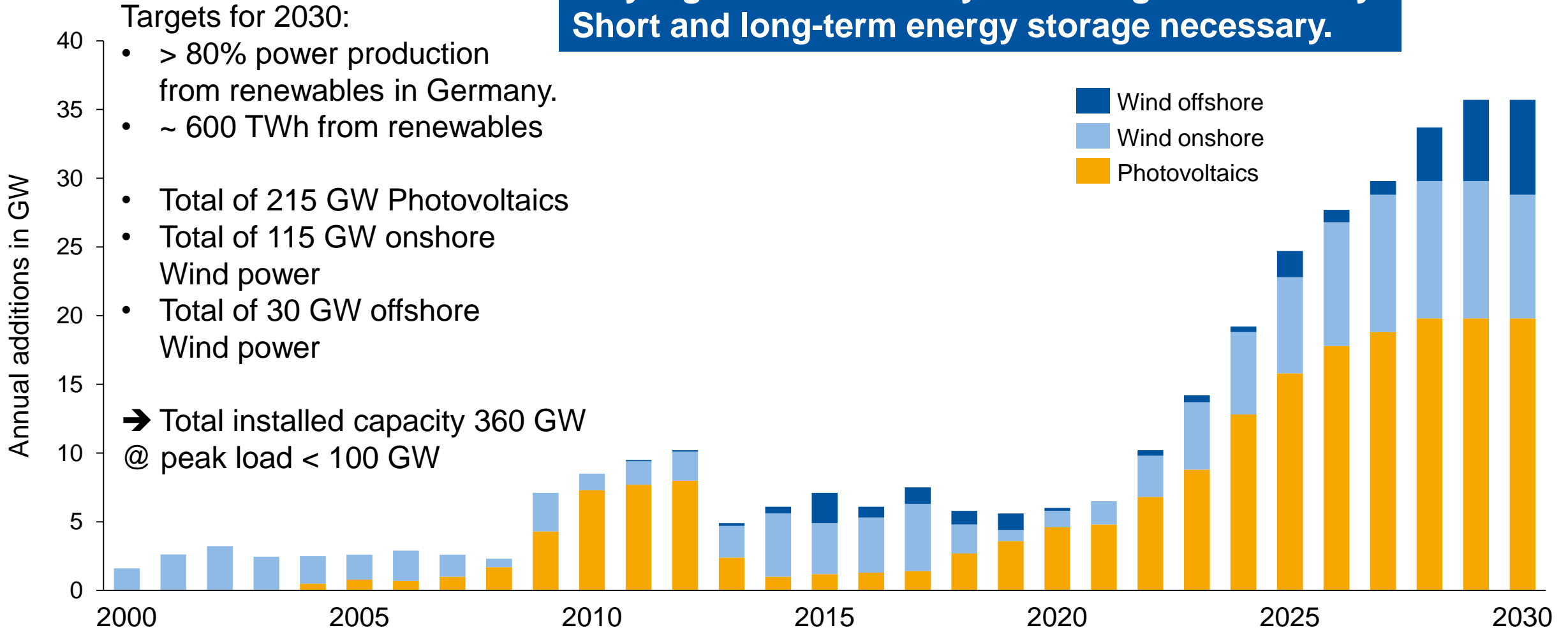
- By 2030: 65% less CO₂ (previously 55%)
- By 2040: 88% less CO₂
- By 2045: Climate neutrality (previously 2050)



Source: [Umweltbundesamt](https://www.umweltbundesamt.de)

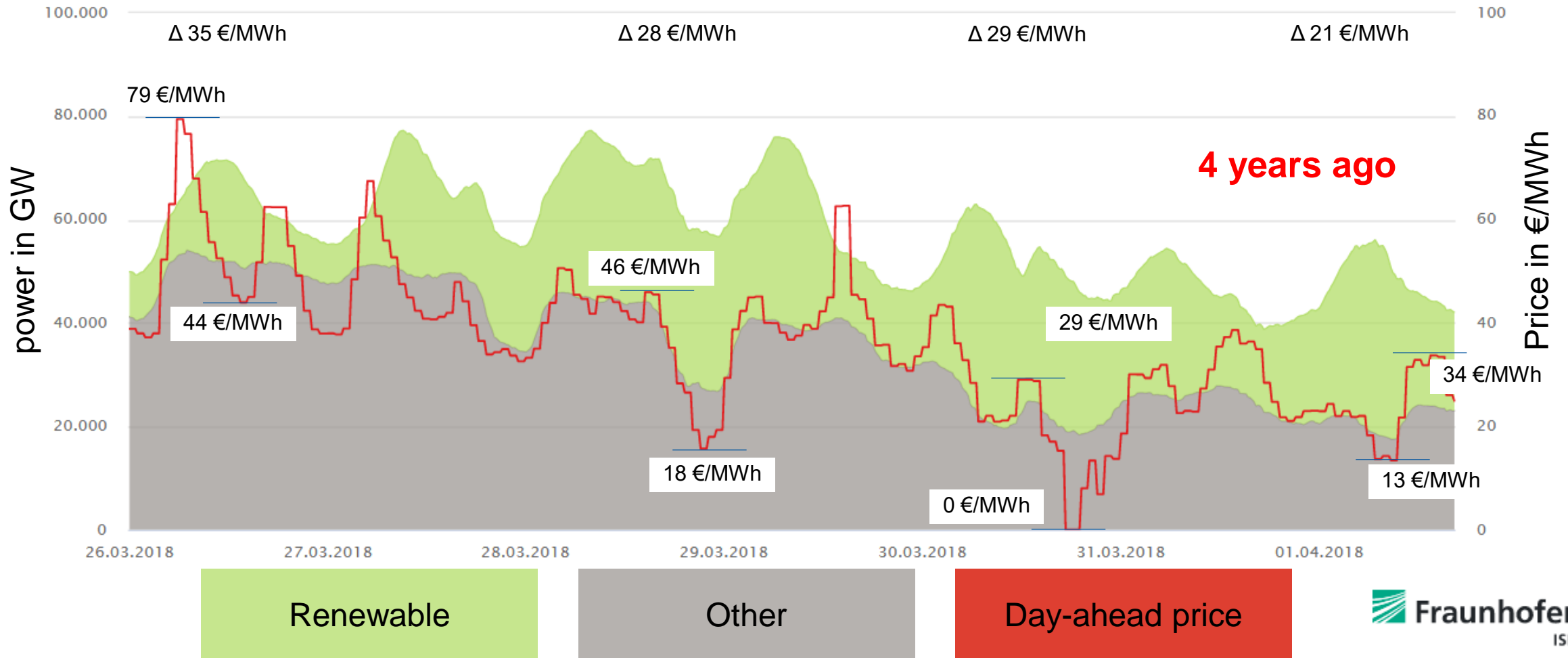
Targets for renewable energy expansion in Germany until 2030

**Very significant flexibility technologies necessary.
Short and long-term energy storage necessary.**



Source: FEDERAL MINISTRY FOR ECONOMIC AFFAIRS AND CLIMATE ACTION

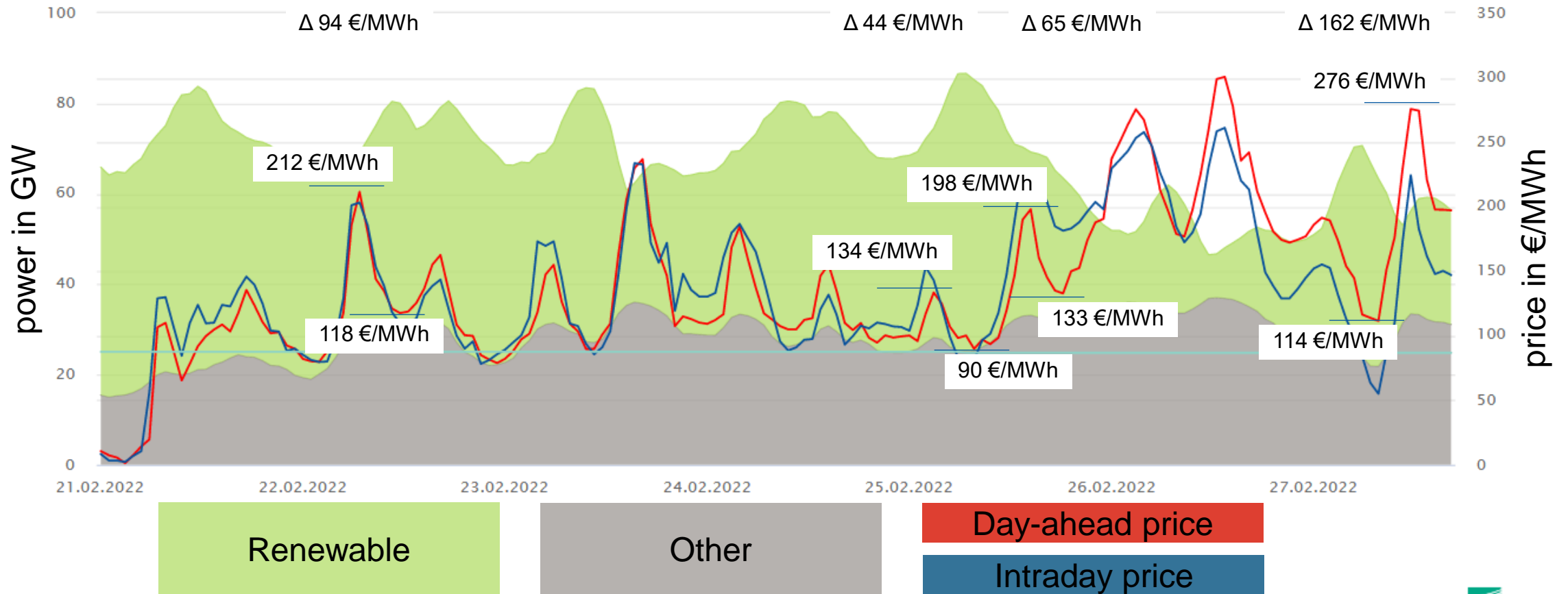
Power production and price at power exchange (Germany, week 13, 2018)



Energy-Charts

Source: www.energy-charts.info

Power production and price at power exchange (Germany, week 8, 2022)



Strong intraday fluctuations in the exchange price make it possible to operate energy storage systems economically.

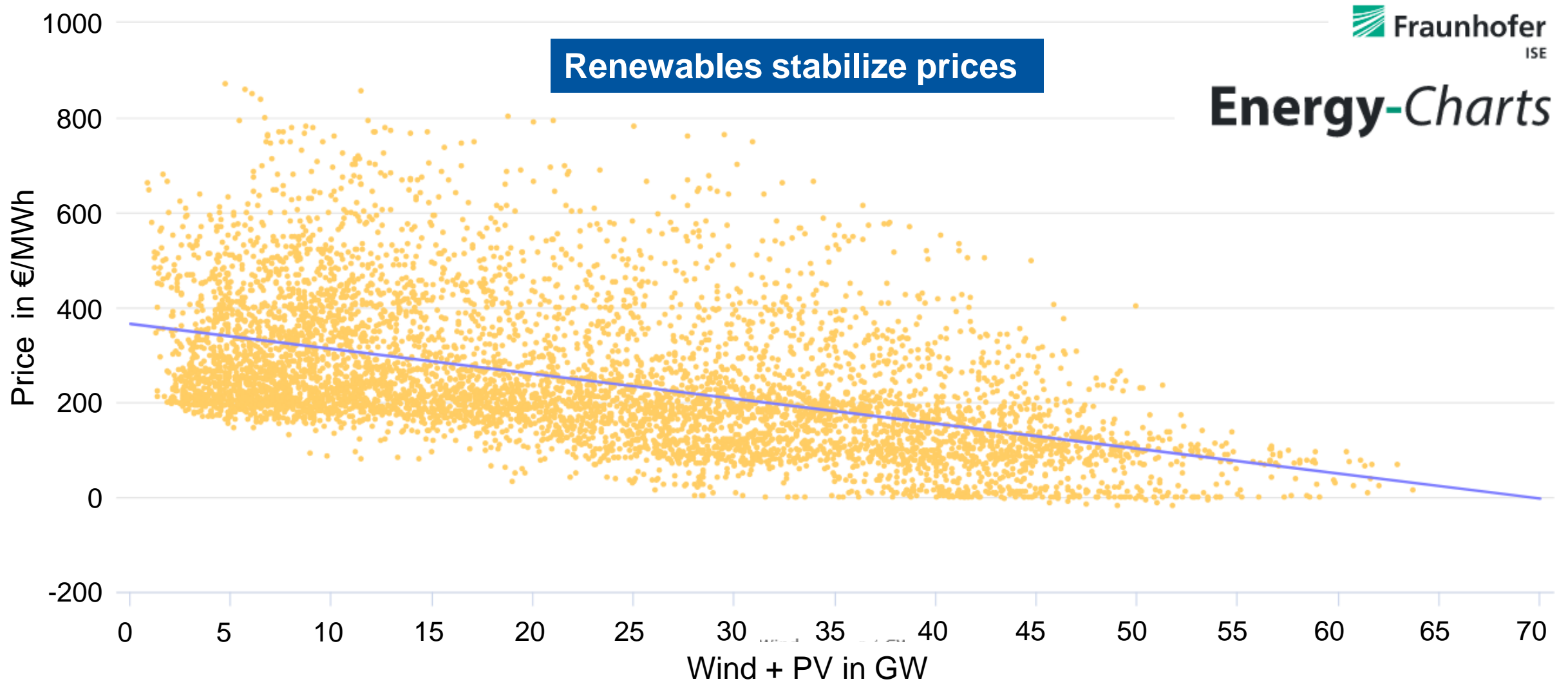


Energy-Charts

Source: www.energy-charts.info

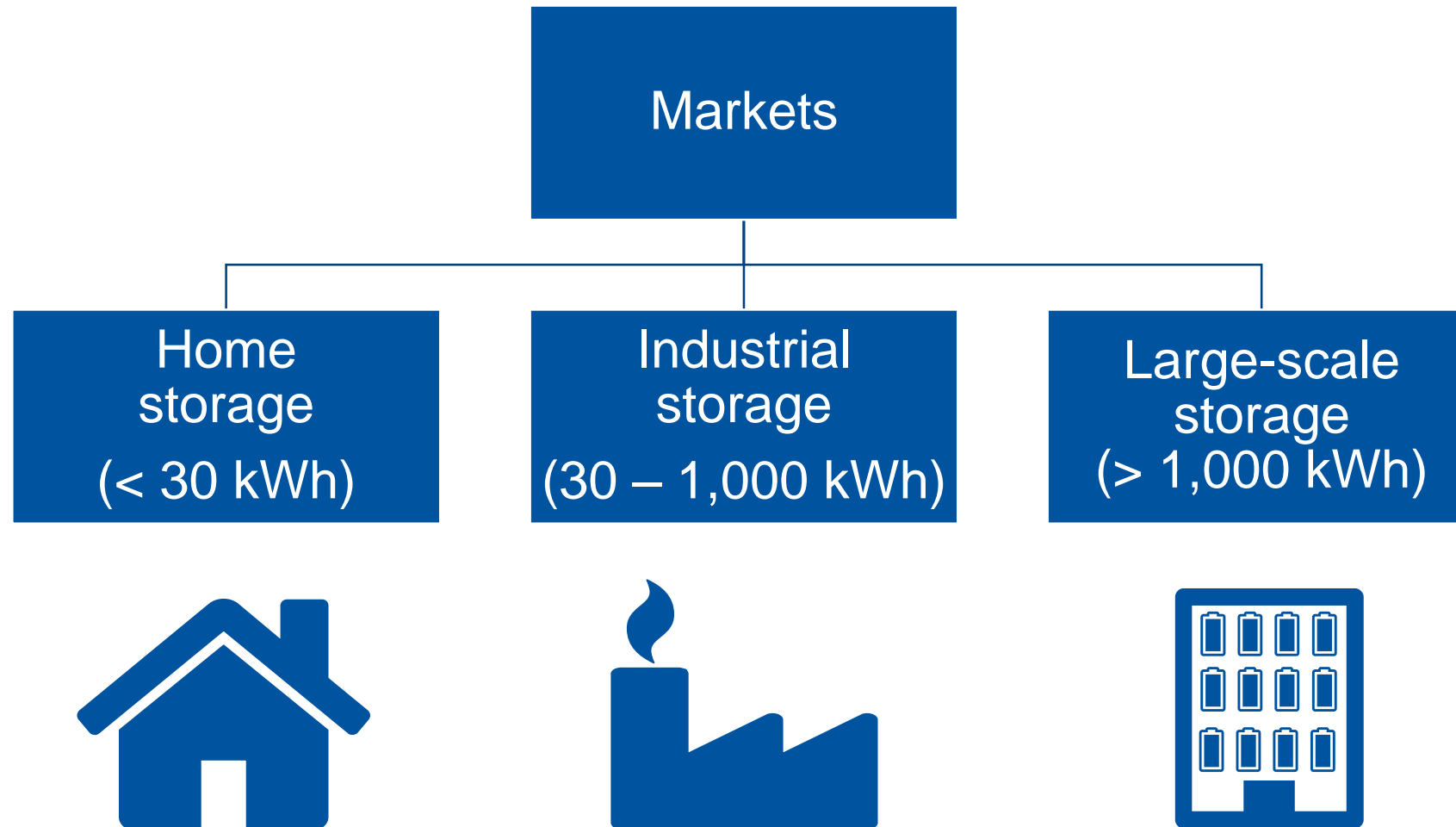
Power day-ahead auction vs. wind plus PV generation in Germany

(01.01. – 18.09.2022)



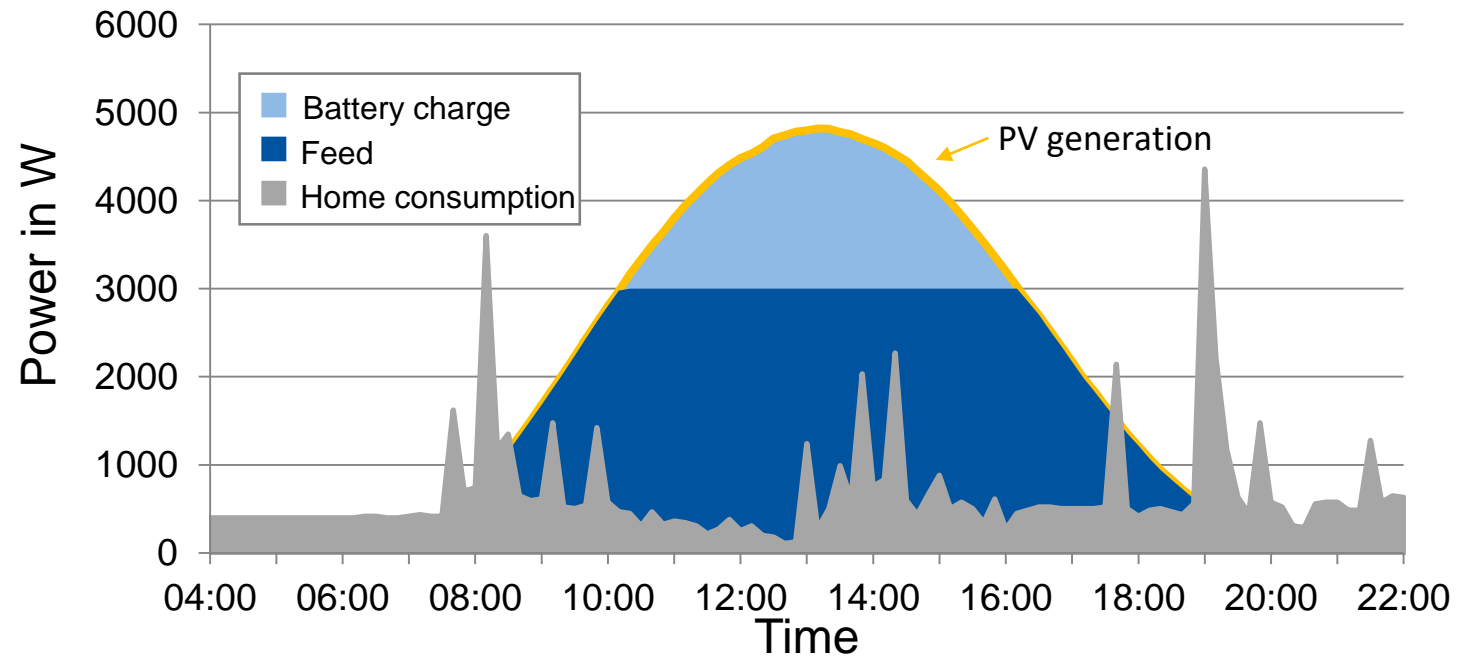
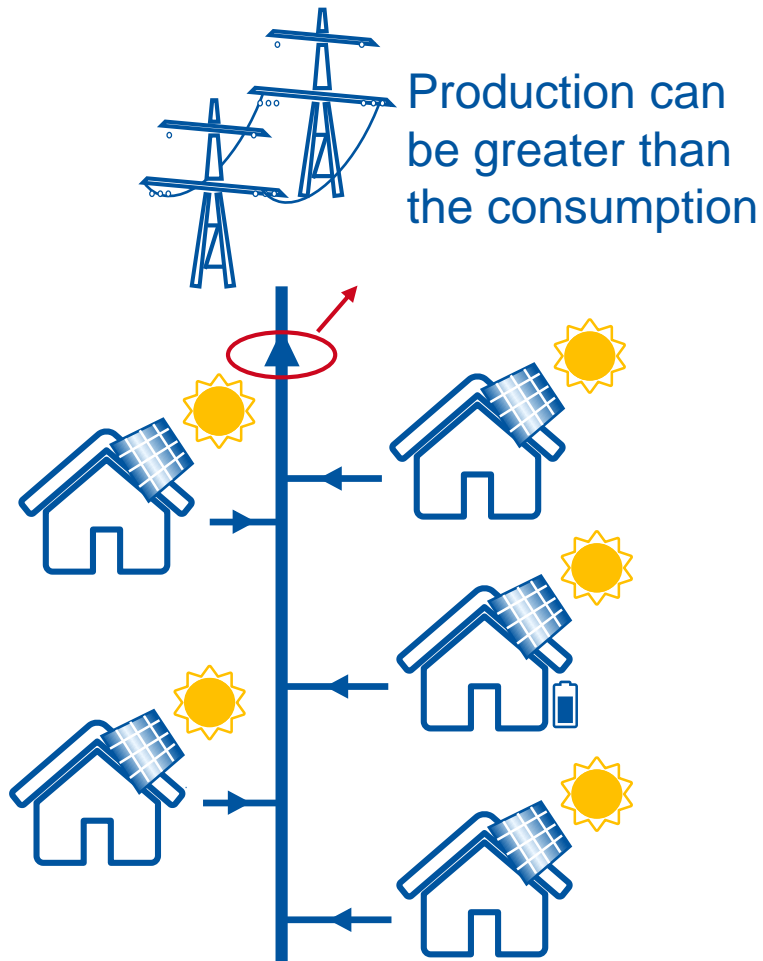
Source: www.energy-charts.info

Overview – Stationary battery energy storage systems

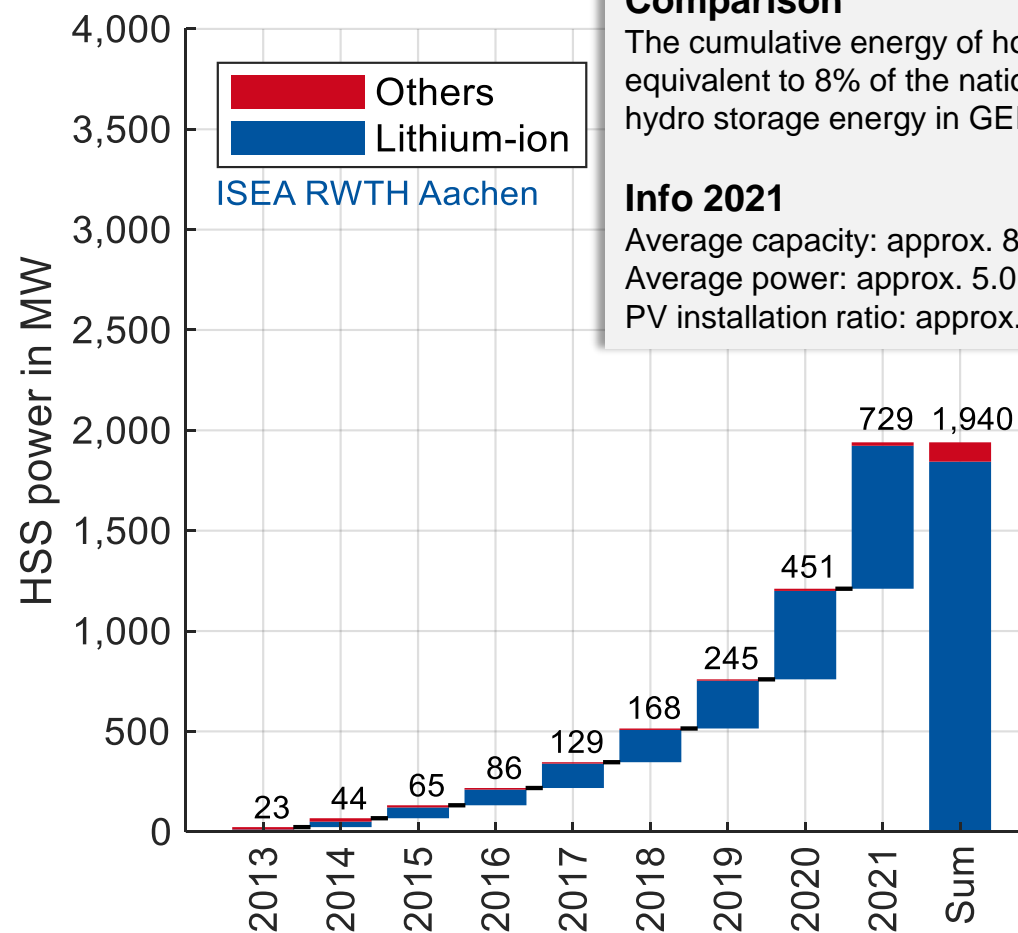
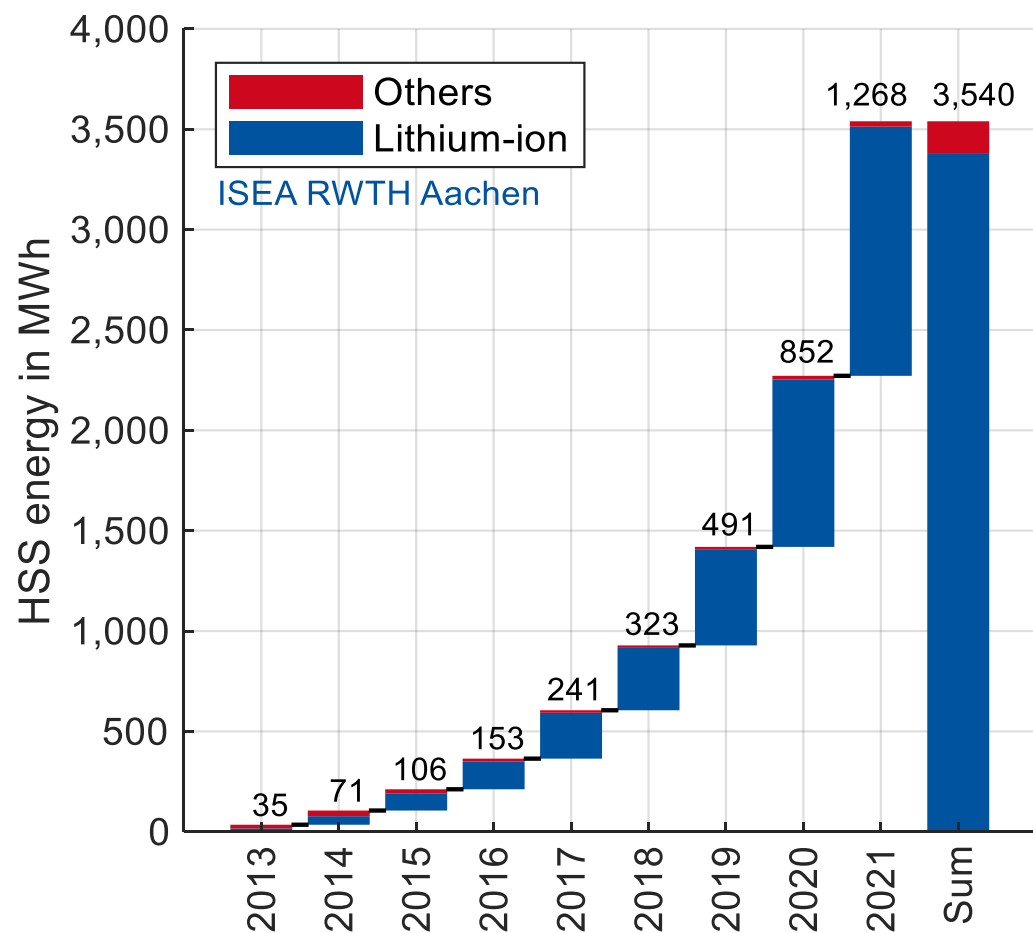


Technical potential of home storage: grid relief

- **Problem:** Possible grid overload due to increased integration of PV systems
- **Solution:** Limitation of the feed-in power by home storage systems



Battery energy and power of home storage systems (HSS) in Germany (430,000 systems)

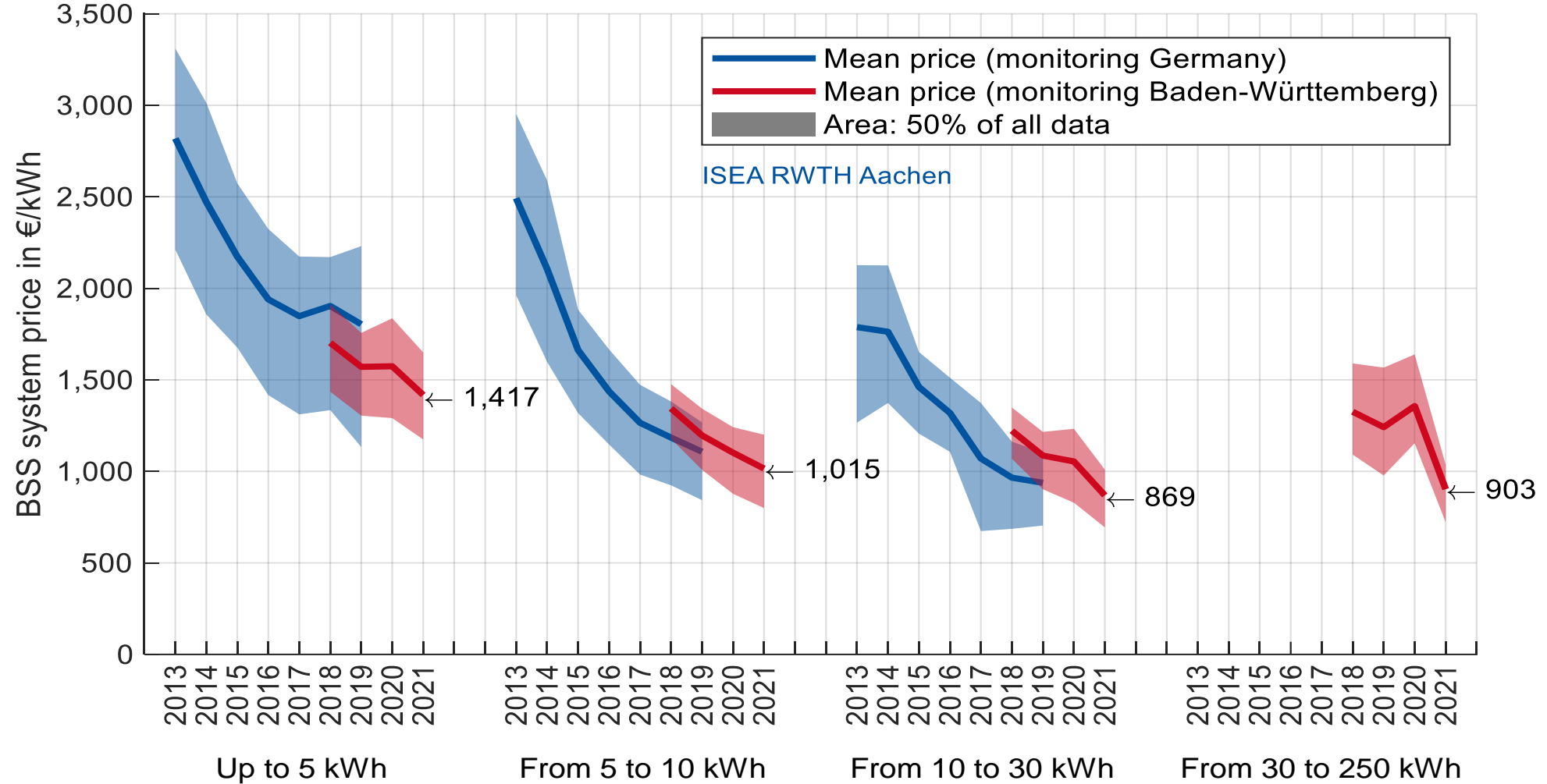


Comparison
 The cumulative energy of home storage is equivalent to 8% of the national pumped hydro storage energy in GER

Info 2021
 Average capacity: approx. 8.8 kWh
 Average power: approx. 5.0 kW
 PV installation ratio: approx. 1 kWh / kWp

Source: based on Figgenger, Hecht et al. 2022: <https://arxiv.org/ftp/arxiv/papers/2203/2203.06762.pdf>

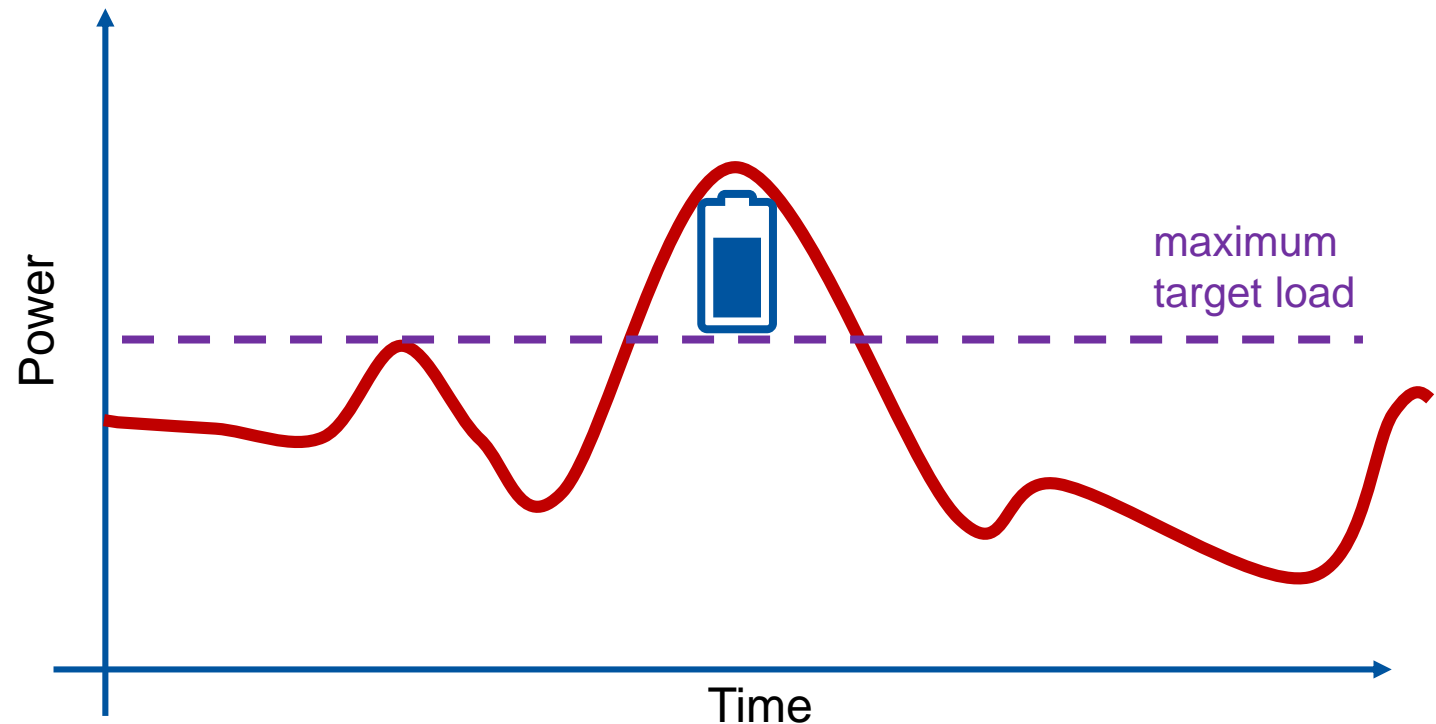
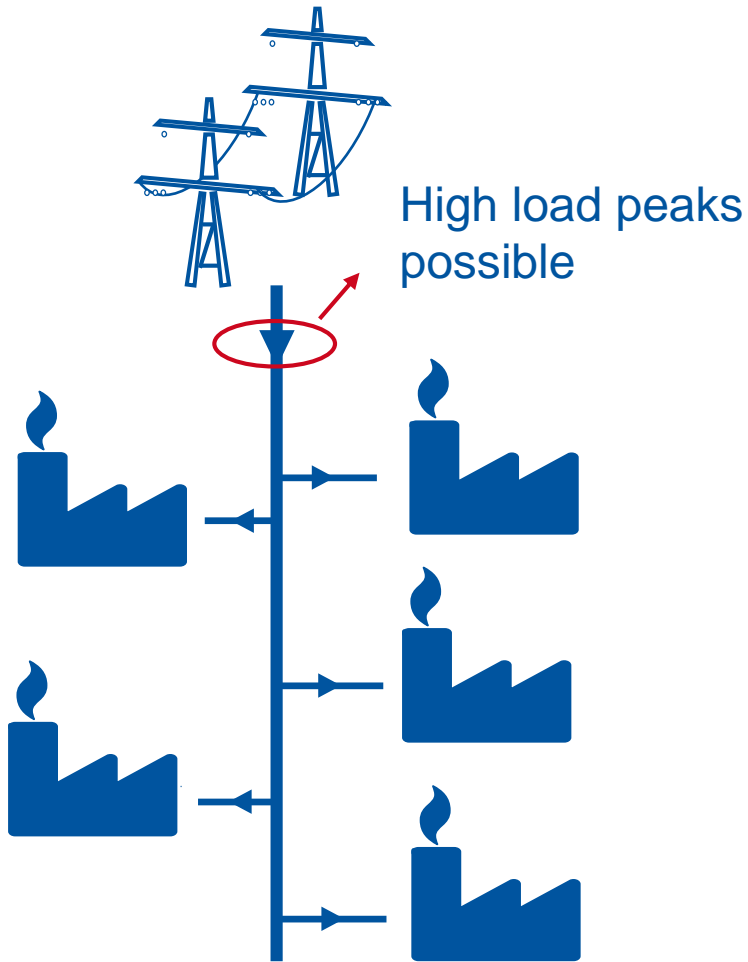
Development of storage system prices of lithium-ion storage systems (including power electronics and VAT)



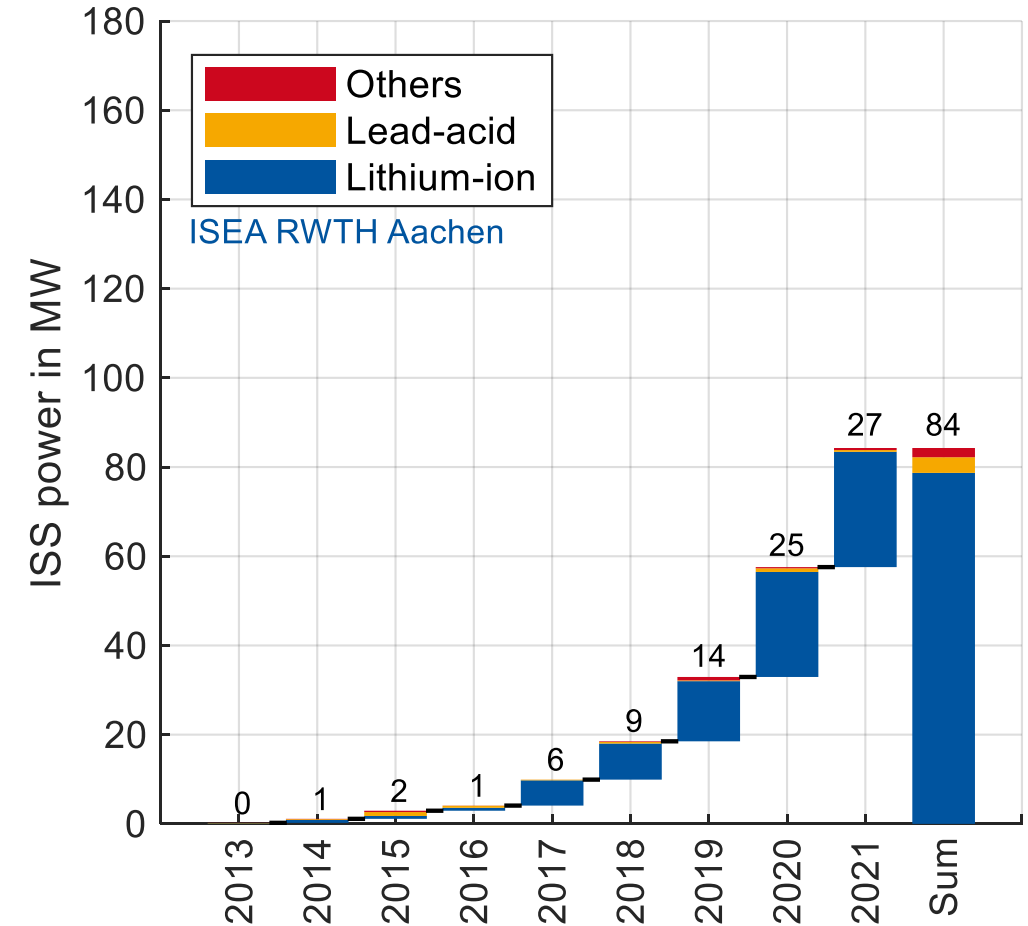
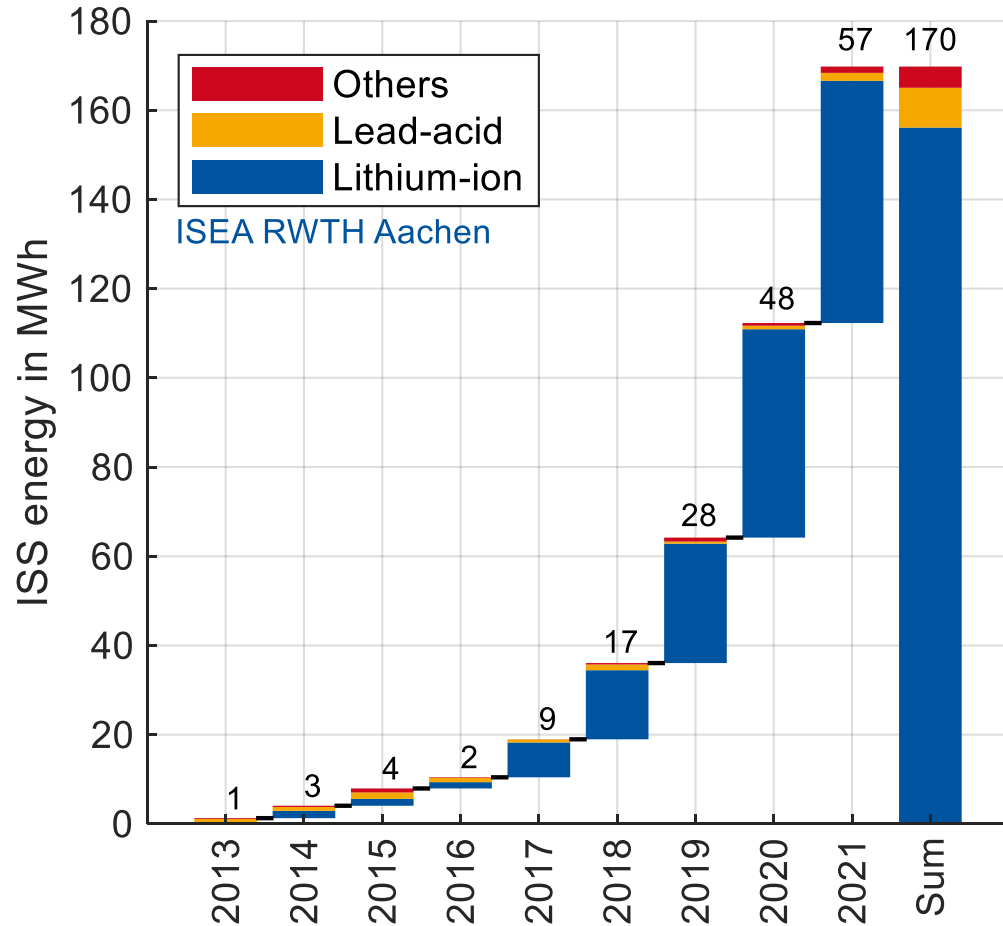
Source: based on Figgenger, Hecht et al. 2022: <https://arxiv.org/ftp/arxiv/papers/2203/2203.06762.pdf>

(One) motivation for industrial storage besides self-consumption: Cost reduction through peak shaving

- Problem: Individual load peaks determine the power price
- Solution: Peak shaving with industrial storage systems
 - Goal: Large power reduction with small battery
→ High savings at low cost

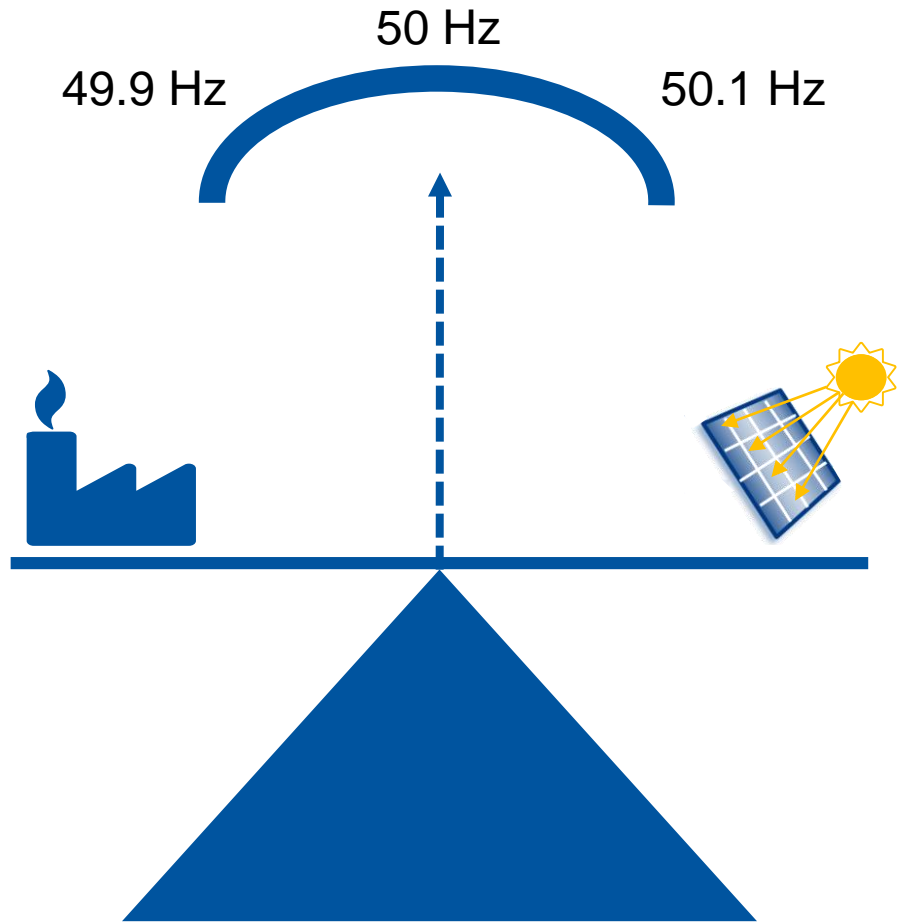


Registered energy and power of industrial storage systems (ISS) in Germany (~2,500 systems)

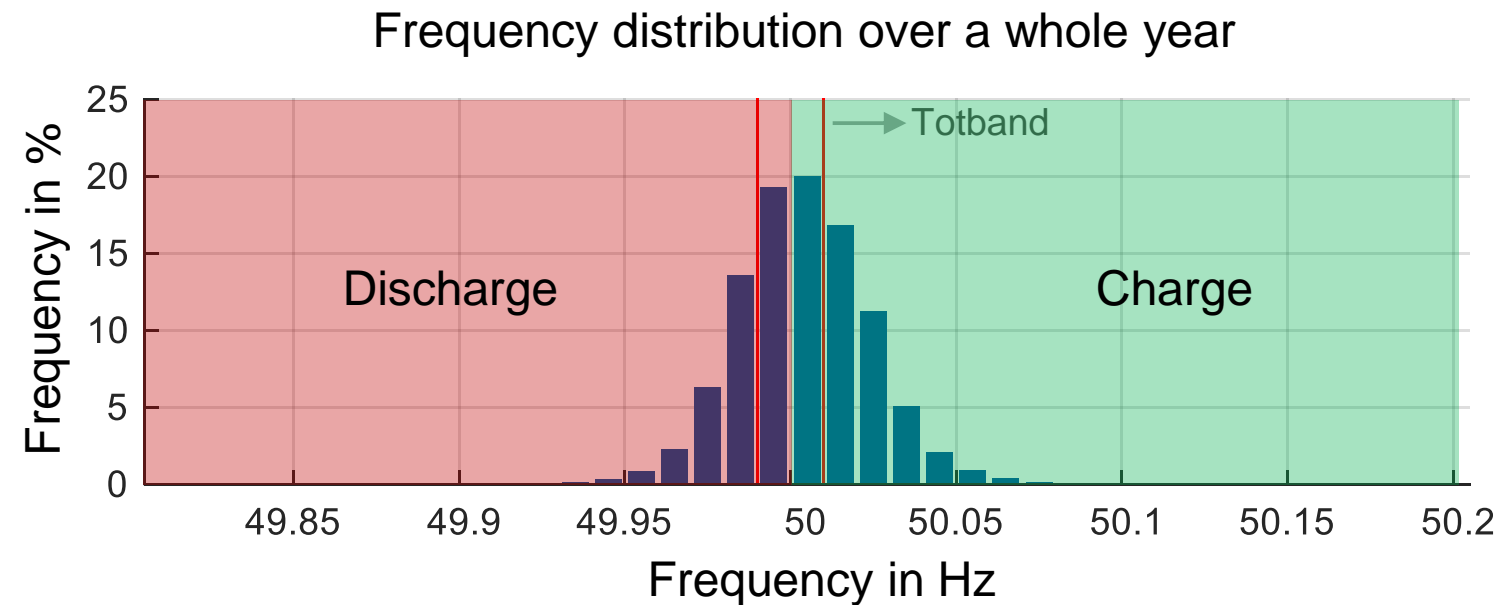


Source: based on Figgenger, Hecht et al. 2022: <https://arxiv.org/ftp/arxiv/papers/2203/2203.06762.pdf>

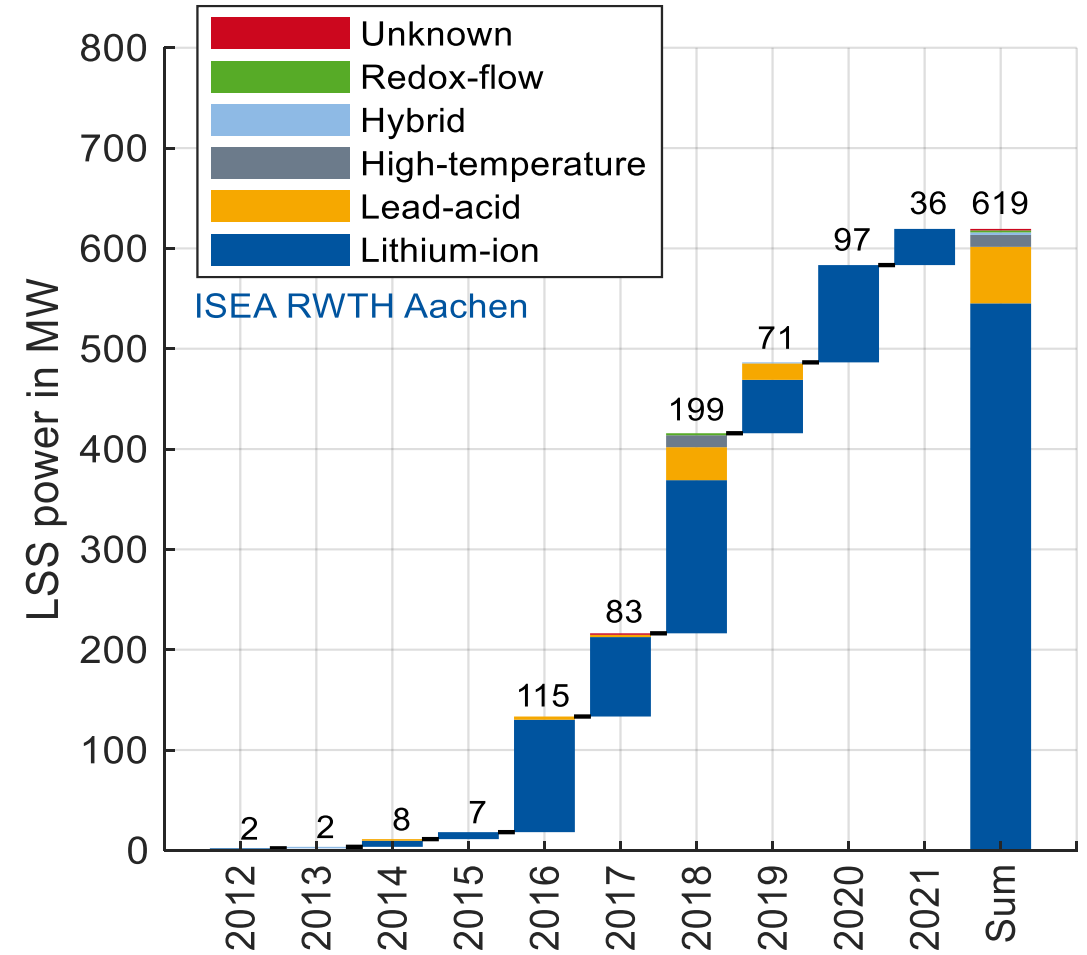
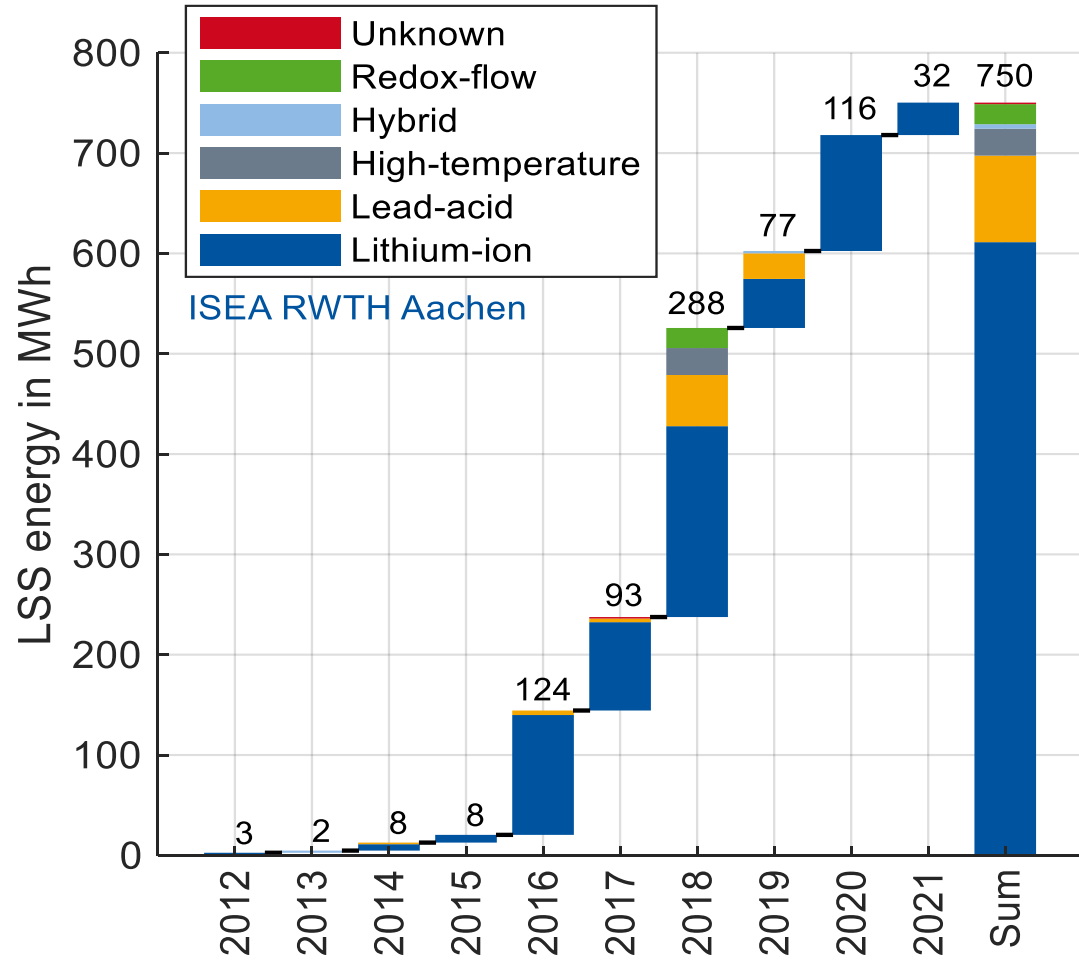
Previous motivation for large-scale storage: Frequency containment reserve (new applications: RE integration, grid booster)



- In the power grid, generation and consumption must be equal to obtain a frequency of 50 Hz.
- Battery storage can provide frequency containment reserve power to stabilize the grid

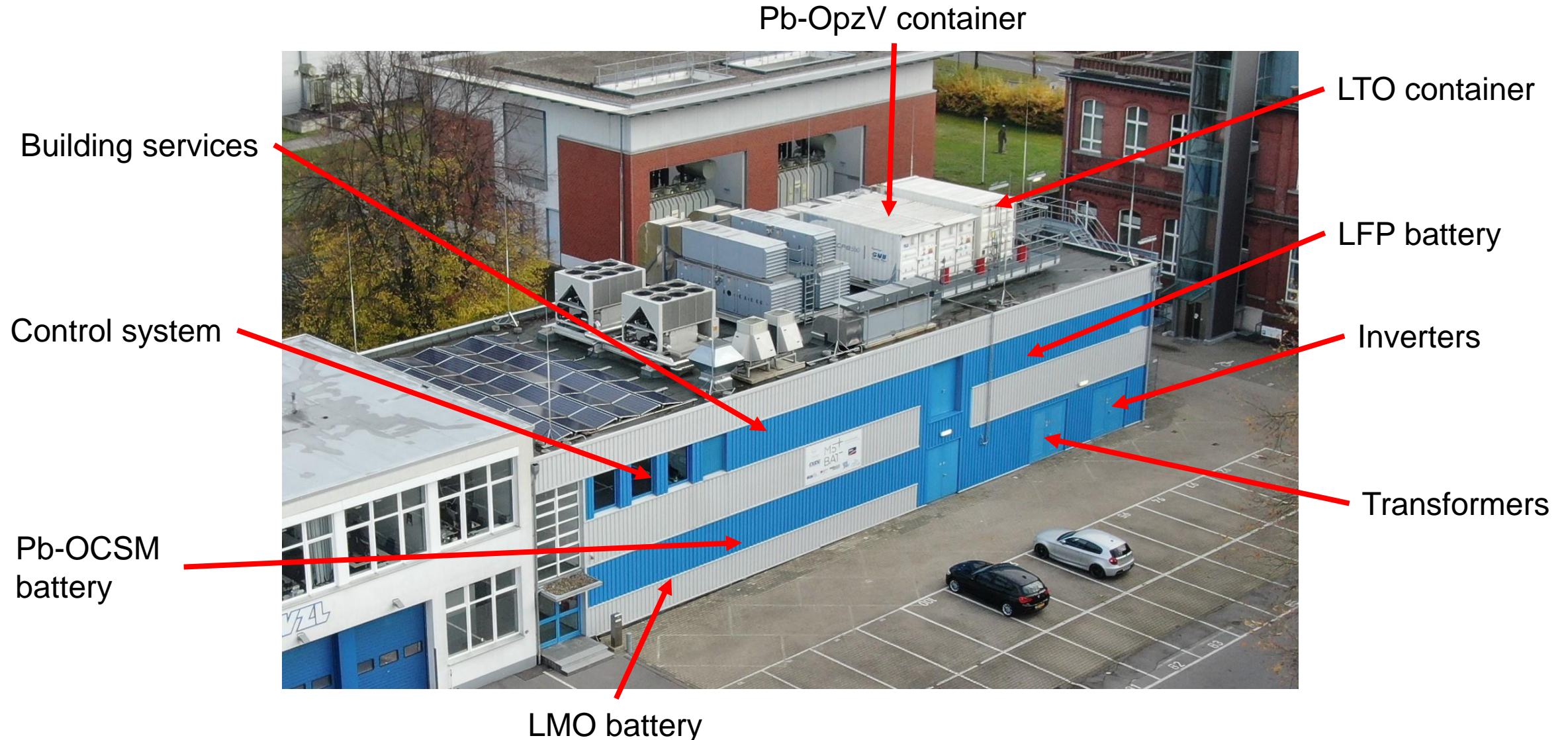
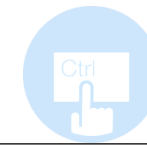


Development of energy and power of large-scale storage systems (LSS) in Germany (~100 systems)

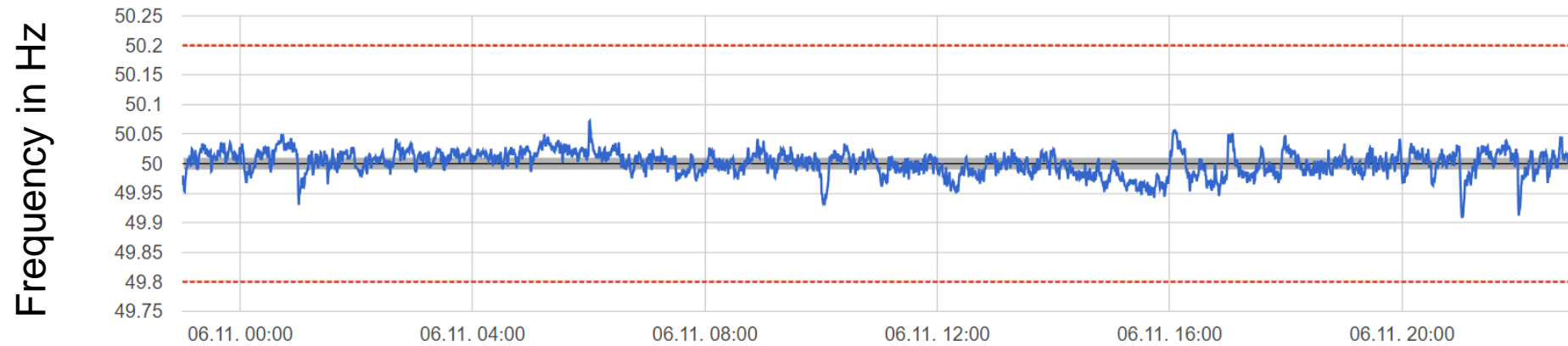


Source: based on Figgenger, Hecht et al. 2022: <https://arxiv.org/ftp/arxiv/papers/2203/2203.06762.pdf>

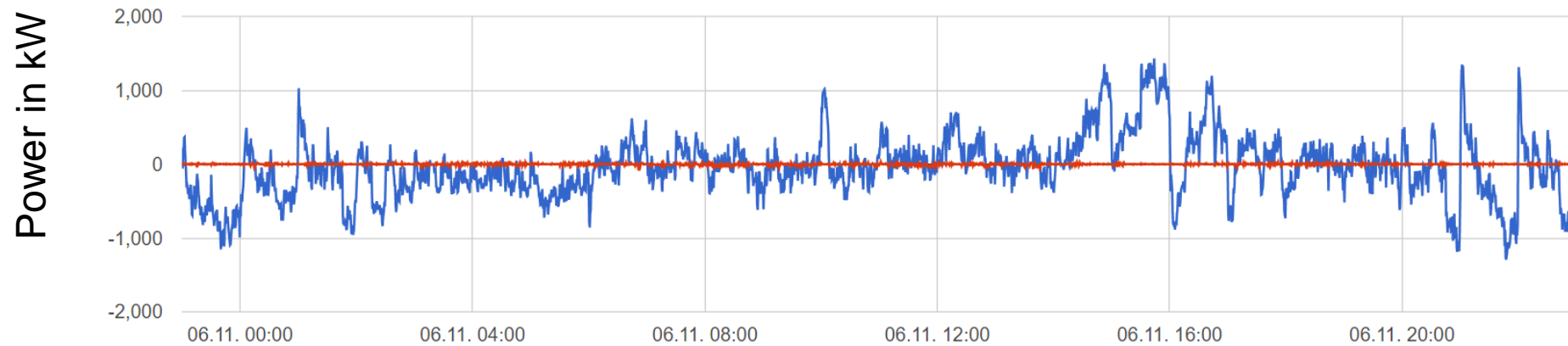
Battery storage M5BAT



Operation from Sunday



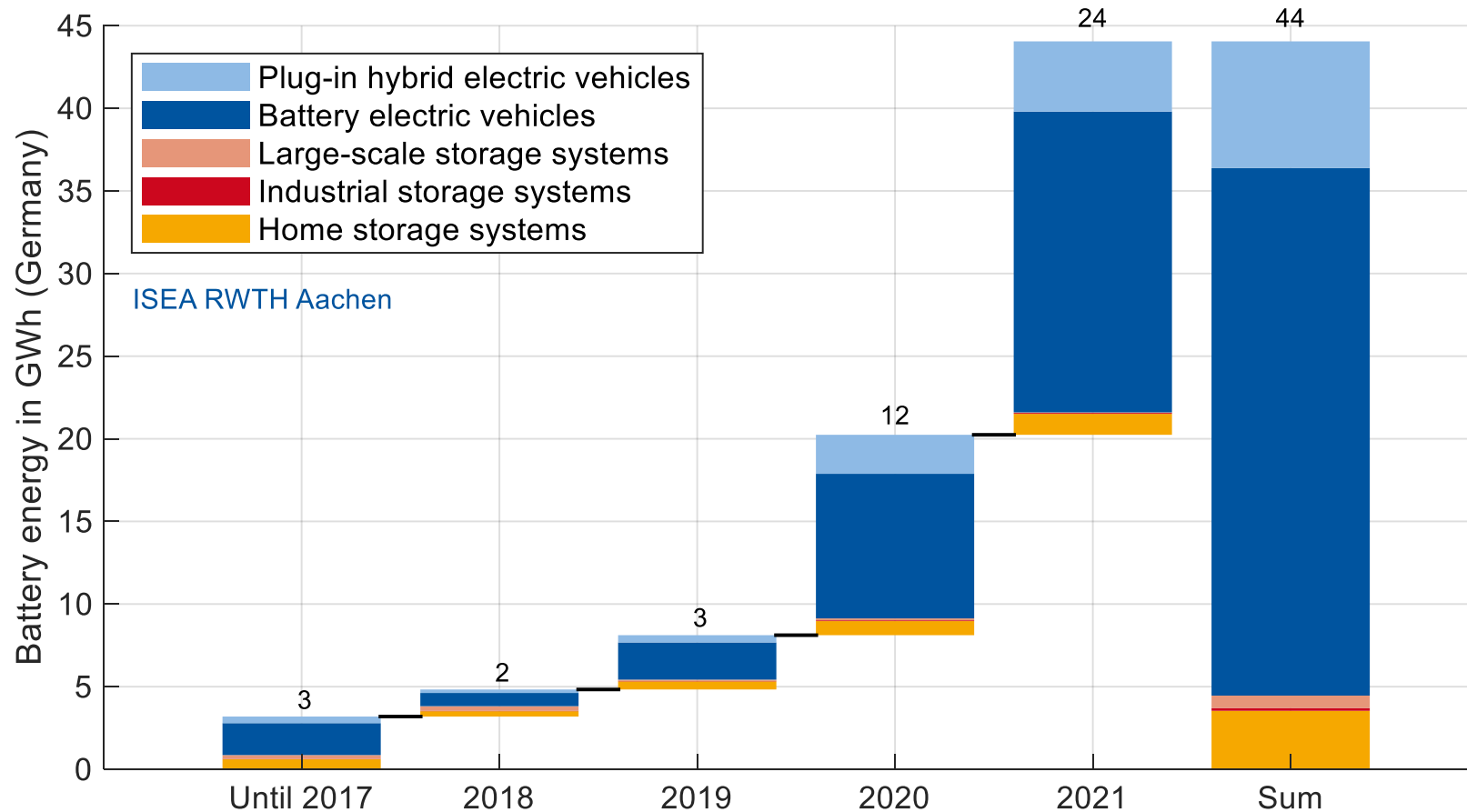
06.11.2022



06.11.2022

https://m5bat.isea.rwth-aachen.de/Historische_Daten/index.php

Market development of battery storage in Germany (estimate)



40 GWh battery capacity in mobility applications (end of 2021) from only 2.5% of the total vehicle stock equals the total capacity of all pumped hydro power systems in Germany: big potential for vehicle-to-grid applications

Source: based on Figgner, Hecht et al. 2022: <https://arxiv.org/ftp/arxiv/papers/2203/2203.06762.pdf>

Thank you for your attention

More market data:
www.battery-charts.de
www.mobility-charts.de

Contact

Jan Figgener

Phone: +49 241 80 49312

jan.figgener@isea.rwth-aachen.de



Chair for Electrochemical Energy Conversion
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Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
RWTH Aachen University

Jaegerstrasse 17/19
52066 Aachen
GERMANY

www.isea.rwth-aachen.de



We thank



Gefördert durch:



Bundesministerium
für Wirtschaft
und Klimaschutz

aufgrund eines Beschlusses
des Deutschen Bundestages



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