ÜBERBLICK DER ANWENDUNGSMÖGLICHKEITEN VON ENERGIESPEICHERN IN UNTERNEHMEN

Markt, Anwendungen und Empfehlungen

Johannes Wüllner

Fraunhofer Institute for Solar Energy Systems ISE

BVES Industrieworkshop –

Relevanz und Zukunft von Batteriespeichern in mittelständischen Unternehmen

30. April 2021

www.ise.fraunhofer.de

AGENDA

- Brief introduction Fraunhofer

<u>Commercial & Industrial Energy Storage Systems:</u>

- Market overview
- Applications overview
- Business cases in Germany

- Key Topics to Consider
- Conclusions

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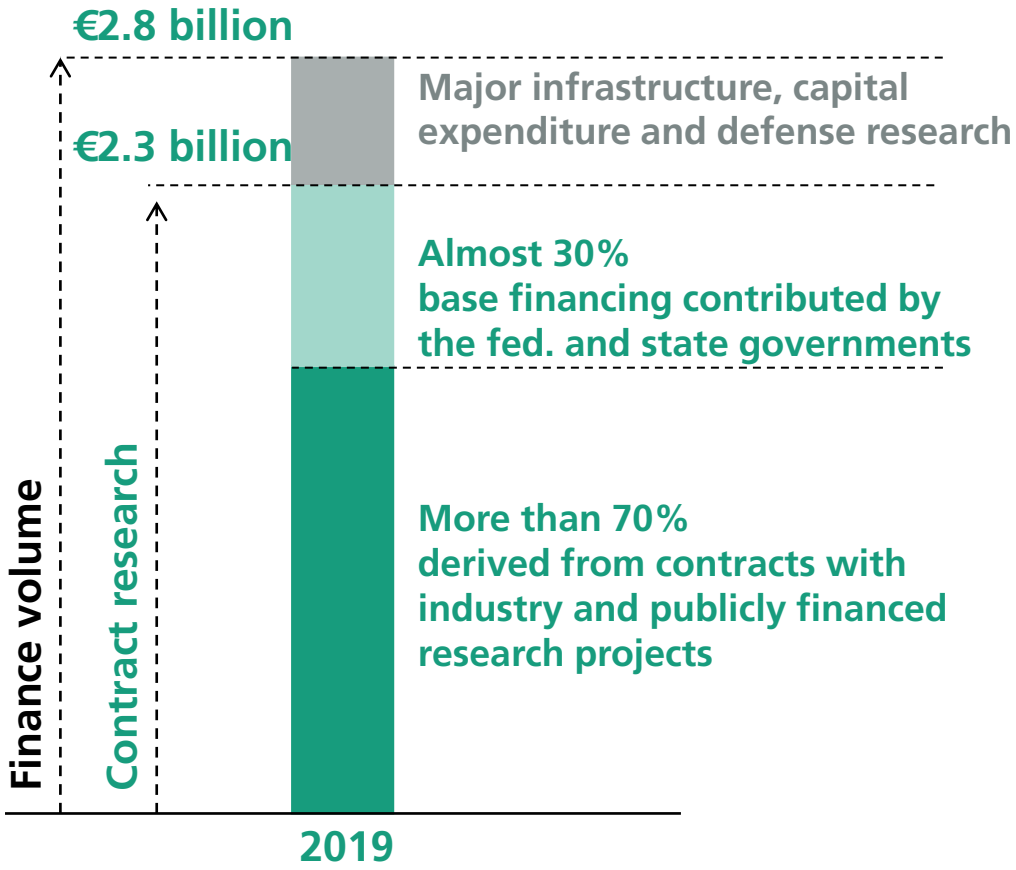
The Fraunhofer-Gesellschaft
At a Glance

ca. 28 000 staff

74 institutes and research units



Fraunhofer ISE

Fraunhofer ISE
At a Glance

Directors:
Prof. Dr. Hans-Martin Henning
Prof. Dr. Andreas Bett

Staff: ca. 1250

Budget 2020: €104.8 million (preliminary)

Established: 1981

Photovoltaics

Energy Efficient Buildings

Solar Thermal Power Plants and Industrial Processes

Hydrogen Technologies and Electrical Energy Storage

Power Electronics, Grids and Smart Systems

Fraunhofer ISE
Scope of Our Work

Research	Development	Implementation
■ Materials	■ Equipment	■ System design
■ New devices	■ Process technology	■ Monitoring
■ Proof-of-principle	■ Transfer to industrial scale	■ Demonstration
■ Simulation and modeling	■ Proof-of-concept	■ Testing and certification
■ Methods		■ Quality assurance

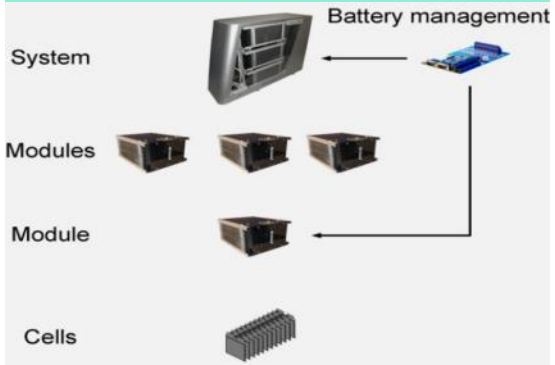
Department Electrical Energy Storage

Overview – Research, Development and Services

Battery Cell Technology
materials, architecture, production

- Development and characterization of materials and battery cells
- Development of process technologies
- Aqueous systems for stationary energy storage
- Lithium ion battery cells
- Solid state battery cells
- Technical and economical analysis
- Life cycle analysis

Battery Engineering
from cells to systems



- Cell formation
- Cell and system characterization
- Ageing and performance scrutiny
- System design and engineering
- Thermal management
- Battery management
- Algorithms for state estimation and life time prediction
- Optimized charging and operating control strategies

Applied Storage Systems
system design, integration and quality assurance

- Realization of lighthouse projects
- Business case development
- Consulting during complete life cycle of storage projects
- System modelling, analysis and optimized system design
- Simulation based storage sizing
- Energy management systems
- Technical due diligence: Site inspection, testing and monitoring

TestLab Batteries
electrical, thermal, mechanical testing

- Ageing: calendric and cyclic
- Safety: components and systems including functional safety
- Reliability: consideration of operating conditions and system behavior with aged components
- Performance: efficiency and effectiveness
- End-of-line quality control for cell production

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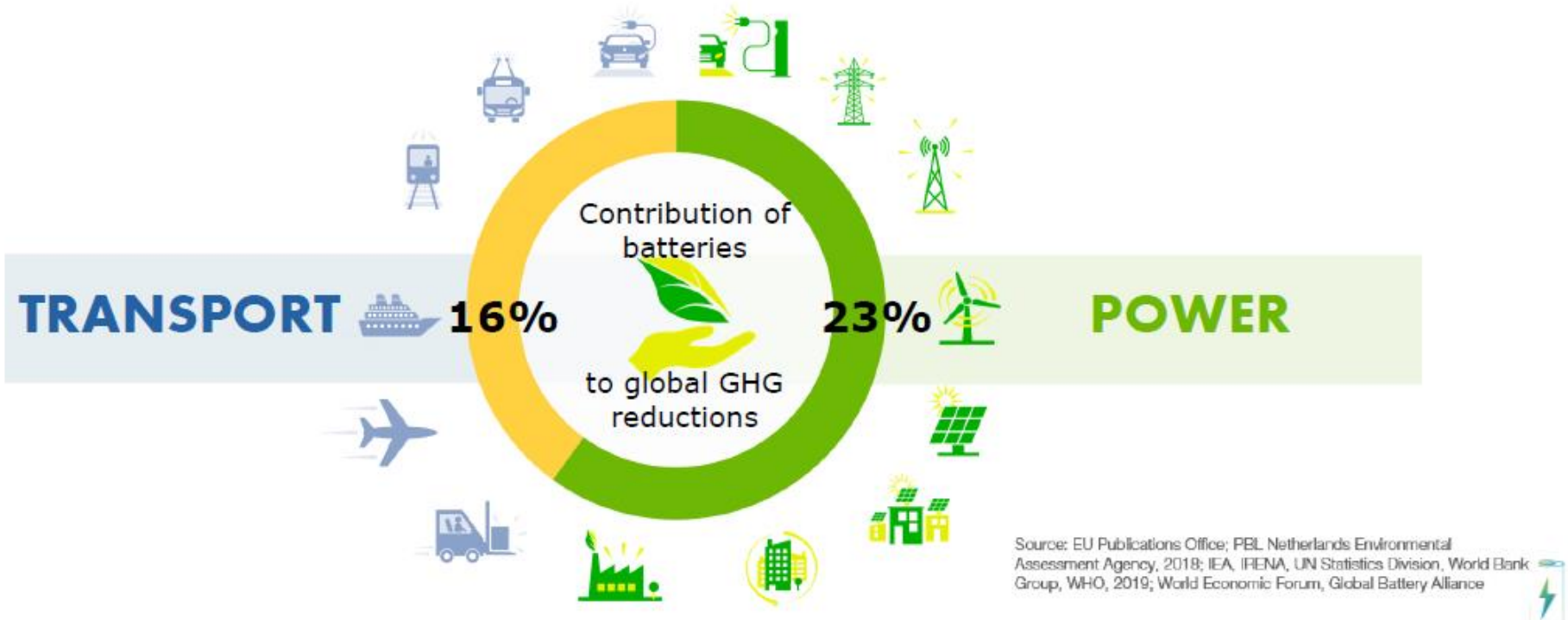
Stationary battery storage – Mission

Batteries Europe: Strategic Research Agenda – Extract

BATTERIES EUROPE
EUROPEAN TECHNOLOGY
AND INNOVATION PLATFORM

« Everything we can electrify will be electrified »



Source: EU Publications Office; PBL Netherlands Environmental Assessment Agency, 2018; IEA, IRENA, UN Statistics Division, World Bank Group, WHO, 2019; World Economic Forum, Global Battery Alliance

Source: E. Sheridan: Batteries Europe, European Technology and Innovation Platform – Overview of Strategic Research Agenda, Batteries Europe Webinar, 28th of October 2020.

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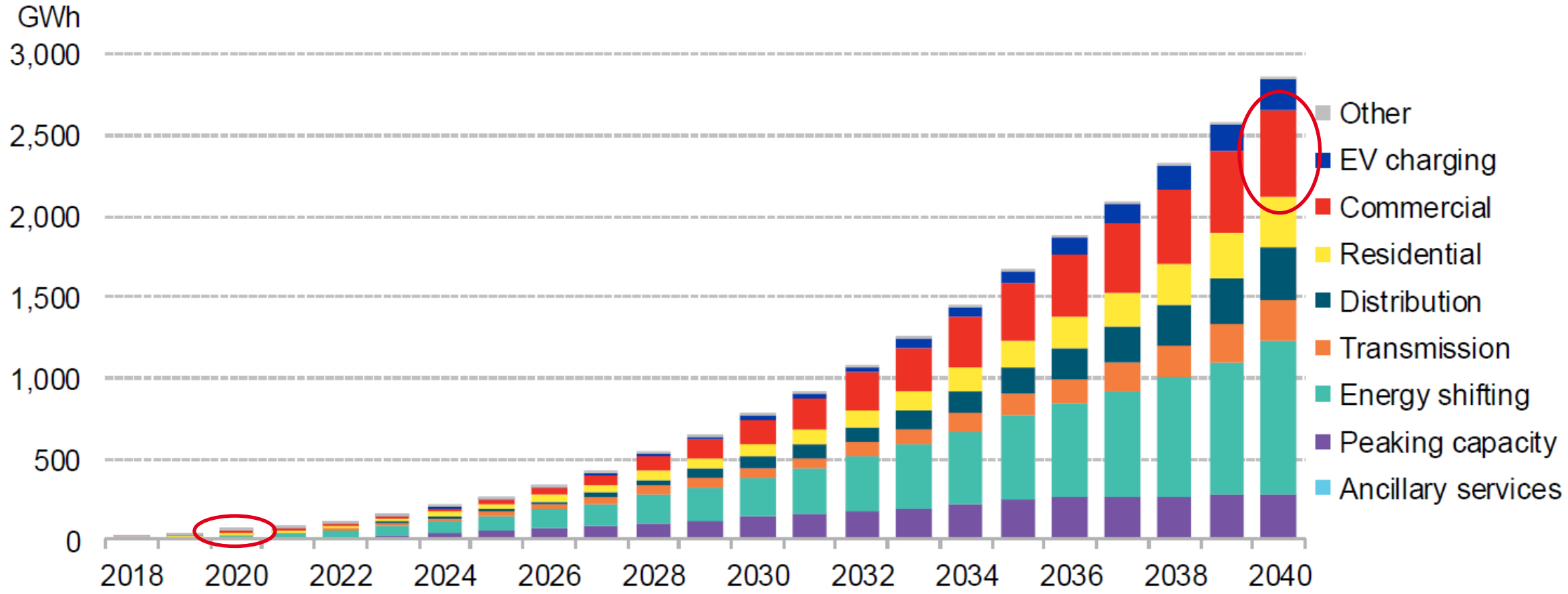
Stationary battery storage – Market developments

Prognosis for global cumulative deployments



Source: BloombergNEF, 2019.

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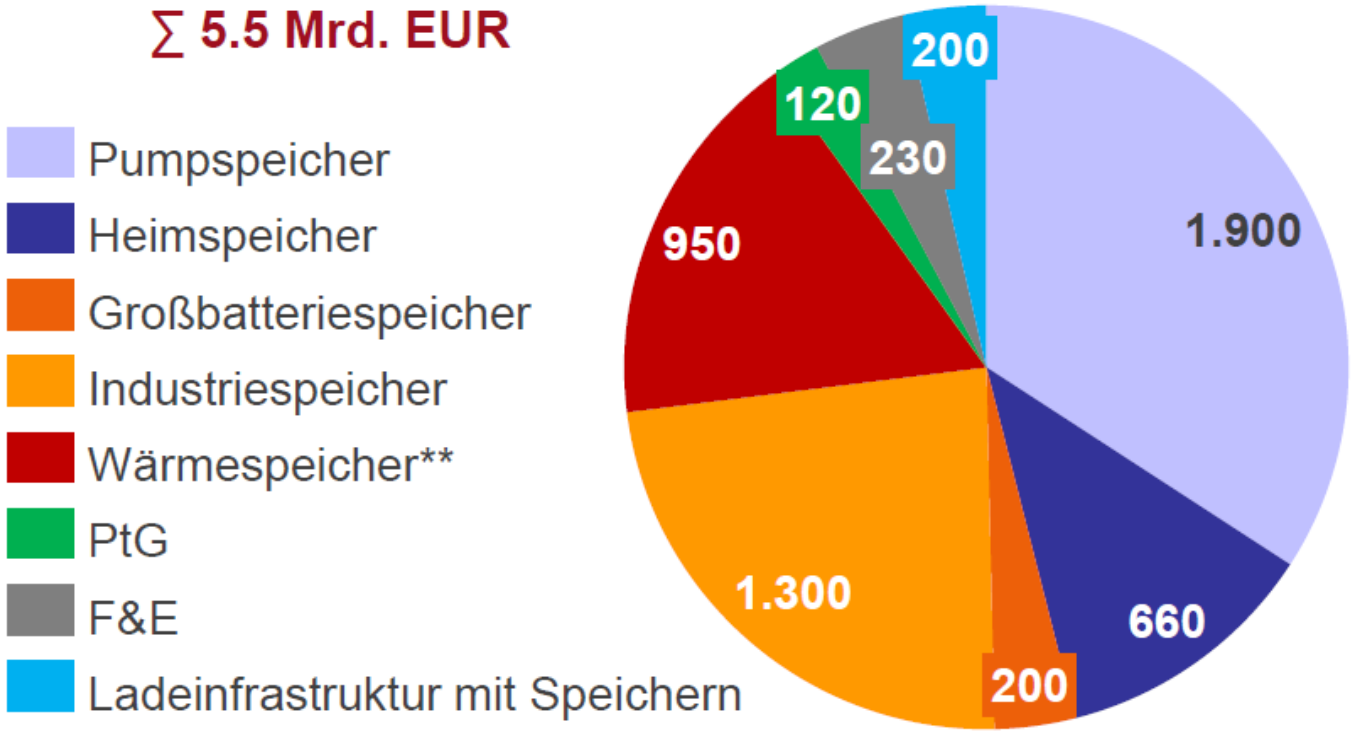
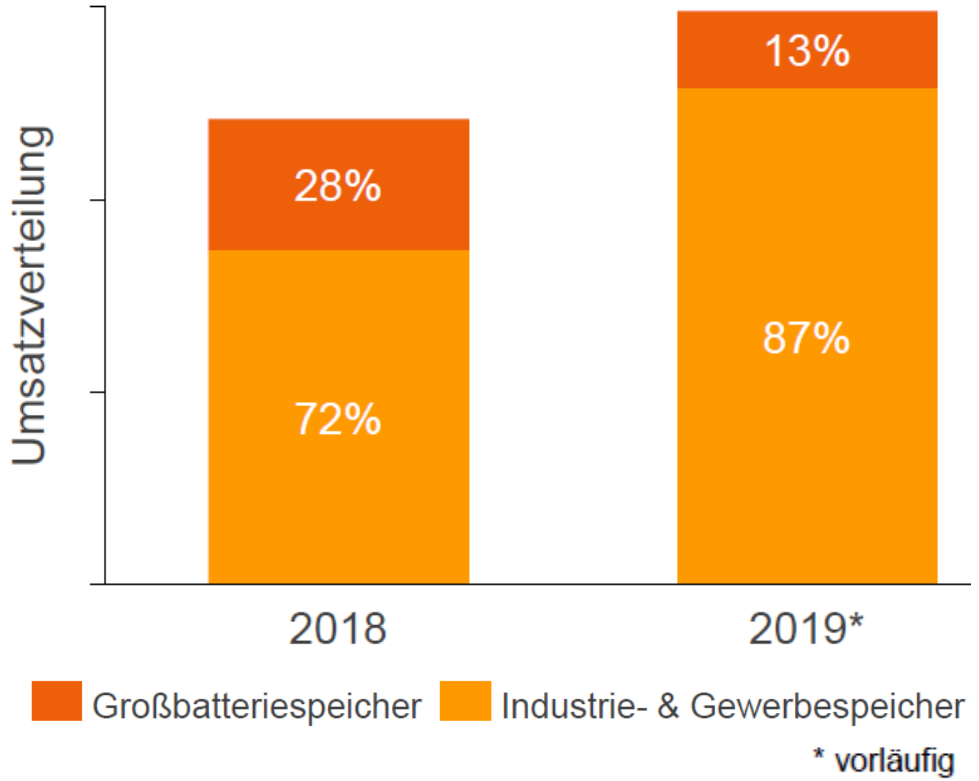
Stationary battery storage – Market size Germany

Revenue distribution energy storage industry* in Germany 2019 (in million €)



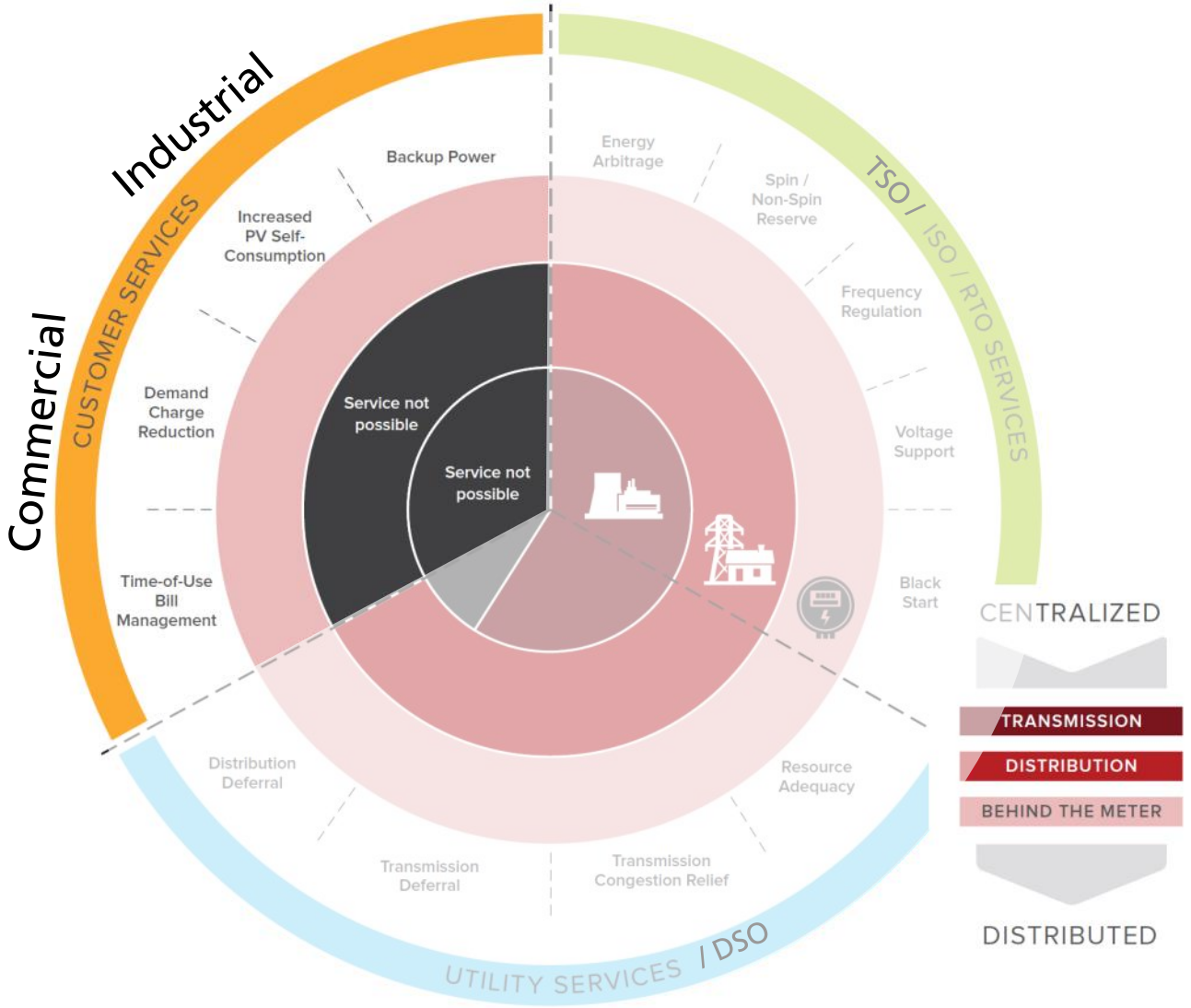


* Umsatz von in Deutschland ansässigen Unternehmen im In- und Ausland;
Werte sind teilweise noch vorläufig
** inkl. Kraftwerkswärmespeicher und Wärmepumpen

Source: BVES Branchenanalyse 2020, 12.3.2020

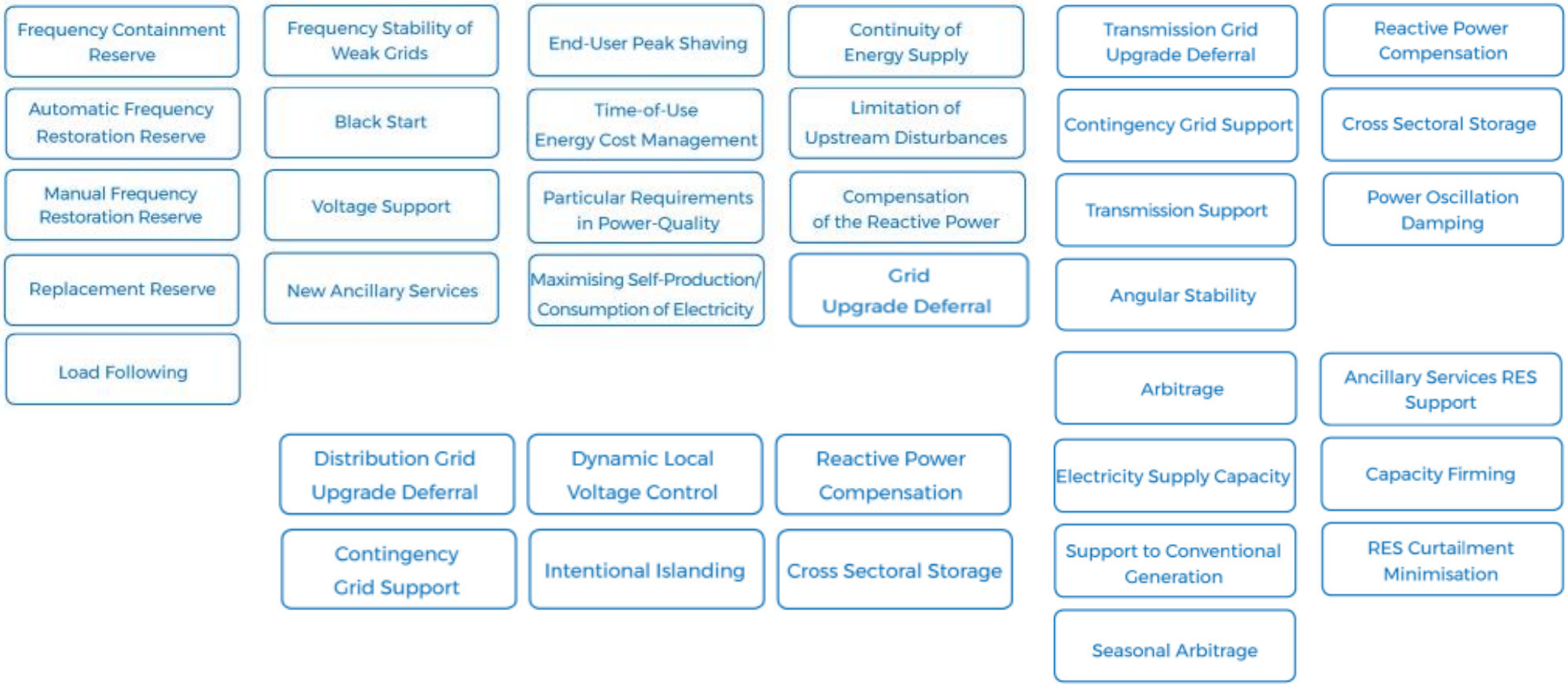
Stationary battery storage – Market segments

Provision of services to three stakeholder groups



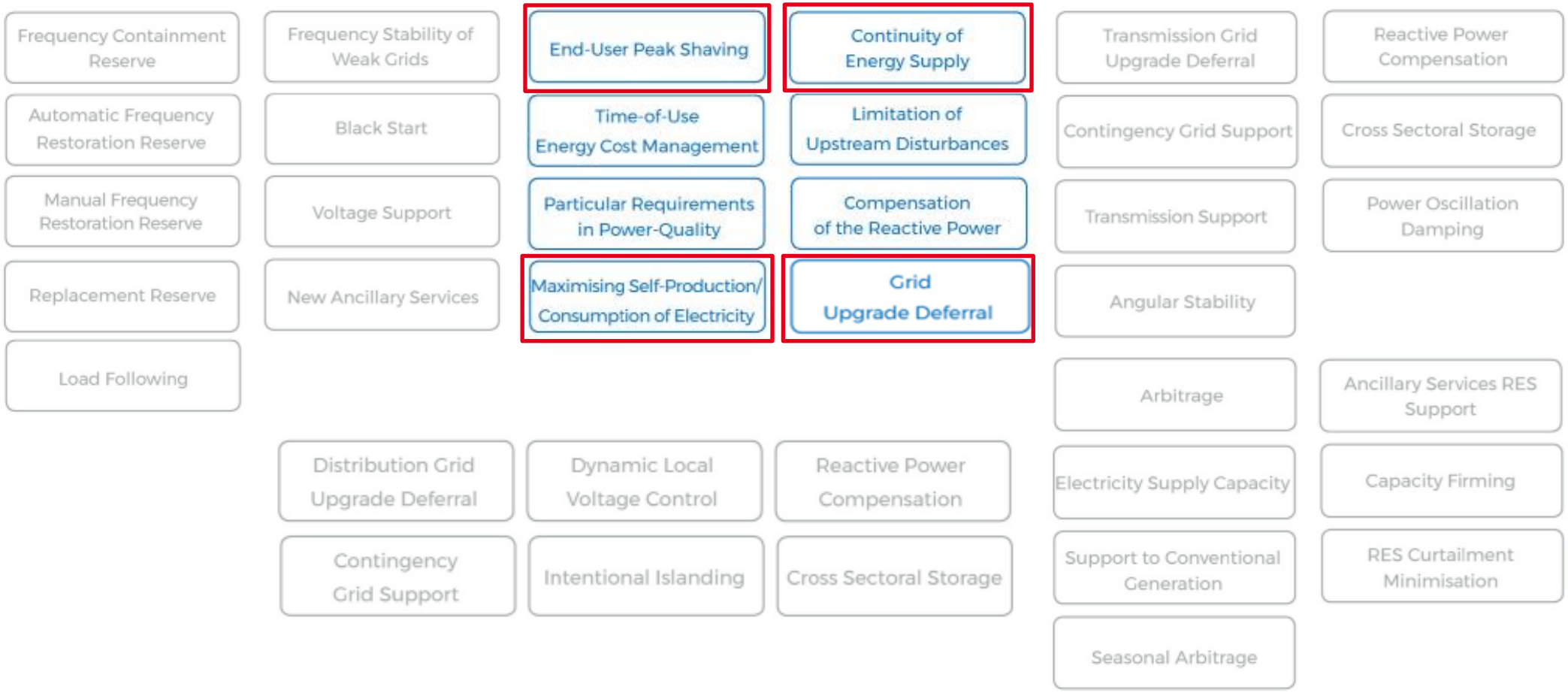
Source: F. Garrett, The Economics of Battery Energy Storage, Rocky Mountain Institute, September 2015.

Stationary battery storage – possible Revenues on Storage Applications
and most important Revenues for Commercial and Industrial Applications



Source: EASE Energy Storage Applications Summary, Brussels, June 2020.

Stationary battery storage – possible Revenues on Storage Applications
and most important Revenues for Commercial and Industrial Applications



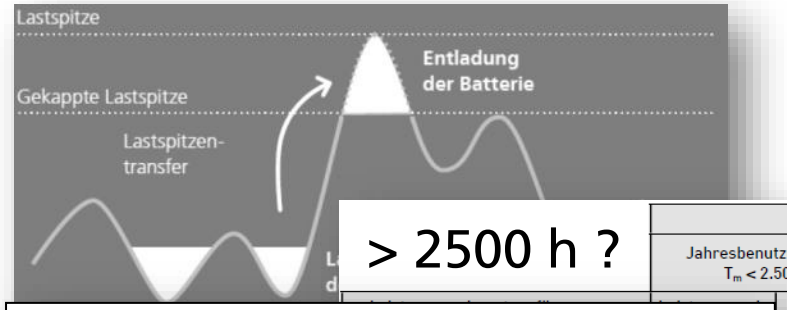
Source: EASE Energy Storage Applications Summary, Brussels, June 2020.

Most important Revenues for Commercial and Industrial Applications

End-User Peak Shaving

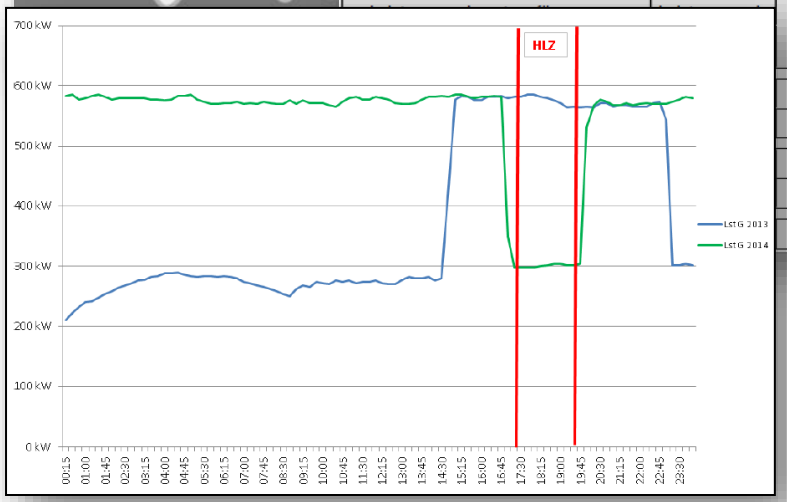
End-User Peak Shaving	Grid Upgrade Deferral	Maximising Self-Production/ Consumption of Electricity	Continuity of Energy Supply

- Goal: Reduction of demand / grid charges (Netzentgelte) (StromNEV §19)
- 4 Options:
  - Performance Price: Shaving occasional peak loads in 15 Min. intervals
  - Perform. Price Classification: Increase of full-load hours over 2500h
  - Atypical grid usage: Reduction of power consumption during high load hours
  - Energy-intensive Consumer: > 10 GWh/a and min. 7000h full-load hours



> 2500 h ?

Jahresleistungspreissystem				
Jahresbenutzungsdauer T_m < 2.500 h/a		Jahresbenutzungsdauer T_m >= 2.500 h/a		
Arbeitspreis	Leistungspreis	Arbeitspreis		
Cent/kWh	€/kWa	Cent/kWh		
3,82	101,48	0,26		
3,90	103,31	0,27		
5,23	129,11	0,80		
5,31	131,36	0,80		
5,32	113,78	1,52		



Sources:
- Netzentgelte durch batt. Speicher, EDF RE, R. Schuster, 2019
- Netzzugangsentgelte Strom, Preisblatt, bnNETZE GmbH, 2020
- Faktenpapier Atypische Netznutzung, DIHK, 2015.

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Most important Revenues for Commercial and Industrial Applications

Grid Upgrade / CAPEX Deferral

End-User Peak Shaving | **Grid Upgrade Deferral** | Maximising Self-Production/ Consumption of Electricity | Continuity of Energy Supply

- Goal: Reduction / Deferral of capex intensive investments
- For example:
  - Deferral of grid (MV Ring / Transformator) extension e.g. due to production extension, new machinery or e-mobility charging infrastructure
  - Often in combination with integration of renewable energies (see next slide)

Source:
- Picture : Vermessungsamt Freiburg
- Graph: Fraunhofer ISE

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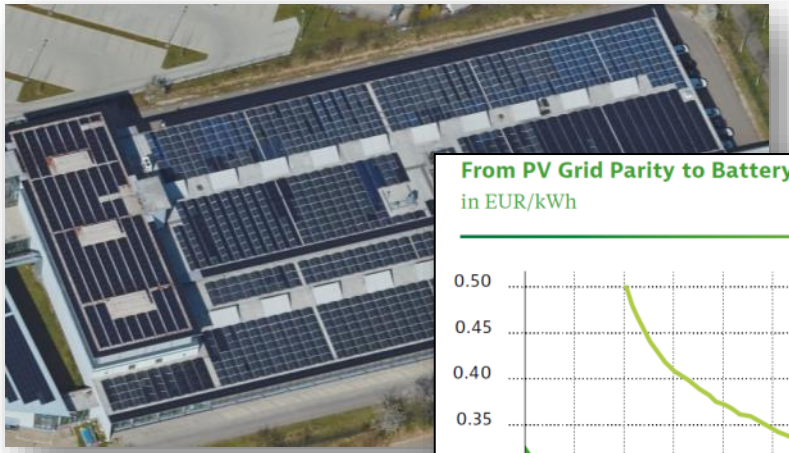
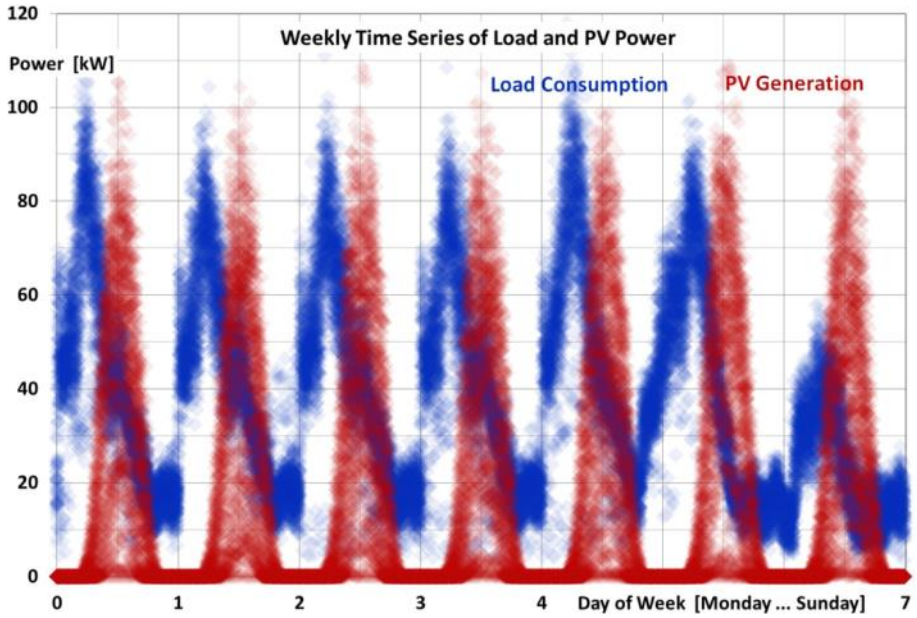
Most important Revenues for Commercial and Industrial Applications

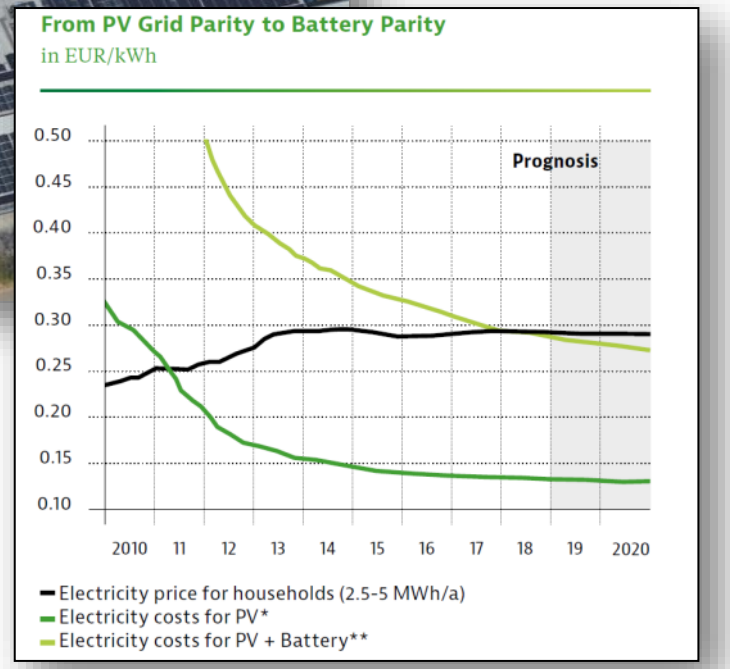
Maximize Self-Production / Self-Consumption

End-User Peak Shaving | Grid Upgrade Deferral | **Maximising Self-Production/ Consumption of Electricity** | Continuity of Energy Supply

- Goal: Maximize self-consumption in combination with RE (Solar, Wind, BHKW)







Sources:

- Picture : Vermessungsamt Freiburg
- GTAI (2019) The Energy Storage Market in Germany

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Most important Revenues for Commercial and Industrial Applications

Continuity of Energy Supply / UPS

End-User Peak Shaving | Grid Upgrade Deferral | Maximising Self-Production/ Consumption of Electricity | **Continuity of Energy Supply**

- Goal: Secure continuity of supply by an UPS (Uninterruptable Power Supply) Service
- E.G. for
  - IT infrastructure
  - Critical production processes
  - Work safety / fire prevention

Recently submitted review paper on Energy Storage Systems Applications

Springer

Current Sustainable/Renewable Energy Reports

Review of Stationary Energy Storage Systems Applications, their Placement and Techno-Economic Potential

(Beneficiary, Customer)	BESS Applications:	Where do you place it? (Provider)						
		Consumer		Grid / Distribution				Bulk Generation
		Low voltage		Medium Voltage				High Voltage
	Operation level / Place	Local		Regional / Municipal				National
	Operator	Residential	C&I	3rd Party	Utility	DSO*	TSO*	Utility
Generation support	Arbitrage			[9, 10]	[9]			[11]
	System Electric Supply capacity		[12]	[13]	[13]			[13]
	Support Conv. Generation							
	Seasonal Arbitrage							[14]
	Ancillary Services RES Support		[15–17]	[15–17]	[15–18]	[15–17]	[15–17]	[11,15–17,19]
	Capacity Firming							
	RES Curtailment Minimization			[20–22]	[20–23]			[21]
Transmission	*Transmission Grid upgrade deferral*						[24–26]	[24–26]
	Contingency Grid Support						[27]	[27]
	Transmission Support	[28]	[28]			[29]	[29, 30]	
	Angular Stability							
	Reactive Power Compensation							
	Cross Sectoral Storage	[31]	[31]	[32]	[32]			[32]
	Power Oscillation Damping (POD)							
Distribution	*Distribution Grid upgrade deferral*	[33, 34]	[33, 34]		[33–35]	[33–35]		
	Contingency Grid Support			[23]	[23, 29]	[29]		
	Dynamic Local Voltage Control			[18]	[18, 29]	[18, 29]		
	Intentional Islanding		[36]					
	Reactive Power Compensation		[33]	[37]	[23, 33, 37]	[33, 37]		
	Cross Sectoral Storage			[32]	[32]			
Ancillary Services	*Frequency Containment Reserve*	[28]	[10, 28, 38]	[28]	[39–44]	[45]	[30]	[11, 19, 43]
	Automatic Frequency Restoration Reserve	[12]			[43, 44]	[45]	[30]	[19, 43]
	Manual Frequency Restoration Reserve				[44]			[19]
	Replacement Reserve							
	Load Following					[46]		
	Frequency Stability (Weak grids)				[47]			
	Black Start				[27]			[27]
	Voltage Support	[12]			[18]	[46]	[30]	
	New Ancillary Services		[17, 48]	[17, 48]	[17, 44, 48]	[17, 48]	[17, 48]	[17, 43, 48]
EMS / Customer Services	*End-User Peak-Shaving*		[10, 38, 49, 50]	[10]		[46]		
	Time-of-use / energy cost Mgmt.	[51]	[51]					
	Energy Quality		[52, 53]	[52, 53]				
	Maximizing Self- Production / Self-Consumption	[28, 54–56]		[28, 55, 57, 58]	[54–56, 59]	[46]		
	Continuity of Energy Supply / UPS							
	Limitation of upstream disturbances (Distribution)					[46]		
	Compensation of reactive power		[52, 53, 60]	[52, 53]		[46]		

Submitted manuscript

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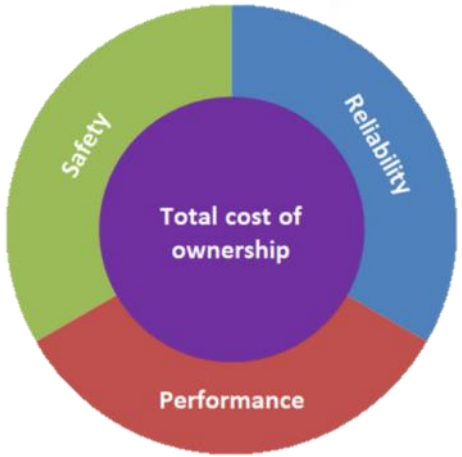
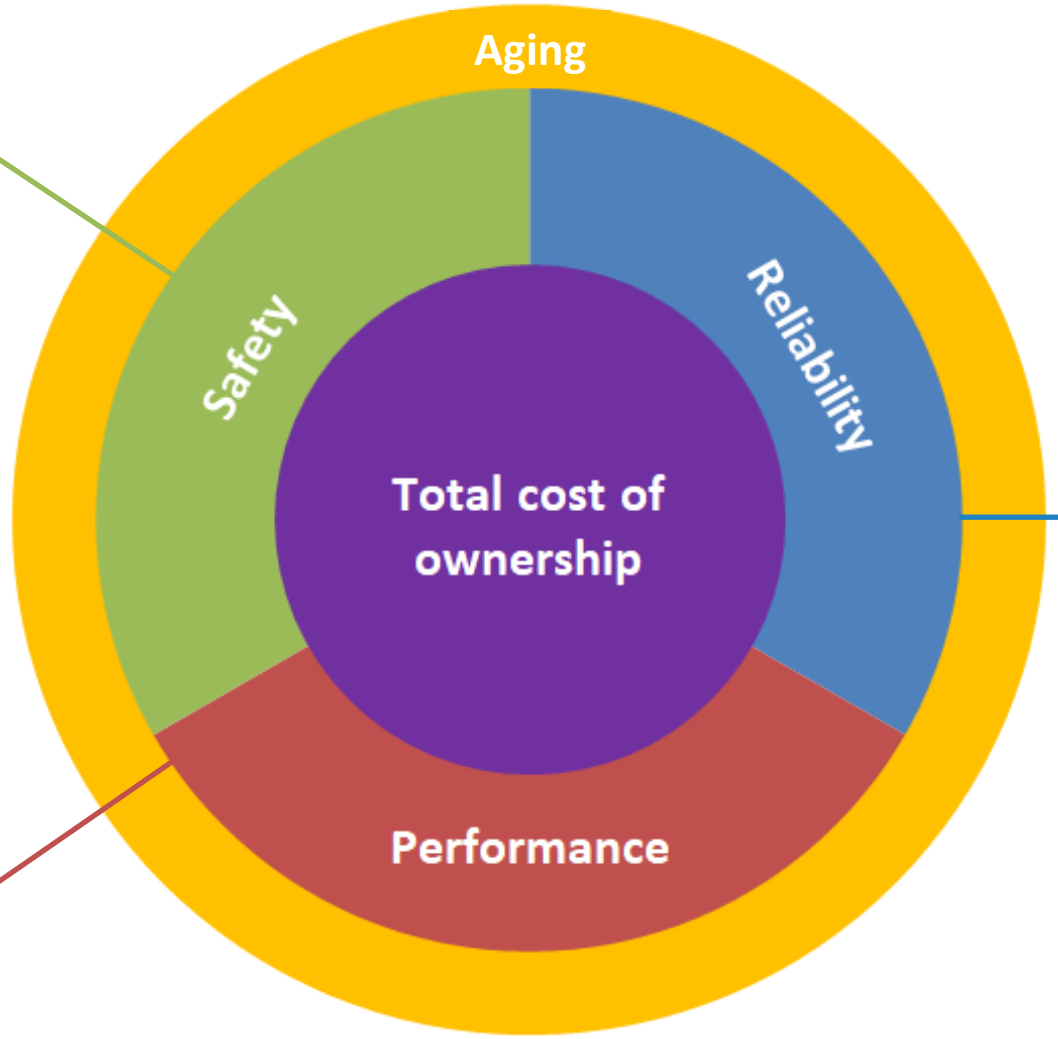


Success factors for battery storage product and project evaluation

- Component and system level
- Functional safety

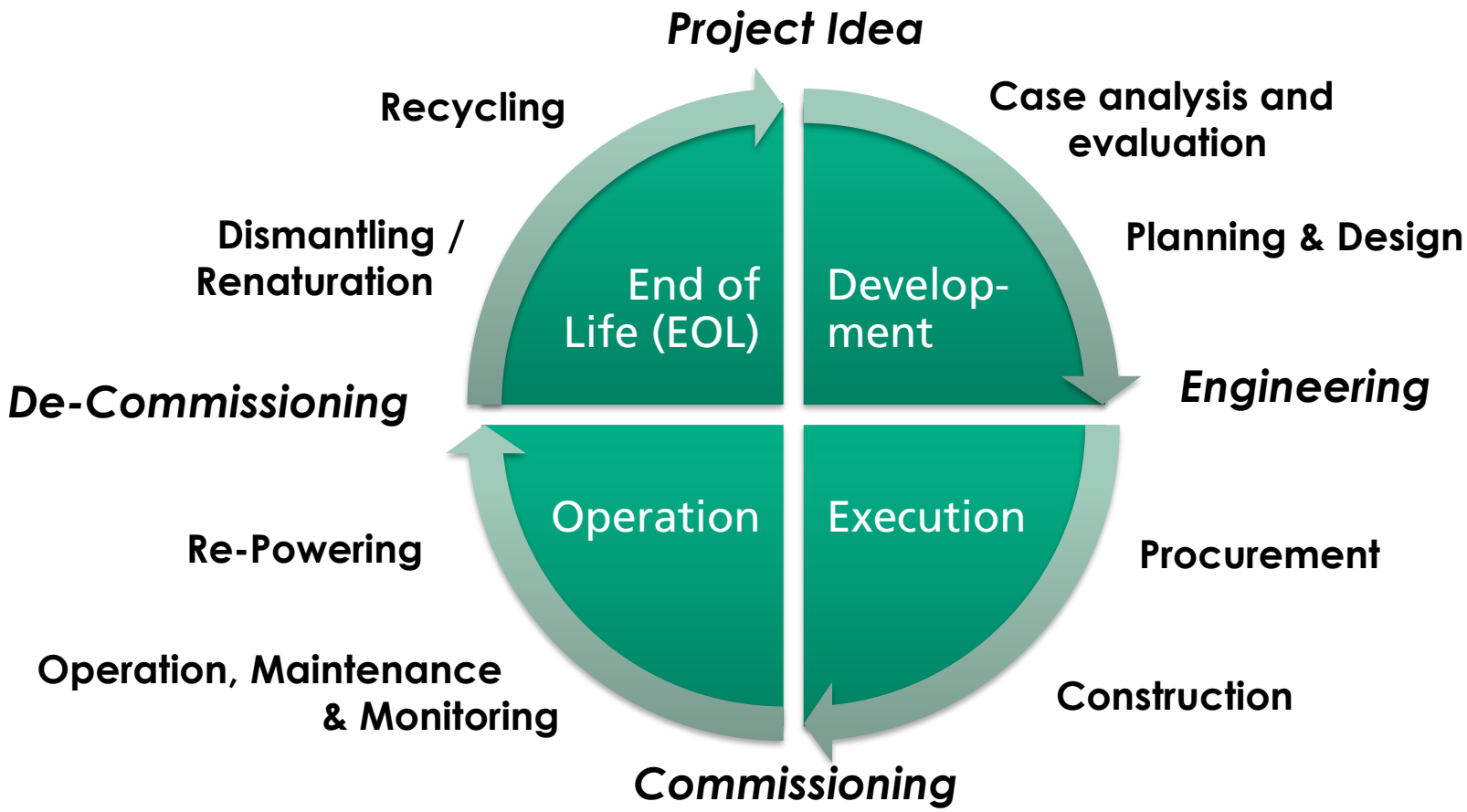


- Component and system level
- Operating conditions

- System efficiency
- System effectiveness

Source: Fraunhofer ISE, Germany

Secure Quality Assurance in all Life Cycle Phases
for a successful energy storage project



Source: Fraunhofer ISE, Germany

Energy Storage Project Life Cycles

supporting quality assurance services at Fraunhofer ISE

Development

CONSULTING:

- (Pre-)feasibility study
- Project design
- FMEA / FMECA
- Technology consulting
- Modelling / simulation
- Environmental Stress and Site assessment
- Techno-economic analysis and assessments

Execution

CONSULTING:

- Independent & owners engineering services
- Basic/detail engineering design & review
- HSE & safety assessment
- Installation, workmanship and reliability of EPC work
- Equipment benchmark, selection and testing

Operation

CONSULTING:

- Independent & owners engineering services
- Project (re)commissioning supervision & assessment
- Grid compliance testing
- Spare part and O&M monitoring & optimization
- Quality monitoring
- Re-powering assessment

End of Life

CONSULTING: +

- Independent & owners engineering services
- Project de-commissioning supervision & assessment
- Renaturation supervision
- Lifecycle & TCO verification
- Recycling

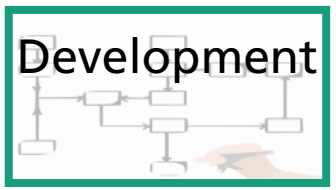
+ *in Cooperation with other Fraunhofer Institutes*

* *in Preparation with VDE Renewables*

Energy Storage Project Life Cycles

supporting quality assurance services at Fraunhofer ISE

Development



INDEPENDENT & CERTIFIED*

- Design approval
- Site approval
- (Tech.) due diligence

Execution

INDEPENDENT & CERTIFIED*

- Equipment certification
- EPC work
- (Tech.) due diligence

Operation

INDEPENDENT & CERTIFIED*

- Project (re)commissioning and acceptance testing
- O&M quality / performance

End of Life

INDEPENDENT & CERTIFIED*

- De-commissioning

** in Preparation with VDE Renewables*

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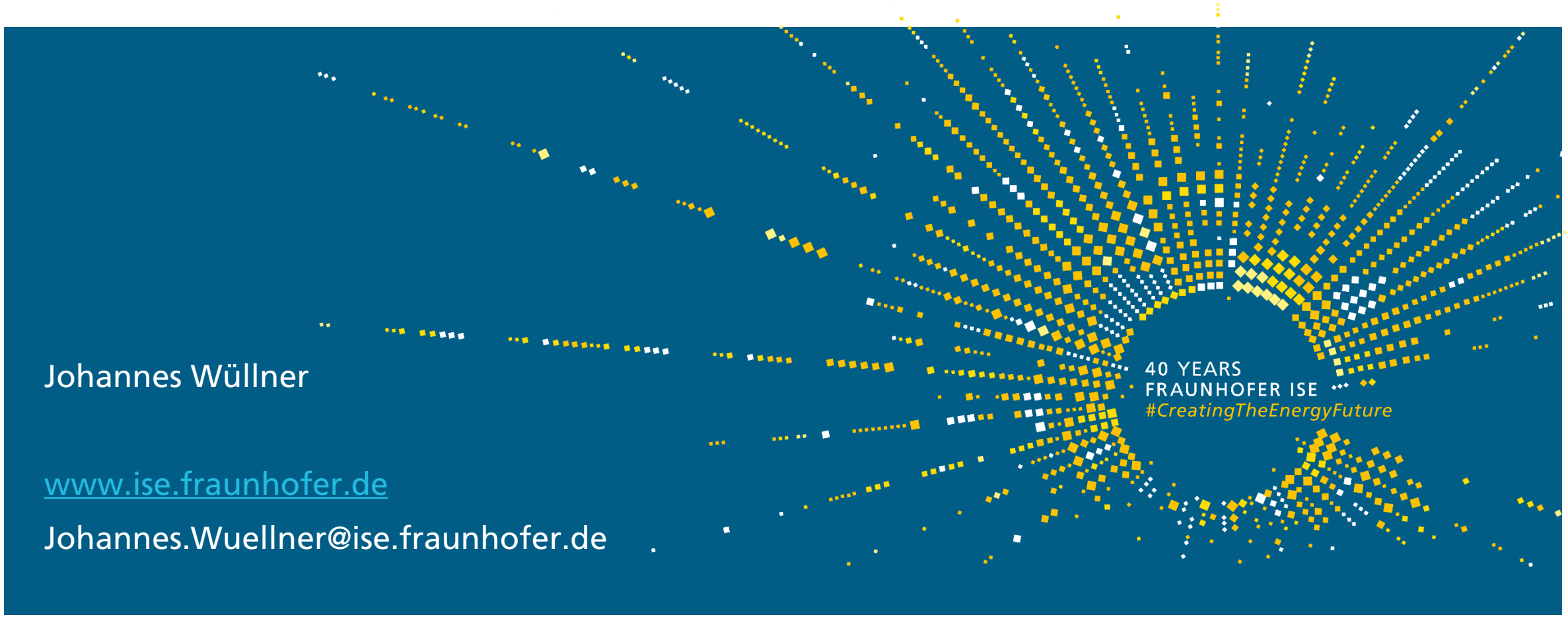
Conclusions

- Large-scale system integration of fluctuating renewable energies and (fast) charging stations for the transport sector require decoupling of production and consumption
- Due to continuously falling prices, new business cases are developing
- Energy storage market is continuously (and fast) growing

- Revenue stacking allow promising business cases
- Choosing the right applications is the key for successful integration of storage

- Considering the key factors (Safety, Reliability, Performance, Aging) secure a proper operation and a successful investment
- Appropriate and holistic quality assurance measures have to consider all these topics

Thank You for Your Attention!



Johannes Wüllner

www.ise.fraunhofer.de

Johannes.Wuellner@ise.fraunhofer.de

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