Business Models

How to Stay Successful in a Maturing Market?

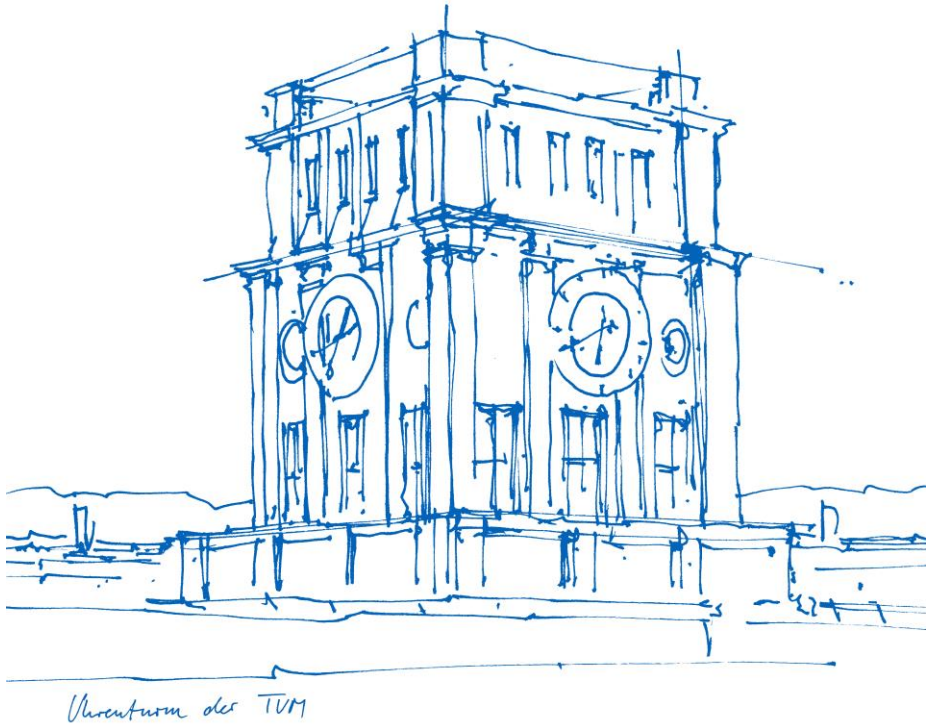
Intersolar 2021 - EES Europe The smarter E

Dr. Holger Hesse

Technical University Munich

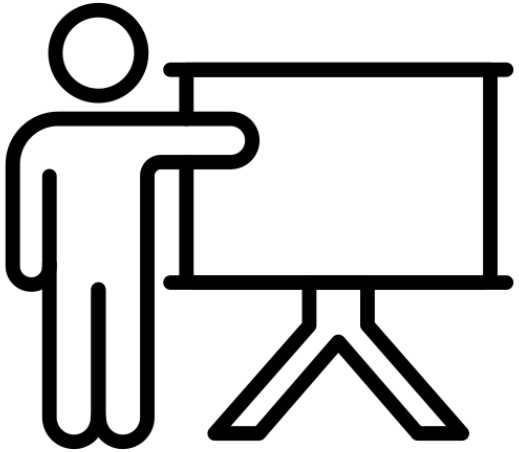
Chair for Electrical Energy Storage Technology

06.10.2021

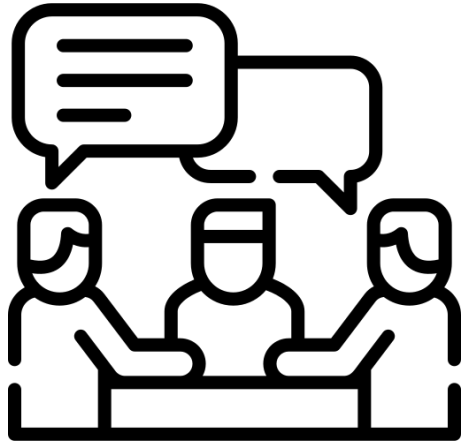


Session Business Models

How to Stay Successful in a Maturing Market?



Pitch Presentations



Panel Discussion

Florian Mayr
Apricum - The Cleantech Advisory

Ulrich Bürger
ECO STOR GmbH

Dr. Michael Baumann
TWAICE

Dr. Martin Kruska
Siemens AG

Marcus Fendt
The Mobility House GmbH

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TUM - Technische Universität München

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Florian Mayr

APRICUM

THE CLEANTECH ADVISORY.

Business Models for Grid Integrated Storage - A Market Trend Analysis


THE
CLEANTECH
ADVISORY
WWW.APRICUM-GROUP.COM
Apricum –
A global transaction and strategy advisory firm dedicated to renewable energy and cleantech
APRICUM

The industries we cover…

Solar

- PV/CSP
- Hybrid systems
- Solar materials

Energy storage

- Batteries
- Thermal/mechanical
- Storage materials

Green mobility

- E-mobility
- Alternative fuels
- Charging infrastructure

Water

- Desalination
- Water infrastructure
- Hydropower

Waste

- Waste water treatment
- Waste to energy
- Waste management

Green hydrogen

- Electrolyzers
- Power-to-X
- Hydrogen materials

Wind

- Onshore
- Offshore
- Wind materials

Bioenergy

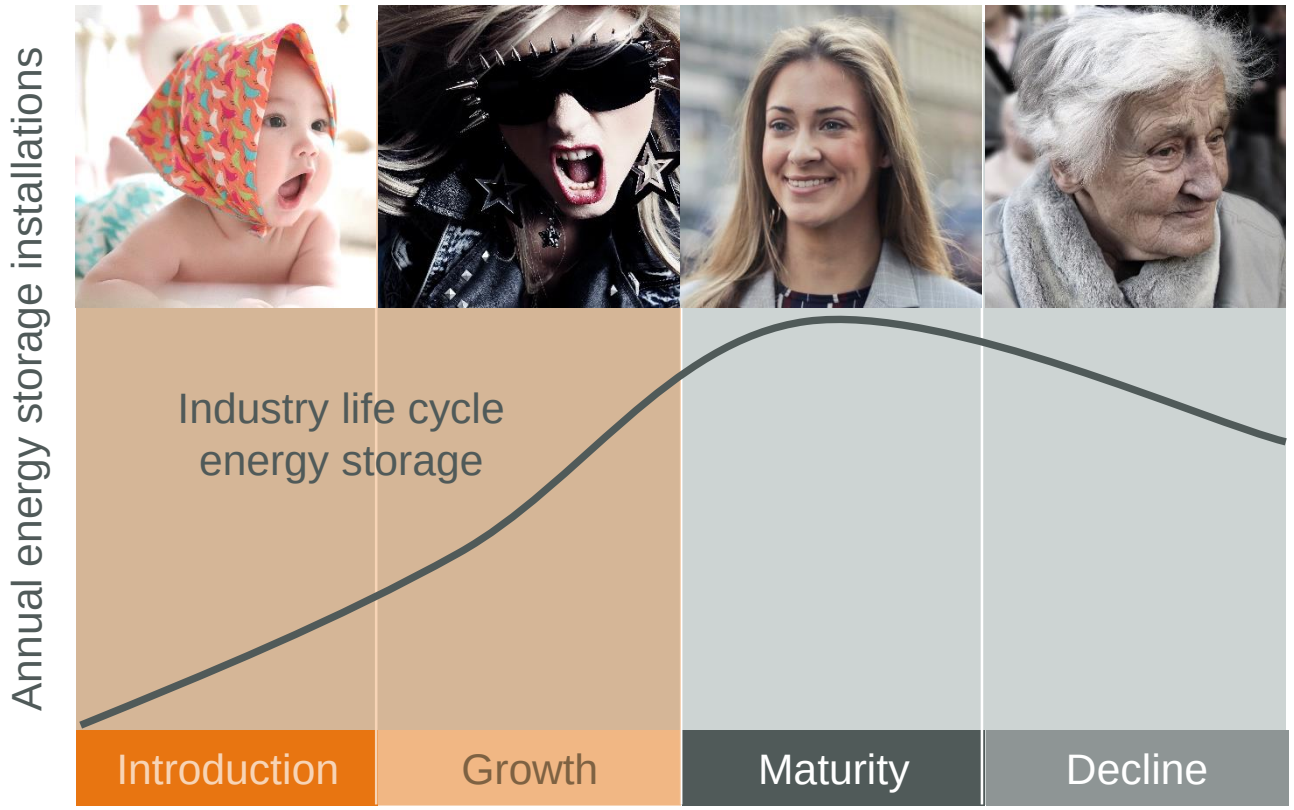
- Biomethane
- Alternative fuels
- Industry decarbonization

Digital energy

- Energy management systems
- Smart grids
- Virtual power plants

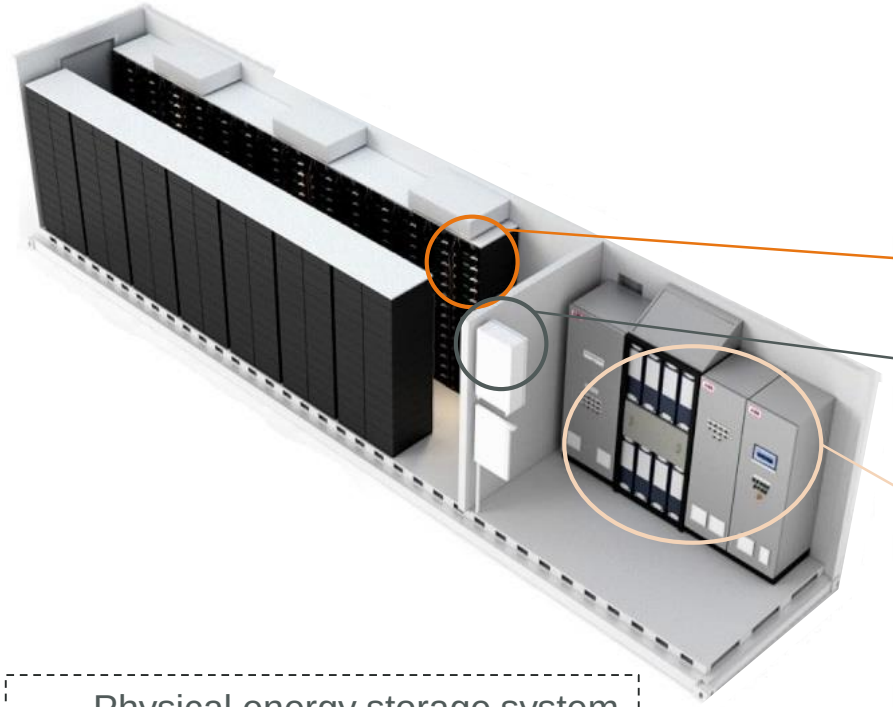
…and (some of) the clients we have served.

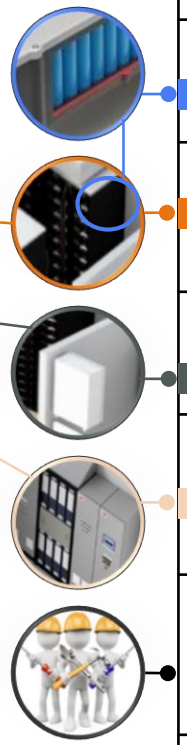
The decade of energy storage has just begun – we help you to successfully participate.



Multiple components and services are required to realize grid integrated energy storage.

Battery energy storage system ("BESS") components





Physical energy storage system

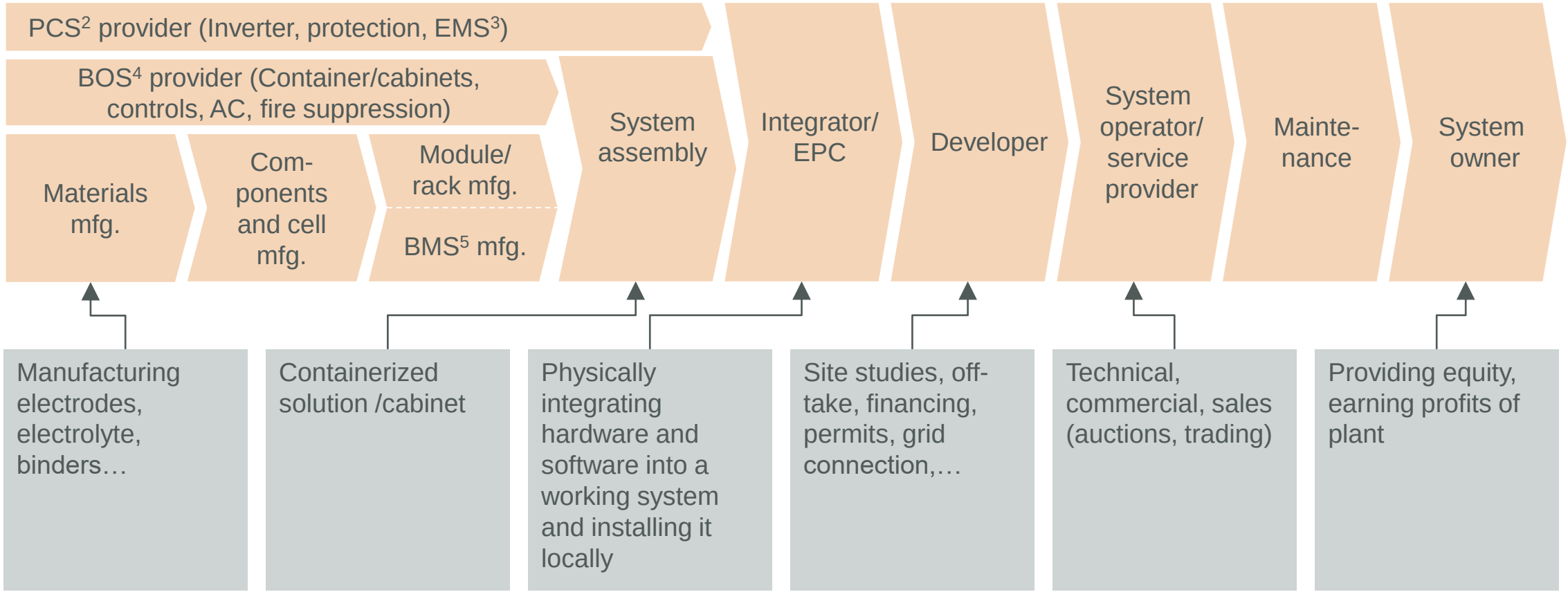
BC BR | BOS | PCS

System layer		Components/services		
BC	Battery cell	• Electrodes • Electrolyte	• Electrical contacts	~35%
BR	Battery rack	• Battery modules • Racking frame	• Battery management system ("BMS")	~20%
BOS	Balance-of-system	• Container/cabinet • Monitors, controls	• Thermal control • Fire suppression	~10%
PCS	Power control system	• Inverter • Protection (Switches, etc.)	• Energy management system ("EMS")	~20%
EPC	Engineering, procurement, construction	• Engineering studies/Permitting • Construction	• Commissioning • Project management	~10%
Other		• SCADA • Shipping	• Grid integration • Land	~5%

Source: Apricum analysis, ABB; 1) Of installed utility-scale BESS system

Consequently, business models to address the market opportunity can cover various steps along the value chain.

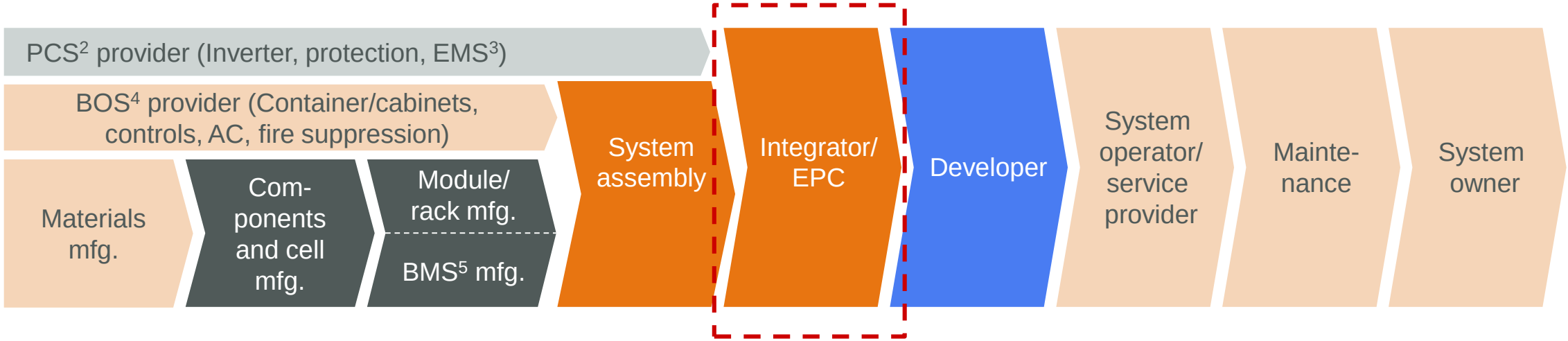
Stationary battery energy storage[1] value chain



Source: Apricum; 1) Lithium-ion battery energy storage systems; 2) Power Control System; 3) Energy Management System; 4) Balance of System; 5) Battery Management System

A central role is taken by the energy storage system integrator, with physical integration of hardware and software at its core.

Stationary battery energy storage[1] value chain

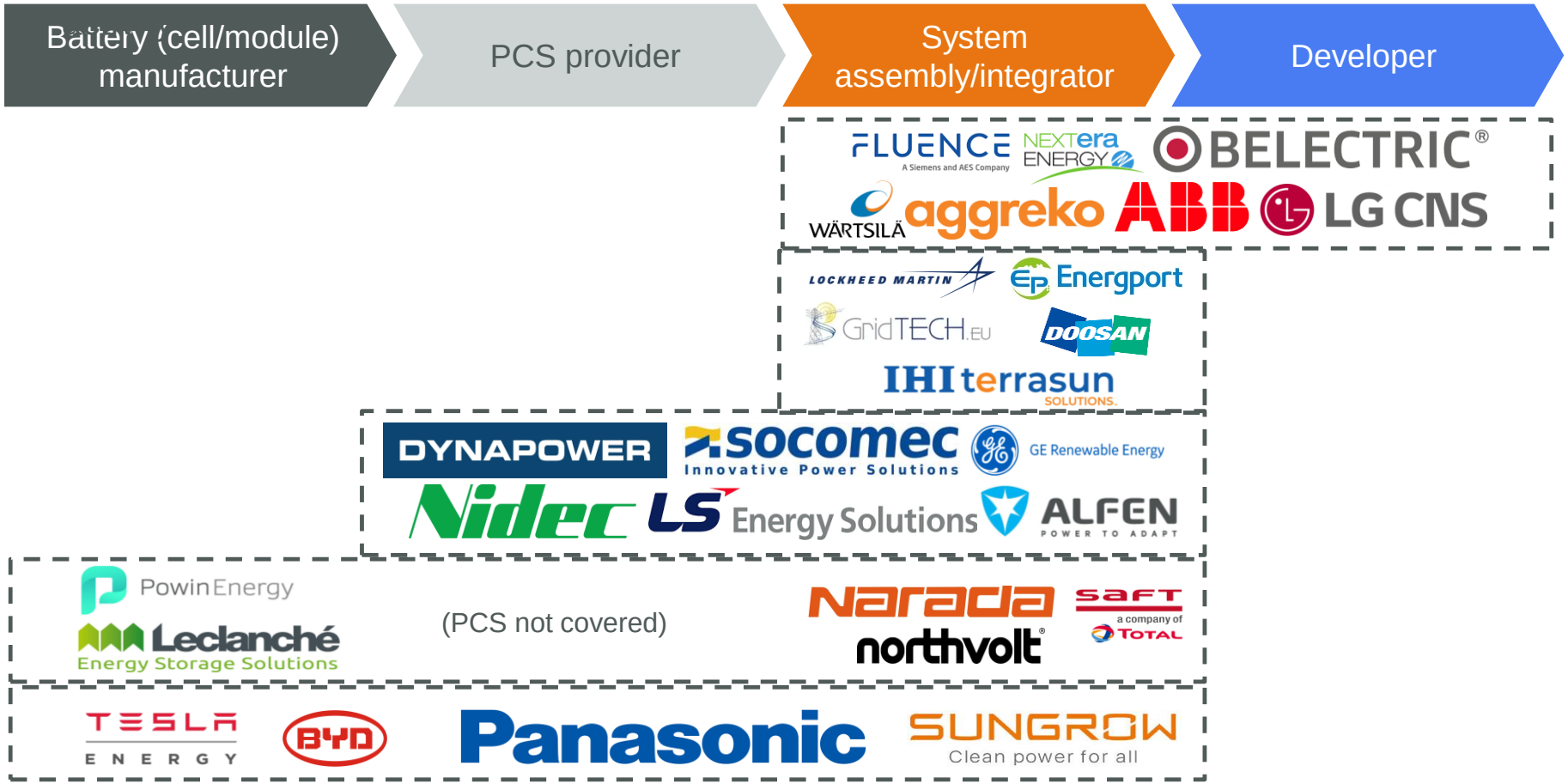


Source: Apricum; 1) Lithium-ion battery energy storage systems; 2) Power Control System; 3) Energy Management System; 4) Balance of System; 5) Battery Management System

NOT EXHAUSTIVE

Player analysis reveals different levels of value chain coverage and increasing competition through vertical downstream integration.

Overview of stationary energy storage system integrator (ESSI) landscape by company[1]

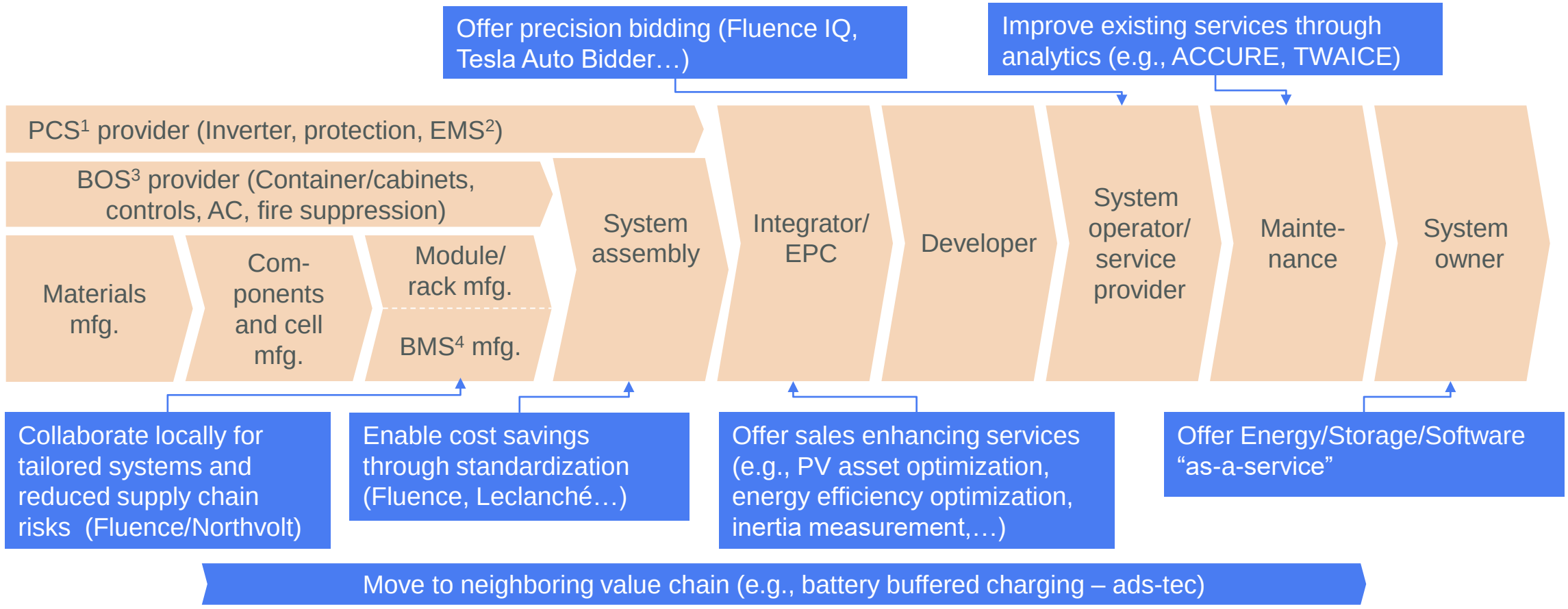


Key trends observed in the ESSI market:

- Increasing competition as PCS players (and cell manufacturers?) move downstream
- Limited consolidation so far
- Increasing price pressure as players focus on securing market shares

Source: IHS Markit, Apricum analysis; 1) Selected players only; focus on utility-scale and C&I segment

Players need to differentiate – luckily, various opportunities exist.



Source: Apricum; 1) Power Control System; 2) Energy Management System; 3) Balance of System; 4) Battery Management System; 5) E.g., illiquid market, superior market power of companies in neighboring stages, very early/very late industry stage

Dr. Martin Kruska

SIEMENS

Ingenuity for life

Monetizing Storage in European Power Grids: Asset Management in the Flexibility and Balancing Markets

Monetizing Storage in European Power Grids

Asset Management in the Flexibility and Balancing Markets

Business Models – How to Stay Successful in a Maturing Market

The smarter E Europe Restart 2021 | Munich, 6 October 2021

SIEMENS

Intelligent energy storage solutions contributing to flexibility markets and generating additional revenue

Challenges

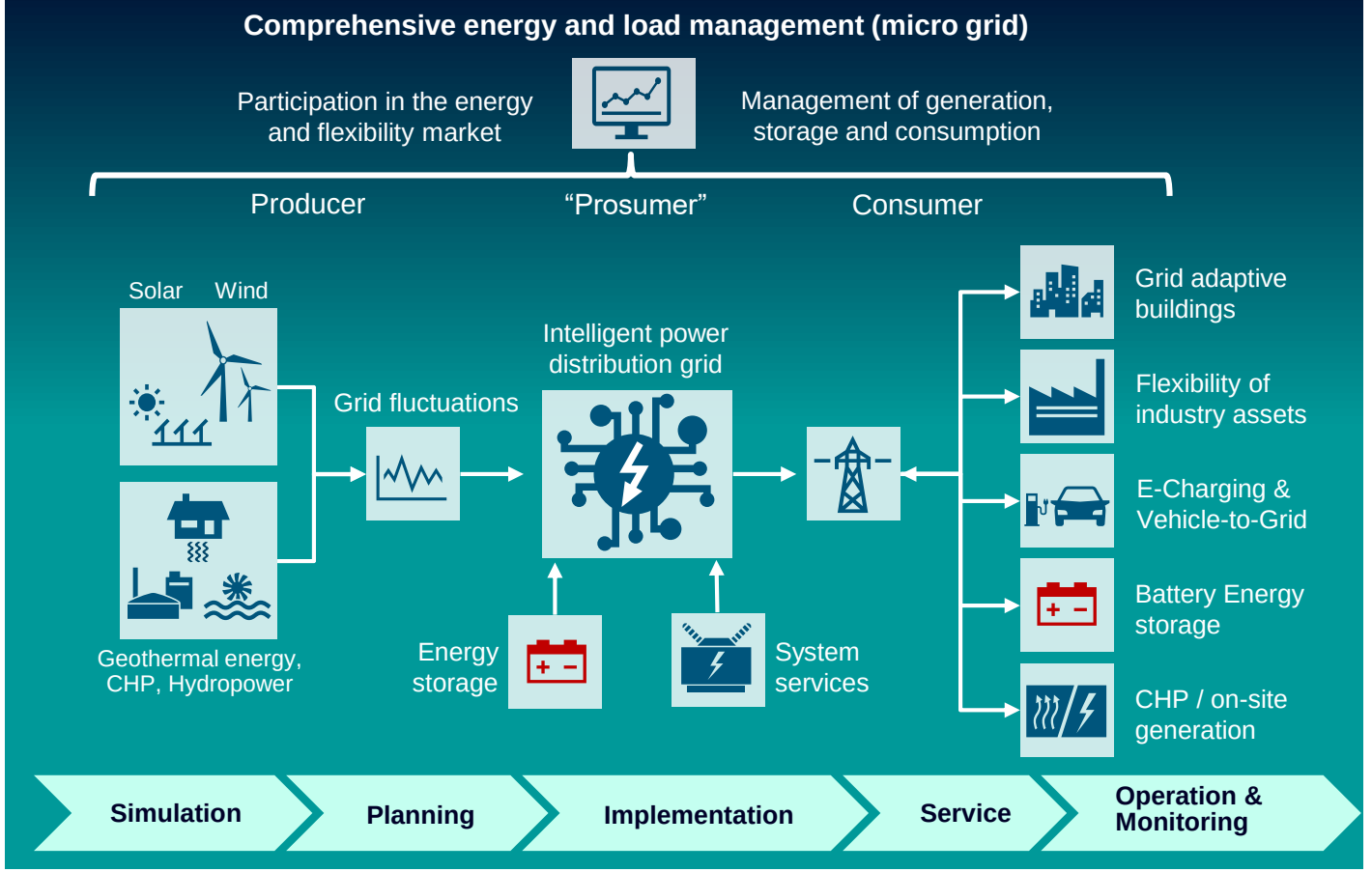
Cost pressure
Increased grid levies and (non-commodity) costs

Efficiency
Power quality issues and potential losses due to power curtailment

Security of supply
Need for UPS & resilient power supply

Resource constraints
Limited staff resources, lack of investment budget

Solution: Flexible, efficient and resilient energy system



Benefits

Cost reduction of grid connection and grid charges through load management

Flexible operation of producers & consumers

New Revenue streams through participation in the flexibility market

No budget required, risk minimization through **performance guarantees**

Holistic approach – All from a single source

SIEMENS

Key Messages

- BESS are very suitable for – and have become an important pillar in – the balancing / flexibility markets
- Applicability and business case depend largely on circumstances & market environment
- In general, three main use cases / business models:
  - Ancillary services (FCR-N / FCR-D, FFR)
  - Peak-load management (e.g. grid-levy optimisation in GER – INN, AtNN)
  - Intraday trading
- Fringe benefits can be power quality improvements and power factor correction
- Combination with other use cases possible, but increases complexity and requires sound control strategies
- A careful balancing of market requirements and BESS degradation is key for economical feasibility

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Example: Shopping Center Sello, Finland
Smart energy solution and services landscape

Electricity spot market

nordpool spot

Demand response / balancing market

FINGRID

Siemens smart grid controllers and demand response applications

24 EV Charging points

Solar panels 500kW

Battery storage 1,68 MW

CHP

Siemens building automation

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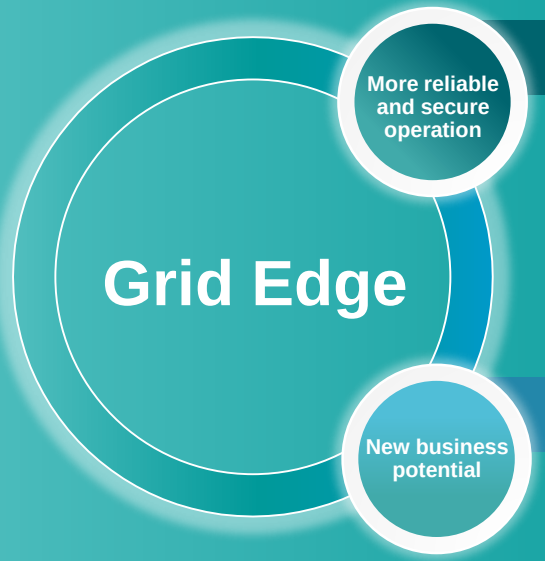
Sello Shopping Center, Espoo, Finland

Data-driven services transform Sello into one of the greenest shopping centers in Europe

- Remote Analytics: connecting 1,500 energy- and heating/cooling/ air conditioning data points with a cloud-based building automation system
- Micro-Grid: 0,5 MW own solar electricity, 1.68 MW energy storage
- Demand response: Enabling participation on the energy market
- Connect power generation and storage to the grid to optimize energy efficiency, demand and supply in electricity market



More reliable and secure operation

- **50% reduction in district heating**
- **€118,000 p.a. savings in energy and maintenance**
- **€60,000 p.a. earnings from the PV installation**

New business potential

- **€480,000 p.a. benefits from the energy market**
- **Emissions reduction of 281 tonnes CO_2 p.a.**

20 MW / 20 MWh BESS project at Sinebrychoff's beverage factory in Finland

Virtual power plant

+

Lease-based energy storage

+

Financing solutions

INNOVATIVE SERVICE MODEL

for Sinebrychoff contributes to Finland's ambition to become a carbon neutral country by 2035

- Improved power quality in production facilities
- Lower electricity costs
- Reduced CO2 emissions in the national electricity network of Finland
- Active participation in the energy market
- Minimal expense and investment risk

Power flexibility

~300 million liters

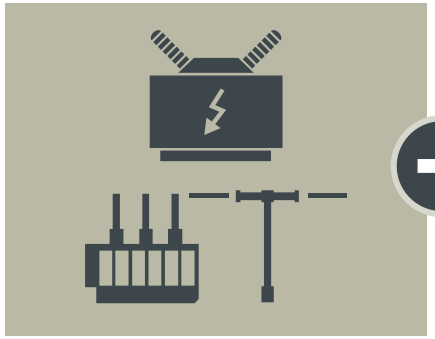
... beer, cider, soft and energy drinks p.a.

SIEMENS Ingenuity for life | FLUENCE A Siemens and AES Company | STORAGE | VIBECO Virtual Buildings Ecosystem Oy

- BESS connected Vibeco – Siemens' Virtual Power Plant in Finland
- BESS provides ancillary services to Fingrid
- Markets: FCR-N, FCR-D, FFR and potentially intraday trade

BESS Application Case: Grid Levy Optimisation in Germany

1.600 kVA – 6 kV – 0’4 kV



1.000 kW/1.500 kWh

Battery Storage

Covering the first minutes

1.200 kW

CHP

Taking over the Load

1.200 kW

CHP

Taking over the Load

1.500 kW

Load Management

Shutting off pre-defined consumers

Grid Connection	Battery Storage	CHP 1	CHP 2	Load Management
	• 530 Events • 5,5 hrs max. duration • Run time: 450 h./a	• 41 Events • 96 hrs max. Duration • Run time: 809 h./a	• 43 Events • 24 hrs max. duration • Run time 207 h./a	• 4 Events • 15 min max. duration • Run time 1 h./a

Annual Savings: Approx. 3 mEUR
Invest: approx. 6 mEUR

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Planned 100 MW / 200 MWh Battery Energy Storage Project at Wunsiedel, Germany

- BESS: Fluence
- BESS Rating: 100 MW / 200 MWh
- Space Requirements: 5.000 m²
- Markets (planned): FCR, Intraday
- Investors: Consortium
- Main Stakeholders: Siemens SI, ZENOB GmbH
- Stage: LoI, development of financing concept

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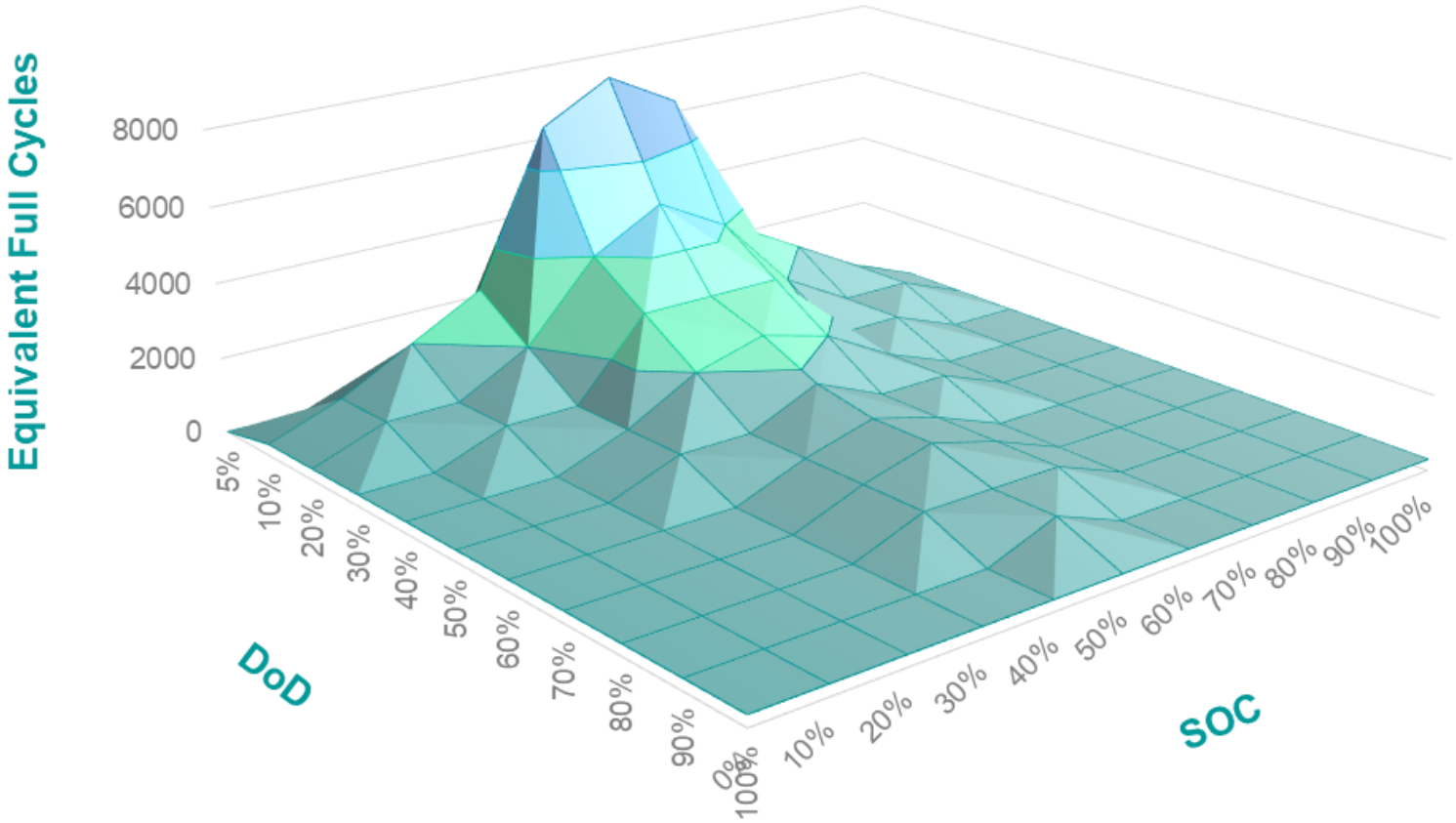
Aging behaviour
Cycle life vs. DoD vs. SOC



Aging speed shows nonlinear correlation to multiple external factors.

- State of Charge – SOC
  Operation at very high or low SOC leads to quicker aging
- Depth of Discharge – DoD
  Strongly nonlinear: Doubling the Energy throughput leads to more than twice the aging

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Disclaimer

Subject to changes and errors. The information given in this document only contains general descriptions and/or performance features which may not always specifically reflect those described, or which may undergo modification in the course of further development of the products. The requested performance features are binding only when they are expressly agreed upon in the concluded contract.

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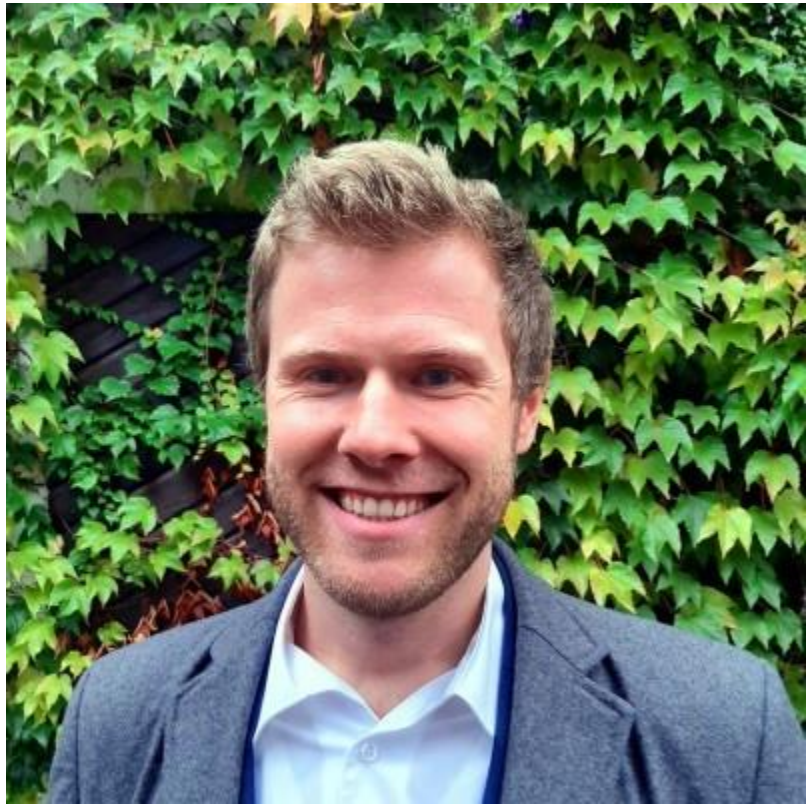


Technical University of Munich

A Science View to Multi-Use and Vehicle-to-grid - Where are the Obstacles?

A Scientific View on Multi-Use and Vehicle-to-grid - Where are the Obstacles?

Stefan Englberger

Technical University of Munich

TUM School of Engineering and Design

Chair for Electrical Energy Storage Technology

Business Models - How to Stay Successful in a Maturing Market

ees Europe, 2021-10-06

Classification of stationary energy storage systems

Home storage system

< 30 kWh

Source: sonnen.de

Industry scale storage

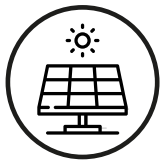
30 – 1000 kWh

Source: nec.com

Utility scale storage

> 1 MWh

Source: tesla.com



Self-consumption increase (SCI)

Peak shaving (PS)

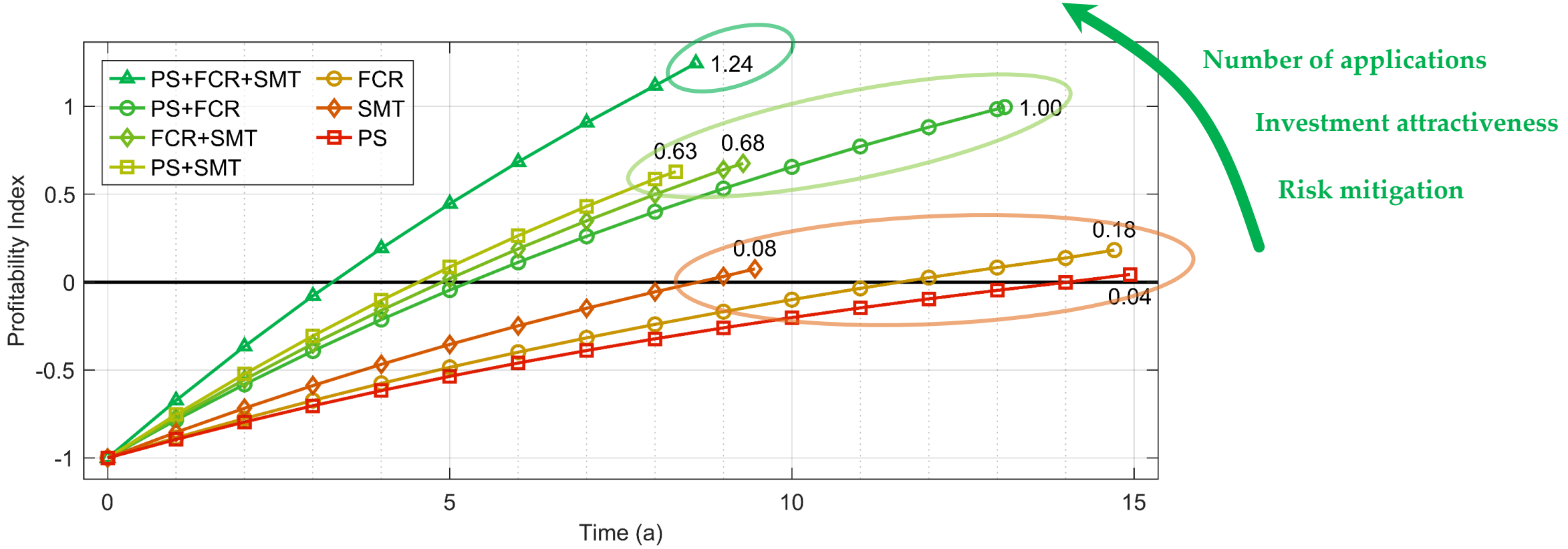
Frequency regulation (FCR)

Spot market trading (SMT)

Behind-the-meter (BTM)

Front-of-the-meter (FTM)

Multi-use increases the utilization of the energy storage

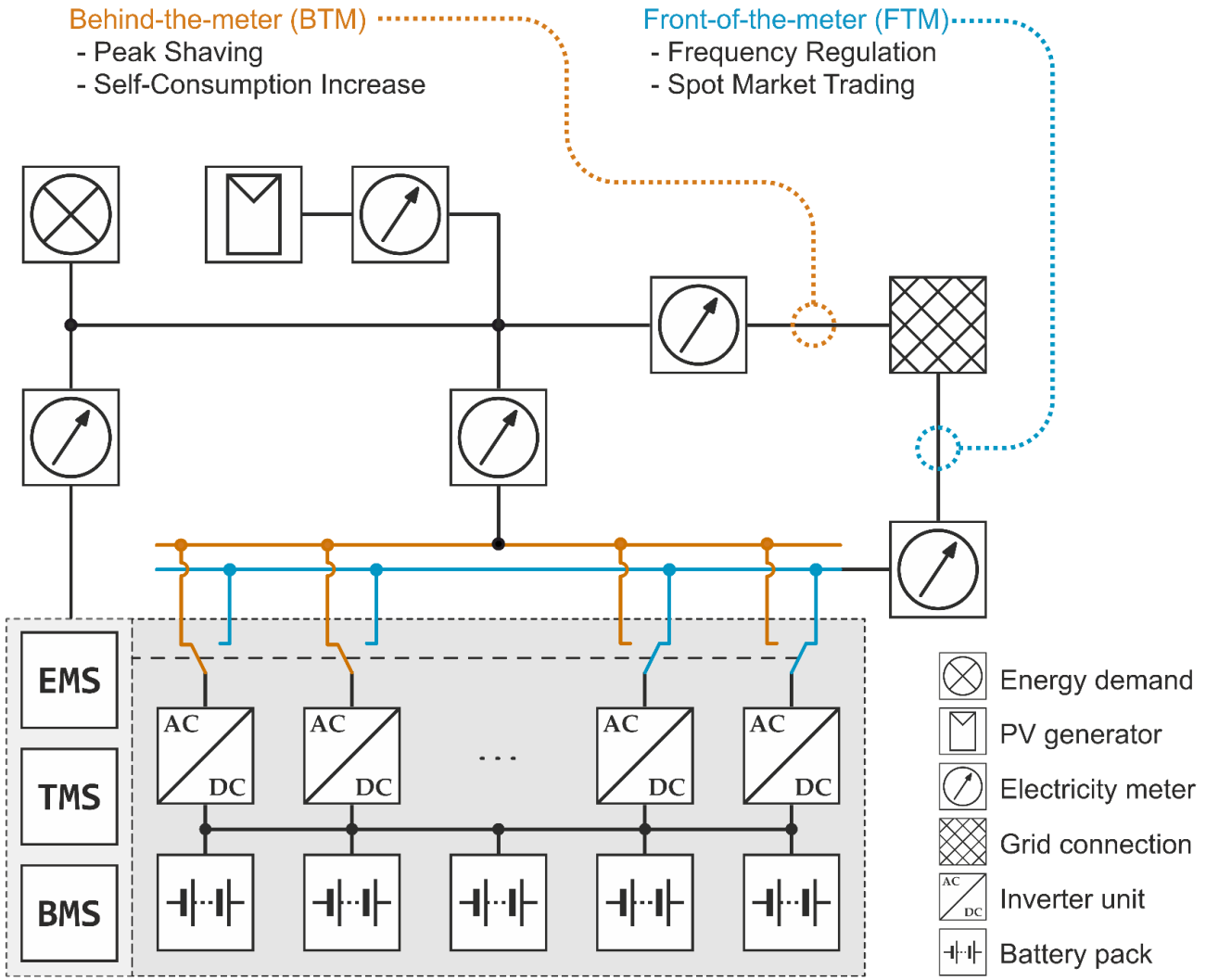


- Only moderate profitability for single-use cases over the battery lifetime
- Multiple-sourcing allows risk diversification and multi-use focuses on lucrative markets
- Multi-use increases the technical and economic potential of the battery storage system

[1] S. Englberger, A. Jossen, and H. Hesse, "Unlocking the Potential of Battery Storage With the Dynamic Stacking of Multiple Applications," *Cell Reports Physical Science 1*, 2020.

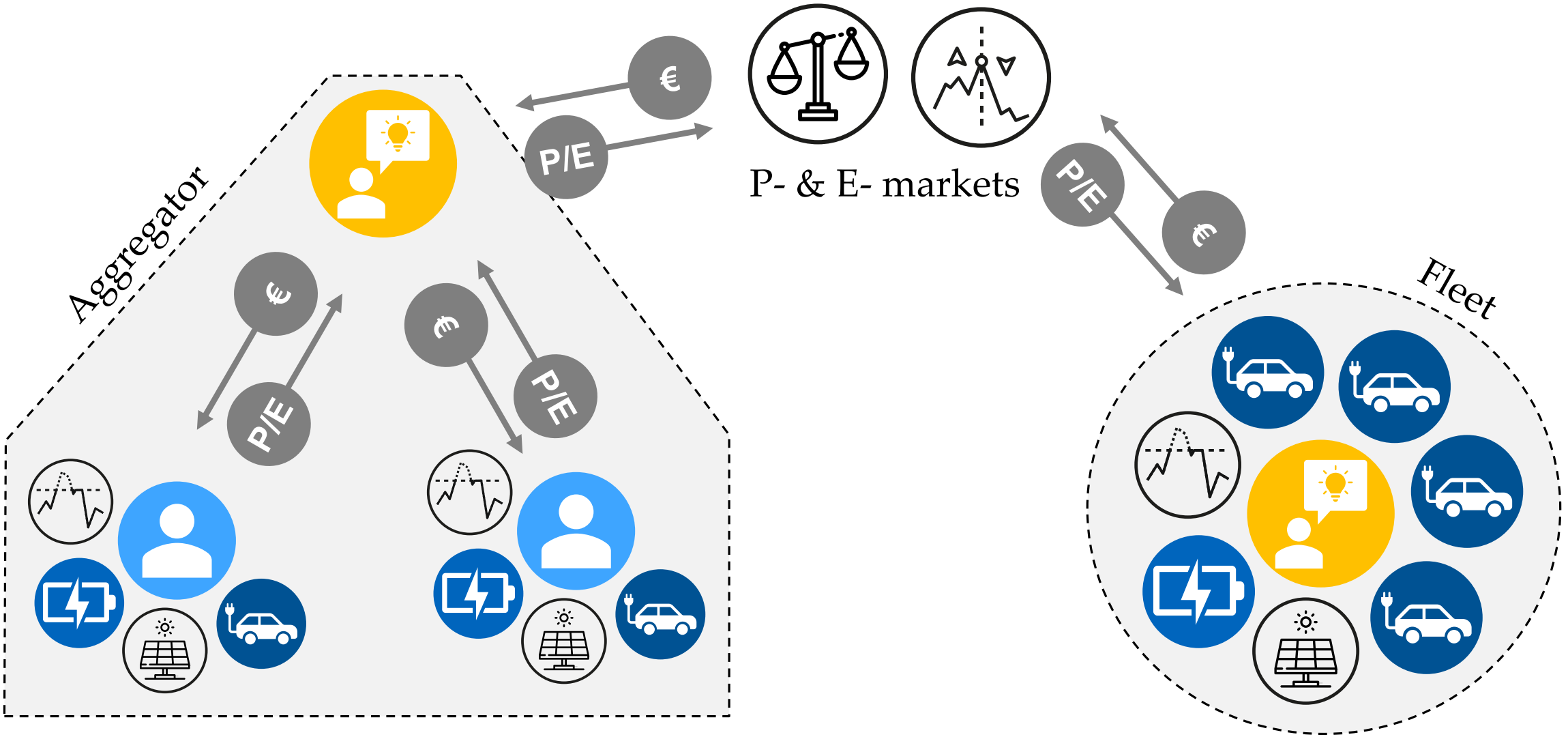
Allocation of energy and power

- Applications tap different locations in the electricity value chain
  - Behind-the-meter
  - Front-of-the-meter
- Physical storage system is divided into virtual storage partitions
- Allocation of storage capacities
  - Energy limited by battery cells
  - Power limited by power electronics



[1] S. Englberger, A. Jossen, and H. Hesse, "Unlocking the Potential of Battery Storage With the Dynamic Stacking of Multiple Applications," *Cell Reports Physical Science 1*, 2020.

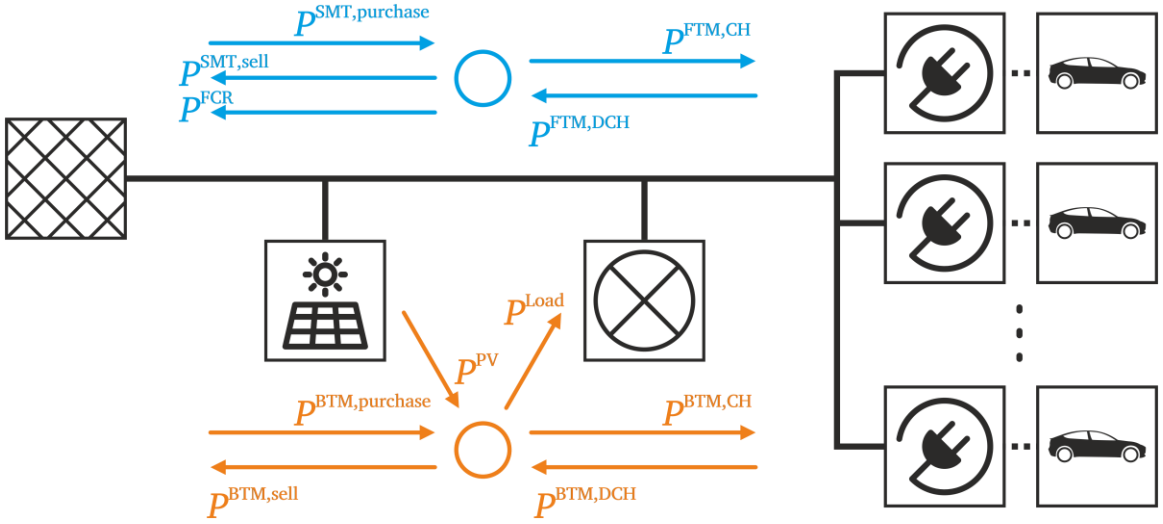
What about electric vehicles?



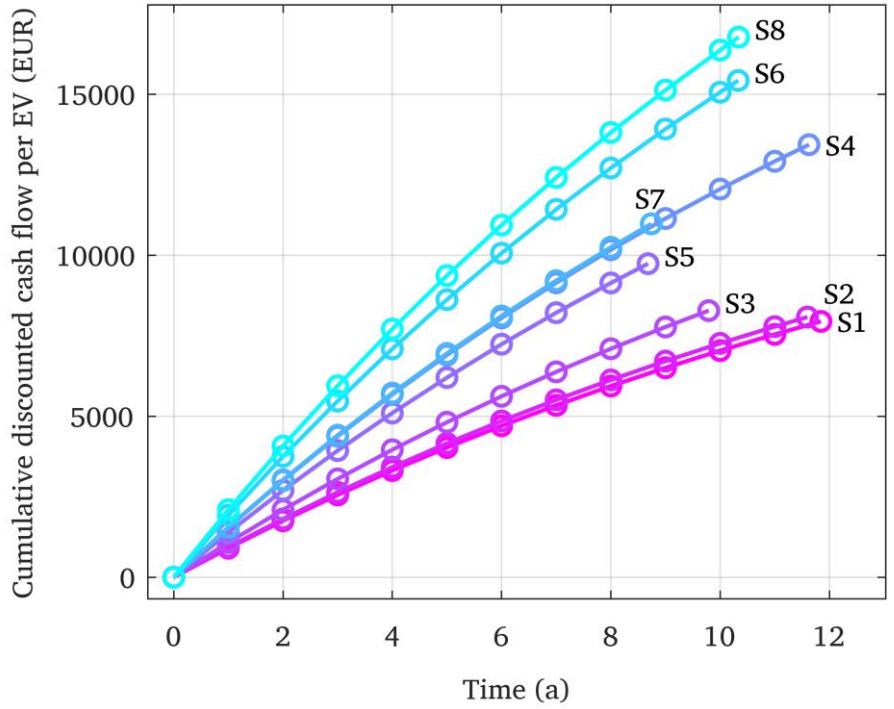
[2] S. Englberger *et al.*, "Electric vehicle multi-use: Optimizing multiple value streams using mobile storage systems in a vehicle-to-grid context," *Applied Energy 304*, 2021.

Multi-use with electric vehicles

- Passenger vehicles are parked 96% of the time
- The top priority is mobility provision
- No fixed point of common coupling
- No permanent connection to the grid
- No allocatable power electronics

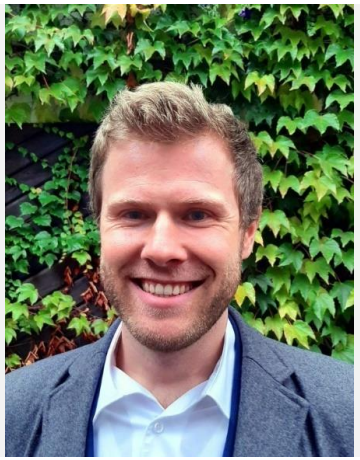


Scenario	Applications	Optimized charging	V2G	FTM2BTM
S0	–	no	no	no
S1	SCI, PS	yes	no	no
S2	SCI, PS	yes	yes	no
S3	SCI, PS, FCR	yes	yes	no
S4	SCI, PS, FCR	yes	yes	yes
S5	SCI, PS, SMT	yes	yes	no
S6	SCI, PS, SMT	yes	yes	yes
S7	SCI, PS, FCR, SMT	yes	yes	no
S8	SCI, PS, FCR, SMT	yes	yes	yes



[2] S. Englberger *et al.*, "Electric vehicle multi-use: Optimizing multiple value streams using mobile storage systems in a vehicle-to-grid context," *Applied Energy 304*, 2021.

Thank you!



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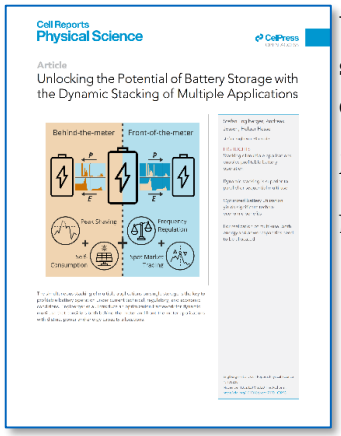
Selected publications:



Unlocking the potential of battery storage with the dynamic stacking of multiple applications

Englberger S., Jossen A., Hesse H.

DOI: 10.1016/j.xcrp.2020.100238

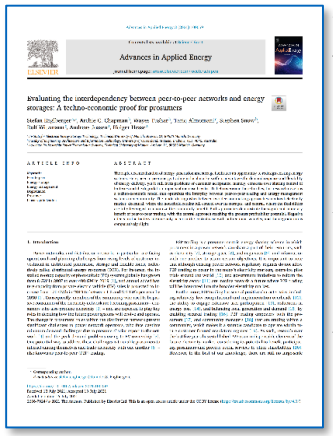
[1]

Electric vehicle multi-use: Optimizing multiple value streams using mobile storage systems in a vehicle-to-grid context

Englberger S., Abo Gamra K., Tepe B., Schreiber M., Jossen A., Hesse H.

DOI: 10.1016/j.apenergy.2021.117862

[2]



Evaluating the interdependency between peer-to-peer networks and energy storages: A techno-economic proof for prosumers

Englberger S., Chapman A., Tushar W., Almomani T., Snow S., Witzmann R., Jossen A., Hesse H.

DOI: 10.1016/j.adapen.2021.100059

Ulrich Bürger

ecostor

Profitability of Large Scale Stationary Energy Storage Beyond 2025 -

Techno-Economical Requirements

EES Conference

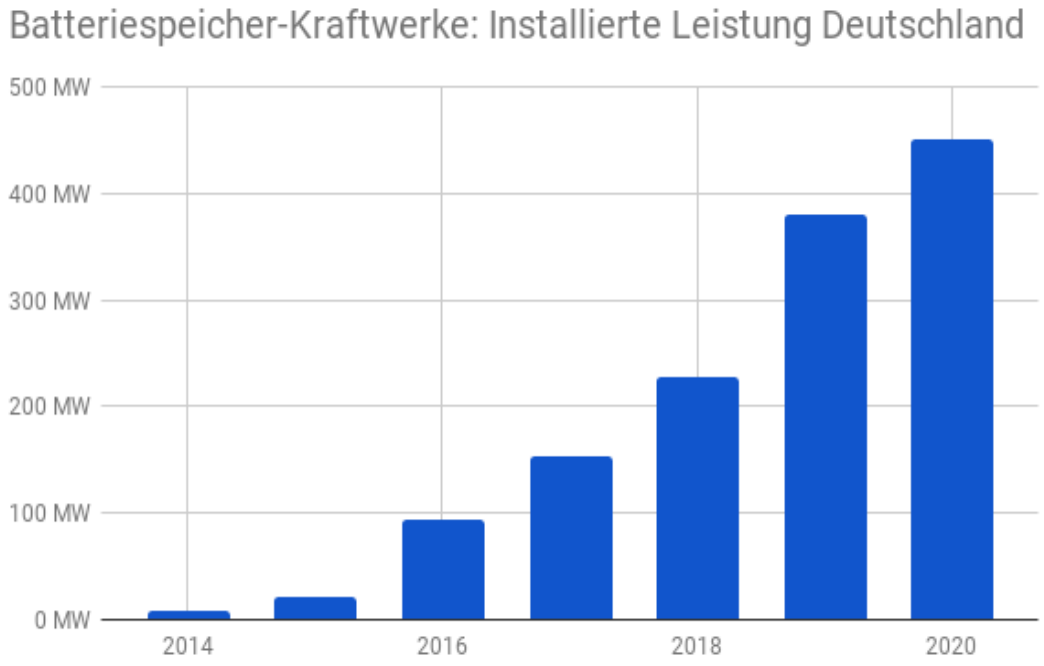
Profitability of large scale stationary energy storage beyond 2025 - techno-economical requirements

ECO STOR GmbH - kontakt@eco-stor.com – Sonnenallee 1, 85551 Kirchheim b. München

Use cases and development

FCR and expected development:

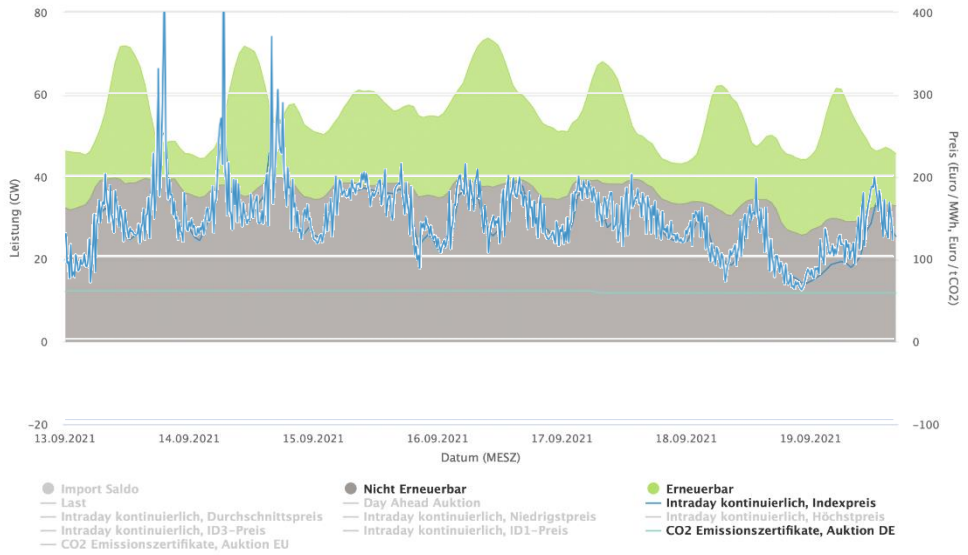
- Capacity fixed (approx. 600 MW for Germany, approx. 3‘000 MW in continental Europe)
- In Germany full provision of FCR with batteries possible
- Risk of substentially lowering the bids
- Risk of not beeing awarded



Source: https://www.regelleistung-online.de/update-2020-weiteres-wachstum-der-batteriespeicher-im-prl-markt/

Use cases and development

Intraday market (Germany)



- Growth even in 2020 (4 % according to EPEX)
- Massive growth due to higher renewable production
- Higher price spikes
- Strorage can fish for short peaks
- In future volatility on a day to night / night to day basis

Source: https://energy-charts.info/charts/price_spot_market/chart.htm?l=de&c=DE&week=37&zoom=0.5&legendItems=0110010000010

Technical challenges

New control and trading algorithms

- Trading in different market
- Inter market optimization
- Controlling, taking grid limitations into account

New technologies

- Less demand for power, more demand for capacity (growing over 2 h to 4 or even 8 h storage)
- Demand for cheap capacity (getting more and more important)
- Platform for new technologies like low power lithium or sodium batteries

The winner takes it all? – a best guess for 2030

Rising new technologies could change the storage market:

Li^+

Current marketleader

Approx. 100 $ per kWh (Fraunhofer ISI 2020)

https://www.strommarkttreffen.org/2020-02-21_George_Kostenentwicklungsprognose_stationaerer_Batteriespeichertypen.pdf

Na^+

New technology

Chance to decrease to 30 to 80 $ per kWh

H_2

Long experience

Expected cost 3.75 to 200 € per kWh (BVES)

https://www.bves.de/wp-content/uploads/2016/03/FactSheet_chemisch_P2G.pdf

Marcus Fendt

THE MOBILITY HOUSE

Vehicle-to-Grid: How EVs will Revolutionize the Energy Storage Landscape!

THE MOBILITY HOUSE

ZERO, ZERO

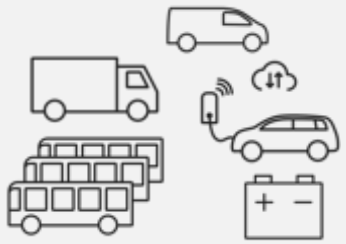
Marcus Fendt, October, 6th 2021

POWER DRIVE EUROPE

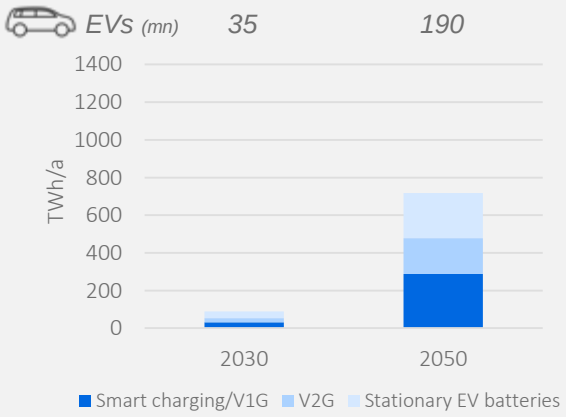
TMH will leverage and monetize EV flexibilities

The opportunity

Automotive industry



Potential flexibility contribution of EV batteries in EU

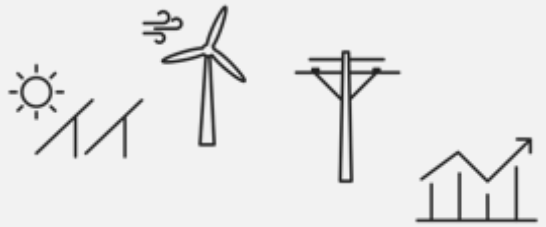


Monetize the battery

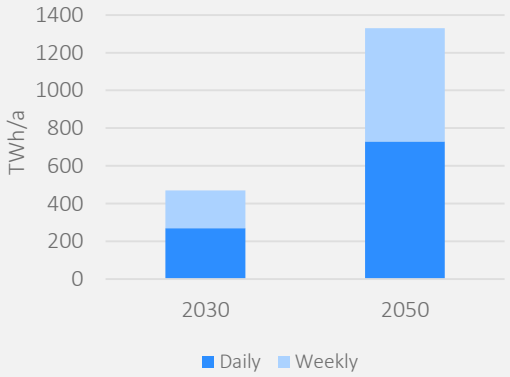
Reduce CO_2

Reduce EV price

Energy industry



Need for flexibility in EU

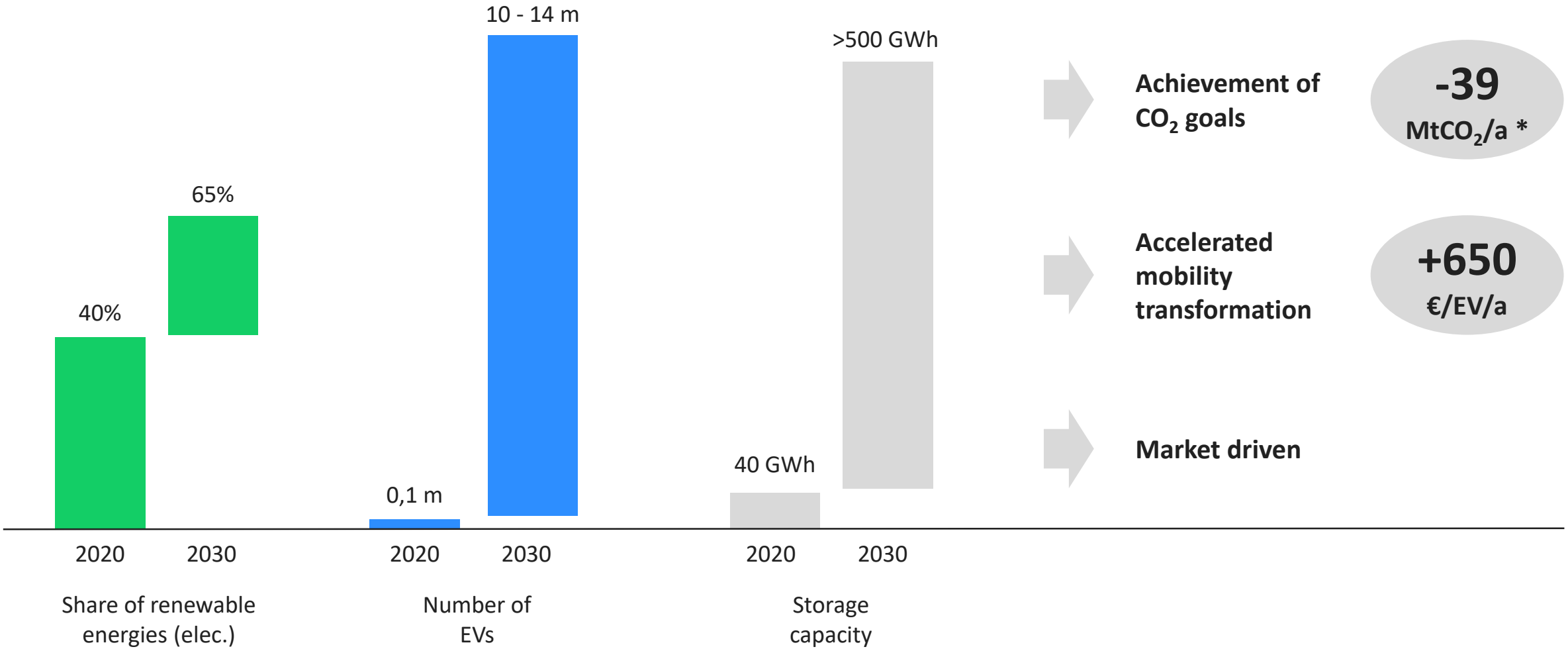


[1] Energy market for short term flexibility in 2025

Source: European Commission, Bernstein Report, Bloomberg NEF, The Mobility House

2030 – 10+ m EVs in the energy market reduce CO_2 und vehicle price

The market parameters

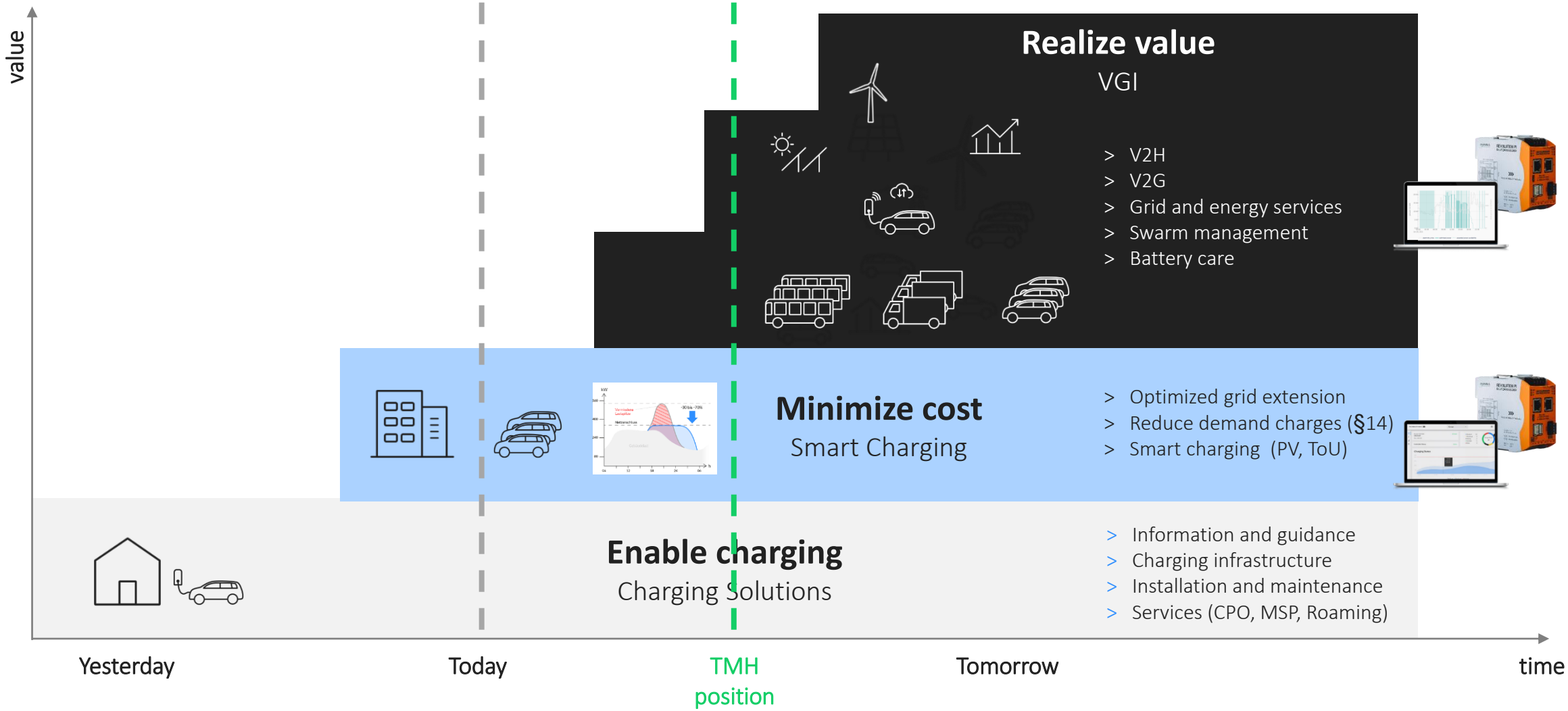


* 22 $MtCO_2$/a through change in drive train and 17 $MtCO_2$/a through VGI in 2030

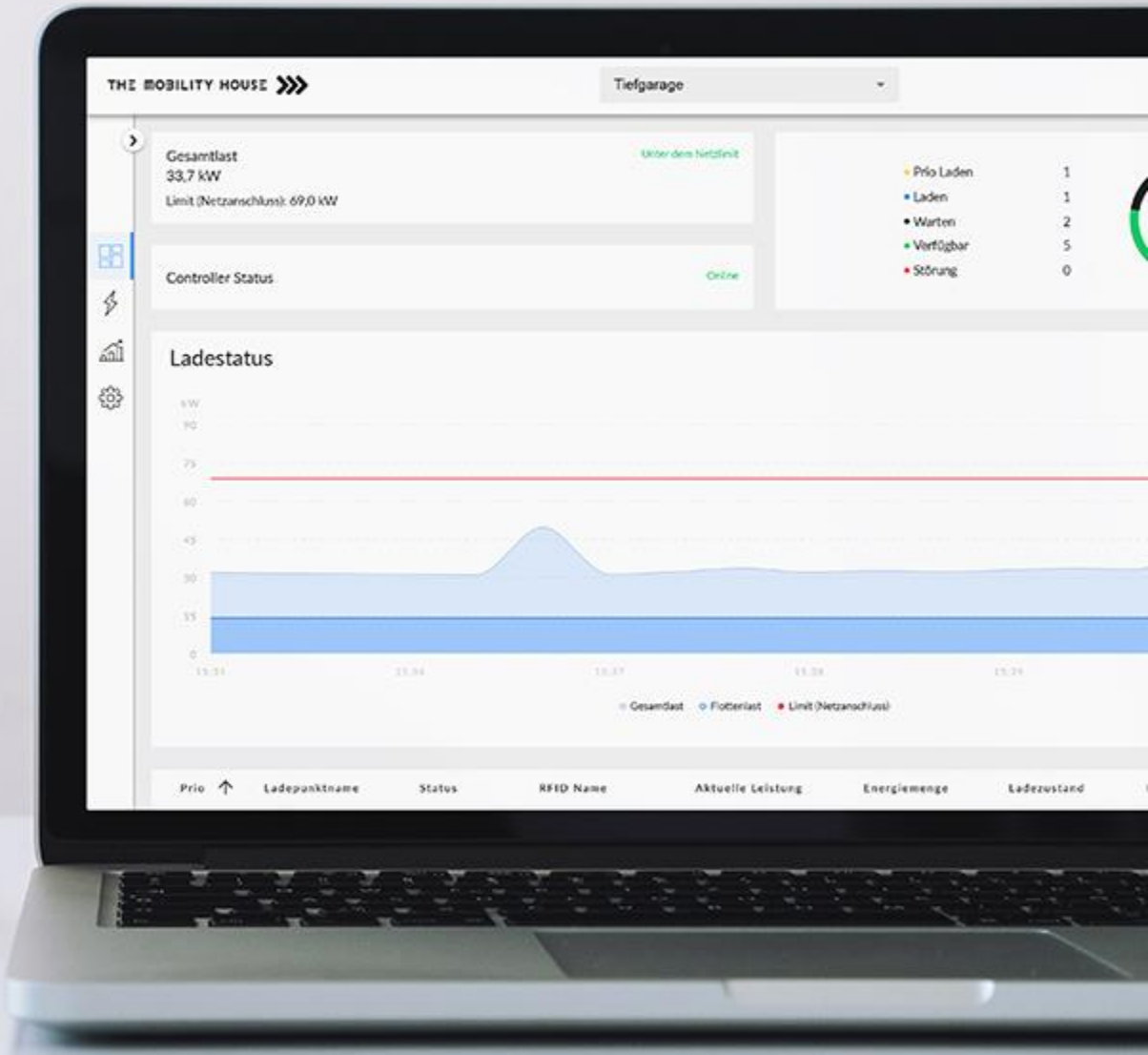
Source: KBA, BDEW, Fraunhofer ISE

The e-mobility industry pathway

The business model - from charging to future value



ChargePilot



Handelsblatt ENERGY AWARDS 2020

1. PLATZ

Mobilität

The Mobility House

Fleet: Irish Post AnPost

- **LOCATIONS:** more than 100 depots in Ireland
- **CHARGING STATIONS:** Installation of 2,800 AC wall boxes (22 kW) and 180 DC charging stations (25-50 kW)
- **SPECIAL CHALLENGE:** Highest requirements for charging management, fault monitoring, reliability and data protection
- **ENERGY MANAGEMENT:** ChargePilot
- **MODULE:** dynamic load management | 24/7 fault monitoring I Time of Use tariff optimization
- **PERFORMANCE of TMH:** Load Management | Monitoring

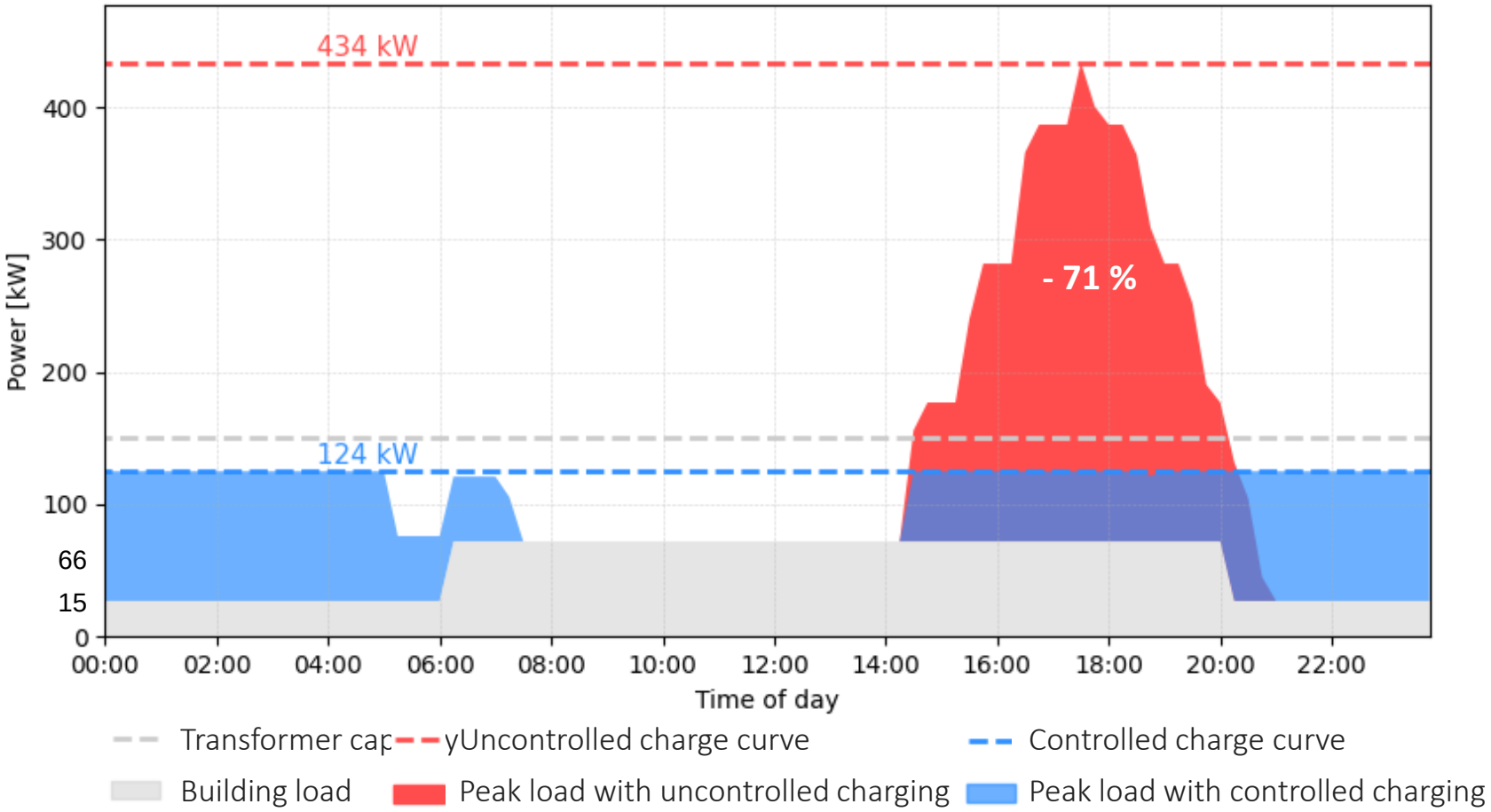
approx. 50 MW*
Saving grid connection power

> 500,000 € / year*
Savings operation

* Calculated on the basis of AnPost input data

Controlled charging reduces grid connection power by over 70%

Simulation: Comparison of load peak with uncontrolled charging and charging with ChargePilot in one depot



Framework

- 60 connected charging points
- Building load varies between 15 kW and 66 kW
- 150 kW available power
- Vehicles arrive at the depot from 2 p.m. and start loading (15 vehicles per hour)
- Fleet will leave the depot in the morning between 7:00 and 8:00 a.m.

Result

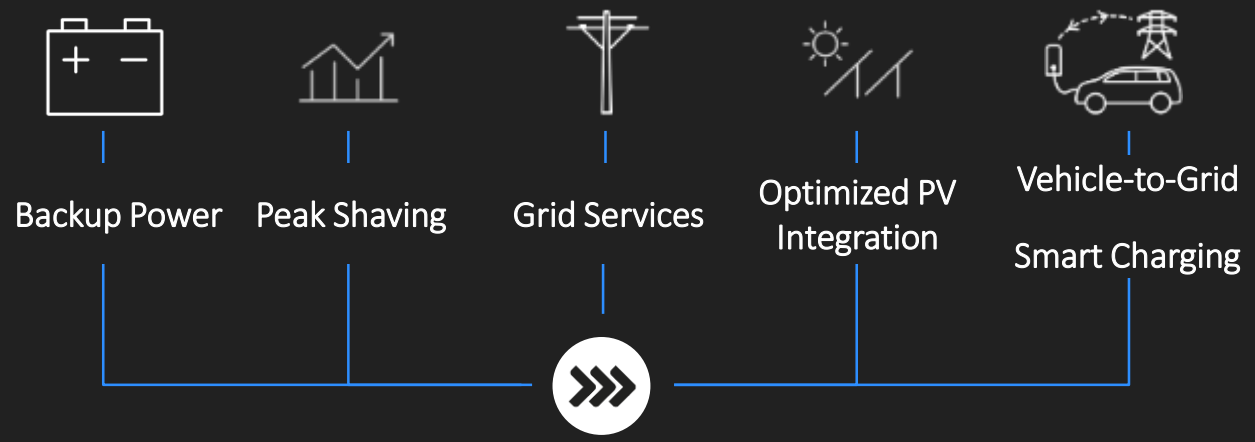
- Uncontrolled charging generates a load peak of >430kW
- Dynamic load management reduces the maximum load to 124kW - without restricting fleet availability

Source: The Mobility House

Stationary storage Johan Cruijff Arena

Flexibility Monetization Example

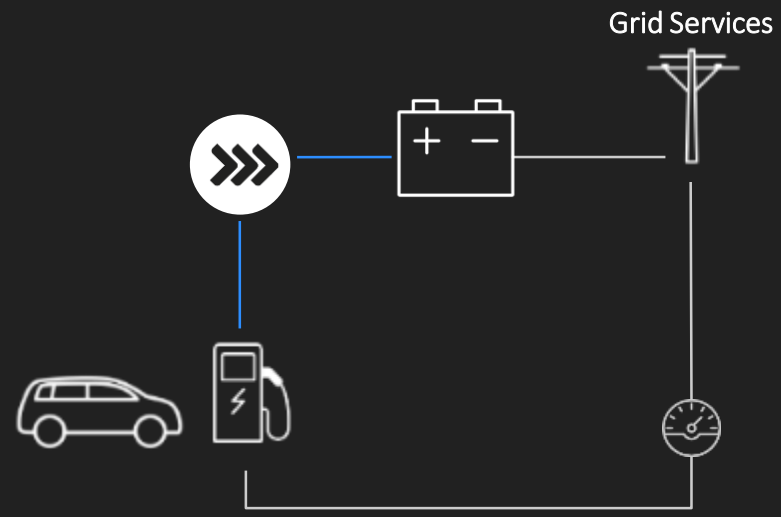
- **LOCATION:** Amsterdam, Netherlands
- **STORAGE PARAMETERS:** 3 MW / 2.8 MWh
- **BATTERIES**: 148 Nissan Leaf batteries (42% 2nd-life)
- **EMISSION REDUCTION**: -116 tCO_2/10a
- **APPLICATION**: Multi-use stationary storage
- **PERFORMANCE OF TMH:** Development | operation | commercialization



Grid stabilization for ISO Amprion

Flexibility Monetization Example

- **LOCATION:** Hagen, Germany
- First EV as power plant in German electricity grid
- Prequalification for FCR (Frequency Containment Reserve) following ISO directives identical to large-scale power plants
- Generation of revenues through supply of FCR



amprion NISSAN Enervie THE MOBILITY HOUSE

Source: The Mobility House

Dr. Michael Baumann

TWAICE

Endure or Surrender: the Decisive Role of Battery Lifetime for Profitability of Grid Tied Storage

TWAICE

BATTERY ANALYTICS SOFTWARE

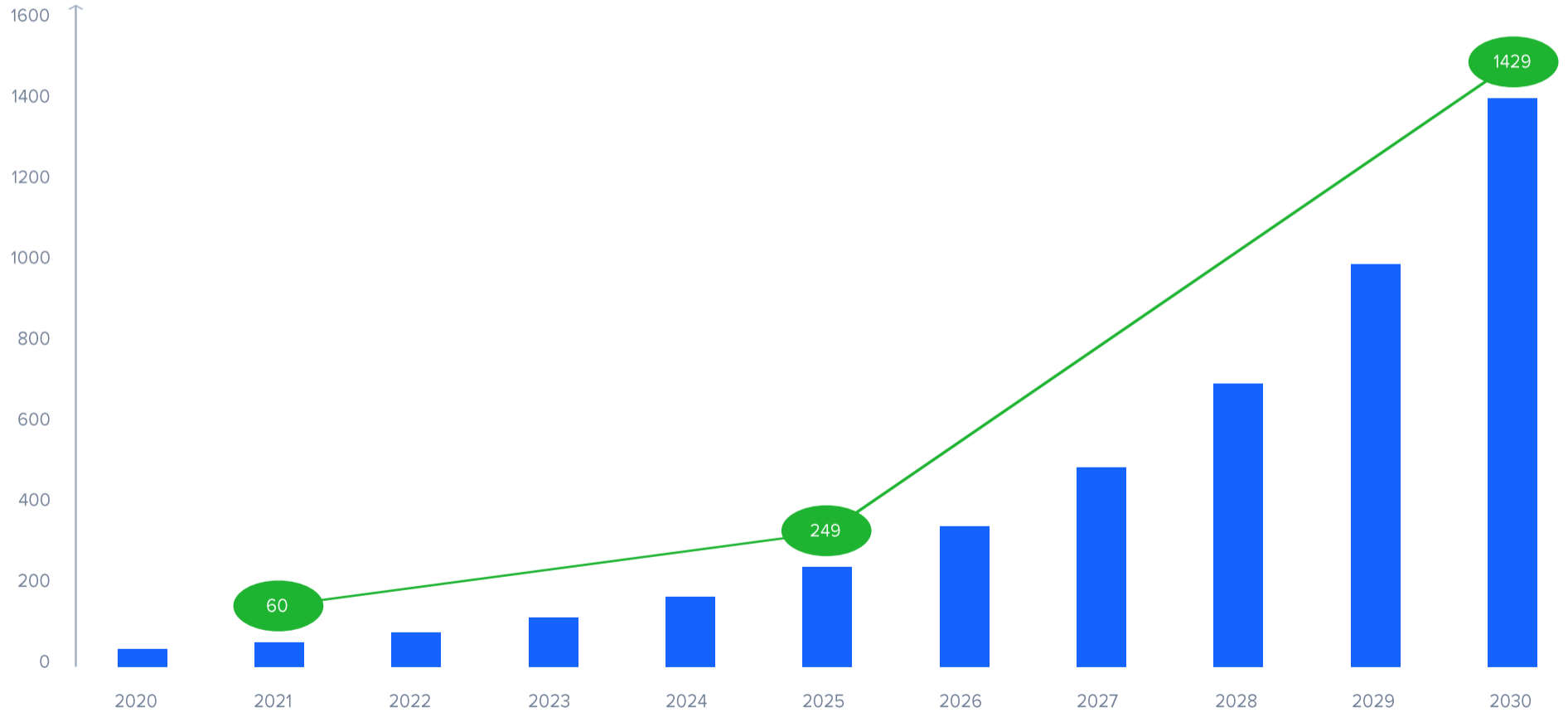
BATTERIES POWER THE WORLD
SOFTWARE UNLEASHES THEIR FULL POTENTIAL

Dr. Michael Baumann, Co-CEO & Co-Founder
Munich, 01-Oct-21

BATTERIES ARE ON THE RISE

TWAICE

Globally installed GWh of Energy Storage Systems (ESS)



BASED ON: ARK INVEST / BLOOMBERG NEF (1:1)

CHALLENGES

TWAICE

UNCLEAR OPERATION IMPACT
& RESTRICTIVE WARRANTIES

LIMITED FLEXIBILITY

COMPLICATED STATE OF
HEALTH DETERMINATION

UNTAPPED POTENTIAL

HIGH BATTERY HEALTH
DEGRADATION

COSTLY

THE SOLUTION

TWAICE

OPERATING STRATEGY PLANNER

- ALERTS & REPORTS
- DATA EXPORT & APIS
- REAL-TIME INSIGHTS
- ALL WARRANTIES IN ONE PLACE
- OPERATING STRATEGY ASSESSMENT
- FULL AGING TRANSPARENCY

UNDERSTAND BATTERY AGING BETTER

TWAICE

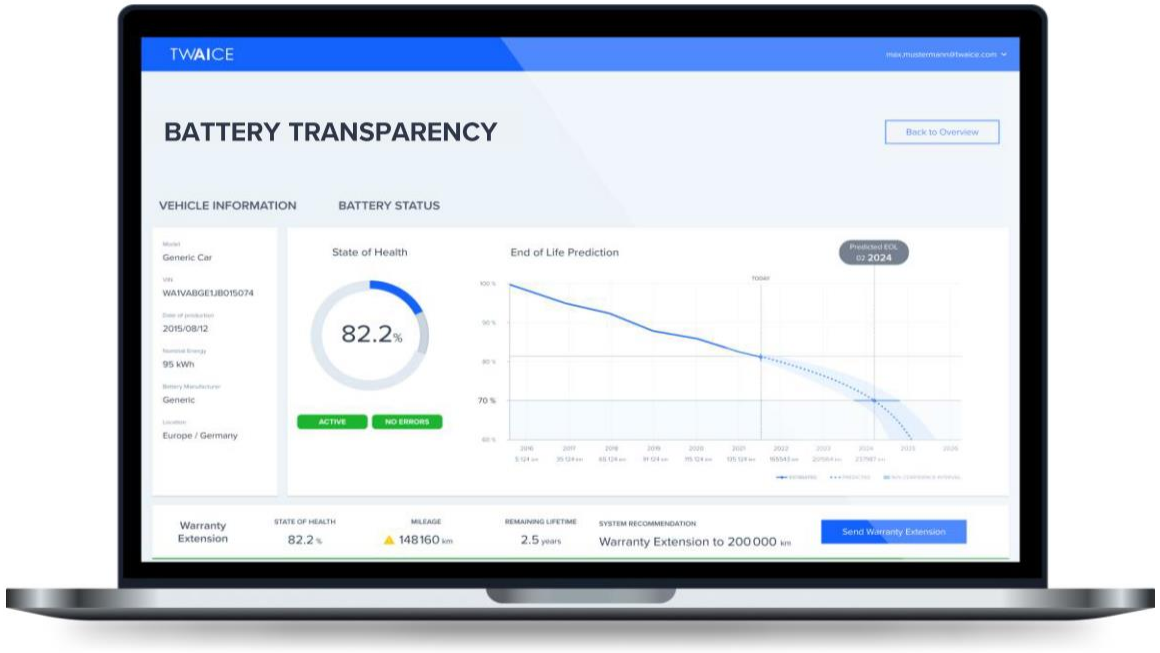
END-TO-END APPROACH
WITH HEALTH ANALYTICS & PREDICTION AT ITS HEART

DATA INTEGRATION
SECURE AND CLEAN IN REAL-TIME

CUTTING EDGE ANALYTICS
MACHINE LEARNING & DOMAIN-SPECIFIC ALGORITHMS

USER INTERFACE

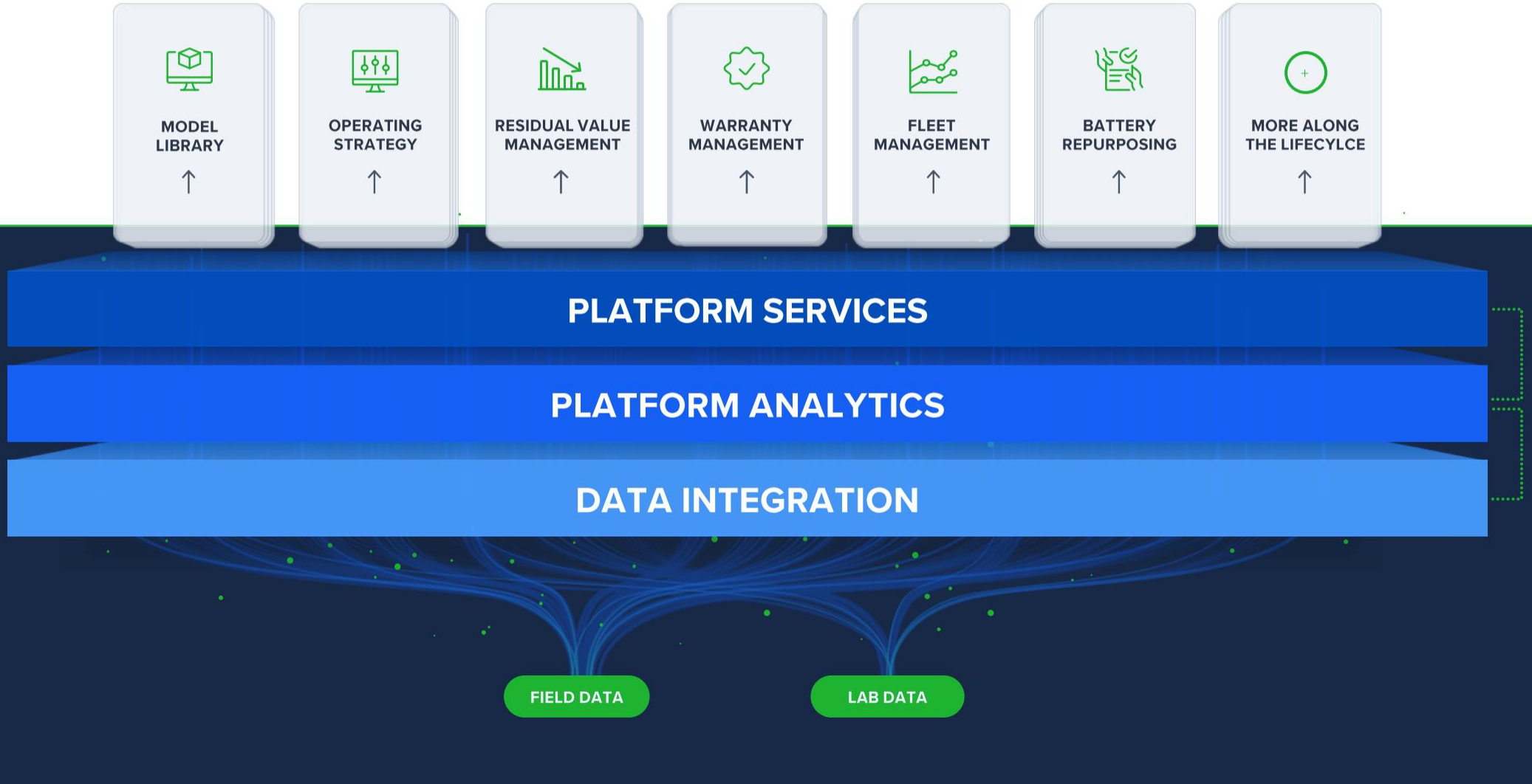
IN- AND OUTPUT APIS



TWAICE PLATFORM

TWAICE

HELPING YOU GENERATE THE VALUE OF A LIFETIME



VALUE

TWAICE

UP TO
+20%
ROI

HIGHER UTILIZATION & MORE BUSINESS FLEXIBILITY

HIGHER RETURNS

UP TO
-10%
O&M

ONLINE HEALTH & STATE DIAGNOSTICS AND SOFTWARE OPTIMIZATION

BETTER UTILIZATION

UP TO
+25%
LIFETIME

OPTIMIZED USAGE AND IDENTIFICATION OF AGING DRIVERS

LONGER LIFETIME

A STRONG PARTNER AT YOUR SIDE

TWAICE

Leading battery analytics solutions based on
strong **BATTERY, MACHINE LEARNING & SOFTWARE** expertise

75+ battery & software engineers and data scientists

20+ patents[1]

10+ industry partners, incl. Munich RE & TÜV Rheinland

25+ battery simulation models

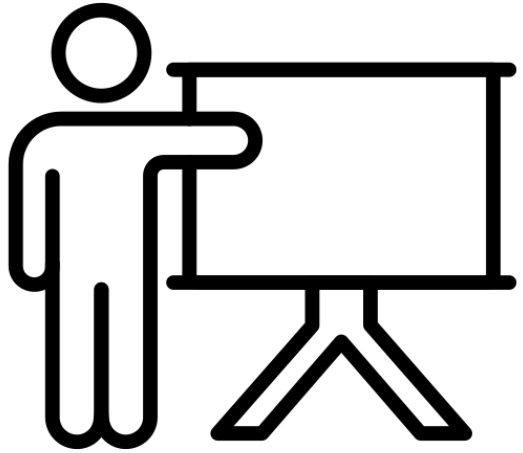
200+ cell testing channels onsite

DAIMLER
PORSCHE
Hero
Verbund
pepper
smart POWER
ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™
SEtrade
ENERGY REVOLUTION
Munich RE
VIRICITI
TÜVRheinland®
Genau. Richtig.

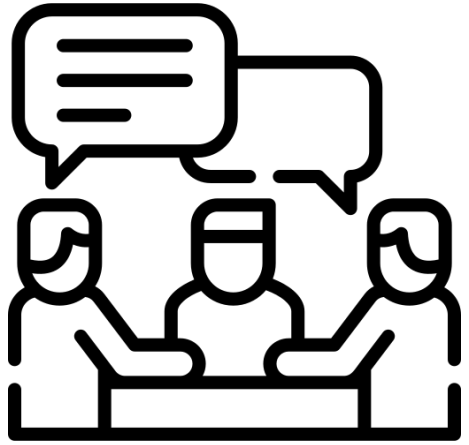

TWAICE
BATTERY EXPERTISE + DATA SCIENCE + SCALABLE SOFTWARE

Session Business Models

How to Stay Successful in a Maturing Market?



Pitch Presentations



Panel Discussion

Florian Mayr
Apricum - The Cleantech Advisory

Ulrich Bürger
ECO STOR GmbH

Dr. Michael Baumann
TWAICE

Dr. Martin Kruska
Siemens AG

Marcus Fendt
The Mobility House GmbH

Stefan Englberger
TUM - Technische Universität München

APRICUM THE CLEANTECH ADVISORY.

SIEMENS Ingenuity for life

Technical University of Munich

ecoSTOR

THE MOBILITY HOUSE

TWAICE

Market Trends, Applications and Maturity

Classification of stationary energy storage systems

Home storage system	Industry scale storage	Utility scale storage
< 30 kWh	30 – 1000 kWh	> 1 MWh

Source: sonnen.de

Source: ne

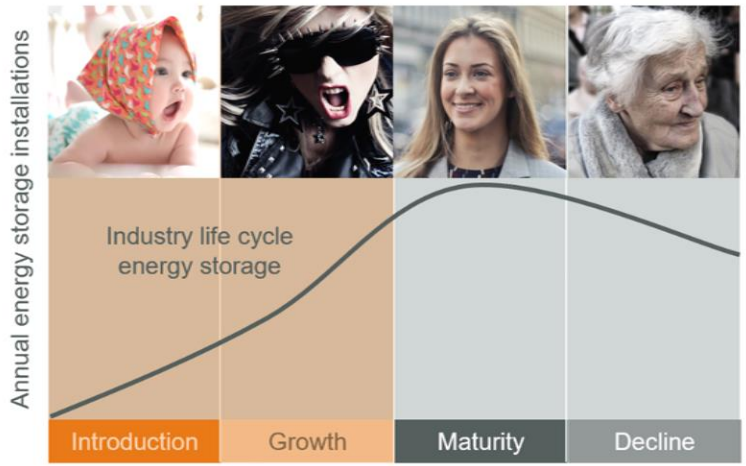
Self-consumption increase

Peak shavin

Behind-the-meter (BTM)

Stefan Englberger | ees Europe | 2021-10-06

The decade of energy storage has just commenced.

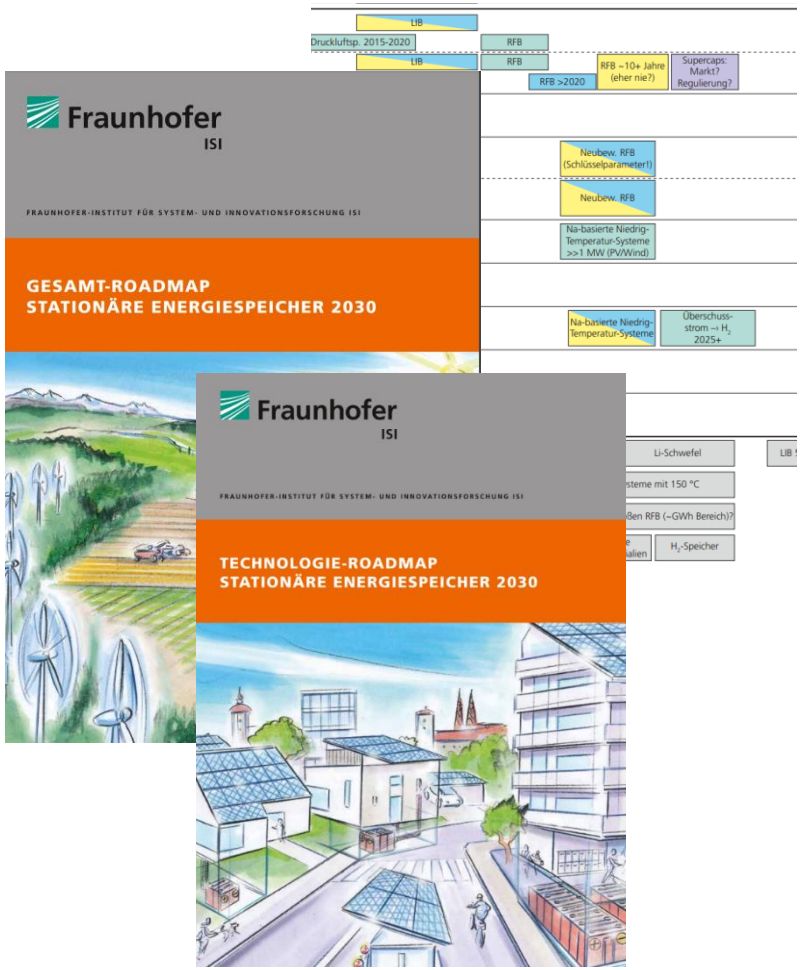


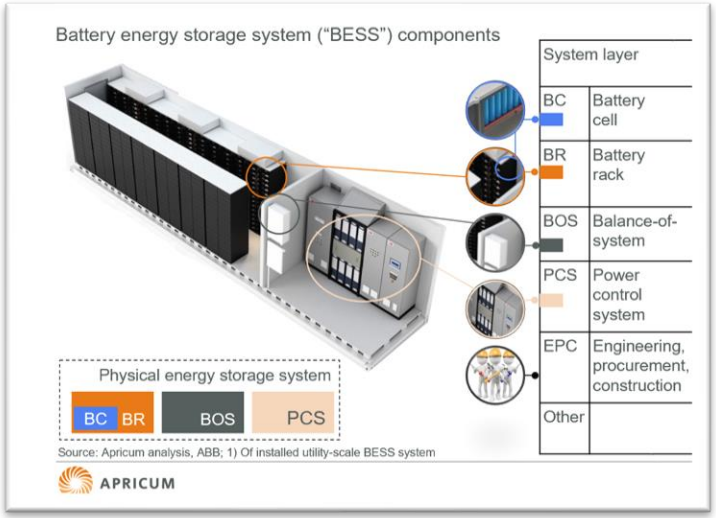
Growing up can be confusing and challenging –
but good parenting helps to take the right decisions

APRICUM

4

Storage Technology & EV Rise: Enabler for Business?



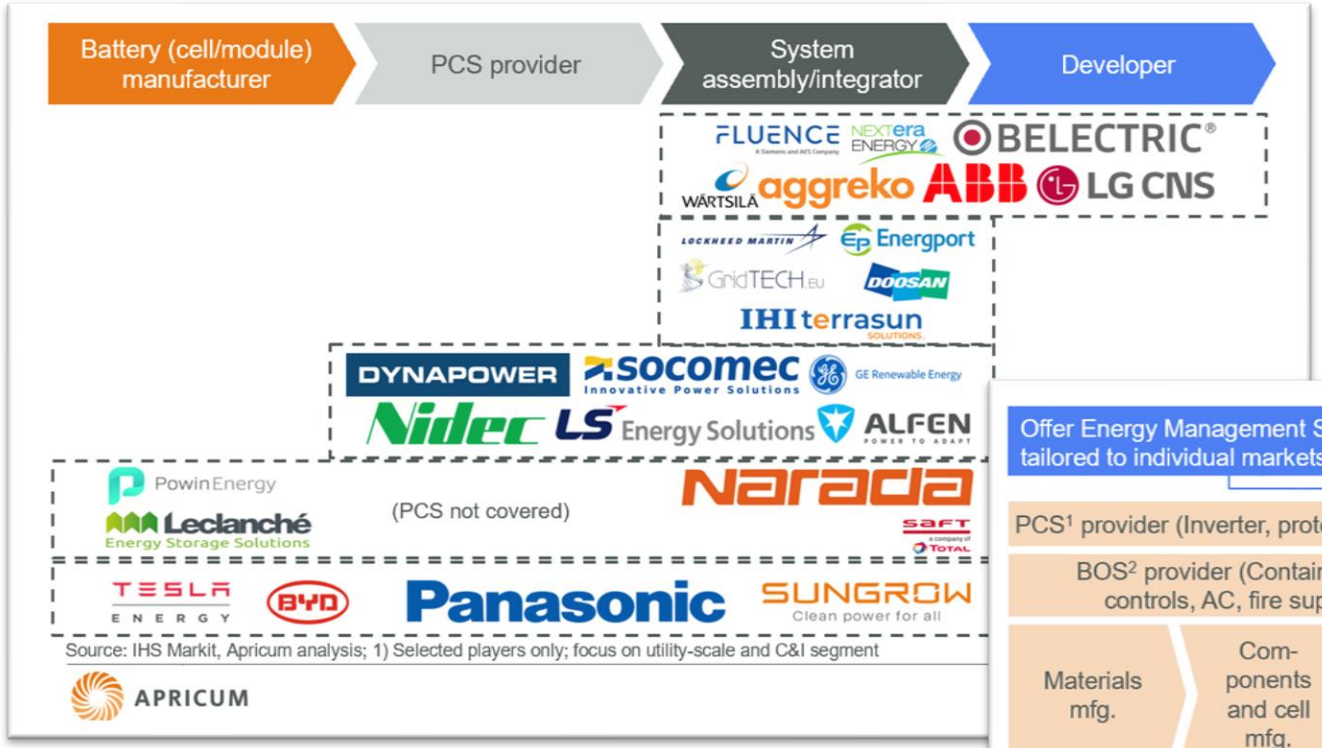


Source: EES 2019, Apricum

Source: tesla.com

Source: isi.fraunhofer.de

New Business Models – Review and Forecast



Source: Apricum