SOLUTIONS FOR THE EXPANSION OF RENEWABLE ENERGIES THROUGH ENERGY STORAGE TECHNOLOGIES AND SMART GRIDS

VIII Deutsch-Kapverdisches Energie-Symposium
26.11.2022

Aaron Schwaderer, BVES

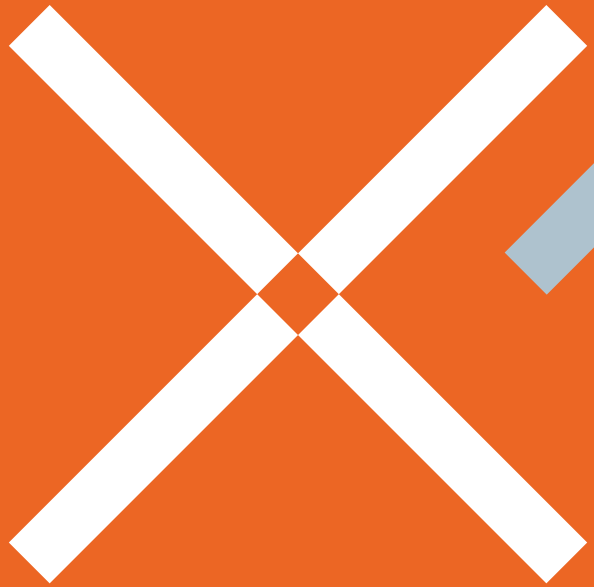
MITTELSTAND GLOBAL
ENERGY SOLUTIONS MADE IN GERMANY

AHK
Deutsch-Portugiesische Industrie- und Handelskammer
Câmara de Comércio e Indústria Luso-Alemã

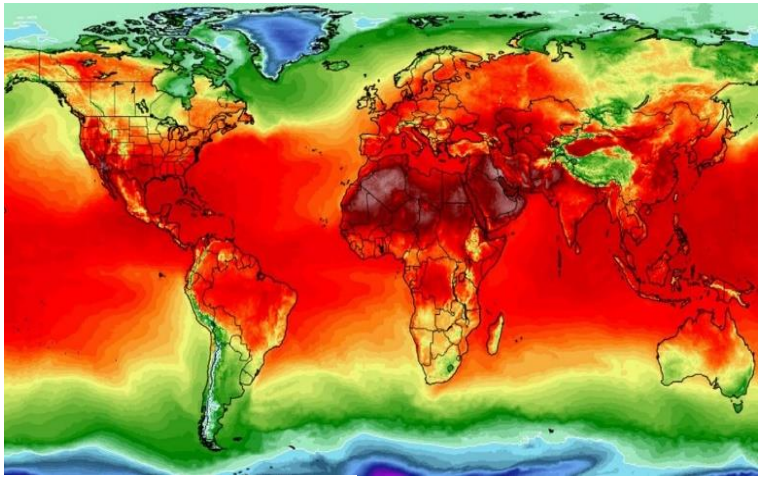
THE GERMAN ENERGY STORAGE SYSTEMS ASSOCIATION

- The BVES is the industrial association of energy storage companies that is open to all technologies in the areas of electricity, heat and mobility.
- More than 250 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 working for the improvement of the regulation and policy framework for energy storage (national and international).
- In addition, the BVES monitors research and development activities and informs members of new results and developments.

WHY IS STORAGE KEY?



ENERGIEWENDE, PARIS AGREEMENT, SECTOR TARGETS, GREEN DEAL, CLIMATE NEUTRALITY, CARBON FREE, ~~2050~~ 2045 2035



Energiewende
Umschalten auf Zukunft

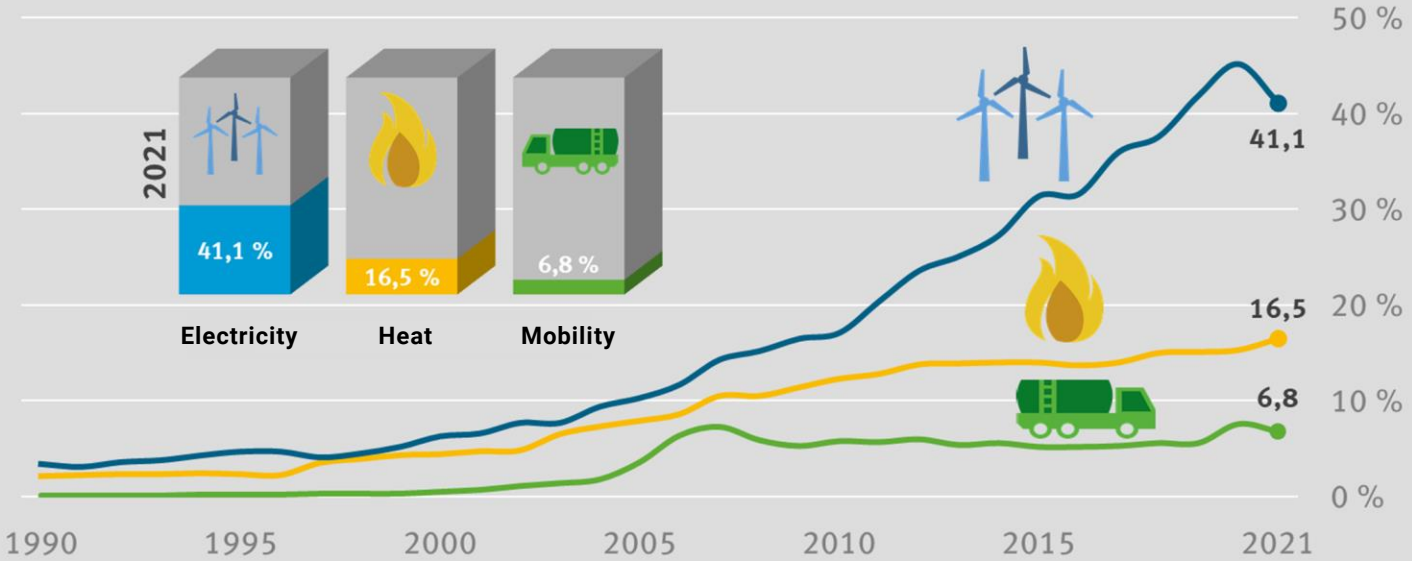
UNITED NATIONS
PARIS CLIMATE AGREEMENT
SIGNING CEREMONY
22 APRIL 2016

How do we achieve the goals?

- Energy storage technologies are ready and available on the market to make their contribution to a climate-friendly energy system
- There are various applications for storage in the sectors of electricity, heat and mobility
- Research and development continuously advance the technologies

ON THE WAY TO 100% RENEWABLES

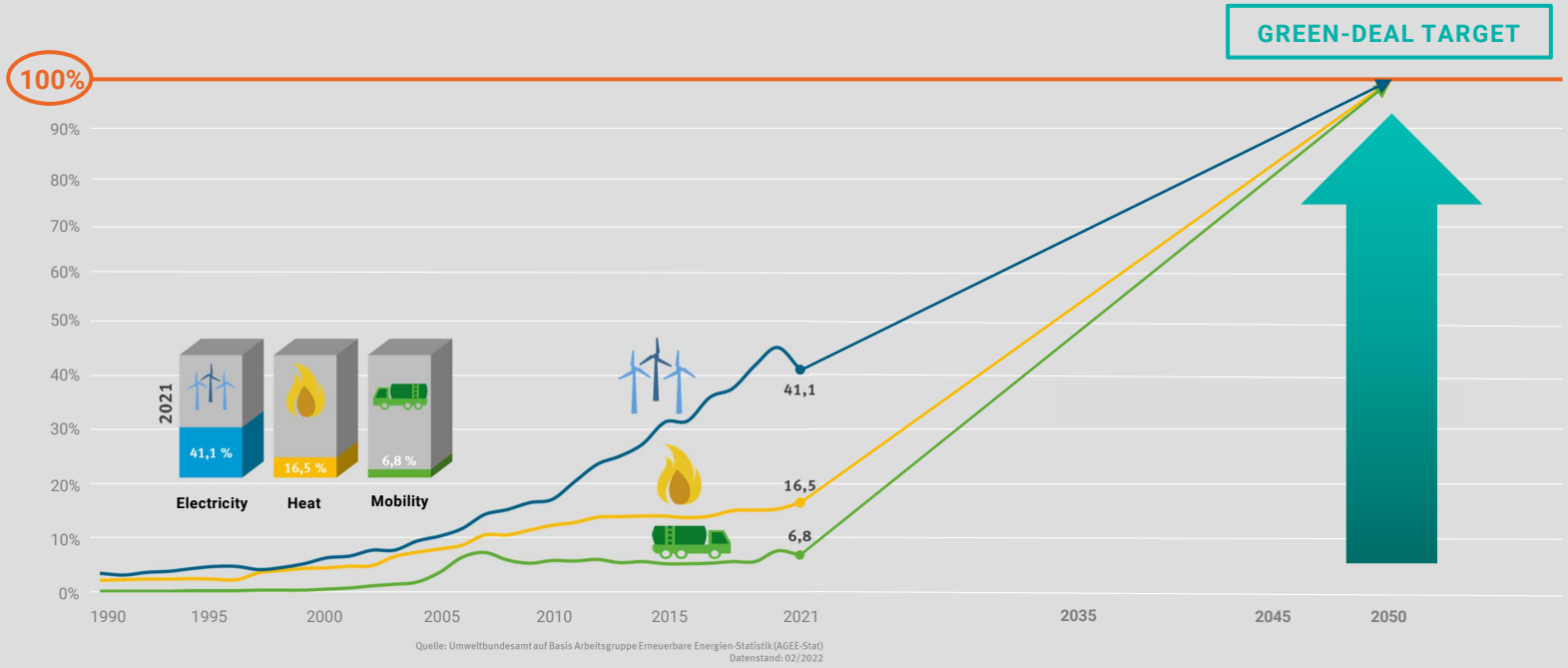
RENEWABLES SHARE IN ELECTRICITY, HEATING AND MOBILITY



Quelle: Umweltbundesamt auf Basis Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat)
Datenstand: 02/2022

ON THE WAY TO NET ZERO

RENEWABLES SHARE IN ELECTRICITY, HEATING AND MOBILITY



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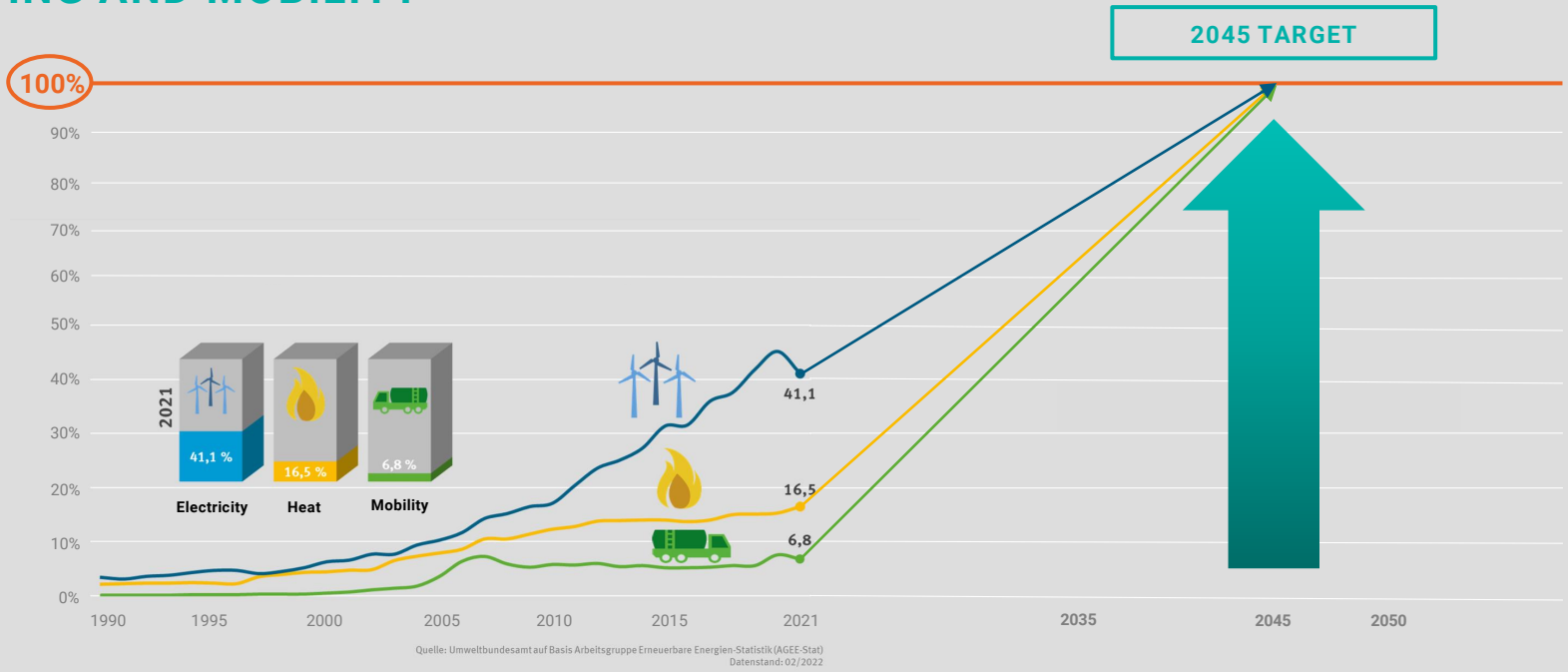

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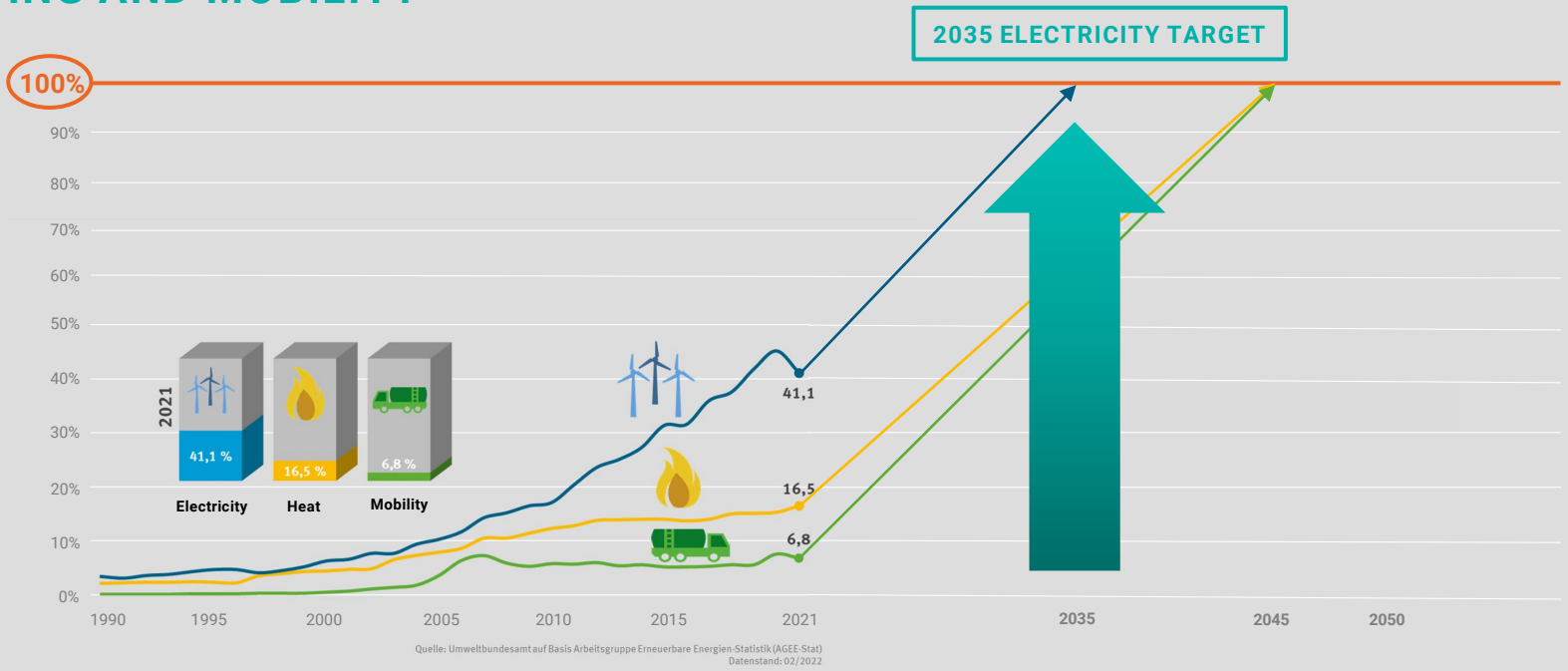
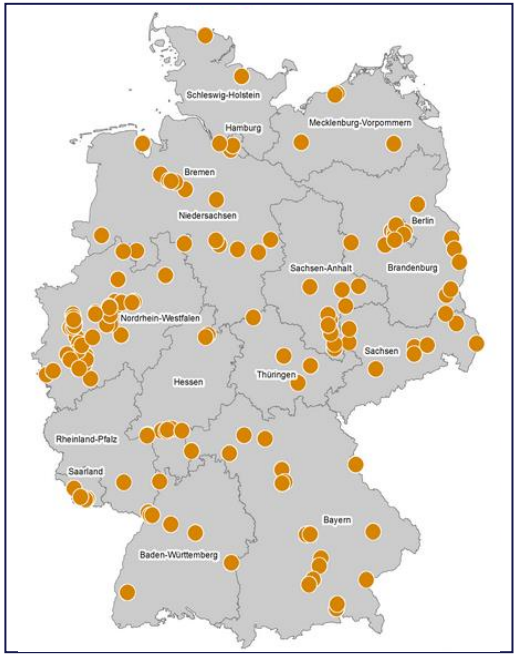
ON THE WAY TO 100% RENEWABLE ELECTRICITY

RENEWABLES SHARE IN ELECTRICITY, HEATING AND MOBILITY

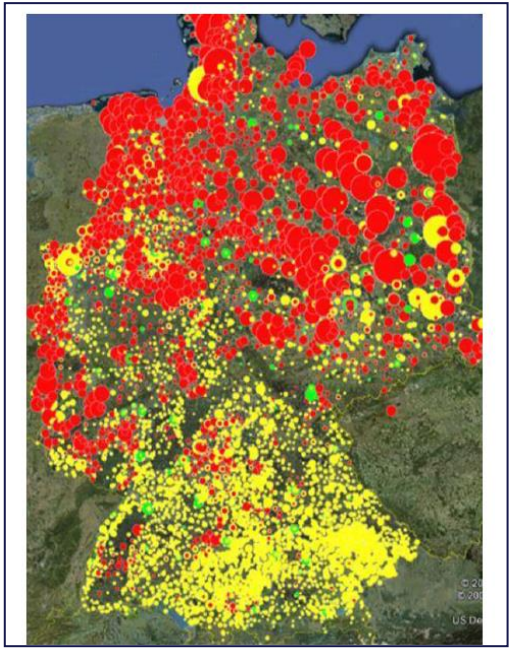


Quelle: Umweltbundesamt auf Basis Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat)
Datenstand: 02/2022

ENERGY TRANSITION:
RESULT NO. 01 = DECENTRALIZATION

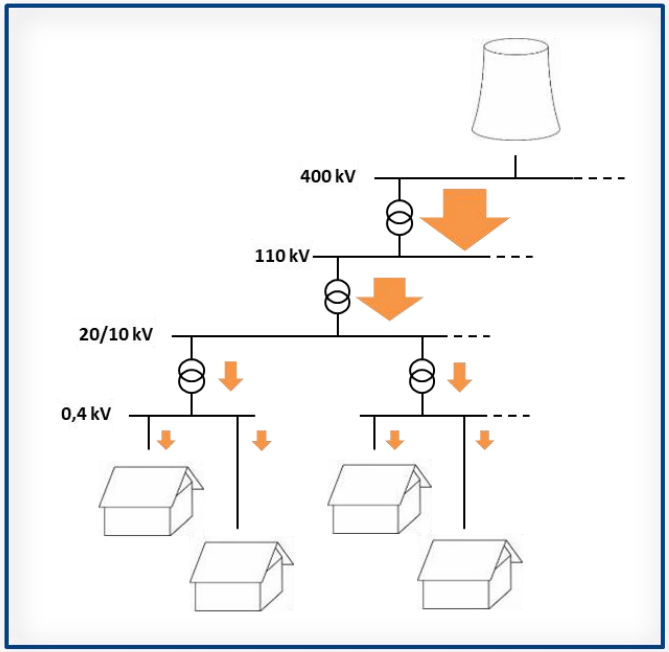


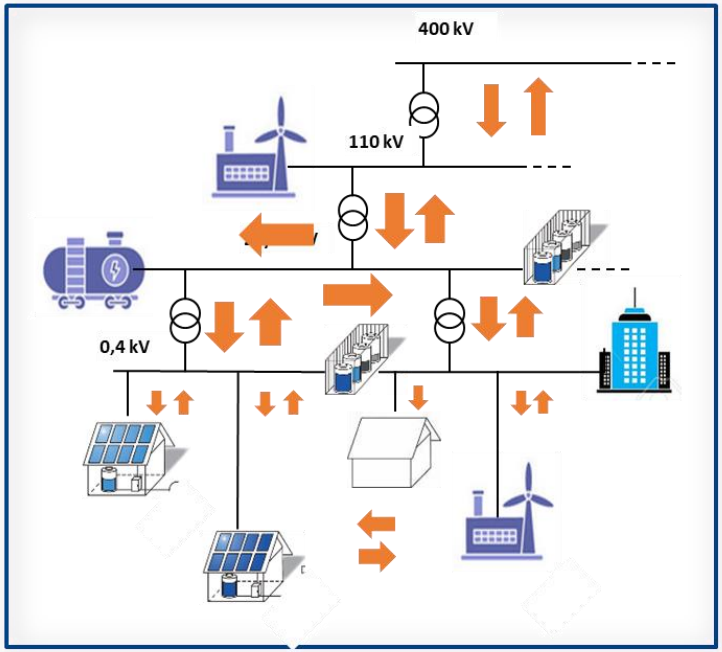
Fossil Power Plants



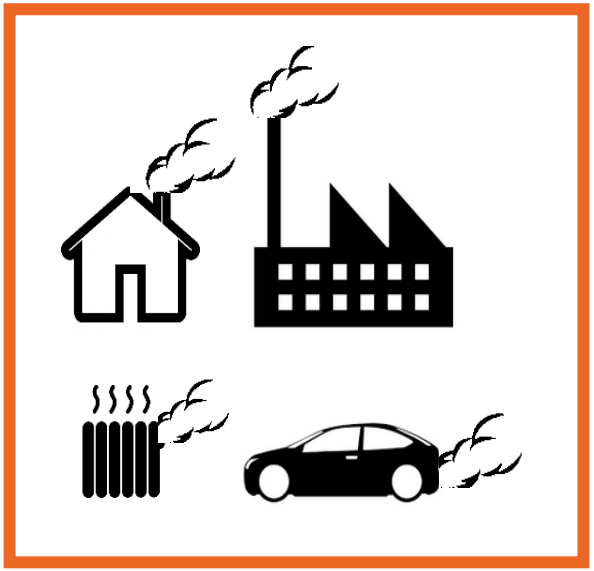
Renewable Generation

ENERGY TRANSITION:
RESULT NO. 02 = NEW STRUCTURE, NEW TASKS, NEW ISSUES

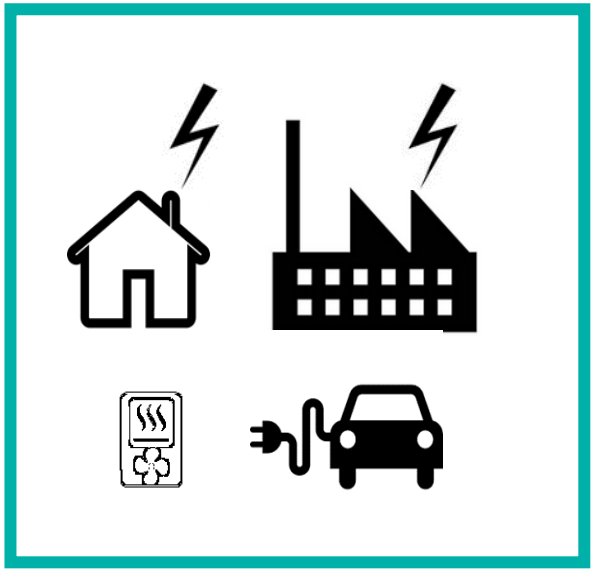




ENERGY TRANSITION:
RESULT NO. 03 = POWER IS THE NEW CURRENCY



FOSSIL AGE:
Energy is sufficient.



ELECTRIFICATION WAVE:
Power is needed.

„THE 3 D‘S“

Decarbonization » Decentralization » Digitalization

Local availability » Temporary availability

- Renewable Energies can be generated **ANYWHERE**.
- But not **ANYTIME**.
- **ANYTIME** Availability: **ONLY** with storage.

AVAILABILITY OF ENERGY

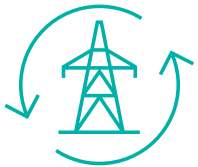
NO SUN = NO ELECTRICITY, NO POWER, NO HEAT DURING NIGHT

FLEXIBILITY

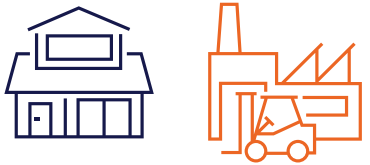
TO SECURE A RENWABLES-BASED ENERGY SYSTEM AND THE ENERGY DEMAND – FLEXIBILITY IS NEEDED

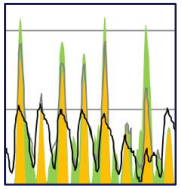
GENERATION

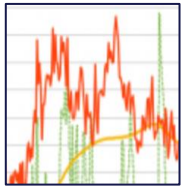
GRID



CONSUMER







FLEXIBILITY

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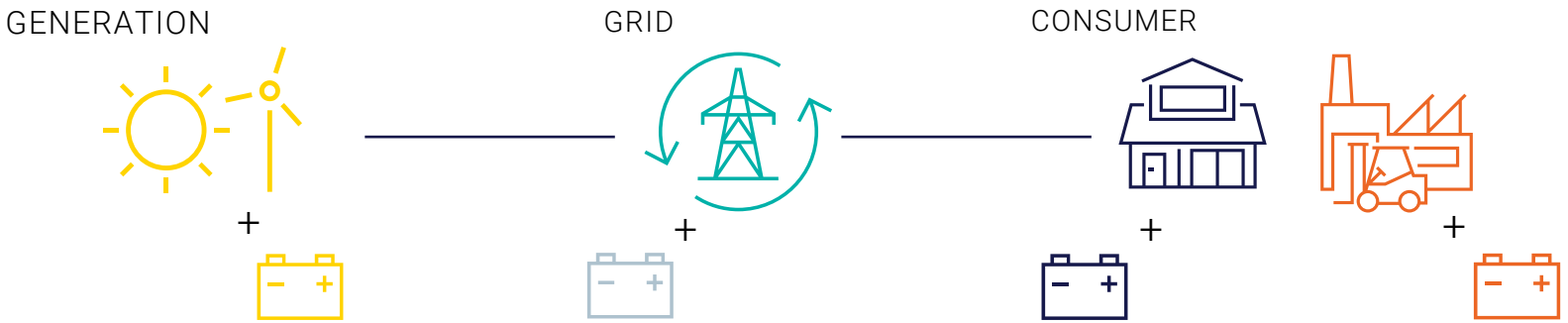
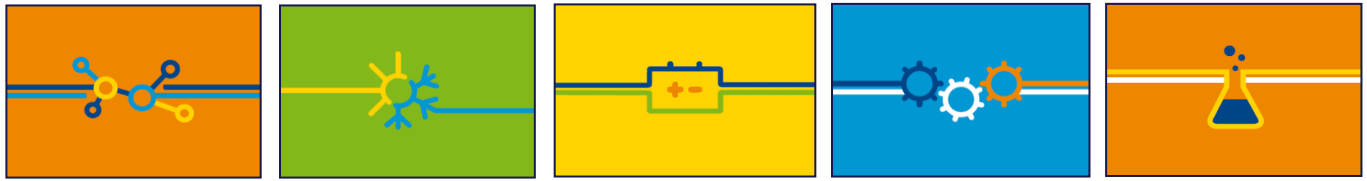


STORAGE TECHNOLOGIES AND APPLICATIONS

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

SPEICHERTECHNOLOGIEN STECKBRIEF

Li-Ionen Stromspeicher

ALLGEMEINE BESCHREIBUNG:

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»)
  - …cher (LAES) (FactSheet»)
  - …sche Energiespeicher
  - Kondensatoren

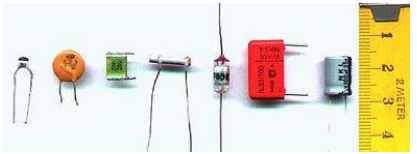
www.bves.de

STORAGE OF ELECTRICITY

STORAGE OF ELECTRICAL ENERGY

- Superconducting Magnetic Energy Storage (SMES)
- Supercapacitator





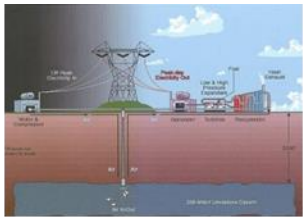
ELECTROCHEMICAL STORAGE OF ELECTRICITY

- Natrium-Sulphur Battery (NaS-Cells)
- Lead-Acid Battery
- Redox-Flow Battery



MECHANICAL STORAGE OF ELECTRICITY

- Pumped Hydro Storage
- Compressed-Air Storage (CAES)
- Flywheel

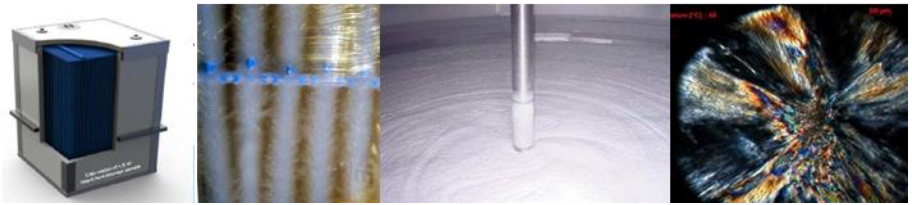

THERMAL ENERGY STORAGE

STORAGE OF SENSIBLE HEAT

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

STORAGE OF LATENT HEAT

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



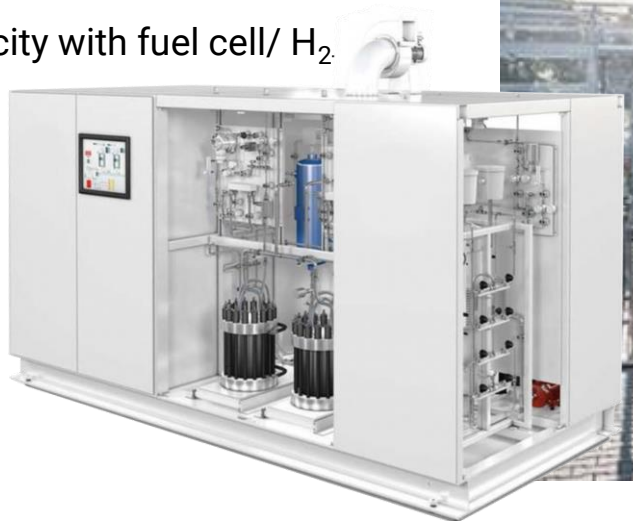
THERMOCHEMICAL STORAGE

- Sorption heat storage (e. g. zeolite)
- Thermochemical materials (TCM)

CHEMICAL ENERGY STORAGE

PRODUCTION 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



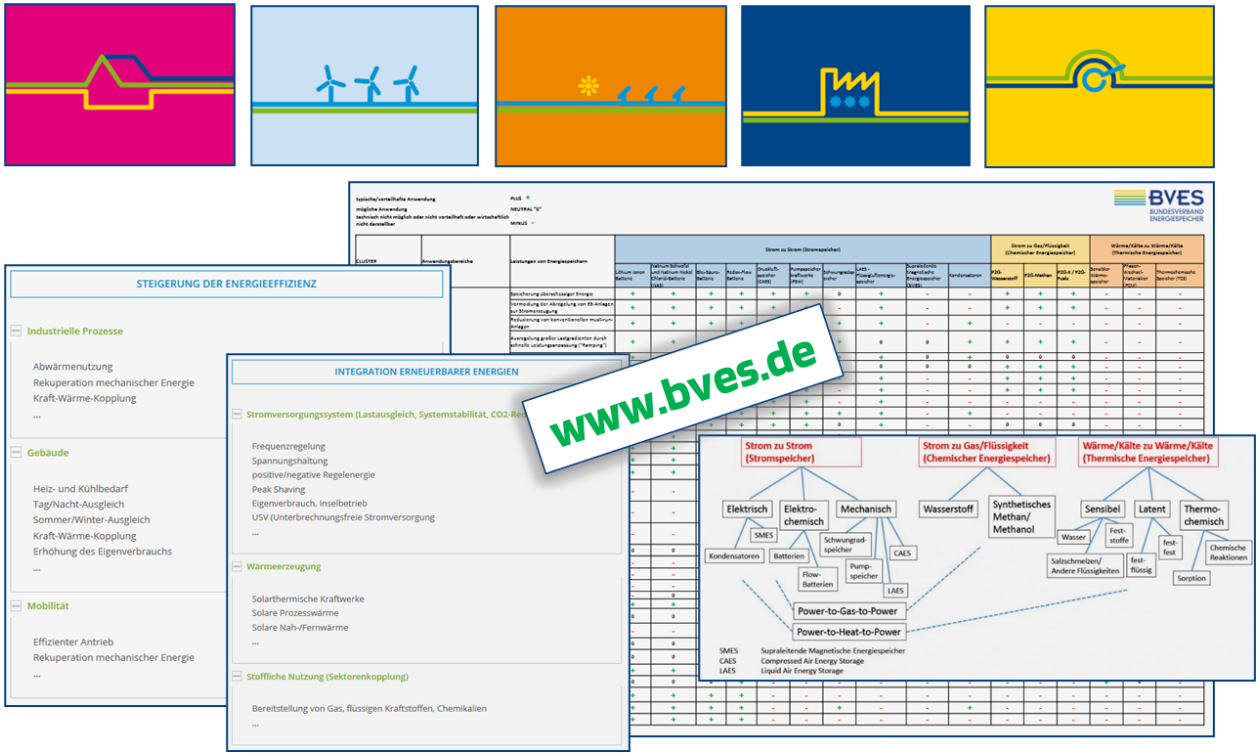
Hydrogen-Electrolyser (Indoor-Version)

Bild: iGas Energy

Power-to-Gas-Facility

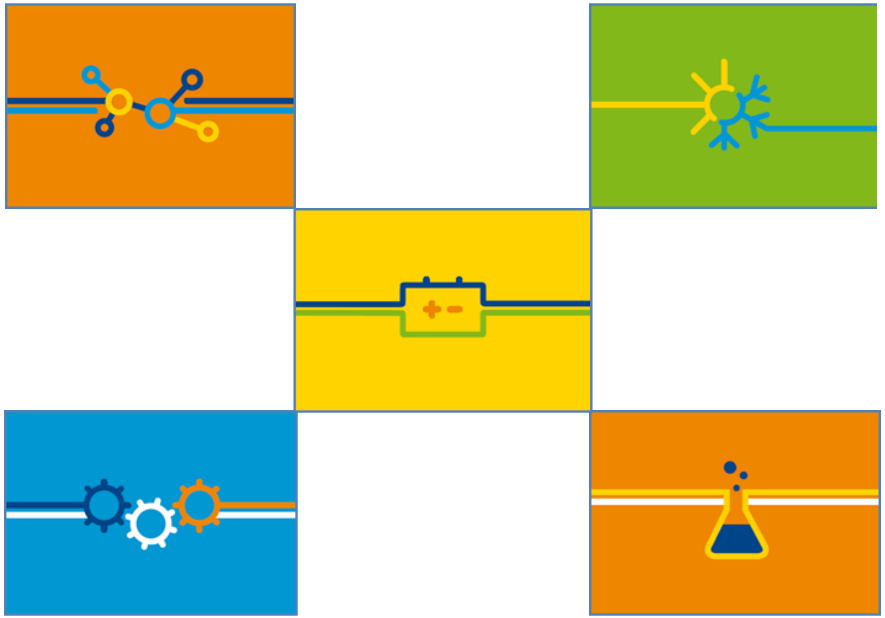
Quelle: https://people.man-es.com/

A BASKET FULL OF APPLICATIONS…



THE APPLICATION DETERMINES THE STORAGE

- The technical and economic requirements for a storage device are determined by the exact use of the storage in the supply system.
- An assessment of different storage technologies (and a comparison) is only possible on the basis of a specific applications.
- The application specifies technical requirements (form of energy, power, storage capacity, response time).
- The application also defines the economic environment (e.g. which energy prices can be set, depth of use, etc.).

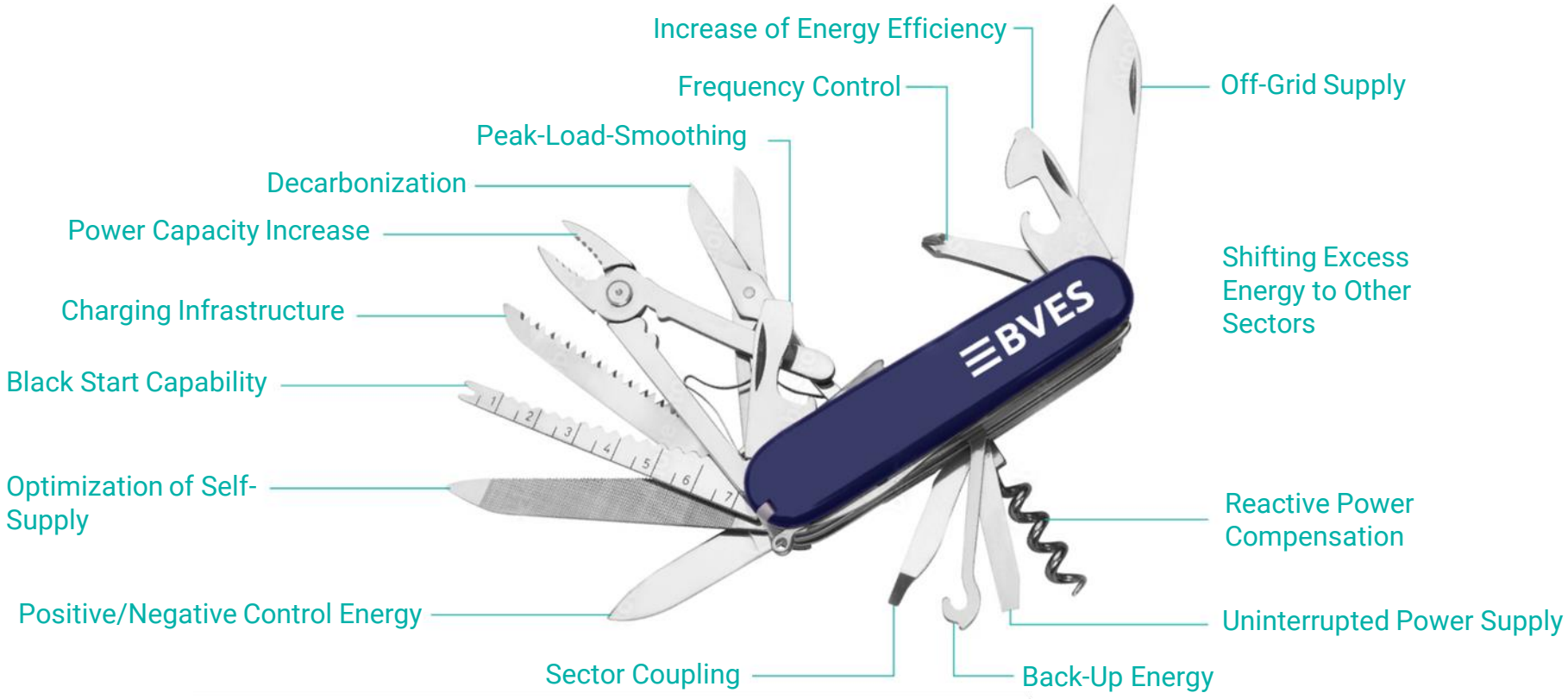


DIVERSITY IN TECHNOLOGIES & APPLICATIONS

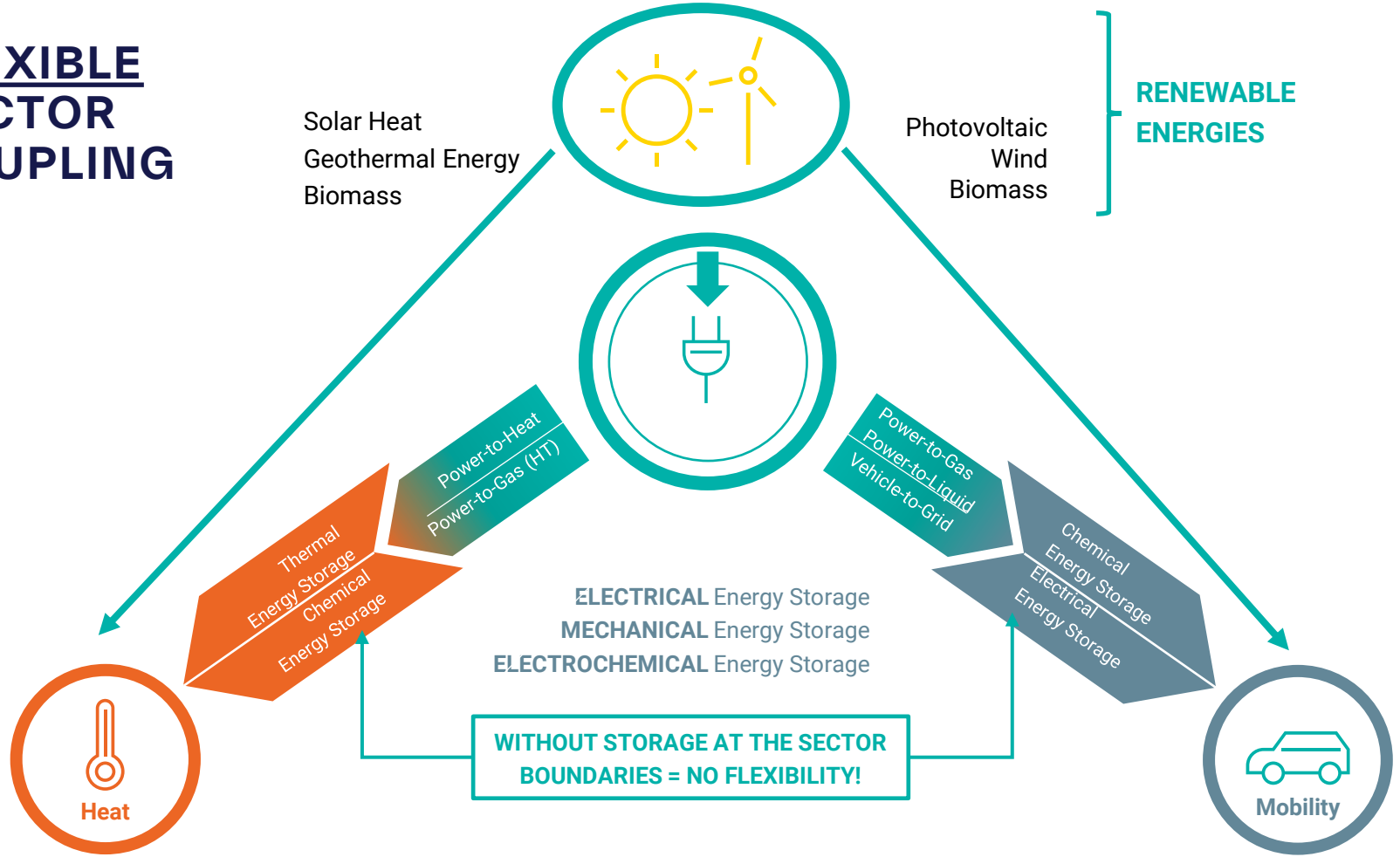
A MATRIX OF TECHNOLOGIES AND APPLICATIONS REPRESENTED BY BVES MEMBER ORGANISATIONS

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 SCMES)	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 / Vorsteigle Wärmebereitstellung von solarer Nah-/Fernwärme	-	-	-	-	-	-	-	-	-	-	-	-	-	+	0	0
		Nachfragegesteuerte / Vorsteigle Wärmebereitstellung von solarer Prozesswärme	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+
		Nachfragegesteuerte / Vorsteigle 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 Kältebereitstellung 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 Kältebereitstellung 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	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-

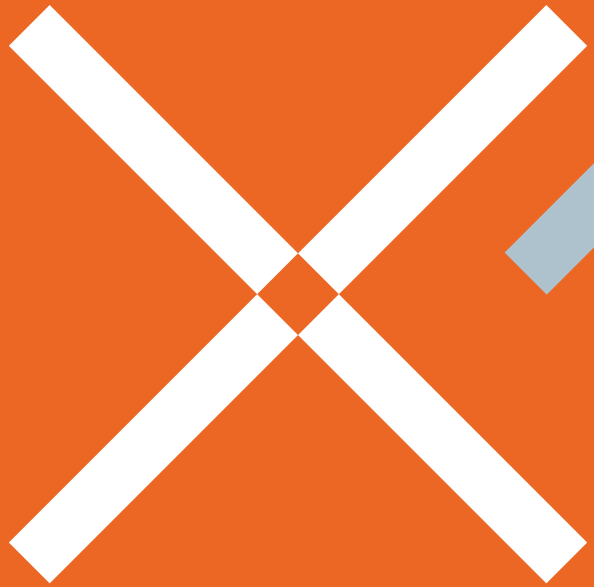
MULTI TOOL ENERGY STORAGE



FLEXIBLE SECTOR COUPLING

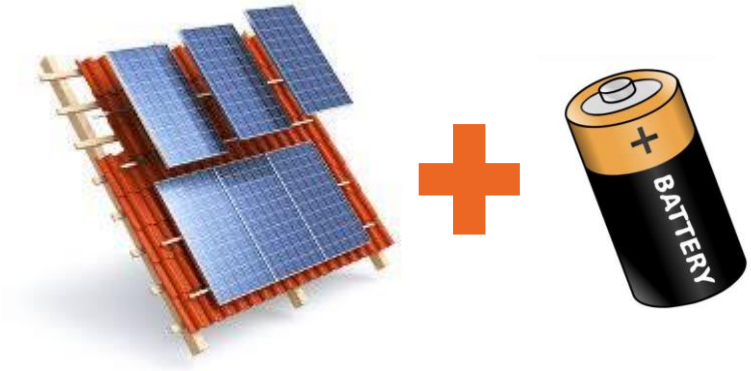


CURRENT MARKETS FOR STORAGE



RESIDENTIAL STORAGE MARKET

Self-consumption ~ 35 %



Self-consumption ~ 70 %

HOME GENERATION AND CONSUMPTION OF ELECTRICITY AND HEAT

Residential:

- Ca. 750.000 Storage Systems installed (End 2022)
- 250.000+ new installations per annum
- Installations mostly incl. Heat pumps
- Huge retrofit potential of existing Rooftop-PV (~ 2 Mio.)

TREND: ELECTRICITY + HEAT + MOBILITY

A carefree package for all energy needs at the lowest costs.

RESIDENTIAL/MOBILITY
BEST PRACTICE

Application: Vehicle to home- Car as an energy storage

Technology: Bidirectional charging with direct current

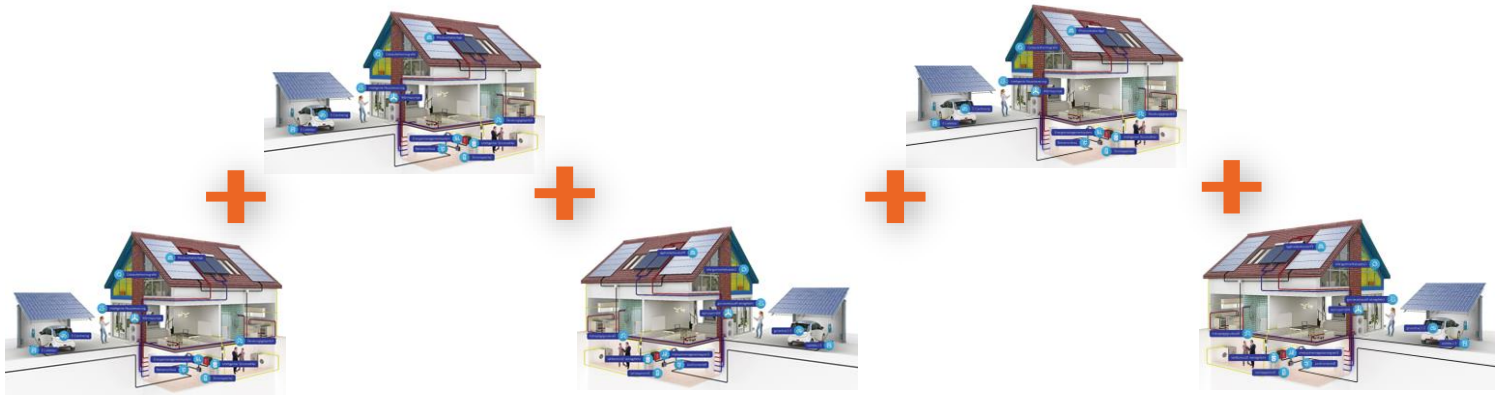
Concrete benefit: Use the car as home storage, increase the efficiency of self-supply, peak load capping

Further Information:
https://thedriven.io/2018/10/19/v2g-whats-the-state-of-play-with-vehicle-to-grid-vehicle-to-home-technology/

Vehicle-to-home (V2H)

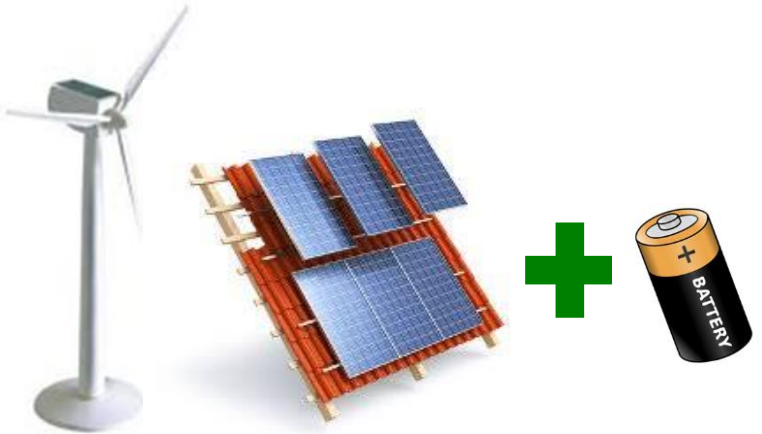
LATEST DEVELOPMENT RESIDENTIAL MARKET:

- Connecting households with storage device to a virtual powerplant for grid services
- Establishing digital energy markets on local and regional level (peer to peer)
- BUT: suitable regulation needed!!!



INDUSTRIAL STORAGE MARKET

Self-consumption



Self-consumption

+ UPS + PLS + Backup Power

+ no Diesel

ELECTRICITY, POWER, HEATING, COOLING + MOBILITY

INDUSTRY: CA. 1600 PROJECTS IN GERMANY

INDUSTRY/ELECTRICITY
BEST PRACTICE

Application: Industrial storage in Echte, Lower Saxony

Completion: 2019

Company: smart power GmbH

Technology: Container with battery stacks as diesel hybrid system with Samsung SDI cells (lithium-ion battery)

Power / Capacity: 1100 kVA; 1370kWh

Concrete benefit: Peak shaving

Further Information:
https://smart-power.net/portfolio/113/

AGRICULTURE
BEST PRACTICE

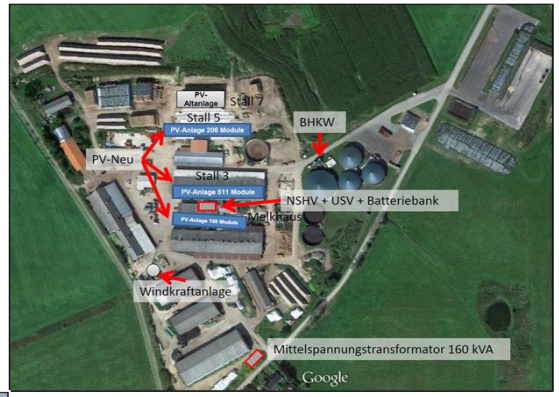
Application: Dairy farmer in Brandenburg

Completion: 2019

Technology: Container Flow-Battery, Heat-Storage, Heat-Pump

Direct Benefit: Reduction of
Energy Costs (- 0,3 € Cent/litre milk)

Power & Cooling = 100% Self-Sufficiency



INDUSTRY/HEAT
BEST PRACTICE

Application: Waste heat recycling in flue gas utilisation of high-temperature potentials in the ceramics industry

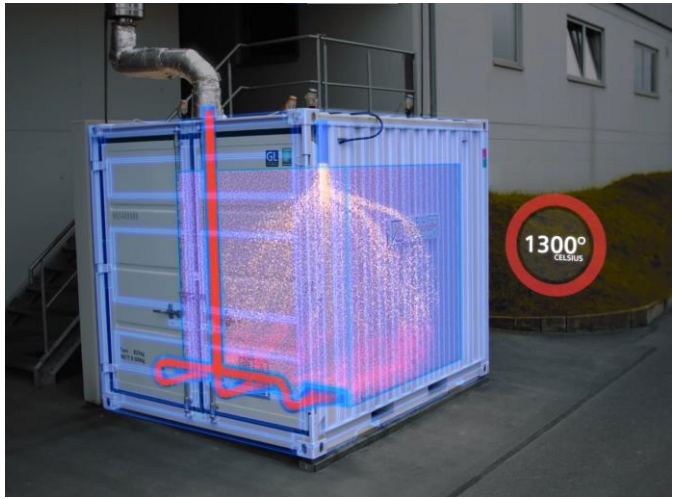
Technology: Granules with heat transfer media such as air, flue gas, liquid salt or thermal oil, up to 1,300°C storage temperature

Company: Kraftblock GmbH

Power / Capacity: 1,8MW / 4.2MWh per Container (=1,2MWh/m²)

Concrete Benefit: Waste heat utilisation, cascade utilisation, efficiency increase, also mobile in container units

Further Information:
https://kraftblock.com/de/applications/industrielle-abwaerme.html

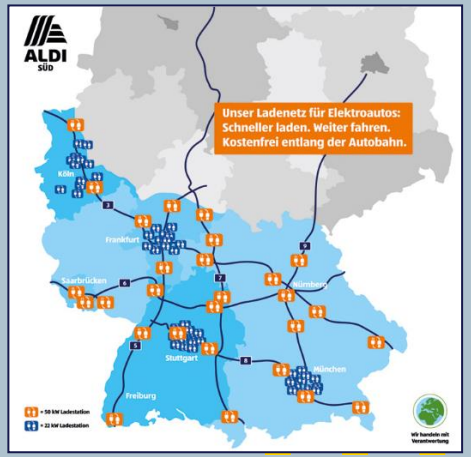


GAME CHANGER: E-MOBILITY

NEW + ADDITIONAL APPLICATION

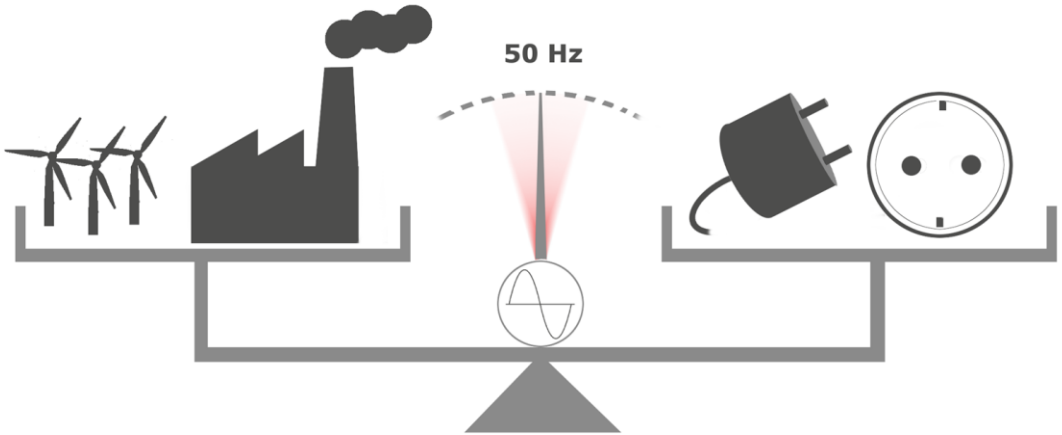
FAST CHARGING INFRASTRUCTURE

NEW BUSINESS MODELS
NEW PLAYERS
NEW ADDED VALUE



LARGE SCALE STORAGE MARKET
MANAGING AND BALANCING THE GRID

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

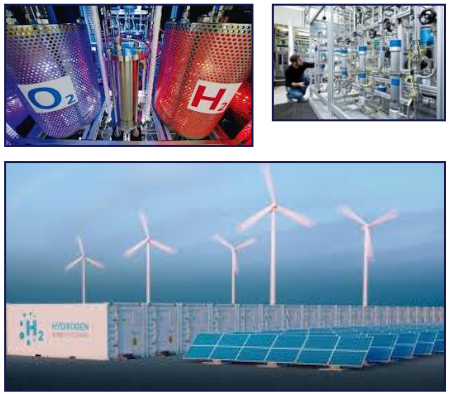


LARGE STORAGE SYSTEMS FOR ELECTRICITY INFRASTRUCTURE

CONTROL ENERGY | SYSTEM SERVICES | FLEXIBILITY (GRID BOOSTER)

PUMPED HYDRO STORAGE CA. 7 GW

BATTERY STORAGE CA. 550 MW



HYDROGEN/ PTX

SYSTEM INFRASTRUCTURE
POWER - CONCEPT

Application: Grid Booster concept in Kupferzell

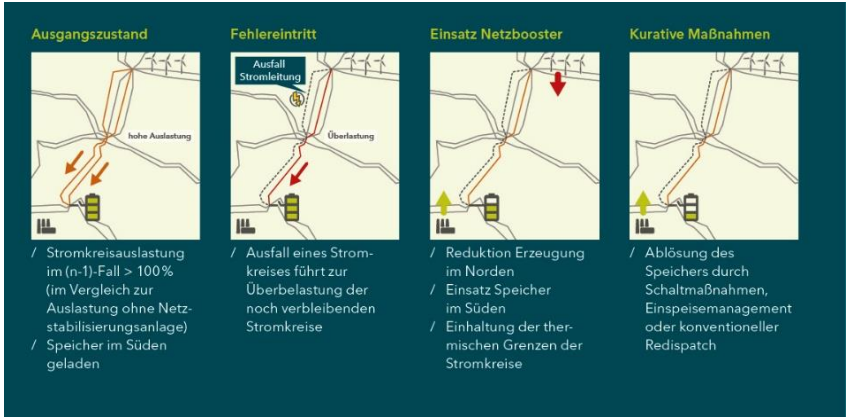
Technology: Battery systems that provide system services in the extra-high voltage range (250MW/250MWh)

Planned Completion: regular plant operation 2026

Company/operator: TransnetBW GmbH / Fluence Energy Inc.

Direct Benefit: Step in during grid overload, PRL, reactive power, black start, lower electricity prices

Further Information:
Netzbooster Pilotanlage | TransnetBW GmbH
https://www.transnetbw.de/files/pdf/netzentwicklung/projekte/netzbooster-pilotanlage/broschuere.pdf



BEST PRACTICE
SYSTEM INFRASTRUCTURE
HEAT & POWER

Application: Wind power storage in Hamburg

Technology: Electrothermal storage with approx. 1,000t of volcanic rock, can be heated up to 750 °C (PtHtP)

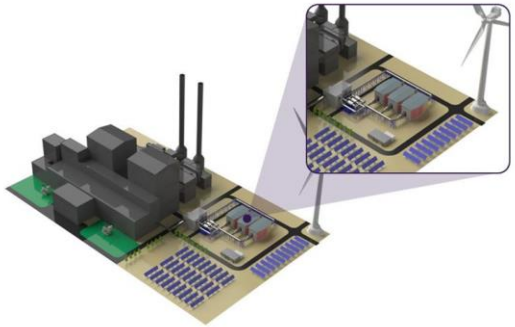
Company: Siemens Gamesa Renewable Energy

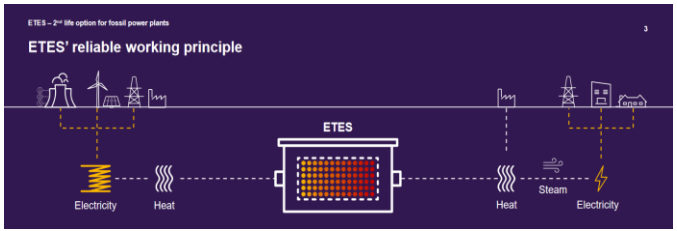
Completion: 2019

Performance/Capacity: 5.4MW/130MWh (Pilot)

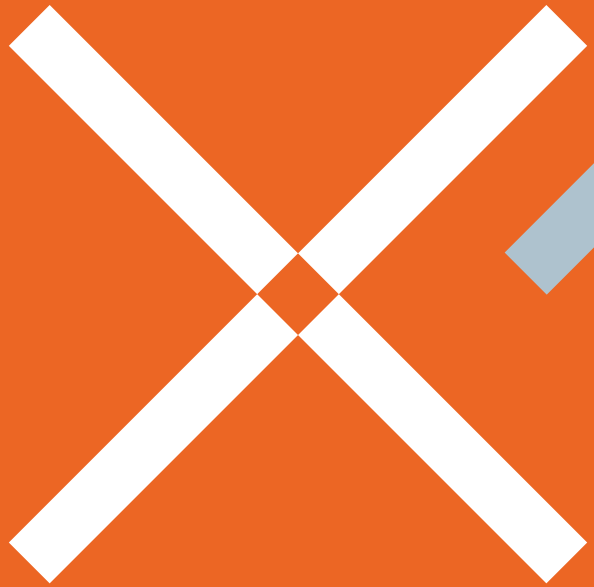
Direct Benefit: Peak shaving, second-life option for conventional power plants, use of peak power generation

Further Information:
https://www.siemensgamesa.com/en-int/-/media/siemensgamesa/downloads/en/products-and-services/hybrid-power-and-storage/etes/siemens-gamesa-etes_switch_teaser_2nd-life-option.pdf

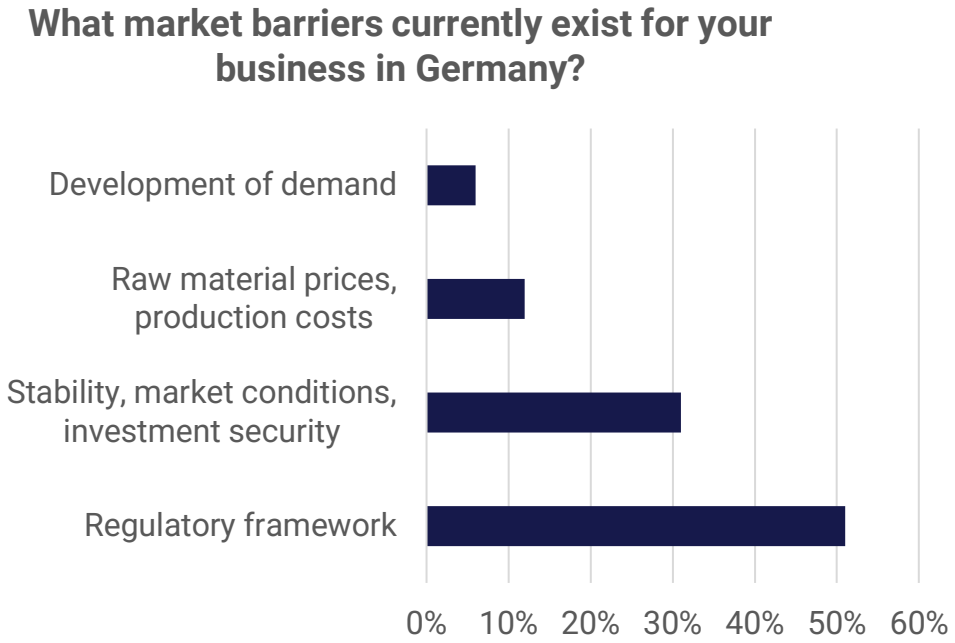




LEGAL FRAMEWORK



THE REGULATORY FRAMEWORK IS THE BIGGEST OBSTACLE TO GROWTH



Regulatory market barriers remain dominant, in particular:

- The classification of energy storage as a final consumer
- Prolonged authorization procedures
- Grid connection conditions with impracticable metering and billing concepts
- Lack of transparency of the current rules
- The influence of the Chinese market and access to battery cells are increasingly seen as obstacles

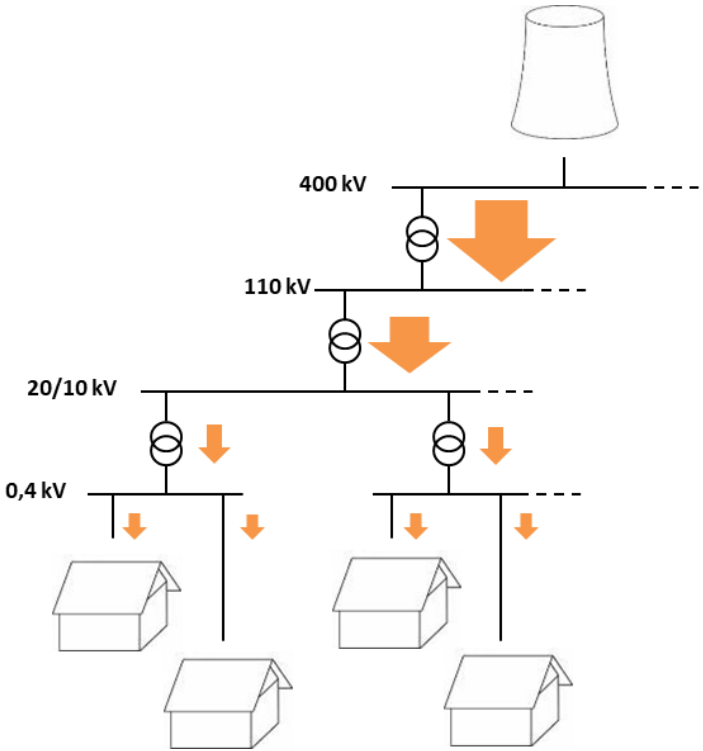
LATEST DEVELOPMENT REGULATION:

- YES, WE HAVE A DEFINITION OF STORAGE!!
- Regulatory definition of energy storage - in line with EU
- Storage device ist not longer generation AND consumption of energy
- No double fees and taxes

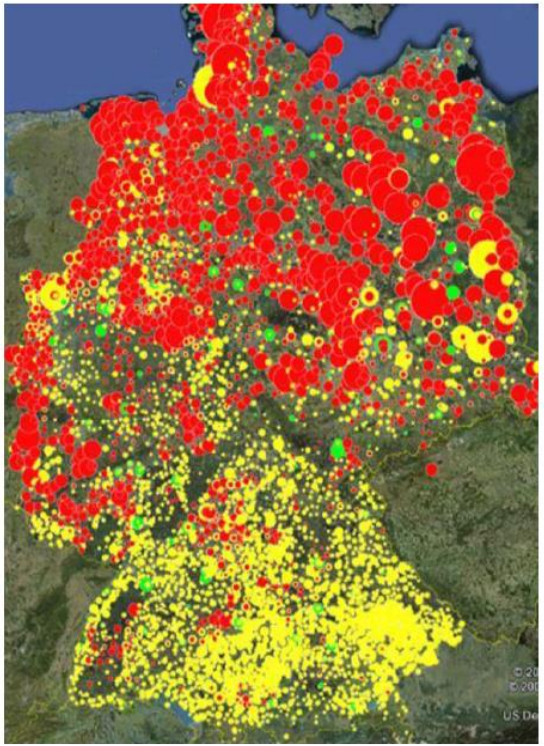
"Energy storage" means, in the electricity system, deferring the final use of electricity to a moment later than when it was generated.

EU Market Design Directive 2019

ENERGY LAW IS MAINLY STILL BASED ON THE OLD ENERGY SYSTEM...



… AND NOT SUITABLE FOR THE NEW ENERGY REALITY!



THANK YOU

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