ENERGY STORAGE: ADVANTAGES, TECHNOLOGIES & APPLICATIONS FOR THE NET ZERO ENERGY SYSTEM

25/05/2023

Discussion: “Energy storage as a key technology for the success of the energy transition”

Katja Esche, BVES

GERMAN ENERGY STORAGE ASSOCIATION (BVES)

- BVES is the industry association of German and EU energy storage companies.
- BVES represents all storage technologies across the sectors of electricity, heat, and mobility
- BVES is a dialogue partner for politics, administration, science, and publicity working for the improvement of the regulation and policy framework for energy storage
- BVES is active at the national, EU, and international levels

BVES

Energy Storage Systems Assoc.

GERMAN ENERGY STORAGE SYSTEM ASSOCIATION

EXCERPT OF OUR MEMBERSHIP – ACROSS ALL INDUSTRIES AND ENERGY SECTORS

ENERGY TRANSITION AS A PART OF GLOBAL CLIMATE EFFORTS

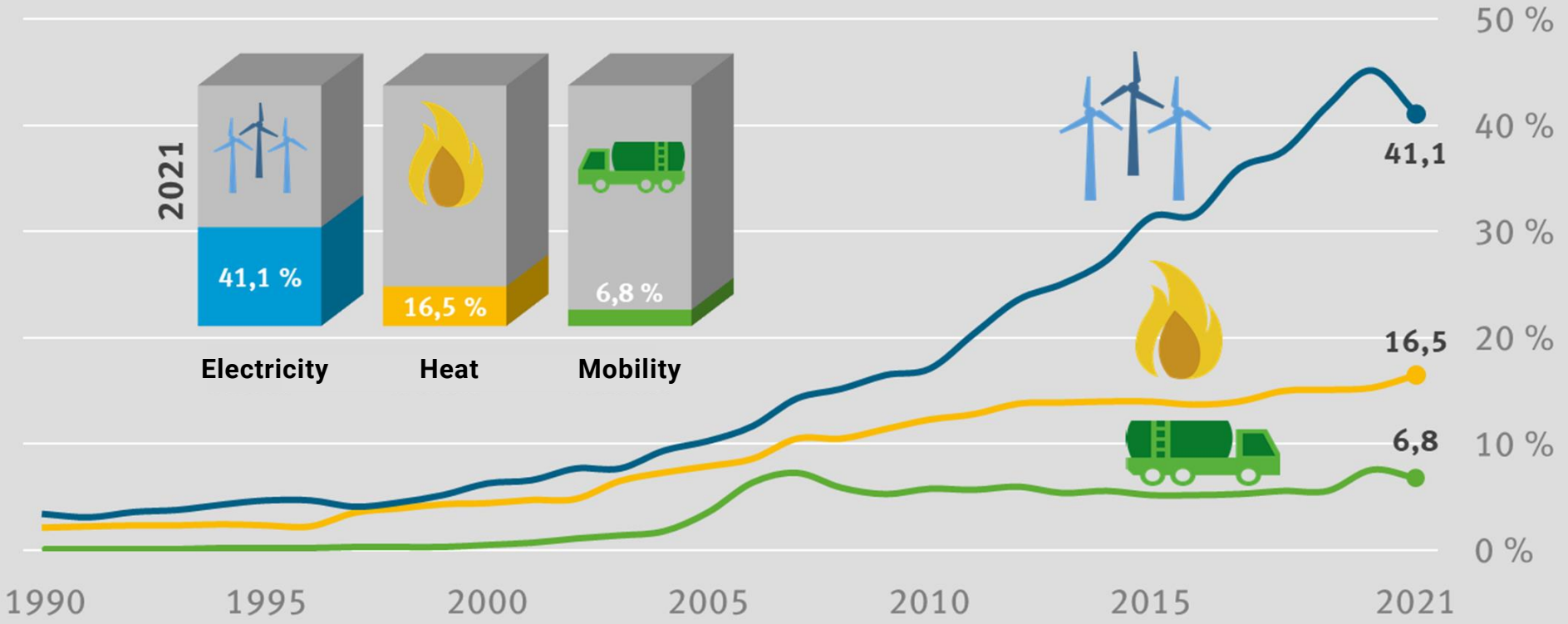
- Paris Climate Accords:
- 1.5 Degrees

- EU Green Deal ~~2050~~ 2045
- Carbon Free by 2050
- Intermediate goal: 55% by 2030

- Germany:
- Electricity supply based almost entirely on renewable energies by 2035.

ON THE WAY TO 100% RENEWABLES

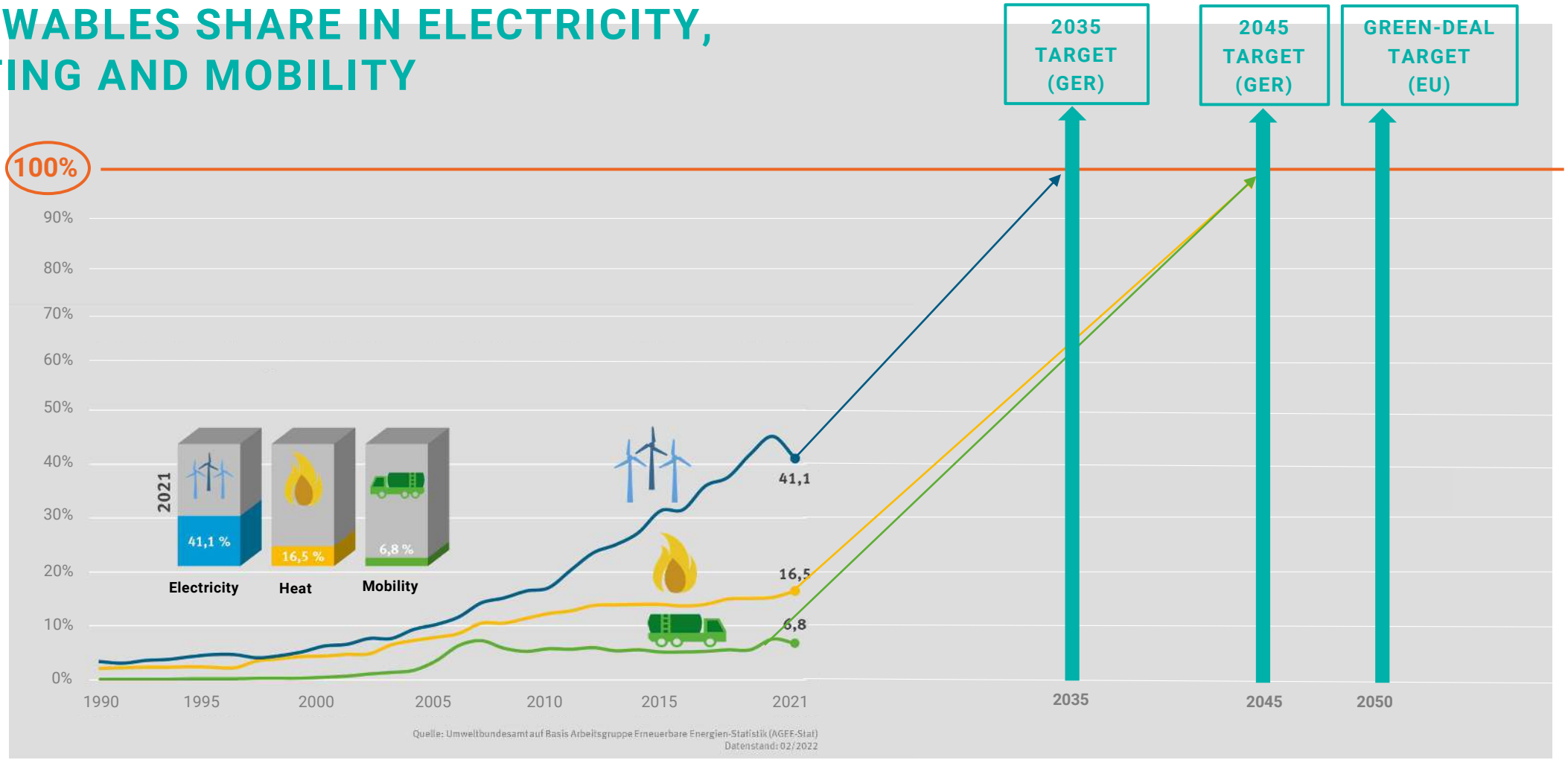
RENEWABLES SHARE IN ELECTRICITY, HEATING AND MOBILITY



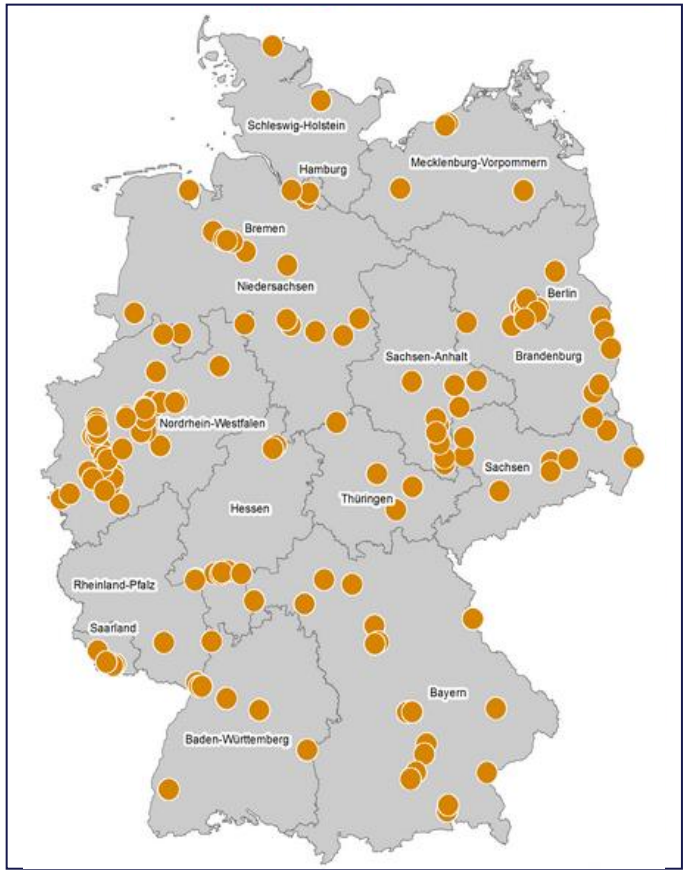
Quelle: Umweltbundesamt auf Basis Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat)
Datenstand: 02/2022

ON THE WAY TO NET ZERO

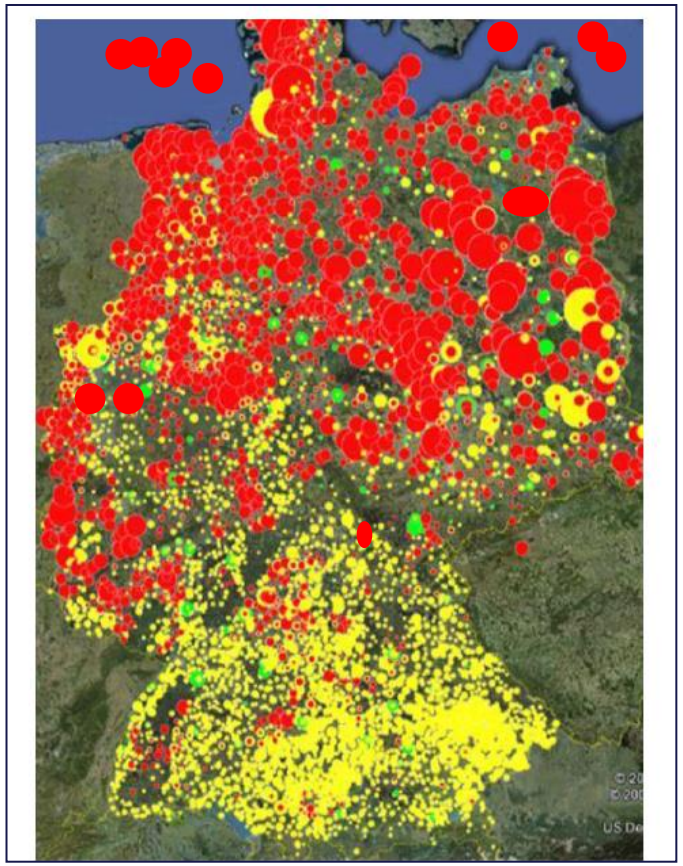
RENEWABLES SHARE IN ELECTRICITY, HEATING AND MOBILITY



ENERGY TRANSITION:
RESULT NO. 01 = DECENTRALIZATION

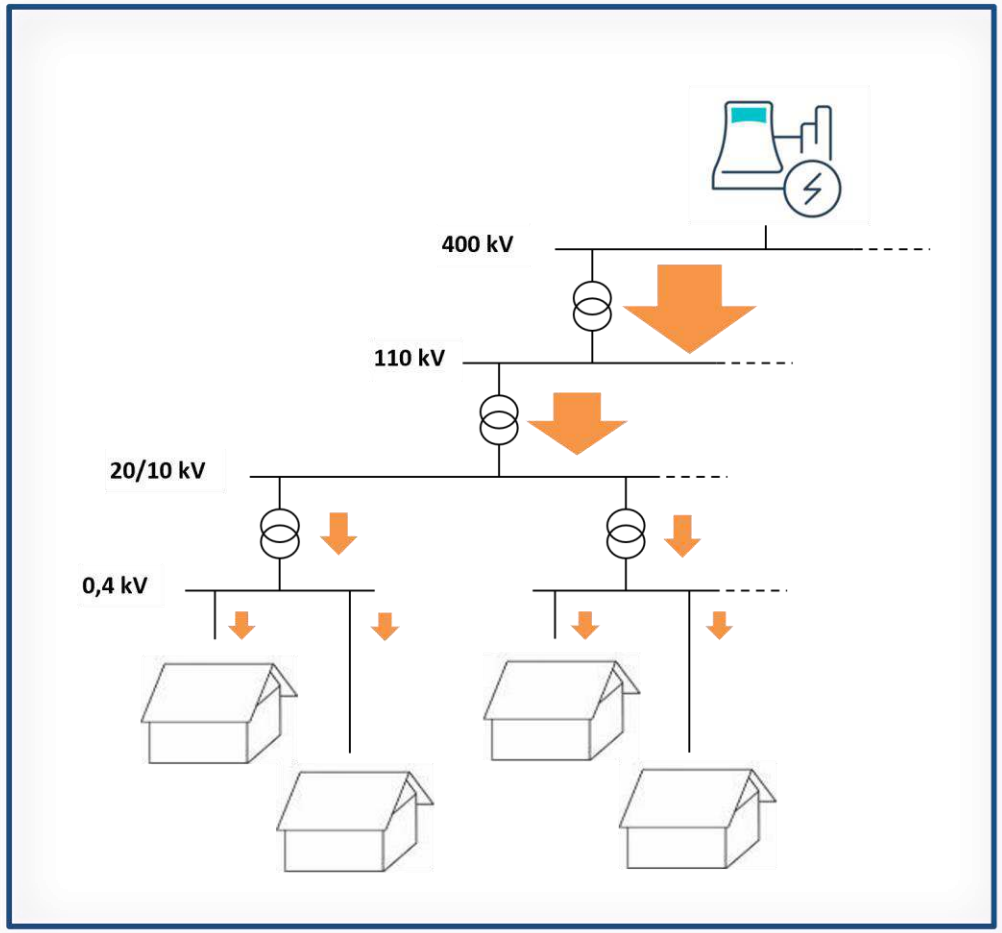


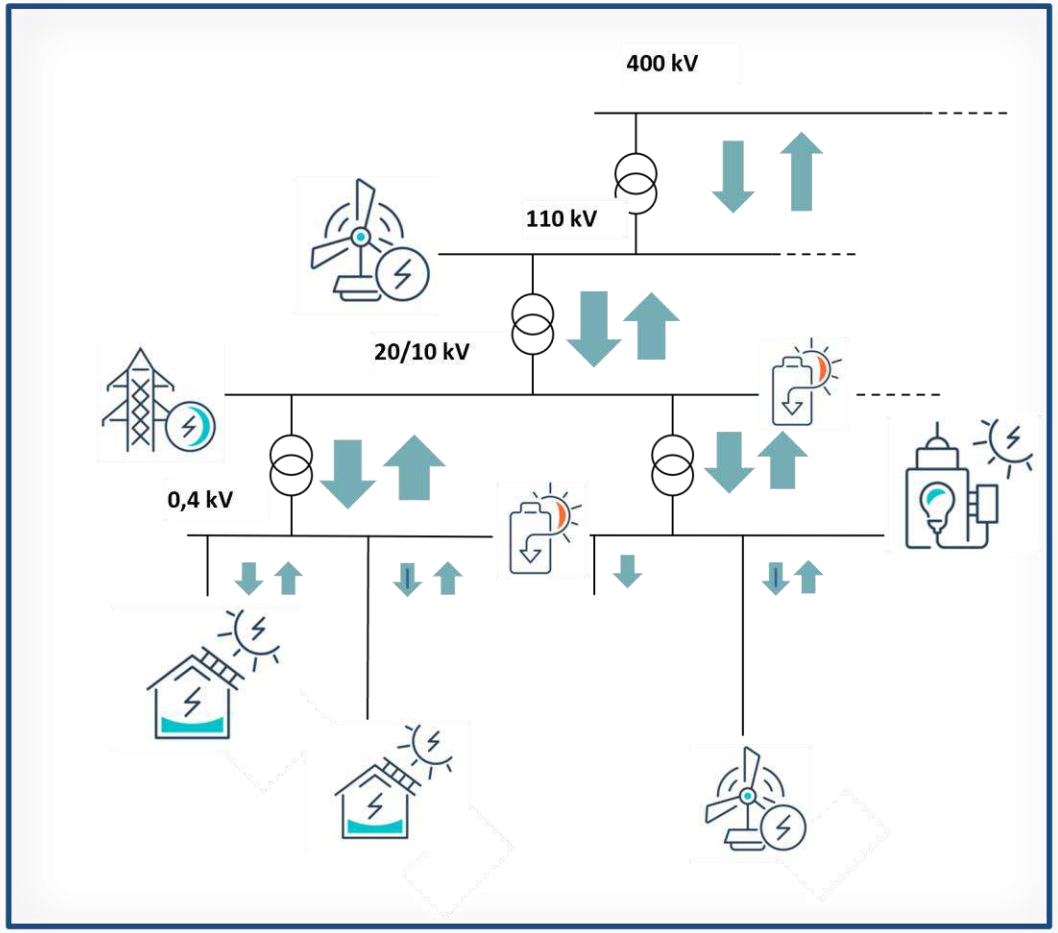
Fossil Power Plants



Renewable Generation

RESULT: NEW STRUCTURES



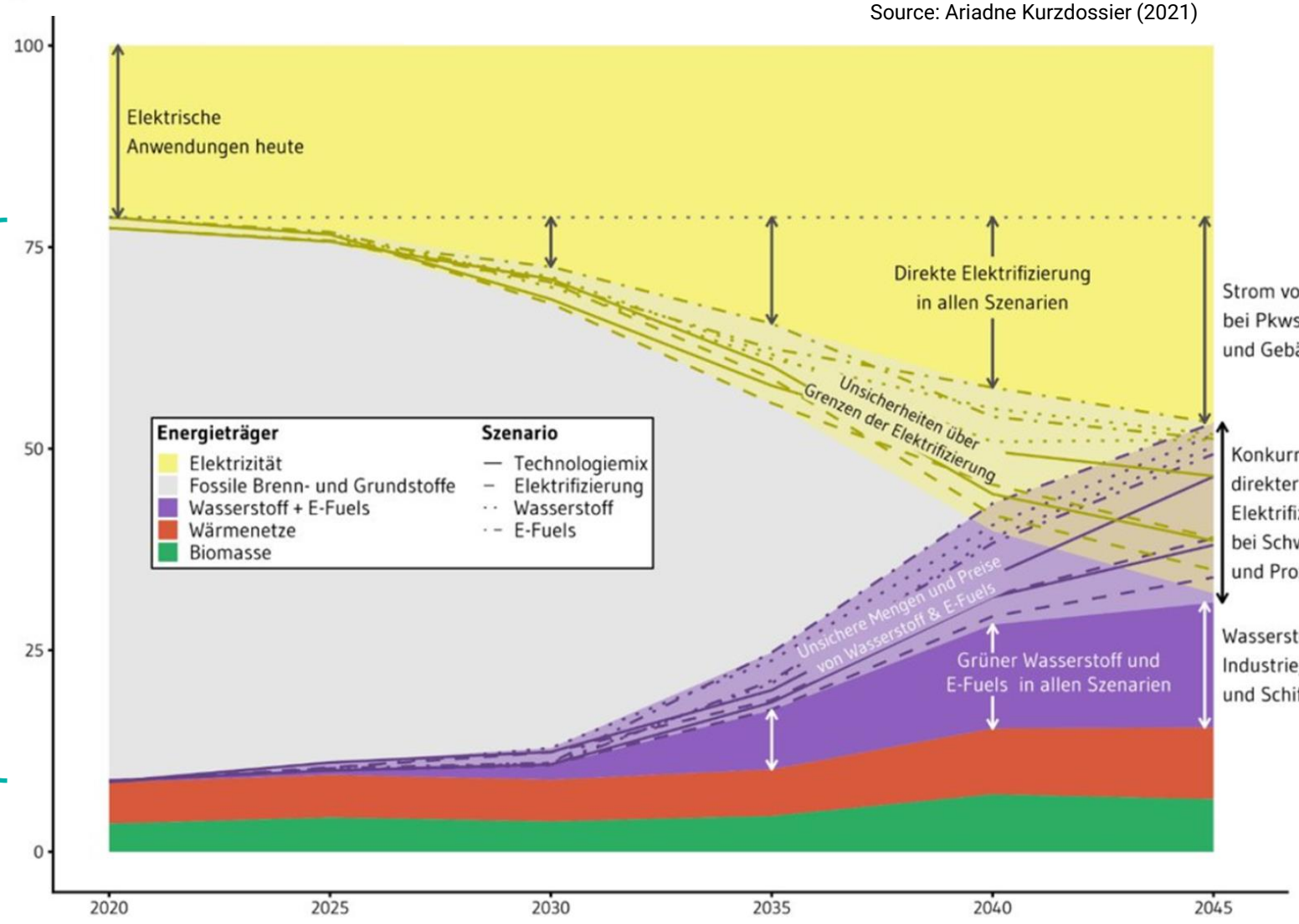


ENERGY TRANSITION MEANS (MOSTLY) ELECTRIFICATION

~ 80 % fossil fuels

a shares of final energy

Source: Ariadne Kurzdossier (2021)



~ 75 % via electrification

~ 25 % via H2, biomass, etc.

TREND 2: FROM ENERGY TO POWER

- High level of electrification
- More energy at a moment
- Power is the new currency

TREND 3: TEMPORAL AVAILABILITY

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

WHAT IS THE SOLUTION?

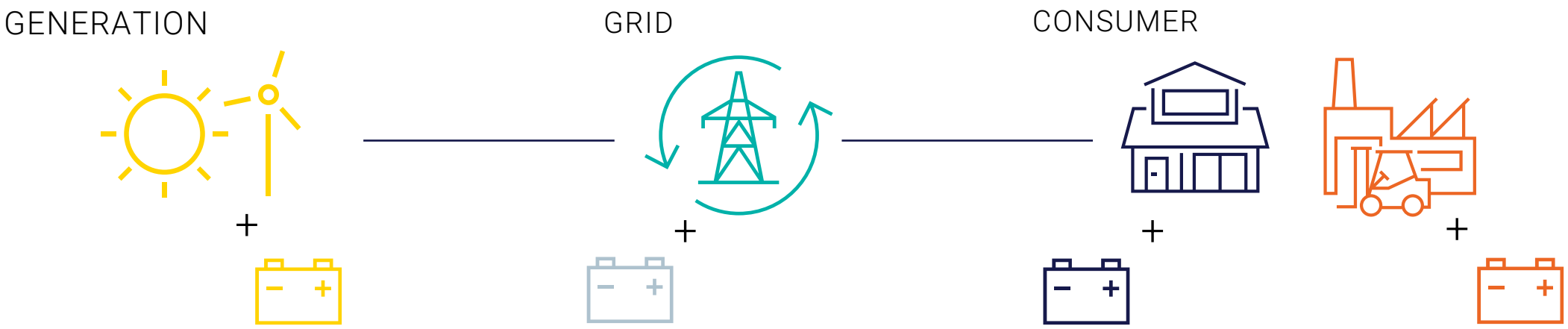
WHAT IS ENERGY STORAGE

"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

FLEXIBILITY

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

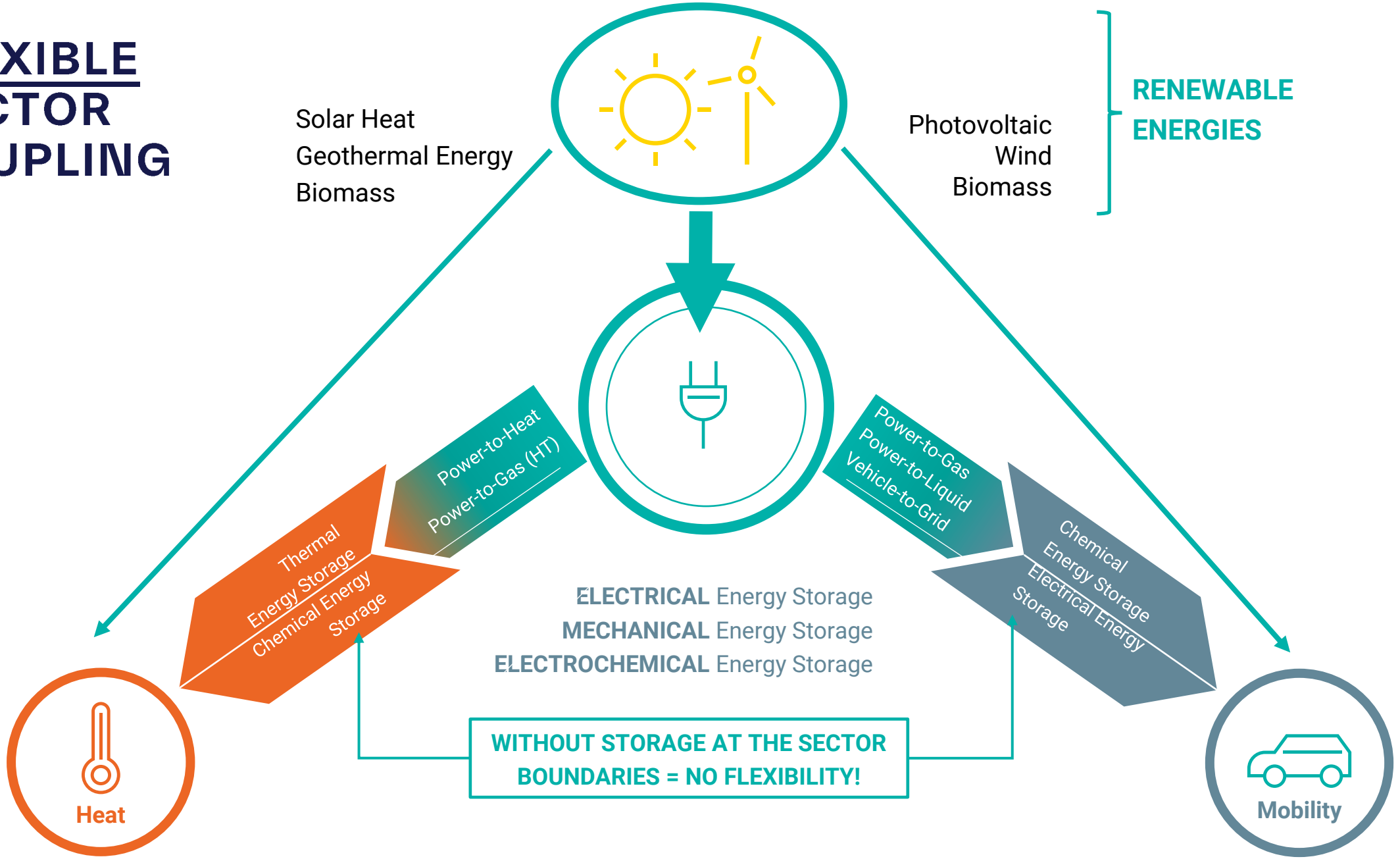


TO FLATTEN THE CURVE

TO BALANCE THE FREQUENCY

TO SECURE POWER

FLEXIBLE SECTOR COUPLING



ENERGY STORAGE TECHNOLOGIES

ELECTRICITY STORAGE

STORAGE OF ELECTRICAL ENERGY

e.g. Supercapacitator, Capacitators

ELECTROCHEMICAL STORAGE

e.g. Lead-Acid Battery, Redox-Flow Battery, Li-Ion Battery

MECHANICAL STORAGE

e.g. Pumped Hydro, Compressed-Air Storage, Flywheel

CHEMICAL ENERGY STORAGE

PRODUCTION AND STORAGE OF GREEN HYDROGEN

usage of fuel cell, electrolyzer

THERMAL ENERGY STORAGE

STORAGE OF SENSIBLE HEAT

e.g. hot-water, minerals, steel

STORAGE OF LATENT HEAT

e.g. phase-change material (PCM), slurries

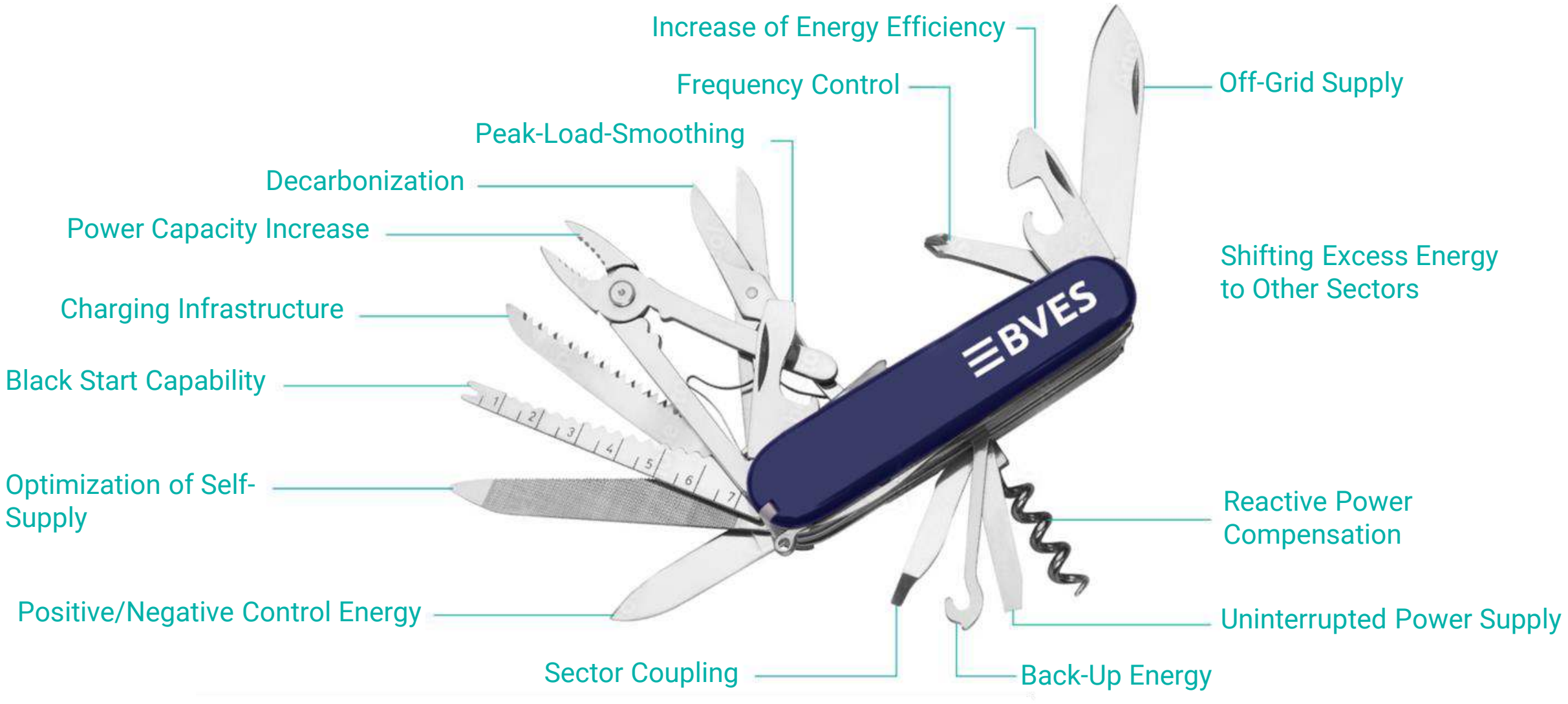
THERMOCHEMICAL STORAGE

e.g. sorption storage, thermochemical material (TCM)

APPLICATION DETERMINES A TYPE OF 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 technologies (and a comparison) is only possible on the basis of a specific applications.
- The application also defines the economic environment (e.g. which energy prices can be set, depth of use, etc.).

MULTI TOOL ENERGY STORAGE



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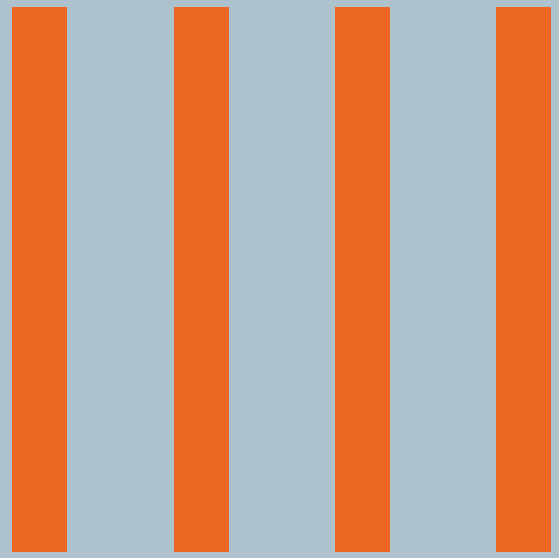
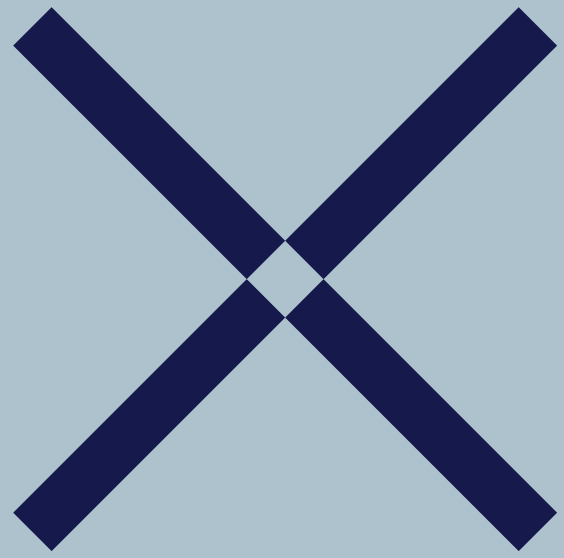
ENERGY STORAGE MARKETS & APPLICATIONS



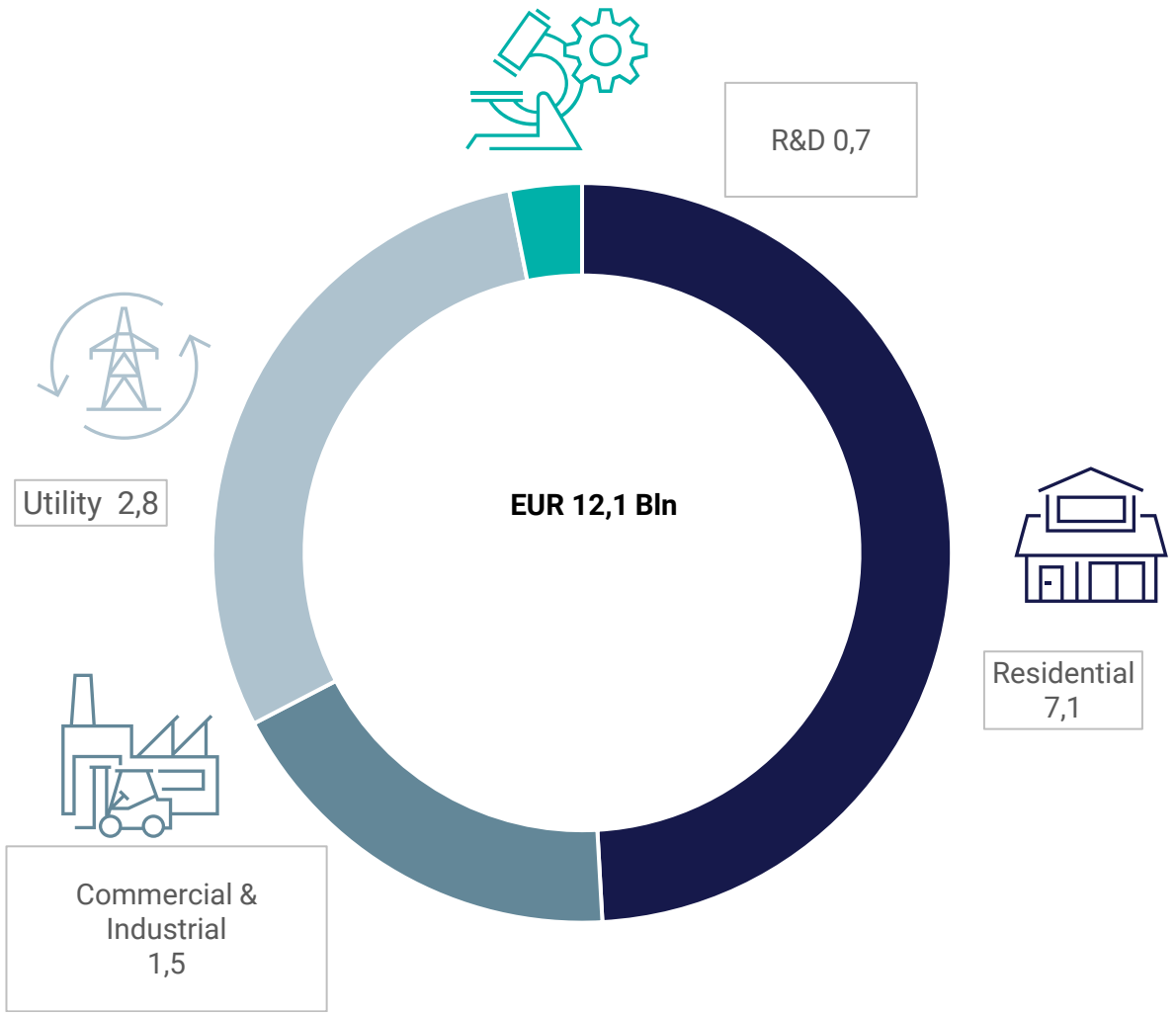


ENERGY STORAGE MARKET IN 2021-2022

- Residential storage - largest segment. Strong growth in both home and heat storage.
- Utility revenues are growing, dominated by pump storage.
- Decarbonization is driving revenues in commercial & industrial segment.

Growth in line with 2022 is expected for 2022.

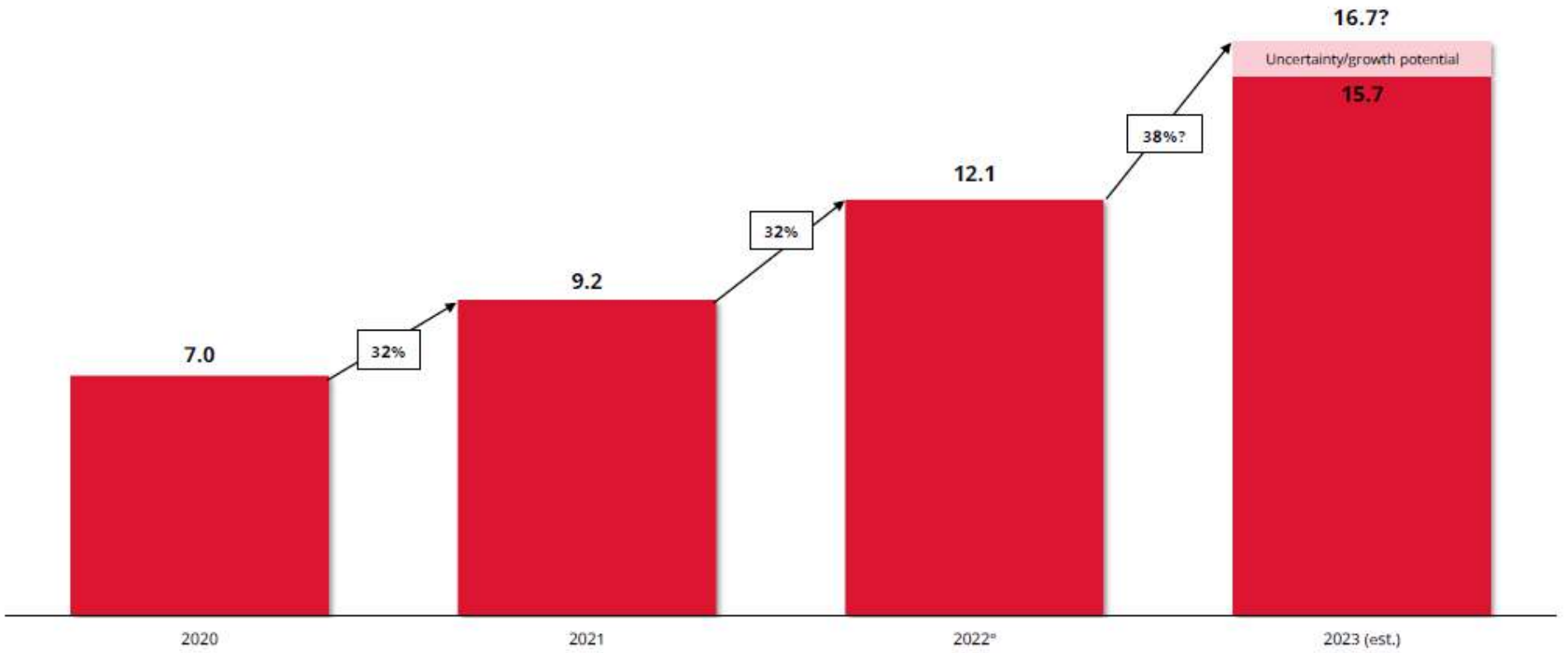
- H2 storage showing the first signs of commercial applications; so far still mainly used in field tests.



GERMAN ENERGY STORAGE INDUSTRY
REVENUES AND OUTLOOK

GROWTH RATES ARE ACCELERATING

Energy storage industry revenues* in Germany 2020-2023 (in €B)



* Domestic and international revenues of companies registered in Germany

° Preliminary

Source: 3EC

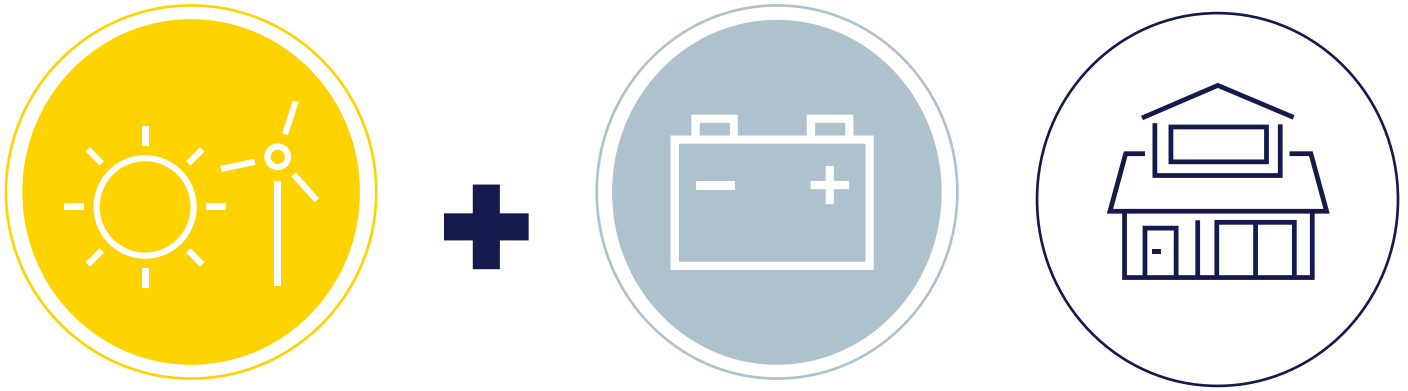
COMPILED FOR BVES

WITH ENERGY STORAGE TO SELF-SUFFIENCY

Just renewables

Self-supply ~ 30/35 %

With energy storage

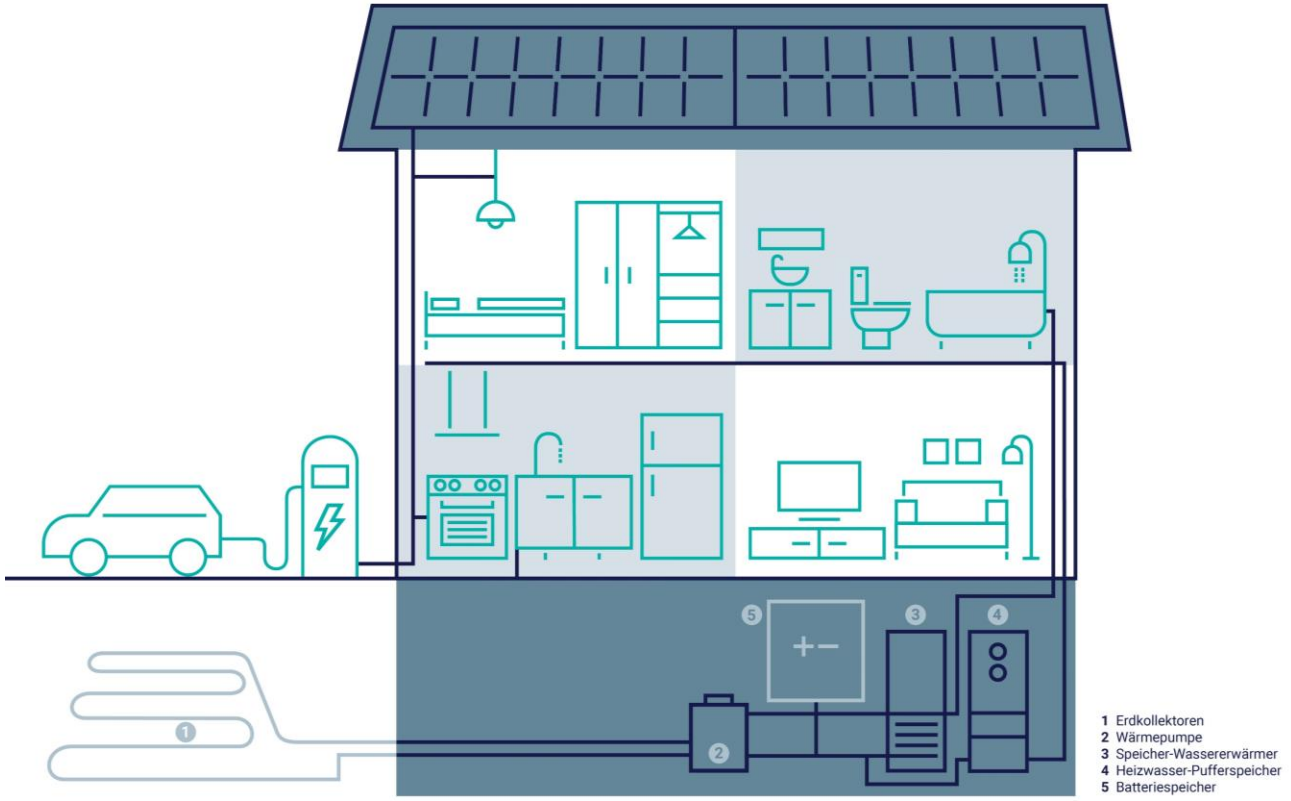


Self-supply ~ 80 %

RESIDENTIAL: SELF-GENERATION AND CONSUMPTION

- Ca. 1000 000 Storage Systems installed.
- + 250.000 year
- Installations mostly incl. Heatpump + Wallbox
- Huge retrofit potential of existing Rooftop-PV

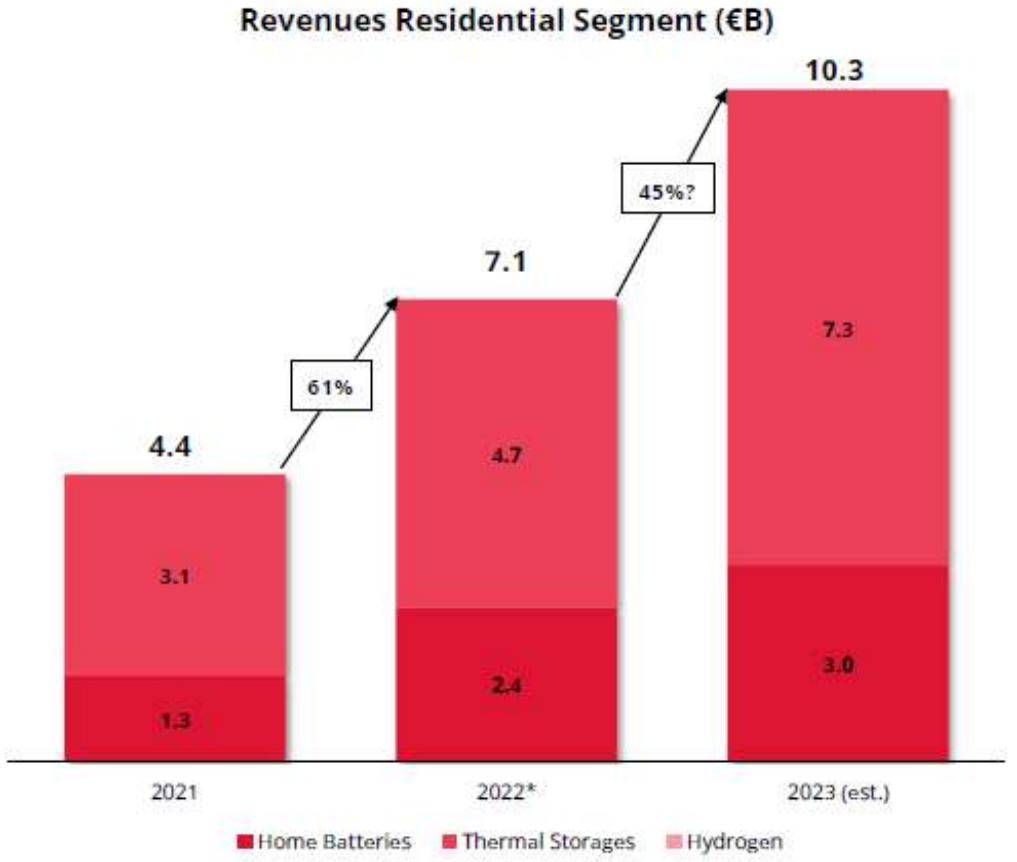
(~ 2 Mio.)



RESIDENTIAL MARKET
EXTRAORDINARY GROWTH RATES IN 2022

Developments in 2022

- Much stronger growth than expected: **€7.1B revenues** vs. €5.4B.
- **Biggest demand drivers:** High energy prices as well as self-sufficiency initiatives and security of supply concerns.
- Hydrogen-based concepts for residential segment have doubled sales, but still at low level overall.



Source: 3EC

* Some figures still preliminary

COMPILED FOR BVES

RESIDENTIAL/MOBILITY – V2H

Application: Vehicle to home- Car as an energy storage

Technology: Bidirectional charging with direct current

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/

… ALSO IN URBAN AREAS

Example: Project in Darmstadt/ Germany in housing complex with 43 flats + shared spaces

Specifications:

- 80 kWp PV plant
- 76,8 kWh, 18 kW Lithium-Ion battery

Benefits:

- Lower energy prices
- 22% increase of self-consumption
- provision of high-power charging for e-mobility

Source: TESVOLT, https://www.tesvolt.com/de/projekte/vom-dach-in-die-wohnung.html

ELECTRICITY, POWER, HEATING, COOLING + MOBILITY

INDUSTRY: CA. 1600 PROJECTS IN GERMANY

C&I MARKET
LOWER REVENUES AND GROWTH THAN EXPECTED

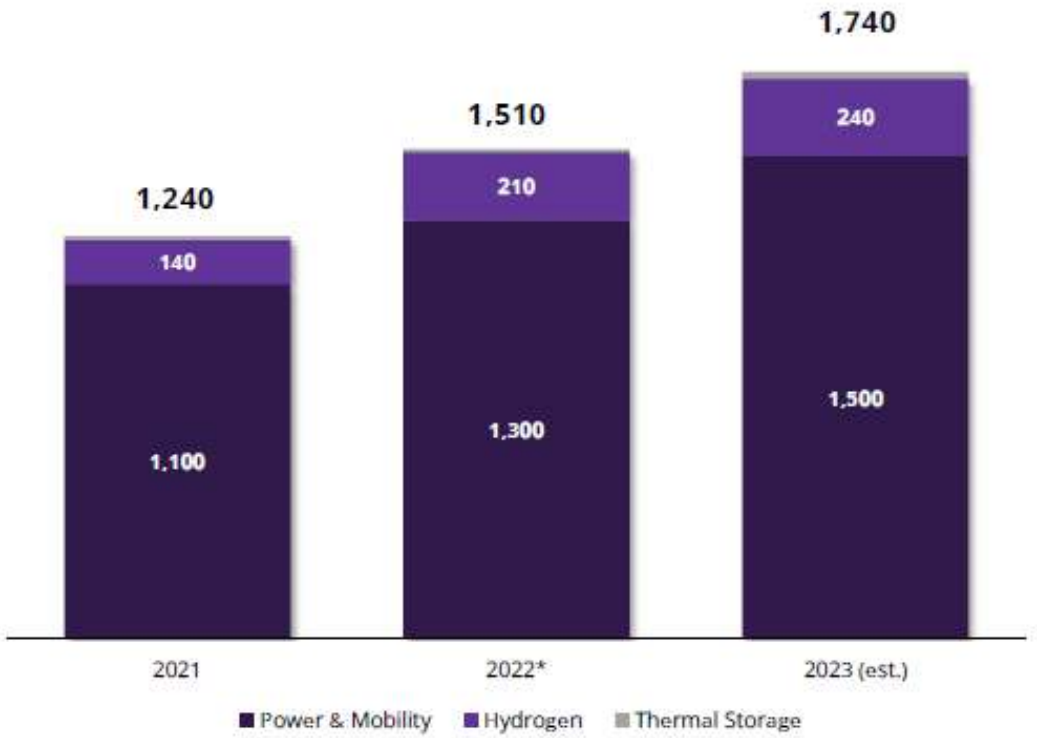
Developments in 2022

- 2021/22 below last year's projections; **revenue growth of 20% from 2022+ expected**.
- Drivers: **High energy prices, e-mobility, security of supply**. Self-sufficiency, decarbonization obligations becoming more relevant.
- **Hydrogen applications** remain marginal; some demand seen in 1-10 MW range. More field tests and IPCEIs expected from 2025.
- **Thermal storage gaining significance**: Still mostly project-linked but seeing growing demand. Mindset change from molecules to electrons major obstacle.
- **Complex subsidy rules, long approval processes**, relatively low interest in/understanding of self-sufficiency concepts hinder segment.

Expectations for 2023

- Growth rate in line with prior year. Impact of war in Ukraine could provide boost.

Revenues Commercial & Industrial Segment (€M)



* Some figures still preliminary

Source: 3EC

COMPILED FOR BVES

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

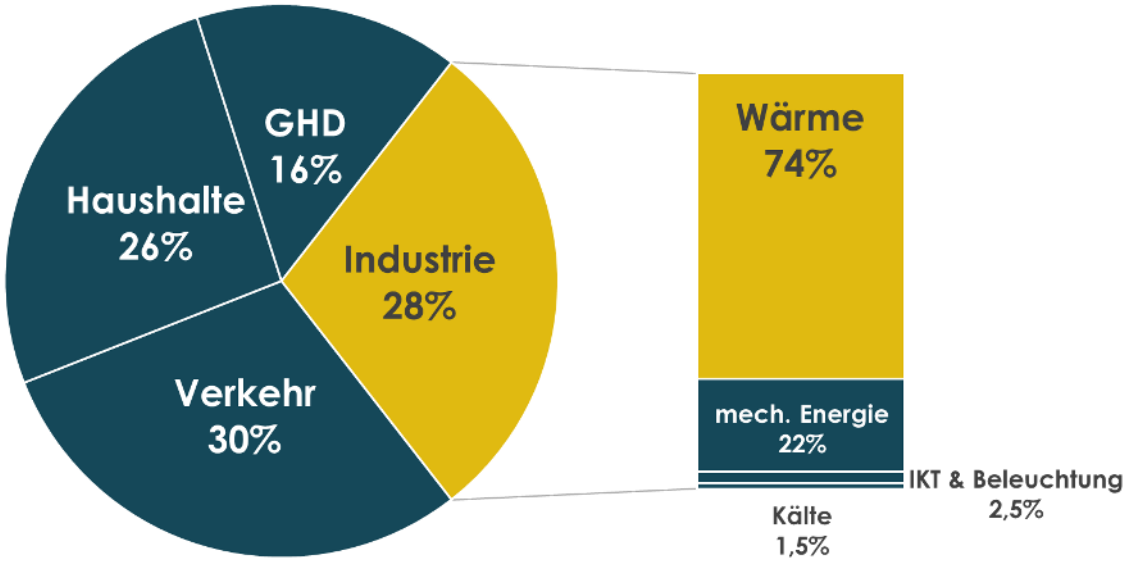
Concrete benefit: Peak shaving

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

DECARBONIZATION OF INDUSTRIAL SECTOR WITH ENERGY STORAGE

Challenge

- In industry, process heat > 60% of energy consumption
- 27% of all CO2 emissions come from industrial heating and cooling



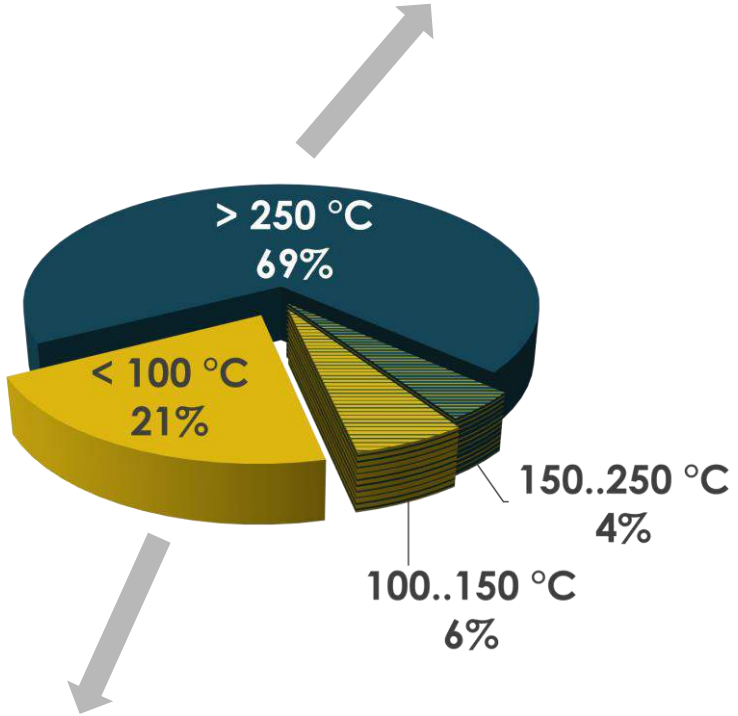
ENERGY TRANSITION IN THE INDUSTRY MEANS MOSTLY HEAT TRANSITION

Solution

- Thermal energy storage to store process heat
- Modern thermal storage technologies cover temperature ranges up to 1200°C Use in all industrial sectors.
- Industrial waste heat could cover ~ 46% of Germany's household heating demand

Datenbasis: Energiedaten BMWi, 2019

Temperature range > 250 = greatest impact



Temperature range < 100 = „low hanging fruits“

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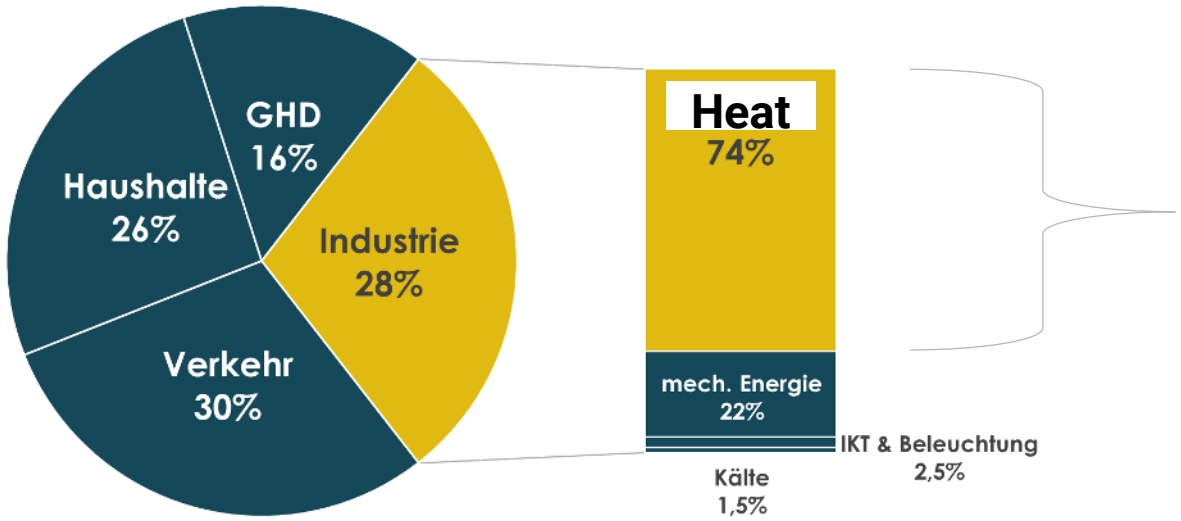
ENERGY TRANSITION IN THE INDUSTRY MEANS MOSTLY HEAT TRANSITION



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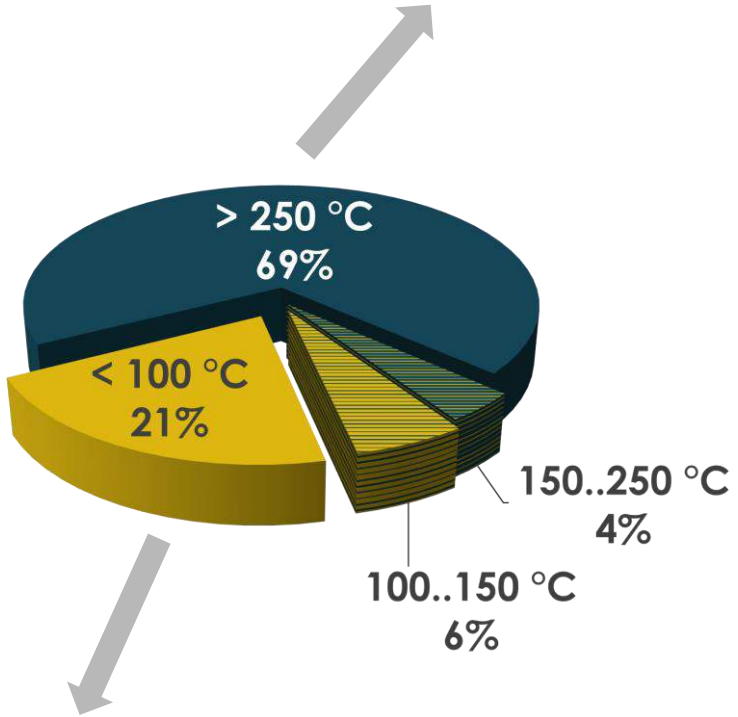

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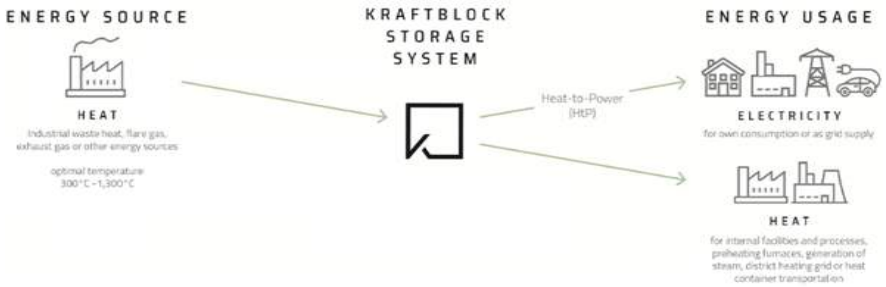
INDUSTRY/HEAT
BEST PRACTICE



Application: Power-to-heat storage system to decarbonise process heat in potato chip production

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

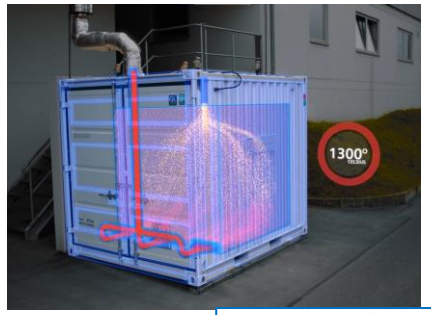
Company: Kraftblock GmbH

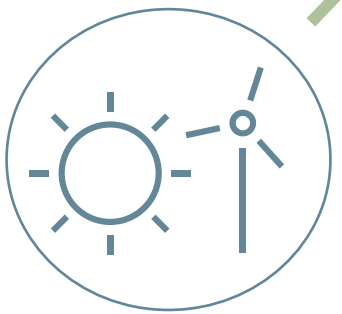
Capacity: 22 MW, > 150 MWh

Storage temperature: > 800°C

Benefits: replacement of gas boiler, enable renewable process heat delivery 24/7, 8,500 t CO_2 reduction/year

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





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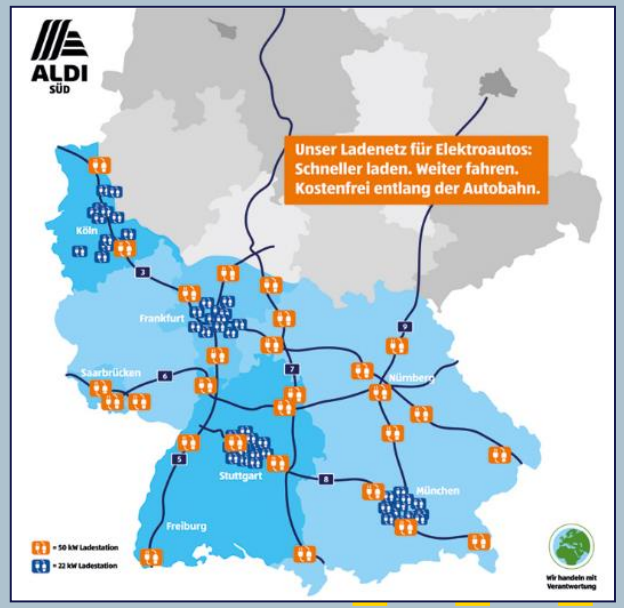
NEW BUSINESS MODELS
NEW PLAYERS
NEW ADDED VALUE

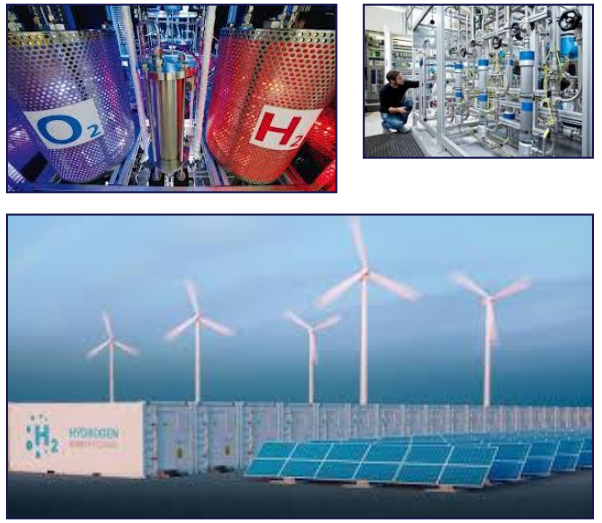


UTILITY/LARGE STORAGE MARKET FOR ELECTRICITY INFRASTRUCTURE

CONTROL ENERGY | SYSTEM SERVICES | FLEXIBILITY

PUMPED HYDRO STORAGE CA. 7 GW

BATTERY STORAGE CA. 1000 MW



HYDROGEN/ PTX

UTILITY MARKET
ENERGY PRICE VOLATILITY DRIVING REVENUES

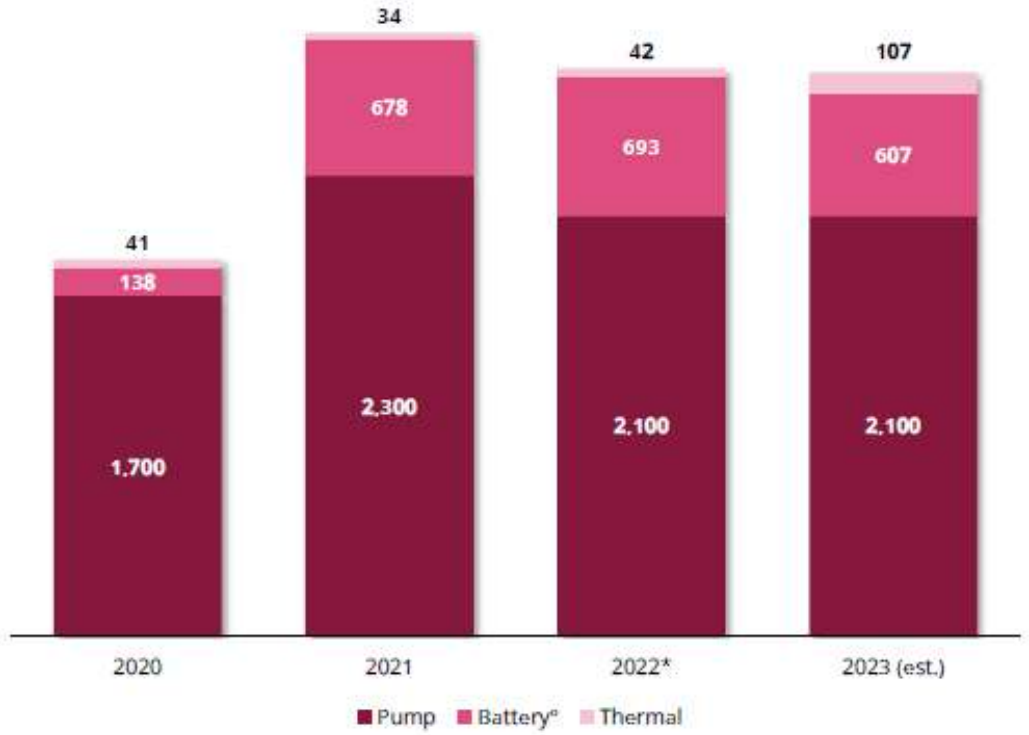
Developments in 2022

- Pump storage seeing **revenues spike due to price volatility**.
- Significant increase in battery storage revenues on **higher control energy prices**. Multiple new units online to manage grid flexibility.
- Thermal as well as battery storages **often linked to large projects**; growth in sector thus dependent on their progress.
- Hydrogen caverns in Krummhörn (Uniper), „Clean Hydrogen Coastline" project (EWE), energy park Bad Lauchstädt (VNG) potentially gaining relevance from 2024+ through field tests and IPCEIs.

Expectations for 2023

- Trend in new large battery storage connections to continue. New pump storages in planning phase.

Revenues Utility Segment (€M)



Source: 3EC

* Some figures still preliminary

° Revenues from arbitrage activities not included

COMPILED FOR BVES

BEST PRACTICE
POWER INFRASTRUCTURE CONCEPT

Application: Grid Booster concept in Kupferzell

Technology: Battery systems that provide system services in the extra-high voltage range

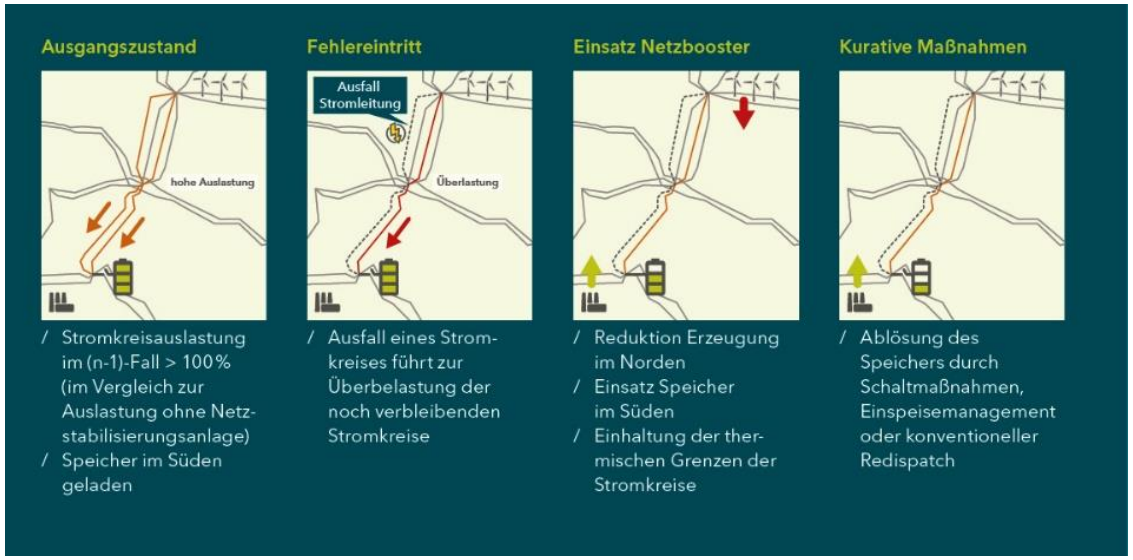
Planned Completion: regular plant operation 2026

Company/operator: TransnetBW GmbH

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)

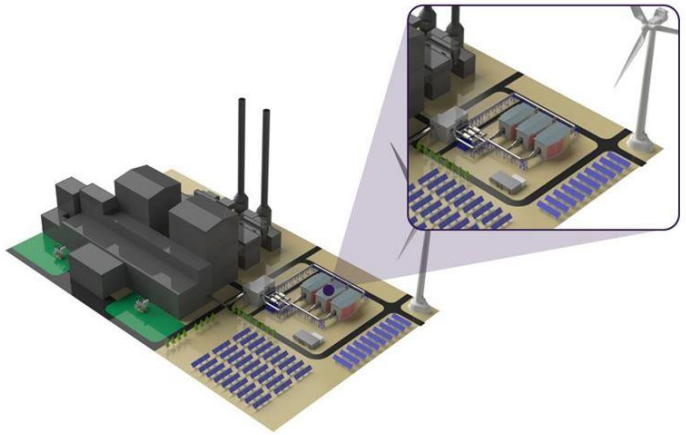
Company: Siemens Gamesa Renewable Energy

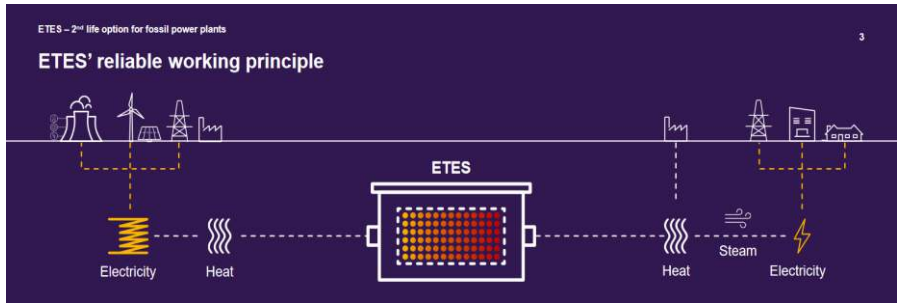
Completion: 2019

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





GAME CHANGER: E-MOBILITY
FAST CHARGING INFRASTRUCTURE

BEST PRACTICE
SYSTEM INFRASTRUCTURE MOBILITY

Application: Europe's largest charging park at the Hilden interchange between the A3 and A46 motorways

Technology: 20 Superchargers of the new V3 generation from Tesla and 16 fast-charging stations from the Dutch provider Fastned

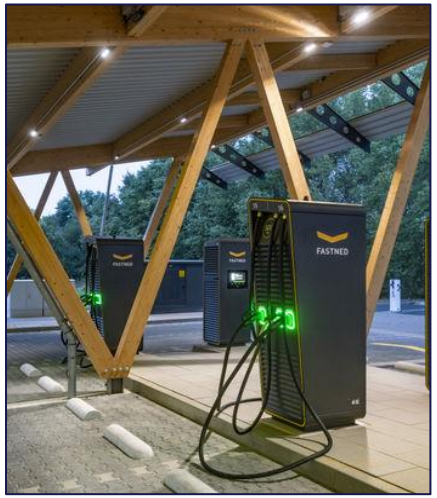
Company: Tesvolt GmbH

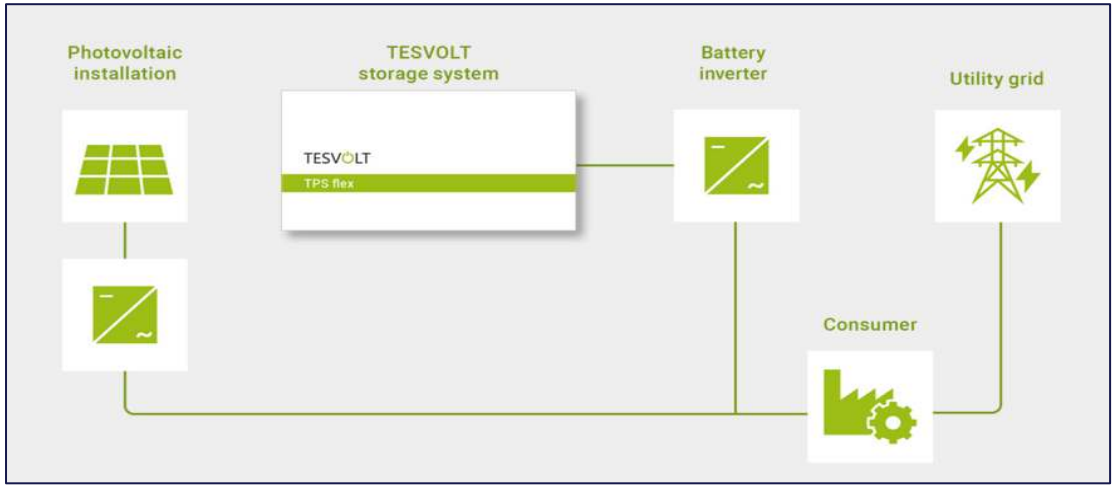
Completion: 2021, currently building the extension

Power / Capacity: 114 charging points with 300kW charging capacity, up to 2 MWh total capacity

Direct Benefit: Peak shaving, expandable, long-lasting, system services, only one hour (un)charging time

Further Information:
https://www.tesvolt.com/_media/07%20PROJEKTE/Ladepark_Hilden/Use_Case_Lastspitzenkappung_Ladepark_DEU.pdf





BEST PRACTICE
SYSTEM INFRASTRUCTURE MOBILITY

Application: Power Booster for fast charging stations

Technology: Battery stacks with Samsung SDI cells

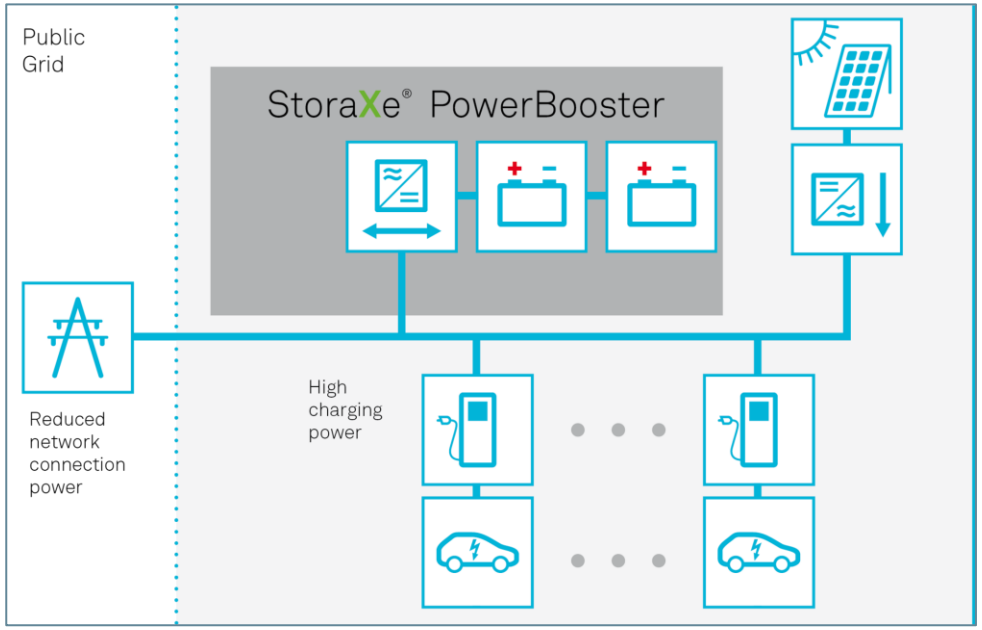
Company: ads-tec Energy GmbH

Power / Capacity : 280kW/240kWh per Container

Direct Benefit: Scalable, increase in the power capacity of the charging columns, grid services (voltage maintenance, frequency regulation, peak capping, reactive power).

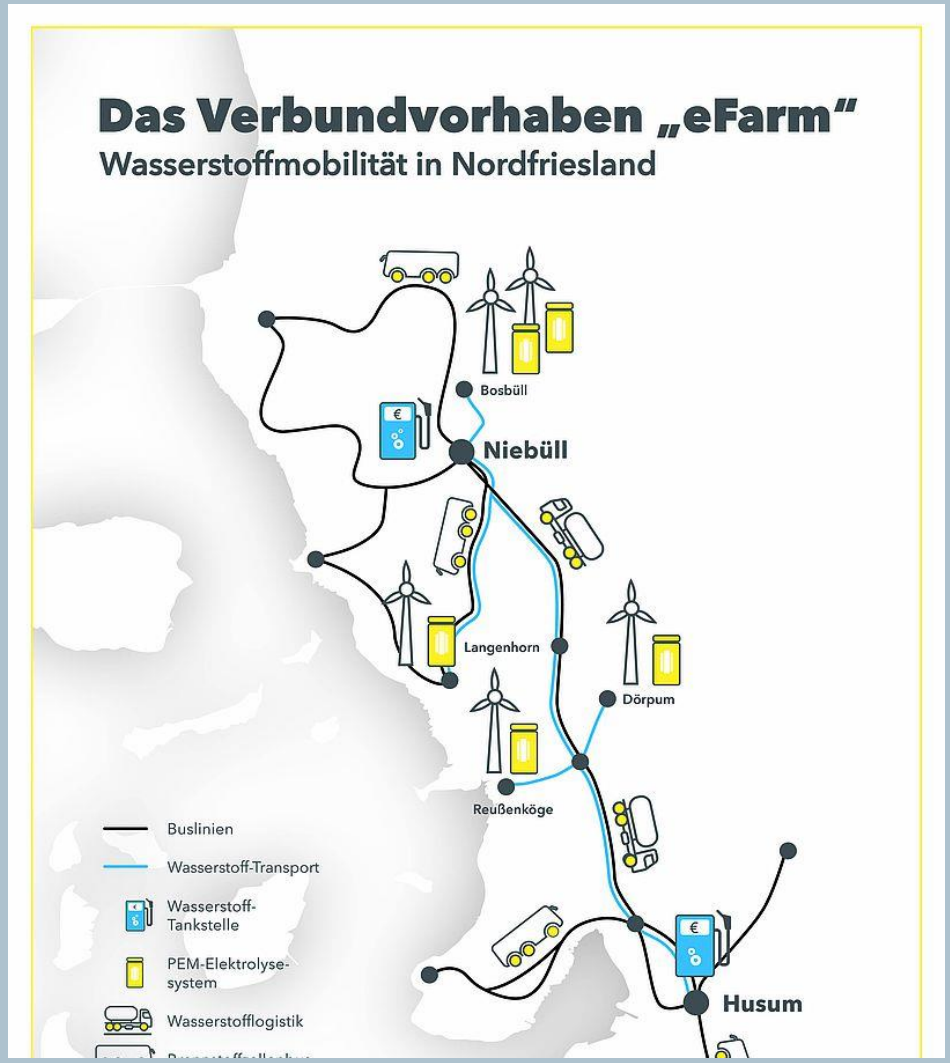
Further Information:

https://www.ads-tec-energy.com/commercial-industrial/powerbooster/technische-daten.html

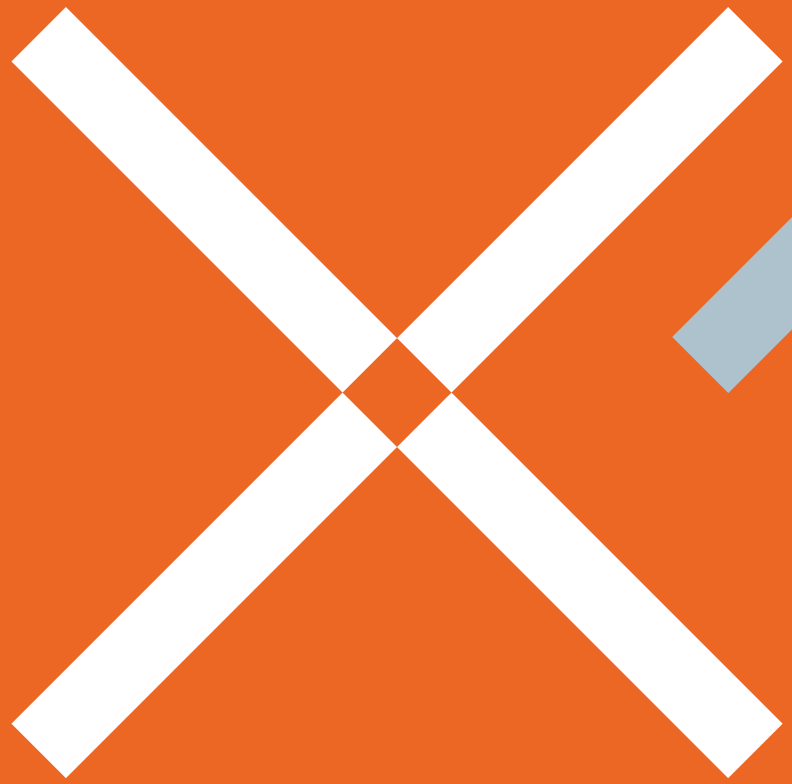


BEST PRACTICE HYDROGEN: EFARM PROJECT (JP GOULE)

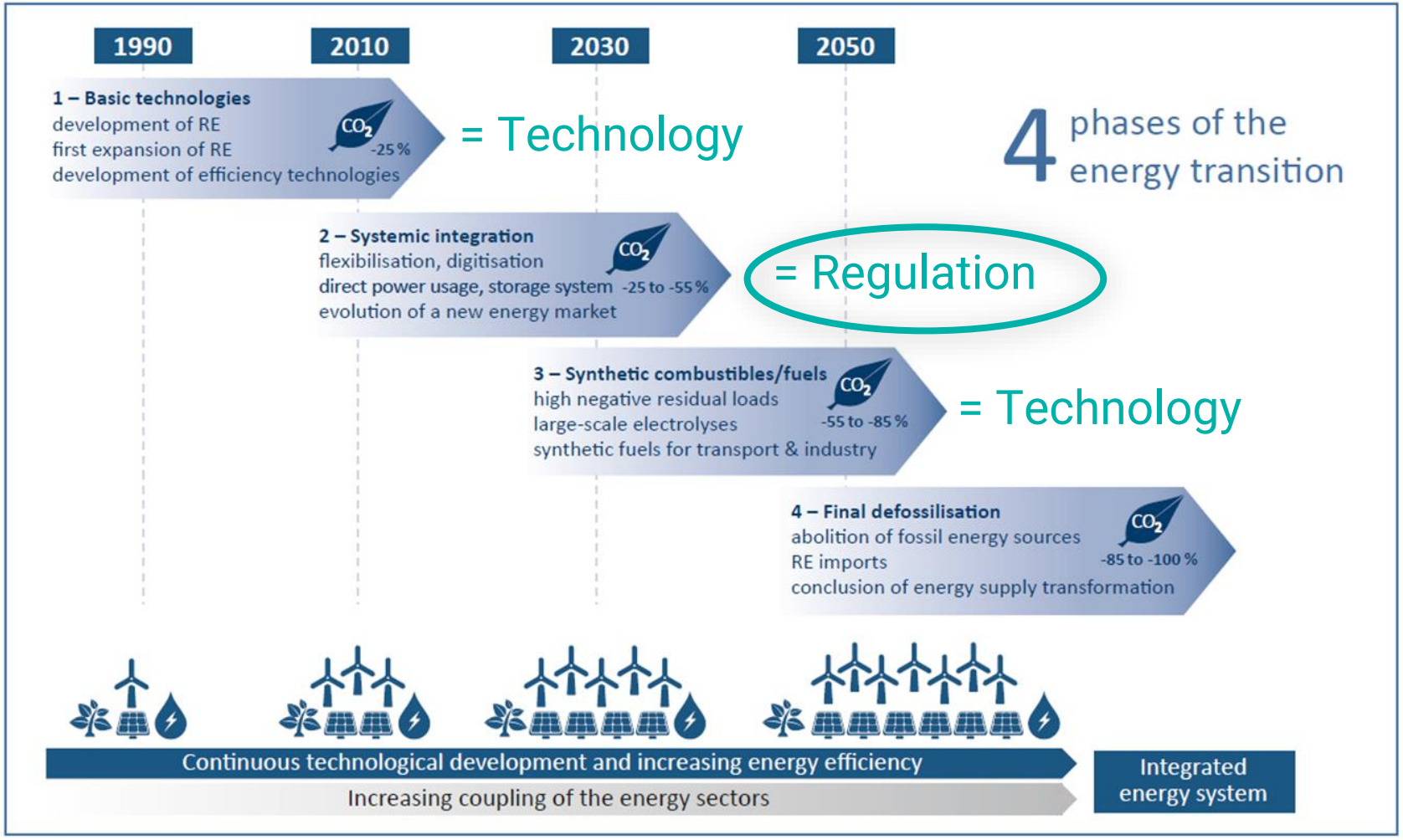
- Generating green hydrogen fuel from wind power in North Frisia
- 5 hydrogen production sites (1.125 MW total capacity) close to existing wind farms
- 2 hydrogen filling stations in Husum and Niebüll
- 2 fuel cell buses for public bus transport (commissioning in December 2020)
- 30 fuel cell cars with the potential for fuelling more than 100 vehicles



LEGAL FRAMEWORK



ENERGY TRANSITION: STEP BY STEP



Source: acatech/Leopoldina/Akademienunion: Sektorkopplung – Optionen für die nächste Phase der Energiewende (Schriftenreihe zur wissenschaftsbasierten Politikberatung), 2017

NEW ENERGY SYSTEM REQUIRES NEW REGULATION

GERMAN REGULATION

- **„Easter Package“: Draft of an Act on Immediate Measures for an Accelerated expansion of renewable energies**
- Regulatory definition of energy storage unit in line with EU
- Different measures to promote the expansion of renewable energy technologies, inkl. storage
- New objective: 100% renewable electricity by 2035

CONCLUSIONS

Energy storage ensures the effective integration of renewables in power systems

Energy storage offers flexibility and security of supply for a variety of applications

Energy storage market shows constant growth despite the economic uncertainity

Regulatory framework needs to support the application of energy storage systems

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