

C & I Electricity Storage Systems

The Next Big Thing?

Dr. Holger Hesse

EES Europe / The smarter E

Intersolar 2022

10. 05. 2022



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Classification of stationary energy storage systems

Home storage system (HSS)
< 30 kWh



Source: sonnen.de

Industry scale storage (ISS)
30 – 1000+ kWh

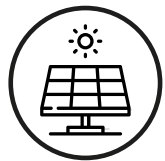


Source: nec.com

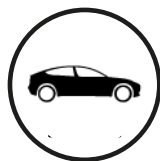
Utility scale storage (USS)
> 1 MWh



Source: tesla.com



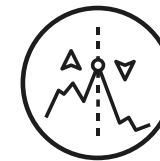
Self-consumption increase



EV-Charge



Peak shaving



Spot market trading

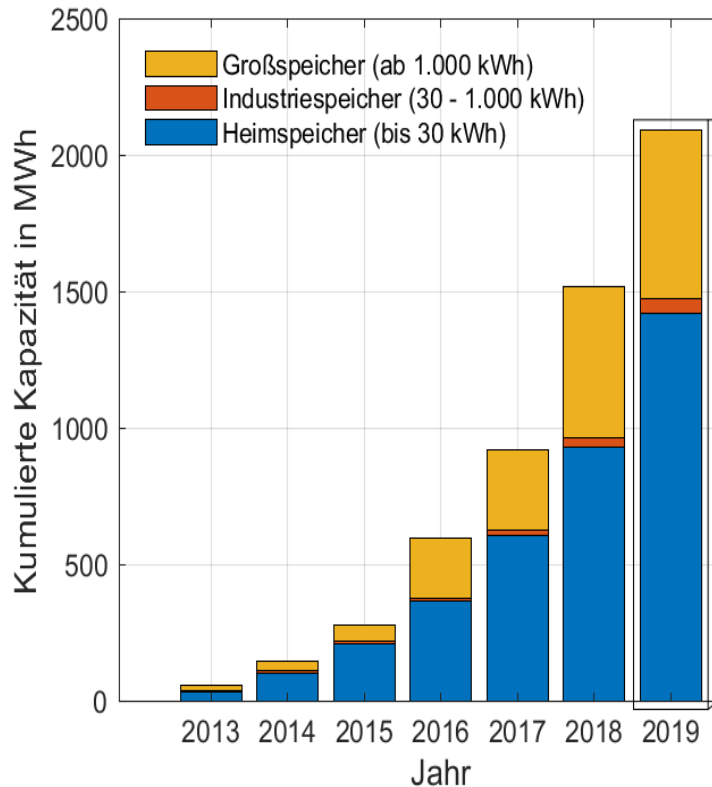


Frequency regulation

Behind-the-meter (BTM)

Front-of-the-meter (FTM)

C& I Storage – The next big Thing?



- Regulatory constraints?
- Technical feasibility?
- Applications of choice?
- Battery life?
- Field demonstration?

J. Figgner et al - The development of battery storage systems in Germany – A market review (status 2022) - ArXiv

B. Tepe et al. Stationäre Batteriespeicher in Deutschland: Aktuelle Entwicklungen und Trends in 2021 – Energiewirtschaftliche Tagesfragen (BVES)

C & I Electricity Storage Systems



An International Comparison of C&I Business Cases - How to Uncover the Value of Storage!



Lars Stephan

Policy & Market Development Manager
Fluence



Success Factors in C&I Storage



Franz-Josef Feilmeier

CEO
FENECON GmbH



Flexibility- and Large-Scale Storage Solutions - Use Cases and Experiences



Matthias Jakob

Leiter Vertrieb B2B und Lösungsentwicklung
Bayernwerk



Increasing the Profitability of EES by Managing the Aging Impact



Dr Stephan Rohr

Founder & Co-CEO
TWAICE

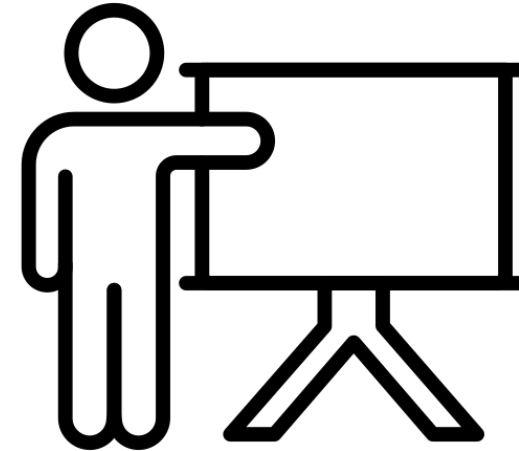


A Technical Feasibility and Field Trial Analysis of C & I Storage Systems

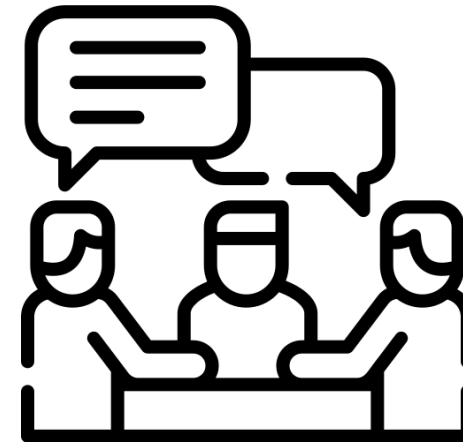


Johannes Wüllner

Head of Group Applied Storage Systems
Fraunhofer Institute for Solar Energy Systems ISE



Pitch Presentations



Panel Discussion

C & I Electricity Storage Systems



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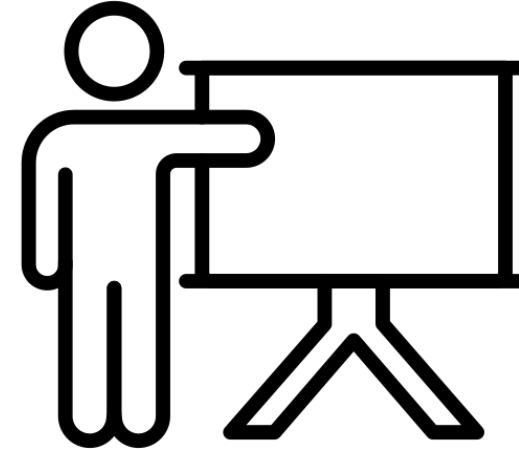


A Technical Feasibility and Field Trial Analysis of C & I Storage Systems



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Panel Discussion

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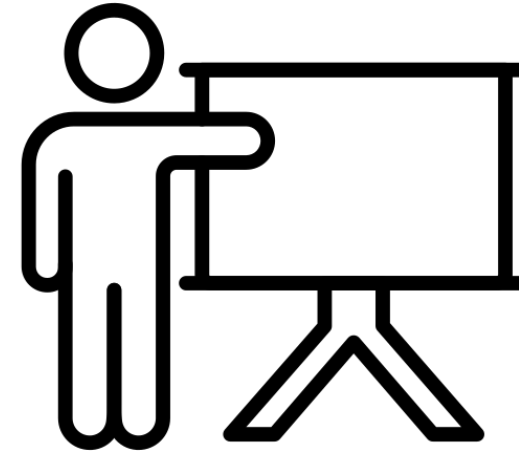
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EES EUROPE 2022

An International Insight of C&I Business Cases How to Uncover the Value of Storage

Fluence is a global leader in energy storage products and services and digital offerings for renewables & storage

FLUENCE ENERGY STORAGE ⁽³⁾ & OS



4,250+

TOTAL MW



150+

PROJECTS



30

Markets



40+

CONTROLS APPLICATIONS

FLUENCE SERVICES ⁽⁴⁾



25+

OPERATING PROJECTS



2,900+ MW

ASSETS UNDER MANAGEMENT

FLUENCE IQ DIGITAL PLATFORM ⁽³⁾



5,070

Total MW of AI-optimized Bidding of Renewables and Storage



50%

STORAGE REVENUE UPLIFT THROUGH AUTOMATED BIDDING ⁽¹⁾



90%

PERCENT OF PERFECT FORESIGHT ⁽²⁾



(1) Fluence analysis: performed with one year of prices at HAAS_7_B11 price node and NP-15 AS trading zone in CAISO
(2) The maximum amount of revenue that an asset can generate with perfect knowledge of future market prices in the next 48 hours; statistic calculated for customers located in Australia's NEM
(3) Deployed and contracted as of December 31, 2021
(4) Assets under management or contracted as of December 31, 2021

Zero-Emission Backup Power System for Datacenter

Google

St. Ghislain, Belgium

2.75 MW / 5.5 MWh

SERVICE

- Zero-Emission Back-Up Power
- Demand Response Program
- Grid Support

IMPACT

- Supporting Google' 2030 Carbon-Free Energy Goal
- Market Optimization by Centrica



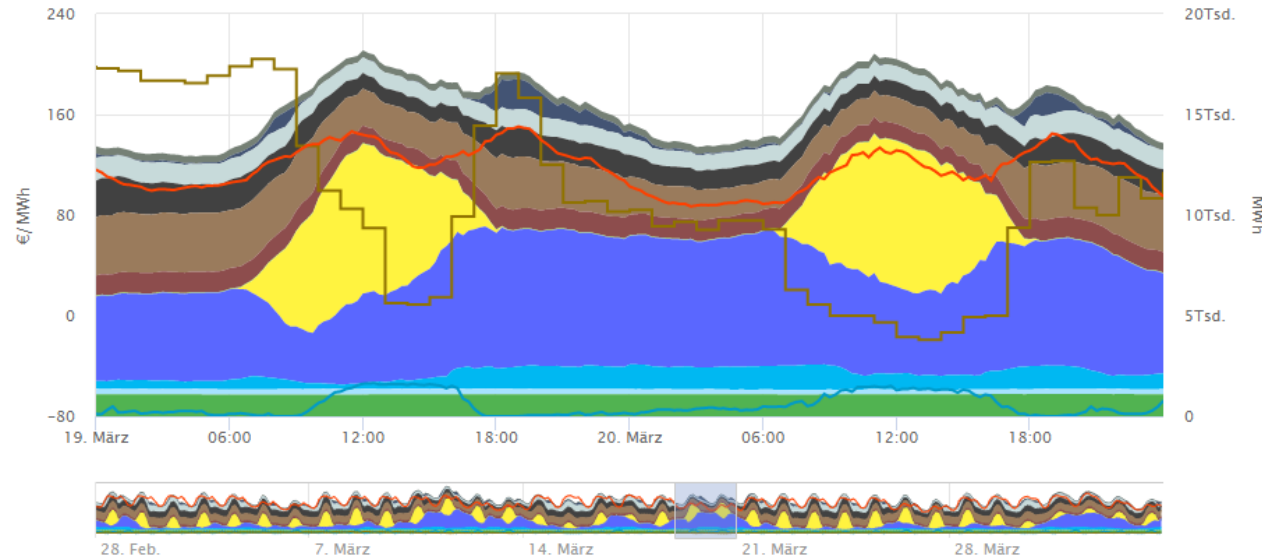
Flexibility from C&I – a missed opportunity?

- C&I storage is not widely developed in Europe, as business cases are typically based on customer specific requirements
- As the market design does not provide price signals on energy cost or grid congestion to consumers (except §19 StromNEV), the power consumption of C&I customers is widely unutilised
- Today, we see instances in which the German power system could run on renewables alone, but we miss the flexibility to do so



Source: European Commission

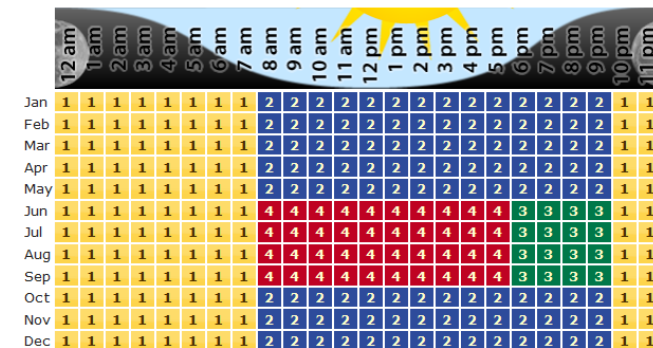
Generation profile, Germany, March 20th 2022



Time of Use Demand Charge Structure

Period	Tier	Max kW Usage ?	Rate \$/kW ?	Adjustments \$/kW ?
1	1		0	14.97
2	1		13.92	
3	1		18.84	14.97
4	1		26.74	14.97

Weekday Schedule



Source: Bundesnetzagentur | SMARD.de; www. openei.org

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The value of storage in providing flexibility to our power system

- French day-ahead auction for April 4th cleared above 2,700€ / MWh between 7 and 9 am, with a total volume of around 28 GWh transacted
- Supply/Demand curve of an auction shows that 500 MW / 2h would have reduced clearing price substantially, providing millions in savings to French consumers

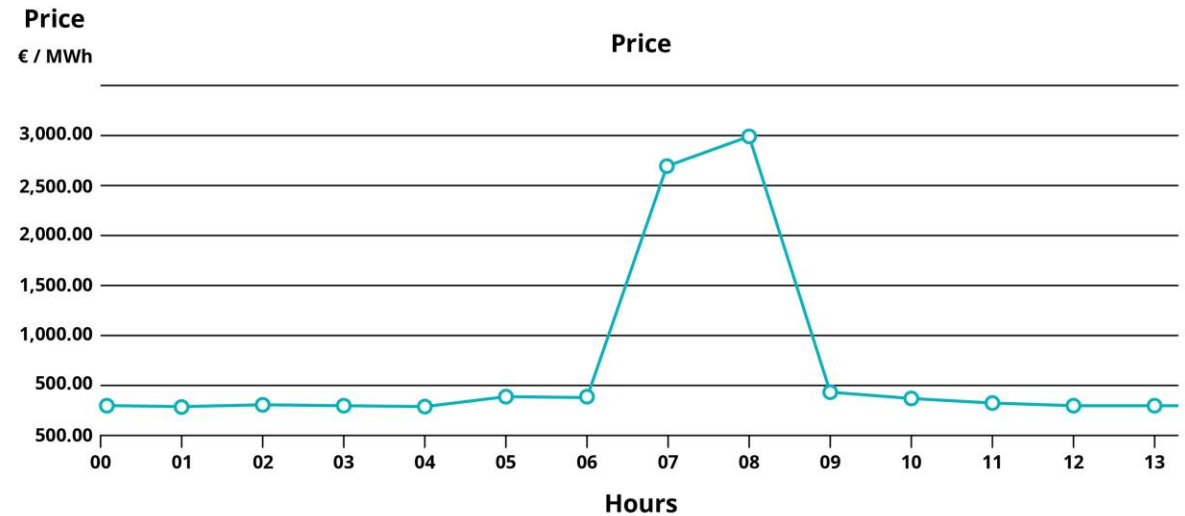
Storage has a clear path to lower costs to consumers in a power system with increased levels of price volatility



Source: European Commission

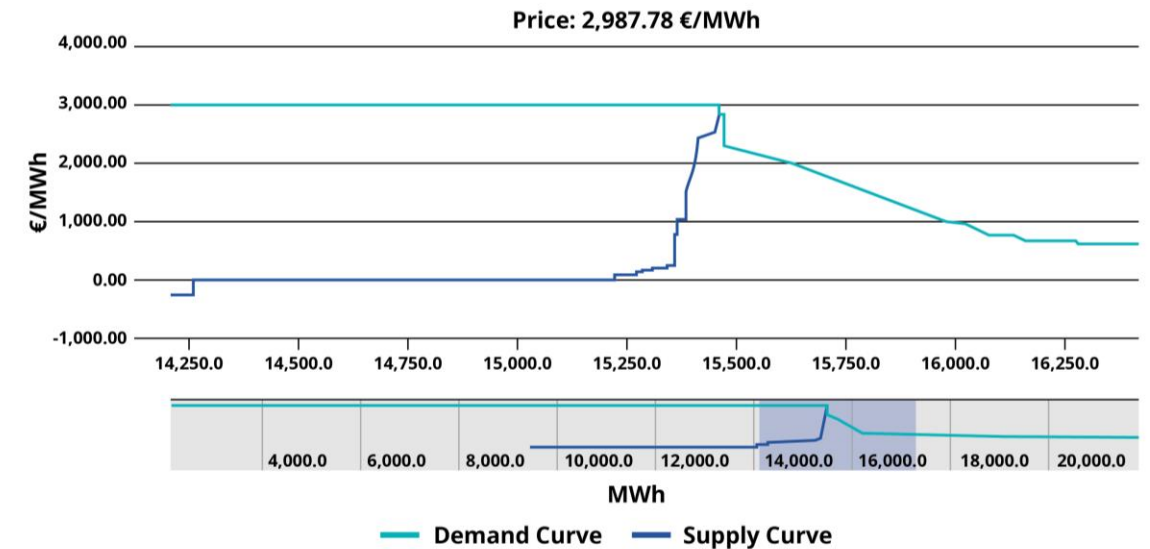
Auction > Day-Ahead > 60min > FR > 04 April 2002

Last update: 03 April 2022 (13:44:01 CET/CEST)



Auction > Day-Ahead > 60min > FR > 04 April 2002

Last update: 03 April 2022 (13:58:17 CET/CEST)



Source: EPEX SPOT

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E-MAIL: LARS.STEPHAN@FLUENCEENERGY.COM

Thank You

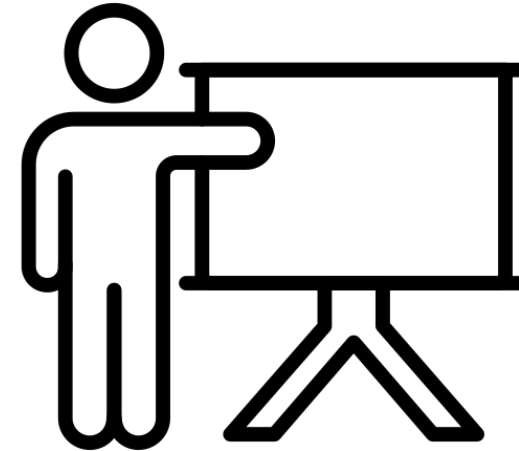
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Franz-Josef Feilmeyer

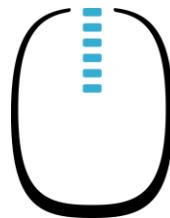
CEO

FENECON GmbH



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Success Factors in C&I Storage



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Panel Discussion

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Success Factors in C&I Storage

FENECON GmbH

May 2022

Franz-Josef Feilmeier, CEO

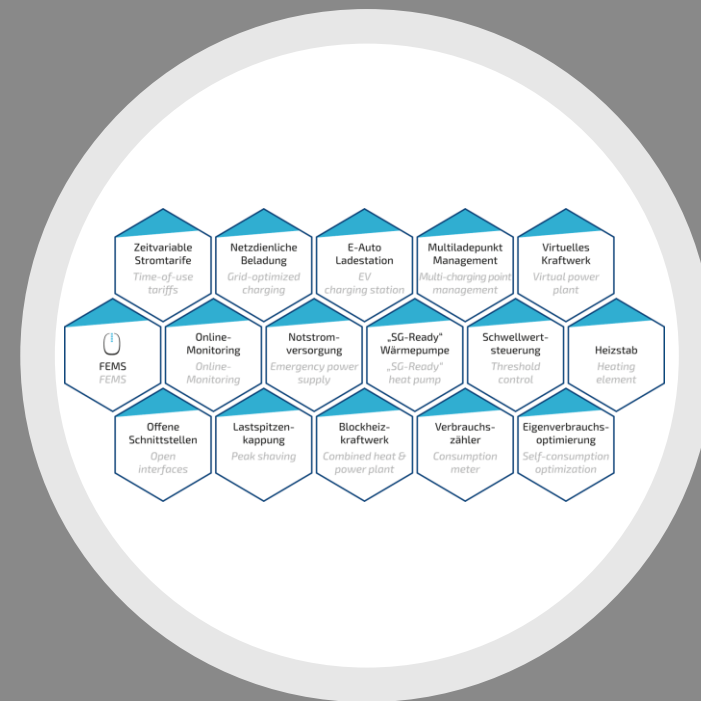
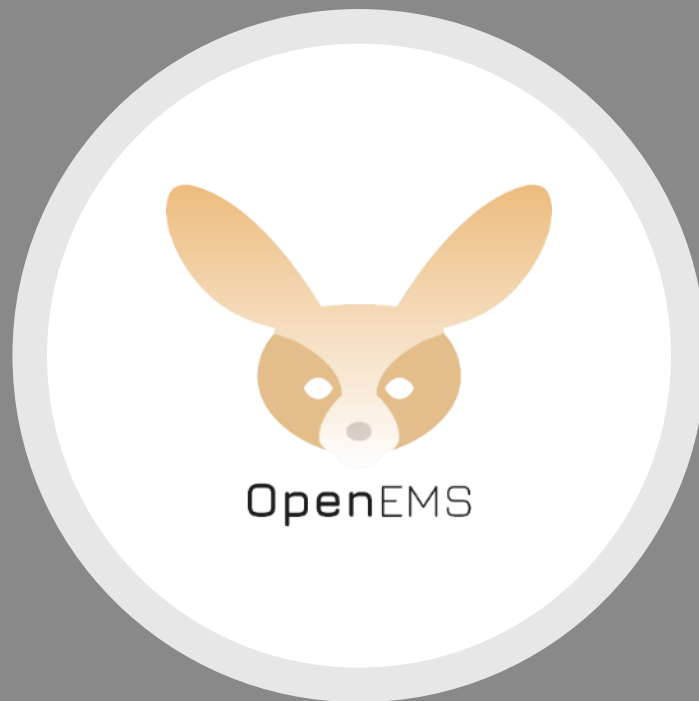




hardware + software from one source
closed system
only manufacturer's own solutions
dependency & status quo fixation



hardware – firmware – software (apps)
open-source
external applications – full flexibility
independence & continuous improvement
standard & mass-produced hardware – individualization with apps

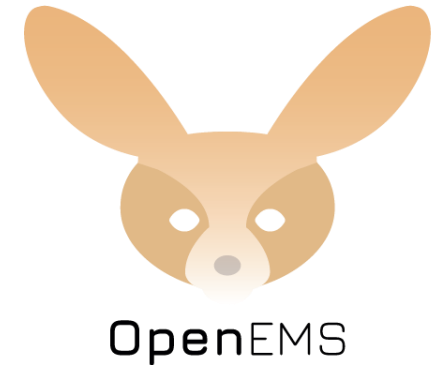


OpenEMS = Open Energy Management System
The “operating system of energy transition”

1) Multi-Use & Open Energy Management



- C&I systems expand their EMS-functions over the time
 - Clustering to bigger system
 - Load management of wallboxes, heat-pumps & others
 - Peak-shaving for consumption & feed-in
 - Time-of-use tariffs
 - Grid or power quality support
- Limited bankability if only possible by storage system or EMS-supplier



2) Scalability & Modularity

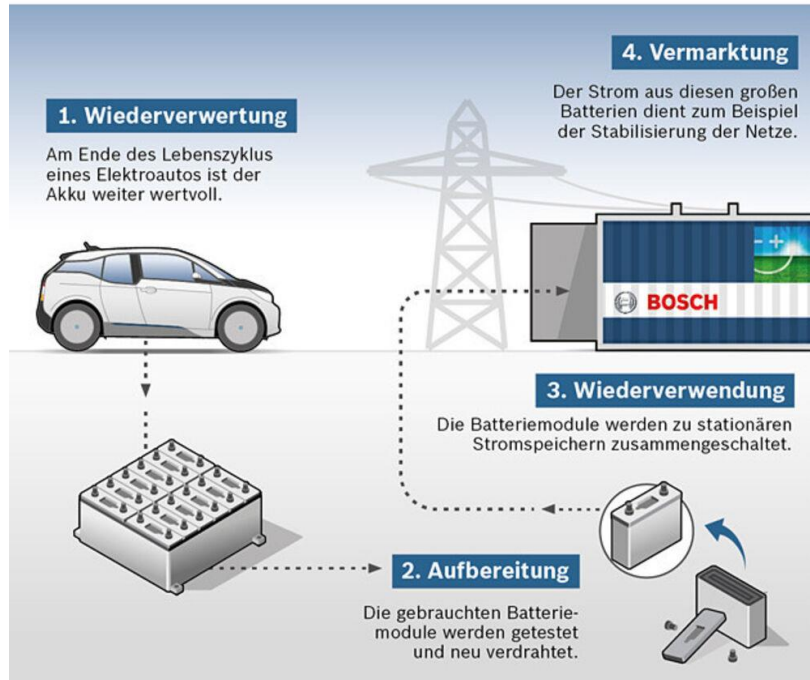
- Start with optimal sizing in power & capacity
- C&I systems grow over the time
 - Capacity increase
 - Power increase
 - Application setting increase
- Serial extension within the battery string
- Parallel connection of several strings
- Clustering of several homogeneous inverter-battery-units
- Clustering of several heterogeneous inverter-battery-units



3) EV-Batteries

Second Life für Elektrofahrzeug-Batterien

Nach ihrem Einsatz in Elektroautos werden Lithium-Ionen-Batterien für stationäre Anwendungen wiederverwendet.




Source: Bosch

- Classic 2nd life approach
 - High material & workforce costs
 - Low sales price


3) EV-Batteries

Second Life für Elektrofahrzeug-Batterien

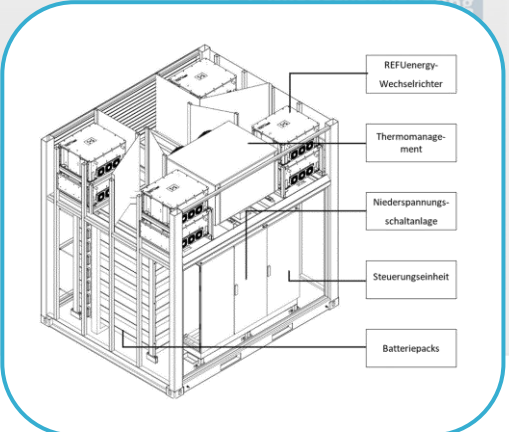

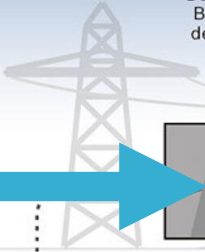
Nach ihrem Einsatz in Elektroautos werden Lithium-Ionen-Batterien für stationäre Anwendungen wiederverwendet.



1. Wiederverwertung
Am Ende des Lebenszyklus eines Elektroautos ist der Akku weiter wertvoll.



4. Vermarktung
Der Strom aus diesen großen Batterien dient zum Beispiel der Stabilisierung der Netze.



Source: Bosch

- Classic 2nd life approach
 - High material & workforce costs
 - Low sales price
- Full-pack approach
 - Decentral inverter concept
 - Solve challenges on software-side



4) Rental Storage

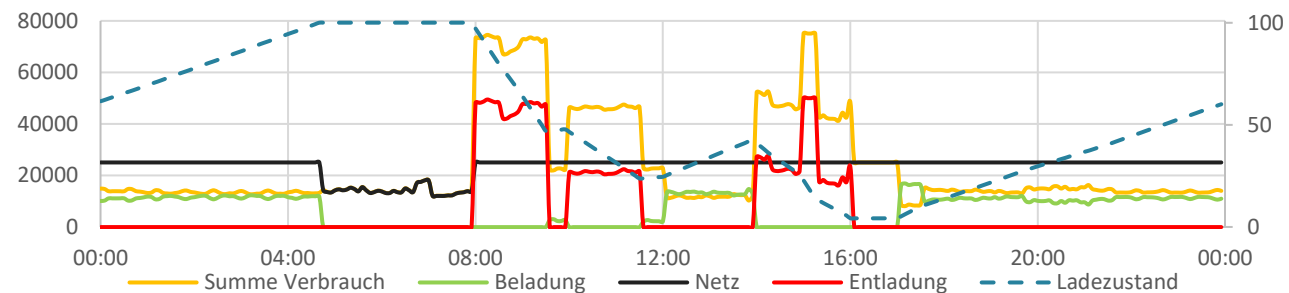


- Temporary business cases of C&I storage
 - Avoid grid extension & Peak-shaving
 - Seasonal peaks or applications
 - Events & construction sites
- Purchasing means
 - Budgeting & Funding
 - Capitalization & Depreciation
 - Service & Operations
 - End-of-Life & Recycling

4) Rental Storage

■ Rental Storage

- Just pay a monthly use fee
- Including all services
- Perfect match with 2nd life
- Understand „the year“ and „the life“ of a storage system



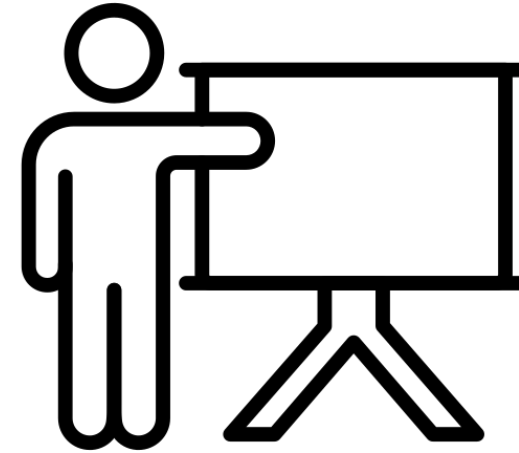


Matthias Jakob

Leiter Vertrieb B2B und Lösungsentwicklung
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Flexibility- and Large-Scale Storage Solutions - Use Cases and Experiences

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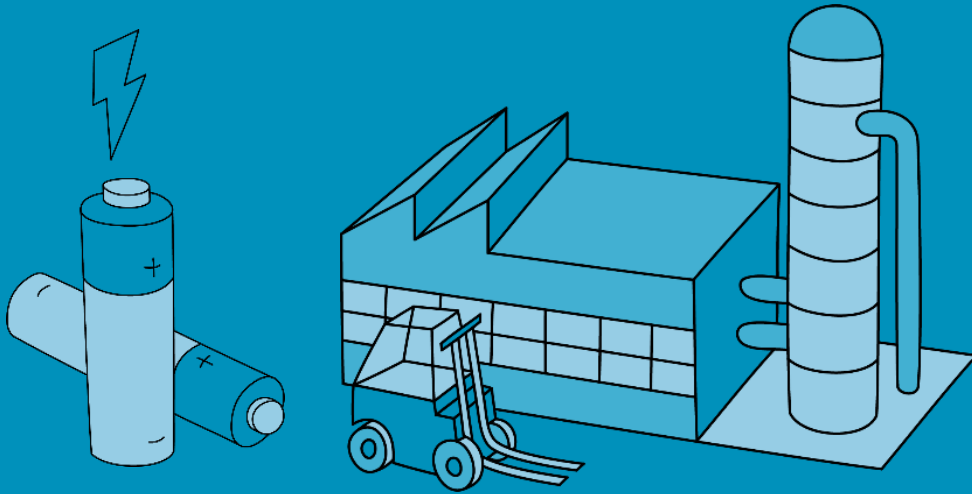


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Panel Discussion

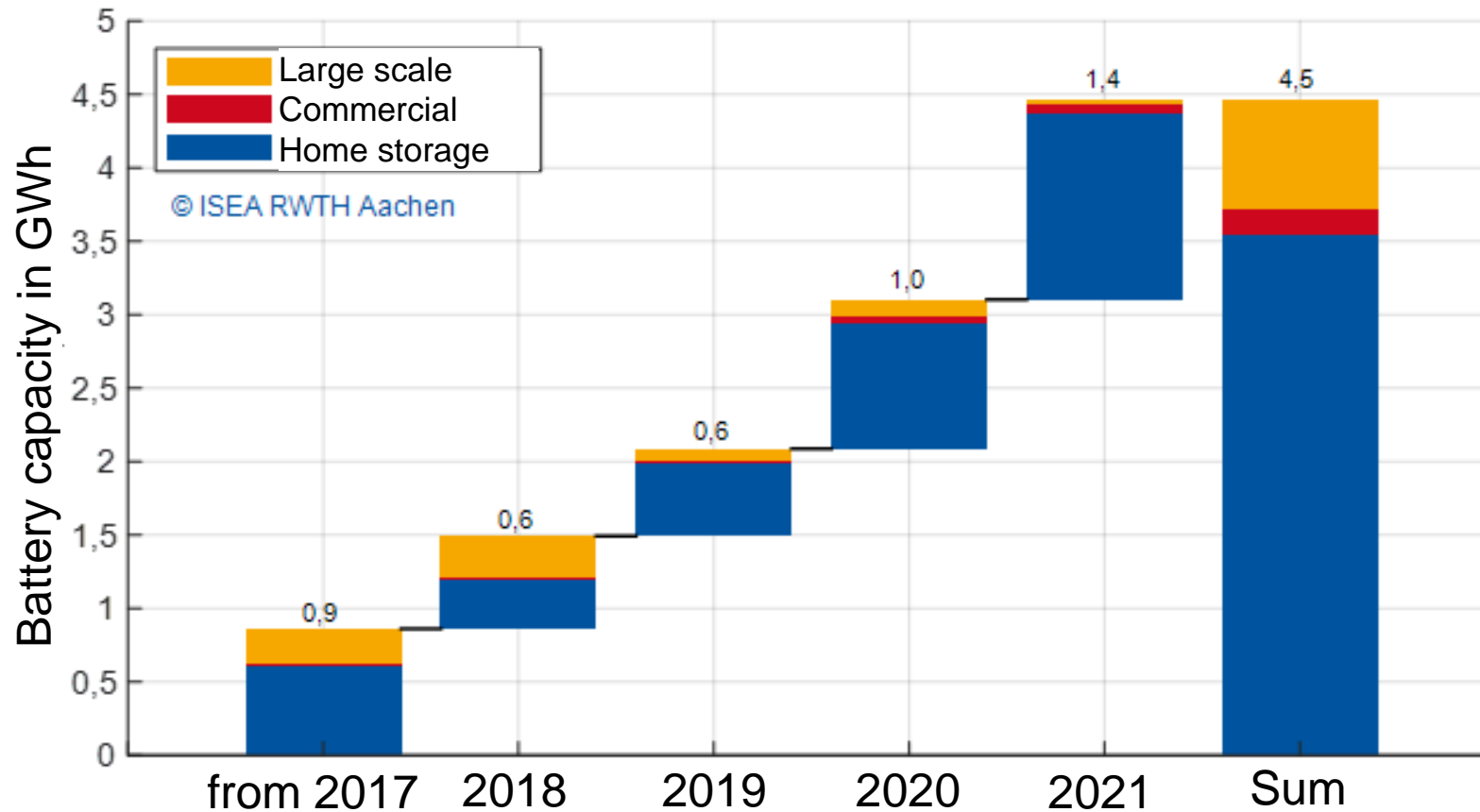
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Flexibility and large-scale storage solutions - industrial use cases and experiences

Bayernwerk Natur GmbH, Mathias Jakob
ees Munich - 10th May, 2022

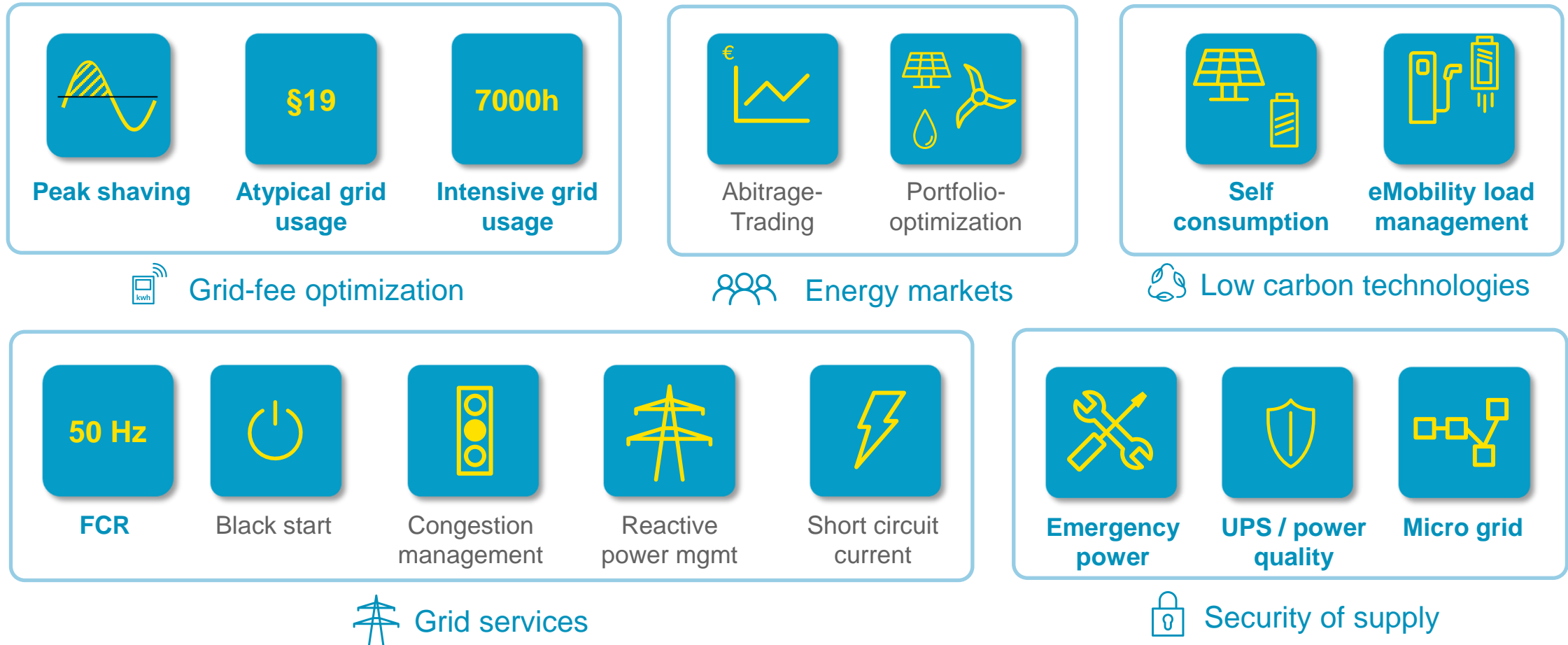
Market Growth of battery storage systems in Germany



- Largest market share and growth in field of home storage systems
- Commercial systems (30 kWh – 1 MWh) with continuous market growth
- Year 2021: 900 systems with 27 MW and 58 MWh installed

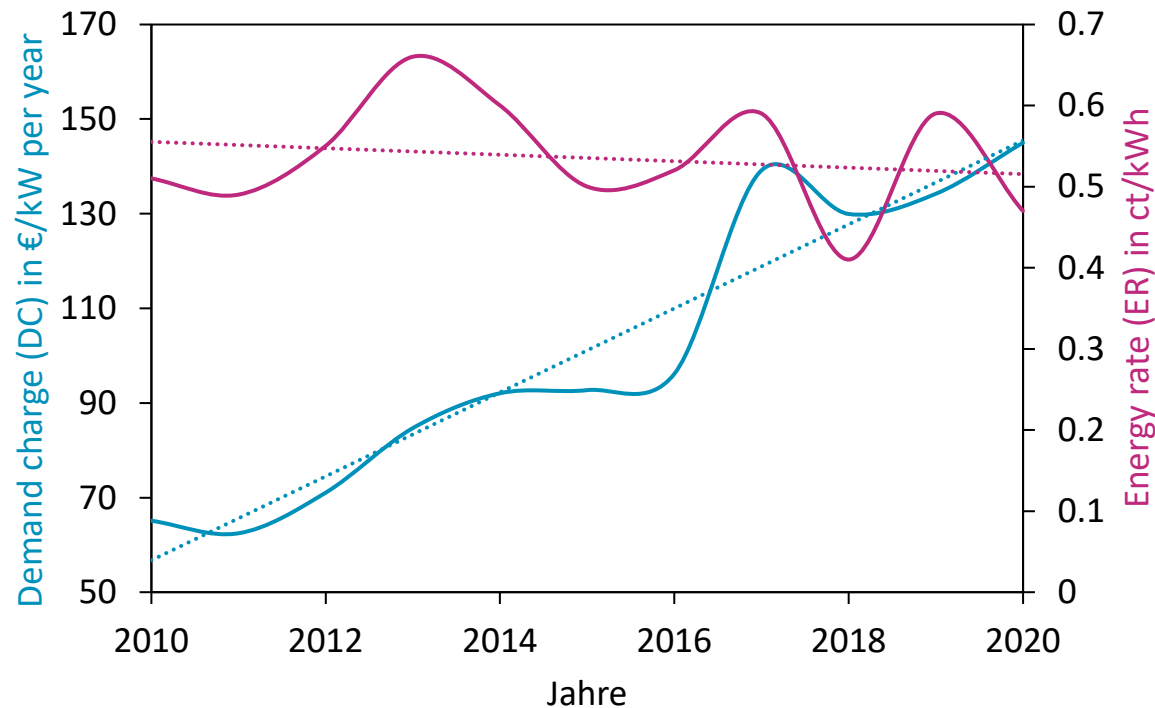
Source: <https://www.pv-magazine.de/2022/03/15/rekordjahr-im-speichermarkt-privathaushalte-tragen-2021-gesamtzubau-von-rund-14-gigawattstunden/>

Battery applications in general and **highlighted** for industrial sites



9 of 15 applications relevant for industrial sites

Demand charges in grid fees are drivers for grid-fee optimization



Jahr	DC €/kW*a	ER ct/kWh
2010	65,11	0,51
2011	62,45	0,49
2012	71,02	0,55
2013	84,66	0,66
2014	92,04	0,6
2015	92,7	0,5
2016	96,11	0,52
2017	139,12	0,59
2018	129,92	0,41
2019	134,18	0,59
2020	144,97	0,47

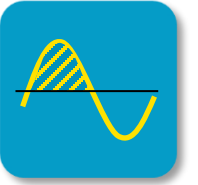
Prices for medium voltage level grid customers of Bayernwerk Netz GmbH with power metering, more than 2.500 hours utilization per annum and yearly demand charge

Rising prices due to expansion of distributed renewable energies and roll-out of electric vehicles

Project peak shaving by intensive grid usage in dairy industry

7000h

Intensive grid usage



Peak shaving



30 Overview battery-hybrid-system



Battery system scale-block



Control cabinet



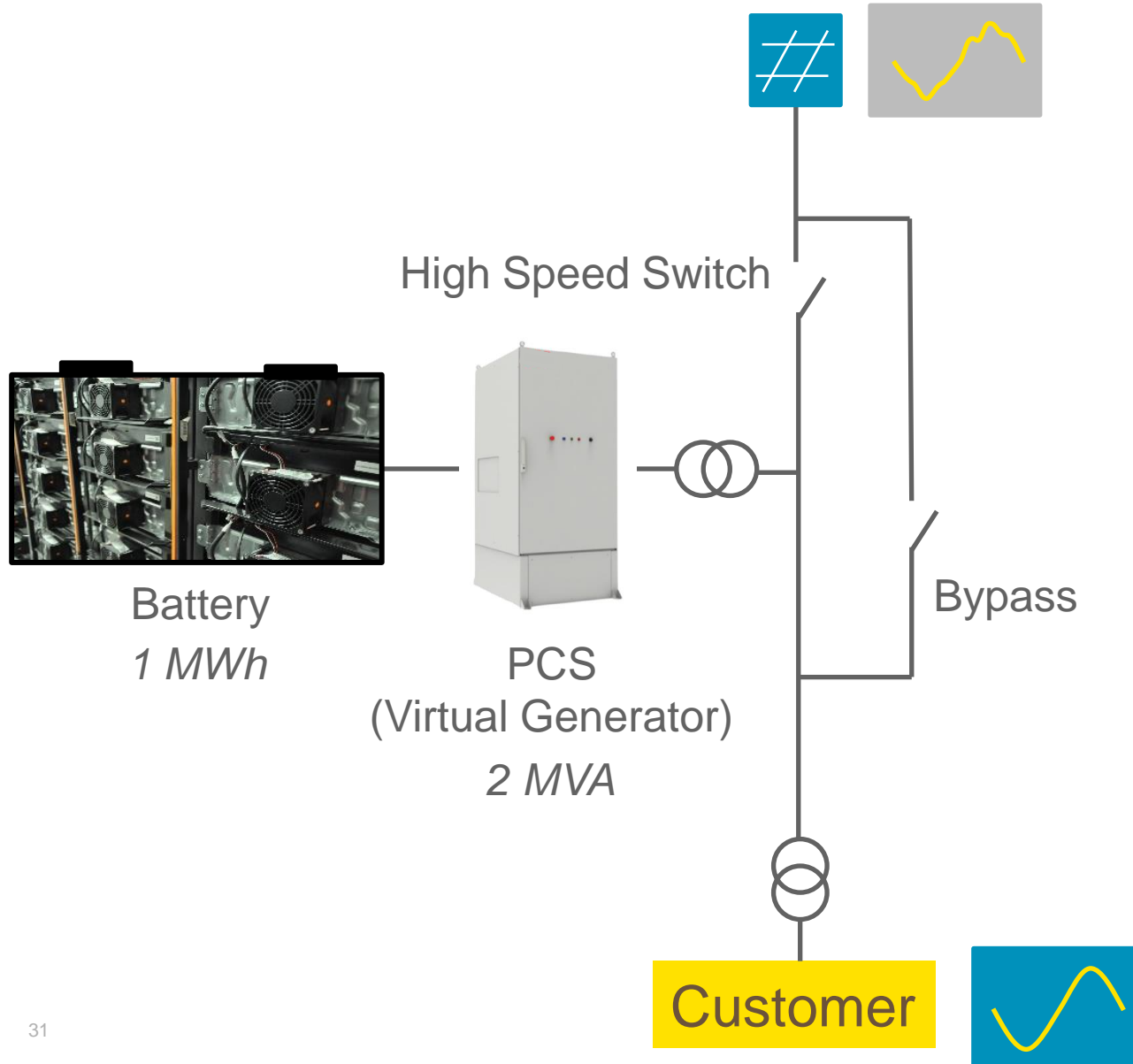
Genset

bayernwerk

Voltage dip operation mode



UPS / power quality

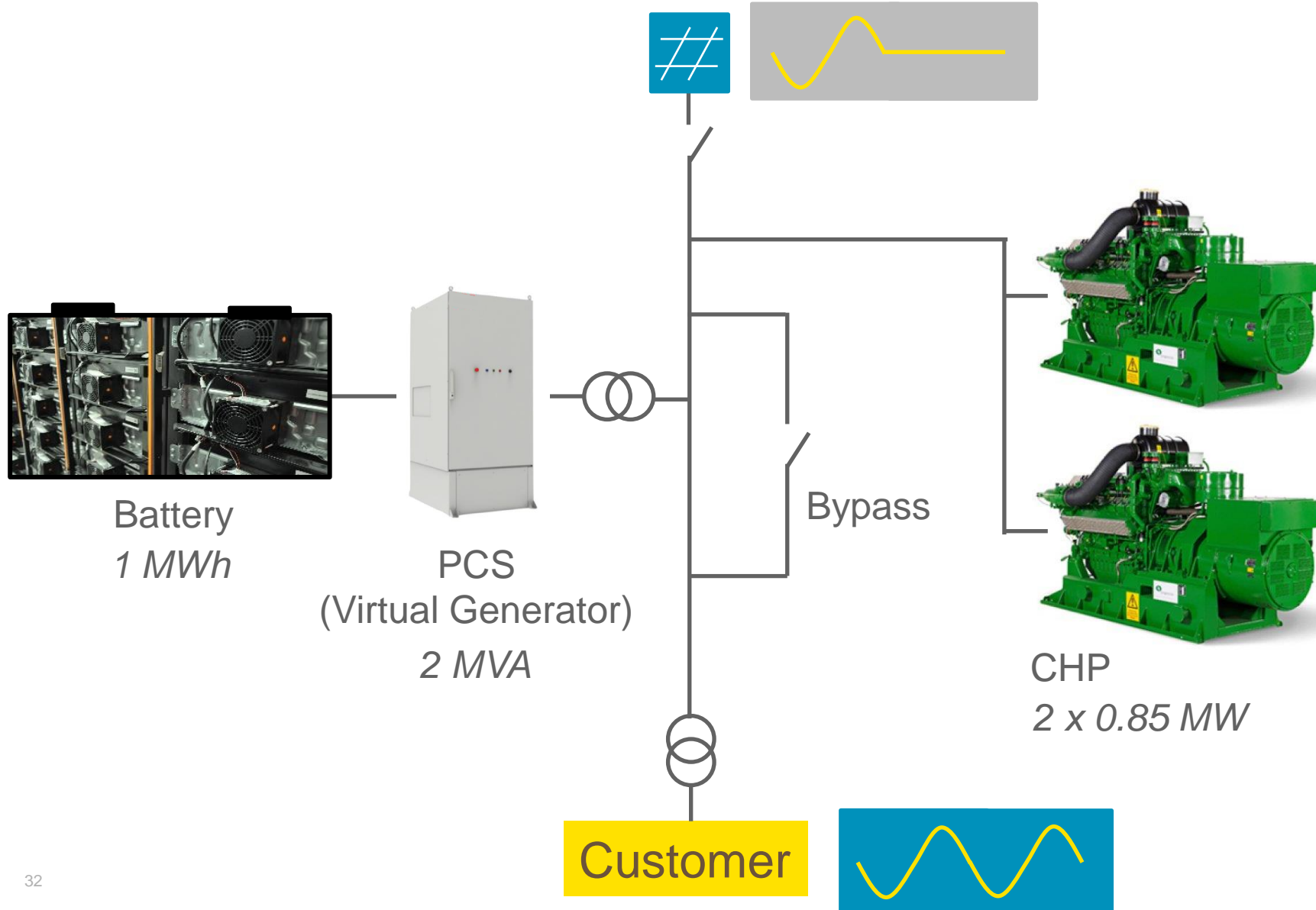


- The customer can be decoupled from the public grid by a high-speed switch
- When disconnecting, the battery takes the load and provides the demand to the customer
- After the voltage dip the battery system resynchronizes to the public grid
- In case of maintenance or failure a bypass is used

Micro grid operation mode



Micro grid



- While longer down-times the CHP units start-up
- The CHPs synchronize to the battery
- The CHPs and the battery build a local micro grid
- Power can be provided as long as the gas supply of the city lasts
- When the grid is back online the micro grid resynchronizes

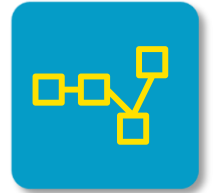
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Clean voltage micro grid

- Battery system power 2 MW and capacity 1 MWh
- Line-interactive wiring for high efficiency
- Detection of faults by ultra fast switching from grid support to virtual generator mode
- For longer take outs of the public grids battery builds local micro grid with two 850 kW CHP units



UPS / power
quality



Micro grid



Outlook electric mobility and battery storage at commercial sites

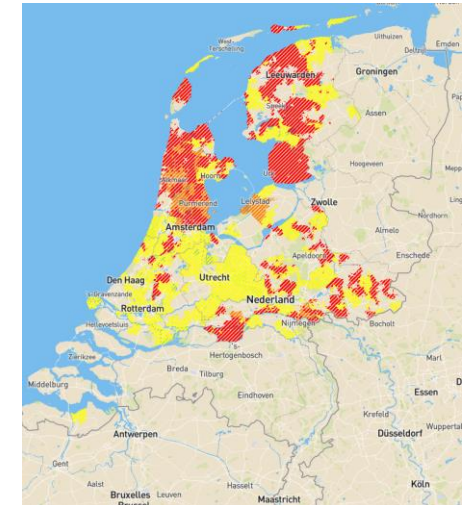
- Need for charging infrastructure at commercial sites for customers, employees and fleets growth with uptake of electric mobility
- In case of high demand charges prices for peak power (e.g. Germany ~100 €/kW) can be pressuring when installing large number of charging points

e.g. 20 charging points x 11 kW + 2 x 150 kW = 520 kW x 100 €/kW = 52.000 €/yr without active load management

- In case the transformer capacity is not sufficient an expensive transformer extension next to rising grid charges may be needed
- In some European countries there is already an extensive congestion problem at the power grid, where new requests are not honored

Commercial and industrial sites face capacity challenges by extending charging infrastructure, this will raise demand for decentralized storage systems

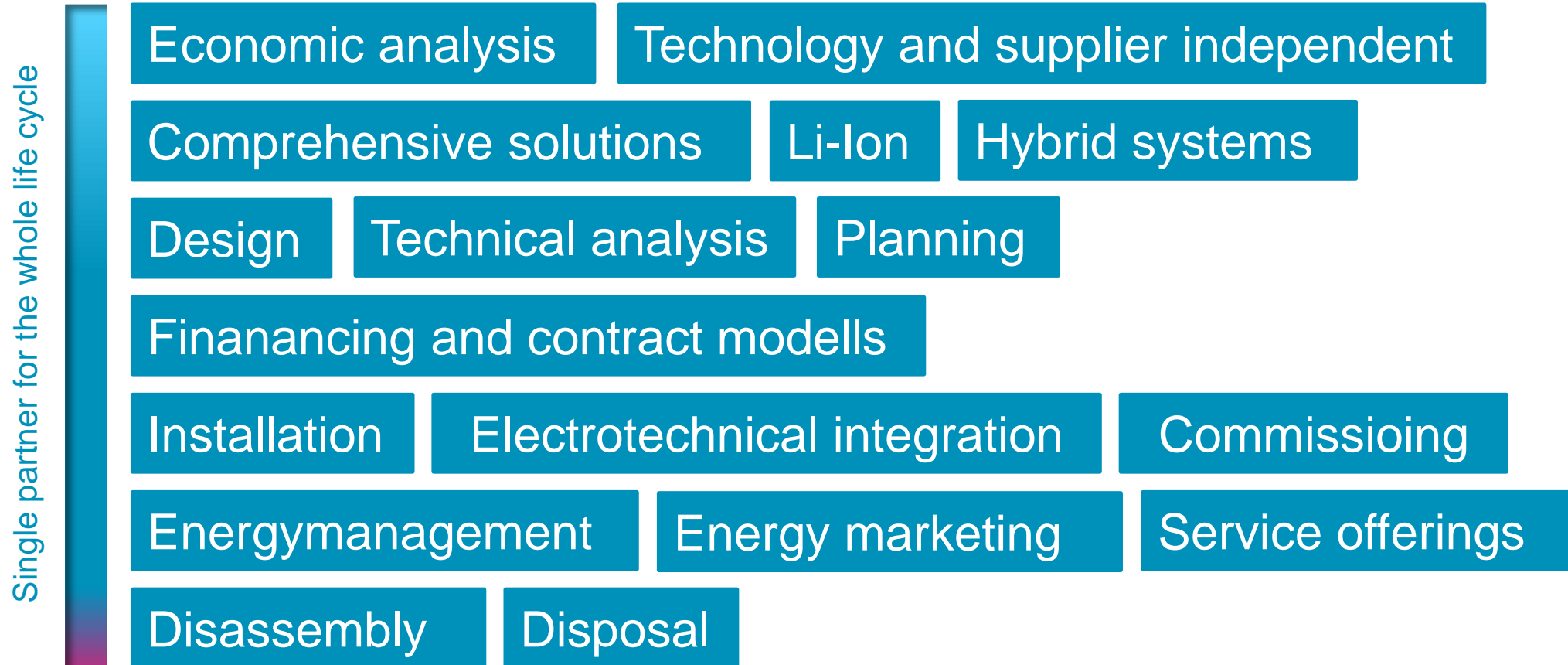
Power grid capacity map for loads in the Netherlands¹



- Structural congestion; new requests not honored
- Pre-announcement of structural congestion
- Scarcity risk; adjusted quotation regime in place

Note: Congestion map applies to three-phase connections at 3x80 Amperes
Sources: 1 Dutch Network Operators Association

Bayernwerk Natur a full service solutions provider



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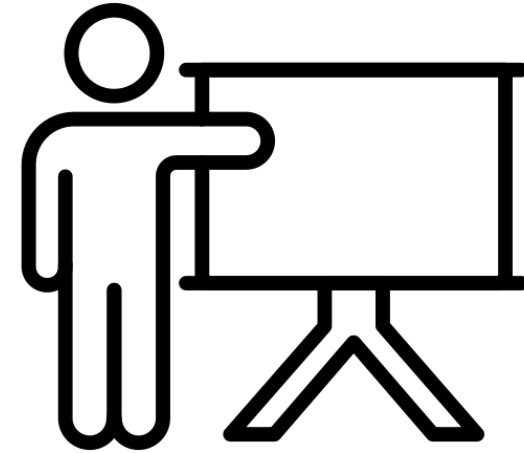
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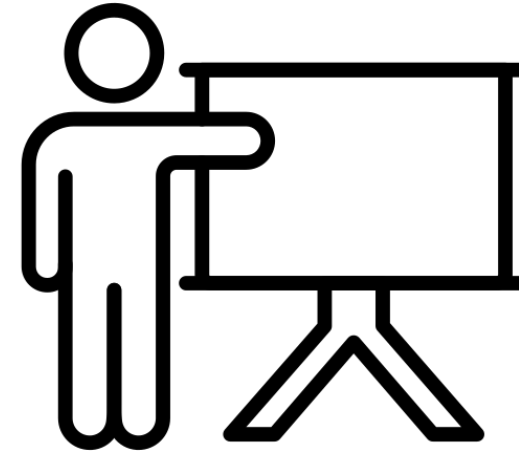
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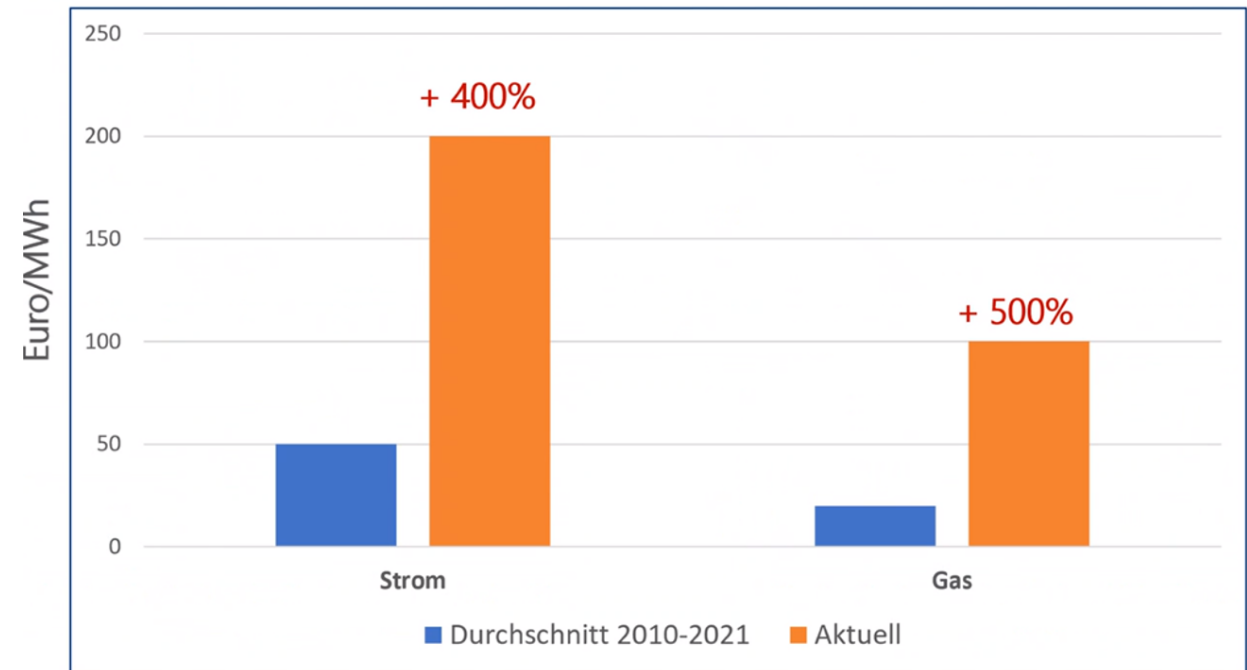
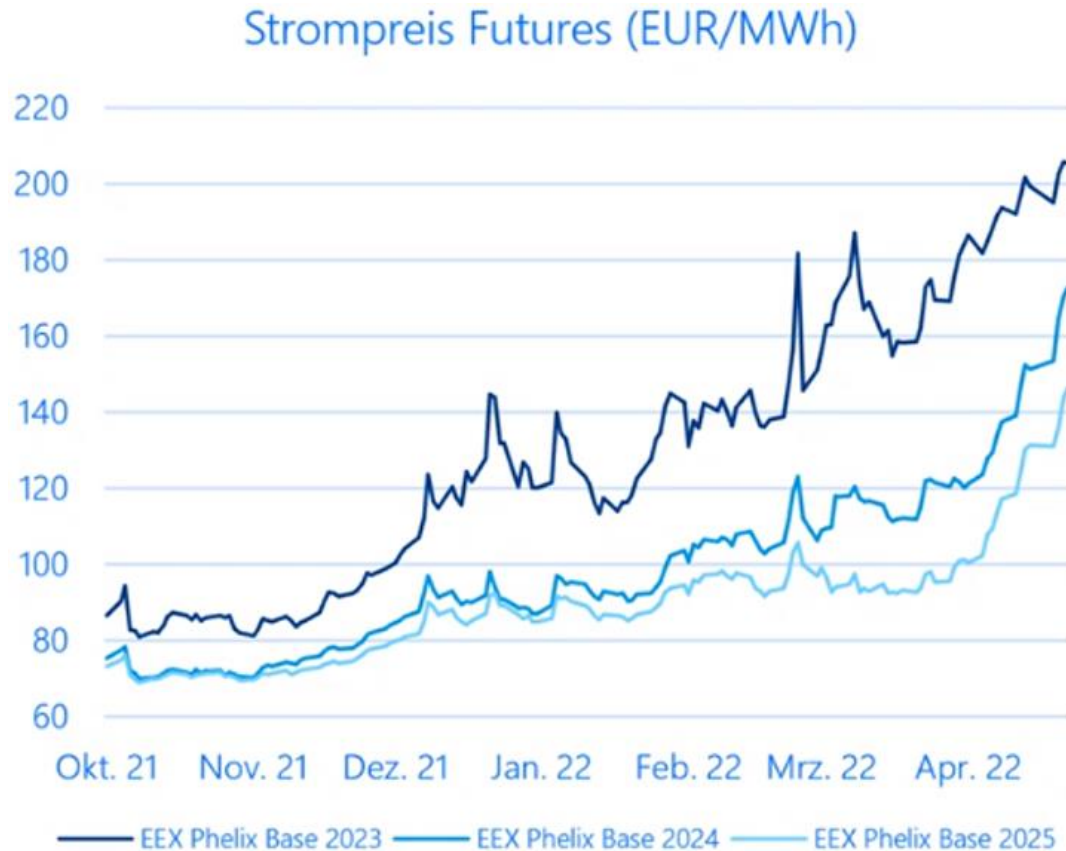
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Johannes Wüllner,
EES Conference: The Next Big Thing? C&I Electricity Storage Systems
10. May 2022

The major C&I Applications for Germany and Technologies besides LiB for C&I Storage Systems

Challenge 1: Increasing Energy Prices and Volatility



Challenge 2: Increasing Electrical Requirements in an Heavily Loaded Industrial Distribution Grid

Increasing (power & energy) demand caused by change (or extension) of the commercial use case or energy carrier

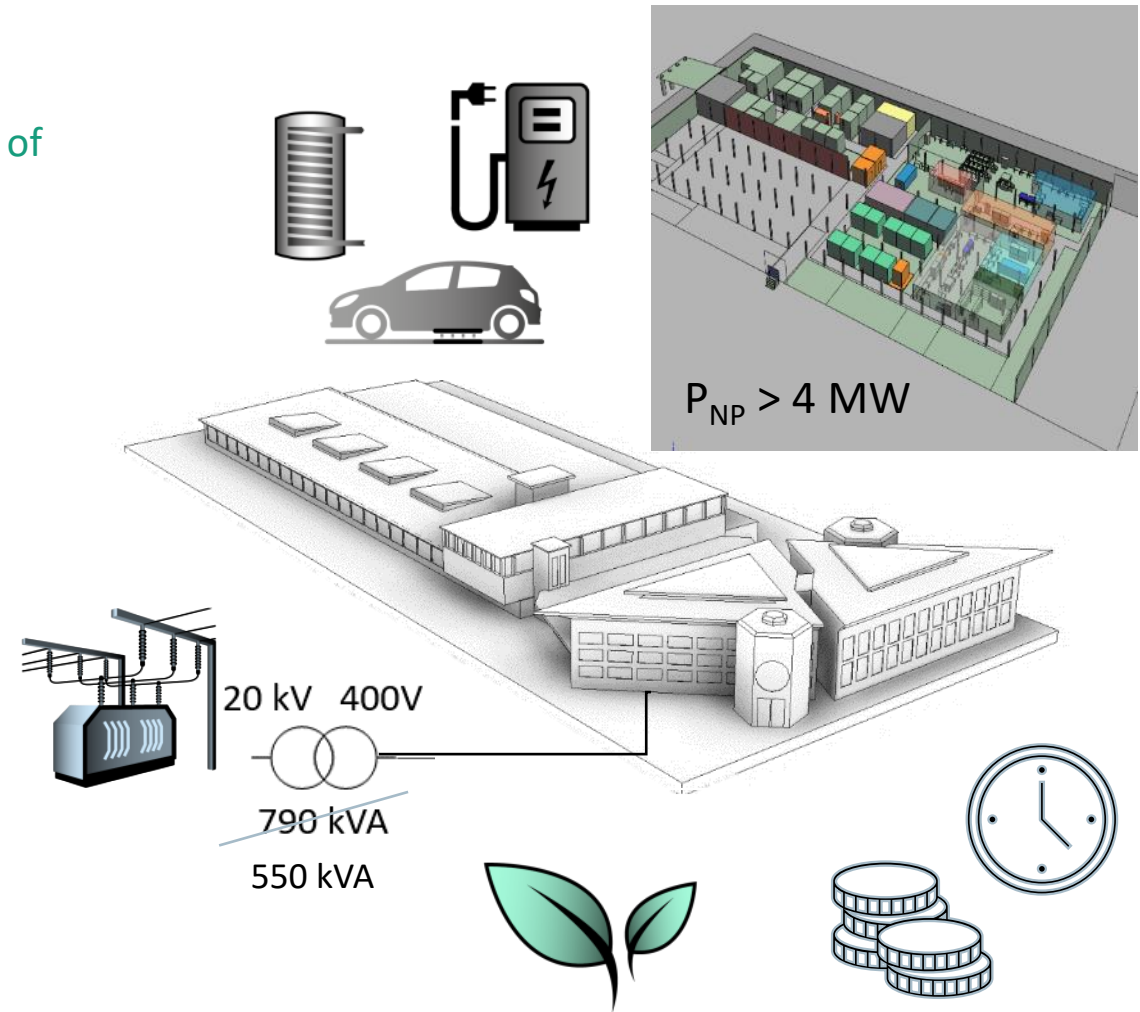
Sector coupling increase peak load demand of the MV Ring in this industrial distribution grid

Existing local electrical infrastructure is not sufficient for the new use case

Cost and time intensive effort to extend the transformer capacity

Distribution Grid capacity is already heavily loaded

Strategic goal to reduce ext. dependencies and CO₂



The Solution: PV – Battery Green Energy Supply –

Most Important Revenues for C&I Applications - View FhG ISE



Project ANLEIBAT - Anforderungen zur Leistungsbewertung gewerblicher und industrieller (G&I) Batteriespeichersysteme

Partner:

VDE Renewables

DKE
VDE DIN

 **StoREgio**
Metropolregion Rhein-Neckar

 **BVES**
Energy Storage System Association

 **Fraunhofer**
ISE

Duration: 01.09.2021 – 31.08.2023

Funded by BMWK
within the framework of the WIPANO funding
guideline

Efficiency guideline for home storage systems and preliminary standard VDE V0510-200 enable comparative assessment and support investment decisions

Transfer to C&I Storage

Differences to consider:

- Applications more diverse than with home storage, multi-use scenarios will be standart
- Installation conditions differ widely in industrial context.
- Safety requirements to be assessed differently due to size and environment
- Much higher invest and economic impact of system failure or mal function significantly higher
- (still) Project-specific planning of storage system instead of standard products
- Integration into local SCADA / EMS required / production data sensitivity

Supported by:



FHG-SK: ISE-INTERNAL

Project ANLEIBAT - Anforderungen zur Leistungsbewertung gewerblicher und industrieller (G&I) Batteriespeichersysteme

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Metropolregion Rhein-Neckar

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Transfer to C&I Storage

Research on
already existing
national and
international
norms, standards
and publications

Stakeholder
workshops with
users, Industry,
investors,
insurances

Simulation &
modelling of
technical
parameters

identify key tech. parameter and meas. Instructions as
results for

Int. Standard

VDE SPEC

Supported by:



FHG-SK: ISE-INTERNAL

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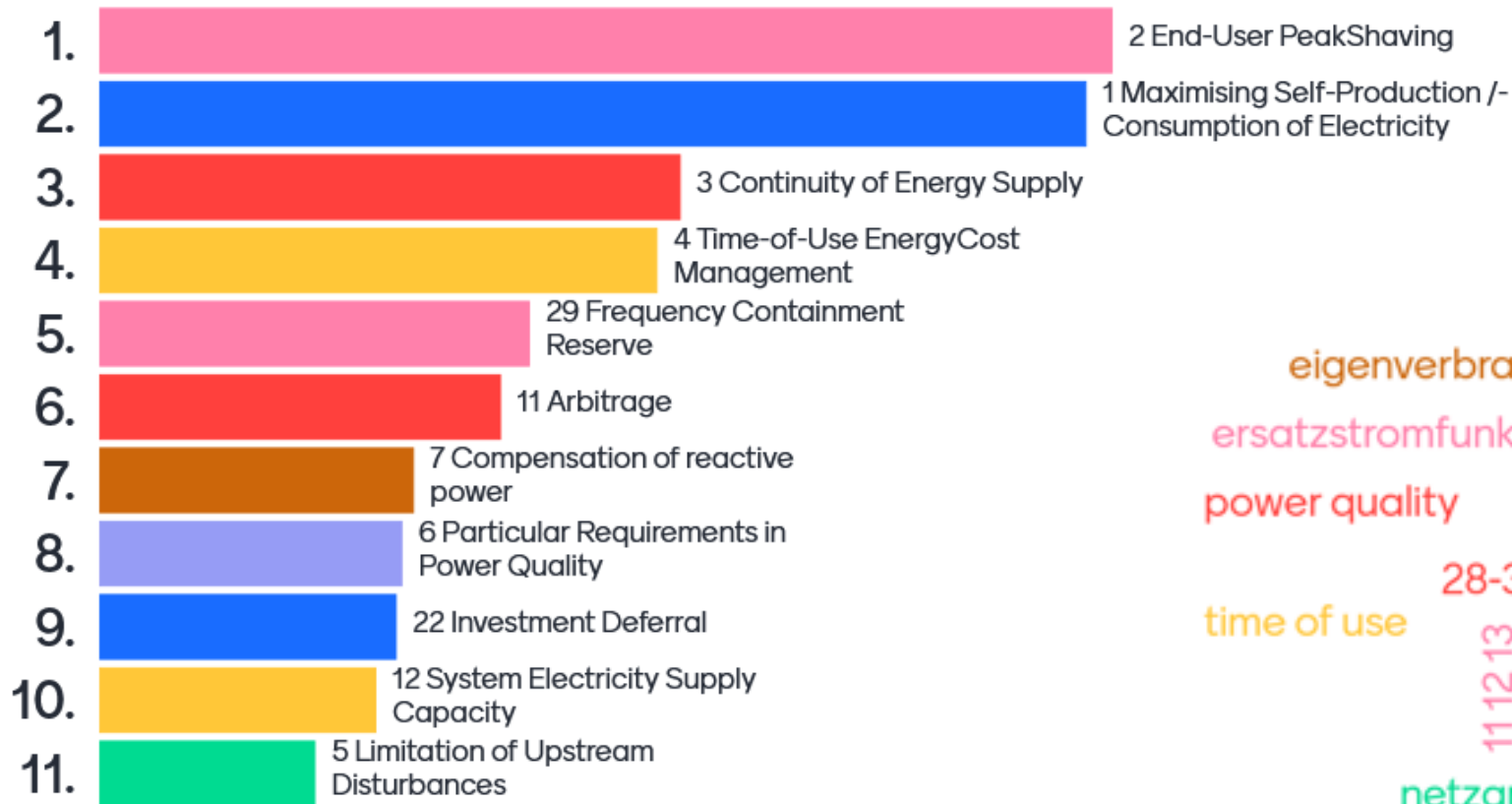
Project ANLEIBAT – Results from BVES Workshop from 26.4.2022:

Most Important Revenues for Commercial and Industrial Applications

Main Revenues (primary Applications) of C&I Storage Systems	
Application	votes
1 Maximising Self-Production /-Consumption of Electricity	88%
2 End-User Peak Shaving	79%
3 Continuity of Energy Supply	50%
4 Time-of-Use Energy Cost Management	50%
6 Particular Requirements in Power Quality	26%
5 Limitation of Upstream Disturbances	24%
7 Compensation of reactive power	21%
29 Frequency Containment Reserve	15%
11 Arbitrage	9%
22 Investment Deferral	9%



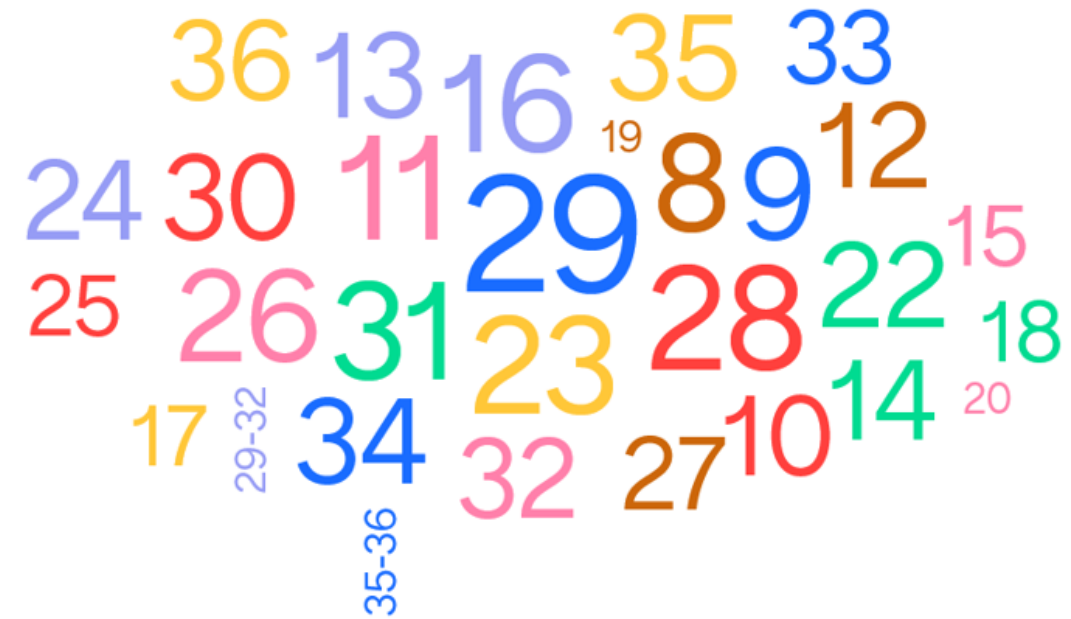
Project ANLEIBAT – Results from BVES Workshop from 26.4.2022: Priorisation of Most Important Commercial and Industrial Applications



Project ANLEIBAT – Results from BVES Workshop from 26.4.2022:

Most Important Secondary C&I Applications

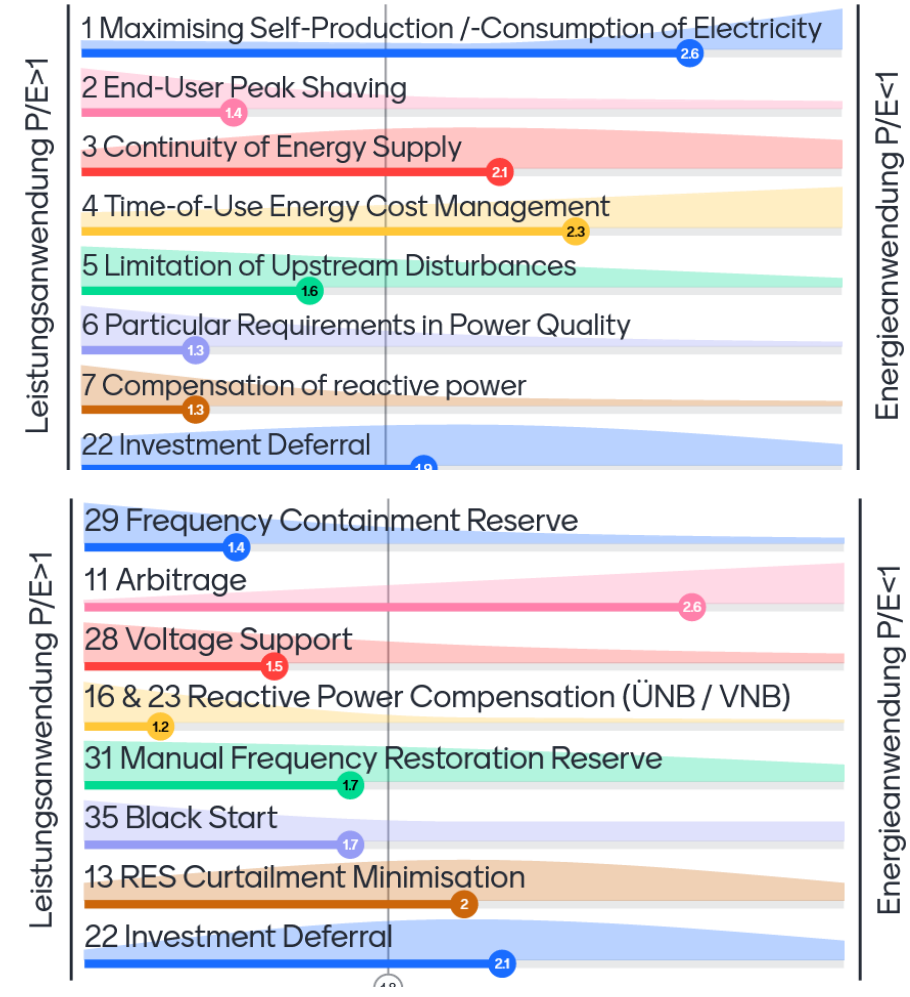
Secondary Applications of C&I Storage Systems	
Application	votes
16 & 23 Reactive Power Compensation	60%
29 Frequency Containment Reserve (Prim. Reserve)	53%
11 Arbitrage	40%
28 Voltage Support	37%
30 Autom. Frequency Restoration Reserve (Sec. Res.)	33%
8 Support to Conventional Generation	30%
9 Storage Services for RES Support	27%
26 Dynamic Local Voltage Control	23%
31 Manual Frequency Restoration Reserve	23%



Project ANLEIBAT – Results from BVES Workshop from 26.4.2022:

Group Applications to Identify Technical Key Parameters

Application	Type:
1 Maximising Self-Production /-Consumption of Electricity	Energy
2 End-User Peak Shaving	Power
3 Continuity of Energy Supply	Power Energy
4 Time-of-Use Energy Cost Management	Energy
6 Particular Requirements in Power Quality	Power
5 Limitation of Upstream Disturbances	Power
7 Compensation of reactive power	Power
29 Frequency Containment Reserve	Power
11 Arbitrage	Energy
22 Investment Deferral	Power Energy
16 & 23 Reactive Power Compensation	Power
29 Frequency Containment Reserve	Power
11 Arbitrage	Energy
28 Voltage Support	Power
31 Manual Frequency Restoration Reserve	Power
8 Support to Conventional Generation	Energy
9 Storage Services for RES Support	Energy



Alternative Battery Technologies

Metal-Ion (2 main Chemistries: Sodium-Ion, Zinc-Ion)

Advantages:

- High low-cost potential (\$50/kWh)
- Non-flammable and safe
- Non-toxic
- System modularity and flexibility

Disadvantages

- still limited cycle life (~ 1000 cycles at 100% DOD)
- Capacity degradation at high c-rates
- Low energy density (45 Wh/L)
→ not (yet) suitable for mobile applications



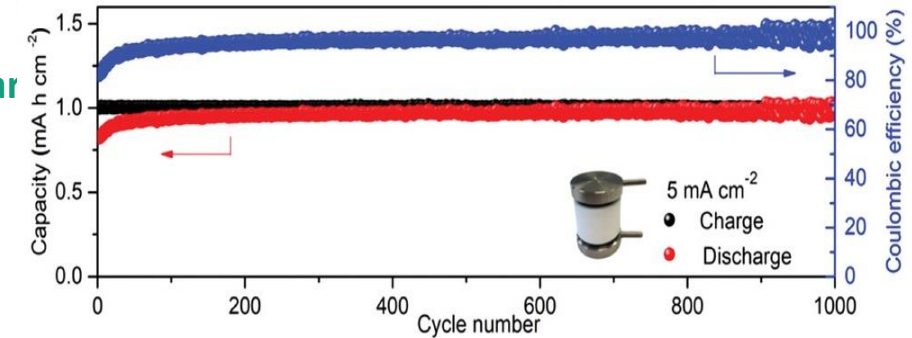
Intercalation chemistry similar lithium-ion



Automation and reproducibility (QS)



Further increase Cycle stability



[1] Zeng et al., Toward a Reversible Mn⁴⁺/Mn²⁺ Redox Reaction and Dendrite-Free Zn Anode in Near-Neutral Aqueous Zn/MnO₂ Batteries via Salt Anion Chemistry. *Adv. Energy Mater.* **2020**, *10*, 1904163, doi:10.1002/aenm.201904163.
FHG-SK: ISE-INTERNAL

[2] © Fraunhofer from WELTSPEICHER: WinZIB Project, funded by BMBF

Alternative Battery Technologies

Redox Flow

Most common chemistries

- Vanadium (1.3-1.4 V)
- All-Iron (1.2 V)
- Zinc-bromine (1.8 V)



Promising new chemistries under research e.g. Hydrogen-based or organic (lignin) RFB and more (e.g. FhG ICT: SonarRedox)

Advantages

- High cycle life at deep discharging (up to 20,000 cycles)
- Non-flammable and high electrolyte safety
- Cost competitive for long discharge durations (>6 hrs)



Reduction of stack costs by:
- increase of power density >400 mW/cm²
- increase automation of stack production

Disadvantages

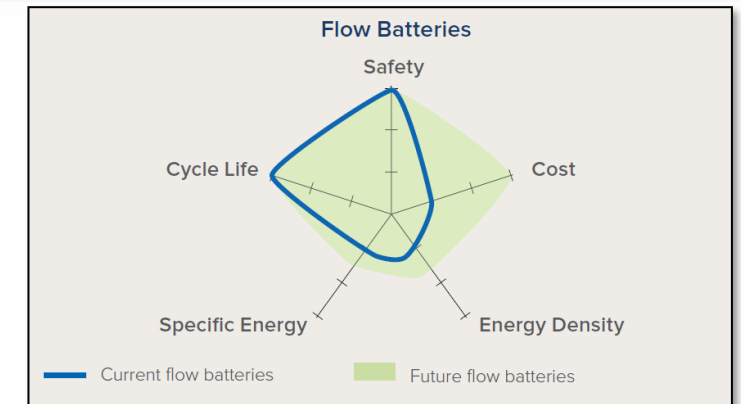
- Cost optimization still required → material still costly
- Sensitive to extreme operating temperatures
- Still at a low energy density compared to lithium-ion



holistic approach: use of electrolyte as heat storage (KIT: Bi-Flow)



[1]



[2]



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Panel Discussion



#1 Market Status, Policy and Politics

#2 Application Tasks and Profitability Trends

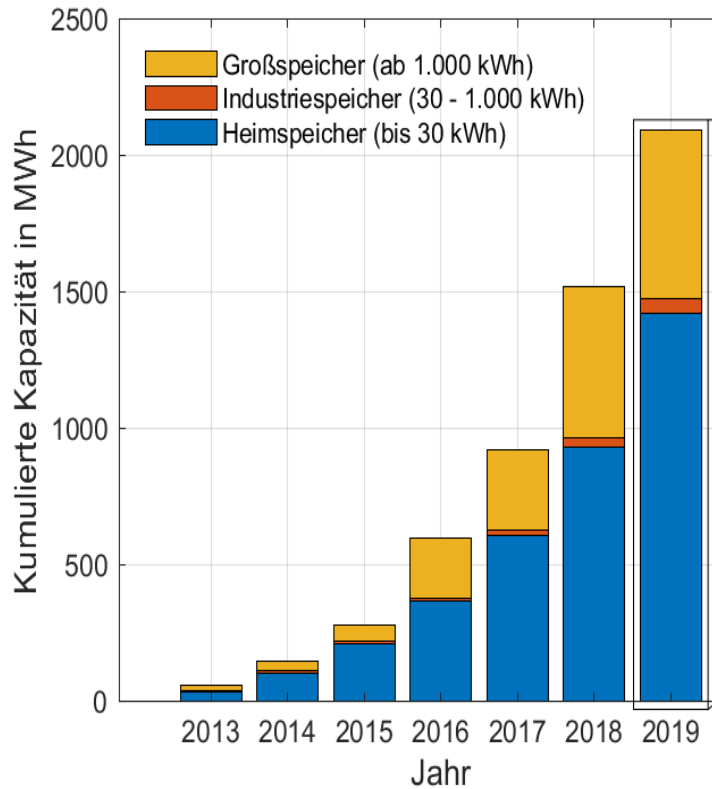
#3 Hardware and Storage Technology Trends



Or use QR code

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1 Market growth, Policy and Politics



Or use QR code

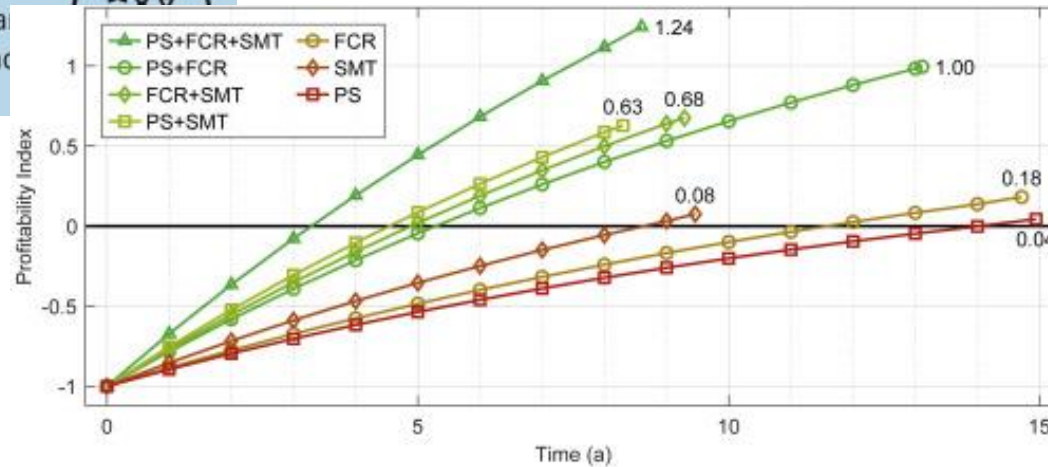
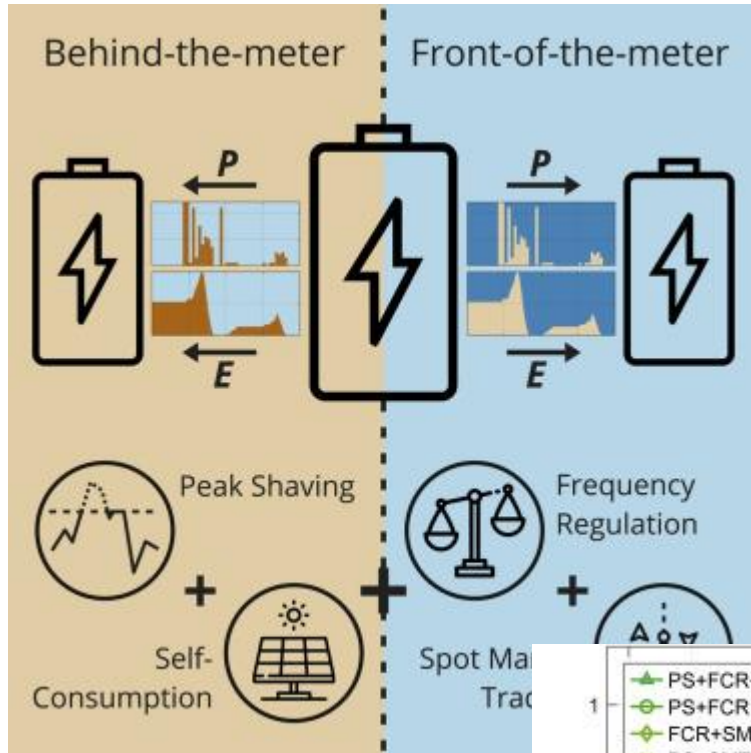
www.menti.com code 7490 6012

J. Figgner et al - The development of battery storage systems in Germany – A market review (status 2022) - ArXiv

B. Tepe et al. Stationäre Batteriespeicher in Deutschland: Aktuelle Entwicklungen und Trends in 2021 – Energiewirtschaftliche Tagesfragen (BVES)

Dr. Holger Hesse | EES Europe 2022 - C & I Storage | 10.05.2022

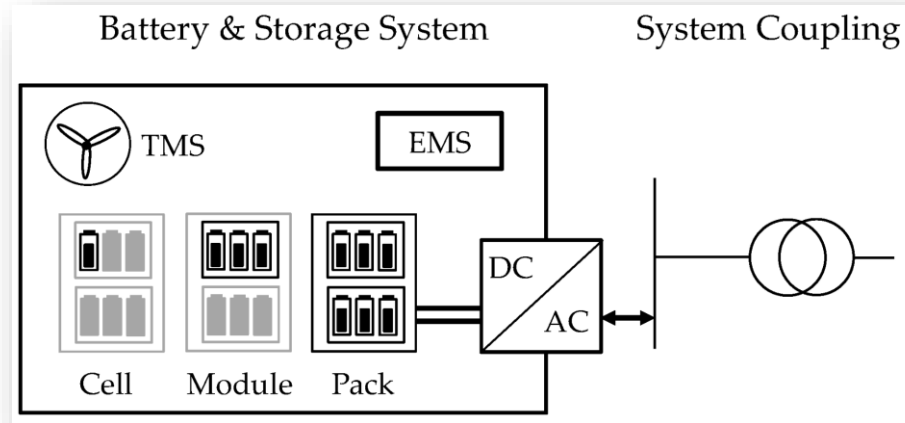
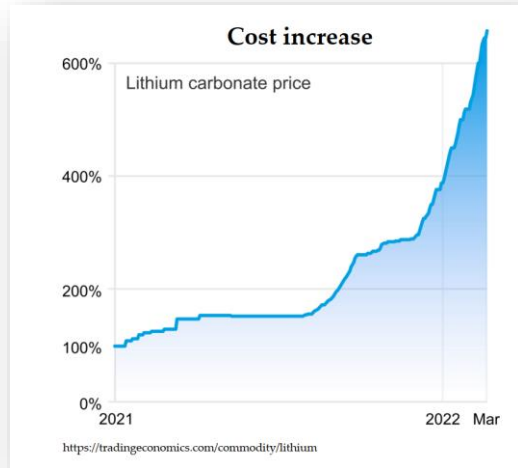
#2 Application Tasks and Profitability Trends



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#3 Hardware and Storage Technology Trends



CATL goes all in on next-gen sodium-ion EV batteries

Chinese company looks to industrialize alternative to lithium-ion cells in 2023



asia.nikkei.com – CATL press release

Operations And Supply Chain Management

How the War in Ukraine Is Further Disrupting Global Supply Chains

by David Simchi-Levi and Pierre Haren

March 17, 2022



HBR Staff/Nittaya Singhaseri/Getty Images

Hbr.org – Harvard Business Reviews



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Thank you!



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