What is the Value of Energy Storage?

WRETC 2021

Andreas Hauer

BVES Bundesverband Energiespeicher Systeme e.V.

ZAE BAYERN

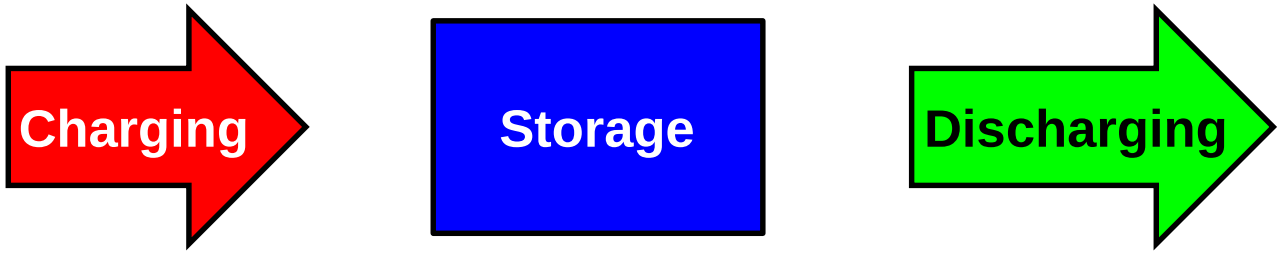
Contents

- **Energy Storage – Basic Definitions**
- What is the Value of Storage?
  - Example: Cold storage as Dispatchable Load
- Energy Storage – Technologies
- Energy Storage – Applications
  - Energy Efficiency - Examples
  - Renewable Energies - Distributed Energy Storage Systems
  - Renewable Energies - Flexible Sector Coupling
- Conclusions

Definitions „Energy Storage“

What is energy storage?

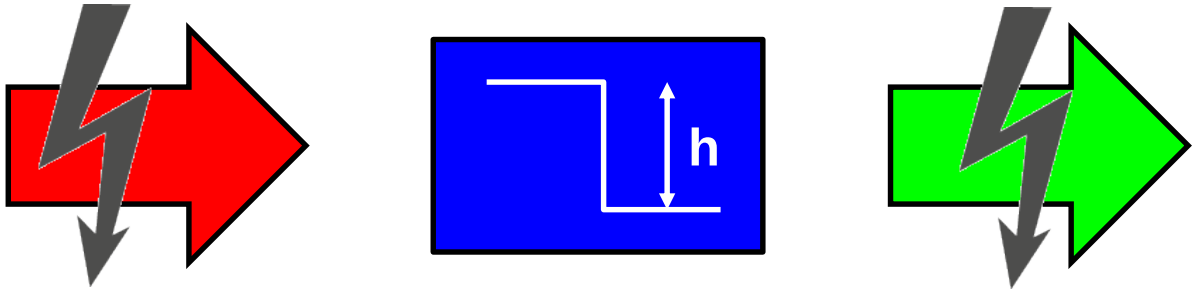
An energy storage system can take up energy and deliver it at a later point in time. The storage process itself consists of three stages: The charging, the storage and the discharging. After the discharging step the storage can be charged again.



Definitions „Energy Storage“

What is actually stored?

The form of energy (electricity, heat, cold, mechanical energy, chemical energy), which is taken up by an energy storage system, is usually the one, which is delivered.
However, in many cases the charged type of energy has to be transformed for the storage (e.g. pumped hydro storage or batteries). It is re-transformed for the discharging. In some energy storage systems the transformed energy type is delivered (e.g. Power-to-Gas or Power-to-Heat).

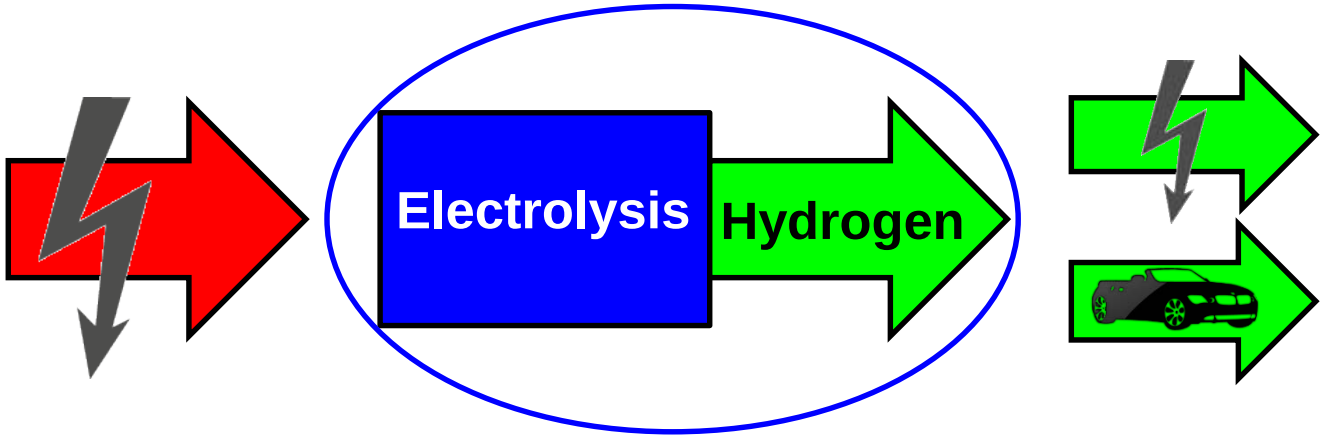


Definitions „Energy Storage“

Relation between energy storage systems and their applications

The technical and economical requirements for an energy storage system are determined by its actual application within the energy system. Therefore any evaluation and comparison of energy storage technologies is only possible with respect to this application.

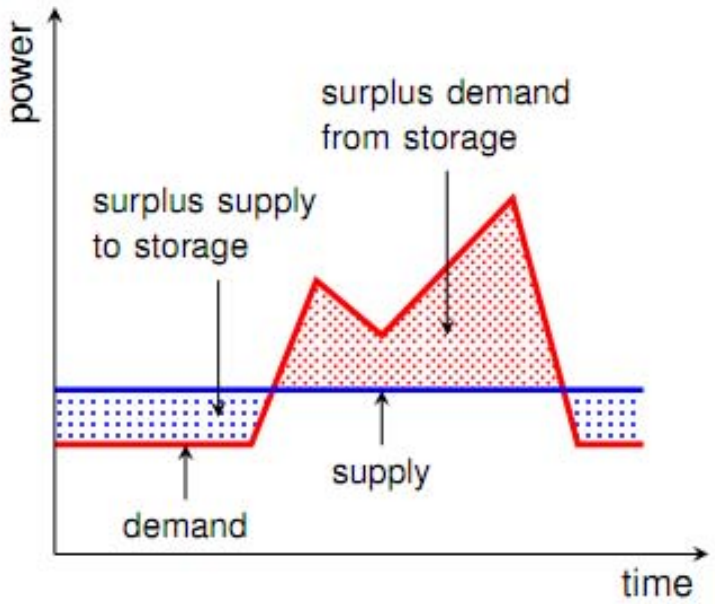
The application determines the technical requirements (e.g. type of energy, storage capacity, charging/discharging power,…) as well as the economical environment (e.g. expected pay-back time, price for delivered energy,…).



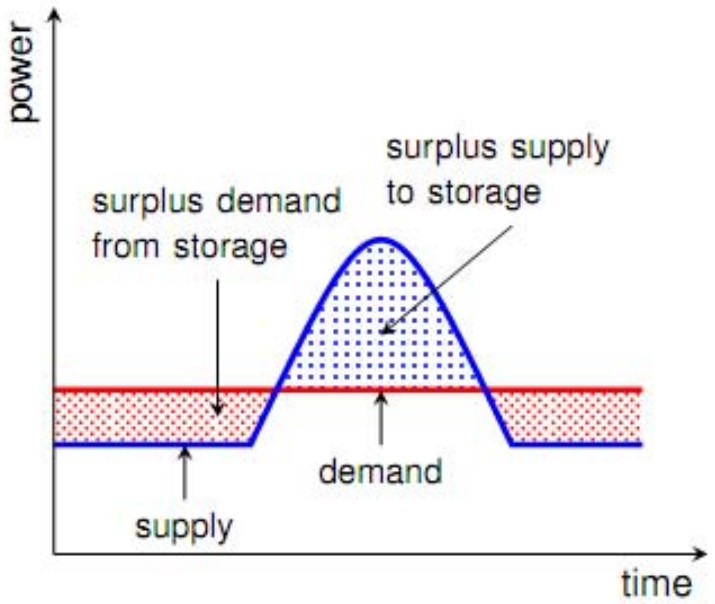
Matching Supply and Demand

ZAE BAYERN

Constant Supply



Fluctuating Supply



Difference between Power & Energy

ZAE BAYERN

„Storage of Power“

„Storage of Energy“

- Energy Storage – Basic Definitions
- **What is the Value of Storage?**
  - Example: Cold storage as Dispatchable Load
- Energy Storage – Technologies
- Energy Storage – Applications
  - Energy Efficiency - Examples
  - Renewable Energies - Distributed Energy Storage Systems
  - Renewable Energies - Flexible Sector Coupling
- Conclusions

From Benefit to Business Case

What is the benefit of energy storage?
What is the value of energy storage?
Who would pay for it?

Benefit	→	Value	→	Business Case
Availability of energy and power (in many applications by many technologies)		How much would somebody pay for the benefit?		Who would pay for the benefit?

Basic Question

What do we expect from energy storage?

- **Energy: constant, peak, offline, … supply**
- **Power: positive / negative (e.g. bathtub, EV fast charging, grid services…)**

Diversity of Benefits

From availability of energy and power we can derive the following services:

- **Flexibility – grid services, integration of renewables, …**
- **Reliability / Security – uninterruptable power supply, …**
- **Mobility – electric vehicles, mobile phones, …**
- **Autarky – island solutions, self sufficiency, …**
- **…**

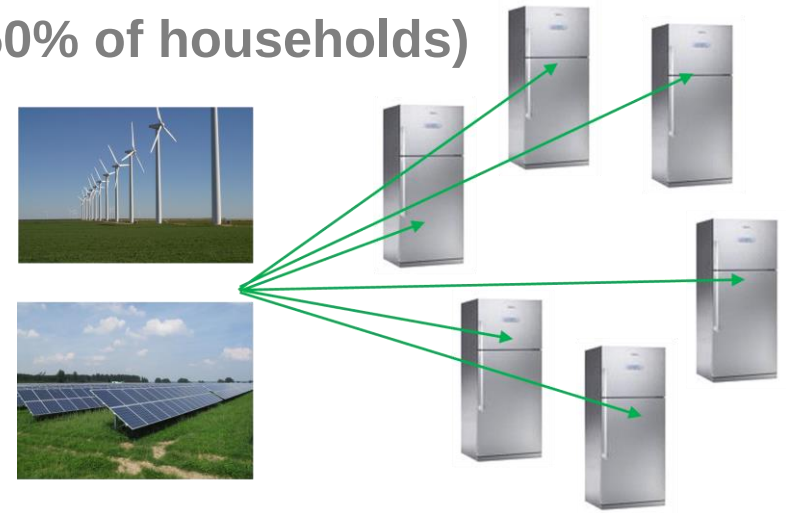
- Energy Storage – Basic Definitions
- What is the Value of Storage?
  - **Example: Cold storage as Dispatchable Load**
- Energy Storage – Technologies
- Energy Storage – Applications
  - Energy Efficiency - Examples
  - Renewable Energies - Distributed Energy Storage Systems
  - Renewable Energies - Flexible Sector Coupling
- Conclusions

„Power-to-Cold – Energy Storage within a Fridge“

ZAE BAYERN

Cold storage can generate **dispatchable load** within the electricity grid by transforming electricity to cold

- **20 Million Fridges in Germany (<50% of households)**
- **PCM cold storage for 7-8 hours**
- **Charging time 2-3 hours**
- **Cost about 5 €**



⇨	**Electric Power**	**1,15 GW**
⇨	**Storage Capacity**	**3,5 GWh**

More Questions…

What is the benefit of a dispatchable load?
What is the value of dispatachble load?
Who would pay for that?

In countries with a relieable grid:
- **Not the owner of the fridge.**
- **Not the producer of fridges.**
- **The utility, the grid operator, society?**

In coutries with a weak grid:
- **The consumer.**
- **The producer of fridges.**
- **The utility, the grid operator, society?**

„Even if it is a good thing to do, it is not certain, that somebody will pay for it“

- Energy Storage – Basic Definitions
- **What is the Value of Storage?**
  - Example: Cold storage as Dispatchable Load
- Energy Storage – Technologies
- Energy Storage – Applications
  - Energy Efficiency - Examples
  - Renewable Energies - Distributed Energy Storage Systems
  - Renewable Energies - Flexible Sector Coupling
- Conclusions

What is the value of storage?

≈ 10.000 €/kWh

Examples:

Mobile Phones ➡ to have no free time at all!

Hot Water Tank ➡ to fill up you bath tub fast!

≈ 1 €/kWh

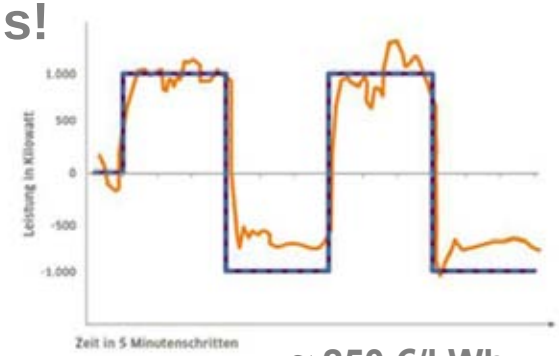
E-Mobility ➡ for the possibility of a CO_2-free transportation

≈ 500 €/kWh

What is the value of storage?

Examples:

Grid Services ➡ for fast and exact response on fluctuations!



≈ 250 €/kWh

Competitive Production ➡ by improving energy efficiency in industry!

≈ 100 €/kWh

Integration of Renewable Energies ➡ by increasing self consumption !

≈ 250 €/kWh

© Jim Petersen

What are you willing to pay?

ZAE BAYERN

Many aspects (even non-technical!) are influencing the value of storage!

- Energy Storage – Basic Definitions
- What is the Value of Storage?
  - Example: Cold storage as Dispatchable Load
- **Energy Storage – Technologies**
- Energy Storage – Applications
  - Energy Efficiency - Examples
  - Renewable Energies - Distributed Energy Storage Systems
  - Renewable Energies - Flexible Sector Coupling
- Conclusions

Energy Storage Technologies

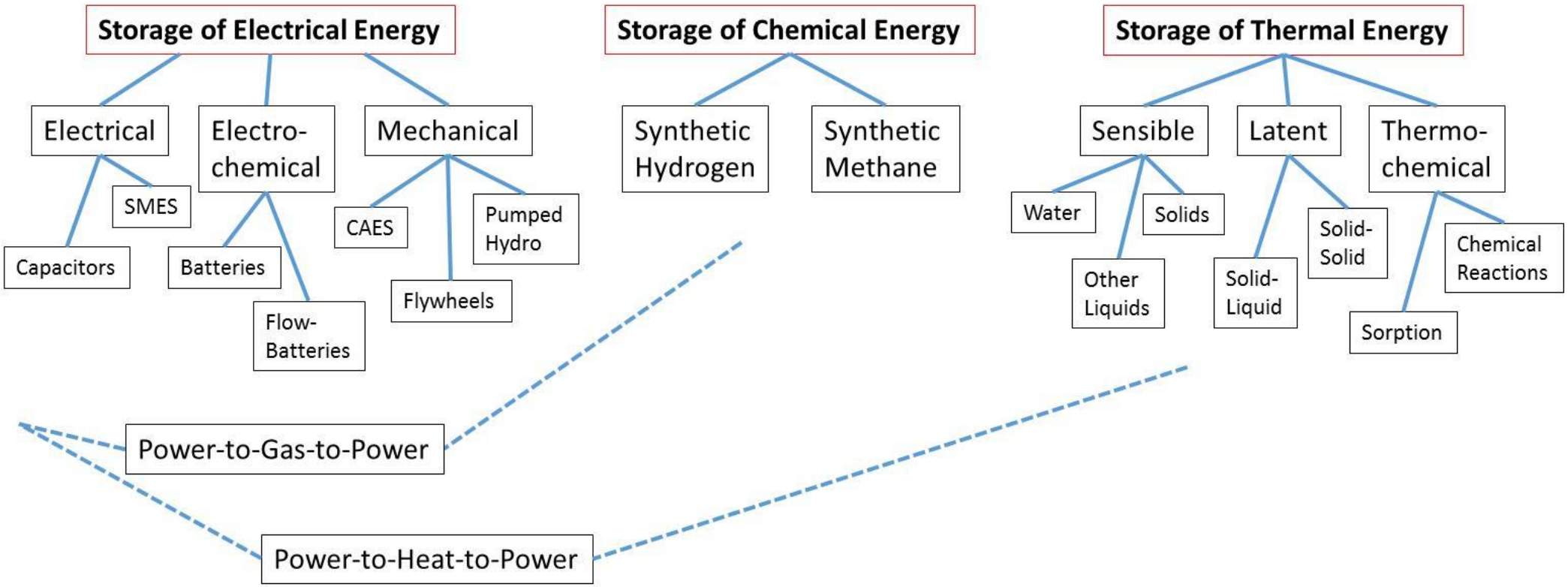
ZAE BAYERN

Electrical Energy Storage

Thermal Energy Storage

Chemical Energy Storage

Structure of Energy Storage Technologies following the Physical Storage Effect
(not the relevance of the technologies!)



- Energy Storage – Basic Definitions
- What is the Value of Storage?
  - Example: Cold storage as Dispatchable Load
- Energy Storage – Technologies
- **Energy Storage – Applications**
  - Energy Efficiency - Examples
  - Renewable Energies - Distributed Energy Storage Systems
  - Renewable Energies - Flexible Sector Coupling
- Conclusions

- Energy Storage – Basic Definitions
- What is the Value of Storage? (I)
  - Example: Cold storage as Dispatchable Load
- Energy Storage – Technologies
- Energy Storage – Applications
  - **Energy Efficiency - Examples**
  - Renewable Energies - Distributed Energy Storage Systems
  - Renewable Energies - Flexible Sector Coupling
- What is the Value of Storage? (II)
  - Example: Maximum Acceptable Storage Cost
- Conclusions

Recuperation of Mechanical Energy

ZAE BAYERN

- Recuperation of mechanical energy by flywheel electrical energy storage
- Recovering breaking energy (trains)
- High power input/output and short charging/discharging times (25 s)
- Reduction of energy consumption (CO_2 emissions)
- Reduction of peak power demand

- Energy Storage – Basic Definitions
- What is the Value of Storage? Example: Cold storage as Dispatchable Load
- Energy Storage – Technologies
- Energy Storage – Applications
  - Energy Efficiency - Examples
  - **Renewable Energies - Distributed Energy Storage Systems**
  - Renewable Energies - Flexible Sector Coupling
- Conclusions

Distributed Energy Storage for the Intergration of Renewable Energy - DESIRE

- Ostpreußenhütte, Austria: Completely grid-independent energy supply for remote areas (PV + Battery)
- Replacing conventional diesel generators
- Supply of cheap and reliable renewable electricity around the clock

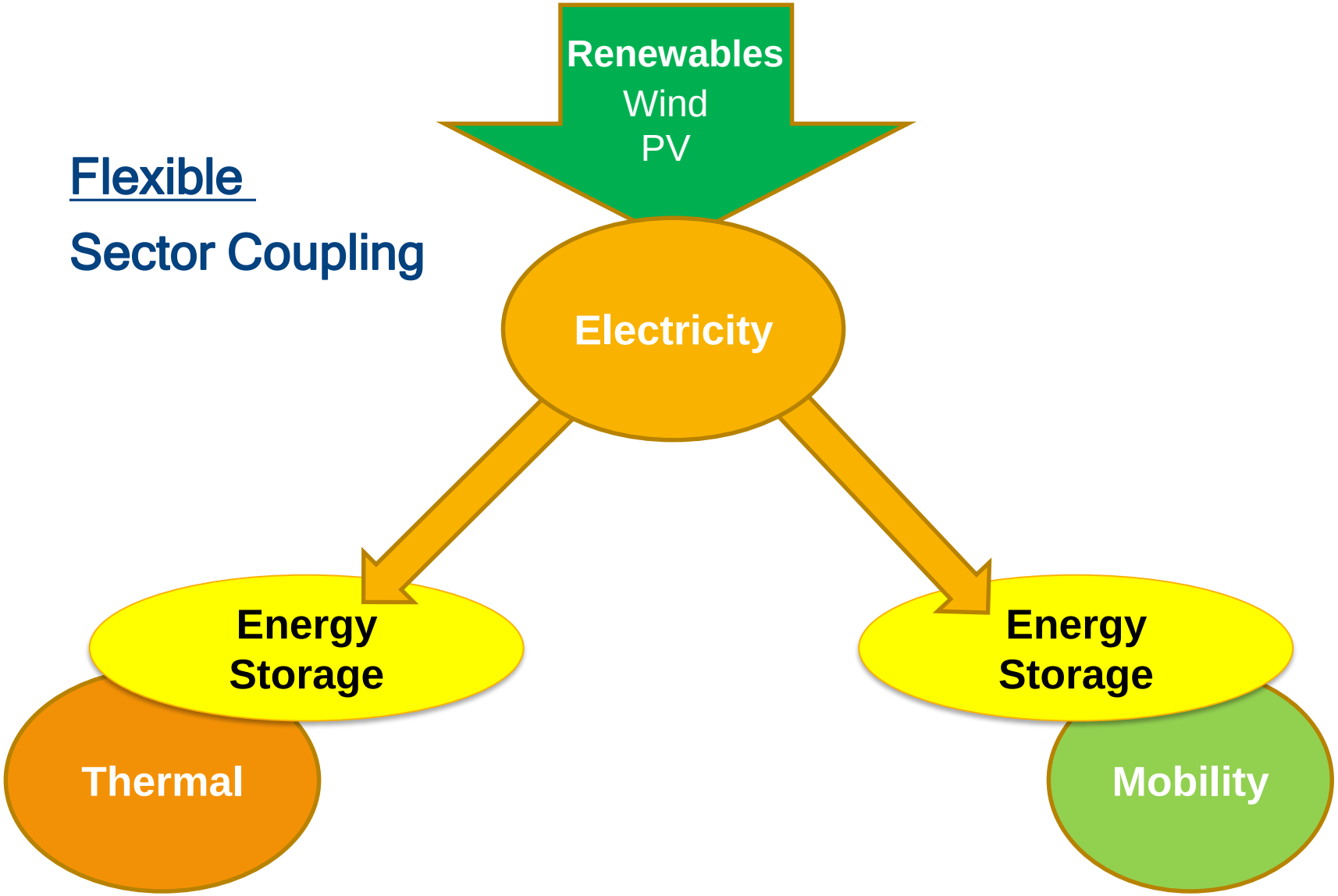
- Energy Storage – Basic Definitions
- What is the Value of Storage? Example: Cold storage as Dispatchable Load
- Energy Storage – Technologies
- Energy Storage – Applications
  - Energy Efficiency - Examples
  - Renewable Energies - Distributed Energy Storage Systems
  - **Renewable Energies - Flexible Sector Coupling**
- Conclusions

BVES
Bundesverband Energiespeicher Systeme e.V.

ZAE BAYERN

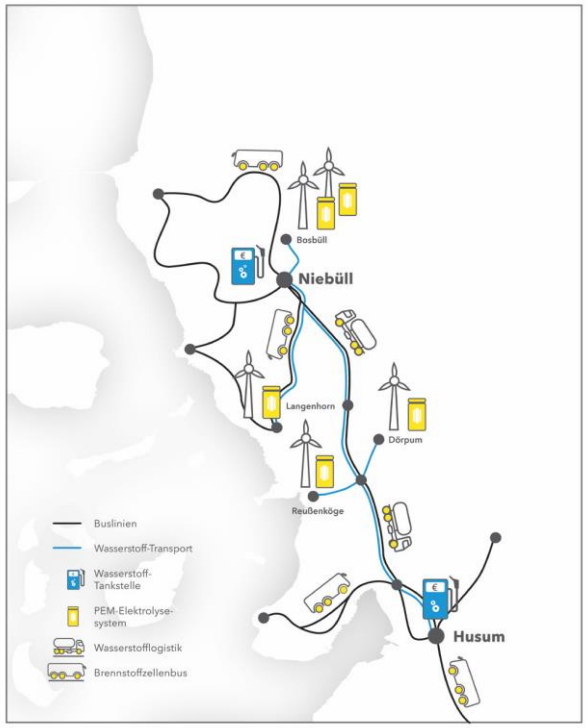
Flexible

Sector Coupling



Power-to-Hydrogen (Mobility Sector)

Goal is to replace existing diesel-fueled commuter buses with fuel cell buses powered by green hydrogen and avoiding CO2 and NOx emissions. The green H2 fuel will be supplied from an electrolyzer operated on electricity from solar photovoltaic (PV) and wind.



Pilot Project „eFarm“ in the North of Germany – Wind Energy for Local Public Transportation

- 5 Electrolysers at 4 Locations – 1.125 MW
- 2 H_2 Filling Stations
- 2 Fuel Cell Buses and 30 Fuel Cell Cars

ZAE BAYERN

- Energy Storage – Basic Definitions
- What is the Value of Storage? Example: Cold storage as Dispatchable Load
- Energy Storage – Technologies
- Energy Storage – Applications
  - Energy Efficiency - Examples
  - Renewable Energies - Distributed Energy Storage Systems
  - Renewable Energies - Flexible Sector Coupling
- **Conclusions**

Conclusions

- A large number of energy storage technolgies is available or under development
- A large number of possible energy storage applications can be identified
- Energy storage can support the increase of energy efficiency
- Energy storage can contribute to the integration of renewable energy through
  - Distributed energy storage systems
  - Flexible sector coupling
- The value of energy storage can only be quantified for actual applications

Conclusion(s)

ZAE BAYERN

Main Message:

Always think Energy Storage within real applications!

…only then we can quantify the value of Energy Storage

Thank you very much for your Attention!

BVES
Bundesverband
Energiespeicher
Systeme e.V.

ZAE BAYERN