



Value stacking of battery storages

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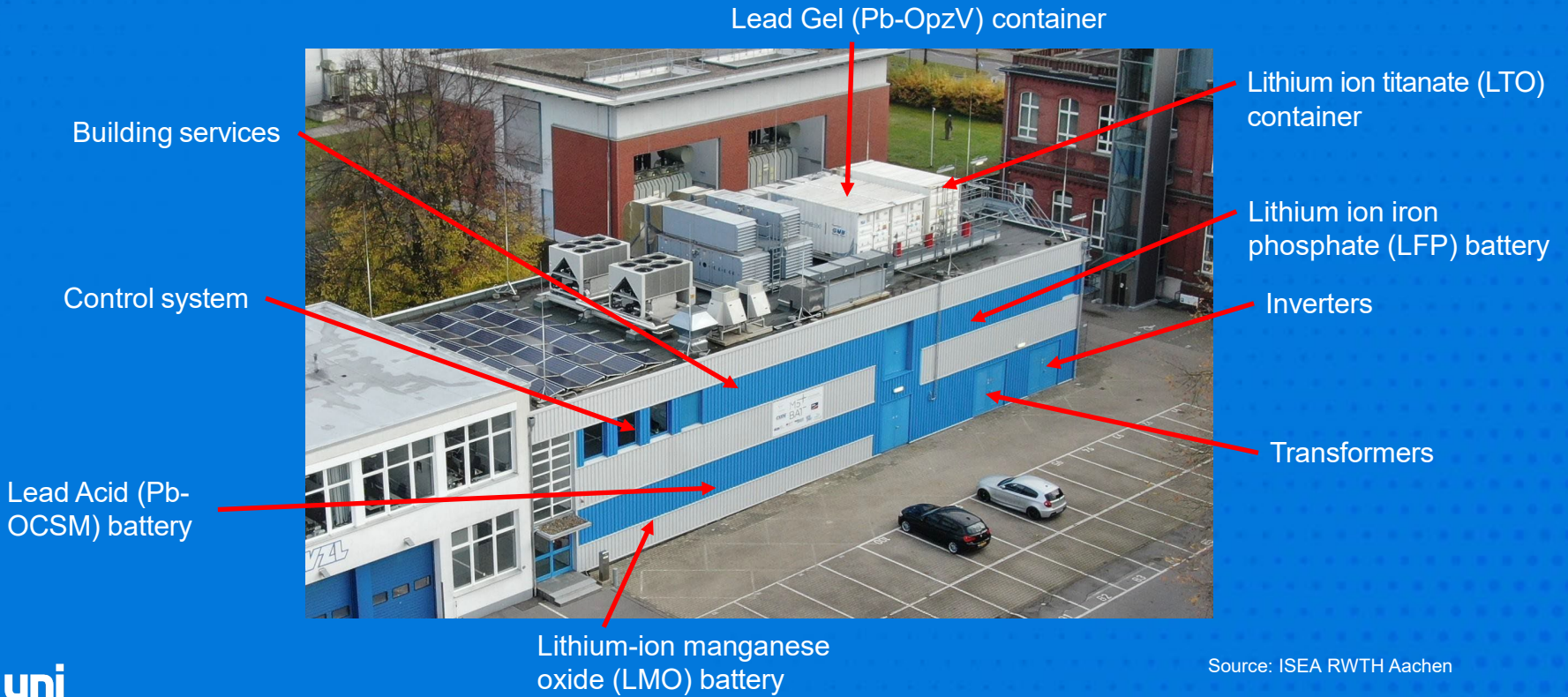


Battery storage M5BAT – successful cooperation between business and academia

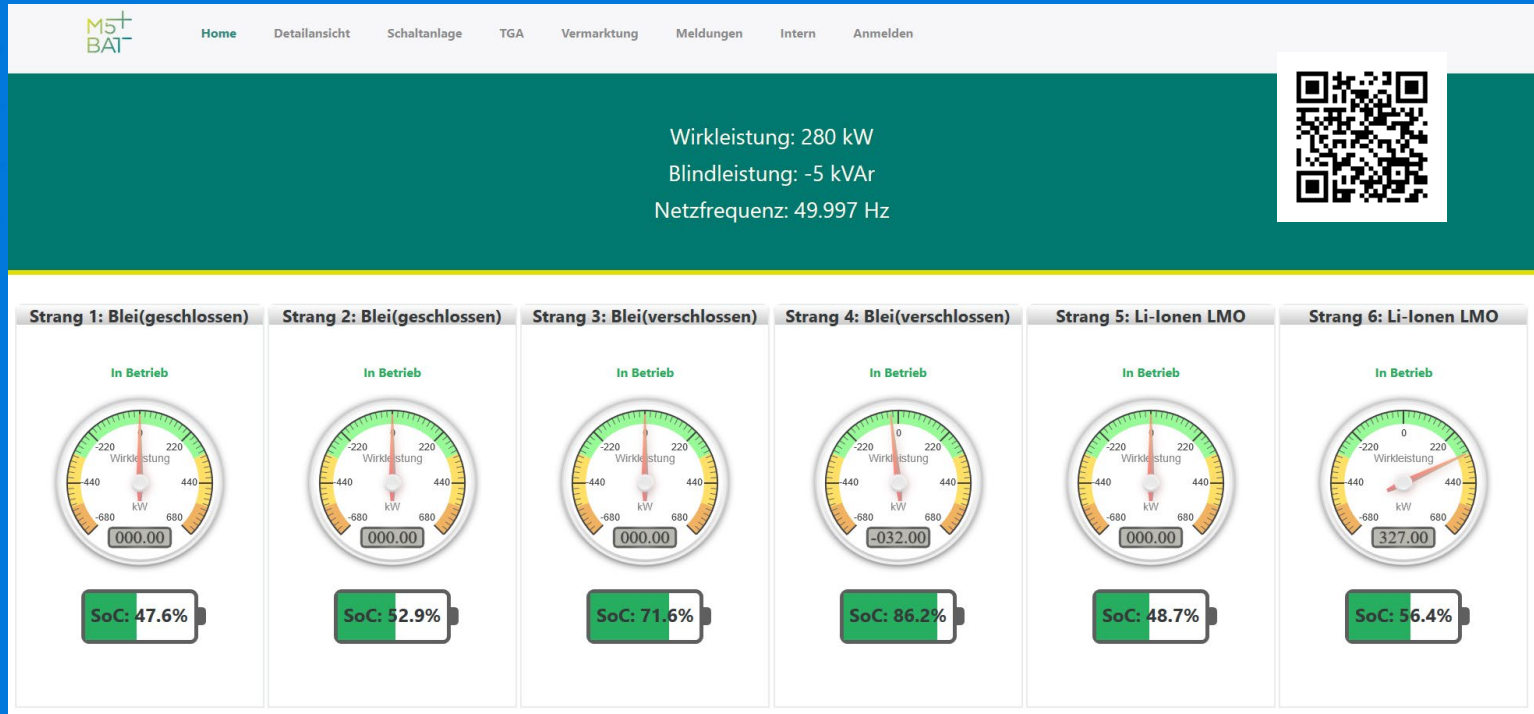
- Cooperation between ISEA RWTH Aachen and Uniper
- 5 different battery technologies
- 10 separate battery strings
- 5.6 MW / 5.5MWh
- COD 2016, project development started 2013
- Providing ancillary services (FCR)
- Plus: test of new market channels
- Extensive operation & marketing experience



Battery storage M5BAT – research battery on ISEA RWTH Aachen campus

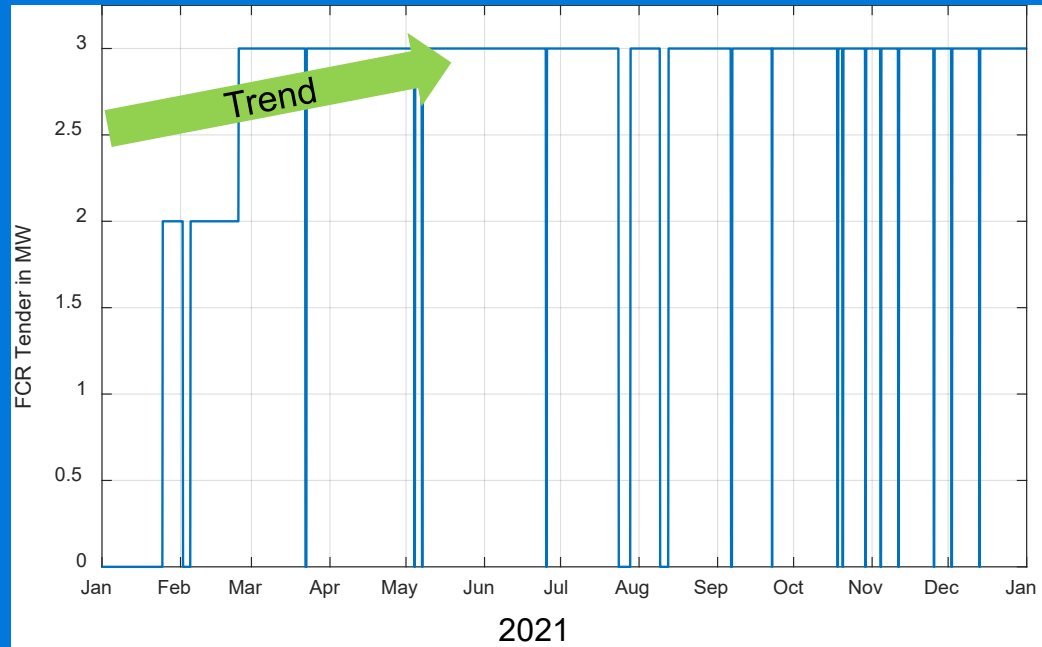


Web Visualization of operational data



Live View: <https://m5bat.isea.rwth-aachen.de>

M5BAT – FCR Nomination development



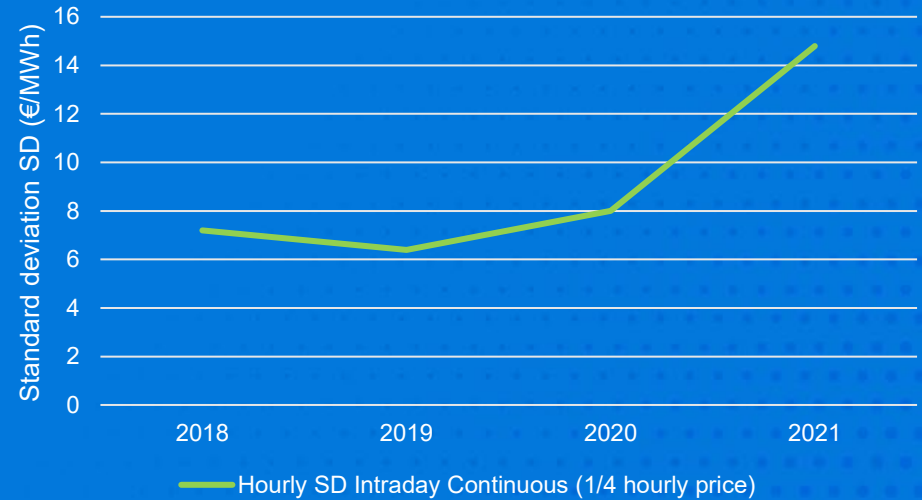
- FCR nomination gaps result from research projects as well as maintenance work

Source: ISEA RWTH Aachen

Market conditions have changed rationale how to market batteries tremendously

- Intraday volatility has more than doubled in the last two years, and we expect it to increase further over coming years
- Batteries are a great asset class to grasp the value out of this market

Volatility development in German EPEX intraday trading

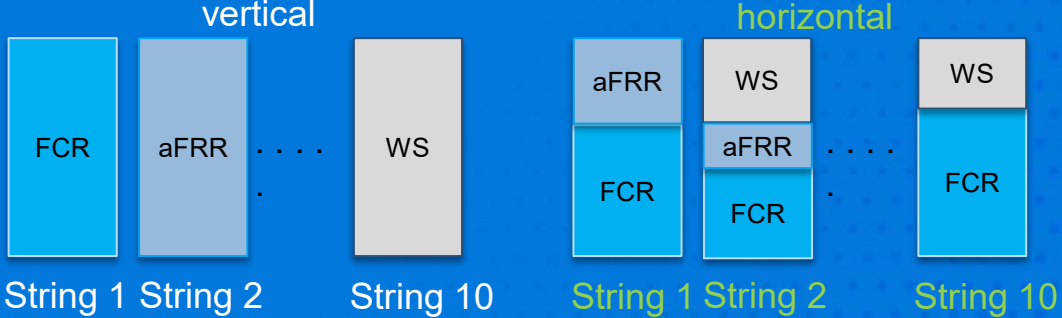


Source: FfE

Multi channel marketing optimization is the next big thing! But how?

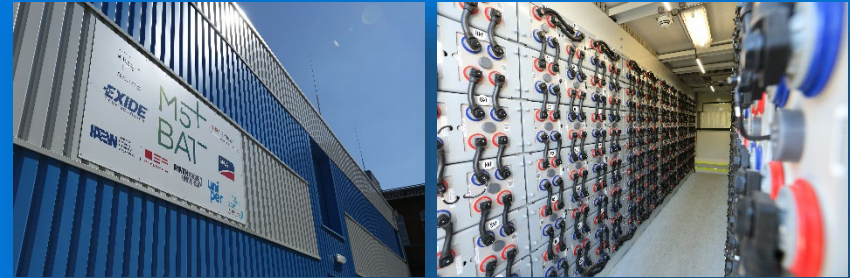
timewise

00:00-04:00	04:00-08:00	08:00-12:00	12:00-16:00	16:00-20:00	20:00-00:00
FCR					
		WS		WS	
			aFRR		



EMMUseBat – continuing the cooperation between RWTH and Uniper

- Follow-up research project since June 2021
- Research on developing energy management algorithms for parallel use of batteries
- Identify ways to increase economic efficiency by simultaneously marketing the battery to various markets



Backup

M5BAT - Overview of technologies and parameters

Battery Technology	Power / Capacity	Manufacturer / Supplier	Ready for operation	Abbreviation
Lead acid (OCMSM)	1,23 MW / 2,0 MWh	GNB Industrial Power (Exide)	Yes	Pb 1 - 2
VRLA Lead-Gel (OPzV)	1,13 MW / 1,3 MWh	GNB Industrial Power (Exide)	Yes	Pb 3 - 4
Lithium-Ionen-Manganoxid (LMO)	2,47 MW / 2,99 MWh	Samsung SDI/Qinous	Yes	LMO 1 - 4
Lithium-Ionen-Eisenphosphat (LFP)	0,62 MW / 0,73 MWh	CATL/RES	Yes	LFP
Lithium-Ionen-Titanat (LTO)	0,62 MW / 0,22 MWh	Microvast	Yes	LTO
Overall system	6,07 MW / 7,52 MWh		Yes, 3 MW FCR marketable	Battery energy storage systems (BESS)