Federal Ministry
for Economic Affairs
and Energy

MITTELSTAND
GLOBAL
ENERGY SOLUTIONS
MADE IN GERMANY

Energy Storage – Technologies, Applications, Markets

Urban Windelen, Executive Director,
German Energy Storage Association

Barcelona, Nov. 05, 2019

BVES
BUNDESVERBAND
ENERGIESPEICHER

Facilitator
eclareon

The German Energy Storage Association (BVES)

- The BVES is the industrial association of German energy storage companies that is open to all technologies in the areas of electricity, heat and mobility. (~ 200 Member Companies)
- We are a dialogue partner for politics, administration, science and publicity. With targeted lobbying at the interfaces of political decision making we are trying to improve the German regulation and policy framework.
- In addition, the BVES monitors research and development activities and informs members of new results and developments.

BVES
BUNDESVERBAND
ENERGIESPEICHER

BVES - The German Energy Storage Association

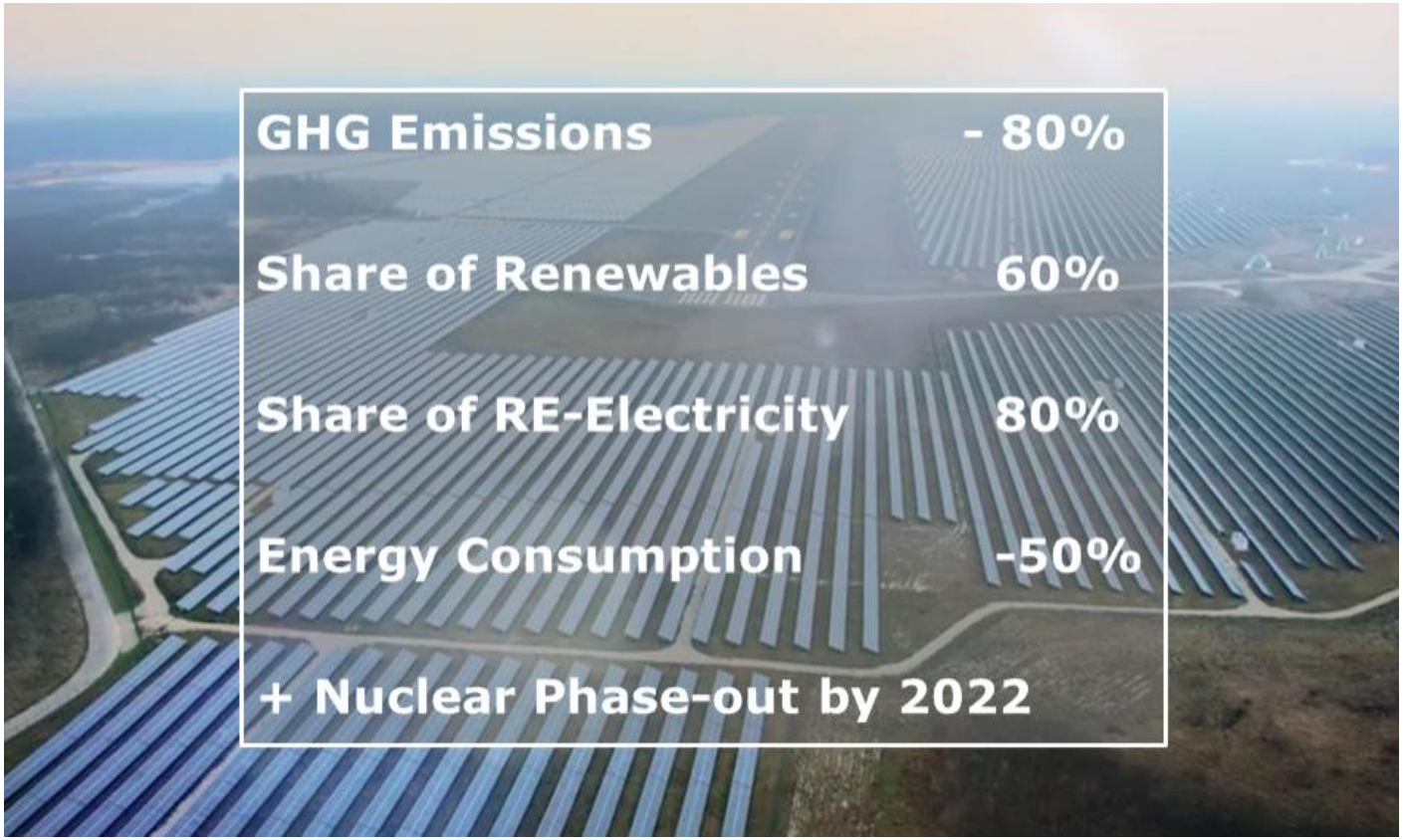
An Excerpt of our Members

Agenda

- BVES – German Energy Storage Association
- ‚Energy Transition' creates the need of storage
- Technologies and Applications
- Regulatory framework
- Conclusions

BVES
BUNDESVERBAND
ENERGIESPEICHER

Goals of the ‚Energiewende'

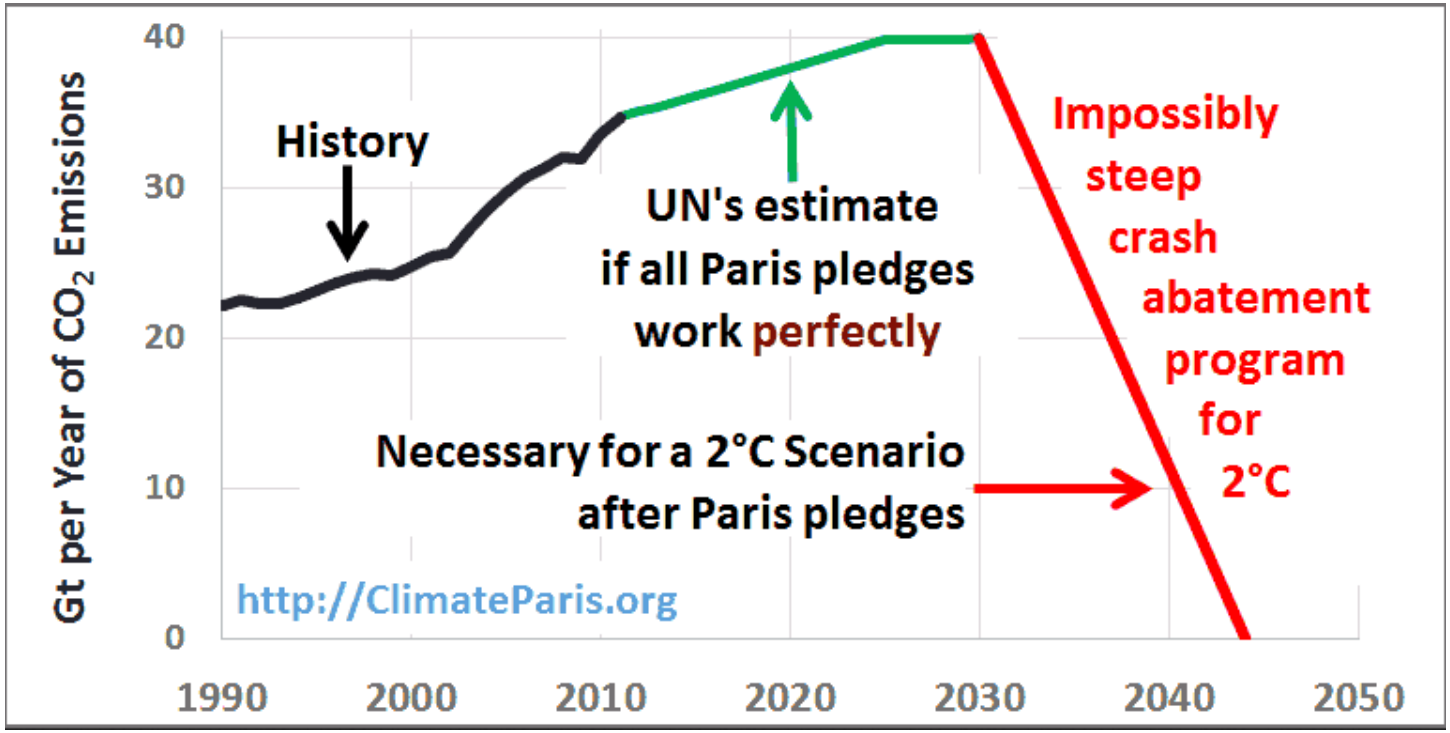


Source: Germany Trade and Invest

BVES
BUNDESVERBAND ENERGIESPEICHER

Paris Agreement (COP 21)

Goal: Limiting global warming to 2° C

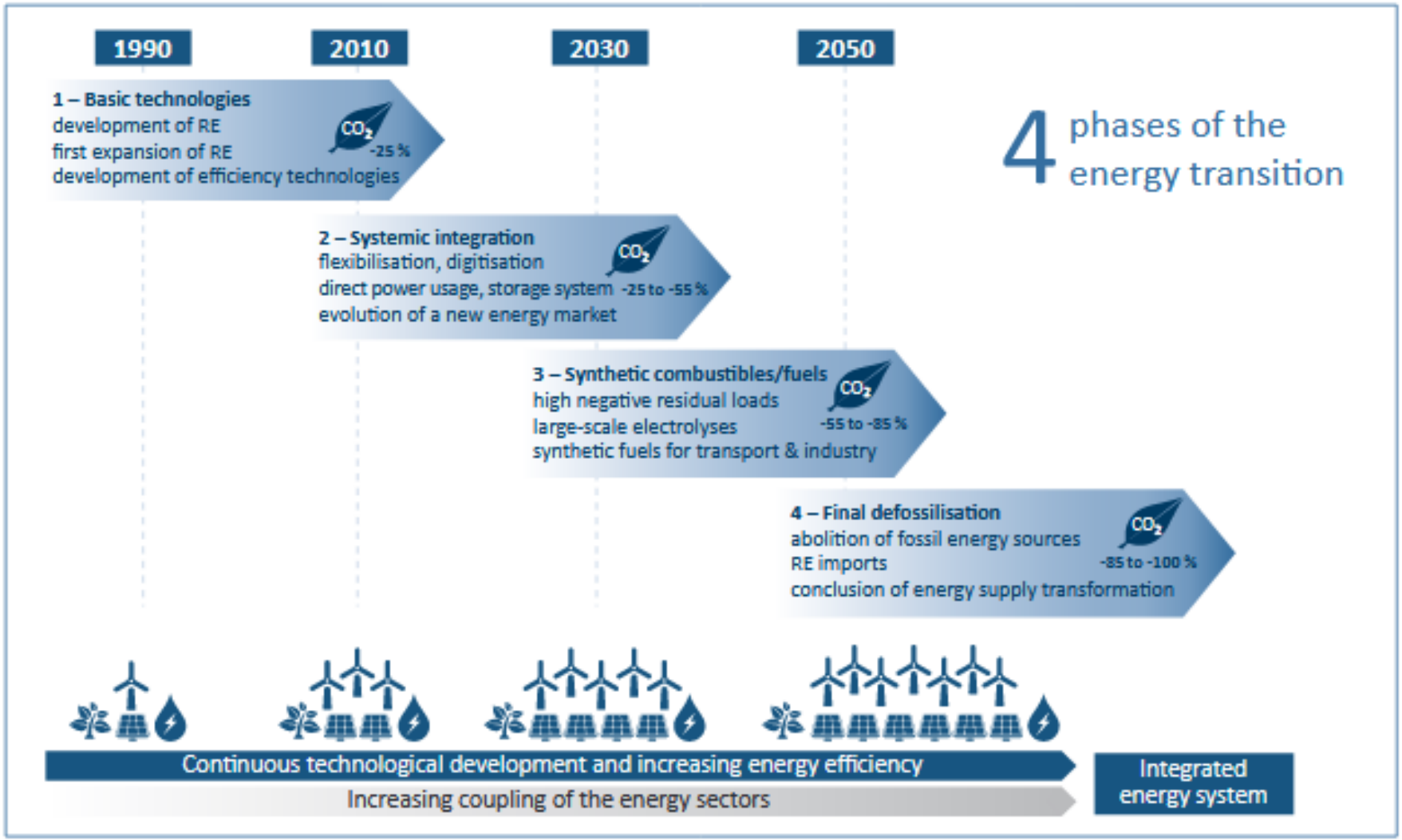


Source: www. http://climateparis.org

→ Limiting the Energiewende to the electricity sector is not sufficient !

BVES
BUNDESVERBAND
ENERGIESPEICHER

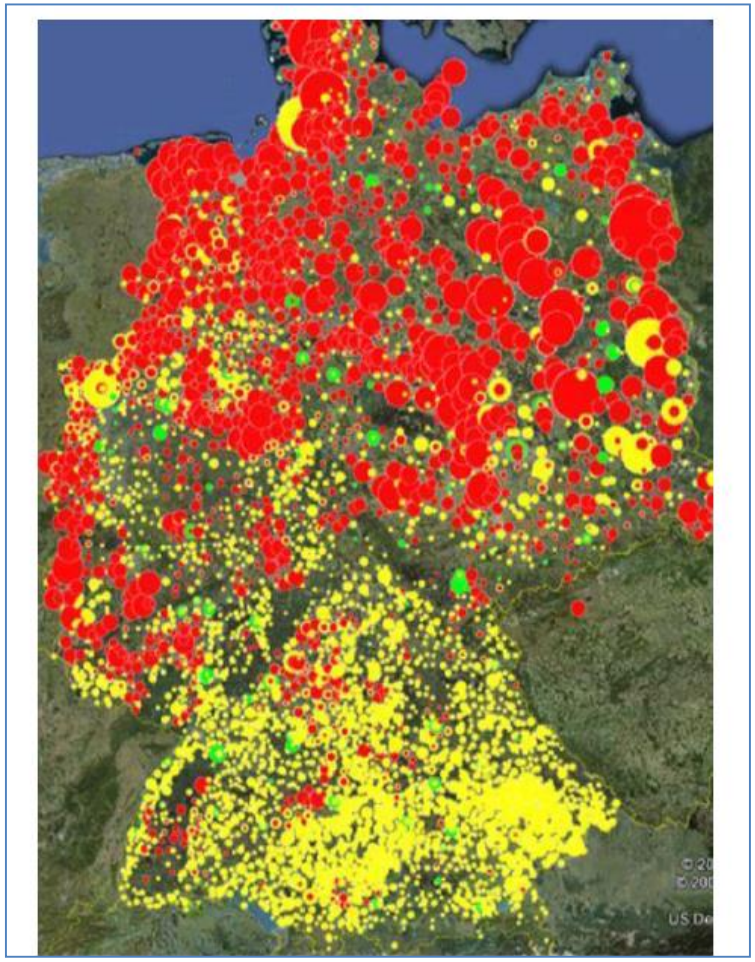
4 Phases of the Energiewende: Step 2 +3 still to be done



Quelle: Studie „Energiesysteme der Zukunft“ (ESYS)

BVES
BUNDESVERBAND ENERGIESPEICHER

Main Challenge No.1 – The “Local Issue”



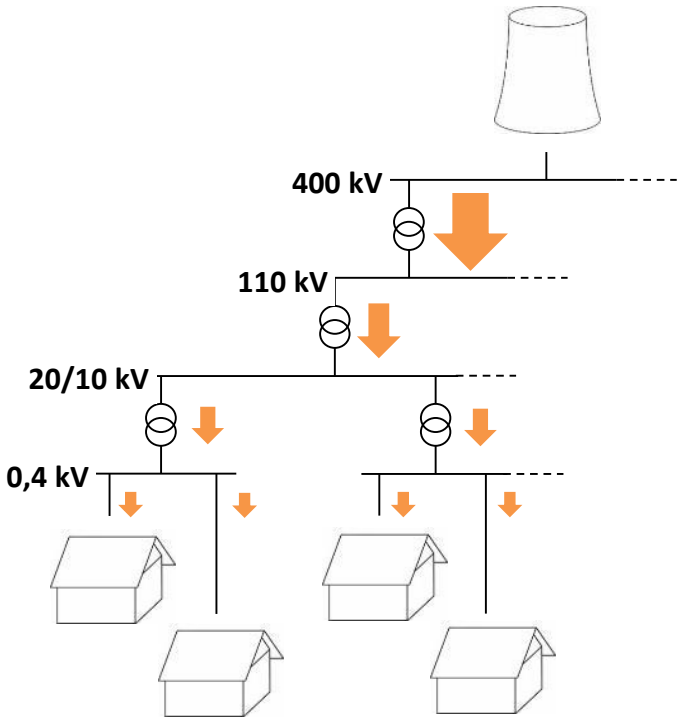
Energyintensive industry sits mostly in the south of Germany

Task is, to bring wind-energy (onshore and offshore) from the north to the south

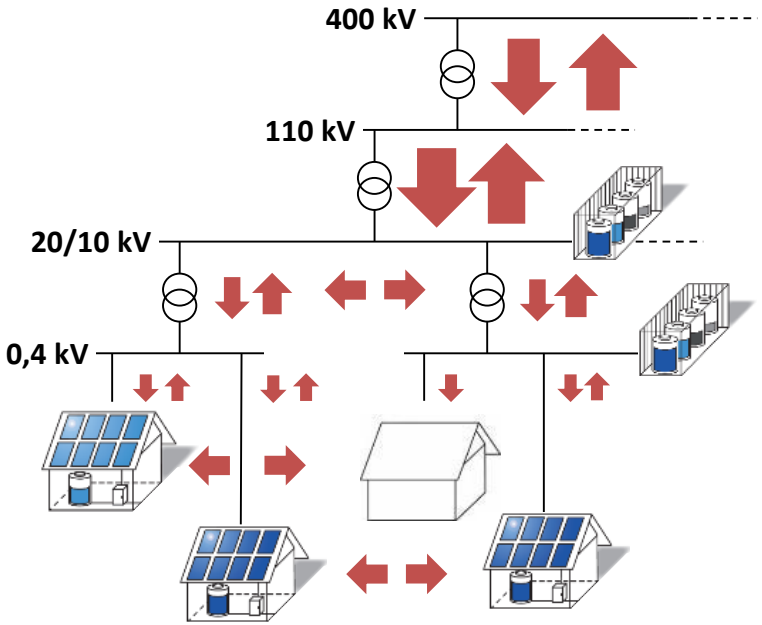
BVES
GERMAN ENERGY STORAGE ASSOCIATION

Main Challenge No.2 – The "System Issue"

The Fossil Age



New Electrification Wave



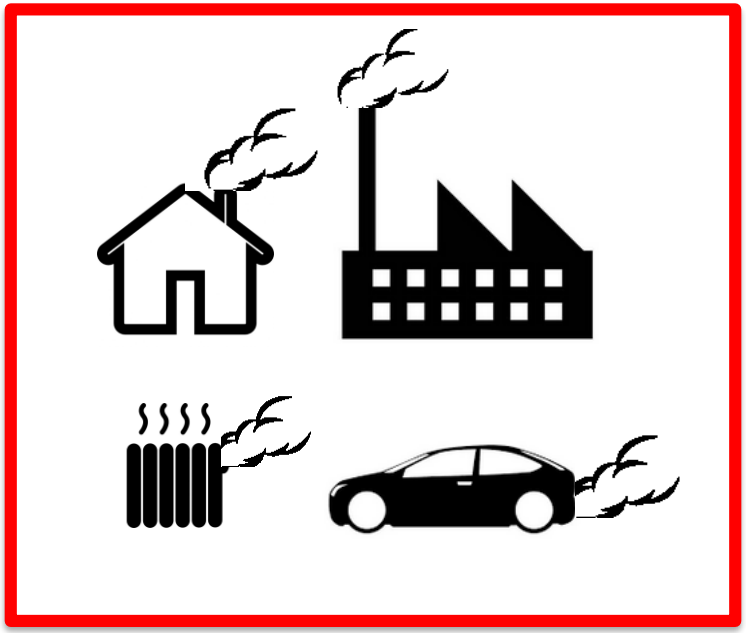
Source: Alexander Zeh, Simon Müller, Marcus Müller (2016)

BVES
GERMAN ENERGY STORAGE ASSOCIATION

Main Challenge No.3 – The "Power Issue"

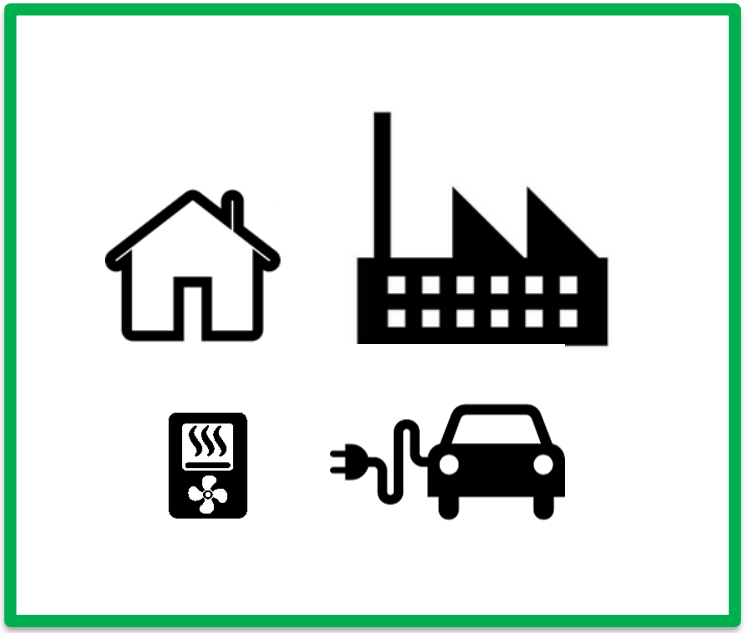
In an all electric world is POWER the essential task, not only energy.

The Fossil Age



ENERGY is sufficient.

New Electrification Wave



POWER is required!

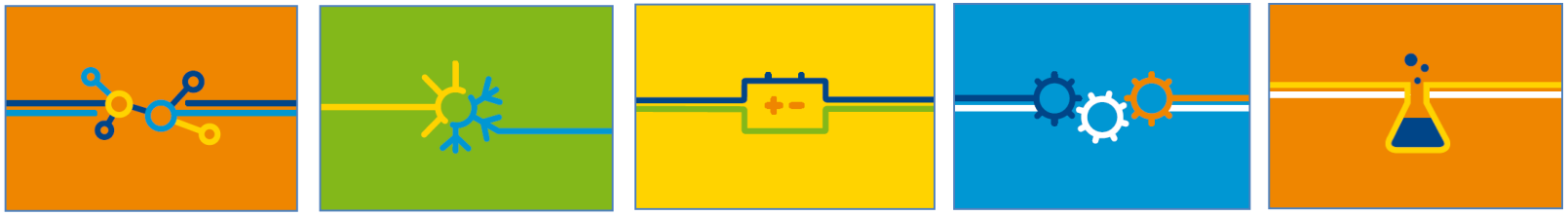
BVES
GERMAN ENERGY
STORAGE ASSOCIATION

Agenda

- BVES – German Energy Storage Association
- ‚Energy Transition' creates the need for storage
- Technologies and Applications
- Regulatory framework
- Conclusions

BVES
BUNDESVERBAND ENERGIESPEICHER

A basket full of technologies…



WÄRME/KÄLTE ZU WÄRME/KÄLTE (THERMISCHE ENERGIESPEICHER)

- **Sensibel**
  - Wasser (FactSheet»)
  - Salzschmelze und andere Flüssigkeiten (FactSheet»)
  - Feststoffe (FactSheet in Arbeit)
- **Latent**
  - fest-flüssig Niedertemperatur (FactSheet»)
  - fest-flüssig Hochtemperatur (FactSheet»)
- **Thermochemisch**
  - Sorption (FactSheet»)
  - Chemische Reaktion (FactSheet»)

BVES BUNDESVERBAND ENERGIESPEICHER

SPEICHERTECHNOLOGIEN STECKBRIEF

Li-Ionen Stromspeicher

ALLGEMEINE BESCHREIBUNG:

Form der Energieaufnahme und -abgabe: Strom zu Strom

Kurzbeschreibung des Speicherprozesses: Stromspeicher dienen zur Speicherung von bereits erzeugtem Strom, um diesen zu einem späteren Zeitpunkt zu nutzen.

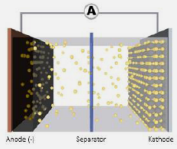


Abb. 1: Schematischer Aufbau einer Lithium-Ionen-Zelle[1]

STROM ZU GAS/FLÜSSIGKEIT (CHEMISCHER ENERGIESPEICHER)

- **Wasserstoff**
  - Power to Gas (FactSheet»)
- **Synthetisches Methan/ Methanol**
  - Power to Gas (FactSheet»)

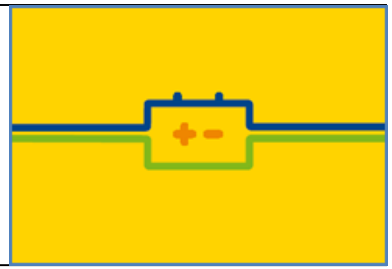
STROM ZU STROM (STROMSPEICHER)

- **Elektrochemisch**
  - Vanadium Redox Flow Batterie (FactSheet»)
  - Hochtemperatur Batterie (FactSheet»)
  - …ctSheet»)
  - …Sheet»)
  - …FactSheet»)
  - …rke (PSW) (FactSheet»)
  - …cher (CAES) (FactSheet»)
  - …icher (LAES) (FactSheet»)
  - …tische Energiespeicher
  - Kondensatoren

www.bves.de

BVES BUNDESVERBAND ENERGIESPEICHER

Storage of Electricity



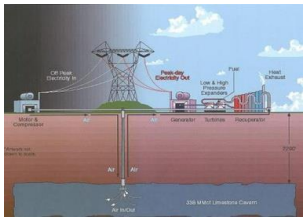
- **Storage of electrical energy**

  - Super-conducting Magnetic Energy Storage (SMES)
  - Super-capacitor

- **Electrochemical storage of electricity**

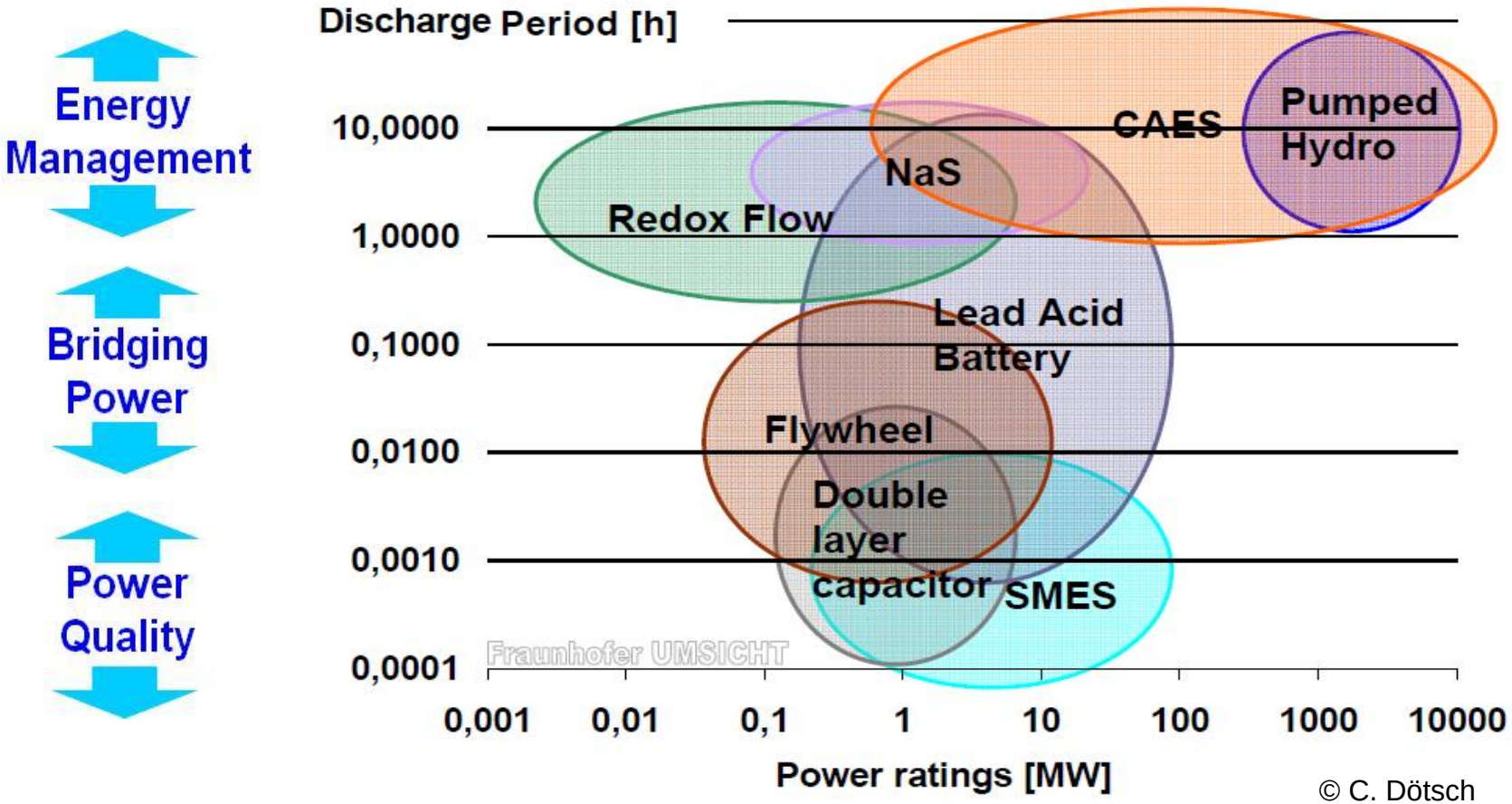
  - Natrium-Sulphur batteries(NaS-Cells)
  - Lead acid batteries
  - Redox-Flow batteries
  - Lithium-Ion batteries

- **Mechanical storage of electricity**



  - Hydro pump storage
  - Compressed-air storage (CAES)
  - Fly wheel

Density and capacity



BVES
BUNDESVERBAND ENERGIESPEICHER

Thermal Storage

- **Storage of sensible heat**

- Hot-water accumulator
- Underground Thermal Energy Storage (UTES)

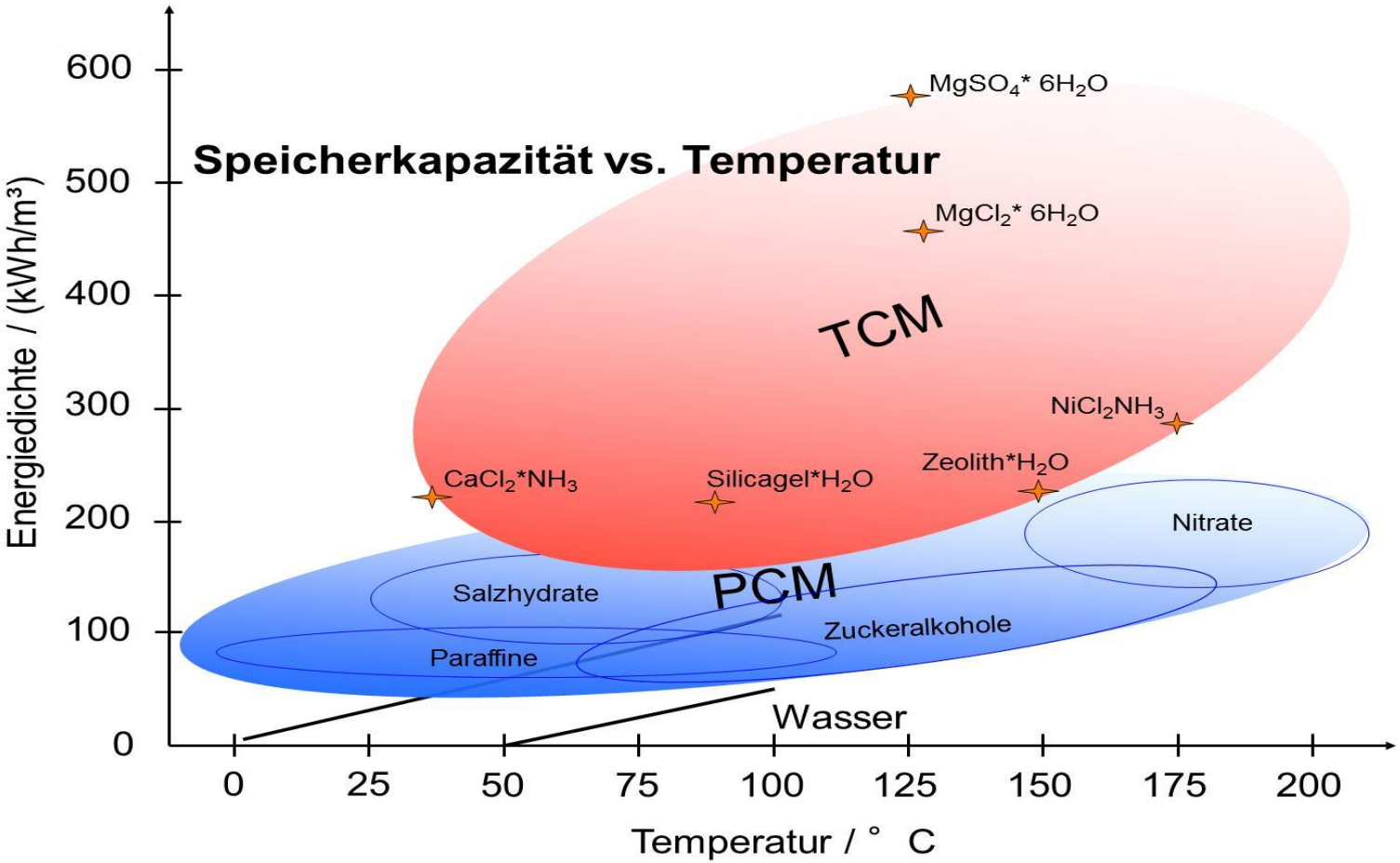
- **Storage of latent heat**

- Phase change material (PCM) PCM-device
- Slurries

- **Thermochemical storage**

- Adsorption-(zeolite) and Absorption-storage (LiCl)
- Thermochemical materials (TCM)

Density and temperature



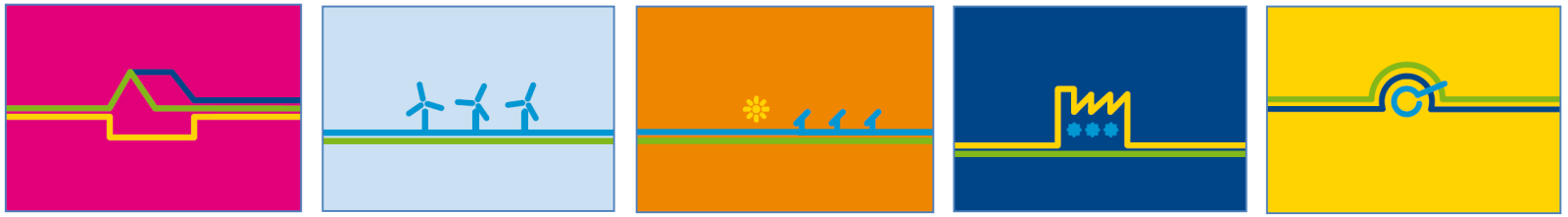
BVES
BUNDESVERBAND
ENERGIESPEICHER

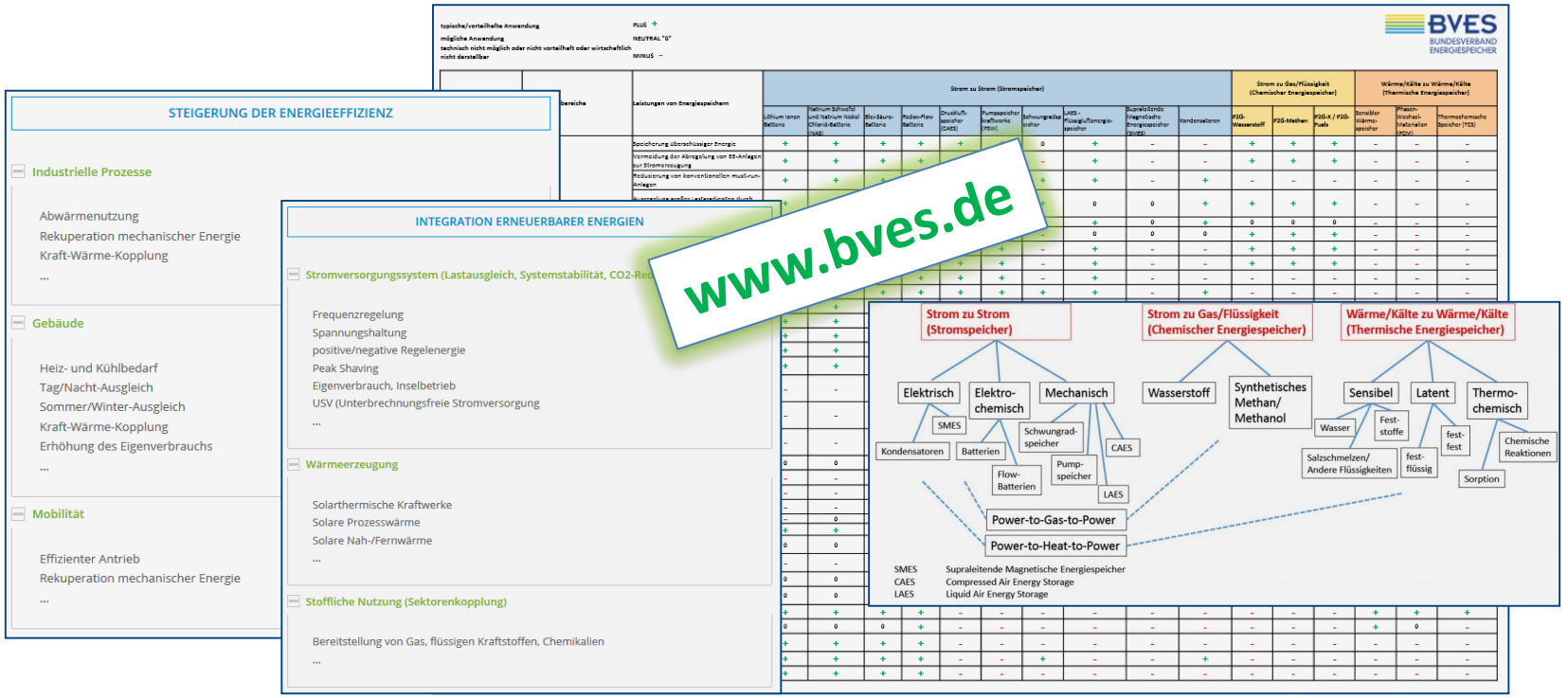
Chemical Energy Storage

Production of hydrogen and storing of hydrogen.

- Hydrogen is the energy-richest power fuel (in relation to its inertia)
- Lossless long-time storage
- Production of electricity with fuel cell / H_2-turbine

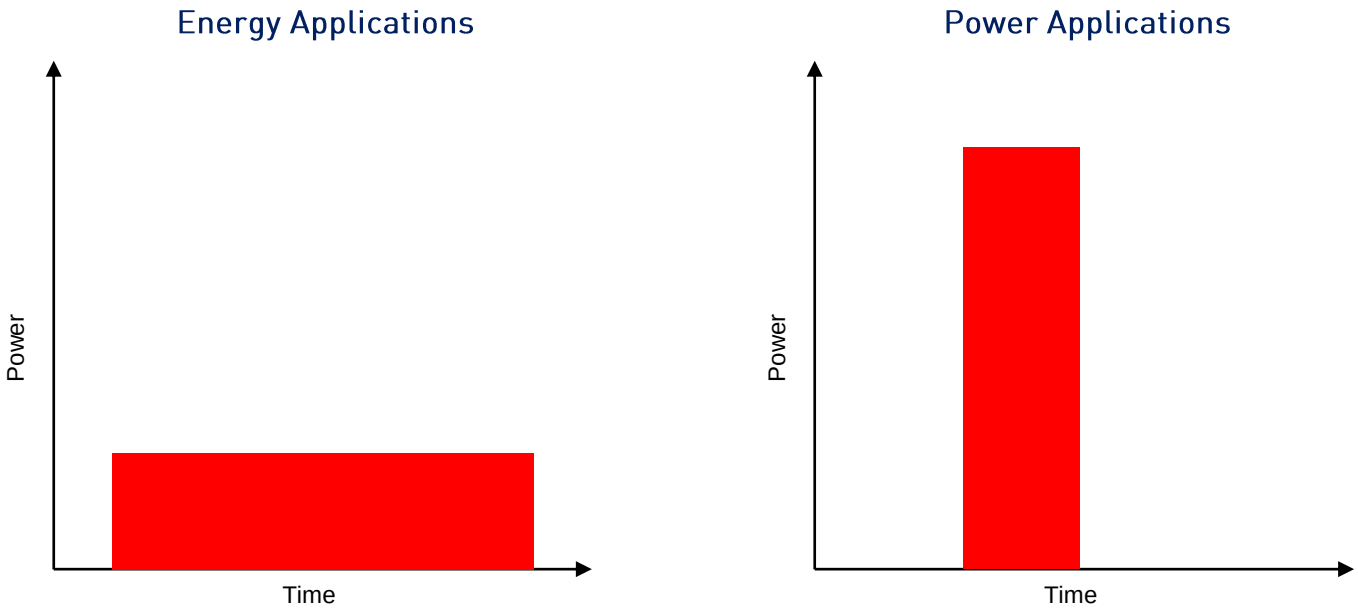
A basket full of applications…





BVES
BUNDESVERBAND
ENERGIESPEICHER

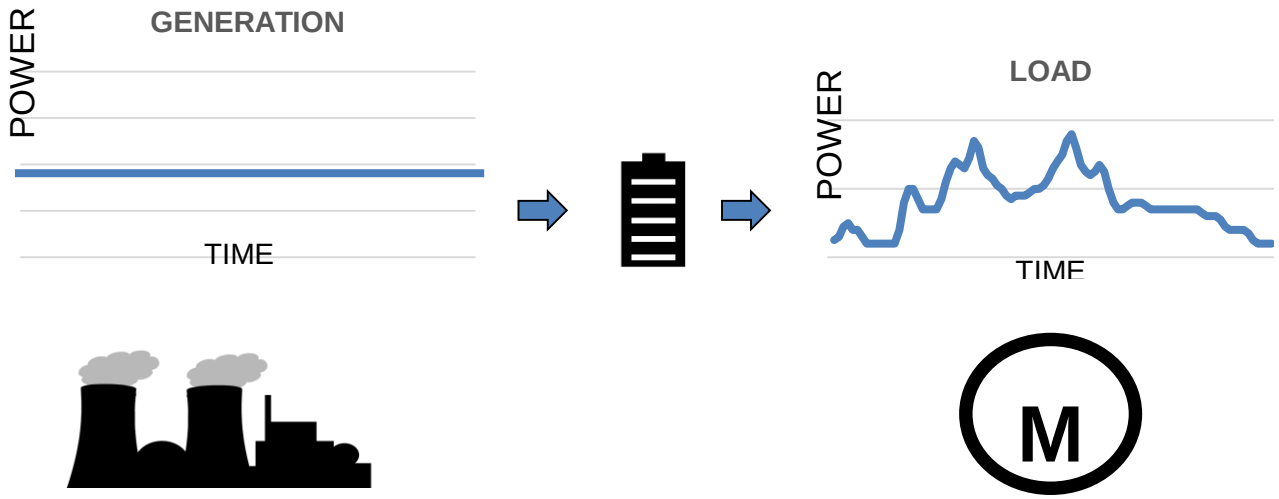
The Application Defines the Storage



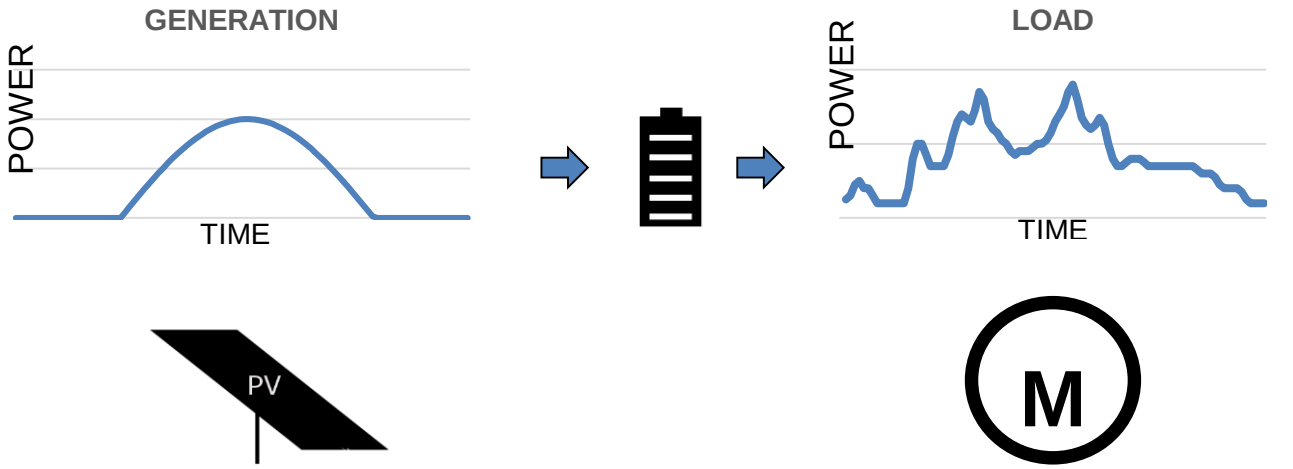
- The application defines the Storage-Technology
- The application and the local needs defines the economic feasability

BVES
BUNDESVERBAND ENERGIESPEICHER

Energy Storage in the „old“ and the „new“ world of energy



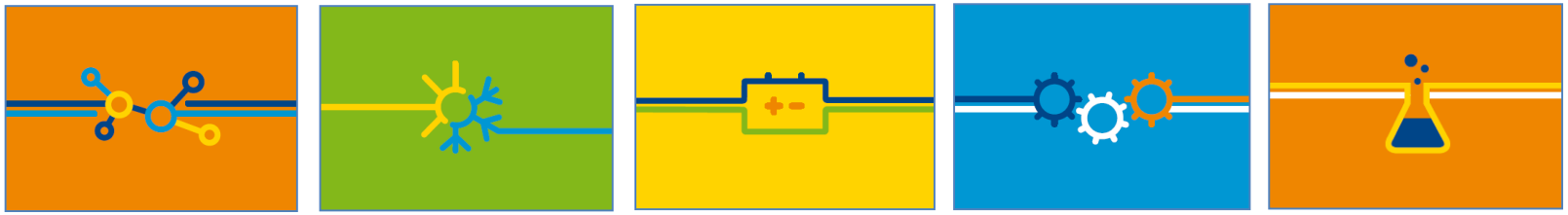
Optimizing Energy Generation



Optimizing Demand & Supply

BVES
BUNDESVERBAND ENERGIESPEICHER

Relation of energy storage technologies and applications



- The technical and economic requirements for the storage facility are determined by the actual application of the storage facility in the supply system.
- Therefore, an assessment of different storage technologies (and a comparison) is only possible on the basis of concrete applications.
- The application specifies technical requirements (form of energy, storage capacity, reaction time, etc.).
- The application also determines the economic environment (e.g. which energy prices can be applied, what life cycle is achieved, etc.).

BVES
BUNDESVERBAND ENERGIESPEICHER

Economic feasibility of storage and „Benefit stacking“

≈ 1,0 €/kWh

≈ 150 €/kWh

≈ 60 €/kWh

BVES
BUNDESVERBAND ENERGIESPEICHER

Economic feasibility of storage and „Benefit stacking“

≈ 1,0 €/kWh

≈ 150 €/kWh

≈ 60 €/kWh

≈ 10.000 €/kWh

BVES
BUNDESVERBAND ENERGIESPEICHER

Matrix Technologies/Applications

CLUSTER	Anwendungsbereiche	Leistungen von Energiespeichern	Strom zu Strom (Stromspeicher)										Strom zu Gas/Flüssigkeit (Chemischer Energiespeicher)			Wärme/Kälte zu Wärme/Kälte (Thermische Energiespeicher)		
			Lithium Ionen Batterie	Natrium Schwefel und Natrium Nickel Chlorid-Batterie (NAS)	Blei-Säure-Batterie	Redox-Flow Batterie	Druckluft-speicher (CAES)	Pumpspeicher Kraftwerke (PSW)	Schwungradspeicher	LAES - Flüssigluftenergie-speicher	Supraleitende Magnetische Energiespeicher (SMES)	Kondensatoren	P2G-Wasserstoff	P2G-Methan	P2G-X / P2G-Fuels	Sensibler Wärme-speicher	Phasen-Wechsel-Materialien (PCM)	Thermochemische Speicher (TCS)
Nutzung und Integration erneuerbarer Energien	Stromversorgungssystem (Lastausgleich, Systemstabilität, CO2-Reduktion)	Speicherung überschüssiger Energie	+	+	+	+	+	+	0	+	-	-	+	+	+	-	-	-
		Vermeidung der Abregelung von EE-Anlagen zur Stromerzeugung	+	+	+	+	+	+	-	+	-	-	+	+	+	-	-	-
		Reduzierung von konventionellen must-run-Anlagen	+	+	+	+	+	+	+	+	-	+	-	-	-	-	-	-
		Ausregelung großer Lastgradienten durch schnelle Leistungsanpassung ("Ramping")	+	+	+	0	0	+	+	0	0	+	+	+	+	-	-	-
		Momentanreserve / Frequenzhaltung	+	+	+	+	+	+	+	+	0	+	0	0	0	-	-	-
		Primärregelleistung	+	+	+	0	0	+	-	0	0	0	+	+	+	-	-	-
		Sekundärregelleistung	+	+	+	+	+	+	-	+	-	-	+	+	+	-	-	-
		Minutenreserve	+	+	+	+	+	+	-	+	-	-	+	+	+	-	-	-
		Beitrag zur gesicherten Leistung	+	+	+	+	+	+	-	+	-	-	-	-	-	-	-	-
		Kurzschlussleistung	+	+	+	+	+	+	+	+	-	+	-	-	-	-	-	-
		Eignung zum Redispatch	+	+	+	+	+	+	0	+	-	-	0	0	0	-	-	-
		Schwarzstartfähigkeit	+	+	+	+	+	+	0	+	-	-	-	-	-	-	-	-
		Blindleistungserbringung	+	+	+	+	+	+	+	+	+	+	0	0	0	-	-	-
		Spannungshaltung	+	+	+	+	+	+	+	+	+	+	0	0	0	-	-	-
		Bereitstellung von Spitzenlast (Peak Shaving)	+	+	+	0	+	+	+	+	+	-	-	-	-	-	-	-
	Wärme-Erzeugung	Nachfragegesteuerte / Verstetigte Wärmebereitstellung von solarer Nah-/Fernwärme	-	-	-	-	-	-	-	-	-	-	-	-	-	+	0	0
		Nachfragegesteuerte / Verstetigte Wärmebereitstellung von solarer Prozesswärme	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+
		Nachfragegesteuerte / Verstetigte Leistungsbereitstellung in Solarthermischen Kraftwerken	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	0
		solare Kombisysteme	0	0	0	0	-	-	-	-	-	-	-	-	-	+	0	0
	Stoffliche Nutzung (Sektorenkopplung)	Bereitstellung von Gas	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-
		Bereitstellung von flüssigen Kraftstoffen	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
		Bereitstellung von Chemikalien	-	-	-	-	-	-	-	+	-	-	+	+	+	-	-	-
Steigerung der Energieeffizienz	Industrielle Prozesse	Nutzung industrieller Abwärme	-	0	-	-	+	-	-	+	-	-	-	-	-	+	+	+
		Rekuperation mechanischer Energie	+	+	+	+	-	-	+	-	-	+	-	-	-			
		Entkopplung Strom-, Wärme- und Kälteerzeugung in KWK-Anlagen	0	0	0	0	+	-	-	+	-	-	0	0	0	+	+	0
		Bereitstellung alternativer Brenn-/Rohstoffe	-	-	-	-	-	-	-	-	-	-	+	+	+			
	Gebäude	Ausgleich von Heiz- und Kühlbedarf	0	0	0	0	-	-	-	-	-	-	-	-	-	+	+	+
		Entkopplung Strom-, Wärme- und Kälteerzeugung in Micro-KWK-Anlagen	0	0	0	0	-	-	-	-	-	-	-	-	-	+	+	0
		Tag/Nacht-Ausgleich	+	+	+	+	-	-	-	-	-	-	-	-			+	+
		Sommer/Winter-Ausgleich	0	0	0	+	-	-	-	-	-	-	-				0	-
		Erhöhung Eigenverbrauchsanteil (z.B. Hausbatterien)	+	+	+	+	-	-	-	-	-	-					-	-
	Mobilität	Rekuperation mechanischer Energie	+	+	+	+	-	-	+	-	-						-	-
		effizienter Antrieb	+	+	+	+	-	-	-	-	-					-	-	-

BVES
BUNDESVERBAND ENERGIESPEICHER

Storage is an ideal tool…

- Optimization of self-consumption
- Positive/negative control energy
- Peak load smoothing
- Reactive power compensation
- Black-Start capability
- Off-grid supply
- Voltage control
- Shifting excess energy to other sectors
- Inertia reserve
- Back up energy

BVES
BUNDESVERBAND
ENERGIESPEICHER

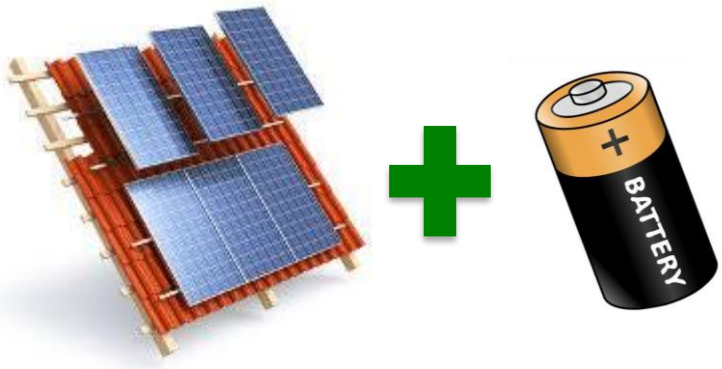
Agenda

- BVES – German Energy Storage Association
- ‚Energy Transition creates the need for storage
- Markets and Trends
- Regulatory framework
- Conclusions

BVES
BUNDESVERBAND
ENERGIESPEICHER

Residential Storage Market

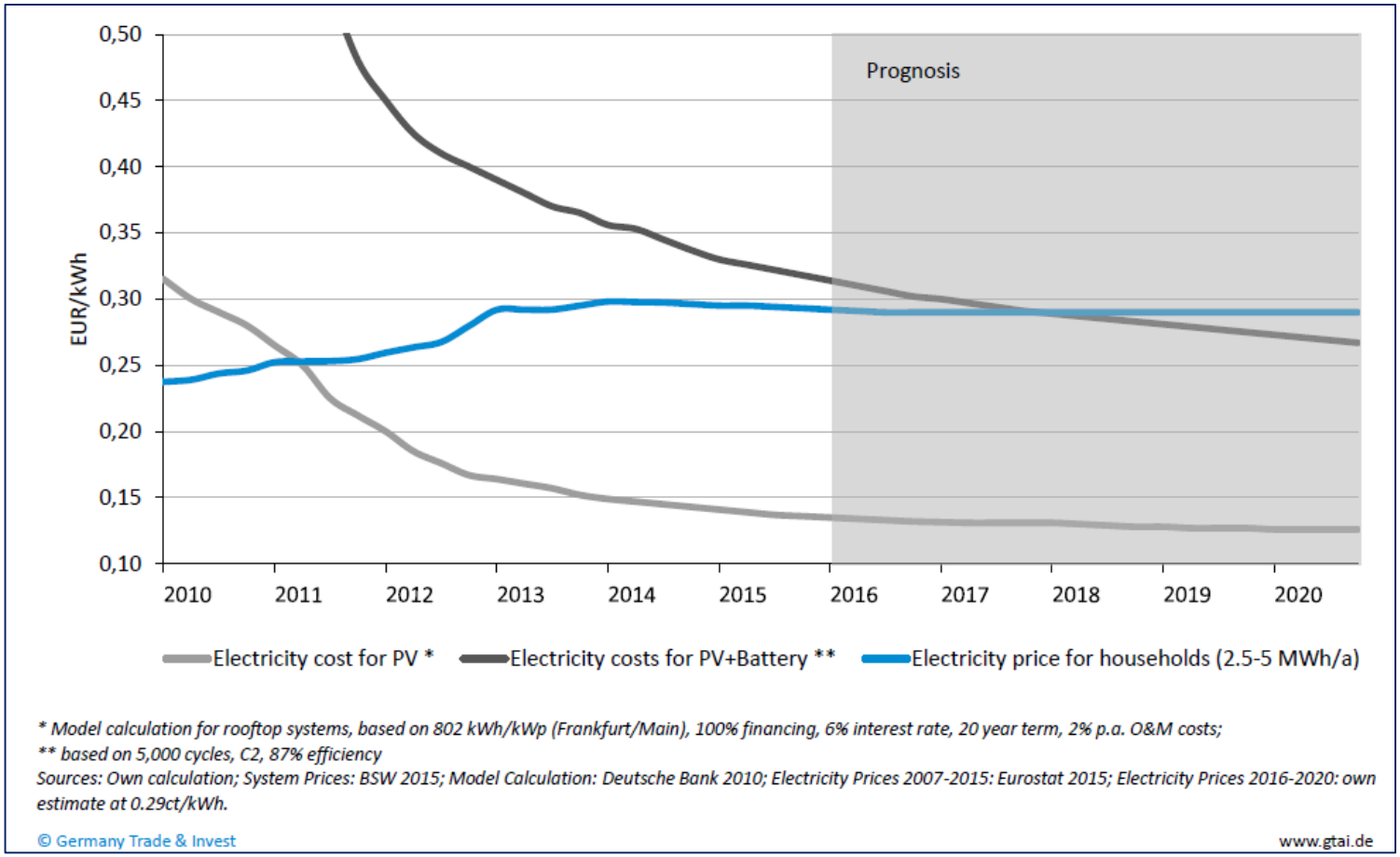
Self consumption ~ 35 %



Self consumption ~ 70 %

BVES
BUNDESVERBAND
ENERGIESPEICHER

Until 2011: Market driven by Feed-in tariff
Since 2011: Market driven by own-consumption
Today: Optimized self-consumption with batteries



** Model calculation for rooftop systems, based on 802 kWh/kWp (Frankfurt/Main), 100% financing, 6% interest rate, 20 year term, 2% p.a. O&M costs;*
*** based on 5,000 cycles, C2, 87% efficiency*
Sources: Own calculation; System Prices: BSW 2015; Model Calculation: Deutsche Bank 2010; Electricity Prices 2007-2015: Eurostat 2015; Electricity Prices 2016-2020: own estimate at 0.29ct/kWh.

BVES
BUNDESVERBAND ENERGIESPEICHER

Residential Storage Market in Germany





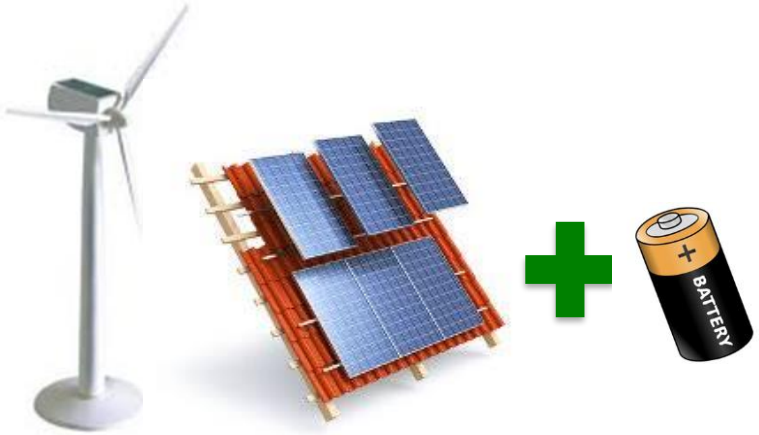



- ~180.000 home storage systems (+50.000 in 2018)
- New systems mostly bundle of PV + storage unit
- Major companies step into the market
- ~1.500.000 PV on rooftop = huge retrofit-potential

BVES
BUNDESVERBAND ENERGIESPEICHER

Industrial Storage Market

Self consumption



Self consumption

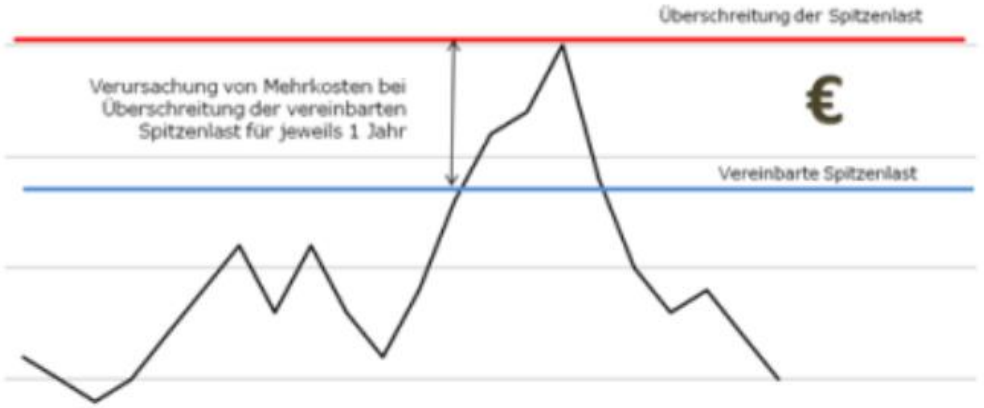
+ UPS + PLS + Backup Power

+ no Diesel

BVES
BUNDESVERBAND
ENERGIESPEICHER

Peak Load Shaving Reduces Costs

Peak load shaving and atypical grid usage



- Companies with an annual electricity consumption > 100,000 kWh receive an individual grid fee.
- The annual maximum load serves as an indicator
- Avoidance of peak loads saves costs over the entire year

BVES
BUNDESVERBAND ENERGIESPEICHER

UPS – Uninteruptible Power Supply

Applications used e.g. in hospitals or sensitive production processes

Emergency Power Generators

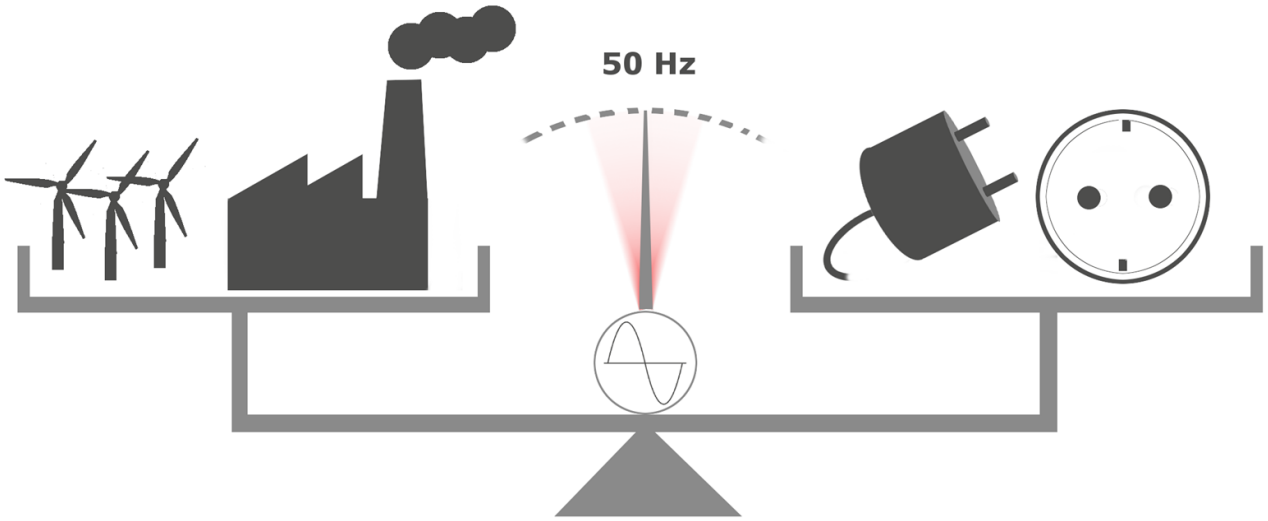
BVES
BUNDESVERBAND ENERGIESPEICHER

Industrial Storage Market in Germany

- ~ 1000 projects in Germany. (agriculture, multi-family houses, industry, trade business)
- Subsidies in various federal states (e.g. North Rhine-Westphalia, Thuringia).
- UPS, Backup Power & Peak-load management
- NEW: Combination of PV, Storage and E-mobility (fast charging)

BVES
BUNDESVERBAND ENERGIESPEICHER

Large Scale Storage Market

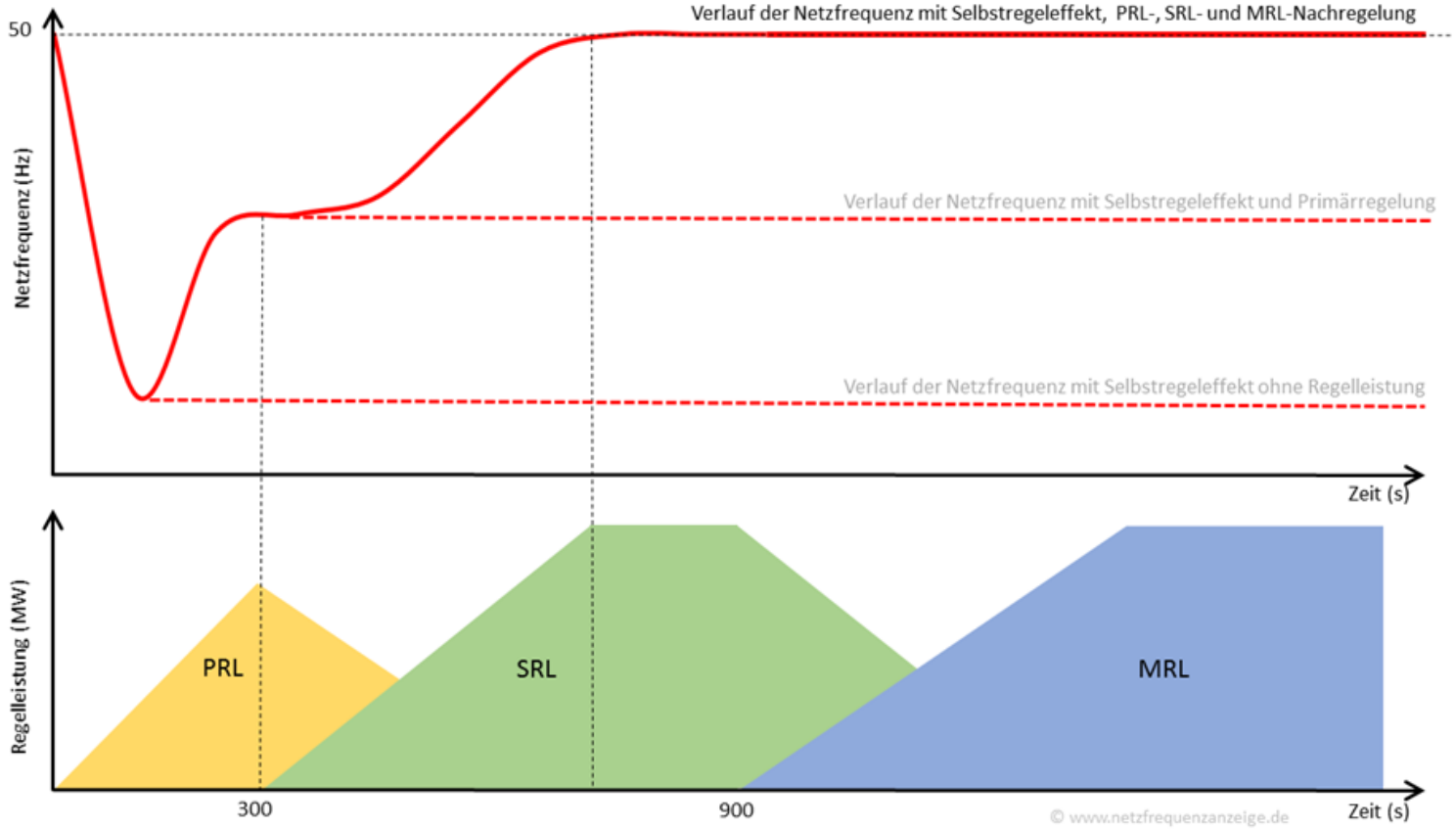


Managing and balancing the grid:

- Inertia reserve
- Control energy
- Reactive power
- Blackstart capability
- ...

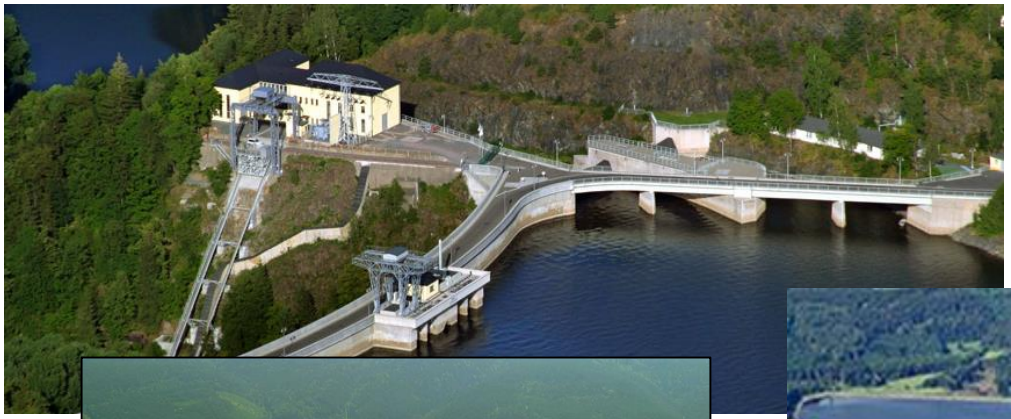
BVES
BUNDESVERBAND ENERGIESPEICHER

Large Scale Storage: Balancing the Grid



BVES
BUNDESVERBAND ENERGIESPEICHER

Large scale storage market



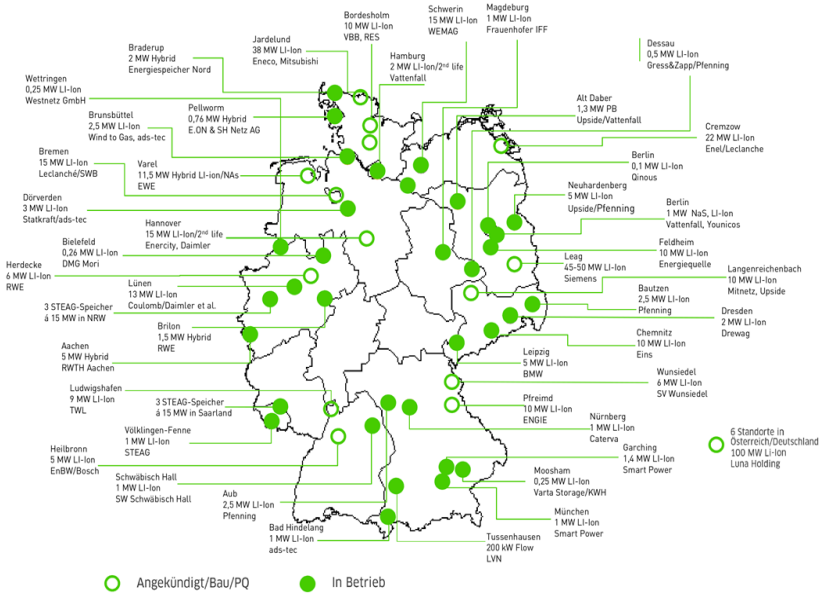
Source: Vattenfall

Hidden Champions of the electricity system!

- Crucial for system stability

BVES
BUNDESVERBAND ENERGIESPEICHER

Large Scale Storage Market

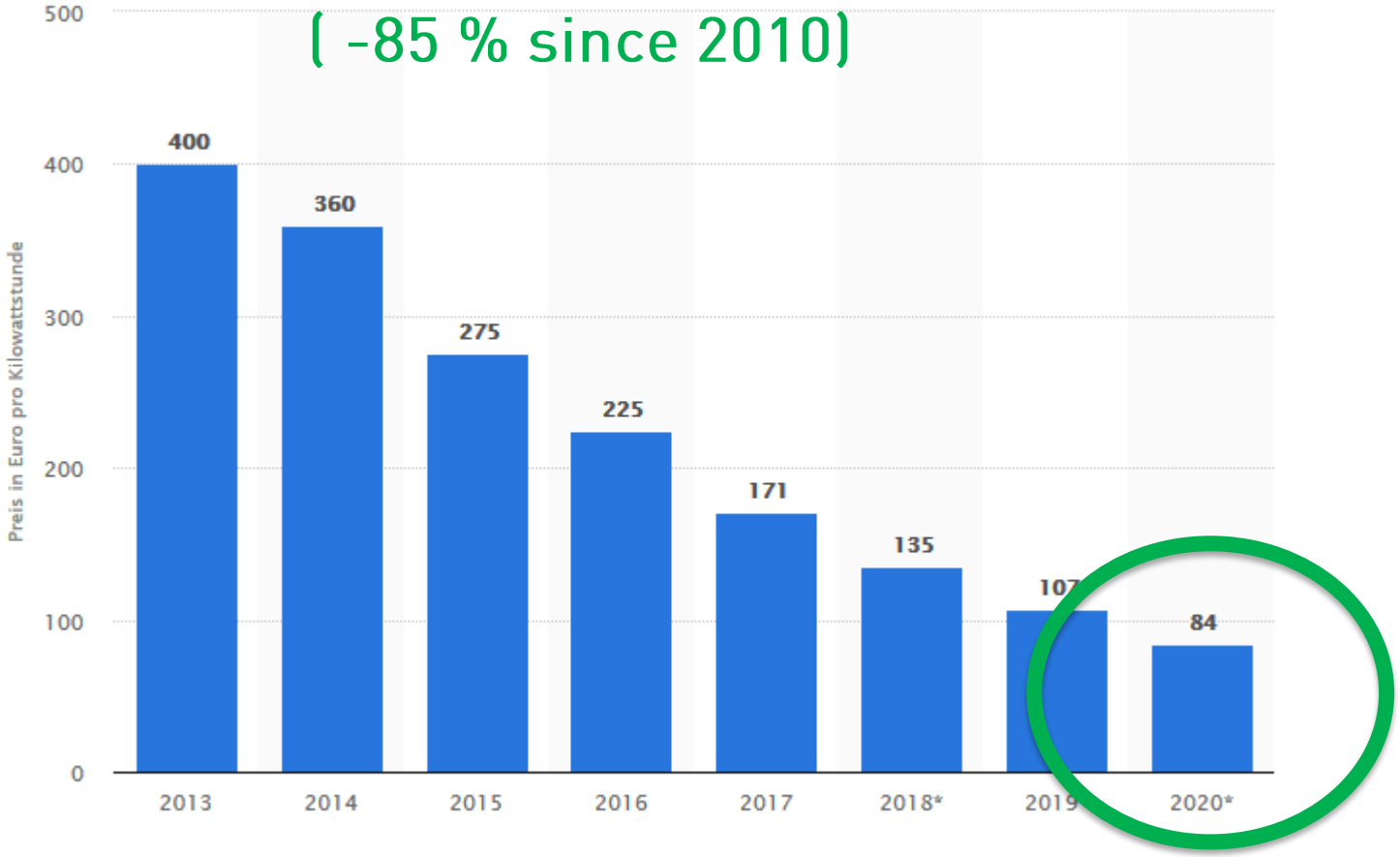


2017: 180 MW - 2018: ~ 320 MW - 2019: ~ 430 MW

BVES
BUNDESVERBAND
ENERGIESPEICHER

Battery Cell Prizes Li-Ion

(-85 % since 2010)



Ihre Daten visualisiert tableau

BVES
BUNDESVERBAND
ENERGIESPEICHER

3 existing and fast growing markets for storage technologies…

Current development:

- 1 New technologies
- 2 Storage goes system
- 3 Multi-use models

BVES
BUNDESVERBAND ENERGIESPEICHER

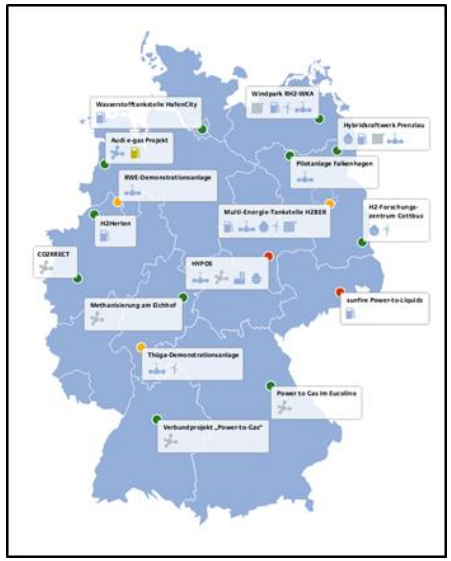
- 1 New technologies are arriving..

- Power to Gas
- Redox flow
- Thermal Storage
- Super-capacitors
- Fly Wheel

BVES
BUNDESVERBAND ENERGIESPEICHER

Power to Gas

Conversion of 1 MWh electricity into 50 Nm3 of biomethane for grid injection



Electrochaea

BVES
BUNDESVERBAND
ENERGIESPEICHER

Redox Flow

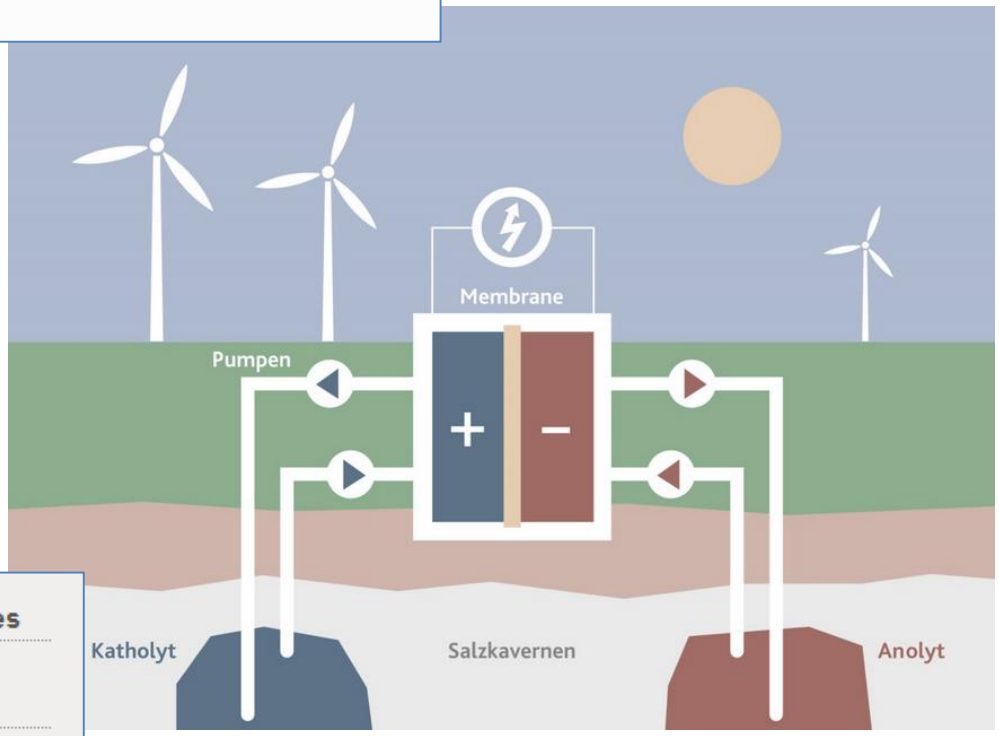
The world's largest battery

EWE is an expert in large storage facilities, operating salt caverns for secure gas storage and future secure electricity storage in salt domes under the low North German plain and in Brandenburg.

EWE

Project: brine4power

"Green mega-battery for green energy"

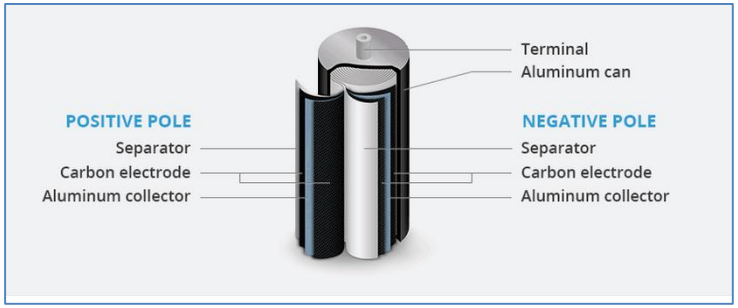


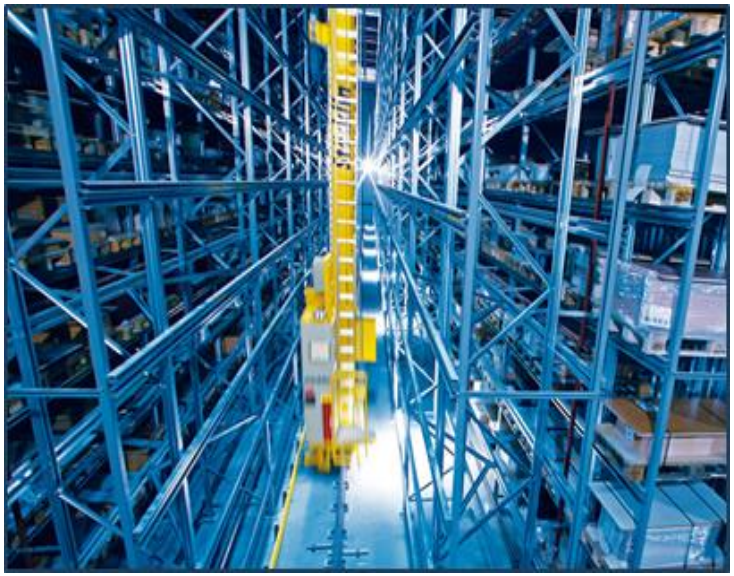
Phase	Facility	Planned operating figures
1	Test facility 1 (above ground)	10 - 20 kW 10 - 40 kWh
2	Test facility 2 (above ground)	100 - 500 kW 500 - 2,500 kWh
3	Pilot facility (underground cavern)	up to 120 MW up to 700 MWh

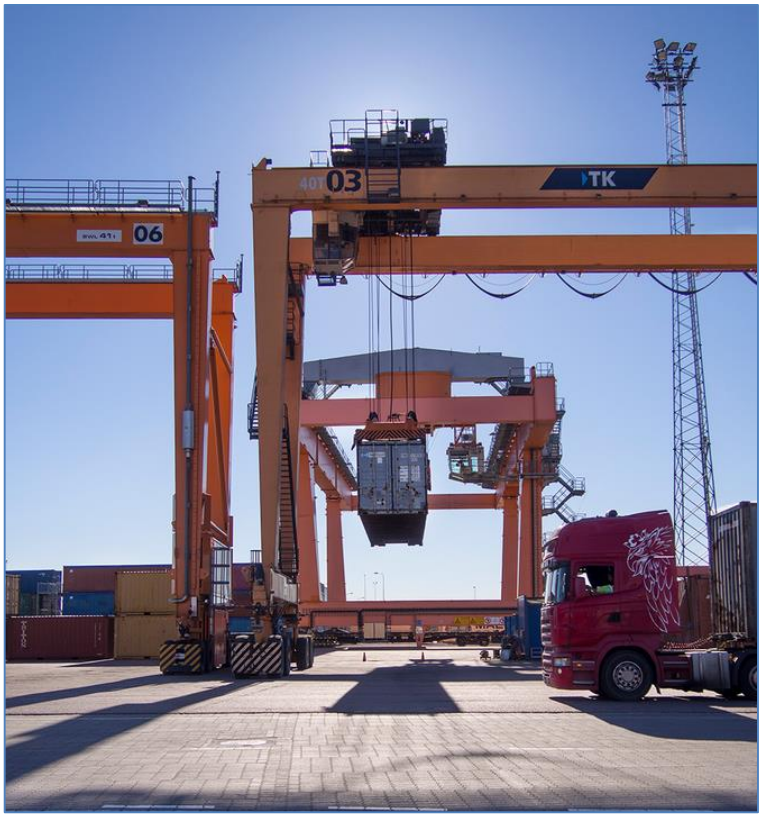
BVES
BUNDESVERBAND ENERGIESPEICHER

Supercapacitors

Up to 60 times the power density achieved by batteries





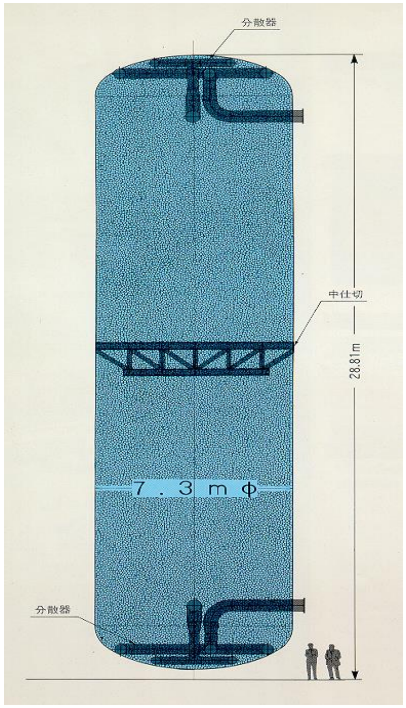


SKELETON TECHNOLOGIES

BVES
BUNDESVERBAND ENERGIESPEICHER

Thermal Storage

Japan:
Storage of ice for air-conditioning.



BVES
BUNDESVERBAND
ENERGIESPEICHER

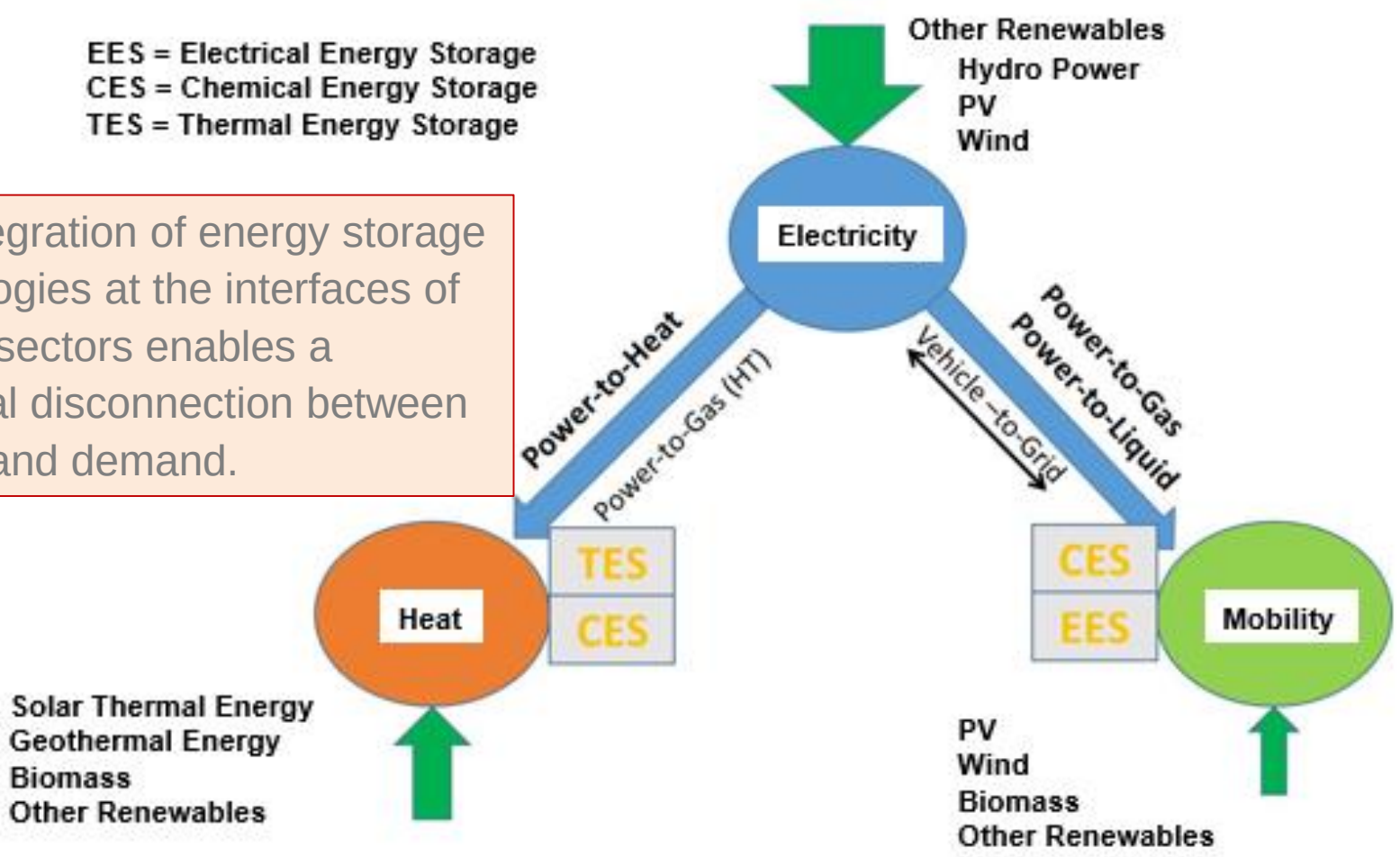
- 2 Storage goes system…
  - Combination of technologies
  - Cross-sectoral integration

BVES
BUNDESVERBAND
ENERGIESPEICHER

Flexible Sector Coupling

EES = Electrical Energy Storage
CES = Chemical Energy Storage
TES = Thermal Energy Storage

The integration of energy storage technologies at the interfaces of energy sectors enables a temporal disconnection between supply and demand.



BVES
BUNDESVERBAND ENERGIESPEICHER

Combination of technologies and Cross-Sectoral integration

Combination of technologies:

- PV
- battery storage
- heat pump
- electrical storage heating
- EVs

electricity + heating + cooling

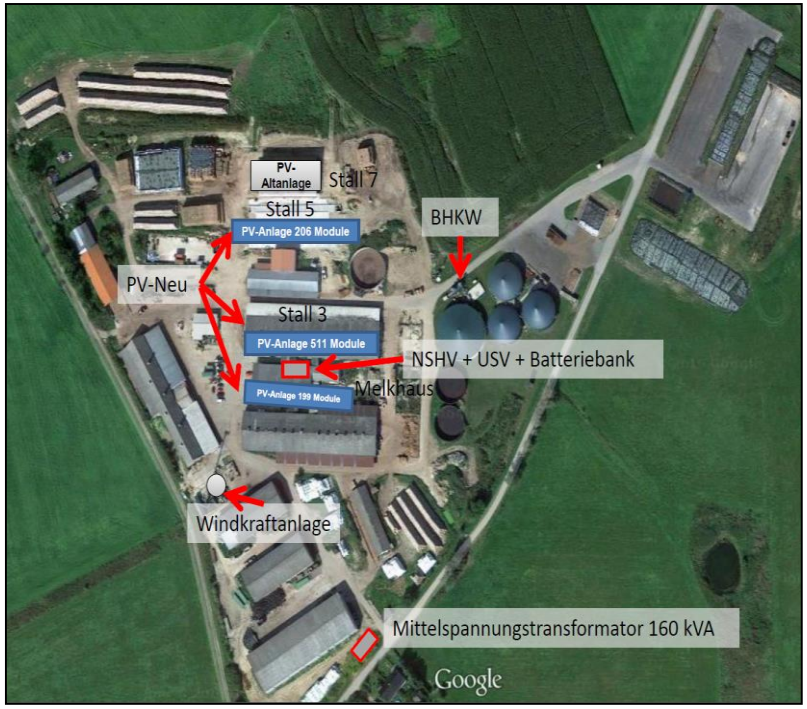
→ digitally controlled

→ 90% of newly installed home storage batteries including heatpump

BVES
BUNDESVERBAND ENERGIESPEICHER

Combination of Technologies and Cross-Sectoral Integration

PV + wind + biogas plant + Li-ion battery + heat storage = 100 % autarchy



Reduction of energy costs: 0,3 € cent/liter

BVES
BUNDESVERBAND ENERGIESPEICHER

New trend in storage

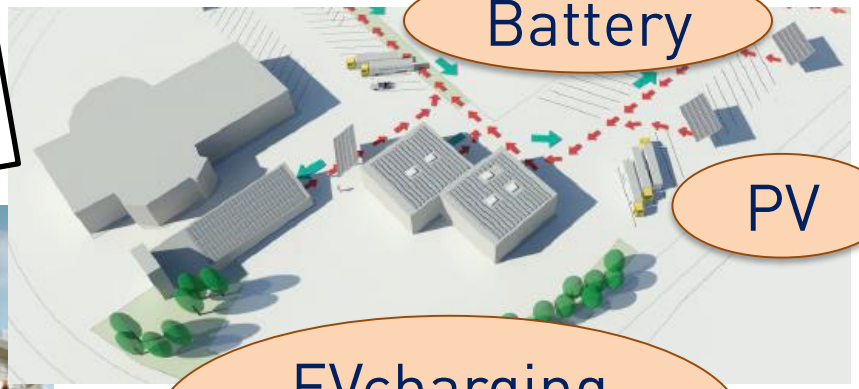
Combination of storage technologies, combination of sectors

Concept stages:

- Increase in self-generation via PV tracker since 2013
- Charging infrastructure for electrifying the fleet
- Optimized self-consumption via battery storage
- Renewable heat supply: planned for 2017

GRESS+ZAPP UNTERNEHMENSGRUPPE

Exemplary combination of sectors by shipping company Gress + Zapp



BVES
BUNDESVERBAND ENERGIESPEICHER

Combination of Technologies and Cross-Sectoral Integration

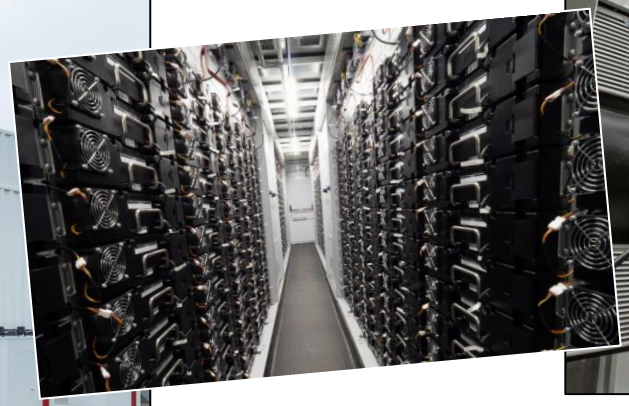
Bremen: Hybrid Power Plant „HyRek“ = 18 MW Li-Ion battery + Power-to-Heat (PtH) + CHP

Provided Services

- Frequency Containment Reserve (FCR)
- Surplus electricity of CHP converted to heat for the district heating system

World's first Power and Heat coupled FCR Storage:

- Positive FCR: battery
- Negative FCR: PtH
- Charging of the battery: CHP



Modern Sector Coupling at its best!

BVES
BUNDESVERBAND ENERGIESPEICHER

Current Trend

Combination of different (Storage)Technologies and Sectors

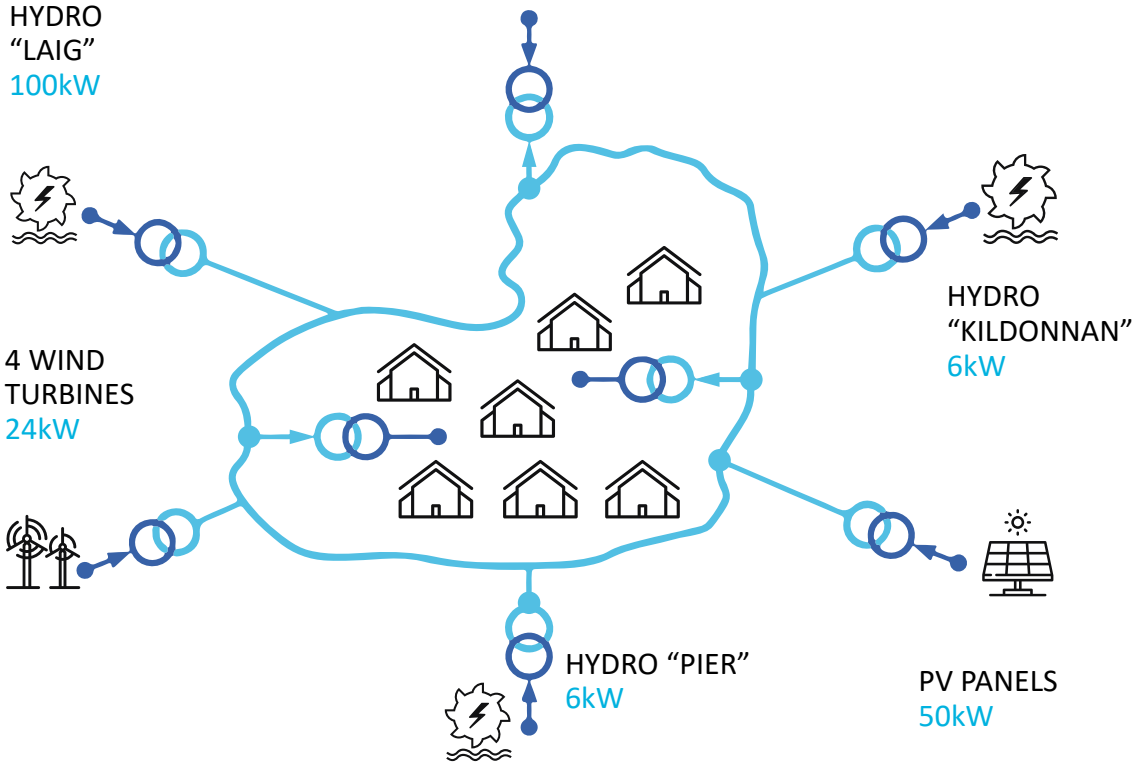
„Microgrids in Remote / Off-Grid Areas“

ISLE OF EIGG
ELECTRIC GRID

ENERGY STORAGE CENTER
BATTERIES 212kWh CAPACITY
ULTRACAPACITORS 90kW
FLYWHEEL 100kW

ENERGY SOURCES

Wind 24kW
Solar 55kW peak
3 x Hydro 110 kW



HIGH VOLTAGE GRID — LOW VOLTAGE

BVES
BUNDESVERBAND ENERGIESPEICHER

Current Trend

Combination of different (Storage)Technologies and Sectors

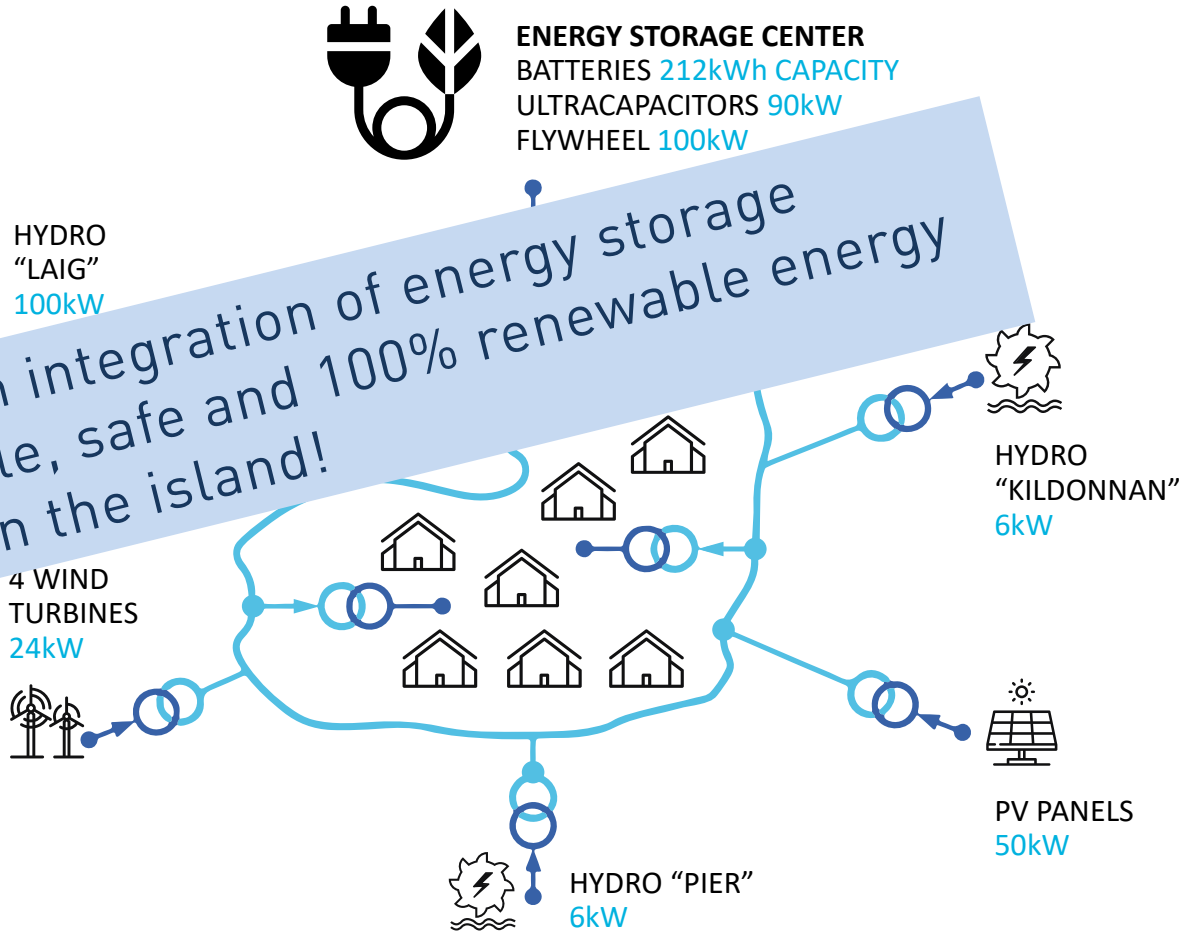
„Microgrids in Remote / Off-Grid Areas“

ISLE OF EIGG
ELECTRIC GRID

ENERGY SOURCES

Wind 24kW
3

Thanks to the system integration of energy storage technologies, a stable, safe and 100% renewable energy supply is possible on the island!



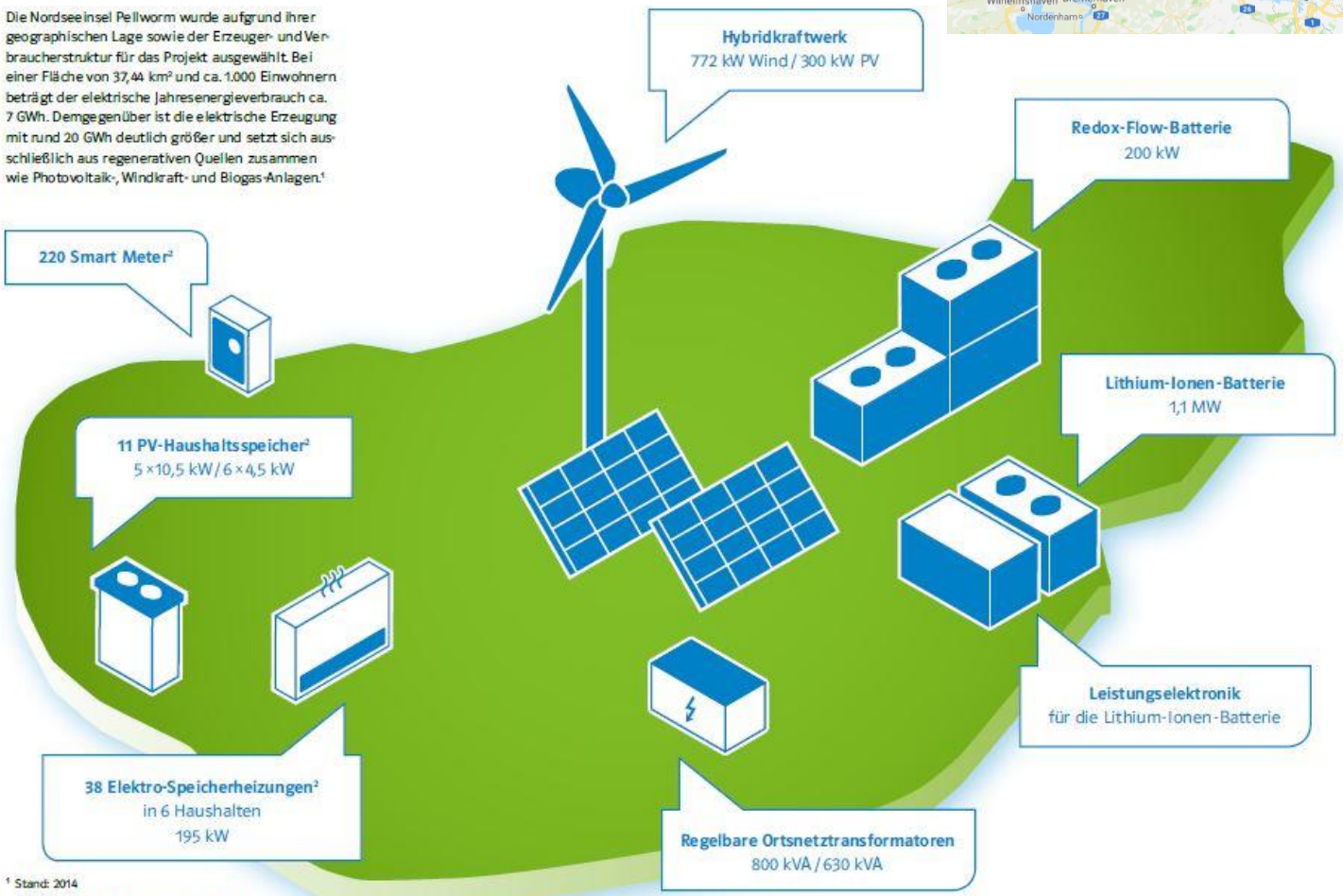
BVES
BUNDESVERBAND
ENERGIESPEICHER

Current Trend

Combination of different (Storage)Technologies and Sectors

„Microgrids in Remote / Off-Grid Areas“

Die Nordseeinsel Pellworm wurde aufgrund ihrer geographischen Lage sowie der Erzeuger- und Verbraucherstruktur für das Projekt ausgewählt. Bei einer Fläche von 37,44 km² und ca. 1.000 Einwohnern beträgt der elektrische Jahresenergieverbrauch ca. 7 GWh. Demgegenüber ist die elektrische Erzeugung mit rund 20 GWh deutlich größer und setzt sich ausschließlich aus regenerativen Quellen zusammen wie Photovoltaik-, Windkraft- und Biogas-Anlagen.[1]



[1] Stand: 2014
[2] Nur in der ersten Projektphase betrachtet

Project Smart Region Pellworm

The project is divided into two test phases:

- The first test phase from 2012 - 2015 focused on the technical feasibility of setting up and operating large batteries and intelligent power grids.

- the second test phase from 2015 - 2018 investigated the economic viability of large batteries in various marketing types

BVES
BUNDESVERBAND ENERGIESPEICHER

New Trend in Storage

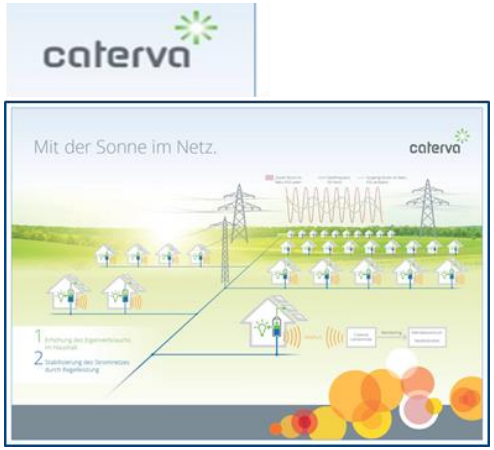
Utilities offer storage systems, storage devices get interconnected, rental and leasing models are developing

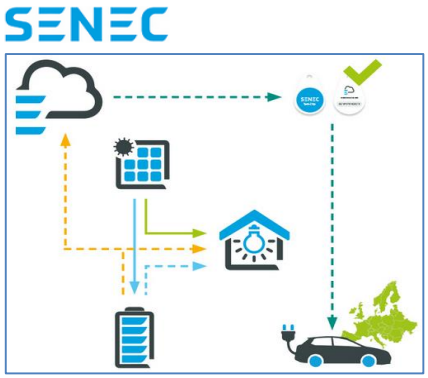
BVES
BUNDESVERBAND ENERGIESPEICHER

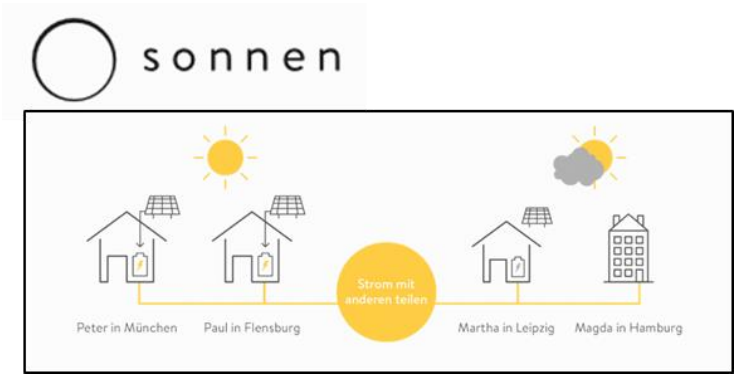
- # 3 Multi-Use Models

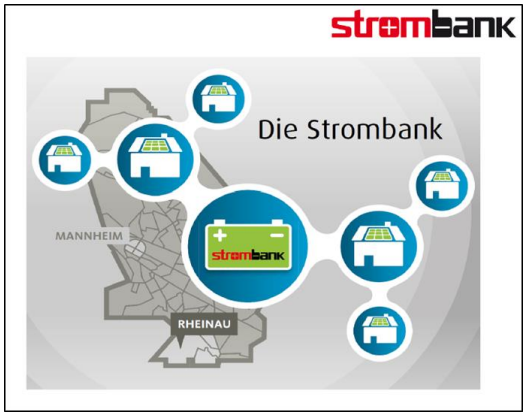
Combination of applications = multi use solutions

Quarter storage, Swarm storage, Energy communities, Sharing communities, Block-Chain









BVES
BUNDESVERBAND
ENERGIESPEICHER

Multi-Use Models

Combination of applications = multi use solutions

NEW + Additional application: FAST CHARGING INFRASTRUCTURE

BVES
BUNDESVERBAND
ENERGIESPEICHER

Agenda

- BVES – German Energy Storage Association
- German „Energiewende“ – Status Quo
- Applications of Energy Storage in Germany
- Regulatory framework
- Conclusions

BVES
BUNDESVERBAND ENERGIESPEICHER

Regulatory Framework - Lack of legal classification

The absurd situation of charging twice...

Concession fee
§ 19(2) Strom NEV
Interruptible loads surcharge

Grid usage fee
EEG surcharge
CHP surcharge
Offshore liability surcharge
VAT
+
Concession fee
§ 19 NEV surcharge,
Interruptible loads surcharge

We need a definition of storage as 4th column of the energy system – besides generation, transport and consumption

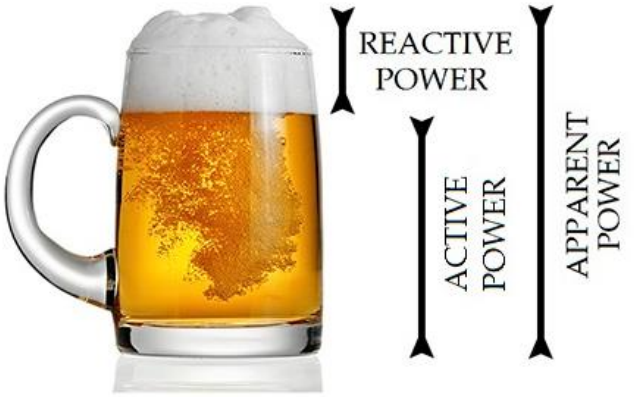
Source: BVES + DIHK, Faktenpapier Speicher, p. 11

BVES
BUNDESVERBAND ENERGIESPEICHER

Regulatory Framework - No reward for reactivity

Energy storage has to pay fees when providing grid-supportive Services, such as:

- *inertia reserve*
- *voltage control*
- *reactive power compensation*
- *services for re-dispatch*
- *short circuit power*
- *black-start capability*



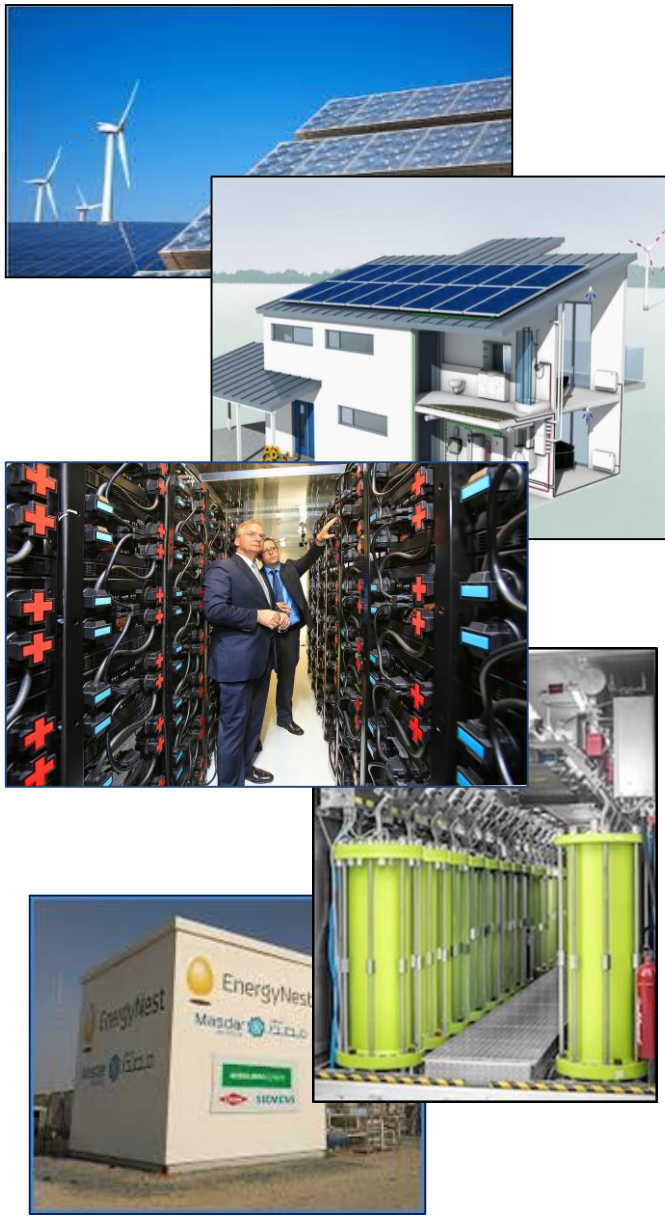
Source: http://enarlux.com

→ Energy storage: cost-effective and supports to reduce carbon emissions

→ Need for change towards a market-driven return

BVES
BUNDESVERBAND ENERGIESPEICHER

Conclusions



- Energy storage = Swiss army knife
- Numerous applications in residential, industrial and large scale applications are in service and economically viable
- Multi-use of storage devices foster efficiency and economic feasibility
  - win-win situation for prosumers, utilities and grid operators
- Cross sectoral integration offers a huge potential of useful applications
- Regulation is still not suitable
- **Energy storage is crucial to offer a POWER-system and not only an electricity-system**

BVES
BUNDESVERBAND ENERGIESPEICHER

Federal Ministry for Economic Affairs and Energy

MITTELSTAND GLOBAL ENERGY SOLUTIONS MADE IN GERMANY

Facilitator

eclareon

BVES BUNDESVERBAND ENERGIESPEICHER